

# Complete Listing of CWP Free Program Self-Documentations

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# Names and Short descriptions of the Codes

CWPROOT = /usr/local/cwp

Mains:

In CWPROOT/src/cwp/main:

- \* CTRLSTRIP - Strip non-graphic characters
- \* DOWNFORT - change Fortran programs to lower case, preserving strings
- \* FCAT - fast cat with 1 read per file
- \* ISATTY - pass on return from isatty(2)
- \* MAXINTS - Compute maximum and minimum sizes for integer types
- \* PAUSE - prompt and wait for user signal to continue
- \* T - time and date for non-military types
- \* UPFORT - change Fortran programs to upper case, preserving strings

In CWPROOT/src/par/main:

- A2B - convert ascii floats to binary
- A2I - convert Ascii to binary Integers
- ADDRVL3D - Add a random velocity layer (RVL) to a gridded
- B2A - convert binary floats to ascii
- CELLAUTO - Two-dimensional CELLular AUTOmata
- char\* sdoc[] = {
- CSHOTPLOT - convert CSHOT data to files for CWP graphers
- DZDV - determine depth derivative with respect to the velocity ",
- FARITH - File ARITHmetic -- perform simple arithmetic with binary files
- FLOAT2IBM - convert native binary FLOATS to IBM tape FLOATS
- FTNSTRIP - convert a file of binary data plus record delimiters created
- FTNUNSTRIP - convert C binary floats to Fortran style floats
- GRM - Generalized Reciprocal refraction analysis for a single layer
- H2B - convert 8 bit hexadecimal floats to binary
- HTI2STIFF - convert HTI parameters alpha, beta, d(V), e(V), gamma
- HUDSON - compute effective parameters of anisotropic solids
- I2A - convert binary integers to ascii
- IBM2FLOAT - convert IBM tape FLOATS to native binary FLOATS
- KAPERTURE - generate the k domain of a line scatterer for a seismic array
- LINRORT - linearized P-P, P-S1 and P-S2 reflection coefficients
- MAKEVEL - MAKE a VELOCITY function v(x,y,z)
- MKPARFILE - convert ascii to par file format
- MRAFXZWT - Multi-Resolution Analysis of a function F(X,Z) by Wavelet
- PDFHISTOGRAM - generate a HISTOGRAM of the Probability Density function
- PRPLOT - PRinter PLOT of 1-D arrays f(x1) from a 2-D function f(x1,x2)

RANDVEL3D - Add a random velocity layer (RVL) to a gridded  
 RAYT2DAN -- P- and SV-wave raytracing in 2D anisotropic media  
 RAYT2D - traveltimes Tables calculated by 2D paraxial RAY tracing  
 RECAST - RECAST data type (convert from one data type to another)  
 REFREALAZIHTI - REAL AZimuthal REFL/transm coeff for HTI media  
 REFREALVTI - REAL REFL/transm coeff for VTI media and symmetry-axis  
 REGRID3 - REwrite a [ni3][ni2][ni1] GRID to a [no3][no2][no1] 3-D grid  
 RESAMP - RESAMPlE the 1st dimension of a 2-dimensional function f(x1,x2)

SMOOTH2 --- SMOOTH a uniformly sampled 2d array of data, within a user-  
 SMOOTH3D - 3D grid velocity SMOOTHing by the damped least squares  
 SMOOTHINT2 --- SMOOTH non-uniformly sampled INTERfaces, via the damped  
 STIFF2VEL - Transforms 2D elastic stiffnesses to (vp,vs,epsilon,delta)  
 SUBSET - select a SUBSET of the samples from a 3-dimensional file  
 SWAPBYTES - SWAP the BYTES of various data types  
 THOM2HTI - Convert Thompson parameters V\_p0, V\_s0, eps, gamma,  
 THOM2STIFF - convert Thomsen's parameters into (density normalized)  
 TRANSP3D - TRANSPOSE an n1 by n2 by n3 element matrix  
 TRANSP - TRANSPOSE an n1 by n2 element matrix  
 TVNMOQC - Check tnmo-vnmo pairs; create t-v column files  
 UNIF2ANISO - generate a 2-D UNIFormly sampled profile of elastic  
 UNIF2 - generate a 2-D UNIFormly sampled velocity profile from a layered  
 UNIF2TI2 - generate a 2-D UNIFormly sampled profile of stiffness  
 UNISAM2 - UNIFormly SAMple a 2-D function f(x1,x2)  
 UNISAM - UNIFormly SAMple a function y(x) specified as x,y pairs  
 UTMCONV - CONVERt longitude and latitude to UTM, and vice versa  
 VEL2STIFF - Transforms VELOCities, densities, and Thomsen or Sayers  
 VELCONV - VELOCITY CONVersion  
 VELPERTAN - Velocity PERTurbation analysis in ANisotropic media to  
 VELPERT - estimate velocity parameter perturbation from covariance

VTLVZ -- Velocity as function of Time for Linear V(Z);  
 WKBJ - Compute WKBJ ray theoretic parameters, via finite differencing  
 XY2Z - converts (X,Y)-pairs to spike Z values on a uniform grid  
 Z2XYZ - convert binary floats representing Z-values to ascii

In CWPROOT/src/psplot/main:

PSBBOX - change BoundingBox of existing PostScript file  
 PSCONTOUR - PostScript CONTOURING of a two-dimensional function f(x1,x2)  
 PSCUBE - PostScript image plot with Legend of a data CUBE  
 PSCONTOUR - PostScript Contour plot of a data CUBE  
 PSEPSI - add an EPSI formatted preview bitmap to an EPS file  
 PSGRAPH - PostScript GRAPHer

PSIMAGE - PostScript IMAGE plot of a uniformly-sampled function  $f(x_1, x_2)$   
PSLABEL - output PostScript file consisting of a single TEXT string  
PSMANAGER - printer MANAGER for HP 4MV and HP 5Si Mx Laserjet  
PSMERGE - MERGE PostScript files  
PSMOVIE - PostScript MOVIE plot of a uniformly-sampled function  $f(x_1, x_2, x_3)$   
PSWIGB - PostScript WIGgle-trace plot of  $f(x_1, x_2)$  via Bitmap  
PSWIGP - PostScript WIGgle-trace plot of  $f(x_1, x_2)$  via Polygons

In CWPROOT/src/xplot/main:

- \* LCMAP - List Color Map of root window of default screen
- \* LPROP - List PROPERTIES of root window of default screen of display
- \* SCMAP - set default standard color map (RGB\_DEFAULT\_MAP)

XCONTOUR - X CONTOUR plot of  $f(x_1, x_2)$  via vector plot call

- \* XESPB - X windows display of Encapsulated PostScript as a single Bitmap
- \* XEPPS - X windows display of Encapsulated PostScript

XIMAGE - X IMAGE plot of a uniformly-sampled function  $f(x_1, x_2)$   
XPICKER - X wiggle-trace plot of  $f(x_1, x_2)$  via Bitmap with PICKing

- \* XPSP - Display conforming PostScript in an X-window

XWIGB - X WIGgle-trace plot of  $f(x_1, x_2)$  via Bitmap

In CWPROOT/src/Xtcwp/main:

XGRAPH - X GRAPHer  
XMOVIE - image one or more frames of a uniformly sampled function  $f(x_1, x_2)$   
XRECTS - plot rectangles on a two-dimensional grid

In CWPROOT/src/Xmcwp/main:

- \* FFTLAB - Motif-X based graphical 1D Fourier Transform

In CWPROOT/src/su/graphics/psplot:

SUPSCONTOUR - PostScript CONTOUR plot of a segy data set  
SUPSCUBE - PostScript CUBE plot of a segy data set  
SUPSCUBECONTOUR - PostScript CUBE plot of a segy data set  
SUPSGRAPH - PostScript GRAPH plot of a segy data set  
SUPSIMAGE - PostScript IMAGE plot of a segy data set  
SUPSMAX - PostScript of the MAX, min, or absolute max value on each trace  
SUPSMOVIE - PostScript MOVIE plot of a segy data set  
SUPSWIGB - PostScript Bit-mapped WIGgle plot of a segy data set  
SUPSWIGP - PostScript Polygon-filled WIGgle plot of a segy data set

In CWPROOT/src/su/main/amplitudes:

SUCENTSAMP - CENTROID SAMPLE seismic traces  
SUDIPDIVCOR - Dip-dependent Divergence (spreading) correction  
SUDIVCOR - Divergence (spreading) correction

SUGAIN - apply various types of gain  
SUNAN - remove NaNs & Infs from the input stream  
SUNORMALIZE - Trace NORMALIZatIon by rms, max, or median",  
SUPGC - Programmed Gain Control--apply agc like function  
SUWEIGHT - weight traces by header parameter, such as offset  
SUZERO -- zero-out (or set constant) data within a time window

In CWPROOT/src/su/main/attributes\_parameter\_estimation:

SUATTRIBUTES - instantaneous trace ATTRIBUTES

SUHISTOGRAM - create histogram of input amplitudes  
SUMAX - get trace by trace local/global maxima, minima, or absolute maximum  
SUMEAN - get the mean values of data traces",  
SUQUANTILE - display some quantiles or ranks of a data set

In CWPROOT/src/su/main/convolution\_correlation:

SUACOR - auto-correlation  
SUACORFRAC -- general FRActional Auto-CORrelation/convolution  
SUCONV - convolution with user-supplied filter  
SUREFCON - Convolution of user-supplied Forward and Reverse  
SUXCOR - correlation with user-supplied filter

In CWPROOT/src/su/main/data\_compression:

DCTCOMP - Compression by Discrete Cosine Transform  
SUPACK1 - pack segy trace data into chars  
SUPACK2 - pack segy trace data into 2 byte shorts  
SUUNPACK1 - unpack segy trace data from chars to floats  
SUUNPACK2 - unpack segy trace data from shorts to floats

In CWPROOT/src/su/main/data\_conversion:

DT1TOSU - Convert ground-penetrating radar data in the  
SEGYCLEAN - zero out unassigned portion of header  
SEGYHDRMOD - replace the text header on a SEG-Y file  
SEGYHDRS - make SEG-Y ascii and binary headers for segywrite  
SEGYREAD - read an SEG-Y tape  
SEGYSKAN -- SCANS SEG-Y file trace headers for min-max in several  
SEGYWRITE - write an SEG-Y tape  
SETBHED - SET the fields in a SEG-Y Binary tape HEaDer file, as would be  
SUASCII - print non zero header values and data in various formats  
SUINTVEL - convert stacking velocity model to interval velocity model  
SUOLDTONEW - convert existing su data to xdr format  
SUSTKVEL - convert constant dip layer interval velocity model to the  
SUSWAPBYTES - SWAP the BYTES in SU data to convert data from big endian

SWAPBHED - SWAP the BYTES in a SEG Y Binary tape HEaDer file

In CWPROOT/src/su/main/datuming:

SUDATUMFD - 2D zero-offset Finite Difference acoustic wave-equation

SUDATUMK2DR - Kirchhoff datuming of receivers for 2D prestack data

SUDATUMK2DS - Kirchhoff datuming of sources for 2D prestack data

SUKDMDCR - 2.5D datuming of receivers for prestack, common source

SUKDMDCS - 2.5D datuming of sources for prestack common receiver

In CWPROOT/src/su/main/decon\_shaping:

SUCDDECON - DECONvolution with user-supplied filter by straightforward

SUFXDECON - random noise attenuation by FX-DECONvolution

SUPEF - Wiener (least squares) predictive error filtering

SUPHIDECON - PHase Inversion Deconvolution

SUSHAPE - Wiener shaping filter

In CWPROOT/src/su/main/dip\_moveout:

SUDMOFK - DMO via F-K domain (log-stretch) method for common-offset gathers

SUDMOFKCW - converted-wave DMO via F-K domain (log-stretch) method for

SUDMOTIVZ - DMO for Transeversely Isotropic V(Z) media for common-offset

SUDMOTX - DMO via T-X domain (Kirchhoff) method for common-offset gathers

SUDMOVZ - DMO for V(Z) media for common-offset gathers

SUTIHAIEDMO - TI Hale Dip MoveOut (based on Hale's PhD thesis)

In CWPROOT/src/su/main/filters:

SUBFILT - apply Butterworth bandpass filter

SUCCFILT - FX domain Correlation Coefficient FILTER

SUDIPFILT - DIP--or better--SLOPE Filter in f-k domain

SUFILTER - applies a zero-phase, sine-squared tapered filter

SUFRAC -- take general (fractional) time derivative or integral of

SUFWATRIM - FX domain Alpha TRIM

SUK1K2FILTER - symmetric box-like K-domain filter defined by the

SUKFILTER - radially symmetric K-domain,  $\sin^2$ -tapered, polygonal

SUKFRAC - apply FRACtional powers of  $i|k|$  to data, with phase shift

SULFAF - Low frequency array forming ",

SUMEDIAN - MEDIAN filter about a user-defined polygonal curve with

SUPHASE - PHASE manipulation by linear transformation

SUSMGAUSS2 --- SMOOTH a uniformly sampled 2d array of velocities

SUTVBAND - time-variant bandpass filter (sine-squared taper)

In CWPROOT/src/su/main/headers:

BHEDTOPAR - convert a Binary tape HEaDer file to PAR file format

SU3DCHART - plot x-midpoints vs. y-midpoints for 3-D data

SUABSHW - replace header key word by its absolute value  
 SUADDHEAD - put headers on bare traces and set the traci and ns fields  
 SUAHW - Assign Header Word using another header word  
 SUAZIMUTH - compute trace AZIMUTH, offset, and midpoint coordinates  
 SUCDPBIN - Compute CDP bin number  
 SUCHART - prepare data for x vs. y plot  
 SUCHW - Change Header Word using one or two header word fields  
 SUCLIPHEAD - Clip header values  
 SUCOUNTKEY - COUNT the number of unique values for a given KEYword.  
 SUDUMPTRACE - print selected header values and data.  
 SUEEDIT - examine segy diskfiles and edit headers  
 SUGEOM - Fill up geometry in trace headers.  
 SUGETHW - sugethw writes the values of the selected key words  
 SUHTMATH - do unary arithmetic operation on segy traces with  
 SUKEYCOUNT - sukeycount writes a count of a selected key  
 SULCTHW - Linear Coordinate Transformation of Header Words  
 SULHEAD - Load information from an ascii column file into HEADERS based  
 SUPASTE - paste existing SU headers on existing binary data  
 surandhw - set header word to random variable  
 SURANGE - get max and min values for non-zero header entries  
 SUSEHW - Set the value the Header Word denoting trace number within  
 SUSHW - Set one or more Header Words using trace number, mod and  
 SUSTRIP - remove the SEG Y headers from the traces  
 SUTRCOUNT - SU program to count the TRaces in infile  
 SUUTM - UTM projection of longitude and latitude in SU trace headers  
 SUXEDIT - examine segy diskfiles and edit headers

In CWROOT/src/su/main/interp\_extrap:

SUINTERP - interpolate traces using automatic event picking  
 SUINTERPFWLER - interpolate output image from constant velocity panels  
 SUOCEXT - smaller Offset EXTrapolation via Offset Continuation

In CWROOT/src/su/main/migration\_inversion:

SUGAZMIGQ - SU version of Jeno GAZDAG's phase-shift migration  
 SUINVXZCO - Seismic INVersion of Common Offset data for a smooth  
 SUINVZCO3D - Seismic INVersion of Common Offset data with V(Z) velocity  
 SUKDMIG2D - Kirchhoff Depth Migration of 2D poststack/prestack data  
 SUKDMIG3D - Kirchhoff Depth Migration of 3D poststack/prestack data  
 SUKTMIG2D - prestack time migration of a common-offset  
 SUMIGFD - 45-90 degree Finite difference depth migration for  
 SUMIGFFD - Fourier finite difference depth migration for  
 SUMIGGBZOAN - MIGration via Gaussian beams ANisotropic media (P-wave)  
 SUMIGGBZO - MIGration via Gaussian Beams of Zero-Offset SU data

SUMIGPREFD --- The 2-D prestack common-shot 45-90 degree  
SUMIGPREFFD - The 2-D prestack common-shot Fourier finite-difference  
char \*sdoc[] = {  
SUMIGPRESP - The 2-D prestack common-shot split-step Fourier ",  
SUMIGPS - MIGration by Phase Shift with turning rays  
SUMIGPSPI - Gazdag's phase-shift plus interpolation depth migration  
SUMIGPSTI - MIGration by Phase Shift for TI media with turning rays  
SUMIGSPLIT - Split-step depth migration for zero-offset data.  
SUMIGTK - MIGration via T-K domain method for common-midpoint stacked data  
SUMIGTOP02D - Kirchhoff Depth Migration of 2D poststack/prestack data  
SUSTOLT - Stolt migration for stacked data or common-offset gathers  
SUTIFOWLER VTI constant velocity prestack time migration

In CWPROOT/src/su/main/multicomponent:

SUALFORD - trace by trace Alford Rotation of shear wave data volumes  
SUEIPOFI - EIGenimage (SVD) based POLarization FILTER for  
SUHROT - Horizontal ROTation of three-component data  
SULTT - trace by trace, sample by sample, rotation of shear wave data  
SUPOFILT - POLarization FILTER for three-component data  
SUPOLAR - POLarization analysis of three-component data

In CWPROOT/src/su/main/noise:

SUADDDNOISE - add noise to traces  
SUHARLAN - signal-noise separation by the invertible linear  
SUJITTER - Add random time shifts to seismic traces

In CWPROOT/src/su/main/operations:

SUFLIP - flip a data set in various ways  
SUFWMIX - FX domain multidimensional Weighted Mix  
SUMATH - do math operation on su data  
SUMIX - compute weighted moving average (trace MIX) on a panel  
SUOP2 - do a binary operation on two data sets  
SUOP - do unary arithmetic operation on segys  
SUPERMUTE - permute or transpose a 3d datacube  
SUSIMAT - Correlation similarity matrix for two traces.  
SUVCAT - append one data set to another, with or without an ",  
SUVLENGTH - Adjust variable length traces to common length

In CWPROOT/src/su/main/picking:

SUFBPICKW - First break auto picker  
SUFNZERO - get Time of First Non-ZERO sample by trace  
SUPICKAMP - pick amplitudes within user defined and resampled window



In CWPROOT/src/su/main/stacking:

SUCVS4FOWLER --compute constant velocity stacks for input to Fowler codes  
SUDIVSTACK - Diversity Stacking using either average power or peak  
SUPWS - Phase stack or phase-weighted stack (PWS) of adjacent traces  
SURECIP - sum opposing offsets in prepared data (see below)  
SUSTACK - stack adjacent traces having the same key header word

In CWPROOT/src/su/main/statics:

SUADDSTATICS - ADD random STATICS on seismic data  
SURANDSTAT - Add RANDom time shifts STATIC errors to seismic traces  
SURESSAT - Surface consistent source and receiver statics calculation  
SUSTATICB - Elevation static corrections, apply corrections from  
SUSTATIC - Elevation static corrections, apply corrections from  
SUSTATICRRS - Elevation STATIC corrections, apply corrections from

In CWPROOT/src/su/main/stretching\_moveout\_resamp:

SUILOG -- time axis inverse log-stretch of seismic traces  
SULOG -- time axis log-stretch of seismic traces  
SUNMO\_a - NMO for an arbitrary velocity function of time and CDP with  
SUNMO - NMO for an arbitrary velocity function of time and CDP  
SUREDUCE - convert traces to display in reduced time ",  
SURESAMP - Resample in time  
SUSHIFT - shifted/windowed traces in time  
SUTAUPNMO - NMO for an arbitrary velocity function of tau and CDP  
SUTSQ -- time axis time-squared stretch of seismic traces  
SUTTOZ - resample from time to depth  
SUZTOT - resample from depth to time

In CWPROOT/src/su/main/supromax:

SUGET - Connect SU program to file descriptor for input stream.  
SUPUT - Connect SU program to file descriptor for output stream.

In CWPROOT/src/su/main/synthetics\_waveforms\_testpatterns:

SUDGWAVEFORM - make Gaussian derivative waveform in SU format  
SUEA2DF - SU version of (an)elastic anisotropic 2D finite difference  
SUFCTANISMOD - Flux-Corrected Transport correction applied to the 2D  
SUFDMOD1 - Finite difference modelling (1-D 1st order) for the  
SUFDMOD2 - Finite-Difference MODELing (2nd order) for acoustic wave equation  
SUFDMOD2\_PML - Finite-Difference MODELing (2nd order) for acoustic wave  
SUGOUPILLAUD - calculate 1D impulse response of  
SUGOUPILLAUDPO - calculate Primaries-Only impulse response of a lossless  
SUIMP2D - generate shot records for a line scatterer

SUIMP3D - generate inplane shot records for a point  
 SUIMPEDANCE - Convert reflection coefficients to impedances.  
 SUKDSYN2D - Kirchhoff Depth SYNthesis of 2D seismic data from a  
 SUNHMOSPIKE - generates SPIKE test data set with a choice of several  
 SUNULL - create null (all zeroes) traces  
 SUPLANE - create common offset data file with up to 3 planes  
 SURANDSPIKE - make a small data set of RANDom SPIKEs  
 SUREMAC2D - Acoustic 2D Fourier method modeling with high accuracy  
 SUREMEL2DAN - Elastic anisotropic 2D Fourier method modeling with high  
 SUSPIKE - make a small spike data set  
 SUSYN CZ - SYNthetic seismograms for piecewise constant  $V(Z)$  function  
 SUSYN LV - SYNthetic seismograms for Linear Velocity function  
 SUSYN LVCW - SYNthetic seismograms for Linear Velocity function  
 SUSYN LVFTI - SYNthetic seismograms for Linear Velocity function in a  
 SUSYN VXZ - SYNthetic seismograms of common offset  $V(X,Z)$  media via  
 SUSYN VXZCS - SYNthetic seismograms of common shot in  $V(X,Z)$  media via  
 SUVIBRO - Generates a Vibroseis sweep (linear, linear-segment,  
 SUWAVEFORM - generate a seismic wavelet

In CWPROOT/src/su/main/tapering:

SUGAUSSTAPER - Multiply traces with gaussian taper  
 SURAMP - Linearly taper the start and/or end of traces to zero.  
 SUTAPER - Taper the edge traces of a data panel to zero.  
 SUTXTAPER - TAPER in (X,T) the edges of a data panel to zero.

In CWPROOT/src/su/main/transforms:

SUAMP - output amp, phase, real or imag trace from  
 SUANALYTIC - use the Hilbert transform to generate an ANALYTIC  
 SUCCEPSTRUM - Compute the complex CEPSTRUM of a seismic trace "  
 SUCCWT - Complex continuous wavelet transform of seismic traces  
 SUCEPSTRUM - transform to the CEPSTRal domain  
 SUCLOGFFT - fft real time traces to complex log frequency domain traces  
 SUCWT - generates Continous Wavelet Transform amplitude, regularity  
 SUFFT - fft real time traces to complex frequency traces  
 SUGABOR - Outputs a time-frequency representation of seismic data via  
 SUHILB - Hilbert transform  
 SUICEPSTRUM - fft of complex log frequency traces to real time traces  
 SUICLOGFFT - fft of complex log frequency traces to real time traces  
 SUIFFT - fft complex frequency traces to real time traces  
 SUMINPHASE - convert input to minimum phase  
 SUPHASEVEL - Multi-mode PHASE VELOCITY dispersion map computed  
 SURADON - compute forward or reverse Radon transform or remove multiples  
 SUSLOWFT - Fourier Transforms by a (SLOW) DFT algorithm (Not an FFT)

SUSLOWIFT - Fourier Transforms by (SLOW) DFT algorithm (Not an FFT)  
SUSPECFK - F-K Fourier SPECTrum of data set  
SUSPECFX - Fourier SPECTrum (T -> F) of traces  
SUSPECK1K2 - 2D (K1,K2) Fourier SPECTrum of (x1,x2) data set  
SUTAUP - forward and inverse T-X and F-K global slant stacks  
SUWFFT - Weighted amplitude FFT with spectrum flattening 0->Nyquist  
SUZEROPHASE - convert input to zero phase equivalent

In CWPROOT/src/su/main/velocity\_analysis:

SURELANAN - REsidual-moveout semblance ANalysis for ANisotropic media  
SURELAN - compute residual-moveout semblance for cdp gathers based  
SUTIVEL - SU Transversely Isotropic velocity table builder  
SUVEL2DF - compute stacking VELOCITY semblance for a single time in  
SUVELAN - compute stacking velocity semblance for cdp gathers  
SUVELAN\_NCCS - compute stacking VELOCITY panel for cdp gathers  
SUVELAN\_NSEL - compute stacking VELOCITY panel for cdp gathers  
SUVELAN\_UCCS - compute stacking VELOCITY panel for cdp gathers  
SUVELAN\_USEL - compute stacking velocity panel for cdp gathers

In CWPROOT/src/su/main/well\_logs:

LAS2SU - convert las2 format well log curves to su traces  
SUBACKUS - calculate Thomsen anisotropy parameters from  
SUBACKUSH - calculate Thomsen anisotropy parameters from  
SUGASSMAN - Model reflectivity change with rock/fluid properties  
SULPRIME - find appropriate Backus average length for  
SUWELLRF - convert WELL log depth, velocity, density data into a

In CWPROOT/src/su/main/windowing\_sorting\_muting:

SUCOMMAND - pipe traces having the same key header word to command  
SUGETGTHR - Gets su files from a directory and put them  
SUGPRFB - SU program to remove First Breaks from GPR data  
SUKILL - zero out traces  
SUMIXGATHERS - mix two gathers  
SUMUTE - MUTE above (or below) a user-defined polygonal curve with "  
SUPAD - Pad zero traces  
SUPUTGTHR - split the stdout flow to gathers on the bases of given  
SUSORT - sort on any segy header keywords  
SUSORTY - make a small 2-D common shot off-end  
SUSPLIT - Split traces into different output files by keyword value  
SUWIND - window traces by key word  
SUWINDPOLY - WINDow data to extract traces on or within a respective

In CWPROOT/src/su/graphics/psplot:

SUPSCONTOUR - PostScript CONTOUR plot of a segy data set  
SUPSCUBE - PostScript CUBE plot of a segy data set  
SUPSCUBECONTOUR - PostScript CUBE plot of a segy data set  
SUPSGRAPH - PostScript GRAPH plot of a segy data set  
SUPSIMAGE - PostScript IMAGE plot of a segy data set  
SUPSMAX - PostScript of the MAX, min, or absolute max value on each trace  
SUPSMOVIE - PostScript MOVIE plot of a segy data set  
SUPSWIGB - PostScript Bit-mapped WIGgle plot of a segy data set  
SUPSWIGP - PostScript Polygon-filled WIGgle plot of a segy data set

In CWPROOT/src/su/graphics/xplot:

SUXCONTOUR - X CONTOUR plot of Seismic UNIX tracefile via vector plot call  
SUXGRAPH - X-windows GRAPH plot of a segy data set  
SUXIMAGE - X-windows IMAGE plot of a segy data set  
SUXMAX - X-windows graph of the MAX, min, or absolute max value on  
SUXMOVIE - X MOVIE plot of a 2D or 3D segy data set  
SUXPICKER - X-windows WIGgle plot PICKER of a segy data set  
SUXWIGB - X-windows Bit-mapped WIGgle plot of a segy data set

In CWPROOT/src/tri/main:

GBBEAM - Gaussian beam synthetic seismograms for a sloth model  
NORMRAY - dynamic ray tracing for normal incidence rays in a sloth model  
TRI2UNI - convert a TRIangulated model to UNIformly sampled model  
TRIMODEL - make a triangulated sloth ( $1/\text{velocity}^2$ ) model  
TRIRAY - dynamic RAY tracing for a TRIangulated sloth model  
TRISEIS - Gaussian beam synthetic seismograms for a sloth model  
UNI2TRI - convert UNIformly sampled model to a TRIangulated model

In CWPROOT/src/xtri:

SXPLOT - X Window plot a triangulated sloth function  $s(x_1, x_2)$

In CWPROOT/src/tri/graphics/psplot:

SPSPLOT - plot a triangulated sloth function  $s(x, z)$  via PostScript

In CWPROOT/src/comp/dct/main:

DCTCOMP - Compression by Discrete Cosine Transform  
DCTUNCOMP - Discrete Cosine Transform Uncompression  
ENTROPY - compute the ENTROPY of a signal  
WPTCOMP - Compression by Wavelet Packet Compression  
WPTUNCOMP - Uncompress WPT compressed data  
WTCOMP - Compression by Wavelet Transform  
WTUNCOMP - UNCOMPression of WT compressed data

In CWPROOT/src/comp/dwpt/1d/main:  
WPC1COMP2 --- COMPRESS a 2D seismic section trace-by-trace using  
WPC1UNCOMP2 --- UNCOMPRESS a 2D seismic section, which has been

In CWPROOT/src/comp/dwpt/2d/main:  
WPCCOMPRESS --- COMPRESS a 2D section using Wavelet Packets  
WPCUNCOMPRESS --- UNCOMPRESS a 2D section

Shells:

In CWPROOT/src/cwp/shell:  
# ARGV - give examples of dereferencing char \*\*argv  
# COPYRIGHT - insert CSM COPYRIGHT lines at top of files in working directory  
# CPALL , RCPALL - for local and remote directory tree/file transfer  
# CWPFind - look for files with patterns in CWPROOT/src/cwp/lib  
# Grep - recursively call egrep in pwd  
# DIRTREE - show DIRectory TREE  
# FILETYPE - list all files of given type  
# NEWCASE - Changes the case of all the filenames in a directory, dir  
# OVERWRITE - copy stdin to stdout after EOF  
# PRECEDENCE - give table of C precedences from Kernighan and Ritchie  
# REPLACE - REPLACE string1 with string2 in files  
# THIS\_YEAR - print the current year  
# TIME\_NOW - prints time in ZULU format with no spaces  
# TODAYS\_DATE - prints today's date in ZULU format with no spaces  
# USERNAMES - get list of all login names  
# VARLIST - list variables used in a Fortran program  
# WEEKDAY - prints today's WEEKDAY designation  
# ZAP - kill processes by name

In CWPROOT/src/par/shell:  
# GENDOCS - generate complete list of selfdocs in latex form  
# STRIPTOTXT - put files from \$CWPROOT/src/doc/Stripped into a new  
# UPDATEDOCALL - put self-docs in ../doc/Stripped  
# UPDATEDOC - put self-docs in ../doc/Stripped and ../doc/Headers  
# UPDATEHEAD - update ../doc/Headers/Headers.all

In CWPROOT/src/psplot/shell:  
# MERGE2 - put 2 standard size PostScript figures on one page  
# MERGE4 - put 4 standard size PostScript plots on one page

In CWPROOT/src/su/shell:  
# LOOKPAR - show getpar lines in SU code with defines evaluated

```

# MAXDIFF - find absolute maximum difference in two segy data sets
# RECIP - sum opposing (reciprocal) offsets in cdp sorted data
# RMAXDIFF - find percentage maximum difference in two segy data sets
# SUAGC - perform agc on SU data
# SUBAND - Trapezoid-like Sin squared tapered Bandpass filter via  SUFILTER
# SUDIFF, SUSUM, SUPROD, SUQUO, SUPTDIFF, SUPTSUM,
# SUDOC - get DOC listing for code
# SUENV - Instantaneous amplitude, frequency, and phase via: SUATTRIBUTES
# SUFIND - get info from self-docs
# SUFIND - get info from self-docs
# SUGENDOCs - generate complete list of selfdocs in latex form
# SUHELP - list the CWP/SU programs and shells
# SUKEYWORD -- guide to SU keywords in segy.h
# SUNAME - get name line from self-docs
# UNGLITCH - zonk outliers in data

```

Libs:

In CWP/ROOT/src/cwp/lib:

```

ABEL - Functions to compute the discrete ABEL transform:
AIRY - Approximate the Airy functions Ai(x), Bi(x) and their respective
ALLOC - Allocate and free multi-dimensional arrays
ANTIALIAS - Butterworth anti-aliasing filter
AXB - Functions to solve a linear system of equations Ax=b by LU
BIGMATRIX - Functions to manipulate 2-dimensional matrices that are too big
BUTTERWORTH - Functions to design and apply Butterworth filters:
COMPLEX - Functions to manipulate complex numbers
COMPLEXD - Functions to manipulate double-precision complex numbers
COMPLEXF - Subroutines to perform operations on complex numbers.
COMPLEXFD - Subroutines to perform operations on double complex numbers.
Conjugate Gradient routines -
CONVOLUTION - Compute z = x convolved with y
CUBICSPLINE - Functions to compute CUBIC SPLINE interpolation coefficients
DBLAS - Double precision Basic Linear Algebra subroutines
DGE - Double precision Gaussian Elimination matrix subroutines adapted
DIFFERENTIATE - simple DIFFERENTIATOR codes
PFAFFT - Functions to perform Prime Factor (PFA) FFT's, in place
*CWP_Exit - exit subroutine for CWP/SU codes
FRANNOR - functions to generate a pseudo-random float normally distributed
FRANUNI - Functions to generate a pseudo-random float uniformly distributed
HANKEL - Functions to compute discrete Hankel transforms
Hartley - routines for fast Hartley transform
HILBERT - Compute Hilbert transform y of x

```

HOLBERG1D - Compute coefficients of Holberg's 1st derivative filter  
 INTCUB - evaluate  $y(x)$ ,  $y'(x)$ ,  $y''(x)$ , ... via piecewise cubic interpolation  
 INTL2B - bilinear interpolation of a 2-D array of bytes  
 INTLIN - evaluate  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...  
 INTLINC - evaluate complex  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...  
 INTLIRR2B - bilinear interpolation of a 2-D array of bytes  
 INTSINC8 - Functions to interpolate uniformly-sampled data via 8-coeff. sinc  
 INTTABLE8 - Interpolation of a uniformly-sampled complex function  $y(x)$   
 LINEAR\_REGRESSION - Compute linear regression of  $(y_1, y_2, \dots, y_n)$  against  
 maxmin - subroutines that pertain to maximum and minimum values  
 MKDIFF - Make an n-th order DIFFerentiator via Taylor's series method.  
 MKHDIFF - Compute filter approximating the bandlimited HalF-DIFFerentiator.  
 MKSINC - Compute least-squares optimal sinc interpolation coefficients.  
 MNEWT - Solve non-linear system of equations  $f(x) = 0$  via Newton's method  
 ORTHPOLYNOMIALS - compute ORTHogonal POLYNOMIALS  
 PFAFFT - Functions to perform Prime Factor (PFA) FFT's, in place  
 POLAR - Functions to map data in rectangular coordinates to polar and vice versa  
 PRINTERPLOT - Functions to make a printer plot of a 1-dimensional array  
 QUEST - Functions to ESTimate Quantiles:  
 RESSINC8 - Functions to resample uniformly-sampled data via 8-coefficient sinc  
 RFWTVA - Rasterize a Float array as Wiggle-Trace-Variable-Area.  
 RFWTVAINT - Rasterize a Float array as Wiggle-Trace-Variable-Area, with  
 SBLAS - Single precision Basic Linear Algebra Subroutines  
 SCAXIS - compute a readable scale for use in plotting axes  
 SGA - Single precision general matrix functions adapted from LINPACK FORTRAN:  
 SHFS8R - Shift a uniformly-sampled real-valued function  $y(x)$  via  
 SINC - Return SINC(x) for as floats or as doubles  
 SORT - Functions to sort arrays of data or arrays of indices  
 SQR - Single precision QR decomposition functions adapted from LINPACK FORTRAN:  
 STOEP - Functions to solve a symmetric Toeplitz linear system of equations  
 STRSTUFF -- STRing manipulation subs  
 SWAPBYTE - Functions to SWAP the BYTE order of binary data  
 SYMMEIGEN - Functions solving the eigenvalue problem for symmetric matrices  
  
 TRIDIAGONAL - Functions to solve tridiagonal systems of equations  $Tu=r$  for  $u$ .  
 UNWRAP\_PHASE - routines to UNWRAP phase of fourier transformed data  
 VANDERMONDE - Functions to solve Vandermonde system of equations  $Vx=b$   
 WAVEFORMS Subroutines to define some wavelets for modeling of seismic  
 WINDOW - windowing routines  
 wrapArray - wrap an array  
 XCOR - Compute  $z = x$  cross-correlated with  $y$   
 XINDEX - determine index of  $x$  with respect to an array of  $x$  values  
 YCLIP - Clip a function  $y(x)$  defined by linear interpolation of the

YXTOXY - Compute a regularly-sampled, monotonically increasing function  $x(y)$   
ZASC - routine to translate ncharacters from ebcdic to ascii  
ZEBC - routine to translate ncharacters from ascii to ebcdic

In CWPROOT/src/par/lib:

ATOPKGE - convert ascii to arithmetic and with error checking  
DOCPKGE - Function to implement the CWP self-documentation facility  
EALLOC - Allocate and free multi-dimensional arrays with error reports.  
ERRPKGE - routines for reporting errors  
FILESTAT - Functions to determine and output the type of a file from file  
GETPARS - Functions to GET PARAmeterS from the command line. Numeric  
LINCOEFF - subroutines to create linearized reflection coefficients  
MINFUNC - routines to MINimize FUNCtions  
MODELING - Seismic Modeling Subroutines for SUSYNLV and clones  
REFANISO - Reflection coefficients for Anisotropic media  
RKE - integrate a system of n-first order ordinary differential equations  
SMOOTH - Functions to compute smoothing of 1-D or 2-D input data  
SUBCALLS - routines for system functions with error checking  
SYSCALLS - routines for SYSTEM CALLs with error checking  
TAUP - Functions to perform forward and inverse taup transforms (radon or  
UPWEIK - Upwind Finite Difference Eikonal Solver  
VND - large out-of-core multidimensional block matrix transpose  
WTLIB - Functions for wavelet transforms

In CWPROOT/src/su/lib:

FGETGTHR - get gathers from SU datafiles  
fgethdr - get segy tape identification headers from the file by file pointer  
FGETTR - Routines to get an SU trace from a file  
FPUTGTHR - put gathers to a file  
FPUTTR - Routines to put an SU trace to a file  
HDRPKGE - routines to access the SEGy header via the hdr structure.  
TABPLOT - TABPLOT selected sample points on selected trace  
VALPKGE - routines to handle variables of type Value

In CWPROOT/src/psplot/lib:

BASIC - Basic C function interface to PostScript  
PSAXESBOX3 - Functions draw an axes box via PostScript, estimate bounding box  
PSAXESBOX - Functions to draw PostScript axes and estimate bounding box  
PSCAXESBOX - Draw an axes box for cube via PostScript  
PSCONTOUR - draw contour of a two-dimensional array via PostScript  
PSDRAWCURVE - Functions to draw a curve from a set of points  
PSLEGENDBOX - Functions to draw PostScript axes and estimate bounding box  
PSWIGGLE - draw wiggle-trace with (optional) area-fill via PostScript



In CWPROOT/src/xplot/lib:

AXESBOX - Functions to draw axes in X-windows graphics  
COLORMAP - Functions to manipulate X colormaps:  
DRAWCURVE - Functions to draw a curve from a set of points  
IMAGE - Function for making the image in an X-windows image plot  
LEGENDBOX - draw a labeled axes box for a legend (i.e. colorscale)  
RUBBERBOX - Function to draw a rubberband box in X-windows plots  
WINDOW - Function to create a window in X-windows graphics  
XCONTOUR - draw contour of a two-dimensional array via X vectorplot calls

In CWPROOT/src/Xtcwp/lib:

AXES - the Axes Widget  
COLORMAP - Functions to manipulate X colormaps:  
FX - Functions to support floating point coordinates in X  
MISC - Miscellaneous X-Toolkit functions  
RESCONV - general purpose resource type converters  
RUBBERBOX - Function to draw a rubberband box in X-windows plots

In CWPROOT/src/Xmcwp/lib:

RADIOBUTTONS - convenience functions creating and using radio buttons  
SAMPLES - Motif-based Graphics Functions

In CWPROOT/src/tri/lib:

CHECK - CHECK triangulated models  
CIRCUM - define CIRCUMcircles for Delaunay triangulation  
COLINEAR - determine if edges or vertecies are COLINEAR in triangulated  
CREATE - create model, boundary edge triangles, edge face, edge vertex, add  
DELETE - DELETE vertex, model, edge, or boundary edge from triangulated model  
DTE - Distance to Edge  
FIXEDGES - FIX or unFIX EDGES between verticies  
INSIDE - Is a vertex or point inside a circum circle, etc. of a triangulated  
NEAREST - NEAREST edge or vertex in triangulated model  
PROJECT - project to edge in triangulated model  
READWRITE - READ or WRITE a triangulated model

In CWPROOT/src/cwputils:

CPUSEC - return cpu time (UNIX user time) in seconds  
CPUTIME - return cpu time (UNIX user time) in seconds using ANSI C built-ins  
WALLSEC - Functions to time processes  
WALLTIME - Function to show time a process takes to run

In CWPROOT/src/comp/dct/lib:

BUFFALLOC - routines to ALLOCate/initialize and free BUFFers  
 DCT1 - 1D Discrete Cosine Transform Routines  
 DCT2 - 2D Discrete Cosine Transform Routines  
 DCTALLOC - ALLOCate space for transform tables for 1D DCT  
 GETFILTER - GET wavelet FILTER type  
 HUFFMAN - Routines for in memory Huffman coding/decoding  
 LCT1 - functions used to perform the 1D Local Cosine Transform (LCT)  
 LPRED - Lateral Prediction of Several Plane Waves  
 PENCODING - Routines to en/decode the quantized integers for lossless  
 QUANT - QUANTization routines  
 RLE - routines for in memory silence en/decoding  
 WAVEPACK1 - 1D wavelet packet transform  
 WAVEPACK2 - 2D Wavelet PACKet transform  
 WAVEPACK1 - 1D wavelet packet transform  
 WAVETRANS2 - 2D wavelet transform by tensor-product of two 1D transforms

In CWPROOT/src/comp/dct/lib:

BUFFALLOC - routines to ALLOCate/initialize and free BUFFers  
 DCT1 - 1D Discrete Cosine Transform Routines  
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 WAVEPACK1 - 1D wavelet packet transform  
 WAVEPACK2 - 2D Wavelet PACKet transform  
 WAVEPACK1 - 1D wavelet packet transform  
 WAVETRANS2 - 2D wavelet transform by tensor-product of two 1D transforms

In CWPROOT/src/comp/dwpt/1d/lib:

WBUFFALLOC - routines to allocate/initialize and free buffers in wavelet  
 WPC1 - routines for compress a single seismic trace using wavelet packets  
 WPC1CODING - routines for encoding the integer symbols in 1D WPC  
 wpc1Quant - quantize  
 WPC1TRANS - routines to perform a 1D wavelet packet transform

In CWPROOT/src/comp/dwpt/2d/lib:

WPCBUFFAL - routines to allocate/initialize and free buffers  
 WPC - routines for compress a 2D seismic section using wavelet packets

WPCCODING - Routines for in memory coding of the quantized coefficients  
WPCENDEC - Wavelet Packet Coding, Encoding and Decoding routines  
WPCHUFF - Routines for in memory Huffman coding/decoding  
WPCPACK2 - routine to perform a 2D wavelet packet transform  
WPCQUANT - quantization routines for WPC  
WPCSILENCE - routines for in memory silence en/decoding

To search on a program name fragment, type:  
    suname name\_fragment <CR>

For more information type: program\_name <CR>

Items labeled with an asterisk (\*) are C programs that may  
or may not have this self documentation feature.

Items labeled with a pound sign (#) are shell scripts that may,  
or may not have the self documentation feature.

## Self Documentations

Mains:

-----  
CTRLSTRIP - Strip non-graphic characters  
  
ctrlstrip <dirtyfile> >cleanfile

-----  
DOWNFORT - change Fortran programs to lower case, preserving strings  
  
Usage: downfort < infile.f > outfile.f

Credits:  
Brian Sumner c. 1984

-----  
FCAT - fast cat with 1 read per file  
  
Usage: fcat file1 file2 ... > file3

Credits:  
Shuki

This program belongs to the Center for Wave Phenomena  
Colorado School of Mines  
/

-----  
ISATTY - pass on return from isatty(2)  
  
Usage: isatty filedes  
  
See: man isatty for further information

Credits:  
CWP: Shuki

This program belongs to the Center for Wave Phenomena  
Colorado School of Mines

-----  
MAXINTS - Compute maximum and minimum sizes for integer types  
(quick and dirty)

Usage: maxints

Note: These results will be in limits.h on most systems

Credits:  
CWP: Jack K. Cohen

This program belongs to the Center for Wave Phenomena  
Colorado School of Mines

-----  
PAUSE - prompt and wait for user signal to continue

Usage: pause [optional arguments]

Note:  
Default prompt is "press return key to continue" which is \*evoked  
by calling pause with no arguments. The word,  
"continue", is replaced by any optional arguments handed to pause.  
Thus, the command "pause do plot" will evoke the prompt,  
"press return key to do plot".

-----  
T - time and date for non-military types

Usage: t

Credit: Jack

-----

UPFORT - change Fortran programs to upper case, preserving strings

Usage: upfort < infile.f > outfile.f

Reverse of: downfort

A2B - convert ascii floats to binary

a2b <stdin >stdout outpar=/dev/null

Required parameters:

none

Optional parameters:

n1=2 floats per line in input file

outpar=/dev/null output parameter file, contains the  
number of lines (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Credits:

CWP: Jack K. Cohen, Dave Hale

Hans Ecke 2002: Replaced line-wise file reading via gets() with  
float-wise reading via fscanf(). This makes it  
much more robust: it does not impose a specific  
structure on the input file.

A2I - convert Ascii to binary Integers

a2i <stdin >stdout outpar=/dev/tty

Required parameters:

none

Optional parameters:

n1=2 integers per line in input file

outpar=/dev/tty output parameter file, contains the  
number of lines (n=)



ADDRVL3D - Add a random velocity layer (RVL) to a gridded  
v(x,y,z) velocity model

addrvl3d <infile n1= n2= >outfile [parameters]

Required Parameters:

n1= number of samples along 1st dimension

n2= number of samples along 2nd dimension

Optional Parameters:

n3=1            number of samples along 3rd dimension

mode=1            add single layer populated with random vels  
                  =2 add nrvl layers of random thickness and vel

seed=from\_clock    random number seed (integer)

---->New layer geometry info

i1beg=1           1st dimension beginning sample

i1end=n1/5        1st dimension ending sample

i2beg=1           2nd dimension beginning sample

i2end=n2          2nd dimension ending sample

i3beg=1           3rd dimension beginning sample

i3end=n3          3rd dimension ending sample

---->New layer velocity info

vlsd=v/3          range (std dev) of random velocity in layer,  
                  where v=v(0,0,i1) and i1=(i1beg+i1end)/2

add=1            add random vel to original vel (v\_orig) at that point  
                  =0 replace vel at that point with (v\_orig+v\_rand)

how=0            random vels can be higher or lower than v\_orig  
                  =1 random vels are always lower than v\_orig  
                  =2 random vels are always higher than v\_orig

cvel=2000        layer filled with constant velocity cvel  
                  (overrides vlsc,add,how params)

---->Smoothing parameters (0 = no smoothing)

r1=0.0 1st dimension operator length in samples

r2=0.0 2nd dimension operator length in samples

r3=0.0 3rd dimension operator length in samples

slowness=0 =1 smoothing on slowness; =0 smoothing on velocity

nrvl=n1/10       number of const velocity layers to add

pdv=10.          percentage velocity deviation (max) from input model

Notes:

1. Smoothing radii usually fall in the range of [0,20].
2. Smoothing radii can be used to set aspect ratio of random velocity anomalies in the new layer. For example (r1=5,r2=0,r3=0) will result in vertical vel streaks that mimic vertical fracturing.
3. Smoothing on slowness works better to preserve traveltimes relative to the unsmoothed case.
4. Default case is a random velocity (+/-30%) near surface layer whose thickness is 20% of the total 2D model thickness.
5. Each layer vel is a random perturbation on input model at that level.
6. The depth dimension is assumed to be along axis 1.

Example:

1. 2D RVL with no smoothing  
makevel nz=250 nx=200 | addrvl3d n1=250 n2=200 | ximage n1=250
2. 3D RVL with no smoothing  
makevel nz=250 nx=200 ny=220 |  
addrvl3d n1=250 n2=200 n3=220 |  
xmovie n1=250 n2=200

Author: Saudi Aramco: Chris Liner Jan/Feb 2005  
Based on smooth3d (CWP: Zhenyue Liu March 1995)

B2A - convert binary floats to ascii

b2a <stdin >stdout

Required parameters:

none

Optional parameters:

n1=2 floats per line in output file

format=0 scientific notation

=1 long decimal float form

outpar=/dev/tty output parameter file, contains the  
number of lines (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Note:

Parameter: ",

format=0 uses printf("%15.10e ", x[i1])

format=1 uses printf("%15.15f ", x[i1])

Credits:

CWP: Jack K. Cohen

## CELLAUTO - Two-dimensional CELLular AUTOmata

```
cellauto > stdout [optional params]
```

### Optional Parameters:

n1=500 output dimensions of image (n1 x n1 pixels)

rule=30 CA rule (Wolfram classification)

Others: 54,60,62,90,94,102,110,122,126

150,158,182,188,190,220,222,225,226,250

fill=0 Don't fill image (=1 fill image)

f0=330 fill zero values with f0

f1=3000 fill non-zero values with f1

ic=1 initial condition for centered unit value at t=0

= 2 for multiple random units

nc=20 number of random units (if ic=2)

tc=1 random initial units at t=0 (if ic=2)

= 2 for initial units at random (t,x)

verbose=0 silent operation

= 1 echos 'porosity' of the CA in bottom half of image

seed=from\_clock random number seed (integer)

### Notes:

This program generates a select set of Wolframs fundamental cellular automata. This may be useful for constructing rough, vuggy wavespeed profiles. The numbering scheme follows Stephen Wolfram's.

### Example:

```
cellauto rule=110 ic=2 nc=100 fill=1 f1=3000 | ximage n1=500 nx=500 &
```

Here we simulate a complex near surface with air-filled  
vugs in hard country rock, with smoothing applied via smooth2

```
cellauto rule=110 ic=2 nc=100 fill=1 f1=3000 n1=500 |  
smooth2 n1=500 n2=500 r1=5 r2=5 > vfile.bin
```

### Credits:

UHouston: Chris Liner

Trace header fields accessed: ns

Trace header fields modified: ns and delrt



CSHOTPLOT - convert CSHOT data to files for CWP graphers

cshotplot <cshot1plot [optional parameter file]

Required parameters:

none

Optional parameter:

outpar=/dev/tty output parameter file, contains:

number of plots (n2=)

points in each plot (n1=)

colors for plots (linecolor=)

DZDV - determine depth derivative with respect to the velocity ",  
parameter,  $dz/dv$ , by ratios of migrated data with the primary  
amplitude and those with the extra amplitude

dzdv <infile afile=afile dfile=dfile>outfile [parameters]

Required Parameters:

infile= input of common image gathers with primary amplitude  
afile= input of common image gathers with extra amplitude  
dfile= output of imaged depths in common image gathers  
outfile= output of  $dz/dv$  at the imaged points  
nx= number of migrated traces  
nz= number of points in migrated traces  
dx= horizontal spacing of migrated trace  
dz= vertical spacing of output trace  
fx= x-coordinate of first migrated trace  
fz= z-coordinate of first point in migrated trace  
off0= first offset in common image gathers  
noff= number of offsets in common image gathers  
doff= offset increment in common image gathers  
cip=x1,z1,r1,..., cip=xn,zn,rn description of input CIGS  
x x-value of a common image point  
z z-value of a common image point at zero offset  
r r-parameter in a common image gather

Optional Parameters:

nwx, nzw=0 window widths along x- and z-directions in  
which points are contributed in solving  $dz/dv$ .

Notes:

This program is used as part of the velocity analysis technique developed  
by Zhenyue Liu, CWP:1995.

Author: CWP: Zhenyue Liu, 1995

Reference:

Liu, Z. 1995, "Migration Velocity Analysis", Ph.D. Thesis, Colorado  
School of Mines, CWP report #168.

FARITH - File ARITHmetic -- perform simple arithmetic with binary files

farith <infile >outfile [optional parameters]

Optional Parameters:

in=stdin input file

out=stdout output file

in2= second input file (required for binary operations)

if it can't be opened as a file, it might be a scalar

n=size\_of\_in, fastest dimension (used only for op=cartprod is set)

isig= index at which signum function acts (used only for

op=signum)

scale= value to scale in by, used only for op=scale)

bias= value to bias in by, used only for op=bias)

op=noop noop for out = in

neg for out = -in

abs for out = abs(in)

scale for out = in \*scale

bias for out = in + bias

exp for out = exp(in)

sin for out = sin(in)

cos for out = cos(in)

log for out = log(in)

sqr for out = (signed) sqrt(in)

sqr for out = in\*in

degrad for out = in\*PI/180

raddeg for out = in\*180/PI

pinv for out = (punctuated) 1 / in

pinvsqr for out = (punctuated) 1 /in\*in

pinvsqrt for out = (punctuated signed) 1 /sqrt(in)

add for out = in + in2

sub for out = in - in2

mul for out = in \* in2

div for out = in / in2

cartprod for out = in x in2

requires: n=size\_of\_in, fastest dimension in output

signum for out[i] = in[i] for i< isig and

= -in[i] for i>= isig

requires: isig=point where signum function acts

Seismic operations:

sloth for out = 1/in^2 Sloth from velocity in

slowp for out = 1/in - 1/in2 Slowness perturbation



slothp for out =  $1/in^2 - 1/in2^2$  Sloth perturbation

Notes:

op=sqrt takes sqrt(x) for  $x \geq 0$  and -sqrt(ABS(x)) for  $x < 0$  (signed sqrt)

op=pinv takes  $y=1/x$  for  $x \neq 0$ , if  $x=0$  then  $y=0$ . (punctuated inverse)

The seismic operations assume that in and in2 are wavespeed profiles.

"Slowness" is  $1/\text{wavespeed}$  and "sloth" is  $1/\text{wavespeed}^2$ .

Use "suop" and "suop2" to perform unary and binary operations on data in the SU (SEG-Y trace) format.

The options "pinvsq" and "pinvsqrt" are also useful for seismic computations involving converting velocity to sloth and vice versa.

The option "cartprod" (cartesian product) requires also that the parameter `n=size_of_in` be set. This will be the fastest dimension of the rectangular array that is output.

The option "signum" causes a flip in sign for all values with index greater than "isig" (really  $-1 * \text{signum}(\text{index})$ ).

For file operations on SU format files, please use: suop, suop2

AUTHOR: Dave Hale, Colorado School of Mines, 07/07/89

Zhaobo Meng added scale and cartprod, 10/01/96

Zhaobo Meng added signum, 9 May 1997

Tony Kocurko added scalar operations, August 1997

John Stockwell added bias option 4 August 2004

Float2IBM - convert native binary FLOATS to IBM tape FLOATS

float2ibm <stdin >stdout

Required parameters:

none

Optional parameters:

endian= byte order of your system (autodetected)

outpar=/dev/tty output parameter file, contains the  
number of values (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes:

endian=1 (big endian) endian=0 (little endian) byte order

You probably will not have to set this, as the byte order of  
your system is autodetected by the program.

This program is usable for writing SEG Y traces with the headers  
stripped off.

Credits:

CWP: John Stockwell, based on code by Jack K. Cohen

FTNSTRIP - convert a file of binary data plus record delimiters created  
via Fortran to a file containing only binary values (as created via C)

```
ftnstrip <ftn_data >c_data
```

Caveat: this code assumes the conventional Fortran format of header  
and trailer integer containing the number of byte in the  
record. This is overwhelmingly common, but not universal.

Credits:

CWP: Jack K. Cohen

FTNUNSTRIP - convert C binary floats to Fortran style floats

ftnunstrip <stdin >stdout

Required parameters:

none

Optional parameters:

n1=1 floats per line in output file

outpar=/dev/tty output parameter file, contains the  
number of lines (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes: This program assumes that the record length is constant  
throughout the input and output files.

In fortran code reading these floats, the following implied  
do loop syntax would be used:

```
      DO i=1,n2
          READ (10) (someARRAY(j), j=1,n1)
      END DO
```

Here n1 is the number of samples per record, n2 is the number  
of records, 10 is some default file (fort.10, for example), and  
someArray(j) is an array dimensioned to size n1

Credits:

CWP: John Stockwell, Feb 1998,  
based on ftnstrip by: Jack K. Cohen

GRM - Generalized Reciprocal refraction analysis for a single layer

grm <stdin >stdout [parameters]

Required parameters:

nt= Number of arrival time pairs

dx= Geophone spacing (m)

v0= Velocity in weathering layer (m/s)

abtime= If set to 0, use last time as a-b, else give time (ms)

Optional parameters:

XY= Value of XY if you want to override the optimum XY algorithm in the program. If it is not an integer multiple of dx, then it will be converted to the closest one.

XYmax Maximum offset distance allowed when searching for optimum XY (m) (Default is 2\*dx\*10)

depthres Size of increment in x during vertical depth search(m) (Default is 0.5m)

Input file:

4 column ASCII - x,y, forward time, reverse time

Output file:

1) XYoptimum

2) apparent refractor velocity

3) x, y, z(x,y), y-z(x,y)

z(x,y) = calculated (GRM) depth below (x y)

y-z(x,y) = GRM depth subtracted from y - absolute depth

.....

4) x, y, d(x,y), y-d(x,y), (error)

d(x,y) = dip corrected depth estimate below (x,y)

y-d(x,y) = dip corrected absolute depth

error = estimated error in depth due only to the inexact matching of tangents to arcs in dip estimate.

If the XY calculation is bypassed and XY specified, the values used will precede 1) above. XYoptimum will still be calculated and displayed for reference.

Notes:

Uses average refractor velocity along interface.

Credits:

CWP: Steven D. Sheaffer

D. Palmer, "The Generalized Reciprocal Method of Seismic Refraction Interpretation", SEG, 1982.

H2B - convert 8 bit hexadecimal floats to binary

```
h2b <stdin >stdout outpar=/dev/tty
```

Required parameters:

none

Optional parameters:

outpar=/dev/tty output parameter file, contains the  
number of lines (n=)  
other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Note: this code may be used to recover binary data from PostScript  
bitmaps. To do this, strip away all parts of the PSfile that  
are not the actual hexadecimal bitmap and run through h2b.

Note: that the binary file may need to be transposed using  
"transp" to appear to be the same as input data.

Note: output will be floats with the values 0-255

HTI2STIFF - convert HTI parameters alpha, beta, d(V), e(V), gamma into stiffness tensor

hti2stiff [optional parameter] (output is to outpar)

Optional Parameters

alpha=2 isotropy-plane p-wave velocity  
beta=1 fast isotropy-plan s-wave velocity  
ev=0 e(V)  
dv=0 d(V)  
gamma=0 shear-wave splitting parameter  
rho=1 density  
sign sign of c13+c55 ( for most materials sign=1)  
outpar=/dev/tty output parameter file

Output:

c\_ijkl stiffness components for x1=symmetry axis  
x3= vertical

Credits: Andreas Rueger, CWP Aug 01, 1996

Reference: Andreas Rueger, P-wave reflection coefficients for transverse isotropy with vertical and horizontal axis of symmetry, GEOPHYSICS



HUDSON - compute effective parameters of anisotropic solids  
using Hudson's crack theory.

Required paramters: <none>

Optional parameters

vp=4.5	p-wave velocity uncracked solid
vs=2.53	s-wave velocity uncracked solid
rho=2.8	density
cdens=0	crack density
aspect=0	aspect ratio
fill=0	gas filled cracks
	=1 water filled
outpar	=/dev/tty output file

Notes:

The cracks are assumed to be vertically aligned, penny-shaped and the matrix is isotropic. The resulting anisotropic solid is of HTI symmetry.

Output:

Computes(a) stiffness elements  
(b) density normalized stiffness components  
(c) generic Thomsen parameters (vp0,vs0,eps,delta,gamma)  
(d) equivalent VTI parameters (alpha,beta,ev,dv,gv)

AUTHOR:: Andreas Rueger, Colorado School of Mines, 10/10/96

Additional notes:

The routine can be easily modified to allow for any  
filling adding attenuation is not trivial

Technical Reference:

Hudson's theory: Hudson, 1981: Wave speed and attenuation of elastic  
waves in material containing cracks.

Geophys. J. R. astr. Soc 64, 133-150

Crampin, 1984: Effective anisotropic elastic constants  
for waves propagating through cracked  
solids:

Geophys. J. R. astr. Soc 76, 135-145

Equivalent VTI : Rueger, 1996: Reflection coefficients in transversely  
isotropic media with vertical and  
horizontal axis of symmetry: Geophysics

I2A - convert binary integers to ascii

i2a <stdin >stdout

Required parameters:

none

Optional parameters:

n1=2 floats per line in output file

outpar=/dev/tty output parameter file, contains the  
number of lines (n=)

Credits:

Potash Corporation: c. 2008, Balazs Nemeth, Saskatoon, Saskatchewan.

based on b2a.c by: CWP: Jack K. Cohen

IBM2FLOAT - convert IBM tape FLOATS to native binary FLOATS

ibm2float <stdin >stdout

Required parameters:

none

Optional parameters:

endian= byte order of your system (autodetected)

outpar=/dev/tty output parameter file, contains the  
number of values (n=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes:

endian=1 (big endian) endian=0 (little endian) byte order

You probably will not have to set this, as the byte order of  
your system is autodetected by the program.

This program is usable for reading SEG Y files with the headers  
stripped off.

Credits:

CWP: John Stockwell, based on code by Jack K. Cohen

KAPERTURE - generate the k domain of a line scatterer for a seismic array

kaperture [optional parameters] >stdout

Optional parameters

x0=1000 point scatterer location  
z0=1000 point scatterer location  
nshot=1 number of shots  
sxmin=0 first shot location  
szmin=0 first shot location  
dsx=100 x-steps in shot location  
dsz=0 z-steps in shot location  
ngeo=1 number of receivers  
gxmin=0 first receiver location  
gzmin=0 first receiver location  
dgx=100 x-steps in receiver location  
dgz=0 z-steps in receiver location  
fnyq=125 Nyquist frequency (Hz)  
fmax=125 maximum frequency (Hz)  
fmin=5 minimum frequency (Hz)  
nfreq=2 number of frequencies  
both=0 = 1 gives negative freqs too  
nstep=60 points on Nyquist circle  
c=5000 speed  
outpar=/dev/tty output parameter file, contains:  
xmin, xmax, ymin, ymax  
and npairs (needed for psgraph or xgraph)  
other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes:

    nfreq=1 produces fmin  
    nstep=0 suppresses the Nyquist circle  
    and npairs

Examples:

Default case: both=0 nfreq=2

kaperture nshot=NSHOT ngeo=NGEO nstep=NSTEP |  
psgraph n=NPAIRS,NSTEP mark=1,0 marksize=1,0 linewidth=0,1 |...  
WHERE: NPAIRS=NSHOT\*NGEO

Other cases:

```
both=0 nfreq=NFREQ > 2
  kaperture both=0 nfreq=NFREQ nshot=NSHOT ngeo=NGEO nstep=NSTEP |
  psgraph n=NPAIRS,NSTEP mark=1,0 marksize=1,0 linewidth=0,1 |...
  WHERE: NPAIRS=NFREQ*NSHOT*NGEO
```

```
both=1 nfreq=NFREQ > 2
  kaperture both=1 nfreq=NFREQ nshot=NSHOT ngeo=NGEO nstep=NSTEP |
  psgraph n=NPAIRS,NSTEP mark=1,0 marksize=1,0 linewidth=0,1 |...
  WHERE: NPAIRS=NFREQ*NSHOT*NGEO*2
```

When in doubt to the size of NPAIRS, redirect output of kaperture to /dev/tty the first time to get npairs=:

```
kaperture [optional parameters] > /dev/tty
```

LINRORT - linearized P-P, P-S1 and P-S2 reflection coefficients for a horizontal interface separating two of any of the following halfspaces: ISOTROPIC, VTI, HTI and ORTHORHOMBIC.

linrort [optional parameters]

hspace1=ISO medium type of the incidence halfspace:

=ISO ... isotropic

=VTI ... VTI anisotropy

=HTI ... HTI anisotropy

=ORT ... ORTHORHOMBIC anisotropy

for ISO:

vp1=2 P-wave velocity, halfspace1

vs1=1 S-wave velocity, halfspace1

rho1=2.7 density, halfspace1

for VTI:

vp1=2 P-wave vertical velocity (V33), halfspace1

vs1=1 S-wave vertical velocity (V44=V55), halfspace1

rho1=2.7 density, halfspace1

eps1=0 Thomsen's generic epsilon, halfspace1

delta1=0 Thomsen's generic delta, halfspace1

gamma1=0 Thomsen's generic gamma, halfspace1 ",

for HTI:

vp1=2 P-wave vertical velocity (V33), halfspace1

vs1=1 "fast" S-wave vertical velocity (V44), halfspace1

rho1=2.7 density, halfspace1

eps1\_v=0 Tsvankin's "vertical" epsilon, halfspace1

delta1\_v=0 Tsvankin's "vertical" delta, halfspace1

gamma1\_v=0 Tsvankin's "vertical" gamma, halfspace1 ",

for ORT:

vp1=2 P-wave vertical velocity (V33), halfspace1

vs1=1 x2-polarized S-wave vertical velocity (V44), halfspace1

rho1=2.7 density, halfspace1

eps1\_1=0 Tsvankin's epsilon in [x2,x3] plane, halfspace1

delta1\_1=0 Tsvankin's delta in [x2,x3] plane, halfspace1

gamma1\_1=0 Tsvankin's gamma in [x2,x3] plane, halfspace1

eps1\_2=0 Tsvankin's epsilon in [x1,x3] plane, halfspace1

delta1\_2=0 Tsvankin's delta in [x1,x3] plane, halfspace1

gamma1\_2=0 Tsvankin's gamma in [x1,x3] plane, halfspace1

delta1\_3=0 Tsvankin's delta in [x1,x2] plane, halfspace1

hspace2=ISO medium type of the reflecting halfspace (the same convention as above)

medium parameters of the 2nd halfspace follow the same convention as above:

```
vp2=2.5  vs2=1.2 rho2=3.0
eps2=0    delta2=0
eps2_v=0  delta2_v=0 gamma2_v=0
eps2_1=0  delta2_1=0 gamma2_1=0
eps2_2=0  delta2_2=0 gamma2_2=0
delta2_3=0
```

(note you do not need "gamma2" parameter for evaluation of weak-anisotropy reflection coefficients)

a\_file=-1 the string '-1' ... incidence and azimuth angles are generated automatically using the setup values below  
a\_file=file\_name ... incidence and azimuth angles are read from a file "file\_name"; the program expects a file of two columns [inc. angle, azimuth]

in the case of a\_file=-1:  
fangle=0 first incidence phase angle  
langle=30 last incidence angle  
dangle=1 incidence angle increment  
fazim=0 first azimuth (in deg)  
lazim=0 last azimuth (in deg)  
dazim=1 azimuth increment (in deg)

kappa=0. azimuthal rotation of the lower halfspace2 (e.t. a symmetry axis plane for HTI, or a symmetry plane for ORTHORHOMBIC) with respect to the x1-axis

out\_inf=info.out information output file  
out\_P=Rpp.out file with Rpp reflection coefficients  
out\_S=Rps.out file with Rps reflection coefficients  
out\_SVSH=Rsvsh.out file with SV and SH projections of reflection coefficients  
out\_Error=error.out file containing error estimates evaluated during the computation of the reflection coefficients;



Output:

out\_P:

inc. phase angle, azimuth, reflection coefficient; for a\_file=-1, the inc. angle is the fast dimension

out\_S:

inc. phase angle, azimuth, Rps1, Rps2, cos(PHI), sin(PHI); for a\_file=-1, the inc. angle is the fast dimension "

out\_SVSH:

inc. phase angle, azimuth, Rsv, Rsh, cos(PHI), sin(PHI); for a\_file=-1, the inc. angle is the fast dimension

out\_Error:

error estimates of Rpp, Rpsv and RpsH approximations; global error is analysed as well as partial contributions to the error due to the isotropic velocity contrasts, and due to anisotropic upper and lower halfspaces. The error file is self-explanatory, see also descriptions of subroutines P\_err\_2nd\_order, SV\_err\_2nd\_order and SH\_err\_2nd\_order.

#### Adopted Convention:

The right-hand Cartesian coordinate system with the x3-axis pointing upward has been chosen. The upper halfspace (halfspace1) contains the incident P-wave. Incidence angles can vary from  $<0, \pi/2$ , azimuths are unlimited, +azimuth sense counted from x1->x2 axes (azimuth=0 corresponds to the direction of x1-axis). In the current version, the coordinate system is attached to the halfspace1 (e.t. the symmetry axis plane of HTI halfspace1, or one of symmetry planes of ORTHORHOMBIC halfspace1, is aligned with the x1-axis), however, the halfspace2 can be arbitrarily rotated along the x3-axis with respect to the halfspace1. The positive weak-anisotropy polarization of the reflected P-P wave (e.t. positive P-P reflection coefficient) is close to the direction of isotropic slowness vector of the wave (pointing outward the interface). Similarly, weak-anisotropy S-wave reflection coefficients are described in terms of "SV" and "SH" isotropic polarizations, "SV" and "SH" being unit vectors in the plane perpendicular to the isotropic slowness vector. Then, the positive "SV" polarization vector lies in the incidence plane and points towards the interface, and positive "SH" polarization vector is perpendicular to the incidence plane, aligned with the positive x2-axis, if azimuth=0. Rotation angle "PHI", characterizing a rotation of "the best projection" of the S1-wave polarization vector in the isotropic SV-SH plane in the incidence halfspace1, is

counted in the positive sense from "SV" axis ( $\text{PHI}=0$ ) towards the "SH" axis ( $\text{PHI}=\text{PI}/2$ ). Of course, S2 is perpendicular to S1, and the projection of S1 and S2 polarizations onto the SV-SH plane coincides with SV and SH directions, respectively, for  $\text{PHI}=0$ .

The units for velocities are km/s, angles I/O are in degrees

Additional Notes:

The coefficients are computed as functions of phase incidence angle and azimuth (determined by the incidence slowness vector). Vertical symmetry planes of the HTI and ORTHORHOMBIC halfspaces can be arbitrarily rotated along the x3-axis. The linearization is based on the assumption of weak ", contrast in elastic medium parameters across the interface, and the assumption of weak anisotropy in both halfspaces. See the "Adopted Convention" paragraph below for a proper input.

Author: Petr Jilek, CSM-CWP, December 1999.

LORENZ - compute the LORENZ attractor

```
lorenz > [stdout]
```

Required Parameters: none

Optional Parameters:

rho=28.0 parameter for lorenz equations

sigma=10.0 parameter for lorenz equations

eta=1.6666667 parameter for lorenz equations

y0=1.0 initial value of y[0]

y1=-1.0 initial value of y[1]

y2=1.0 initial value of y[2]

h=.01 increment in time

tol=1.e-08 error tolerance

stepmax=500 maximum number of steps to compute

mode=xy xy-pairs, =yz yz-pairs, =xz xz-pairs,

=xyz xyz-triplet, =x only, =y only, =z only

Notes:

This program is really just a demo showing how to use the differential equation solver rke\_solve written by Francois Pinard, based on a modified form of the 4th order Runge-Kutta method, which employs the error checking method of R. England 1969.

The output consists of unformatted C-style binary floats, of either pairs or triplets as specified by the "mode" parameter.

Examples:

```
lorenz stepmax=1000 mode=xy | xgraph n=1000 &
```

```
lorenz stepmax=1000 mode=yz | xgraph n=1000 &
```

```
lorenz stepmax=1000 mode=xz | xgraph n=1000 &
```

```
lorenz stepmax=1000 mode=x | suaddhead ns=1000 | suxwigb &
```

```
lorenz stepmax=1000 mode=y | suaddhead ns=1000 | suxwigb &
```

```
lorenz stepmax=1000 mode=z | suaddhead ns=1000 | suxwigb &
```

GNUPLOT 3D plot example:

```
lorenz stepmax=2000 mode=xyz > lorenz.bin
```

...when you run gnuplot type the following command ...

```
splot "lorenz.bin" binary record=2000:2000:2000 with points pointsize .1
```

The lorenz equations describe a simplified model of a convection cell, and are given by the autonomous system of ODE's

$$\begin{aligned}x'(t) &= \text{sigma} * (y - x) \\y'(t) &= x * (\text{rho} - z) - y \\z'(t) &= x * y - \text{eta} * z\end{aligned}$$

Author: CWP: Aug 2004: John Stockwell

MAKEVEL - MAKE a VELOCITY function  $v(x,y,z)$

makevel > outfile nx= nz= [optional parameters]

Required Parameters:

nx=	number of x samples (3rd dimension)
nz=	number of z samples (1st dimension)

Optional Parameters:

ny=1	number of y samples (2nd dimension)
dx=1.0	x sampling interval
fx=0.0	first x sample
dy=1.0	y sampling interval
fy=0.0	first y sample
dz=1.0	z sampling interval
fz=0.0	first z sample
v000=2.0	velocity at $(x=0,y=0,z=0)$
dvdx=0.0	velocity gradient with respect to x
dvdy=0.0	velocity gradient with respect to y
dvdz=0.0	velocity gradient with respect to z
vlens=0.0	velocity perturbation in parabolic lens
tlens=0.0	thickness of parabolic lens
dlens=0.0	diameter of parabolic lens
xlens=	x coordinate of center of parabolic lens
ylens=	y coordinate of center of parabolic lens
zlens=	z coordinate of center of parabolic lens
lambda=1.0	make lambda larger to sharpen edge of lens
vrans=0.0	standard deviation of random perturbation
vzfile=	file containing $v(z)$ profile
vzrans=0.0	standard deviation of random perturbation to $v(z)$
vzc=0.0	$v(z)$ chirp amplitude
z1c=fz	z at which to begin chirp
z2c=fz+(nz-1)*dz	z at which to end chirp
l1c=dz	wavelength at beginning of chirp
l2c=dz	wavelength at end of chirp
exc=1.0	exponent of chirp

MKPARFILE - convert ascii to par file format

mkparfile <stdin >stdout

Optional parameters:

string1="par1" first par string

string2="par2" second par string

This is a tool to convert values written line by line to parameter vectors in the form expected by getpar. For example, if the input file looks like:

t0 v0

t1 v1

...

then

mkparfile <input >output string1=tnmo string2=vnmo

yields:

tnmo=t0,t1,...

vnmo=v0,v1,...

MRAFXZWT - Multi-Resolution Analysis of a function  $F(X,Z)$  by Wavelet Transform. Modified to perform different levels of resolution analysis for each dimension and also to allow to transform back only the lower level of resolution.

mrafxzwt [parameters] < infile > mrafile

Required Parameters:

n1= size of first (fast) dimension

n2= size of second (slow) dimension

Optional Parameters:

p1= maximum integer such that  $2^{p1} \leq n1$

p2= maximum integer such that  $2^{p2} \leq n2$

order=6 order of Daubechies wavelet used (even,  $4 \leq \text{order} \leq 20$ )

mrlevel1=3 maximum multi-resolution analysis level in dimension 1

mrlevel2=3 maximum multi-resolution analysis level in dimension 2

trunc=0.0 truncation level (percentage) of the reconstruction

verbose=0 =1 to print some useful information

reconfile= reconstructed data file to write

reconmrafile= reconstructed data file in MRA domain to write

dfile= difference between infile and reconfile to write

dmrafile= difference between mrafile and reconmrafile to write

donly=0 =1 keep only dc component of MRA

verbose=0 =1 to print some useful information

if (n1 or n2 is not integer powers of 2) specify the following:

nc1=n1/2 center of trimmed image in the 1st dimension

nc2=n2/2 center of trimmed image in the 2nd dimension

trimfile= if given, output the trimmed file

Notes:

This program performs multi-resolution analysis of an input function  $f(x,z)$  via the wavelet transform method. Daubechies's least asymmetric wavelets are used. The smallest wavelet coefficient retained is given by trunc times the absolute maximum size coefficient in the MRA.

The input dimensions of the data must be expressed by (p1,p2) which

Author: Zhaobo Meng, 11/25/95, Colorado School of Mines \*

Modified: Carlos E. Theodoro, 06/25/97, Colorado School of Mines \*

Included options for: \*

- different level of resolutionf or each dimension; \*

- transform back the lower level of resolution, only. \*

\*

Reference: \*

Daubechies, I., 1988, Orthonormal Bases of Compactly Supported \*  
Wavelets, Communications on Pure and Applied Mathematics, Vol. XLI, \*  
909-996. \*



PDFHISTOGRAM - generate a HISTOGRAM of the Probability Density function

pdfhistogram < stdin > sdtout [Required params] (Optional params)

Required parameters:

ix= column containing X variable

iy= column containing Y variable

min\_x= minimum X bin

max\_x= maximum X bin

min\_y= minimum Y bin

max\_y= maximum Y bin

logx=0 =1 use logarithmic scale for X axis

logy=0 =1 use logarithmic scale for Y axis

norm= selected normalization type

sqrt - bin / sqrt( xnct\*ycnt)

avg\_cnt - 0.5\* bin / (xcnt + ycnt)

avg\_sum - (bin / xcnt + bin / ycnt ) / 2

xcnt - bin / xcnt

ycnt - bin / ycnt

log - log(bin)

total - bin / total

Optional parameters:

nx=100 - number of X bins

ny=100 - number of Y bins

ir= - column containing reject variable

rmin= - reject values below rmin

rmax= - reject values above rmax

NOTE: only one, rmin or rmax, may be used

Notes:

PDFHISTOGRAM creates a 2D histogram representing the probability density function of the input data. The output is in the form of a binary array that can then be plotted via ximage.

Commandline options allow selecting any of several normalizations to apply to the distributions.

Credits:

Reginald H. Beardsley rhb@acm.org

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PRPLOT - PRinter PLOT of 1-D arrays  $f(x_1)$  from a 2-D function  $f(x_1, x_2)$

prplot <infile >outfile [optional parameters]

Optional Parameters:

n1=all	number of samples in 1st dimension
d1=1.0	sampling interval in 1st dimension
f1=d1	first sample in 1st dimension
n2=all	number of samples in 2nd dimension
d2=1.0	sampling interval in 2nd dimension
f2=d2	first sample in 2nd dimension
label2=Trace	label for 2nd dimension

RANDVEL3D - Add a random velocity layer (RVL) to a gridded  
v(x,y,z) velocity model

randvel3d <infile n1= n2= >outfile [parameters]

Required Parameters:

n1= number of samples along 1st dimension

n2= number of samples along 2nd dimension

Optional Parameters:

n3=1            number of samples along 3rd dimension

mode=1            add single layer populated with random vels  
                  =2 add nrvt layers of random thickness and vel

seed=from\_clock    random number seed (integer)

---->New layer geometry info

i1beg=1           1st dimension beginning sample

i1end=n1/5        1st dimension ending sample

i2beg=1           2nd dimension beginning sample

i2end=n2           2nd dimension ending sample

i3beg=1           3rd dimension beginning sample

i3end=n3           3rd dimension ending sample

---->New layer velocity info

vlsd=v/3          range (std dev) of random velocity in layer,  
                  where v=v(0,0,i1) and i1=(i1beg+i1end)/2

add=1            add random vel to original vel (v\_orig) at that point  
                  =0 replace vel at that point with (v\_orig+v\_rand)

how=0            random vels can be higher or lower than v\_orig  
                  =1 random vels are always lower than v\_orig  
                  =2 random vels are always higher than v\_orig

cvel=2000        layer filled with constant velocity cvel  
                  (overrides vl原因,add,how params)

---->Smoothing parameters (0 = no smoothing)

r1=0.0 1st dimension operator length in samples

r2=0.0 2nd dimension operator length in samples

r3=0.0 3rd dimension operator length in samples

slowness=0 =1 smoothing on slowness; =0 smoothing on velocity

nrvt=n1/10       number of const velocity layers to add

pdv=10.          percentage velocity deviation (max) from input model

Notes:

1. Smoothing radii usually fall in the range of [0,20].
2. Smoothing radii can be used to set aspect ratio of random velocity anomalies in the new layer. For example (r1=5,r2=0,r3=0) will result in vertical vel streaks that mimic vertical fracturing.
3. Smoothing on slowness works better to preserve traveltimes relative to the unsmoothed case.
4. Default case is a random velocity (+/-30%) near surface layer whose thickness is 20% of the total 2D model thickness.
5. Each layer vel is a random perturbation on input model at that level.
6. The depth dimension is assumed to be along axis 1.

Example:

1. 2D RVL with no smoothing  
makevel nz=250 nx=200 | randvel3d n1=250 n2=200 | ximage n1=250
2. 3D RVL with no smoothing  
makevel nz=250 nx=200 ny=220 |  
randvel3d n1=250 n2=200 n3=220 |  
xmovie n1=250 n2=200

Author: U Houston: Chris Liner c. 2008

Based on smooth3d (CWP: Zhenyue Liu March 1995)

RAYT2DAN -- P- and SV-wave raytracing in 2D anisotropic media

rayt2dan > ttime parameterfiles= nt= nx= nz= [optional parameters]

Required Parameters:

VP0file= name of file containing VP0(x,z)

nt= number of time samples for each ray

nx= number of samples (x) for the parameter fields

nz= number of samples (z) for the parameter fields

Optional Parameters:

SV=0 for P-waves, SV=1 for Shear waves

Parameters defining the velocity field

dt=0.008 time sampling interval ",

fx=0 first lateral sample (x) in parameter field

fz=0 first lateral sample (z) in parameter field

dx=100.0 sample spacing (x) for the parameter fields

dz=100.0 sample spacing (z) for the parameter fields

Parameters defining the takeoff angle of a ray at a source position ",

fa=-60 first take-off angle of rays (degrees)

na=61 number of rays ",

da=2 increment of take-off angle

amin=0 minimum emergence angle; must be > -90 degrees

amax=90 maximum emergence angle; must be < 90 degrees

Parameters defining the output traveltimes table

fxo=fx first lateral sample in traveltimes table

nxo=nx number of lateral samples in traveltimes table

dxo=dx lateral interval in traveltimes table

fzo=fz first depth sample in traveltimes table

nzo=nz number of depth samples in traveltimes table

dzo=dz depth interval in traveltimes table

fac=0.01 factor to determine the radius of extrap.

Parameters defining the source positions

fsx=fx x-coordinate of first source

nsx=1 number of sources

dsx=2\*dx x-coordinate increment of sources

aperx=0.5\*nx\*dx ray tracing aperture in x-direction

Files for general anisotropic parameters confined to a vertical plane:

a1111file name of file containing a1111(x,z)  
a1133file name of file containing a1133(x,z)  
VS0file name of file containing VS0(x,z)  
a1113file name of file containing a1113(x,z)  
a3313file name of file containing a3313(x,z)

For transversely isotropic media Thomsen's parameters could be used:

deltafile name of file containing delta(x,z)

epsilonfile name of file containing epsilon(x,z)

if anisotropy parameters are not given the program considers ",  
isotropic media. ",

Credits:

Debashish Sarkar

Technical Reference:

Cerveny, V., 1972, Seismic rays and ray intensities  
in inhomogeneous anisotropic media:  
Geophys. J. R. Astr. Soc., 29, 1--13.

Hangya, A., 1986, Gaussian beams in anisotropic elastic media:  
Geophys. J. R. Astr. Soc., 85, 473--563.

Gajewski, D. and Psencik, I., 1987, Computation of high frequency  
seismic wavefields in 3-D laterally inhomogeneous anisotropic  
media: Geophys. J. R. Astr. Soc., 91, 383-411.

RAYT2D - traveltimes Tables calculated by 2D paraxial RAY tracing

rayt2d vfile= tfile= [optional parameters]

Required parameters:

vfile=stdin file containning velocity v[nx][nz]

tfile=stdout file containning traveltimes tables

t[nxs][nxo][nzo]

Optional parameters

dt=0.008 time sample interval in ray tracing

nt=401 number of time samples in ray tracing

fz=0 first depth sample in velocity

nz=101 number of depth samples in velocity

dz=100 depth interval in velocity

fx=0 first lateral sample in velocity

nx=101 number of lateral samples in velocity

dx=100 lateral interval in velocity

fzo=fz first depth sample in traveltimes table

nzo=nz number of depth samples in traveltimes table

dzo=dz depth interval in traveltimes table

fxo=fx first lateral sample in traveltimes table

nxo=nx number of lateral samples in traveltimes table

dxo=dx lateral interval in traveltimes table

surf="0,0;99999,0" Recording surface "x1,z1;x2,z2;x3,z3;...

fxs=fx x-coordinate of first source

nxs=1 number of sources

dxs=2\*dxo x-coordinate increment of sources

aperx=0.5\*nx\*dx ray tracing aperture in x-direction

fa=-60 first take-off angle of rays (degrees)

na=61 number of rays

da=2 increment of take-off angle

amin=0 minimum emergence angle

amax=90 maximum emergence angle

fac=0.01 factor to determine radius for extrapolation

ek=1 flag of implementing eikonal in shadow zones

ms=10 print verbal information at every ms sources

restart=n job is restarted (=y yes; =n no)

```

npv=0 flag of computing quantities for velocity analysis
if npv>0 specify the following three files
pvfile=pvfile input file of velocity variation pv[nxo][nzo]
tvfile=tvfile output file of traveltime variation tables
tv[nxs][nxo][nzo]
csfile=csfile output file of cosine tables cs[nxs][nxo][nzo]

```

Notes:

1. Each traveltime table is calculated by paraxial ray tracing; then traveltimes in shadow zones are compensated by solving eikonal equation.
2. Input velocity is uniformly sampled and smooth one preferred.
3. Traveltime table and source ranges must be within velocity model.
4. Ray tracing aperture can be chosen as sum of migration aperture plus half of maximum offset.
5. Memory requirement for this program is about  

$$[nx*nz+4*mx*nz+3*nxo*nzo+na*(nx*nz+mx*nz+3*nxo*nzo)]*4 \text{ bytes}$$
where  $mx = \min(nx, 2*(1+aperx/dx))$ .

Note: spatial units of  $v(z,x)$  must be the same as those of  $dx$ .  
 $v(z,x)$  is represented numerically in C-style binary floats  $v[xn][zn]$ ,  
where the depth direction is the fast direction in the data. Such  
models can be created with `unif2` or `makevel`.       ",

Author: Zhenyue Liu, 10/11/94, Colorado School of Mines

Trino Salinas, 01/01/96 included the option to handle nonflat  
reference surfaces.

Subroutines from Dave Hale's modeling library were adapted in  
this code to define topography using cubic splines.

References:

- Beydoun, W. B., and Keho, T. H., 1987, The paraxial ray method:  
Geophysics, vol. 52, 1639-1653.
- Cerveny, V., 1985, The application of ray tracing to the numerical  
modeling of seismic wavefields in complex structures, in Dohr, G.,  
ED., Seismic shear waves (part A: Theory): Geophysical Press,  
Number 15 in Handbook of Geophysical Exploration, 1-124.



RECAST - RECAST data type (convert from one data type to another)

recast <stdin [optional parameters] >stdout

Required parameters:

none

Optional parameters:

in=float input type (float)

=double (double)

=int (int)

=char (char)

=uchar (unsigned char)

=short (short)

=long (long)

=ulong (unsigned long)

out=double output type (double)

=float (float)

=int (int)

=char (char)

=uchar (unsigned char)

=short (short)

=long (long)

=ulong (unsigned long)

outpar=/dev/tty output parameter file, contains the  
number of values (n1=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes: Converting bigger types to smaller is hazardous. For float  
or double conversions to integer types, the results are  
rounded to the nearest integer.

Credits:

CWP: John Stockwell, Jack K. Cohen

REFREALAZIHTI - REAL AZimuthal REFL/transm coeff for HTI media

refRealAziHTI [optional parameters] >coeff.data

Optional parameters:

vp1=2            p-wave velocity medium 1 (with respect to symm.axes)  
vs1=1            s-wave velocity medium 1 (with respect to symm.axes)  
eps1=0           epsilon medium1  
delta1=0 delta medium 1  
gamma1=0 gamma medium 1  
rho1=2.7 density medium 1  
vp2=2            p-wave velocity medium 2 (with respect to symm.axes)  
vs2=1            s-wave velocity medium 2 (with respect to symm.axes)  
eps2=0           epsilon medium 2  
delta2=0 delta medium 2  
gamma2=0 gamma medium 2  
rho2=2.7 density medium 2  
modei=0 incident mode is qP  
=1 incident mode is qSV  
=2 incident mode is SP  
modet=0 scattered mode  
rort=1 reflection(1) or transmission (0)  
azimuth=0 azimuth with respect to x1-axis (clockwise)  
fangle=0 first incidence angle  
langle=45 last incidence angle  
dangle=1 angle increment  
iscale=0        default: angle in degrees  
=1 angle-axis in rad  
                 =2 axis horizontal slowness  
                 =3  $\sin^2$  of incidence angle  
ibin=1 binary output  
=0 Ascii output  
outparfile =outpar parameter file for plotting  
coeffile =coeff.data coefficient-output file  
test=1 activate testing routines in code  
info=0 output intermediate results

Notes:

Axes of symmetry have to coincide in both media. This code computes all 6 REAL reflection/transmissions coefficients on the fly. However, the set-up is such Real reflection/transmission coefficients in HTI-media with coinciding symmetry axes.

However, the set-up is such that currently only one coefficient is

dumped into the output. This is easily changed. The solution of the scattering problem is obtained numerically and involves the Gaussian elimination of a 6X6 matrix. ",

AUTHOR:: Andreas Rueger, Colorado School of Mines, 02/10/95  
original name of code <graebnerTIH.c>  
modified, extended version of this code <refTIH3D>

Technical references:

Sebastian Geoltrain: Asymptotic solutions to direct and inverse scattering in anisotropic elastic media; CWP 082.

Graebner, M.; Geophysics, Vol 57, No 11:  
Plane-wave reflection and transmission coefficients for a transversely isotropic solid.

Cerveny, V., 1972, Seismic rays and ray intensities in inhomogeneous anisotropic media: Geophys. J. R. astr. Soc., 29, 1-13.

.. and some derivations by Andreas Rueger.

If propagation is perpendicular or parallel to the symmetry axis, the solution is analytic (see graebner2D.c and rtRealIso.c

REFREALVTI - REAL REFL/transm coeff for VTI media and symmetry-axis  
planes of HTI media

refRealVTI [Optional parameters]

Optional parameters:

vp1=2                p-wave velocity medium 1 (along symm.axes)  
vs1=1                s-wave velocity medium 1 (along symm.axes)  
eps1=0                Thomsen's epsilon medium 1  
delta1=0              Thomsen's delta medium 1  
rho1=2.7              density medium 1  
axis1=0               medium 1 is VTI  
=1 medium 1 is HTI  
vp2=2.5               p-wave velocity medium 2 (along symm.axes)  
vs2=1.2               s-wave velocity medium 2 (along symm.axes)  
eps2=0                epsilon medium2  
delta2=0               delta medium 2  
rho2=3.0               density medium 2  
axis2=0               medium 2 is VTI  
=2 medium 2 is HTI  
modei=0               incident mode is qP  
=1 incident mode is qSV  
modet=0               scattered mode  
rort=1                reflection(1) or transmission (0)  
fangle=0               first angle  
langle=45               last angle  
dangle=1               angle increment  
iscale=0               =1 angle-axis in rad  
                      =2 axis   horizontal slowness  
                      =3  $\sin^2$  of incidence angle  
ibin=1                binary output  
=0 Ascii output  
outparfile =outpar parameter file for plotting  
coefffile =coeff.data coefficient-output file

Notes:

Coefficients are based on Graebner's 1992 Geophysics paper. Note the  
mistype in the equation for K1. The algorithm can be used for VTI  
and HTI media on the incidence and scattering side.

AUTHOR:: Andreas Rueger, Colorado School of Mines, 01/20/95

original name of algorithm: graebner1.c

Technical reference: Graebner, M.; Geophysics, Vol 57, No 11:  
Plane-wave reflection and transmission coefficients  
for a transversely isotropic solid.  
Rueger, A.; Geophysics 1996 (accepted):  
P-wave reflection coefficients ...



RESAMP - RESAMPle the 1st dimension of a 2-dimensional function  $f(x_1, x_2)$

resamp <infile >outfile [optional parameters]

Required Parameters:

Optional Parameters:

n1=all	number of samples in 1st (fast) dimension
n2=all	number of samples in 2nd (slow) dimension
d1=1.0	sampling interval in 1st dimension
f1=d1	first sample in 1st dimension
n1r=n1	number of samples in 1st dimension after resampling
d1r=d1	sampling interval in 1st dimension after resampling
f1r=f1	first sample in 1st dimension after resampling

NOTE: resamp currently performs NO ANTI-ALIAS FILTERING before resampling!

Caveat: this program resamples data that are oscillatory in the fast dimension only, such as seismic data with no SU headers. To resample other 2d data, such as velocity profiles, use "unisam" or "unisam2"

ROSSLER - compute the ROSSLER attractor

```
rossler > [stdout]
```

Required Parameters: none

Optional Parameters:

a=.2 parameter for rossler equations

b=.2 parameter for rossler equations

c=5.7 parameter for rossler equations

y0=1.0 initial value of y[0]

y1=-1.0 initial value of y[1]

y2=1.0 initial value of y[2]

h=.01 increment in time

tol=1.e-08 error tolerance

stepmax=500 maximum number of steps to compute

mode=xy xy-pairs, =yz yz-pairs, =xz xz-pairs,

=xyz xyz-triplet, =x only, =y only, =z only

Notes:

This program is really just a demo showing how to use the differential equation solver rke\_solve written by Francois Pinard, based on a modified form of the 4th order Runge-Kutta method, which employs the error checking method of R. England 1969.

The output consists of unformatted C-style binary floats, of either pairs or triplets as specified by the "mode" parameter.

Examples:

```
rossler stepmax=1000 mode=xy | xgraph n=1000 &
```

```
rossler stepmax=1000 mode=yz | xgraph n=1000 &
```

```
rossler stepmax=1000 mode=xz | xgraph n=1000 &
```

```
rossler stepmax=1000 mode=x | suaddhead ns=1000 | suxwigg &
```

```
rossler stepmax=1000 mode=y | suaddhead ns=1000 | suxwigg &
```

```
rossler stepmax=1000 mode=z | suaddhead ns=1000 | suxwigg &
```

GNUPLOT 3D plot example:

```
rossler stepmax=2000 mode=xyz > rossler.bin
```

...when you run gnuplot type the following command ...

```
splot "rossler.bin" binary record=2000:2000:2000 with points pointsize .1
```



The rossler equations describe a simple example of a chaotic system and are given by the autonomous system of ODE's

$$\begin{aligned}x'(t) &= -y - z \\y'(t) &= x + a y \\z'(t) &= b + z(x - c)\end{aligned}$$

Author: CWP: Aug 2013: John Stockwell

SMOOTH2 --- SMOOTH a uniformly sampled 2d array of data, within a user-defined window, via a damped least squares technique

```
smooth2 < stdin n1= n2= [optional parameters ] > stdout
```

Required Parameters:

n1= number of samples in the 1st (fast) dimension

n2= number of samples in the 2nd (slow) dimension

Optional Parameters:

r1=0 smoothing parameter in the 1 direction

r2=0 smoothing parameter in the 2 direction

win=0,n1,0,n2 array for window range

rw=0 smoothing parameter for window function

efile=                      =efilename if set write relative error(x1) to  
efilename

Notes:

Larger r1 and r2 result in a smoother data. Recommended ranges of r1 ",  
and r2 are from 1 to 20.

The file verror gives the relative error between the original velocity  
and the smoothed one, as a function of depth. If the error is  
between 0.01 and 0.1, the smoothing parameters are suitable. Otherwise,  
consider increasing or decreasing the smoothing parameter values.

Smoothing can be implemented in a selected window. The range of 1st  
dimension for window is from win[0] to win[1]; the range of 2nd  
dimension is from win[2] to win[3].

Smoothing the window function (i.e. blurring the edges of the window)  
may be done by setting a nonzero value for rw, otherwise the edges  
of the window will be sharp.

Credits:

CWP: Zhen-yue Liu,

adapted for par/main by John Stockwell 1 Oct 92

Windowing feature added by Zliu on 16 Nov 1992

SMOOTH3D - 3D grid velocity SMOOTHing by the damped least squares

smooth3d <infile >outfile [parameters]

Required Parameters:

n1= number of samples along 1st dimension

n2= number of samples along 2nd dimension

n3= number of samples along 3rd dimension

Optional Parameters:

Smoothing parameters (0 = no smoothing)

r1=0.0 operator length in 1st dimension

r2=0.0 operator length in 2nd dimension

r3=0.0 operator length in 3rd dimension

Sample intervals:

d1=1.0 1st dimension

d2=1.0 2nd dimension

d3=1.0 3rd dimension

iter=2 number of iteration used

time=0 which dimension the time axis is (0 = no time axis)

depth=1 which dimension the depth axis is (ignored when time>0)

mu=1 the relative weight at maximum depth (or time)

verbose=0 =1 for printing minimum wavelengths

slowness=0 =1 smoothing on slowness; =0 smoothing on velocity

vminc=0 velocity values below it are clipped before smoothing

vmaxc=99999 velocity values above it are clipped before smoothing

Notes:

1. The larger the smoothing parameters, the smoother the output velocity. These parameters are lengths of smoothing operators in each dimension.
2. iter controls the orders of derivatives to be smoothed in the output velocity. e.g., iter=2 means derivatives until 2nd order smoothed.
3. mu is the multiplier of smoothing parameters at the bottom compared to those at the surface.
4. Minimum wavelengths of each dimension and the total may be printed for the resulting output velocity is. To compute these parameters for the input velocity, use r1=r2=r3=0.
5. Smoothing directly on slowness works better to preserve traveltimes. So the program optionally converts the input velocity into slowness, and smooths the slowness, then converts back into velocity.

Author: CWP: Zhenyue Liu March 1995

Reference:

Liu, Z., 1994, "A velocity smoothing technique based on damped least squares in Project Reveiw, May 10, 1994, Consortium Project on Seismic Inverse Methods for Complex Stuctures.

SMOOTHINT2 --- SMOOTH non-uniformly sampled INTERfaces, via the damped  
least-squares technique

smoothint2 <input ninf= >output [optional parameters]

Required Parameters:

<input	file containing original interfaces
>output	file containing smoothed interfaces

Optional Parameters:

ninf=5	number of interfaces
r=100	smoothing parameter
npmax=101	maximum number of points in interfaces

Notes:

The input file is an ASCII file. Each interface is represented by pairs (non-uniform sampling) of x and z values, with one pair of values on each line, separated by spaces or tabs. Each interface is separated with an entry with a large negative z value for example: 1.0 -9999. There is no entry for the surface. The surface is assumed to be flat with z=0.

This is similar to a CSHOT model file without a surface entry and without comments.

The smoothing method is analogous to a moving window averaging process (but not the same) with the parameter "r" being analogous to the "width of the window. Thus, the size of "r" must be chosen to be compatible with the scale (wavelengths) of the variations of the interfaces in the model being smoothed.

Example using the test data set generated by unif2:

unif2 tfile=tfilename

Compare the unsmoothed interface model:

```
unif2 < tfilename method=interpolation_method |  
psimage n1=100 n2=100 d1=10 d2=10 | ...
```

To the smoothed interface model:

```
smoothint2 r=100 < tfilename | unif2 method=interpolation_method | ",  
psimage n1=100 n2=100 d1=10 d2=10 | ...
```

Credits:

CWP: Zhenyue Liu, Jan 1994

Reference:

Liu, Zhenyue, 1994, Velocity smoothing: theory and implementation,  
Project Review, 1994, Consortium Project on Seismic Inverse Methods  
for Complex Stuctures (in review)

STIFF2VEL - Transforms 2D elastic stiffnesses to (vp,vs,epsilon,delta)

stiff2vel nx= nz= [optional parameters]

Required parameters:

nx= number of x samples (2nd dimension)

nz= number of z samples (1st dimension)

rho\_file='rho.bin' input file containing rho(x,z)

c11\_file='c11.bin' input file containing c11(x,z)

c13\_file='c13.bin' input file containing c13(x,z)

c33\_file='c33.bin' input file containing c33(x,z)

c44\_file='c44.bin' input file containing c44(x,z)

Optional Parameters:

vp\_file='vp.bin' output file containing P-wave velocities

vs\_file='vs.bin' output file containing S-wave velocities

rho\_file='rho.bin' output file containing densities

eps\_file='eps.bin' output file containing Thomsen epsilon

delta\_file='delta.bin' output file containing Thomsen delta

Notes:

1. All quantities in MKS units
2. Isotropy implied by  $c_{11}(x,z)=c_{33}(x,z)=0$
3. Vertical symmetry axis is assumed.

Coded:

Aramco: Chris Liner 9/25/2005

(based on vel2stiff.c)

SUBSET - select a SUBSET of the samples from a 3-dimensional file

subset <infile >outfile [optional parameters]

Optional Parameters:

n1=nfloats	number of samples in 1st dimension
n2=nfloats/n1	number of samples in 2nd dimension
n3=nfloats/(n1*n2)	number of samples in 3rd dimension
id1s=1	increment in samples selected in 1st dimension
if1s=0	index of first sample selected in 1st dimension
n1s=1+(n1-if1s-1)/id1s	number of samples selected in 1st dimension
ix1s=if1s,if1s+id1s,...	indices of samples selected in 1st dimension
id2s=1	increment in samples selected in 2nd dimension
if2s=0	index of first sample selected in 2nd dimension
n2s=1+(n2-if2s-1)/id2s	number of samples selected in 2nd dimension
ix2s=if2s,if2s+id2s,...	indices of samples selected in 2nd dimension
id3s=1	increment in samples selected in 3rd dimension
if3s=0	index of first sample selected in 3rd dimension
n3s=1+(n3-if3s-1)/id3s	number of samples selected in 3rd dimension
ix3s=if3s,if3s+id3s,...	indices of samples selected in 3rd dimension

For the 1st dimension, output is selected from input as follows:

output[i1s] = input[ix1s[i1s]], for i1s = 0 to n1s-1

Likewise for the 2nd and 3rd dimensions.

AUTHOR: Dave Hale, Colorado School of Mines, 07/07/89



SWAPBYTES - SWAP the BYTES of various data types

swapbytes <stdin [optional parameters] >stdout

Required parameters:

none

Optional parameters:

in=float input type (float)

=double (double)

=short (short)

=ushort (unsigned short)

=long (long)

=ulong (unsigned long)

=int (int)

outpar=/dev/tty output parameter file, contains the  
number of values (n1=)

other choices for outpar are: /dev/tty,  
/dev/stderr, or a name of a disk file

Notes:

The byte order of the mantissa of binary data values on PC's and DEC's is the reverse of so called "big endian" machines (IBM RS6000, SUN, etc.) hence the need for byte-swapping capability. The subroutines in this code have been tested for swapping between PCs and big endian machines, but have not been tested for DEC products.

Caveat:

2 byte short, 4 byte long, 4 byte float, 4 byte int,  
and 8 bit double assumed.

Credits:

CWP: John Stockwell (Jan 1994)

Institut fur Geophysik, Hamburg: Jens Hartmann supplied byte swapping subroutines

THOM2HTI - Convert Thompson parameters  $V_p0$ ,  $V_s0$ ,  $\epsilon$ ,  $\gamma$ ,  
to the HTI parameters  $\alpha$ ,  $\beta$ ,  $\epsilon(V)$ ,  $\delta(V)$ ,  
 $\gamma$

thom2hti [optional parameter]

$v_p=2$             symm.axis p-wave velocity  
 $v_s=1$             symm.axis s-wave velocity  
 $\epsilon=0$             Thomsen's (generic) epsilon  
 $\gamma=0$             Thomsen's generic gamma  
 $weak=1$           compute weak approximation  
outpar=/dev/tty output parameter file

Outputs:

$\alpha$ ,  $\beta$ ,  $\epsilon(V)$ ,  $\delta(V)$ ,  $\gamma$

Notes:

Output is dumped to the screen and, if selected to outpar

Code can be used to find models that satisfy the constraints  
that are imposed on HTI models caused by vertically fractured  
layers. For definition and use of the HTI parameter set see CWP-235.

Credits: Andreas Rueger, CWP

For definition and use of the HTI parameter set see CWP-235.

THOM2STIFF - convert Thomsen's parameters into (density normalized)  
stiffness components for transversely isotropic  
material with in-plane-tilted axis of symmetry

thom2stiff [optional parameter]

vp=2            symm.axis p-wave velocity  
vs=1            symm.axis s-wave velocity  
eps=0           Thomsen's (generic) epsilon  
delta=0          Thomsen's (generic) delta  
gamma=0          Thomsen's (generic) gamma  
rho=1           density  
phi=0           angle(DEG) vertical --> symmetry axes (clockwise)  
sign=1           sign of c11+c44 (generally sign=1)  
outpar=/dev/tty output parameter file

Output:

aijkl,cijkl (density normalized) stiffness components

Author: CWP: Andreas Rueger 1995

TRANSP3D - TRANSPOSE an n1 by n2 by n3 element matrix

transp3d <infile >outfile n1= n2= [optional parameters]

Required Parameters:

n1 number of elements in 1st (fast) dimension of matrix

n2 number of elements in 2nd (middle) dimension of matrix

Optional Parameters:

n3=all number of elements in 3rd (slow) dimension of matrix

perm=231 desired output axis ordering

nbpe=sizeof(float) number of bytes per matrix element

scratchdir=/tmp directory for scratch files

scratchstem=foo stem prefix for scratch file names

verbose=0 =1 for diagnostic information

TRANSP - TRANSPose an n1 by n2 element matrix

transp <infile >outfile n1= [optional parameters]

Required Parameters:

n1                                number of elements in 1st (fast) dimension of matrix

Optional Parameters:

n2=all                            number of elements in 2nd (slow) dimension of matrix

nbpe=sizeof(float)            number of bytes per matrix element

verbose=0                        =1 for diagnostic information

TVNMOQC - Check tnmo-vnmo pairs; create t-v column files

```
tvnmoqc [parameters] cdp=... tnmo=... vnmo=...
```

Example:

```
tvnmoqc mode=1 \\  
cdp=15,35 \\  
tnmo=0.0091,0.2501,0.5001,0.7501,0.9941 \\  
vnmo=1497.0,2000.0,2500.0,3000.0,3500.0 \\  
tnmo=0.0082,0.2402,0.4902,0.7402,0.9842 \\  
vnmo=1495.0,1900.0,2400.0,2900.0,3400.0
```

Required Parameter:

```
prefix=          Prefix of output t-v file(s)  
                  Required only for mode=2
```

Optional Parameter:

```
mode=1           1=qc: check that tnmo values increase  
                  2=qc and output t-v files
```

mode=1

TVNMOQC checks that there is a tnmo and vnmo series for each CDP  
and it checks that each tnmo series increases in time.

mode=2

TVNMOQC does mode=1 checking, plus ...

TVNMOQC converts par (MKPARFILE) values written as:

```
cdp=15,35,...,95 \\  
tnmo=t151,t152,...,t15n \\  
vnmo=v151,v152,...,v15n \\  
tnmo=t351,t352,...,t35n \\  
vnmo=v351,v352,...,v35n \\  
tnmo=... \\  
vnmo=... \\  
tnmo=t951,t952,...,t95n \\  
vnmo=v951,v952,...,v95n \\  

```

to column format. The format of each output file is:

```
t1 v1  
t2 v2
```

...  
tn vn

One file is output for each input pair of tnmo-vnmo series.

A CDP VALUE MUST BE SUPPLIED FOR EACH TNMO-VNMO ROW PAIR.

Prefix of each output file is the user-supplied value of  
parameter PREFIX.

Suffix of each output file is the cdp value.

For the example above, output files names are:

PREFIX.15 PREFIX.35 ... PREFIX.95

Credits:

MTU: David Forel (adapted from SUNMO)

UNIF2ANISO - generate a 2-D UNIFormly sampled profile of elastic constants from a layered model.

unif2aniso < infile [Parameters]

Required Parameters:

none

Optional Parameters:

ninf=5 number of interfaces

nx=100 number of x samples (2nd dimension)

nz=100 number of z samples (1st dimension)

dx=10 x sampling interval

dz=10 z sampling interval

npmax=201 maximum number of points on interfaces

fx=0.0 first x sample

fz=0.0 first z sample

x0=0.0,0.0,..., distance x at which vp00 and vs00 are specified

z0=0.0,0.0,..., depth z at which vp00 and vs00 are specified

vp00=1500,2000,...,P-velocity at each x0,z0 (m/sec)

vs00=866,1155...,S-velocity at each x0,z0 (m/sec)

rho00=1000,1100,...,density at each x0,z0 (kg/m<sup>3</sup>)

q00=110,120,130,...,attenuation Q, at each x0,z0 (kg/m<sup>3</sup>)

eps00=0,0,0...,Thomsen or Sayers epsilon

delta00=0,0,0...,Thomsen or Sayers delta

gamma00=0,0,0...,Thomsen or Sayers gamma

dqdx=0.0,0.0,...,x-derivative of Q (d q/dx)

dqdz=0.0,0.0,...,z-derivative of Q (d q/dz)

drdx=0.0,0.0,...,x-derivative of density (d rho/dx)

drdz=0.0,0.0,...,z-derivative of density (d rho/dz)

dvpdx=0.0,0.0,...,x-derivative of P-velocity (dvp/dx)

dvpdz=0.0,0.0,...,z-derivative of P-velocity (dvs/dz)

dvsdx=0.0,0.0,...,x-derivative of S-velocity (dvs/dx)



dvsdz=0.0,0.0,...,z-derivative of S-velocity (dvs/dz)

dedx=0.0,0.0,...,x-derivative of epsilon (de/dx)

dedz=0.0,0.0,...,z-derivative of epsilon with depth z (de/dz)

dddx=0.0,0.0,...,x-derivative of delta (dd/dx)

dddz=0.0,0.0,...,z-derivative of delta (dd/dz)

dgdz=0.0,0.0,...,x-derivative of gamma (dg/dz)

dgdx=0.0,0.0,...,z-derivative of gamma (dg/dx)

phi00=0,0,..., rotation angle(s) in each layer

...output filenames

c11\_file=c11\_file output filename for c11 values

c13\_file=c13\_file output filename for c13 values

c15\_file=c15\_file output filename for c15 values

c33\_file=c33\_file output filename for c33 values

c35\_file=c35\_file output filename for c35 values

c44\_file=c44\_file output filename for c44 values

c55\_file=c55\_file output filename for c55 values

c66\_file=c66\_file output filename for c66 values

rho\_file=rho\_file output filename for density values

q\_file=q\_file output filename for Q values

paramtype=1 =1 Thomsen parameters, =0 Sayers parameters(see below)

method=linear for linear interpolation of interface

=mono for monotonic cubic interpolation of interface

=akima for Akima's cubic interpolation of interface

=spline for cubic spline interpolation of interface

tfile= =testfilename if set, a sample input dataset is  
output to "testfilename".

Notes:

The input file is an ASCII file containing x z values representing a piecewise continuous velocity model with a flat surface on top.

The surface and each successive boundary between media is represented by a list of selected x z pairs written column form. The first and last x values must be the same for all boundaries. Use the entry 1.0 -99999 to separate the entries for successive boundaries. No

boundary may cross another. Note that the choice of the method of interpolation may cause boundaries to cross that do not appear to cross in the input data file.

The number of interfaces is specified by the parameter "ninf". This number does not include the top surface of the model. The input data format is the same as a CSHOT model file with all comments removed.

The algorithm works by transforming the P-wavespeed, S-wavespeed, density and the Thomsen or Sayers parameters epsilon, delta, and gamma into elastic stiffness coefficients. Furthermore, the user can specify rotations, phi, to the elasticity tensor in each layer.

Common ranges of Thomsen parameters are

epsilon: 0.0 -> 0.5

delta: -0.2 -> 0.4

gamma: 0.0 -> 0.4

If only P-wave, S-wave velocities and density is given as input, the model is, by definition, isotropic.

If files containing Thomsen/Sayers parameters are given, the model will be assumed to have VTI symmetry.

Example using test input file generating feature:

unif2aniso tfile=testfilename produces a 5 interface demonstration model

unif2aniso < testfilename

ximage < c11\_file n1=100 n2=100

ximage < c13\_file n1=100 n2=100

ximage < c15\_file n1=100 n2=100

ximage < c33\_file n1=100 n2=100

ximage < c35\_file n1=100 n2=100

ximage < c44\_file n1=100 n2=100

ximage < c55\_file n1=100 n2=100

ximage < c66\_file n1=100 n2=100

ximage < rho\_file n1=100 n2=100

ximage < q\_file n1=100 n2=100

Credits:

CWP: John Stockwell, April 2005.

CWP: based on program unif2 by Zhenyue Liu, 1994



UNIF2 - generate a 2-D UNIFormly sampled velocity profile from a layered model. In each layer, velocity is a linear function of position.

unif2 < infile > outfile [parameters]

Required parameters:

none

Optional Parameters:

ninf=5 number of interfaces

nx=100 number of x samples (2nd dimension)

nz=100 number of z samples (1st dimension)

dx=10 x sampling interval

dz=10 z sampling interval

npmax=201 maximum number of points on interfaces

fx=0.0 first x sample

fz=0.0 first z sample

x0=0.0,0.0,..., distance x at which v00 is specified

z0=0.0,0.0,..., depth z at which v00 is specified

v00=1500,2000,2500...,velocity at each x0,z0 (m/sec)

dvdx=0.0,0.0,...,derivative of velocity with distance x (dv/dx)

dvdz=0.0,0.0,...,derivative of velocity with depth z (dv/dz)

method=linear for linear interpolation of interface

=mono for monotonic cubic interpolation of interface

=akima for Akima's cubic interpolation of interface

=spline for cubic spline interpolation of interface

tfile= =testfilename if set, a sample input dataset is  
output to "testfilename".

Notes:

The input file is an ASCII file containing x z values representing a piecewise continuous velocity model with a flat surface on top. The surface and each successive boundary between media are represented by a list of selected x z pairs written column form. The first and last x values must be the same for all boundaries. Use the entry 1.0 -99999 to separate entries for successive boundaries. No boundary may cross another. Note that the choice of the method of interpolation may cause boundaries to cross that do not appear to cross in the input data file.

The number of interfaces is specified by the parameter "ninf". This number does not include the top surface of the model. The input data format is the same as a CSHOT model file with all comments removed.

Example using test input file generating feature:

```
unif2 tfile=testfilename      produces a 5 interface demonstration model
unif2 < testfilename | psimage n1=100 n2=100 d1=10 d2=10 | ...
```

Credits:

CWP: Zhenyue Liu, 1994

CWP: John Stockwell, 1994, added demonstration model stuff.

UNIF2TI2 - generate a 2-D UNIFormly sampled profile of stiffness coefficients of a layered medium (only for P waves).

```
unif2ti2 < infile [Parameters]
```

Required Parameters:

none

Optional Parameters:

ninf=5 number of interfaces

nx=100 number of x samples (2nd dimension)

nz=100 number of z samples (1st dimension)

dx=10 x sampling interval

dz=10 z sampling interval

ns=0 number of samples in vertical direction for smoothing parameters across boundary

npmax=201 maximum number of points on interfaces

fx=0.0 first x sample

fz=0.0 first z sample

x0=0.0,0.0,..., distance x at which vp00 and vs00 are specified

z0=0.0,0.0,..., depth z at which vp00 and vs00 are specified

vp00=1500,2000,...,P-velocity at each x0,z0 (m/sec)

eps00=0,0,0...,Thomsen parameter epsilon at each x0,z0

delta00=0,0,0...,Thomsen parameter delta at each x0,z0

rho00=1000,1100,...,density at each x0,z0 (kg/m<sup>3</sup>)

dvpdx=0.0,0.0,...,x-derivative of P-velocity (dvp/dx)

dvpdz=0.0,0.0,...,z-derivative of P-velocity (dvs/dz)

dedx=0.0,0.0,...,x-derivative of epsilon (de/dx)

dedz=0.0,0.0,...,z-derivative of epsilon with depth z (de/dz)

dddx=0.0,0.0,...,x-derivative of delta (dd/dx)

dddz=0.0,0.0,...,z-derivative of delta (dd/dz)

drdx=0.0,0.0,...,x-derivative of density (d rho/dx)

drdz=0.0,0.0,...,z-derivative of density (d rho/dz)

nufile= binary file containning tilt value at each grid point

...output filenames

c11\_file=c11\_file output filename for c11 values

c13\_file=c13\_file output filename for c13 values

c15\_file=c15\_file output filename for c15 values

c33\_file=c33\_file output filename for c33 values

c35\_file=c35\_file output filename for c35 values

c55\_file=c55\_file output filename for c55 values

method=linear for linear interpolation of interface

=mono for monotonic cubic interpolation of interface

=akima for Akima's cubic interpolation of interface

=spline for cubic spline interpolation of interface

tfile= =testfilename if set, a sample input dataset is  
output to "testfilename".

Notes:

The input file is an ASCII file containing x z values representing a piecewise continuous velocity model with a flat surface on top.

The surface and each successive boundary between media is represented by a list of selected x z pairs written column form. The first and last x values must be the same for all boundaries. Use the entry 1.0 -99999 to separate the entries for successive boundaries. No boundary may cross another. Note that the choice of the method of interpolation may cause boundaries to cross that do not appear to cross in the input data file.

The number of interfaces is specified by the parameter "ninf". This number does not include the top surface of the model. The input data format is the same as a CSHOT model file with all comments removed.

The algorithm works by transforming the P-wavespeed, Thomsen parameters epsilon and delta, and the tilt of the symmetry axis into density-normalized", stiffness coefficients.

At this stage, the tilt-field file can be prepared using the Matlab M-file nu\_mod.m based on 2D interpolation between interfaces. ",  
The binary file contains nu values at each grid point.

The interfaces are obtained by interpolation on the picked ones stored in the infile, and the symmetry axis at each point of interface is assumed to be parallel to the normal direction.

Common ranges of Thomsen parameters are

epsilon: 0.0 -> 0.5

delta: -0.2 -> 0.4

If the tilt-field file is not given, the model will be assumed to have VTI symmetry.

Example using test input file generating feature:

unif2aniso tfile=testfilename produces a 5 interface demonstration model

unif2aniso < testfilename

ximage < c11\_file n1=100 n2=100

ximage < c13\_file n1=100 n2=100

ximage < c15\_file n1=100 n2=100

ximage < c33\_file n1=100 n2=100

ximage < c35\_file n1=100 n2=100

ximage < c55\_file n1=100 n2=100

ximage < rho\_file n1=100 n2=100

Credits:

Modified by Pengfei Cai (CWP), Dec 2011

Modified by Xiaoxiang Wang (CWP), Aug 2010

Based on program unif2aniso by John Stockwell, 2005



UNISAM2 - UNIformly SAMple a 2-D function  $f(x_1, x_2)$

unisam2 [optional parameters] <inputfile >outputfile

Required Parameters:

none

Optional Parameters:

x1=                    array of x1 values at which input  $f(x_1, x_2)$  is sampled  
... Or specify a uniform linear set of values for x1 via:  
nx1=1                number of input samples in 1st dimension  
dx1=1                input sampling interval in 1st dimension  
fx1=0                first input sample in 1st dimension  
...  
n1=1                number of output samples in 1st dimension  
d1=                output sampling interval in 1st dimension  
f1=                first output sample in 1st dimension  
x2=                    array of x2 values at which input  $f(x_1, x_2)$  is sampled  
... Or specify a uniform linear set of values for x2 via:  
nx2=1                number of input samples in 2nd dimension  
dx2=1                input sampling interval in 2nd dimension  
fx2=0                first input sample in 2nd dimension  
...  
n2=1                number of output samples in 2nd dimension  
d2=                output sampling interval in 2nd dimension  
f2=                first output sample in 2nd dimension  
...  
method1=linear    =linear for linear interpolation  
                     =mono for monotonic bicubic interpolation  
                     =akima for Akima bicubic interpolation  
                     =spline for bicubic spline interpolation  
method2=linear    =linear for linear interpolation  
                     =mono for monotonic bicubic interpolation  
                     =akima for Akima bicubic interpolation  
                     =spline for bicubic spline interpolation

NOTES:

The number of input samples is the number of x1 values times the number of x2 values. The number of output samples is n1 times n2. The output sampling intervals (d1 and d2) and first samples (f1 and f2) default to span the range of input x1 and x2 values. In other words,  $d1 = (x1_{max} - x1_{min}) / (n1 - 1)$  and  $f1 = x1_{min}$ ; likewise for d2 and f2.

Interpolation is first performed along the 2nd dimension for each

value of  $x_1$  specified. Interpolation is then performed along the 1st dimension.

AUTHOR: Dave Hale, Colorado School of Mines, 01/12/91\n"

UNISAM - UNIformly SAMple a function  $y(x)$  specified as x,y pairs

```
unisam xin= yin= nout= [optional parameters] >binaryfile
... or ...
unisam xfile= yfile= npairs= nout= [optional parameters] >binaryfile
... or ...
unisam xyfile= npairs= nout= [optional parameters] >binaryfile
```

Required Parameters:

```
xin=,,,array of x values (number of xin = number of yin)
yin=,,,array of y values (number of yin = number of xin)
... or
xfile= binary file of x values
yfile= binary file of y values
... or
xyfile= binary file of x,y pairs
npairs= number of pairs input (active only if xfile= and yfile=
or xyfile= are set)
```

```
nout= number of y values output to binary file
```

Optional Parameters:

```
dxout=1.0 output x sampling interval
fxout=0.0 output first x
method=linear =linear for linear interpolation (continuous y)
=mono for monotonic cubic interpolation (continuous y')
=akima for Akima's cubic interpolation (continuous y')
=spline for cubic spline interpolation (continuous y'')
isint=,,, where these sine interpolations to apply
amp=,,, amplitude of sine interpolations
phase0=,,, starting phase (defaults: 0,0,0,...,0)
totalphase=,,, total phase (default pi,pi,pi,...,pi.)
nwidth=0 apply window smoothing if nwidth>0
sloth=0 apply interpolation in input (velocities)
=1 apply interpolation to 1/input (slowness),
=2 apply interpolation to 1/input (sloth), and write
out velocities in each case.
smooth=0 apply damped least squares smoothing to output
r=10 ... damping coefficient, only active when smooth=1
```

AUTHOR: Dave Hale, Colorado School of Mines, 07/07/89  
Zhaobo Meng, Colorado School of Mines,

added sine interpolation and window smoothing, 09/16/96

CWP: John Stockwell, added file input options, 24 Nov 1997

Remarks: In interpolation, suppose you need 2 pieces of  
sine interpolation before index 3 to 4, and index 20 to 21  
then set: `isint=3,20`. The sine interpolations use a sine  
function with starting phase being `phase0`, total phase  
being `totalphase` (i.e. ending phase being `phase0+totalphase`  
for each interpolation).

UTMCONV - CONVert longitude and latitude to UTM, and vice versa

utmconv <stdin >stdout [optional parameters]

Optional parameters:

idx=23	reference ellipsoid index (default is WGS 1984)
format=%.3f	output number format (printf style for one float)
a=(from idx)	user-specified semimajor axis of ellipsoid
f=(from idx)	user-specified flattening of ellipsoid
letter=0	=1: use UTM letter designator for latitude/Northing
invert=0	=0: convert latitude and longitude to UTM =1: convert UTM to latitude and longitude
verbose=0	=1: echo parameters and number of converted coords
lon0=	central meridian for TM projection in degrees (default uses the 60 standard UTM longitude zones)
xoff=500000	false Easting (default: UTM)
ysoff=10000000	false Northing, southern hemisphere (default: UTM)
ynoff=0	false Northing, northern hemisphere (default: UTM)

Notes:

Universal Transverse Mercator (UTM) coordinates are defined between latitudes 80S (-80) and 84N (84). Longitude values must be between -180 degrees (west) and 179.999... degrees (east).

Input and output is in ASCII format. For a conversion from lon/lat to UTM (invert=0), input is a two-column table of longitude and latitude in decimal degrees. Output is a three-column table of UTM Easting, UTM Northing, and UTM zone. The zone is given either by the zone number only (default, negative on southern hemisphere) or by the positive zone number plus a letter designator (letter=1).

Example:

Convert 40.822N, 14.125E to UTM with zone number and letter, output values rounded to nearest integer:  
echo 14.125 40.822 | utmconv letter=1 format=%.0f  
The output is "426213 4519366 33T" (Easting, Northing, UTM zone).

Reference ellipsoids:

An ellipsoid may be specified by its semimajor axis *a* and its flattening *f*, or one of the following ellipsoids may be selected by its index *idx* (semimajor axes in meters):

0 Sphere with radius of 6371000 m

- 1 Airy 1830
- 2 Australian National 1965
- 3 Bessel 1841 (Ethiopia, Indonesia, Japan, Korea)
- 4 Bessel 1841 (Namibia)
- 5 Clarke 1866
- 6 Clarke 1880
- 7 Everest (Brunei, E. Malaysia)
- 8 Everest (India 1830)
- 9 Everest (India 1956)
- 10 Everest (Pakistan)
- 11 Everest (W. Malaysia, Singapore 1948)
- 12 Everest (W. Malaysia 1969)
- 13 Geodetic Reference System 1980 (GRS 1980)
- 14 Helmert 1906
- 15 Hough 1960
- 16 Indonesian 1974
- 17 International 1924 / Hayford 1909
- 18 Krassovsky 1940
- 19 Modified Airy
- 20 Modified Fischer 1960
- 21 South American 1969
- 22 World Geodetic System 1972 (WGS 1972)
- 23 World Geodetic System 1984 (WGS 1984) / NAD 1983

#### UTM grid:

The Universal Transverse Mercator (UTM) system is a world wide coordinate system defined between 80S and 84N. It divides the Earth into 60 six-degree zones. Zone number 1 has its central meridian at 177W (-177 degrees), and numbers increase eastward.

Within each zone, an Easting of 500,000 m is assigned to its central meridian to avoid negative coordinates. On the northern hemisphere, Northings start at 0 m at the equator and increase northward. On the southern hemisphere a false Northing of 10,000,000 m is applied, i.e. Northings start at 10,000,000 m at the equator and decrease southward. Letters are sometimes used to identify different zones of latitude. The letters C-M indicate zones on the southern and the letters N-X zones on the northern hemisphere.

#### Author:

Nils Maercklin, RISSC, University of Naples, Italy, March 2007

References:

- NIMA (2000). Department of Defense World Geodetic System 1984 - its definition and relationships with local geodetic systems. Technical Report TR8350.2. National Imagery and Mapping Agency, Geodesy and Geophysics Department, St. Louis, MO. 3rd edition.
- J. P. Snyder (1987). Map Projections - A Working Manual. U.S. Geological Survey Professional Paper 1395, 383 pages. U.S. Government Printing Office.

VEL2STIFF - Transforms VELOCities, densities, and Thomsen or Sayers parameters to elastic STIFFnesses

```
vel2stiff [Required parameters] [Optional Parameters] > stdout
```

Required parameters:

vpfile= file with P-wave velocities

vsfile= file with S-wave velocities

rhofile= file with densities

Optional Parameters:

epsfile= file with Thomsen/Sayers epsilon

deltafile= file with Thomsen/Sayers delta

gammafile= file with Thomsen/Sayers gamma

phi\_file= angle of axis of symmetry from vertical (radians)

c11\_file=c11\_file        output filename for c11 values

c13\_file=c13\_file        output filename for c13 values

c15\_file=c15\_file        output filename for c15 values

c33\_file=c33\_file        output filename for c33 values

c35\_file=c35\_file        output filename for c35 values

c44\_file=c44\_file        output filename for c44 values

c55\_file=c55\_file        output filename for c55 values

c66\_file=c66\_file        output filename for c66 values

paramtype=1    (1) Thomsen parameters, (0) Sayers parameters(see below)

nx=101 number of x samples 2nd (slow) dimension

nz=101 number of z samples 1st (fast) dimension

Notes:

Transforms velocities, density and Thomsen/Sayers parameters epsilon, delta, and gamma into elastic stiffness coefficients.

If only P-wave, S-wave velocities and density is given as input, the model is assumed to be isotropic.

If files containing Thomsen/Sayers parameters are given, the model will be assumed to have VTI symmetry.

All input files vpfile, vsfile, rhofile etc. are assumed to consist only of C style binary floating point numbers representing the corresponding material values of vp, vs, rho etc. Similarly, the output



files consist of the corresponding stiffnesses as C style binary floats. If the output files are to be used as input for a modeling program, such as suea2df, then further, the contents are assumed be arrays of floating point numbers of the form of `Array[n2][n1]`, where the fast dimension, dimension 1, represents depth.

Author:

CWP: Sverre Brandsberg-Dahl 1999

Extended:

CWP: Stig-Kyrre Foss 2001

- to include the option to use the parameters by Sayers (1995) instead of the Thomsen parameters

Technical reference:

Sayers, C. M.: Simplified anisotropy parameters for transversely isotropic sedimentary rocks. Geophysics 1995, pages 1933-1935.

## VELCONV - VELOCITY CONVERSION

velconv <infile >outfile intype= outtype= [optional parameters]

### Required Parameters:

intype=                      input data type (see valid types below)  
outtype=                    output data type (see valid types below)

### Valid types for input and output data are:

vintt              interval velocity as a function of time  
vrms              RMS velocity as a function of time  
vintz              velocity as a function of depth  
zt                depth as a function of time  
tz                time as a function of depth

### Optional Parameters:

nt=all              number of time samples  
dt=1.0              time sampling interval  
ft=0.0              first time  
nz=all              number of depth samples  
dz=1.0              depth sampling interval  
fz=0.0              first depth  
nx=all              number of traces

Example: "intype=vintz outtype=vrms" converts an interval velocity function of depth to an RMS velocity function of time.

Notes: nt, dt, and ft are used only for input and output functions of time; you need specify these only for vintt, vrms, orzt. Likewise, nz, dz, and fz are used only for input and output functions of depth.

The input and output data formats are C-style binary floats.

AUTHOR: Dave Hale, Colorado School of Mines, 07/07/89

VELPERTAN - Velocity PERTurbation analysis in ANisotropic media to  
determine the model update required to flatten image gathers",

```
velperten boundary= par=cig.par refl1= refl2= npicks1=
npicks2= cdp1= cdp2= vfile= efile= dfile= nx= dx= fx=
ncdp= dcdp= fcdp= off0= noff= doff= >outfile [parameters]
```

Required Parameters:

```
refl1= file with picks on the 1st reflector
refl2= file with picks on the 2nd reflector
vfile= file defining VP0 at all grid points from prev. iter. ",
efile= file defining eps at all grid points from prev. iter. ",
dfile= file defining del at all grid points from prev. iter. ",
boundary= file defining the boundary above which
           parameters are known; update is done below this ",
boundary ",
npicks1= number of picks on the 1st reflector
npicks2= number of picks on the 2nd reflector
ncdp= number of cdp's
dcdp= cdp spacing
fcdp= first cdp
off0= first offset in common image gathers
noff= number of offsets in common image gathers
doff= offset increment in common image gathers
cip1=x1,r1,r2,..., cip=xn,r1n,r2n      description of input CIGS
cip2=x2,r1,r2,..., cip=xn,r1n,r2n      description of input CIGS
x x-value of a common image point
r1 hyperbolic component of the residual moveout
r2 non-hyperbolic component of residual moveout
```

Optional Parameters:

```
method=akima          for linear interpolation of the interface
                      =mono for monotonic cubic interpolation of interface
                      =akima for Akima's cubic interpolation of interface
                      =spline for cubic spline interpolation of interface
VP0=2000 Starting value for vertical velocity at a point in the
target layer
x00=0.0 x-coordinate at which VP0 is defined
z00=0.0 z-coordinate at which VP0 is defined
eps=0.0 Starting value for Thomsen's parameter epsilon
del=0.0 Starting value for Thomsen's parameter delta
kz=0.0 Starting value for the vertical gradient in VP0
kx=0.0 Starting value for the lateral gradient in VP0
nx=100 number of nodes in the horizontal direction for the
```

velocity grid

nz=100 number of nodes in the vertical direction for the

velocity grid

dx=10 horizontal grid increment

dz=10 vertical grid increment

fx=0 first horizontal grid point

fz=0 first vertical grid point

dt=0.008 traveltime increment

nt=500 no. of points on the ray

amax=360 max. angle of emergence

amin=0 min. angle of emergence

Smoothing parameters:

r1=0 smoothing parameter in the 1 direction

r2=0 smoothing parameter in the 2 direction

win=0,n1,0,n2 array for window range

rw=0 smoothing parameter for window function

nbound=2 number of points picked on the boundary

tol=0.1 tolerance in computing the offset (m)

Notes:

This program is used as part of the velocity analysis technique developed by Debashish Sarkar, CWP:2003.

Notes:

The output par file contains the coefficients describing the residual moveout. This program is used in conjunction with surelanan.

Author: CSM: Debashish Sarkar, December 2003

based on program: velpert.c written by Zhenuye Liu.

VELPERT - estimate velocity parameter perturbation from covariance of imaged depths in common image gathers (CIGs)

verpert <dfile dzfile=dzfile >outfile [parameters]

Required Parameters:

dfile input of imaged depths in CIGs

dzfile=dzfile input of dz/dv at the imaged depths in CIGs

outfile output of the estimated parameter

noff number of offsets

ncip number of common image gathers

Optional Parameters:

moff=noff number of first offsets used in velocity estimation

Notes:

1. This program is part of Zhenyue Liu's velocity analysis technique. The input dzdv values are computed using the program dzdv.
2. For given depths, using moff smaller than noff may avoid poor values of dz/dv at far offsets. However, a too small moff used will the sensitivity of velocity error to the imaged depth.
3. Outfile contains three parts:  
dlambda correction of the velocity paramter. dlambda plus the initial parameter (used in migration) will be the updated one.  
deviation to measure how close imaged depths are to each other in CIGs. Old deviation corresponds to the initial parameter; new deviation corresponds to the updated one.  
sensitivity to predict how sensitive the error in the estimated parameter is to an error in the measurement of imaged depths.

error of parameter <= sensitivity \* error of depth.

Author: Zhenyue Liu, 12/29/93, Colorado School of Mines

Reference:

Liu, Z. 1995, "Migration Velocity Analysis", Ph.D. Thesis, Colorado School of Mines, CWP report #168.

VERHULST - solve the VERHULST logistic equation

verhulst > [stdout]

Required Parameters: none

Optional Parameters:

a1=1.0 parameter for verhulst equation

a2=2000 parameter for verhulst equation

y0=10 initial value of y[0]

h=.01 increment in time

tol=1.e-08 error tolerance

stepmax=2000 maximum number of steps to compute

mode=x xy-pairs, =yz yz-pairs, =xz xz-pairs,

=xyz xyz-triplet, =x only, =y only, =z only

Notes:

This program is really just a demo showing how to use the differential equation solver rke\_solve written by Francois Pinard, based on a modified form of the 4th order Runge-Kutta method, which employs the error checking method of R. England 1969.

The output consists of unformatted C-style binary floats, of either pairs or triplets as specified by the "mode" parameter.

Examples:

x is the population

verhulst stepmax=2000 mode=x | suaddhead ns=2000 | suxwigb &

y is dx/dt, the rate of growth of the population

verhulst stepmax=2000 mode=y | suaddhead ns=2000 | suxwigb &

In the Verhulst equation, a1 is the reproduction rate and

a2 is the carrying capacity

$$x'(t) = a1 * x * ( 1 - x/a2 )$$

The verhulst equation describes a simplified model of a population reproducing in an environment with limited resources,

and are given by the autonomous system of ODE's

$$y'(t) = a1 * y ( 1 - y/a2 )$$

Author: CWP: Aug 2009: John Stockwell



VTLVZ -- Velocity as function of Time for Linear V(Z);  
writes out a vector of velocity =  $v_0 \exp(a t/2)$

vtlvz > velfile nt= dt= v0= a=

Required parameters

nt= number of time samples

dt= time sampling interval

v0= velocity at the surface

a= velocity gradient



WKBj - Compute WKBj ray theoretic parameters, via finite differencing

wkbj <vfile >tfile nx= nz= xs= zs= [optional parameters]

Required Parameters:

<vfile file containing velocities v[nx][nz]

nx= number of x samples (2nd dimension)

nz= number of z samples (1st dimension)

xs= x coordinate of source

zs= z coordinate of source

Optional Parameters:

dx=1.0 x sampling interval

fx=0.0 first x sample

dz=1.0 z sampling interval

fz=0.0 first z sample

sfile=sfile file containing sigmas sg[nx][nz]

bfile=bfile file containing incident angles bet[nx][nz]

afile=afile file containing propagation angles a[nx][nz]

Notes:

Traveltimes, propagation angles, sigmas, and incident angles in WKBj by finite differences in polar coordinates. Traveltimes are calculated by upwind scheme; sigmas and incident angles by a Crank-Nicolson scheme.

Credits:

CWP: Zhenyue Liu, Dave Hale, pre 1992.

XY2Z - converts (X,Y)-pairs to spike Z values on a uniform grid

```
xy2z < stdin npairs= [optional parameters] >stdout
```

Required parameter:

npairs= number of pairs input

Optional parameter:

scale=1.0 value to scale spikes by

nx1=100 dimension of first (fast) dimension of output array

nx2=100 dimension of second (slow) dimension of output array

x1pad=2 zero padding in x1 dimension

x2pad=2 zero padding in x2 dimension

yx=0 assume (x,y) pairs

=1 assume (y,x) pairs

Notes:

Converts ordered (x,y) pairs to spike x1values, of height=scale on a uniform grid.

Credits:

CWP: John Stockwell, Nov 1995

Z2XYZ - convert binary floats representing Z-values to ascii  
form in X Y Z ordered triples

```
z2xyz <stdin >stdout
```

Required parameters:

n1= number of floats in 1st (fast) dimension

Optional parameters:

outpar=/dev/tty output parameter file

Notes: This program is useful for converting panels of float  
data (representing evenly spaced z values) to the x y z  
ordered triples required for certain 3D plotting packages.

Example of NXplot3d usage on a NeXT:

```
suplane | sufilter | z2xyz n1=64 > junk.ascii
```

Now open junk.ascii as a mesh data file with NXplot3d.

(NXplot3d is a NeXTStep-only utility for viewing 3d data sets

Credits:

CWP: John Stockwell based on "b2a" by Jack Cohen

SUCENTSAMP - CENTROID SAMPLE seismic traces

```
suentsamp <stdin [optional parameters] >sdout
```

Required parameters:

none

Optional parameters:

dt=from header sampling interval

verbose=1 =0 to stop advisory messages

Notes:

This program takes seismic traces as input, and returns traces consisting of spikes of height equal to the area of each lobe of each oscillation, located at the centroid of the lobe in question. The height of each spike equal to the area of the corresponding lobe.

Caveat: No check is made that the data are real time traces!

Credits:

Providence Technologies: Tom Morgan

Trace header fields accessed: ns, dt

SUDIPDIVCOR - Dip-dependent Divergence (spreading) correction

sudipdivcor <stdin >stdout [optional parms]

Required Parameters:

dxcdp distance between successive cdps in meters

Optional Parameters:

np=50 number of slopes

tmig=0.0 times corresponding to rms velocities in vmig

vmig=1500.0 rms velocities corresponding to times in tmig

vfile=binary (non-ascii) file containing velocities vmig(t)

conv=0 =1 to apply the conventional divergence correction

trans=0 =1 to include transmission factors

verbose=0 =1 for diagnostic print

Notes:

The tmig, vmig arrays specify an rms velocity function of time. Linear interpolation and constant extrapolation is used to determine rms velocities at times not specified. Values specified in tmig must increase monotonically.

Alternatively, rms velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the tmig and vmig arrays are ignored. The time of the first sample is assumed to be constant, and is taken as the value of the first trace header field delrt.

Whereas the conventional divergence correction (sudivcor) is valid only for horizontal reflectors, which have zero reflection slope, the dip-dependent divergence correction is valid for any reflector dip or reflection slope. Only the conventional correction will be applied to the data if conv=1 is specified. Note that the conventional correction over-amplifies reflections from dipping beds

The transmission factor should be applied when the divergence corrected data is to be migrated with a reverse time migration based on the constant density wave equation.

Trace header fields accessed: ns, dt, delrt

SUDIVCOR - Divergence (spreading) correction

sudivcor <stdin >stdout [optional parms]

Required Parameters:

none

Optional Parameters:

trms=0.0 times corresponding to rms velocities in vrms

vrms=1500.0 rms velocities corresponding to times in trms

vfile= binary (non-ascii) file containing velocities vrms(t)

Notes:

The trms, vrms arrays specify an rms velocity function of time. Linear interpolation and constant extrapolation is used to determine rms velocities at times not specified. Values specified in trms must increase monotonically.

Alternatively, rms velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the trms and vrms arrays are ignored.

The time of the first sample is assumed to be constant, and is taken as the value of the first trace header field delrt.

Credits:

CWP: Jack K. Cohen, Francesca Fazarri

Trace header fields accessed: ns, dt, delrt

SUGAIN - apply various types of gain

sugain <stdin >stdout [optional parameters]

Required parameters:

none (no-op)

Optional parameters:

panel=0               =1 gain whole data set (vs. trace by trace)

tpow=0.0 multiply data by  $t^{tpow}$

epow=0.0 multiply data by  $\exp(epow*t)$

etpow=1.0 multiply data by  $\exp(epow*t^{etpow})$

gpow=1.0 take signed gpowth power of scaled data

agc=0     flag; 1 = do automatic gain control

gagc=0    flag; 1 = ... with gaussian taper

wagc=0.5 agc window in seconds (use if agc=1 or gagc=1)

trap=none zero any value whose magnitude exceeds trapval

clip=none clip any value whose magnitude exceeds clipval

pclip=none clip any value greater than clipval

nclip=none clip any value less than clipval

qclip=1.0 clip by quantile on absolute values on trace

qbal=0    flag; 1 = balance traces by qclip and scale

pbal=0    flag; 1 = bal traces by dividing by rms value

mbal=0    flag; 1 = bal traces by subtracting the mean

maxbal=0 flag; 1 = balance traces by subtracting the max

scale=1.0 multiply data by overall scale factor

norm=0.0 divide data by overall scale factor

bias=0.0 bias data by adding an overall bias value

jon=0     flag; 1 means tpow=2, gpow=.5, qclip=.95

verbose=0 verbose = 1 echoes info

mark=0 apply gain only to traces with tr.mark=0

=1 apply gain only to traces with tr.mark!=0

vred=0    reducing velocity of data to use with tpow

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Operation order:

if (norm) scale/norm

$out(t) = scale * BAL\{CLIP[AGC\{[t^{tpow} * \exp(epow * t^{tpow}) * (in(t)-bias)]^{gpow}\}$

Notes:

The jon flag selects the parameter choices discussed in Claerbout's Imaging the Earth, pp 233-236.

Extremely large/small values may be lost during agc. Windowing these off and applying a scale in a preliminary pass through sugain may help.

Sugain only applies gain to traces with tr.mark=0. Use sushw, suchw, suedit, or suxedit to mark traces you do not want gained. See the selfdocs of sushw, suchw, suedit, and suxedit for more information about setting header fields. Use "sukeyword mark for more information about the mark header field.

debias data by using mbal=1

option etpow only becomes active if epow is nonzero

Credits:

SEP: Jon Claerbout

CWP: Jack K. Cohen, Brian Sumner, Dave Hale

Note: Have assumed tr.deltr >= 0 in tpow routine.

Technical Reference:

Jon's second book, pages 233-236.

Trace header fields accessed: ns, dt, delrt, mark, offset



SUNAN - remove NaNs & Infs from the input stream

```
sunan < in.su >out.su
```

Optional parameters:

verbose=1 echo locations of NaNs or Infs to stderr

      =0 silent

...user defined ...

value=0.0 NaNs and Inf replacement value

... and/or....

interp=0 =1 replace NaNs and Infs by interpolating  
          neighboring finite values

Notes:

A simple program to remove NaNs and Infs from an input stream.  
The program sets NaNs and Infs to "value" if interp=0. When  
interp=1 NaNs are replaced with the average of neighboring values  
provided that the neighboring values are finite, otherwise  
NaNs and Infs are replaced by "value".

Author: Reginald H. Beardsley 2003    rhb@acm.org

A simple program to remove NaNs & Infs from an input stream. They  
shouldn't be there, but it can be hard to find the cause and fix  
the problem if you can't look at the data.

Interpolation idea comes from a version of sunan modified by  
Balasz Nemeth while at Potash Corporation in Saskatchewan.

SUNORMALIZE - Trace NORMALIZatIon by rms, max, or median ",  
or median balancing

sunormalize <stdin >stdout t0=0 t1=TMAX norm=rms

Required parameters:

dt=tr.dt if not set in header, dt is mandatory  
ns=tr.ns if not set in header, ns is mandatory

Optional parameters:

norm=rms type of norm rms, max, med , balmed  
t0=0.0 starting time for window  
t1=TMAX ending time for window

Notes:

Traces are divided by either the root mean squared amplitude, trace maximum, or the median value. The option "balmed" is median balancing which is a shift of the amplitudes by the median value of the amplitudes.

Author: Ramone Carbonell,

Inst. Earth Sciences-CSIC Barcelona, Spain, April 1998.

Modifications: Nils Maercklin,

RISSC, University of Naples, Italy, September 2006

(fixed user input of ns, dt, if values are not set in header).

Trace header fields accessed: ns, dt

Trace header fields modified: none

SUPGC - Programmed Gain Control--apply agc like function  
but the same function to all traces preserving  
relative amplitudes spatially.

Required parameter:

file= name of input file

Optional parameters:

ntrscan=200 number of traces to scan for gain function

lwindow=1.0 length of time window in seconds

Author: John Anderson (visitor to CWP from Mobil)

Trace header fields accessed: ns, dt

SUWEIGHT - weight traces by header parameter, such as offset

suweight < stdin > stdout [optional parameters]

Required Parameters:

<none>

Optional parameters:

key=offset keyword of header field to weight traces by

a=1.0 constant weighting parameter (see notes below)

b=.0005 variable weighting parameter (see notes below)

... or use values of a header field for the weighting ...

key2= keyword of header field to draw weights from

scale=.0001 scale factor to apply to header field values

inv=0 weight by header value

=1 weight by inverse of header value

Notes:

This code is initially written with offset weighting in mind, but may be used for other, user-specified schemes.

The rationale for this program is to correct for unwanted linear amplitude trends with offset prior to either CMP stacking or AVO work. The code has to be edited should other functions of a keyword be required.

The default form of the weighting is to multiply the amplitudes of the traces by a factor of: ( a + b\*keyword).

If key2= header field is set then this program uses the weighting values read from that header field, instead. Note, that because most header fields are integers, the scale=.0001 permits 10001 in the header to represent 1.0001.

To see the list of available keywords, type: sukeyword -o <CR>

Credits:

Author: CWP: John Stockwell February 1999.

Written for Chris Walker of UniqueStep Ltd., Bedford, U.K.

inv option added by Garry Perratt (Geocon).

header fields accessed: ns, keyword

SUZERO -- zero-out (or set constant) data within a time window

suzero itmax= < indata > outdata

Required parameters

itmax= last time sample to zero out

Optional parameters

itmin=0 first time sample to zero out

value=0 value to set

See also: sukill, sumute

Credits:

CWP: Chris

Geocon: Garry Perratt (added value= option)

Trace header fields accessed: ns

## SUATTRIBUTES - instantaneous trace ATTRIBUTES

suattributes <stdin >stdout mode=amp

Required parameters:

none

Optional parameter:

mode=amp output flag

=amp envelope traces

=phase phase traces

=freq frequency traces

=bandwidth Instantaneous bandwidth

=normamp Normalized Phase (Cosine Phase)

=fdenv 1st envelope traces derivative

=sdenv 2nd envelope traces derivative

=q Ins. Q Factor

... unwrapping related options ....

unwrap= default unwrap=0 for mode=phase

default unwrap=1 for freq, uphase, freqw, Q

dphase\_min=PI/unwrap

trend=0 =1 remove the linear trend of the inst. phase

zeromean=0 =1 assume instantaneous phase is zero mean

=freqw Frequency Weighted Envelope

=thin Thin-Bed (inst. freq - average freq)

wint= windowing for freqw

windowing for thin

default=1

o-----o-----o

data-1 data data+1

Notes:

This program performs complex trace attribute analysis. The first three attributes, amp, phase, freq are the classical Taner, Kohler, and Sheriff, 1979.

The unwrapping algorithm is the "simple" unwrapping algorithm that searches for jumps in phase.

The quantity dphase\_min is the minimum change in the phase angle taken to be the result of phase wrapping, rather than natural phase variation in the data. Setting unwrap=0 turns off phase-unwrapping

alltogether. Choosing `unwrap > 1` makes the unwrapping function more sensitive to instantaneous phase changes.

Setting `unwrap > 1` may be necessary to resolve higher frequencies in data (or sample data more finely).

Examples:

```
su vibro f1=10 f2=50 t1=0 t2=0 tv=1 | suattributes2 mode=amp | ...
su vibro f1=10 f2=50 t1=0 t2=0 tv=1 | suattributes2 mode=phase | ...
su vibro f1=10 f2=50 t1=0 t2=0 tv=1 | suattributes2 mode=freq | ...
su plane | suattributes mode=... | supswigb |...
```

Credits:

CWP: Jack K. Cohen

CWP: John Stockwell (added `freq` and `unwrap` features)

UGM (Geophysics Students): Agung Wiyono

email:aakanjas@gmail.com (others) added more attributes

Algorithm:

`c(t) = hilbert_tranform_kernel(t) convolved with data(t)`

`amp(t) = sqrt( c.re^2(t) + c.im^2(t) )`

`phase(t) = arctan( c.im(t)/c.re(t) )`

`freq(t) = d(phase)/dt`

Reference: Taner, M. T., Koehler, A. F., and Sheriff R. E.

"Complex seismic trace analysis", Geophysics, vol.44, p. 1041-1063, 1979

Trace header fields accessed: `ns`, `trid`

Trace header fields modified: `d1`, `trid`



SUCMP - CoMPare two seismic data sets, returns 0 to the shell "  
if the same and 1 if different

```
sucmp file_A file_B
```

Required parameters:  
none

Optional parameters:  
limit=1.0e-4 normalized difference threshold value

Notes:

This program is the seismic equivalent of the Unix cmp(1) command. However, unlike cmp(1), it understands seismic data and will consider files which have only small numerical differences to be the same.

Sucmp first checks that the number of traces and number of samples are the same. It then compares the trace headers bit for bit. Finally it checks that the fractional difference of A & B is less than limit.

This program is intended as an aid in regression testing changes to seismic processing programs.

Expected usage is in shell scripts or Makefiles, e.g.

```
#!/bin/sh
#-----
# Run a test data set and verify the result is correct
# If the data doesn't match show the data on the screen.
#-----

./fubar par=tst1.par
sucmp tst1.su ref/tst1.su
if [ $? ]
then
suxwigb <tst1.su &
suxwigb <ref/tst1.su & "
fi
```

Author: Reginald H. Beardsley

rhb@acm.org

sucmp - compare two seismic files in CWP/SU format to see if they are the same within the user specified limit.

Algorithm:

Loop over both input files comparing data values. To be considered the same files must have:

- same number of traces
- same number of samples per trace
- trace values within limits of each other

Note that the program exits as soon as the files fail to match.

For readability, explicit temporary variables are used which the compiler will optimize away. Braces are used on all conditionals so that a breakpoint can be set to stop the debugger only if the condition is true.

Because of the overloading of trace header fields in CWP/SU, the headers are compared bit for bit.

SUHISTOGRAM - create histogram of input amplitudes

```
suhistogram <in.su >out.dat
```

Required parameters:

min= minimum bin

max= maximum bin

bins= number of bins

Optional parameters

trend=0 =0 1-D histogram

=1 2-D histogram picks on cumulate

=2 2-D histogram in trace format

clip= threshold value to drop outliers

dt= sample rate in feet or milliseconds. Defaults to  
tr.dt\*1e-3

datum= header key to get datum shift if desired (e.g. to  
hang from water bottom)

Notes:

trend=0 produces a two column ASCII output for use w/ gnuplot.  
Extreme values are counted in the end bins.

trend=1 produces a 6 column ASCII output for use w/ gnuplot  
The columns are time/depth and picks on the cumulate  
at 2.28%, 15.87%, 50%, 84.13% & 97.72% of the total points  
corresponding to the median and +- 1 or 2 standard deviations  
for a Gaussian distribution.

trend=2 produces an SU trace panel w/ one trace per bin that  
can be displayed w/ suximage, etc.

Example for plotting with xgraph:

```
suhistogram < data.su min=MIN max=MAX bins=BINS |  
a2b n1=2 | xgraph n=BINS nplot=1
```

Author: Reginald H. Beardsley 2006 rhb@acm.org

SUMAX - get trace by trace local/global maxima, minima, or absolute maximum

sumax <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

output=ascii write ascii data to outpar

=binary for binary floats to stdout

=segy for SEGY traces to stdout

mode=maxmin output both minima and maxima

=max maxima only

=min minima only

=abs absolute maxima only

=rms RMS

=thd search first max above threshold

threshamp=0 threshold amplitude value

threshtime=0 tmin to start search for threshold

verbose=0 writes global quantities to outpar

=1 trace number, values, sample location

=2 key1 & key2 instead of trace number

key1=fldr key for verbose=2

key2=ep key for verbose=2

outpar=/dev/tty output parameter file; contains output  
from verbose

Examples:

For global max and min values: sumax < segy\_data

For local and global max and min values: sumax < segy\_data verbose=1

To plot values specified by mode:

sumax < segy\_data output=binary mode=modeval | xgraph n=npairs

To plot seismic data with the only values nonzero being those specified  
by mode=modeval:

sumax < segy\_data output=segy mode=modeval | suxwigb

Note: while traces are counted from 1, sample values are counted from 0.  
Also, if multiple min, max, or abs max values exist on a trace,  
only the first one is captured.

See also: suxmax, supsmax

Credits:

CWP : John Stockwell (total rewrite)

Geocon : Garry Perratt (all ASCII output changed from %e to %e)  
(added mode=rms).

ESCI: Reginald Beardsley (added header key option)

based on an original program by:

SEP: Shuki Ronen

CWP: Jack K. Cohen

IFM-GEOMAR: Gerald Klein (added threshold option)

Trace header fields accessed: ns dt & user specified keys

SUMEAN - get the mean values of data traces ",

sumean < stdin > stdout [optional parameters]

Required parameters:

power = 2.0 mean to the power  
(e.g. = 1.0 mean amplitude, = 2.0 mean energy)

Optional parameters:

verbose = 0 writes mean value of section to outpar  
= 1 writes mean value of each trace / section to  
outpar  
outpar=/dev/tty output parameter file  
abs = 1 average absolute value  
= 0 preserve sign if power=1.0

Notes:

Each sample is raised to the requested power, and the sum of all those values is averaged for each trace (verbose=1) and the section.  
The values power=1.0 and power=2.0 are physical, however other powers represent other mathematical L-p norms and may be of use, as well.

Credits:

Bjoern E. Rommel, IKU, Petroleumsforskning / October 1997  
bjorn.rommel@iku.sintef.no

SUQUANTILE - display some quantiles or ranks of a data set

suquantile <stdin >stdout [optional parameters]

Required parameters:

none (no-op)

Optional parameters:

panel=1 flag; 0 = do trace by trace (vs. whole data set)

quantiles=1 flag; 0 = give ranks instead of quantiles

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Credits:

CWP: Jack K. Cohen

Trace header fields accessed: ns, tracl, mark

SUACORFRAC -- general FRACTIONal Auto-CORrelation/convolution

suacorfrac power= [optional parameters] <indata >outdata

Optional parameters:

a=0 exponent of complex amplitude

b=0 multiplier of complex phase

dt=(from header) time sample interval (in seconds)

verbose=0 =1 for advisory messages

ntout=tr.ns number of time samples output

sym=0 if non-zero, produce a symmetric output from

lag -(ntout-1)/2 to lag +(ntout-1)/2

Notes:

The calculation is performed in the frequency domain.

The fractional autocorrelation/convolution is obtained by raising

Fourier coefficients to separate real powers

(a,b) for amp and phase:

$$A_{out} \exp[-i P_{out}] = A_{in} A_{in}^a \exp[-i (1+b) P_{in}]$$

where A=amplitude P=phase.

Some special cases:

(a,b)=(1,1) -->auto-correlation

(a,b)=(0.5,0.5) -->half-auto-correlation

(a,b)=(0,0) -->no change to data

(a,b)=(0.5,-0.5)-->half-auto-convolution

(a,b)=(1,-1) -->auto-convolution

Credits:

UHouston: Chris Liner, Sept 2009

CWP: Based on Hale's crpow

Trace header fields accessed: ns, dt, trid, d1

/



SUACOR - auto-correlation

suacor <stdin >stdout [optional parms]

Optional Parameters:

ntout=101 odd number of time samples output

norm=1 if non-zero, normalize maximum absolute output to 1

sym=1 if non-zero, produce a symmetric output from

lag  $-(ntout-1)/2$  to lag  $+(ntout-1)/2$

Credits:

CWP: Dave Hale

Trace header fields accessed: ns

Trace header fields modified: ns and delrt

SUCONV - convolution with user-supplied filter

```
suconv <stdin >stdout filter= [optional parameters]
```

Required parameters: ONE of

sufile= file containing SU trace to use as filter

filter= user-supplied convolution filter (ascii)

Optional parameters:

panel=0 use only the first trace of sufile

  =1 convolve corresponding trace in sufile with  
  trace in input data

Trace header fields accessed: ns

Trace header fields modified: ns

Notes: It is quietly assumed that the time sampling interval on the single trace and the output traces is the same as that on the traces in the input file. The sufile may actually have more than one trace, but only the first trace is used in panel=0. In panel=1 the corresponding trace from the sufile are convolved with its counterpart in the data. Caveat, in panel=1 there have to be at least as many traces in sufile as in the input data. If not, a warning is returned, and later traces in the dataset are returned unchanged.

Examples:

```
suplane | suwind min=12 max=12 >TRACE
```

```
suconv<DATA sufile=TRACE | ...
```

Here, the su data file, "DATA", is convolved trace by trace with the the single su trace, "TRACE".

```
suconv<DATA filter=1,2,1 | ...
```

Here, the su data file, "DATA", is convolved trace by trace with the the filter shown.

Credits:

CWP: Jack K. Cohen, Michel Dietrich

CAVEATS: no space-variable or time-variable capacity.

The more than one trace allowed in sufile is the beginning of a hook to handle the spatially variant case.

Trace header fields accessed: ns  
Trace header fields modified: ns

SUREFCON - Convolution of user-supplied Forward and Reverse refraction shots using XY trace offset in reverse shot

```
surefcon <forshot sufile=revshot xy=trace offseted >stdout
```

Required parameters:

sufile= file containing SU trace to use as reverse shot

xy= Number of traces offseted from the 1st trace in sufile

Optional parameters:

none

Trace header fields accessed: ns

Trace header fields modified: ns

Notes:

This code implements the Refraction Convolution Section (RCS) method of generalized reciprocal refraction traveltime analysis developed by Derecke Palmer and Leoni Jones.

The time sampling interval on the output traces is half of that on the traces in the input files.

Example:

```
surefcon <DATA sufile=DATA xy=1 | ...
```

Here, the su data file, "DATA", convolved the nth trace by (n+xy)th trace in the same file

Credits: (based on suconv)

CWP: Jack K. Cohen, Michel Dietrich

UNSW: D. Palmer, K.T. LEE

CAVEATS: no space-variable or time-variable capacity.

The more than one trace allowed in sufile is the beginning of a hook to handle the spatially variant case.

Trace header fields accessed: ns

Trace header fields modified: ns

Notes:

This code implements the refraction convolution

section (RCS) method  
method described in:

Palmer, D, 2001a, Imaging refractors with the convolution section,  
Geophysics 66, 1582-1589.

Palmer, D, 2001b, Resolving refractor ambiguities with amplitudes,  
Geophysics 66, 1590-1593.

Exploration Geophysics (2005) 36, 1825

Butsuri-Tansa (Vol. 58, No.1)

Mulli-Tansa (Vol. 8,

A simple approach to refraction statics with the  
Generalized Main Reciprocal Method and the Refraction  
Convolution Section Heading

by Derecke Palmer Leonie Jones

SUXCOR - correlation with user-supplied filter

```
suxcor <stdin >stdout filter= [optional parameters]
```

Required parameters: ONE of

sufile= file containing SU traces to use as filter

filter= user-supplied correlation filter (ascii)

Optional parameters:

vibroseis=0 =nsout for correlating vibroseis data

first=1 supplied trace is default first element of correlation. =0 for it to be second.

panel=0 use only the first trace of sufile as filter

=1 xcor trace by trace an entire gather

ftwin=0 first sample on the first trace of the window (only with panel=1)

ltwin=0 first sample on the last trace of the window (only with panel=1)

ntwin=nt number of samples in the correlation window (only with panel=1)

ntrc=48 number of traces on a gather (only with panel=1)

Trace header fields accessed: ns

Trace header fields modified: ns

Notes: It is quietly assumed that the time sampling interval on the single trace and the output traces is the same as that on the traces in the input file. The sufile may actually have more than one trace, but only the first trace is used when panel=0. When panel=1 the number of traces in the sufile MUST be the same as the number of traces in the input.

Examples:

```
suplane | suwind min=12 max=12 >TRACE
```

```
suxcor<DATA sufile=TRACE |...
```

Here, the su data file, "DATA", is correlated trace by trace with the the single su trace, "TRACE".

```
suxcor<DATA filter=1,2,1 | ...
```

Here, the su data file, "DATA", is correlated trace by trace with the the filter shown.

Correlating vibroseis data with a vibroseis sweep:

```
suxcor < data sufile=sweep vibroseis=nsout |...
```

is equivalent to, but more efficient than:

```
suxcor < data sufile=sweep |  
suwind itmin=nsweep itmax=nsweep+nsout | sushw key=delrt a=0.0 |...
```

sweep=vibroseis sweep in SU format, nsweep=number of samples on the vibroseis sweep, nsout=desired number of samples on output

or

```
suxcor < data sufile=sweep |  
suwind itmin=nsweep itmax=nsweep+nsout | sushw key=delrt a=0.0 |...
```

tsweep=sweep length in seconds, tout=desired output trace length in seconds

In the spatially variant case (panel=1), a window with linear slope can be defined:

ftwin is the first sample of the first trace in the gather,  
ltwin is the first sample of the last trace in the gather,  
ntwin is the length of the window,  
ntrc is the the number of traces in a gather.

If the data consists of a number gathers which need to be correlated with the same number gathers in the sufile, ntrc assures that the correlating window re-starts for each gather.

The default window is non-sloping and takes the entire trace into account (ftwin=ltwin=0, ntwin=nt).

Credits:

CWP: Jack K. Cohen, Michel Dietrich

CWP: modified by Ttjan to include cross correlation of panels permitting spatially and temporally varying cross correlation.

UTK: modified by Rick Williams for vibroseis correlation option.

CAVEATS:

In the option, panel=1 the number of traces in the sufile must be the same as the number of traces on the input.

Trace header fields accessed: ns

Trace header fields modified: ns



DCTCOMP - Compression by Discrete Cosine Transform

```
dctcomp < stdin n1= n2= [optional parameter] > sdtout
```

Required Parameters:

n1= number of samples in the fast (first) dimension

n2= number of samples in the slow (second) dimension

Optional Parameters:

blocksize1=16 blocksize in direction 1

blocksize2=16 blocksize in direction 2

error=0.01 acceptable error

Author: CWP: Tong Chen Dec 1995

fixed by Graham Ganssle, Sandstone Oil & Gas, Sept 2015

SUPACK1 - pack segy trace data into chars

supack1 <seggy\_file >packed\_file gpow=0.5

Required parameters:

none

Optional parameter:

gpow=0.5 exponent used to compress the dynamic range of the traces

Credits:

CWP: Jack K. Cohen, Shuki Ronen, Brian Sumner

Caveats:

This program is for single site use. Use segywrite to make a portable tape.

We are storing the local header words, ungpow and unscale, required by suunpack1 as floats. Although not essential (compare the handling of such fields as dt), it allows us to demonstrate the convenience of using the natural data type. In any case, the data itself is non-portable floats in general, so we aren't giving up any intrinsic portability.

Notes:

ungpow and unscale are defined in segy.h

trid = CHARPACK is defined in su.h and segy.h

Trace header fields accessed: ns

Trace header fields modified: ungpow, unscale, trid

SUPACK2 - pack segy trace data into 2 byte shorts

supack2 <seggy\_file >packed\_file gpow=0.5

Required parameters:

none

Optional parameter:

gpow=0.5 exponent used to compress the dynamic range of the traces

Credits:

CWP: Jack K. Cohen, Shuki Ronen, Brian Sumner

Revised: 7/4/95 Stewart A. Levin Mobil

Changed encoding to ensure 2 byte length (short is 8 bytes on Cray).

Caveats:

This program is for single site use. Use segywrite to make a portable tape.

We are storing the local header words, ungpow and unscale, required by suunpack2 as floats.

Notes:

ungpow and unscale are defined in segy.h

trid = SHORTPACK is defined in su.h and segy.h

Trace header fields accessed: ns

Trace header fields modified: ungpow, unscale, trid

SUUNPACK1 - unpack segy trace data from chars to floats

```
suunpack1 <packed_file >unpacked_file
```

suunpack1 is the approximate inverse of supack1

Credits:

CWP: Jack K. Cohen, Shuki Ronen, Brian Sumner

Caveats:

This program is for single site use with supack1. See the supack1 header comments.

Notes:

ungpow and unscale are defined in segy.h

trid = CHARPACK is defined in su.h and segy.h

Trace header fields accessed: ns, trid, ungpow, unscale

Trace header fields modified: trid, ungpow, unscale

SUUNPACK2 - unpack segy trace data from shorts to floats

suunpack2 <packed\_file >unpacked\_file

suunpack2 is the approximate inverse of supack2

Credits:

CWP: Jack K. Cohen, Shuki Ronen, Brian Sumner

Revised: 7/4/95 Stewart A. Levin Mobil

Changed decoding to parallel 2 byte encoding of supack2

Caveats:

This program is for single site use with supack2. See the supack2 header comments.

Notes:

ungpow and unscale are defined in segy.h

trid = SHORTPACK is defined in su.h and segy.h

Trace header fields accessed: ns, trid, ungpow, unscale

Trace header fields modified: trid, ungpow, unscale

DT1TOSU - Convert ground-penetrating radar data in the  
Sensors & Software X.DT1 GPR format to SU format.

```
dt1tosu < gpr_data_in_dt1_format > stdout
```

Optional parameters:

ns=from header number of samples per trace  
dt=.8 time sample interval (see below)  
swap=endian endian is auto-determined =1 (big endian) swap  
=0 don't swap bytes (little endian machines)  
verbose=0 silent  
=1 S & S header values from first trace  
sent to outpar  
=2 S & S header values from all traces  
sent to outpar  
outpar=/dev/tty output parameter file  
list=0 silent  
=1 list explaining labels used in verbose  
is printed to stderr

Caution: An incorrect ns field will munge subsequent processing.

Notes:

For compatibility with SEG Y header, apparent dt is set to  
.8 ms (800 microsecs). Actual dt is .8 nanosecs.  
Using TRUE DISTANCES, this scales velocity  
and frequency by a factor of 1 million.  
Example:  $v_{air} = 9.83 \times 10^8$  ft/s (real)  
 $v_{air} = 983$  ft/s (apparent for su)  
Example: fnyquist = 625 MHz (real)  
fnyquist = 625 Hz (apparent for su)

IBM RS6000, NeXT, SUN are examples of big endian machines  
PC's and DEC are examples of little endian machines

Caveat:

This program has not been tested on DEC, some modification of the  
byte swapping routines may be required.

Credits:

CWP: John Stockwell, Jan 1994 Based on a code "sugpr" by  
UTULSA: Chris Liner & Bill Underwood (Dec93)

modifications permit S & S dt1 header information to be transferred directly to SU header

March 2012: CWP John Stockwell updated for the revised S&S DT1, which they still call "DT1" though it is different.

Trace header fields set: ns, tracl, tracr, dt, delrt, trid,  
hour, minute, second

Reference: Sensors & Software pulseEKKO and Noggin<sup>+</sup>plus Data File  
Formats

Publication of:

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SEGYCLEAN - zero out unassigned portion of header

segyclean <stdin >stdout

Since "foreign" SEG-Y tapes may use the unassigned portion of the trace headers and since SU now uses it too, this program zeros out the fields meaningful to SU.

Example:

```
segypread trmax=200 | segyclean | suximage
```

Credits:

CWP: Jack Cohen



SEGYHDRMOD - replace the text header on a SEG Y file

```
seg HDRMOD text=file data=file
```

Required parameters:

```
text=      name of file containing new 3200 byte text header
data=      name of file containing SEG Y data set
```

Notes:

This program simply does a replacement of the content of the first 3200 bytes of the SEG Y file with the contents of the file specified by the text= parameter. If the text header in the SEG Y standard ebcdic format, the user will need to supply an ebcdic format file as the text= as input file. A text file may be converted from ascii to ebcdic via:

```
dd if=ascii_filename of=ebcdic_filename conv=ebcdic ibs=3200 count=1
or from ebcdic to ascii via:
```

```
dd if=ebcdic_filename of=ascii_filename ibs=3200 conv=ascii count=1
```

=====\*\

sgyhdrmod - replace the text header on a SEG Y data file in place

This program only reads and writes 3200 bytes

Reginald H. Beardsley

rhb@acm.org

\\*=====\*/

SEGYHDRS - make SEG-Y ascii and binary headers for segywrite

segyhdrs [ < sudata ] [optional parameters] [ > copy of sudata ]

Required parameters:

ns= if no input trace header

dt= if no input trace header

Optional parameters:

ns=tr.ns from header      number of samples on input traces

dt=tr.dt from header sample rate (microseconds) from traces

bfile=binary name of file containing binary block

hfile=header name of file containing ascii block

Some binary header fields are set:

jobid=1 job id field

lino=1 line number (only one line per reel)

reno=1 reel number

format=1 data format

All other fields are set to 0, by default.

To set any binary header field, use sukeyword to find out the appropriate keyword, then use the getpar form:

keyword=value to set keyword to value

The header file is created as ascii and is translated to ebcdic by segywrite before being written to tape. Its contents are formal but can be edited after creation as long as the forty line format is maintained.

Caveat: This program has not been tested under XDR for machines not having a 2 byte unsigned short integral data type.

Credits:

CWP: Jack K. Cohen, John Stockwell

MOBIL: Stew Levin

SEGYREAD - read an SEG-Y tape

```
segypread > stdout tape=
```

or

```
SEG-Y data stream ... | segypread tape=- > stdout
```

Required parameter:

tape= input tape device or seg-y filename (see notes)

Optional parameters:

buff=1 for buffered device (9-track reel tape drive)

=0 possibly useful for 8mm EXABYTE drives

verbose=0 silent operation

=1 ; echo every 'vblock' traces

vblock=50 echo every 'vblock' traces under verbose option

hfile=header file to store ebcdic block (as ascii)

bfile=binary file to store binary block

xfile=xhdrs file to store extended text block

over=0 quit if bhed format not equal 1, 2, 3, 5, or 8

= 1 ; override and attempt conversion

format=bh.format if over=1 try to convert assuming format value

conv=1 convert data to native format

= 0 ; assume data is in native format

ebcdic=1 perform ebcdic to ascii conversion on 3200 byte textual

header. =0 do not perform conversion

ns=bh.hns number of samples (use if bhed ns wrong)

trcwt=1 apply trace weighting factor (bytes 169-170)

=0, do not apply. (Default is 0 for formats 1 and 5)

trmin=1 first trace to read

trmax=INT\_MAX last trace to read

endian=(autodetected) =1 for big-endian, =0 for little-endian byte order

swapbhed=endian swap binary reel header?

swaphdrs=endian swap trace headers?

swapdata=endian swap data?

errmax=0 allowable number of consecutive tape IO errors

remap=...,... remap key(s)

byte=...,... formats to use for header remapping

Notes:

Traditionally tape=/dev/rmt0. However, in the modern world tape device names are much less uniform. The magic name can often be deduced by

"ls /dev". Likely man pages with the names of the tape devices are: "mt", "sd" "st". Also try "man -k scsi", " man mt", etc. Sometimes "mt status" will tell the device name.

For a SEG-Y diskfile use tape=filename.

The xfile argument will only be used if the file contains extended text headers.

Remark: a SEG-Y file is not the same as an su file. A SEG-Y file consists of three parts: an ebcdic header, a binary reel header, and the traces. The traces are (usually) in 32 bit IBM floating point format. An SU file consists only of the trace portion written in the native binary floats.

Formats supported:

- 1: IBM floating point, 4 byte (32 bits)
- 2: two's complement integer, 4 byte (32 bits)
- 3: two's complement integer, 2 byte (16 bits)
- 5: IEEE floating point, 4 byte (32 bits)
- 8: two's complement integer, 1 byte (8 bits)

tape=- read from standard input. Caveat, under Solaris, you will need to use the buff=1 option, as well.

Header remap:

The value of header word remap is mapped from the values of byte

Map a float at location 221 to sample spacing d1:

```
segypread <data >outdata remap=d1 byte=221f
```

Map a long at location 225 to source location sx:

```
segypread <data >outdata remap=sx byte=225l
```

Map a short at location 229 to gain constant igc:

```
segypread <data >outdata remap=igc byte=229s
```

Or all combined:

```
segypread <data >outdata remap=d1,sx,igc byte=221f,225l,229s
```

Segy header words are accessed as Xt where X denotes the byte number starting at 1 in correspondance with the SEG-Y standard (1975)

Known types include: f float (4 bytes)

l long int (4 bytes)  
s short int (2 bytes)  
b byte (1 bytes)

type:   sudoc segyread   for further information

Note:

    If you have a tape with multiple sequences of ebcdic header, binary header, traces, use the device that invokes the no-rewind option and issue multiple segyread commands (making an appropriate shell script if you want to save all the headers). Consider using >> if you want a single trace file in the end. Similar considerations apply for multiple reels of tapes, but use the standard rewind on end of file.

    Note: For buff=1 (default) tape is accessed with 'read', for buff=0 tape is accessed with fread. We suggest that you try buff=1 even with EXABYTE tapes.

    Caveat: may be slow on an 8mm streaming (EXABYTE) tapedrive

    Warning: segyread or segywrite to 8mm tape is fragile. Allow sufficient time between successive reads and writes.

    Warning: may return the error message "efclose: fclose failed" intermittently when segyreading/segywriting to 8mm (EXABYTE) tape even if actual segyread/segywrite is successful. However, this error message may be returned if your tape drive has a fixed block size set.

    Caution: When reading or writing SEG-Y tapes, the tape drive should be set to be able to read variable block length tape files.

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen, Brian Sumner, Chris Liner

    : John Stockwell (added 8mm tape stuff)

    conv parameter added by:

Tony Kocurko

Department of Earth Sciences

Memorial University of Newfoundland

St. John's, Newfoundland

read from stdin via tape=- added by Tony Kocurko  
bhed format = 2,3 conversion by:  
Remco Romijn (Applied Geophysics, TU Delft)  
J.W. de Bruijn (Applied Geophysics, TU Delft)  
bhed format = 8 conversion by: John Stockwell  
header remap feature added by:  
Matthias Imhof, Virginia Tech

---

Additional Notes:  
Brian's subroutine, `ibm_to_float`, which converts IBM floating point to IEEE floating point is NOT portable and must be altered for non-IEEE machines. See the subroutine notes below.

A direct read by `dd` would suck up the entire tape; hence the dancing around with buffers and files.

SEGYSKAN -- SCANS SEGY file trace headers for min-max in several possible formats.

```
segyscan < segyfile
```

Notes:

The SEGY file trace headers are scanned assuming short, ushort, int, uint, float, and double and the results are printed as tables.

Credits: Stew Levin, June 2013

SEGWRITE - write an SEG-Y tape

segwrite <stdin tape=

Required parameters:

tape= tape device to use (see sudoc segyread)

Optional parameter:

verbose=0 silent operation  
=1 ; echo every 'vblock' traces  
vblock=50 echo every 'vblock' traces under verbose option  
buff=1 for buffered device (9-track reel tape drive)  
=0 possibly useful for 8mm EXABYTE drive  
conv=1 =0 don't convert to IBM format  
ebcdic=1 convert text header to ebcdic, =0 leave as ascii  
hfile=header ebcdic card image header file  
bfile=binary binary header file  
trmin=1 first trace to write  
trmax=INT\_MAX last trace to write  
endian=(autodetected) =1 for big-endian and =0 for little-endian byte order  
errmax=0 allowable number of consecutive tape IO errors  
format= override value of format in binary header file

Note: The header files may be created with 'segyhdrs'.

Note: For buff=1 (default) tape is accessed with 'write', for buff=0 tape is accessed with fwrite. Try the default setting of buff=1 for all tape types.

Caveat: may be slow on an 8mm streaming (EXABYTE) tapedrive

Warning: segyread or segywrite to 8mm tape is fragile. Allow time between successive reads and writes.

Precaution: make sure tapedrive is set to read/write variable blocksize tapefiles.

For more information, type: sudoc <segwrite>

Warning: may return the error message "efclose: fclose failed" intermittently when segyreading/segywriting to 8mm EXABYTE tape, even if actual segyread/segywrite is successful. However, this may indicate that your tape drive has been set to a fixed block



size. Tape drives should be set to variable block size before reading or writing tapes in the SEG-Y format.

Credits:

SEP: Einar Kjartansson

CWP: Jack, Brian, Chris

: John Stockwell (added EXABYTE functionality)

Notes:

Brian's subroutine, `float_to_ibm`, for converting IEEE floating point to IBM floating point is NOT portable and must be altered for non-IEEE machines. See the subroutine notes below.

On machines where shorts are not 2 bytes and/or ints are not 4 bytes, routines to convert SEG-Y 16 bit and 32 bit integers will be required.

The program, `segyhdrs`, can be used to make the ascii and binary files required by this code.

SETBHED - SET the fields in a SEG Y Binary tape HEaDer file, as would be produced by segyread and segyhdrs

setbhed par= [optional parameters]

Required parameter:

none

Optional parameters:

bfile= binary output binary tape header file

par= =parfile

Set field by field, if desired:

jobid= job id field

lino= line number (only one line per reel)

reno= reel number

format= data format

... etc....

To set any binary header field, use sukeyword to find out the appropriate keyword, then use the getpar form:

keyword=value to set keyword to value

Notes:

As with all other programs in the CWP/SU package that use getpars, (GET PARAmeters from the command line) a file filled with such statments may be included via option par=parfile. In particular, a parfile created by "bhedtopar" may be used as input for the program "setbhed".

The binary header file that results from running segyread may have the wrong byte order. You will need to use "swapbhed" to change the byte," order before applying this program.

Example:

seggyread tape=yourdata.segy bfile=yourdata.b > yourdata.su

If

bhedtopar < yourdata.b | more

shows impossible values, then apply

swapbhed < yourdata.b > swapped.b

then apply

bhedtopar < swapped.b | more

bhedtopar < swapped.b outpar=parfile

hand edit parfile, and then apply

setbhed par=parfile bfile=swapped.b > new.b

then apply

seggywrite tape=fixeddata.segy bfile=new.b < yourdata.su

Caveat: This program breaks if a "short" isn't 2 bytes since  
the SEG-Y standard demands a 2 byte integer for ns.

Credits:

CWP: John Stockwell 11 Nov 1994

SUASCII - print non zero header values and data in various formats

suascii <stdin >ascii\_file

Optional parameter:

bare=0      print headers and data  
      =1      print only data  
      =2      print headers only  
      =3      print data in print data in .csv format, e.g. for Excel  
      =4      print data as tab delimited .txt file, e.g. for GnuPlot  
      =5      print data as .xyz file, e.g. for plotting with GMT

ntr=50      maximum number of output traces (bare=3 or bare=4 only)  
index=0     don't include time/depth index in ascii file (bare=4)  
      =1      include time/depth index in ascii file

key=        if set, name of keyword containing x-value  
            in .xyz output (bare=5 only)

sep=        if set, string separating traces in .xyz output  
            (bare=5; default is no separation)

verbose=0   =1 for detailed information

Notes:

The programs suwind and suresamp provide trace selection and subsampling, respectively.

With bare=0 and bare=1 traces are separated by a blank line.

With bare=3 a maximum of ntr traces are output in .csv format ("comma-separated value"), e.g. for import into spreadsheet applications like Excel.

With bare=4 a maximum of ntr traces are output in as tab delimited columns. Use bare=4 for plotting in GnuPlot.

With bare=5 traces are written as "x y z" triples as required by certain plotting programs such as the Generic Mapping Tools (GMT). If sep= is set, traces are separated by a line containing the string provided, e.g. sep=">" for GMT multisegment files.

"option=" is an acceptable alias for "bare=".

Related programs: sugethw, sudumptrace

Credits:

CWP: Jack K. Cohen c. 1989

CENPET: Werner M. Heigl 2006 - bug fixes & extensions

RISSC: Nils Maercklin 2006

Trace header field accessed: ns, dt, delrt, d1, f1, trid

SUINTVEL - convert stacking velocity model to interval velocity model

```
suintvel vs= t0= outpar=/dev/tty
```

Required parameters:

vs= stacking velocities

t0= normal incidence times

Optional parameters:

mode=0 output h= v= ; =1 output v= t=

outpar=/dev/tty output parameter file in the form:

h=layer thicknesses vector

v=interval velocities vector

....or ...

t=vector of times from t0

v=interval velocities vector

Examples:

```
suintvel vs=5000,5523,6339,7264 t0=.4,.8,1.125,1.425 outpar=intpar
```

```
suintvel par=stkpar outpar=intpar
```

If the file, stkpar, contains:

```
vs=5000,5523,6339,7264
```

```
t0=.4,.8,1.125,1.425
```

then the two examples are equivalent.

Note: suintvel does not have standard su syntax since it does not operate on seismic data. Hence stdin and stdout are not used.

Note: may go away in favor of par program, velconv, by Dave

Credits:

CWP: Jack

Technical Reference:

The Common Depth Point Stack

William A. Schneider

Proc. IEEE, v. 72, n. 10, p. 1238-1254

1984

Formulas:

Note: All sums on  $i$  are from 1 to  $k$

From Schneider:

Let  $h[i]$  be the  $i$ th layer thickness measured at the cmp and  $v[i]$  the  $i$ th interval velocity.

Set:

$$t[i] = h[i]/v[i]$$

Define:

$$t0by2[k] = 0.5 * t0[k] = \text{Sum } h[i]/v[i]$$

$$vh[k] = vs[k]*vs[k]*t0by2[k] = \text{Sum } v[i]*h[i]$$

Then:

$$dt[i] = h[i]/v[i] = t0by2[i] - t0by2[i-1]$$

$$dvh[i] = h[i]*v[i] = vh[i] - vh[i-1]$$

$$h[i] = \text{sqrt}(dvh[i] * dt[i])$$

$$v[i] = \text{sqrt}(dvh[i] / dt[i])$$

SUOLDTONEW - convert existing su data to xdr format

suoldtnew <oldsu >newsu

Required parameters:

none

Optional parameters:

none

Notes:

This program is used to convert native machine datasets to xdr-based, system-independent format.

Author: Stewart A. Levin, Mobil, 1966



SUSTKVEL - convert constant dip layer interval velocity model to the stacking velocity model required by sunmo

```
sustkvel v= h= dip=0.0 outpar=/dev/tty
```

Required parameters:

v= interval velocities

h= layer thicknesses at the cmp

Optional parameters:

dip=0.0 (constant) dip of the layers (degrees)

outpar=/dev/tty output parameter file in the form required by sunmo:

tv=zero incidence time pick vector

v=stacking velocities vector

Examples:

```
sustkvel v=5000,6000,8000,10000 h=1000,1200,1300,1500 outpar=stkpar  
sunmo <data.cdp par=stkpar >data.nmo
```

```
sustkvel par=intpar outpar=stkpar  
sunmo <data.cdp par=stkpar >data.nmo
```

If the file, intpar, contains:

```
v=5000,6000,8000,10000
```

```
h=1000,1200,1300,1500
```

then the two examples are equivalent. The created parameter file, stkpar, is in the form of the velocity model required by sunmo.

Note: sustkvel does not have standard su syntax since it does not operate on seismic data. Hence stdin and stdout are not used.

Caveat: Does not accept a series of interval velocity models to produce a variable velocity file for sunmo.

Credits:

CWP: Jack

Technical Reference:

The Common Depth Point Stack

William A. Schneider

Proc. IEEE, v. 72, n. 10, p. 1238-1254

1984

Formulas:

Note: All sums on  $i$  are from 1 to  $k$

From Schneider:

Let  $h[i]$  be the  $i$ th layer thickness measured at the cmp and  $v[i]$  the  $i$ th interval velocity.

Set:

$$t[i] = h[i]/v[i]$$

$$t0[k] = 2 \sum t[i] * \cos(\text{dip})$$

$$vs[k] = (1.0/\cos(\text{dip})) \sqrt{\sum v[i]*v[i]*t[i] / \sum t[i]}$$

Define:

$$t0by2[k] = \sum h[i]/v[i]$$

$$vh[k] = \sum v[i]*h[i]$$

Then:

$$t0[k] = 2 * t0by2[k] * \cos(\text{dip})$$

$$vs[k] = \sqrt{vh[k] / t0by2[k]} / \cos(\text{dip})$$

SUSWAPBYTES - SWAP the BYTES in SU data to convert data from big endian to little endian byte order, and vice versa

suswapbytes < stdin [optional parameter] > sdtout

format=0 foreign to native

=1 native to foreign

swaphdr=1 swap the header byte order

=0 do not change the header byte order

swapdata=1 swap the data byte order

=0 do not change the data byte order

ns=from header if ns not set in header, must be set by hand

Notes:

The 'native' endian is the endian (byte order) of the machine you are running this program on. The 'foreign' endian is the opposite byte order.

Examples of big endian machines are: IBM RS6000, SUN, NeXT

Examples of little endian machines are: PCs, DEC

Caveat: this code has not been tested on DEC

Credits:

CWP: adapted for SU by John Stockwell

based on a code supplied by:

Institute fur Geophysik, Hamburg: Jens Hartmann (June 1993)

Trace header fields accessed: ns

SWAPBHED - SWAP the BYTES in a SEGY Binary tape HEaDer file

swapbhed < binary\_in > binary out

Required parameter:

none

Optional parameters:

none

Credits:

CWP: John Stockwell 13 May 2011

SUDATUMFD - 2D zero-offset Finite Difference acoustic wave-equation  
DATUMing

sudatumfd <stdin > stdout [optional parameters]

Required parameters:

nt= number of time samples on each trace  
nx= number of receivers per shot gather  
nsx= number of shot gathers  
nz= number of downward continuation depth steps  
dz= depth sampling interval (in meters)  
mx= number of horizontal samples in the velocity model  
mz= number of vertical samples in the velocity model  
vfile1= velocity file used for thin-lens term  
vfile2= velocity file used for diffraction term  
dx= horizontal sampling interval (in meters)

Optional parameters:

dt=.004 time sampling interval (in seconds)  
buff=5 number of zero traces added to each side of each  
shot gather as a pad  
tap\_len=5 taper length (in number of traces)  
x\_0=0.0 x coordinate of leftmost position in velocity model

Notes:

The algorithm is a 45-degree implicit-finite-difference scheme based on the one-way wave equation. It works on poststack (zero-offset) data only. The two velocity files, vfile1 and vfile2, are binary files containing floats with the format v[ix][iz]. There are two potentially different velocity files for the thin-lens and diffraction terms to allow for the use of a zero-velocity layer which allows for datuming from an irregular surface.

Source and receiver locations must be set in the header values in order for the datuming to work properly. The leftmost position of the velocity models given in vfile1 and vfile2 must also be given.

Author: Chris Robinson, 10/16/00, CWP, Colorado School of Mines

References:

Beasley, C., and Lynn, W., 1992, The zero-velocity layer: migration from irregular surfaces: *Geophysics*, 57, 1435-1443.

Claerbout, J. F., 1985, *Imaging the earth's interior*: Blackwell Scientific Publications.

SUDATUMK2DR - Kirchhoff datuming of receivers for 2D prestack data  
(shot gathers are the input)

```
sudatumk2dr infile= outfile= [parameters]
```

Required parameters:

infile=stdin file for input seismic traces

outfile=stdout file for common offset migration output

tfile= file for input traveltime tables

The following 9 parameters describe traveltime tables:

fzt= first depth sample in traveltime table

nzt= number of depth samples in traveltime table

dzt= depth interval in traveltime table

fxt= first lateral sample in traveltime table

nxt= number of lateral samples in traveltime table

dxt= lateral interval in traveltime table

fs= x-coordinate of first source

ns= number of sources

ds= x-coordinate increment of sources

fxi= x-coordinate of the first surface location

dxi= horizontal spacing on surface

nxi= number of input surface locations

sgn= Sign of the datuming process (up=-1 or down=1)

Optional Parameters:

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

surf="0,0;99999,0" The first surface defined the recording surface

surf="0,0;99999,0" and the second one, the new datum.

"x1,z1;x2,z2;x3,z3;...

fzo=fzt z-coordinate of first point in output trace

dzo=0.2\*dzt vertical spacing of output trace

nzo=5\*(nzt-1)+1 number of points in output trace ",

fxso=fxt x-coordinate of first shot

dxso=0.5\*dxt shot horizontal spacing

nxso=2\*(nxt-1)+1 number of shots

fxgo=fxt x-coordinate of first receiver

dxgo=0.5\*dxt receiver horizontal spacing

nxgo=nxso number of receivers per shot

fmax=0.25/dt frequency-highcut for input traces

offmax=99999 maximum absolute offset allowed in migration

aperx=nxt\*dxt/2 migration lateral aperature

angmax=60 migration angle aperture from vertical  
v0=1500(m/s) reference velocity value at surface  
dvz=0.0 reference velocity vertical gradient  
antiali=1 Antialias filter (no-filter = 0)  
jpfiler=stderr job print file name  
mtr=100 print verbal information at every mtr traces  
ntr=100000 maximum number of input traces to be migrated

verbose=0 silent, =1 chatty

Notes:

1. Traveltime tables were generated by program rayt2d (or other ones) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the datuming process, traveltimes are interpolated into shot/geophone positions and output grids.
2. Input traces must be SU format and organized in common rec. gathers
3. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
4. Amplitudes are computed using the reference velocity profile,  $v(z)$ , specified by the parameters v0= and dvz=.
5. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx. Offset is computed automatically.

Author: Trino Salinas, 05/01/96, Colorado School of Mines

This code is based on sukzmig2d.c written by Zhenyue Liu, 03/01/95.  
Subroutines from Dave Hale's modeling library were adapted in this code to define topography using cubic splines.

This code implements a Kirchhoff extrapolation operator that allows to transfer data from one reference surface to another. The formula used in this application is a far field approximation of the Berryhill's original formula (Berryhill, 1979). This equation is the result of a stationary phase analysis to get an analog asymptotic expansion for the two-and-one half dimensional extrapolation formula (Bleistein, 1984).

The extrapolation formula permits the downward continuation of upgoing waves and upward continuation of downgoing waves. For upward continuation of upgoing waves and downward continuation of downgoing waves, the conjugate transpose of the equation is used (Bevc, 1993).

References :



Berryhill, J.R., 1979, Wave equation datuming: Geophysics,  
44, 1329--1344.

-----, 1984, Wave equation datuming before stack  
(short note) : Geophysics, 49, 2064--2067.

Bevc, D., 1993, Data parallel wave equation datuming with  
irregular acquisition topography : 63rd Ann. Internat.  
Mtg., SEG, Expanded Abstracts, 197--200.

Bleistein, N., 1984, Mathematical methods for wave phenomena,  
Academic Press Inc. (Harcourt Brace Jovanovich Publishers),  
New York.

SUDATUMK2DS - Kirchhoff datuming of sources for 2D prestack data  
(input data are receiver gathers)

```
sudatumk2ds infile= outfile= [parameters]
```

Required parameters:

infile=stdin file for input seismic traces

outfile=stdout file for common offset migration output

tfile= file for input traveltimes tables

The following 9 parameters describe traveltimes tables:

fzt= first depth sample in traveltimes table

nzt= number of depth samples in traveltimes table

dzt= depth interval in traveltimes table

fxt= first lateral sample in traveltimes table

nxt= number of lateral samples in traveltimes table

dxt= lateral interval in traveltimes table

fs= x-coordinate of first source

ns= number of sources

ds= x-coordinate increment of sources

fxi= x-coordinate of the first surface location

dxi= horizontal spacing on surface

nxi= number of input surface locations

sgn= Sign of the datuming process (up=-1 or down=1)

Optional Parameters:

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

surf="0,0;99999,0" The first surface defined the recording surface

surf="0,0;99999,0" and the second one, the new datum.

"x1,z1;x2,z2;x3,z3;...

fzo=fzt z-coordinate of first point in output trace

dzo=0.2\*dzt vertical spacing of output trace

nzo=5\*(nzt-1)+1 number of points in output trace ",

fxso=fxt x-coordinate of first shot

dxso=0.5\*dxt shot horizontal spacing

nxso=2\*(nxt-1)+1 number of shots

fxgo=fxt x-coordinate of first receiver

exgo=fxgo+(nxgo-1)\*dxgo x-coordinate of the last receiver

dxgo=0.5\*dxt receiver horizontal spacing

nxgo=nxso number of receivers per shot

fmax=0.25/dt frequency-highcut for input traces

offmax=99999 maximum absolute offset allowed in migration

```

aperx=nxt*dxt/2  migration lateral aperature
angmax=60 migration angle aperature from vertical
v0=1500(m/s) reference velocity value at surface
dvz=0.0  reference velocity vertical gradient
antiali=1      Antialias filter (no-filter = 0)
jpfile=stderr job print file name
mtr=100  print verbal information at every mtr traces
ntr=100000 maximum number of input traces to be migrated

```

Notes:

1. Traveltime tables were generated by program rayt2d (or other ones) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the migration process, traveltimes are interpolated into shot/geophone positions and output grids.
2. Input traces must be SU format and organized in common shot gathers
3. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
4. Amplitudes are computed using the reference velocity profile,  $v(z)$ , specified by the parameters  $v0=$  and  $dvz=$ .
5. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx. Offset is computed automatically.

Author: Trino Salinas, 05/01/96, Colorado School of Mines

This code is based on sukzmig2d.c written by Zhenyue Liu, 03/01/95. Subroutines from Dave Hale's modeling library were adapted in this code to define topography using cubic splines.

This code implements a Kirchhoff extrapolation operator that allows to transfer data from one reference surface to another. The formula used in this application is a far field approximation of the Berryhill's original formula (Berryhill, 1979). This equation is the result of a stationary phase analysis to get an analog asymptotic expansion for the two-and-one half dimensional extrapolation formula (Bleistein, 1984).

The extrapolation formula permits the downward continuation of upgoing waves and upward continuation of downgoing waves. For upward continuation of upgoing waves and downward continuation of downgoing waves, the conjugate transpose of the equation is used (Bevc, 1993).

References :

Berryhill, J.R., 1979, Wave equation datuming: Geophysics,  
44, 1329--1344.

-----, 1984, Wave equation datuming before stack  
(short note) : Geophysics, 49, 2064--2067.

Bevc, D., 1993, Data parallel wave equation datuming with  
irregular acquisition topography : 63rd Ann. Internat.  
Mtg., SEG, Expanded Abstracts, 197--200.

Bleistein, N., 1984, Mathematical methods for wave phenomena,  
Academic Press Inc. (Harcourt Brace Jovanovich Publishers),  
New York.

SUKDMDCR - 2.5D datuming of receivers for prestack, common source data using constant-background data mapping formula.  
(See selfdoc for specific survey requirements.)

```
sukdmdcr infile= outfile= [parameters]
```

Required file parameters:

infile=stdin file for input seismic traces

outfile=stdout file for output

tfile file for input traveltime tables

Required parameters describing the traveltime tables:

fzt first depth sample in traveltime table

nzt number of depth samples in traveltime table

dzt depth interval in traveltime table

fxt first lateral sample in traveltime table

nxt number of lateral samples in traveltime table

dxt lateral interval in traveltime table

fs x-coordinate of first source in table

ns number of sources in table

ds x-coordinate increment of sources in table

Parameters describing the input data:

nxso number of shots

dxso shot interval

fxso=0 x-coordinate of first shot

nxgo number of receiver offsets per shot

dxgo receiver offset interval

fxgo=0 first receiver offset

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

Parameters describing the domain of the problem:

dzo=0.2\*dzt vertical spacing in surface determination

offmax=99999 maximum absolute offset allowed

Parameters describing the recording and datuming surfaces:

recsurf=0 recording surface (horizontal=0, topographic=1)

zrec defines recording surface when recsurf=0

recfile= defines recording surface when recsurf=1

datsurf=0 datuming surface (horizontal=0, irregular=1)

zdat defines datuming surface when datsurf=0

datfile= defines datuming surface when datsurf=1

Optional parameters describing the extrapolation:

aperx=nxt\*dxt/2 lateral half-aperture

v0=1500(m/s) reference wavespeed

freq=50 dominant frequency in data, used to determine  
the minimum distance below the datum that  
the stationary phase calculation is valid.

scale=1.0 user defined scale factor for output

jpfile=stderr job print file name

mtr=100 print verbal information at every mtr traces

ntr=100000 maximum number of input traces to be datumed

#### Computational Notes:

1. Input traces must be SU format and organized in common shot gathers.
2. Traveltime tables were generated by program rayt2d (or equivalent) on any grid, with dimension ns\*nxt\*nzt. In the extrapolation process, traveltimes are interpolated into shot/geophone locations and output grids.
3. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
4. Amplitudes are computed using the constant reference wavepeed v0.
5. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx.
6. Recording and datuming surfaces are defined as follows: If recording surface is horizontal, set recsurf=0 (default). Then, zrec will be a required parameter, set to the depth of surface. If the recording surface is topographic, then set recsurf=1. Then, recfile is a required input file. The input file recfile should be a single column ascii file with the depth of the recording surface at every surface location (first source to last offset), with spacing equal to dxgo.

The same holds for the datuming surface, using datsurf, zdat, and datfile.

#### Assumptions and limitations:

1. This code implements a 2.5D extrapolation operator that allows to transfer data from one reference surface to another. The formula used in this application is an adaptation of Bleistein & Jaramillo's 2.5D data mapping formula for receiver extrapolation. This is the result of a stationary phase analysis of the data mapping equation in the case of a constant source location (shot gather).

Credits:

Authors: Steven D. Sheaffer (CWP), 11/97

References: Sheaffer, S., 1999, "2.5D Downward Continuation of the Seismic Wavefield Using Kirchhoff Data Mapping." M.Sc. Thesis, Dept. of Mathematical & Computer Sciences, Colorado School of Mines.

SUKDMDCS - 2.5D datuming of sources for prestack common receiver data, using constant-background data-mapping formula.  
 (See selfdoc for specific survey geometry requirements.)

```
sukdmdcs  infile=  outfile=  [parameters]
```

Required parameters:

infile=stdin file for input seismic traces

outfile=stdout file for output

tfile file for input traveltime tables

Required parameters describing the traveltime tables:

fzt first depth sample in traveltime table

nzt number of depth samples in traveltime table

dzt depth interval in traveltime table

fxt first lateral sample in traveltime table

nxt number of lateral samples in traveltime table

dxt lateral interval in traveltime table

fs x-coordinate of first source in table

ns number of sources in table

ds x-coordinate increment of sources in table

Parameters describing the input data:

nxso number of shots

dxso shot interval

fxso=0 x-coordinate of first shot

nxgo number of receiver offsets per shot

dxgo receiver offset interval

fxgo=0 first receiver offset

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

dc=0 flag for previously datumed receivers:

dc=0 receivers on recording surface

dc=1 receivers on datum

",

Parameters describing the domain of the problem:

dzo=0.2\*dzt vertical spacing in surface determination

offmax=99999 maximum absolute offset allowed

Parameters describing the recording and datuming surfaces:

recsurf=0 recording surface (horizontal=0, topographic=1)

zrec defines recording surface when recsurf=0

recfile= defines recording surface when recsurf=1



<code>dat surf=0</code>	<code>datuming surface (horizontal=0, irregular=1)</code>
<code>zdat</code>	<code>defines datuming surface when dat surf=0</code>
<code>datfile=</code>	<code>defines datuming surface when dat surf=1</code>

Parameters describing the extrapolation:

<code>aperx=nxt*dxt/2</code>	<code>lateral aperture</code>
<code>v0=1500(m/s)</code>	<code>reference wavespeed</code>
<code>freq=50</code>	<code>dominant frequency in data, used to determine the minimum distance below the datum that the stationary phase calculation is valid.</code>
<code>scale=1.0</code>	<code>user defined scale factor for output</code>
<code>jpfile=stderr</code>	<code>job print file name</code>
<code>mtr=100</code>	<code>print verbal information at every mtr traces</code>
<code>ntr=100000</code>	<code>maximum number of input traces to be datumed</code>

#### Computational Notes:

1. Input traces must be SU format and organized in common receiver gathers.
2. Traveltime tables were generated by program rayt2d (or equivalent) on any grid, with dimension `ns*nxt*nzt`. In the extrapolation process, traveltimes are interpolated into shot/geophone locations and output grids.
3. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
4. Amplitudes are computed using the constant reference wavespeed `v0`.
5. Input traces must specify source and receiver positions via the header fields `tr.sx` and `tr.gx`.
6. Recording and datuming surfaces are defined as follows: If recording surface is horizontal, set `recsurf=0` (default). Then, `zrec` will be a required parameter, set to the depth of surface. If the recording surface is topographic, then set `recsurf=1`. Then, `recfile` is a required input file. The input file `recfile` should be a single column ascii file with the depth of the recording surface at every surface location (first source to last offset), with spacing equal to `dxgo`.

The same holds for the datuming surface, using `dat surf`, `zdat`, and `datfile`.

Assumptions and limitations:

1. This code implements a 2.5D extrapolation operator that allows to transfer data from one reference surface to another. The formula used in this application is an adaptation of Bleistein & Jaramillo's 2.5D data mapping formula for receiver extrapolation. This is the result of a stationary phase analysis of the data mapping equation in the case of a constant input receiver location (receiver gather).

Credits:

Authors: Steven D. Sheaffer (CWP), 11/97

References: Sheaffer, S., 1999, "2.5D Downward Continuation of the Seismic Wavefield Using Kirchhoff Data Mapping." M.Sc. Thesis, Dept. of Mathematical & Computer Sciences, Colorado School of Mines.

SUCDDECON - DECONvolution with user-supplied filter by straightforward  
Complex Division in the frequency domain

sucddecon <stdin >stdout [optional parameters]

Required parameters:

filter= ascii filter values separated by commas

...or...

sufile= file containing SU traces to use as filter

(must have same number of traces as input data

for panel=1)

Optional parameters:

panel=0 use only the first trace of sufile as filter

=1 decon trace by trace an entire gather

pnoise=0.001 white noise factor for stabilizing results

(see below)

sym=0 not centered, =1 center the output on each trace

verbose=0 silent, =1 chatty

Notes:

For given time-domain input data  $I(t)$  (stdin) and deconvolution

filter  $F(t)$ , the frequency-domain deconvolved trace can be written as:

$I(f) \quad I(f) * \text{complex\_conjugate}[F(f)]$

$D(f) = \text{-----} \implies D(f) = \text{-----}$

$F(f) \quad |F(f)|^2 + \text{delta}$

The real scalar delta is introduced to prevent the resulting deconvolved trace to be dominated by frequencies at which the filter power is close to zero. As described above, delta is set to some fraction (pnoise) of the mean of the filter power spectra. Time sampling rate must be the same in the input data and filter traces. If panel=1 the two input files must have the same number of traces. Data and filter traces don't need to necessarily have the same number of samples, but the filter trace length be always equal or shorter than the data traces.

Caveat:

You may need to apply frequency filtering to get acceptable output

sucddecon ...| sufilter f=f1,f2,f3,f4

where f1,f2,f3,f4 are an acceptable frequency range, and you may need to mute artifacts that appear at the beginning of the output, as well.

Trace header fields accessed: ns, dt

Trace header fields modified: none

Credits:

CWP: Ivan Vasconcelos

some changes by John Stockwell

CAVEATS:

In the option, panel=1 the number of traces in the sufile must be the same as the number of traces on the input.

Trace header fields accessed: ns,dt

Trace header fields modified: none

SUFXDECON - random noise attenuation by FX-DECONvolution

sufxdecon <stdin >stdout [...]

Required Parameters:

Optional Parameters:

taper=.1 length of taper

fmin=6. minimum frequency to process in Hz (accord to twlen)

fmax=.6/(2\*dt) maximum frequency to process in Hz

twlen=entire trace time window length (minimum .3 for lower freqs)

ntrw=10 number of traces in window

ntrf=4 number of traces for filter (smaller than ntrw)

verbose=0 =1 for diagnostic print

tmpdir= if non-empty, use the value as a directory path prefix  
for storing temporary files; else, if the CWP\_TMPDIR  
environment variable is set, use its value for the path;  
else use tmpfile()

Notes: Each trace is transformed to the frequency domain.

For each frequency, Wiener filtering, with unity prediction in  
space, is used to predict the next sample.

At the end of the process, data is mapped back to t-x domain. ",

Credits:

CWP: Carlos E. Theodoro (10/07/97)

References:

Canales(1984): 'Random noise reduction' 54th. SEG

Gulunay(1986): 'FXDECON and complex Wiener Prediction  
filter' 56th. SEG

Galbraith(1991): 'Random noise attenuation by F-X  
prediction: a tutorial' 61th. SEG

Algorithm:

- read data
- loop over time windows
- select data
- FFT (t -> f)
- loop over space windows

- select data
- loop over frequencies
- autocorelation
- matrix problem
- construct filter
- filter data
- loop along space window
- FFT (f -> t)
- reconstruct data
  - output data

Trace header fields accessed: ns, dt, d1

Trace header fields modified:

SUPEF - Wiener (least squares) predictive error filtering

supef <stdin >stdout [optional parameters]

Required parameters:

dt is mandatory if not set in header

Optional parameters:

cdp= CDPs for which minlag, maxlag, pnoise, mincorr,  
maxcorr are set (see Notes)  
minlag=dt first lag of prediction filter (sec)  
maxlag=last lag default is (tmax-tmin)/20  
pnoise=0.001 relative additive noise level  
mincorr=tmin start of autocorrelation window (sec)  
maxcorr=tmax end of autocorrelation window (sec)  
wienerout=0 =1 to show Wiener filter on each trace  
mix=1,... array of weights (floats) for moving  
average of the autocorrelations  
outpar=/dev/null output parameter file, contains the Wiener filter  
if wienerout=1 is set  
method=linear for linear interpolation of cdp values  
=mono for monotonic cubic interpolation of cdps  
=akima for Akima's cubic interpolation of cdps  
=spline for cubic spline interpolation of cdps

Trace header fields accessed: ns, dt

Trace header fields modified: none

Notes:

1) To apply spiking decon (Wiener filtering with no gap):

Run the following command

```
suacor < data.su | suximage perc=95
```

You will see horizontal stripe running across the center of your plot. This is the autocorrelation wavelet for each trace. The idea of spiking decon is to apply a Wiener filter with no gap to the data to collapse the waveform into a spike. The idea is to pick the width of the autocorrelation waveform \_from beginning to end\_ (not trough to trough) and use this time for MAXLAG\_SPIKING:

```
supef < data.su maxlag=MAXLAG_SPIKING > dataspiked.su
```

## 2) Prediction Error Filter (i.e. gapped Wiener filtering)

The purpose of gapped decon is to suppress repetitions in the data such as those caused by water bottom multiples.

To look for the period of the repetitions

```
suacor ntout=1000 < dataspiked.su | suximage perc=95  
or  
suacor ntout=1000 < dataspiked.su | sustack key=dt |suxwigb
```

The value of ntout must be larger than the default 100. The idea is to look for repetitions in the autocorrelation. These repetitions will appear as a family of parallel stripes above and below the main autocorrelation waveform. Or, if you stack the data, these will be repetitive spikes. This repetition time is the GAP. We set MINLAG\_PEF to the value of this repetition time.

We set the minlag to MINLAG\_PEF = GAP

We set the maxlag to MAXLAG\_PEF = GAP + MAXLAG\_SPIKING

```
supef < dataspiked.su minlag=MINLAG_PEF maxlag=MAXLAG_PEF > datapef.su
```

Some experimentation may be required to get a satisfactory result. In particular you may find that you need to reduce the value of the minlag

3) It may be effective to sort your data into cdp gathers with susort, and perform sunmo correction to the water speed with sunmo, prior to attempts to suppress water bottom multiples. After applying supef, the user should apply inverse nmo to undo the nmo to water speed prior to further processing. Or, do the predictive decon on fully nmo-corrected gathers.

If you flatten your data with sunmo, then make sure that you turn off the stretch mute by using smute=20

```
| sunmo vnmo=v1,v2,... tnmo=t1,t2,... smute=20 | supef ...
```

For a filter expressed as a function of cdp, specify the array  
cdp=cdp1,cdp2,...



and for each cdp specified, specify the minlag and maxlag arrays as  
minlag=min1,min2,... maxlag=max1,max2,...

It is required that the number of minlag and maxlag values be equal to the number of cdp's specified. If the number of values in these arrays does not equal the number of cdp's, only the first value will be used.

Caveat:

The wienerout=1 option writes out the wiener filter to outpar, and the prediction error filter to stdout, which is ",

1,0,0,...,-wiener[0],...,-wiener[imaxlag-1]

where the sample value of -wiener[0], is iminlag in the pe-filter.

The pe-filter is output as a SU format datafile, one pe-filter for each trace input.

...| supef ... wienerout | suxwigb  
shows the prediction error filters

Credits:

CWP: Shuki Ronen, Jack K. Cohen, Ken Lerner

CWP: John Stockwell, added mixing feature (April 1998)

CSM: Tanya Slota (September 2005) added cdp feature

Technical Reference:

A. Ziolkowski, "Deconvolution", for value of maxlag default:  
page 91: imaxlag < nt/10. I took nt/20.

Notes:

The prediction error filter is 1,0,0...,0,-wiener[0], ...,  
so no point in explicitly forming it.

If imaxlag < 2\*iminlag - 1, then we don't need to compute the autocorrelation for lags:

imaxlag-iminlag+1, ..., iminlag-1

It doesn't seem worth the duplicated code to implement this.

Trace header fields accessed: ns

## SUPHIDECON - PHase Inversion Deconvolution

```
suphidecon < stdin > stdout
```

Required parameters:

none

Optional parameters:

... time range used for wavelet extraction:

tm=-0.1 Pre zero time (maximum phase component )

tp=+0.4 Post zero time (minimum phase component + multiples)

pad=.1 percentage padding for nt prior to cepstrum calculation

pnoise=0.001 Pre-withening (assumed noise to prevent division by zero)

Notes:

The wavelet is separated from the reflectivity and noise based on their different 'smoothness' in the pseudo cepstrum domain.

The extracted wavelet also includes multiples.

The wavelet is reconstructed in frequency domain, end removed ", from the trace. (Method by Lichman and Northwood, 1996.)

Credits: Potash Corporation, Saskatchewan Balasz Nemeth  
given to CWP by Potash Corporation 2008 (originally as supid.c)

Reference:

Lichman, and Northwood, 1996; Phase Inversion deconvolution for long and short period multiples attenuation, in SEG Deconvolution 2, Geophysics reprint Series No. 17 p. 701-718, originally presented at the 54th EAGE meeting, Paris, June 1992, revised March 1993, revision accepted September 1994.

SUSHAPE - Wiener shaping filter

```
sushape <stdin >stdout [optional parameters]
```

Required parameters:

w= vector of input wavelet to be shaped or ...

...or ...

wfile= ... file containing input wavelet in SU (SEG Y trace) format

d= vector of desired output wavelet or ...

...or ...

dfile= ... file containing desired output wavelet in SU format

dt=tr.dt if tr.dt is not set in header, then dt is mandatory

Optional parameters:

nshape=trace length of shaping filter

pnoise=0.001 relative additive noise level

showshaper=0 =1 to show shaping filter

verbose=0 silent; =1 chatty

Notes:

Example of commandline input wavelets:

```
sushape < indata w=0,-.1,.1,... d=0,-.1,1,.1,... > shaped_data
```

```
sushape < indata wfile=inputwavelet.su dfile=desire.su > shaped_data
```

To get the shaping filters into an ascii file:

```
... | sushape ... showshaper=1 2>file | ... (sh or ksh)
```

```
(... | sushape ... showshaper=1 | ...) >&file (csh)
```

Credits:

CWP: Jack Cohen

CWP: John Stockwell, added wfile and dfile options

Trace header fields accessed: ns, dt

Trace header fields modified: none

SUDMOFKCW - converted-wave DMO via F-K domain (log-stretch) method for common-offset gathers

sudmofkcw <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]

Required Parameters:

cdpmin    minimum cdp (integer number) for which to apply DMO  
cdpmax    maximum cdp (integer number) for which to apply DMO  
dxcdp    distance between adjacent cdp bins (m)  
noffmix   number of offsets to mix (see notes)

Optional Parameters:

tdmo=0.0 times corresponding to rms velocities in vdm (s)  
vdm=1500.0 rms velocities corresponding to times in tdm (m/s)  
gamma=0.5 velocity ratio, upgoing/downgoing  
ntable=1000 number of tabulated z/h and b/h (see notes)  
sdmo=1.0 DMO stretch factor; try 0.6 for typical v(z)  
flip=0    =1 for negative shifts and exchanging s1 and s2  
          (see notes below)  
fmax=0.5/dt maximum frequency in input traces (Hz)  
verbose=0 =1 for diagnostic print

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

The tdm and vdm arrays specify a velocity function of time that is used to implement a first-order correction for depth-variable velocity. The times in tdm must be monotonically increasing. The velocity function is assumed to have been gotten by traditional NMO.

For each offset, the minimum time at which a non-zero sample exists is used to determine a mute time. Output samples for times earlier than this mute time will be zeroed. Computation time may be significantly reduced

if the input traces are zeroed (muted) for early times at large offsets.

$z/h$  is horizontal-reflector depth normalized to half source-reciver offset  $h$ . Normalized shift of conversion point is  $b/h$ . The code now does not support signed offsets, therefore it is recommended that only end-on data, not split-spread, be used as input (of course after being sorted into common-offset gathers).  $z/h$  vs  $b/h$  depends on  $\gamma$  (see Alfaraj's Ph.D. thesis, 1993).

Flip factor = 1 implies positive shift of traces (in the increasing CDP bin number direction). When processing split-spread data, for example, if one side of the spread is processed with  $\text{flip}=0$ , then the other side of the spread should be processed with  $\text{flip}=1$ . The flip factor also determines the actions of the factors  $s1$  and  $s2$ , i.e., stretching or squeezing.

Trace header fields accessed:  $nt$ ,  $dt$ ,  $\text{delrt}$ ,  $\text{offset}$ ,  $\text{cdp}$ .

#### Credits:

CWP: Mohamed Alfaraj

Dave Hale

#### Technical Reference:

Transformation to zero offset for mode-converted waves

Mohammed Alfaraj, Ph.D. thesis, 1993, Colorado School of Mines

Dip-Moveout Processing - SEG Course Notes

Dave Hale, 1988

SUDMOFK - DMO via F-K domain (log-stretch) method for common-offset gathers

```
sudmofk <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]
```

Required Parameters:

cdpmin minimum cdp (integer number) for which to apply DMO

cdpmax maximum cdp (integer number) for which to apply DMO

dxcdp distance between adjacent cdp bins (m)

noffmix number of offsets to mix (see notes)

Optional Parameters:

tdmo=0.0 times corresponding to rms velocities in vdm (s)

vdm=1500.0 rms velocities corresponding to times in tdmo (m/s)

sdmo=1.0 DMO stretch factor; try 0.6 for typical  $v(z)$

fmax=0.5/dt maximum frequency in input traces (Hz)

verbose=0 =1 for diagnostic print

tmpdir= if non-empty, use the value as a directory path prefix  
for storing temporary files; else if the CWP\_TMPDIR  
environment variable is set use its value for the path;  
else use tmpfile()

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically no smaller than the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdp's within that mix. (Values of noffmix 2 or 3 times the ratio of shotpoint spacing to the cdp spacing often yield better results.)

The tdmo and vdm arrays specify a velocity function of time that is used to implement a first-order correction for depth-variable velocity. The times in tdmo must be monotonically increasing.

For each offset, the minimum time at which a non-zero sample exists is used to determine a mute time. Output samples for times earlier than this", mute time will be zeroed. Computation time may be significantly reduced

if the input traces are zeroed (muted) for early times at large offsets.

Credits:

CWP: Dave

Technical Reference:

Dip-Moveout Processing - SEG Course Notes

Dave Hale, 1988

Trace header fields accessed: ns, dt, delrt, offset, cdp.

SUDMOTIVZ - DMO for Transeversely Isotropic V(Z) media for common-offset gathers

sudmotivz <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]

Required Parameters:

cdpmin	minimum cdp (integer number) for which to apply DMO
cdpmax	maximum cdp (integer number) for which to apply DMO
dxcdp	distance between adjacent cdp bins (m)
noffmix	number of offsets to mix (see notes)

Optional Parameters:

vnfile=	binary (non-ascii) file containing NMO interval velocities (m/s)
vfile=	binary (non-ascii) file containing interval velocities (m/s)
etafile=	binary (non-ascii) file containing eta interval values (m/s)
tdmo=0.0	times corresponding to interval velocities in vdm (s)
vndmo=1500.0	NMO interval velocities corresponding to times in tdm (m/s)
vdm=vndmo	interval velocities corresponding to times in tdm (m/s)
etadm=1500.0	eta interval values corresponding to times in tdm (m/s)
fmax=0.5/dt	maximum frequency in input traces (Hz)
smute=1.5	stretch mute used for NMO correction
speed=1.0	twist this knob for speed (and aliasing)
verbose=0	=1 for diagnostic print

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

vnfile, vfile and etafile should contain the regularly sampled interval values of NMO velocity, velocity and eta respectively as a function of time. If, for example, vfile is not supplied, the interval velocity function is defined by linear interpolation of the values in the tdm and vdm arrays. The times in tdm must be monotonically increasing.



If vfile or vdm0 are not given it will be equated to vnfile or vndm0.

For each offset, the minimum time to process is determined using the smute parameter. The DMO correction is not computed for samples that have experienced greater stretch during NMO.

Trace header fields accessed: nt, dt, delrt, offset, cdp.

SUDMOTX - DMO via T-X domain (Kirchhoff) method for common-offset gathers

sudmotx <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [optional parms]

Required Parameters:

cdpmin	minimum cdp (integer number) for which to apply DMO
cdpmax	maximum cdp (integer number) for which to apply DMO
dxcdp	distance between successive cdps
noffmix	number of offsets to mix (see notes)

Optional Parameters:

offmax=3000.0	maximum offset
tmute=2.0	mute time at maximum offset offmax
vrms=1500.0	RMS velocity at mute time tmute
verbose=0	=1 for diagnostic print
tmpdir=	if non-empty, use the value as a directory path prefix for storing temporary files; else if the CWP_TMPDIR environment variable is set use its value for the path; else use tmpfile()

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

The defaults for offmax and vrms are appropriate only for metric units. If distances are measured in feet, then these parameters should be specified explicitly.

offmax, tmute, and vrms need not be specified precisely. If these values are unknown, then one should overestimate offmax and underestimate tmute and vrms.

No muting is actually performed. The tmute parameter is used only to

determine parameters required to perform DMO.

Credits:

CWP: Dave Hale

Technical Reference:

A non-aliased integral method for dip-moveout

Dave Hale

submitted to Geophysics, June, 1990

Trace header fields accessed: ns, dt, delrt, offset, cdp.

SUDMOVZ - DMO for V(Z) media for common-offset gathers

sudmovz <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]

Required Parameters:

cdpmin	minimum cdp (integer number) for which to apply DMO
cdpmax	maximum cdp (integer number) for which to apply DMO
dxcdp	distance between adjacent cdp bins (m)
noffmix	number of offsets to mix (see notes)

Optional Parameters:

vfile=	binary (non-ascii) file containing interval velocities (m/s)
tdmo=0.0	times corresponding to interval velocities in vdm (s)
vdm=1500.0	interval velocities corresponding to times in tdm (m/s)
fmax=0.5/dt	maximum frequency in input traces (Hz)
smute=1.5	stretch mute used for NMO correction
speed=1.0	twist this knob for speed (and aliasing)
verbose=0	=1 for diagnostic print

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

vfile should contain the regularly sampled interval velocities as a function of time. If vfile is not supplied, the interval velocity function is defined by linear interpolation of the values in the tdm and vdm arrays. The times in tdm must be monotonically increasing.

For each offset, the minimum time to process is determined using the smute parameter. The DMO correction is not computed for samples that have experienced greater stretch during NMO.

Trace header fields accessed: nt, dt, delrt, offset, cdp.

SUTIHAELEDMO - TI Hale Dip MoveOut (based on Hale's PhD thesis)

sutihaleldmo <infile >outfile [optional parameters]

Required Parameters:

nxmax    maximum number of midpoints in common offset gather

Optional Parameters:

option=1 1 = traditional Hale DMO (from PhD thesis)  
2 = Bleistein's true amplitude DMO  
3 = Bleistein's cos\*cos weighted DMO  
4 = Zhang's DMO  
5 = Tsvankin's anisotropic DMO  
6 = Tsvankin's VTI DMO weak anisotropy approximation  
dx=50. midpoint sampling interval between traces  
in a common offset gather. (usually shot  
interval in meters)  
v=1500.0 velocity (in meters/sec)  
(must enter a positive value for option=3)  
(for excluding evanescent energy)  
h=200.0 source-receiver half-offset (in meters)  
ntpad=0 number of time samples to pad  
nxpad=h/dx number of midpoints to pad  
file=vnmo name of file with vnmo as a function of p  
used for option=5--otherwise not used  
(Generate this file by running program  
sutivel with appropriate list of Thomsen's  
parameters.)  
e=0. Thomsen's epsilon  
d=0. Thomsen's delta

Note:

This module assumes a single common offset gather after NMO is to be input, DMO corrected, and output. It is useful for computing theoretical DMO impulse responses. The Hale algorithm is computationally intensive and not commonly used for bulk processing of all of the offsets on a 2-D line as there are cheaper alternative algorithms. The Hale algorithm is commonly used in theoretical studies. Bulk processing for multiple common offset gathers is typically done using other modules.

Test run:    suspike | sutihaledmo nxmax=32 option=1 v=1500 | suxwigb &

Author:    (Visitor to CSM from Mobil) John E. Anderson Spring 1994

References: Anderson, J.E., and Tsvankin, I., 1994, Dip-moveout by  
Fourier transform in anisotropic media, CWP-146

SUBFILT - apply Butterworth bandpass filter

subfilt <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters: (nyquist calculated internally)

zerophase=1 =0 for minimum phase filter

locut=1 =0 for no low cut filter

hicut=1 =0 for no high cut filter

fstoplo=0.10\*(nyq) freq(Hz) in low cut stop band

astoplo=0.05 upper bound on amp at fstoplo

fpasslo=0.15\*(nyq) freq(Hz) in low cut pass band

apasslo=0.95 lower bound on amp at fpasslo

fpasshi=0.40\*(nyq) freq(Hz) in high cut pass band

apasshi=0.95 lower bound on amp at fpasshi

fstophi=0.55\*(nyq) freq(Hz) in high cut stop band

astophi=0.05 upper bound on amp at fstophi

verbose=0 =1 for filter design info

dt = (from header) time sampling interval (sec)

... or set filter by defining poles and 3db cutoff frequencies

npoleselo=calculated number of poles of the lo pass band

npolesehi=calculated number of poles of the hi pass band

f3dblo=calculated frequency of 3db cutoff frequency

f3dbhi=calculated frequency of 3db cutoff frequency

Notes:

Butterworth filters were originally of interest because they can be implemented in hardware form through the combination of inductors, capacitors, and an amplifier. Such a filter can be constructed in such a way as to have very small oscillations in the flat portion of the bandpass---a desirable attribute. Because the filters are composed of LC circuits, the impulse response is an ordinary differential equation, which translates into a polynomial in the transform domain. The filter is expressed as the division by this polynomial. Hence the poles of the filter are of interest.

The user may define low pass, high pass, and band pass filters that are either minimum phase or are zero phase. The default is to let the program calculate the optimal number of poles in

low and high cut bands.

Alternately the user may manually define the filter by the 3db frequency and by the number of poles in the low and or high cut region.

The advantage of using the alternate method is that the user can control the smoothness of the filter. Greater smoothness through a larger pole number results in a more bell shaped amplitude spectrum.

For simple zero phase filtering with sin squared tapering use "sufilter".

Credits:

CWP: Dave Hale c. 1993 for bf.c subs and test drivers

CWP: Jack K. Cohen for su wrapper c. 1993

SEAM Project: Bruce Verwest 2009 added explicit pole option  
in a program called "subfiltpole"

CWP: John Stockwell (2012) combined Bruce Verwests changes  
into the original subfilt.

Caveat: zerophase will not do good if trace has a spike near the end. One could make a try at getting the "effective" length of the causal filter, but padding the traces seems painful in an already expensive algorithm.

Theory:

The

Trace header fields accessed: ns, dt, trid



SUCCFILT - FX domain Correlation Coefficient FILTER

```
sucff < stdin > stdout [optional parameters]
```

Optional parameters:

cch=1.0 Correlation coefficient high pass value

ccl=0.3 Correlation coefficient low pass value

key=ep ensemble identifier

padd=25 FFT padding in percentage

Notes:

This program uses "get\_gather" and "put\_gather" so requires that the data be sorted into ensembles designated by "key", with the ntr field set to the number of traces in each respective ensemble.

Example:

```
susort ep offset < data.su > datasorted.su
```

```
suputgthr dir=Data verbose=1 < datasorted.su
```

```
sugetgthr dir=Data verbose=1 > dataupdated.su
```

```
succfilt < dataupdated.su > ccfiltdata.su
```

(Work in progress, editing required)

Credits:

Potash Corporation: Balazs Nemeth, Saskatoon Canada. c. 2008

SUDIPFILT - DIP--or better--SLOPE Filter in f-k domain

sudipfilt <infile >outfile [optional parameters]

Required Parameters:

dt=(from header) if not set in header then mandatory

dx=(from header, d1) if not set in header then mandatory

Optional parameters:

slopes=0.0 monotonically increasing slopes

amps=1.0 amplitudes corresponding to slopes

bias=0.0 slope made horizontal before filtering

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

d2 is an acceptable alias for dx in the getpar

Slopes are defined by  $\Delta t / \Delta x$ , where  $\Delta$  means change. Units of  $\Delta t$  and  $\Delta x$  are the same as dt and dx. It is sometimes useful to fool the program with dx=1 dt=1, thus avoiding units and small slope values.

Linear interpolation and constant extrapolation are used to determine amplitudes for slopes that are not specified. Linear moveout is removed before slope filtering to make slopes equal to bias appear horizontal. This linear moveout is restored after filtering. The bias parameter may be useful for spatially aliased data. The slopes parameter is compensated for bias, so you need not change slopes when you change bias.

Credits:

CWP: Dave (algorithm--originally called slopef)  
Jack (reformatting for SU)

Trace header fields accessed: ns, dt, d2

SUFILTER - applies a zero-phase, sine-squared tapered filter

sufilter <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters:

f=f1,f2,... array of filter frequencies(HZ)

amps=a1,a2,... array of filter amplitudes

dt = (from header) time sampling interval (sec)

verbose=0 =1 for advisory messages

Defaults:f=.10\*(nyquist),.15\*(nyquist),.45\*(nyquist),.50\*(nyquist)  
(nyquist calculated internally)

amps=0.,1.,...,1.,0. trapezoid-like bandpass filter

Examples of filters:

Bandpass: sufilter <data f=10,20,40,50 | ...

Bandreject: sufilter <data f=10,20,30,40 amps=1.,0.,0.,1. | ..

Lowpass: sufilter <data f=10,20,40,50 amps=1.,1.,0.,0. | ...

Highpass: sufilter <data f=10,20,40,50 amps=0.,0.,1.,1. | ...

Notch: sufilter <data f=10,12.5,35,50,60 amps=1.,.5,0.,.5,1. |..

Credits:

CWP: John Stockwell, Jack Cohen

CENPET: Werner M. Heigl - added well log support

Possible optimization: Do assignments instead of crmuls where  
filter is 0.0.

Trace header fields accessed: ns, dt, d1

SUFRAC -- take general (fractional) time derivative or integral of data, plus a phase shift. Input is CAUSAL time-indexed or depth-indexed data.

sufrac power= [optional parameters] <indata >outdata

Optional parameters:

power=0 exponent of  $(-i*\omega)$

=0 ==> phase shift only

>0 ==> differentiation

<0 ==> integration

sign=-1 sign in front of  $i * \omega$

dt=(from header) time sample interval (in seconds)

phasefac=0 phase shift by phase=phasefac\*PI

verbose=0 =1 for advisory messages

Examples:

preprocess to correct 3D data for 2.5D migration

sufrac < sudata power=.5 sign=1 | ...

preprocess to correct susynlv, susynvxz, etc. (2D data) for 2D migration

sufrac < sudata phasefac=.25 | ...

The filter is applied in frequency domain.

if dt is not set in header, then dt is mandatory

Algorithm:

$g(t) = \text{Re}[\text{INVFTT}\{ ( (\text{sign}) i\omega )^{\text{power}} \text{FFT}(f) \}]$

Caveat:

Large amplitude errors will result if the data set has too few points.

Good numerical integration routine needed!

For example, see Gnu Scientific Library.

Credits:

CWP: Chris Liner, Jack K. Cohen, Dave Hale (pfas)

CWP: Zhenyue Liu and John Stockwell added phase shift option

CENPET: Werner M. Heigl - added well log support

Trace header fields accessed: ns, dt, trid, d1

/

SUFWATRIM - FX domain Alpha TRIM

sufwatrim <stdin > stdout [optional parameters]

Required parameters:

key=key1,key2,.. Header words defining mixing dimesnion

dx=d1,d2,.. Distance units for each header word

Optional parameters:

keyg=ep Header word indicating the start of gather

vf=0 =1 Do a frequency dependent mix

vmin=5000 Velocity of the reflection slope

than should not be attenuated

Notes:

Trace with the header word mark set to one will be  
the output trace

Credits: Potash Corporation of Saskatchewan, Balasz Nemeth

Code given to CWP in 2008

SUK1K2FILTER - symmetric box-like K-domain filter defined by the cartesian product of two  $\sin^2$ -tapered polygonal filters defined in k1 and k2

suk1k2filter <infile >outfile [optional parameters]

Optional parameters:

k1=val1,val2,... array of K1 filter wavenumbers

k2=val1,val2,... array of K2 filter wavenumbers

amps1=a1,a2,... array of K1 filter amplitudes

amps2=a1,a2,... array of K2 filter amplitudes

d1=tr.d1 or 1.0 sampling interval in first (fast) dimension

d2=tr.d1 or 1.0 sampling interval in second (slow) dimension

quad=0 =0 all four quadrants

=1 (quadrants 1 and 4)

=2 (quadrants 2 and 3)

Defaults:

k1=.10\*(nyq1),.15\*(nyq1),.45\*(nyq1),.50\*(nyq1)

k2=.10\*(nyq2),.15\*(nyq2),.45\*(nyq2),.50\*(nyq2)

amps1=0.,1.,...,1.,0. trapezoid-like bandpass filter

amps2=0.,1.,...,1.,0. trapezoid-like bandpass filter

The nyquist wavenumbers, nyq1 and nyq2, are computed internally.

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

The filter is assumed to be symmetric, to yield real output

Because the data are assumed to be purely spatial (i.e. non-seismic), the data are assumed to have trace id (30), corresponding to (z,x) data

The relation:  $w = 2 \pi F$  is well known for frequency, but there doesn't seem to be a commonly used letter corresponding to F for the spatial conjugate transform variables. We use K1 and K2 for this.

More specifically we assume a phase:

$-i(k_1 x_1 + k_2 x_2) = -2 \pi i(K_1 x_1 + K_2 x_2).$

and  $K_1$ ,  $K_2$  define our respective wavenumbers.

Credits:

CWP: John Stockwell, November 1995.

Trace header fields accessed: ns, d1, d2



SUKFILTER - radially symmetric K-domain,  $\sin^2$ -tapered, polygonal filter

sukfilter <infile >outfile [optional parameters]

Optional parameters:

k=val1,val2,... array of K filter wavenumbers

amps=a1,a2,... array of K filter amplitudes

d1=tr.d1 or 1.0 sampling interval in first (fast) dimension

d2=tr.d1 or 1.0 sampling interval in second (slow) dimension

Defaults:

k=.10\*(nyq),.15\*(nyq),.45\*(nyq),.50\*(nyq)

amps=0.,1.,...,1.,0. trapezoid-like bandpass filter

The nyquist wavenumbers,  $nyq = \sqrt{nyq1^2 + nyq2^2}$  is computed internally.

Notes:

The filter is assumed to be symmetric, to yield real output.

Because the data are assumed to be purely spatial (i.e. non-seismic), the data are assumed to have trace id (30), corresponding to (z,x) data

The relation:  $w = 2 \pi F$  is well known for frequency, but there doesn't seem to be a commonly used letter corresponding to F for the spatial conjugate transform variables. We use K1 and K2 for this.

More specifically we assume a phase:

$-i(k_1 x_1 + k_2 x_2) = -2 \pi i(K_1 x_1 + K_2 x_2).$

and K1, K2 define our respective wavenumbers.

Credits:

CWP: John Stockwell, June 1997.

Trace header fields accessed: ns, d1, d2

SUKFRAC - apply FRActional powers of  $i|k|$  to data, with phase shift

sukfrac <infile >outfile [optional parameters]

Optional parameters:

power=0 exponent of  $(i*\sqrt{k_1^2 + k_2^2})^{\text{power}}$

=0 ==> phase shift only

>0 ==> differentiation

<0 ==> integration

sign=1 sign on transform exponent

d1=1.0 x1 sampling interval

d2=1.0 x2 sampling interval

phasefac=0 phase shift by  $\text{phase}=\text{phasefac}*\text{PI}$

...directional derivative, active only if angle= is set ....

angle= if set applies operator directionally in the  
direction specified by the value of angle,  
-360.0 <= angle < 359.99999 degrees

Notes:

The relation:  $w = 2 \pi F$  is well known for frequency, but there  
doesn't seem to be a commonly used letter corresponding to F for the  
spatial conjugate transform variables. We use K1 and K2 for this.

More specifically we assume a phase:

$-i(k_1 x_1 + k_2 x_2) = -2 \pi i(K_1 x_1 + K_2 x_2).$

and K1, K2 define our respective wavenumbers.

Algorithms

$g(x_1, x_2) = \text{Re}[2\text{DINVFFT}\{ ( (\text{sign}) i |k| )^{\text{power}} 2\text{DFFT}(f) \} e^{i(\text{phase})}]$

where:

$|k| = \sqrt{(k_1)^2 + (k_2)^2}$

or when angle= is set

$|k| = \sqrt{(k_1 \cos(\text{angle}))^2 + (k_2 \sin(\text{angle}))^2}$

In the default mode a factor of  $(i|k|)^{(\text{power})}$  is applied in the  
transform domain. For time data the time axis direction is taken to  
be the k1-direction. The effect of this filter is to differentiate  
the input in the normal direction to any curvilinear features in  
in the data, and thus be a non-directional-specific edge enhancer.

If angle= is set, then the intended effect is a derivative in the  
direction specified by the angle, with the k1-direction being angle=0,  
corresponding to curves whose normals lie in the x1-direction.

Caveat:

Large amplitude errors will result if the data set has too few points.

Examples:

Edge sharpening:

Laplacian :

```
sukfrac < image_data power=2 phasefac=-1 | ...
```

Image enhancement:

Derivative filter:

```
sukfrac < image_data power=1 phasefac=-.5 | ...
```

Image enhancement:

Half derivative (this one is the best for photographs):

```
sukfrac < image_data power=.5 phasefac=-.25 | ...
```

Credits:

CWP: John Stockwell, June 1997, based on sufrac.

Trace header fields accessed: ns, d1, d2

SULFAF - Low frequency array forming ",

sulfaf < stdin > stdout [optional parameters]

Optional Parameters:

key=ep header keyword describing the gathers

f1=3 lower frequency cutoff

f2=20 high frequency cutoff

fr=5 frequency ramp

vel=1000 surface wave velocity

dx=10 trace spacing

maxmix=tr.ntr default is the entire gather

adb=1.0 add back ratio 1.0=pure filtered 0.0=original

tri=0 1 Triangular weight in mixing window

Notes:

The traces transformed into the frequency domain

where a trace mix is performed in the specified frequency range

as  $Mix = vel / (freq * dx)$

This program uses "get\_gather" and "put\_gather" so requires that the data be sorted into ensembles designated by "key", with the ntr field set to the number of traces in each respective ensemble.

Example:

susort ep offset < data.su > datasorted.su

suputgthr dir=Data verbose=1 < datasorted.su

sugetgthr dir=Data verbose=1 > dataupdated.su

sulfaf < dataupdated.su > ccfiltdata.su

(Work in progress, editing required)

```
define LOOKFAC 1 /* Look ahead factor for npfaro
define PFA_MAX 720720 /* Largest allowed nfft */
define PIP2 PI/2.0 /* IP/2 */
```

```
int
main( int argc, char *argv[] )
{
  cwp_String key; /* header key word from segy.h */
  cwp_String type; /* ... its type */
```

```

Value val; /* ... its value */
segy **rec_o; /* trace header+data matrix */
int first=0; /* true when we passed the first gather
int ng=0;
float dt; /* time sampling interval */
int nt; /* num time samples per trace */
int ntr; /* num of traces per ensemble */

int nfft=0; /* length of padded array */
float snfft; /* scale factor for inverse fft
int nf=0; /* number of frequencies */
float d1; /* frequency sampling interval. */
float *rt=NULL; /* real trace */
complex *ct=NULL; /* complex trace */
float **ffdr=NULL; /* frequency domain data */
float **ffdi=NULL; /* frequency domain data */
float **ffdrm=NULL; /* frequency domain mixed data */
float **ffdim=NULL; /* frequency domain mixed data */

int verbose; /* flag: =0 silent; =1 chatty */

float f1; /* minimum frequency */
int if1; /* ...      ... integerized */
float f2; /* maximum frequency */
int if2; /* ...      ... integerized */
float fr; /* slope of frequency ramp */
int ifr; /* ...      ... integerized */
float vel; /* velocity of guided waves */
float dx; /* spatial sampling intervall */
int maxmix; /* size of mix */
int tri; /* flag: =1 triangular window */
float adb; /* add back ratio */

/* Initialize
initargs(argc, argv);
requestdoc(1);

if (!getparstring("key", &key)) key = "ep";
if (!getparfloat("f1", &f1)) f1 = 3.0;
if (!getparfloat("f2", &f2)) f2 = 20.0;
if (!getparfloat("dx", &dx)) dx = 10;
if (!getparfloat("vel", &vel)) vel = 1000;

```

```

if (!getparfloat("fr", &fr)) fr = 5;
if (!getparint("maxmix", &maxmix)) maxmix = -1;
if (!getparint("tri", &tri)) tri = 0;
if (!getparfloat("adb", &adb)) adb = 1.0;

if (!getparint("verbose", &verbose)) verbose = 0;

/* get the first record
rec_o = get_gather(&key,&type,&val,&nt,&ntr,&dt,&first);
if(ntr==0) err("Can't get first record\n");

/* set up the fft
nfft = npfaro(nt, LOOKFAC * nt);
if (nfft >= SU_NFLTS || nfft >= PFA_MAX)
    err("Padded nt=%d--too big", nfft);
nf = nfft/2 + 1;
snfft=1.0/nfft;
d1=1.0/(nfft*dt);

ct=ealloc1complex(nf);
rt=ealloc1float(nfft);

if1=NINT(f1/d1);
if2=NINT(f2/d1);
ifr=NINT(fr/d1);

do {
if(maxmix==-1) maxmix=ntr;
ng++;

/* Allocate arrays for fft
ffdr = ealloc2float(nf,ntr);
ffdi = ealloc2float(nf,ntr);
ffdrm = ealloc2float(if2+ifr,ntr);
ffdim = ealloc2float(if2+ifr,ntr);
{ int itr,iw;
for(itr=0;itr<ntr;itr++) {

memcpy( (void *) rt, (const void *) (*rec_o[itr]).data, nt*FSIZE);

memset( (void *) &rt[nt], 0,(nfft-nt)*FSIZE);

pfarc(1,nfft,rt,ct);

```

```

for(iw=0;iw<nf;iw++) {
ffdr[itr][iw] = ct[iw].r;
ffdi[itr][iw] = ct[iw].i;
}
}
}

/* Mixing
{ int mix,iw,nmix;
  int ims,ime;
  int itr,itrm,iww,ws;
  float tmpr,tmpi,wh;

for(iw=if1;iw<if2+ifr;iw++) {

mix=MIN(NINT(vel/iw*d1*dx),maxmix);
if(!ISODD(mix)) mix -=1;
if (verbose) warn(" %f %d",iw*d1,mix);

for(itr=0;itr<ntr;itr++) {

ims=MAX(itr-mix/2,0);
ime=MIN(ims+mix,ntr-1);

tmpr=0.0; tmpi=0.0;
wh=1.0; ws=mix/2;
nmix=0;
for(itrm=ims,iww=-mix/2;itrm<ime;++itrm,++iww) {
++nmix;
if(tri) wh = (float)(ws-abs(iww));
tmpr+=ffdr[itrm][iw]*wh;
tmpi+=ffdi[itrm][iw]*wh;
}
ffdrm[itr][iw]=tmpr/nmix;
ffdim[itr][iw]=tmpi/nmix;
}
}

for(iw=if1;iw<if2;iw++) {
for(itr=0;itr<ntr;itr++) {
ffdr[itr][iw]=ffdrm[itr][iw]*adb+ffdr[itr][iw]*(1.0-adb);
ffdi[itr][iw]=ffdim[itr][iw]*adb+ffdi[itr][iw]*(1.0-adb);

```

```

}
}

for(iw=if2,iww=0;iw<if2+ifr;iw++,iww++) {

wh=(float)(1.0-(float)iww/(float)ifr);

for(itr=0;itr<ntr;itr++) {
ffdr[itr][iw] = (wh*ffdrm[itr][iw]+ffdr[itr][iw]*(1.0-wh))*adb+ffdr[itr][iw]*(1.0-adb);
ffdi[itr][iw] = (wh*ffdim[itr][iw]+ffdi[itr][iw]*(1.0-wh))*adb+ffdi[itr][iw]*(1.0-adb);
}
}

}

{ int itr,iw;
for(itr=0;itr<ntr;itr++) {

for(iw=0;iw<nf;iw++) {
ct[iw].r = ffdr[itr][iw]*snfft;
ct[iw].i = ffdi[itr][iw]*snfft;
}

pfacr(-1,nfft,ct,rt);
memcpy( (void *) (*rec_o[itr]).data, (const void *) rt, nt*FSIZE);

}
}

rec_o = put_gather(rec_o,&nt,&ntr);

free2float(ffdr);
free2float(ffdi);
free2float(ffdrm);
free2float(ffdim);
rec_o = get_gather(&key,&type,&val,&nt,&ntr,&dt,&first);

} while(ntr);

warn("Number of gathers %10d\n",ng);

return EXIT_SUCCESS;

```



}

SUMEDIAN - MEDIAN filter about a user-defined polygonal curve with the distance along the curve specified by key header word

sumedian <stdin >stdout xshift= tshift= [optional parameters]

Required parameters:

xshift=                    array of position values as specified by  
                          the 'key' parameter  
tshift=                    array of corresponding time values (sec)  
... or input via files:  
nshift=                    number of x,t values defining median times  
xfile=                    file containing position values as specified by  
                          the 'key' parameter  
tfile=                    file containing corresponding time values (sec)

Optional parameters:

key=trac1                Key header word specifying trace number  
                          =offset use trace offset instead  
  
mix=.6,1,1,1,.6        array of weights for mix (weighted moving average)  
median=0                =0 for mix  
                          =1 for median filter  
nmed=5                    odd no. of traces to median filter  
sign=-1                   =-1 for upward shift  
                          =+1 for downward shift  
subtract=1                =1 subtract filtered data from input  
                          =0 don't subtract  
verbose=0                =1 echoes information

tmpdir=    if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
          the CWP\_TMPDIR environment variable is set use  
          its value for the path; else use tmpfile()

Notes:

-----

Median filtering is a process for suppressing a particular moveout on seismic sections. Its advantage over traditional dip filtering is that events with arbitrary moveout may be suppressed. Median filtering is commonly used in up/down wavefield separation of VSP data.

The process generally consists of 3 steps:

1. A copy of the data panel is shifted such that the polygon in x,t

specifying moveout is flattened to horizontal. The x,t pairs are specified either by the vector xshift,tshift or by the values in the datafiles xfile,tfile. For fractional shift, the shifted data is interpolated.

2. Then a mix (weighted moving average) is performed over the shifted panel to emphasize events with the specified moveout and suppress events with other moveouts.
3. The panel is then shifted back (and interpolated) to its original moveout, and subtracted from the original data. Thus all events with the user-specified moveout are removed.

For VSP data the following modifications are provided:

1. The moveout polygon in x,t is usually the first break times for each trace. The parameter sign allows for downward shift in order align upgoing events.
2. Alternative to a mix, a median filter can be applied by setting the parameter median=1 and nmed= to the number of traces filtered.
3. By setting subtract=0 the filtered panel is only shifted back but not subtracted from the original data.

The values of tshift are linearly interpolated for traces falling between given xshift values. The tshift interpolant is extrapolated to the left by the smallest time sample on the trace and to the right by the last value given in the tshift array.

The files tfile and xfile are files of binary (C-style) floats.

The number of values defined by mix=val1,val2,... determines the number of traces to be averaged, the values determine the weights.

Caveat:

The median filter may perform poorly on the edges of a section. Choosing larger beginning and ending mix values may help, but may also introduce additional artifacts.

Examples:

Credits:

CWP: John Stockwell, based in part on sumute, sureduce, sumix

CENPET: Werner M. Heigl - fixed various errors, added VSP functionality

U of Durham, UK: Richard Hobbs - fixed the program so it applies the  
median filter

ideas for improvement:

a versatile median filter needs to do:

shift traces by fractional amounts -> needs sinc interpolation

positive and negative shifts similar to SUSTATIC

make subtraction of filtered events a user choice

provide a median stack as well as a weighted average stack

Trace header fields accessed: ns, dt, delrt, key=keyword

SUPHASE - PHASE manipulation by linear transformation

suphase <stdin >sdout

Required parameters:

none

Optional parameters:

a=90 constant phase shift

b=180/PI linear phase shift

c=0.0 phase = a +b\*(old\_phase)+c\*f;

Notes:

A program that allows the user to experiment with changes in the phase spectrum of a signal.

SUSMGAUSS2 --- SMOOTH a uniformly sampled 2d array of velocities using a Gaussian filter specified with correlation lengths a1 and a2.

```
susmgauss2 < stdin [optional parameters ] > stdout
```

Optional Parameters:

a1=0 smoothing parameter in the 1 direction

a2=0 smoothing parameter in the 2 direction

Notes:

Larger a1 and a2 result in a smoother velocity. The velocities are first transformed to slowness and then a Gaussian filter is applied in the wavenumber domain.

Input file must be in SU format. The output file is smoothed velocity

Credits:

CWP: Carlos Pacheco, 2005

SUTVBAND - time-variant bandpass filter (sine-squared taper)

sutvband <stdin >stdout tf= f=

Required parameters:

dt = (from header)	time sampling interval (sec)
tf=	times for which f-vector is specified
f=f1,f2,f3,f4	Corner frequencies corresponding to the times in tf. Specify as many f= as there are entries in tf.

The filters are applied in frequency domain.

Example:

sutvband <data tf=.2,1.5 f=10,12.5,40,50 f=10,12.5,30,40 | ...

Credits:

CWP: Jack, Ken

Trace header fields accessed: ns, dt, delrt





BHEDTOPAR - convert a Binary tape HEaDer file to PAR file format

```
bhedtopar < stdin outpar=parfile
```

Required parameter:

none

Optional parameters:

swap=0 =1 to swap bytes

outpar=/dev/tty =parfile name of output param file

Notes:

This program dumps the contents of a SEG-Y binary tape header file, as would be produced by segyread and segyhds to a file in "parfile" format. A "parfile" is an ASCII file containing entries of the form param=value. Here "param" is the keyword for the binary tape header field and "value" is the value of that field. The parfile may be edited as any ASCII file. The edited parfile may then be made into a new binary tape header file via the program setbhed.

See sudoc setbhed for examples

Credits:

CWP: John Stockwell 11 Nov 1994

SU3DCHART - plot x-midpoints vs. y-midpoints for 3-D data

```
su3dchart <stdin >stdout
```

Optional parameters:

outpar=null name of parameter file

degree=0 =1 convert seconds of arc to degrees

The output is the (x, y) pairs of binary floats

Example:

```
su3dchart <segy_data outpar=pfile >plot_data
psgraph <plot_data par=pfile \\
linewidth=0 marksize=2 mark=8 | ...
rm plot_data
```

```
su3dchart <segy_data | psgraph n=1024 d1=.004 \\
linewidth=0 marksize=2 mark=8 | ...
```

Note: sx, etc., are declared double because float has only 7 significant numbers, that's not enough, for example, when tr.scalco=100 and coordinates are in second of arc and located near 30 degree latitude and 59 degree longitude

Credits:

CWP: Shuki Ronen

Toralf Foerster

Trace header fields accessed: sx, sy, gx, gy, counit, scalco.

SUABSHW - replace header key word by its absolute value

suabshw <stdin >stdout key=offset

Required parameters:

none

Optional parameter:

key=offset header key word

Credits:

CWP: Jack K. Cohen

SUADDHEAD - put headers on bare traces and set the tracl and ns fields

```
suaddhead <stdin >stdout ns= ftn=0
```

Required parameter:

ns=the number of samples per trace

Optional parameter:

```
ifndef SU_LINE_HEADER
```

```
head=          file to read headers in
```

```
                not supplied -- will generate headers
```

```
                given          -- will read in headers and attach  
                                floating point arrays to form  
                                traces "
```

```
                                (head can be created via sustrip program)
```

```
endif
```

```
    ftn=0 Fortran flag
```

```
    0 = data written unformatted from C
```

```
    1 = data written unformatted from Fortran
```

```
        tsort=3          trace sorting code:
```

```
                        1 = as recorded (no sorting)
```

```
                        2 = CDP ensemble
```

```
                        3 = single fold continuous profile
```

```
                        4 = horizontally stacked "
```

```
        ntrpr=1          number of data traces per record
```

```
                        if tsort=2, this is the number of traces per cdp",
```

Trace header fields set: ns, tracl

Use sushw/suchw to set other needed fields.

Caution: An incorrect ns field will munge subsequent processing.

Note: n1 and nt are acceptable aliases for ns.

Example:

```
suaddhead ns=1024 <bare_traces | sushw key=dt a=4000 >segy_traces
```

This command line adds headers with ns=1024 samples. The second part of the pipe sets the trace header field dt to 4 ms. See also the selfdocs of related programs sustrip and supaste.

See: sudoc supaste

Related Programs: supaste, sustrip

SUAHW - Assign Header Word using another header word

```
suahw <stdin >stdout [optional parameters]
```

Required parameters:

key1=ep output key

key2=fldr input key

a= array of key1 output values

b= array of key2 input values

mode=extrapolate how to assign a key1-value, when the key2-value is not found in b:

=interpolate interpolate

=extrapolate interpolate and extrapolate

=zero zero key1-values

=preserve preserve key1-values

=transfer transfer key2-values to key1

Optional parameters:

key3=tracf input key

c= array of key3 input values

The key1-value is assigned based on the key2-value and the arrays a,b. If the header value of key2= equals the n'th element in b=, then the header value key1= is set to the n'th element in a=.

The arrays a= and b= must have the same size, and the elements of b= must be in ascending order.

The mode-switch decides what to do when a trace header has a key2-value that is not an element of the b-array:

zero - the key1-value will be set to zero

preserve - the key1-value will not be modified

transfer - the key2-value will be assigned to key1

interpolate - if the key2-value is greater than the n'th element and less than the (n+1)'th element of b=, then the key1-value will be interpolated accordingly from the n'th and (n+1)'th element of a=. Otherwise, key1 will not be changed.

extrapolate - same as interpolate, plus, if the key2-value is smaller/greater than the first/last element of b=, then the key1-value will be set to the first/last element of a=

The array c= can be used to prevent the modification of trace headers with certain key3-values. The number of elements in c= is independent of the other arrays.

The key1-value will not be modified, if the mode-switch is set to zero, preserve, transfer - and the key3-value is an element of c= interpolate, extrapolate - and the key3-value is outside of c= (smaller than the first or greater than the last element of c=)

Examples:

Assign shot numbers 1-3 to field file ID 1009,1011,1015 and 0 to the remaining FFID (fldr):

```
suahw <data a=1,2,3 b=1009,1011,1015 mode=zero
```

Use channel numbers (tracf) to assign stations numbers (tracr) for a split spread with a gap:

```
suahw <data key1=tracr a=151,128,124,101 key2=tracf b=1,24,25,48
```

Assign shot-statics:

```
suahw <data key1=sstat key2=ep a=-32,13,-4 b=1,2,3
```

Set trid to 0 for channel 1-24, but only for the record 1016:

```
suahw <data key1=trid key2=tracf key3=fldr a=0,0 b=1,24 c=1016
```

Credits:

Florian Bleibinhaus, U Salzburg, Austria  
cloned from suchw of Einar Kajartansson, SEP

SUAZIMUTH - compute trace AZIMUTH, offset, and midpoint coordinates  
and set user-specified header fields to these values

suazimuth <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

key=otrav	header field to store computed azimuths in
scale=1.0	value(key) = scale * azimuth
az=0	azimuth convention flag
	0: 0-179.999 deg, reciprocity assumed
	1: 0-359.999 deg, points from receiver to source
	-1: 0-359.999 deg, points from source to receiver
sector=1.0	if set, defines output in sectors of size sector=degrees_per_sector, the default mode is the full range of angles specified by az
offset=0	if offset=1 then set offset header field
signedflag=0	is offset signed? if =1 signedflag=1
offkey=offset	header field to store computed offsets in
offkey=offset	header field to store computed offsets in
cmp=0	if cmp=1, then compute midpoint coordinates and set header fields for (cmpx, cmpy)
mxkey=ep	header field to store computed cmpx in
mykey=cdp	header field to store computed cmpy in

Notes:

All values are computed from the values in the coordinate fields  
sx,sy (source) and gx,gy (receiver).

The output field "otrav" for the azimuth was chosen arbitrarily as  
an example of a little-used header field, however, the user may  
choose any field that is convenient for his or her application.

Setting the sector=number\_of\_degrees\_per\_sector sets key field to  
sector number rather than an angle in degrees.

For az=0, azimuths are measured from the North, however, reciprocity  
is assumed, so azimuths go from 0 to 179.9999 degrees. If sector  
option is set, then the range is from 0 to 180/sector.

For az=1, azimuths are measured from the North, with the assumption that the direction vector points from the receiver to the source. For az=-1, the direction vector points from the source to the receiver. No reciprocity is assumed in these cases, so the angles go from 0 to 359.999 degrees. If the sector option is set, then the range is from 0 to 360/sector.

#### Caveat:

This program honors the value of scalco in scaling the values of sx,sy,gx,gy. Type "sukeyword scalco" for more information.

Type "sukeyword -o" to see the keywords and descriptions of all header fields.

To plot midpoints, use: su3dchart

#### Credits:

based on suchw, su3dchart

CWP: John Stockwell and UTulsa: Chris Liner, Oct. 1998

UTulsa: Chris Liner added offset option, Feb. 2002

c11: fixed offset option and added cmp option, May 2003

RISSC: Nils Maercklin added key options for offset and midpoints, and added azimuth direction option, Sep. 2006

#### Algorithms:

offset = osign \* sqrt( (gx-sx)\*(gx-sx) + (gy-sy)\*(gy-sy) )  
with osign = sgn( min((sx-gx),(sy-gy)) )

midpoint x value xm = (sx + gx)/2

midpoint y value ym = (sy + gy)/2

Azimuth will be defined as the angle, measured in degrees, turned from North, of a vector pointing to the source from the midpoint, or from the midpoint to the source. Azimuths go from 0-179.000 degrees or from 0-180.0 degrees.

value(key) = scale\*[90.0 - (180.0/PI)\*(atan((sy - ym)/(sx - xm))) ]  
or  
value(key) = scale\*[180.0 - (180.0/PI)\*(atan2((ym - sy),(xm - sx)) ) ]

Trace header fields accessed: sx, sy, gx, gy, scalco.

Trace header fields modified: (user-specified keys)





SUCDPBIN - Compute CDP bin number

sucdpbin <stdin >stdout xline= yline= dcdp=

Required parameters:

xline= array of X defining the CDP line

yline= array of Y defining the CDP line

dcdp= distance between bin centers

Optional parameters

verbose=0 <>0 output informations

cdpmin=1001 min cdp bin number

distmax=dcdp search radius

xline,yline defines the CDP line made of continuous straight lines.

If a smoother line is required, use unisam to interpolate.

Bin centers are located at dcdp constant interval on this line.

Each trace will be numbered with the number of the closest bin. If no bin center is found within the search radius. cdp is set to 0

Credits:

2009 Dominique Rousset - Mohamed Hamza

Universit de Pau et des Pays de l'Adour (France)

SUCHART - prepare data for x vs. y plot

```
suchart <stdin >stdout key1=sx key2=gx
```

Required parameters:

none

Optional parameters:

key1=sx abscissa

key2=gx ordinate

outpar=null name of parameter file

The output is the (x, y) pairs of binary floats

Examples:

```
suchart < sudata outpar=pfile >plot_data
psgraph <plot_data par=pfile title="CMG" \\
linewidth=0 marksize=2 mark=8 | ...
rm plot_data
```

```
suchart < sudata | psgraph n=1024 d1=.004 \\
linewidth=0 marksize=2 mark=8 | ...
```

fold chart:

```
suchart < stacked_data key1=cdp key2=nhs |
          psgraph n=NUMBER_OF_TRACES d1=.004 \\
linewidth=0 marksize=2 mark=8 > chart.ps
```

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen

Notes:

The vtof routine from valpkge converts values to floats.

SUCHW - Change Header Word using one or two header word fields

```
suchw <stdin >stdout [optional parameters]
```

Required parameters:

none

Optional parameters:

```
key1=cdp,... output key(s)
key2=cdp,... input key(s)
key3=cdp,... input key(s)
a=0,... overall shift(s)
b=1,... scale(s) on first input key(s)
c=0,... scale on second input key(s)
d=1,... overall scale(s)
e=1,... exponent on first input key(s)
f=1,... exponent on second input key(s)
```

The value of header word key1 is computed from the values of key2 and key3 by:

$$\text{val}(\text{key1}) = (a + b * \text{val}(\text{key2})^e + c * \text{val}(\text{key3})^f) / d$$

Examples:

Shift cdp numbers by -1:

```
suchw <data >outdata a=-1
```

Add 1000 to tracr value:

```
suchw key1=tracr key2=tracr a=1000 <infile >outfile
```

We set the receiver point (gx) field by summing the offset and shot point (sx) fields and then we set the cdp field by averaging the sx and gx fields (we choose to use the actual locations for the cdp fields instead of the conventional 1, 2, 3, ... enumeration):

```
suchw <indata key1=gx key2=offset key3=sx b=1 c=1 |
suchw key1=cdp key2=gx key3=sx b=1 c=1 d=2 >outdata
```

Do both operations in one call:

```
suchw<indata key1=gx,cdp key2=offset,gx key3=sx,sx b=1,1 c=1,1 d=1,2 >outdata
```

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen

CWP: John Stockwell, 7 July 1995, added array of keys feature

Delphi: Alexander Koek, 6 November 1995, changed calculation so  
headers of different types can be expressed in each other

SUCLIPHEAD - Clip header values

succliphead <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

key=cdp,... header key word(s) to clip

min=0,... minimum value to clip

max=ULONG\_MAX,ULONG\_MAX,... maximum value to clip

Credits:

Geocon: Garry Perratt

SUCOUNTKEY - COUNT the number of unique values for a given KEYword.

```
sucountkey < input.su key=[sx,gx,cdp,...]
```

Required parameter:

key= array of SU header keywords being counted

Optional parameters:

verbose=1 chatty, =0 just print keyword number

Example:

```
suplane | sucountkey key=tracl,tracr,offset
```

Credits: Baoniu Han, bhan@mines.edu, Nov, 2000

SUDUMPTRACE - print selected header values and data.  
Print first num traces.  
Use SUWIND to skip traces.

sudumptrace < stdin [> ascii\_file]

Optional parameters:

num=4	number of traces to dump
key=key1,key2,...	key(s) to print above trace values
hpf=0	header print format is float
	=1 print format is exponential

Examples:

```
sudumptrace < inseis.su          PRINTS: 4 traces, no headers
sudumptrace < inseis.su key=tracf,offset
sudumptrace < inseis.su num=7 key=tracf,offset > info.txt
sudumptrace < inseis.su num=7 key=tracf,offset hpf=1 > info.txt
```

Related programs: suascii, sugethw

Credits:

MTU: David Forel, Jan 2005

Trace header field accessed: nt, dt, delrt



SUEDIT - examine segy diskfiles and edit headers

suedit diskfile (open for possible header modification if writable)  
suedit <diskfile (open read only)

The following commands are recognized:

number read in that trace and print nonzero header words  
<CR>go to trace one step away (step is initially -1)  
+ read in next trace (step is set to +1)  
-read in previous trace (step is set to -1)  
dN advance N traces (step is set to N)  
% print some percentiles of the trace data  
r print some ranks (rank[j] = jth smallest datum)  
p [n1 [n2]] tab plot sample n1 to n2 on current trace  
g [tr1 tr2] ximage plot the trace [traces tr1 to tr2]  
w [tr1 tr2] xwigb plot the trace [traces tr1 to tr2]  
f [tr1 tr2] ximage plot the amplitude spectra of the trace  
u [tr1 tr2] apply user pipeline to specified traces  
! key=val change a value in a field (e.g. ! tracr=101)  
? print help file  
q quit

NOTE: sample numbers are 1-based (first sample is 1).

'u 1000000 1000100 suwind >subset.su' will quickly extract a few traces from the middle of a large dataset

Credits:

SEP: Einar Kjartansson, Shuki Ronen, Stew Levin

CWP: Jack K. Cohen

Unocal: Reg Beardsley

Trace header fields accessed: ns

Trace header fields modified: ntr (only for internal plotting)

SUGEOM - Fill up geometry in trace headers.

```
sugeom rps= sps= xps= <stdin >stdout [optional parameters]
```

Required parameters:

```
  rps= filename for the receiver points definitions. (AKA R file)
  sps= filename for the source   points definitions. (AKA S file)
  xps= filename for the relation specification.       (AKA X file)
```

OBS: if 'prefix' (see bellow) is given the last three parameters become optional, but any one can be used as an override for the name built using prefix.

```
  Ex: sugeom prefix=blah xps=bleh.xxx
```

```
      Used filenames:  blah.s blah.r and bleh.xxx
```

Optional parameters:

```
  prefix= prefix name for the SPS files.  If given the filename will
          be constructed as '<prefix>.s', '<prefix>.r' and
          '<prefix>.x'.
  rev=0           for SPS revision 0 format.
      =2 (Default) for SPS revision 2.1 format.
  verbose=0 (Default) silent run.
      =1           verbose stats.
  ibin=0 (default) inline binsize (cdp interval)
          0 -> do not compute cdp number
```

For SPS format specification consult:

```
  http://www.seg.org/resources/publications/misc/technical-standards
```

WARNING: This is not a full fledged geometry program.

The SPS format is fully described in two documents available at the above SEG address.

To make short what can be a loooong discussion, the SPS file format is intended to describe completely a land (or tranzition zone) survey. The main difference between land and marine survey is that in land all points are meant to be previously located and remain fixed along acquisition operation. In a marine survey the cables and boat can be dragged by current and wind, making the prosition of source and receivers unpredictable. The planning and survey description of a marine program must take into account all moving points, being necessary a full

positioning description of source and receivers at every single shot.

The SPS format standard is composed of three text files with 80 columns each. Two of those files are Point Record Specification and are used to describe all survey points, that is the receiver stations and source points. The remaining file is the Relation Record Specification and is used to describe how each source point is related to a set of corresponding receiver points during the registration of each record (fldr).

These files usually have a number of lines at the start describing the survey and the projections used for coordinates. This program just skip them. Those are header entries and have an 'H' in first column.

Each line (entry) of the Point Record Specification contain the information of a single point. The only difference of a source point specification entry and a receiver point specification entry is the first column of the file, it has an 'S' for a source point description and an 'R' for a receiver point description. For each point entry there is an identification with a pair of informations, the Line it belongs and the Point Number, a set of coordinates (X, Y, surface Elevation, depth of element), and the static correction. All source points description are in a single file (known as S-File), and all receiver station informations are in another file (R-File).

The Relation Record Specification (X-File) is a file with as many entries (text lines) as necessary to completely describe each record (fldr) acquired. Each entry containing a record information starts with an 'X' in first column. The informations in the entry starts with the tape number in which the register was recorded (not used for this program) and the Field Record Number (fldr). Next comes the source point description (the same Line and Point(ep) from the S-File). Then a sequence of channels (tracf) numbers (just first and last) and a channel increment. Next comes the receiver description using the same Line and Point/station from the R-File). The Receiver Points are specified as the first and last station used at that line. Finally comes the recording time. If the spread has a gap, very common for older lines, it will require at least two entries (text lines) to describe this record, one describing the channels and receiver stations before the gap, and another for the channels and stations after the gap. The initial informations (tape, record, and source) are repeated for all entries. In a 3D there is one entry for each line of the patch.

To use this program it is necessary to use all three SPS files. The S-File and the R-File can describe more points than will be used for the processing. For example, if one is processing just a section of a 2D line the Point Record Specification files can describe all points of the complete line, the information in excess will be disregarded.

The X-File must have the information in the same order of the input SU file, if not so all files (fldr) that do not match the order will be skipped until the program find the fldr corresponding to the sequence of the X-File.

Although this program read all of the SPS files, it is not ready for 3D geometry processing. It is just a basic 2D straight line geometry processing program that (hopefully) will fill correctly the informations in header. It can be used for a crooked line for the coordinates (X, Y Elevation, and element depth), the static correction, and offset. The cdp numbering will need an specialized program for computation.

All coordinates are expected to be an UTM projection in meters or feet. ",

The X file order must be the same as the input file. Upon reading a trace whose trcf is not the next record to be processed in X file, this record, and the following, will be skipped until a match is found for the current entry in X file. This is a way to, e.g., skip a noisy record, just remove its entry from X file.

If a trace (understand fldr/tracf pair) is not represented in the X file it will be skipped until a trace in current fldr matches the current set of X entry for that fldr. If it is desirable to process just a subset of channels, just keep in the X-File information about those channels.

Updated trace header positions:

trac1 - it keeps counting to overcome possible trace skipping.  
ep - If zeroed out in header it uses the relation (X) file info.

sx, sy, gx, gy - will be updated with the coordinates in point files  
R and S. The scalco value used is the already  
stored in header, almost ever equal zero.  
gelev, selev, sdepth - will be updated with values in point files  
R and S. The scalel value used is the already  
stored in header, almost ever equal zero.

sstat, gstatt - these values are filled with the information of the Point Record Specification files. If not available will be zero.

offset - is computed from source and receiver coordinates. The offset signal is made negative if source station number is greater than the receiver station number. It consider that source and receiver numbering are the same. Fractionary stations, e.g. source point halfway between stations are ok.

cdp - if parameter 'ibin' is passed it is considered the cdp spacing and the cdp number will be computed as follow:  
The cdp position is computed as the midpoint between source and receiver. The distance from this point to the first station of R point file is divided by 'ibin' and added to 100. This 100 is absolutely arbitrary. ;)

Credits:

Fernando Roxo <petro@roxo.org>

Trace header fields accessed:

fldr, tracf, scalco, scalel, ep, sx, sy, gx, gy, gelev, selev, sdepth, cdp

SUGETHW - sugethw writes the values of the selected key words

```
sugethw key=key1,... [output=] <infile [>outfile]
```

Required parameters:

key=key1,... At least one key word.

Optional parameters:

output=ascii output written as ascii for display

=binary for output as binary floats

=geom ascii output for geometry setting

verbose=0 quiet

=1 chatty

Output is written in the order of the keys on the command line for each trace in the data set.

Example:

```
sugethw <stdin key=sx,gx
```

writes sx, gx values as ascii trace by trace to the terminal.

Comment:

Users wishing to edit one or more header field (as in geometry setting) may do this via the following sequence:

```
sugethw < sudata output=geom key=key1,key2,... > hdrfile
```

Now edit the ASCII file hdrfile with any editor, setting the fields appropriately. Convert hdrfile to a binary format via:

```
a2b < hdrfile n1=nfields > binary_file
```

Then set the header fields via:

```
sushw < sudata infile=binary_file key=key1,key2,... > sudata.edited
```

Credits:

SEP: Shuki Ronen

CWP: Jack K. Cohen

CWP: John Stockwell, added geom stuff, and getparstringarray

SUHTMATH - do unary arithmetic operation on segy traces with  
headers values

suhtmath <stdin >stdout

Required parameters:  
none

Optional parameter:  
key=trac1 header word to use  
op=nop operation flag  
nop : no operation  
add : add header to trace  
mult : multiply trace with header  
div : divide trace by header

scale=1.0 scalar multiplier for header value  
const=0.0 additive constant for header value

Operation order: ",

op=add:  $\text{out}(t) = \text{in}(t) + (\text{scale} * \text{key} + \text{const})$   
op=mult:  $\text{out}(t) = \text{in}(t) * (\text{scale} * \text{key} + \text{const})$   
op=div:  $\text{out}(t) = \text{in}(t) / (\text{scale} * \text{key} + \text{const})$

Credits:  
Matthias Imhof, Virginia Tech, Fri Dec 27 09:17:29 EST 2002

SUKEYCOUNT - sukeycount writes a count of a selected key

```
sukeycount key=keyword < infile [> outfile]
```

Required parameters:

key=keyword        One key word.

Optional parameters:

verbose=0    quiet  
          =1   chatty

Writes the key and the count to the terminal or a text file when a change of key occurs. This does not provide a unique key count (see SUCOUNTKEY for that).

Note that for key values 1 2 3 4 2 5  
value 2 is counted once per occurrence since this program only recognizes a change of key, not total occurrence.

Examples:

```
sukeycount < stdin key=fldr  
sukeycount < stdin key=fldr > out.txt
```

Credits:

MTU: David Forel, Jan 2005



## SULCTHW - Linear Coordinate Transformation of Header Words

sulcthw <infile >outfile

xt=0.0 Translation of X  
yt=0.0 Translation of Y  
zt=0.0 Translation of Z  
xr=0.0 Rotation around X in degrees  
yr=0.0 Rotation around Y in degrees  
zr=0.0 Rotation around Z in degrees

Notes:

Translation:

$x = x' + xt; y = y' + yt; z = z' + zt;$

Rotations:

Around Z axis

$X = x \cos(zr) + y \sin(zr);$

$Y = y \cos(zr) - x \sin(zr);$

Around Y axis

$Z = z \cos(yr) + x \sin(yr);$

$X = x \cos(yr) - z \sin(yr);$

Around X axis

$Y = y \cos(xr) + z \sin(xr);$

$Z = Z \cos(xr) - y \sin(xr);$

Header words triplets that are transformed

sx,sy,selev

gx,gy,gelev

The header words restored as 32 bit integers using SEG-Y convention (with coordinate scalers scalco and scalel).

After transformation they are converted back to integers and stored.

Credits: Potash Corporation of Saskatchewan: Balasz Nemeth c. 2008

SULHEAD - Load information from an ascii column file into HEADERS based on the value of the user specified header field  
sulhead < inflie > outfile cf=Column\_file key=.. [ optional parameters]

Required parameters:

cf=Name of column file

key=key1,key2,...Number of column entires

Optional parameters:

mc=1 Column number to use to match rows to traces

Notes:

Caveat: This is not simple trace header setting, but conditional setting.

This utility reads the column file and loads the values into the specified header locations. Each column represents one set of header words, one of them (#mc) is used to match the rows to the traces using header tr.key[mc].

Example:

key=cdp,ep,sx mc=1 cf=file

file contains:

1 2 3

2 3 4

if tr.cdp = 1 then tr.ep and tr.sx will be set to 2 and 3

if tr.cdp = 2 then tr.ep and tr.sx will be set to 3 and 4

if tr.cdp=other than tr.trid=3

Caveat: the user has to make it sure that number of entires in key= is equal the number of columns stored in the file.

For simple mass setting of header words, see selfdoc of: sushw

Credits: Balasz Nemeth, Potash Corporation, Saskatoon Saskatchewan  
Given to CWP in 2008

SUPASTE - paste existing SU headers on existing binary data

```
supaste <bare_data >segys ns= head=headers ftn=0
```

Required parameter:

ns=the number of samples per trace

Optional parameters:

head=headers file with segy headers

ftn=0 Fortran flag

0 = unformatted data from C

1 = ... from Fortran

verbose=0 1= echo number of traces pasted

Caution:

An incorrect ns field will munge subsequent processing.

Notes:

This program is used when the option head=headers is used in  
sustrip. See: sudoc sustrip for more details.

Related programs: sustrip, suaddhead

Credits:

CWP: Jack K. Cohen, November 1990

surandhw - set header word to random variable

surandhw <stdin >stdout key=tstat a=0 min=0 max=1

Required parameters:

none (no op)

Optional parameters:

key=tstat header key word to set

a=0 =1 flag to add original value to final key

noise=gauss noise probability distribution

=flat for uniform; default Gaussian

seed=from\_clock random number seed (integer)

min=0 minimum random number

max=1 maximum random number

NOTES:

The value of header word key is computed using the formula:

$\text{val}(\text{key}) = a * \text{val}(\text{key}) + \text{rand}$

Example:

surandhw <indata key=tstat a=0 min=0 max=10 > outdata

SURANGE - get max and min values for non-zero header entries

surange <stdin

Optional parameters:

key= Header key(s) to range (default=all)

Note: Gives partial results if interrupted

Output is:

number of traces

keyword min max (first - last)

north-south-east-west limits of shot, receiver and midpoint

Credits:

Stanford: Stewart A. Levin

Added print of eastmost, northmost, westmost,  
southmost coordinates of shots, receivers, and  
midpoints. These coordinates have had any  
nonzero coscal header value applied.

Geocon: Garry Perratt (output one header per line;  
option to specify headers to range;  
added first & last values where min<max)

Based upon original by:

SEP: Stew Levin

CWP: Jack K. Cohen

Note: the use of "signal" is inherited from BSD days and may  
break on some UNIXs. It is dicey in that the responsibility  
for program termination is lateraled back to the main.

SUSEHW - Set the value the Header Word denoting trace number within an Ensemble defined by the value of another header word

susehw <stdin >stdout [options]

Required Parameters:

none

Optional Parameters:

key1=cdp Key header word defining the ensemble

key2=cdpt Key header word defining the count within the ensemble

a=1 starting value of the count in the ensemble

b=1 increment or decrement within the ensemble

Notes:

This code was written because suresstat requires cdpt to be set.

The computation is

$val(key2) = a + b*i$

The input data must first be sorted into constant key1 gathers.

Example: setting the cdpt field ",

susetehw < cdpgather.su a=1 b=1 key1=cdp key2=cdpt > new.su

Credits:

CWP: John Stockwell (Feb 2008) in answer to a question by Warren Franz based on various codes, including susplit, susshw, suchw

SUSHW - Set one or more Header Words using trace number, mod and integer divide to compute the header word values or input the header word values from a file

... compute header fields

```
sushw <stdin > stdout key=cdp,... a=0,... b=0,... c=0,... d=0,... j=...,...
```

... or read headers from a binary file

```
sushw <stdin > stdout key=key1,... infile=binary_file
```

Required Parameters for setting headers from infile:

key=key1,key2 ... is the list of header fields as they appear in infile

infile= binary file of values for field specified by

key1,key2,...

Optional parameters ():

key=cdp,... header key word(s) to set

a=0,... value(s) on first trace

b=0,... increment(s) within group

c=0,... group increment(s)

d=0,... trace number shift(s)

j=ULONG\_MAX,ULONG\_MAX,... number of elements in group

Notes:

Fields that are getparred must have the same number of entries as key words being set. Any field that is not getparred is set to the default value(s) above. Explicitly setting j=0 will set j to ULONG\_MAX.

The value of each header word key is computed using the formula:

$$i = itr + d$$
$$val(key) = a + b * (i \% j) + c * (int(i / j))$$

where itr is the trace number (first trace has itr=0, NOT 1)

Examples:

1. set every dt field to 4ms

```
sushw <indata key=dt a=4000 |...
```

2. set the sx field of the first 32 traces to 6400, the second 32 traces to 6300, decrementing by -100 for each 32 trace groups

```
...| sushw key=sx a=6400 c=-100 j=32 |...
```

3. set the offset fields of each group of 32 traces to 200,400,...,6400

```
...| sushw key=offset a=200 b=200 j=32 |...
```

4. perform operations 1., 2., and 3. in one call

```
..| sushw key=dt,sx,offset a=4000,6400,200 b=0,0,200 c=0,-100,0 j=0,32,32 |
```

In this example, we set every dt field to 4ms. Then we set the first 32 shotpoint fields to 6400, the second 32 shotpoint fields to 6300 and so forth. Next we set each group of 32 offset fields to 200, 400, ..., 6400.

Example of a typical processing sequence using suchw:

```
sushw <indata key=dt a=4000 |
sushw key=sx a=6400 c=-100 j=32 |
sushw key=offset a=200 b=200 j=32 |
suchw key1=gx key2=offset key3=sx b=1 c=1 |
suchw key1=cdp key2=gx key3=sx b=1 c=1 d=2 >outdata
```

Again, it is possible to eliminate the multiple calls to both sushw and suchw, as in Example 4.

Reading header values from a binary file:

If the parameter infile=binary\_file is set, then the values that are to be set for the fields specified by key=key1,key2,... are read from that file. The values are read sequentially from the file and assigned trace by trace to the input SU data. The infile consists of C (unformatted) binary floats in the form of an array of size (nkeys)\*(ntraces) where nkeys is the number of floats in the first (fast) dimension and ntraces is the number of traces.

Comment:

Users wishing to edit one or more header fields (as in geometry setting) may do this via the following sequence:

```
sugethw < sudata output=geom key=key1,key2 ... > hdrfile
```

Now edit the ASCII file hdrfile with any editor, setting the fields appropriately. Convert hdrfile to a binary format via:

```
a2b < hdrfile n1=nfields > binary_file
```

Then set the header fields via:

```
sushw < sudata infile=binary_file key=key1,key2,... > sudata.edited
```

Caveat:

If the (number of traces)\*(number of key words) exceeds the number of values in the infile then the user may still set a single header field on the remaining traces via the parameters key=keyword a,b,c,d,j.

Example:

```
sushw < sudata=key1,key2 ... infile=binary_file [Optional Parameters]
```



Credits:

SEP: Einar Kajartansson

CWP: Jack K. Cohen

CWP: John Stockwell, added multiple fields and infile= options

Caveat:

All constants are cast to doubles.

SUSTRIP - remove the SEG Y headers from the traces

```
sustrip <stdin >stdout head=/dev/null outpar=/dev/tty ftn=0
```

Required parameters:

none

Optional parameters:

head=/dev/null file to save headers in

outpar=/dev/tty output parameter file, contains:

number of samples (n1=)

number of traces (n2=)

sample rate in seconds (d1=)

ftn=0 Fortran flag

0 = write unformatted for C

1 = ... for Fortran

Notes:

Invoking head=filename will write the trace headers into filename.

You may paste the headers back onto the traces with supaste

See: sudoc supaste for more information

Related programs: supaste, suaddhead

Credits:

SEP: Einar Kjartansson c. 1985

CWP: Jack K. Cohen April 1990

Trace header fields accessed: ns, dt

SUTRCOUNT - SU program to count the TRaces in infile

```
sutrcount < infile
```

Required parameters:

```
none
```

Optional parameter:

```
outpar=stdout
```

Notes:

Once you have the value of ntr, you may set the ntr header field via:

```
sushw key=ntr a=NTR < datain.su > dataout.su
```

Where NTR is the value of the count obtained with sutrcount

Credits: B.Nemeth, Potash Corporation, Saskatchewan

given to CWP in 2008 with permission of Potash Corporation

SUUTM - UTM projection of longitude and latitude in SU trace headers

suutm <stdin >stdout [optional parameters]

Optional parameters:

counit=(from header)	input coordinate units code:
	=1: length (meters or feet; no UTM projection)
	=2: seconds of arc
	=3: decimal degrees
	=4: degrees, minutes, seconds
idx=23	reference ellipsoid index (default is WGS 1984)
a=(from idx)	user-specified semimajor axis of ellipsoid
f=(from idx)	user-specified flattening of ellipsoid
zkey=	if set, header key to store UTM zone number
verbose=0	=1: echo ellipsoid parameters
lon0=	central meridian for TM projection in degrees (default uses the 60 standard UTM longitude zones)
xoff=500000	false Easting (default: UTM)
ysoff=10000000	false Northing, southern hemisphere (default: UTM)
ynoff=0	false Northing, northern hemisphere (default: UTM)

Notes:

Universal Transverse Mercator (UTM) coordinates are defined between latitudes 80S (-80) and 84N (84). Longitude values must be between -180 degrees (west) and 179.999... degrees (east).

Latitudes are read from sy and gy (N positive), and longitudes are read from sx and gx (E positive).

The UTM zone is determined from the receiver coordinates gy and gx.

Use suazimuth to calculate shot-receiver azimuths and offsets.

Reference ellipsoids:

An ellipsoid may be specified by its semimajor axis a and its flattening f, or one of the following ellipsoids may be selected by its index idx (semimajor axes in meters):

- 0 Sphere with radius of 6371000 m
- 1 Airy 1830
- 2 Australian National 1965
- 3 Bessel 1841 (Ethiopia, Indonesia, Japan, Korea)
- 4 Bessel 1841 (Namibia)
- 5 Clarke 1866

- 6 Clarke 1880
- 7 Everest (Brunei, E. Malaysia)
- 8 Everest (India 1830)
- 9 Everest (India 1956)
- 10 Everest (Pakistan)
- 11 Everest (W. Malaysia, Singapore 1948)
- 12 Everest (W. Malaysia 1969)
- 13 Geodetic Reference System 1980 (GRS 1980)
- 14 Helmert 1906
- 15 Hough 1960
- 16 Indonesian 1974
- 17 International 1924 / Hayford 1909
- 18 Krassovsky 1940
- 19 Modified Airy
- 20 Modified Fischer 1960
- 21 South American 1969
- 22 World Geodetic System 1972 (WGS 1972)
- 23 World Geodetic System 1984 (WGS 1984) / NAD 1983

#### UTM grid:

The Universal Transverse Mercator (UTM) system is a world wide coordinate system defined between 80S and 84N. It divides the Earth into 60 six-degree zones. Zone number 1 has its central meridian at 177W (-177 degrees), and numbers increase eastward.

Within each zone, an Easting of 500,000 m is assigned to its central meridian to avoid negative coordinates. On the northern hemisphere, Northings start at 0 m at the equator and increase northward. On the southern hemisphere a false Northing of 10,000,000 m is applied, i.e. Northings start at 10,000,000 m at the equator and decrease southward.

#### Coordinate encoding (sx,sy,gx,gy):

- counit=1 units of length (coordinates are not converted)
- counit=2 seconds of arc
- counit=3 decimal degrees
- counit=4 degrees, minutes and seconds encoded as integer DDDMMSS  
with scalco=1 or DDDMMSS.ss with scalco=-100 (see segy.h)

Units of length are also assumed, if counit <= 0 or counit >= 5.

Author:

Nils Maercklin, RISSC, University of Naples, Italy, March 2007

References:

- NIMA (2000). Department of Defense World Geodetic System 1984 - its definition and relationships with local geodetic systems. Technical Report TR8350.2. National Imagery and Mapping Agency, Geodesy and Geophysics Department, St. Louis, MO. 3rd edition.
- J. P. Snyder (1987). Map Projections - A Working Manual. U.S. Geological Survey Professional Paper 1395, 383 pages. U.S. Government Printing Office.

Trace header fields accessed: sx, sy, gx, gy, scalco, counit

Trace header fields modified: sx, sy, gx, gy, scalco, counit

SUXEDIT - examine segy diskfiles and edit headers

suxedit diskfile (open for possible header modification if writable)

suxedit <diskfile (open read only)

The following commands are recognized:

number read in that trace and print nonzero header words

<CR>go to trace one step away (step is initially -1)

+ read in next trace (step is set to +1)

-read in previous trace (step is set to -1)

dN advance N traces (step is set to N)

% print some percentiles of the trace data

r print some ranks (rank[j] = jth smallest datum)

p [n1 [n2]] tab plot sample n1 to n2 on current trace

g [tr1 tr2] ["opts"] wiggle plot (graph) the trace  
[traces tr1 to tr2]

f wiggle plot the Fourier transform of the trace

! key=val change a value in a field (e.g. ! tracr=101)

? print help file

q quit

NOTE: sample numbers are 1-based (first sample is 1).

Credits:

SEP: Einar Kjartansson, Shuki Ronen, Stew Levin

CWP: Jack K. Cohen

Trace header fields accessed: ns

Trace header fields modified: ntr (only for internal plotting)

SUINTERPFOWLER - interpolate output image from constant velocity panels  
built by SUTIFOWLER or CVS

These parameters should be specified the same as in SUTIFOWLER:

vmin=1500. minimum velocity  
vmax=2500. maximum velocity  
nv=21 number of velocity panels  
etamin=0.10 minimum eta value  
etamax=0.25 maximum eta value  
neta=11 number of eta values  
ncdps=1130 number of cdp points

If these parameters are specified so that nvstack>5, then the input  
data are assumed to come from CVS and the SUTIFOWLER parameters are ignored.

nvstack=0 number of constant velocity stack panels output by CVS  
vminstack=1450 minimum velocity specified for CVS  
vscale=1.0 scale factor for velocity functions

These parameters specify the desired output (time,velocity,eta) model  
at each cdp location. The sequential cdp numbers should be specified in  
increasing order from 0 to 'ncdps-1' at from 1 to 'ncdps' control point  
locations. (Time values are in seconds.)

cdp=0 cdp number for (t,v,eta) triplets (specify more than  
once if needed)

t=0. array of times for (t,v,eta) triplets (specify more  
than once if needed)

v=1500. array of velocities for (t,v,eta) triplets (specify  
more than once if needed)

eta=0. array of etas for (t,v,eta) triplets (specify more  
than once if needed)

Note: This is a simple research code based on linear interpolation.  
There are no protections against aliasing built into the code beyond  
suggesting that this program have a knowledgeable user. A final version  
should do a better job taking care of endpoint conditions.

Author: (Visitor from Mobil) John E. Anderson, Spring 1994



SUINTERP - interpolate traces using automatic event picking

suinterp < stdin > stdout

ninterp=1      number of traces to output between each pair of input traces  
nxmax=500      maximum number of input traces  
freq1=4.        starting corner frequency of unaliased range  
freq2=20.       ending corner frequency of unaliased range  
deriv=0        =1 means take vertical derivative on pick section  
                 (useful if interpolating velocities instead of seismic)  
linear=0        =0 means use 8 point sinc temporal interpolation  
                 =1 means use linear temporal interpolation  
                 (useful if interpolating velocities instead of seismic)  
lent=5         number of time samples to smooth for dip estimate  
lenx=1         number of traces to smooth for dip estimate  
lagc=400        number of ms agc for dip estimate  
xopt=0         0 compute spatial derivative via FFT  
                 (assumes input traces regularly spaced and relatively  
                 noise-free)  
                 1 compute spatial derivative via differences  
                 (will work on irregularly spaced data)  
iopt=0         0 = interpolate  
                 1 = output low-pass model: useful for QC if interpolator failing  
                 2 = output dip picks in units of samples/trace

verbose=0      verbose = 1 echoes information

tmpdir=      if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
              the CWP\_TMPDIR environment variable is set use  
              its value for the path; else use tmpfile()

#### Notes:

This program outputs 'ninterp' interpolated traces between each pair of input traces. The values for lagc, freq1, and freq2 are only used for event tracking. The output data will be full bandwidth with no agc. The default parameters typically will do a satisfactory job of interpolation for dips up to about 12 ms/trace. Using a larger value for freq2 causes the algorithm to do a better job on the shallow dips, but to fail on the steep dips. Only one dip is assumed at each time sample between each pair of input traces.

The key assumption used here is that the low frequency data are unaliased

and can be used for event tracking. Those dip picks are used to interpolate the original full-bandwidth data, giving some measure of interpolation at higher frequencies which otherwise would be aliased. Using iopt equal to 1 allows you to visually check whether the low-pass picking model is aliased.

Trace headers for interpolated traces are not updated correctly. The output header for an interpolated traces equals that for the preceding trace in the original input data. The original input traces are passed through this module without modification.

The place this code is most likely to fail is on the first breaks.

Example run:     suplane | suinterp | suxwigb &

Credit: John Anderson (visiting scholar from Mobil) July 1994

Trace header fields accessed: ns, dt

SUOCEXT - smaller Offset EXTrapolation via Offset Continuation  
method for common-offset gathers

```
suocext <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= offextr= [...]
```

Required Parameters:

cdpmin= minimum cdp (integer number) for which to apply DMO  
cdpmax= maximum cdp (integer number) for which to apply DMO  
dxcdp= distance between adjacent cdp bins (m)  
noffmix= number of offsets to mix (see notes)  
offextr= offset to extrapolate

Optional Parameters:

tdmo=0.0 times corresponding to rms velocities in vdm (s)  
vdm=1500.0 rms velocities corresponding to times in tdmo (m/s)  
sdmo=1.0 DMO stretch factor; try 0.6 for typical v(z)  
fmax=0.5/dt maximum frequency in input traces (Hz)  
verbose=0 =1 for diagnostic print  
tmpdir= if non-empty, use the value as a directory path prefix  
for storing temporary files; else if the CWP\_TMPDIR  
environment variable is set use its value for the path;  
else use tmpfile()

Notes:

Input traces should be sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes. One common-offset gather usually is enough.

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through DMO to other traces in adjacent cdps within that mix.

The tdmo and vdm arrays specify a velocity function of time that is used to implement a first-order correction for depth-variable velocity. The times in tdmo must be monotonically increasing.

For each offset, the minimum time at which a non-zero sample exists is used to determine a mute time. Output samples for times earlier than this", mute time will be zeroed. Computation time may be significantly reduced

if the input traces are zeroed (muted) for early times at large offsets.

A term for better amplitude reconstruction was added to Hale's formulation.

Credits: Carlos E. Theodoro (modification of Hale's SUDMOFK program)

Technical Reference:

C. Theodoro & K. Larner, 1998

Extrapolation of seismic data to small offsets (CWP-276).

Dip-Moveout Processing - SEG Course Notes

Dave Hale, 1988

Bleistein, Cohen & Jaramillo, 1997

True amplitude transformation to zero offset of data from  
curved reflectors (CWP-262).

Trace header fields accessed: ns, dt, delrt, offset, cdp.

Trace header fields modified: offset.

SUGAZMIGQ - SU version of Jeno GAZDAG's phase-shift migration  
for zero-offset data, with attenuation Q.

sugazmig <infile >outfile vfile= [optional parameters]

Optional Parameters:

dt=from header(dt) or .004 time sampling interval

dx=from header(d2) or 1.0 midpoint sampling interval

ft=0.0 first time sample

ntau=nt(from data) number of migrated time samples

dtau=dt(from header) migrated time sampling interval

ftau=ft first migrated time sample

tmig=0.0 times corresponding to interval velocities in vmig

vmig=1500.0 interval velocities corresponding to times in tmig

vfile= name of file containing velocities

Q=1e6 quality factor

ceil=1e6 gain ceiling beyond which migration ceases

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note: ray bending effects not accounted for in this version.

The tmig and vmig arrays specify an interval velocity function of time.  
Linear interpolation and constant extrapolation is used to determine  
interval velocities at times not specified. Values specified in tmig  
must increase monotonically.

Alternatively, interval velocities may be stored in a binary file  
containing one velocity for every time sample in the data that is to be  
migrated. If vfile is specified, then the tmig and vmig arrays are ignored.

Caveat: Adding Q is a first attempt to address GPR issues.

Credits:

Constant Q attenuation correction by Chuck Oden 5 May 2004

CWP John Stockwell 12 Oct 1992

Based on a constant v version by Dave Hale.

Trace header fields accessed: ns, dt, delrt, d2  
Trace header fields modified: ns, dt, delrt

SUINVXZCO - Seismic INVersion of Common Offset data for a smooth velocity function  $V(X,Z)$  plus a slowness perturbation  $vp(x,z)$

suinvvxzco <infile >outfile [optional parameters]

Required Parameters:

vfile                      file containing velocity array  $v[nx][nz]$   
nx=                        number of x samples (2nd dimension) in velocity  
nz=                        number of z samples (1st dimension) in velocity  
nxm= number of midpoints of input traces

Optional Parameters:

dt= or from header (dt)   time sampling interval of input data  
offs= or from header (offset)   source-receiver offset  
dxm= or from header (d2)   sampling interval of midpoints  
fxm=0 first midpoint in input trace  
nxd=5 skipped number of midpoints (see note)  
dx=50.0 x sampling interval of velocity  
fx=0.0 first x sample of velocity  
dz=50.0 z sampling interval of velocity  
nxb=nx/2 band centered at midpoints (see note)  
nxc=0 hozizontal range in which velocity is changed  
nzc=0 vertical range in which velocity is changed  
fxo=0.0 x-coordinate of first output trace  
dxo=15.0 horizontal spacing of output trace  
nxo=101 number of output traces ",  
fzo=0.0 z-coordinate of first point in output trace  
dzo=15.0 vertical spacing of output trace  
nzo=101 number of points in output trace ",  
fmax=0.25/dt Maximum frequency set for operator antialiasing  
ang=180 Maximum dip angle allowed in the image  
ls=0 =1 for line source; =0 for point source  
pert=0 =1 calculate time correction from  $v_p[nx][nz]$   
vpfile file containing slowness perturbation array  $v_p[nx][nz]$   
verbose=1                      =1 to print some useful information

Notes:

Traveltime and amplitude are calculated by finite difference which is done only in one of every NXD midpoints; in the skipped midpoint, interpolation is used to calculate traveltime and amplitude. ",  
For each midpoint, traveltime and amplitude are calculated in the horizontal range of  $(xm-nxb*dx, xm+nxb*dx)$ . Velocity is changed by constant extropolation in two upper triangular corners whose width is

$n_{xc} \cdot dx$  and height is  $n_{zc} \cdot dz$ .

Eikonal equation will fail to solve if there is a polar turned ray. In this case, the program shows the related geometric information. There are three ways to remove the turned ray: smoothing velocity, reducing  $n_{xb}$ , and increaing  $n_{xc}$  and  $n_{zc}$  (if the turned ray occurs in the shallow areas). To prevent travelttime distortion from a over smoothed velocity, travelttime is corrected based on the slowness perturbation.

Offsets are signed - may be positive or negative.

Author: Zhenyue Liu, 08/28/93, Colorado School of Mines

Reference:

Bleistein, N., Cohen, J. K., and Hagin, F., 1987,

Two-and-one-half dimensional Born inversion with an arbitrary reference  
Geophysics Vol. 52, no.1, 26-36.



SUINVZCO3D - Seismic INVersion of Common Offset data with V(Z) velocity function in 3D

suinvzco3d <infile >outfile [optional parameters]

Required Parameters:

vfile                      file containing velocity array v[nz]  
nz=                        number of z samples (1st dimension) in velocity  
nxm= number of midpoints of input traces  
ny= number of lines

Optional Parameters:

dt= or from header (dt)   time sampling interval of input data  
offs= or from header (offset)   source-receiver offset  
dxm= or from header (d2)   sampling interval of midpoints  
fxm=0                      first midpoint in input trace  
nxd=5 skipped number of midpoints (see note)  
dx=50.0                    x sampling interval of velocity  
fx=0.0                    first x sample of velocity  
dz=50.0                    z sampling interval of velocity  
nxb=nx/2 band centered at midpoints (see note)  
fxo=0.0                    x-coordinate of first output trace  
dxo=15.0 horizontal spacing of output trace  
nxo=101                    number of output traces ",  
fyo=0.0 y-coordinate of first output trace  
dyo=15.0 y-coordinate spacing of output trace  
nyo=101 number of output traces in y-direction  
fzo=0.0                    z-coordinate of first point in output trace  
dzo=15.0                   vertical spacing of output trace  
nzo=101                    number of points in output trace ",  
fmax=0.25/dt Maximum frequency set for operator antialiasing  
ang=180 Maximum dip angle allowed in the image  
verbose=1                   =1 to print some useful information

Notes:

This algorithm is based on formula (50) in Geophysics Vol. 51, 1552-1558, by Cohen, J., Hagin, F., and Bleistein, N.

Traveltime and amplitude are calculated by ray tracing. Interpolation is used to calculate traveltime and amplitude. ", For each midpoint, traveltime and amplitude are calculated in the horizontal range of (xm-nxb\*dx, xm+nxb\*dx). Velocity is changed by

linear interpolation in two upper triangular corners whose width is  $nxc \cdot dx$  and height is  $nzc \cdot dz$ . ",

Eikonal equation will fail to solve if there is a polar turned ray. In this case, the program shows the related geometric information.

Offsets are signed - may be positive or negative. ",

## SUKDMIG2D - Kirchhoff Depth Migration of 2D poststack/prestack data

```
sukdmig2d infile= outfile= ttfile= [parameters]
```

### Required parameters:

infile=stdin file for input seismic traces

outfile=stdout file for common offset migration output

ttfile= file for input traveltimes tables

... The following 9 parameters describe traveltimes tables:

fzt= first depth sample in traveltimes table

nzt= number of depth samples in traveltimes table

dzt= depth interval in traveltimes table

fxt= first lateral sample in traveltimes table

nxt= number of lateral samples in traveltimes table

dxt= lateral interval in traveltimes table

fs= x-coordinate of first source

ns= number of sources

ds= x-coordinate increment of sources

### Optional Parameters:

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

dxm= or from header (d2) sampling interval of midpoints

fzo=fzt z-coordinate of first point in output trace

dzo=0.2\*dzt vertical spacing of output trace

nzo=5\*(nzt-1)+1 number of points in output trace ",

fxo=fxt x-coordinate of first output trace

dxo=0.5\*dxt horizontal spacing of output trace

nxo=2\*(nxt-1)+1 number of output traces ",

off0=0 first offset in output

doff=99999 offset increment in output

noff=1 number of offsets in output ",

absoff=0 flag for using absolute offsets of input traces

=0 means use offset=gx-sx

=1 means use abs(gx-sx)

limoff=0 flag for only using input traces that fall within the range of defined output offset bins (off0,doff,noff)

=0 means use all input traces

=1 means limit traces used by offset

fmax=0.25/dt frequency-highcut for input traces

offmax=99999 maximum absolute offset allowed in migration

aperx=nxt\*dxt/2 migration lateral aperture

angmax=60 migration angle aperture from vertical  
v0=1500(m/s) reference velocity value at surface ",  
dvz=0.0 reference velocity vertical gradient

ls=1 flag for line source  
jpfile=stderr job print file name

mtr=100 print verbal information at every mtr traces  
ntr=100000 maximum number of input traces to be migrated  
npv=0 flag of computing quantities for velocity analysis  
rscale=1000.0 scaling for roundoff error suppression

...if npv>0 specify the following three files:  
tvfile=tvfile input file of traveltime variation tables  
tv[ns][nxt][nzt]  
csfile=csfile input file of cosine tables cs[ns][nxt][nzt]  
outfile1=outfile1 file containing additional migration output  
with extra amplitude

#### Notes:

1. Traveltime tables were generated by program rayt2d (or other ones) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the migration process, traveltimes are interpolated into shot/geophone positions and output grids.
2. Input seismic traces must be SU format and can be any type of gathers (common shot, common offset, common CDP, and so on). ",
3. Migrated traces are output in CDP gathers if velocity analysis is required, with dimension nxo\*noff\*nzo. ",
4. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
5. Memory requirement for this program is about  

$$[ns*nxt*nzt+noff*nxo*nzo+4*nr*nzt+5*nxt*nzt+npa*(2*ns*nxt*nzt+noff*nxo*nzo+4*nxt*nzt)]*4 \text{ bytes}$$
where  $nr = 1 + \min(nxt*dxt, 0.5*offmax+aperx)/dxo$ .
6. Amplitudes are computed using the reference velocity profile, v(z), specified by the parameters v0= and dvz=.
7. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx. Offset is computed automatically.
8. if limoff=0, input traces from outside the range defined by off0, doff, noff, will get migrated into the extremal offset bins/planes. E.g. if absoff=0 and limoff=0, all traces with gx<sx will get migrated into the off0 bin.

Author: Zhenyue Liu, 03/01/95, Colorado School of Mines

Modifications:

Gary Billings, Talisman Energy, Sept 2005: added absoff, limoff.

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: sx, gx

## SUKDMIG3D - Kirchhoff Depth Migration of 3D poststack/prestack data

sukdmig3d datain= dataout= [parameters]

Required parameters:

ttfile file for input tttables

Optional Parameters:

datain=stdin file for input seismic traces

dataout=stdout file for common offset migration output

crfile=NULL file for cos theta and ray paths

The following 17 parameters describe tttables: (from ttfile header)

fxgd= or from header (f1) first x-sample in tttable

nxt= or from header (ns) number of x-samples in tttable

dxgd= or from header (d1) x-interval in tttable

fygd= or from header (f2) first y-sample in tttable

nyt= or from header (ntr) number of y-samples in tttable

dygd= or from header (d2) y-interval in tttable

ixsf= or from header (sdel) x in dxgd of first source

nxs= or from header (nhs) number of sources in x

ixsr= or from header (swdep) ratio of source & gd spacing

iysf= or from header (gdel) y in dygd of first source

nys= or from header (nvs) number of sources in y

iysr= or from header (gwdep) ratio of source & gd spacing

fzs= or from header (sdepth/1000) first depth sample in tttable

nzs= or from header (duse) number of depth samples in tttable

dzs= or from header (ep/1000) depth interval in tttable

nxgd= or from header (selev) x size of the traveltime region

nygd= or from header (gelev) y size of the traveltime region

multit= or from header (scalel) number of multivalued traveltime

The following two parameters are from data header

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

dxm= or from header (d2) mid point spacing of input data

Default: output is 5 times finer in depth and 2 times finer in lateral

fzo=fzs z-coordinate of first point in output trace

dzo=0.2\*dzs vertical spacing of output trace (5 times finer)

nzo=5\*(nzs-1)+1 number of points in output trace (5 times finer) ",

fxo=fxgd x-coordinate of first output trace

$dxo=0.5*dxgd$  horizontal spacing of output trace (2 times finer)  
 $nxo=2*(nxgd-1)+1$  number of output traces (2 times finer)  
 $fyo=fygd$  y-coordinate of first output trace  
 $dyo=0.5*dygd$  horizontal spacing of output trace (2 times finer)  
 $nyo=2*(nygd-1)+1$  number of output traces (2 times finer)

Default: poststack migration "  
 $fxoffset=0$  first offset in output in x  
 $fyoffset=0$  first offset in output in y  
 $dxoffset=99999$  offset increment in output in x  
 $dyoffset=99999$  offset increment in output in y  
 $nxoffset=1$  number of offsets in output in x  
 $nyoffset=1$  number of offsets in output in y "  
 $xoffsetmax=99999$  x-maximum absolute offset allowed in migration  
 $yoffsetmax=99999$  y-maximum absolute offset allowed in migration  
 $xaper=nxt*dxgd/2.5$  migration lateral aperture in x  
 $yaper=nyt*dygd/2.5$  migration lateral aperture in y  
 $angmax=60$  max angle to handle  
 $fmax=0.25/dt$  max frequency in the data  
 $jpfile=stderr$  job print file name  
 $pptr=100$  print verbal information at every pptr traces  
 $ntrmax=100000$  maximum number of input traces to be migrated  
 $ls=0$  point =0 line source =1

#### Notes:

1. Traveltime tables were generated by program SUTETRRARY (or other ones) on very sparse tetrahedral model, with dimension  $nys*nxs*nzs*nyt*nxt$ .
2. Input seismic traces must be SU format and can be any type of gathers (common shot, common offset, common CDP, and so on). "
3. Migrated traces are output in CDP gathers if velocity analysis is required, with dimension  $nyoffset*nxoffset*nyo*nxo*nzo$ . "
4. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
5. Memory requirement for this program is about  
 $[nys*nxs*nzs*nyt*nxt+nyoffset*nxoffset*nxo*nyo*nzo+nys*nxo*nzo*nyt*nxt]$
6. Input traces must specify source and receiver positions via header fields  $tr.sx$  and  $tr.gx$ , as well as  $tr.sy$  and  $tr.gy$ . Offset is computed automatically.

#### Disclaimer:

This is a research code that will take considerable work to get into

the form of a a production level 3D migration code. The code is offered as is, along with tetramod and sutetrray, to provide a starting point for researchers who wish to write their own 3D migration codes.

Author: Zhaobo Meng, 01/10/97, Colorado School of Mines

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: sx, gx



SUKTMIG2D - prestack time migration of a common-offset section with the double-square root (DSR) operator

```
suktmig2d < infile vfile= [parameters] > outfile
```

Required Parameters:

vfile= rms velocity file (units/s)  $v(t,x)$  as a function of time  
dx= distance (units) between consecutive traces

Optional parameters:

fcdpdata=tr.cdp first cdp in data  
firstcdp=fcdpdata first cdp number in velocity file  
lastcdp=from header last cdp number in velocity file  
dcdp=from header number of cdp between consecutive traces  
angmax=40 maximum aperture angle for migration (degrees)  
hoffset=.5\*tr.offset half offset (m)  
nfc=16 number of Fourier-coefficients to approximate low-pass filters. The larger nfc the narrower the filter  
fwidth=5 high-end frequency increment for the low-pass filters  
in Hz. The lower this number the more the number of lowpass filters to be calculated for each input trace.

Caveat: this code may need some work

Notes:

Data must be preprocessed with sufrac to correct for the wave-shaping factor using phasefac=.25 for 2D migration.

Input traces must be sorted into offset and cdp number. The velocity file consists of rms velocities for all CMPs as a function of vertical time and horizontal position  $v(t,x)$  in C-style binary floating point numbers. It's easiest to supply  $v(t,x)$  that has the same dimensions as the input data to be migrated. Note that time  $t$  is the fast dimension in these the input velocity file.

The units may be feet or meters, as long as these are consistent.

Antialias filter is performed using (Gray,1992, Geoph. Prosp),

using nc low- pass filtered copies of the data. The cutoff frequencies are calculated as fractions of the Nyquist frequency.

The maximum allowed angle is 80 degrees(a 10 degree taper is applied to the end of the aperture)

```
define LOOKFAC 2      /* Look ahead factor for npfaro
define PFA_MAX 720720 /* Largest allowed nfft
```

```
    Prototype of functions used internally
void lpfilt(int nfc, int nfft, float dt, float fhi, float *filter);
```

```
segy intrace; /* input traces
segy outtrace; /* migrated output traces
```

```
int
main(int argc, char **argv)
{
    int i,k,imp,iip,it,ix,ifc; /* counters
    int ntr,nt; /* x,t
```

```
    int verbose; /* is verbose? */
    int nc; /* number of low-pass filtered versions */
    /* of the data for antialiasing */
    int nfft,nf; /* number of frequencies */
    int nfc; /* number of Fourier coefficients for low-pass filter
    int fwidth; /* high-end frequency increment for the low-pass
    /* filters */
    int firstcdp=0; /* first cdp in velocity file */
    int lastcdp=0; /* last cdp in velocity file */
    int oldcdp=0; /* temporary storage */
    int fcdpdata=0; /* first cdp in the data */
    int olddeltacdp=0;
    int deltacdp;
    int ncdp=0; /* number of cdps in the velocity file */
    int dcdp=0; /* number of cdps between consecutive traces
```

```
    float dx=0.0; /* cdp sample interval
    float hoffset=0.0; /* half receiver-source
    float p=0.0; /* horizontal slowness of the migration operator
    float pmin=0.0; /* maximum horizontal slowness for which there's
```

```

/* no aliasing of the operator
float dt; /* t sample interval
float h; /* offset
float x; /* aperture distance
float xmax=0.0; /* maximum aperture distance

float obliq; /* obliquity factor
float geoms; /* geometrical spreading factor
float angmax; /* maximum aperture angle

float mp,ip; /* mid-point and image-point coordinates
float t; /* time
float t0; /* vertical travelttime
float tmax; /* maximum time

float fnyq; /* Nyquist frequency
float ang; /* aperture angle
float angtaper=0.0; /* aperture-angle taper
float v; /* velocity

float *fc=NULL; /* cut-frequencies for low-pass filters
float *filter=NULL; /* array of low-pass filter values

float **vel=NULL; /* array of velocity values from vfile
float **data=NULL; /* input data array*/
float **lowpass=NULL; /* low-pass filtered version of the trace
float **mig=NULL; /* output migrated data array

register float *rtin=NULL,*rtout=NULL; /* real traces
register complex *ct=NULL; /* complex trace

/* file names
char *vfile=""; /* name of velocity file
FILE *vfp=NULL;
FILE *tracefp=NULL; /* temp file to hold traces*/
FILE *hfp=NULL; /* temp file to hold trace headers

float datalo[8], datahi[8];
int itb, ite;
float firstt, amplo, amphi;

cwp_Bool check_cdp=cwp_false; /* check cdp in velocity file */

```

```

/* Hook up getpar to handle the parameters
initargs(argc,argv);
requestdoc(0);

/* Get info from first trace
if (!gettr(&intrace)) err("can't get first trace");
nt=intrace.ns;
dt=(float)intrace.dt/1000000;
tmax=(nt-1)*dt;

MUSTGETPARFLOAT("dx",&dx);
MUSTGETPARSTRING("vfile",&vfile);
if (!getparfloat("angmax",&angmax)) angmax=40;
if (!getparint("firstcdp",&firstcdp)) firstcdp=intrace.cdp;
if (!getparint("fcdpdata",&fcdpdata)) fcdpdata=intrace.cdp;
if (!getparfloat("hoffset",&hoffset)) hoffset=.5*intrace.offset;
if (!getparint("nfc",&nfc)) nfc=16;
if (!getparint("fwidth",&fwidth)) fwidth=5;
if (!getparint("verbose",&verbose)) verbose=0;

h=hoffset;

/* Store traces in tmpfile while getting a count of number of traces
tracefp = etmpfile();
hfp = etmpfile();
ntr = 0;
do {
++ntr;

/* get new deltacdp value
deltacdp=intrace.cdp-oldcdp;

/* read headers and data
efwrite(&intrace,HDRBYTES, 1, hfp);
efwrite(intrace.data, FSIZE, nt, tracefp);

/* error trappings.
/* ...did cdp value interval change?
if ((ntr>3) && (olddeltacdp!=deltacdp)) {

if (verbose) {
warn("cdp interval changed in data");
warn("ntr=%d olddeltacdp=%d deltacdp=%d"

```

```

,ntr,olddeltacdp,deltacdp);
    check_cdp=cwp_true;
}
}

/* save cdp and deltacdp values
oldcdp=intrace.cdp;
olddeltacdp=deltacdp;

} while (gettr(&intrace));

/* get last cdp and dcdp
if (!getparint("lastcdp",&lastcdp)) lastcdp=intrace.cdp;
if (!getparint("dcdp",&dcdp)) dcdp=deltacdp - 1;

checkpars();

/* error trappings
if ( (firstcdp==lastcdp)
|| (dcdp==0)
|| (check_cdp==cwp_true) ) warn("Check cdp values in data!");

/* rewind trace file pointer and header file pointer
erewind(tracefp);
erewind(hfp);

/* total number of cdp's in data
ncdp=lastcdp-firstcdp+1;

/* Set up FFT parameters
nfft = npfaro(nt, LOOKFAC*nt);
if(nfft>= SU_NFLTS || nfft >= PFA_MAX)
    err("Padded nt=%d -- too big",nfft);
nf = nfft/2 + 1;

/* Determine number of filters for antialiasing
fnyq= 1.0/(2*dt);
nc=ceil(fnyq/fwidth);
if (verbose)
warn(" The number of filters for antialiasing is nc= %d",nc);

/* Allocate space

```

```

data = alloc2float(nt,ntr);
lowpass=alloc2float(nt,nc+1);
mig=    alloc2float(nt,ntr);
vel=    alloc2float(nt,ncdp);
fc = alloc1float(nc+1);
rtin= ealloc1float(nfft);
rtout= ealloc1float(nfft);
ct= ealloc1complex(nf);
filter= alloc1float(nf);

/* Read data from temporal array
for (ix=0; ix<ntr; ++ix){
efread(data[ix],FSIZE,nt,tracefp);
}

/* read velocities
vfp=fopen(vfile,"r");
efread(vel[0],FSIZE,nt*ncdp,vfp);
efclose(vfp);

/* Zero all arrays
memset((void *) mig[0], 0,nt*ntr*FSIZE);
memset((void *) rtin, 0, nfft*FSIZE);
memset((void *) filter, 0, nf*FSIZE);
memset((void *) lowpass[0], 0,nt*(nc+1)*FSIZE);

/* Calculate cut frequencies for low-pass filters
for(i=1; i<nc+1; ++i){
fc[i]= fnyq*i/nc;
}

/* Start the migration process
/* Loop over input mid-points first
if (verbose) warn("Starting migration process...\n");
for(imp=0; imp<ntr; ++imp){
float perc;

mp=imp*dx;
perc=imp*100.0/(ntr-1);
if(fmod(imp*100,ntr-1)==0 && verbose)
warn("migrated %g\n ",perc);

/* Calculate low-pass filtered versions

```

```

/* of the data to be used for antialiasing
for(it=0; it<nt; ++it){
rtin[it]=data[imp][it];
}
for(afc=1; afc<nc+1; ++afc){
memset((void *) rtout, 0, nfft*FSIZE);
memset((void *) ct, 0, nf*FSIZE);
lpfilt(nfc,nfft,dt,fc[afc],filter);
pfarc(1,nfft,rtin,ct);

for(it=0; it<nf; ++it){
ct[it] = crmul(ct[it],filter[it]);
}
pfacr(-1,nfft,ct,rtout);
for(it=0; it<nt; ++it){
lowpass[afc][it]= rtout[it];
}
}

/* Loop over vertical traveltimes
for(it=0; it<nt; ++it){
int lx,ux;

t0=it*dt;
v=vel[imp*dcdp+fcddpdata-1][it];
xmax=tan((angmax+10.0)*PI/180.0)*v*t0;
lx=MAX(0,imp - ceil(xmax/dx));
ux=MIN(ntr,imp + ceil(xmax/dx));

/* loop over output image-points to the left of the midpoint
for(iip=imp; iip>lx; --iip){
float ts,tr;
int fplo=0, fphi=0;
float ref,wlo,whi;

ip=iip*dx;
x=ip-mp;
ts=sqrt( pow(t0/2,2) + pow((x+h)/v,2) );
tr=sqrt( pow(t0/2,2) + pow((h-x)/v,2) );
t= ts + tr;
if(t>=tmax) break;
geoms=sqrt(1/(t*v));
obliq=sqrt(.5*(1 + (t0*t0/(4*ts*tr)))

```

```

- (1/(ts*tr))*sqrt(ts*ts - t0*t0/4)*sqrt(tr*tr - t0*t0/4));
    ang=180.0*fabs(acos(t0/t))/PI;
    if(ang<=angmax) angtaper=1.0;
    if(ang>angmax) angtaper=cos((ang-angmax)*PI/20);
    /* Evaluate migration operator slowness p to determine
/* the low-pass filtered trace for antialiasing
pmin=1/(2*dx*fnyq);
p=fabs((x+h)/(pow(v,2)*ts) + (x-h)/(pow(v,2)*tr));
if(p>0){fplo=floor(nc*pmin/p);}
if(p==0){fplo=nc;}
ref=fmod(nc*pmin,p);
wlo=1-ref;
fphi=++fplo;
whi=ref;
itb=MAX(ceil(t/dt)-3,0);
ite=MIN(itb+8,nt);
firstt=(itb-1)*dt;
/* Move energy from CMP to CIP
if(fplo>=nc){
for(k=itb; k<ite; ++k){
datalo[k-itb]=lowpass[nc][k];
}
ints8r(8,dt,firstt,datalo,0.0,0.0,1,&t,&amplo);
mig[iip][it] +=geoms*obliq*angtaper*amplo;
} else if(fplo<nc){
for(k=itb; k<ite; ++k){
datalo[k-itb]=lowpass[fplo][k];
datahi[k-itb]=lowpass[fphi][k];
}
ints8r(8,dt,firstt,datalo,0.0,0.0,1,&t,&amplo);
ints8r(8,dt,firstt,datahi,0.0,0.0,1,&t,&amphi);
mig[iip][it] += geoms*obliq*angtaper*(wlo*amplo + whi*amphi);
}
}

/* loop over output image-points to the right of the midpoint
for(iip=imp+1; iip<ux; ++iip){
float ts,tr;
int fplo=0, fphi;
float ref,wlo,whi;

ip=iip*dx;
x=ip-mp;

```



```

t0=it*dt;
ts=sqrt( pow(t0/2,2) + pow((x+h)/v,2) );
tr=sqrt( pow(t0/2,2) + pow((h-x)/v,2) );
t= ts + tr;
if(t>=tmax) break;
geoms=sqrt(1/(t*v));
obliq=sqrt(.5*(1 + (t0*t0/(4*ts*tr))
- (1/(ts*tr))*sqrt(ts*ts
- t0*t0/4)*sqrt(tr*tr
- t0*t0/4)));
ang=180.0*fabs(acos(t0/t))/PI;
if(ang<=angmax) angtaper=1.0;
if(ang>angmax) angtaper=cos((ang-angmax)*PI/20.0);

/* Evaluate migration operator slowness p to determine the
/* low-pass filtered trace for antialiasing
pmin=1/(2*dx*fnyq);
p=fabs((x+h)/(pow(v,2)*ts) + (x-h)/(pow(v,2)*tr));
if(p>0){
fplo=floor(nc*pmin/p);
}
if(p==0){
fplo=nc;
}

ref=fmod(nc*pmin,p);
wlo=1-ref;
fphi=fplo+1;
whi=ref;
itb=MAX(ceil(t/dt)-3,0);
ite=MIN(itb+8,nt);
firstt=(itb-1)*dt;

/* Move energy from CMP to CIP
if(fplo>=nc){
for(k=itb; k<ite; ++k){
datalo[k-itb]=lowpass[nc][k];
}
ints8r(8,dt,firstt,datalo,0.0,0.0,1,&t,&ampl);
mig[iip][it] +=geoms*obliq*angtaper*ampl;
} else if(fplo<nc){
for(k=itb; k<ite; ++k){
datalo[k-itb]=lowpass[fplo][k];
}

```

```

datahi[k-itb]=lowpass[fphi][k];
}
ints8r(8,dt,firstt,datalo,0.0,0.0,1,&t,&ampl);
ints8r(8,dt,firstt,datahi,0.0,0.0,1,&t,&amphi);
mig[iip][it] += geoms*obliq*angtaper*(wlo*ampl + whi*amphi);
}
}

}
}

/* Output migrated data
erewind(hfp);
for (ix=0; ix<ntr; ++ix) {
efread(&outtrace, HDRBYTES, 1, hfp);
for (it=0; it<nt; ++it) {
outtrace.data[it] = mig[ix][it];
}
puttr(&outtrace);
}

efclose(hfp);

return(CWP_Exit());
}

void
lpfilt(int nfc, int nfft, float dt, float fhi, float *filter)
lpfilt -- low-pass filter using Lanczos Smoothing
(R.W. Hamming:"Digital Filtering",1977)
Input:
nfc number of Fourier coefficients to approximate ideal filter
nfft number of points in the fft
dt time sampling interval
fhi cut-frequency

Output:
filter array[nf] of filter values
Notes: Filter is to be applied in the frequency domain
Author: CWP: Carlos Pacheco 2006
{
int i,j; /* counters
int nf; /* Number of frequencies (including Nyquist)

```

```

float onfft; /* reciprocal of nfft
float fn; /* Nyquist frequency
float df; /* frequency interval
float dw; /* frequency interval in radians
float whi; /* cut-frequency in radians
float w; /* radian frequency

nf= nfft/2 + 1;
onfft=1.0/nfft;
fn=1.0/(2*dt);
df=onfft/dt;
whi=fhi*PI/fn;
dw=df*PI/fn;

for(i=0; i<nf; ++i){
filter[i]= whi/PI;
w=i*dw;

for(j=1; j<nfc; ++j){
float c= sin(whi*j)*sin(PI*j/nfc)*2*nfc/(PI*PI*j*j);
filter[i] +=c*cos(j*w);
}
}
}

```

SUMIGFD - 45-90 degree Finite difference depth migration for zero-offset data.

sumigfd <infile >outfile vfile= [optional parameters]

Required Parameters:

nz= number of depth samples

dz= depth sampling interval

vfile= name of file containing velocities

(see Notes below concerning format of this file)

Optional Parameters:

dt=from header(dt) or .004 time sampling interval

dx=from header(dx) or 1.0 midpoint sampling interval

dip=45,65,79,80,87,89,90 Maximum angle of dip reflector

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes: ",

The computation cost by dip angle is 45=65=79<80<87<89<90

The input velocity file \'vfile\' consists of C-style binary floats. ",  
The structure of this file is vfile[iz][ix]. Note that this means that  
the x-direction is the fastest direction instead of z-direction! Such a  
structure is more convenient for the downward continuation type  
migration algorithm than using z as fastest dimension as in other SU  
programs. (In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]  
denotes a v(z,x) array, the opposite of what Matlab and Fortran  
programmers may expect.) ",

Because most of the tools in the SU package (such as unif2, unisam2,  
and makevel) produce output with the structure vfile[ix][iz], you will  
need to transpose the velocity files created by these programs. You may  
use the SU program \'transp\' in SU to transpose such files into the  
required vfile[iz][ix] structure.

Credits: CWP Baoniu Han, April 20th, 1998

Trace header fields accessed: ns, dt, delrt, d2  
Trace header fields modified: ns, dt, delrt

SUMIGFFD - Fourier finite difference depth migration for zero-offset data. This method is a hybrid migration which combines the advantages of phase shift and finite difference", migrations.

sumigffd <infile >outfile vfile= [optional parameters]

Required Parameters:

nz= number of depth samples ",  
dz= depth sampling interval  
vfile= name of file containing velocities

Optional Parameters:

dt=from header(dt) or .004 time sampling interval  
dx=from header(d2) or 1.0 midpoint sampling interval  
ft=0.0 first time sample  
fz=0.0 first depth sample

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

The input velocity file \'vfile\' consists of C-style binary floats. ",  
The structure of this file is vfile[iz][ix]. Note that this means that  
the x-direction is the fastest direction instead of z-direction! Such a  
structure is more convenient for the downward continuation type  
migration algorithm than using z as fastest dimension as in other SU ",  
programs. (In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]  
denotes a v(z,x) array, the opposite of what Matlab and Fortran  
programmers may expect.) ",

Because most of the tools in the SU package (such as unif2, unisam2, ",  
and makevel) produce output with the structure vfile[ix][iz], you will  
need to transpose the velocity files created by these programs. You may  
use the SU program \'transp\' in SU to transpose such files into the  
required vfile[iz][ix] structure.

Credits: CWP Baoniu Han, July 21th, 1997

Trace header fields accessed: ns, dt, delrt, d2  
Trace header fields modified: ns, dt, delrt

SUMIGGBZOAN - MIGration via Gaussian beams ANisotropic media (P-wave)

sumiggbzoan <infile >outfile vfile= nt= nx= nz= [optional parameters]

Required Parameters:

a3333file= name of file containing a3333(x,z)  
nx= number of inline samples (traces)  
nz= number of depth samples

Optional Parameters:

dt=tr.dt time sampling interval  
dx=tr.d2 inline sampling interval (trace spacing)  
dz=1.0 depth sampling interval  
fmin=0.025/dt minimum frequency  
fmax=10\*fmin maximum frequency  
amin=-amax minimum emergence angle; must be > -90 degrees  
amax=60 maximum emergence angle; must be < 90 degrees  
bwh=0.5\*vavg/fmin beam half-width; vavg denotes average velocity  
verbose=0 silent, =1 chatty

Files for general anisotropic parameters confined to a vertical plane:

a1111file= name of file containing a1111(x,z)  
a1133file= name of file containing a1133(x,z)  
a1313file= name of file containing a1313(x,z)  
a1113file= name of file containing a1113(x,z)  
a3313file= name of file containing a3313(x,z)

For transversely isotropic media Thomsen's parameters could be used:

deltafile= name of file containing delta(x,z)  
epsilonfile= name of file containing epsilon(x,z)  
a1313file= name of file containing a1313(x,z)

if anisotropy parameters are not given the program considers "  
the medium to be isotropic.

Credits:

CWP: Tariq Alkhalifah, based on MIGGBZO by Dave Hale

CWP: repackaged as an SU program by John Stockwell, April 2006

Technical Reference:

Alkhailfah, T., 1993, Gaussian beam migration for



anisotropic media: submitted to Geophysics.

Cerveny, V., 1972, Seismic rays and ray intensities  
in inhomogeneous anisotropic media:  
Geophys. J. R. Astr. Soc., 29, 1--13.

Hale, D., 1992, Migration by the Kirchhoff,  
slant stack, and Gaussian beam methods:  
CWP,1992 Report 121, Colorado School of Mines.

Hale, D., 1992, Computational Aspects of Gaussian  
Beam migration:  
CWP,1992 Report 121, Colorado School of Mines.

SUMIGGBZO - MIGration via Gaussian Beams of Zero-Offset SU data

sumiggbzo <infile >outfile vfile= nz= [optional parameters]

Required Parameters:

vfile=	name of file containing v(z,x)
nz=	number of depth samples

Optional Parameters:

dt=	from header time sampling interval
dx=	from header(d2) or 1.0 spatial sampling interval
dz=	1.0 depth sampling interval
fmin=	0.025/dt minimum frequency
fmax=	10*fmin maximum frequency
amin=	-amax minimum emergence angle; must be > -90 degrees
amax=	60 maximum emergence angle; must be < 90 degrees
bwh=	0.5*vavg/fmin beam half-width; vavg denotes average velocity
verbose=	0 =0 silent; =1 chatty

Note: spatial units of v(z,x) must be the same as those of dx.  
v(z,x) is represented numerically in C-style binary floats v[x][z],  
where the depth direction is the fast direction in the data. Such  
models can be created with unif2 or makevel.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]  
denotes a v(z,x) array, the opposite of what Matlab and Fortran  
programmers may expect.) ",

Caveat:

In the event of a "Segmentation Violation" try reducing the value of  
the "bwh" parameter. Run program with verbose=1 do see the default  
value.

Credits:

CWP: Dave Hale (algorithm), Jack K. Cohen, and John Stockwell  
(reformatting for SU)

SUMIGPREFD --- The 2-D prestack common-shot 45-90 degree finite-difference depth migration.

```
sumigprefd <indata >outfile [parameters] ",
```

Required Parameters: ",

nxo= number of total horizontal output samples

nxshot= number of shot gathers to be migrated

nz= number of depth samples

dx= horizontal sampling interval ",

dz= depth sampling interval

vfile= velocity profile, it must be binary format (see Notes)

Optional Parameters:

dip=79 the maximum dip to migrate, possible values are:

45,65,79,80,87,89,90 degrees

The computation cost is 45<65<79<80<87<89<90

fmax=25 peak frequency of Ricker wavelet used as source wavelet

f1=5,f2=10,f3=40,f4=50 frequencies to build a Hamming window

lpad=9999, rpad=9999 number of zero traces padded on both sides of depth section to determine the migration aperture, the default values are using the full aperture.

verbose=0 silent, =1 additional runtime information

Notes:

The input velocity file \'vfile\' consists of C-style binary floats.

The structure of this file is vfile[iz][ix]. Note that this means that the x-direction is the fastest direction instead of z-direction! Such a structure is more convenient for the downward continuation type migration algorithm than using z as fastest dimension as in other SU programs.

Because most of the tools in the SU package (such as unif2, unisam2, ", and makevel) produce output with the structure vfile[ix][iz], you will need to transpose the velocity files created by these programs. You may use the SU program \'transp\' in SU to transpose such files into the required vfile[iz][ix] structure.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz] denotes a v(z,x) array, the opposite of what Matlab and Fortran programmers may expect.) ",

Also, `sx` must be monotonically increasing throughout the dataset, and `gx` must be monotonically increasing within a shot. You may resort your data with `\susort\`, accordingly.

The `scalco` header field is honored so this field must be set correctly. See selfdocs of `\susort\`, `\suchw\`. Also: `sukeyword scalco`

Credits: CWP, Baoniu Han, `bhan@dix.mines.edu`, April 19th, 1998

Modified: Chris Stolk, 11 Dec 2005, - changed data input  
to remove erroneous time delay.

Modified: CWP, John Stockwell 26 Sept 2006 - replaced Han's  
"goto-loop" in two places with "do { }while loops".

Fixed it so that `sx`, `gx`, and `scalco` are honored.

Trace header fields accessed: `ns`, `dt`, `delrt`, `d2`, `sx`, `gx`,

Trace header fields modified: `ns`, `dt`, `delrt`

SUMIGPREFFD - The 2-D prestack common-shot Fourier finite-difference depth migration.

```
sumigpreffd <indata >outfile [parameters] ",
```

Required Parameters: ",

nxo= number of total horizontal output samples

nxshot= number of shot gathers to be migrated

nz= number of depth samples

dx= horizontal sampling interval

dz= depth sampling interval

vfile= velocity profile, it must be binary format.

Optional Parameters:

fmax=25 the peak frequency of Ricker wavelet used as source wavelet

f1=5,f2=10,f3=40,f4=50 frequencies to build a Hamming window

lpad=9999, rpad=9999 number of zero traces padded on both sides of depth section to determine the

migration aperture, the default

values are using the full aperture.

verbose=0 silent, =1 additional runtime information

Notes:

The input velocity file consists of C-style binary floats. ",

The structure of this file is vfile[iz][ix]. Note that this means that the x-direction is the fastest direction instead of z-direction! Such a structure is more convenient for the downward continuation type migration algorithm than using z as fastest dimension as in other SU ", programs.

Because most of the tools in the SU package (such as unif2, unisam2, ", and makevel) produce output with the structure vfile[ix][iz], you will need to transpose the velocity files created by these programs. You may use the SU program \'transp\' in SU to transpose such files into the required vfile[iz][ix] structure.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz] denotes a v(z,x) array, the opposite of what Matlab and Fortran programmers may expect.) ",

Also, sx must be monotonically increasing throughout the dataset, and gx must be monotonically increasing within a shot. You may resort your data with \'susort\' , accordingly.

The scalco header field is honored so this field must be set correctly.  
See selfdocs of \'susort\', \'suchw\'. Also: sukeyword scalco

Credits: CWP, Baoniu Han, bhan@dix.mines.edu, April 19th, 1998

Modified: Chris Stolk, 11 Dec 2005, - changed data input  
to remove erroneous time delay.

Modified: CWP, John Stockwell 26 Sept 2006 - replaced Han's  
"goto-loop" with "do { }while loops".

Fixed it so that sx, gx, and scalco are honored.

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: ns, dt, delrt

```

char *sdoc[] = {

" SUMIGPREPSPI --- The 2-D PREstack commom-shot Phase-Shift-Plus
" interpolation depth MIGration.

"   sumigprepspi <indata >outfile [parameters] ",

" Required Parameters:

" nxo=      number of total horizontal output samples
" nxshot=   number of shot gathers to be migrated
" nz=       number of depth samples
" dx=       horizontal sampling interval    ",
" dz=       depth sampling interval
" vfile=    velocity profile, it must be binary format.

" Optional Parameters:
" fmax=25    the peak frequency of Ricker wavelet used as source wavelet
" f1=5,f2=10,f3=40,f4=50    frequencies to build a Hamming window
" lpad=9999, rpad=9999      number of zero traces padded on both
"                            sides of depth section to determine the
"                            migration aperture, the default values
"                            are using the full aperture.
" nflag=0    normalization of cross-correlation:
"            0: none, 1: by source wave field
" verbose=0  silent, =1 additional runtime information

" Notes:
" The input velocity file \'vfile\' consists of C-style binary floats. ",
" The structure of this file is vfile[iz][ix]. Note that this means that
" the x-direction is the fastest direction instead of z-direction! Such a
" structure is more convenient for the downward continuation type
" migration algorithm than using z as fastest dimension as in other SU  ",
" programs.

" Because most of the tools in the SU package (such as  unif2, unisam2, ",
" and makevel) produce output with the structure vfile[ix][iz], you will
" need to transpose the velocity files created by these programs. You may
" use the SU program \'transp\' in SU to transpose such files into the
" required vfile[iz][ix] structure.

" (In C  v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]
" denotes a v(z,x) array, the opposite of what Matlab and Fortran

```

" programmers may expect.) ",

" Also, sx must be monotonically increasing throughout the dataset, and  
" and gx must be monotonically increasing within a shot. You may resort  
" your data with \'susort\', accordingly.

" The scalco header field is honored so this field must be set correctly.  
" See selfdocs of \'susort\', \'suchw\'. Also:   sukeyword scalco

\* Credits: CWP, Baoniu Han, bhan@dix.mines.edu, April 19th, 1998  
\*   Modified: Chris Stolk, 11 Dec 2005, - changed data input  
\*   to remove erroneous time delay.  
\*   Modified: CWP, John Stockwell 26 Sept 2006 - replaced Han's  
\*   "goto-loop" in two places with "do { }while loops".  
\*   Fixed it so that sx, gx, and scalco are honored.  
\*  
\*  
\* Trace header fields accessed: ns, dt, delrt, d2  
\* Trace header fields modified: ns, dt, delrt



SUMIGPRESP - The 2-D prestack common-shot split-step Fourier ",  
migration

sumigpresp <indata >outfile [parameters] ",

Required Parameters:

nxo= number of total horizontal output samples  
nxshot= number of shot gathers to be migrated  
nz= number of depth samples  
dx= horizontal sampling interval  
dz= depth sampling interval  
vfile= velocity profile, it must be binary format.

Optional Parameters:

fmax=25 The peak frequency of Ricker wavelet used as source wavelet  
f1=5,f2=10,f3=40,f4=50 frequencies to build a Hamming window  
lpad=9999, rpad=9999 number of zero traces padded on both  
sides of depth section to determine the  
migration aperture, the default values  
are using the full aperture.  
verbose=0 silent, =1 additional runtime information

Notes:

The input velocity file consists of C-style binary floats.  
The structure of this file is vfile[iz][ix]. Note that this means that  
the x-direction is the fastest direction instead of z-direction! Such a  
structure is more convenient for the downward continuation type  
migration algorithm than using z as fastest dimension as in other SU  
programs.

Because most of the tools in the SU package (such as unif2, unisam2, ",  
and makevel) produce output with the structure vfile[ix][iz], you will  
need to transpose the velocity files created by these programs. You may  
use the SU program \'transp\' in SU to transpose such files into the  
required vfile[iz][ix] structure.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]  
denotes a v(z,x) array, the opposite of what Matlab and Fortran  
programmers may expect.) ",

Also, sx must be monotonically increasing throughout the dataset, and  
gx must be monotonically increasing within a shot. You may resort  
your data with \'susort\', accordingly.

The scalco header field is honored so this field must be set correctly.  
See selfdocs of \'susort\', \'suchw\'. Also:   sukeyword scalco

Credits: CWP, Baoniu Han, bhan@dix.mines.edu, April 19th, 1998  
Modified: Chris Stolk, 11 Dec 2005, - changed data input  
          to remove erroneous time delay.  
Modified: CWP, John Stockwell 26 Sept 2006 - replaced Han's  
"goto-loop" in two places with "do { }while loops".  
Fixed it so that sx, gx, and scalco are honored.

Trace header fields accessed: ns, dt, delrt, d2, sx, gx, scalco  
Trace header fields modified: ns, dt, delrt

SUMIGPSPI - Gazdag's phase-shift plus interpolation depth migration  
for zero-offset data, which can handle the lateral  
velocity variation.

sumigpspi <infile >outfile vfile= [optional parameters]

Required Parameters:

nz= number of depth samples

dz= depth sampling interval

vfile= name of file containing velocities

(Please see Notes below concerning the format of vfile)

Optional Parameters:

dt=from header(dt) or .004      time sampling interval

dx=from header(d2) or 1.0      midpoint sampling interval

tmpdir=            if non-empty, use the value as a directory path  
                  prefix for storing temporary files; else if the  
                  the CWP\_TMPDIR environment variable is set use  
                  its value for the path; else use tmpfile()

Notes:

The input velocity file 'vfile' consists of C-style binary floats.  
The structure of this file is vfile[iz][ix]. Note that this means that  
the x-direction is the fastest direction instead of z-direction! Such a  
structure is more convenient for the downward continuation type  
migration algorithm than using z as fastest dimension as in other SU  
programs. (In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz]  
denotes a v(z,x) array, the opposite of what Matlab and Fortran  
programmers may expect.)

Because most of the tools in the SU package (such as unif2, unisam2,  
and makevel) produce output with the structure vfile[ix][iz], you will  
need to transpose the velocity files created by these programs. You may  
use the SU program 'transp' in SU to transpose such files into the  
required vfile[iz][ix] structure.

Credits: CWP, Baoniu Han, April 20th, 1998

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: ns, dt, delrt

SUMIGPS - MIGration by Phase Shift with turning rays

sumigps <stdin >stdout [optional parms]

Required Parameters:

None

Optional Parameters:

dt=from header(dt) or .004 time sampling interval  
dx=from header(d2) or 1.0 distance between successive cdp's  
ffil=0,0,0.5/dt,0.5/dt trapezoidal window of frequencies to migrate  
tmig=0.0 times corresponding to interval velocities in vmig  
vmig=1500.0 interval velocities corresponding to times in tmig  
vfile= binary (non-ascii) file containing velocities v(t)  
nxpad=0 number of cdp's to pad with zeros before FFT  
ltaper=0 length of linear taper for left and right edges",  
verbose=0 =1 for diagnostic print

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

Input traces must be sorted by either increasing or decreasing cdp.

The tmig and vmig arrays specify an interval velocity function of time. Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in tmig must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the tmig and vmig arrays are ignored.

The time of first sample is assumed to be zero, regardless of the value of the trace header field delrt.

Credits:

CWP: Dave Hale (originally called supsmig.c)

Trace header fields accessed: ns, dt, d2



SUMIGPSTI - MIGration by Phase Shift for TI media with turning rays

sumigpsti <stdin >stdout [optional parms]

Required Parameters:

None

Optional Parameters:

dt=from header(dt) or .004 time sampling interval  
dx=from header(d2) or 1.0 distance between successive cdp's  
ffil=0,0,0.5/dt,0.5/dt trapezoidal window of frequencies to migrate  
tmig=0.0 times corresponding to interval velocities in vmig  
vnmig=1500.0 interval NMO velocities corresponding to times in tmig  
vmig=1500.0 interval velocities corresponding to times in tmig  
etamig=0.0 interval eta values corresponding to times in tmig  
vnfile= binary (non-ascii) file containing NMO velocities vn(t)  
vfile= binary (non-ascii) file containing velocities v(t)  
etafile= binary (non-ascii) file containing eta values eta(t)  
nxpad=0 number of cdp's to pad with zeros before FFT  
ltaper=0 length of linear taper for left and right edges "  
verbose=0 =1 for diagnostic print

Notes:

Input traces must be sorted by either increasing or decreasing cdp.

The tmig, vnmig, vmig and etamig arrays specify an interval values function of time. Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in tmig must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vnfile is specified, then the tmig and vnmig arrays are ignored.

The time of first sample is assumed to be zero, regardless of the value of the trace header field delrt.

Trace header fields accessed: ns and dt

SUMIGSPLIT - Split-step depth migration for zero-offset data.

sumigsplit <infile >outfile vfile= [optional parameters]

Required Parameters:

nz=	number of depth samples
dz=	depth sampling interval
vfile=	name of file containing velocities

Optional Parameters:

dt=from header(dt) or .004	time sampling interval
dx=from header(dx) or 1.0	midpoint sampling interval
ft=0.0	first time sample
fz=	first depth sample

tmpdir=	if non-empty, use the value as a directory path prefix for storing temporary files; else if the the CWP_TMPDIR environment variable is set use its value for the path; else use tmpfile()
---------	--

Notes:

The input velocity file \'vfile\' consists of C-style binary floats. The structure of this file is vfile[iz][ix]. Note that this means that the x-direction is the fastest direction instead of z-direction! Such a structure is more convenient for the downward continuation type migration algorithm than using z as fastest dimension as in other SU programs.

Because most of the tools in the SU package (such as unif2, unisam2, and makevel) produce output with the structure vfile[ix][iz], you will need to transpose the velocity files created by these programs. You may use the SU program \'transp\' in SU to transpose such files into the required vfile[iz][ix] structure.

(In C v[iz][ix] denotes a v(x,z) array, whereas v[ix][iz] denotes a v(z,x) array, the opposite of what Matlab and Fortran programmers may expect.) ",

Credits: CWP Baoniu Han, July 21th, 1997

Reference:



Stoffa, P. L. and Fokkema, J. T. and Freire, R. M. and Kessinger, W. P.,  
1990, Split-step Fourier migration, Geophysics, 55, 410-421.

Trace header fields accessed: ns, dt, delrt, d2

Trace header fields modified: ns, dt, delrt

SUMIGTK - MIGration via T-K domain method for common-midpoint stacked data

sumigtk <stdin >stdout dxcdp= [optional parms]

Required Parameters:

dxcdp                                distance between successive cdps

Optional Parameters:

fmax=Nyquist                        maximum frequency  
tmig=0.0                            times corresponding to interval velocities in vmig  
vmig=1500.0                        interval velocities corresponding to times in tmig  
vfile=                              binary (non-ascii) file containing velocities v(t)  
nxpad=0                            number of cdps to pad with zeros before FFT  
ltaper=0                           length of linear taper for left and right edges",  
verbose=0                           =1 for diagnostic print

tmpdir=    if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
          the CWP\_TMPDIR environment variable is set use  
          its value for the path; else use tmpfile()

Notes:

Input traces must be sorted by either increasing or decreasing cdp.

The tmig and vmig arrays specify an interval velocity function of time. Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in tmig must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the tmig and vmig arrays are ignored.

The time of first sample is assumed to be zero, regardless of the value of the trace header field delrt.

The migration is a reverse time migration in the (t,k) domain. In the first step, the data  $g(t,x)$  are Fourier transformed  $x \rightarrow k$  into the ", the time-wavenumber domain  $g(t,k)$ .

Then looping over wavenumbers, the data are then reverse-time finite-difference migrated, wavenumber by wavenumber. The resulting migrated data  $m(\tau,k)$ , now in the tau (migrated time) and k domain,

are inverse fourier transformed back into  $m(\tau, x_{out})$  and written out.",

Credits:

CWP: Dave Hale

Trace header fields accessed: ns and dt

SUMIGTOP02D - Kirchhoff Depth Migration of 2D poststack/prestack data  
from the (variable topography) recording surface

sumigtopo2d infile= outfile= [parameters]

Required parameters:

infile=stdin file for input seismic traces

outfile=stdout file for common offset migration output

tfile file for input traveltime tables

The following 9 parameters describe traveltime tables:

fzt first depth sample in traveltime table

nzt number of depth samples in traveltime table

dzt depth interval in traveltime table

fxt first lateral sample in traveltime table

nxt number of lateral samples in traveltime table

dxt lateral interval in traveltime table

fs x-coordinate of first source

ns number of sources

ds x-coordinate increment of sources

fxi x-coordinate of the first input trace

dx horizontal spacing of input data

nxi number of input trace locations in surface

Optional Parameters:

dt= or from header (dt) time sampling interval of input data

ft= or from header (ft) first time sample of input data

dxm= or from header (d2) sampling interval of midpoints

surf="0,0;99999,0" Recording surface "x1,z1;x2,z2;x3,z3;...

fzo=fzt z-coordinate of first point in output trace

dzo=0.2\*dzt vertical spacing of output trace

nzo=5\*(nzt-1)+1 number of points in output trace "

fxo=fxt x-coordinate of first output trace

dxo=0.5\*dxt horizontal spacing of output trace

nxo=2\*(nxt-1)+1 number of output traces "

off0=0 first offset in output

doff=99999 offset increment in output

noff=1 number of offsets in output "

fmax=0.25/dt frequency-highcut for input traces

offmax=99999 maximum absolute offset allowed in migration

aperx=nxt\*dxt/2 migration lateral aperture

angmax=60 migration angle aperture from vertical

v0=1500(m/s) reference velocity value at surface "

dvz=0.0    reference velocity vertical gradient  
ls=1                      flag for line source  
jpfile=stderr job print file name  
mtr=100    print verbal information at every mtr traces  
ntr=100000 maximum number of input traces to be migrated

Notes:

1. Traveltime tables were generated by program rayt2dtopo (or any other one that considers topography) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the migration process, traveltimes are interpolated into shot/geophone positions and output grids.
2. Input seismic traces must be SU format and can be any type of gathers (common shot, common offset, common CDP, and so on). ",
3. Migrated traces are output in CDP gathers if velocity analysis is required, with dimension nxo\*noff\*nzo. ",
4. If the offset value of an input trace is not in the offset array of output, the nearest one in the array is chosen.
5. Amplitudes are computed using the reference velocity profile,  $v(z)$ , specified by the parameters  $v0=$  and  $dvz=$ .
6. Input traces must specify source and receiver positions via the header fields tr.sx and tr.gx. Offset is computed automatically.

Author: Zhenyue Liu, 03/01/95, Colorado School of Mines

Trino Salinas, 07/01/96, Colorado School of Mines,  
extended the code to migrate data from a nonflat  
recording surface.

References :

- Bleistein, N., Cohen, J., and Hagin, F., 1987, Two and one-half dimensional Born inversion with arbitrary reference: Geophysics, 52, 26-36.
- Liu, Z., 1993, A Kirchhoff approach to seismic modeling and pre-stack depth migration: CWP Annual Report, CWP, Colorado School of Mines.
- Wiggins, J. W., 1984, Kirchhoff integral extrapolation and migration of nonplanar data: Geophysics, 49, 1239-1248.

SUSTOLT - Stolt migration for stacked data or common-offset gathers

sustolt <stdin >stdout cdpmin= cdpmax= dxcdp= noffmix= [...]

Required Parameters:

cdpmin= minimum cdp (integer number) in dataset  
cdpmax= maximum cdp (integer number) in dataset  
dxcdp= distance between adjacent cdp bins (m)

Optional Parameters:

noffmix=1 number of offsets to mix (for unstacked data only)  
tmig=0.0 times corresponding to rms velocities in vmig (s)  
vmig=1500.0 rms velocities corresponding to times in tmig (m/s)  
smig=1.0 stretch factor (0.6 typical if vrms increasing)  
vscale=1.0 scale factor to apply to velocities  
fmax=Nyquist maximum frequency in input data (Hz)  
lstaper=0 length of side tapers (# of traces)  
lbtaper=0 length of bottom taper (# of samples)  
verbose=0 =1 for diagnostic print  
tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

If unstacked traces are input, they should be NMO-corrected and sorted into common-offset gathers. One common-offset gather ends and another begins when the offset field of the trace headers changes. If both NMO and DMO are applied, then this is equivalent to prestack time migration (though the velocity profile is assumed  $v(t)$ , only).

The cdp field of the input trace headers must be the cdp bin NUMBER, NOT the cdp location expressed in units of meters or feet.

The number of offsets to mix (noffmix) should be specified for unstacked data only. noffmix should typically equal the ratio of the shotpoint spacing to the cdp spacing. This choice ensures that every cdp will be represented in each offset mix. Traces in each mix will contribute through migration to other traces in adjacent cdps within that mix.

The tmig and vmig arrays specify a velocity function of time that is used to implement Stolt's stretch for depth-variable velocity. The

stretch factor smig is often referred to as the "W" factor.  
The times in tmig must be monotonically increasing.

Credits:

CWP: Dave Hale c. 1990

Trace header fields accessed: ns, dt, delrt, offset, cdp

SUTIFOWLER VTI constant velocity prestack time migration  
velocity analysis via Fowler's method

sutifowler ncdps=250 vmin=1500 vmax=6000 dx=12.5

Required Parameter:

ncdps= number of input cdp's

Optional Parameters:

choose=1 1 do full prestack time migration

2 do only DMO

3 do only post-stack migrations

4 do only stacking velocity analysis

getcvstacks=0 flag to set to 1 if inputting precomputed cvstacks  
(vmin, nvstack, and ncdps must match SUCVS4FOWLER job)

vminstack=vmin minimum velocity panel in m/s in input cvstacks

etamin=0. minimum eta (see paper by Tariq Alkhalifah)

etamax=0.5 maximum eta (see paper by Tariq Alkhalifah)

neta=1 number of eta values to image

d=0. Thomsen's delta

vpvs=0.5 assumed vp/vs ratio (not critical -- default almost always ok)

dx=25. cdp x increment

vmin=1500. minimum velocity panel in m/s to output

vmax=8000. maximum velocity panel in m/s to output

nv=75 number of velocity panels to output

nvstack=180 number of stacking velocity panels to compute

( Let offmax be the maximum offset, fmax be

the maximum freq to preserve, and tmute be

the starting mute time in sec on offmax, then

the recommended value for nvstack would be

$$nvstack = 4 + (offmax * offmax * fmax) / (0.6 * vmin * tmute)$$

---you may want to make do with less---

nypad=0 number of traces to padd for spatial fft

Ideally nypad =  $(0.5 * tmax * vmax + 0.5 * offmax) / dx$

lmute=24 length of mute taper in ms

nonhyp=1 1 if do mute at  $2 * offset / vmin$  to avoid non-hyperbolic  
moveout, 0 otherwise

lbtaper=0 length of bottom taper in ms

lstaper=0 length of side taper in traces

dtout=1.5\*dt output sample rate in s, note: typically

fmax=salias\*0.5/dtout

mxfold=120 maximum number of offsets/input cmp

salias=0.8 fraction of output frequencies to force within sloth  
antialias limit. This controls muting by offset of



the input data prior to computing the cv stacks  
for values of choose=1 or choose=2.  
file=sutifowler root name for temporary files  
p=not Enter a path name where to put temporary files.  
specified Can enter multiple times to use multiple disk  
systems.  
The default uses information from the .VND file  
in the current directory if it exists, or puts  
unique temporary files in the current directory.  
ngroup=20 Number of cmps per velocity analysis group.  
printfile=stderr The output file for printout from this program.

Required trace header words on input are ns, dt, cdp, offset.

On output, trace headers are rebuilt from scratch with

ns - number of samples

dt - sample rate in usec

cdp - the output cmp number (0 based)

offset - the output velocity

tracf - the output velocity index (0 based)

fldr - index for velocity analysis group (0 based, groups of ngroup cdp)

ep - central cmp for velocity analysis group

igc - index for choice of eta (0 based)

igi - eta\*100

sx=gx - x coordinate as icmp\*dx

trac1=tracr -sequential trace count (1 based)

Note: Due to aliasing considerations, the small offset-to-depth ratio assumption inherent in the TI DMO derivation, and the poor stacking of some large-offset events associated with TI non-hyperbolic moveout, a fairly stiff initial mute is recommended for the long offsets. As a result, this method may not work well where you have multiple reflections to remove via stacking.

Note: The temporary files can be split over multiple disks by building a .VND file in your working directory. The .VND file is ascii text with the first line giving the number of directories followed by successive lines with one line per directory name.

Note: The output data order has primary key equal to cdp, secondary key equal to eta, and tertiary key equal to velocity.

Credits:

CWP: John Anderson (visitor to CSM from Mobil) Spring 1993



SUALFORD - trace by trace Alford Rotation of shear wave data volumes

```
sualford inS11=file1 inS22=file2 inS12=file3 inS21=file4
outS11=file5 outS22=file6 outS12=file7 outS21=file8 [optional
parameters]
```

Required Parameters:

inS11= input data volume for the 11 component  
inS12= input data volume for the 12 component  
inS21= input data volume for the 21 component  
inS22= input data volume for the 22 component  
outS11= output data volume for the 11 component  
outS12= output data volume for the 11 component  
outS21= output data volume for the 11 component  
outS22= output data volume for the 11 component

Optional parameters:

angle\_inc= sets the increment to the angle by which  
the data sets are rotated. The minimum is  
set to be 1 degree and default is 5.

Az\_key= to set the header field storing the azimuths  
for the fast shear wave on the output volumes

Q\_key= to set the header field storing the quality  
factors of performed optimum rotations

lag\_key= to set the header field storing the lag in  
miliseconds the fast and slow shear components

xcorr\_key= to set the header field containing the maxi-  
mum normalized cross-correlation between the  
and slow shear waves.

taper= 2\*taper+1 is the length of the sample overlap  
between the unrotated data with the rotated  
data on the traces. The boundary between them  
is defined by time windowing.

taper = -1, for no-overlap

taper = 0, for overlap of one sample

taper =>1, for use of cosine scale to  
to interpolate between the  
unrotated and rotated parts  
of the traces

taperwin= another taper used to taper the data within  
the window of analysis to diminish the effect  
of data near the window edges. In this way one

can focus on a given reflector. Also given in  
number of samples

maxlag= maximum limit in ms for the lag between fast  
and slow shear waves. If this threshold is  
attained or surpassed, the quality factor for  
the rotation is zeroed as well as all the  
parameters found for that certain rotation

ntraces= number of traces to be used per computation  
ntraces=3 will use three adjacent traces to  
compute the angle of rotation "

#### Notes:

The Alford Rotation is a method to rotate the four components  
of a shear wave survey into its natural coordinate system, where  
the fast and slow shear correspond to the inline to inline shear (S11)  
and xline to xline (S22) volumes, respectively.

This Alford Rotation code tries to maximize the energy in the  
diagonal volumes, i.e., S11 and S22, while minimizing the energy  
in the off-diagonals, i.e., in volumes S12 and S21, in a trace by  
trace manner. It then returns the new rotated volumes, saving the  
the quality factor for the rotation and azimuth angle of the fast  
shear wave direction for each trace headers of the new rotated S11  
volume.

The fields in the header containing the Azimuth and Quality factor  
and the sample lag between fast and slow shear are otrav, grnolf and  
grnofr, respectively, by default. The values are multiplied by ten in  
the case of the angles and by a thousand for quality factors. To  
change this defaults use the optional parameters Az\_key, Q\_key and  
lag\_key

#### modified header fields:

the ones specified by Az\_key, Q\_key, lag\_key and xcorr\_key. By default  
these are otrav, grnlof, tstat and grnors, respectively.

#### Credits:

CWP: Rodrigo Felicio Fuck

Code translated and adapted from original version in Fortran  
by Ted Schuck (1993)

Schuck, E. L. , 1993, Multicomponent, three dimensional seismic  
characterization of a fractured coalbed methane reservoir,  
Cedar Hill Field, San Juan County, New Mexico, Ph.D. Thesis,  
Colorado School of Mines

SUEIPOFI - EIGenimage (SVD) based POLarization Filter for  
three-component data

sueipofi <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

dt=(from header)	time sampling intervall in seconds
wl=0.1	SVD time window length in seconds
pwr=1.0	exponent of filter weights
interp=cubic	interpolation between initially calculated weights, choose "cubic" or "linear"
verbose=0	1 = echo additional information
file=polar	base name for additional output file(s) of filter weights (see flags below)
rl1=0	1 = rectilinearity along first principal axis
rl2=0	1 = rectilinearity along second principal axis
pln=0	1 = planarity

Notes:

Three adjacent traces are considered as one three-component dataset.

The filter is the sum of the first two eigenimages of the singular value decomposition (SVD) of the signal matrix (time window). Weighting functions depending on linearity and planarity of the signal are applied, additionally. To avoid edge effects, these are interpolated linearly or via cubic splines between initially calculated values of non-overlapping time windows.

The algorithm is based on the assumption that the particle motion trajectory is essentially 2D (elliptical polarization).

Caveat:

Cubic spline interpolation may result in filter weights exceeding the set of values of initial weights. Weights outside the valid interval [0.0, 1.0] are clipped.

Author: Nils Maercklin,  
GeoForschungsZentrum (GFZ) Potsdam, Germany, 2001.  
E-mail: nils@gfz-potsdam.de

References:

- Franco, R. de, and Musacchio, G., 2000: Polarization Filter with Singular Value Decomposition, submitted to Geophysics and published electronically in Geophysics online ([www.geo-online.org](http://www.geo-online.org)).
- Jurkevics, A., 1988: Polarization analysis of three-component array data, Bulletin of the Seismological Society of America, vol. 78, no. 5.
- Press, W. H., Teukolsky, S. A., Vetterling, W. T., and Flannery, B. P. 1996: Numerical Recipes in C - The Art of Scientific Computing, Cambridge University Press, Cambridge.

Trace header fields accessed: ns, dt  
Trace header fields modified: none

SUHROT - Horizontal ROTation of three-component data

suhrot <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

angle=rad unit of angles, choose "rad", "deg", or "gon

inv=0 1 = inverse rotation (counter-clockwise)

verbose=0 1 = echo angle for each 3-C station

a=... array of user-supplied rotation angles

x=0.0,... array of corresponding header value(s)

key=tracf header word defining 3-C station ("x")

... or input angles from files:

n=0 number of x and a values in input files

xfile=... file containing the x values as specified by the  
"key" parameter

afile=... file containing the a values

Notes:

Three adjacent traces are considered as one three-component dataset.

By default, the data will be rotated from the Z-North-East (Z,N,E) coordinate system into Z-Radial-Transverse (Z,R,T).

If one of the parameters "a=" or "afile=" is set, the data are rotated by these user-supplied angles. Specified x values must be monotonically increasing or decreasing, and afile and xfile are files of binary (C-style) floats.

Author: Nils Maercklin,

Geophysics, Kiel University, Germany, 1999.

Trace header fields accessed: ns, sx, sy, gx, gy, key=keyword

Trace header fields modified: trid



SULTT - trace by trace, sample by sample, rotation of shear wave data volumes using the Linear Transform Technique of Li & Crampin (1993)

```
sultt inS11=file1 inS22=file2 inS12=file3 inS21=file4 [optional parameters]
```

optional parameters:

mode determines what the linear transform will compute  
mode=1, computes asymmetry indexes  
mode=2, computes Polarization and main reflectivity series.  
mode=3, same as above, but using eigenvalues

mode=3 is more robust estimation for Polarization angle than mode=2. In both cases the reflectivity series is computed in the same way. mode=1 outputs two other data volumes, each containing the asymmetry parameters theta, and gamma. The other two modes only output an extra data volume, the instant polarization alpha

outSij defines the names of the output seismic data files, i and j equal either 1 or 2

alpha, gamma name for optional output volumes: instantaneous polarity theta, alpha; theta, for angle misalignment between source and receiver; gamma, the medium asymmetric response coefficient

wl running window acting on traces (in samples)

ntraces number of traces to be average for each location

CAVEAT

Naming convention for off-diagonal volumes:  
S12 - Inline source, Xline receiver  
S21 - Xline source, Inline receiver

the running will always have an odd number of samples, despite the input length.

Credits:

CWP/RCP: Rodrigo Felicio Fuck

Code based on algorithms presented in Li & Crampin (1993) and  
Li & MacBeth (1997)

Li, X.Y., and Crampin, S., 1993, Linear-transform techniques for  
processing shear-wave anisotropy in four-component  
seismic data, *Geophysics*, 58, 240-256.

Li, X.Y., and MacBeth, C., 1997, Data-Matrix asymmetry and polar-  
ization changes from multicomponent surface seismics

SUPOFILT - POLarization FILTer for three-component data

supofilt <stdin >stdout [optional parameters]

Required parameters:

dfile=polar.dir	file containing the 3 components of the direction of polarization
wfile=polar.rl	file name of weighting polarization parameter

Optional parameters:

dt=(from header)	time sampling intervall in seconds
smooth=1	1 = smooth filter operators, 0 do not
sl=0.05	smoothing window length in seconds
wpow=1.0	raise weighting function to power wpow
dpow=1.0	raise directivity functions to power dpow
verbose=0	1 = echo additional information

Notes:

Three adjacent traces are considered as one three-component dataset.

This program SUPOFILT is an extension to the polarization analysis program supolar. The files wfile and dfile are SU files as written by SUPOLAR.

Author: Nils Maercklin,

GeoForschungsZentrum (GFZ) Potsdam, Germany, 1999-2000.

E-mail: nils@gfz-potsdam.de

References:

- Benhama, A., Cllet, C. and Dubesset, M., 1986: Study and Application of spatial directional filtering in three component recordings. Geophysical Prospecting, vol. 36.
- Kanasewich, E. R., 1981: Time Sequence Analysis in Geophysics, The University of Alberta Press.
- Kanasewich, E. R., 1990: Seismic Noise Attenuation, Handbook of Geophysical Exploration, Pergamon Press, Oxford.

Trace header fields accessed: ns, dt

SUPOLAR - POLarization analysis of three-component data

supolar <stdin [optional parameters]

Required parameters:

none

Optional parameters:

dt=(from header)	time sampling intervall in seconds
wl=0.1	correlation window length in seconds
win=boxcar	correlation window shape, choose "boxcar", "hanning", "bartlett", or "welsh"
file=polar	base of output file name(s)
rl=1	1 = rectilinearity evaluating 2 eigenvalues, 2, 3 = rectilinearity evaluating 3 eigenvalues
rlq=1.0	contrast parameter for rectilinearity
dir=1	1 = 3 components of direction of polarization (the only three-component output file)
tau=0	1 = global polarization parameter
ellip=0	1 = principal, subprincipal, and transverse ellipticities e21, e31, and e32
pln=0	1 = planarity measure
f1=0	1 = flatness or oblateness coefficient
l1=0	1 = linearity coefficient
amp=0	1 = amplitude parameters: instantaneous, quadratic, and eigenresultant ir, qr, and er
theta=0	1, 2, 3 = incidence angle of principal axis
phi=0	1, 2, 3 = horizontal azimuth of principal axis
angle=rad	unit of angles theta and phi, choose "rad", "deg", or "gon"
all=0	1, 2, 3 = set all output flags to that value
verbose=0	1 = echo additional information

Notes:

Three adjacent traces are considered as one three-component dataset.

Correct calculation of angles theta and phi requires the first of these traces to be the vertical component, followed by the two horizontal components (e.g. Z, N, E, or Z, inline, crossline). Significant signal energy on Z is necessary to resolve the 180 deg ambiguity of phi (options phi=2,3 only).

Each calculated polarization attribute is written into its own SU file. These files get the same base name (set with "file=") and the parameter flag as an extension (e.g. polar.rl).

In case of a tapered correlation window, the window length wl may have to be increased compared to the boxcar case, because of their smaller effective widths (Bartlett, Hanning: 1/2, Welsh: 1/3).

#### Range of values:

parameter	option	interval	
rl	1, 2	0.0 ... 1.0	(1.0: linear polarization)
rl	3	-1.0 ... 1.0	
tau, l1	1	0.0 ... 1.0	(1.0: linear polarization)
pln, f1	1	0.0 ... 1.0	(1.0: planar polarization)
e21, e31, e32	1	0.0 ... 1.0	(0.0: linear polarization)
theta	1	-pi/2... pi/2	rad
theta	2, 3	0.0 ... pi/2	rad
phi	1	-pi/2... pi/2	rad
phi	2	-pi ... pi	rad (see notes above)
phi	3	0.0 ... 2 pi	rad (see notes above)

Author: Nils Maercklin,

GeoForschungsZentrum (GFZ) Potsdam, Germany, 1998-2001.

E-mail: nils@gfz-potsdam.de

#### References:

- Jurkevics, A., 1988: Polarization analysis of three-component array data. Bulletin of the Seismological Society of America, vol. 78, no. 5.
- Kanasewich, E. R., 1981: Time Sequence Analysis in Geophysics. The University of Alberta Press.
- Kanasewich, E. R., 1990: Seismic Noise Attenuation. Handbook of Geophysical Exploration, Pergamon Press, Oxford.
- Meyer, J. H. 1988: First Comparative Results of Integral and Instantaneous Polarization Attributes for Multicomponent Seismic Data. Institut Francais du Petrole.
- Press, W. H., Teukolsky, S. A., Vetterling, W. T., and Flannery, B. P. 1996: Numerical Recipes in C - The Art of Scientific Computing. Cambridge University Press, Cambridge.

Samson, J. C., 1973: Description of the Polarisation States of Vector Processes: Application to ULF Electromagnetic Fields. Geophysical Journal vol. 34, p. 403-419.  
Sheriff, R. E., 1991: Encyclopedic Dictionary of Exploration Geophysics. 3rd ed., Society of Exploration Geophysicists, Tulsa.

Trace header fields accessed: ns, dt  
Trace header fields modified: none

SUADDNOISE - add noise to traces

```
suaddnoise <stdin >stdout sn=20 noise=gauss seed=from_clock
```

Required parameters:

if any of  $f=f_1, f_2, \dots$  and  $\text{amp}=a_1, a_2, \dots$  are specified by the user and if  $dt$  is not set in header, then  $dt$  is mandatory

Optional parameters:

$sn=20$  signal to noise ratio  
 $\text{noise}=\text{gauss}$  noise probability distribution  
 $=\text{flat}$  for uniform; default Gaussian  
 $\text{seed}=\text{from\_clock}$  random number seed (integer)  
 $f=f_1, f_2, \dots$  array of filter frequencies (as in `sufilter`)  
 $\text{amps}=a_1, a_2, \dots$  array of filter amplitudes  
 $dt=$  (from header) time sampling interval (sec)  
 $\text{verbose}=0$   $=1$  for echoing useful information

$\text{tmpdir}=\text{}$  if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the `CWP_TMPDIR` environment variable is set use  
its value for the path; else use `tmpfile()`

Notes:

$\text{Output} = \text{Signal} + \text{scale} * \text{Noise}$

$\text{scale} = (1/sn) * (\text{absmax\_signal}/\sqrt{2})/\sqrt{\text{energy\_per\_sample}}$

If the signal is already band-limited,  $f=f_1, f_2, \dots$  and  $\text{amps}=a_1, a_2, \dots$  can be used, as in `sufilter`, to bandlimit the noise traces to match the signal band prior to computing the scale defined above.

Examples of noise bandlimiting:

```
low frequency:    suaddnoise < data f=40,50 amps=1,0 | ...
high frequency:   suaddnoise < data f=40,50 amps=0,1 | ...
near monochromatic: suaddnoise < data f=30,40,50 amps=0,1,0 | ...
with a notch:     suaddnoise < data f=30,40,50 amps=1,0,1 | ...
bandlimited:       suaddnoise < data f=20,30,40,50 amps=0,1,1,0 | ...
```

Credits:

CWP: Jack Cohen, Brian Sumner, Ken Larner  
John Stockwell (fixed filtered noise option)



Notes:

At  $S/N = 2$ , the strongest reflector is well delineated, so to see something  $1/n$ th as strong as this dominant reflector requires  $S/N = 2*n$ .

Trace header field accessed: ns

SUHARLAN - signal-noise separation by the invertible linear transformation method of Harlan, 1984

suharlan <infile >outfile [optional parameters]

Required Parameters:

<none>

Optional Parameters:

FLAGS:

niter=1 number of requested iterations  
anenv=1 =1 for positive analytic envelopes  
=0 for no analytic envelopes (not recommended)  
scl=0 =1 to scale output traces (not recommended)  
plot=3 =0 for no plots. =1 for 1-D plots only  
=2 for 2-D plots only. =3 for all plots  
norm=1 =0 not to normalize reliability values  
verbose=1 =0 not to print processing information  
rgt=2 =1 for uniform random generator  
=2 for gaussian random generator  
sts=1 =0 for no smoothing (not recommended)

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

General Parameters:

dx=20 offset sampling interval (m)  
fx=0 offset on first trace (m)  
dt=0.004 time sampling interval (s)

Tau-P Transform Parameters:

gopt=1 =1 for parabolic transform. =2 for Foster/Mosher  
=3 for linear. =4 for absolute value of linear  
pmin1=-400 minimum moveout at farthest offset for fwd transf(ms)  
pmax1=400 maximum moveout at farthest offset for fwd transf(ms)  
pmin2=pmin1 minimum moveout at farthest offset for inv transf(ms)  
pmax2=pmax1 maximum moveout at farthest offset for inv transf(ms)  
np=100 number of p-values for taup transform  
prewhite=0.01 prewhitening value (suggested between 0.1 and 0.01)  
offref=2000 reference offset for p-values (m)  
depthref=500 reference depth for Foster/Mosher taup (if gopt=4)

pmula=pmax1 maximum p-value preserved in the data (ms)  
pmulb=pmax1 minimum p-value muted on the data (ms)  
ninterp=0 number of traces to interpolate in input data

Extraction Parameters:

nintlh=50 number of intervals (bins) in histograms  
sditer=5 number of steepest descent iterations to compute ps  
c=0.04 maximum noise allowed in a sample of signal(%)  
rel1=0.5 reliability value for first pass of the extraction  
rel2=0.75 reliability value for second pass of the extraction

Smoothing Parameters: ",

r1=10 number of points for damped lsq vertical smoothing  
r2=2 number of points for damped lsq horizontal smoothing

Output Files:

signal=out\_signal name of output file for extracted signal  
noise=out\_noise name of output file for extracted noise

Notes:

The signal-noise separation algorithm was developed by Dr. Bill Harlan in 1984. It can be used to separate events that can be focused by a linear transformation (signal) from events that can't (noise). The linear transform is whatever is well suited for the application at hand. Here, only the discrete Radon transform is used, so the program is capable of separating events focused by that transform (linear, parabolic or time-invariantly hyperbolic). Should other transform be required, the changes to the program will be relatively straightforward.

The reliability parameter is the most critical one to determine what to extract as signal and what to reject as noise. It should be tested for every dataset. The way to test it is to start with a small value, say 0.1 or 0.01. If too much noise is present in the extracted noise, it is too low. If too much signal was extracted, that is, part of the signal was lost, it is too big. All other parameters have good default values and should perhaps not be changed in a first encounter with the program. The transform parameters are also critical. They should be chosen such that no aliasing is present and such that the range of interesting slopes is spanned by the transform but not much more. The program `suradon.c` has more documentation on the transform parameters.

Credits:

Gabriel Alvarez CWP (1995)

Some subroutines are direct translations to C from Fortran versions written by Dr. Bill Harlan (1984)

References:

Harlan, S., Claerbout, J., and Roca, F. (1984), Signal/noise separation and velocity estimation, *Geophysics*, v. 49, no. 11, p 1869-1880.

Harlan, S. (1988), Separation of signal and noise applied to vertical seismic profiles, *Geophysics*, v. 53, no. 7, p 932-946.

Alvarez, G. (1995), Comparison of moveout-based approaches to ground roll and multiple suppression, MSc., Department of Geophysics, Colorado School of Mines, (Chapter 3 deals exclusively with this method).

SUJITTER - Add random time shifts to seismic traces

sujitter <stdin >stdout [optional parameters]

Required parameters:

none

Optional Parameters:

seed=from\_clock random number seed (integer)

min=1 minimum random time shift (samples)

max=1 maximum random time shift (samples)

pon=1 shift can be positive or negative

=0 shift is positive only

fldr=0 each trace has new shift

=1 new shift when fldr header field changes

Notes:

Useful for simulating random statics. See also: suaddstatics

Credits:

U of Houston: Chris Liner

UH: Chris added fldr, min, pon options 12/10/08

SUFLIP - flip a data set in various ways

```
suflip <data1 >data2 flip=1 verbose=0
```

Required parameters:

none

Optional parameters:

flip=1 rotational sense of flip

+1 = flip 90 deg clockwise

-1 = flip 90 deg counter-clockwise

0 = transpose data

2 = flip right-to-left

3 = flip top-to-bottom

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

verbose=0 verbose = 1 echoes flip info

NOTE: tr.dt header field is lost if flip=-1,+1. It can be  
reset using sushw.

EXAMPLE PROCESSING SEQUENCES:

1. suflip flip=-1 <data1 | sushw key=dt a=4000 >data2

2. suflip flip=2 <data1 | suflip flip=2 >data1\_again

3. suflip tmpdir=/scratch <data1 | ...

Caveat: may fail on large files.

Credits:

CWP: Chris Liner, Jack K. Cohen, John Stockwell

Caveat:

right-left flip (flip = 2) and top-bottom flip (flip = 3)  
don't require the matrix approach. We sacrificed efficiency  
for uniform coding.

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt, tracl



SUFWMIX - FX domain multidimensional Weighted Mix

sufwmix < stdin > stdout [optional parameters]

Required parameters:

key=key1,key2,... Header words defining mixing dimension

dx=d1,d2,... Distance units for each header word

Optional parameters:

keyg=ep Header word indicating the start of gather

vf=0 =1 Do a frequency dependent mix

vmin=5000 Velocity of the reflection slope  
than should not be attenuated

Notes:

Trace with the header word mark set to one will be  
the output trace

(a work in progress)

Credits:

Potash Corporation: Balazs Nemeth, Saskatoon Saskatchewan CA,  
given to CWP in 2008



SUMATH - do math operation on su data

suop <stdin >stdout op=mult

Required parameters:

none

Optional parameter:

op=mult operation flag

----- operations -----

add : o = i + a (o=out; i=in)

sub : o = i - a

mult : o = i \* a

div : o = i / a

pow : o = i ^ a

spow : o = sgn(i) \* abs(i) ^ a

----- operation parameter -----

a=1

copy=1 n>1 copy each trace n times

Note:

There is overlap between this program and "sugain" and  
"suop"

Credits:

U Arkansas: Chris Liner Jun 2013

Notes:

SUMIX - compute weighted moving average (trace MIX) on a panel  
of seismic data

sumix <stdin >sdout

mix=.6,1,1,1,.6 array of weights for weighted average

Note:

The number of values defined by mix=val1,val2,... determines the number  
of traces to be averaged, the values determine the weights.

Examples:

sumix <stdin mix=.6,1,1,1,.6 >sdout (default) mix over 5 traces weights

sumix <stdin mix=1,1,1 >sdout simple 3 trace moving average

Author:

CWP: John Stockwell, Oct 1995

Trace header fields accessed: ns

SUOP2 - do a binary operation on two data sets

```
suop2 data1 data2 op=diff [trid=111] >stdout
```

Required parameters:

none

Optional parameter:

op=diff difference of two panels of seismic data  
=sum sum of two panels of seismic data  
=prod product of two panels of seismic data  
=quo quotient of two panels of seismic data  
=ptdiff differences of a panel and single trace  
=ptsum sum of a panel and single trace  
=ptprod product of a panel and single trace  
=ptquo quotient of a panel and single trace  
=zipper do "zipper" merge of two panels  
=zippol convert polar to rectangular and then zip

trid=FUNPACKNYQ output trace identification code. (This option is active only for op=zipper)

For SU version 39-43 FUNPACNYQ=111

(See: sukeyword trid for current value)

Note1: Output = data1 "op" data2 with the header of data1

Note2: For convenience and backward compatibility, this program may be called without an op code as:

For: panel "op" panel operations:

```
susum file1 file2 == suop2 file1 file2 op=sum  
sudiff file1 file2 == suop2 file1 file2 op=diff  
suprod file1 file2 == suop2 file1 file2 op=prod  
suquo file1 file2 == suop2 file1 file2 op=quo
```

For: panel "op" trace operations:

```
suptsum file1 file2 == suop2 file1 file2 op=ptsum  
suptdiff file1 file2 == suop2 file1 file2 op=ptdiff  
suptprod file1 file2 == suop2 file1 file2 op=ptprod  
suptquo file1 file2 == suop2 file1 file2 op=ptquo
```

Note3: If an explicit op code is used it must FOLLOW the

filenames.

Note4: With op=quo and op=ptquo, divide by 0 is trapped and 0 is returned.

Note5: Weighted operations can be specified by setting weighting coefficients for the two datasets:

w1=1.0

w2=1.0

Note6: With op=zipper, it is possible to set the output trace id code (See: sukeyword trid)

This option processes the traces from two files interleaving its samples. Both files must have the same trace length and must not longer than SU\_NFLTS/2 (as in SU 39-42 SU\_NFLTS=32768).

Being "tr1" a trace of data1 and "tr2" the corresponding trace of data2, The merged trace will be :

```
tr[2*i]= tr1[i]
tr[2*i+1] = tr2[i]
```

The default value of output tr.trid is that used by sufft and suifft, which is the trace id reserved for the complex traces obtained through the application of sufft. See also, suamp.

Note 7: op=zippol is like op=zipper, but the input samples are polar (amplitude and phase) and are converted to cartesian (real, imag) before interleaving them.

For operations on non-SU binary files use:farith

Credits:

SEP: Shuki Ronen

CWP: Jack K. Cohen

CWP: John Stockwell, 1995, added panel op trace options.

: Fernando M. Roxo da Motta <petro@roxo.org> - added zipper op

Notes:

If efficiency becomes important consider inverting main loop and repeating operation code within the branches of the switch.

SUOP - do unary arithmetic operation on segys

suop <stdin >stdout op=abs

Required parameters:

none

Optional parameter:

op=abs operation flag

abs : absolute value

avg : remove average value

ssqrt : signed square root

sqr : square

ssqr : signed square

sgn : signum function

exp : exponentiate

sexp : signed exponentiate

slog : signed natural log

slog2 : signed log base 2

slog10: signed common log

cos : cosine

sin : sine

tan : tangent

cosh : hyperbolic cosine

sinh : hyperbolic sine

tanh : hyperbolic tangent

cnorm : norm complex samples by modulus "

norm : divide trace by Max. Value

db : 20 \* slog10 (data)

neg : negate value

posonly : pass only positive values

negonly : pass only negative values

sum : running sum trace integration

diff : running diff trace differentiation

refl :  $(v[i+1] - v[i]) / (v[i+1] + v[i])$

mod2pi : modulo 2 pi

inv : inverse

rmsamp : rms amplitude

s2v : sonic to velocity (ft/s) conversion

s2vm : sonic to velocity (m/s) conversion

d2m : density (g/cc) to metric (kg/m<sup>3</sup>) conversion

drv2 : 2nd order vertical derivative

drv4 : 4th order vertical derivative

```

            integ : top-down integration
            spike : local extrema to spikes
            saf   : spike and fill to next spike
            freq  : local dominant frequency
            lnza  : preserve least non-zero amps
            ----- window operations -----
            mean  : arithmetic mean
            despik : despiking based on median filter
            std   : standard deviation
            var   : variance
            nw=21 : number of time samples in window
            -----
nop      : no operation

```

Note: Binary ops are provided by suop2.  
Operations inv, slog, slog2, and slog10 are "punctuated",  
meaning that if, the input contains 0 values,  
0 values are returned. ",

For file operations on non-SU format binary files use: farith

Credits:

CWP: Shuki Ronen, Jack K Cohen (c. 1987)  
Toralf Foerster: norm and db operations, 10/95.  
Additions by Reg Beardsley, Chris Liner, and others.

Notes:

If efficiency becomes important consider inverting main loop  
and repeating operation code within the branches of the switch.

Note on db option. The following are equivalent:

```
... | sufft | suamp | suop op=norm | suop op=slog10 | \
sugain scale=20 | suxgraph style=normal
```

```
... | sufft | suamp | suop op=db | suxgraph style=normal
```

SUPERMUTE - permute or transpose a 3d datacube

supermute <stdin >sdout

Required parameters:

none

Optional parameters:

n1=ns from header number of samples in the fast direction

n2=ntr from header number of samples in the med direction ",

n3=1 number of samples in the slow direction

o1=1 new fast direction

o2=2 new med direction

o3=3 new slow direction

d1=1 output interval in new fast direction

d2=1 output interval in new med direction

d3=1 output interval in new slow direction

Notes:

header fields d1 and d2 default to d1=1.0 and d2=1.0

Credits:

VT: Matthias Imhof

Trace header fields accessed: ns, ntr

Trace header fields modified: d1=1, f1=1, d2=1, f2=1, ns, ntr

SUSIMAT - Correlation similarity matrix for two traces.

Output is zero lag of cross-correlation of traces,  
or linear regression correlation coefficient.

Horizontal axis is time of trace 1, vertical is trace 2.

```
susimmat <data12 sufile=data2 >dataout
```

Required parameters:

sufile= file containing SU traces to use as filter

Optional parameters:

panel=0 use only the first trace of sufile as filter

=1 compute sim matrix trace by trace an entire  
gather

mt=21 operator window length (odd integer)

eps=1e-3 stability parameter

taper=0 no taper to data fragments

=1 apply exponential taper (1/e at ends)

method=1 use xcorrelation as similarity measure

=2 same but normalized by (rms+eps)

=3 use linear regression CC

=4 use mt-dimensional vector angle

EXAMPLE PROCESSING SEQUENCES:

1. Look for all possible alignments of OBC P and Z data

```
susimmat < P_Z.su sufile=OBC_P.su mt=71 > P_Zxcor.su
```

Note: xcor window is collapsed as needed to compute edge values

It is quietly assumed that the time sampling interval on the single  
trace

and the output traces is the same as that on the traces in the input  
file.

The sufile may actually have more than one trace, but only the first  
trace is used when panel=0. When panel=1 the number of traces in the  
sufile MUST be the same as the number of traces in the input.

Credits:

U Arkansas: Chris Liner (originally 11/2009 at U Houston)

CWP: John Stockwell, some i/o modifications Jul 2015

References:

Liner, Christopher L., and Robert G. Clapp. "Nonlinear pairwise  
alignment of seismic traces." The Leading Edge 23.11 (2004): 1146-1150.



Liner, C. L, and R. G. Clapp (2004), Nonlinear pairwise alignment of seismic traces GEOPHYSICS, VOL. 69, NO. 6 (NOVEMBER-DECEMBER 2004); P. 15521559, 7 FIGS. 10.1190/1.1836828

Caveat:

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt, tracr1

SUVCAT - append one data set to another, with or without an ", overlapping region. Data in the overlap may be determined by one of several methods.

```
suvcat data1 data2 >stdout
```

Required parameters:  
none

Optional parameters for overlapping sections:

taplen=0      Length of overlap in integer number of  
                 samples. (Default is 0.)

taptype=0      Type of taper or combination method in the  
                 overlap region.    0 - average  
                                      1 - maximum magnitude  
                                      2 - cosine scaled  
                                      3 - summation

Computational Notes:

This program vertically concatenates traces from data2 onto the end of the corresponding traces in data1, with a region of overlap, defined by taplen. Data in the overlapping ", region is combined by the method specified by taptype. The currently available methods are:

taptype=0	output is assigned the unweighted average of each point in the overlap
taptype=1	output is assigned the value of the maximum absolute value of each point in the overlap
taptype=2	output is assigned the weighted average of each point in the overlap, where the output is the sum of $\cos(x)$ times the values on the first section, and $1-\cos(x)$ times the values on the second section, where $x$ is factor that goes from 0 to $\pi/2$ across the overlap. This favors the upper section in the upper part of the overlap, and favors the lower section in the lower part of the overlap.
taptype=3	output is assigned the sum of the amplitudes at each sample in the overlap

Credits:  
CWP: Jack K. Cohen, Michel Dietrich (Original SUVCAT)  
Steven D. Sheaffer (modified to include overlap)  
IfG Kiel: Thies Beilecke (added taptypes=3)

Trace header fields accessed: ns  
Trace header fields modified: ns

SUVLENGTH - Adjust variable length traces to common length

suvlength <vdata >stdout

Required parameters:

none

Optional parameters:

ns= output number of samples (default: 1st trace ns)

SUFBPICKW - First break auto picker

```
sufbpickw < infile >outfile
```

Required parameters:

none

Optional parameters:

keyg=ep

window=.03 Length of forward and backward windows (s)

test=1 Output the characteristic function

This can be used for testing window size

Template

o= offset...

t= time pairs for defining first break search

window centre

tdv=.05 Half length of the search window

If the template is specified the maximum value of the characteristic function is searched in the window defined by the template only. Default is the whole trace.

The time of the pick is stored in header word unscale

```
segy data
segy *trp; /* SEGY trace array
segy trtp; /* SEGY trace
int
main( int argc, char *argv[] )
{

segy **rec_o;    /* trace header+data matrix

cwp_String keyg;
cwp_String typeg;
Value valg;

int first=0; /* true when we passed the first gather
int ng=0;
float dt;
int nt;
int ntr;
```

```

unsigned int np; /* Number of points in pick template
float *t=NULL; /* array defining pick template times
float *o=NULL; /* array defining pick template offsets

float window;
int iwindow;
int *itimes;
int *itimes2;
float *offset;
float tdv;
int itdv;
float *find;
int nowindow=0;
int test=0;

FILE *ttp;

initargs(argc, argv);
    requestdoc(1);

if (!countparval("t")) {
np=2;
nowindow=1;
} else {
np=countparval("t");
}

if(!nowindow) {
t  = ealloc1float(np);
o  = ealloc1float(np);

if( np == countparval("o")) {
getparfloat("t",t);
getparfloat("o",o);
} else {
err(" t and o has different number of elements\n");
}
}

ttp = eopen("test.su","w");

```

```

if (!getparstring("keyg", &keyg)) keyg = "ep";

if (!getparfloat("window",&window)) window = 0.02;
if (!getparfloat("tdv",&tdv)) tdv = -1.0;
if (!getparint("test",&test)) test = 1;

        checkpars();
/* get information from the first header
rec_o = get_gather(&keyg,&typeg,&valg,&nt,&ntr,&dt,&first);

iwindow=NINT(window/dt);
if(tdv== -1.0) {
itdv=nt;
} else {
itdv=NINT(2.0*tdv/dt);
}

if(ntr==0) err("Can't get first record\n");
do {
ng++;

itimes = ealloc1int(ntr);
itimes2 = ealloc1int(ntr);
offset = ealloc1float(ntr);

/* Phase 1
/* Loop through traces
{ int itr,ifbt;
  int it;
  float fbt;
  float ampb;
  float ampf;
  float *wf,*wb;
  float *cf; /* Characteristic function

  cf=ealloc1float(nt);
  find=ealloc1float(nt);
  for(it=0;it<nt;it++)
    find[it]=(float)it;

  for(itr=0;itr<ntr;itr++) {

```

```

    memset( (void *) cf, (int) '\0', nt*FSIZE);

if(nowindow) {
    ifbt=0;
} else {
    /* Linear interpolation of estimated fb time
offset[itr] = (*rec_o[itr]).offset;
    intlin(np,o,t,t[0],t[np-1],1,&offset[itr],&fbt);
    ifbt = NINT(fbt/dt);
}

wb = &(*rec_o[itr]).data[0];
wf = &(*rec_o[itr]).data[iwindow];
ampb = sasum(iwindow,wb,1)+FLT_EPSILON;
ampf = sasum(iwindow,wf,1)+FLT_EPSILON;
    for(it=iwindow;it<nt-iwindow-1;it++) {
cf[it] = ampf/ampb;
/* setup next window
ampb -= fabs((*rec_o[itr]).data[it-iwindow]);
ampf -= fabs((*rec_o[itr]).data[it]);
ampb += fabs((*rec_o[itr]).data[it]);
ampf += fabs((*rec_o[itr]).data[it+iwindow]);
}
/* Smooth the characteristic function
smooth_segmented_array(&find[iwindow],&cf[iwindow],nt-iwindow-1,iwindow,1,5);

/* find the maximum*/
it=MIN(MAX(ifbt-itdv/2,0),nt-1);

wb = &cf[it];

itimes[itr] = isamax(itdv,wb,1)+it;

/* Final check
if(itimes[itr] == ifbt-itdv/2 || itimes[itr] == ifbt+itdv/2)
itimes[itr]=0;

(*rec_o[itr]).unscale=dt*itimes[itr];

if(test)
memcpy( (void *) &(*rec_o[itr]).data[0], (const void *) cf, nt*FSIZE);

```



```

    }
    free1float(cf);
    free1float(find);
}

free1int(itimes);
free1int(itimes2);
free1float(offset);

rec_o = put_gather(rec_o,&nt,&ntr);
rec_o = get_gather(&keyg,&typeg,&valg,&nt,&ntr,&dt,&first);
} while(ntr);
return EXIT_SUCCESS;

}

```

SUFNZERO - get Time of First Non-ZERO sample by trace

sufnzero <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

mode=first     Output time of first non-zero sample  
                 =last for last non-zero sample  
                 =both for both first & last non-zero samples

min=0     Threshold value for considering as zero

Any abs(sample)<min is considered to be zero

key=key1,... Keyword(s) to print

Credits:

Geocon : Garry Perratt

based on surms by the same, itself based on sugain & sumax by:

CWP : John Stockwell

SUPICKAMP - pick amplitudes within user defined and resampled window

```
supickamp <stdin >stdout d2= [optional parameters]
```

Required parameters:

d2= sampling interval for slow dimension

(required if key-parameter not specified)

Optional parameters:

key= Key header word specifying trace offset

(alternatively, specify d2,x2beg)

x\_above= array of lateral position values

(upper window corner)

t\_above= array of time values

(upper window corner)

... or input via files:

t\_xabove= file containing time and lateral position values

(upper window corner)

t\_xbelow= file containing time and lateral position values

(lower window corner)

wl= window width if t\_xbelow is not specified

(No windowing if not specified)

dt\_resamp=dt resampling interval within pick window

(dt has to come from trace headers)

tmin=0 minimum time in input trace

x2beg=0 first lateral position

format=ascii write ascii data to stdout

=binary for binary floats to stdout

verbose=1 writes complete pick information into outpar

=2 writes complete pick information into outpar

in tab-delimited column format

outpar=/dev/tty output parameter file; contains output  
from verbose

arg1=max output (first dimension) to stdout

arg2=i2 output (second dimension) to stdout

(see notes for other options)

Notes:

Window can be defined using

(1) vectors x\_above, t\_above, [wl]

(2) file t\_xabove, [wl] or

(3) files t\_xabove, t\_xbelow

files t\_xabove, t\_xbelow can be generated using xwigb's picking algorithm. The lateral positions have to be monotonically increasing or decreasing for both vector and file input.

verbose=1 or 2 writes min, max, abs[max], energy and associated times tmin,tmax,tabs to outpar, together with global values. verbose=0 only outputs global values.

Acceptable arg-parameters for lateral positions are

(1) x2 (2) i2 = trace number

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset)

Type sukeyword -o to see the complete list of SU keywords.

Credits:

CWP: Andreas Rueger July 06, 1996

MTU: David Forel, Jan. 26, 2005 Add verbose=2 option

SUCVS4FOWLER --compute constant velocity stacks for input to Fowler codes

Required Parameter:

ncdps= number of input cdp gathers

Optional Parameters:

vminstack=1500. minimum velocity panel in m/s to output

nvstack=180 number of stacking velocity panels to compute

( Let offmax be the maximum offset, fmax be

the maximum freq to preserve, and tmute be

the starting mute time in sec on offmax, then

the recommended value for nvstack would be

$nvstack = 4 + (offmax*offmax*fmax)/(0.6*vmin*vmin*tmute)$

---you may want to make do with less---

lmute=24 length of mute taper in ms

nonhyp=1 1 if do mute at  $2*offset/vhyp$  to avoid

non-hyperbolic moveout, 0 otherwise

vhyp=2500. velocity to use for non-hyperbolic moveout mute

lbtaper=0 length of bottom taper in ms

lstaper=0 length of side taper in traces

dtout=1.5\*dt output sample rate in s,

note: typically  $fmax=salias*0.5/dtout$

mxfold=120 maximum number of offsets/input cmp

salias=0.8 fraction of output frequencies to force within sloth  
antialias limit. This controls muting by offset of  
the input data prior to computing the cv stacks  
for values of choose=1 or choose=2.

Required trace header words on input are ns, dt, cdp, offset.

Author: (Visitor to CSM from Mobil): John E. Anderson, Spring 1994

References:

Fowler, P., 1988, Ph.D. Thesis, Stanford University.

Anderson, J.E., Alkhalifah, T., and Tsvankin, I., 1994, Fowler

DMO and time migration for transversely isotropic media,

1994 CWP project review

SUDIVSTACK - Diversity Stacking using either average power or peak power within windows

Required parameters:

none

Optional parameters:

key=tracf            key header word to stack on  
winlen=0.064        window length in seconds.  
                      typical choices: 0.064, 0.128, 0.256,  
    0.512, 1.024, 2.048, 4.096  
                      if not specified the entire trace is used  
  
peak=1                peak power option default is average power

Notes:

Diversity stacking is a noise reduction technique used in the summation of duplicate data. Each trace is scaled by the inverse of its average power prior to stacking. The composite trace is then renormalized by dividing by the sum of the scalars used.

This program stacks adjacent traces having the same key header word, which can be specified by the key parameter. The default is "tracf" (trace number within field record).  
For more information on key header words, type "sukeyword -o".

Examples:

For duplicate field shot records:  
    susort < field.data tracf | sudivstack > stack.data  
For CDP ordered data:  
    sudivstack < cdp.data key=cdp > stack.data

Author: Mary Palen-Murphy,  
        Masters' candidate, Colorado School of Mines,  
        Geophysics Department, 1994

Implementation of "key=" option: Nils Maercklin,  
        GeoForschungsZentrum (GFZ) Potsdam, Germany, 2002.

References:

Embree, P., 1968, Diversity seismic record stacking method and system:  
U.S. patent 3,398,396.

Gimlin, D. R., and Smith, J. W., 1980, A comparison of seismic trace  
summing techniques: Geophysics, vol. 45, pages 1017-1041.

Trace header fields accessed: ns, dt, key=keyword

Trace header fields modified: tracr

SUPWS - Phase stack or phase-weighted stack (PWS) of adjacent traces having the same key header word

supws <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

key=cdp      key header word to stack on  
pwr=1.0      raise phase stack to power pwr  
dt=(from header)   time sampling intervall in seconds  
sl=0.0 window length in seconds used for smoothing  
of the phase stack (weights)  
ps=0 0 = output is PWS, 1 = output is phase stack  
verbose=0 1 = echo additional information

Note:

Phase weighted stacking is a tool for efficient incoherent noise reduction. An amplitude-unbiased coherency measure is designed based on the instantaneous phase, which is used to weight the samples of an ordinary, linear stack. The result is called the phase-weighted stack (PWS) and is cleaned from incoherent noise. PWS thus permits detection of weak but coherent arrivals.

The phase-stack (coherency measure) has values between 0 and 1.

If the stacking is over cdp and the PWS option is set, then the offset header field is set to zero. Otherwise, output traces get their headers from the first trace of each data ensemble to stack, including the offset field. Use "sushw" afterwards, if this is not acceptable.

Author: Nils Maercklin,  
GeoForschungsZentrum (GFZ) Potsdam, Germany, 2001.  
E-mail: nils@gfz-potsdam.de

References:

B. L. N. Kennett, 2000: Stacking three-component seismograms.  
Geophysical Journal International, vol. 141, p. 263-269.  
M. Schimmel and H. Paulssen, 1997: Noise reduction and detection



of weak , coherent signals through phase-weighted stacks.  
Geophysical Journal International, vol. 130, p. 497-505.  
M. T. Taner, A. F. Koehler, and R. E. Sheriff, 1979: Complex  
seismic trace analysis. Geophysics, vol. 44, p. 1041-1063.

Trace header fields accessed: ns

Trace header fields modified: nhs, offset

SURECIP - sum opposing offsets in prepared data (see below)

```
surecip <stdin >stdout
```

Sum traces with equal positive and negative offsets (i.e. assume reciprocity holds).

Usage:

```
suabshw <data >absdata
```

```
susort cdp offset <absdata | surecip >sumdata
```

Note that this processing stream can be simply evoked by:

```
recip data sumdata
```

Credits:

SEP: Shuki Ronen

CWP: Jack Cohen

Caveat:

The assumption is that this operation is not a mainstay processing item. Hence the recommended implementation via the 'recip' shell script. If it becomes a mainstay, then a much faster code can quickly be drummed up by incorporating portions of suabshw and susort.

Trace header fields accessed: ns

Trace header fields modified: nhs, tracl, sx, gx

SUSTACK - stack adjacent traces having the same key header word

sustack <stdin >stdout [Optional parameters]

Required parameters:

none

Optional parameters:

key=cdp header key word to stack on

normpow=1.0 each sample is divided by the  
normpow'th number of non-zero values  
stacked (normpow=0 selects no division)  
repeat=0 =1 repeats the stack trace nrepeat times  
nrepeat=10 repeats stack trace nrepeat times in  
output file

verbose=0 verbose = 1 echos information

Notes:

-----

The offset field is set to zero on the output traces, unless  
the user is stacking with key=offset. In that case, the value  
of the offset field is left unchanged.

Sushw can be used afterwards if this is not acceptable.

For VSP users:

The stack trace appears ten times in the output file when  
setting repeat=1 and nrepeat=10. Corridor stacking can be  
achieved by properly muting the upgoing data with SUMUTE  
before stacking.

Credits:

SEP: Einar Kjartansson

CWP: Jack K. Cohen, Dave Hale

CENPET: Werner M. Heigl - added repeat trace functionality

Note:

The "valxxx" subroutines are in su/lib/valpkge.c. In particular,  
"valcmp" shares the annoying attribute of "strcmp" that  
if (valcmp(type, val, valnew) {  
...  
}

will be performed when val and valnew are different.

Trace header fields accessed: ns

Trace header fields modified: nhs, tracl, offset

SUADDSTATICS - ADD random STATICS on seismic data

suaddstatics required parameters [optional parameters] > stdout

Required parameters:

shift= the static shift will be generated  
randomly in the interval [+shift,-shif] (ms)  
sources= number of source locations  
receivers= number of receiver locations  
cmps= number of common mid point locations  
maxfold= maximum fold of input data  
datafile= name and COMPLETE path of the input file

Optional parameters:

dt=tr.dt time sampling interval (ms)  
seed=getpid() seed for random number generator  
verbose=0 =1 print useful information

Notes:

Input data should be sorted into cdp gathers.

SUADDSTATICS applies static time shifts in a surface consistent way on seismic data sets. SUADDSTATICS writes the static time shifts in the header field TSTAT. To perform the actual shifts the user should use the program SUSTATIC after SUADDSTATICS. SUADDSTATICS outputs the corrupted data set to stdout.

Header field used by SUADDSTATICS: cdp, sx, gx, tstat, dt.

Credits: CWP Wences Gouveia, 11/07/94, Colorado School of Mines

SURANDSTAT - Add RANDom time shifts STATIC errors to seismic traces

```
surandstat <stdin >stdout [optional parameters]
```

Required parameters:

none

Optional Parameters:

seed=from\_clock random number seed (integer)

max=tr.dt maximum random time shift (ms)

scale=1.0 scale factor for shifts

Credits:

U Houston: Chris Liner c. 2009

SURESSTAT - Surface consistent source and receiver statics calculation

```
suresstat fn= [optional parameters]
```

Required parameters:

fn= seismic file

ssol= output file source statics

rsol= output file receiver statics

Optional parameters:

ntpick=50 maximum static shift (samples)

niter=5 number of iterations

imax=100000 largest shot (fldr), receiver(tracf) or cmp(cdp) number

sub=0 subtract super trace 1 from super trace 2 (=1)

sub=0 strongly biases static to a value of 0

mode=0 use global maximum in cross-correlation window

=1 choose the peak perc=percent smaller than the global max.

perc=10. percent of global max (used only for mode=1)

verbose=0 print diagnostic output (verbose=1)

Notes:

Estimates surface-consistent source and receiver statics, meaning that there is one static correction value estimated for each shot and receiver position.

The method employed here is based on the method of Ronen and Claerbout: Geophysics 50, 2759-2767 (1985).

The input data are NMO-corrected and sorted into shot gathers ( fldr)

Receiver id position should be stored in headerword tracf

The output files are binary files containing the source and receiver statics, as a function of shot number (trace header fldr) and receiver station number (trace header tracf).

The code builds a supertrace1 and supertrace2, which are subsequently cross-correlated. The program then picks the time lag associated with the largest peak in the cross-correlation according to two possible criteria set by the parameter "mode". If mode=0, the maximum of the cross-correlation window is chosen. If mode=1, the program will pick a peak which is up to perc=percent smaller than the global maximum, but closer to zero lag than the global maximum. (Choosing mode=0 is recommended.)

The geometry can be irregular: the program simply computes a static correction for each shot record (fldr=1 to fldr=nshot), with any missing shots being assigned a static of 0. A static correction for each receiver station (tracf=1 to tracf=nr) is calculated, with missing receivers again assigned a static of 0. ",

To window out the most coherent region use suwind tmin= tmax= and save the result into a file. This will reduce the amount of time the code will spent on scanning the file, since the file is much smaller. The ntpick parameter sets the maximum allowable shift desired (in samples NOT time).

To apply the static corrections, use sustatic with hdrs=3

#### Reference:

Ronen, J. and Claerbout, J., 1985, Surface-consistent residual statics estimation by stack-power maximization: Geophysics, vol. 50, 2759-2767.

#### Credits:

CWP: Timo Tjan, 4 October 1994

rewritten by Thomas Pratt, USGS, Feb. 2000.

Modified by A. Bitri, BRGM-France, Apr. 2015

Trace header fields accessed: ns, dt, tracf, fldr, cdp



SUSTATICB - Elevation static corrections, apply corrections from headers or from a source and receiver statics file (beta submitted by J. W. Neese)

sustaticB <stdin >stdout [optional parameters]

Required parameters:

none

Optional Parameters:

v0=v1 or user-defined or from header, weathering velocity

v1=user-defined or from header, subweathering velocity

hdrs=0 =1 to read statics from headers

=2 to read statics from files

=3 to read from output files of suresstat

sign=1 apply static correction (add tstat values)

=-1 apply negative of tstat values

Options when hdrs=2 and hdrs=3:

sou\_file= input file for source statics (ms)

rec\_file= input file for receiver statics (ms)

ns=240 (2)number of sources; (3) max fldr

nr=335 number of receivers

no=96 number of offsets

Notes:

For hdrs=1, statics calculation is not performed, statics correction is applied to the data by reading statics (in ms) from the header.

For hdrs=0, field statics are calculated, and

input field sut is assumed measured in ms.

output field sstat =  $10^{\text{scale1}} * (\text{sdel} - \text{selev} + \text{sdepth}) / \text{swevel}$

output field gstat = sstat - sut/1000.

output field tstat = sstat + gstat +  $10^{\text{scale1}} * (\text{selev} - \text{gelev}) / \text{wevel}$

For hdrs=2, statics are surface consistently obtained from the statics files. The geometry should be regular.

The source- and receiver-statics files should be unformatted C binary floats and contain the statics (in ms) as a function of surface location.

For hdrs=3, statics are read from the output files of suresstat, with the same options as hdrs=2 (but use no=max traces per shot and assume that ns=max fldr number and nr=max receiver number).

For each shot number (trace header fldr) and each receiver number (trace header tracf) the program will look up the appropriate static

correction. The geometry need not be regular as each trace is treated independently.

Caveat: The static shifts are computed with the assumption that the desired datum is sea level (elevation=0). You may need to shift the selev and gelev header values via suchw.

Example: subtracting min(selev,gelev)=25094431

```
suchw < CR290.su key1=selev,gelev key2=selev,gelev key3=selev,gelev \\  
a=-25094431,-25094431 b=1,1 c=0,0 > CR290datum.su
```

Credits:

CWP: Jamie Burns

CWP: Modified by Mohammed Alfaraj, 11/10/1992, for reading  
statics from headers and including sign (+-) option

CWP: Modified by Timo Tjan, 29 June 1995, to include input of  
source and receiver statics from files.

modified by Thomas Pratt, USGS, Feb, 2000 to read statics from  
the output files of suresstat

Logic changed by JWN to fix options hdrs=2,3 ???

Trace header fields accessed: ns, dt, delrt, gelev, selev,  
sdepth, gdel, sdel, swevel, sut, scalel, fldr, tracf

Trace header fields modified: sstat, gstat, tstat

SUSTATICRRS - Elevation STATIC corrections, apply corrections from headers or from a source and receiver statics file, includes application of Residual Refraction Statics

sustaticrrs <stdin >stdout [optional parameters]

Required parameters:

none

Optional Parameters:

v0=v1 or user-defined or from header, weathering velocity

v1=user-defined or from header, subweathering velocity

hdrs=0 =1 to read statics from headers

=2 to read statics from files

sign=1 =-1 to subtract statics from traces(up shift)

Options when hdrs=2:

sou\_file= input file for source statics (ms)

rec\_file= input file for receiver statics (ms)

ns=240 number of sources

nr=335 number of receivers

no=96 number of offsets

Options when hdrs=3:

blvl\_file= base of the near-surface model file (sampled at CMP locations)

refr\_file= horizontal reference datum file (sampled at CMP locations)

nsamp= number of midpoints on line

fx= first x location in velocity model

dx= midpoint interval

V\_r= replacement velocity

mx= number of velocity model samples in lateral direction

mz= number of velocity model samples in vertical direction

dzv= velocity model depth interval

vfile= near-surface velocity model

Options when hdrs=4:

nsamp= number of midpoints on line

fx= first x location in velocity model ",

dx= midpoint interval ",

Options when hdrs=5:

none

Notes:

For hdrs=1, statics calculation is not performed, statics correction is applied to the data by reading statics (in ms) from the header.

For hdrs=0, field statics are calculated, and

input field sut is assumed measured in ms.

output field sstat =  $10^{\text{scale1}} * (\text{sdel} - \text{selev} + \text{sdepth}) / \text{swevel}$

output field gstat = sstat - sut/1000.

output field tstat = sstat + gstat +  $10^{\text{scale1}} * (\text{selev} - \text{gelev}) / \text{wevel}$

For hdrs=2, statics are surface consistently obtained from the statics files. The geometry should be regular.

The source- and receiver-statics files should be unformatted C binary floats and contain the statics (in ms) as a function of surface location.

For hdrs=3, residual refraction statics and average refraction statics are computed. For hdrs=4, residual refraction statics are applied, and for hdrs=5, average refraction statics are applied (Cox, 1999). These three options are coupled in many data processing sequences: before stack residual and average refraction statics are computed but only residual refractions statics are applied, and after stack average refraction statics are applied. Refraction statics are often split like this to avoid biasing stacking velocities. The files blvl\_file and refr\_file are the base of the velocity model defined in vfile and the final reference datum, as described by Cox (1999), respectively. Residual refraction statics are stored in the header field gstat, and the average statics are stored in the header field tstat. V\_r is the replacement velocity as described by Cox (1999). The velocity file, vfile, is designed to work with a horizontal upper surface defined in refr\_file. If the survey has irregular topography, the horizontal upper surface should be above the highest topographic point on the line, and the velocity between this horizontal surface and topography should be some very large value, such as 999999999, so that the traveltimes through that region are inconsequential.

Credits:

CWP: Jamie Burns

CWP: Modified by Mohammed Alfaraj, 11/10/1992, for reading statics from headers and including sign (+-) option

CWP: Modified by Timo Tjan, 29 June 1995, to include input of source and receiver statics from files.

CWP: Modified by Chris Robinson, 11/2000, to include the splitting of refraction statics into residuals and averages

Trace header fields accessed: ns, dt, delrt, gelev, selev, sdepth, gdel, sdel, swevel, sut, scalel

Trace header fields modified: sstat, gstat, tstat

#### References:

Cox, M., 1999, Static corrections for seismic reflection surveys: Soc. Expl. Geophys.

SUSTATIC - Elevation static corrections, apply corrections from headers or from a source and receiver statics file

sustatic <stdin >stdout [optional parameters]

Required parameters:

none

Optional Parameters:

v0=v1 or user-defined or from header, weathering velocity

v1=user-defined or from header, subweathering velocity

hdrs=0 =1 to read statics from headers

=2 to read statics from files

=3 to read from output files of suresstat

sign=1 apply static correction (add tstat values)

=-1 apply negative of tstat values

Options when hdrs=2 and hdrs=3:

sou\_file= input file for source statics (ms)

rec\_file= input file for receiver statics (ms)

ns=240 number of sources

nr=335 number of receivers

no=96 number of offsets

Notes:

For hdrs=1, statics calculation is not performed, statics correction is applied to the data by reading statics (in ms) from the header.

For hdrs=0, field statics are calculated, and

input field sut is assumed measured in ms.

output field sstat =  $10^{\text{scale1}} * (\text{sdel} - \text{selev} + \text{sdepth}) / \text{swevel}$

output field gstat = sstat - sut/1000.

output field tstat = sstat + gstat +  $10^{\text{scale1}} * (\text{selev} - \text{gelev}) / \text{wevel}$

For hdrs=2, statics are surface consistently obtained from the statics files. The geometry should be regular.

The source- and receiver-statics files should be unformatted C binary floats and contain the statics (in ms) as a function of surface location.

For hdrs=3, statics are read from the output files of suresstat, with the same options as hdrs=2 (but use no=max traces per shot and assume that ns=max shot number and nr=max receiver number).

For each shot number (trace header fldr) and each receiver number (trace header tracf) the program will look up the appropriate static correction. The geometry need not be regular as each trace is treated

independently.

Caveat: The static shifts are computed with the assumption that the desired datum is sea level (elevation=0). You may need to shift the selev and gelev header values via suchw.

Example: subtracting min(selev,gelev)=25094431

```
suchw < CR290.su key1=selev,gelev key2=selev,gelev key3=selev,gelev \\  
a=-25094431,-25094431 b=1,1 c=0,0 > CR290datum.su
```

Credits:

CWP: Jamie Burns

CWP: Modified by Mohammed Alfaraj, 11/10/1992, for reading  
statics from headers and including sign (+-) option

CWP: Modified by Timo Tjan, 29 June 1995, to include input of  
source and receiver statics from files.

modified by Thomas Pratt, USGS, Feb, 2000 to read statics from  
the output files of suresstat

Trace header fields accessed: ns, dt, delrt, gelev, selev,  
sdepth, gdel, sdel, swevel, sut, scalel, fldr, tracf

Trace header fields modified: sstat, gstat, tstat

SUILOG -- time axis inverse log-stretch of seismic traces

suilog nt= ntmin= <stdin >stdout

Required parameters:

nt= nt output from sulog prog

ntmin= ntmin output from sulog prog

dt= dt output from sulog prog

Optional parameters:

none

NOTE: Parameters needed by suilog to reconstruct the original data may be input via a parameter file.

EXAMPLE PROCESSING SEQUENCE:

suilog outpar=logpar <data1 >data2

suilog par=logpar <data2 >data3

where logpar is the parameter file

Credits:

CWP: Shuki Ronen, Chris Liner

Caveats:

amplitudes are not well preserved

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt



SULOG -- time axis log-stretch of seismic traces

sulog [optional parameters] <stdin >stdout

Required parameters:

none

Optional parameters:

ntmin= .1\*nt minimum time sample of interest  
outpar=/dev/tty output parameter file, contains:  
number of samples (nt=)  
minimum time sample (ntmin=)  
output number of samples (ntau=)  
m=3 length of stretched data  
is set according to  
ntau = nextpow(m\*nt)  
ntau= pow of 2 override for length of stretched  
data (useful for padding zeros  
to avoid aliasing)

NOTES:

ntmin is required to avoid taking log of zero and to  
keep number of outsamples (ntau) from becoming enormous.

Data above ntmin is zeroed out.

The output parameters will be needed by suilog to  
reconstruct the original data.

EXAMPLE PROCESSING SEQUENCE:

sulog outpar=logpar <data1 >data2

suiolog par=logpar <data2 >data3

Credits:

CWP: Shuki, Chris

Caveats:

Amplitudes are not well preserved.

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt

SUNMO\_a - NMO for an arbitrary velocity function of time and CDP with experimental Anisotropy options

```
sunmo <stdin >stdout [optional parameters]
```

Optional Parameters:

```
tnmo=0,... NMO times corresponding to velocities in vnmo
vnmo=1500,... NMO velocities corresponding to times in tnmo
anis1=0 two anisotropy coefficients making up quartic term
anis2=0 in traveltime curve, corresponding to times in tnmo
cdp= CDPs for which vnmo & tnmo are specified (see Notes)
smute=1.5 samples with NMO stretch exceeding smute are zeroed
lmute=25 length (in samples) of linear ramp for stretch mute
sscale=1 =1 to divide output samples by NMO stretch factor
invert=0 =1 to perform (approximate) inverse NMO
upward=0 =1 to scan upward to find first sample to kill
```

Notes:

For constant-velocity NMO, specify only one vnmo=constant and omit tnmo.

NMO interpolation error is less than 1% for frequencies less than 60% of the Nyquist frequency.

Exact inverse NMO is impossible, particularly for early times at large offsets and for frequencies near Nyquist with large interpolation errors.

The "offset" header field must be set.

Use suazimuth to set offset header field when sx,sy,gx,gy are all nonzero.

For NMO with a velocity function of time only, specify the arrays

```
vnmo=v1,v2,... tnmo=t1,t2,...
```

where v1 is the velocity at time t1, v2 is the velocity at time t2, ...

The times specified in the tnmo array must be monotonically increasing.

Linear interpolation and constant extrapolation of the specified velocities is used to compute the velocities at times not specified.

The same holds for the anisotropy coefficients as a function of time only.

For NMO with a velocity function of time and CDP, specify the array

```
cdp=cdp1,cdp2,...
```

and, for each CDP specified, specify the vnmo and tnmo arrays as described above. The first (vnmo,tnmo) pair corresponds to the first cdp, and so on. Linear interpolation and constant extrapolation of  $1/\text{velocity}^2$  is used to compute velocities at CDPs not specified.

Anisotropy option:

Caveat, this is an experimental option,

The anisotropy coefficients anis1, anis2 permit non-hyperbolicity due to layering, mode conversion, or anisotropy. Default is isotropic NMO.

The same holds for the anisotropy coefficients as a function of time and CDP.

Moveout is defined by

$$v^2 = \frac{1}{1 + \text{anis2} \cdot x^2} \left( \text{anis1} + x^2 + \frac{\text{anis2} \cdot x^4}{1 + \text{anis2} \cdot x^2} \right)$$

Note: In general, the user should set the cdp parameter. The default is to use tr.cdp from the first trace and assume only one cdp.

Caveat:

Nmo cannot handle negative moveout as in triplication caused by anisotropy. But negative moveout happens necessarily for negative anis1 at sufficiently large offsets. Then the error-negative moveout- is printed. Check anis1. An error (anis2 too small) is also printed if the denominator of the quartic term becomes negative. Check anis2. These errors are prompted even if they occur in traces which would not survive the NMO-stretch threshold. Chop off enough far-offset traces (e.g. with suwind) if anis1, anis2 are fine for near-offset traces.

Credits:

SEP: Shuki, Chuck Sword

CWP: Shuki, Jack, Dave Hale, Bjoern Rommel

Modified: 08/08/98 - Carlos E. Theodoro - option for lateral offset

Modified: 07/11/02 - Sang-yong Suh -

added "upward" option to handle decreasing velocity function.

CWP: Sept 2010: John Stockwell

replaced Carlos Theodoro's fix

and added the instruction in the selfdoc to use suazimuth to set offset so that it accounts for lateral offset

note that by the segy standard "scale1" does not scale the offset field

Technical Reference:

The Common Depth Point Stack

William A. Schneider

Proc. IEEE, v. 72, n. 10, p. 1238-1254

1984

Trace header fields accessed: ns, dt, delrt, offset, cdp, scale1

SUNMO - NMO for an arbitrary velocity function of time and CDP

```
sunmo <stdin >stdout [optional parameters]
```

Optional Parameters:

tnmo=0,... NMO times corresponding to velocities in vnmo  
vnmo=1500,... NMO velocities corresponding to times in tnmo  
cdp= CDPs for which vnmo & tnmo are specified (see Notes)  
smute=1.5 samples with NMO stretch exceeding smute are zeroed  
lmute=25 length (in samples) of linear ramp for stretch mute  
sscale=1 =1 to divide output samples by NMO stretch factor  
invert=0 =1 to perform (approximate) inverse NMO  
upward=0 =1 to scan upward to find first sample to kill  
voutfile= if set, interpolated velocity function  $v[cdp][t]$  is  
output to named file.

Notes:

For constant-velocity NMO, specify only one vnmo=constant and omit tnmo.

NMO interpolation error is less than 1% for frequencies less than 60% of the Nyquist frequency.

Exact inverse NMO is impossible, particularly for early times at large offsets and for frequencies near Nyquist with large interpolation errors.

The "offset" header field must be set.

Use suazimuth to set offset header field when sx,sy,gx,gy are all nonzero.

For NMO with a velocity function of time only, specify the arrays

vnmo=v1,v2,... tnmo=t1,t2,...

where v1 is the velocity at time t1, v2 is the velocity at time t2, ...

The times specified in the tnmo array must be monotonically increasing.

Linear interpolation and constant extrapolation of the specified velocities is used to compute the velocities at times not specified.

The same holds for the anisotropy coefficients as a function of time only.

For NMO with a velocity function of time and CDP, specify the array

cdp=cdp1,cdp2,...

and, for each CDP specified, specify the vnmo and tnmo arrays as described above. The first (vnmo,tnmo) pair corresponds to the first cdp, and so on. Linear interpolation and constant extrapolation of  $1/\text{velocity}^2$  is used to compute velocities at CDPs not specified.

The format of the output interpolated velocity file is unformatted C floats with `vout[cdp][t]`, with time as the fast dimension and may be used as an input velocity file for further processing.

Note that this version of `sunmo` does not attempt to deal with anisotropy. The version of `sunmo` with experimental anisotropy support is `"sunmo_a`

#### Credits:

SEP: Shuki Ronen, Chuck Sword

CWP: Shuki Ronen, Jack, Dave Hale, Bjoern Rommel

Modified: 08/08/98 - Carlos E. Theodoro - option for lateral offset

Modified: 07/11/02 - Sang-yong Suh -

added "upward" option to handle decreasing velocity function.

CWP: Sept 2010: John Stockwell

1. replaced Carlos Theodoro's fix
2. added the instruction in the selfdoc to use `suazimuth` to set offset so that it accounts for lateral offset.
3. removed Bjoren Rommel's anisotropy stuff. `sunmo_a` is the version with the anisotropy parameters left in.
4. note that `scalel` does not scale the offset field in the segy standard.

#### Technical Reference:

The Common Depth Point Stack

William A. Schneider

Proc. IEEE, v. 72, n. 10, p. 1238-1254

1984

Trace header fields accessed: `ns`, `dt`, `delrt`, `offset`, `cdp`, `scalel`

SUREDUCE - convert traces to display in reduced time ",

sureduce <stdin >stdout rv=

Required parameters:

dt=tr.dt if not set in header, dt is mandatory

Optional parameters:

rv=8.0 reducing velocity in km/sec ",

Note: Useful for plotting refraction seismic data.

To remove reduction, do:

suflip < reduceddata.su flip=3 | sureduce rv=RV > flip.su

suflip < flip.su flip=3 > unreduceddata.su

Trace header fields accessed: dt, ns, offset

Trace header fields modified: none

Author: UC Davis: Mike Begnaud March 1995

Trace header fields accessed: ns, dt, offset

## SURESAMP - Resample in time

suresamp <stdin >stdout [optional parameters]

Required parameters:

none

Optional Parameters:

nt=tr.ns	number of time samples on output
dt=	time sampling interval on output
	default is:
	tr.dt/10 <sup>6</sup> seismic data
	tr.d1 non-seismic data
tmin=	time of first sample in output
	default is:
	tr.delrt/10 <sup>3</sup> seismic data
	tr.f1 non-seismic data
rf=	resampling factor;
	if defined, set nt=nt_in*rf and dt=dt_in/rf
verbose=0	=1 for advisory messages

Example 1: (assume original data had dt=.004 nt=256)

```
sufilter <data f=40,50 amps=1.,0. |  
suresamp nt=128 dt=.008 | ...
```

Using the resampling factor rf, this example translates to:

```
sufilter <data f=40,50 amps=1.,0. | suresamp rf=0.5 | ...
```

Note the typical anti-alias filtering before sub-sampling!

Example 2: (assume original data had dt=.004 nt=256)

```
suresamp <data nt=512 dt=.002 | ...
```

or use:

```
suresamp <data rf=2 | ...
```

Example 3: (assume original data had d1=.1524 nt=8192)

```
sufilter <data f=0,1,3,3.28 amps=1,1,1,0 |  
suresamp <data nt=4096 dt=.3048 | ...
```

Example 4: (assume original data had d1=.5 nt=4096)

```
suresamp <data nt=8192 dt=.25 | ...
```



Credits:

CWP: Dave (resamp algorithm), Jack (SU adaptation)  
CENPET: Werner M. Heigl - modified for well log support  
RISSC: Nils Maercklin 2006 - minor fixes, added rf option

Algorithm:

Resampling is done via 8-coefficient sinc-interpolation.  
See "\$CWPROOT/src/cwp/lib/intsinc8.c" for technical details.

Trace header fields accessed: ns, dt, delrt, d1, f1, trid  
Trace header fields modified: ns, dt, delrt (only when set tmin)  
d1, f1 (only when set tmin)

SUSHIFT - shifted/windowed traces in time

sushift <stdin >stdout [tmin= ] [tmax= ]

tmin= min time to pass

tmax= max time to pass

dt= sample rate in microseconds

fill=0.0 value to place in padded samples

(defaults for tmin and tmax are calculated from the first trace.

verbose= 1 echos parameters to stdout

Background :

tmin and tmax must be given in seconds

In the high resolution single channel seismic profiling the sample interval is short, the shot rate and the number of samples are high. To reduce the file size the delrt time is changed during a profiling trip. To process and display a seismic section a constant delrt is needed. This program does this job.

The SEG-Y header variable delrt (delay in ms) is a short integer. That's why in the example shown below delrt is rounded to 123 !

```
... | sushift tmin=0.1234 tmax=0.2234 | ...
```

The dt= and fill= options are intended for manipulating velocity volumes in trace format. In particular models which were hung from the water bottom when created & which then need to have the water layer added.

Author:

Toralf Foerster  
Institut fuer Ostseeforschung Warnemuende  
Sektion Marine Geologie  
Seestrasse 15  
D-18119 Rostock, Germany

Trace header fields accessed: ns, delrt

Trace header fields modified: ns, delrt



SUTAUPNMO - NMO for an arbitrary velocity function of tau and CDP

сутаупнмо <stdin >stdout [optional parameters]

Optional Parameters:

tnmo=0,... NMO times corresponding to velocities in vnmo

vnmo=1500,... NMO velocities corresponding to times in tnmo

cdp= CDPs for which vnmo & tnmo are specified (see Notes)

smute=1.5 samples with NMO stretch exceeding smute are zeroed

lmute=25 length (in samples) of linear ramp for stretch mute

sscale=1 =1 to divide output samples by NMO stretch factor

Notes:

For constant-velocity NMO, specify only one vnmo=constant and omit tnmo.

For NMO with a velocity function of tau only, specify the arrays

vnmo=v1,v2,... tnmo=t1,t2,...

where v1 is the velocity at tau t1, v2 is the velocity at tau t2, ...

The taus specified in the tnmo array must be monotonically increasing.

Linear interpolation and constant extrapolation of the specified velocities is used to compute the velocities at taus not specified.

For NMO with a velocity function of tau and CDP, specify the array

cdp=cdp1,cdp2,...

and, for each CDP specified, specify the vnmo and tnmo arrays as described above. The first (vnmo,tnmo) pair corresponds to the first cdp, and so on.

Linear interpolation and constant extrapolation of velocity<sup>2</sup> is used to compute velocities at CDPs not specified.

Moveout is defined by

$$\tau^2 + \tau^2 \cdot p^2 \cdot v^2$$

Note: In general, the user should set the cdp parameter. The default is to use tr.cdp from the first trace and assume only one cdp.

Caveat:

Taunmo should handle triplication

NMO interpolation error is less than 1% for frequencies less than 60% of the Nyquist frequency.

Exact inverse NMO is not implemented, nor has anisotropy

Example implementation:

```
sutaup dx=25 option=2 pmin=0 pmax=0.0007025 < cmpgather.su |  
supef minlag=0.2 maxlag=0.8 |  
sutaupnmo tnmo=0.5,2,4 vnmo=1500,2000,3200 smute=1.5 |  
sumute key=tracr mode=1 ntaper=20 xmute=1,30,40,50,85,15  
tmute=7.8,7.8,4.5,3.5,2.0,0.35 |  
sustack key=cdp | ... [...]
```

Credits:

Durham, Richard Hobbs modified from SUNMO credited below

SEP: Shuki Ronen, Chuck Sword

CWP: Shuki Ronen, Jack K. Cohen , Dave Hale

Technical Reference:

van der Baan papers in geophysics (2002 & 2004)

Trace header fields accessed: ns, dt, delrt, offset, cdp, sy

SUTSQ -- time axis time-squared stretch of seismic traces

sutsq [optional parameters] <stdin >stdout

Required parameters:

none

Optional parameters:

tmin= .1*nt*dt	minimum time sample of interest (only needed for forward transform)
dt= .004	output sample rate (only needed for inverse transform)
flag= 1	1=forward transform: time to time squared -1=inverse transform: time squared to time

Note: The output of the forward transform always starts with time squared equal to zero. 'tmin' is used to avoid aliasing the early times.

Caveats:

Amplitudes are not well preserved.

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt

SUTTOZ - resample from time to depth

suttoz <stdin >stdout [optional parms]

Optional Parameters:

$nz=1+(nt-1)*dt*vmax/(2.0*dz)$  number of depth samples in output

$dz=vmin*dt/2$  depth sampling interval (defaults avoids aliasing)

$fz=v(ft)*ft/2$  first depth sample

$t=0.0, \dots$  times corresponding to interval velocities in  $v$

$v=1500.0, \dots$  interval velocities corresponding to times in  $t$

$vfile=$  binary (non-ascii) file containing velocities  $v(t)$

$verbose=0 >0$  to print depth sampling information

Notes:

Default value of  $nz$  set to avoid aliasing

The  $t$  and  $v$  arrays specify an interval velocity function of time.

Note that  $t$  and  $v$  are given as arrays of floats separated by commas, for example:

$t=0.0, 0.01, .2, \dots$   $v=1500.0, 1720.0, 1833.5, \dots$  with the number of  $t$  values equaling the number of  $v$  values. The velocities are linearly interpolated to make a continuous, piecewise linear  $v(t)$  profile.

Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in  $t$  must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If  $vfile$  is specified, then the  $t$  and  $v$  arrays are ignored.

see selfdoc of `suztot` for depth to time conversion

Trace header fields accessed:  $ns$ ,  $dt$ , and  $delrt$

Trace header fields modified:  $trid$ ,  $ns$ ,  $d1$ , and  $f1$

Credits:

CWP: Dave Hale c. 1992

SUZTOT - resample from depth to time

suztot <stdin >stdout [optional parms]

Optional Parameters:

nt=1+(nz-1)\*2.0\*dz/(vmax\*dt)      number of time samples in output

dt=2\*dz/vmin time sampling interval (defaults avoids aliasing)

ft=2\*fz/v(fz) first time sample

z=0.0,... depths corresponding to interval velocities in v

v=1500.0,... interval velocities corresponding to depths in v

vfile= binary (non-ascii) file containing velocities v(z)

verbose=0 >0 to print depth sampling information

Notes:

Default value of nt set to avoid aliasing

The z and v arrays specify an interval velocity function of depth.

Note that z and v are given as arrays of floats separated by commas, for example:

z=0.0,100,200,... v=1500.0,1720.0,1833.5,... with the number of z values equaling the number of v values. The velocities are linearly interpolated to produce a piecewise linear v(z) profile. This fact must be taken into account when attempting to use this program as the inverse of suttoz.

Linear interpolation and constant extrapolation is used to determine interval velocities at times not specified. Values specified in z must increase monotonically.

Alternatively, interval velocities may be stored in a binary file containing one velocity for every time sample. If vfile is specified, then the z and v arrays are ignored.

see the selfdoc of   suttoz   for time to depth conversion

Trace header fields accessed: ns, dt, and delrt

Trace header fields modified: trid, ns, d1, and f1

Credits:

CWP: John Stockwell, 2005,

based on suttoz.c written by Dave Hale c. 1992



SUGET - Connect SU program to file descriptor for input stream.

```
suget fd=$1 | next_su_module
```

This program is for interfacing " outside processing systems with SU. Typically, an outside system would execute the su command file and a file descriptor would be passed by an outside system to the su command file so that output data from the outside system could be piped into the su programs executing inside the command file.

Example: suget fd=\$1 | next\_su\_module

```
fd=-1      file_descriptor_for_input_stream
verbose=0   minimal listing
           =1  asks for message with each trace processed.
```

Author: John Anderson (visiting scholar from Mobil) July 1994

SUPUT - Connect SU program to file descriptor for output stream.

```
su_module | suput fp=$1
```

This program is for interfacing " outside processing systems with SU. Typically, the outside system would execute the SU command file. The outside system provides the file descriptor it would like to read from to the command file to be an argument for suput.

Example: su\_module | suput fp=\$1

```
fd=-1      file_descriptor_for_output_stream_from_su
verbose=0   minimal listing
           =1  asks for message with each trace processed.
```

Author: John Anderson (visiting scholar from Mobil) July 1994

SUADDEVENT - add a linear or hyperbolic moveout event to seismic data

suaddevent <stdin >stdout [optional parameters]

Required parameters:

none

Optional parameters:

type=nmo      =lmo for linear event  
t0=1.0        zero-offset intercept time IN SECONDS  
vel=3000.     moveout velocity in m/s  
amp=1.        amplitude  
dt=    must provide if 0 in headers (seconds)

Typical usage:

```
sunull nt=500 dt=0.004 ntr=100 | sushw key=offset a=-1000 b=20 \\  
| suaddevent v=1000 t0=0.05 type=lmo | suaddevent v=1800 t0=0.8 \  
| sufILTER f=8,12,75,90 | suxwigb clip=1 &
```

Credits:

Gary Billings, Talisman Energy, May 1996, Apr 2000, June 2001

Note: code is inefficient in that to add a single "spike", with sinc interpolation, an entire trace is generated and added to the input trace. In fact, only a few points needed be created and added, but the current coding avoids the bookkeeping re which are the relevant points!

SUDGWAVEFORM - make Gaussian derivative waveform in SU format

```
sudgwaveform >stdout [optional parameters]
```

Optional parameters:

n=2 order of derivative ( $n \geq 1$ )

fpeak=35 peak frequency

nfpeak=n\*n max. frequency = nfpeak \* fpeak

nt=128 length of waveform

shift=0 additional time shift in s (used for plotting)

sign=1 use -1 to change sign

verbose=0 =0 don't display diagnostic messages

=1 display diagnostic messages

Notes:

This code computes a waveform that is the n-th order derivative of a Gaussian. The variance of the Gaussian is specified through its peak frequency, i.e. the frequency at which the amplitude spectrum of the Gaussian has a maximum. nfpeak is used to compute maximum frequency, which in turn is used to compute the sampling interval. Increasing nfpeak gives smoother plots. In order to have a (pseudo-) causal pulse, the program computes a time shift equal to  $\sqrt{n}/f_{\text{peak}}$ . An additional shift can be applied with the parameter shift. A positive value shifts the waveform to the right.

Examples:

2-loop Ricker: dgwaveform n=1 >ricker2.su

3-loop Ricker: dgwaveform n=2 >ricker3.su

Sonic transducer pulse: dgwaveform n=10 fpeak=300 >sonic.su

To display use suxgraph. For example:

```
dgwaveform n=10 fpeak=300 | suxgraph style=normal &
```

For other seismic waveforms, please use "suwaveform".

Credits:

Werner M. Heigl, February 2007

This copyright covers parts that are not part of the original CWP/SU: Seismic Un\*x codes called by this program:

Copyright (c) 2007 by the Society of Exploration Geophysicists.  
For more information, go to <http://software.seg.org/2007/0004> .  
You must read and accept usage terms at:  
<http://software.seg.org/disclaimer.txt> before use.

Revision history:

Original SEG version by Werner M. Heigl, Apache E&P Technology,  
February 2007.

Jan 2010 - subroutines deriv\_n\_gauss and hermite\_n\_polynomial moved  
to libcwp.a

/

SUEA2DF - SU version of (an)elastic anisotropic 2D finite difference forward modeling, 4th order in space

```
suea2df > outfile c11file= c55file [optional parameters]
```

Required Parameters:

c11file=c11\_file c11 voigt elasticity parameter filename

c55file=c55\_file c55 voigt elasticity parameter filename

Optional Parameters:

rhofile=rho\_file density filename

(if rhofile is not set, rho=1000 is assumed)

Anisotropy parameters:

aniso=0 =1 - include anisotropy parameters

mode=0 =0 output particle velocity, =1 output stresses  
(snapshots only)

... the next 3 parameters become active only when aniso=1....

c13file=c13\_file c13 voigt elasticity parameter filename

c33file=c33\_file c33 voigt elasticity parameter filename

c15file=c15\_file c15 voigt elasticity parameter filename

c35file=c35\_file c35 voigt elasticity parameter filename

Attenuation parameters:

qsw=0 switch to include attenuation =1 - include

... the next parameter becomes active only when qsw=1....

qfile=Q\_file Q parameter filename

dt=0.001 time sampling interval (s)

ft=0.0 first time (s)

lt=1.0 last time (s)

nx=200 number of values in slow (x-direction)

dx=10.0 spatial sampling interval (m) x-coor

fx=-1000 first x coor (m)

nz=100 number of values in fast (z)-dimension

dz=dx spatial sampling interval (m) z-coor

fz=0 firstz coor (m)

Source parameters:

sx=0 source x position (m)

sz=500 source location (m)

stype='p' source type  
   p: P-wave  
   v: velocity  
 pw: P plane-wave  
 sang=0 for stype='pw': plane wave angle  
 wtype='dg' wave type  
   dg: Gaussian derivative  
   ga: Gaussian  
   ri: Ricker  
   sp: spike, sp2: double spike  
 ts=0.05 source duration (s)  
 favg=50 source average frequency

#### Attenuation parameters:

qsw=0 switch to include attenuation =1 - include

#### Boundary condition parameters:

bc=10,10,10,10 Top,left,bottom,right boundary condition  
   =0 none  
   =1 symmetry  
   =2 free surface (top only)  
   >2 absorbing (value indicates width of absorbing

layer

bc\_a=0.95; bc initial taper value for absorbing boundary  
 bc\_r=0.; bc exponential factor for absorbing boundary  
 variables are scaled by  $bc\_a \cdot \text{pow}(i, -bc\_r)$

#### Optional output parameters:

sofile= name of source file  
 snfile= name of file containing for snapshots  
 snaptime= times of snapshots i.e. snaptime=0.1,0.2,0.3

vsx= x coordinate of vertical line of seismograms  
 hsz= z coordinate of horizontal line of seismograms  
 vrsfile="vsp.su" output file for vertical line of seismograms[nz][nt]  
 hsfile="hs.su" output file for horizontal line of seismograms[nx][nt]  
 tsw=0 switch to use shear stress only in non-fluid  
 media - may help reduce dispersion tsw=1. If  
 tsw=0 then standard calculation  
 verbose=0 =1 to print progress on screen

#### Notes:

1) The outfile contains information generated by the input parameters,

such as memory allocation, stability, etc. If your input file does not work, check this file first.

The model is specified as binary files of stiffness parameters and densities. These may be created any way the user desires. The program `unif2` or `makevel` may be used to generate densities, and the program `unif2aniso` may be used to generate the stiffnesses. You will need to transpose these files (stiffnesses and densities), as the input format for `suea2df` assumes that the fast dimension is the horizontal or the x-dimension. You may do this via

```
transp n1=nz < c11_file > transp_c11_file
```

If `aniso=1` then the program will expect the additional stiffnesss files.

If `qsw=1` `unif2anis` can be used to generate the Q values on a grid. These value also need to be transposed, as with the stiffnesses.

Output files (always generated)

`hsfile`  
`vrslfile`  
`hsfile.chd` - header for `hsfile`  
`vrslfile.chd` - header for `vrslfile`  
`hsfile.mod` - model file

Output files (if requested)

`sofile` - ascii source file  
`snfile` - su format snapshots file

Caveat:

A common error in using this program is to compute stiffnesses with a specified density, but forget to specify this density as the `rho`file.

Credits: UU GEOPHY Chris Juhlin 15 May 1999

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Parts of program use Seismic Unix Package - CSM

Changes - C. Juhlin

1. Fixed upgrading of stresses. There was an error in the coding for the Tzz term, `c15` was being used instead of `c35`. This only caused problems for dipping anisotropic layers



2. Added some header information for hutput of snapshots.
3. 2001-01-30: Added option to set absorbing bc constants bc\_a and bc\_r
4. 2001-02-23: Corrected bug in outputting model boundaries to standard output in routine get\_econst
5. 2001-04-26: Added option for updating velocities to only use shear stress if material is non-fluid, this appears to reduce dispersion at near grazing angles for fluid-solid boundary. Set tsw=1 to invoke
6. 2001-05-14: Changed loop in free-surface boundary condition for velocities Thanks goes to Mike Holzrichter for pointing out this problem and the wrong scaling factor in the updating.
7. 2001-05-16: Changed set\_layers function to avoid negative indexing. Thanks goes to Mike Holzrichter for pointing out this problem
8. 2001-05-17: Modified make\_seis to take into account VSP geometry correctly and not store unnecessary data.
9. 2001-08-21: Fixed set\_layers so mode fills properly in depth. Earlier versions were accessing incorrect array locations at last defined depth.
10. 2003-04-21: Fixed boundary conditions.
11. 2003-05-02: Extended the model area by half the grid spacing on the RHS. This makes the model area symmetric allowing a plane wave source to be introduced into the model (stype=pw). The w, txx and tzz grids contain now one more column than the u and txz grids.
12. 2003-05-02: Added routines to allow plane waves to be introduced at a specified angle (sang) into the model with functions add\_pw\_source\_V and add\_pw\_source\_S.
13. 15 Oct 2005 -- tossed all the model building stuff. Read models from binary files made by unif2aniso (CWP:John Stockwell)
14. 25 Feb 2008 -- Fixed attenuation option (qsw=1) so that Q values are from binary files made by makevel or similar program

15. 1 April 2010 -- Changed free surface velocity BC back to original.  
Someone had changed the scaling factor from 2.0 to 0.5 in fs4v\_bc\_top

Algorithm based on Juhlin (1995, Geophys. Prosp.)  
and Levander (1988, Geophysics)  
Attenuation included as in Graves (1996, BSSA)

SUFCTANISMOD - Flux-Corrected Transport correction applied to the 2D elastic wave equation for finite difference modeling in anisotropic media

sufctanismo > outfile [optional parameters]  
outfile is the final wavefield snapshot x-component  
x-component of wavefield snapshot is in snapshotx.data  
y-component of wavefield snapshot is in snapshoty.data  
z-component of wavefield snapshot is in snapshotz.data

Optional Output Files:

reflxfile= reflection seismogram file name for x-component  
no output produced if no name specified  
reflyfile= reflection seismogram file name for y-component  
no output produced if no name specified  
reflzfile= reflection seismogram file name for z-component  
no output produced if no name specified  
vspxfile= VSP seismogram file name for x-component  
no output produced if no name specified  
vspyfile= VSP seismogram file name for y-component  
no output produced if no name specified  
vspzfile= VSP seismogram file name for z-component  
no output produced if no name specified

suhead=1        To get SU-header output seismograms (else suhead=0)

New parameter:

Optional Parameters:

mt=1            number of time steps per output snapshot  
dofct=1    1 do the FCT correction  
0 do not do the FCT correction  
FCT Related parameters:  
eta0=0.03 diffusion coefficient  
typical values ranging from 0.008 to 0.06  
about 0.03 for the second-order method  
about 0.012 for the fourth-order method  
eta=0.04 anti-diffusion coefficient  
typical values ranging from 0.008 to 0.06  
about 0.04 for the second-order method  
about 0.015 for the fourth-order method  
fctxbeg=0    x coordinate to begin applying the FCT correction  
fctzbeg=0    z coordinate to begin applying the FCT correction

```

fctxend=nx  x coordinate to stop applying the FCT correction
fctzend=nz  z coordinate to stop applying the FCT correction

deta0dx=0.0 gradient of eta0 in x-direction  d(eta0)/dx
deta0dz=0.0 gradient of eta0 in z-direction  d(eta0)/dz
detadx=0.0 gradient of eta in x-direction    d(eta)/dx
detadz=0.0 gradient of eta in z-direction    d(eta)/dz

General Parameters:
order=2 2 second-order finite-difference
4 fourth-order finite-difference

nt=200      number of time steps
dt=0.004 time step

nx=100  number of grid points in x-direction
nz=100  number of grid points in z-direction

dx=0.02 spatial step in x-direction
dz=0.02 spatial step in z-direction

sx=nx/2 source x-coordinate (in gridpoints)
sz=nz/2 source z-coordinate (in gridpoints)

fpeak=20 peak frequency of the wavelet

receiverdepth=sz  depth of horizontal receivers (in gridpoints)
vspnx=sx x grid loc of vsp

verbose=0      silent operation
=1 for diagnostic messages, =2 for more

wavelet=1 1 AKB wavelet
        2 Ricker wavelet
3 impulse
4 unity

isurf=2 1 absorbing surface condition
2 free surface condition
3 zero surface condition

source=1 1 point source
        2 sources are located on a given refelector      ",

```

(two horizontal and one dipping reflectors)

3 sources are located on a given dipping reflector ",

sfile= the name of input source file, if no name specified then  
use default source location. (source=1 or 2)

Density and Elastic Parameters:

dfile= the name of input density file,  
if no name specified then

assume a linear density profile with ...

rho00=2.0 density at (0, 0)

drhidx=0.0 density gradient in x-direction  $d(\rho)/dx$

drhodz=0.0 density gradient in z-direction  $d(\rho)/dz$

afile= name of input elastic param. (c11) aa file, if no name  
specified then, assume a linear profile with ...

aa00=2.0 elastic parameter at (0, 0)

daadx=0.0 parameter gradient in x-direction  $d(aa)/dx$

daadz=0.0 parameter gradient in z-direction  $d(aa)/dz$

cfile= name of input elastic param. (c33) cc file, if no name  
specified then, assume a linear profile with ...

cc00=2.0 elastic parameter at (0, 0)

dccdx=0.0 parameter gradient in x-direction  $d(cc)/dx$

dccdz=0.0 parameter gradient in z-direction  $d(cc)/dz$

ffile= name of input elastic param. (c13) ff file, if no name  
specified then, assume a linear profile with ...

ff00=2.0 elastic parameter at (0, 0)

dffdx=0.0 parameter gradient in x-direction  $d(ff)/dx$

fffdz=0.0 parameter gradient in z-direction  $d(ff)/dz$

lfile= name of input elastic param. (c44) ll file, if no name  
specified then, assume a linear profile with ...

ll00=2.0 elastic parameter at (0, 0)

dllldx=0.0 parameter gradient in x-direction  $d(ll)/dx$

dllldz=0.0 parameter gradient in z-direction  $d(ll)/dz$

nfile= name of input elastic param. (c66) nn file, if no name  
specified then, assume a linear profile with ...

nn00=2.0 elastic parameter at (0, 0)

dnndx=0.0 parameter gradient in x-direction  $d(nn)/dx$

dnndz=0.0 parameter gradient in z-direction  $d(nn)/dz$

#### Optimizations:

The moving boundary option permits the user to restrict the computations of the wavefield to be confined to a specific range of spatial coordinates.

The boundary of this restricted area moves with the wavefield

movebc=0 0 do not use moving boundary optimization

1 use moving boundaries

Author: Tong Fei, Center for Wave Phenomena,  
Colorado School of Mines, Dec 1993

Some additional features by: Stig-Kyrre Foss, CWP  
Colorado School of Mines, Oct 2001

New features (Oct 2001):

- setting receiver depth
- outputfiles with SU-headers
- additional commentary

Modifications (Mar 2010) Chris Liner, U Houston

- added snapshot mt param to parallel sufdmod2d functionality
- added verbose and some basic info echos
- error check that source loc is in grid
- dropped mbx1 etc from selfdoc (they were internally computed)
- moved default receiver depth to source depth
- added vspnx to selfdoc and moved default vspnx to source x
- changed sy in selfdoc to sz (typo)
- fixed bug in vsp file(s) allocation: was [nt,nx] now is [nt,nz]

#### Notes:

This program performs seismic modeling for elastic anisotropic media with vertical axis of symmetry.

The finite-difference method with the FCT correction is used.

Stability condition:  $v_{max} \cdot dt / (\sqrt{2} \cdot \min(dx, dz)) < 1$

Two major stages are used in the algorithm:

- (1) conventional finite-difference wave extrapolation
- (2) followed by an FCT correction

#### References:

The detailed algorithm description is given in the article

"Elimination of dispersion in finite-difference modeling and migration" in CWP-137, project review, page 155-174.

Original reference to the FCT method:

Boris, J., and Book, D., 1973, Flux-corrected transport. I. SHASTA, a fluid transport algorithm that works:  
Journal of Computational Physics, vol. 11, p. 38-69.

/

SUFDMOD1 - Finite difference modelling (1-D 1st order) for the acoustic wave equation "

sufdmod1 <vfile >sfile nz= tmax= sz= [optional parameters]

Required parameters :

<vfile or vfile= binary file containing velocities[nz]

>sfile or sfile= SU file containing seimogram[nt]

nz= number of z samples

tmax= maximum propagation time

sz= z coordinate of source

Optional parameters :

dz=1 z sampling interval

fz=0.0 first depth sample

rz=1 coordinate of receiver

sz=1 coordinate of source

dfile= binary input file containing density[nz]

wfile= output file for wave field (snapshots in a SU trace panel)

abs=0,1 absorbing conditions on top and bottom

styp=0 source type (0: gauss, 1: ricker 1, 2: ricker 2)

freq=15.0 approximate source center frequency (Hz)

nt=1+tmax/dt number of time samples (dt determined for numerical stability)

zt=1 trace undersampling factor for trace and snapshots

zd=1 depth undersampling factor for snapshots

press=1 to record the pressure field; 0 records the particle velocity

verbose=0 =1 for diagnostic messages

Notes :

This program uses a first order explicit velocity/pressure finite difference equation.

The source function is applied on the pressure component.

If no density file is given, constant density is assumed

Wavefield can be easily viewed with suximage, user must provide f2=0 to the ximage program in order to get correct time labelling

Seismic trace is shifted in order to get a zero phase source

Source begins and stop when it's amplitude is  $10^{-4}$  its maximum

Time and depth undersampling only modify the output trace and snapshots.

These parameters are useful for keeping snapshot file small and the number of samples under SU\_NFLTS.



```

NULL  };

float source (float t, int styp, float dt, float dz, float t0, float alpha);

int main (int argc, char **argv)
{
float *rv; /* array of rock velocity from cfile
float *rd; /* array of rock density from dfile on p knots
float *rd1_5; /* array of rock density from dfile on v knots
float *p; /* pressure
float *v; /* particle velocity
float tmax, dt, t0; /* maximum time , time step,  */
/* time delay for near causal source */
float vmax; /* maximum rock velocity */
int verbose; /* is verbose? */
int nz, nt; /* number of z samples, time samples */
float fz, dz; /* first sample depth spatial depth */
float sz; /* source coordinate */
int abs[2]; /* array of absorbing conditions */
int isz; /* source location index */
float rz; /* receiver depth
int irz; /* zcoordinate (in samples) of the source
int iz, it, itsis; /* counter
int ies; /* end of source index
int press; /* to choose  between pressure or particle
/* velocity
float t; /* time
int td=1, zd=1; /* time and depth decimation
segy snapsh, sismo; /* recording of the seismic field,
/* seismogram
char *dfile=""; /* density file name
char *wfile=""; /* seismogram file name
char *velfile=""; /* velocity file name
char *sfile=""; /* velocity file name
float freq=0.0; /* source center freq
float alpha=0.0; /* source exp */
float epst0=0.0; /* source first amp ratio
int styp; /* source type

FILE *seisfp=stdout; /* pointer to seismic trace output file
FILE *wavefp=NULL; /* pointer to wave field output file
FILE *velocityfp=stdin; /* pointer to input velocity file
FILE *densityfp=NULL; /* pointer to input density file

```

```

/* hook up getpar to handle the parameters
initargs (argc, argv);
requestdoc(0);

/* verbose
if (!getparint ("verbose",&verbose)) verbose=0;

/* get required parameters
if (!getparint ("nz",&nz)) err("must specify nz ! ");
if (verbose) warn("nz= %d", nz);

if (!getparfloat ("tmax",&tmax)) err("must specify tmax ! ");
if (verbose) warn("tmax= %f", tmax);

if (!getparfloat("sz", &sz)) err ("must specify sz ! ");
if (verbose) warn("sz= %f", sz);


/* get optional parameters
if (!getparint ("nt", &nt)) nt=0;
if (verbose) warn("nt= %d", nt);
if (!getparint ("styp", &styp)) styp=0;
if (verbose) warn("styp= %d ", styp);
if (!getparfloat ("dz", &dz)) dz=1;
if (!getparfloat ("fz", &fz)) fz=0.0;

/* source coordinates to samples
isz=NINT((sz-fz)/dz);
if (verbose) warn( "source on knot number %d ", isz);


if (!getparfloat("rz", &rz)) rz=0.0;
irz = NINT ((rz-fz)/dz);
if (verbose) warn("receiver depth : %f on knot # %d ", rz, irz);

if (!getparfloat("freq", &freq)) freq=15.0;
if (verbose) warn("frequency : %f Hz",freq);

getparstring ("velfile", &velfile);
if (verbose) {

```

```

if (*velfile != '\0' ) warn("Velocity file : %s ",velfile);
else warn("Velocity file supplied via stdin");
}

getparstring ("sfile", &sfile);
if (verbose) {
if (*sfile != '\0' ) warn("Output trace file : %s ",sfile);
else warn("Output trace via stdout");
}

getparstring ("dfile", &dfile);
if (verbose) {
if (*dfile != '\0' ) warn("Density file : %s ",dfile);
else warn("No density file supplied ");
}

getparstring ("wfile", &wfile);
if (verbose) {
if (*wfile != '\0' ) warn("Wave file : %s ",wfile);
else warn("No wave file requested ");
}

if ( NINT((float) nz/((float) zd)) + 1 >SU_NFLTS) {
warn ("Too many depth points : impossible to output wave field. Increase zd ?");
*wfile='\0';
}

/* get absorbing conditions
if (!getparint("abs",&abs)) { abs[0]=0; abs[1]=1; }
if (verbose) {
if (abs[0]==1) warn("absorbing condition on top ");
if (abs[1]==1) warn("absorbing condition on bottom ");
}
/* get decimation coefficients
if (!getparint("td",&td)) td=1 ;
if (verbose) warn("time decimation ccoefficient: %d ",td);
if (!getparint("zd",&zd)) zd=1 ;
if (verbose) warn("depth decimation ccoefficient: %d ",zd);

/* choose pressure or particle velocity
if (!getparint("press", &press)) press=1 ;
if ((press != 0) && (press != 1)) err ("press must equal 0 or 1");

```

```

if (verbose) {
if (press==1) warn( "program will output pressure values");
else if (press==0) warn( "program will output particle velocity values");
}

/* allocate space
p=alloc1float(nz);
v=alloc1float(nz);
rv=alloc1float(nz);
rd=alloc1float(nz);
rd1_5=alloc1float(nz);

/* read velocity file
if (*velfile != '\0' ) {
if ((velocityfp=fopen(velfile,"r"))=='\0') err("cannot open velfile=%s ",velfile);
}
if (efread (rv, sizeof(float), nz, velocityfp)!=nz)
err("cannot read %d velocity values ", nz);

/* read density file and linearly interpolate on correct location
if (*dfile != '\0') {
if ((densityfp=fopen(dfile,"r"))=='\0') err("cannot open dfile=%s ",dfile);
if (fread(rd,sizeof(float), nz, densityfp)!=nz) err("error reading dfile %s",dfile);
fclose(densityfp);
}
else for (iz=0; iz<nz; iz++) rd[iz]=2500;
for (iz=0; iz<nz-1; iz++) rd1_5[iz]=(rd[iz]+rd[iz+1])/2;
rd1_5[nz-1]=rd[nz-1];

/* time step computation
vmax=0;
for (iz=0; iz<nz; iz++) if (rv[iz]>vmax) vmax=rv[iz];if (verbose) warn( "vmax= %f ",
dt=dz/1.414/vmax/2; if (verbose) warn( "time step dt= %f ", dt);

/* maximum number of iterations
if (nt==0) nt=1+tmax/dt;
if (verbose) warn( "number of time steps nt= %d ", nt);
if (NINT( (float) nt/((float)td))+1>SU_NFLTS) err("too many time steps. Increase td

/* source parameter computation
alpha=2*9.8696*freq*freq;

```

```

/* time shift to get a t0 centered source

if ((styp==0) || (styp == 2)) epst0=fabs(source (0, styp, dt, dz, 0, alpha) / 1e4);
else if (styp==1) epst0=fabs(source (1/sqrt(2*alpha), styp, dt, dz, 0, alpha)) / 1e4;
if (verbose) warn( "epst0 = %f ", epst0);

t=tmax+dt;
do t=t-dt; while (fabs(source(t, styp, dt, dz, 0, alpha))<epst0);
t0=t;
ies=2*t/dt;

if (verbose) warn("time shift t0 = %f s", t0);

array initialization
for (iz=0; iz<nz; iz++) { v[iz]=0; p[iz]=0; }

if (*wfile != '\0') {
wavefp=fopen (wfile,"w");
snapsh.d1=dz*zd; snapsh.f1=fz ; snapsh.ns=nz/zd+1; snapsh.d2=dt*td; snapsh.f2=0;
/* snapsh.f2=0 is useless since 0 is the "no value" code for SU headers
}
/* propagation computation
itsis=0;
for (it=0; it<=nt; it++) {
t=it*dt;
if (abs[0]==1) p[0]=(p[0]*(1-rv[0]*dt/dz)+2*rd[0]*rv[0]*rv[0]*dt/dz*v[0])/(1+rv[0]*d);
else p[0]=0;
for (iz=1; iz<nz; iz++) p[iz]=p[iz]+rd[iz]*rv[iz]*rv[iz]*dt/dz*(v[iz]-v[iz-1]);
if (abs[1]!=1) p[nz-1]=0;
if (it<ies) {
p[isiz]=p[isiz]+source(t, styp, dt, dz, t0, alpha);
}

for (iz=0; iz<nz-1; iz++) v[iz]=v[iz]+dt/rd1_5[iz]/dz*(p[iz+1]-p[iz]);

if (abs[1] != 1) v[nz-1]=0;
else
v[nz-1]=((rd1_5[nz-1]*dz-dt*rd[nz-1]*rv[nz-1])*v[nz-1]-2*dt*p[nz-1])/(rd1_5[nz-1]*dz+dt*rd[nz-1]*rv[nz-1]);

if (it % td == 0) {
if (press==1)
sismo.data[itsis]=p[irz];
else

```

```

sismo.data[itsis]=v[irz];
    itsis++;
}

if ((*wfile!='\0') && (it % td == 0)) {
if (press==1)
for (iz=0; iz<nz/zd; ++iz) snapsh.data[iz]=p[iz*zd];
else
for (iz=0; iz<nz/zd; ++iz) snapsh.data[iz]=v[iz*zd];

    fputtr(wavefp, &snapsh);
}

}

if (*wfile!='\0') fclose (wavefp);

sismo.dt=td*dt*1e6;
sismo.ns=itsis;
sismo.delrt=-t0*1000;
sismo.trid=TREAL;
sismo.tracl=1;

if (*sfile != '\0') seisfp=fopen(sfile,"w");
fputtr (seisfp, &sismo);

return(CWP_Exit());
}

float source (float t, int styp, float dt, float dz, float t0, float alpha)
{
float x=0.0, sou=0.0;
x=-alpha*(t-t0)*(t-t0);
if (x>-40) {
    if (styp==0) sou=exp(x);
    else if (styp==1) sou=-2*alpha*(t-t0)*exp(x);
    else if (styp==2) sou=2*alpha*(1+2*x)*exp(x);
}
else sou=0;
return sou/dz*dt*1e8;
}

```

SUFDMOD2\_PML - Finite-Difference Modeling (2nd order) for acoustic wave equation with PML absorbing boundary conditions.  
Caveat: experimental PML absorbing boundary condition version, may be buggy!

```
sufdmod2_pml <vfile >wfile nx= nz= tmax= xs= zs= [optional parameters]
```

Required Parameters:

```
<vfile file containing velocity[nx][nz]
>wfile file containing waves[nx][nz] for time steps
nx= number of x samples (2nd dimension)
nz= number of z samples (1st dimension)
xs= x coordinates of source
zs= z coordinates of source
tmax= maximum time
```

Optional Parameters:

```
nt=1+tmax/dt number of time samples (dt determined for stability)
mt=1 number of time steps (dt) per output time step
```

```
dx=1.0 x sampling interval
fx=0.0 first x sample
dz=1.0 z sampling interval
fz=0.0 first z sample
```

```
fmax = vmin/(10.0*h) maximum frequency in source wavelet
fpeak=0.5*fmax peak frequency in ricker wavelet
```

```
dfile= input file containing density[nx][nz]
vsx= x coordinate of vertical line of seismograms
hsz= z coordinate of horizontal line of seismograms
vsfile= output file for vertical line of seismograms[nz][nt]
hsfile= output file for horizontal line of seismograms[nx][nt]
ssfile= output file for source point seismograms[nt]
verbose=0 =1 for diagnostic messages, =2 for more
```

```
abs=1,1,1,1 Absorbing boundary conditions on top,left,bottom,right
sides of the model.
=0,1,1,1 for free surface condition on the top
```

...PML parameters....

```
pml_max=1000.0          PML absorption parameter
pml_thick=0             half-thickness of pml layer (0 = do not use PML)
```

Notes:

This program uses the traditional explicit second order differencing method.

Two different absorbing boundary condition schemes are available. The first is a traditional absorbing boundary condition scheme created by Hale, 1990. The second is based on the perfectly matched layer (PML) method of Berenger, 1995.

Authors: CWP:Dave Hale

CWP:modified for SU by John Stockwell, 1993.

CWP:added frequency specification of wavelet: Craig Artley, 1993

TAMU:added PML absorbing boundary condition:

Michael Holzrichter, 1998

CWP/WesternGeco:corrected PML code to handle density variations:

Greg Wimpey, 2006

References: (Hale's absorbing boundary conditions)

Clayton, R. W., and Engquist, B., 1977, Absorbing boundary conditions for acoustic and elastic wave equations, Bull. Seism. Soc. Am., 6, 1529-1540.

Clayton, R. W., and Engquist, B., 1980, Absorbing boundary conditions for wave equation migration, Geophysics, 45, 895-904.

Hale, D., 1990, Adaptive absorbing boundaries for finite-difference modeling of the wave equation migration, unpublished report from the Center for Wave Phenomena, Colorado School of Mines.

Richtmyer, R. D., and Morton, K. W., 1967, Difference methods for initial-value problems, John Wiley & Sons, Inc, New York.

Thomee, V., 1962, A stable difference scheme for the mixed boundary problem for a hyperbolic, first-order system in two dimensions, J. Soc. Indust. Appl. Math., 10, 229-245.

Toldi, J. L., and Hale, D., 1982, Data-dependent absorbing side boundaries, Stanford Exploration Project Report SEP-30, 111-121.

References: (PML boundary conditions)



Jean-Pierre Berenger, ‘‘A Perfectly Matched Layer for the Absorption of Electromagnetic Waves,’’ Journal of Computational Physics, vol. 114, pp. 185-200.

Hastings, Schneider, and Broschat, ‘‘Application of the perfectly matched layer (PML) absorbing boundary condition to elastic wave propogation,’’ Journal of the Accoustical Society of America, November, 1996.

Allen Taflove, ‘‘Electromagnetic Modeling: Finite Difference Time Domain Methods’’, Baltimore, Maryland: Johns Hopkins University Press, 1995, chap. 7, pp. 181-195.

Trace header fields set: ns, delrt, tracl, tracr, offset, d1, d2,  
sdepth, trid

SUFDMOD2 - Finite-Difference MODELing (2nd order) for acoustic wave equation

sufdmod2 <vfile >wfile nx= nz= tmax= xs= zs= [optional parameters]

Required Parameters:

<vfile file containing velocity[nx][nz]  
>wfile file containing waves[nx][nz] for time steps  
nx= number of x samples (2nd dimension)  
nz= number of z samples (1st dimension)  
xs= x coordinates of source, or, alternatively, the name  
of a file that contains the x- and z-coordinates,  
with the number of pairs as the first record and  
the actual pairs of (x,z) locations following.  
zs= z coordinates of source  
tmax= maximum time

Optional Parameters:

sstrength=1.0 strength of source  
pw=0 use point or extended source geometry parameters  
    =1 use horizontal plane wave source  
pwt=20 amp taper on ends of line src (in grid points)  
mono=0 use ricker wavelet as source function  
    =1 use single frequency src (freq=2\*fpeak)  
nt=1+tmax/dt number of time samples (dt determined for stability)  
mt=1 number of time steps (dt) per output time step

dx=1.0 x sampling interval  
fx=0.0 first x sample  
dz=1.0 z sampling interval  
fz=0.0 first z sample

fmax = vmin/(10.0\*h) maximum frequency in source  
fpeak=0.5\*fmax peak frequency in ricker wavelet

dfile= input file containing density[nx][nz]  
vsx= x coordinate of vertical line of seismograms  
hsz= z coordinate of horizontal line of seismograms  
vsfile= output file for vertical line of seismograms[nz][nt]  
hsfile= output file for horizontal line of seismograms[nx][nt]  
ssfile= output file for source point seismograms[nt]  
verbose=0 =1 for diagnostic messages, =2 for more  
abs=1,1,1,1 absorbing boundary conditions on top,left,bottom,right  
sides of the model.

=0,1,1,1 for free surface condition on the top

Notes:

This program uses the traditional explicit second order differencing method.

Authors: CWP:Dave Hale

CWP:modified for SU by John Stockwell, 1993.

U Houston: added plane wave and monochromatic wave  
source options. Chris Liner, 2010

Trace header fields set: sx, gx, ns, delrt, tracl, tracr, offset, d1, d2,  
sdepth, trid

Modifications: Tony Kocurko (TK:)

Memorial University in Newfoundland and Labrador

- Allow user to supply the name of a file containing shot point locations, rather than supplying them as values to the xs= and zs= command line arguments.
- Correct the calculation of ize[is].

Technical reference:

Kelly, K. R., R. W. Ward, S. Treitel, and R. M. Alford (1976),  
Synthetic Seismograms: A finite-difference approach,  
Geophysics, Vol. 41. No. I (February, 1976), p. 2-27.

SUGOUPILLAUDPO - calculate Primaries-Only impulse response of a lossless  
GOUPILLAUD medium for plane waves at normal incidence

sugoupillaudpo < stdin > stdout [optional parameters]

Required parameters:

none

Optional parameters:

l=1     source layer number; 1 <= l <= tr.ns  
        Source is located at the top of layer l.  
k=1     receiver layer number; 1 <= k  
        Receiver is located at the top of layer k.  
tmax    number of output time-samples;  
        default: long enough to capture all primaries  
pV=1    flag for vector field seismogram  
        (displacement, velocity, acceleration);  
        =-1 for pressure seismogram.  
verbose=0     silent operation, =1 list warnings

Input: Reflection coefficient series:

$$r[i] = \frac{\text{impedance}[i] - \text{impedance}[i+1]}{\text{impedance}[i] + \text{impedance}[i+1]}$$

r[0]= surface refl. coef. (as seen from above)

r[n]= refl. coef. of the deepest interface

Input file is to be in SU format, i.e., binary floats with a SU header.

Remarks:

1. For vector fields, a buried source produces a spike of amplitude 1 propagating downwards and a spike of amplitude -1 propagating upwards. A buried pressure source produces spikes of amplitude 1 both in the up- and downward directions.

A surface source induces only a downgoing spike of amplitude 1 at the top of the first layer (both for vector and pressure fields).

2. The sampling interval dt in the header of the input reflectivity file is interpreted as a two-way traveltime thickness of the layers. The sampling interval of the output seismogram is the same as that of the input file.

Credits:  
CWP: Albena Mateeva, April 2001.

SUGOUPILLAUD - calculate 1D impulse response of  
non-absorbing Goupillaud medium

sugoupillaud < stdin > stdout [optional parameters]

Required parameters:

none

Optional parameters:

l=1 source layer number;  $1 \leq l \leq \text{tr.ns}$

Source is located at the top of layer l.

k=1 receiver layer number;  $1 \leq k$

Receiver is located at the top of layer k.

tmax number of output time-samples; default:

$\text{tmax} = \text{NINT}((2 * \text{tr.ns} - (l - 1) - (k - 1)) / 2)$  if  $k < \text{tr.ns}$

tmax=k if  $k \geq \text{tr.ns}$

pV=1 flag for vector field seismogram

(displacement, velocity, acceleration);

=-1 for pressure seismogram.

verbose=0 silent operation, =1 list warnings

Input: Reflection coefficient series:

$\text{impedance}[i] - \text{impedance}[i+1]$

$r[i] = \frac{\text{impedance}[i] - \text{impedance}[i+1]}{\text{impedance}[i] + \text{impedance}[i+1]}$

$\text{impedance}[i] + \text{impedance}[i+1]$

$r[0]$  = surface refl. coef. (as seen from above)

$r[n]$  = refl. coef. of the deepest interface

Input file is to be in SU format, i.e., binary floats with a SU header.

Remarks:

1. For vector fields, a buried source produces a spike of amplitude 1 propagating downwards and a spike of amplitude -1 propagating upwards. A buried pressure source produces spikes of amplitude 1 both in the up and downward directions.

A surface source induces only a downgoing spike of amplitude 1 at the top of the first layer (both for vector and pressure fields).

2. The sampling interval dt in the header of the input reflectivity file is interpreted as a two-way traveltime thickness of the layers. The sampling interval of the output seismogram is the same as that of the input file.

Credits:

CWP: Albena Mateeva, May 2000, a summer project at Western Geophysical

ANOTATION used in the code comments [arises from the use of z-transforms]:

Z-sampled: sampling interval equal to the TWO-way  
traveltime of the layers;

z-sampled: sampling interval equal to the ONE-way  
traveltime of the layers;

REFERENCES:

1. Ganley, D. C., 1981, A method for calculating synthetic seismograms which include the effects of absorption and dispersion. Geophysics, Vol.46, No. 8, p. 1100-1107.

The burial of the source is based on the Appendix of that article.

2. Robinson, E. A., Multichannel Time Series Analysis with Digital Computer Programs: 1983 Goose Pond Press, 2nd edition.

The recursive polynomials Q, P used in this code are described in Chapter 3 of the book: Wave Propagation in Layered Media.

My polynomial multiplication and division functions "prod" and "pratio" are based on Robinson's Fortran subroutines in Chapter 1.

4. Clearbout, J. F., Fundamentals of Geophysical Data Processing with Applications to Petroleum Prospecting: 1985 Blackwell Scientific Publications.

Chapter 8, Section 3: Introduces recursive polynomials F, G in a more intuitive way than Robinson.

The connection between the Robinson's  $P_k$ ,  $Q_k$  and Clearbout's  $F_k$ ,  $G_k$  is:

$$P_k(Z) = F_k(Z)$$

$$Q_k(Z) = -Z^k G_k(1/Z)$$

SUIMP2D - generate shot records for a line scatterer  
embedded in three dimensions using the Born  
integral equation ",

suimp2d [optional parameters] >stdout

Optional parameters

nshot=1 number of shots

nrec=1 number of receivers

c=5000 speed

dt=.004 sampling rate

nt=256 number of samples

x0=1000 point scatterer location

z0=1000 point scatterer location

sxmin=0 first shot location

szmin=0 first shot location

gxmin=0 first receiver location

gzmin=0 first receiver location

dsx=100 x-step in shot location

dsz=0 z-step in shot location

dgx=100 x-step in receiver location

dgz=0 z-step in receiver location

Example:

suimp2d nrec=32 | sufilter | supswigp | ...

Credits:

CWP: Norm Bleistein, Jack K. Cohen

Theory: Use the 3D Born integral equation (e.g., Geophysics,  
v51, n8, p1554(7)). Use 2-D delta function for alpha and do  
remaining y-integral by stationary phase.

Note: Setting a 2D offset in a single offset field beats the  
hell out of us. We did \_something\_.

Trace header fields set: ns, dt, tracl, tracr, fldr, sx, selev,  
gx, gelev, offset



SUIMP3D - generate inplane shot records for a point scatterer embedded in three dimensions using the Born integral equation ",

suimp3d [optional parameters] >stdout

Optional parameters

nshot=1 number of shots

nrec=1 number of receivers

c=5000 speed

dt=.004 sampling rate

nt=256 number of samples

x0=1000 point scatterer location

y0=0 point scatterer location

z0=1000 point scatterer location

dir=0 do not include direct arrival

=1 include direct arrival

sxmin=0 first shot location

symin=0 first shot location

szmin=0 first shot location

gxmin=0 first receiver location

gymin=0 first receiver location

gzmin=0 first receiver location

dsx=100 x-step in shot location

dsy=0 y-step in shot location

dsz=0 z-step in shot location

dgx=100 x-step in receiver location

dgy=0 y-step in receiver location

dgz=0 z-step in receiver location

Example:

suimp3d nrec=32 | sufilter | supswigp | ...

Credits:

CWP: Norm Bleistein, Jack K. Cohen

UHouston: Chris Liner 2010 (added direct arrival option)

Theory: Use the 3D Born integral equation (e.g., Geophysics, v51, n8, p1554(7)). Use 3-D delta function for alpha.

Note: Setting a 3D offset in a single offset field beats the hell out of us. We did `_something_`.

Trace header fields set: ns, dt, tracr, fldr, tracr, sx, sy, selev, gx, gy, gelev, offset

SUIMPEDANCE - Convert reflection coefficients to impedances.

suimpedance <stdin >stdout [optional parameters]

Optional Parameters:

v0=1500. Velocity at first sample (m/sec)

rho0=1.0e6 Density at first sample (g/m<sup>3</sup>)

Notes:

Implements recursion  $[1-R(k)]Z(k) = [1+R(k)]Z(k-1)$ .

The input traces are assumed to be reflectivities, and thus are expected to have amplitude values between -1.0 and 1.0.

Credits:

SEP: Stew Levin

Trace header fields accessed: ns

SUKDSYN2D - Kirchhoff Depth SYNthesis of 2D seismic data from a  
migrated seismic section

sukdsyn2d infile outfile [parameters]

Required parameters:

infile=stdin input migrated section

outfile=stdout file for output seismic traces

tfile file for input traveltimes tables

The following 9 parameters describe traveltimes tables:

fzt= first depth sample

nzt= number of depth samples

dzt= depth interval

fxt= first lateral sample

nxt= number of lateral samples

dxt= lateral interval

fs= x-coordinate of first source

ns= number of sources

ds= x-coordinate increment of sources

The following 6 parameters describe the migration section:

fz= first z-coordinate in migrated section

dz= vertical spacing of migrated section

nz= number of depth points in migrated section

fx= first x-coordinate of migrated section

dx= horizontal spacing of migrated section

nx= number of lateral points in migrated section

Optional Parameters:

nt=501 number of time samples

dt=0.004 time sampling interval (sec)

ft=0.0 first time (sec)

nxo=1 number of source-receiver offsets

dxo=25 offset sampling interval

fxo=0.0 first offset

nxs=101 number of shotpoints

dxs=25 shotpoint sampling interval

fxs=0.0 first shotpoint

fmax=1/(4\*dt) maximum frequency in migration section (Hz)

aperx=nxt\*dxt/2 modeling lateral aperture

angmax=60 modeling angle aperture from vertical

v0=1500(m/s) reference velocity value at surface

dvz=0.0    reference velocity vertical gradient  
ls=1                      flag for line source  
jpfile=stderr job print file name  
mtr=100    print verbal information at every mtr traces

Notes:

This program takes a migrated seismic section and a set of travel time tables generated using rayt2d for a specific background velocity model and generates synthetic seismic data in the form of common shot gathers. (Common offset gathers may be generated by using nxo=1.) (Demigration.)

This program is a tool which may be used for the migration residual statics estimation technique of Tjan, Audebert, and Larner 1994.

1. The traveltimes tables are generated by program rayt2d (or other ones) on relatively coarse grids, with dimension ns\*nxt\*nzt. In the modeling process, traveltimes are interpolated into shot/geophone positions and migration section grids.
2. The input migration section must be an array of binary floats (no SU headers). ",
3. The synthesized traces are output in common-shot gathers in SU format.
4. The memory requirement for this program is about  
(ns\*nxt\*nzt+nx\*nz+4\*nr\*nzt+3\*nxt\*nzt)\*4 bytes  
where nr = 1+min(nxt\*dxt,0.5\*offmax+aperx)/dxo.

Author: CWP: Zhenyue Liu, 07/24/95, Colorado School of Mines

References:

- Tjan, T., F. Audebert, and K. Larner, 1994,  
Prestack migration for residual statics estimation in complex media  
(Appeared in 1994 Project Review, CWP-153.)
- Tjan, T., 1995, Residual statics estimation for data from structurally complex areas using prestack depth migration: M.Sc. thesis, Colorado School of Mines. (In progress.)
- Larner, K., and Tjan, T., 1995, Simultaneous statics and velocity estimation for data from structurally complex areas.  
(Appeared in 1995 Project Review, CWP-185.)

Trace header fields set: ns, dt, delrt, tracl, tracr, fldr, tracf  
offset, sx, gx, trid, cunit

SUNHMOSPIKE - generates SPIKE test data set with a choice of several  
Non-Hyperbolic MOveouts

```
sunhmospike [optional parameters] > out_data_file
```

Optional parameters:

nt=300 number of time samples

ntr=20 number of traces

dt=0.001 time sample rate in seconds

offref=2000 reference offset

gopt= 1 = parabolic transform model

2 = Foster/Mosher pseudo hyperbolic option model

3 = linear tau-p model

depthref=400 reference depth used when gopt=2

offinc=100 offset increment

nspk=4 number of events

p1 = 0 event moveout for event #1 in ms on reference offset

t1 = 100 intercept time ms event #1

a1 = 1.0 amplitude for event #1

p2 = 200 event moveout for event #2 in ms on reference offset

t2 = 100 intercept time ms for spike #2

a2 = 1.0 amplitude for event #2

p3 = 0; event moveout for event #3 in ms on reference offset

t3 = 200 intercept time for spike #3

a3 = 1.0 amplitude for event #3

p4 = 120 event moveout for event #4 in ms on reference offset

t4 = 200 intercept time s for spike #4

a4 = 1.0 amplitude for event #4

cdp = 1 output cdp number

Notes:

Creates a common cdp su data file with up to four spike events  
for impulse response studies for suradon, and sutifowler

Credits:

CWP: Shuki Ronen, Chris Liner,

Modified: CWP by John Anderson, April, 1994, to have  
appropriate trace header words and default values  
for SUTIFOWLER tests



SUNULL - create null (all zeroes) traces

```
sunull nt= [optional parameters] >outdata
```

Required parameter

nt= number of samples per trace

Optional parameters

ntr=5 number of null traces to create

dt=0.004 time sampling interval

Rationale: It is sometimes useful to insert null traces between "panels" in a shell loop.

See also: sukill, sumute, suzero

Credits:

CWP: Jack K. Cohen

Trace header fields set: ns, dt, tracr

SUPLANE - create common offset data file with up to 3 planes

suplane [optional parameters] >stdout

Optional Parameters:

npl=3 number of planes  
nt=64 number of time samples  
ntr=32 number of traces  
taper=0 no end-of-plane taper  
= 1 taper planes to zero at the end  
offset=400 offset  
dt=0.004 time sample interval in seconds  
...plane 1 ...  
dip1=0 dip of plane #1 (ms/trace)  
len1= 3\*ntr/4 HORIZONTAL extent of plane (traces)  
ct1= nt/2 time sample for center pivot  
cx1= ntr/2 trace for center pivot  
...plane 2 ...  
dip2=4 dip of plane #2 (ms/trace)  
len2= 3\*ntr/4 HORIZONTAL extent of plane (traces)  
ct2= nt/2 time sample for center pivot  
cx2= ntr/2 trace for center pivot  
...plane 3 ...  
dip3=8 dip of plane #3 (ms/trace)  
len3= 3\*ntr/4 HORIZONTAL extent of plane (traces)  
ct3= nt/2 time sample for center pivot  
cx3= ntr/2 trace for center pivot  
  
liner=0 use parameters  
= 1 parameters set for 64x64 data set  
with separated dipping planes.

Credits:

CWP: Chris Liner

Trace header fields set: ns, dt, offset, tracr

SURANDSPIKE - make a small data set of RANDom SPIKEs

```
surandspike [optional parameters] > out_data_file
```

Creates a common offset su data file with random spikes

Optional parameters:

n1=500 number of time samples

n2=200 number of traces

dt=0.002 time sample rate in seconds

nspk=20 number of spikes per trace

amax=0.2 abs(max) spike value

mode=1 different spikes on each trace

=2 same spikes on each trace

seed=from\_clock random number seed (integer)

Credits:

ARAMCO: Chris Liner

Trace header fields set: ns, dt, offset

SUREMAC2D - Acoustic 2D Fourier method modeling with high accuracy  
Rapid Expansion Method (REM) time integration

suremac2d [parameters]

Required parameters:

opflag=        0: variable density wave equation  
              1: constant density wave equation  
              2: non-reflecting wave equation

nx=            number of grid points in horizontal direction  
nz=            number of grid points in vertical direction  
nt=            number of time samples  
dx=            spatial increment in horizontal direction  
dz=            spatial increment in vertical direction  
dt=            time sample interval in seconds  
isx=           grid point # of horizontal source positions  
isz=           grid point # of vertical source positions

Optional parameters:

fx=0.0        first horizontal coordinate  
fz=0.0        first vertical coordinate  
irx=           horizontal grid point # of vertical receiver lines  
irz=           vertical grid point # of horizontal receiver lines  
w=0.1         width of spatial source distribution (see notes)  
sflag=2        source time function  
              0: user supplied source function  
              1: impulse (spike at t=0)  
              2: Ricker wavelet

fmax=         maximum frequency of Ricker (default) wavelet  
amps=1.0      amplitudes of sources  
prec=0        1: precompute Bessel coefficients b\_k (see notes)  
              2: use precomputed Bessel coefficients b\_k

fsflag=0      1: perform run with free surface b.c.  
vmaxu=        user-defined maximum velocity  
dtsnap=0.0    time interval in seconds of wave field snapshots  
iabso=1       apply absorbing boundary conditions (0: none)  
abso=0.1      damping parameter for absorbing boundaries  
nbwx=20       horizontal width of absorbing boundary  
nbwz=20       vertical width of absorbing boundary  
verbose=0     1: show parameters used  
              2: print maximum amplitude at every expansion term

velfile=vel	velocity filename
densfile=dens	density filename
sname=wavelet.su	user supplied source time function filename
sepxname=sectx.su	x-direction pressure sections filename
sepzname=sectz.su	z-direction pressure sections filename
snpname=snap.su	pressure snapshot filename
jpfile=stderr	diagnostic output

Notes:

0. The combination of the Fourier method with REM time integration allows the computation of synthetic seismograms which are free of numerical grid dispersion. REM has no restriction on the time step size  $\Delta t$ . The Fourier method requires at least two grid points per shortest wavelength.
1.  $n_x$  and  $n_z$  must be valid numbers for pfaft transform lengths.  $n_x$  and  $n_z$  must be odd numbers (unless  $opflag=1$ ). For valid numbers see e.g. numbers in structure 'nctab' in source file `$CWPROOT/src/cwp/lib/pfaft.c`.
2. Velocities (and densities) are stored as plain C style files of floats where the fast dimension is along the z-direction.
3. Units must be consistent, e.g. m, s and m/s.
4. A 20 grid points wide border at the sides and the bottom of the modeling grid is used for sponge boundary conditions (default:  $iabso=1$ ).  
Source and receiver lines should be placed some (e.g. 10) grid points away from the absorbing boundaries in order to reduce reflections due to obliquely incident wavefronts.
5. Dominant frequency is about  $f_{max}/2$  ( $sflag=2$ ), absolute maximum is delayed by  $3/f_{max}$  from beginning of wavelet.
6. If  $opflag \neq 1$  the source should be not a spike in space; the parameter  $w$  determines at which distance (in grid points) from the source's center the Gaussian weight decays to 10 percent of its maximum.  $w=2$  may be a reasonable choice; however, the waveform will be distorted.
7. Horizontal and vertical receiver line sections are written to separate files. Each file can hold more than one line.
8. Parameter  $v_{maxu}$  may need to be chosen larger than the highest propagation velocity if the modeling run becomes unstable. This happens if the largest eigenvalue of the modeling operator  $L$  is larger than estimated from the largest velocity due to variations of the density.  
In particular if using the variable density acoustic wave

equation the eigenvalues depend also on the density and it is impossible to estimate the largest eigenvalue analytically.

9. Bessel coefficients can be precomputed (prec=1) and stored on disk to save CPU time when several shots need to be run.  
In this case computation of Bessel coefficients can be skipped and read from disk file for reuse (prec=2).  
For reuse of Bessel coefficients the user may need to define the overall maximum velocity (vmaxu).
10. If snapshots are not required, a spike source (sflag=1) may be applied and the resulting impulse response seismograms can be convolved later with a desired wavelet.
11. The free surface (fsflag=1) does not coincide with the first vertical grid index (0). It appears to be half a grid spacing above that position.

#### Acoustic 2D Fourier method modeling with REM time integration

##### Reference:

Kosloff, D., Fihlo A.Q., Tessmer, E. and Behle, A., 1989,  
Numerical solution of the acoustic and elastic wave equations by a  
new rapid expansion method, Geophysical Prospecting, 37, 383-394

##### Credits:

University of Hamburg: Ekkehart Tessmer, October 2012

SUREMEL2DAN - Elastic anisotropic 2D Fourier method modeling with high accuracy Rapid Expansion Method (REM) time integration

suremel2dan [parameters]

Required parameters:

nx=            number of grid points in horizontal direction  
nz=            number of grid points in vertical direction  
nt=            number of time samples  
dx=            spatial increment in horizontal direction  
dz=            spatial increment in vertical direction  
dt=            time sample interval in seconds  
isx=           grid point # of horizontal source positions  
isz=           grid point # of vertical source positions  
styp=          source types (pressure, shear, single forces)  
samp=          amplitudes of sources  
amode=         0: isotropic, 1: anisotropic  
vmax=          global maximum velocity (only if amode=1)  
vmin=          global minimum velocity (only if amode=1)

Optional parameters:

fx=0.0        first horizontal coordinate  
fz=0.0        first vertical coordinate  
irx=           horizontal grid point # of vertical receiver lines  
irz=           vertical grid point # of horizontal receiver lines  
rxtyp=        types of horizontal receiver lines  
rztyp=        types of vertical receivers lines  
sntyp=        types of snapshots  
              0: P, 1: S, 2: UX, 3: UZ  
w=0.1         width of spatial source distribution (see notes)  
sflag=2       source time function  
              0: user supplied source function  
              1: impulse (spike at t=0)  
              2: Ricker wavelet  
fmax=         maximum frequency of Ricker (default) wavelet  
amps=1.0      amplitudes of sources  
prec=0        1: precompute Bessel coefficients b\_k (see notes)  
              2: use precomputed Bessel coefficients b\_k  
vmaxu=        user-defined maximum velocity  
dtsnap=0.0    time interval in seconds of wave field snapshots  
iabso=1       apply absorbing boundary conditions (0: none)  
abso=0.1      damping parameter for absorbing boundaries

nbwx=20        horizontal width of absorbing boundary  
 nbwz=20        vertical width of absorbing boundary  
 verbose=0     1: show parameters used  
               2: print maximum amplitude at every expansion term

c11file=c11        c11 filename  
 c13file=c13        c13 filename  
 c15file=c15        c15 filename  
 c33file=c33        c33 filename  
 c35file=c35        c35 filename  
 c55file=c55        c55 filename  
 vpfile=vp         P-velocity filename  
 vsfile=vs         S-velocity filename  
 densfile=dens      density filename

sname=wavelet.su   user supplied source time function filename

Basenames of seismogram and snapshot files:

xsect=xsect\_       x-direction section files basename  
 zsect=zsect\_       z-direction section files basename  
 snap=snap\_         snapshot files basename

jpfile=stderr       diagnostic output

Notes:

0. The combination of the Fourier method with REM time integration allows the computation of synthetic seismograms which are free of numerical grid dispersion. REM has no restriction on the time step size  $\Delta t$ . The Fourier method requires at least two grid points per shortest wavelength.
1.  $n_x$  and  $n_z$  must be valid numbers for pfafft transform lengths.  $n_x$  and  $n_z$  must be odd numbers. For valid numbers see e.g. numbers in structure 'nctab' in source file `$CWPROOT/src/cwp/lib/pfafft.c`.
2. Velocities and densities are stored as plain C style files of floats where the fast dimension is along the z-direction.
3. Units must be consistent, e.g. m, s and m/s.
4. A 20 grid points wide border at the sides and the bottom of the modeling grid is used for sponge boundary conditions (default: `iabso=1`).  
 Source and receiver lines should be placed some (e.g. 10) grid points away from the absorbing boundaries in order to reduce reflections due to obliquely incident wavefronts.



5. Dominant frequency is about  $f_{\max}/2$  (sflag=2), absolute maximum is delayed by  $3/f_{\max}$  from beginning of wavelet.
6. If source is not single force (i.e. pressure or shear source) it should be not a spike in space; the parameter w determines at which distance (in grid points) from the source's center the Gaussian weight decays to 10 percent of its maximum. w=2 may be a reasonable choice; however, the waveform will be distorted.
7. Horizontal and vertical receiver line sections are written to separate files. Each file can hold more than one line.
8. Parameter v<sub>maxu</sub> may need to be chosen larger than the highest propagation velocity if the modeling run becomes unstable. This happens if the largest eigenvalue of the modeling operator L is larger than estimated from the largest velocity due to variations of the density.
9. Bessel coefficients can be precomputed (prec=1) and stored on disk to save CPU time when several shots need to be run. In this case computation of Bessel coefficients can be skipped and read from disk file for reuse (prec=2). For reuse of Bessel coefficients the user may need to define the overall maximum velocity (v<sub>maxu</sub>).
10. If snapshots are not required, a spike source (sflag=1) may be applied and the resulting impulse response seismograms can be convolved later with a desired wavelet.
11. Output is written to SU style files. ",  
 Basenames of seismogram and snapshot output files will be extended by the type of the data (p, s, ux, or uz).  
 Additionally seismogram files will be consecutively numbered.

Caveat:

Time sections and snapshots are kept entirely in memory during run time. Therefore, lots of time section and snapshots may eat up a large amount of memory.

Elastic anisotropic 2D Fourier method modeling with REM time integration

Reference:

Kosloff, D., Fihlo A.Q., Tessmer, E. and Behle, A., 1989,  
 Numerical solution of the acoustic and elastic wave equations by a new rapid expansion method, Geophysical Prospecting, 37, 383-394

Credits:

University of Hamburg: Ekkehart Tessmer, July 2013

SUSPIKE - make a small spike data set

```
suspike [optional parameters] > out_data_file
```

Creates a common offset su data file with up to four spikes  
for impulse response studies

Optional parameters:

nt=64 number of time samples

ntr=32 number of traces

dt=0.004 time sample rate in seconds

offset=400 offset

nspk=4 number of spikes

ix1= ntr/4 trace number (from left) for spike #1

it1= nt/4 time sample to spike #1

ix2 = ntr/4 trace for spike #2

it2 = 3\*nt/4 time for spike #2

ix3 = 3\*ntr/4; trace for spike #3

it3 = nt/4; time for spike #3

ix4 = 3\*ntr/4; trace for spike #4

it4 = 3\*nt/4; time for spike #4

Credits:

CWP: Shuki Ronen, Chris Liner

Trace header fields set: ns, dt, offset

SUSYNCZ - SYNthetic seismograms for piecewise constant  $V(Z)$  function  
True amplitude (primaries only) modeling for 2.5D

```
susyncz > outfile [parameters]
```

Required parameters:

none

Optional Parameters:

ninf=4            number of interfaces (not including upper surface)  
dip=5\*i           dips of interfaces in degrees (i=1,2,3,4)  
zint=100\*i        z-intercepts of interfaces at x=0 (i=1,2,3,4)  
v=1500+ 500\*i     velocities below surface & interfaces (i=0,1,2,3,4)  
rho=1,1,1,1,1    densities below surface & interfaces (i=0,1,2,3,4)  
nline=1    number of (identical) lines  
ntr=32        number of traces  
dx=10        trace interval  
tdelay=0      delay in recording time after source initiation  
dt=0.004      time interval  
nt=128        number of time samples

Notes:

The original purpose of this code was to create some nontrivial data for Brian Sumner's CZ suite.

The program produces zero-offset data over dipping reflectors.

In the original fortran code, some arrays had the index interval 1:ninf, as a natural way to index over the subsurface reflectors. This indexing was preserved in this C translation. Consequently, some arrays in the code do not use the 0 "slot".

Example:

```
susyncz | sufilter | sugain tpow=1 | display_program
```

Trace header fields set: tracl, ns, dt, delrt, ntr, sx, gx

Credits:

CWP: Brian Sumner, 1983, 1985, Fortran design and code  
CWP: Stockwell & Cohen, 1995, translation to C



SUSYNLVCW - SYNthetic seismograms for Linear Velocity function  
for mode Converted Waves

susynlvcw >outfile [optional parameters]

Optional Parameters:

nt=101 number of time samples  
dt=0.04 time sampling interval (sec)  
ft=0.0 first time (sec)  
nxo=1 number of source-receiver offsets  
dxo=0.05 offset sampling interval (km)  
fxo=0.0 first offset (km, see notes below)  
xo=fxo,fxo+dxo,... array of offsets (use only for non-uniform offsets)  
nxm=101 number of midpoints (see notes below)  
dxm=0.05 midpoint sampling interval (km)  
fxm=0.0 first midpoint (km)  
nxs=101 number of shotpoints (see notes below)  
dxs=0.05 shotpoint sampling interval (km)  
fxs=0.0 first shotpoint (km)  
x0=0.0 distance x at which v00 is specified  
z0=0.0 depth z at which v00 is specified  
v00=2.0 velocity at x0,z0 (km/sec)  
gamma=1.0 velocity ratio, upgoing/downgoing  
dvdx=0.0 derivative of velocity with distance x (dv/dx)  
dvdz=0.0 derivative of velocity with depth z (dv/dz)  
fpeak=0.2/dt peak frequency of symmetric Ricker wavelet (Hz)  
ref="1:1,2;4,2" reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;...  
smooth=0 =1 for smooth (piecewise cubic spline) reflectors  
er=0 =1 for exploding reflector amplitudes  
ls=0 =1 for line source; default is point source  
ob=1 =1 to include obliquity factors  
sp=1 =1 to account for amplitude spreading  
=0 for constant amplitudes throughout  
tmin=10.0\*dt minimum time of interest (sec)  
ndpfz=5 number of diffractors per Fresnel zone  
verbose=0 =1 to print some useful information

Notes:

Offsets are signed - may be positive or negative. Receiver locations are computed by adding the signed offset to the source location.

Specify either midpoint sampling or shotpoint sampling, but not both.

If neither is specified, the default is the midpoint sampling above.

More than one ref (reflector) may be specified. When obliquity factors are included, then only the left side of each reflector (as the x,z reflector coordinates are traversed) is reflecting. For example, if x coordinates increase, then the top side of a reflector is reflecting. Note that reflectors are encoded as quoted strings, with an optional reflector amplitude: preceding the x,z coordinates of each reflector. Default amplitude is 1.0 if amplitude: part of the string is omitted.

Note that  $\gamma < 1$  implies P-SV mode conversion,  $\gamma > 1$  implies SV-P, and  $\gamma = 1$  implies no mode conversion.

based on Dave Hale's code susynlv, but modified  
by Mohammed Alfaraj to handle mode conversion  
Date of modification: 01/07/92

Trace header fields set: trid, counit, ns, dt, delrt,  
trac1, tracr, fldr, tracf,  
cdp, cdpt, d2, f2, offset, sx, gx

SUSYNLVFTI - SYNthetic seismograms for Linear Velocity function in a  
Factorized Transversely Isotropic medium

susynlvfti >outfile [optional parameters]

Optional Parameters:

nt=101 number of time samples

dt=0.04 time sampling interval (sec)

ft=0.0 first time (sec)

kilounits=1                   input length units are km or kilo-feet  
                              =0 for m or ft

Note: Output (sx,gx,offset) are always m or ft

nxo=1 number of source-receiver offsets

dxo=0.05 offset sampling interval (kilounits)

fxo=0.0 first offset (kilounits, see notes below)

xo=fxo,fxo+dxo,...       array of offsets (use only for non-uniform offsets)

nxm=101 number of midpoints (see notes below)

dxm=0.05 midpoint sampling interval (kilounits)

fxm=0.0 first midpoint (kilounits)

nxs=101 number of shotpoints (see notes below)

dxs=0.05 shotpoint sampling interval (kilounits)

fxs=0.0 first shotpoint (kilounits)

x0=0.0 distance x at which v00 is specified

z0=0.0 depth z at which v00 is specified

v00=2.0 velocity at x0,z0 (kilounits/sec)

dvdx=0.0 derivative of velocity with distance x (dv/dx)

dvdz=0.0 derivative of velocity with depth z (dv/dz)

fpeak=0.2/dt peak frequency of symmetric Ricker wavelet (Hz)

ref=1:1,2;4,2 reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;...

smooth=0 =1 for smooth (piecewise cubic spline) reflectors

er=0 =1 for exploding reflector amplitudes

ls=0 =1 for line source; default is point source

ob=0 =1 to include obliquity factors

tmin=10.0\*dt minimum time of interest (sec)

ndpfz=5 number of diffractors per Fresnel zone

verbose=1 =1 to print some useful information

For transversely isotropic media:

angxs=0.0 angle of symmetry axis with the vertical (degrees)

define the media using either

a=1.0 corresponding to the ratio of elastic coef.(c1111/c3333)

f=0.4 corresponding to the ratio of elastic coef. (c1133/c3333)

l=0.3 corresponding to the ratio of elastic coef. (c1313/c3333)



Alternately use Thompson\'s parameters:  
delta=0 Thomsen\'s 1986 defined parameter  
epsilon=0 Thomsen\'s 1986 defined parameter  
ntries=40 number of iterations in Snell\'s law and offset searches  
epsx=.001 lateral offset tolerance  
epst=.0001 reflection time tolerance  
nitmax=12 max number of iterations in travel time integrations

Notes:

Offsets are signed - may be positive or negative. Receiver locations are computed by adding the signed offset to the source location.

Specify either midpoint sampling or shotpoint sampling, but not both. If neither is specified, the default is the midpoint sampling above.

More than one ref (reflector) may be specified. When obliquity factors are included, then only the left side of each reflector (as the x,z reflector coordinates are traversed) is reflecting. For example, if x coordinates increase, then the top side of a reflector is reflecting. Note that reflectors are encoded as quoted strings, with an optional reflector amplitude: preceding the x,z coordinates of each reflector. Default amplitude is 1.0 if amplitude: part of the string is omitted.

Concerning the choice of delta and epsilon. The difference between delta", and epsilon should not exceed one. A possible break down of the program is the result. This is caused primarily by the break down in the two point", ray-tracing. Also keep the values of delta and epsilon between 2 and -2.

## SUSYNLV - SYNthetic seismograms for Linear Velocity function

susynlv >outfile [optional parameters]

### Optional Parameters:

nt=101	number of time samples
dt=0.04	time sampling interval (sec)
ft=0.0	first time (sec)
kilounits=1	input length units are km or kilo-feet
=0 for m or ft	
Note: Output (sx,gx,offset) are always m or ft	
nxo=1	number of source-receiver offsets
dxo=0.05	offset sampling interval (kilounits)
fxo=0.0	first offset (kilounits, see notes below)
xo=fxo,fxo+dxo,...	array of offsets (use only for non-uniform offsets)
nxm=101	number of midpoints (see notes below)
dxm=0.05	midpoint sampling interval (kilounits)
fxm=0.0	first midpoint (kilounits)
nxs=101	number of shotpoints (see notes below)
dxs=0.05	shotpoint sampling interval (kilounits)
fxs=0.0	first shotpoint (kilounits)
x0=0.0	distance x at which v00 is specified
z0=0.0	depth z at which v00 is specified
v00=2.0	velocity at x0,z0 (kilounits/sec)
dvdx=0.0	derivative of velocity with distance x (dv/dx)
dvdz=0.0	derivative of velocity with depth z (dv/dz)
fpeak=0.2/dt	peak frequency of symmetric Ricker wavelet (Hz)
ref="1:1,2;4,2"	reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;..."
smooth=0	=1 for smooth (piecewise cubic spline) reflectors
er=0	=1 for exploding reflector amplitudes
ls=0	=1 for line source; default is point source
ob=1	=1 to include obliquity factors
tmin=10.0*dt	minimum time of interest (sec)
ndpfz=5	number of diffractors per Fresnel zone
verbose=0	=1 to print some useful information

### Notes:

Offsets are signed - may be positive or negative. Receiver locations are computed by adding the signed offset to the source location.

Specify either midpoint sampling or shotpoint sampling, but not both. If neither is specified, the default is the midpoint sampling above.

More than one ref (reflector) may be specified. Do this by putting additional ref= entries on the commandline. When obliquity factors are included, then only the left side of each reflector (as the x,z reflector coordinates are traversed) is reflecting. For example, if x coordinates increase, then the top side of a reflector is reflecting. Note that reflectors are encoded as quoted strings, with an optional reflector amplitude: preceding the x,z coordinates of each reflector. Default amplitude is 1.0 if amplitude: part of the string is omitted.

Credits: CWP Dave Hale, 09/17/91, Colorado School of Mines  
UTulsa Chris Liner 5/22/03 added kilounits flag

Trace header fields set: trid, cunit, ns, dt, delrt,  
trac1. tracr, fldr, tracf,  
cdp, cdpt, d2, f2, offset, sx, gx

SUSYNVXZCS - SYNthetic seismograms of common shot in V(X,Z) media via Kirchhoff-style modeling

susynvxzcs<vfile >outfile nx= nz= [optional parameters]

Required Parameters:

<vfile            file containing velocities v[nx][nz]  
>outfile        file containing seismograms of common offset  
nx=             number of x samples (2nd dimension) in velocity  
nz=             number of z samples (1st dimension) in velocity

Optional Parameters:

nt=501           number of time samples  
dt=0.004        time sampling interval (sec)  
ft=0.0           first time (sec)  
fpeak=0.2/dt peak frequency of symmetric Ricker wavelet (Hz)  
nxg= number of receivers of input traces  
dxg=15 receiver sampling interval (m)  
fxg=0.0 first receiver (m)  
nxd=5            skipped number of receivers  
nxs=1 number of offsets  
dxs=50 shot sampling interval (m)  
fxs=0.0 first shot (m)  
dx=50            x sampling interval (m)  
fx=0.            first x sample (m)  
dz=50            z sampling interval (m)  
nxb=nx/2        band width centered at midpoint (see note)  
nxc=0            hozizontal range in which velocity is changed  
nzc=0            vertical range in which velocity is changed  
pert=0           =1 calculate time correction from v\_p[nx][nz]  
vpfile           file containing slowness perturbation array v\_p[nx][nz]  
ref="1:1,2;4,2" reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;...  
smooth=0 =1 for smooth (piecewise cubic spline) reflectors  
ls=0 =1 for line source; =0 for point source  
tmin=10.0\*dt minimum time of interest (sec)  
ndpfz=5 number of diffractors per Fresnel zone  
cable=1 roll reciever spread with shot  
      =0 static reciever spread  
verbose=0 =1 to print some useful information

Notes:

This algorithm is based on formula (58) in Geo. Pros. 34, 686-703, by N. Bleistein.

Traveltime and amplitude are calculated by finite difference which is done only in one of every NXD receivers; in skipped receivers, interpolation is used to calculate traveltime and amplitude. ", For each receiver, traveltime and amplitude are calculated in the horizontal range of  $(xg-nxb*dx, xg+nxb*dx)$ . Velocity is changed by constant extrapolation in two upper triangular corners whose width is  $nxc*dx$  and height is  $nzc*dz$ .

Eikonal equation will fail to solve if there is a polar turned ray. In this case, the program shows the related geometric information. There are three ways to remove the turned rays: smoothing velocity, reducing  $nxb$ , and increasing  $nxc$  and  $nzc$  (if the turned ray occurs in shallow areas). To prevent traveltime distortion from an over-smoothed velocity, traveltime is corrected based on the slowness perturbation.

More than one ref (reflector) may be specified. Note that reflectors are encoded as quoted strings, with an optional reflector amplitude: preceding the x,z coordinates of each reflector. Default amplitude is 1.0 if amplitude: part of the string is omitted.

Author: Zhenyue Liu, 07/20/92, Center for Wave Phenomena  
Many subroutines borrowed from Dave Hale's program: SUSYNLV

Trino Salinas, 07/30/96, fixed a bug in the geometry setting to allow the spread move with the shots.

Chris Liner 12/10/08 added cable option, set fldr header word

Trace header fields set: trid, counit, ns, dt, delrt,  
tracl, tracr, fldr, tracf,  
sx, gx

SUSYNVXZ - SYNthetic seismograms of common offset V(X,Z) media via Kirchhoff-style modeling

susynvxz >outfile [optional parameters]

Required Parameters:

<vfile file containing velocities v[nx] [nz]

nx= number of x samples (2nd dimension)

nz= number of z samples (1st dimension)

Optional Parameters:

nxb=nx band centered at midpoint

nxd=1 skipped number of midpoints

dx=100 x sampling interval (m)

fx=0.0 first x sample

dz=100 z sampling interval (m)

nt=101 number of time samples

dt=0.04 time sampling interval (sec)

ft=0.0 first time (sec)

nxo=1 number of offsets

dxo=50 offset sampling interval (m)

fxo=0.0 first offset (m)

nxm=101 number of midpoints

dxm=50 midpoint sampling interval (m)

fxm=0.0 first midpoint (m)

fpeak=0.2/dt peak frequency of symmetric Ricker wavelet (Hz)

ref="1:1,2;4,2" reflector(s): "amplitude:x1,z1;x2,z2;x3,z3;...

smooth=0 =1 for smooth (piecewise cubic spline) reflectors

ls=0 =1 for line source; default is point source

tmin=10.0\*dt minimum time of interest (sec)

ndpfz=5 number of diffractors per Fresnel zone

verbose=0 =1 to print some useful information

Notes:

This algorithm is based on formula (58) in Geo. Pros. 34, 686-703, by N. Bleistein.

Offsets are signed - may be positive or negative. ",  
Traveltime and amplitude are calculated by finite differences which is done only in part of midpoints; in the skipped midpoint, interpolation is used to calculate traveltime and amplitude. ",

More than one ref (reflector) may be specified.

Note that reflectors are encoded as quoted strings, with an optional

reflector amplitude: preceding the x,z coordinates of each reflector.  
Default amplitude is 1.0 if amplitude: part of the string is omitted.

CWP: Zhenyue Liu, 07/20/92  
Many subroutines borrowed from Dave Hale's program: SUSYNLV

Trace header fields set: trid, counit, ns, dt, delrt,  
trac1. tracr,  
cdp, cdpt, d2, f2, offset, sx, gx

SUVIBRO - Generates a Vibroseis sweep (linear, linear-segment, dB per Octave, dB per Hertz, T-power)

```
suviBro [optional parameters] > out_data_file
```

Optional Parameters:

dt=0.004 time sampling interval

sweep=1 linear sweep

=2 linear-segment

=3 decibel per octave

=4 decibel per hertz

=5 t-power

swconst=0.0 sweep constant (see note)

f1=10.0 sweep frequency at start

f2=60.0 sweep frequency at end

tv=10.0 sweep length

phz=0.0 initial phase (radians=1 default)

radians=1 =0 degrees

fseg=10.0,60.0 frequency segments (see notes)

tseg=0.0,10.0 time segments (see notes)

t1=1.0 length of taper at start (see notes)

t2=1.0 length of taper at end (see notes)

taper=1 linear

=2 sine

=3 cosine

=4 gaussian (+/-3.8)

=5 gaussian (+/-2.0)

Notes:

The default tapers are linear envelopes. To eliminate the taper, choose t1=t2=0.0.

"swconst" is active only with nonlinear sweeps, i.e. when sweep=3,4,5. ",

"tseg" and "fseg" arrays are used when only sweep=2

Sweep is a modulated cosine function.

Author: CWP: Michel Dietrich

Rewrite: Tagir Galikeev, CWP, 7 October 1994

Trace header fields set: ns, dt, tracl, sfs, sfe, slen, styp





SUWAVEFORM - generate a seismic wavelet

suwaveform <stdin >stdout [optional parameters]

Required parameters:

one of the optional parameters listed below

Optional parameters:

type=akb wavelet type

akb: AKB wavelet defined by max frequency fpeak

berlage: Berlage wavelet

gauss: Gaussian wavelet defined by frequency fpeak

gaussd: Gaussian first derivative wavelet

ricker1: Ricker wavelet defined by frequency fpeak

ricker2: Ricker wavelet defined by half and period

spike: spike wavelet, shifted by time tspike

unit: unit wavelet, i.e. amplitude = 1 = const.

dt=0.004 time sampling interval in seconds

ns= if set, number of samples in output trace

fpeak=20.0 peak frequency of a Berlage, Ricker, or Gaussian,  
and maximum frequency of an AKB wavelet in Hz

half=1/fpeak Ricker wavelet "ricker2": half-length

period=c\*half Ricker wavelet "ricker2": period ( $c=\sqrt{6}/\pi$ )

distort=0.0 Ricker wavelet "ricker2": distortion factor

decay=4\*fpeak Berlage wavelet: exponential decay factor in 1/sec

tn=2 Berlage wavelet: time exponent

ipa=-90 Berlage wavelet: initial phase angle in degrees

tspike=0.0 Spike wavelet: time at spike in seconds

verbose=0 1: echo output wavelet length

Notes:

If ns is not defined, the program determines the trace length depending on the dominant signal period.

The Ricker wavelet "ricker1" and the Gaussian wavelet "gauss" are zero-phase. For these two wavelets, the trace header word delrt is set such that the peak amplitude is at t=0 seconds. If this is not acceptable, use "sushw key=delrt a=0".

The Ricker wavelets can be defined either by the peak frequency `fpeak` ("ricker1") or by its half-length, the period, and a distortion factor ("ricker2"). "ricker" is an acceptable alias for "ricker1".

The Berlage wavelet is defined by the peak frequency `fpeak`, a time time exponent `tn` describing the wavelet shape at its beginning, and an exponential decay factor describing the amplitude decay towards later times. The parameters `tn` and `decay` are non-negative, real numbers; `tn` is typically a small integer number and `decay` a multiple of the dominant signal period  $1/f_{\text{peak}}$ . Additionally, an initial phase angle can be given; use -90 or 90 degrees for zero-amplitude at the beginning.

For an AKB wavelet, `fpeak` is the maximum frequency; the peak frequency is about  $1/3$  of the `fpeak` value.

The output wavelet can be normalized or scaled with "sugain". Use "suviibro" to generate a Vibroseis sweep.

Example:

A normalized, zero-phase Ricker wavelet with a peak frequency of 15 Hz is generated and convolved with a spike dataset:

```
suwaveform type=ricker1 fpeak=15 | sugain pbal=1 > wavelet.su  
suplane npl=1 | suconv sufile=wavelet.su | suxwigg
```

Gaussian and derivatives of Gaussians:

Use "sudgwaveform" to generate these

Caveat:

This program does not check for aliasing.

Author:

Nils Maercklin, RISSC, University of Napoli, Italy, 2006

References:

Aldridge, D. F. (1990). The Berlage wavelet.

Geophysics, vol. 55(11), p. 1508-1511.

Alford, R., Kelly, K., and Boore, D. (1947). Accuracy of finite-difference modeling of the acoustic wave

equation. Geophysics, vol. 39, p. 834-842. (AKB wavelet)  
Sheriff, R. E. (2002). Encyclopedic dictionary of  
applied geophysics. Society of Exploration Geophysicists,  
Tulsa. (Ricker wavelet, page 301)

Notes:

For more information on the wavelets type "sudoc waveforms"  
or have a look at "\$CWPROOT/src/cwp/lib/waveforms.c".

Credits:

CWP, the authors of the subroutines in "waveforms.c".

Trace header fields set: ns, dt, trid, delrt

SUGAUSSTAPER - Multiply traces with gaussian taper

sugausstaper < stdin > stdout [optional parameters]

Required Parameters:

<none>

Optional parameters:

key=offset      keyword of header field to weight traces by  
x0=300          key value defining the center of gaussian window",  
xw=50          width of gaussian window in units of key value

Notes:

Traces are multiplied with a symmetrical gaussian taper

$w(t) = \exp(-((key-x0)/xw)**2)$

unlike "sutaper" the value of x0 defines center of the taper  
rather than the edges of the data.

Credits:

Thomas Bohlen, formerly of TU Bergakademie, Freiberg GDR  
most recently of U Karlsruhe  
04.01.2002

Trace header fields accessed: ns

SURAMP - Linearly taper the start and/or end of traces to zero.

suramp <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters

tmin=tr.delrt/1000 end of starting ramp (sec)

tmax=(nt-1)\*dt beginning of ending ramp (sec)

dt = (from header) sampling interval (sec)

The taper is a linear ramp from 0 to tmin and/or tmax to the end of the trace. Default is a no-op!

Credits:

CWP: Jack K. Cohen, Ken Larner

Trace header fields accessed: ns, dt, delrt

SUTAPER - Taper the edge traces of a data panel to zero.

sutaper <stdin >stdout [optional parameters]

Optional Parameters:

ntr=tr.ntr number of traces. If tr.ntr is not set, then

ntr is mandatory

tr1=0 number of traces to be tapered at beginning

tr2=tr1 number of traces to be tapered at end

min=0. minimum amplitude factor of taper

tbeg=0 length of taper (ms) at trace start

tend=0 length of taper (ms) at trace end

taper=1 taper type

=1 linear (default)

=2 sine

=3 cosine

=4 gaussian (+/-3.8)

=5 gaussian (+/-2.0)

Notes:

To eliminate the taper, choose tbeg=0. and tend=0. and tr1=0

Credits:

CWP: Chris Liner, Jack K. Cohen

Trace header fields accessed: ns, ntr

Rewrite: Tagir Galikeev, October 2002

SUTXTAPER - TAPER in (X,T) the edges of a data panel to zero.

sutxtaper <stdin >stdout [optional parameters]

Optional Parameters:

low=0.        minimum amplitude factor of taper  
tbeg=0       length of taper (ms) at trace start  
tend=0       length of taper (ms) at trace end  
taper=1       taper type  
              =1 linear (default)  
              =2 sine  
              =3 cosine  
              =4 gaussian (+/-3.8)  
              =5 gaussian (+/-2.0)

key=tr set key to compute x-domain taper weights

              default is using internal tracecount (tr)

tr1=0        number of traces to be tapered at beg (key=tr)

tr2=tr1       number of traces to be tapered at end (key=tr)

min=0. minimum value of key where taper starts (amp=1.)

max=0. maximum value of key where taper starts (amp=1.)

dx=1. length of taper (in key units)

if key=tr (unset) length is tr1 and (ntr-tr2)

Notes:

Taper type is used for trace (x-domain) tapering as well as for time domain tapering.

The taper is applied to all traces <tr1 (or key<min) and >tr2 (or key >max) and all time samples <tbeg and >tend.

Taper weights are amp\*1 for traces n tr1<n<tr2 and computed for all other traces corresponding to the taper typ.

If key is given the taper length is defined by dx, otherwise the length of taper is tr1 and (ntr-tr2) respectively.

To eliminate the taper, choose tbeg=0. and tend=0. and tr1=0

If key is set, min,max values take precedence over tr1,tr2.

Credits: (based on sutaper)

CWP: Chris Liner, Jack K. Cohen

Trace header fields accessed: ns



Rewrite: Tagir Galikeev, October 2002

Rewrite: Gerald Klein, IFM-GEOMAR, April 2004

SUAMP - output amp, phase, real or imag trace from  
(frequency, x) domain data

```
suamp <stdin >stdout mode=amp
```

Required parameters:

none

Optional parameter:

mode=amp output flag

=amp output amplitude traces

=logamp output log(amplitude) traces

=phase output phase traces

=ouphase output unwrapped phase traces (oppenheim)

=suphase output unwrapped phase traces (simple)

=real output real parts

=imag output imag parts

jack=0 =1 divide value at zero frequency by 2

(operative only for mode=amp)

.... phase unwrapping options .....

unwrap=1 |dphase| > pi/unwrap constitutes a phase wrapping

(operative only for mode=suphase)

trend=1 remove linear trend from the unwrapped phase

zeromean=0 assume phase(0)=0.0, else assume phase is zero mean

smooth=0 apply damped least squares smoothing to unwrapped phase

r=10.0 ... damping coefficient, only active when smooth=1

Notes:

The trace returned is half length from 0 to Nyquist.

Example:

```
sufft <data | suamp >amp_traces
```

Example:

```
sufft < data > complex_traces
```

```
suamp < complex_traces mode=real > real_traces
```

```
suamp < complex_traces mode=imag > imag_traces
```

Note: the inverse of the above operation is:

```
suop2 real_traces imag_traces op=zipper > complex_traces
```

Note: Explanation of jack=1

The amplitude spectrum is the modulus of the complex output of the fft. f(0) is thus the average over the range of integration

of the transform. For causal functions, or equivalently, half transforms,  $f(0)$  is 1/2 of the average over the full range. Most oscillatory functions encountered in wave applications are zero mean, so this is usually not an issue.

Note: Phase unwrapping:

The mode=ouphase uses the phase unwrapping method of Oppenheim and Schaffer, 1975.

The mode=supphase generates unwrapped phase assuming that jumps in phase larger than  $\pi/\text{unwrap}$  constitute a phase wrapping.

Credits:

CWP: Shuki Ronen, Jack K. Cohen c.1986

Notes:

If efficiency becomes important consider inverting main loop  
and repeating extraction code within the branches of the switch.

Trace header fields accessed: ns, trid

Trace header fields modified: ns, trid

SUANALYTIC - use the Hilbert transform to generate an ANALYTIC (complex) trace

`suanalytic <stdin >sdout`

Optional Parameter:

`phaserot`= phase rotation in degrees of complex trace

Notes:

The output are complex valued traces. The analytic trace is defined as",  
$$\text{ctr}[i] = \text{indata}[i] + i \text{hilb}[\text{indata}[t]]$$
  
where the imaginary part is the hilbert tranform of the original trace

The Hilbert transform is computed in the direct (time) domain

If `phaserot` is set, then a phase rotated complex trace is produced  
$$\text{ctr}[i] = \cos[\text{phaserot}] * \text{indata}[i] + i \sin[\text{phaserot}] * \text{hilb}[\text{indata}[t]]$$

Use "suamp" to extract real, imaginary, amplitude (modulus), etc

Exmple:

`suanalytic < sudata | suamp mode=amp | suxgraph`

Use "suattributes" for instantaneous phase, frequency, etc.

Credits:

CWP: John Stockwell, based on `suhilb` by Jack K. Cohen.

Trace header fields accessed: `ns`, `trid`

Technical references:

Oppenheim, A. V. and Schafer, R. W. (1999).

Discrete-Time Signal Processing. Prentice Hall Signal Processing Series.  
Prentice Hall, New Jersey, 2.

Taner, M. T., F. Koehler, and R. E. Sheriff, 1979, Complex seismic trace analysis: Geophysics, 44, 1041-1063.

SUCEPSTRUM - Compute the complex CEPSTRUM of a seismic trace "

sucepstrum < stdin > stdout

Required parameters:

none

Optional parameters:

sign1=1 sign of real to complex transform

sign2=-1 sign of complex to complex (inverse) transform

...phase unwrapping .....

mode=ouphase Oppenheim's algorithm for phase unwrapping

=suphase simple unwrap phase

unwrap=1 |dphase| > pi/unwrap constitutes a phase wrapping  
(operative only for mode=suphase)

trend=1 deramp the phase, =0 do not deramp the phase

zeromean=0 assume phase starts at 0, =1 phase is zero mean

Notes:

The cepstrum is defined as the fourier transform of the the decibel spectrum, as though it were a time domain signal.

$$CC(t) = FT[\ln|T(\omega)|] = FT[\ln|T(\omega)| + i \phi(\omega)]$$
$$T(\omega) = |T(\omega)| \exp(i \phi(\omega))$$
$$\phi(\omega) = \text{unwrapped phase of } T(\omega)$$

Phase unwrapping:

The mode=ouphase uses the phase unwrapping method of Oppenheim and Schaffer, 1975, which operates integrating the derivative of the phase

The mode=suphase generates unwrapped phase assuming that jumps in phase larger than dphase=pi/unwrap constitute a phase wrapping. In this case the jump in phase is replaced with the average of the jumps in phase on either side of the location where the suspected phase wrapping occurs.

In either mode, the user has the option of de-ramping the phase, by removing its linear trend via trend=1 and of deciding whether the phase starts at phase=0 or is of zero mean via zeromean=1.

Author: John Stockwell, Dec 2010

based on sucepstrum.c by:

Credits:  
Balazs Nemeth of Potash Corporation of Saskatchewan Inc.  
given to CWP in 2008

SUCCWT - Complex continuous wavelet transform of seismic traces

succwt < tdata.su > tfdata.su [optional parameters]

Required Parameters:

None

Optional Parameters:

noct=5 Number of octaves (int)

nv=10 Number of voices per octave (int)

fmax=Nyq Highest frequency in transform

p=-0.5 Power of scale value normalizing CWT

=0 for amp-preserved spec. decomp.

c=1/(2\*fmax) Time-domain inverse gaussian damping parameter  
(bigger c means more wavelet oscillations,  
default gives minimal oscillations)

k=1 Use complex Morlet as wavelet transform kernel

=2 use Fourier kernel ...  $\text{Exp}[i 2 \pi f t]$

fs=1 Use dyadic freq sampling (CWT standard, honors  
noct, nv)

=2 use linear freq sampling (Fourier standard)

df=1 Frequency sample interval in Hz (used only for fs=2)

NOTE: not yet implimented (hardwired to df=1)

dt=(from tr.dt) Sample interval override (in secs, if time data)

verbose=0 Run silent, except echo c value. (=1 for more info)

Examples:

This generates amplitude spec of the CWT impulse response (IR).

suspike ntr=1 ix1=1 nt=125 | succwt | suamp | suximage &

Real part of Fourier IR with linear freq sampling:

suspike ntr=1 ix1=1 nt=125 | succwt k=2 fs=2 | suamp mode=real | suximage &

Real part of Fourier IR with dyadic freq sampling:

suspike ntr=1 ix1=1 nt=125 | succwt k=2 | suamp mode=real | suximage &

Inverse CWT: (within a constant scale factor)

... | succwt p=-1 | suamp mode=real | sustack key=cdp > inv.su

Notes:

1. Total number of scales:  $\text{n scale} = \text{noct} * \text{nv}$
2. Each input trace spawns n scale complex output traces
3. Lowest frequency in the transform is  $\text{fmax} / (2^{(\text{noct}-1/\text{nv})})$
4. Header field (cdp) used as cwt spectrum counter
5. Header field (cdpt) used as scale counter within cwt spectrum

6. Header field (gut) holds number of cwt scales 'na'
7. Header field (unscale) holds CWT scale 'a'

Header fields set: tracl, cdp, cdpt, unscale, gut

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All rights reserved.  
Author: UTulsa: Chris Liner, SEP: Bob Clapp

todo:  
fix fs=2 case to allow df not equal to 1  
History:  
6/18/04  
major overhaul by Clapp, including fourier implementation.  
Speedup ~ 41 times (4100 %)  
2/20/04  
made p=-0.5 default  
2/16/04  
added p option to experiment with CWT normalization  
2/12/04  
replace fb (bandwidth parameter) with c (t-domain gaussian damping const.)  
2/10/04 --- in sync with EAS paper in prep  
changed morlet scaling (c = 1) to preserve time-domain peak amplitude  
changed morlet exp sign to std CWT definition (conjugate) and  
mathematica result that only gives positive freq gaussian with neg exp  
1/26/04  
added linear frequency sampling option  
1/23/04  
figured out fb and made it a getpar  
key: Look at real ccwt output and determine fb by number of  
oscillations desired: Default gives -+--+--  
1/20/04  
beefed up verbose output  
dimension wavelet to length 2\*nt and change correlation call  
... this is done to avoid conv edge effects  
1/19/04  
added fourier wavlet option for comparison with Fourier Transform action  
1/17/04  
complex morlet amp scaling now set to preserve first scale amp with IR  
1/16/04  
added dt getpar to handle depth input properly



preserves first tracl so tracl is ok after spice

11/11/03

initial version

Trace header fields set: tracl, cdp, cdpt, unscale, gut

SUCEPSTRUM - transform to the CEPSTRal domain

```
sucepstrum <stdin >sdout sign1=1
```

Required parameters:

none

Optional parameters:

sign1=1 sign in exponent of fft

sign2=-1 sign in exponent of ifft

dt=from header sampling interval

verbose=1 =0 to stop advisory messages

.... phase unwrapping options .....

mode=ouphase Oppenheim's phase unwrapping

=suphase simple jump detecting phase unwrapping

unwrap=1 |dphase| > pi/unwrap constitutes a phase wrapping

=0 no phase unwrapping (in mode=suphase only)

trend=1 remove linear trend from the unwrapped phase

zeromean=0 assume phase(0)=0.0, else assume phase is zero mean

smooth=0 apply damped least squares smoothing to unwrapped phase

r=10 ... damping coefficient, only active when smooth=1

Notes:

The complex log fft of a function  $F(t)$  is given by:

$$\text{clogfft}(F(t)) = \log(\text{FFT}(F(t))) = \log|F(\omega)| + i\phi(\omega)$$

where  $\phi(\omega)$  is the unwrapped phase. Note that  $0 < \text{unwrap} \leq 1.0$

allows phase unwrapping to be tuned, if desired.

The ceptrum is the inverse Fourier transform of the log fft of  $F(t)$

$$F(t_c) = \text{cepstrum}(F(t)) = \text{INVFFT}[\log(\text{FFT}(F(t)))]$$
$$= \text{INVFFT}[\log|F(\omega)| + i\phi(\omega)]$$

Here  $t_c$  is the cepstral time domain.

To facilitate further processing, the sampling interval in quefrency and first quefrency (0) are set in the output header.

Caveats:

No check is made that the data ARE real time traces!

Use suminphase to make minimum phase representations of signals

Credits:

CWP: John Stockwell, June 2013 based on  
sufft by:  
CWP: Shuki Ronen, Chris Liner, Jack K. Cohen  
CENPET: Werner M. Heigl - added well log support  
U Montana: Bob Lankston - added m\_unwrap\_phase feature

Note: leave dt set for later inversion

Trace header fields accessed: ns, dt, d1, f1  
Trace header fields modified: ns, d1, f1, trid

SUCLOGFFT - fft real time traces to complex log frequency domain traces

suclogfft <stdin >sdout sign=1

Required parameters:

none

Optional parameters:

sign=1 sign in exponent of fft

dt=from header sampling interval

verbose=1 =0 to stop advisory messages

.... phase unwrapping options .....

mode=suphase simple jump detecting phase unwrapping

=ouphase Oppenheim's phase unwrapping

unwrap=1 |dphase| > pi/unwrap constitutes a phase wrapping

=0 no phase unwrapping (in mode=suphase only)

trend=1 remove linear trend from the unwrapped phase

zeromean=0 assume phase(0)=0.0, else assume phase is zero mean

Notes:

$\text{clogfft}(F(t)) = \log(\text{FFT}(F(t))) = \log|F(\omega)| + i\phi(\omega)$

where  $\phi(\omega)$  is the unwrapped phase. Note that  $0 < \text{unwrap} \leq 1.0$

allows phase unwrapping to be tuned, if desired.

To facilitate further processing, the sampling interval in frequency and first frequency (0) are set in the output header.

suclogfft unwrap=0 | suiclogfft is not quite a no-op since the trace length will usually be longer due to fft padding.

Caveats:

No check is made that the data ARE real time traces!

Output is type complex. To view amplitude, phase or real, imaginary parts, use suamp

PI/unwrap = minimum dphase is assumed to constitute a wrap in phase for suphase unwrapping only

Examples:

suclogfft < stdin | suamp mode=real | ....

suclogfft < stdin | suamp mode=imag | ....

The real and imaginary parts of the complex log spectrum are the respective amplitude and phase (unwrapped) phase spectra of the input signal.

Example: Homomorphic wavelet estimation

```
suclogfft < shotgather | suamp mode=real | sustack key=dt > real.su
```

```
suclogfft < shotgather | suamp mode=imag | sustack key=dt > imag.su
```

```
suop2 real.su imag.su op=zipper | suiclogfft | suminphase > wavelet.su
```

Credits:

CWP: John Stockwell, Dec 2010 based on  
sufft by:

CWP: Shuki Ronen, Chris Liner, Jack K. Cohen

CENPET: Werner M. Heigl - added well log support

U Montana: Bob Lankston - added m\_unwrap\_phase feature

Note: leave dt set for later inversion

Trace header fields accessed: ns, dt, d1, f1

Trace header fields modified: ns, d1, f1, trid

SUCWT - generates Continuous Wavelet Transform amplitude, regularity analysis in the wavelet basis

```
sucwt < stdin [Optional parameters ] > stdout
```

Required Parameters:

none

Optional Parameters:

base=10 Base value for wavelet transform scales

first=-1 First exponent value for wavelet transform scales

expinc=0.01 Exponent increment for wavelet transform scales

last=1.5 Last exponent value for wavelet transform scales

Wavelet Parameters:

wtype=0 2nd derivative of Gaussian (Mexican hat)

=1 4th derivative of Gaussian (witch's hat)

=2 6th derivative of Gaussian (wizard's hat)

nwavelet=1024 number of samples in the wavelet

xmin=-20 minimum x value wavelet is computed

xcenter=0 center x value wavelet is computed

xmax=20 maximum x value wavelet is computed

sigma=1 sharpness parameter ( sigma > 1 sharper)

verbose=0 silent, =1 chatty

holder=0 =1 compute Holder regularity estimate

divisor=1.0 a floating point number >= 1.0 (see notes)

Notes:

This is the CWT version of the time frequency analysis notion that is applied in sugabor.

The parameter base is the base of the power that is applied to scale the wavelet. Some mathematical literature assume base 2. Base 10 works well here.

Default option yields an output similar to that of sugabor. With the parameter holder=1 an estimate of the instantaneous Holder regularity (the Holder exponent) is output for each input data value. The result is a Holder exponent trace for each corresponding input data trace.

The strict definition of the Holder exponent is the maximum slope of the rise of the spectrum in the log(amplitude) versus log(scale) domain:

divisor=1.0 means the exponent is computed simply by fitting a line through all of the values in the transform. A value of divisor>1.0 indicates that the Holder exponent is determined as the max of slopes found in (total scales)/divisor length segments.

Some experimentation with the parameters nwavelet, first, last, and expinc may be necessary before a desirable output is obtained. The most effective way to proceed is to perform a number of tests with holder=0 to determine the range of first, last, and expinc that best represents the data in the wavelet domain. Then experimentation with holder=1 and values of divisor>=1.0 may proceed.

#### Credits:

CWP: John Stockwell, Nov 2004

inspired in part by "bhpcwt" in the BHP\_SU package, code written by

BHP: Michael Glinsky, c. 2002, based loosely on a Matlab CWT function

#### References:

Li C.H., (2004), Information passage from acoustic impedance to seismogram: Perspectives from wavelet-based multiscale analysis, Journal of Geophysical Research, vol. 109, B07301, p.1-10.

Mallat, S. and W. L. Hwang, (1992), Singularity detection and processing with wavelets, IEEE Transactions on information, v 38, March 1992, p.617 - 643.

SUFFT - fft real time traces to complex frequency traces

```
suftt <stdin >sdout sign=1
```

Required parameters:

none

Optional parameters:

sign=1 sign in exponent of fft

dt=from header sampling interval

verbose=1 =0 to stop advisory messages

Notes: To facilitate further processing, the sampling interval in frequency and first frequency (0) are set in the output header.

suftt | suifft is not quite a no-op since the trace length will usually be longer due to fft padding.

Caveats:

No check is made that the data IS real time traces!

Output is type complex. To view amplitude, phase or real, imaginary parts, use      suamp

Examples:

```
suftt < stdin | suamp mode=amp | ....
```

```
suftt < stdin | suamp mode=phase | ....
```

```
suftt < stdin | suamp mode=uphase | ....
```

```
suftt < stdin | suamp mode=real | ....
```

```
suftt < stdin | suamp mode=imag | ....
```

Credits:

CWP: Shuki Ronen, Chris Liner, Jack K. Cohen

CENPET: Werner M. Heigl - added well log support

Note: leave dt set for later inversion

Trace header fields accessed: ns, dt, d1, f1

Trace header fields modified: ns, d1, f1, trid



SUGABOR - Outputs a time-frequency representation of seismic data via the Gabor transform-like multifilter analysis technique presented by Dziewonski, Bloch and Landisman, 1969.

sugabor <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters:

dt=(from header) time sampling interval (sec)  
fmin=0 minimum frequency of filter array (hz)  
fmax=NYQUIST maximum frequency of filter array (hz)  
beta=3.0 ln[filter peak amp/filter endpoint amp]  
band=.05\*NYQUIST filter bandwidth (hz)  
alpha=beta/band<sup>2</sup> filter width parameter  
verbose=0 =1 supply additional info  
holder=0 =1 output Holder regularity estimate  
=2 output linear regularity estimate

Notes: This program produces a multifilter (as opposed to moving window) representation of the instantaneous amplitude of seismic data in the time-frequency domain. (With Gaussian filters, moving window and multifilter analysis can be shown to be equivalent.)

An input trace is passed through a collection of Gaussian filters to produce a collection of traces, each representing a discrete frequency range in the input data. For each of these narrow bandwidth traces, a quadrature trace is computed via the Hilbert transform. Treating the narrow bandwidth trace and its quadrature trace as the real and imaginary parts of a "complex" trace permits the "instantaneous" amplitude of each narrow bandwidth trace to be computed. The output is thus a representation of instantaneous amplitude as a function of time and frequency.

Some experimentation with the "band" parameter may be necessary to produce the desired time-frequency resolution. A good rule of thumb is to run sugabor with the default value for band and view the image. If band is too big, then the t-f plot will consist of stripes parallel to the frequency axis. Conversely, if band is too small, then the stripes will be parallel to the time axis.

Caveat:

The Gabor transform is not a wavelet transform, but rather are sharp

frame basis. However, it is nearly a Morlet continuous wavelet transform so the concept of Holder regularity may have some meaning. If you are computing Holder regularity of, say, a migrated seismic section, then set band to 1/3 of the frequency band of your data.

Examples:

```
suviBro | sugaBoR | suXiMaGe
suviBro | sugaBoR | suXMoViE n1= n2= n3=
    (because suXMoViE scales it's amplitudes off of the first panel,
    may have to experiment with the wclip and bclip parameters
suviBro | sugaBoR | suPsImaGe | ... ( your local PostScript utility)
```

Credits:

CWP: John Stockwell, Oct 1994

CWP: John Stockwell Oct 2004, added holder=1 option

Algorithm:

This programs takes an input seismic trace and passes it through a collection of truncated Gaussian filters in the frequency domain.

The bandwidth of each filter is given by the parameter "band". The decay of these filters is given by "alpha", and the number of filters is given by  $n_{filt} = (f_{max} - f_{min})/band$ . The result, upon inverse Fourier transforming, is that  $n_{filt}$  traces are created, with each trace representing a different frequency band in the original data.

For each of the resulting bandlimited traces, a quadrature (i.e.  $\pi/2$  phase shifted) trace is computed via the Hilbert transform. The bandlimited trace constitutes a "complex trace", with the bandlimited trace being the "real part" and the quadrature trace being the "imaginary part". The instantaneous amplitude of each bandlimited trace is then computed by computing the modulus of each complex trace. (See Taner, Koehler, and Sheriff, 1979, for a discussion of complex trace analysis.

The final output for a given input trace is a map of instantaneous amplitude as a function of time and frequency.

This is not a wavelet transform, but rather a redundant frame representation.

References: Dziewonski, Bloch, and Landisman, 1969, A technique for the analysis of transient seismic signals, Bull. Seism. Soc. Am., 1969, vol. 59, no.1, pp.427-444.

Taner, M., T., Koehler, F., and Sheriff, R., E., 1979, Complex seismic trace analysis, Geophysics, vol. 44, pp.1041-1063.

Chui, C., K., 1992, Introduction to Wavelets, Academic Press, New York.

Trace header fields accessed: ns, dt, trid, ntr

Trace header fields modified: tracl, tracr, d1, f2, d2, trid, ntr

SUHILB - Hilbert transform

suhilb <stdin >sdout

Note: the transform is computed in the direct (time) domain

Credits:

CWP: Jack Cohen

CWP: John Stockwell, modified to use Dave Hale's hilbert() subroutine

Trace header fields accessed: ns, trid

SUICEPSTRUM - fft of complex log frequency traces to real time traces

```
suicepstrum <stdin >sdout sign2=-1
```

Required parameters:

none

Optional parameter:

sign1=1 sign in exponent of first fft

sign2=-1 sign in exponent of inverse fft

sym=0 =1 center output

dt=tr.dt time sampling interval (s) from header

if not set assumed to be .004s

Output traces are normalized by 1/N where N is the fft size.

Note:

The forward cepstral transform is the

$$F(t\_c) = \text{InvFFT}[\ln[\text{FFT}(F(t))]]$$

The inverse cepstral transform is the

$$F(t) = \text{InvFFT}[\exp[\text{FFT}(F(t\_c))]]$$

Here t\_c is the cepstral time (quefrency) domain

Credits:

CWP: John Stockwell, Dec 2010 based on

suifft.c by:

CWP: Shuki Ronen, Chris Liner, Jack K. Cohen, c. 1989

Trace header fields accessed: ns, trid

Trace header fields modified: ns, trid

SUICLOGFFT - fft of complex log frequency traces to real time traces

```
suiclogfft <stdin >sdout sign=-1
```

Required parameters:

none

Optional parameter:

sign=-1 sign in exponent of inverse fft

sym=0 =1 center output

Output traces are normalized by 1/N where N is the fft size.

Note:

Nominally this is the inverse to the complex log fft, but  
suclogfft | suiclogfft is not quite a no-op since the trace  
length will usually be longer due to fft padding.

Example: Homomorphic wavelet estimation

```
suclogfft < shotgather | suamp mode=real | sustack key=dt > real.su
```

```
suclogfft < shotgather | suamp mode=imag | sustack key=dt > imag.su
```

```
suop2 real.su imag.su op=zipper | suiclogfft | suminphase > wavelet.su
```

Credits:

CWP: John Stockwell, Dec 2010 based on

suifft.c by:

CWP: Shuki Ronen, Chris Liner, Jack K. Cohen, c. 1989

Trace header fields accessed: ns, trid

Trace header fields modified: ns, trid

SUIFFT - fft complex frequency traces to real time traces

suifft <stdin >sdout sign=-1

Required parameters:

none

Optional parameter:

sign=-1 sign in exponent of inverse fft

Output traces are normalized by  $1/N$  where  $N$  is the fft size.

Note: sufft | suifft is not quite a no-op since the trace length will usually be longer due to fft padding.

Credits:

CWP: Shuki, Chris, Jack

Trace header fields accessed: ns, trid

Trace header fields modified: ns, trid

SUMINPHASE - convert input to minimum phase

suminphase <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters:

sign1=1 sign of first transform (1 or -1)

sign2=-1 sign of second transform (-1 or 1)

pnoise=1.e-9 white noise in spectral routine

verbose=0 =1 for advisory messages

Example: Homomorphic wavelet estimation

suclogfft < shotgather | suamp mode=real | sustack key=dt > real.su

suclogfft < shotgather | suamp mode=imag | sustack key=dt > imag.su

suop2 real.su imag.su op=zipper | suiclogfft | suminphase > wavelet.su

Credits:

SEAM Project: Bruce VerWest c. 2013

Trace header fields accessed: ns, dt, d1



SUPHASEVEL - Multi-mode PHASE VELOCITY dispersion map computed  
from shot record(s)

suphasevel <infile >outfile [optional parameters]

Optional parameters:

fv=330 minimum phase velocity (m/s)

nv=100 number of phase velocities

dv=25 phase velocity step (m/s)

fmax=50 maximum frequency to process (Hz)

=0 process to nyquist

norm=0 do not normalize by amplitude spectrum

=1 normalize by amplitude spectrum

verbose=0 verbose = 1 echoes information

Notes: Offsets read from headers.

1. output is complex frequency data
2. offset header word must be set (signed offset is ok)
3. norm=1 tends to blow up aliasing and other artifacts
4. For correct suifft later, use fmax=0
5. For later processing outtrace.dt=domega
6. works for 2D or 3D shots in any offset order

Using this program:

First: use

suspecfx < shotrecord.su | suximage

to see what the maximum bandwidth is in your data. This will  
give you an idea about the possible value for fmax.

Second: Plot your data or some subset of your data via:

suxwigg < shotrecord.su key=offset

You can then estimate the range of phase velocities by looking  
at the maximum and minimum slopes of arrivals in your data.  
This will allow you to set first velocity fv and the increment  
in velocity dv, that make sense for your data.

You can pick values of offset and time by placing the cursor  
on the desired location on the plot and pressing the '\s\' key  
The picks will appear in your terminal window.

When displaying, don't forget to use suamp to compute the modulus of the complex values that this program puts out.

```
suphasevel < shotrecord.su [parameters] | suamp | suximage
```

Credits:

UHouston: Chris Liner June2008 (cloned from suscepck)

This code implements the following integral transform

$$u(w,v) = \int_{-\infty}^{\infty} k(w,x,v) u(w,x) dx$$

where

$u(w,v)$  is the phase velocity dispersion image

$k(w,x,v)$  is the transform kernel....  $\exp(-i w x / v)$

$u(w,x) = \text{FT}[u(t,x)]$  is the input shot record(s)

—/

Reference: Park, Miller, and Xia (1998, SEG Abstracts)

Trace header fields accessed: dt, offset, ns

Trace header fields modified: nx,dt,trid,d1,f1,d2,f2,tracl

SURADON - compute forward or reverse Radon transform or remove multiples by using the parabolic Radon transform to estimate multiples and subtract.

suradon <stdin >stdout [Optional Parameters]

#### Optional Parameters:

choose=0	0 Forward Radon transform
	1 Compute data minus multiples
	2 Compute estimate of multiples
	3 Compute forward and reverse transform
	4 Compute inverse Radon transform
igopt=1	1 parabolic transform: $g(x) = \text{offset}^2$
	2 Foster/Mosher psuedo hyperbolic transform $g(x) = \text{sqrt}(\text{depth}^2 + \text{offset}^2)$
	3 Linear tau-p: $g(x) = \text{offset}$
	4 abs linear tau-p: $g(x) = \text{abs}(\text{offset})$
offref=2000.	reference maximum offset to which maximum and minimum moveout times are associated
interoff=0.	intercept offset to which tau-p times are associated
pmin=-200	minimum moveout in ms on reference offset
pmax=400	maximum moveout in ms on reference offset
dp=16	moveout increment in ms on reference offset
pmula=80	moveout in ms on reference offset where multiples begin at maximum time
pmulb=200	moveout in ms on reference offset where multiples begin at zero time
depthref=500.	Reference depth for Foster/Mosher hyperbolic transform
nwin=1	number of windows to use through the mute zone
f1=60.	High-end frequency before taper off
f2=80.	High-end frequency
prewhite=0.1	Prewhitening factor in percent.
cdpkey=cdp	name of header word for defining ensemble
offkey=offset	name of header word with spatial information
nxmax=240	maximum number of input traces per ensemble
ltaper=7	taper (integer) for mute tapering function

#### Optimizing Parameters:

The following parameters are occasionally used to avoid spatial aliasing problems on the linear tau-p transform. Not recommended for other transforms...

ninterp=0	number of traces to interpolate between each input trace prior to computing transform
-----------	---

freq1=4.0	low-end frequency in Hz for picking (good default: 3 Hz) (Known bug: freq1 cannot be zero)
freq2=20.0	high-end frequency in Hz for picking (good default: 20 Hz)
lagc=400	length of AGC operator for picking (good default: 400 ms)
lent=5	length of time smoother in samples for picker (good default: 5 samples)
lenx=7	length of space smoother in samples for picker (good default: 1 sample)
xopt=1	1 = use differences for spatial derivative (works with irregular spacing) 0 = use FFT derivative for spatial derivatives (more accurate but requires regular spacing and at least 16 input traces--will switch to differences automatically if have less than 16 input traces)

#### Credits:

CWP: John Anderson (visitor to CSM from Mobil) Spring 1993

#### Multiple removal notes:

Usually the input data are NMO corrected CMP gathers. The first pass is to compute a parabolic Radon transform and identify the multiples in the transform domain. Then, the module is run on all the data using "choose=1" to estimate and subtract the multiples. See the May, 1993 CWP Project Review for more extensive documentation.

#### NWIN notes:

The parabolic transform runs with higher resolution if the mute zone is honored. When "nwin" is specified larger than one (say 6), then multiple windows are used through the mute zone. It is assumed in this case that the input data are sorted by the offkey header item from small offset to large offset. This causes the code to run 6 times longer. The mute time is taken from the "mutts" header word. You may have to manually set this header field yourself, if it is not already set.

#### References:

Anderson, J. E., 1993, Parabolic and linear 2-D, tau-p transforms using the generalized radon tranform, in May 11-14, 1993 Project Review, Consortium Project on Seismic Inverse methods for Complex Structures, CWP-137, Center for Wave Phenomena

internal report.

Other References cited in above paper:

- Beylkin, G., 1987, The discrete Radon transform: IEEE Transactions of Acoustics, Speech, and Signal Processing, 35, 162-712.
- Chapman, C.H., 1981, Generalized Radon transforms and slant stacks: Geophysical Journal of the Royal Astronomical Society, 66, 445-453.
- Foster, D. J. and Mosher, C. C., 1990, Multiple suppression using curvilinear Radon transforms: SEG Expanded Abstracts 1990, 1647-1650.
- Foster, D. J. and Mosher, C. C., 1992, Suppression of multiples using the Radon transform: Geophysics, 57, No. 3, 386-395.
- Gulunay, N., 1990, F-X domain least-squares Tau-P and Tau-Q: SEG Expanded Abstracts 1990, 1607-1610.
- Hampson, D., 1986, Inverse velocity stacking for multiple elimination: J. Can. Soc. Expl. Geophs., 22, 44-55.
- Hampson, D., 1987, The discrete Radon transform: a new tool for image enhancement and noise suppression: SEG Expanded Abstracts 1978, 141-143.
- Johnston, D.E., 1990, Which multiple suppression method should I use? SEG Expanded Abstracts 1990, 1750-1752.

Trace header words accessed: ns, dt, cdpkey, offkey, muts

SUSLOWFT - Fourier Transforms by a (SLOW) DFT algorithm (Not an FFT)

suslowft <stdin >sdout sign=1

Required parameters:

none

Optional parameters:

sign=1 sign in exponent of fft

dt=from header sampling interval

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt, trid

Notes: To facilitate further processing, the sampling interval  
in frequency and first frequency (0) are set in the  
output header.

Warning: This program is *\*not\** fft based. Use only for demo  
purposes, *\*not\** for large data processing.

No check is made that the data are real time traces!  
suslowft | suslowift is not quite a no-op since the trace  
length will usually be longer due to fft padding.

Caveats:

No check is made that the data IS real time traces!

Output is type complex. To view amplitude, phase or real, imaginary  
parts, use suamp

Examples:

suslowft < stdin | suamp mode=amp | ....

suslowft < stdin | suamp mode=phase | ....

suslowft < stdin | suamp mode=real | ....

suslowft < stdin | suamp mode=imag | ....

Credits:

CWP: Shuki, Chris, Jack

Note: leave dt set for later inversion



SUSLOWIFT - Fourier Transforms by (SLOW) DFT algorithm (Not an FFT)  
complex frequency to real time domain traces

suslowift <stdin >sdout sign=-1

Required parameters:

none

Optional parameters:

sign=-1 sign in exponent of fft

dt=from header sampling interval

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt, trid

Notes: To facilitate further processing, the sampling interval  
in frequency and first frequency (0) are set in the  
output header.

Warning: This program is *\*not\** fft based. Use only for demo  
purposes, *\*not\** for large data processing.

No check is made that the data are real time traces!

Credits:

CWP: John Stockwell c. 1993

based on suiff: Shuki Ronen, Chris Liner, Jack K. Cohen

Note: leave dt set for later inversion



SUSPECFK - F-K Fourier SPECTrum of data set

suspecfk <infile >outfile [optional parameters]

Optional parameters:

dt=from header time sampling interval

dx=from header(d2) or 1.0 spatial sampling interval

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note: To facilitate further processing, the sampling intervals  
in frequency and wavenumber as well as the first  
frequency (0) and the first wavenumber are set in the  
output header (as respectively d1, d2, f1, f2).

Note: The relation:  $w = 2 \pi F$  is well known, but there  
doesn't seem to be a commonly used letter corresponding  
to F for the spatial conjugate transform variable. We  
use K for this. More specifically we assume a phase:  
 $i(w t - k x) = 2 \pi i(F t - K x)$ .  
and F, K define our notion of frequency, wavenumber.

Credits:

CWP: Dave (algorithm), Jack (reformatting for SU)

Trace header fields accessed: ns, dt, d2

Trace header fields modified: tracl, ns, dt, trid, d1, f1, d2, f2

SUSPECFX - Fourier SPECTrum (T -> F) of traces

suspecfx <infile >outfile

Note: To facilitate further processing, the sampling interval  
in frequency and first frequency (0) are set in the  
output header.

Credits:

CWP: Dave (algorithm), Jack (reformatting for SU)

Trace header fields accessed: ns, dt

Trace header fields modified: ns, dt, trid, d1, f1

SUSPECK1K2 - 2D (K1,K2) Fourier SPECTrum of (x1,x2) data set

suspeck1k2 <infile >outfile [optional parameters]

Optional parameters:

d1=from header(d1) or 1.0 spatial sampling interval in first (fast)  
dimension

d2=from header(d2) or 1.0 spatial sampling interval in second  
(slow) dimension

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

Because the data are assumed to be purely spatial (i.e. non-seismic),  
the data are assumed to have trace id (30), corresponding to (z,x) data

To facilitate further processing, the sampling intervals in wavenumber  
as well as the first frequency (0) and the first wavenumber are set in  
the output header (as respectively d1, d2, f1, f2).

The relation:  $w = 2 \pi F$  is well known for frequency, but there  
doesn't seem to be a commonly used letter corresponding to F for the  
spatial conjugate transform variables. We use K1 and K2 for this.

More specifically we assume a phase:

$$-i(k_1 x_1 + k_2 x_2) = -2 \pi i(K_1 x_1 + K_2 x_2).$$

and K1, K2 define our respective wavenumbers.

Credits:

CWP: John Stockwell, 26 April 1995, based on original code by  
Dave Hale and Jack Cohen

Trace header fields accessed: ns, d1, d2, trid

Trace header fields modified: tracl, ns, dt, trid, d1, f1, d2, f2

SUTAUP - forward and inverse T-X and F-K global slant stacks

sutaup <infile >outfile [optional parameters]

Optional Parameters:

option=1 =1 for forward F-K domain computation  
=2 for forward T-X domain computation  
=3 for inverse F-K domain computation  
=4 for inverse T-X domain computation  
dt=tr.dt (from header) time sampling interval (secs)  
nx=ntr (counted from data) number of horizontal samples (traces)  
dx=1 horizontal sampling interval (m)  
npoints=71 number of points for rho filter  
pmin=0.0 minimum slope for Tau-P transform (s/m)  
pmax=.006 maximum slope for Tau-P transform (s/m)  
np=nx number of slopes for Tau-P transform  
ntau=nt number of time samples in Tau-P domain  
fmin=3 minimum frequency of interest  
xmin=0 offset on first trace

verbose=0 verbose = 1 echoes information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Notes:

The cascade of a forward and inverse tau-p transform preserves the relative amplitudes in a data panel, but not the absolute amplitudes meaning that a scale factor must be applied to data output by such a cascade before the output may be compared to the original data. This is a characteristic of the algorithm employed in this program. (Suradon does not have this problem.)

Credits: CWP: Gabriel Alvarez, 1995.

Reference:

Levin, F., editor, 1991, Slant-Stack Processing, Geophysics Reprint Series #14, SEG Press, Tulsa.

Trace header fields accessed: ns, dt  
Trace header fields modified: dt,d2,f2

SUWFFT - Weighted amplitude FFT with spectrum flattening 0->Nyquist

`suwfft <stdin | suifft >sdout`

Required parameters:

none

Optional parameters:

`w0=0.75` weight for `AmpSpectrum[f-df]`

`w1=1.00` weight for `AmpSpectrum[f].. center value`

`w2=0.75` weight for `AmpSpectrum[f+df]`

Notes:

1. output format is same as `sufft`
2. `suwfft | suifft` is not quite a no-op since the trace length will usually be longer due to fft padding.
3. using `w0=0 w1=1 w2=0` gives truly flat spectrum, for other weight choices the spectrum retains some of its original topography

Examples:

1. boost data bandwidth to 10-90 Hz  
`suwfft < data.su | suifft | sufilter f=5,8,90,100 | suximage`
1. view amplitude spectrum after flattening  
`suwfft < data.su | suamp | suximage`

Caveat: The process of cascading the forward and inverse Fourier transforms may result in the output trace length being greater than the input trace length owing to zero padding. The user may wish to apply `suwind` to return the number of samples per trace to the original value: Here NS is the number of samples per trace on the original data  
`... | suwind itmax=NS | ...`

Credits:

UHouston: Chris Liner

Note: Concept from UTulsa PhD thesis of Bassel Al-Moughraby

Trace header fields accessed: `ns, dt`

Trace header fields modified: `ns, d1, f1, trid`

SUZEROPHASE - convert input to zero phase equivalent

suzerophase <stdin >stdout [optional parameters]

Required parameters:

if dt is not set in header, then dt is mandatory

Optional parameters:

t0=1.0 time of peak value t0

verbose=0 =1 for advisory messages

Credits:

c. 2011 Bruce VerWest as part of the SEAM project

Trace header fields accessed: ns, dt, d1

SURELANAN - REsidual-moveout semblance ANalysis for ANisotropic media

surelan refl= npicks= [optional parameters]

Required parameters:

reflector file: reflec =

number of points in the reflector file =

Optional Parameters:

nr1=51 number of r1-parameter samples

dr1=0.01 r1-parameter sampling interval

fr1=-0.25 first value of r1-parameter

nr2=51 number of r2-parameter samples

dr2=0.01 r2-parameter sampling interval

fr2=-0.25 first value of r2-parameter

dzratio=5 ratio of output to input depth sampling intervals

nsmooth=dzratio\*2+1 length of semblance num and den smoothing window

verbose=0 =1 for diagnostic print on stderr

method=linear for linear interpolation of the interface

=mono for monotonic cubic interpolation of interface

=akima for Akima's cubic interpolation of interface

=spline for cubic spline interpolation of interface

Note:

1. This program is part of Debashish Sarkar's anisotropic model building technique.
2. Input migrated traces should be sorted by cdp - surelan outputs a group of semblance traces every time cdp changes. Therefore, the output will be useful only if cdp gathers are input.
3. The residual-moveout semblance for cdp gathers is based on  $z(h)*z(h) = z(0)*z(0) + r1*h^2 + r2*h^4/[h^2+z(0)^2]$  where  $z$  depth and  $h$  is the half-offset.



SURELAN - compute residual-moveout semblance for cdp gathers based on  $z(h)*z(h) = z(0)*z(0) + r*h*h$  where  $z$  depth and  $h$  offset.

surelan <stdin >stdout [optional parameters]

Optional Parameters:

nr=51 number of r-parameter samples

dr=0.01 r-parameter sampling interval

fr=-0.25 first value of b-parameter

smute=1.5 samples with RMO stretch exceeding smute are zeroed

dzratio=5 ratio of output to input depth sampling intervals

nsmooth=dzratio\*2+1 length of semblance num and den smoothing window

verbose=0 =1 for diagnostic print on stderr

Note:

1. This program is part of Zhenyue Liu's velocity analysis technique.
2. Input migrated traces should be sorted by cdp - surelan outputs a group of semblance traces every time cdp changes. Therefore, the output will be useful only if cdp gathers are input.
3. The parameter  $r$  may take negative values. The range of  $r$  can be controlled by maximum of  $(z(h)*z(h)-z(0)*z(0))/(h*h)$

SUTIVEL - SU Transversely Isotropic velocity table builder  
computes vnmo or vphase as a function of Thomsen's parameters and  
theta and optionally interpolate to constant increments in slowness

Optional Parameters:  
a=2500. alpha (vertical p velocity)  
b=1250. beta (vertical sv velocity)  
e=.20 epsilon (horiz p-wave anisotropy)  
d=.10 delta (strange parameter)  
maxangle=90.0 max angle in degrees  
nangle=9001 number of angles to compute  
verbose=0 set to 1 to see full listing  
np=8001 number of slowness values to output  
option=1 1=output vnmo(p) (result used for TI DMO)  
2=output vnmo(theta) in degrees  
3=output vnmo(theta) in radians  
4=output vphase(p)  
5=output vphase(theta) in degrees  
6=output vphase(theta) in radians  
7=output first derivative vphase(p)  
8=output first derivative vphase(theta) in degrees  
9=output first derivative vphase(theta) in radians  
10=output second derivative vphase(p)  
11=output second derivative vphase(theta) in degrees  
12=output second derivative vphase(theta) in radians  
13=( 1/vnmo(0)^2 -1/vnmo(theta)^2 )/p^2 test vs theta  
    (result should be zero for all theta for d=e)  
14=return vnmo(p) for weak anisotropy  
    normalize=0 =1 means scale vnmo by cosine and scale vphase by  
        1/sqrt(1+2\*e\*sin(theta)\*sin(theta))  
        (only useful for vphase when d=e for constant  
result)  
=0 means output vnmo or vphase unnormalized

Output on standard output is ascii text with:

line 1: number of values  
line 2: abscissa increment (p or theta increment, always starts at zero)  
line 3-n: one value per line

Author: (visitor to CSM from Mobil) John E. Anderson, Spring 1994

SUVEL2DF - compute stacking VELOCITY semblance for a single time in  
over Vnmo and eta in 2-D

suvel2df <stdin >stdout [optional parameters]

Required Parameters:

tn zero-offset time of reflection  
offsetm Maximum offset considered

Optional Parameters:

nv=50 number of velocities  
dv=50.0 velocity sampling interval  
fv=1500.0 first velocity  
nvh=50 number of horizontal velocities  
dvh=50.0 horizontal velocity sampling interval  
fvh=1500.0 first horizontal velocity  
xod=1.5 maximum offset-to-depth ratio to resolve  
dtratio=5 ratio of output to input time sampling intervals  
nsmooth=dtratio\*2+1 length of semblance num and den smoothing window  
verbose=0 =1 for diagnostic print on stderr  
vavg=fv+0.5\*(nv-1)\*dv average velocity used in the search

Notes:

Semblance is defined by the following quotient:

$$s(t) = \frac{\sum_{j=0}^{n-1} q(t,j)^2}{\sum_{j=0}^{n-1} [q(t,j)]^2}$$

where n is the number of non-zero samples after muting.

Smoothing (nsmooth) is applied separately to the numerator and denominator  
before computing this semblance quotient.

Input traces should be sorted by cdp - suvel2df outputs a group of  
semblance traces every time cdp changes. Therefore, the output will  
be useful only if cdp gathers are input.

Credits:

CWP: Tariq Alkhalifah, February 1997

Trace header fields accessed: ns, dt, delrt, offset, cdp.

Trace header fields modified: ns, dt, offset.

SUVELAN\_NCCS - compute stacking VELOCITY panel for cdp gathers  
using Normalized CrossCorrelation Sum

suvelan\_uccs <stdin >stdout [optional parameters]

Optional Parameters:

nx=tr.cdpt	number of traces in cdp
nv=50	number of velocities
dv=50.0	velocity sampling interval
fv=1500.0	first velocity
smute=1.5	samples with NMO stretch exceeding smute are zeroed
dtratio=5	ratio of output to input time sampling intervals
nsmooth=dtratio*2+1	length of smoothing window
verbose=0	=1 for diagnostic print on stderr
pwr=1.0	semblance value to the power

Notes:

Normalized CrossCorrelation sum: sum all possible crosscorrelation trace pairs in a CMP gather for each trial velocity and zero-offset two-way travel time inside a time window. This coherence measure is normalized by dividing each crosscorrelation trace pair by the geometric mean of the energy, inside the chosen time window, of each trace pair involved in each crosscorrelation. Then, to achieve a maximum amplitude of unity, the result is multiplied by  $2/(M(M-1))$ , which is the inverse of the total number of crosscorrelation. The normalization allows to bring out weak reflection as long as these reflections have moveouts close to a hyperbola.

Credits:

CWP: Valmore Celis, Sept 2002

Based on the original code: suvelan.c

Colorado School of Mines: Dave Hale, c. 1989

Trace header fields accessed: ns, dt, delrt, offset, cdp, cdpt

Trace header fields modified: ns, dt, offset, cdp

Reference: Neidell, N.S., and Taner, M.T., 1971, Semblance and other coherency measures for multichannel data: Geophysics, 36, 498-509.



SUVELAN\_NSEL - compute stacking VELOCITY panel for cdp gathers  
using the Normalized Selective CrossCorrelation sum

```
suvelan_usel <stdin >stdout [optional parameters]
```

Optional Parameters:

<code>nx=tr.cdpt</code>	number of traces in cdp
<code>dx=tr.d2</code>	offset increment
<code>nv=50</code>	number of velocities
<code>dv=100.0</code>	velocity sampling interval
<code>fv=1500.0</code>	first velocity
<code>tau=0.5</code>	threshold for significance values
<code>smute=1.5</code>	samples with NMO stretch exceeding smute are zeroed
<code>dtratio=5</code>	ratio of output to input time sampling intervals
<code>nsmooth=dtratio*2+1</code>	length of smoothing window
<code>verbose=0</code>	=1 for diagnostic print on stderr
<code>pwr=1.0</code>	semblance value to the power

Notes:

Normalized Selective CrossCorrelation Sum: is based on the coherence measure known as crosscorrelation sum. The difference is that the selective approach sum only crosscorrelation pairs with relatively large differential moveout, thus increasing the resolving power in the velocity spectra compared to that achieved by conventional methods. The normalization is achieved in much the same way of normalizing the conventional crosscorrelation sum.

Each crosscorrelation is divided by the geometric mean of the energy of the traces involved, and the multiplying by a constant to achieve maximum amplitude of unity. The constant is just the inverse of the total number of crosscorrelations included in the sum. The selection is made using a parabolic approximation of the differential moveout and imposing a threshold for those differential moveouts.

That threshold is the parameter tau in this program, which varies between 0 to 1. A value of tau=0, means conventional crosscorrelation sum is applied implying that all crosscorrelations are included in the sum. In contrast, a value of tau=1 (not recommended) means that only the crosscorrelation formed by the trace pair involving the shortest and longest offset is included in the sum. Intermediate values will produce percentages of the crosscorrelations included in the sum that will be shown in the screen before computing the velocity spectra. Typical values for tau are between 0.2 and 0.6, producing approximated percentages of crosscorrelations summed

between 60% and 20%. The higher the value of tau the lower the percentage and higher the increase in the resolving power of velocity spectra.

Keeping the percentage of crosscorrelations included in the sum between 20% and 60% will increase resolution and avoid the presence of artifacts in the results. In data contaminated by random noise or statics distortions is recommended to maintain the percentage of crosscorrelations included in the sum above 25%. After computing the velocity spectra one might want to adjust the level and number of contours before velocity picking.

Credits: CWP: Valmore Celis, Sept 2002

Based on the original code: suvelan.c

Colorado School of Mines: Dave Hale c. 1989

#### References:

Neidell, N.S., and Taner, M.T., 1971, Semblance and other

coherency measures for multichannel data: Geophysics, 36, 498-509.

Celis, V. T., 2002, Selective-correlation velocity analysis: CSM thesis.

Trace header fields accessed: ns, dt, delrt, offset, cdp

Trace header fields modified: ns, dt, offset, cdp



SUVELAN - compute stacking velocity semblance for cdp gathers

suvelan <stdin >stdout [optional parameters]

Optional Parameters:

nv=50	number of velocities
dv=50.0	velocity sampling interval
fv=1500.0	first velocity
anis1=0.0	quartic term, numerator of an extended quartic term
anis2=0.0	in denominator of an extended quartic term
smute=1.5	samples with NMO stretch exceeding smute are zeroed
dtratio=5	ratio of output to input time sampling intervals
nsmooth=dtratio*2+1	length of semblance num and den smoothing window
verbose=0	=1 for diagnostic print on stderr
pwr=1.0	semblance value to the power

Notes:

Velocity analysis is usually a two-dimensional screen for optimal values of the vertical two-way travelttime and stacking velocity. But if the travel-time curve is no longer close to a hyperbola, the quartic term of the travelttime series should be considered. In its easiest form (with anis2=0) the optimization of all parameters requires a three-dimensional screen. This is done by a repetition of the conventional two-dimensional screen with a variation of the quartic term. The extended quartic term is more accurate, though the function is no more a polynomial. When screening for optimal values the theoretical dependencies between these paramters can be taken into account. The travelttime function is defined by

$$t^2 = t_0^2 + \frac{1}{v^2} x^2 + \frac{\text{anis1}}{1 + \text{anis2} x^2} x^4$$

The coefficients anis1, anis2 are assumed to be small, that means the non-hyperbolicity is assumed to be small. Triplications cannot be handled.

Semblance is defined by the following quotient:

$$s(t) = \frac{\sum_{j=0}^{n-1} q(t,j)^2}{n \sum_{j=0}^{n-1} [q(t,j)]^2}$$

j=0

where n is the number of non-zero samples after muting.  
Smoothing (nsmooth) is applied separately to the numerator and denominator before computing this semblance quotient.

Then, the semblance is set to the power of the parameter pwr. With  $pwr > 1$  the difference between semblance values is stretched in the upper half of the range of semblance values [0,1], but compressed in the lower half of it; thus, the few large semblance values are enhanced. With  $pwr < 1$  the many small values are enhanced, thus more discernible against background noise. Of course, always at the expense of the respective other feature.

Input traces should be sorted by cdp - suvelan outputs a group of semblance traces every time cdp changes. Therefore, the output will be useful only if cdp gathers are input.

Credits:

CWP, Colorado School of Mines:

Dave Hale (everything except ...)

Bjoern Rommel (... the quartic term)

SINTEF, IKU Petroleumsforskning

Bjoern Rommel (... the power-of-semblance function)

Trace header fields accessed: ns, dt, delrt, offset, cdp

Trace header fields modified: ns, dt, offset, cdp

SUVELAN\_UCCS - compute stacking VELOCITY panel for cdp gathers  
using UnNormalized CrossCorrelation Sum

suvelan\_uccs <stdin >stdout [optional parameters]

Optional Parameters:

nx=tr.cdpt	number of traces in cdp
nv=50	number of velocities
dv=50.0	velocity sampling interval
fv=1500.0	first velocity
smute=1.5	samples with NMO stretch exceeding smute are zeroed
dtratio=5	ratio of output to input time sampling intervals
nsmooth=dtratio*2+1	length of smoothing window
verbose=0	=1 for diagnostic print on stderr
pwr=1.0	semblance value to the power

Notes:

Unnormalized crosscorrelation sum: sum all possible crosscorrelation trace pairs in a CMP gather for each trial velocity and zero-offset two-way travel time inside a time window. This unnormalized coherency measure produces large spectral amplitudes for strong reflections and small spectral amplitudes for weaker ones. If M is the number of traces in the CMP gather  $M(M-1)/2$  is the total number of crosscorrelations for each trial velocity and zero-offset two-way traveltime.

Credits: CWP: Valmore Celis, Sept 2002

Based on the original code: suvelan.c

Colorado School of Mines: Dave Hale c. 1989

Reference: Neidell, N.S., and Taner, M.T., 1971, Semblance and other coherency measures for multichannel data: Geophysics, 36, 498-509.

Trace header fields accessed: ns, dt, delrt, offset, cdp

Trace header fields modified: ns, dt, offset, cdp

SUVELAN\_USEL - compute stacking velocity panel for cdp gathers  
using the UnNormalized Selective CrossCorrelation Sum

suvelan\_usel <stdin >stdout [optional parameters]

Optional Parameters:

nx=tr.cdpt	number of traces in cdp
dx=tr.d2	offset increment
nv=50	number of velocities
dv=50.0	velocity sampling interval
fv=1500.0	first velocity
tau=0.5	threshold for significance values
smute=1.5	samples with NMO stretch exceeding smute are zeroed
dtratio=5	ratio of output to input time sampling intervals
nsmooth=dtratio*2+1	length of smoothing window
verbose=0	=1 for diagnostic print on stderr
pwr=1.0	semblance value to the power

Notes:

UnNormalized Selective CrossCorrelation sum: is based on the coherence measure known as crosscorrelation sum. The difference is that the selective approach sum only crosscorrelation pairs with relatively large differential moveout, thus increasing the resolving power in the velocity spectra compared to that achieved by conventional methods. The selection is made using a parabolic approximation of the differential moveout and imposing a threshold for those differential moveouts.

That threshold is the parameter tau in this program, which varies between 0 to 1. A value of tau=0, means conventional crosscorrelation sum is applied implying that all crosscorrelations are included in the sum. In contrast, a value of tau=1 (not recommended) means that only the crosscorrelation formed by the trace pair involving the shortest and longest offset is included in the sum. Intermediate values will produce percentages of the crosscorrelations included in the sum that will be shown in the screen before computing the velocity spectra. Typical values for tau are between 0.2 and 0.6, producing approximated percentages of crosscorrelations summed between 60% and 20%. The higher the value of tau the lower the percentage and higher the increase in the resolving power of velocity spectra.

Keeping the percentage of crosscorrelations included in the sum between 20% and 60% will increase resolution and avoid the precense of artifacts in the results. In data contaminated by random noise or statics distortions is

recommended to maintaining the percentage of crosscorrelations included in the sum above 25%. After computing the velocity spectra one might want to adjust the level and number of contours before velocity picking.

Credits: CWP: Valmore Celis, Sept 2002

Based on the original code: suvelan\_.c

Colorado School of Mines: Dave Hale c. 1989

References:

Neidell, N.S., and Taner, M.T., 1971, Semblance and other coherency measures for multichannel data: Geophysics, 36, 498-509.

Celis, V. T., 2002, Selective-correlation velocity analysis: CSM thesis.

Trace header fields accessed: ns, dt, delrt, offset, cdp

Trace header fields modified: ns, dt, offset, cdp

LAS2SU - convert las2 format well log curves to su traces

las2su <stdin nskip= ncurve= >stdout [optional params]

Required parameters:

none

Optional parameters:

ncurve=automatic number of log curves in the las file

dz=0.5 input depth sampling (ft)

m=0 output (d1,f1) in feet

=1 output (d1,f1) in meters

ss=0 do not subsample (unless nz > 32767 )

=1 pass every other sample

verbose=0 =1 to echo las header lines to screen

outhdr=las\_header.asc name of file for las headers

Notes:

1. It is recommended to run LAS\_CERTIFY available from CWLS at <http://cwls.org>.
2. First log curve MUST BE depth.
3. If number of depth levels > 32767 (segy NT limit) then input is subsampled by factor of 2 or 4 as needed
4. Logs may be isolated using tracl header word (1,2,...,ncurve) tracl=1 is depth

If the input LAS file contains sonic data as delta t or interval transit time and you plan to use these data for generating a reflection coefficient time series in suwellrf, convert the sonic trace to velocity using suop with op=s2v (sonic to velocity) before input of the velocity trace to suwellrf. ",

Caveat: ",

No trap is made for the commonly used null value in LAS files (-999.25). The null value will be output as ?999.25, which really messes up a suxwigb display of density data because the ?999.25 skews the more or less 2.5 values of density.

The user needs to edit out null values (-999.25) before running other programs, such as "suwellrf".

Credits:

- \* Chris Liner based on code by Ferhan Ahmed and a2b.c (June 2005)
- \* (Based on code by Ferhan Ahmed and a2b.c)

```

*           I gratefully acknowledge Saudi Aramco for permission
*           to release this code developed while I worked for the
*           EXPEC-ARC research division.
* CWP: John Stockwell 31 Oct 2006, combining lasstrip and
* CENPET: lasstrip 2006 by Werner Heigl
*
*   Rob Hardy: allow the ncurve parameter to work correctly if set
*   - change string length to 400 characters to allow more curves
*   - note nskip in header is totally ignored !
*
* Ideas for improvement:
* add option to chop off part of logs (often shallow
*   portions are not of interest
* cross check sampling interval from header against
*   values found from first log curve (=depth)
*

```

SUBACKUSH - calculate Thomsen anisotropy parameters from  
 well log (vp,vs,rho) data and optionally include  
 intrinsic VTI shale layers based on gamma ray log  
 via BACKUS averaging  
 subackush < vp\_vs\_rho.su >stdout [options]  
 subackush < vp\_vs\_rho\_gr.su gr=1 >stdout [options]

Required parameters:  
 none

Optional parameter:  
 navg=101 number of depth samples in Backus avg window

Intrinsic anisotropy of shale layers can be included ...  
 gr=0 no gamma ray log input for shale  
 =1 input is vp\_vs\_rho\_gr  
 grs=100 pure shale gamma ray value (API units)  
 grc=10 0% shale gamma ray value (API units)  
 smode=1 include shale anis params prop to shale volume  
 =0 include shale anis for pure shale only  
 se=0.209 shale epsilon (Thomsen parameter)  
 sd=0.033 shale delta (Thomsen parameter)  
 sg=0.203 shale gamma (Thomsen parameter)

Notes:

1. Input are (vp,vs,rho) traces in metric units
2. Output are  
 tracl =(1,2,3,4,5,6)  
 quantity =(vp0,vs0,<rho>,epsilon,delta,gamma)  
 units =(m/s,m/s,kg/m^3,nd,nd,nd) nd=dimensionless  
 tracl =(7,8)  
 quantity =(Vsh,shaleEps) Vsh=shale volume fraction  
 units =(nd,nd)
3. (epsilon,delta,etc.) can be isolated by tracl header field
4. (vp0,vs0) are backus averaged vertical wavespeeds
5. <rho> is backus averaged density, etc.

Example:

```
las2su < logs.las nskip=34 nlog=4 > logs.su
suwind < logs.su key=tracl min=2 max=3 | suop op=s2vm > v.su
suwind < logs.su key=tracl min=4 max=4 | suop op=d2m > d.su
fcatt v.su d.su > vp_vs_rho.su
subackus < vp_vs_rho.su > vp0_vs0_rho_eps_delta_gamma.su
```



In this example we start with a well las file containing 34 header lines and 4 log tracks (depth,p\_son,s\_son,den). This is converted to su format by las2su. Then we pull off the sonic logs and convert them to velocity in metric units. Then the density log is pulled off and converted to metric. All three metric curves are bundled into one su file which is the input to subackus. ",

Related programs: subackus, sulprime

Credits:

UHouston: Chris Liner

I gratefully acknowledge Saudi Aramco for permission to release this code developed while I worked for the EXPEC-ARC research division.

References:

Anisotropy parameters: Thomsen, 2002, DISC Notes (SEG)

Backus Method: Berryman, Grechka, and Berge, 1997, SEP94

Shale params: Wang, 2002, Geophysics, p. 1427

SUBACKUS - calculate Thomsen anisotropy parameters from  
well log (vp,vs,rho) data via BACKUS averaging

subackus < vp\_vs\_rho.su >stdout [options]

Required parameters:

none

Optional parameter:

navg=201 number of depth samples in Backus avg window

all=0 =1 to output extra parameters

(<vp0>,<vs0>,<rho>,<eta>,<vang>,<a>,<f>,<c1>,<l>,<A>,<B>,<lam>,<mu>)

ang=30 angle (deg) for use in vang

Notes:

1. Input are (vp,vs,rho) traces in metric units

2. Output are (epsilon,delta,gamma) dimensionless traces

trac1=(1,2,3)=(epsilon,delta,gamma)

(all=1 output optional traces listed below)

trac1=(4,5,6,7,8)=(vp0,vs0,<rho>,<eta>,<vang>)

trac1=(9,10,11,12)=(a,f,c,l)=(c11,c13,c33,c44) backus avg'd

trac1=(13,14)=(<lam/lamp2mu><sup>2</sup>,4<mu\*lampmu/lamp2mu>)=(A,B)

used to analyze  $\epsilon = (a - c) / 2c$ ;  $a = c_{11} = A * x + B$ ;  $c = c_{33} = x$

trac1=(15,16)=(<lambda>,<mu>)

for fluid analysis (lambda affected by fluid, mu not)

trac1=(17,18,19)=(vp,vs,rho) orig log values

trac1=(20)=(m)=(c66) Backus avg'd

trac1=(21,22,23,24,25)=(a,f,c,l,m)=(c11,c13,c33,c44,c66) orig

3. (epsilon,delta,etc.) can be isolated by trac1 header field

4. (vp0,vs0) are backus averaged vertical wavespeeds

5. <rho> is backus averaged density, etc.

6.  $\eta = (\epsilon - \delta) / (1 + 2 \delta)$

7.  $\text{vang} = \text{vp}(\text{ang\_deg}) / \text{vp0}$  phase velocity ratio

The idea being that if  $\text{vang} \sim \text{vp0}$  there are small time effects

(30 deg comes from ~ max ray angle preserved in processing)

Example:

las2su < logs.las nskip=34 nlog=4 > logs.su

suwind < logs.su key=trac1 min=2 max=3 | suop op=s2vm > v.su

suwind < logs.su key=trac1 min=4 max=4 | suop op=d2m > d.su

fcatt v.su d.su > vp\_vs\_rho.su

subackus < vp\_vs\_rho.su > eps\_delta\_gamma.su

In this example we start with a well las file containing

34 header lines and 4 log tracks (depth,p\_son,s\_son,den).  
This is converted to su format by las2su. Then we pull off  
the sonic logs and convert them to velocity in metric units.  
Then the density log is pulled off and converted to metric.  
All three metric curves are bundled into one su file which  
is the input to subackus. ",

Related codes: sulprime subackush

Credits:

UHouston: Chris Liner

I gratefully acknowledge Saudi Aramco for permission  
to release this code developed while I worked for the  
EXPEC-ARC research division.

References:

Anisotropy parameters: Thomsen, 2002, DISC Notes (SEG)

Backus Method: Berryman, Grechka, and Berge, 1997, SEP94

SUGASSMAN - Model reflectivity change with rock/fluid properties

sugassman [optional parameters] > data.su

Optional parameters:

nt=500 number of time samples  
ntr=200 number of traces  
dt=0.004 time sampling interval in seconds  
mode=0 model isolated gassmann refl coefficient  
=1 embed gassmann RC in random RC series  
=2 R0 parameter sensitivity output  
p=0.15 parameter sensitivity test range (if mode=2)  
.... Environment variables ...  
temp=140 Temperature in degrees C  
pres=20 Pressure in megaPascals  
.... Caprock variables ....  
v1=37900 caprock P-wave speed (m/s)  
r1=44300 caprock mass density (g/cc)  
.... Reservoir fluid variables ....  
g=0.56 Gas specific gravity 0.56 (methane)-1.8 (condensate)  
api=50 Gas specific gravity 10 (heavy)-50 (ultra light)  
s=35 Brine salinity in ppm/(1000 000)  
so=.7 Oil saturation (0-1)  
sg=.2 Gas saturation (0-1)  
.... Reservoir rock frame variables ....  
kmin=37900 Bulk modulus (MPa) of rock frame mineral(s) [default=quartz]  
mumin=44300 Shear modulus (MPa) of rock frame mineral(s) [default=quartz]  
rmin=2.67 Mass density (g/cc) of rock frame mineral(s) [default=quartz]  
phi=.24 Rock frame porosity (0-1)  
a=1 Fitting parameters:  $M_{dry}/M_{mineral} \sim 1/(a + b \phi^c)$   
b=15 ... where M is P-wave modulus and defaults are for  
c=1 ... Glenn sandstone [see Liner (2nd ed, table 26.2)]  
h=20 Reservoir thickness (m)

Notes:

Creates a reflection coefficient series based on Gassmann theory of velocity and density for porous elastic media

Credits: UHouston: Chris Liner 9/23/2009

trace header fields set:

SULPRIME - find appropriate Backus average length for  
a given log suite, frequency, and purpose

```
sulprime < vp_vs_rho.su  [options] or  
sulprime < vp_vs_rho_gr.su  [options]
```

Required parameters:  
none

Optional parameter:  
b=2.0 target value of Backus number  
b=2 is transmission limit (ok for proc, mig, etc.)  
b=0.3 is scattering limit (ok for modeling)  
dz=1 input depth sample interval (ft)  
f=60 frequency (Hz)... dominant or max (to be safe)  
nmax=301 maximum averaging length (samples)  
verbose=1 print intermediate results  
=0 print final result only

Notes:

1. input is in sync with subackus, but vp and gr not used  
(gr= gamma ray log)

Related codes: subackus, subackush

Credits:

UHouston: Chris Liner Sept 2008

I gratefully acknowledge Saudi Aramco for permission  
to release this code developed while I worked for the  
EXPEC-ARC research division.

Reference:

The Backus Number (Liner and Fei, 2007, TLE)

SUWELLRF - convert WELL log depth, velocity, density data into a uniformly sampled normal incidence Reflectivity Function of time

```
suwellrf [required parameters] [optional parameters] > [stdout]
```

Required Parameters:

dvrfile= file containing depth, velocity, and density values

...or...

dvfile= file containing depth and velocity values

drfile= file containing depth and density values

...or...

dfile= file containing depth values

vfile= file containing velocity log values

rhofile= file containing density log values

nval= number of triplets of d,v,r values if dvrfile is set,  
number of pairs of d,v and d,r values dvfile and drfile  
are set, or number of values if dfile, vfile, and rhofile  
are set.

Optional Parameters:

dtout=.004 desired time sampling interval (sec) in output

ntr=1 number of traces to output

Notes:

The format of the input file(s) is C-style binary float. These files may be constructed from ascii file via:

```
a2b n1=3 < dvrfile.ascii > dvrfile.bin
```

...or...

```
a2b n1=2 < dvfile.ascii > dvfile.bin
```

```
a2b n1=2 < drfile.ascii > drfile.bin
```

...or...

```
a2b n1=1 < dfile.ascii > dfile.bin
```

```
a2b n1=1 < vfile.ascii > dfile.bin
```

```
a2b n1=1 < rhofile.ascii > rhofile.bin
```

A raw normal-incidence impedance reflectivity as a function of time is generated using the smallest two-way traveltime implied by the input velocities as the time sampling interval. This raw reflectivity trace is then resampled to the desired output time sampling interval via 8 point sinc interpolation. If the number of samples on the output exceeds SU\_NFLTS the output trace will be truncated to that value.

Caveat:

This program is really only a first rough attempt at creating a well log utility. User input and modifications are welcome.

See also: suresamp

Author: CWP: John Stockwell, Summer 2001, updated Summer 2002.  
inspired by a project by GP grad student Leo Brown

SUCOMMAND - pipe traces having the same key header word to command

sucommand <stdin >stdout [Optional parameters]

Required parameters:

none

Optional parameters:

verbose=0 wordy output

key=cdp header key word to pipe on

command="suop nop" command piped into

dir=0 0: change of header key

-1: break in monotonic decrease of header key

+1: break in monotonic increase of header key

Notes:

This program permits limited parallel processing capability by opening pipes for processes, signaled by a change in key header word value.

Credits:

VT: Matthias Imhof

Note:

The "valxxx" subroutines are in su/lib/valpkge.c. In particular,

"valcmp" shares the annoying attribute of "strcmp" that

if (valcmp(type, val, valnew) {

...

}

will be performed when val and valnew are different.



SUGETGTHR - Gets su files from a directory and put them  
through the unix pipe. This creates continuous data flow.

```
sugetgthr <stdin >sdout
```

Required parameters:

dir=                    Name of directory to fetch data from  
                        Every file in the directory is treated as an su file

Optional parameters:

verbose=0 =1 more chatty

vt=0 =1 allows gathers with variable length traces

no header checking is done!

ns= must be specified if vt=1; number of samples to read

```
segy tr;
```

```
int
```

```
main(int argc, char **argv)
```

```
{
```

```
cwp_String dir=""; /* input directory containng the gathers
```

```
char *fname=NULL;
```

```
char *ffname=NULL;
```

```
DIR *dp=NULL;
```

```
struct dirent *d=NULL;
```

```
struct stat __st;
```

```
FILE *fp=NULL;
```

```
int fd=0;
```

```
int verbose;
```

```
int vt=0;
```

```
ssize_t nread;
```

```
int ns=0;
```

```
/* Initialize
```

```
initargs(argc, argv);
```

```
requestdoc(1);
```

```

        /* Get parameters
        MUSTGETPARSTRING("dir", &dir);
        if (!getparint ("verbose", &verbose)) verbose = 0;
        if (!getparint ("vt", &vt)) vt = 0;
if(vt)MUSTGETPARINT("ns",&ns);
        checkpars();

/* Open the directory
if ((dp = opendir(dir)) == NULL)
err(" %s directory not found\n",dir);

/* For each file in directory
while (( d = readdir(dp)) !=NULL) {

fname = ealloc1(strlen(d->d_name)+1,sizeof(char));
strcpy(fname,d->d_name);

/* Skip . and .. directory entries
if(strcmp(fname, ".") && strcmp(fname, "..")) {
ffname = ealloc1(strlen(d->d_name)+strlen(dir)+2,sizeof(char));

/* Create full filename
sprintf(ffname, "%s/%s",dir,fname);
if(verbose==1) warn("%s",ffname);

/* get some info from the file
stat(ffname,&__st);
if(__st.st_size > 0) {

/* Open the file and read traces into stdout*/
    if(vt) {
fd = open(ffname,O_RDONLY|CWP_O_LARGEFILE);
/* nread=fread(&tr,(size_t) HDRBYTES,1,fp);
nread=read(fd,&tr,(size_t) HDRBYTES);
memset((void *) &tr.data[tr.ns], (int) '\0' ,MAX(ns-tr.ns,0)*FSIZE);
/* nread+=fread(&tr.data[0],(size_t) tr.ns*FSIZE,1,fp);
nread+=read(fd,&tr.data[0],(size_t) tr.ns*FSIZE);
    } else {
fp = fopen(ffname, "r");
nread=fgettr(fp, &tr);
    }
do {

```

```

if(vt) {
tr.ns=ns;
fwrite(&tr,ns*FSIZE+HDRBYTES,1,stdout);
} else {
puttr(&tr);
}
if(vt) {
/* nread=fread(&tr,(size_t) HDRBYTES,1,fp);
nread=read(fd,&tr,(size_t) HDRBYTES);
memset((void *) &tr.data[tr.ns], (int) '\0', MAX(ns-tr.ns,0)*FSIZE);
/* nread+=fread(&tr.data[0],(size_t) tr.ns*FSIZE,1,fp);
nread+=read(fd,&tr.data[0],(size_t) tr.ns*FSIZE);
} else {
nread=fgettr(fp, &tr);
}
} while(nread);
if(vt) close(fd);
else efclose(fp);
} else {
warn(" File %s has zero size, skipped.\n",ffname);
}
free1(ffname);
}
free1(fname);

}
closedir(dp);
return(CWP_Exit());
}

```

SUGPRFB - SU program to remove First Breaks from GPR data

```
sugprfb < radar traces >outfile
```

```
nx=51 number of traces to sum to create pilot trace (odd)
fbt=60 length of first break in number of samples
```

Notes:

The first fbt samples from nx traces are stacked to form a pilot first break trace, this is fitted to the actual traces by shifting and scaling. The nx traces long spatial window is slided along the section and a new pilot traces is formed for each position. The scalers in percent and the time shifts are stored in header words trwf and grnors.

```
Segy data constans
seggy tr; /* SEGgy trace
```

```
void remove_fb(float *data,float *wavelet,int n,short *scaler,short *shft);
```

```
int
main( int argc, char *argv[] )
{
```

```
int nx;
int fbt;
int nt;
```

```
float *stacked=NULL;
int *nnz=NULL;
int itr=0;
```

```
initargs(argc, argv);
    requestdoc(1);
```

```
if (!getparint("nx", &nx)) nx = 51;
if( !ISODD(nx) ) {
    nx++;
    warn(" nx has been changed to %d to be odd.\n",nx);
}
```

```

if (!getparint("fbt", &fbt)) fbt = 60;
    checkpars();

/* Get info from first trace
if (!gettr(&tr)) err("can't get first trace");
nt = tr.ns;

stacked = ealloc1float(fbt);
nnz = ealloc1int(fbt);
memset((void *) nnz, (int) '\0', fbt*ISIZE);
memset((void *) stacked, (int) '\0', fbt*FSIZE);

/* read nx traces and stack them
/* The first trace is already read

{ int i,it;
  float **tr_b;
  char **hdr_b;
  int NXP2=nx/2;
  short shift,scaler;

/* ramp on read the first nx traces and create stack

    tr_b = ealloc2float(nt,nx);
hdr_b = (char**)ealloc2(HDRBYTES,nx,sizeof(char));

memcpy((void *) hdr_b[0], (const void *) &tr, HDRBYTES);
memcpy((void *) tr_b[0], (const void *) &tr.data, nt*FSIZE);

for(i=1;i<nx;i++) {
gettr(&tr);
memcpy((void *) hdr_b[i], (const void *) &tr, HDRBYTES);
memcpy((void *) tr_b[i], (const void *) &tr.data, nt*FSIZE);
}

for(i=0;i<nx;i++)
for(it=0;it<fbt;it++)
stacked[it] += tr_b[i][it];

for(it=0;it<fbt;it++)
stacked[it] /=(float)nx;

```

```

/* filter and write out the first nx/2 +1 traces
for(i=0;i<NXP2+1;i++) {
memcpy((void *) &tr, (const void *) hdr_b[i], HDRBYTES);
memcpy((void *) tr.data, (const void *) tr_b[i], nt*FSIZE);

remove_fb(tr.data,stacked,fbt,&scaler,&shft);
tr.trwf = scaler;
tr.grnors = shft;

puttr(&tr);
++itr;
}

/* do the rest of the traces
gettr(&tr);

do {

/* Update the stacked trace - remove old
for(it=0;it<fbt;it++)
stacked[it] -= tr_b[0][it]/(float)nx;

/* Bump up the storage arrays
/* This is not very efficient , but good enough
{int ib;
for(ib=1;ib<nx;ib++) {
    memcpy((void *) hdr_b[ib-1],
(const void *) hdr_b[ib], HDRBYTES);
memcpy((void *) tr_b[ib-1],
(const void *) tr_b[ib], nt*FSIZE);
}
}

/* Store the new trace
memcpy((void *) hdr_b[nx-1], (const void *) &tr, HDRBYTES);
memcpy((void *) tr_b[nx-1], (const void *) &tr.data, nt*FSIZE);

/* Update the stacked array - add new
for(it=0;it<fbt;it++)
stacked[it] += tr_b[nx-1][it]/(float)nx;

```

```

/* Filter and write out the middle one NXP2+1
memcpy((void *) &tr, (const void *) hdr_b[NXP2], HDRBYTES);
memcpy((void *) tr.data, (const void *) tr_b[NXP2], nt*FSIZE);

remove_fb(tr.data,stacked,fbt,&scaler,&shft);

tr.trwf = scaler;
tr.grnors = shft;
puttr(&tr);
++itr;

} while(gettr(&tr));

/* Ramp out - write ot the rest of the traces
/* filter and write out the last nx/2 traces
for(i=NXP2+1;i<nx;i++) {
memcpy((void *) &tr, (const void *) hdr_b[i], HDRBYTES);
memcpy((void *) tr.data, (const void *) tr_b[i], nt*FSIZE);

remove_fb(tr.data,stacked,fbt,&scaler,&shft);

tr.trwf = scaler;
tr.grnors = shft;
puttr(&tr);
itr++;

}

}

free1float(stacked);
free1int(nnz);
    return EXIT_SUCCESS;
}

void remove_fb(float *yp,float *ym,int n,short *scaler,short *shft)
    Find Scale and timeshift

Yp = data trace

```

```

Ym = wavelet

F=min(Yp(x) - Ym(x)*a)^2 is a function to minimize for scaler

find shift first with xcorrelation then

solve for a - scaler
/

{

define RAMPR 5

void find_p(float *ym,float *yp,float *a,int *b,int n);

int it,ir;

float a=1.0;
int b=0;
int ramps;
float *a_ramp;

ramps=NINT(n-n/RAMPR);

find_p(ym,yp,&a,&b,n);

a_ramp = ealloc1float(n);

for(it=0;it<ramps;it++)
a_ramp[it]=1.0;

for(it=ramps,ir=0;it<n;it++,ir++) {
a_ramp[it]=1.0-(float)ir/(float)(n-ramps-1);
}

if (b<0) {
for(it=0;it<n+b;it++)
yp[it-b] -=ym[it]*a*a_ramp[it-b];
} else {

```



```

for(it=0;it<n-b;it++)
yp[it] -=ym[it-b]*a*a_ramp[it+b];
}

*scaler = NINT((1.0-a)*100.0);
*shft = b;

free1float(a_ramp);
}

void find_p(float *ym,float *yp,float *a,int *b,int n)
{
define NP 1

float *y,**x;
int n_s;

int k;
float *res;
int jpvt[NP];
float qraux[NP];
float work[NP];

x = ealloc2float(n,1);
y = ealloc1float(n);
res = ealloc1float(n);

memcpy((void *) &x[0][0], (const void *) &ym[0], n*FSIZE);
memset((void *) y, (int) '\0', n*FSIZE);

/* Solve for shift
   xcor (n,0,ym,n,0,yp,n,-n/2,y);
/* pick the maximum
*b = -max_index(n,y,1)+n/2;

n_s = n-abs(*b);

if (*b < 0) {
memcpy((void *) &x[0][0], (const void *) &ym[*b], n_s*FSIZE);
} else {
memcpy((void *) &x[0][*b], (const void *) &ym[0], n_s*FSIZE);

```

```
}  
/* Solve for scaler  
sqrst(x, n_s, 1,yp,0.0,a,res,&k,&jpvt[0],&qraux[0],&work[0]);  
  
free2float(x);  
free1float(res);  
free1float(y);  
}
```

SUKILL - zero out traces

sukill <stdin >stdout [optional parameters]

Optional parameters:

key=trid header name to select traces to kill

a=2 header value identifying traces to kill

or

min= first trace to kill (one-based)

count=1 number of traces to kill

Notes:

If min= is set it overrides selecting traces by header.

Credits:

CWP: Chris Liner, Jack K. Cohen

header-based trace selection: Florian Bleibinhaus

Trace header fields accessed: ns

SUMIXGATHERS - mix two gathers

sumixgathers file1 file2 > stdout [optional parameters]

Required Parameters:

ntr=tr.ntr if ntr header field is not set, then ntr is mandatory

Optional Parameters: none

Notes: Both files have to be sorted by offset

Mixes two gathers keeping only the traces of the first file if the offset is the same. The purpose is to substitute only traces non existing in file1 by traces interpolated store in file2. ",

Example. If file1 is original data file and file 2 is obtained by resampling with Radon transform, then the output contains original traces with gaps filled

Credits:

Daniel Trad. UBC

Trace header fields accessed: ns, dt, ntr

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SUMUTE - MUTE above (or below) a user-defined polygonal curve with ",  
the distance along the curve specified by key header word

sumute <stdin >stdout xmute= tmute= [optional parameters]

Required parameters:

xmute= array of position values as specified by  
the 'key' parameter

tmute= array of corresponding time values (sec)  
in case of air wave muting, correspond to  
air blast duration

... or input via files:

nmute= number of x,t values defining mute

xfile= file containing position values as specified by  
the 'key' parameter

tfile= file containing corresponding time values (sec)  
... or via header:

hmute= key header word specifying mute time

Optional parameters:

key=offset Key header word specifying trace offset  
=trac1 use trace number instead

ntaper=0 number of points to taper before hard  
mute (sine squared taper)

mode=0 mute ABOVE the polygonal curve

=1 to zero BELOW the polygonal curve

=2 to mute below AND above a straight line. In this case

xmute,tmute describe the total time length of  
the muted zone as a function of xmute the slope  
of the line is given by the velocity linvel=

=3 to mute below AND above a constant velocity hyperbola  
as in mode=2 xmute,tmute describe the total time  
length of the mute zone as a function of xmute,  
the velocity is given by the value of linvel=

=4 to mute below AND above a user defined polygonal line  
given by xmute, tmute pairs. The widths in time ",  
of the muted zone are given by the twindow vector

linvel=330 constant velocity for linear or hyperbolic mute

tm0=0 time shift of linear or hyperbolic mute at

\'key\'=0

twindow= vector of mute zone widths in time, operative only in mode=4

... or input via file:

twfile=

Notes:

The `tmute` interpolant is extrapolated to the left by the smallest time sample on the trace and to the right by the last value given in the `tmute` array.

The files `tfile` and `xfile` are files of binary (C-style) floats.

In the context of this program "above" means earlier time and "below" means later time (above and below as seen on a seismic section).

The `mode=2` option is intended for removing air waves. The mute is over a narrow window above and below the line specified by the `linvel`. Here the values of `tmute`, `xmute` or `tfile` and `xfile` define the total time width of the mute.

If data are spatial, such as the (z-x) output of a migration, then depth values are used in place of times in `tmute` and `tfile`. The value of the depth sampling interval is given by the `d1` header field. You must use the option `key=trac1` in `sumute` in this case.

Caveat: if data are seismic time sections, then `tr.dt` must be set. If data are seismic depth sections, then `tr.trid` must be set to the value of `TRID_DEPTH` and the `tr.d1` header field must be set.

To find the value of `TRID_DEPTH`:

type:

`sukeyword trid`

and look for the entry for "Depth-Range (z-x) traces"

Credits:

SEP: Shuki Ronen

CWP: Jack K. Cohen, Dave Hale, John Stockwell

DELPHI: Alexander Koek added airwave mute.

    CWP: John Stockwell added modes 3 and 4

USBG: Florian Bleibinhaus added `hmute` + some range checks on mute times

Trace header fields accessed: `ns`, `dt`, `delrt`, `key=keyword`, `trid`, `d1`

Trace header fields modified: `muts` or `mute`

SUPAD - Pad zero traces

```
supad <stdin >stdout min= max= [optional parameters]
```

Required parameters:

min= trace key start

max= trace key end

Optional parameters:

key1=ep panel key

key2=tracf trace key

key3=trid flag key

val3=2 value assigned to padded traces

d=1 trace key spacing

Notes:

In contrast to most SU codes, supad recognizes panels, or ensembles.

If the input consists of several panels, each panel will be padded individually.

key1 and key2 are the primary and secondary sort key of the data set.

The sort order of key1 does not matter at all.

The sort order of key2 must be monotonous - if key2 is descending, supply a negative value for the spacing d.

Traces with a key2-value outside the min/max range will be lost.

Traces with a key2-value that is not a multiple of the spacing from the min-value (the max-value, if the spacing is negative) will not be lost. Instead, they will shift the series of key2-values.

By default the dead trace flag will be raised for the padded traces.

This should make it easy to remove the zero traces later on, if need be.

Examples:

```
suplane | supad min=1 max=40 key1=offset key2=tracr | ...  
... appends eight empty traces.
```

```
suplane | supad min=1 max=32 key1=offset key2=tracr d=0.5 | ...  
... inserts a zero trace after each trace (even though the  
header tracr is integer and cannot properly store the floats)
```

```
suplane | supad min=1 max=32 | ...  
... produces an error because the panel and trace key are all 0.
```

Credits:

Florian Bleibinhaus, U Salzburg, Austria



SUPUTGTHR - split the stdout flow to gathers on the bases of given key parameter.

```
suputgthr <stdin  dir= [Optional parameters]
```

Required parameters:

dir= Name of directory where to put the gathers

Optional parameters:

key=ep header key word to watch

suffix=".hsu" extension of the output files

verbose=0 verbose = 1 echos information

numlength=7 Length of numeric part of filename

Notes:

The name of the file is constructed from the key parameter. Traces are put into a temporary disk file, and renamed when key parameter changes in the input flow to "key.suffix". The result is that the directory "dir" contains separate files by "key" ensemble. ",

Header field modified: ntr to be the number of traces in a given ensemble.

Related programs: sugetgthr, susplit

Credits: Balazs Nemeth, Potash Corporation, Saskatoon Saskatchewan given to CWP in 2008

Note:

The "valxxx" subroutines are in su/lib/valpkge.c. In particular, "valcmp" shares the annoying attribute of "strcmp" that

```
if (valcmp(type, val, valnew) {
```

```
...
```

```
}
```

will be performed when val and valnew are different.

SUSORT - sort on any segy header keywords

```
susort <stdin >stdout [[+]-]key1 [+]-]key2 ...]
```

Susort supports any number of (secondary) keys with either ascending (+, the default) or descending (-) directions for each. The default sort key is cdp.

Note: Only the following types of input/output are supported  
Disk input --> any output  
Pipe input --> Disk output

Caveat: On some Linux systems Pipe input and or output often fails

Disk input ---> Disk output is recommended

Note: If the the CWP\_TMPDIR environment variable is set use its value for the path; else use tmpfile()

Example:

To sort traces by cdp gather and within each gather by offset with both sorts in ascending order:

```
susort <INDATA >OUTDATA cdp offset
```

Caveat: In the case of Pipe input a temporary file is made to hold the ENTIRE data set. This temporary is either an actual disk file (usually in /tmp) or in some implementations, a memory buffer. It is left to the user to be SENSIBLE about how big a file to pipe into susort relative to the user's computer.

Credits:

SEP: Einar Kjartansson , Stew Levin

CWP: Shuki Ronen, Jack K. Cohen

Caveats:

Since the algorithm depends on sign reversal of the key value to obtain a descending sort, the most significant figure may be lost for unsigned data types. The old SEP support for tape input was removed in version 1.16---version 1.15 is in the Portability directory for those who may want to input SU data

stored on tape.

Trace header fields modified: tracr, tracr

SUSORTY - make a small 2-D common shot off-end data set in which the data show geometry values to help visualize data sorting.

```
susorty [optional parameters] > out_data_file
```

Optional parameters:

nt=100 number of time samples  
nshot=10 number of shots  
dshot=10 shot interval (m)  
noff=20 number of offsets  
doff=20 offset increment (m)

Notes:

Creates a common shot su data file for sort visualization

time samples	quantity
-----	-----
first 25%	shot coord
second 25%	rec coord
third 25%	offset
fourth 25%	cmp coord

1. default is shot ordered (hsv2 cmap looks best to me)

```
susorty | suximage legend=1 units=meters cmap=hsv2
```

2. sort on cmp (note random order within a cmp)

```
susorty | susort cdp > junk.su  
suximage < junk.su legend=1 units=meters cmap=hsv2
```

3. sort to cmp and subsort on offset

```
susorty | susort cdp offset > junk.su  
suximage < junk.su legend=1 units=meters cmap=hsv2
```

Credits:

CWP: Chris Liner 10.09.01

Trace header fields set: ns, dt, sx, gx, offset, cdp, trac1

SUSPLIT - Split traces into different output files by keyword value

```
susplit <stdin >stdout [options]
```

Required Parameters:

none

Optional Parameters:

key=cdp Key header word to split on (see segy.h)

stem=split\_ Stem name for output files

middle=key middle of name of output files

suffix=.su Suffix for output files

numlength=7 Length of numeric part of filename

verbose=0 =1 to echo filenames, etc.

close=1 =1 to close files before opening new ones

Notes:

The most efficient way to use this program is to presort the input data into common keyword gathers, prior to using susplit. "

Use "suputgthr" to put SU data into SU data directory format.

Credits:

Geocon: Garry Perratt hacked together from various other codes

SUWINDPOLY - WINDOW data to extract traces on or within a respective POLYgonal line or POLYgon with coordinates specified by header keyword values

```
suwindpoly <stdin [Required parameters] [Optional params] file=outfile
```

Required parameters:

x=x1,x2,... list of X coordinates for vertices

y=y1,y2,... list of Y coordinates for vertices

file=file1,file2,... output filename(s)

Optional parameters

xkey=fldr X coordinate header key

ykey=ep Y coordinate header key

pass=0 polyline mode: pass traces near the polygonal line

=1 pass all traces interior to polygon

=2 pass all traces exterior to polygon

Optional parameters used in polyline pass=0 mode only:

The following need to be given if the unit increments in the X & Y directions are not equal. For example, if fldr increments by 1 and ep increments by 4 to form 25 x 25 m bins specify dx=25.0 & dy=6.25. The output binning key will be converted to integers by the scaling with the smaller of the two values.

dx=1.0 unit increment distance in X direction

dy=1.0 unit increment distance in Y direction

ilkey=trac1 key for resulting inline index in polyline mode

xlkey=tracr key for resulting xline index in polyline mode

dw=1.0 distance in X-Y coordinate units of extracted line

to pass points to output. Width of resulting line is

2\*dw. Ignored if polygon mode is specified.

Notes:

In polyline mode (pass=0), a single trace may be output multiple times if it meets the acceptance criteria (distance from line segment < dw) for multiple line segments. However, the headers will be distinct and will associate the output trace with a line segment. This behavior facilitates creation of 3D supergathers from polyline output. Use susort after running in polyline mode.

x=& y=lists should be repeated for as many polygons as needed when pass=1 or pass=2.

In polygon mode, the polygon closes itself from the last vertex to the first.

Example:

```
suwindpoly <input.su x=10,20,50 y=0,30,60 dw=10 pass=0 file=out.su
```

Credits: Reginald H. Beardsley [rhb@acm.org](mailto:rhb@acm.org)

originally: `suxarb.c` adapted from the SLT/SU package.

SUWIND - window traces by key word

suwind <stdin >stdout [options]

Required Parameters:

none

Optional Parameters:

verbose=0 =1 for verbose

key=trac1 Key header word to window on (see segy.h)

min=LONG\_MIN min value of key header word to pass

max=LONG\_MAX max value of key header word to pass

abs=0 =1 to take absolute value of key header word

j=1 Pass every j-th trace ...

s=0 ... based at s (if ((key - s)%j) == 0)

skip=0 skip the initial N traces

count=ULONG\_MAX ... up to count traces

reject=none Skip traces with specified key values

accept=none Pass traces with specified key values(see notes)

processing, but do no window the data

ordered=0 =1 if traces sorted in increasing keyword value

=-1 if traces are sorted in a decreasing order

Options for vertical windowing (time gating):

dt=tr.dt (from header) time sampling interval (sec) (seismic data)

=tr.d1 (nonseismic)

f1=tr.delrt (from header) first sample (seismic data)

=tr.f1 (nonseismic)

tmin=0.0 min time to pass

tmax=(from header) max time to pass

itmin=0 min time sample to pass

itmax=(from header) max time sample to pass

nt=itmax-itmin+1 number of time samples to pass

Notes:

On large data sets, the count parameter should be set if possible. Otherwise, every trace in the data set will be examined. However, the count parameter overrides the accept parameter, so you can't specify count if you want true unconditional acceptance.



The skip= option allows the user to skip over traces, which helps for selecting traces far from the beginning of the dataset.

Caveat: skip only works with disk input.

The ordered= option will speed up the process if the data are sorted in according to the key.

The accept option is a bit strange--it does NOT mean accept ONLY the traces on the accept list! It means accept these traces, even if they would otherwise be rejected (except as noted in the previous paragraph). To implement accept-only, you can use the max=0 option (rejecting everything). For example, to accept only the traci values 4, 5 and 6:

```
... | suwind max=0 accept=4,5,6 | ...
```

Another example is the case of suppressing nonseismic traces in a seismic data set. By the SEG-Y standard header field trace id, trid=1 designates traces as being seismic traces. Other traces, such as calibration traces may be designated by another value.

Example: trid=1 seismic and trid=0 is nonseismic. To reject nonseismic traces

```
... | suwind key=trid reject=0 | ...
```

On most 32 bit machines, LONG\_MIN, LONG\_MAX and ULONG\_MAX are about -2E9,+2E9 and 4E9, they are defined in limits.h.

Selecting times beyond the maximum in the data induces zero padding (up to SU\_NFLTS).

The time gating here is to the nearest neighboring sample or time value. Gating to the exact temporal value requires resampling if the selected times fall between samples on the trace. Use suresamp to perform the time gating in this case.

It doesn't really make sense to specify both itmin and tmin, but specifying itmin takes precedence over specifying tmin. Similarly, itmax takes precedence over tmax and tmax over nt. If dt in header is not set, then dt is mandatory

Credits:

SEP: Einar Kjartansson

CWP: Shuki Ronen, Jack Cohen, Chris Liner

Warnemuende: Toralf Foerster

CENPET: Werner M. Heigl (modified to include well log data)

Trace header fields accessed: ns, dt, delrt, keyword

Trace header fields modified: ns, delrt, ntr

SUPSCONTOUR - PostScript CONTOUR plot of a segy data set

supscntour <stdin [optional parameters] | ...

Optional parameters:

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the pscontour selfdoc for the remaining parameters.

On NeXT: supscntour < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2

Credits:

CWP: Dave Hale and Zhiming Li (pscontour, etc.)

Jack Cohen and John Stockwell (supscontour, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Aarhus University: Morten W. Pedersen copied everything from the xwigb source and just replaced all occurrences of the word

#### Notes:

When the number of traces isn't known, we need to count the traces for pscontour. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSCUBECONTOUR - PostScript CUBE plot of a segy data set

supscubecontour <stdin [optional parameters] | ...

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the pscubecontour selfdoc for the remaining parameters.

example: supscubecontour < infile [optional parameters] | gv -

Credits:

CWP: Dave Hale and Zhiming Li (pscube)  
      Jack K. Cohen (suxmovie)  
      John Stockwell (supscubecontour)

Notes:

When `n2` isn't getparred, we need to count the traces for pscube. Although we compute `ntr`, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use `tr.data`, we allocate a trace buffer for code clarity.

SUPSCUBE - PostScript CUBE plot of a segy data set

supscube <stdin [optional parameters] | ...

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the pscube selfdoc for the remaining parameters.

On NeXT: supscube < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pscube)  
Jack K. Cohen (suxmovie)  
John Stockwell (supscube)

Notes:

When `n2` isn't getparred, we need to count the traces for pscube. Although we compute `ntr`, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use `tr.data`, we allocate a trace buffer for code clarity.



SUPSGRAPH - PostScript GRAPH plot of a segy data set

supsgraph <stdin [optional parameters] | ...

Optional parameters:

style=seismic seismic is default here, =normal is alternate  
(see psgraph selfdoc for style definitions)

nplot is the number of traces (ntr is an acceptable alias for nplot)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the psgraph selfdoc for the remaining parameters.

On NeXT: supsgraph < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pswigp, etc.)  
Jack Cohen and John Stockwell (supswigp, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for pswigp. You can make this value "known" either by getparring nplot or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSIMAGE - PostScript IMAGE plot of a segy data set

supsimage <stdin [optional parameters] | ...

Optional parameters:

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the psimage selfdoc for the remaining parameters.

On NeXT: supsimage < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2

Credits:

CWP: Dave Hale and Zhiming Li (psimage, etc.)  
Jack Cohen and John Stockwell (supsimage, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for psimage. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.  
"remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSMAX - PostScript of the MAX, min, or absolute max value on each trace  
of a SEG Y (SU) data set

```
supsmx <stdin >postscript file [optional parameters]
```

Optional parameters:

mode=max max value

=min min value

=abs absolute max value

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0

=1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to over-ride the header values if  
not.

See the sumax selfdoc for additional parameter.

See the psgraph selfdoc for the remaining parameters.

Credits:

CWP: John Stockwell, based on Jack Cohen's SU JACKet

Notes:

When the number of traces isn't known, we need to count the traces for psgraph. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

SUPSMOVIE - PostScript MOVIE plot of a segy data set

```
supsmovie <stdin [optional parameters] | ...
```

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the psmovie selfdoc for the remaining parameters.

On NeXT: supsmovie < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (psmovie)  
      Jack K. Cohen (suxmovie)  
      John Stockwell (supsmovie)

Notes:

When `n2` isn't getparred, we need to count the traces for psmovie. In this case: we are using `tmpfile` because on many machines it is implemented as a memory area instead of a disk file. Although we compute `ntr`, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use `tr.data`, we allocate a trace buffer for code clarity.



SUPSWIGB - PostScript Bit-mapped WIGgle plot of a segy data set

supswigb <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or

vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: pswigb  
See the pswigb selfdoc for the remaining parameters.

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2, keyword (if set)

Credits:

CWP: Dave Hale and Zhiming Li (pswigb, etc.)

Jack Cohen and John Stockwell (supswigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count the traces for pswigb. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSWIGP - PostScript Polygon-filled WIGgle plot of a segy data set

supswigp <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or

vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: pswigp  
See the pswigp selfdoc for the remaining parameters.

On NeXT: supswigp < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2, key specified by key

Credits:

CWP: Dave Hale and Zhiming Li (pswigp, etc.)

Jack Cohen and John Stockwell (supswigp, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count the traces for pswigp. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXCONTOUR - X CONTOUR plot of Seismic UNIX tracefile via vector plot call

suxwigb <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: xcontour  
See the xcontour selfdoc for the remaining parameters.

Credits:

CWP: Dave Hale and Zhiming Li (xwigb, etc.)

Jack Cohen and John Stockwell (suxwigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Aarhus University: Morten W. Pedersen copied everything from the xwigb source and just replaced all occurrences of the word xwigb with xcountour ;-)

#### Notes:

When the number of traces isn't known, we need to count the traces for xcountour. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXGRAPH - X-windows GRAPH plot of a segy data set

suxgraph <stdin [optional parameters] | ...

Optional parameters:

(see xgraph selfdoc for optional parametes)

nplot= number of traces (ntr is an acceptable alias for nplot)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the xgraph selfdoc for the remaining parameters.

On NeXT:        suxgraph < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pswigp, etc.)

Jack Cohen and John Stockwell (supswigp, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for pswigp. You can make this value "known" either by getparring nplot or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.



SUXIMAGE - X-windows IMAGE plot of a segy data set

```
suximage infile= [optional parameters] | ... (direct I/O)
or
suximage <stdin [optional parameters] | ... (sequential I/O)
```

Optional parameters:

infile=NULL SU data to be plotted, default stdin with sequential access  
if 'infile' provided, su data read by (fast) direct access

with ftr,dtr and n2 suximage will pass a subset of data  
to the plotting program-ximage:  
ftr=1 First trace to be plotted  
dtr=1 Trace increment to be plotted  
n2=tr.ntr (Max) number of traces to be plotted (ntr is an alias for n2)  
Priority: first try to read from parameter line;  
if not provided, check trace header tr.ntr;  
if still not provided, figure it out using ftello

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set or was set to 0)

key= key for annotating d2 (slow dimension)  
If annotation is not at proper increment, try  
setting d2; only first trace's key value is read

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the ximage selfdoc for the remaining parameters.

#### Credits:

CWP: Dave Hale and Zhiming Li (ximage, etc.)  
Jack Cohen and John Stockwell (suximage, etc.)  
MTU: David Forel, June 2004, added key for annotating d2  
ConocoPhillips: Zhaobo Meng, Dec 2004, added direct I/O

#### Notes:

When provide ftr and dtr and infile, suximage can be used to plot multi-dimensional volumes efficiently. For example, for a Offset-CDP dataset with 32 offsets, the command line  
suximage infile=volume3d.su ftr=1 dtr=32 ... &  
will display the zero-offset common offset data with ranrom access. It is highly recommend to use infile= to view large datasets, since using stdin only allows sequential access, which is very slow for large datasets.

When the number of traces isn't known, we need to count the traces for ximage. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXMAX - X-windows graph of the MAX, min, or absolute max value on each trace of a SEG-Y (SU) data set

```
suxmax <stdin [optional parameters]
```

Optional parameters:

mode=max max value

=min min value

=abs absolute max value

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0

=1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the sumax selfdoc for additional parameter.

See the xgraph selfdoc for the remaining parameters.

Credits:

CWP: John Stockwell, based on Jack Cohen's SU JACKet

Notes:

When the number of traces isn't known, we need to count the traces for xgraph. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

SUXMOVIE - X MOVIE plot of a 2D or 3D segy data set

suxmovie <stdin [optional parameters]

Optional parameters:

n1=tr.ns                    number of samples per trace  
ntr=tr.ntr                number of traces in the data set  
n2=tr.shorthead or tr.ntr number of traces in inline direction  
n3=ntr/n2                number of traces in crossline direction  
  
d1=tr.d1 or tr.dt/10<sup>6</sup>    sampling interval in the fast dimension  
    =.004 for seismic    (if not set)  
    =1.0 for nonseismic (if not set)  
  
d2=tr.d2                sampling interval in the slow dimension  
    =1.0    (if not set)  
  
d3=1.0                sampling interval in the slowest dimension  
  
f1=tr.f1 or 0.0           first sample in the z dimension  
f2=tr.f2 or 1.0           first sample in the x dimension  
f3=1.0  
  
mode=0                0= x,z slice movie through y dimension (in line)  
                      1= y,z slice movie through x dimension (cross line)  
                      2= x,y slice movie through z dimension (time slice)  
  
verbose=0                =1 to print some useful information  
  
tmpdir=    if non-empty, use the value as a directory path  
          prefix for storing temporary files; else if the  
          the CWP\_TMPDIR environment variable is set use  
          its value for the path; else use tmpfile()

Notes:

For seismic data, the "fast dimension" is either time or depth and the "slow dimension" is usually trace number. The 3D data set is expected to have n3 sets of n2 traces representing the horizontal coverage of n2\*d2 in x and n3\*d3 in y direction.

The data is read to memory with and piped to xmovie with the respective sampling parameters.

See the xmovie selfdoc for the remaining parameters and X functions.

SUXPICKER - X-windows WIGgle plot PICKER of a segy data set

suxpicker <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword

specified by keyword

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0

=1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is

time and the "slow dimension" is usually trace number or range.

Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

See the xpicker selfdoc for the remaining parameters.

#### Credits:

CWP: Dave Hale and Zhiming Li (xpicker, etc.)  
Jack Cohen and John Stockwell (suxpicker, etc.)

#### Notes:

When the number of traces isn't known, we need to count the traces for xpicker. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.



SUXWIGB - X-windows Bit-mapped WIGgle plot of a segy data set  
This is a modified suxwigb that uses the depth or coordinate scaling  
when such values are used as keys.

suxwigb <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: xwigb  
See the xwigb selfdoc for the remaining parameters.

#### Credits:

CWP: Dave Hale and Zhiming Li (xwigb, etc.)

Jack Cohen and John Stockwell (suxwigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor  
scale factors, added vsp style

#### Notes:

When the number of traces isn't known, we need to count  
the traces for xwigb. You can make this value "known"  
either by getparring n2 or by having the ntr field set  
in the trace header. A getparred value takes precedence  
over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array,  
but just content ourselves with copying trace by trace from  
the data "file" to the pipe into the plotting program.  
Although we could use tr.data, we allocate a trace buffer  
for code clarity.

PSBBOX - change BoundingBox of existing PostScript file

psbbox < PostScriptfile [optional parameters] > PostScriptfile

Optional Parameters:

llx= new llx

lly= new lly

urx= new urx

ury= new ury

verbose=1 =1 for info printed on stderr (0 for no info)

PSCONTOUR - PostScript CONTOURING of a two-dimensional function  $f(x_1, x_2)$

pscontour n1= [optional parameters] <binaryfile >postscriptfile

Required Parameters:

n1                                      number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0	sampling interval in 1st dimension
f1=d1	first sample in 1st dimension
x1=f1,f1+d1,...	array of monotonic sampled values in 1st dimension
n2=all	number of samples in 2nd (slow) dimension
d2=1.0	sampling interval in 2nd dimension
f2=d2	first sample in 2nd dimension
x2=f2,f2+d2,...	array of monotonic sampled values in 2nd dimension
nc=5	number of contour values
dc=(zmax-zmin)/nc	contour interval
fc=min+dc	first contour
c=fc,fc+dc,...	array of contour values
cwidth=1.0,...	array of contour line widths
cgray=0.0,...	array of contour grays (0.0=black to 1.0=white)
ccolor=none,...	array of contour colors; none means use cgray
cdash=0.0,...	array of dash spacings (0.0 for solid)
labelcf=1	first labeled contour (1,2,3,...)
labelcper=1	label every labelcper-th contour
nlabelc=nc	number of labeled contours (0 no contour label)
nplaces=6	number of decimal places in contour label
xbox=1.5	offset in inches of left side of axes box
ybox=1.5	offset in inches of bottom side of axes box
wbox=6.0	width in inches of axes box
hbox=8.0	height in inches of axes box
x1beg=x1min	value at which axis 1 begins
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
ntic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
x2end=x2max	value at which axis 2 ends
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2

grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
labelcfont=Helvetica-Bold	font name for contour labels
labelcsize=6	font size of contour labels
labelccolor=black	color of contour labels
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
axeswidth=1	width (in points) of axes
ticwidth=axeswidth	width (in points) of tic marks
gridwidth=axeswidth	width (in points) of grid lines
style=seismic	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)

Note.

The line width of unlabeled contours is designed as a quarter of that of labeled contours.

All color specifications may also be made in X Window style Hex format  
example: axescolor=#255

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCentrySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic  
type: sudoc pscontour for more information

Notes:

For nice even-numbered contours, use the parameters `fc` and `dc`

Example: if the range of the `z` values of a data set range between approximately -1000 and +1000, then use `fc=-1000` `nc=10` and `dc=100` to get contours spaced by even 100's.

AUTHOR: Dave Hale, Colorado School of Mines, 05/29/90

MODIFIED: Craig Artley, Colorado School of Mines, 08/30/91

BoundingBox moved to top of PostScript output

MODIFIED: Zhenyue Liu, Colorado School of Mines, 08/26/93

Values are labeled on contours

MODIFIED: Craig Artley, Colorado School of Mines, 12/16/93

Added color options (Courtesy of Dave Hale, Advance Geophysical).

Modified: Morten Wendell Pedersen, Aarhus University, 23/3-97

Added `ticwidth`, `axeswidth`, `gridwidth` parameters

PSCCONTOUR - PostScript Contour plot of a data CUBE

```
pscubecontour n1= n2= n3= [optional parameters] <binaryfile >postscriptfile
or
pscubecontour n1= n2= n3= front= side= top= [optional parameters] >postscriptfile
```

Data formats supported:

1. Entire cube read from stdin ( $n1*n2*n3$  floats) [default format]
2. Faces read from stdin ( $n1*n2$  floats for front, followed by  $n1*n3$  floats for side, and  $n2*n3$  floats for top) [specify faces=1]
3. Faces read from separate data files [specify filenames]

Required Parameters:

n1	number of samples in 1st (fastest) dimension
n2	number of samples in 2nd dimension
n3	number of samples in 3rd (slowest) dimension

Optional Parameters:

front	name of file containing front panel
side	name of file containing side panel
top	name of file containing top panel
faces=0	=1 to read faces from stdin (data format 2)
d1=1.0	sampling interval in 1st dimension
f1=0.0	first sample in 1st dimension
d2=1.0	sampling interval in 2nd dimension
f2=0.0	first sample in 2nd dimension
d3=1.0	sampling interval in 3rd dimension
f3=0.0	first sample in 3rd dimension
d1s=1.0	factor by which to scale d1 before imaging
d2s=1.0	factor by which to scale d2 before imaging
d3s=1.0	factor by which to scale d3 before imaging
nc=5	number of contour values
dc=(zmax-zmin)/nc	contour interval
fc=min+dc	first contour
c=fc,fc+dc,...	array of contour values
cwidth=1.0,...	array of contour line widths
cgray=0.0,...	array of contour grays (0.0=black to 1.0=white)
ccolor=none,...	array of contour colors; none means use cgray
cdash=0.0,...	array of dash spacings (0.0 for solid)
labelcf=1	first labeled contour (1,2,3,...)
labelcper=1	label every labelcper-th contour
nlabelc=nc	number of labeled contours (0 no contour label)
nplaces=6	number of decimal places in contour label

xbox=1.5	offset in inches of left side of axes box
ybox=1.5	offset in inches of bottom side of axes box
size1=4.0	size in inches of 1st axes (vertical)
size2=4.0	size in inches of 2nd axes (horizontal)
size3=3.0	size in inches of 3rd axes (projected)
angle=45	projection angle of cube in degrees ( $0 < \text{angle} < 90$ ) (angle between 2nd axis and projected 3rd axis)
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
x3end=x3max	value at which axis 3 ends
d3num=0.0	numbered tic interval on axis 3 (0.0 for automatic)
f3num=x3min	first numbered tic on axis 3 (used if d3num not 0.0)
n3tic=1	number of tics per numbered tic on axis 3
grid3=none	grid lines on axis 3 - none, dot, dash, or solid
label3=	label on axis 3
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
labelcfont=Helvetica-Bold	font name for contour labels
labelcsize=6	font size of contour labels
labelccolor=black	color of contour labels
axescolor=black	color of axes
gridcolor=black	color of grid

All color specifications may also be made in X Window style Hex format  
example: axescolor=#255

Note: The values of x1beg=x1min, x2end=x2max and x3beg=x3min cannot be changed.



Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCentrySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

(Original codes pscontour and pscube)

AUTHOR: Craig Artley, Colorado School of Mines, 03/12/93

NOTE: Original written by Zhiming Li & Dave Hale, CSM, 07/01/90

Completely rewritten, the code now bears more similarity to  
psimage than the previous pscube. Faces of cube now rendered  
as three separate images, rather than as a single image. The  
output no longer suffers from stretching artifacts, and the  
code is simpler. -Craig

MODIFIED: Craig Artley, Colorado School of Mines, 12/17/93

Added color options.

PSCCONTOUR: mashed together from pscube and pscontour  
to generate 3d contour plots by Claudia Vanelle, Institute of Geophysics,  
University of Hamburg, Germany somewhen in 2000

PSCUBE was "merged" with PSCONTOUR to create PSCUBECONTOUR  
by Claudia Vanelle, Applied Geophysics Group Hamburg  
somewhen in 2000

PSCUBE - PostScript image plot with Legend of a data CUBE

```
pscube n1= n2= n3= [optional parameters] <binaryfile >postscriptfile
or
pscube n1= n2= n3= front= side= top= [optional parameters] >postscriptfile
```

Data formats supported:

1. Entire cube read from stdin (n1\*n2\*n3 floats) [default format]
2. Faces read from stdin (n1\*n2 floats for front, followed by n1\*n3 floats for side, and n2\*n3 floats for top) [specify faces=1]
3. Faces read from separate data files [specify filenames]

Required Parameters:

n1	number of samples in 1st (fastest) dimension
n2	number of samples in 2nd dimension
n3	number of samples in 3rd (slowest) dimension

Optional Parameters:

front	name of file containing front panel
side	name of file containing side panel
top	name of file containing top panel
faces=0	=1 to read faces from stdin (data format 2)
d1=1.0	sampling interval in 1st dimension
f1=0.0	first sample in 1st dimension
d2=1.0	sampling interval in 2nd dimension
f2=0.0	first sample in 2nd dimension
d3=1.0	sampling interval in 3rd dimension
f3=0.0	first sample in 3rd dimension
perc=100.0	percentile used to determine clip
clip=(perc percentile)	clip used to determine bclip and wclip
bperc=perc	percentile for determining black clip value
wperc=100.0-perc	percentile for determining white clip value
bclip=clip	data values outside of [bclip,wclip] are clipped
wclip=-clip	data values outside of [bclip,wclip] are clipped
brgb=0.0,0.0,0.0	red, green, blue values corresponding to black
wrgb=1.0,1.0,1.0	red, green, blue values corresponding to white
bhls=0.0,0.0,0.0	hue, lightness, saturation corresponding to black
whls=0.0,1.0,0.0	hue, lightness, saturation corresponding to white
bps=12	bits per sample for color plots, either 12 or 24
d1s=1.0	factor by which to scale d1 before imaging
d2s=1.0	factor by which to scale d2 before imaging
d3s=1.0	factor by which to scale d3 before imaging
verbose=1	=1 for info printed on stderr (0 for no info)

xbox=1.5	offset in inches of left side of axes box
ybox=1.5	offset in inches of bottom side of axes box
size1=4.0	size in inches of 1st axes (vertical)
size2=4.0	size in inches of 2nd axes (horizontal)
size3=3.0	size in inches of 3rd axes (projected)
angle=45	projection angle of cube in degrees (0<angle<90) (angle between 2nd axis and projected 3rd axis)
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
x3end=x3max	value at which axis 3 ends
d3num=0.0	numbered tic interval on axis 3 (0.0 for automatic)
f3num=x3min	first numbered tic on axis 3 (used if d3num not 0.0)
n3tic=1	number of tics per numbered tic on axis 3
grid3=none	grid lines on axis 3 - none, dot, dash, or solid
label3=	label on axis 3
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
legend=0	=1 display the color scale if ==1, resize xbox,ybox,width,height
lstyle=vertleft	Vertical, axis label on left side =vertright (Vertical, axis label on right side) =horibottom (Horizontal, axis label on bottom)
units=	unit label for legend
legendfont=times_roman10	font name for title
following are defaults for lstyle=0. They are changed for other lstyles	
lwidth=1.2	colorscale (legend) width in inches
lheight=height/3	colorscale (legend) height in inches

lx=1.0                      colorscale (legend) x-position in inches  
 ly=(height-lheight)/2+xybox      colorscale (legend) y-position in pixels  
 lbeg= lmin or wclip-5\*perc      value at which legend axis begins  
 lend= lmax or bclip+5\*perc      value at which legend axis ends  
 ldnum=0.0                  numbered tic interval on legend axis (0.0 for automatic)  
 lfnum=lmin                  first numbered tic on legend axis (used if dlnum not 0.0)  
 lntic=1                    number of tics per numbered tic on legend axis  
 lgrid=none                  grid lines on legend axis - none, dot, dash, or solid

All color specifications may also be made in X Window style Hex format  
 example:    axescolor=#255

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
 Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
 Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
 Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
 Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
 Helvetica-Narrow-Oblique NewCenturySchlbk-Bold"  
 NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
 Palatino-BoldItalic Palatino-Italics Palatino-Roman  
 SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
 Symbol Times-Bold Times-BoldItalic  
 Times-Roman Times-Italic ZapfChancery-MediumItalic

Note: The values of x1beg=x1min, x2end=x2max and x3beg=x3min cannot  
 be changed.

PSEPSI - add an EPSI formatted preview bitmap to an EPS file

```
psepsi <epsfile >epsifile
```

Note:

This application requires

- (1) that gs (the Ghostscript interpreter) exist, and
  - (2) that the input EPS file contain a BoundingBox and EndComments.
- Ghostscript is used to build the preview bitmap, which is then merged with the input EPS file to make the output EPSI file.

## PSGRAPH - PostScript GRAPHer

Graphs  $n[i]$  pairs of  $(x,y)$  coordinates, for  $i = 1$  to  $nplot$ .

`psgraph n= [optional parameters] <binaryfile >postscriptfile`

### Required Parameters:

`n`                                      array containing number of points per plot

### Data formats supported:

- 1.a.  $x_1, y_1, x_2, y_2, \dots, x_n, y_n$
- b.  $x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_n$  (must set `pairs=0`)
2.     $y_1, y_2, \dots, y_n$  (must give non-zero `d1[]=`)
3.     $x_1, x_2, \dots, x_n$  (must give non-zero `d2[]=`)
4.    `nil` (must give non-zero `d1[]=` and non-zero `d2[]=`)

The formats may be repeated and mixed in any order, but if formats 2-4 are used, the `d1` and `d2` arrays must be specified including `d1[]=0.0 d2[]=0.0` entries for any internal occurrences of format 1. Similarly, the `pairs` array must contain place-keeping entries for plots of formats 2-4 if they are mixed with both formats 1.a and 1.b. Also, if formats 2-4 are used with non-zero `f1[]` or `f2[]` entries, then the corresponding array(s) must be fully specified including `f1[]=0.0` and/or `f2[]=0.0` entries for any internal occurrences of format 1 or formats 2-4 where the zero entries are desired.

Available colors are all the common ones and many more. The complete list of 68 colors is in the file `$CWPROOT/src/psplot/basic.c`.

### Optional Parameters:

<code>nplot=</code> number of <code>n</code> 's	number of plots
<code>d1=0.0,...</code>	<code>x</code> sampling intervals (0.0 if <code>x</code> coordinates input)
<code>f1=0.0,...</code>	first <code>x</code> values (not used if <code>x</code> coordinates input)
<code>d2=0.0,...</code>	<code>y</code> sampling intervals (0.0 if <code>y</code> coordinates input)
<code>f2=0.0,...</code>	first <code>y</code> values (not used if <code>y</code> coordinates input)
<code>pairs=1,...</code>	=1 for data pairs in format 1.a, =0 for format 1.b
<code>linewidth=1.0,...</code>	line widths (in points) (0.0 for no lines)
<code>linegray=0.0,...</code>	line gray levels (black=0.0 to white=1.0)
<code>linecolor=none,...</code>	line colors; none means use <code>linegray</code>
	Typical use: <code>linecolor=red,yellow,blue,...</code>
<code>lineon=1.0,...</code>	length of line segments for dashed lines (in points)
<code>lineoff=0.0,...</code>	spacing between dashes (0.0 for solid line)
<code>mark=0,1,2,3,...</code>	indices of marks used to represent plotted points
<code>marksize=0.0,0.0,...</code>	size of marks (0.0 for no marks)
<code>xbox=1.5</code>	offset in inches of left side of axes box

ybox=1.5	offset in inches of bottom side of axes box
wbox=6.0	width in inches of axes box
hbox=8.0	height in inches of axes box
x1beg=x1min	value at which axis 1 begins
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
x2end=x2max	value at which axis 2 ends
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
axeswidth=1	width (in points) of axes
ticwidth=axeswidth	width (in points) of tic marks
gridwidth=axeswidth	width (in points) of grid lines
style=normal	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)
reverse=0	=1 to reverse sequence of plotting curves",

Note: n1 and n2 are acceptable aliases for n and nplot, respectively.

mark index:

1. asterisk
2. x-cross
3. open triangle
4. open square
5. open circle
6. solid triangle
7. solid square
8. solid circle

All color specifications may also be made in X Window style Hex format  
example: `axescolor=#255`

Example:

```
psgraph n=50,100,20 d1=2.5,1,0.33 <datafile >psfile
plots three curves with equally spaced x values in one plot frame
x1-coordinates are  $x1(i) = f1+i*d1$  for  $i = 1$  to  $n$  ( $f1=0$  by default)
number of x2's and then x2-coordinates for each curve are read
sequentially from datafile.
```

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCentrySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic



PSIMAGE - PostScript IMAGE plot of a uniformly-sampled function  $f(x_1, x_2)$   
with the option to display a second attribute

psimage n1= [optional parameters] <binaryfile >postscriptfile

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

n2=all number of samples in 2nd (slow) dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

perc=100.0 percentile used to determine clip

clip=(perc percentile) clip used to determine bclip and wclip

bperc=perc percentile for determining black clip value

wperc=100.0-perc percentile for determining white clip value

bclip=clip data values outside of [bclip,wclip] are clipped

wclip=-clip data values outside of [bclip,wclip] are clipped

bclip and wclip will be set to be inside

[lbeg,lend] if lbeg and/or lend are supplied

threecolor=1 supply 3 color values instead of only two,  
using not only black and white, but f.e. red,  
green and blue

brgb=0.0,0.0,0.0 red, green, blue values corresponding to black

grgb=1.0,1.0,1.0 red, green, blue values corresponding to grey

wrgb=1.0,1.0,1.0 red, green, blue values corresponding to white

bhls=0.0,0.0,0.0 hue, lightness, saturation corresponding to black

ghls=0.0,1.0,0.0 hue, lightness, saturation corresponding to grey

whls=0.0,1.0,0.0 hue, lightness, saturation corresponding to white

bps=12 bits per sample for color plots, either 12 or 24

d1s=1.0 factor by which to scale d1 before imaging

d2s=1.0 factor by which to scale d2 before imaging

verbose=1 =1 for info printed on stderr (0 for no info)

xbox=1.5 offset in inches of left side of axes box

ybox=1.5 offset in inches of bottom side of axes box

width=6.0 width in inches of axes box

height=8.0 height in inches of axes box

xlbeg=x1min value at which axis 1 begins

xlend=x1max value at which axis 1 ends

d1num=0.0 numbered tic interval on axis 1 (0.0 for automatic)

f1num=x1min first numbered tic on axis 1 (used if d1num not 0.0)

```

nltic=1  number of tics per numbered tic on axis 1
grid1=none  grid lines on axis 1 - none, dot, dash, or solid
label1=  label on axis 1
x2beg=x2min  value at which axis 2 begins
x2end=x2max  value at which axis 2 ends
d2num=0.0  numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min  first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1  number of tics per numbered tic on axis 2
grid2=none  grid lines on axis 2 - none, dot, dash, or solid
label2=  label on axis 2
labelfont=Helvetica  font name for axes labels
labelsize=18  font size for axes labels
title=  title of plot
titlefont=Helvetica-Bold  font name for title
titlesize=24  font size for title
titlecolor=black  color of title
axescolor=black  color of axes
gridcolor=black  color of grid
axeswidth=1  width (in points) of axes
ticwidth=axeswidth  width (in points) of tic marks
gridwidth=axeswidth  width (in points) of grid lines
style=seismic  normal (axis 1 horizontal, axis 2 vertical) or
seismic (axis 1 vertical, axis 2 horizontal)
legend=0  =1 display the color scale
lnice=0  =1 nice legend arrangement
          (overrides ybox,lx,width,height parameters)
lstyle=vertleft  Vertical, axis label on left side
=vertright (Vertical, axis label on right side)
=horibottom (Horizontal, axis label on bottom)
units=  unit label for legend
legendfont=times_roman10  font name for title
following are defaults for lstyle=0. They are changed for other lstyles
lwidth=1.2  colorscale (legend) width in inches
lheight=height/3  colorscale (legend) height in inches
lx=1.0  colorscale (legend) x-position in inches
ly=(height-lheight)/2+xybox  colorscale (legend) y-position in pixels
lbeg= lmin or wclip-5*perc  value at which legend axis begins
lend= lmax or bclip+5*perc  value at which legend axis ends
ldnum=0.0  numbered tic interval on legend axis (0.0 for automatic)
lfnum=lmin  first numbered tic on legend axis (used if dlnum not 0.0)
lntic=1  number of tics per numbered tic on legend axis
lgrid=none  grid lines on legend axis - none, dot, dash, or solid

```

curve=curve1,curve2,... file(s) containing points to draw curve(s)  
 npair=n1,n2,n2,... number(s) of pairs in each file  
 curvecolor=black,.. color of curve(s)  
 curvewidth=axeswidth width (in points) of curve(s)  
 curvedash=0 solid curve(s), dash indices 1,...,11 produce  
 curve(s) with various dash styles  
  
 infile=none filename of second attribute n1xn2 array  
 values must be from range 0.0 - 1.0  
 (plain unformatted C-style file)  
 bckgr=0.5 background gray value

#### NOTES:

The curve file is an ascii file with the points specified as x1 x2  
 pairs, one pair to a line. A "vector" of curve files and curve  
 colors may be specified as curvefile=file1,file2,etc.  
 and curvecolor=color1,color2,etc, and the number of pairs of values  
 in each file as npair=npair1,npair2,... .

You may eliminate the blocky appearance of psimages by adjusting the  
 d1s= and d2s= parameters, so that psimages appear similar to ximages.

All color specifications may also be made in X Window style Hex format  
 example: axescolor=#255

Some example colormap settings:

red white blue: wrgb=1.0,0,0 grgb=1.0,1.0,1.0 brgb=0,0,1.0  
 white red blue: wrgb=1.0,1.0,1.0 grgb=1.0,0.0,0.0 brgb=0,0,1.0  
 blue red white: wrgb=0.0,0.0,1.0 grgb=1.0,0.0,0.0 brgb=1.0,1.0,1.0  
 red green blue: wrgb=1.0,0,0 grgb=0,1.0,0 brgb=0,0,1.0  
 orange light-blue green: wrgb=1.0,.5,0 grgb=0,.7,1.0 brgb=0,1.0,0  
 red light-blue dark blue: wrgb=0.0,0,1.0 grgb=0,1.0,1.0 brgb=0,0,1.0

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
 Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
 Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
 Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
 Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
 Helvetica-Narrow-Oblique NewCenturySchlbk-Bold"  
 NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
 Palatino-BoldItalic Palatino-Italics Palatino-Roman  
 SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman

Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

AUTHOR: Dave Hale, Colorado School of Mines, 05/29/90  
MODIFIED: Craig Artley, Colorado School of Mines, 08/30/91  
    BoundingBox moved to top of PostScript output  
MODIFIED: Craig Artley, Colorado School of Mines, 12/16/93  
    Added color options (Courtesy of Dave Hale, Advance Geophysical).  
Modified: Morten Wendell Pedersen, Aarhus University, 23/3-97  
    Added ticwidth, axeswidth, gridwidth parameters  
MODIFIED: Torsten Schoenfelder, Koeln, Germany 006/07/97  
    colorbar (legend) (as in ximage (by Berend Scheffers, Delft))  
MODIFIED: Brian K. Macy, Phillips Petroleum, 01/14/99  
    Added curve plotting option  
MODIFIED: Torsten Schoenfelder, Koeln, Germany 02/10/99  
    color scale with interpolation of three colors  
MODIFIED: Ekkehart Tessmer, University of Hamburg, Germany, 08/22/2007  
    Added dashing option to curve plotting

PSLABEL - output PostScript file consisting of a single TEXT string on a specified background. (Use with psmerge to label plots.)

```
pslabel t= [t=] [optional parameters] > epsfile
```

Required Parameters (can have multiple specifications to mix fonts):

t= text string to write to output

Optional Parameters:

f=Times-Bold	font for text string (multiple specifications for each t)
size=30	size of characters in points (72 points/inch)
tcolor=black	color of text string
bcolor=white	color of background box
nsub=0	number of characters to subtract when computing size of background box (not all characters are the same size so the background box may be too big at times.)

Example:

```
pslabel t="(a) " f=Times-Bold t="h" f=Symbol t="=0.04" nsub=3 > epsfile
```

This example yields the PostScript equivalent of the string  
(written here in LaTeX notation)  $(a)\hbar\eta=0.04$

Notes:

This program produces a (color if desired) PostScript text string that can be positioned and pasted on a PostScript plot using psmerge  
see selfdoc of psmerge for further information.

Possible fonts: Helvetica, Helvetica-Oblique, Helvetica-Bold,  
Helvetica-BoldOblique, Times-Roman, Times-Italic, Times-Bold,  
Times-BoldItalic, Courier, Courier-Bold, Courier-Oblique,  
Courier-BoldOblique, Symbol

Possible colors: greenyellow, yellow, goldenrod, dandelion, apricot,  
peach, melon, yelloworange, orange, burntorange, bittersweet, redorange,  
mahogany, maroon, brickred, red, orangered, rubinered, wildstrawberry,  
salmon, carnationpink, magenta, violetred, rhodamine, mulberry, redviolet,  
fuchsia, lavender, thistle, orchid, darkorchid, purple, plum, violet, royalpurple,  
blueviolet, periwinkle, cadetblue, cornflowerblue, midnightblue, navelblue,  
royalblue, blue, cerulean, cyan, processblue, skyblue, turquoise, tealblue,  
aquamarine, bluegreen, emerald, junglegreen, seagreen, green, forestgreen,

pinegreen, limegreen, yellowgreen, springgreen, olivegreen, rawsienna, sepia,  
brown, tan, white, black, gray

All color specifications may also be made in X Window style Hex format  
example: `tcolor=#255`

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCenturySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

AUTHOR: John E. Anderson, Visiting Scientist from Mobil, 1994

PSMANAGER - printer MANAGER for HP 4MV and HP 5Si Mx Laserjet  
PostScript printing

```
psmanager < stdin [optional parameters] > stdout
```

Required Parameters:

none

Optional Parameters:

papersize=0 paper size (US Letter default)

=1 US Legal

=2 A4

=3 11x17

orient=0 paper orientation (Portrait default)

=1 Landscape

tray=3 printing tray (Bottom tray default)

=1 tray 1 (multipurpose slot)

=2 tray 2

manual=0 no manual feed

=1 (Manual Feed)

media=0 regular paper

=1 Transparency

=2 Letterhead

=3 Card Stock

=4 Bond

=5 Labels

=6 Prepunched

=7 Recycled

=8 Preprinted

=9 Color (printing on colored paper)

Notes:

The option manual=1 implies tray=1. The media options apply only to the HP LaserJet 5Si MX model printer.

Examples:

overheads:

```
psmanager < postscript_file manual=1 media=1 | lpr
```

labels:

```
psmanager < postscript_file manual=1 media=5 | lpr
```

Notes: This code was reverse engineered using output from  
the NeXTStep printer manager.

Author: John Stockwell, June 1995, October 1997

Reference:

PostScript Printer Description File Format Specification,  
version 4.2, Adobe Systems Incorporated



PSMERGE - MERGE PostScript files

psmerge in= [optional parameters] >postscriptfile

Required Parameters:

in=                                postscript file to merge

Optional Parameters:

origin=0.0,0.0                    x,y origin in inches

scale=1.0,1.0                    x,y scale factors

rotate=0.0                        rotation angle in degrees

translate=0.0,0.0                x,y translation in inches

Notes:

More than one set of in, origin, scale, rotate, and translate parameters may be specified. Output x and y coordinates are determined by:

$$x = tx + (x-ox)*sx*\cos(d) - (y-oy)*sy*\sin(d)$$

$$y = ty + (x-ox)*sx*\sin(d) + (y-oy)*sy*\cos(d)$$

where tx,ty are translate coordinates, ox,oy are origin coordinates, sx,sy are scale factors, and d is the rotation angle. Note that the order of operations is shift (origin), scale, rotate, and translate.

If the number of occurrences of a given parameter is less than the number of input files, then the last occurrence of that parameter will apply to all subsequent files.

PSMOVIE - PostScript MOVIE plot of a uniformly-sampled function  $f(x_1, x_2, x_3)$

psmovie n1= [optional parameters] <binaryfile >postscriptfile

Required Parameters:

n1                                      number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0                                  sampling interval in 1st dimension  
f1=0.0                                  first sample in 1st dimension  
n2=all                                  number of samples in 2nd (slow) dimension  
d2=1.0                                  sampling interval in 2nd dimension  
f2=0.0                                  first sample in 2nd dimension  
perc=100.0                              percentile used to determine clip  
clip=(perc percentile)                  clip used to determine bclip and wclip  
bperc=perc                              percentile for determining black clip value  
wperc=100.0-perc                      percentile for determining white clip value  
bclip=clip                              data values outside of [bclip,wclip] are clipped  
wclip=-clip                            data values outside of [bclip,wclip] are clipped  
d1s=1.0                                  factor by which to scale d1 before imaging  
d2s=1.0                                  factor by which to scale d2 before imaging  
verbose=1                                =1 for info printed on stderr (0 for no info)  
xbox=1.0                                offset in inches of left side of axes box  
ybox=1.5                                offset in inches of bottom side of axes box  
wbox=6.0                                width in inches of axes box  
hbox=8.0                                height in inches of axes box  
x1beg=x1min                            value at which axis 1 begins  
x1end=x1max                            value at which axis 1 ends  
d1num=0.0                                numbered tic interval on axis 1 (0.0 for automatic)  
f1num=x1min                            first numbered tic on axis 1 (used if d1num not 0.0)  
n1tic=1                                number of tics per numbered tic on axis 1  
grid1=none                              grid lines on axis 1 - none, dot, dash, or solid  
label1=                                label on axis 1  
x2beg=x2min                            value at which axis 2 begins  
x2end=x2max                            value at which axis 2 ends  
d2num=0.0                                numbered tic interval on axis 2 (0.0 for automatic)  
f2num=x2min                            first numbered tic on axis 2 (used if d2num not 0.0)  
n2tic=1                                number of tics per numbered tic on axis 2  
grid2=none                              grid lines on axis 2 - none, dot, dash, or solid  
label2=                                label on axis 2  
labelfont=Helvetica                    font name for axes labels  
labelsize=18                            font size for axes labels  
title=                                title of plot

titlefont=Helvetica-Bold font name for title  
 titlesize=24 font size for title  
 style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
 seismic (axis 1 vertical, axis 2 horizontal)  
 n3=1 number of samples in third dimension  
 title2= second title to annotate different frames  
 loopdsp=3 display loop type (1=loop over n1; 2=loop over n2;  
 3=loop over n3)  
 d3=1.0 sampling interval in 3rd dimension  
 f3=d3 first sample in 3rd dimension

NeXT: view movie via: `psmovie < infile n1= [optional params...] | open`  
 Note: currently only the Preview Application can handle the multipage  
 PostScript output by this program.

All color specifications may also be made in X Window style Hex format  
 example: `axescolor=#255`

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique"  
 Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
 Courier Courier-Bold Courier-BoldOblique Courier-Oblique  
 Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
 Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
 Helvetica-Narrow-Oblique NewCenturySchlbk-Bold"  
 NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
 Palatino-BoldItalic Palatino-Italics Palatino-Roman  
 SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
 Symbol Times-Bold Times-BoldItalic  
 Times-Roman Times-Italic ZapfChancery-MediumItalic

PSWIGB - PostScript WIGgle-trace plot of  $f(x_1, x_2)$  via Bitmap  
 Best for many traces. Use PSWIGP (Polygon version) for few traces.

pswignb n1= [optional parameters] <binaryfile >postscriptfile

#### Required Parameters:

n1                                      number of samples in 1st (fast) dimension

#### Optional Parameters:

d1=1.0	sampling interval in 1st dimension
f1=0.0	first sample in 1st dimension
n2=all	number of samples in 2nd (slow) dimension
d2=1.0	sampling interval in 2nd dimension
f2=0.0	first sample in 2nd dimension
x2=f2,f2+d2,...	array of sampled values in 2nd dimension
bias=0.0	data value corresponding to location along axis 2
perc=100.0	percentile for determining clip
clip=(perc percentile)	data values < bias+clip and > bias-clip are clipped
xcur=1.0	wiggle excursion in traces corresponding to clip
wt=1	=0 for no wiggle-trace; =1 for wiggle-trace
va=1	=0 for no variable-area; =1 for variable-area fill
	=2 for variable area, solid/grey fill
	SHADING: 2<= va <=5 va=2 lightgrey, va=5 black",
nbpi=72	number of bits per inch at which to rasterize
verbose=1	=1 for info printed on stderr (0 for no info)
xbox=1.5	offset in inches of left side of axes box
ybox=1.5	offset in inches of bottom side of axes box
wbox=6.0	width in inches of axes box
hbox=8.0	height in inches of axes box
x1beg=x1min	value at which axis 1 begins
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
x2end=x2max	value at which axis 2 ends
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2

`labelfont=Helvetica`      font name for axes labels  
`labelsize=18`              font size for axes labels  
`title=`                      title of plot  
`titlefont=Helvetica-Bold` font name for title  
`titlesize=24`              font size for title  
`titlecolor=black`          color of title  
`axescolor=black`          color of axes  
`gridcolor=black`          color of grid  
`axeswidth=1`              width (in points) of axes  
`ticwidth=axeswidth`      width (in points) of tic marks  
`gridwidth=axeswidth`    width (in points) of grid lines  
`style=seismic`            normal (axis 1 horizontal, axis 2 vertical) or  
                             seismic (axis 1 vertical, axis 2 horizontal)  
`interp=0`    no display interpolation  
`=1` use 8 point sinc interpolation  
`curve=curve1,curve2,...` file(s) containing points to draw curve(s)  
`npair=n1,n2,n2,...`      number(s) of pairs in each file  
`curvecolor=black,..`    color of curve(s)  
`curvewidth=axeswidth` width (in points) of curve(s)  
`curvedash=0`            solid curve(s), dash indices 1,...,11 produce  
                             curve(s) with various dash styles

#### Notes:

The `interp` option may be useful for high `nbpi` values, however, it tacitly assumes that the data are purely oscillatory. Non-oscillatory data will not be represented correctly when this option is set.

The curve file is an ascii file with the points specified as `x1 x2` pairs, one pair to a line. A "vector" of curve files and curve colors may be specified as `curvefile=file1,file2,etc.` and `curvecolor=color1,color2,etc.` and the number of pairs of values in each file as `npair=npair1,npair2,...` .

All color specifications may also be made in X Window style Hex format  
example:    `axescolor=#255`

Legal font names are:

`AvantGarde-Book` `AvantGarde-BookOblique` `AvantGarde-Demi` `AvantGarde-DemiOblique`  
`Bookman-Demi` `Bookman-DemiItalic` `Bookman-Light` `Bookman-LightItalic`  
`Courier` `Courier-Bold` `Courier-BoldOblique` `Courier-Oblique`  
`Helvetica` `Helvetica-Bold` `Helvetica-BoldOblique` `Helvetica-Oblique`  
`Helvetica-Narrow` `Helvetica-Narrow-Bold` `Helvetica-Narrow-BoldOblique`  
`Helvetica-Narrow-Oblique` `NewCenturySchlbk-Bold`

NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

PSWIGP - PostScript WIGgle-trace plot of  $f(x_1, x_2)$  via Polygons  
 Best for few traces. Use PSWIGB (Bitmap version) for many traces.

pswign n1= [optional parameters] <binaryfile >postscriptfile

#### Required Parameters:

n1                                      number of samples in 1st (fast) dimension

#### Optional Parameters:

d1=1.0	sampling interval in 1st dimension
f1=0.0	first sample in 1st dimension
n2=all	number of samples in 2nd (slow) dimension
d2=1.0	sampling interval in 2nd dimension
f2=0.0	first sample in 2nd dimension
x2=f2,f2+d2,...	array of sampled values in 2nd dimension
bias=0.0	data value corresponding to location along axis 2
perc=100.0	percentile for determining clip
clip=(perc percentile)	data values < bias+clip and > bias-clip are clipped
xcur=1.0	wiggle excursion in traces corresponding to clip
fill=1 =0 for no fill;	
>0 for pos. fill;	
<0 for neg. fill	
	=2 for pos. fill solid, neg. fill grey
	=-2for neg. fill solid, pos. fill grey
	SHADING: 2<=abs(fill)<=5 2=lightgrey 5=black
linewidth=1.0	linewidth in points (0.0 for thinnest visible line)
tracecolor=black	color of traces; should contrast with background
backcolor=none	color of background; none means no background
verbose=1	=1 for info printed on stderr (0 for no info)
xbox=1.5	offset in inches of left side of axes box
ybox=1.5	offset in inches of bottom side of axes box
wbox=6.0	width in inches of axes box
hbox=8.0	height in inches of axes box
x1beg=x1min	value at which axis 1 begins
x1end=x1max	value at which axis 1 ends
d1num=0.0	numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min	first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
x2beg=x2min	value at which axis 2 begins
x2end=x2max	value at which axis 2 ends
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)

f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelfont=Helvetica	font name for axes labels
labelsize=18	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
axeswidth=1	width (in points) of axes
ticwidth=axeswidth	width (in points) of tic marks
gridwidth=axeswidth	width (in points) of grid lines
frame=1	=0 wiggle traces only, no frame
style=seismic	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)

curve=curve1,curve2,...	file(s) containing points to draw curve(s)
npair=n1,n2,n2,...	number(s) of pairs in each file
curvecolor=black,..	color of curve(s)
curvewidth=axeswidth	width (in points) of curve(s)
curvedash=0	solid curve(s), dash indices 1,...,11 produce curve(s) with various dash styles

Note: linewidth=0.0 produces the thinnest possible line on the output device. Thus the result is device-dependent, but generally looks the best for seismic traces.

The curve file is an ascii file with the points specified as x1 x2 pairs, one pair to a line. A "vector" of curve files and curve colors may be specified as curvefile=file1,file2,etc. and similarly curvecolor=color1,color2,etc, and the number of pairs of values in each file as npair=npair1,npair2,... .

All color specifications may also be made in X Window style Hex format  
example: axescolor=#255

Legal font names are:

AvantGarde-Book AvantGarde-BookOblique AvantGarde-Demi AvantGarde-DemiOblique  
Bookman-Demi Bookman-DemiItalic Bookman-Light Bookman-LightItalic  
Courier Courier-Bold Courier-BoldOblique Courier-Oblique



Helvetica Helvetica-Bold Helvetica-BoldOblique Helvetica-Oblique  
Helvetica-Narrow Helvetica-Narrow-Bold Helvetica-Narrow-BoldOblique  
Helvetica-Narrow-Oblique NewCenturySchlbk-Bold"  
NewCenturySchlbk-BoldItalic NewCenturySchlbk-Roman Palatino-Bold  
Palatino-BoldItalic Palatino-Italics Palatino-Roman  
SanSerif-Bold SanSerif-BoldItalic SanSerif-Roman  
Symbol Times-Bold Times-BoldItalic  
Times-Roman Times-Italic ZapfChancery-MediumItalic

LCMAP - List Color Map of root window of default screen

Usage: lcmsap

LPROP - List PROPERTIES of root window of default screen of display

Usage: lprop

SCMAP - set default standard color map (RGB\_DEFAULT\_MAP)

Usage: scmap

XCONTOUR - X CONTOUR plot of  $f(x_1, x_2)$  via vector plot call

`xcontour n1= [optional parameters] <binaryfile [>psplotfile]`

X Functionality:

Button 1 Zoom with rubberband box

Button 2 Show mouse  $(x_1, x_2)$  coordinates while pressed

q or Q key Quit

s key Save current mouse  $(x_1, x_2)$  location to file

p or P key Plot current window with pswigb (only from disk files)

Required Parameters:

`n1`                      number of samples in 1st (fast) dimension

Optional Parameters:

`d1=1.0`                      sampling interval in 1st dimension

`f1=0.0`                      first sample in 1st dimension

`x1=f1, f1+d1, ...`              array of sampled values in 1st dimension

`n2=all`                      number of samples in 2nd (slow) dimension

`d2=1.0`                      sampling interval in 2nd dimension

`f2=0.0`                      first sample in 2nd dimension

`x2=f2, f2+d2, ...`              array of sampled values in 2nd dimension

`mpicks=/dev/tty`              file to save mouse picks in

`verbose=1`                      =1 for info printed on stderr (0 for no info)

`nc=5`                      number of contour values

`dc=(zmax-zmin)/nc`              contour interval

`fc=min+dc`                      first contour

`c=fc, fc+dc, ...`              array of contour values

`cwidth=1.0, ...`              array of contour line widths

`ccolor=none, ...`              array of contour colors; none means use cgray

`cdash=0.0, ...`              array of dash spacings (0.0 for solid)

`labelcf=1`                      first labeled contour (1,2,3,...)

`labelcper=1`                      label every labelcper-th contour

`nlabelc=nc`                      number of labeled contours (0 no contour label)

`nplaces=6`                      number of decimal places in contour labeling

`xbox=50`                      x in pixels of upper left corner of window

`ybox=50`                      y in pixels of upper left corner of window

`wbox=550`                      width in pixels of window

`hbox=700`                      height in pixels of window

`x1beg=x1min`                      value at which axis 1 begins

`x1end=x1max`                      value at which axis 1 ends

`d1num=0.0`                      numbered tic interval on axis 1 (0.0 for automatic)

`f1num=x1min`                      first numbered tic on axis 1 (used if d1num not 0.0)

n1tic=1	number of tics per numbered tic on axis 1
grid1=none	grid lines on axis 1 - none, dot, dash, or solid
x2beg=x2min	value at which axis 2 begins
x2end=x2max	value at which axis 2 ends
d2num=0.0	numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min	first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1	number of tics per numbered tic on axis 2
grid2=none	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelfont=Erg14	font name for axes labels
title=	title of plot
titlefont=Rom22	font name for title
windowtitle=xwgb	title on window
labelcolor=blue	color for axes labels
titlecolor=red	color for title
gridcolor=blue	color for grid lines
labelccolor=black	color of contour labels
labelcfont=fixed	font name for contour labels
style=seismic	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)

",

#### Notes:

For some reason the contour might slight differ from ones generated by pscontour (propably due to the pixel nature of the plot coordinates)

The line width of unlabeled contours is designed as a quarter of that of labeled contours.

AUTHOR: Morten Wendell Pedersen, Aarhus University

All the coding is based on snippets taken from xwgb, ximage and pscontour  
All I have done is put the parts together and put in some bugs ;-)

So credits should go to the authors of these packages...

#### Caveats and Notes:

The code has been developed under Linux 1.3.20/Xfree 3.1.2E (X11 6.1)  
with gcc-2.7.0 But hopefully it should work on other platforms as well

Since all the contours are drawn by Vector plot call's everytime the

Window is exposed, the exposing can be darn slow  
OOPS This should be history... Now I keep my window content with backing store so I won't have to redraw my window unless I really have to...

Portability Question: I guess I should check if the display supports backingstore and redraw if it doesn't (see DoesBackingStore(3) )  
I have to be able to use CWBackingStore==Always (other values can be NonUseful and WhenMapped)

Since I put the contour labels everytime I draw one contour level the area that contains the label will be crossed by the the next contour lines... (this bug also seems to be present in pscontour)  
To fix this I have to redraw all the labels after been through all the contour calls  
Right now I can't see a way to fix this without actually to through the entire label positioning again....Overkill I would say

The relative short length of the contour segments will propably mask the cdash settings  
which means it is disposable (but I know how to draw dashed lines :)  
A way of fixing this could be to get all connected point and then use XDrawlines or XDrawSegments... just an idea...No idea if it'll work.

I think there is a bug in xContour since my plot coordinates increase North and west ward instead of south and eastward

I need to check the Self Doc so if the right parameters are described (I have been through it a couple of times but....)

All functions need a heavy cleanup for unused variables  
I suppose there is a couple of memory leaks due to missing free'ing of numerous pointers (especially fonts,GC's & colors could be a problem...

I have to browse through the internal pscontour call... basically what I have done is just putting pscontour instead of pswigb... Instead of repositioning the input file pointer (which doesnt work with pipes) one should consider the use of temporary file  
or write your zoombox to pscontour (...how one does that?)

Wish List:

The use of cgray's unused until now... I guess I'll need to allocate a gray Colormap -> meaning that the code not will run at other display

than 8 bit Pseudocolor :( (with the use of present version of the colormap library (code in \$CWPROOT/src/xplot/lib ) )

The format of contour label should be open for the user..

It could be nice if one could choose to have a pixmap (like ximage ) underlying the contours... this should be defined either by the input data or by a separate file

eg useful for viewing traveltime contours on top a plot of the velocity field



XESPB - X windows display of Encapsulated PostScript as a single Bitmap

Usage: xepsb < stdin

Caveat: your system must have Display PostScript Graphics

NOTE: This program is included as a demo of EPS -> X programming.

See: xepsp and xpsp these are more advanced versions

XEPSP - X windows display of Encapsulated PostScript

Usage: xepsp < stdin

Caveat: your system must have Display PostScript Graphics

Note:

this program is a more advanced version of xepsb. See also: xepsp

XIMAGE - X IMAGE plot of a uniformly-sampled function  $f(x_1, x_2)$

ximage n1= [optional parameters] <binaryfile

X Functionality:

Button 1 Zoom with rubberband box

Button 2 Show mouse (x1,x2) coordinates while pressed

q or Q key Quit

s key Save current mouse (x1,x2) location to file

p or P key Plot current window with pswigb (only from disk files)

a or page up keys enhance clipping by 10%

c or page down keys reduce clipping by 10%

up,down,left,right keys move zoom window by half width/height

i or +(keypad) zoom in by factor 2

o or -(keypad) zoom out by factor 2

... change colormap interactively

r install next RGB - colormap

R install previous RGB - colormap

h install next HSV - colormap

H install previous HSV - colormap

H install previous HSV - colormap

(Move mouse cursor out and back into window for r,R,h,H to take effect)

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

n2=all number of samples in 2nd (slow) dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

mpicks=/dev/tty file to save mouse picks in

perc=100.0 percentile used to determine clip

clip=(perc percentile) clip used to determine bclip and wclip

bperc=perc percentile for determining black clip value

wperc=100.0-perc percentile for determining white clip value

bclip=clip data values outside of [bclip,wclip] are clipped

wclip=-clip data values outside of [bclip,wclip] are clipped

balance=0 bclip & wclip individually

=1 set them to the same abs value

if specified via perc (avoids colorbar skew)

cmap=hsv\ 'n\ ' or rgb\ 'm\ '\ 'n\ ' is a number from 0 to 13  
 \ 'm\ ' is a number from 0 to 11  
 cmap=rgb0 is equal to cmap=gray  
 cmap=hsv1 is equal to cmap=hue  
 (compatibility to older versions)  
 legend=0                =1 display the color scale  
 units= unit label for legend  
 legendfont=times\_roman10    font name for title  
 verbose=1 =1 for info printed on stderr (0 for no info)  
 xbox=50 x in pixels of upper left corner of window  
 ybox=50 y in pixels of upper left corner of window  
 wbox=550 width in pixels of window  
 hbox=700 height in pixels of window  
 lwidth=16 colorscale (legend) width in pixels  
 lheight=hbox/3 colorscale (legend) height in pixels  
 lx=3 colorscale (legend) x-position in pixels  
 ly=(hbox-lheight)/3    colorscale (legend) y-position in pixels  
 x1beg=x1min value at which axis 1 begins  
 x1end=x1max value at which axis 1 ends  
 d1num=0.0 numbered tic interval on axis 1 (0.0 for automatic)  
 f1num=x1min first numbered tic on axis 1 (used if d1num not 0.0)  
 n1tic=1 number of tics per numbered tic on axis 1  
 grid1=none grid lines on axis 1 - none, dot, dash, or solid  
 label1= label on axis 1  
 x2beg=x2min value at which axis 2 begins  
 x2end=x2max value at which axis 2 ends  
 d2num=0.0 numbered tic interval on axis 2 (0.0 for automatic)  
 f2num=x2min first numbered tic on axis 2 (used if d2num not 0.0)  
 n2tic=1 number of tics per numbered tic on axis 2  
 grid2=none grid lines on axis 2 - none, dot, dash, or solid  
 label2= label on axis 2  
 labelfont=Erg14 font name for axes labels  
 title= title of plot  
 titlefont=Rom22 font name for title  
 windowtitle=ximage title on window  
 labelcolor=blue color for axes labels  
 titlecolor=red color for title  
 gridcolor=blue color for grid lines  
 style=seismic                normal (axis 1 horizontal, axis 2 vertical) or  
 seismic (axis 1 vertical, axis 2 horizontal)  
 blank=0 This indicates what portion of the lower range  
 to blank out (make the background color). The  
 value should range from 0 to 1.

plotfile=plotfile.ps filename for interactive plotting (P)  
curve=curve1,curve2,... file(s) containing points to draw curve(s)  
npair=n1,n2,n2,... number(s) of pairs in each file  
curvecolor=color1,color2,... color(s) for curve(s)  
blockinterp=0 whether to use block interpolation (0=no, 1=yes)

#### NOTES:

The curve file is an ascii file with the points specified as x1 x2 pairs separated by a space, one pair to a line. A "vector" of curve files and curve colors may be specified as curvefile=file1,file2,etc. and curvecolor=color1,color2,etc, and the number of pairs of values in each file as npair=npair1,npair2,... .

AUTHOR: Dave Hale, Colorado School of Mines, 08/09/90

Stewart A. Levin, Mobil - Added ps print option

Brian Zook, Southwest Research Institute, 6/27/96, added blank option

Toralf Foerster, Baltic Sea Research Institute, 9/15/96, new colormaps

Berend Scheffers, Delft, colorbar (legend)

Brian K. Macy, Phillips Petroleum, 11/27/98, added curve plotting option

G.Klein, GEOMAR Kiel, 2004-03-12, added cursor scrolling and  
interactive change of zoom and clipping.

Zhaobo Meng, ConocoPhillips, 12/02/04, added amplitude display

Garry Perratt, Geocon, 08/04/05, modified perc handling to center colorbar if balan

INTL2B\_block - blocky interpolation of a 2-D array of bytes

intl2b\_block blocky interpolation of a 2-D array of bytes

#### Function Prototype:

```
void intl2b_block(int nxin, float dxin, float fxin,  
int nyin, float dyin, float fyin, unsigned char *zin,  
int nxout, float dxout, float fxout,  
int nyout, float dyout, float fyout, unsigned char *zout);
```

Input:

nxin number of x samples input (fast dimension of zin)  
dxin x sampling interval input  
fxin first x sample input  
nyin number of y samples input (slow dimension of zin)  
dyin y sampling interval input  
fyin first y sample input  
zin array[nyin][nxin] of input samples (see notes)  
nxout number of x samples output (fast dimension of zout)  
dxout x sampling interval output  
fxout first x sample output  
nyout number of y samples output (slow dimension of zout)  
dyout y sampling interval output  
fyout first y sample output

Output:

zout array[nyout][nxout] of output samples (see notes)

Notes:

The arrays zin and zout must be passed as pointers to the first element of a two-dimensional contiguous array of unsigned char values.

Constant extrapolation of zin is used to compute zout for output x and y outside the range of input x and y.

Author: James Gunning, CSIRO Petroleum 1999. Hacked from intl2b() by Dave Hale, Colorado School of Mines, c. 1989-1991

XPICKER - X wiggle-trace plot of  $f(x_1, x_2)$  via Bitmap with PICKing

xpicker n1= [optional parameters] <binaryfile

X Menu functionality:

- Pick Filename Window default is pick\_file
- Load load an existing Pick Filename
- Save save to Pick Filename
- View only/Pick default is View, click to enable Picking
- Add/Delete default is Add, click to delete picks
- Cross off/on default is Cross off, click to enable Crosshairs

In View mode:

- a or page up keys                   enhance clipping by 10%
- c or page down keys                reduce clipping by 10%
- up,down,left,right keys       move zoom window by half width/height
- i or +(keypad)                   zoom in by factor 2
- o or -(keypad)                   zoom out by factor 2
- l   lock the zoom while moving the cursor
- u   unlock the zoom

Notes:

Menu selections and toggles ("clicks") are made with button 1

Pick selections are made with button 3

Edit a pick selection by dragging it with button 3 down or  
by making a new pick on that trace

Reaching the window limits while moving within changes the zoom  
factor in this direction. The use of zoom locking(l) disables it

Other X Mouse functionality:

Mouse Button 1 Zoom with rubberbox

Mouse Button 2 Show mouse (x1,x2) coordinates while pressed

The following keys are active in View Only mode:

Required Parameters:

n1= number of samples in 1st (fast) dimension

Optional Parameters:

mpicks=pick\_file name of output (input) pick file

d1=1.0 sampling interval in 1st dimension

f1=d1   first sample in 1st dimension

n2=all   number of samples in 2nd (slow) dimension

d2=1.0 sampling interval in 2nd dimension  
f2=d2 first sample in 2nd dimension  
x2=f2,f2+d2,... array of sampled values in 2nd dimension  
bias=0.0 data value corresponding to location along axis 2  
perc=100.0 percentile for determining clip  
clip=(perc percentile) data values < bias+clip and > bias-clip are clipped  
xcur=1.0 wiggle excursion in traces corresponding to clip  
wt=1 =0 for no wiggle-trace; =1 for wiggle-trace  
va=1 =0 for no variable-area; =1 for variable-area fill  
              =2 for variable area, solid/grey fill  
              SHADING: 2<=va<=5 va=2 light grey, va=5 black  
verbose=1 =1 for info printed on stderr (0 for no info)  
xbox=50 x in pixels of upper left corner of window  
ybox=50 y in pixels of upper left corner of window  
wbox=550 width in pixels of window  
hbox=700 height in pixels of window  
x1beg=x1min value at which axis 1 begins  
x1end=x1max value at which axis 1 ends  
d1num=0.0 numbered tic interval on axis 1 (0.0 for automatic)  
f1num=x1min first numbered tic on axis 1 (used if d1num not 0.0)  
n1tic=1 number of tics per numbered tic on axis 1  
grid1=none grid lines on axis 1 - none, dot, dash, or solid  
label1= label on axis 1  
x2beg=x2min value at which axis 2 begins  
x2end=x2max value at which axis 2 ends  
d2num=0.0 numbered tic interval on axis 2 (0.0 for automatic)  
f2num=x2min first numbered tic on axis 2 (used if d2num not 0.0)  
n2tic=1 number of tics per numbered tic on axis 2  
grid2=none grid lines on axis 2 - none, dot, dash, or solid  
label2= label on axis 2  
labelfont=Erg14 font name for axes labels  
title= title of plot  
titlefont=Rom22 font name for title  
labelcolor=blue color for axes labels  
titlecolor=red color for title  
gridcolor=blue color for grid lines  
style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
              seismic (axis 1 vertical, axis 2 horizontal)  
endian= =0 little endian, =1 big endian  
interp=0 no sinc interpolation  
=1 perform sinc interpolation  
x2file= file of "acceptable" x2 values  
x1x2=1 save picks in the order (x1,x2)



=0 save picks in the order (x2,x1)

Notes:

Xpicker will try to detect the endian value of the X-display and will set it to the right value. If it gets obviously wrong information the endian value will be set to the endian value of the machine that is given at compile time as the value of CWPENDIAN defined in cwp.h and set via the compile time flag ENDIANFLAG in Makefile.config.

The only time that you might want to change the value of the endian variable is if you are viewing traces on a machine with a different byte order than the machine you are creating the traces on AND if for some reason the automatic detection of the display byte order fails. Set endian to that of the machine you are viewing the traces on.

The interp flag is useful for making better quality wiggle trace for making plots from screen dumps. However, this flag assumes that the data are purely oscillatory. This option may not be appropriate for all data sets.

If the x2file= option is set, then the values from the specified file will define the set of "acceptable" values of x2 for xpicker to output. The format is a single column of ASCII values. The number of specified values is arbitrary.

Such a file can be built from an SU data set via:

```
sugethw < sudata key=offset output=geom > x2example
```

If the value of x2file= is not set, then xpicker will use the values specified via: x2=.,.,.,. or those that are", computed from the values of f2= and d2= as being the "acceptable values.

See the selfdoc of suxpicker for information on using key fields from the SU trace headers directly.

AUTHOR: Dave Hale, Colorado School of Mines, 08/09/90  
with picking by Wenying Cai of University of Utah.  
Endian stuff by Morten Pedersen and John Stockwell of CWP.  
Interp stuff by Tony Kocurko of Memorial University of Newfoundland  
Modified to include acceptable values by Bill Lutter of the

Department of Geology, University of Wisconsin 10/96  
MODIFIED: P. Michaels, Boise State University 29 December 2000  
Added solid/grey color scheme for peaks/troughs

G.Klein, IFG Kiel University, 2003-09-29, added cursor scrolling and  
interactive change of zoom and clipping.

NOTES:

Interactive picker improved to allow x-axis of picks to be  
coordinated with "key=header" parameter set in driver routine  
suxpicker. Multiple picks per trace are now allowed.

Input:

The command line of suxpicker is unchanged. The parameter "key=header"  
set in suxpicker controls a) trace x-axis displayed via xpicker and  
b) the header values in the first column of a pick file either read in  
or written out from xpicker c) header values expected in optional file  
or written out from xpicker c) header values expected in optional file  
x2file= which reads into xpicker allowable trace x-axis values.

a) example command line: suxpicker key=offset < shot10.plotpik

b) pick file format:

x-axis\_value\_1 time\_1  
x-axis\_value\_2 time\_2  
x-axis\_value\_3 time\_3  
etc.  
x-axis\_value\_n time\_n

pick file example:

1000.000000 0.500000  
2000.000000 1.000000  
3000.000000 1.500000  
4000.000000 2.000000  
5000.000000 2.500000

c) format of optional file x2file=:

header\_value\_1  
header\_value\_2  
etc.  
header\_val\_m

If file "x2file=" exists in directory from which suxpicker is

invoked, then these trace header x-axis values are the only allowable x-axis pick values used in the pick "add" or "delete" menu operation. Header values do not need to be sorted or 1 to 1 with input traces. Further, pick file x-axis values can be read into xpicker via load operation without having to match key\_pickx1\_val x-axis values and can also be rewritten out an output pickfile. As indicated, only the "add" and "delete" pick operations are influenced by existence of this file.

Offset header values for "x2file=" can be generated by the command line:

```
sugethw < su_segyfile key=offset output=geom > x2examplefile=
```

Output: Only change is in format of pick\_file (format described above). If x2file= file exists then x-axis value of added picks will be forced to nearest allowable trace x-axis value (input values of x2file= file). If x2file= is not set, then the values of x2 that are either assigned uniformly to the traces via f2 and d2, or by the vector of values of x2=.,.,.,. will be the "acceptable" values.

#### Strategy:

- a) malloc() and realloc() used to dynamically allocate memory for array of x-axis value read in from optional file x2file=. This is done in function read\_keyval().
- b) The pick file dimensions are set in main program via malloc() and then initialized (\*apick)[i].picked = FALSE) in function init\_picks(). The pick file is declared as pick\_t \*\*apick, in order to use realloc() as needed in functions load\_picks where the pick file is read in and edit\_picks where picks are added. The call to realloc() and further initializing is performed in function realloc\_picks().
- c) If x2file= file exists the mouse derived x-axis value for a pick to be added is checked against allowable x-axis values to find the closest match via function add\_pick called from edit\_picks. If the pick is to be deleted, first a search is done to find the closest x-axis value, then the existing pick values are searched to find the closest radial value ( $x^2 + t^2$ ) via function del\_pick() invoked from edit\_picks.

d) Code modifications are limited to above mentioned functions, except for additional parameters passed to functions `edit_picks`, `load_picks`, `save_picks`, and `check_buttons`.

XPSP - Display conforming PostScript in an X-window

```
xpsp < stdin
```

Note: this is the most advanced version of xpsb and xpsp.

Caveat: your system must have Display PostScript Graphics

XWIGB - X WIGgle-trace plot of  $f(x_1, x_2)$  via Bitmap

xwigg n1= [optional parameters] <binaryfile

X Functionality:

Button 1 Zoom with rubberband box

Button 2 Show mouse (x1,x2) coordinates while pressed

q or Q key Quit

s key Save current mouse (x1,x2) location to file

p or P key Plot current window with pswigg (only from disk files)

a or page up keys enhance clipping by 10%

c or page down keys reduce clipping by 10%

up,down,left,right keys move zoom window by half width/height

i or +(keypad) zoom in by factor 2

o or -(keypad) zoom out by factor 2

l lock the zoom while moving the cursor

u unlock the zoom

1,2,...,9 Zoom/Move factor of the window size

Notes:

Reaching the window limits while moving within changes the zoom factor in this direction. The use of zoom locking(l) disables it

Required Parameters:

n1 number of samples in 1st (fast) dimension

Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

n2=all number of samples in 2nd (slow) dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

x2=f2,f2+d2,... array of sampled values in 2nd dimension

mpicks=/dev/tty file to save mouse picks in

bias=0.0 data value corresponding to location along axis 2

perc=100.0 percentile for determining clip

clip=(perc percentile) data values  $< \text{bias} + \text{clip}$  and  $> \text{bias} - \text{clip}$  are clipped

xcur=1.0 wiggle excursion in traces corresponding to clip

wt=1 =0 for no wiggle-trace; =1 for wiggle-trace

va=1 =0 for no variable-area; =1 for variable-area fill

=2 for variable area, solid/grey fill

SHADING: 2 $\leq$ va $\leq$ 5 va=2 light grey, va=5 black

verbose=0 =1 for info printed on stderr (0 for no info)

```

xbox=50  x in pixels of upper left corner of window
ybox=50  y in pixels of upper left corner of window
wbox=550  width in pixels of window
hbox=700  height in pixels of window
x1beg=x1min  value at which axis 1 begins
x1end=x1max  value at which axis 1 ends
d1num=0.0  numbered tic interval on axis 1 (0.0 for automatic)
f1num=x1min  first numbered tic on axis 1 (used if d1num not 0.0)
n1tic=1  number of tics per numbered tic on axis 1
grid1=none  grid lines on axis 1 - none, dot, dash, or solid
x2beg=x2min  value at which axis 2 begins
x2end=x2max  value at which axis 2 ends
d2num=0.0  numbered tic interval on axis 2 (0.0 for automatic)
f2num=x2min  first numbered tic on axis 2 (used if d2num not 0.0)
n2tic=1  number of tics per numbered tic on axis 2
grid2=none  grid lines on axis 2 - none, dot, dash, or solid
label2=  label on axis 2
labelfont=Erg14  font name for axes labels
title=  title of plot
titlefont=Rom22  font name for title
windowtitle=xwigb  title on window
labelcolor=blue  color for axes labels
titlecolor=red  color for title
gridcolor=blue  color for grid lines
style=seismic  normal (axis 1 horizontal, axis 2 vertical) or
seismic (axis 1 vertical, axis 2 horizontal)
endian=  =0 little endian =1 big endian
interp=0  no interpolation in display
=1 use 8 point sinc interpolation
wigclip=0  If 0, the plot box is expanded to accommodate
the larger wiggles created by xcur>1. If this
flag is non-zero, the extra-large wiggles are
are clipped at the boundary of the plot box.
plotfile=plotfile.ps  filename for interactive plotting (P)
curve=curve1,curve2,...  file(s) containing points to draw curve(s)
npair=n1,n2,n2,...  number(s) of pairs in each file
curvecolor=color1,color2,...  color(s) for curve(s)

```

#### Notes:

Xwigb will try to detect the endian value of the X-display and will set it to the right value. If it gets obviously wrong information the endian value will be set to the endian value of the machine that is given at compile time as the value of CWPENDIAN defined in cwp.h

and set via the compile time flag ENDIANFLAG in Makefile.config.

The only time that you might want to change the value of the endian variable is if you are viewing traces on a machine with a different byte order than the machine you are creating the traces on AND if for some reason the automatic detection of the display byte order fails. Set endian to that of the machine you are viewing the traces on.

The interp flag is useful for making better quality wiggle trace for making plots from screen dumps. However, this flag assumes that the data are purely oscillatory. This option may not be appropriate for all data sets.

The curve file is an ascii file with the points specified as x1 x2 pairs, separated by a space, one pair to a line. A "vector" of curve files and curve colors may be specified as curvefile=file1,file2,etc. and curvecolor=color1,color2,etc, and the number of pairs of values in each file as npair=npair1,npair2,... .

AUTHOR: Dave Hale, Colorado School of Mines, 08/09/90

Endian stuff by:

Morten Wendell Pedersen, Aarhus University (visiting CSM, June 1995)  
& John Stockwell, Colorado School of Mines, 5 June 1995

Stewart A. Levin, Mobil - Added ps print option  
John Stockwell - Added optional sinc interpolation  
Stewart A. Levin, Mobil - protect title, labels in pswigb call

Brian J. Zook, SwRI - Added style=normal and wigclip flag

Brian K. Macy, Phillips Petroleum, 11/27/98, added curve plotting option  
Curve plotting notes:

MODIFIED: P. Michaels, Boise State University 29 December 2000  
Added solid/grey color scheme for peaks/troughs

G.Klein, IFG Kiel University, 2002-09-29, added cursor scrolling and  
interactive change of zoom and clipping.  
IFM-GEOMAR Kiel, 2004-03-12, added zoom locking  
IFM-GEOMAR Kiel, 2004-03-25, interactive plotting fixed



## XGRAPH - X GRAPHer

Graphs  $n[i]$  pairs of  $(x,y)$  coordinates, for  $i = 1$  to  $nplot$ .

`xgraph n= [optional parameters] <binaryfile`

### X Functionality:

q or Q key      Quit

### Required Parameters:

`n`                      array containing number of points per plot

### Optional Parameters:

<code>nplot=</code>	number of <code>n</code> 's	number of plots
<code>d1=0.0,...</code>		x sampling intervals (0.0 if x coordinates input)
<code>f1=0.0,...</code>		first x values (not used if x coordinates input)
<code>d2=0.0,...</code>		y sampling intervals (0.0 if y coordinates input)
<code>f2=0.0,...</code>		first y values (not used if y coordinates input)
<code>pairs=1,...</code>		=1 for data pairs in format 1.a, =0 for format 1.b
<code>linewidth=1,1,...</code>		line widths in pixels (0 for no lines)
<code>linecolor=2,3,...</code>		line colors (black=0, white=1, 2,3,4 = RGB, ...)
<code>mark=0,1,2,3,...</code>		indices of marks used to represent plotted points
<code>marksize=0,0,...</code>		size of marks in pixels (0 for no marks)
<code>x1beg=x1min</code>		value at which axis 1 begins
<code>x1end=x1max</code>		value at which axis 1 ends
<code>x2beg=x2min</code>		value at which axis 2 begins
<code>x2end=x2max</code>		value at which axis 2 ends
<code>reverse=0</code>		=1 to reverse sequence of plotting curves "

### Optional resource parameters (defaults taken from resource database):

<code>windowtitle=</code>	title on window
<code>width=</code>	width in pixels of window
<code>height=</code>	height in pixels of window
<code>nTic1=</code>	number of tics per numbered tic on axis 1
<code>grid1=</code>	grid lines on axis 1 - none, dot, dash, or solid
<code>label1=</code>	label on axis 1
<code>nTic2=</code>	number of tics per numbered tic on axis 2
<code>grid2=</code>	grid lines on axis 2 - none, dot, dash, or solid
<code>label2=</code>	label on axis 2
<code>labelFont=</code>	font name for axes labels
<code>title=</code>	title of plot
<code>titleFont=</code>	font name for title
<code>titleColor=</code>	color for title
<code>axesColor=</code>	color for axes

gridColor= color for grid lines  
style= normal (axis 1 horizontal, axis 2 vertical) or  
seismic (axis 1 vertical, axis 2 horizontal)

Data formats supported:

- 1.a.  $x_1, y_1, x_2, y_2, \dots, x_n, y_n$
- b.  $x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_n$
2.  $y_1, y_2, \dots, y_n$  (must give non-zero  $d1[]$ )
3.  $x_1, x_2, \dots, x_n$  (must give non-zero  $d2[]$ )
4. nil (must give non-zero  $d1[]$  and non-zero  $d2[]$ )

The formats may be repeated and mixed in any order, but if formats 2-4 are used, the  $d1$  and  $d2$  arrays must be specified including  $d1[]=0.0$   $d2[]=0.0$  entries for any internal occurrences of format 1. Similarly, the pairs array must contain place-keeping entries for plots of formats 2-4 if they are mixed with both formats 1.a and 1.b. Also, if formats 2-4 are used with non-zero  $f1[]$  or  $f2[]$  entries, then the corresponding array(s) must be fully specified including  $f1[]=0.0$  and/or  $f2[]=0.0$  entries for any internal occurrences of format 1 or formats 2-4 where the zero entries are desired.

mark index:

1. asterisk
2. x-cross
3. open triangle
4. open square
5. open circle
6. solid triangle
7. solid square
8. solid circle

Note:  $n1$  and  $n2$  are acceptable aliases for  $n$  and  $nplot$ , respectively.

Example:

```
xgraph n=50,100,20 d1=2.5,1,0.33 <datafile
  plots three curves with equally spaced x values in one plot frame
  x1-coordinates are  $x1(i) = f1+i*d1$  for  $i = 1$  to  $n$  ( $f1=0$  by default)
  number of x2's and then x2-coordinates for each curve are read
  sequentially from datafile.
```

XMOVIE - image one or more frames of a uniformly sampled function  $f(x_1, x_2)$

xmovie n1= n2= [optional parameters] <fileoffloats

#### X Functionality:

Button 1 Zoom with rubberband box

Button 2 reverse the direction of the movie.

Button 3 stop and start the movie.

q or Q key Quit

s or S key stop display and switch to Step mode

b or B key set frame direction to Backward

f or F key set frame direction to Forward

n or N key same as 'f'

c or C key set display mode to Continuous mode

#### Required Parameters:

n1= number of samples in 1st (fast) dimension

n2= number of samples in 2nd (slow) dimension

#### Optional Parameters:

d1=1.0 sampling interval in 1st dimension

f1=0.0 first sample in 1st dimension

d2=1.0 sampling interval in 2nd dimension

f2=0.0 first sample in 2nd dimension

perc=100.0 percentile used to determine clip

clip=(perc percentile) clip used to determine bclip and wclip

bperc=perc percentile for determining black clip value

wperc=100.0-perc percentile for determining white clip value

bclip=clip data values outside of [bclip,wclip] are clipped

wclip=-clip data values outside of [bclip,wclip] are clipped

x1beg=x1min value at which axis 1 begins

x1end=x1max value at which axis 1 ends

x2beg=x2min value at which axis 2 begins

x2end=x2max value at which axis 2 ends

fframe=1 value corresponding to first frame

dframe=1 frame sampling interval

loop=0 =1 to loop over frames after last frame is input

=2 to run movie back and forth

interp=1 =0 for a non-interpolated, blocky image

verbose=1 =1 for info printed on stderr (0 for no info)

idm=0 =1 to set initial display mode to stepmode

Optional resource parameters (defaults taken from resource database):

windowtitle= title on window and icon  
 width= width in pixels of window  
 height= height in pixels of window  
 nTic1= number of tics per numbered tic on axis 1  
 grid1= grid lines on axis 1 - none, dot, dash, or solid  
 label1= label on axis 1  
 nTic2= number of tics per numbered tic on axis 2  
 grid2= grid lines on axis 2 - none, dot, dash, or solid  
 label2= label on axis 2  
 labelFont= font name for axes labels  
 title= title of plot  
 titleFont= font name for title  
 titleColor= color for title  
 axesColor= color for axes  
 gridColor= color for grid lines  
 style= normal (axis 1 horizontal, axis 2 vertical) or  
 seismic (axis 1 vertical, axis 2 horizontal)  
 sleep= delay between frames in seconds (integer)

#### Color options:

cmap=gray gray, hue, saturation, or default colormaps may be specified  
 bhue=0 hue mapped to bclip (hue and saturation maps)  
 whue=240 hue mapped to wclip (hue and saturation maps)  
 sat=1 saturation (hue map only)  
 bright=1 brightness (hue and saturation maps)  
 white=(bclip+wclip)/2 data value mapped to white (saturation map only)

#### Notes:

Colors are specified using the HSV color wheel model:

Hue: 0=360=red, 60=yellow, 120=green, 180=cyan, 240=blue, 300=magenta

Saturation: 0=white, 1=pure color

Value (brightness): 0=black, 1=maximum intensity

For the saturation mapping (cmap=sat), data values between white and bclip are mapped to bhue, with saturation varying from white to the pure color. Values between wclip and white are similarly mapped to whue.

For the hue mapping (cmap=hue), data values between wclip and bclip are mapped to hues between whue and bhue. Intermediate hues are found by moving counterclockwise around the circle from bhue to whue. To reverse the polarity of the image, exchange bhue and whue. Equivalently, exchange bclip and wclip (setting perc=0 is an easy way to do this). Hues in excess of 360 degrees can be specified in order to reach the opposite side of the color circle, or to wrap around the circle more than once.

The title string may contain a C printf format string containing a conversion character for the frame number. The frame number is computed from dframe and fframe. E.g., try setting title="Frame %g".

XRECTS - plot rectangles on a two-dimensional grid

xrects x1min= x1max= x2min= x2max= [optional parameters] <rectangles

Required Parameters:

x1min	minimum x1 coordinate
x1max	maximum x1 coordinate
x2min	minimum x2 coordinate
x2max	maximum x2 coordinate

Optional Parameters:

color=red	color used for rectangles
-----------	---------------------------

Optional resource parameters (defaults taken from resource database):

width=	width in pixels of window
height=	height in pixels of window
nTic1=	number of tics per numbered tic on axis 1
grid1=	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
nTic2=	number of tics per numbered tic on axis 2
grid2=	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelFont=	font name for axes labels
title=	title of plot
titleFont=	font name for title
titleColor=	color for title
axesColor=	color for axes
gridColor=	color for grid lines
style=	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)

FFTLAB - Motif-X based graphical 1D Fourier Transform

Usage: fftlab

Caveat: you must have the Motif Developer's package to install this code

SUPSCONTOUR - PostScript CONTOUR plot of a segy data set

supscntour <stdin [optional parameters] | ...

Optional parameters:

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the pscontour selfdoc for the remaining parameters.

On NeXT: supscntour < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2

Credits:



CWP: Dave Hale and Zhiming Li (pscontour, etc.)

Jack Cohen and John Stockwell (supscontour, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Aarhus University: Morten W. Pedersen copied everything from the xwigb source and just replaced all occurrences of the word

#### Notes:

When the number of traces isn't known, we need to count the traces for pscontour. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSCUBECONTOUR - PostScript CUBE plot of a segy data set

supscubecontour <stdin [optional parameters] | ...

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the pscubecontour selfdoc for the remaining parameters.

example: supscubecontour < infile [optional parameters] | gv -

Credits:

CWP: Dave Hale and Zhiming Li (pscube)  
      Jack K. Cohen (suxmovie)  
      John Stockwell (supscubecontour)

Notes:

When `n2` isn't getparred, we need to count the traces for pscube. Although we compute `ntr`, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use `tr.data`, we allocate a trace buffer for code clarity.

SUPSCUBE - PostScript CUBE plot of a segy data set

supscube <stdin [optional parameters] | ...

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the pscube selfdoc for the remaining parameters.

On NeXT: supscube < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pscube)  
      Jack K. Cohen (suxmovie)  
      John Stockwell (supscube)

Notes:

When `n2` isn't getparred, we need to count the traces  
for pscube. Although we compute `ntr`, we don't allocate a 2-d array  
and content ourselves with copying trace by trace from  
the data "file" to the pipe into the plotting program.  
Although we could use `tr.data`, we allocate a trace buffer  
for code clarity.

SUPSGRAPH - PostScript GRAPH plot of a segy data set

supsgraph <stdin [optional parameters] | ...

Optional parameters:

style=seismic seismic is default here, =normal is alternate  
(see psgraph selfdoc for style definitions)

nplot is the number of traces (ntr is an acceptable alias for nplot)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the psgraph selfdoc for the remaining parameters.

On NeXT: supsgraph < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pswignp, etc.)  
Jack Cohen and John Stockwell (supswignp, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for pswignp. You can make this value "known" either by getparrnng nplot or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSIMAGE - PostScript IMAGE plot of a segy data set

supsimage <stdin [optional parameters] | ...

Optional parameters:

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the psimage selfdoc for the remaining parameters.

On NeXT: supsimage < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2

Credits:



CWP: Dave Hale and Zhiming Li (psimage, etc.)  
Jack Cohen and John Stockwell (supsimage, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for psimage. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.  
"remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSMAX - PostScript of the MAX, min, or absolute max value on each trace  
of a SEG Y (SU) data set

```
supsmx <stdin >postscript file [optional parameters]
```

Optional parameters:

mode=max max value

=min min value

=abs absolute max value

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to over-ride the header values if  
not.

See the sumax selfdoc for additional parameter.

See the psgraph selfdoc for the remaining parameters.

Credits:

CWP: John Stockwell, based on Jack Cohen's SU JACkeT

Notes:

When the number of traces isn't known, we need to count the traces for psgraph. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

SUPSMOVIE - PostScript MOVIE plot of a segy data set

```
supsmovie <stdin [optional parameters] | ...
```

Optional parameters:

n2 is the number of traces per frame. If not getparred then it is the total number of traces in the data set.

n3 is the number of frames. If not getparred then it is the total number of frames in the data set measured by ntr/n2

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the psmovie selfdoc for the remaining parameters.

On NeXT: supsmovie < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (psmovie)  
      Jack K. Cohen (suxmovie)  
      John Stockwell (supsmovie)

Notes:

When n2 isn't getparred, we need to count the traces for psmovie. In this case: we are using tmpfile because on many machines it is implemented as a memory area instead of a disk file. Although we compute ntr, we don't allocate a 2-d array and content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSWIGB - PostScript Bit-mapped WIGgle plot of a segy data set

supswigb <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or

vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: pswigb  
See the pswigb selfdoc for the remaining parameters.

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2, keyword (if set)

Credits:

CWP: Dave Hale and Zhiming Li (pswigb, etc.)

Jack Cohen and John Stockwell (supswigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count the traces for pswigb. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUPSWIGP - PostScript Polygon-filled WIGgle plot of a segy data set

supswigp <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or

vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: pswigp  
See the pswigp selfdoc for the remaining parameters.



On NeXT: supswigp < infile [optional parameters] | open

Trace header fields accessed: ns, ntr, tracr, tracl, delrt, trid, dt, d1, d2, f1, f2, key specified by key

Credits:

CWP: Dave Hale and Zhiming Li (pswigp, etc.)

Jack Cohen and John Stockwell (supswigp, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor scale factors, added vsp style

Notes:

When the number of traces isn't known, we need to count the traces for pswigp. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXCONTOUR - X CONTOUR plot of Seismic UNIX tracefile via vector plot call

suxwigb <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

If key=keyword is set, then the values of x2 are taken from the header field represented by the keyword (for example key=offset, will show traces in true offset). This permit unequally spaced traces to be plotted. Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: xcontour  
See the xcontour selfdoc for the remaining parameters.

Credits:

CWP: Dave Hale and Zhiming Li (xwigb, etc.)

Jack Cohen and John Stockwell (suxwigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Aarhus University: Morten W. Pedersen copied everything from the xwigb source and just replaced all occurrences of the word xwigb with xcountour ;-)

#### Notes:

When the number of traces isn't known, we need to count the traces for xcountour. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXGRAPH - X-windows GRAPH plot of a segy data set

suxgraph <stdin [optional parameters] | ...

Optional parameters:

(see xgraph selfdoc for optional parametes)

nplot= number of traces (ntr is an acceptable alias for nplot)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the xgraph selfdoc for the remaining parameters.

On NeXT:        suxgraph < infile [optional parameters] | open

Credits:

CWP: Dave Hale and Zhiming Li (pswiggp, etc.)

Jack Cohen and John Stockwell (supswigp, etc.)

Notes:

When the number of traces isn't known, we need to count the traces for pswigp. You can make this value "known" either by getparring nplot or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXIMAGE - X-windows IMAGE plot of a segy data set

```
suximage infile= [optional parameters] | ... (direct I/O)
or
suximage <stdin [optional parameters] | ... (sequential I/O)
```

Optional parameters:

infile=NULL SU data to be plotted, default stdin with sequential access  
if 'infile' provided, su data read by (fast) direct access

with ftr,dtr and n2 suximage will pass a subset of data  
to the plotting program-ximage:  
ftr=1 First trace to be plotted  
dtr=1 Trace increment to be plotted  
n2=tr.ntr (Max) number of traces to be plotted (ntr is an alias for n2)  
Priority: first try to read from parameter line;  
if not provided, check trace header tr.ntr;  
if still not provided, figure it out using ftello

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
=.004 for seismic (if not set)  
=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension  
=1.0 (if not set or was set to 0)

key= key for annotating d2 (slow dimension)  
If annotation is not at proper increment, try  
setting d2; only first trace's key value is read

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
=1.0 for seismic (if not set)  
=d2 for nonseismic (if not set)

verbose=0 =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to override the header values if not.

See the ximage selfdoc for the remaining parameters.

#### Credits:

CWP: Dave Hale and Zhiming Li (ximage, etc.)  
Jack Cohen and John Stockwell (suximage, etc.)  
MTU: David Forel, June 2004, added key for annotating d2  
ConocoPhillips: Zhaobo Meng, Dec 2004, added direct I/O

#### Notes:

When provide ftr and dtr and infile, suximage can be used to plot multi-dimensional volumes efficiently. For example, for a Offset-CDP dataset with 32 offsets, the command line  
suximage infile=volume3d.su ftr=1 dtr=32 ... &  
will display the zero-offset common offset data with ranrom access. It is highly recommend to use infile= to view large datasets, since using stdin only allows sequential access, which is very slow for large datasets.

When the number of traces isn't known, we need to count the traces for ximage. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXMAX - X-windows graph of the MAX, min, or absolute max value on each trace of a SEG-Y (SU) data set

```
suxmax <stdin [optional parameters]
```

Optional parameters:

mode=max max value

=min min value

=abs absolute max value

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0

=1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is time and the "slow dimension" is usually trace number or range. Also note that "foreign" data tapes may have something unexpected in the d2,f2 fields, use segyclean to clear these if you can afford the processing time or use d2= f2= to over-ride the header values if not.

See the sumax selfdoc for additional parameter.

See the xgraph selfdoc for the remaining parameters.



Credits:

CWP: John Stockwell, based on Jack Cohen's SU JACkeT

Notes:

When the number of traces isn't known, we need to count the traces for xgraph. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

SUXMOVIE - X MOVIE plot of a 2D or 3D segy data set

suxmovie <stdin [optional parameters]

Optional parameters:

n1=tr.ns                    number of samples per trace  
ntr=tr.ntr                number of traces in the data set  
n2=tr.shortpad or tr.ntr number of traces in inline direction  
n3=ntr/n2                number of traces in crossline direction  
  
d1=tr.d1 or tr.dt/10<sup>6</sup>    sampling interval in the fast dimension  
    =.004 for seismic    (if not set)  
    =1.0 for nonseismic (if not set)  
  
d2=tr.d2                sampling interval in the slow dimension  
    =1.0    (if not set)  
  
d3=1.0                sampling interval in the slowest dimension  
  
f1=tr.f1 or 0.0           first sample in the z dimension  
f2=tr.f2 or 1.0           first sample in the x dimension  
f3=1.0  
  
mode=0                0= x,z slice movie through y dimension (in line)  
                      1= y,z slice movie through x dimension (cross line)  
                      2= x,y slice movie through z dimension (time slice)  
  
verbose=0                =1 to print some useful information  
  
tmpdir=    if non-empty, use the value as a directory path  
          prefix for storing temporary files; else if the  
          the CWP\_TMPDIR environment variable is set use  
          its value for the path; else use tmpfile()

Notes:

For seismic data, the "fast dimension" is either time or depth and the "slow dimension" is usually trace number. The 3D data set is expected to have n3 sets of n2 traces representing the horizontal coverage of n2\*d2 in x and n3\*d3 in y direction.

The data is read to memory with and piped to xmovie with the respective sampling parameters.

See the xmovie selfdoc for the remaining parameters and X functions.

SUXPICKER - X-windows WIGgle plot PICKER of a segy data set

suxpicker <stdin [optional parameters] | ...

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword

specified by keyword

n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)

d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension

=.004 for seismic (if not set)

=1.0 for nonseismic (if not set)

d2=tr.d2 sampling interval in the slow dimension

=1.0 (if not set)

f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension

f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension

=1.0 for seismic (if not set)

=d2 for nonseismic (if not set)

verbose=0

=1 to print some useful information

tmpdir= if non-empty, use the value as a directory path

prefix for storing temporary files; else if the

the CWP\_TMPDIR environment variable is set use

its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is

time and the "slow dimension" is usually trace number or range.

Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

See the xpicker selfdoc for the remaining parameters.

#### Credits:

CWP: Dave Hale and Zhiming Li (xpicker, etc.)  
Jack Cohen and John Stockwell (suxpicker, etc.)

#### Notes:

When the number of traces isn't known, we need to count the traces for xpicker. You can make this value "known" either by getparring n2 or by having the ntr field set in the trace header. A getparred value takes precedence over the value in the trace header.

When we do have to count the traces, we use the "tmpfile" routine because on many machines it is implemented as a memory area instead of a disk file.

If your system does make a disk file, consider altering the code to remove the file on interrupt. This could be done either by trapping the interrupt with "signal" or by using the "tmpnam" routine followed by an immediate "remove" (aka "unlink" in old unix).

When we must compute ntr, we don't allocate a 2-d array, but just content ourselves with copying trace by trace from the data "file" to the pipe into the plotting program. Although we could use tr.data, we allocate a trace buffer for code clarity.

SUXWIGB - X-windows Bit-mapped WIGgle plot of a segy data set  
This is a modified suxwigb that uses the depth or coordinate scaling  
when such values are used as keys.

```
suxwigb <stdin [optional parameters] | ...
```

Optional parameters:

key=(keyword) if set, the values of x2 are set from header field  
specified by keyword  
n2=tr.ntr or number of traces in the data set (ntr is an alias for n2)  
d1=tr.d1 or tr.dt/10<sup>6</sup> sampling interval in the fast dimension  
    =.004 for seismic (if not set)  
    =1.0 for nonseismic (if not set)  
d2=tr.d2 sampling interval in the slow dimension  
    =1.0 (if not set)  
f1=tr.f1 or tr.delrt/10<sup>3</sup> or 0.0 first sample in the fast dimension  
f2=tr.f2 or tr.tracr or tr.tracl first sample in the slow dimension  
    =1.0 for seismic (if not set)  
    =d2 for nonseismic (if not set)

style=seismic normal (axis 1 horizontal, axis 2 vertical) or  
vsp (same as normal with axis 2 reversed)

Note: vsp requires use of a keyword

verbose=0                      =1 to print some useful information

tmpdir= if non-empty, use the value as a directory path  
prefix for storing temporary files; else if the  
the CWP\_TMPDIR environment variable is set use  
its value for the path; else use tmpfile()

Note that for seismic time domain data, the "fast dimension" is  
time and the "slow dimension" is usually trace number or range.  
Also note that "foreign" data tapes may have something unexpected  
in the d2,f2 fields, use segyclean to clear these if you can afford  
the processing time or use d2= f2= to override the header values if  
not.

If key=keyword is set, then the values of x2 are taken from the header  
field represented by the keyword (for example key=offset, will show  
traces in true offset). This permit unequally spaced traces to be plotted.  
Type sukeyword -o to see the complete list of SU keywords.

This program is really just a wrapper for the plotting program: xwigb  
See the xwigb selfdoc for the remaining parameters.

#### Credits:

CWP: Dave Hale and Zhiming Li (xwigb, etc.)

Jack Cohen and John Stockwell (suxwigb, etc.)

Delphi: Alexander Koek, added support for irregularly spaced traces

Modified by Brian Zook, Southwest Research Institute, to honor  
scale factors, added vsp style

#### Notes:

When the number of traces isn't known, we need to count  
the traces for xwigb. You can make this value "known"  
either by getparring n2 or by having the ntr field set  
in the trace header. A getparred value takes precedence  
over the value in the trace header.

When we must compute ntr, we don't allocate a 2-d array,  
but just content ourselves with copying trace by trace from  
the data "file" to the pipe into the plotting program.  
Although we could use tr.data, we allocate a trace buffer  
for code clarity.

SXPLOT - X Window plot a triangulated sloth function  $s(x_1, x_2)$

sxplot <modelfile [optional parameters]

Optional Parameters:

edgecolor=cyan	color to draw fixed edges
tricolor=yellow	color to draw non-fixed edges of triangles
=none	non-fixed edges of triangles are not shown
bclip=minimum sloth	sloth value corresponding to black
wclip=maximum sloth	sloth value corresponding to white
x1beg=x1min	value at which x1 axis begins
x1end=x1max	value at which x1 axis ends
x2beg=x2min	value at which x2 axis begins
x2end=x2max	value at which x2 axis ends
cmap=gray	gray, hue, or default colormaps may be specified

Optional resource parameters (defaults taken from resource database):

width=	width in pixels of window
height=	height in pixels of window
nTic1=	number of tics per numbered tic on axis 1
grid1=	grid lines on axis 1 - none, dot, dash, or solid
label1=	label on axis 1
nTic2=	number of tics per numbered tic on axis 2
grid2=	grid lines on axis 2 - none, dot, dash, or solid
label2=	label on axis 2
labelFont=	font name for axes labels
title=	title of plot
titleFont=	font name for title
titleColor=	color for title
axesColor=	color for axes
gridColor=	color for grid lines
style=	normal (axis 1 horizontal, axis 2 vertical) or seismic (axis 1 vertical, axis 2 horizontal)

AUTHOR: Dave Hale, Colorado School of Mines, 05/17/91



GBBEAM - Gaussian beam synthetic seismograms for a sloth model

gbbeam <rayends >syntraces xg= zg= [optional parameters]

Required Parameters:

xg=                    x coordinates of receiver surface  
zg=                    z coordinates of receiver surface

Optional Parameters:

ng=101                number of receivers (uniform distributed along surface)  
krecord=1             integer index of receiver surface (see notes below)  
ang=0.0               array of angles corresponding to amplitudes in amp  
amp=1.0               array of amplitudes corresponding to angles in ang  
bw=0                   beamwidth at peak frequency  
nt=251                number of time samples  
dt=0.004             time sampling interval  
ft=0.0                first time sample  
reftrans=0            =1 complex refl/transm. coefficients considered  
prim                   =1, only single-reflected rays are considered ",  
                      =0, only direct hits are considered  
atten=0                =1 add noncausal attenuation  
                      =2 add causal attenuation  
lscale=                if defined restricts range of extrapolation  
aperture=             maximum angle of receiver aperture  
fpeak=0.1/dt          peak frequency of ricker wavelet  
infofile              ASCII-file to store useful information

NOTES:

Only rays that terminate with index krecord will contribute to the synthetic seismograms at the receiver (xg,zg) locations. The receiver locations are determined by cubic spline interpolation of the specified (xg,zg) coordinates.

AUTHOR: Dave Hale, Colorado School of Mines, 02/09/91

MODIFIED: Andreas Rueger, Colorado School of Mines, 08/18/93

Modifications include: 2.5-D amplitudes, computation of reflection/transmission losses, attenuation, timewindow, lscale, aperture, beam width, etc.

NORMRAY - dynamic ray tracing for normal incidence rays in a sloth model

normray <modelfile >rayends [optional parameters]

Optional Parameters:

caustic 0: show all rays 1: show only caustic rays  
nonsurface 0: show rays which reach surface 1: show all rays  
surface 0: shot ray from subsurface 1: from surface  
nrays number of location to shoot rays  
dangle increment of ray angle for one location  
nangle number of rays shot from one location  
ashift shift first taking off angle  
xs1 x of shooting location  
zs1 z of shooting location  
nangle=101 number of takeoff angles  
fangle=-45 first takeoff angle (in degrees)  
rayfile file of ray x,z coordinates of ray-edge intersections  
nxz=101 number of (x,z) in optional rayfile (see notes below)  
wavefile file of ray x,z coordinates uniformly sampled in time  
nt=101 number of (x,z) in optional wavefile (see notes below)  
infofile ASCII-file to store useful information  
fresnelfile used if you want to plot the fresnel volumes.  
default is <fresnelfile.bin>  
outparfile contains parameters for the plotting software.  
default is <outpar>  
krecord if specified, only rays incident at interface with index  
krecord are displayed and stored  
prim =1, only single-reflected rays are plotted ",  
=0, only direct hits are displayed  
ffreq=-1 FresnelVolume frequency  
refseq=1,0,0 index of reflector followed by sequence of reflection (1)  
transmission(0) or ray stops(-1).  
The default rayend is at the model boundary.  
NOTE:refseq must be defined for each reflector

NOTES:

The rayends file contains ray parameters for the locations at which the rays terminate.

The rayfile is useful for making plots of ray paths.

nxz should be larger than twice the number of triangles intersected by the rays.

The wavefile is useful for making plots of wavefronts.

The time sampling interval in the wavefile is  $t_{\max}/(n_t-1)$ , where  $t_{\max}$  is the maximum time for all rays.

The infofile is useful for collecting information along the individual rays. The fresnelfile contains data used to plot the Fresnel volumes. The outparfile stores information used for the plotting software.

AUTHOR: Dave Hale, Colorado School of Mines, 02/16/91

MODIFIED: Andreas Rueger, Colorado School of Mines, 08/12/93

Modifications include: functions writeFresnel, checkIfSourceIsOnEdge; options refseq=, krecord=, prim=, infofile=; computation of reflection/transmission losses, attenuation.

MODIFIED: Boyi Ou, Colorado School of Mines, 4/14/95

#### Notes:

This code can shoot rays from specified interface by users, normally you need to use gbmodel2 to generate interface parameters for this code, both code have a parameter named nrays, it should be same. If you just want to shoot rays from one specified location, you need to specify xs1,zs1, otherwise, leave them alone. If you want to shoot rays from surface, you need to define surface equal to 1. The rays from one location will be approximately symetric with direction Normal\_direction - ashift.(if nangle is odd, it is symetric, even, almost symetric. The formula for the first take off angle is:  $\text{angle} = \text{normal\_direction} - \text{nangle}/2 * \text{dangle} - \text{ashift}$ . If you only want to see caustics, you specify caustic=1, if you want to see rays which does not reach surface, you specify nonsurface=1.

/

TRI2UNI - convert a TRIangulated model to UNIformly sampled model

tri2uni <triangfile >uniformfile n2= n1= [optional parameters]

Required Parameters:

n1=	number of samples in the first (fast) dimension
n2=	number of samples in the second dimension

Optional Parameters:

d1=1.0	sampling interval in first (fast) dimension
d2=1.0	sampling interval in second dimension
f1=0.0	first value in dimension 1 sampled
f2=0.0	first value in dimension 2 sampled

Note:

The triangulated/uniformly-sampled quantity is assumed to be  $\text{sloth} = 1/v^2$

AUTHOR: Dave Hale, Colorado School of Mines, 04/23/91

TRIMODEL - make a triangulated sloth ( $1/\text{velocity}^2$ ) model

trimodel >modelfile [optional parameters]

Optional Parameters:

xmin=0.0	minimum horizontal coordinate (x)
xmax=1.0	maximum horizontal coordinate (x)
zmin=0.0	minimum vertical coordinate (z)
zmax=1.0	maximum vertical coordinate (z)
xedge=	x coordinates of an edge
zedge=	z coordinates of an edge
sedge=	sloth along an edge
kedge=	array of indices used to identify edges
normray	0:do not generate parameters 1: does it
normface	specify which interface to shoot rays
nray	number of locations to shoot rays
sfill=	x, z, x0, z0, s00, dsdx, dsdz to fill a region
densfill=	x, z, dens to fill a region
qfill=	x, z, Q-factor to fill a region
maxangle=5.0	maximum angle (deg) between adjacent edge segments

Notes:

More than set of xedge, zedge, and sedge parameters may be specified, but the numbers of these parameters must be equal.

Within each set, vertices will be connected by fixed edges.

Edge indices in the k array are used to identify edges specified by the x and z parameters. The first k index corresponds to the first set of x and z parameters, the second k index corresponds to the second set, and so on.

After all vertices and their corresponding sloth values have been inserted into the model, the optional sfill parameters are used to fill closed regions bounded by fixed edges. Let (x,z) denote any point inside a closed region. Sloth inside this region is determined by  $s(x,z) = s00 + (x-x0)*dsdx + (z-z0)*dsdz$ . The (x,z) component of the sfill parameter is used to identify a closed region.

AUTHOR: Dave Hale, Colorado School of Mines, 02/12/91  
MODIFIED: Andreas Rueger, Colorado School of Mines, 01/18/93  
Fill regions with attenuation Q-factors and density values.  
MODIFIED: Craig Artley, Colorado School of Mines, 03/27/94  
Corrected bug in computing s00 in makeSlothForTri() function.  
MODIFIED: Boyi Ou, Colorado School of Mines, 4/14/95  
Make code to generate interface parameters for shooting rays  
from specified interface

NOTE:

When you use normface to specify interface, the number of interface might not be the number of interface in the picture, for example, you build a one interface model, this interface is very long, so in the shell, you use three part of xedge,zedge,sedge to make this interface, so when you use normface to specify interface, this interface is just part of whole interface. If you want see the normal rays from entire interface, you need to make normal ray picture few times, and merge them together.

TRIRAY - dynamic RAY tracing for a TRIangulated sloth model

triray <modelfile >rayends [optional parameters]

Optional Parameters:

xs=(max-min)/2 x coordinate of source (default is halfway across model)

zs=min z coordinate of source (default is at top of model)

nangle=101 number of takeoff angles

fangle=-45 first takeoff angle (in degrees)

langle=45 last takeoff angle (in degrees)

rayfile= file of ray x,z coordinates of ray-edge intersections

nxz=101 number of (x,z) in optional rayfile (see notes below)

wavefile= file of ray x,z coordinates uniformly sampled in time

nt=101 number of (x,z) in optional wavefile (see notes below)

infofile= ASCII-file to store useful information

fresnelfile= used if you want to plot the fresnel volumes.

default is <fresnelfile.bin>

outparfile= contains parameters for the plotting software.

default is <outpar>

krecord= if specified, only rays incident at interface with index  
krecord are displayed and stored

prim= 1, only single-reflected rays are plotted  
=0, only direct hits are displayed

ffreq=-1 FresnelVolume frequency

refseq=1,0,0 index of reflector followed by sequence of reflection (1)  
transmission(0) or ray stops(-1).

The default rayend is at the model boundary.

NOTE:refseq must be defined for each reflector

NOTES:

The rayends file contains ray parameters for the locations at which  
the rays terminate.

The rayfile is useful for making plots of ray paths.

nxz should be larger than twice the number of triangles intersected  
by the rays.

The wavefile is useful for making plots of wavefronts.

The time sampling interval in the wavefile is  $t_{\max}/(nt-1)$ ,  
where  $t_{\max}$  is the maximum time for all rays.

The infofile is useful for collecting information along the  
individual rays. The fresnelfile contains data used to plot  
the Fresnel volumes. The outparfile stores information used

for the plotting software.

AUTHOR: Dave Hale, Colorado School of Mines, 02/16/91  
MODIFIED: Andreas Rueger, Colorado School of Mines, 08/12/93  
Modifications include: functions writeFresnel, checkIfSourceIsOnEdge;  
options refseq=, krecord=, prim=, infofile=;  
computation of reflection/transmission losses, attenuation.



TRISEIS - Gaussian beam synthetic seismograms for a sloth model

triseis <modelfile >seisfile xs= zs= xg= zg= [optional parameters]

Required Parameters:

xs=	x coordinates of source surface
zs=	z coordinates of source surface
xg=	x coordinates of receiver surface
zg=	z coordinates of receiver surface

Optional Parameters:

ns=1	number of sources uniformly distributed along s surface
ds=	increment between source locations (see notes below)
fs=0.0	first source location (relative to start of s surface)
ng=101	number of receivers uniformly distributed along g surface
dg=	increment between receiver locations (see notes below)
fg=0.0	first receiver location (relative to start of g surface)
dgds=0.0	change in receiver location with respect to source location
krecord=1	integer index of receiver surface (see notes below)
kreflect=-1	integer index of reflecting surface (see notes below)
prim	=1, only single-reflected rays are considered ", =0, only direct hits are considered
bw=0	beamwidth at peak frequency
nt=251	number of time samples
dt=0.004	time sampling interval
ft=0.0	first time sample
nangle=101	number of ray takeoff angles
fangle=-45	first ray takeoff angle (in degrees)
langle=45	last ray takeoff angle (in degrees)
reftrans=0	=1 complex refl/transm. coefficients considered
atten=0	=1 add noncausal attenuation =2 add causal attenuation
lscale=	if defined restricts range of extrapolation
fpeak=0.1/dt	peak frequency of ricker wavelet
aperture=	maximum angle of receiver aperture

NOTES:

Only rays that terminate with index krecord will contribute to the synthetic seismograms at the receiver (xg,zg) locations. The source and receiver locations are determined by cubic spline interpolation of the specified (xs,zs) and (xg,zg) coordinates. The default source location increment (ds) is determined to span the source surface defined by (xs,zs). Likewise for dg.

AUTHOR: Dave Hale, Colorado School of Mines, 02/09/91  
MODIFIED: Andreas Rueger, Colorado School of Mines, 08/18/93  
Modifications include: 2.5-D amplitudes, correction for ref/transm,  
timewindow, lscale, aperture, beam width, etc.

UNI2TRI - convert UNIformly sampled model to a TRIangulated model

uni2tri <slothfile >modelfile n2= n1= [optional parameters]

Required Parameters:

n1= number of samples in first (fast) dimension  
n2= number of samples in second dimension

Optional Parameters:

d1=1.0 sampling interval in dimension 1  
d2=1.0 sampling interval in dimension 2  
f1=0.0 first value in dimension 1  
f2=0.0 first value in dimension 2  
ifile= triangulated model file used as initial model  
errmax= maximum sloth error (see notes below)  
verbose=1 =0 for silence  
          =1 to report maximum error at each stage to stderr  
          =2 to also write the normalized error to efile  
efile=emax.dat filename for error file (for verbose=2)  
mm=0 output every mm-th intermediate model (0 for none)  
mfile=intmodel intermediate models written to intmodel%d  
method=3 =1 add 1 vertex at maximum error  
          =2 add vertex to every triangle that exceeds errmax  
          =3 method 2, but avoid closely spaced vertices  
tol=10 closeness criterion for (in samples)  
sfill= x, z, x0, z0, s00, dsdx, dsdz to fill a region

Notes:

Triangles are constructed until the maximum error is not greater than the user-specified errmax. The default errmax is 1% of the maximum value in the sampled input file.

After the uniform values have been triangulated, the optional sfill parameters are used to fill closed regions bounded by fixed edges. Let (x,z) denote any point inside a closed region. Values inside this region is determined by  $s(x,z) = s00 + (x-x0)*dsdx + (z-z0)*dsdz$ . The (x,z) component of the sfill parameter is used to identify a closed region.

The uniformly sampled quantity is assumed to be  $sloth=1/v^2$ .

AUTHOR: Craig Artley, Colorado School of Mines, 03/31/94  
NOTE: After a program outlined by Dave Hale, 12/27/90.

SPSPLOT - plot a triangulated sloth function  $s(x,z)$  via PostScript

spsplot <modelfile> >postscriptfile [optional parameters]

Optional Parameters:

gedge=0.0	gray to draw fixed edges (in interval [0.0,1.0])
gtri=1.0	gray to draw non-fixed edges of triangles
gmin=0.0	min gray to shade triangles (in interval [0.0,1.0])
gmax=1.0	max gray to shade triangles (in interval [0.0,1.0])
sgmin=minimum $s(x,z)$	$s(x,y)$ corresponding to gmin
sgmax=maximum $s(x,z)$	$s(x,y)$ corresponding to gmax
xbox=1.5	offset in inches of left side of axes box
ybox=1.5	offset in inches of bottom side of axes box
wbox=6.0	width in inches of axes box
hbox=8.0	height in inches of axes box
xbeg=xmin	value at which x axis begins
xend=xmax	value at which x axis ends
dxnum=0.0	numbered tic interval on x axis (0.0 for automatic)
fxnum=xmin	first numbered tic on x axis (used if dxnum not 0.0)
nxtic=1	number of tics per numbered tic on x axis
gridx=none	grid lines on x axis - none, dot, dash, or solid
labelx=	label on x axis
zbeg=zmin	value at which z axis begins
zend=zmax	value at which z axis ends
dznum=0.0	numbered tic interval on z axis (0.0 for automatic)
fznum=zmin	first numbered tic on z axis (used if dznum not 0.0)
nztic=1	number of tics per numbered tic on z axis
gridz=none	grid lines on z axis - none, dot, dash, or solid
labelz=	label on z axis
labelfont=Helvetica	font name for axes labels
labelsize=12	font size for axes labels
title=	title of plot
titlefont=Helvetica-Bold	font name for title
titlesize=24	font size for title
titlecolor=black	color of title
axescolor=black	color of axes
gridcolor=black	color of grid
style=seismic	normal (z axis horizontal, x axis vertical) or seismic (z axis vertical, x axis horizontal)

Note: A value of gedge or gtri outside the interval [0.0,1.0] results in that class of edge not being drawn.

AUTHOR: Dave Hale, Colorado School of Mines, 10/18/90  
MODIFIED: Craig Artley, Colorado School of Mines, 03/27/94  
Tweaks to improve PostScript header, add basic color support.

NOTE: Have observed errors in output when compiled with optimization  
under NEXTSTEP 3.1. Caveat Emptor.

Modified: Morten Wendell Pedersen, Aarhus University, 23/3-97  
Added ticwidth, axeswidth, gridwidth parameters

Shells:

-----  
ARGV - give examples of dereferencing char \*\*argv

Usage: argv

-----  
COPYRIGHT - insert CSM COPYRIGHT lines at top of files in working directory

Usage: copyright file(s)

-----  
CPALL , RCPALL - for local and remote directory tree/file transfer

Usage: cpall sourcedir destinationdir

Caveat: destinationdir must exist and be writeable by the user

Usage: rcvall sourcedir remotemachine destinationdir

If user name is different on the remote machine, then second" entry is "remotemachine -l remoteusername"

Caveats: rsh, copy, and write permissions required

    You must be on the source machine,  
destinationdir must exist and be writeable by the user.

Notes: Both of these shell scripts use tar to do the transfer.

-----  
CWPFIND - look for files with patterns in CWPROOT/src/cwp/lib

Usage: cwpfind pattern\_fragment  
      cwpfind -e exact\_pattern

-----  
Grep - recursively call egrep in pwd

Usage: Grep [-egrep\_options] pattern

Caution: Do NOT redirect into file in pwd, either use something like >../Grep.out or perhaps pipe output into mail to yourself.

Author: Jack, 7/95

-----  
DIRTREE - show DIRectory TREE

Usage: dirtree

-----  
FILETYPE - list all files of given type

Usage: filetype string\_from\_file\_output

Examples:

filetype text - list printable files  
filetype stripped - list unstripped files

-----  
NEWCASE - Changes the case of all the filenames in a directory, dir

Usage: newcase -l dir change all filenames to lower case  
-u dir change all filenames to upper case

Notes: Useful for files downloaded from VAX.

-----  
OVERWRITE - copy stdin to stdout after EOF

This shell is called from the shell script: replace

-----  
PRECEDENCE - give table of C precedences from Kernighan and Ritchie

Usage: precedence

-----  
REPLACE - REPLACE string1 with string2 in files

Usage: replace string1 string2 files



```

-----
THIS_YEAR - print the current year

Usage: this_year

NOTES - useful for building dated filenames, etc.

-----
TIME_NOW - prints time in ZULU format with no spaces

Usage: time_now

Note: Useful for building dated filenames

-----
TODAYS_DATE - prints today's date in ZULU format with no spaces

Usage: todays_date

Note: Useful for building dated filenames

-----
USERNAMES - get list of all login names

Usage: usernames

-----
VARLIST - list variables used in a Fortran program

Usage: varlist file.f ...

Output is in the file: vars.file

-----
WEEKDAY - prints today's WEEKDAY designation

Usage: weekday

Note: Useful for building dated filenames

```

-----  
ZAP - kill processes by name

Typical usages:  
zap ximage  
zap 'xmovie|xgraph'

Zap accepts full pattern matching for the process names

Caveat: zap assumes that the FIRST field produced by the Unix "ps" command is the pid (process identifier) number. If not, change the number in the awk print statement to the appropriate field.

Author: Jack, 6/95 -- after Kernighan and Pike's zap

-----  
GENDOCs - generate complete list of selfdocs in latex form

Usage: gendocs -o output filename is: selfdocs.tex

-----  
STRIPTOTXT - put files from \$CWPROOT/src/doc/Stripped into a new  
directory in the form \$CWPROOT/src/TXT/NAME.txt

Usage: striptotxt

Author: John Stockwell, Sept 2001

-----  
UPDATEDOCALL - put self-docs in ../doc/Stripped

Usage: updatedocall

Note: this shell uses updatedoc to update the database used by  
suname and gendocs

-----  
UPDATEDOC - put self-docs in ../doc/Stripped and ../doc/Headers

Usage: updatedoc path

Notes:

Paths include: cwp/main cwp/lib cwp/shell par/main par/lib par/shell  
xplot/main xplot/lib psplot/main psplot/lib psplot/shell  
Xtcwp/main Xtcwp/lib Sfiio/main  
su/main/amplitudes su/main/attributes\_parameter\_estimation  
su/main/convolution\_correlation /su/main/data\_compression  
su/main/data\_conversion su/main/datuming su/main/decon\_shaping  
su/main/dip\_moveout su/main/filters su/main/headers su/main/interp\_extrap  
su/main/migration\_inversion su/main/multicomponent su/main/noise  
su/main/operations su/main/picking su/main/stacking su/main/statics  
su/main/stretching\_moveout\_resamp su/main/supromax  
su/main/synthetics\_waveforms\_testpatterns su/main/tapering  
su/main/transforms su/main/velocity\_analysis su/main/well\_logs  
su/main/windowing\_sorting\_muting  
su/lib su/shell su/graphics/psplot  
su/graphics/xplot tri/main tri/lib xtri tri/graphics/psplot

```
tetra/lib tetra/main  
comp/dct/lib comp/dct/main comp/dct/libutil comp/dwpt/1d/lib  
comp/dwpt/1d/main comp/dwpt/2d/lib comp/dwpt/2d/main
```

Use: updatedocall to update full directory, use updatehead to  
to update the master header file.

This shell builds the database used by suname and gendocs

-----  
UPDATEHEAD - update ../doc/Headers/Headers.all

Usage: updatehead

Notes:

This file builds the database used by suname

```

-----
LOOKPAR - show getpar lines in SU code with defines evaluated

Usage: lookpar filename ...

-----
MAXDIFF - find absolute maximum difference in two segy data sets

Usage: maxdiff file1 file2

-----
RECIP - sum opposing (reciprocal) offsets in cdp sorted data

Usage: recip <stdin >stdout

-----
RMAXDIFF - find percentage maximum difference in two segy data sets

Usage: rmaxdiff file1 file2

-----
SUAGC - perform agc on SU data

Note: this is an interface to sugain for backward compatibility
See selfdoc of:  sugain  for more information

-----
SUBAND - Trapezoid-like Sin squared tapered Bandpass filter via  SUFILTER

Usage:  suband < stdin > stdout

Note: this shell mimics the old program SUBAND, supersceded by SUFILTER
See selfdoc of:  sufilter  for more information

-----
SUDIFF, SUSUM, SUPROD, SUQUO, SUPTDIFF, SUPTSUM,
SUPTPROD, SUPTQUO - difference, sum, product, quotient of two SU data
                    sets via suop2

Usage:

```

```
sudiff file1 file2 > stdout
susum file1 file2 > stdout
...etc
```

Note: uses `suop2` to perform the computation

-----  
SUDOC - get DOC listing for code

Usage: `sudoc name`

Note: Use this shell script to get selfdoc information for  
codes labeled with and asterisk (\*) or pound sign (#) in `suname list`

-----  
SUENV - Instantaneous amplitude, frequency, and phase via: SUATTRIBUTES

Usage: `suenv < stdin > stdout`

Note: this shell mimics the old program SUENV, supersceded by SUATTRIBUTES  
See selfdoc of: `suattributes` for more information

-----  
SUFIND - get info from self-docs

Usage: `sufind [-v -n] string`

`sufind string` gives a brief synopsis  
`sufind -v string` is a verbose hunt for relevant items  
`sufind -n name_fragment` searches for command name

-----  
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`sufind string` gives a brief synopsis  
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`sufind -n name_fragment` searches for command name

Author: CWP: Jack K. Cohen, 1992  
Modified by: CWP: S. Narahara, 04/11/1998.

-----  
SUGENDOCs - generate complete list of selfdocs in latex form

Usage: sugendocs -o output filename is: selfdocs.tex

Note: this shell simply calls gendocs

-----  
SUHELP - list the CWP/SU programs and shells

Usage: suhelp

-----  
SUKEYWORD -- guide to SU keywords in segy.h

Usage: sukeyword -o to begin at the top of segy.h  
sukeyword [string] to find [string]

Note: keyword= occurs in many SU programs.

-----  
SUNAME - get name line from self-docs

Usage: suname [name]

Note: dummy selfdocs have been included in all cwp and shell programs  
that don't have automatic selfdocs.

-----  
UNGLITCH - zonk outliers in data

Usage: unglitch < stdin

Note: this shell just invokes: sugain < stdin qclip=.99 > stdout  
See selfdoc of: sugain for further information

-----  
MERGE2 - put 2 standard size PostScript figures on one page

Usage: merge2 fig1 fig2

Notes: Translation values are hard-coded numbers that work well for standard size (8.5 x 11) figures.

See selfdoc of: psmerge for details

-----  
MERGE4 - put 4 standard size PostScript plots on one page

Usage: merge4 ulfig urfig llfig lrfig

Note: Translation values are hard-coded numbers that work well for standard size (8.5 x 11) figures.

See selfdoc of: psmerge for further information



Libs:

BASIC - Basic C function interface to PostScript

```
beginps write PostScript prolog (including %%Pages comment)
endps write PostScript trailer (including %%Pages comment)
begineps write encapsulated PostScript prolog (no %%Pages comment)
endeps write encapsulated PostScript trailer (no %%Pages comment)
boundingbox set BoundingBox to llx lly urx ury
newpage print "%%%Page: label ordinal" to stdout
showpage print "showpage" to stdout
gsave print "GS" to stdout
grestore print "GR" to stdout
newpath print "NP" to stdout
closepath print "CP" to stdout
clip print "clip" to stdout
translate print "tx ty TR" to stdout, tx,ty = translation in x,y
scale print "sx sy SC" to stdout, sx,sy = scaling in x,y
rotate print "angle R0" to stdout, angle = rotation angle
concat print "m[0] m[1] m[2] m[3] m[4] m[5] CAT" to stdout
setgray print "gray setgray" to stdout, gray is 0-255 gray level
setrgbcolor print "red green blue setrgbcolor" to stdout
red,green,blue = 0-255 red,green,blue levels
setcolor set color by name based on definition in color structure
setlinewidth print "width SLW" to stdout, width = desired line width
setlinejoin print "code setlinejoin"
setdash print "[ dash ] offset setdash" to stdout
dash = array defining dash, offset = dash offset
moveto print "x y M" to stdout, move to x,y
rmoveto print "x y RM" to stdout, move to x,y
lineto print "x y L" to stdout, draw a line to x,y
rlineto print "x y RL" to stdout, draw a line to x,y
arc print "x y r ang1 ang2 arc" to stdout, draw an arc
x,y = vertex r = radius from ang1 to ang2
stroke print "S" to stdout
fill print "F" to stdout
show print "str SH" to stdout, show a string
justshow justify and show a string
image write a sampled gray-scale image
rgbimage write sampled color (rgb) image
setfont execute findfont, scalefont, and setfont for specified font
and size
fontbbox determine font bounding box for specified font and size
fontheight return maximum height for specified font and size
```

fontwidth return maximum width for specified font and size  
 fontcapheight return maximum capheight for specified font and size  
 fontxheight return maximum xheight for specified font and size  
 fontdescender return maximum descender for specified font and size  
 polyline draw a segmented line  
 markto draw a mark at specified location  
 rectclip set a rectangular clipping path  
 rectfill draw a filled rectangle  
 strokirect stroke a rectangle

#### Function Prototypes:

```

void beginps (void);
void endps (void);
void begineps (void);
void endeps (void);
void newpage (const char *label, int ordinal);
void boundingbox (int llx, int lly, int urx, int ury);
void showpage (void);
void gsave (void);
void grestore (void);
void newpath (void);
void closepath (void);
void clip(void);
void translate (float tx, float ty);
void scale (float sx, float sy);
void rotate (float angle);
void concat (float m[]);
void setgray (float gray);
void setrgbcolor (float red, float green, float blue);
void setcolor (const char *name);
void setlinewidth (float width);
void setlinejoin (int code);
void setdash (float dash[], int ndash, float offset);
void moveto (float x, float y);
void rmoveto (float x, float y);
void lineto (float x, float y);
void rlineto (float x, float y);
void arc (float x, float y, float r, float ang1, float ang2);
void stroke (void);
void fill (void);
void show (const char *str);
void justshow (float just, const char *str);
void image (int w, int h, int bps, float m[], unsigned char *samples);
  
```

```

void rgbimage (int w, int h, int bpc, float m[], unsigned char *samples);
void cymkimage (int w, int h, int bpc, float m[], unsigned char *samples);
void setfont (const char *fontname, float fontsize);
void fontbbox (const char *fontname, float fontsize, float bbox[]);
float fontheight (const char *fontname, float fontsize);
float fontwidth (const char *fontname, float fontsize);
float fontcapheight (const char *fontname, float fontsize);
float fontxheight (const char *fontname, float fontsize);
float fontdescender (const char *fontname, float fontsize);
float fontascender (const char *fontname, float fontsize);
void polyline (const float *x, const float *y, int n);
void markto (float x, float y, int index, float size);
void rectclip (float x, float y, float width, float height);
void rectfill (float x, float y, float width, float height);
void rectstroke (float x, float y, float width, float height);

```

justshow:

Input:

just justification factor

str string

image:

Input:

w width of image (in samples)

h height of image (in samples)

bpc number of bits per sample

m array[6] containing image matrix

samples array[w\*h] of sample values

rgbimage:

Input:

w width of image (in samples)

h height of image (in samples)

bpc number of bits per component

m array[6] containing image matrix

samples array[3\*w\*h] of sample values

cymkimage:

Input:

w width of image (in samples)

h height of image (in samples)

bpc number of bits per component

m array[6] containing image matrix

samples array[4\*w\*h] of sample values

polyline:

Input:

x array[n] of x-coordinates

y array[n] of y-coordinates

n number of points

markto:

Input:

x x-coordinate of mark

y y-coordinate of mark

index type of mark to draw

size size of mark

rectclip:

Input:

x x-coordinate of clipping path origin

y y-coordinate of clipping path origin

width width of clipping path

height height of clipping path

rectfill:

Input:

x x-coordinate of rectangle origin

y y-coordinate of rectangle origin

width width of rectangle

height height of rectangle

strokerect:

Input:

x x-coordinate of rectangle origin

y y-coordinate of rectangle origin

width width of rectangle

height height of rectangle

Notes:

The majority of these routines are self explanatory. They are just C wrappers that echo PostScript graphics commands.

justshow:

The justification factor positions the string relative to the current point.

just" may assume any value, but the common uses are:

-1.0 right-justify the string

-0.5 center the string on the current point

0.0 left-justify the string (like using "show")

image:

Level 1 PostScript implementations support 1, 2, 4, and 8 bits per sample. Level 2 adds support for 12 bits per sample.

Samples are hex-encoded, and output lines are limited to 78 characters.

rgbimage:

In general, Level 1 PostScript implementations do not support rgbimage. Level 2 supports 1, 2, 4, 8, and 12 bits per color component. The samples array should contain three color components (in R,G,B... order) for each sample value. Samples are hex-encoded, and output lines are limited to 78 characters.

polyline:

The path is stroked every 200 points.

References:

Author: Dave Hale, Colorado School of Mines, 1989

with modifications by Craig Artley, Colorado School of Mines, 1991, and additions by Dave Hale, Advance Geophysical, 1992.

PSAXESBOX3 - Functions draw an axes box via PostScript, estimate bounding box  
these are versions of psAxesBox and psAxesBox3 for psmovie.

psAxesBox3 draw an axes box via PostScript  
psAxesBBox3 estimate bounding box for an axes box drawn via psAxesBox3

Function Prototypes:

```
void psAxesBox3(
float x, float y, float width, float height,
float x1Beg, float x1End, float p1Beg, float p1End,
float d1Num, float f1Num, int n1Tic, int grid1, char *label1,
float x2Beg, float x2End, float p2Beg, float p2End,
float d2Num, float f2Num, int n2Tic, int grid2, char *label2,
char *labelFont, float labelSize,
char *title, char *titleFont, float titleSize,
int style, char *title2);
void psAxesBBox3(
float x, float y, float width, float height,
char *labelFont, float labelSize,
char *titleFont, float titleSize,
int style, int bbox[]);
```

Input:

x x coordinate of lower left corner of box  
y y coordinate of lower left corner of box  
width width of box  
height height of box  
x1Beg axis value at beginning of axis 1  
x1End axis value at end of axis 1  
p1Beg pad value at beginning of axis 1  
p1End pad value at end of axis 1  
d1Num numbered tic increment for axis 1 (0.0 for automatic)  
f1Num first numbered tic for axis 1  
n1Tic number of horizontal tics per numbered tic for axis 1  
grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID  
label1 label for axis 1  
x2Beg axis value at beginning of axis 2  
x2End axis value at end of axis 2  
p2Beg pad value at beginning of axis 2  
p2End pad value at end of axis 2  
d2Num vertical numbered tic increment (0.0 for automatic)  
f2Num first numbered vertical tic  
n2Tic number of vertical tics per numbered tic

grid2 grid code for vertical axis: NONE, DOT, DASH, or SOLID  
 label2 vertical axis label  
 labelFont name of font to use for axes labels  
 labelSize size of font to use for axes labels  
 title axes box title  
 titleFont name of font to use for title  
 titleSize size of font to use for title  
 style NORMAL (axis 1 on bottom, axis 2 on left)  
     SEISMIC (axis 1 on left, axis 2 on top)  
 title2 second title

psAxesBBox3:

Input:

x x coordinate of lower left corner of box  
 y y coordinate of lower left corner of box  
 width width of box  
 height height of box  
 labelFont name of font to use for axes labels  
 labelSize size of font to use for axes labels  
 titleFont name of font to use for title  
 titleSize size of font to use for title  
 style NORMAL (axis 1 on bottom, axis 2 on left)  
     SEISMIC (axis 1 on left, axis 2 on top)  
 Output:  
 bbox bounding box (bbox[0:3] = llx, lly, ulx, uly)

Notes:

psAxesBox3:

psAxesBox will determine the numbered tic increment and first  
 numbered tic automatically, if the specified increment is zero.

Pad values must be specified in the same units as the corresponding  
 axes values. These pads are useful when the contents of the axes box  
 requires more space than implied by the axes values. For example,  
 the first and last seismic wiggle traces plotted inside an axes box  
 will typically extend beyond the axes values corresponding to the  
 first and last traces. However, all tics will lie with the limits  
 specified in the axes values (x1Beg, x1End, x2Beg, x2End).

psAxesBBox3:

psAxesBBox uses font sizes to estimate the bounding box for  
 an axes box drawn with psAxesBox. To be on the safe side,  
 psAxesBBox overestimates.

psAxesBBox assumes that the axes labels and titles do not extend beyond the corresponding edges of the axes box.

References:

(see references in basic.c)

Author: Dave Hale, Colorado School of Mines, 06/27/89

modified by Zhiming Li, CSM, 7/1/90



PSAXESBOX - Functions to draw PostScript axes and estimate bounding box

psAxesBox Draw an axes box via PostScript

psAxesBBox estimate bounding box for an axes box drawn via psAxesBox

Function Prototypes:

```
void psAxesBox(
float x, float y, float width, float height,
float x1Beg, float x1End, float p1Beg, float p1End,
float d1Num, float f1Num, int n1Tic, int grid1, char *label1,
float x2Beg, float x2End, float p2Beg, float p2End,
float d2Num, float f2Num, int n2Tic, int grid2, char *label2,
char *labelFont, float labelSize,
char *title, char *titleFont, float titleSize,
char *titleColor, char *axesColor, char *gridColor,
float ticwidth, float axeswidth, float gridwidth,
int style);
```

```
void psAxesBBox(
float x, float y, float width, float height,
char *labelFont, float labelSize,
char *titleFont, float titleSize,
int style, int bbox[]);
```

psAxesBox:

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

x1Beg axis value at beginning of axis 1

x1End axis value at end of axis 1

p1Beg pad value at beginning of axis 1

p1End pad value at end of axis 1

d1Num numbered tic increment for axis 1 (0.0 for automatic)

f1Num first numbered tic for axis 1

n1Tic number of horizontal tics per numbered tic for axis 1

grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID

label1 label for axis 1

x2Beg axis value at beginning of axis 2

x2End axis value at end of axis 2

p2Beg pad value at beginning of axis 2

p2End pad value at end of axis 2

d2Num vertical numbered tic increment (0.0 for automatic)  
f2Num first numbered vertical tic  
n2Tic number of vertical tics per numbered tic  
grid2 grid code for vertical axis: NONE, DOT, DASH, or SOLID  
label2 vertical axis label  
labelFont name of font to use for axes labels  
labelSize size of font to use for axes labels  
title axes box title  
titleFont name of font to use for title  
titleSize size of font to use for title  
titleColor color to use for title  
axesColor color to use for axes and axes labels  
gridColor color to use for grid lines  
axeswidth width (in points) of axes  
ticwidth width (in points) of tic marks  
gridwidth width (in points) of grid lines  
style NORMAL (axis 1 on bottom, axis 2 on left)  
SEISMIC (axis 1 on left, axis 2 on top)

psAxesBBox:

Input:

x x coordinate of lower left corner of box  
y y coordinate of lower left corner of box  
width width of box  
height height of box  
labelFont name of font to use for axes labels  
labelSize size of font to use for axes labels  
titleFont name of font to use for title  
titleSize size of font to use for title  
style NORMAL (axis 1 on bottom, axis 2 on left)  
SEISMIC (axis 1 on left, axis 2 on top)

Output:

bbox bounding box (bbox[0:3] = llx, lly, ulx, uly)

Notes:

psAxesBox:

psAxesBox will determine the numbered tic increment and first numbered tic automatically, if the specified increment is zero. Axis numbering is in scientific notation, if necessary and is plotted to four significant digits.

Pad values must be specified in the same units as the corresponding axes values. These pads are useful when the contents of the axes box

requires more space than implied by the axes values. For example, the first and last seismic wiggle traces plotted inside an axes box will typically extend beyond the axes values corresponding to the first and last traces. However, all tics will lie with the limits specified in the axes values (x1Beg, x1End, x2Beg, x2End).

psAxesBBox:

psAxesBBox uses font sizes to estimate the bounding box for an axes box drawn with psAxesBox. To be on the safe side, psAxesBBox overestimates.

psAxesBBox assumes that the axes labels and titles do not extend beyond the corresponding edges of the axes box.

References:

(see References for basic.c)

Author: Dave Hale, Colorado School of Mines, 06/27/89

Modified: Ken Larner, Colorado School of Mines, 08/30/90

Modified: Dave Hale, Advance Geophysical, 10/18/92

Added color parameters for title, axes, and grid.

Modified: Morten Wendell Pedersen, Aarhus University, 23/3-97

Added ticwidth, axeswidth, gridwidth parameters

PSCAXESBOX - Draw an axes box for cube via PostScript

psCubeAxesBox Draw an axes box for cube via PostScript

Function Prototype:

```
void psCubeAxesBox(
float x, float y, float size1, float size2, float size3, float angle,
float x1Beg, float x1End, float p1Beg, float p1End,
float d1Num, float f1Num, int n1Tic, int grid1, char *label1,
float x2Beg, float x2End, float p2Beg, float p2End,
float d2Num, float f2Num, int n2Tic, int grid2, char *label2,
float x3Beg, float x3End, float p3Beg, float p3End,
float d3Num, float f3Num, int n3Tic, int grid3, char *label3,
char *labelFont, float labelSize,
char *title, char *titleFont, float titleSize,
char *titleColor, char *axesColor, char *gridColor);
```

Input:

x x coordinate of lower left corner of box  
y y coordinate of lower left corner of box  
size1 size of 1st dimension of the input cube  
size2 size of 2nd dimension of the input cube  
size3 size of 3rd dimension of the input cube  
angle projection angle of the cube  
x1Beg axis value at beginning of axis 1  
x1End axis value at end of axis 1  
p1Beg pad value at beginning of axis 1  
p1End pad value at end of axis 1  
d1Num numbered tic increment for axis 1 (0.0 for automatic)  
f1Num first numbered tic for axis 1  
n1Tic number of tics for axis 1  
grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID  
label1 label for axis 1  
x2Beg axis value at beginning of axis 2  
x2End axis value at end of axis 2  
p2Beg pad value at beginning of axis 2  
p2End pad value at end of axis 2  
d2Num numbered tic increment for axis 2 (0.0 for automatic)  
f2Num first numbered tic for axis 2  
n2Tic number of tics for axis 2  
grid2 grid code for axis 2: NONE, DOT, DASH, or SOLID  
label2 label for axis 2  
x3Beg axis value at beginning of axis 3

x3End axis value at end of axis 3  
p3Beg pad value at beginning of axis 3  
p3End pad value at end of axis 3  
d3Num numbered tic increment for axis 3 (0.0 for automatic)  
f3Num first numbered tic for axis 3  
n3Tic number of tics for axis 3  
grid3 grid code for axis 3: NONE, DOT, DASH, or SOLID  
label3 label for axis 3  
labelFont name of font to use for axes labels  
labelSize size of font to use for axes labels  
title axes box title  
titleFont name of font to use for title  
titleSize size of font to use for title  
titleColor color to use for title  
axesColor color to use for axes and axes labels  
gridColor color to use for grid lines  
Authors: Zhiming Li & Dave Hale, Colorado School of Mines, 6/90  
Modified: Craig Artley, Colorado School of Mines, 3/12/93  
Changed name to psCubeAxesBox (from psAxes3), fixed minor bugs.  
Modified: Craig Artley, Colorado School of Mines, 12/16/93  
Added color parameters for title, axes, and grid.

PSCONTOUR - draw contour of a two-dimensional array via PostScript

psContour draw contour of a two-dimensional array via PostScript

Function Prototype:

```
void psContour (float c, int nx, float x[], int ny, float y[], float z[],
float lcs, char *lcf, char *lcc, float *w, int nplaces);
```

Input:

c contour value

nx number of x-coordinates

x array of x-coordinates (see notes below)

ny number of y-coordinates

y array of y-coordinates (see notes below)

lcs font size of contour label

lcf font name of contour label

lcc color of contour label

LSB flag arrays (see Notes):

z array of nx\*ny z(x,y) values (see notes below)

w array of nx\*ny z(x,y) values (see notes below)

Notes:

The two-dimensional array z is actually passed as a one-dimensional array containing nx\*ny values, stored with nx fast and ny slow.

The x and y arrays define a grid that is not necessarily uniformly-sampled. Linear interpolation of z values on the grid defined by the x and y arrays is used to determine z values between the gridpoints.

The two least significant bits of z are used to mark intersections of the contour with the x,y grid; therefore, the z values will almost always be altered (slightly) by contour.

pscontour isolates the use of PostScript to four internal functions:

void coninit(void) - called before any contour drawing

void conmove(float x, float y) - moves current position to x,y

void condraw(float x, float y) - draws from current position to x,y

void condone(void) - called when contour drawing is done

These functions can usually be replaced with equivalent functions in other graphics environments.

The w array is used to restrict the range of contour labeling that occurs only if  $w < 1$ .

As suggested in the reference, the following scheme is used to refer to a cell of the two-dimensional array z:

```

              north (0)
(ix,iy+1) ----- (ix+1,iy+1)
              | cell |
west (3) | ix,iy | east (1)
              |       |
              (ix,iy) ----- (ix+1,iy)
              south (2)
```

Reference:

Cottafava, G. and Le Moli, G., 1969, Automatic contour map:  
Communications of the ACM, v. 12, n. 7, July, 1969.

Author: Dave Hale, Colorado School of Mines, 06/28/89  
contour labeling added by: Zhenyue Liu, August 1993

PSDRAWCURVE - Functions to draw a curve from a set of points

psDrawCurve Draw a curve from a set of points via PostScript

Function Prototypes:

```
void psDrawCurve(  
float x, float y, float width, float height,  
float x1Beg, float x1End, float p1Beg, float p1End,  
float x2Beg, float x2End, float p2Beg, float p2End,  
float *x1curve, float *x2curve, int ncurve,  
char *curveColor, float curvewidth, int curvedash, int style);  
psDrawCurve:
```

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

x1Beg axis value at beginning of axis 1

x1End axis value at end of axis 1

p1Beg pad value at beginning of axis 1

p1End pad value at end of axis 1

x2Beg axis value at beginning of axis 2

x2End axis value at end of axis 2

p2Beg pad value at beginning of axis 2

p2End pad value at end of axis 2

x1curve vector of x1 coordinates for points along curve

x2curve vector of x2 coordinates for points along curve

ncurve number of points along curve

curveColor color to use for curve

curvewidth width (in points) of curve

style NORMAL (axis 1 on bottom, axis 2 on left)

SEISMIC (axis 1 on left, axis 2 on top)

Author: Brian Macy, Phillips Petroleum Co., 11/20/98

(Adapted after Dave Hale and other's psAxesBox routine)



PSLEGENDBOX - Functions to draw PostScript axes and estimate bounding box

psLegendBox Draw an legend box via PostScript

psLegendBBox estimate bounding box for an legend box drawn via psLegendBox

Function Prototypes:

```
void psLegendBox(
float x, float y, float width, float height,
float x1Beg, float x1End, float p1Beg, float p1End,
float d1Num, float f1Num, int n1Tic, int grid1, char *label1,
char *labelFont, float labelSize,
char *axesColor, char *gridColor,
int style);
```

```
void psLegendBBox(
float x, float y, float width, float height,
char *labelFont, float labelSize,
int style, int bbox[]);
```

psLegendBox:

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

x1Beg axis value at beginning of axis 1

x1End axis value at end of axis 1

p1Beg pad value at beginning of axis 1

p1End pad value at end of axis 1

d1Num numbered tic increment for axis 1 (0.0 for automatic)

f1Num first numbered tic for axis 1

n1Tic number of horizontal tics per numbered tic for axis 1

grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID

label1 label for axis 1

labelFont name of font to use for axes labels

labelSize size of font to use for axes labels

axesColor color to use for axes and axes labels

gridColor color to use for grid lines

style VERTLEFT (Vertical, axis label on left side)

VERTRIGHT (Vertical, axis label on right side)

HORIBOTTOM (Horizontal, axis label on bottom)

psLegendBBox:

Input:

x x coordinate of lower left corner of box

y y coordinate of lower left corner of box

width width of box

height height of box

labelFont name of font to use for axes labels

labelSize size of font to use for axes labels

style VERTLEFT (Vertical, axis label on left side)

VERTRIGHT (Vertical, axis label on right side)

HORIBOTTOM (Horizontal, axis label on bottom)

Output:

bbox bounding box (bbox[0:3] = llx, lly, ulx, uly)

Notes:

psLegendBox:

psLegendBox will determine the numbered tic increment and first numbered tic automatically, if the specified increment is zero. Axis numbering is in scientific notation, if necessary and is plotted to four significant digits.

Pad values must be specified in the same units as the corresponding Legend values. These pads are useful when the contents of the Legend box requires more space than implied by the Legend values. For example, the first and last seismic wiggle traces plotted inside an Legend box will typically extend beyond the Legend values corresponding to the first and last traces. However, all tics will lie with the limits specified in the Legend values (x1Beg, x1End, x2Beg, x2End).

psLegendBBox:

psLegendBBox uses font sizes to estimate the bounding box for an Legend box drawn with psLegendBox. To be on the safe side, psLegendBBox overestimates.

psLegendBBox assumes that the Legend labels and titles do not extend beyond the corresponding edges of the Legend box.

References:

(see References for basic.c)

Author: Dave Hale, Colorado School of Mines, 06/27/89

Modified: Ken Larner, Colorado School of Mines, 08/30/90

Modified: Dave Hale, Advance Geophysical, 10/18/92

Added color parameters for title, axes, and grid.

Modified: Torsten Schoenfelder, Koeln, Germany, 07/06/97  
Display a legend for ps file, move axis from left to right  
Modified: Torsten Schoenfelder, Koeln, Germany, 10/02/98  
Corrected width of bbox to include legend title

PSWIGGLE - draw wiggle-trace with (optional) area-fill via PostScript

psWiggle draw wiggle-trace with (optional) area-fill via PostScript

Function Prototype:

```
void psWiggle (int n, float z[], float zmin, float zmax, float zbase,
float yzmin, float yzmax, float xfirst, float xlast, int fill);
```

Inputs:

n number of samples to draw

z array to draw

zmin z values below zmin will be clipped

zmax z values above zmax will be clipped

zbase z values between zbase and either zmin or zmax will be filled

yzmin y-coordinate corresponding to zmin

yzmax y-coordinate corresponding to zmax

xfirst x-coordinate corresponding to z[0]

xlast x-coordinate corresponding to z[n-1]

fill = 0 for no fill

> 0 for fill between zbase and zmax

< 0 for fill between zbase and zmin

+2 for fill solid between zbase and zmax grey between zbase and zmin

-2 for fill solid between zbase and zmin grey between zbase and zmax

SHADING:  $2 \leq \text{abs}(\text{fill}) \leq 5$      $\text{abs}(\text{fill})=2$  light grey     $\text{abs}(\text{fill})=5$  black

NOTES:

psWiggle reduces PostScript output by eliminating linetos when z values are essentially constant. The tolerance for detecting constant" z values is  $\text{ZEPS} \times (\text{zmax} - \text{zmin})$ , where ZEPS is a fraction defined below.

A more complete optimization would eliminate all connected line segments that are essentially colinear.

psWiggle breaks up the wiggle into segments that can be drawn without exceeding the PostScript pathlimit.

Author: Dave Hale, Colorado School of Mines, 07/03/89

Modified: Craig Artley, Colorado School of Mines, 04/13/92

Corrected dead trace bug. Now the last point of each segment is guaranteed to be drawn.

MODIFIED: Paul Michaels, Boise State University, 29 December 2000

added fill= $\pm 2$  option of solid/grey color scheme

## AXESBOX - Functions to draw axes in X-windows graphics

xDrawAxesBox draw a labeled axes box

xSizeAxesBox determine optimal origin and size for a labeled axes box

### Function Prototypes:

```
void xDrawAxesBox (Display *dpy, Window win,
int x, int y, int width, int height,
float x1beg, float x1end, float p1beg, float p1end,
float d1num, float f1num, int n1tic, int grid1, char *label1,
float x2beg, float x2end, float p2beg, float p2end,
float d2num, float f2num, int n2tic, int grid2, char *label2,
char *labelfont, char *title, char *titlefont,
char *axescolor, char *titlecolor, char *gridcolor,
int style);
void xSizeAxesBox (Display *dpy, Window win,
char *labelfont, char *titlefont, int style,
int *x, int *y, int *width, int *height);
```

xDrawAxesBox:

Input:

dpy display pointer

win window

x x coordinate of upper left corner of box

y y coordinate of upper left corner of box

width width of box

height height of box

x1beg axis value at beginning of axis 1

x1end axis value at end of axis 1

p1beg pad value at beginning of axis 1

p1end pad value at end of axis 1

d1num numbered tic increment for axis 1 (0.0 for automatic)

f1num first numbered tic for axis 1

n1tic number of tics per numbered tic for axis 1

grid1 grid code for axis 1: NONE, DOT, DASH, or SOLID

label1 label for axis 1

x2beg axis value at beginning of axis 2

x2end axis value at end of axis 2

p2beg pad value at beginning of axis 2

p2end pad value at end of axis 2

d2num numbered tic increment for axis 2 (0.0 for automatic)

f2num first numbered tic for axis 2

n2tic number of tics per numbered tic for axis 2

grid2 grid code for axis 2: NONE, DOT, DASH, or SOLID  
 label2 label for axis 2  
 labelfont name of font to use for axes labels  
 title axes box title  
 titlefont name of font to use for title  
 axescolor name of color to use for axes  
 titlecolor name of color to use for title  
 gridcolor name of color to use for grid  
 int style NORMAL (axis 1 on bottom, axis 2 on left)  
 SEISMIC (axis 1 on left, axis 2 on top)

xSizeAxesBox:

Input:

dpy display pointer

win window

labelfont name of font to use for axes labels

titlefont name of font to use for title

int style NORMAL (axis 1 on bottom, axis 2 on left)

SEISMIC (axis 1 on left, axis 2 on top)

Output:

x x coordinate of upper left corner of box

y y coordinate of upper left corner of box

width width of box

height height of box

{

XFontStruct \*fa,\*ft;

Notes:

xDrawAxesBox:

will determine the numbered tic increment and first

numbered tic automatically, if the specified increment is zero.

Pad values must be specified in the same units as the corresponding  
 axes values. These pads are useful when the contents of the axes box  
 requires more space than implied by the axes values. For example,  
 the first and last seismic wiggle traces plotted inside an axes box  
 will typically extend beyond the axes values corresponding to the  
 first and last traces. However, all tics will lie within the limits  
 specified in the axes values (x1beg, x1end, x2beg, x2end).

xSizeAxesBox:

is intended to be used prior to xDrawAxesBox.

An "optimal" axes box is one that more or less fills the window, with little wasted space around the edges of the window.

Author: Dave Hale, Colorado School of Mines, 01/27/90

COLORMAP - Functions to manipulate X colormaps:

`xCreateRGBDefaultMap` create `XA_RGB_DEFAULT_MAP` property of root window if it does not already exist  
`xGetFirstPixel` return first pixel in range of contiguous pixels in `XA_RGB_DEFAULT_MAP`  
`xGetLastPixel` return last pixel in range of contiguous pixels in `XA_RGB_DEFAULT_MAP`  
`xCreateHSVColormap` create a 2 ramp colormap (HSV - Model)  
`xCreateRGBColormap` create a 2 ramp colormap (RGB - Model)

Function Prototypes:

```
Status xCreateRGBDefaultMap (Display *dpy, XStandardColormap *scmap);
unsigned long xGetFirstPixel (Display *dpy);
unsigned long xGetLastPixel (Display *dpy);
Colormap xCreateRGBColormap (Display *dpy, Window win,
char *str_cmap, int verbose)
Colormap xCreateHSVColormap (Display *dpy, Window win,
char *str_cmap, int verbose)
```

`xCreateRGBDefaultMap`:

Input:  
dpy display

Output:  
scmap the standard colormap structure

`xGetFirstPixel`, `xGetLastPixel`:

Input:  
dpy display

Notes:  
PROBLEM  
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Most mid-range display devices today support what X calls the "PseudoColor visual". Typically, only 256 colors (or gray levels) may be displayed simultaneously. Although these 256 colors may be chosen from a much larger (4096 or more) set of available colors, only 256 colors can appear on a display at one time.

These 256 colors are indexed by pixel values in a table called the colormap. Each window can have its own colormap, but only



one colormap can be installed in the display hardware at a time. (Again, only 256 colors may be displayed at one time.) The window manager is responsible for installing a window's colormap when that window becomes the key window.

Many of the applications we are likely to write require a large, contiguous range of pixels (entries in the colormap). In this range, we must be able to:

- (1) given a color (or gray), determine the corresponding pixel.
- (2) given a pixel, determine the corresponding color (or gray).

An example would be an imaging application that uses a gray scale to display images in shades of gray between black and white.

Such applications are also likely to require a few additional colors for drawing axes, text, etc.

The problem is to coordinate the use of the limited number of 256 simultaneous colors so that windows for different applications appear reasonable, even when their particular colormaps are not installed in the display hardware. For example, we might expect an analog `xclock`'s hands to be visible even when `xclock`'s window is not the key window, when its colormap is not installed.

We should ensure that the range of contiguous pixels used by one application (perhaps for imaging) does not conflict with the pixels used by other applications to draw text, clock hands, etc.

## SOLUTION

-----

Applications that do not require special colormaps should simply use the default colormap inherited from the root window when new top-level windows are created.

Applications that do require a special colormap **MUST** create their own colormap. They must not assume that space will be available in the default colormap for a contiguous range of read/write pixels, because the server or window manager may have already allocated these pixels as read-only. Even if sufficient pixels are available in the default colormap, they should not be allocated by a single application. The default colormap should be used only for windows requiring a limited number of typical colors, such as red, yellow, etc.

Applications that require a contiguous range of read/write pixels should allocate these pixels in their window's private colormaps. They should determine which contiguous pixels to allocate from parameters in the standard colormap `XA_RGB_DEFAULT_MAP`. In particular, the first pixel in the range of contiguous pixels should be `base_pixel` and the last pixel in the range should be `base_pixel+red_max*red_mult+green_max*green_mult+blue_max*blue_mult`, where `base_pixel`, `red_max`, etc. are members in the `XStandardColormap` structure. On an 8-bit display, this range will typically provide 216 contiguous pixels, which may be set to a gray scale, color scale, or whatever. This leaves 40 colors for drawing text, axes, etc.

If the `XA_RGB_DEFAULT_MAP` does not exist, it should be created to consist of various colors composed of an equal number of reds, greens, and blues. For example, if 216 colors are to be allocated, then `red_max=green_max=blue_max=5`, `red_mult=36`, `green_mult=6`, and `blue_mult=1`. Because of the difficulty in forcing a particular pixel to correspond to a particular color in read-only color cells, these 216 colors will likely be read/write color cells unless created by the X server. In any case, these 216 colors should not be modified by any application. In creating custom colormaps, the only use of `XA_RGB_DEFAULT_MAP` should be in determining which 216 pixels to allocate for contiguous pixels.

In creating a custom colormap for a window, the application should initialize this colormap to the colors already contained in the window's colormap, which was inherited initially from its parent. This will ensure that typical colors already allocated by other applications will be consistent with pixels used by the application requiring the custom colormap. Ideally, windows might have different colormaps, but the only differences would be in the range of contiguous colors used for imaging, rendering, etc. Ideally, the pixels corresponding to colors used to draw text, axes, etc. would be consistent for all windows.

Unfortunately, it is impractical to maintain complete consistency among various private colormaps. For example, suppose a custom colormap is created for a window before other applications have had the opportunity to allocate their colors from the default colormap. Then, when the window with the custom colormap becomes the key window, the windows of the other applications may be displayed with false colors, since the colormap of the key window

may not contain the true colors. The colors used by the other applications did not exist when the custom colormap was created. One solution to this problem might be to initially allocate a set of "common" colors in the default colormap before launching any applications. This will increase the likelihood that typical colors will be consistent among various colormaps.

Functions are provided below to

- (1) create the standard colormap XA\_RGB\_DEFAULT\_MAP, if it does not exist,
- (2) determine the first and last pixels in the contiguous range of pixels,
- (3) create some common private colormaps

`xCreateRGBDefaultMap`:

This function returns 0 if the XA\_RGB\_DEFAULT\_MAP property does not exist and cannot be created. At least 8 contiguous color cells must be free in the default colormap to create the XA\_RGB\_DEFAULT\_MAP. If created, the `red_max`, `green_max`, and `blue_max` values returned in `scmap` will be equal.

`xGetFirstPixel`, `xGetLastPixel`:

If it does not already exist, XA\_RGB\_DEFAULT\_MAP will be created. If XA\_RGB\_DEFAULT\_MAP does not exist and cannot be created, then this function returns 0.

`xCreateRGBColormap`, `xCreateHSVColormap`:

The returned colormap is only created; the window's colormap attribute is not changed, and the colormap is not installed by this function. The returned colormap is a copy of the window's current colormap, but with an RGB color scale allocated in the range of contiguous cells determined by XA\_RGB\_DEFAULT\_MAP. If it does not already exist, XA\_RGB\_DEFAULT\_MAP will be created.

Author: Dave Hale, Colorado School of Mines, 09/30/90

DRAWCURVE - Functions to draw a curve from a set of points

xDrawCurve draw a curve from a set of points

Function Prototypes:

```
void xDrawCurve(Display *dpy, Window win,
int x, int y, int width, int height,
float x1beg, float x1end, float p1beg, float p1end,
float x2beg, float x2end, float p2beg, float p2end,
float *x1curve, float *x2curve, int ncurve,
char *curvecolor, int style);
```

xDrawCurve:

Input:

dpy display pointer

win window

x x coordinate of upper left corner of box

y y coordinate of upper left corner of box

width width of box

height height of box

x1beg axis value at beginning of axis 1

x1end axis value at end of axis 1

p1beg pad value at beginning of axis 1

p1end pad value at end of axis 1

x2beg axis value at beginning of axis 2

x2end axis value at end of axis 2

p2beg pad value at beginning of axis 2

p2end pad value at end of axis 2

x1curve vector of x1 coordinates for points along curve

x2curve vector of x2 coordinates for points along curve

ncurve number of points along curve

curvecolor name of color to use for axes

int style NORMAL (axis 1 on bottom, axis 2 on left)

SEISMIC (axis 1 on left, axis 2 on top)

Author: Brian Macy, Phillips Petroleum Co., 11/14/98

(Adapted after Dave Hale's xDrawAxesBox routine)

IMAGE - Function for making the image in an X-windows image plot

xNewImage make a new image of pixels from bytes

Function Prototype:

```
XImage *xNewImage (Display *dpy, unsigned long pmin, unsigned long pmax,  
int width, int height, float blank, unsigned char *bytes);
```

Input:

dpy display pointer

pmin minimum pixel value (corresponding to byte=0)

pmax maximum pixel value (corresponding to byte=255)

width number of bytes in x dimension

height number of bytes in y dimension

blank portion for blanking (0 to 1)

bytes unsigned bytes to be mapped to an image

Author: Dave Hale, Colorado School of Mines, 06/08/90

Revision: Brian Zook, Southwest Research Institute, 6/27/96 added blank option

This allows replacing the low end by the background.

LEGENDBOX - draw a labeled axes box for a legend (i.e. colorscale)

Function Prototype:

```
void xDrawLegendBox (Display *dpy, Window win,
int x, int y, int width, int height,
float bclip, float wclip, char *units, char *legendfont,
char *labelfont, char *title, char *titlefont,
char *axescolor, char *titlecolor, char *gridcolor,
int style);
```

Input:

dpy display pointer

win window

x x coordinate of upper left corner of box

y y coordinate of upper left corner of box

width width of box

height height of box

units label for legend

legendfont name of font to use for legend labels

labelfont name of font to use for axes labels

title axes box title

titlefont name of font to use for title

axescolor name of color to use for axes

titlecolor name of color to use for title

gridcolor name of color to use for grid

int style NORMAL (axis 1 on bottom, axis 2 on left)

SEISMIC (axis 1 on left, axis 2 on top)

Notes:

xDrawLegendBox will determine the numbered tic increment and first numbered tic automatically, if the specified increment is zero.

Pad values must be specified in the same units as the corresponding axes values. These pads are useful when the contents of the axes box requires more space than implied by the axes values. For example, the first and last seismic wiggle traces plotted inside an axes box will typically extend beyond the axes values corresponding to the first and last traces. However, all tics will lie within the limits specified in the axes values (x1beg, x1end, x2beg, x2end).

Author: Dave Hale, Colorado School of Mines, 01/27/90

Author: Berend Scheffers , TNO Delft, 06/11/92

RUBBERBOX - Function to draw a rubberband box in X-windows plots

xRubberBox Track pointer with rubberband box

Function Prototype:

```
void xRubberBox (Display *dpy, Window win, XEvent event,  
int *x, int *y, int *width, int *height);
```

Input:

dpy display pointer

win window ID

event event of type ButtonPress

Output:

x x of upper left hand corner of box in pixels

y y of upper left hand corner of box in pixels

width width of box in pixels

height height of box in pixels

Notes:

xRubberBox assumes that event is a ButtonPress event for the 1st button; i.e., it tracks motion of the pointer while the 1st button is down, and it sets x, y, w, and h and returns after a ButtonRelease event for the 1st button.

Before calling xRubberBox, both ButtonRelease and Button1Motion events must be enabled.

This is the same rubberbox.c as in Xtcwp/lib, only difference is that xRubberBox here is XtcwpRubberBox there, and a shift has been added to make the rubberbox more visible.

Author: Dave Hale, Colorado School of Mines, 01/27/90

WINDOW - Function to create a window in X-windows graphics

xNewWindow Create a new window and return the window ID

Function Prototype:

```
Window xNewWindow (Display *dpy, int x, int y, int width, int height,  
int border, int background, char *name);
```

Input:

dpy display pointer

x x in pixels of upper left corner

y y in pixels of upper left corner

width width in pixels

height height in pixels

border border pixel

background background pixel

name name of window (also used for icon)

Notes:

The parent window is the root window.

The border\_width is 4 pixels.

Author: Dave Hale, Colorado School of Mines, 01/06/90



XCONTOUR - draw contour of a two-dimensional array via X vectorplot calls

xContour draw contour of a two-dimensional array via X vector plot calls

Function Prototype:

```
void xContour(Display *dpy, Window win, GC gcc, GC gcl,  
              float *cp, int nx, float x[], int ny, float y[], float z[],  
              char lcflag, char *lcf, char *lcc, float *w, int nplaces)
```

Input:

c contour value

nx number of x-coordinates

x array of x-coordinates (see notes below)

ny number of y-coordinates

y array of y-coordinates (see notes below)

lcf font name of contour label

lcc color of contour label

Least Significant Bits:

z array of nx\*ny z(x,y) values (see notes below)

w array of nx\*ny z(x,y) values (see notes below)

Notes:

The two-dimensional array z is actually passed as a one-dimensional array containing nx\*ny values, stored with nx fast and ny slow.

The x and y arrays define a grid that is not necessarily uniformly-sampled. Linear interpolation of z values on the grid defined by the x and y arrays is used to determine z values between the gridpoints.

The two least significant bits of z are used to mark intersections of the contour with the x,y grid; therefore, the z values will almost always be altered (slightly) by contour.

xContour is a modified version of psContour where the use of conmove and condraw call have been changed to match X-Windows.

Since XDrawLine requires a start and end point, the use of a manually update of the position variables x0 and y0 is used instead of conmove.

The w array is used to restrict the range of contour labeling that occurs only if w<1.

As suggested in the reference, the following scheme is used to refer to a cell of the two-dimensional array z:

```

              north (0)
(ix,iy+1) ----- (ix+1,iy+1)
              | cell |
west (3) | ix,iy | east (1)
              |      |
(ix,iy)  ----- (ix+1,iy)
              south (2)

```

Reference:

Cottafava, G. and Le Moli, G., 1969, Automatic contour map:  
 Commuincations of the ACM, v. 12, n. 7, July, 1969.

Author: Morten Wendell Pedersen Aarhus University 07/20/96

Heavily based on psContour by

Dave Hale, Colorado School of Mines, 06/28/89

and with contour labeling added by: Zhenyue Liu, June 1993  
 (actually most of the credit should go to these two guys)

## AXES - the Axes Widget

`XtcwpPointInAxesRectangle` returns TRUE if point is inside axes rectangle, otherwise FALSE

`XtcwpSetAxesValues` set axes values

`XtcwpSetAxesPads` set axes pads

### Function Prototype:

```
Boolean XtcwpPointInAxesRectangle (Widget w, Position x, Position y);
```

```
void XtcwpSetAxesValues (Widget w, float x1beg, float x1end, float x2beg, float x2end);
```

```
void XtcwpSetAxesPads (Widget w, float p1beg, float p1end, float p2beg, float p2end);
```

`XtcwpPointInAxesRectangle:`

Input:

w axes widget

x x coordinate of point

y y coordinate of point

`XtcwpSetAxesValues:`

Input:

w axes widget

x1beg axis value at beginning of axis 1

x1end axis value at end of axis 1

x2beg axis value at beginning of axis 2

x2end axis value at end of axis 2

`XtcwpSetAxesPads:`

Input:

w axes widget

p1beg axis pad at beginning of axis 1

p1end axis pad at end of axis 1

p2beg axis pad at beginning of axis 2

p2end axis pad at end of axis 2

### Notes:

`XtcwpPointInAxesRectangle:`

This function is useful for determining whether or not input events occurred with the pointer inside the axes rectangle. I.e., the input callback function will typically call this function.

`XtcwpSetAxesPads:`

Pad values must be specified in the same units as the corresponding axes values. These pads are useful when the contents of the axes box require more space than implied by the axes values. For example, the first and last seismic wiggle traces plotted inside an axes box will typically extend beyond the axes values corresponding to the first and last traces. However, all tics will lie within the limits specified in the axes values (x1beg, x1end, x2beg, and x2end).

Author: Dave Hale, Colorado School of Mines, 08/28/90

Modified: Craig Artley, Colorado School of Mines, 06/03/93, Rotate label for vertical axis (Courtesy Dave Hale, Advance Geophysical).

COLORMAP - Functions to manipulate X colormaps:

XtcwpCreateRGBDefaultMap create XA\_RGB\_DEFAULT\_MAP property of root window if it does not already exist

XtcwpGetFirstPixel return first pixel in range of contiguous pixels in XA\_RGB\_DEFAULT\_MAP

XtcwpGetLastPixel return last pixel in range of contiguous pixels in XA\_RGB\_DEFAULT\_MAP

XtcwpCreateRGBColormap create a colormap with an RGB color scale in contiguous cells

XtcwpCreateGrayColormap create a colormap with a gray scale in contiguous cells

XtcwpCreateHueColormap create a colormap with varying hues (blue to red) in contiguous cells

XtcwpCreateSatColormap create a colormap with varying saturations in contiguous cells

Function Prototypes:

Status XtcwpCreateRGBDefaultMap (Display \*dpy, XStandardColormap \*scmap);

unsigned long XtcwpGetFirstPixel (Display \*dpy);

unsigned long XtcwpGetLastPixel (Display \*dpy);

Colormap XtcwpCreateRGBColormap (Display \*dpy, Window win);

Colormap XtcwpCreateGrayColormap (Display \*dpy, Window win);

Colormap XtcwpCreateHueColormap (Display \*dpy, Window win);

Colormap XtcwpCreateSatColormap (Display \*dpy, Window win, float fhue, float lhue, float wfrac, float bright)

XtcwpCreateRGBDefaultMap:

Input:

dpy display

Output:

scmap the standard colormap structure

XtcwpGetFirstPixel, XtcwpGetLastPixel:

Input:

dpy display

XtcwpCreateRGBColormap, XtcwpCreateGrayColormap, XtcwpCreateHueColormap:

Input:

dpy display

win window

XtcwpCreateSatColormap:

Input:  
dpy display  
win window  
fhue first hue in colormap (saturation=1)  
lhue last hue in colormap (saturation=1)  
wfrac fractional position of white within the colormap (saturation=0)  
bright brightness

Notes:  
PROBLEM  
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These 256 colors are indexed by pixel values in a table called the colormap. Each window can have its own colormap, but only one colormap can be installed in the display hardware at a time. (Again, only 256 colors may be displayed at one time.) The window manager is responsible for installing a window's colormap when that window becomes the key window.

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An example would be an imaging application that uses a gray scale to display images in shades of gray between black and white. Such applications are also likely to require a few additional colors for drawing axes, text, etc.

The problem is to coordinate the use of the limited number of 256 simultaneous colors so that windows for different applications appear reasonable, even when their particular colormaps are not installed in the display hardware. For example, we might expect an analog xclock's hands to be visible even when xclock's window is not the key window, when its colormap is not installed.

We should ensure that the range of contiguous pixels used by one

application (perhaps for imaging) does not conflict with the pixels used by other applications to draw text, clock hands, etc.

## SOLUTION

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Applications that do require a special colormap **MUST** create their own colormap. They must not assume that space will be available in the default colormap for a contiguous range of read/write pixels, because the server or window manager may have already allocated these pixels as read-only. Even if sufficient pixels are available in the default colormap, they should not be allocated by a single application. The default colormap should be used only for windows requiring a limited number of typical colors, such as red, yellow, etc.

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and the last pixel in the range should be

`base_pixel+red_max*red_mult+green_max*green_mult+blue_max*blue_mult`, where `base_pixel`, `red_max`, etc. are members in the `XStandardColormap` structure. On an 8-bit display, this range will typically provide 216 contiguous pixels, which may be set to a gray scale, color scale, or whatever. This leaves 40 colors for drawing text, axes, etc.

If the `XA_RGB_DEFAULT_MAP` does not exist, it should be created to consist of various colors composed of an equal number of reds, greens, and blues. For example, if 216 colors are to be allocated, then `red_max=green_max=blue_max=5`, `red_mult=36`, `green_mult=6`, and `blue_mult=1`. Because of the difficulty in forcing a particular pixel to correspond to a particular color in read-only color cells, these 216 colors will likely be read/write color cells unless created by the X server. In any case, these 216 colors should not be modified by any application. In creating custom colormaps, the only use of `XA_RGB_DEFAULT_MAP` should be in determining which 216

pixels to allocate for contiguous pixels.

In creating a custom colormap for a window, the application should initialize this colormap to the colors already contained in the window's colormap, which was inherited initially from its parent. This will ensure that typical colors already allocated by other applications will be consistent with pixels used by the application requiring the custom colormap. Ideally, windows might have different colormaps, but the only differences would be in the range of contiguous colors used for imaging, rendering, etc. Ideally, the pixels corresponding to colors used to draw text, axes, etc. would be consistent for all windows.

Unfortunately, it is impractical to maintain complete consistency among various private colormaps. For example, suppose a custom colormap is created for a window before other applications have had the opportunity to allocate their colors from the default colormap. Then, when the window with the custom colormap becomes the key window, the windows of the other applications may be displayed with false colors, since the colormap of the key window may not contain the true colors. The colors used by the other applications did not exist when the custom colormap was created. One solution to this problem might be to initially allocate a set of "common" colors in the default colormap before launching any applications. This will increase the likelihood that typical colors will be consistent among various colormaps.

Functions are provided below to

- (1) create the standard colormap XA\_RGB\_DEFAULT\_MAP, if it does not exist,
- (2) determine the first and last pixels in the contiguous range of pixels,
- (3) create some common private colormaps - gray scale, hue scale, etc.

**XtcwpCreateRGBDefaultMap:**

This function returns 0 if the XA\_RGB\_DEFAULT\_MAP property does not exist and cannot be created. At least 8 contiguous color cells must be free in the default colormap to create the XA\_RGB\_DEFAULT\_MAP. If created, the red\_max, green\_max, and blue\_max values returned in somap will be equal.

**XtcwpGetFirstPixel, XtcwpGetLastPixel:**

If it does not already exist, XA\_RGB\_DEFAULT\_MAP will be created. If XA\_RGB\_DEFAULT\_MAP does not exist and cannot be created, then this function returns 0.



XtcwpCreateRGBColormap, XtcwpCreateGrayColormap, XtcwpCreateHueColormap, XtcwpCreateSatColormap:

The returned colormap is only created; the window's colormap attribute is not changed, and the colormap is not installed by this function. The returned colormap is a copy of the window's current colormap, but with an RGB color scale allocated in the range of contiguous cells determined by XA\_RGB\_DEFAULT\_MAP. If it does not already exist, XA\_RGB\_DEFAULT\_MAP will be created.

Author: Dave Hale, Colorado School of Mines, 09/30/90

FX - Functions to support floating point coordinates in X

FMapFX map float x to x  
FMapFY map float y to y  
FMapFWidth map float width to width  
FMapFHeight map float height to height  
FMapFAngle map float angle to angle  
FMapFPoint map float x,y to x,y  
FMapFPoints map float points to points  
FMapX inverse map x to float x  
FMapY inverse map y to float y  
FMapWidth inverse map width to float width  
FMapHeight inverse map height to float height  
FMapAngle inverse map angle to float angle  
FMapPoint map x,y to float x,y  
FMapPoints map points to float points  
FSetGC set graphics context  
FSetMap set map (scales and shifts)  
FSetClipRectangle set clip rectangle  
FClipOn turn clip on  
FClipOff turn clip off  
FClipPoint clip point  
FClipLine clip line  
FClipRectangle clip rectangle  
FXCreateFGC create float graphics context  
FXFreeFGC free float graphic context  
FXDrawPoint draw point at float x,y (with clipping)  
FXDrawPoints draw float points (with clipping)  
FXDrawLine draw line from float x1,y1 to float x2,y2  
(with clipping)  
FXDrawLines draw lines between float points (with clipping)  
FXDrawRectangle draw rectangle with float x,y,width,height  
(with clipping)  
FXDrawArc draw arc with float x,y,width,height,angle1,angle2  
FXDrawString draw string at float x,y  
FXFillRectangle fill rectangle with float x,y,width,height (with  
clipping)

Function Prototypes:

```
int FMapFX (FGC fgc, float fx);  
int FMapFY (FGC fgc, float fy);  
int FMapFWidth (FGC fgc, float fwidth);  
int FMapFHeight (FGC fgc, float fheight);
```

```

int FMapFAngle (FGC fgc, float fangle);
void FMapFPoint (FGC fgc, float fx, float fy, int *x_return, int *y_return);
void FMapFPoints (FGC fgc, FXPoint fpoints[], int npoints,
XPoint points_return[]);
float FMapX (FGC fgc, int x);
float FMapY (FGC fgc, int y);
float FMapWidth (FGC fgc, int width);
float FMapHeight (FGC fgc, int height);
float FMapAngle (FGC fgc, int angle);
void FMapPoint (FGC fgc, int x, int y, float *fx_return, float *fy_return);
void FMapPoints (FGC fgc, XPoint points[], int npoints,
FXPoint fpoints_return[]);
void FSetGC (FGC fgc, GC gc);
void FSetMap (FGC fgc, int x, int y, int width, int height,
float fx, float fy, float fwidth, float fheight);
void FSetClipRectangle(FGC fgc, float fxa, float fya, float fxb, float fyb);
void FClipOn (FGC fgc);
void FClipOff (FGC fgc);
int FClipPoint (FGC fgc, float fx, float fy);
int FClipLine (FGC fgc, float fx1, float fy1, float fx2, float fy2,
float *fx1c, float *fy1c, float *fx2c, float *fy2c);
int FClipRectangle (FGC fgc, float fx, float fy, float fwidth, float fheight,
float *fxc, float *fyc, float *fwidthc, float *fheightc);
FGC FXCreateFGC (GC gc, int x, int y, int width, int height,
float fx, float fy, float fwidth, float fheight);
void FXFreeFGC (FGC fgc);
void FXDrawPoint (Display *display, Drawable d, FGC fgc, float fx, float fy);
void FXDrawPoints (Display *display, Drawable d, FGC fgc,
FXPoint fpoints[], int npoints, int mode);
void FXDrawLine (Display *display, Drawable d, FGC fgc,
float fx1, float fy1, float fx2, float fy2);
void FXDrawLines (Display *display, Drawable d, FGC fgc,
FXPoint fpoints[], int npoints, int mode);
void FXDrawRectangle (Display *display, Drawable d, FGC fgc,
float fx, float fy, float fwidth, float fheight);
void FXDrawArc (Display *display, Drawable d, FGC fgc,
float fx, float fy, float fwidth, float fheight,
float fangle1, float fangle2);
void FXDrawString (Display *display, Drawable d, FGC fgc,
float fx, float fy, char *string, int length);
void FXFillRectangle (Display *display, Drawable d, FGC fgc,
float fx, float fy, float fwidth, float fheight);

```

Notes:

The functions defined below are designed to resemble the equivalent X functions. For example, FXDrawLine() is analogous to XDrawLine. Each of the FXDraw<xxx>() functions requires an FGC instead of a GC (graphics context). An FGC contains a GC, along with the information required to transform floating point coordinates to integer (pixel) coordinates.

Additional functions are provided to transform floating point coordinates to integer coordinates and vice versa. Where feasible, macros are also provided to perform these coordinate transformations.

Clipping of floating point coordinates is supported, because clipping after mapping to integer coordinates is not valid when the mapped integer coordinates overflow the range of short integers. By clipping the floating point coordinates before mapping to integers, this overflow can be avoided. By default, clipping is turned off until a clip rectangle is specified or until clipping is explicitly turned on. Clipping is not currently supported for all FXDraw functions.

Author: Dave Hale, Colorado School of Mines, 07/24/90

Modified: Dave Hale, Colorado School of Mines, 05/18/91

Added floating point clipping capability to some FXDraw functions.

MISC - Miscellaneous X-Toolkit functions

XtcwpDrawString90 Draw a string rotated 90 degrees counter-clockwise

Function Prototype:

```
void XtcwpDrawString90 (Display *dpy, Drawable d, GC gc,  
int x, int y, char *string, int count);
```

Input:

dpy X display

d X drawable

gc X graphics context

x,y coordinates of baseline starting position of the string

string array[count] of characters to be drawn

count number of characters in string

Author: Dave Hale, Advance Geophysical, 06/03/93

RESCONV - general purpose resource type converters

XtcwpStringToFloat convert string to float in resource

Function Prototype:

```
void XtcwpStringToFloat (XrmValue *args, int *nargs,  
XrmValue *fromVal, XrmValue *toVal);
```

Author: Dave Hale, Colorado School of Mines, 08/28/90

RUBBERBOX - Function to draw a rubberband box in X-windows plots

XtcwpRubberbox Track pointer with rubberband box

Function Prototype:

```
void XtcwpRubberbox (Display *dpy, Window win, XEvent event,  
int *x, int *y, int *width, int *height);
```

Input:

dpy display pointer

win window ID

event event of type ButtonPress

Output:

x x of upper left hand corner of box in pixels

y y of upper left hand corner of box in pixels

width width of box in pixels

height height of box in pixels

Notes:

XtcwpRubberbox assumes that event is a ButtonPress event for the 1st button; i.e., it tracks motion of the pointer while the 1st button is down, and it sets x, y, w, and h and returns after a ButtonRelease event for the 1st button.

Before calling XtcwpRubberbox, both ButtonRelease and Button1Motion events must be enabled.

Author: Dave Hale, Colorado School of Mines, 01/27/90

RADIOBUTTONS - convenience functions creating and using radio buttons

XtcwpCreateStringRadioButtons create an XmFrame containing radio buttons labeled with strings

Function Prototypes:

```
Widget XtcwpCreateStringRadioButtons (Widget parent, char *label,  
int nstrings, char **strings, int first,  
void (*callback)(int selected, void *clientdata), void *clientdata);
```

Input:

parent parent widget

label label for this collection of radio buttons

nstrings number of strings

strings array[nstrings] of character strings, one per button

first index of button to be initially selected

callback function called when radio buttons change state

clientdata pointer to client data to be passed to callback

Notes:

This code depends on the Motif Developer's Package.

An integer index of the selected button (along with the clientdata pointer) is passed to the callback function.

The returned XmFrame is not managed.

Author: Dave Hale, Colorado School of Mines, 08/28/90



## SAMPLES - Motif-based Graphics Functions

`samplesCreate`  
`samplesDraw`  
`samplesSetN`  
`samplesSetData`  
`samplesSetPlotValue`  
`samplesSetEditMode`  
`samplesSetOrigin`

### Function Prototypes:

```
Samples *samplesCreate (Widget parent, char *title,  
void (*editDone)(Samples *s));  
void samplesDraw (Samples *s);  
void samplesSetN (Samples *s, int n);  
void samplesSetData (Samples *s, float *d);  
void samplesSetPlotValue (Samples *s, float pv);  
void samplesSetEditMode (Samples *s, EditMode m);  
void samplesSetOrigin (Samples *s, int i);
```

### Notes:

Watch this space.

Author: Dave Hale, Colorado School of Mines

FGETGTHR - get gathers from SU datafiles

fget\_gather - get a gather from a file

get\_gather - get a gather from stdin

Function Prototypes:

```
segy **fget_gather(FILE *fp, cwp_String *key, cwp_String *type, Value *n_val,  
int *nt, int *ntr, float *dt, int *first);
```

```
segy **get_gather(cwp_String *key, cwp_String *type, Value *n_val,  
int *nt, int *ntr, float *dt, int *first)
```

fget\_gather - get a gather from a file

Input:

fp file pointer of input file

key header key of ensemble

type header value type

value value of ensemble key word

nt number of time samples

ntr number of traces in ensemble

dt time sampling interval

first flag is this the first ensemble being read?

Notes:

The input seismic dataset must be sorted into ensembles defined by key

Author: Potash Corporation Saskatchewan, Balasz Nemeth  
given to CWP in 2008.

get\_gather - get a gather from stdin

Input:

key header key of ensemble

type header value type

value value of ensemble key word

nt number of time samples

ntr number of traces in ensemble

dt time sampling interval

first flag is this the first ensemble being read?

Notes:

The input seismic dataset must be sorted into ensembles defined by key

Author: Potash Corporation Saskatchewan, Balasz Nemeth  
given to CWP in 2008.

segy tr;

```
segy **fget_gather(FILE *fp, cwp_String *key, cwp_String *type, Value *n_val,  
int *nt, int *ntr, float *dt, int *first)
```

fget\_gather - get a gather from a file

Input:

fp file pointer of input file

key header key of ensemble

type header value type

value value of ensemble key word

nt number of time samples

ntr number of traces in ensemble

dt time sampling interval

first flag is this the first ensemble being read?

Notes:

The input seismic dataset must be sorted into ensembles defined by key

Author: Potash Corporation Saskatchewan, Balasz Nemeth

given to CWP in 2008.

```
{
```

```
int nsegy;
```

```
FILE *tracefp=NULL;
```

```
FILE *headerfp=NULL;
```

```
static FILE *ntracefp=NULL; /* first different trace pointer
```

```
static FILE *nheaderfp=NULL;
```

```
segy **rec=NULL;
```

```
int ntrr=0;
```

```
int indx=0;
```

```
static Value val;
```

```
*type = hdtype(*key);
```

```
indx = getindex(*key);
```

```
    *ntr = 0;
```

```
if(*first==0) {
```

```
    /* get info from first trace
```

```
nsegy = fvgettr(fp,&tr);
```

```
if (nsegy==0) err("can't get first trace");
```

```
*nt = tr.ns;
```

```
    *dt = (float) tr.dt/1000000.0;
```

```
    ++ntrr;
```

```
gethval(&tr, indx, n_val);
```

```
ntracefp = etmpfile();
```

```
nheaderfp = etmpfile();
```

```

*first=1;
} else {
/* This is the first trace of the nex gather
erewind(nheaderfp);
    erewind(ntracefp);
        fread (&tr,HDRBYTES, 1, nheaderfp);
        fread (tr.data,FSIZE, *nt, ntracefp);
gethval(&tr, indx, n_val);
}

/* Store traces in tmpfile while getting a count
tracefp = etmpfile();
headerfp = etmpfile();
    do {
        efwrite(&tr, 1, HDRBYTES, headerfp);
        efwrite(tr.data, FSIZE, *nt, tracefp);

/* read the next trace
*ntr+=1;
val=*n_val;
nsegy = fvgettr(fp,&tr);
if(nsegy) ntrr++;
gethval(&tr, indx, n_val);
} while (nsegy && !valcmp(*type,val,*n_val));

/* If there are no more traces then return
if(nsegy==0 && ntrr==0 ) {
    *ntr=0;
    efclose(nheaderfp);
    efclose(ntracefp);
    return(rec=NULL);
} else {
/* store the first trace of the next gather
erewind(nheaderfp);
    erewind(ntracefp);
        efwrite(&tr, 1, HDRBYTES, nheaderfp);
        efwrite(tr.data, FSIZE, *nt, ntracefp);
}

/* allocate memory for the record

```

```

{ register int i;
rec = ealloc1(*ntr,sizeof(segy *));
for(i=0;i<*ntr;i++)
rec[i] = (segy *)ealloc1((*nt*FSIZE+HDRBYTES),sizeof(char));
}

```

```

/* load traces into an array and close temp file
erewind(headerfp);
    erewind(tracefp);
{ register int ix;
    for (ix=0; ix<*ntr; ix++)
        fread (rec[ix],HDRBYTES, 1, headerfp);
    efclose (headerfp);
for(ix=0; ix<*ntr; ix++)
    fread ((*rec[ix]).data,FSIZE, *nt, tracefp);
    efclose (tracefp);
}

```

```

return(rec);
}

```

segy tr;

```

segy **get_gather(cwp_String *key,cwp_String *type,Value *n_val,
int *nt,int *ntr, float *dt,int *first)

```

get\_gather - get a gather from stdin

Input:

key header key of ensemble

type header value type

value value of ensemble key word

nt number of time samples

ntr number of traces in ensemble

dt time sampling interval

first flag is this the first ensemble being read?

Notes:

The input seismic dataset must be sorted into ensembles defined by key

Author: Potash Corporation Saskatchewan, Balasz Nemeth

given to CWP in 2008.

```
{
```

```
int nsegy;
```

```
FILE *tracefp=NULL;
```

```
FILE *headerfp=NULL;
```

```

static FILE *ntracefp=NULL; /* first different trace pointer
static FILE *nheaderfp=NULL;
segy **rec=NULL;
int ntrr=0;
int indx=0;
static Value val;

*type = hdtype(*key);
indx = getindex(*key);
    *ntr = 0;

if(*first==0) {
    /* get info from first trace
nsegy = vgettr(&tr);
if (nsegy==0) err("can't get first trace");
*nt = tr.ns;
    *dt = (float) tr.dt/1000000.0;
    ++ntrr;
gethval(&tr, indx, n_val);
ntracefp = etmpfile();
nheaderfp = etmpfile();
*first=1;
} else {
/* This is the first trace of the nex gather
erewind(nheaderfp);
    erewind(ntracefp);
        fread (&tr,HDRBYTES, 1, nheaderfp);
        fread (tr.data,FSIZE, *nt, ntracefp);
gethval(&tr, indx, n_val);
}

    /* Store traces in tmpfile while getting a count
tracefp = etmpfile();
headerfp = etmpfile();
    do {
        efwrite(&tr, 1, HDRBYTES, headerfp);
        efwrite(tr.data, FSIZE, *nt, tracefp);

/* read the next trace

```

```

*ntr+=1;
val=*n_val;
nsegy = vgettr(&tr);
if(nsegy) ntrr++;
gethval(&tr, indx, n_val);
} while (nsegy && !valcmp(*type,val,*n_val));

/* If there are no more traces then return
if(nsegy==0 && ntrr==0 ) {
    *ntr=0;
    efclose(nheaderfp);
    efclose(ntracefp);
    return(rec=NULL);
} else {
/* store the first trace of the next gather
erewind(nheaderfp);
    erewind(ntracefp);
        efwrite(&tr, 1, HDRBYTES, nheaderfp);
        efwrite(tr.data, FSIZE, *nt, ntracefp);
}

/* allocate memory for the record
{ register int i;
rec = ealloc1(*ntr,sizeof(segy *));
for(i=0;i<*ntr;i++)
rec[i] = (segy *)ealloc1((*nt*FSIZE+HDRBYTES),sizeof(char));
}

/* load traces into an array and close temp file
erewind(headerfp);
    erewind(tracefp);
{ register int ix;
    for (ix=0; ix<*ntr; ix++)
        fread (rec[ix],HDRBYTES, 1, headerfp);
    efclose (headerfp);
for(ix=0; ix<*ntr; ix++)
    fread ((*rec[ix]).data,FSIZE, *nt, tracefp);
    efclose (tracefp);
}

return(rec);

```

}



fgethdr - get segy tape identification headers from the file by file pointer

Input:

fp            file pointer

Output:

chdr        3200 bytes of segy character header

bhdr        400 bytes of segy binary header

Authors: zhiming li and j. dulac , unocal

modified for CWP/SU: R. Beardsley

FGETTR - Routines to get an SU trace from a file

fgettr get a fixed-length segy trace from a file by file pointer  
fvgettr get a variable-length segy trace from a file by file pointer  
fgettra get a fixed-length trace from disk file by trace number  
gettr macro using fgettr to get a trace from stdin  
vgettr macro using fvgettr to get a trace from stdin  
gettra macro using fgettra to get a trace from stdin by trace number

Function Prototype:

```
int fgettr(FILE *fp, segy *tp);
int fvgettr(FILE *fp, segy *tp);
int fgettra(FILE *fp, segy *tp, int itr);
```

Returns:

fgettr, fvgettr:  
int: number of bytes read on current trace (0 after last trace)

fgettra:  
int: number of traces in disk file

Macros defined in segy.h

```
define gettr(x) fgettr(stdin, (x))
define vgettr(x) fvgettr(stdin, (x))
```

Usage example:

```
    segy tr;
    ...
    while (gettr(&tr)) {
        tr.offset = abs(tr.offset);
        puttr(&tr);
    }
    ...
```

Authors: SEP: Einar Kjartansson, Stew Levin CWP: Shuki Ronen, Jack Cohen

Revised: 7/2/95 Stewart A. Levin Mobil

Major rewrite: Use xdr library for portable su output file  
format. Merge fgettr and fgettra into same source file.  
Make input from multiple streams work (at long last!).

Revised: 11/22/95 Stewart A. Levin Mobil

Always set ntr for DISK input. This fixes susort failure.

Revised: 1/9/96 jkc CWP

Set lastfp on nread <=0 return, too.  
Revised: 28 Mar, 2006 Stewart A. Levin    Landmark Graphics  
Reworked XDR to support random seeks on > 2GB files  
and to read big endian SHORTPACK data on little endian machines.

FPUTGTHR - put gathers to a file

fput\_gather - put a gather to a file

put\_gather - put a gather to stdout

Function Prototypes:

```
segy **fput_gather(FILE *fp, segy **rec,int *nt, int *ntr);
```

```
segy **put_gather(segy **rec,int *nt, int *ntr)
```

fput\_gather - put a gather to a file

Input:

fp pointer to output file

rec array of segy traces

nt number of time samples per trace

ntr number of traces in ensemble

Author: Potash Corporation Saskatchewan, Balasz Nemeth  
given to CWP in 2008.

put\_gather - put a gather to stdout

Input:

rec array of segy traces

nt number of time samples per trace

ntr number of traces in ensemble

Author: Potash Corporation Saskatchewan, Balasz Nemeth  
given to CWP in 2008.

```
include "su.h"
```

```
include "segy.h"
```

```
include "header.h"
```

```
segy tr;
```

```
segy **fput_gather(FILE *fp, segy **rec,int *nt, int *ntr)
```

```
fput_gather - put a gather to a file
```

Input:

fp pointer to output file

rec array of segy traces

nt number of time samples per trace

ntr number of traces in ensemble

Author: Potash Corporation Saskatchewan, Balasz Nemeth  
given to CWP in 2008.

```
{
```

```
segy tr;
```

```
{ register int i;
for(i=0;i<*ntr;i++) {
memcpy( (void *) &tr, (const void *) rec[i],
*nt*FSIZE+HDRBYTES);
fvputtr(fp,&tr);
free1((void *)rec[i]);
}
}
return(rec=NULL);
}
```

```
segy **put_gather(segy **rec,int *nt, int *ntr)
```

put\_gather - put a gather to stdout

Input:

rec array of segy traces

nt number of time samples per trace

ntr number of traces in ensemble

Author: Potash Corporation Saskatchewan, Balasz Nemeth  
given to CWP in 2008.

```
{
segy tr;
```

```
{ register int i;
for(i=0;i<*ntr;i++) {
memcpy( (void *) &tr, (const void *) rec[i],
*nt*FSIZE+HDRBYTES);
vputtr(&tr);
free1((void *)rec[i]);
}
}
return(rec=NULL);
}
```

FPUTTR - Routines to put an SU trace to a file

fputtr put a segy trace to a file by file pointer

fvputtr put a segy trace to a file by file pointer (variable ns)

puttr macro using fputtr to put a trace to stdin

vputtr macro using fputtr to put a trace to stdin (variable ns)

Function Prototype:

```
void fputtr(FILE *fp, segy *tp);
```

```
void fvputtr(FILE *fp, segy *tp);
```

Returns:

void

Notes:

The functions puttr(x) vputtr(x) are macros defined in segy.h

```
define puttr(x) fputtr(stdin, (x))
```

```
define vputtr(x) fvputtr(stdin, (x))
```

Usage example:

```
    segy tr;
```

```
    ...
```

```
    while (gettr(&tr)) {
```

```
        tr.offset = abs(tr.offset);
```

```
        puttr(&tr);
```

```
    }
```

```
    ...
```

Authors: SEP: Einar Kjartansson, Stew Levin CWP: Shuki Ronen, Jack Cohen

HDRPKG - routines to access the SEGY header via the `hdr` structure.

`gethval` get a trace header word by index  
`puthval` put a trace header word by index  
`getbhval` get a binary header word by index  
`putbhval` put a binary header word by index  
`gethdval` get a trace header word by name  
`puthdval` put a trace header word by name

`hdtype` get the data type of a trace header word by name  
`getkey` get the name of a trace header word from its index

`getindex` get the index of a trace header word from the name

`swaphval` swap the trace header words by index  
`swapbhval` swap the binary header words by index  
`gettapehval` get a tape trace header word by index  
`puttapehval` put a tape trace header word by index  
`gettapebhval` get a tape binary header word by index  
`puttapebhval` put a tape binary header word by index  
`printhead` display non-null header field values

#### Function Prototypes:

```
void gethval(const segy *tr, int index, Value *valp);
void puthval(segy *tr, int index, Value *valp);
void putbhval(bhed *bh, int index, Value *valp);
void getbhval(const bhed *bh, int index, Value *valp);
void gethdval(const segy *tr, char *key, Value *valp);
void puthdval(segy *tr, char *key, Value *valp);
char *hdtype(const char *key);
char *getkey(const int index);
int getindex(const char *key);
void swaphval(segy *tr, int index);
void swapbhval(bhed *bh, int index);
void gettapehval(tapesegy *tapetr, int index, Value *valp);
void puttapehval(tapesegy *tapetr, int index, Value *valp);
void gettapebhval(tapebhed *tapetr, int index, Value *valp);
void puttapebhval(tapebhed *tapetr, int index, Value *valp);
void printhead(const segy *tp);
```

#### Notes:

This package includes only those routines that directly access

the "hdr" or "bhdr" structures. It does not include routines such as printfval, printftype, printfhead that use the routines in this package to indirectly access these structures.

Note that while gethdval and puthdval are more convenient to use than gethval and puthval, they incur an inefficiency in the common case of iterating code over a set of traces with a fixed key or keys. In such cases, it is advisable to set the index or indices outside the loop using getindex.

swaphval:

Byte-swapping is needed for converting SU data from big-endian to little-endian formats, and vice versa. The swap\_.... subroutines are based on subroutines provided by Jens Hartmann of the Institut fur Geophysik in Hamburg. These are found in .../cwp/lib/swapbyte.c.

Authors: SEP: Einar Kjartansson CWP: Jack Cohen, Shuki Ronen

swaphval: CWP: John Stockwell



TABPLOT - TABPLOT selected sample points on selected trace

tabplot tabplot selected sample points on selected trace

Function Prototype:

```
void tabplot(segy *tp, int itmin, int itmax);
```

Input:

tp pointer to a segy

itmin minimum time sample printed

itmax maximum time sample printed

Authors: CWP: Brian Sumner, Jack K. Cohen

VALPKGGE - routines to handle variables of type Value

vtoi cast Value variable as an int  
vtol cast Value variable as a long  
vtof cast Value variable as a float  
vtod cast Value variable as a double  
atoval convert ascii to Value  
valtoabs take absolute value of a Value variable  
valcmp compare Value variables  
printfval printf a Value variable  
fprintfval fprintf a Value variable  
scanfval scanf a Value variable  
printftype printf for the type of a segy header word

Function Prototypes:

```
int vtoi(register cwp_String type, Value val);
long vtol(register cwp_String type, Value val);
float vtof(register cwp_String type, Value val);
double vtod(register cwp_String type, Value val);
void atoval(cwp_String type, cwp_String keyval, Value *valp);
Value valtoabs(cwp_String type, Value val);
int valcmp(register cwp_String type, Value val1, Value val2);
void printfval(register cwp_String type, Value val);
void fprintfval(FILE *stream, register cwp_String type, Value val);
void scanfval(register cwp_String type, Value *valp);
```

Notes:

A Value is defined by the following in .../su/include/su.h:

```
typedef union { * storage for arbitrary type *
char s[8];
short h;
unsigned short u;
long l;
unsigned long v;
int i;
unsigned int p;
float f;
double d;
unsigned int U:16;
unsigned int P:32;
} Value;
```

The use of the valpkge routines, as well as the hdrpkge routines, permits the user to change the definition of the types of the various fields of the segy data type, without breaking codes that look at part or all of these fields.

Authors: CWP: Jack K. Cohen, Shuki Ronen

ABEL - Functions to compute the discrete ABEL transform:

abelalloc allocate and return a pointer to an Abel transformer  
abelfree free an Abel transformer  
abel compute the Abel transform

Function prototypes:

```
void *abelalloc (int n);  
void abelfree (void *at);  
void abel (void *at, float f[], float g[]);
```

Input:

ns number of samples in the data to be transformed  
f[] array of floats, the function being transformed

Output:

at pointer to Abel transformer returned by abelalloc(int n)  
g[] array of floats, the transformed data returned by  
abel(\*at,f[],g[])

Notes:

The Abel transform is defined by:

$$g(y) = 2 \int_{|y|}^{\text{Infinity}} dx f(x) / \sqrt{1 - (y/x)^2}$$

Linear interpolation is used to define the continuous function  $f(x)$  corresponding to the samples in  $f[]$ . The first sample  $f[0]$  corresponds to  $f(x=0)$  and the sampling interval is assumed to be 1. Therefore, the input samples correspond to  $0 \leq x \leq n-1$ . Samples of  $f(x)$  for  $x > n-1$  are assumed to be zero. These conventions imply that

$$g[0] = f[0] + 2*f[1] + 2*f[2] + \dots + 2*f[n-1]$$

References:

Hansen, E. W., 1985, Fast Hankel transform algorithm: IEEE Trans. on Acoustics, Speech and Signal Processing, v. ASSP-33, n. 3, p. 666-671. (Beware of several errors in the equations in this paper!)

Authors: Dave Hale and Lydia Deng, Colorado School of Mines, 06/01/90

AIRY - Approximate the Airy functions  $Ai(x)$ ,  $Bi(x)$  and their respective derivatives  $Ai'(x)$ ,  $Bi'(x)$

airya return approximation of  $Ai(x)$   
airypa return approximation of  $Ai'(x)$   
airyb return approximation of  $Bi(x)$   
airybp return approximation of  $Bi'(x)$

Function Prototypes:

```
float airya (float x);  
float airypa (float x);  
float airyb (float x);  
float airybp (float x);
```

Input:

x value at which to evaluate  $Ai(x)$

Returned:

```
airya  $Ai(x)$   
airypa  $Ai'(x)$   
airyb  $Bi(x)$   
airybp  $Bi'(x)$ 
```

Reference:

The approximation is derived from tables and formulas in Abramowitz and Stegun, p. 475-477.

Author: Dave Hale, Colorado School of Mines, 06/06/89

## ALLOC - Allocate and free multi-dimensional arrays

alloc1 allocate a 1-d array  
realloc1 re-allocate a 1-d array  
free1 free a 1-d array  
alloc2 allocate a 2-d array  
free2 free a 2-d array  
alloc3 allocate a 3-d array  
free3 free a 3-d array  
alloc4 allocate a 4-d array  
free4 free a 4-d array  
alloc5 allocate a 5-d array  
free5 free a 5-d array  
alloc6 allocate a 6-d array  
free6 free a 6-d array  
alloc1int allocate a 1-d array of ints  
realloc1int re-allocate a 1-d array of ints  
free1int free a 1-d array of ints  
alloc2int allocate a 2-d array of ints  
free2int free a 2-d array of ints  
alloc3int allocate a 3-d array of ints  
free3int free a 3-d array of ints  
alloc1float allocate a 1-d array of floats  
realloc1float re-allocate a 1-d array of floats  
free1float free a 1-d array of floats  
alloc2float allocate a 2-d array of floats  
free2float free a 2-d array of floats  
alloc3float allocate a 3-d array of floats  
free3float free a 3-d array of floats  
alloc4float allocate a 4-d array of floats  
free4float free a 4-d array of floats  
alloc5float allocate a 5-d array of floats  
free5float free a 5-d array of floats  
alloc6float allocate a 6-d array of floats  
free6float free a 6-d array of floats  
alloc4int allocate a 4-d array of ints  
free4int free a 4-d array of ints  
alloc5int allocate a 5-d array of ints  
free5int free a 5-d array of ints  
alloc5uchar allocate a 5-d array of unsigned chars  
free5uchar free a 5-d array of unsigned chars  
alloc5ushort allocate a 5-d array of unsigned shorts  
free5ushort free a 5-d array of unsigned shorts

alloc6ushort     allocate a 6-d array of unsigned shorts  
 free6ushort     free a 6-d array of unsigned shorts  
 alloc1double    allocate a 1-d array of doubles  
 realloc1double   re-allocate a 1-d array of doubles  
 free1double    free a 1-d array of doubles  
 alloc2double    allocate a 2-d array of doubles  
 free2double    free a 2-d array of doubles  
 alloc3double    allocate a 3-d array of doubles  
 free3double    free a 3-d array of doubles  
 alloc1complex   allocate a 1-d array of complexes  
 realloc1complex   re-allocate a 1-d array of complexes  
 free1complex    free a 1-d array of complexes  
 alloc2complex   allocate a 2-d array of complexes  
 free2complex    free a 2-d array of complexes  
 alloc3complex   allocate a 3-d array of complexes  
 free3complex    free a 3-d array of complexes

alloc1dcomplex   allocate a 1-d array of complexes  
 realloc1dcomplex   re-allocate a 1-d array of complexes  
 free1dcomplex    free a 1-d array of complexes  
 alloc2dcomplex   allocate a 2-d array of complexes  
 free2dcomplex    free a 2-d array of complexes  
 alloc3dcomplex   allocate a 3-d array of complexes  
 free3dcomplex    free a 3-d array of complexes

#### Function Prototypes:

```

void *alloc1 (size_t n1, size_t size);
void *realloc1 (void *v, size_t n1, size_t size);
void free1 (void *p);
void **alloc2 (size_t n1, size_t n2, size_t size);
void free2 (void **p);
void ***alloc3 (size_t n1, size_t n2, size_t n3, size_t size);
void free3 (void ***p);
void ****alloc4 (size_t n1, size_t n2, size_t n3, size_t n4, size_t size);
void free4 (void ****p);
                size_t size);
int *alloc1int (size_t n1);
int *realloc1int (int *v, size_t n1);
void free1int (int *p);
int **alloc2int (size_t n1, size_t n2);
void free2int (int **p);
int ***alloc3int (size_t n1, size_t n2, size_t n3);
void free3int (int ***p);
  
```

```

float *alloc1float (size_t n1);
float *realloc1float (float *v, size_t n1);
void free1float (float *p);
float **alloc2float (size_t n1, size_t n2);
void free2float (float **p);
float ***alloc3float (size_t n1, size_t n2, size_t n3);
void free3float (float ***p);
float ****alloc4float (size_t n1, size_t n2, size_t n3, size_t n4);
void free4float (float ****p);
                                size_t n6);
int ****alloc4int (size_t n1, size_t n2, size_t n3, size_t n4);
void free4int (int ****p);
size_t n5);
                                size_t n5);
                                size_t n5, size_t n6);
double *alloc1double (size_t n1);
double *realloc1double (double *v, size_t n1);
void free1double (double *p);
double **alloc2double (size_t n1, size_t n2);
void free2double (double **p);
double ***alloc3double (size_t n1, size_t n2, size_t n3);
void free3double (double ***p);
complex *alloc1complex (size_t n1);
complex *realloc1complex (complex *v, size_t n1);
void free1complex (complex *p);
complex **alloc2complex (size_t n1, size_t n2);
void free2complex (complex **p);
complex ***alloc3complex (size_t n1, size_t n2, size_t n3);
void free3complex (complex ***p);

complex *alloc1dcomplex (size_t n1);
complex *realloc1dcomplex (dcomplex *v, size_t n1);
void free1dcomplex (dcomplex *p);
complex **alloc2dcomplex (size_t n1, size_t n2);
void free2dcomplex (dcomplex **p);
complex ***alloc3dcomplex (size_t n1, size_t n2, size_t n3);
void free3dcomplex (dcomplex ***p);

```

#### Notes:

The functions defined below are intended to simplify manipulation of multi-dimensional arrays in scientific programming in C. These functions are useful only because true multi-dimensional arrays



in C cannot have variable dimensions (as in FORTRAN). For example, the following function IS NOT valid in C:

```
void badFunc(a,n1,n2)
float a[n2][n1];
{
a[n2-1][n1-1] = 1.0;
}
```

However, the following function IS valid in C:

```
void goodFunc(a,n1,n2)
float **a;
{
a[n2-1][n1-1] = 1.0;
}
```

Therefore, the functions defined below do not allocate true multi-dimensional arrays, as described in the C specification. Instead, they allocate and initialize pointers (and pointers to pointers) so that, for example, `a[i2][i1]` behaves like a 2-D array.

The array dimensions are numbered, which makes it easy to add functions for arrays of higher dimensions. In particular, the 1st dimension of length `n1` is always the fastest dimension, the 2nd dimension of length `n2` is the next fastest dimension, and so on. Note that the 1st (fastest) dimension `n1` is the first argument to the allocation functions defined below, but that the 1st dimension is the last subscript in `a[i2][i1]`. (This is another important difference between C and Fortran.)

The allocation of pointers to pointers implies that more storage is required than is necessary to hold a true multi-dimensional array. The fraction of the total storage allocated that is used to hold pointers is approximately  $1/(n1+1)$ . This extra storage is unlikely to represent a significant waste for large `n1`.

The functions defined below are significantly different from similar functions described by Press et al, 1988, NR in C.

In particular, the functions defined below:

- (1) Allocate arrays of arbitrary size elements.
- (2) Allocate contiguous storage for arrays.
- (3) Return NULL if allocation fails (just like `malloc`).
- (4) Do not provide arbitrary lower and upper bounds for arrays.

Contiguous storage enables an allocated multi-dimensional array to be passed to a C function that expects a one-dimensional array.

For example, to allocate and zero an n1 by n2 two-dimensional array of floats, one could use

```
a = alloc2(n1,n2,sizeof(float));
```

```
zeroFloatArray(n1*n2,a[0]);
```

where zeroFloatArray is a function defined as

```
void zeroFloatArray(int n, float *a)
```

```
{
```

```
int i;
```

```
for (i=0; i<n; i++)
```

```
a[i] = 0.0;
```

```
}
```

Internal error handling and arbitrary array bounds, if desired, should be implemented in functions that call the functions defined below, with the understanding that these enhancements may limit portability.

Author: Dave Hale, Colorado School of Mines, 12/31/89

Zhaobo Meng, added 4D, 5D and 6D functions, 1996

## ANTI\_ALIAS - Butterworth anti-aliasing filter

antialias use before increasing the sampling interval of data  
i.e. subsampling

Function Prototype:

```
void antialias (float frac, int phase, int n, float p[], float q[]);
```

Input:

frac current sampling interval / future interval (should be  $\leq 1$ )

phase =0 for zero-phase filter; =1 for minimum-phase filter

n number of samples

p array[n] of input samples

Output:

q array[n] of output (anti-alias filtered) samples

Notes:

The anti-alias filter is a recursive (Butterworth) filter. For zero-phase anti-alias filtering, the recursive filter is applied forwards and backwards.

Author: Dave Hale, Colorado School of Mines, 06/06/90

AXB - Functions to solve a linear system of equations  $Ax=b$  by LU decomposition, invert a square matrix or directly multiply an inverse matrix by another matrix (without explicitly computing the inverse).

LU\_decomposition Decompose a matrix (A) into a lower triangular (L) and an upper triangular (U) such that  $A=LU$

backward\_substitution Apply backward substitution to an LU decomposed matrix to solve the linear system of equations  $Ax=b$

inverse\_matrix compute the inverse of a square non-singular matrix

inverse\_matrix\_multiply computes the product  $A^{(-1)}*B$  without explicitly computing the inverse matrix

Function prototypes:

```
void LU_decomposition (int nrows, float **matrix, int *idx, float *d);
void backward_substitution (int nrows, float **matrix, int *idx, float *b);
void inverse_matrix (int nrows, float **matrix);
void inverse_matrix_multiply (int nrows1, float **matrix1, int ncols2,
                             int nrows2, float **matrix2, float **out_matrix);
```

LU\_decomposition:

Input:

nrows number of rows of matrix to invert

matrix matrix of coefficients in linear system  $Ax=b$

Output:

matrix matrix containing LU decomposition (original matrix destroyed)

idx vector recording the row permutations effected by partial pivoting

d +/- 1 depending on whether the number of row interchanges was even or odd

backward\_substitution

Input:

nrows number of rows (and columns) of input matrix

matrix matrix of coefficients (after LU decomposition)

idx permutation vector obtained from routine LU\_decomposition

b right hand side vector in equation  $Ax=b$

Output:

b vector with the solution

inverse\_matrix

Input:

nrows number of rows (and columns) of input matrix

matrix matrix to invert

Output:

matrix inverse of input matrix

inverse\_matrix\_multiply

nrows1 number of rows (and columns) of matrix to invert

matrix1 square matrix to invert

ncols2 number of columns of second matrix

nrows2 number of rows of second matrix

matrix second matrix (multiplier)

Output Parameters:

out\_matrix matrix containing the product of the inverse of the first matrix by the second one.

Note:

matrix1 and matrix2 are not destroyed, (not clobbered)

Notes:

To solve the set of linear equations  $Ax=b$ , first do the LU decomposition of A (which will clobber A with its LU decomposition) and then do the backward substitution with this new matrix and the right-hand side vector b. The vector b will be clobbered with the solution. Both, the original matrix and vector B, will have been destroyed.

The LU decomposition is carried out with the Crout's method with implicit partial pivoting that guarantees that the maximum pivot is used in every step of the algorithm.

The operation count to solve a linear system of equations via LU decomposition is  $\frac{1}{3}N^3$  and is a factor of 3 better than the standard Gauss-Jordan algorithm. To invert a matrix the count is the same with both algorithms:  $N^3$ .

Once a linear system  $Ax=b$  has been solved, to solve another linear system with the same matrix A but with different vector b, ONLY the back substitution has to be repeated with the new b (remember that the matrix in backsubstitution is not the original matrix but its LU decomposition)

If you want to compute  $A^{-1}B$  from matrices A and B, it is better to use the subroutine inverse\_matrix\_multiply rather than explicitly computing the inverse. This saves a whole matrix multiplication and is also more accurate.

References:

Press, Teukolsky, Vetterling and Flannery, Numerical Recipes in C:  
The art of scientific computing. Cambridge University Press.  
second edition. (1992).

Golub and Van Loan, Matrix Computations. John Hopkins University Press.  
Second Edition. (1989).

Horn and Johnson, Matrix Analysis. Cambridge University Press. (1985).

Credits:

Adapted from discussions in Numerical Recipes, by Gabriel Alvarez (1995)

BIGMATRIX - Functions to manipulate 2-dimensional matrices that are too big to fit in real memory, but that are small enough to fit in virtual memory:

bmalloc allocate a big matrix  
bfree free a big matrix  
bmaread read a vector from a big matrix  
bmwrite write a vector to a big matrix

Function Prototypes:

```
void *bmalloc (int nbpe, int n1, int n2);  
void bfree (void *bm);  
void bmaread (void *bm, int dir, int k1, int k2, int n, void *v);  
void bmwrite (void *bm, int dir, int k1, int k2, int n, void *v);
```

bmalloc:

Input:

nbpe number of bytes per matrix element  
n1 number of elements in 1st (fastest) dimension  
n2 number of elements in 2nd (slowest) dimension

Returned:

bm pointer to big matrix

bfree:

Input:

bm pointer to big matrix state (returned by bmalloc)

bmaread:

Input:

bm pointer to big matrix state (returned by bmalloc)  
d = 1 or 2: direction in which to read matrix elements  
k1 1st dimension index of first matrix element to read  
k2 2nd dimension index of first matrix element to read  
n number of elements to read

Output:

v array[n] to contain matrix elements read

bmwrite:

Input:

bm pointer to big matrix state (returned by bmalloc)  
d = 1 or 2: direction in which to write matrix elements

k1 1st dimension index of first matrix element to write  
k2 2nd dimension index of first matrix element to write  
n number of elements to write  
v array[n] containing matrix elements to write

Notes:

The bm functions provide access to a big 2-dimensional matrix along either the 1st or 2nd dimensions. Although, the matrix must be small enough to fit in virtual memory, it may be too large to fit in real memory. These functions provide equally efficient (or equally inefficient) access to vectors in a big matrix along either the 1st or 2nd dimensions.

For example, the following algorithm will efficiently transpose an n1 by n2 array of (n1\*n2) floats stored in a file:

```
void *bm;
float *v;
bm = bmalloc(sizeof(float),n1,n2);
for (i2=0; i2<n2; i2++) {
    (read n1 floats from input file into array v);
    bmwrite(bm,1,0,i2,n1,(char*)v);
}
for (i1=0; i1<n1; i1++) {
    bmread(bm,2,i1,0,n2,(char*)v);
    (write n2 floats in array v to output file);
}
bmfree(bm);
```

Author: Dave Hale, Colorado School of Mines, 05/17/89



BUTTERWORTH - Functions to design and apply Butterworth filters:

bfdesign design a Butterworth filter  
bfhighpass apply a high-pass Butterworth filter  
bflowpass apply a low-pass Butterworth filter

Function Prototypes:

```
void bfhighpass (int npoles, float f3db, int n, float p[], float q[]);  
void bflowpass (int npoles, float f3db, int n, float p[], float q[]);  
void bfdesign (float fpass, float apass, float fstop, float astop,  
int *npoles, float *f3db);
```

bfdesign:

Input:

fpass frequency in pass band at which amplitude is  $\geq$  apass  
apass amplitude in pass band corresponding to frequency fpass  
fstop frequency in stop band at which amplitude is  $\leq$  astop  
astop amplitude in stop band corresponding to frequency fstop

Output:

npoles number of poles  
f3db frequency at which amplitude is  $\sqrt{0.5}$  (-3 db)

bfhighpass and bflowpass:

Input:

npoles number of poles (and zeros); npoles $\geq$ 0 is required  
f3db 3 db frequency; nyquist = 0.5;  $0.0 \leq f3db \leq 0.5$  is required  
n length of p and q  
p array[n] to be filtered

Output:

q filtered array[n] (may be equivalent to p)

Notes:

(1) Nyquist frequency equals 0.5

(2) The following conditions must be true:

$(0.0 < fpass \ \&\& \ fpass < 0.5) \ \&\&$   
 $(0.0 < fstop \ \&\& \ fstop < 0.5) \ \&\&$   
 $(fpass \neq fstop) \ \&\&$   
 $(0.0 < astop \ \&\& \ astop < apass \ \&\& \ apass < 1.0)$

(3) if  $(fpass < fstop)$

bfdesign:

Butterworth filter: compute number of poles and -3 db frequency for a low-pass or high-pass filter, given a frequency response constrained at two frequencies.

Author: Dave Hale, Colorado School of Mines, 06/02/89

## COMPLEX - Functions to manipulate complex numbers

cadd add two complex numbers  
csub subtract two complex numbers  
cmul multiply two complex numbers  
cdiv divide two complex numbers  
cmplx make a complex number from two real numbers  
conjg complex conjugate of a complex number  
cneg negate a complex number  
cinv invert a complex number  
cwp\_csqrt complex square root of a complex number  
cwp\_cexp complex exponential of a complex number  
crmul multiply a complex number by a real number  
rcabs real magnitude of a complex number

### Structure:

```
typedef struct _complexStruct {  complex number
float r,i;
} complex;
```

### Function Prototypes:

```
complex cadd (complex a, complex b);
complex csub (complex a, complex b);
complex cmul (complex a, complex b);
complex cdiv (complex a, complex b);
float rcabs (complex z);
complex cmplx (float re, float im);
complex conjg (complex z);
complex cneg (complex z);
complex cinv (complex z);
complex cwp_csqrt (complex z);
complex cwp_cexp (complex z);
complex crmul (complex a, float x);
```

### Notes:

The function "rcabs" was originally called "fcabs". This produced a collision on some systems so a new name was chosen.

### Reference:

Adapted from Press et al, 1988, Numerical Recipes in C (Appendix E).

Author: Dave Hale, Colorado School of Mines, 06/02/89

Modified: Dave Hale, Colorado School of Mines, 04/26/90

Added function `cinv()`.

## COMPLEXD - Functions to manipulate double-precision complex numbers

dcadd add two dcomplex numbers  
dcsb subtract two dcomplex numbers  
dcmul multiply two dcomplex numbers  
dcdv divide two dcomplex numbers  
dcmplx make a dcomplex number from two real numbers  
dconjg dcomplex conjugate of a dcomplex number  
dcneg negate a dcomplex number  
dcinv invert a dcomplex number  
dcsqrt dcomplex square root of a dcomplex number  
dcexp dcomplex exponential of a dcomplex number  
dcrmul multiply a dcomplex number by a real number  
drcabs real magnitude of a dcomplex number

### Structure:

```
typedef struct _dcomplexStruct { dcomplex number  
double r,i;  
} dcomplex;
```

### Function Prototypes:

```
dcomplex dcadd (dcomplex a, dcomplex b);  
dcomplex dcsb (dcomplex a, dcomplex b);  
dcomplex dcmul (dcomplex a, dcomplex b);  
dcomplex dcdv (dcomplex a, dcomplex b);  
double drcabs (dcomplex z);  
dcomplex dcmplx (double re, double im);  
dcomplex dconjg (dcomplex z);  
dcomplex dcneg (dcomplex z);  
dcomplex dcinv (dcomplex z);  
dcomplex dcsqrt (dcomplex z);  
dcomplex dcexp (dcomplex z);  
dcomplex dcrmul (dcomplex a, double x);
```

### Notes:

The function "drcabs" was originally called "fcabs". This produced a collision on some systems so a new name was chosen.

### Reference:

Adapted from Press et al, 1988, Numerical Recipes in C (Appendix E).

Author: Dave Hale, Colorado School of Mines, 06/02/89

Modified: Dave Hale, Colorado School of Mines, 04/26/90

Added function `dcinv()`.

COMPLEXF - Subroutines to perform operations on complex numbers.  
This set of functions complement the one in complex.c  
of the CWP library

cipow raise a complex number to an integer power  
crpow raise a complex number to a real power  
rcpow raise a real number to a complex power  
ccpow raise a complex number to a complex power  
cwp\_ccos compute the complex cosine of a complex angle  
cwp\_csin compute the complex sine of a complex angle  
cwp\_ccosh compute the complex hyperbolic cosine of a complex angle  
cwp\_csinh compute the complex hyperbolic sine of a complex angle  
cwp\_cexp1 compute the complex exponential of a complex number  
cwp\_clog compute the complex logarithm of a complex number

Function Prototypes:

```
complex cipow(complex a, int p);  
complex crpow(complex a, float p);  
complex rcpow(float a, complex p);  
complex ccpow (complex a, complex p)  
complex cwp_ccos(complex a);  
complex cwp_csin(complex a);  
complex cwp_ccosh(complex a);  
complex cwp_csinh(complex a);  
complex cwp_cexp1(complex a);  
complex cwp_clog(complex a);
```

Credits:

Dave Hale, original version in C++  
Gabriel Alvarez, translation to C

COMPLEXFD - Subroutines to perform operations on double complex numbers.  
This set of functions complement the one in complexd.c  
of the CWP library

dcipow raise a double complex number to an integer power  
dcrpow raise a double complex number to a real power  
rdcpow raise a real number to a double complex power  
dcdcpow raise a double complex number to a double complex power  
dccos compute the double complex cosine of a double complex angle  
dcsin compute the double complex sine of a double complex angle  
dccosh compute the double complex hyperbolic cosine of a double complex angle  
dcsinh compute the double complex hyperbolic sine of a double complex angle  
dcexp1 compute the double complex exponential of a double complex number  
dclog compute the double complex logarithm of a double complex number

Function Prototypes:

```
dcomplex dcipow(dcomplex a, int p);  
dcomplex dcrpow(dcomplex a, float p);  
dcomplex rdcpow(float a, dcomplex p);  
dcomplex dcdcpow (dcomplex a, dcomplex p)  
dcomplex dccos(dcomplex a);  
dcomplex dcsin(dcomplex a);  
dcomplex dccosh(dcomplex a);  
dcomplex dcsinh(dcomplex a);  
dcomplex dcexp1(dcomplex a);  
dcomplex dclog(dcomplex a);
```

Credits:

Dave Hale, original version in C++  
Gabriel Alvarez, translation to C



Conjugate Gradient routines -

simple\_conj\_gradient - simple conjugate gradient routine.

Function Prototypes:

```
void simple_conj_gradient(int n, float *x, int m, float *b, float **a, int niter);
```

References:

Claerbout, J. F. (1985), Conjugate gradients for beginners, SEP 44, Stanford Exploration Project.

Shewchuk, Jonathan Richard (1994), An introduction to the conjugate gradient method without the agonizing pain, edition 1 1/4, School of Computer Science Carnegie Mellon University

Credits:

CWP: John Stockwell, May 2014

Based on the subroutine cg() which appeared in (Claerbout, 1985)

CONVOLUTION - Compute  $z = x$  convolved with  $y$

convolve\_cwp compute the convolution of two input vector arrays

Input:

lx length of x array

ifx sample index of first x

x array[ $lx$ ] to be convolved with y

ly length of y array

ify sample index of first y

y array[ $ly$ ] with which x is to be convolved

lz length of z array

ifz sample index of first z

Output:

z array[ $lz$ ] containing x convolved with y

Function Prototype:

```
void convolve_cwp (int lx, int ifx, float *x, int ly, int ify, float *y,
int lz, int ifz, float *z);
```

Notes:

The operation  $z = x$  convolved with  $y$  is defined to be

$$z[i] = \sum_{j=ifx}^{ifx+lx-1} x[j] * y[i-j] \quad ; \quad i = ifz, \dots, ifz+lz-1$$

The x samples are contained in  $x[0], x[1], \dots, x[lx-1]$ ; likewise for the y and z samples. The sample indices of the first x, y, and z values determine the location of the origin for each array. For example, if z is to be a weighted average of the nearest 5 samples of y, one might use

```
...
x[0] = x[1] = x[2] = x[3] = x[4] = 1.0/5.0;
conv(5,-2,x,lx,0,y,ly,0,z);
...
```

In this example, the filter x is symmetric, with index of first sample = -2.

This function is optimized for architectures that can simultaneously perform a multiply, add, and one load from memory; e.g., the IBM RISC System/6000. Because, for each value of i, it accumulates the convolution sum  $z[i]$  in a scalar, this function is not likely to be optimal for vector architectures.

Author: Dave Hale, Colorado School of Mines, 11/23/91

CUBICSPLINE - Functions to compute CUBIC SPLINE interpolation coefficients

cakima compute cubic spline coefficients via Akima's method

(continuous 1st derivatives, only)

cmonot compute cubic spline coefficients via the Fritsch-Carlson method

(continuous 1st derivatives, only)

csplin compute cubic spline coefficients for interpolation

(continuous 1st and 2nd derivatives)

chermite compute cubic spline coefficients via Hermite Polynomial

(continuous 1st derivatives only)

Function Prototypes:

```
void cakima (int n, float x[], float y[], float yd[][4]);
```

```
void cmonot (int n, float x[], float y[], float yd[][4]);
```

```
void csplin (int n, float x[], float y[], float yd[][4]);
```

```
void chermite (int n, float x[], float y[], float yd[][4]);
```

Input:

n number of samples

x array[n] of monotonically increasing or decreasing abscissae

y array[n] of ordinates

Output:

yd array[n][4] of cubic interpolation coefficients (see notes)

Notes:

The computed cubic spline coefficients are as follows:

$yd[i][0] = y(x[i])$  (the value of y at  $x = x[i]$ )

$yd[i][1] = y'(x[i])$  (the 1st derivative of y at  $x = x[i]$ )

$yd[i][2] = y''(x[i])$  (the 2nd derivative of y at  $x = x[i]$ )

$yd[i][3] = y'''(x[i])$  (the 3rd derivative of y at  $x = x[i]$ )

To evaluate  $y(x)$  for  $x$  between  $x[i]$  and  $x[i+1]$  and  $h = x - x[i]$ ,  
use the computed coefficients as follows:

$$y(x) = yd[i][0] + h * (yd[i][1] + h * (yd[i][2] / 2.0 + h * yd[i][3] / 6.0))$$

Akima's method provides continuous 1st derivatives, but 2nd and 3rd derivatives are discontinuous. Akima's method is not linear, in that the interpolation of the sum of two functions is not the same as the sum of the interpolations.

The Fritsch-Carlson method yields continuous 1st derivatives, but 2nd and 3rd derivatives are discontinuous. The method will yield a

monotonic interpolant for monotonic data. 1st derivatives are set to zero wherever first divided differences change sign.

The method used by "csplin" yields continuous 1st and 2nd derivatives.

References:

See Akima, H., 1970, A new method for interpolation and smooth curve fitting based on local procedures, Journal of the ACM, v. 17, n. 4, p. 589-602.

For more information, see Fritsch, F. N., and Carlson, R. E., 1980, Monotone piecewise cubic interpolation: SIAM J. Numer. Anal., v. 17, n. 2, p. 238-246.

Also, see the book by Kahaner, D., Moler, C., and Nash, S., 1989, Numerical Methods and Software, Prentice Hall. This function was derived from SUBROUTINE PCHEZ contained on the diskette that comes with the book.

For more general information on spline functions of all types see the book by: Greville, T.N.E, 1969, Theory and Applications of Spline Functions, Academic Press.

Author: Dave Hale, Colorado School of Mines c. 1989, 1990, 1991

DBLAS - Double precision Basic Linear Algebra subroutines  
(adapted from LINPACK FORTRAN):

idamax return index of element with maximum absolute value  
dasum return sum of absolute values  
daxpy compute  $y[i] = a*x[i] + y[i]$   
dcopy copy  $x[i]$  to  $y[i]$  (i.e., set  $y[i] = x[i]$ )  
ddot return sum of  $x[i]*y[i]$  (i.e., return the dot product of  $x$  and  $y$ )  
dnrm2 return square root of sum of squares of  $x[i]$   
dscal compute  $x[i] = a*x[i]$   
dswap swap  $x[i]$  and  $y[i]$

Function Prototypes:

```
int idamax (int n, double *sx, int incx);  
double dasum (int n, double *sx, int incx);  
void daxpy (int n, double sa, double *sx, int incx, double *sy, int incy);  
void dcopy (int n, double *sx, int incx, double *sy, int incy);  
double ddot (int n, double *sx, int incx, double *sy, int incy);  
double dnrm2 (int n, double *sx, int incx);  
void dscal (int n, double sa, double *sx, int incx);  
void dswap (int n, double *sx, int incx, double *sy, int incy);
```

idamax:

Input:

n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned:

index of element with maximum absolute value (idamax)

dasum:

Input:

n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned:

sum of absolute values (dasum)

daxpy:

Input:

n number of elements in arrays

sa the scalar multiplier  
sx array[n] of elements to be scaled and added  
incx increment between elements of sx  
sy array[n] of elements to be added  
incy increment between elements of sy

Output:  
sy array[n] of accumulated elements

dcopy:  
Input:  
n number of elements in arrays  
sx array[n] of elements to be copied  
incx increment between elements of sx  
incy increment between elements of sy

Output:  
sy array[n] of copied elements

ddot:  
Input:  
n number of elements in arrays  
sx array[n] of elements  
incx increment between elements of sx  
sy array[n] of elements  
incy increment between elements of sy

Returned: dot product of the two arrays

dnrm2:  
Input:  
n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned: square root of sum of squares of x[i]

dscal:  
Input:  
n number of elements in array  
sa the scalar multiplier  
sx array[n] of elements  
incx increment between elements

Output:  
sx array[n] of scaled elements

Author: Dave Hale, Colorado School of Mines, 10/01/89

DGE - Double precision Gaussian Elimination matrix subroutines adapted from LINPACK FORTRAN:

dgefa Gaussian elimination to obtain the LU factorization of a matrix.  
dgeco Gaussian elimination to obtain the LU factorization and condition number of a matrix.

dgesl Solve linear system  $Ax = b$  or  $A'x = b$  after LU factorization.

Function Prototypes:

```
void dgefa (double **a, int n, int *ipvt, int *info);  
void dgeco (double **a, int n, int *ipvt, double *rcond, double *z);  
void dgesl (double **a, int n, int *ipvt, double *b, int job);
```

dgfa:

Input:

a matrix[n][n] to be factored (see notes below)

n dimension of a

Output:

a matrix[n][n] factored (see notes below)

ipvt indices of pivot permutations (see notes below)

info index of last zero pivot (or -1 if no zero pivots)

dgeco:

Input:

a matrix[n][n] to be factored (see notes below)

n dimension of a

Output:

a matrix[n][n] factored (see notes below)

ipvt indices of pivot permutations (see notes below)

rcond reciprocal of condition number (see notes below)

Workspace:

z array[n]

dgesl:

Input:

a matrix[n][n] that has been LU factored (see notes below)

n dimension of a

ipvt indices of pivot permutations (see notes below)

b right-hand-side vector[n]

job =0 to solve  $Ax = b$



=1 to solve  $A'x = b$

Output:

b solution vector[n]

Notes:

These functions were adapted from LINPACK FORTRAN. Because two-dimensional arrays cannot be declared with variable dimensions in C, the matrix a is actually a pointer to an array of pointers to floats, as declared above and used below.

Elements of a are stored as follows:

```
a[0][0]    a[1][0]    a[2][0]    ... a[n-1][0]
a[0][1]    a[1][1]    a[2][1]    ... a[n-1][1]
a[0][2]    a[1][2]    a[2][2]    ... a[n-1][2]
.
.
.
.
a[0][n-1]  a[1][n-1]  a[2][n-1] ... a[n-1][n-1]
```

Both the factored matrix a and the pivot indices ipvt are required to solve linear systems of equations via dgesl.

dgeco:

Given the reciprocal of the condition number, rcond, and the double epsilon, DBL\_EPSILON, the number of significant decimal digits, nsdd, in the solution of a linear system of equations may be estimated by:  
`nsdd = (int)log10(rcond/DBL_EPSILON)`

Author: Dave Hale, Colorado School of Mines, 1989

DIFFERENTIATE - simple DIFFERENTIATOR codes

differentiate - 1D two point centered difference based derivative

Function Prototype:

```
void differentiate(int n, float h, float *f, float *fprime);
```

```
void ddifferentiate(int n, double h, double *f, double *fprime);
```

differentiate:

Input:

n number of samples

h sample rate

f array[n] of input values

Output:

fprime array[n], the derivative of f

fprime:

Notes:

This is a simple 2 point centered-difference differentiator.

The derivatives at the endpoints are computed via 2 point leading and lagging differences.

Author: John Stockwell, CWP, 1994

PFAFFT - Functions to perform Prime Factor (PFA) FFT's, in place

npfa\_d return valid n for complex-to-complex PFA  
npfar\_d return valid n for real-to-complex/complex-to-real PFA  
npfao\_d return optimal n for complex-to-complex PFA  
npfaro\_d return optimal n for real-to-complex/complex-to-real PFA  
pfacc\_d 1D PFA complex to complex  
pfacr\_d 1D PFA complex to real  
pfarc\_d 1D PFA real to complex  
pfamcc\_d multiple PFA complex to real  
pfa2cc\_d 2D PFA complex to complex  
pfa2cr\_d 2D PFA complex to real  
pfa2rc\_d 2D PFA real to complex

Function Prototypes:

```
int npfa_d (int nmin);  
int npfao_d (int nmin, int nmax);  
int npfar_d (int nmin);  
int npfaro_d (int nmin, int nmax);  
void pfacc_d (int isign, int n, real_complex z[]);  
void pfacr_d (int isign, int n, real_complex cz[], real rz[]);  
void pfarc_d (int isign, int n, real rz[], real_complex cz[]);  
void pfamcc_d (int isign, int n, int nt, int k, int kt, real_complex z[]);  
void pfa2cc_d (int isign, int idim, int n1, int n2, real_complex z[]);  
void pfa2cr_d (int isign, int idim, int n1, int n2, real_complex cz[], real rz[]);  
void pfa2rc_d (int isign, int idim, int n1, int n2, real rz[], real_complex cz[]);
```

npfa\_d:

Input:

nmin lower bound on returned value (see notes below)

Returned: valid n for prime factor fft

npfao\_d

Input:

nmin lower bound on returned value (see notes below)

nmax desired (but not guaranteed) upper bound on returned value

Returned: valid n for prime factor fft

npfar\_d

Input:

nmin lower bound on returned value

Returned: valid n for real-to-real\_complex/real\_complex-to-real prime factor fft

npfaro\_d:

Input:

nmin lower bound on returned value

nmax desired (but not guaranteed) upper bound on returned value

Returned: valid n for real-to-real\_complex/real\_complex-to-real prime factor fft

pfacc\_d:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform (see notes below)

z array[n] of real\_complex numbers to be transformed in place

Output:

z array[n] of real\_complex numbers transformed

pfacr\_d:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform (see notes below)

cz array[n/2+1] of real\_complex values (may be equivalenced to rz)

Output:

rz array[n] of real values (may be equivalenced to cz)

pfarc\_d:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform; must be even (see notes below)

rz array[n] of real values (may be equivalenced to cz)

Output:

cz array[n/2+1] of real\_complex values (may be equivalenced to rz)

pfamcc\_d:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n number of real\_complex elements per transform (see notes below)

nt number of transforms

k stride in real\_complex elements within transforms

kt                stride in real\_complex elements between transforms  
z                array of real\_complex elements to be transformed in place

Output:  
z array of real\_complex elements transformed

pfa2cc\_d:

Input:  
isign            sign of isign is the sign of exponent in fourier kernel  
idim            dimension to transform, either 1 or 2 (see notes)  
n1              1st (fast) dimension of array to be transformed (see notes)  
n2              2nd (slow) dimension of array to be transformed (see notes)  
z               array[n2][n1] of real\_complex elements to be transformed in place

Output:  
z array[n2][n1] of real\_complex elements transformed

pfa2cr\_d:

Input:  
isign            sign of isign is the sign of exponent in fourier kernel  
idim            dimension to transform, which must be either 1 or 2 (see notes)  
n1              1st (fast) dimension of array to be transformed (see notes)  
n2              2nd (slow) dimension of array to be transformed (see notes)  
cz               array of real\_complex values (may be equivalenced to rz)

Output:  
rz               array of real values (may be equivalenced to cz)

pfa2rc\_d:

Input:  
isign            sign of isign is the sign of exponent in fourier kernel  
idim            dimension to transform, which must be either 1 or 2 (see notes)  
n1              1st (fast) dimension of array to be transformed (see notes)  
n2              2nd (slow) dimension of array to be transformed (see notes)  
rz               array of real values (may be equivalenced to cz)

Output:  
cz               array of real\_complex values (may be equivalenced to rz)

Notes:

Table of valid n and cost for prime factor fft. For each n, cost was estimated to be the inverse of the number of ffts done in 1 sec on an IBM RISC System/6000 Model 320H, by Dave Hale, 08/04/91.

(Redone by Jack Cohen for 15 sec to rebuild NTAB table on advice of David and Gregory Chudnovsky, 05/03/94).

Cost estimates are least accurate for very small  $n$ . An alternative method for estimating cost would be to count multiplies and adds, but this method fails to account for the overlapping of multiplies and adds that is possible on some computers, such as the IBM RS/6000 family.

`npfa_d:`

The returned  $n$  will be composed of mutually prime factors from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . Because  $n$  cannot exceed  $720720 = 5*7*9*11*13*16$ ,  $720720$  is returned if  $nmin$  exceeds  $720720$ .

`npfao_d:`

The returned  $n$  will be composed of mutually prime factors from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . Because  $n$  cannot exceed  $720720 = 5*7*9*11*13*16$ ,  $720720$  is returned if  $nmin$  exceeds  $720720$ . If  $nmin$  does not exceed  $720720$ , then the returned  $n$  will not be less than  $nmin$ . The optimal  $n$  is chosen to minimize the estimated cost of performing the fft, while satisfying the constraint, if possible, that  $n$  not exceed  $nmax$ .

`npfar and npfaro:`

Current implemenations of `real-to-real_complex` and `real_complex-to-real` prime factor ffts require that the transform length  $n$  be even and that  $n/2$  be a valid length for a `real_complex-to-real_complex` prime factor fft. The value returned by `npfar` satisfies these conditions. Also, see notes for `npfa`.

`pfacc:`

$n$  must be factorable into mutually prime factors taken from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . in other words,  
 $n = 2^{**p} * 3^{**q} * 5^{**r} * 7^{**s} * 11^{**t} * 13^{**u}$   
where  
 $0 \leq p \leq 4, \quad 0 \leq q \leq 2, \quad 0 \leq r,s,t,u \leq 1$   
is required for `pfa` to yield meaningful results. this restriction implies that  $n$  is restricted to the range  
 $1 \leq n \leq 720720 (= 5*7*9*11*13*16)$

`pfacr:`

Because `pfacr` uses `pfacc` to do most of the work,  $n$  must be even and  $n/2$  must be a valid length for `pfacc`. The simplest way to obtain a valid  $n$  is via  $n = npfar(nmin)$ . A more optimal  $n$  can be obtained with `npfaro`.

`pfarc:`

Because `pfarc` uses `pfacc` to do most of the work, `n` must be even and `n/2` must be a valid length for `pfacc`. The simplest way to obtain a valid `n` is via `n = npfar(nmin)`. A more optimal `n` can be obtained with `npfaro`.

`pfamcc:`

To perform a two-dimensional transform of an `n1` by `n2` `real_complex` array (assuming that both `n1` and `n2` are valid "n"), stored with `n1` fast and `n2` slow:

```
    pfamcc(isign,n1,n2,1,n1,z); (to transform 1st dimension)
    pfamcc(isign,n2,n1,n1,1,z); (to transform 2nd dimension)
```

`pfa2cc:`

Only one (either the 1st or 2nd) dimension of the 2-D array is transformed.

If `idim` equals 1, then `n2` transforms of `n1` `real_complex` elements are performed; else, if `idim` equals 2, then `n1` transforms of `n2` `real_complex` elements are performed.

Although `z` appears in the argument list as a one-dimensional array, `z` may be viewed as an `n1` by `n2` two-dimensional array: `z[n2][n1]`.

Valid `n` is computed via the "np" subroutines.

To perform a two-dimensional transform of an `n1` by `n2` `real_complex` array (assuming that both `n1` and `n2` are valid "n"), stored with `n1` fast and `n2` slow: `pfa2cc(isign,1,n1,n2,z); pfa2cc(isign,2,n1,n2,z);`

`pfa2cr:`

If `idim` equals 1, then `n2` transforms of `n1/2+1` `real_complex` elements to `n1` real elements are performed; else, if `idim` equals 2, then `n1` transforms of `n2/2+1` `real_complex` elements to `n2` real elements are performed.

Although `rz` appears in the argument list as a one-dimensional array, `rz` may be viewed as an `n1` by `n2` two-dimensional array: `rz[n2][n1]`. Likewise, depending on `idim`, `cz` may be viewed as either an `n1/2+1` by `n2` or an `n1` by `n2/2+1` two-dimensional array of `real_complex` elements.

Let `n` denote the transform length, either `n1` or `n2`, depending on `idim`. Because `pfa2rc` uses `pfa2cc` to do most of the work, `n` must be even and `n/2` must be a valid length for `pfa2cc`. The simplest way to

obtain a valid  $n$  is via  $n = \text{npfar}(\text{nmin})$ . A more optimal  $n$  can be obtained with `npfaro`.

`pfa2rc`:

If `idim` equals 1, then  $n_2$  transforms of  $n_1$  real elements to  $n_1/2+1$  `real_complex` elements are performed; else, if `idim` equals 2, then  $n_1$  transforms of  $n_2$  real elements to  $n_2/2+1$  `real_complex` elements are performed.

Although `rz` appears in the argument list as a one-dimensional array, `rz` may be viewed as an  $n_1$  by  $n_2$  two-dimensional array: `rz[n2][n1]`. Likewise, depending on `idim`, `cz` may be viewed as either an  $n_1/2+1$  by  $n_2$  or an  $n_1$  by  $n_2/2+1$  two-dimensional array of `real_complex` elements.

Let  $n$  denote the transform length, either  $n_1$  or  $n_2$ , depending on `idim`. Because `pfa2rc` uses `pfa2cc` to do most of the work,  $n$  must be even and  $n/2$  must be a valid length for `pfa2cc`. The simplest way to obtain a valid  $n$  is via  $n = \text{npfar}(\text{nmin})$ . A more optimal  $n$  can be obtained with `npfaro`.

References:

Temperton, C., 1985, Implementation of a self-sorting in-place prime factor fft algorithm: *Journal of Computational Physics*, v. 58, p. 283-299.

Temperton, C., 1988, A new set of minimum-add rotated rotated dft modules: *Journal of Computational Physics*, v. 75, p. 190-198.

Press et al, 1988, *Numerical Recipes in C*, p. 417.

Author: Dave Hale, Colorado School of Mines, 04/27/89  
Revised by Baoniu Han to handle double precision. 12/14/98



CWP\_Exit - exit subroutine for CWP/SU codes

FRANNOR - functions to generate a pseudo-random float normally distributed with  $N(0,1)$ ; i.e., with zero mean and unit variance.

frannor return a normally distributed random float  
srannor seed random number generator for normal distribution

Function Prototypes:  
float frannor (void);  
void srannor (int seed);

frannor:  
Input: (none)  
Returned: normally distributed random float

srannor:  
Input:  
seed different seeds yield different sequences of random numbers.

Notes:  
Adapted from subroutine rnor in Kahaner, Moler and Nash (1988)  
which in turn was based on an algorithm by  
Marsaglia and Tsang (1984).

References:  
Numerical Methods and Software", D.  
Kahaner, C. Moler, S. Nash, Prentice Hall, 1988.

Marsaglia G. and Tsang, W. W., 1984,  
A fast, easily implemented method for sampling from decreasing or symmetric  
unimodal density functions: SIAM J. Sci. Stat. Comput., v. 5, no. 2,  
p. 349-359.

Author: Dave Hale, Colorado School of Mines, 01/21/89

FRANUNI - Functions to generate a pseudo-random float uniformly distributed on [0,1); i.e., between 0.0 (inclusive) and 1.0 (exclusive)

franuni return a random float  
sranuni seed random number generator

Function Prototypes:  
float franuni (void);  
void sranuni (int seed);

franuni:  
Input: (none)  
Returned: pseudo-random float

sranuni:  
seed different seeds yield different sequences of random numbers.

Notes:  
Adapted from subroutine uni in Kahaner, Moler, and Nash (1988).  
This book references a set of unpublished notes by  
Marsaglia.

According to the reference, this random  
number generator "passes all known tests and has a period that is ...  
approximately  $10^{19}$ ".

References:  
Numerical Methods and Software", D. Kahaner, C. Moler, S. Nash,  
Prentice Hall, 1988.

Marsaglia G., "Comments on the perfect uniform random number generator  
Unpublished notes, Wash S. U.

Author: Dave Hale, Colorado School of Mines, 12/30/89

## HANKEL - Functions to compute discrete Hankel transforms

`hankelalloc` allocate and return a pointer to a Hankel transformer  
`hankelfree` free a Hankel transformer  
`hankel0` compute the zeroth-order Hankel transform  
`hankel1` compute the first-order Hankel transform

### Function Prototypes:

```
void *hankelalloc (int nfft);  
void hankelfree (void *ht);  
void hankel0 (void *ht, float f[], float h[]);  
void hankel1 (void *ht, float f[], float h[]);
```

### `hankelalloc`:

#### Input:

`nfft` valid length for real to complex fft (see notes below)

#### Returned:

pointer to Hankel transformer

### `hankelfree`:

#### Input:

`ht` pointer to Hankel transformer (as returned by `hankelalloc`)

### `hankel0`:

#### Input:

`ht` pointer to Hankel transformer (as returned by `hankelalloc`)

`f` array[`nfft/2+1`] to be transformed

#### Output:

`h` array[`nfft/2+1`] transformed

### `hankel1`:

#### Input:

`ht` pointer to Hankel transformer (as returned by `hankelalloc`)

`f` array[`nfft/2+1`] to be transformed

#### Output:

`h` array[`nfft/2+1`] transformed

### Notes:

The zeroth-order Hankel transform is defined by:

$$h_0(k) = \int_0^{\infty} dr \, r \, j_0(k*r) f(r)$$

where  $j_0$  denotes the zeroth-order Bessel function.

The first-order Hankel transform is defined by:

$$h_1(k) = \int_0^{\infty} dr \, r \, j_1(k*r) f(r)$$

where  $j_1$  denotes the first-order Bessel function.

The Hankel transform is its own inverse.

The Hankel transform is computed by an Abel transform followed by a Fourier transform.

#### References:

Hansen, E. W., 1985, Fast Hankel transform algorithm: IEEE Trans. on Acoustics, Speech and Signal Processing, v. ASSP-33, n. 3, p. 666-671. (Beware of several errors in the equations in this paper!)

Authors: Dave Hale, Colorado School of Mines, 06/04/90

Hartley - routines for fast Hartley transform

srfht - in-place FHT using the split-radix algorithm  
dsrfht - in-place FHT using the split-radix algorithm (double precision)  
r4fht - in-place FHT using the radix-4 algorithm  
nextpow2 - find  $m$  such that  $n=2^m$  via lookup table  
nextpow4 - find  $m$  such that  $n=4^m$  via lookup table  
srfht - split-radix in-place FHT

Function Prototypes:

```
void srfht(int *n, int *m, float *f);  
void dsrfht(int *n, int *m, double *f);  
void r4fht(int n, int m, float *f);  
int nextpow2(int n);  
int nextpow4(int n);
```

Notes:

srfht - in-place FHT using the split-radix algorithm  
(single precision)  
does not include division by  $n$   
 $n$  and  $m$  are not modified  
usage: srfht(int \*n, int \*m, float \*f)  
 $n$  length of input sequence  $n=2^m$   
 $m$  exponent such that  $n=2^m$   
 $f$  input sequence to FHT

dsrfht - in-place FHT using the split-radix algorithm  
(double precision)  
does not include division by  $n$   
 $n$  and  $m$  are not modified  
usage: dsrfht(int \*n, int \*m, double \*f)  
 $n$  length of input sequence  $n=2^m$   
 $m$  exponent such that  $n=2^m$   
 $f$  input sequence to FHT

r4fht - in-place FHT using the radix-4 algorithm  
does not include division by  $n$   
usage: r4fht(int n, int m, float \*f)  
 $n$  length of input sequence  $n=4^m$   
 $m$  exponent such that  $n=4^m$

f input sequence to FHT  
  
 nextpow2 - find m such that  $n=2^m$  via lookup table  
 max(n)= $2^{24}$   
  
 nextpow4 - find m such that  $n=4^m$  via lookup table  
 max(n)= $4^{12}$   
  
 srfht - split-radix in-place FHT  
   n length of input sequence  $n=2^m$   
   m exponent such that  $n=2^m$   
   f input sequence to FHT  
   Reference:  
       Sorensen, H. V., Jones, D. L., Burrus, C. S, & Heideman, M. T.,  
       1985, On computing the Hartley transform: IEEE Trans. Acoust.,  
       Speech, and Signal Proc., v. ASSP-33, no. 4, p. 1231-1238.  
  
 possible improvements:  
 find optimum length for FHT (nfhto)  
 use bit shift operators in r4fht  
   Credits: CENPET: Werner M. Heigl, April 2006

HILBERT - Compute Hilbert transform y of x

hilbert compute the Hilbert transform

Function Prototype:

```
void hilbert (int n, float x[], float y[]);
```

Input:

n length of x and y

x array[n] to be Hilbert transformed

Output:

y array[n] containing Hilbert transform of x

Notes:

The Hilbert transform is computed by convolving x with a windowed (approximate) version of the ideal Hilbert transformer.

Author: Dave Hale, Colorado School of Mines, 06/02/89



HOLBERG1D - Compute coefficients of Holberg's 1st derivative filter

holberg1d comput the coefficients of Holberg's 1st derivative filter

Function Prototype:

```
void holberg1d (float e, int n, float d[]);
```

Input:

e maximum relative error in group velocity

n number of coefficients in filter (must be 2, 4, 6, or 8)

Output:

d array[n] of coefficients

Notes:

Coefficients are output in a form suitable for convolution. The derivative is centered halfway between coefficients  $d[n/2-1]$  and  $d[n/2]$ .

Coefficients are computed via the power series method of Kindelan et al., 1990, On the construction and efficiency of staggered numerical differentiators for the wave equation: Geophysics 55, 107-110. See also, Holberg, 1987, Computational aspects of the choice of operator and sampling interval for numerical differentiation in large-scale simulation of wave phenomena: Geophys. Prosp., 35, 629-655

Reference:

Kindelan et al., 1990,

On the construction and efficiency of staggered numerical differentiators for the wave equation: Geophysics 55, 107-110.

See also, Holberg, 1987, Computational aspects of the choice of operator and sampling interval for numerical differentiation in large-scale simulation of wave phenomena: Geophys. Prosp., 35, 629-655

Author: Dave Hale, Colorado School of Mines, 06/06/91

INTCUB - evaluate  $y(x)$ ,  $y'(x)$ ,  $y''(x)$ , ... via piecewise cubic interpolation

intcub evaluate  $y(x)$ ,  $y'(x)$ ,  $y''(x)$ , ... via piecewise spline interpolation

Function Prototype:

```
void intcub (int ideriv, int nin, float xin[], float ydin[][4],
```

Input:

ideriv =0 if  $y(x)$  desired; =1 if  $y'(x)$  desired, ...

nin length of xin and ydin arrays

xin array[nin] of monotonically increasing or decreasing x values

ydin array[nin][4] of  $y(x)$ ,  $y'(x)$ ,  $y''(x)$ , and  $y'''(x)$

nout length of xout and yout arrays

xout array[nout] of x values at which to evaluate  $y(x)$ ,  $y'(x)$ , ...

Output:

yout array[nout] of  $y(x)$ ,  $y'(x)$ , ... values

Notes:

xin values must be monotonically increasing or decreasing.

Extrapolation of the function  $y(x)$  for xout values outside the range spanned by the xin values is performed using the derivatives in ydin[0][0:3] or ydin[nin-1][0:3], depending on whether xout is closest to xin[0] or xin[nin-1], respectively.

Reference:

See: Greville, T. N., Theory and Application of Spline Functions, Academic Press for a general discussion of spline functions.

Author: Dave Hale, Colorado School of Mines, 06/02/89

INTL2B - bilinear interpolation of a 2-D array of bytes

intl2b bilinear interpolation of a 2-D array of bytes

Function Prototype:

```
void intl2b (int nxin, float dxin, float fxin,  
int nyin, float dyin, float fyin, unsigned char *zin,  
int nxout, float dxout, float fxout,  
int nyout, float dyout, float fyout, unsigned char *zout);
```

Input:

nxin number of x samples input (fast dimension of zin)  
dxin x sampling interval input  
fxin first x sample input  
nyin number of y samples input (slow dimension of zin)  
dyin y sampling interval input  
fyin first y sample input  
zin array[nyin][nxin] of input samples (see notes)  
nxout number of x samples output (fast dimension of zout)  
dxout x sampling interval output  
fxout first x sample output  
nyout number of y samples output (slow dimension of zout)  
dyout y sampling interval output  
fyout first y sample output

Output:

zout array[nyout][nxout] of output samples (see notes)

Notes:

The arrays zin and zout must be passed as pointers to the first element of a two-dimensional contiguous array of unsigned char values.

Constant extrapolation of zin is used to compute zout for output x and y outside the range of input x and y.

For efficiency, this function builds a table of interpolation coefficients pre-multiplied by byte values. To keep the table reasonably small, the interpolation does not distinguish between x and y values that differ by less than  $dxin/ICMAX$  and  $dyin/ICMAX$ , respectively, where ICMAX is a parameter defined above.

Author: Dave Hale, Colorado School of Mines, c. 1989-1991.

INTLINC - evaluate complex  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...

Function Prototype:

```
void intlinc (int nin, float xin[], complex yin[], complex yinl, complex yinr,
int nout, float xout[], complex yout[]);
```

Input:

nin length of xin and yin arrays

xin array[nin] of monotonically increasing or decreasing x values

yin array[nin] of input  $y(x)$  values

yinl value used to extrapolate  $y(x)$  to left of input yin values

yinr value used to extrapolate  $y(x)$  to right of input yin values

nout length of xout and yout arrays

xout array[nout] of x values at which to evaluate  $y(x)$

Output:

yout array[nout] of linearly interpolated  $y(x)$  values

Notes:

xin values must be monotonically increasing or decreasing.

Extrapolation of the function  $y(x)$  for xout values outside the range spanned by the xin values is performed as follows:

For monotonically increasing xin values,

yout=yinl if  $xout < xin[0]$ , and yout=yinr if  $xout > xin[nin-1]$ .

For monotonically decreasing xin values,

yout=yinl if  $xout > xin[0]$ , and yout=yinr if  $xout < xin[nin-1]$ .

If  $nin==1$ , then the monotonically increasing case is used.

/

INTLIN - evaluate  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...

intlin evaluate  $y(x)$  via linear interpolation of  $y(x[0])$ ,  $y(x[1])$ , ...

Function Prototype:

```
void intlin (int nin, float xin[], float yin[], float yinl, float yinr,  
int nout, float xout[], float yout[]);
```

Input:

nin length of xin and yin arrays

xin array[nin] of monotonically increasing or decreasing x values

yin array[nin] of input  $y(x)$  values

yinl value used to extrapolate  $y(x)$  to left of input yin values

yinr value used to extrapolate  $y(x)$  to right of input yin values

nout length of xout and yout arrays

xout array[nout] of x values at which to evaluate  $y(x)$

Output:

yout array[nout] of linearly interpolated  $y(x)$  values

Notes:

xin values must be monotonically increasing or decreasing.

Extrapolation of the function  $y(x)$  for xout values outside the range spanned by the xin values is performed as follows:

For monotonically increasing xin values,

yout=yinl if  $xout < xin[0]$ , and yout=yinr if  $xout > xin[nin-1]$ .

For monotonically decreasing xin values,

yout=yinl if  $xout > xin[0]$ , and yout=yinr if  $xout < xin[nin-1]$ .

If  $nin==1$ , then the monotonically increasing case is used.

Author: Dave Hale, Colorado School of Mines, 06/02/89

INTLIRR2B - bilinear interpolation of a 2-D array of bytes

intlirr2b bilinear interpolation of a 2-D array of bytes  
where x spacings are irregular

Function Prototype:

```
void intlirr2b (int nxin, float *xin,  
int nyin, float dyin, float fyin, unsigned char *zin,  
int nxout, float dxout, float fxout,  
int nyout, float dyout, float fyout, unsigned char *zout);
```

Input:

nxin number of x samples input (fast dimension of zin)  
xin array of (irregular) input x-coordinates  
nyin number of y samples input (slow dimension of zin)  
dyin y sampling interval input  
fyin first y sample input  
zin array[nyin][nxin] of input samples (see notes)  
nxout number of x samples output (fast dimension of zout)  
dxout x sampling interval output  
fxout first x sample output  
nyout number of y samples output (slow dimension of zout)  
dyout y sampling interval output  
fyout first y sample output

Output:

zout array[nyout][nxout] of output samples (see notes)

Notes:

The arrays zin and zout must be passed as pointers to the first element of a two-dimensional contiguous array of unsigned char values.

Constant extrapolation of zin is used to compute zout for output x and y outside the range of input x and y.

For efficiency, this function builds a table of interpolation coefficients pre-multiplied by byte values. To keep the table reasonably small, the interpolation does not distinguish between x and y values that differ by less than  $dxin/ICMAX$  and  $dyin/ICMAX$ , respectively, where  $ICMAX$  is a parameter defined above.

Author: Dave Hale, Colorado School of Mines, c. 1989-1991.

INTSINC8 - Functions to interpolate uniformly-sampled data via 8-coeff. sinc approximations:

ints8c interpolation of a uniformly-sampled complex function  $y(x)$  via an 8-coefficient sinc approximation.

ints8r Interpolation of a uniformly-sampled real function  $y(x)$  via a table of 8-coefficient sinc approximations

Function Prototypes:

```
void ints8c (int nxin, float dxin, float fxin, complex yin[],
             complex yinl, complex yinr, int nxout, float xout[], complex yout[]);
void ints8r (int nxin, float dxin, float fxin, float yin[],
             float yinl, float yinr, int nxout, float xout[], float yout[]);
```

Input:

nxin number of  $x$  values at which  $y(x)$  is input

dxin  $x$  sampling interval for input  $y(x)$

fxin  $x$  value of first sample input

yin array[nxin] of input  $y(x)$  values:  $yin[0] = y(fxin)$ , etc.

yinl value used to extrapolate yin values to left of  $yin[0]$

yinr value used to extrapolate yin values to right of  $yin[nxin-1]$

nxout number of  $x$  values at which  $y(x)$  is output

xout array[nxout] of  $x$  values at which  $y(x)$  is output

Output:

yout array[nxout] of output  $y(x)$ :  $yout[0] = y(xout[0])$ , etc.

Notes:

Because extrapolation of the input function  $y(x)$  is defined by the left and right values yinl and yinr, the xout values are not restricted to lie within the range of sample locations defined by nxin, dxin, and fxin.

The maximum error for frequencies less than 0.6 nyquist is less than one percent.

Author: Dave Hale, Colorado School of Mines, 06/02/89

INTTABLE8 - Interpolation of a uniformly-sampled complex function  $y(x)$  via a table of 8-coefficient interpolators

intt8c interpolation of a uniformly-sampled complex function  $y(x)$  via a table of 8-coefficient interpolators  
intt8r interpolation of a uniformly-sampled real function  $y(x)$  via a table of 8-coefficient interpolators

Function Prototype:

```
void intt8c (int ntable, float table[][8],
int nxin, float dxin, float fxin, complex yin[],
complex yinl, complex yinr, int nxout, float xout[], complex yout[]);
void intt8r (int ntable, float table[][8],
int nxin, float dxin, float fxin, float yin[],
float yinl, float yinr, int nxout, float xout[], float yout[]);
```

Input:

ntable number of tabulated interpolation operators;  $ntable \geq 2$   
table array of tabulated 8-point interpolation operators  
nxin number of  $x$  values at which  $y(x)$  is input  
dxin  $x$  sampling interval for input  $y(x)$   
fxin  $x$  value of first sample input  
yin array of input  $y(x)$  values:  $yin[0] = y(fxin)$ , etc.  
yinl value used to extrapolate yin values to left of  $yin[0]$   
yinr value used to extrapolate yin values to right of  $yin[nxin-1]$   
nxout number of  $x$  values at which  $y(x)$  is output  
xout array of  $x$  values at which  $y(x)$  is output

Output:

yout array of output  $y(x)$  values:  $yout[0] = y(xout[0])$ , etc.

NOTES:

ntable must not be less than 2.

The table of interpolation operators must be as follows:

Let  $d$  be the distance, expressed as a fraction of  $dxin$ , from a particular  $xout$  value to the sampled location  $xin$  just to the left of  $xout$ . Then, for  $d = 0.0$ ,

$table[0][0:7] = 0.0, 0.0, 0.0, 1.0, 0.0, 0.0, 0.0, 0.0$

are the weights applied to the 8 input samples nearest  $xout$ .



Likewise, for  $d = 1.0$ ,

```
table[ntable-1][0:7] = 0.0, 0.0, 0.0, 0.0, 1.0, 0.0, 0.0, 0.0
```

are the weights applied to the 8 input samples nearest  $x_{out}$ . In general, for  $d = (\text{float})itable/(\text{float})(ntable-1)$ , `table[itable][0:7]` are the weights applied to the 8 input samples nearest  $x_{out}$ . If the actual sample distance  $d$  does not exactly equal one of the values for which interpolators are tabulated, then the interpolator corresponding to the nearest value of  $d$  is used.

Because extrapolation of the input function  $y(x)$  is defined by the left and right values  $y_{inl}$  and  $y_{inr}$ , the  $x_{out}$  values are not restricted to lie within the range of sample locations defined by  $n_{xin}$ ,  $dx_{in}$ , and  $fx_{in}$ .

AUTHOR: Dave Hale, Colorado School of Mines, 06/02/89

LINEAR\_REGRESSION - Compute linear regression of (y1,y2,...,yn) against (x1,x2,...,xn)

Function Prototype:

```
void linear_regression(float *y, float *x, int n, float coeff[4]);
```

Input:

y array of y values

x array of x values

n length of y and x arrays

Output:

coeff[4] where:

coeff[0] slope of best fit line

coeff[1] intercept of best fit line

coeff[2] correlation coefficient of fit (1 = perfect) [dimensionless]

coeff[3] standard error of fit (0 = perfect) [dimensions of y]

Notes:

y(x)

```

|      * .      fit is y(x) = a x + b
|      .
|      . *
| * .
| . *
|----- x

```

$$a = \frac{n \text{ Sum}[x*y] - \text{Sum}[x]*\text{Sum}[y]}{n \text{ Sum}[x*x] - \text{Sum}[x]*\text{Sum}[x]}$$

$$b = \frac{\text{Sum}[y] - a*\text{Sum}[x]}{n}$$

cc = std definition

se = std definition

Author: Chris Liner, UTulsa, 11/16/03

maxmin - subroutines that pertain to maximum and minimum values  
min\_index - find the value of the index where an array is a minimum

function prototypes:

```
int max_index(int n, float *a,int inc);  
int min_index(int n, float *a,int inc);
```

Author: Balasz Nemeth: Potash Corporation, given to CWP in 2008

MKDIFF - Make an n-th order DIFFerentiator via Taylor's series method.

mkdiff make discrete Taylor series approximation to n'th derivative.

Function Prototype:

```
void mkdiff (int n, float a, float h, int l, int m, float d[]);
```

Input:

n order of desired derivative (n>=0 && n<=m-1 is required)

a fractional distance from integer sampling index (see notes)

h sampling interval

l sampling index of first coefficient (see notes below)

m sampling index of last coefficient (see notes below)

Output:

d array[m-l+1] of coefficients for n'th order differentiator

Notes:

The abscissae x of a sampled function f(x) can always be expressed as  $x = (j+a)*h$ , where j is an integer, a is a fraction, and h is the sampling interval. To approximate the n'th order derivative  $f_n(x)$  of the sampled function f(x) at  $x = (j+a)*h$ , use the m-l+1 coefficients in the output array d[] as follows:

$$f_n(x) = d[0]*f(j-l) + d[1]*f(j-l-1) + \dots + d[m-l]*f(j-m)$$

i.e., convolve the coefficients in d with the samples in f.

m-l+1 (the number of coefficients) must not be greater than the NCMAX parameter specified below.

For best approximations,

when n is even, use a = 0.0, l = -m

when n is odd, use a = 0.5, l = -m-1

Author: Dave Hale, Colorado School of Mines, 06/02/89

MKHDIFF - Compute filter approximating the bandlimited Half-DIFFerentiator.

mkhdiff - Compute filter approximating the bandlimited half-differentiator.

Function Prototype:

```
void mkhdiff (float h, int l, float d[]);
```

Input:

h sampling interval

l half-length of half-differentiator (length = 1+2\*l is odd)

Output:

d array[1+2\*l] of coefficients for half-differentiator

Notes:

The half-differentiator is defined by

$$\begin{aligned} d[l+j] &= \frac{\sqrt{1/h}}{(2\pi)} * \int_{-\pi}^{\pi} dw \sqrt{-iw} \exp(-iwj) \\ &= \frac{\sqrt{2/h}}{(2\pi)} * \int_0^{\pi} dw \sqrt{w} (\cos(wj) - \sin(wj)) \\ &\quad \text{for } j = -l, -l+1, \dots, l. \end{aligned}$$

An alternative definition is that  $f'(j) = d(j) * d(j) * f(j)$ , where  $f'(j)$  denotes the derivative of a sampled function  $f(j)$  and  $*$  denotes a convolution sum.

The half-derivative  $g(j)$  of  $f(j)$  may be computed by the following sum:

$$g(j) = d[0]*f(j+1) + d[1]*f(j+1-1) + \dots + d[2*l]*f(j-1)$$

The integral over frequency is evaluated numerically using Simpson's method. Although the Filon method of numerical integration is more appropriate for this integral, the truncation of  $d[l+j]$  for  $|j| > l$  is probably the greatest source of error. In any case,  $d[l+j]$  is cosine-tapered to reduce these truncation errors.

Author: Dave Hale, Colorado School of Mines, 06/02/89

MKSINC - Compute least-squares optimal sinc interpolation coefficients.

mksinc Compute least-squares optimal sinc interpolation coefficients.

Function Prototype:

```
void mksinc (float d, int lsinc, float sinc[]);
```

Input:

d fractional distance to interpolation point;  $0.0 \leq d \leq 1.0$

lsinc length of sinc approximation;  $lsinc \% 2 == 0$  and  $lsinc \leq 20$

Output:

sinc array[lsinc] containing interpolation coefficients

Notes:

The coefficients are a least-squares-best approximation to the ideal sinc function for frequencies from zero up to a computed maximum frequency. For a given interpolator length, lsinc, mksinc computes the maximum frequency, fmax (expressed as a fraction of the nyquist frequency), using the following empirically derived relation (from a Western Geophysical Technical Memorandum by Ken Larner):

$$fmax = \min(0.066 + 0.265 \cdot \log(lsinc), 1.0)$$

Note that fmax increases as lsinc increases, up to a maximum of 1.0. Use the coefficients to interpolate a uniformly-sampled function y(i) as follows:

$$y(i+d) = \sum_{j=0}^{lsinc-1} sinc[j] \cdot y(i+j+1-lsinc/2)$$

Interpolation error is greatest for  $d=0.5$ , but for frequencies less than fmax, the error should be less than 1.0 percent.

Author: Dave Hale, Colorado School of Mines, 06/02/89

MNEWT - Solve non-linear system of equations  $f(x) = 0$  via Newton's method

mnewt Solve non-linear system of equations  $f(x) = 0$  via Newton's method

Function Prototype:

```
int mnewt (int maxiter, float ftol, float dxtol, int n, float *x, void *aux,  
void (*fdfdx)(int n, float *x, float *f, float **dfdx, void *aux));
```

Input:

maxiter maximum number of iterations

ftol converged when sum of absolute values of  $f$  less than ftol

dxtol converged when sum of absolute values of  $dx$  less than dxtol

$n$  number of equations

$x$  array[ $n$ ] containing initial guess of solution

aux pointer to auxiliary parameters to be passed to fdfdx

fdfdx pointer to function to evaluate  $f(x)$  and  $f'(x)$

Output:

$x$  array[ $n$ ] containing solution

Returned: number of iterations; -1 if failed to converge in maxiter

Input to the user-supplied function fdfdx:

$n$  number of equations

$x$  array[ $n$ ] of  $x_0, x_1, \dots$

aux pointer to auxiliary variables required by fdfdx.

Output from the user-supplied function fdfdx:

$f$  array[ $n$ ] of  $f_0(x), f_1(x), \dots$

dfdx array[ $n$ ][ $n$ ] of  $f'(x)$ ;  $dfdx[j][i] = df_i/dx_j$

Author: Dave Hale, Colorado School of Mines, 06/06/91

ORTHPOLYNOMIALS - compute ORTHogonal POLYNOMIALS

hermite\_n\_polynomial: Compute n-th order generalized Hermite polynomial.

hermite\_n\_polynomial:

Input:

h0 array of size nt holding  $H_{\{n-1\}}$

h1 array of size nt holding  $H_{\{n\}}$

t array of size nt holding time vector

nt size of arrays, no. of samples

n order of polynomial

sigma variance

Output:

h array of size nt holding  $H_{\{n+1\}}$

Notes: Note that n in the function call is the order of the derivative and  
j in the code below is the n in the recurrence relation

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Author: Werner M. Heigl, Apache Corporation, E&P Technology, December 2006

```
include "cwp.h"
```

```
void
```

```
hermite_n_polynomial(double *h, double *h0, double *h1, double *t, int nt, int n, double sigma)
```

```
hermite_n_polynomial: Compute n-th order generalized Hermite polynomial.
```

```
Input:
```

```
h0 array of size nt holding  $H_{\{n-1\}}$ 
```

```
h1 array of size nt holding  $H_{\{n\}}$ 
```

```
t array of size nt holding time vector
```

```
nt size of arrays, no. of samples
```

```
n order of polynomial
```

```
sigma variance
```

```
Output:
```

```
h array of size nt holding  $H_{\{n+1\}}$ 
```

```
Note: Note that n in the function call is the order of the derivative and  
j in the code below is the n in the recurrence relation
```



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Author: Werner M. Heigl, Apache Corporation, E&P Technology, December 2006

```

{
int i; /* loop variable
int j=1; /* recurrence counter

/* as long as necessary use recurrence relation
do {
/* current instance of recurrence relation
for (i = 0; i < nt; ++i)
h[i] = ( t[i] * h1[i] - j * h0[i] ) / sigma;

/* update inputs to recurrence relation
memcpy((void *) h0, (const void *) h1, DSIZE * nt);
memcpy((void *) h1, (const void *) h , DSIZE * nt);

/* update counter
++j;

} while (j < n);

}

```

PFAFFT - Functions to perform Prime Factor (PFA) FFT's, in place

npfa return valid n for complex-to-complex PFA  
npfar return valid n for real-to-complex/complex-to-real PFA  
npfao return optimal n for complex-to-complex PFA  
npfaro return optimal n for real-to-complex/complex-to-real PFA  
pfacc 1D PFA complex to complex  
pfacr 1D PFA complex to real  
pfarc 1D PFA real to complex  
pfamcc multiple PFA complex to real  
pfa2cc 2D PFA complex to complex  
pfa2cr 2D PFA complex to real  
pfa2rc 2D PFA real to complex

Function Prototypes:

```
int npfa (int nmin);
int npfao (int nmin, int nmax);
int npfar (int nmin);
int npfaro (int nmin, int nmax);
void pfacc (int isign, int n, complex z[]);
void pfacr (int isign, int n, complex cz[], float rz[]);
void pfarc (int isign, int n, float rz[], complex cz[]);
void pfamcc (int isign, int n, int nt, int k, int kt, complex z[]);
void pfa2cc (int isign, int idim, int n1, int n2, complex z[]);
void pfa2cr (int isign, int idim, int n1, int n2, complex cz[], float rz[]);
void pfa2rc (int isign, int idim, int n1, int n2, float rz[], complex cz[]);
```

npfa:

Input:

nmin lower bound on returned value (see notes below)

Returned: valid n for prime factor fft

npfao

Input:

nmin lower bound on returned value (see notes below)

nmax desired (but not guaranteed) upper bound on returned value

Returned: valid n for prime factor fft

npfar

Input:

nmin lower bound on returned value

Returned: valid n for real-to-complex/complex-to-real prime factor fft

npfaro:

Input:

nmin lower bound on returned value

nmax desired (but not guaranteed) upper bound on returned value

Returned: valid n for real-to-complex/complex-to-real prime factor fft

pfacc:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform (see notes below)

z array[n] of complex numbers to be transformed in place

Output:

z array[n] of complex numbers transformed

pfacr:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform (see notes below)

cz array[n/2+1] of complex values (may be equivalenced to rz)

Output:

rz array[n] of real values (may be equivalenced to cz)

pfarc:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n length of transform; must be even (see notes below)

rz array[n] of real values (may be equivalenced to cz)

Output:

cz array[n/2+1] of complex values (may be equivalenced to rz)

pfamcc:

Input:

isign sign of isign is the sign of exponent in fourier kernel

n number of complex elements per transform (see notes below)

nt number of transforms

k stride in complex elements within transforms

kt            stride in complex elements between transforms  
z            array of complex elements to be transformed in place

Output:  
z array of complex elements transformed

pfa2cc:

Input:  
isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, either 1 or 2 (see notes)  
n1          1st (fast) dimension of array to be transformed (see notes)  
n2          2nd (slow) dimension of array to be transformed (see notes)  
z           array[n2][n1] of complex elements to be transformed in place

Output:  
z array[n2][n1] of complex elements transformed

pfa2cr:

Input:  
isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, which must be either 1 or 2 (see notes)  
n1          1st (fast) dimension of array to be transformed (see notes)  
n2          2nd (slow) dimension of array to be transformed (see notes)  
cz          array of complex values (may be equivalenced to rz)

Output:  
rz           array of real values (may be equivalenced to cz)

pfa2rc:

Input:  
isign        sign of isign is the sign of exponent in fourier kernel  
idim        dimension to transform, which must be either 1 or 2 (see notes)  
n1          1st (fast) dimension of array to be transformed (see notes)  
n2          2nd (slow) dimension of array to be transformed (see notes)  
rz          array of real values (may be equivalenced to cz)

Output:  
cz           array of complex values (may be equivalenced to rz)

Notes:

Table of valid n and cost for prime factor fft. For each n, cost was estimated to be the inverse of the number of ffts done in 1 sec on an IBM RISC System/6000 Model 320H, by Dave Hale, 08/04/91.

(Redone by Jack Cohen for 15 sec to rebuild NTAB table on advice of David and Gregory Chudnovsky, 05/03/94).

Cost estimates are least accurate for very small  $n$ . An alternative method for estimating cost would be to count multiplies and adds, but this method fails to account for the overlapping of multiplies and adds that is possible on some computers, such as the IBM RS/6000 family.

npfa:

The returned  $n$  will be composed of mutually prime factors from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . Because  $n$  cannot exceed  $720720 = 5*7*9*11*13*16$ , 720720 is returned if  $n_{min}$  exceeds 720720.

npfao:

The returned  $n$  will be composed of mutually prime factors from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . Because  $n$  cannot exceed  $720720 = 5*7*9*11*13*16$ , 720720 is returned if  $n_{min}$  exceeds 720720. If  $n_{min}$  does not exceed 720720, then the returned  $n$  will not be less than  $n_{min}$ . The optimal  $n$  is chosen to minimize the estimated cost of performing the fft, while satisfying the constraint, if possible, that  $n$  not exceed  $n_{max}$ .

npfar and npfaro:

Current implemenations of real-to-complex and complex-to-real prime factor ffts require that the transform length  $n$  be even and that  $n/2$  be a valid length for a complex-to-complex prime factor fft. The value returned by npfar satisfies these conditions. Also, see notes for npfa.

pfacc:

$n$  must be factorable into mutually prime factors taken from the set  $\{2,3,4,5,7,8,9,11,13,16\}$ . in other words,  
 $n = 2^{**p} * 3^{**q} * 5^{**r} * 7^{**s} * 11^{**t} * 13^{**u}$   
where  
 $0 \leq p \leq 4, \quad 0 \leq q \leq 2, \quad 0 \leq r,s,t,u \leq 1$   
is required for pfa to yield meaningful results. this restriction implies that  $n$  is restricted to the range  
 $1 \leq n \leq 720720 (= 5*7*9*11*13*16)$

pfacr:

Because pfacr uses pfacc to do most of the work,  $n$  must be even and  $n/2$  must be a valid length for pfacc. The simplest way to obtain a valid  $n$  is via  $n = npfar(n_{min})$ . A more optimal  $n$  can be obtained with npfaro.

`pfarc:`

Because `pfarc` uses `pfacc` to do most of the work, `n` must be even and `n/2` must be a valid length for `pfacc`. The simplest way to obtain a valid `n` is via `n = npfar(nmin)`. A more optimal `n` can be obtained with `npfaro`.

`pfamcc:`

To perform a two-dimensional transform of an `n1` by `n2` complex array (assuming that both `n1` and `n2` are valid "n"), stored with `n1` fast and `n2` slow:

```
    pfamcc(isign,n1,n2,1,n1,z); (to transform 1st dimension)
    pfamcc(isign,n2,n1,n1,1,z); (to transform 2nd dimension)
```

`pfa2cc:`

Only one (either the 1st or 2nd) dimension of the 2-D array is transformed.

If `idim` equals 1, then `n2` transforms of `n1` complex elements are performed; else, if `idim` equals 2, then `n1` transforms of `n2` complex elements are performed.

Although `z` appears in the argument list as a one-dimensional array, `z` may be viewed as an `n1` by `n2` two-dimensional array: `z[n2][n1]`.

Valid `n` is computed via the "np" subroutines.

To perform a two-dimensional transform of an `n1` by `n2` complex array (assuming that both `n1` and `n2` are valid "n"), stored with `n1` fast and `n2` slow: `pfa2cc(isign,1,n1,n2,z); pfa2cc(isign,2,n1,n2,z);`

`pfa2cr:`

If `idim` equals 1, then `n2` transforms of `n1/2+1` complex elements to `n1` real elements are performed; else, if `idim` equals 2, then `n1` transforms of `n2/2+1` complex elements to `n2` real elements are performed.

Although `rz` appears in the argument list as a one-dimensional array, `rz` may be viewed as an `n1` by `n2` two-dimensional array: `rz[n2][n1]`. Likewise, depending on `idim`, `cz` may be viewed as either an `n1/2+1` by `n2` or an `n1` by `n2/2+1` two-dimensional array of complex elements.

Let `n` denote the transform length, either `n1` or `n2`, depending on `idim`. Because `pfa2rc` uses `pfa2cc` to do most of the work, `n` must be even and `n/2` must be a valid length for `pfa2cc`. The simplest way to

obtain a valid  $n$  is via  $n = \text{npfar}(\text{nmin})$ . A more optimal  $n$  can be obtained with `npfaro`.

`pfa2rc`:

If `idim` equals 1, then  $n_2$  transforms of  $n_1$  real elements to  $n_1/2+1$  complex elements are performed; else, if `idim` equals 2, then  $n_1$  transforms of  $n_2$  real elements to  $n_2/2+1$  complex elements are performed.

Although `rz` appears in the argument list as a one-dimensional array, `rz` may be viewed as an  $n_1$  by  $n_2$  two-dimensional array: `rz[n2][n1]`. Likewise, depending on `idim`, `cz` may be viewed as either an  $n_1/2+1$  by  $n_2$  or an  $n_1$  by  $n_2/2+1$  two-dimensional array of complex elements.

Let  $n$  denote the transform length, either  $n_1$  or  $n_2$ , depending on `idim`. Because `pfa2rc` uses `pfa2cc` to do most of the work,  $n$  must be even and  $n/2$  must be a valid length for `pfa2cc`. The simplest way to obtain a valid  $n$  is via  $n = \text{npfar}(\text{nmin})$ . A more optimal  $n$  can be obtained with `npfaro`.

#### References:

Temperton, C., 1985, Implementation of a self-sorting in-place prime factor fft algorithm: *Journal of Computational Physics*, v. 58, p. 283-299.

Temperton, C., 1988, A new set of minimum-add rotated rotated dft modules: *Journal of Computational Physics*, v. 75, p. 190-198.

Differ significantly from Press et al, 1988, *Numerical Recipes in C*, p. 417.

Author: Dave Hale, Colorado School of Mines, 04/27/89

POLAR - Functions to map data in rectangular coordinates to polar and vice versa

recttopolar convert a function  $p(x,y)$  to a function  $q(a,r)$

polartorect convert a function  $q(a,r)$  to a function  $p(x,y)$

Function Prototypes:

```
void recttopolar ( int nx, float dx, float fx, int ny, float dy, float fy,
float **p, int na, float da, float fa, int nr,
float dr, float fr, float **q);
void polartorect ( int na, float da, float fa, int nr, float dr, float fr,
float **q, int nx, float dx, float fx, int ny,
float dy, float fy, float **p)
```

recttopolar:

Input:

nx number of x samples

dx x sampling interval

fx first x sample

ny number of y samples

dy y sampling interval

fy first y sample

p array[ny][nx] containing samples of  $p(x,y)$

na number of a samples

da a sampling interval

fa first a sample

nr number of r samples

dr r sampling interval

fr first r sample

Output:

q array[nr][na] containing samples of  $q(a,r)$

polartorect:

Input:

na number of a samples

da a sampling interval

fa first a sample

nr number of r samples

dr r sampling interval

fr first r sample

nx number of x samples

dx x sampling interval

fx first x sample



ny number of y samples  
dy y sampling interval  
fy first y sample  
q array[nr][na] containing samples of  $q(a,r)$

Output:  
p array[nr][nx] containing samples of  $p(x,y)$

Notes:  
The polar angle  $a$  is measured in radians,  
 $x = r \cos(a)$  and  $y = r \sin(a)$ .

recttopolar:  
Linear extrapolation is used to determine the value of  $p(x,y)$  for  
 $x$  and  $y$  coordinates not in the range corresponding to  $nx$ ,  $dx$ , ....

polartorect:  
Linear extrapolation is used to determine the value of  $q(a,r)$  for  
 $a$  and  $r$  coordinates not in the range corresponding to  $na$ ,  $da$ , ....

Author: Dave Hale, Colorado School of Mines, 06/15/90

PRINTERPLOT - Functions to make a printer plot of a 1-dimensional array

pp1d printer plot of 1d array

pplot1 printer plot of 1d array

Function Prototypes:

```
void pp1d (FILE *fp, char *title, int lx, int ifx, float x[]);
```

```
void pplot1 (FILE *fp, char *title, int nx, float ax[]);
```

pp1d:

Input:

fp file pointer for output (e.g., stdout, stderr, etc.)

title title of plot

lx length of x

ifx index of first x

x array[lx] to be plotted

pplot1:

Input:

fp file pointer for printed output (e.g., stdout, stderr, etc.)

title title of plot

nx number of x values to be plotted

ax array[nx] of x values

Notes:

Are two subroutines to do this really necessary?

Author: Dave Hale, Colorado School of Mines, 06/02/89

## QUEST - Functions to ESTimate Quantiles:

quest returns estimate - use when entire array is in memory  
questalloc returns quantile estimator - use before questupdate  
questupdate updates and returns current estimate - use for large  
numbers of floats, too big to fit in memory at one time  
questfree frees quantile estimator

quest:

Input:

p quantile to be estimated ( $0.0 \leq p \leq 1.0$  is required)

n number of samples in array x ( $n \geq 5$  is required)

x array[n] of floats

Returned: the estimate of a specified quantile

questalloc:

Input:

p quantile to be estimated ( $0.0 \leq p \leq 1.0$  is required)

n number of samples in array x ( $n \geq 5$  is required)

x array[n] of floats

Returned: pointer to a quantile estimator

questupdate:

Input:

q pointer to quantile estimator (as returned by questalloc)

n number of samples in array x

x array[n] of floats

Returned: quantile estimate

questfree:

q pointer to quantile estimator (as returned by questalloc)

Notes:

quest:

The estimate should approach the sample quantile in the limit of large n.

The estimate is most accurate for cumulative distribution functions that are smooth in the neighborhood of the quantile specified by p.

This function is an implementation of the algorithm published by

Jain and Chlamtac (1985).

questalloc:

This function must be called before calling function questupdate.  
See also notes in questupdate.

questupdate:

The estimate should approach the sample quantile in the limit of large  $n$ .

The estimate is most accurate for cumulative distribution functions that are smooth in the neighborhood of the quantile specified by  $p$ .

This function is an implementation of the algorithm published by Jain, R. and Chlamtac, I., 1985, The PP algorithm for dynamic calculation of quantiles and histograms without storing observations: Comm. ACM, v. 28, n. 10.

Reference:

Jain, R. and Chlamtac, I., 1985, The PP algorithm for dynamic calculation of quantiles and histograms without storing observations: Comm. ACM, v. 28, n. 10.

Author: Dave Hale, Colorado School of Mines, 05/07/89

RESSINC8 - Functions to resample uniformly-sampled data via 8-coefficient sinc approximations:

ress8c resample a uniformly-sampled complex function via 8-coeff. sinc approx.  
ress8r resample a uniformly-sampled real function via 8-coeff. sinc approx.

Function Prototypes:

```
void ress8r (int nxin, float dxin, float fxin, float yin[],
float yinl, float yinr,
int nxout, float dxout, float fxout, float yout[]);
void ress8c (int nxin, float dxin, float fxin, complex yin[],
complex yinl, complex yinr,
int nxout, float dxout, float fxout, complex yout[]);
```

Input:

nxin number of x values at which y(x) is input  
dxin x sampling interval for input y(x)  
fxin x value of first sample input  
yin array[nxin] of input y(x) values: yin[0] = y(fxin), etc.  
yinl value used to extrapolate yin values to left of yin[0]  
yinr value used to extrapolate yin values to right of yin[nxin-1]  
nxout number of x values at which y(x) is output  
dxout x sampling interval for output y(x)  
fxout x value of first sample output

Output:

yout array[nxout] of output y(x) values: yout[0] = y(fxout), etc.

Notes:

Because extrapolation of the input function y(x) is defined by the left and right values yinl and yinr, the output x values defined by nxout, dxout, and fxout are not restricted to lie within the range of input x values defined by nxin, dxin, and fxin.

The maximum error for frequencies less than 0.6 nyquist is less than one percent.

Author: Dave Hale, Colorado School of Mines, 06/06/90

RFWTVA - Rasterize a Float array as Wiggle-Trace-Variable-Area.

rftvta rasterize a float array as wiggle-trace-variable-area.

Function Prototype:

```
void rftvta (int n, float z[], float zmin, float zmax, float zbase,
int yzmin, int yzmax, int xfirst, int xlast,
int wiggle, int nbpr, unsigned char *bits, int endian);
```

Input:

n number of samples in array to rasterize

z array[n] to rasterize

zmin z values below zmin will be clipped

zmax z values above zmax will be clipped

zbase z values between zbase and zmax will be filled (see notes)

yzmin horizontal raster coordinate corresponding to zmin

yzmax horizontal raster coordinate corresponding to zmax

xfirst vertical raster coordinate of z[0] (see notes)

xlast vertical raster coordinate of z[n-1] (see notes)

wiggle =0 for no wiggle (VA only); =1 for wiggle (with VA)

wiggle 2<=wiggle<=5 for solid/grey coloring of VA option

shade of grey: wiggle=2 light grey, wiggle=5 black

nbpr number of bytes per row of bits

bits pointer to first (top,left) byte in image

endian byte order =1 big endian =0 little endian

Output:

bits pointer to first (top,left) byte in image

Notes:

The raster coordinate of the (top,left) bit in the image is (0,0).

In other words, x increases downward and y increases to the right.

Raster scan lines run from left to right, and from top to bottom.

Therefore, xfirst, xlast, yzmin, and yzmax should not be less than 0.

Likewise, yzmin and yzmax should not be greater than nbpr\*8-1, and

care should be taken to ensure that xfirst and xlast do not cause bits to be set outside (off the bottom) of the image.

Variable area fill is performed on the right-hand (increasing y) side of the wiggle. If yzmin is greater than yzmax, then z values between zmin will be plotted to the right of zmax, and z values between zbase and zmin are filled. Swapping yzmin and yzmax is an easy way to reverse the polarity of a wiggle.

The variable "endian" must have a value of 1 or 0. If this is not a case an error is returned.

Author: Dave Hale, Colorado School of Mines, 07/01/89

MODIFIED: Paul Michaels, Boise State University, 29 December 2000

Added solid/grey shading scheme, wiggle>=2 option for peaks/troughs

MODIFIED: Kris Vanneste, Royal Observatory of Belgium, July 2005

Added missing wiggle trace bits in y (amplitude) direction

RFWTVAIN - Rasterize a Float array as Wiggle-Trace-Variable-Area, with 8 point sinc INTERpolation.

rfwtvaint rasterize a float array as wiggle-trace-variable-area, and apply sinc interpolation for display purposes.

Function Prototype:

```
void rfwtvaint (int n, float z[], float zmin, float zmax, float zbase,
int yzmin, int yzmax, int xfirst, int xlast,
int wiggle, int nbpr, unsigned char *bits, int endian);
```

Input:

n number of samples in array to rasterize  
z array[n] to rasterize  
zmin z values below zmin will be clipped  
zmax z values above zmax will be clipped  
zbase z values between zbase and zmax will be filled (see notes)  
yzmin horizontal raster coordinate corresponding to zmin  
yzmax horizontal raster coordinate corresponding to zmax  
xfirst vertical raster coordinate of z[0] (see notes)  
xlast vertical raster coordinate of z[n-1] (see notes)  
wiggle =0 for no wiggle (VA only); =1 for wiggle (with VA)  
          wiggle 2<=wiggle<=5 for solid/grey coloring of VA option  
          shade of grey: wiggle=2 light grey, wiggle=5 black  
nbpr number of bytes per row of bits  
bits pointer to first (top,left) byte in image  
endian byte order =1 big endian =0 little endian

Output:

bits pointer to first (top,left) byte in image

Notes:

The raster coordinate of the (top,left) bit in the image is (0,0). In other words, x increases downward and y increases to the right. Raster scan lines run from left to right, and from top to bottom. Therefore, xfirst, xlast, yzmin, and yzmax should not be less than 0. Likewise, yzmin and yzmax should not be greater than nbpr\*8-1, and care should be taken to ensure that xfirst and xlast do not cause bits to be set outside (off the bottom) of the image.

Variable area fill is performed on the right-hand (increasing y) side of the wiggle. If yzmin is greater than yzmax, then z values between zmin will be plotted to the right of zmax, and z values between zbase



and zmin are filled. Swapping yzmin and yzmax is an easy way to reverse the polarity of a wiggle.

The variable "endian" must have a value of 1 or 0. If this is not a case an error is returned.

The interpolation is by the 8 point sinc interpolation routine s8r.

Author: Dave Hale, Colorado School of Mines, 07/01/89

Memorial University of Newfoundland: Tony Kocurko, Sept 1995.

Added sinc interpolation.

MODIFIED: Paul Michaels, Boise State University, 29 December 2000

added solid/grey color scheme for peaks/troughs wiggle=2 option

MODIFIED: Kris Vanneste, Royal Observatory of Belgium, July 2005

Added missing wiggle trace bits in y (amplitude) direction

SBLAS - Single precision Basic Linear Algebra Subroutines  
(adapted from LINPACK FORTRAN):

isamax return index of element with maximum absolute value  
sasum return sum of absolute values  
saxpy compute  $y[i] = a \cdot x[i] + y[i]$   
scopy copy  $x[i]$  to  $y[i]$  (i.e., set  $y[i] = x[i]$ )  
sdot return sum of  $x[i] \cdot y[i]$  (i.e., return the dot product of  $x$  and  $y$ )  
snrm2 return square root of sum of squares of  $x[i]$   
sscal compute  $x[i] = a \cdot x[i]$   
sswap swap  $x[i]$  and  $y[i]$

Function Prototypes:

```
int isamax (int n, float *sx, int incx);
float sasum (int n, float *sx, int incx);
void saxpy (int n, float sa, float *sx, int incx, float *sy, int incy);
void scopy (int n, float *sx, int incx, float *sy, int incy);
float sdot (int n, float *sx, int incx, float *sy, int incy);
float snrm2 (int n, float *sx, int incx);
void sscal (int n, float sa, float *sx, int incx);
void sswap (int n, float *sx, int incx, float *sy, int incy);
```

isamax:

Input:

n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned: index of element with maximum absolute value

sasum:

Input:

n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned: sum of absolute values

saxpy:

Input:

n number of elements in arrays  
sa the scalar multiplier  
sx array[n] of elements to be scaled and added

incx increment between elements of sx  
sy array[n] of elements to be added  
incy increment between elements of sy

Output:  
sy array[n] of accumulated elements

scopy:  
Input:  
n number of elements in arrays  
sx array[n] of elements to be copied  
incx increment between elements of sx  
incy increment between elements of sy

Output:  
sy array[n] of copied elements

sdot:  
Input:  
n number of elements in arrays  
sx array[n] of elements  
incx increment between elements of sx  
sy array[n] of elements  
incy increment between elements of sy

Returned: dot product of the two arrays

snrm2  
Input:  
n number of elements in array  
sx array[n] of elements  
incx increment between elements

Returned: square root of sum of squares of x[i]

sscal:  
Input:  
n number of elements in array  
sa the scalar multiplier  
sx array[n] of elements  
incx increment between elements

Output:

sx array[n] of scaled elements

sswap:

Input:

n number of elements in arrays

sx array[n] of elements

incx increment between elements of sx

sy array[n] of elements

incy increment between elements of sy

Output:

sx array[n] of swapped elements

sy array[n] of swapped elements

Notes:

Adapted from Linpack Fortran.

snrm2:

This simple version may cause overflow or underflow!

Author: Dave Hale, Colorado School of Mines, 10/01/89

SCAXIS - compute a readable scale for use in plotting axes

scaxis compute a readable scale for use in plotting axes

Function Prototype:

```
void scaxis (float x1, float x2, int *nxnum, float *dxnum, float *fxnum);
```

Input:

x1 first x value

x2 second x value

nxnum desired number of numbered values

Output:

nxnum number of numbered values

dxnum increment between numbered values (dxnum>0.0)

fxnum first numbered value

Notes:

scaxis attempts to honor the user-specified nxnum. However, nxnum will be modified if necessary for readability. Also, fxnum and nxnum will be adjusted to compensate for roundoff error; in particular, fxnum will not be less than xmin-eps, and fxnum+(nxnum-1)\*dxnum will not be greater than xmax+eps, where eps = 0.0001\*(xmax-xmin). xmin is the minimum of x1 and x2. xmax is the maximum of x1 and x2.

Author: Dave Hale, Colorado School of Mines, 01/13/89

SGA - Single precision general matrix functions adapted from LINPACK FORTRAN:

sgefa Gaussian elimination to obtain the LU factorization of a matrix.

sgeco Gaussian elimination to obtain the LU factorization and condition number of a matrix.

sgesl Solve linear system  $Ax = b$  or  $A'x = b$  after LU factorization.

Function Prototypes:

```
void sgefa (float **a, int n, int *ipvt, int *info);
```

```
void sgeco (float **a, int n, int *ipvt, float *rcond, float *z);
```

```
void sgesl (float **a, int n, int *ipvt, float *b, int job);
```

sgefa:

Input:

a matrix[n][n] to be factored (see notes below)

n dimension of a

Output:

a matrix[n][n] factored (see notes below)

ipvt indices of pivot permutations (see notes below)

info index of last zero pivot (or -1 if no zero pivots)

sgeco:

Input:

a matrix[n][n] to be factored (see notes below)

n dimension of a

Output:

a matrix[n][n] factored (see notes below)

ipvt indices of pivot permutations (see notes below)

rcond reciprocal condition number (see notes below)

Workspace:

z array[n]

sgesl

Input:

a matrix[n][n] that has been LU factored (see notes below)

n dimension of a

ipvt indices of pivot permutations (see notes below)

b right-hand-side vector[n]

job =0 to solve  $Ax = b$

=1 to solve  $A'x = b$

Output:

b solution vector[n]

Notes:

These functions were adapted from LINPACK FORTRAN. Because two-dimensional arrays cannot be declared with variable dimensions in C, the matrix a is actually a pointer to an array of pointers to floats, as declared above and used below.

Elements of a are stored as follows:

```
a[0][0]    a[1][0]    a[2][0]    ... a[n-1][0]
a[0][1]    a[1][1]    a[2][1]    ... a[n-1][1]
a[0][2]    a[1][2]    a[2][2]    ... a[n-1][2]
.
.
.
.
a[0][n-1]  a[1][n-1]  a[2][n-1]  ... a[n-1][n-1]
```

Both the factored matrix a and the pivot indices ipvt are required to solve linear systems of equations via sgesl.

sgeco:

Given the reciprocal of the condition number, rcond, and the float epsilon, FLT\_EPSILON, the number of significant decimal digits, nsdd, in the solution of a linear system of equations may be estimated by:  
nsdd = (int)log10(rcond/FLT\_EPSILON)

This function was adapted from LINPACK FORTRAN. Because two-dimensional arrays cannot be declared with variable dimensions in C, the matrix a is actually a pointer to an array of pointers to floats, as declared above and used below.

Author: Dave Hale, Colorado School of Mines, 10/01/89

SHFS8R - Shift a uniformly-sampled real-valued function  $y(x)$  via a table of 8-coefficient sinc approximations.

shfs8r shift a uniformly-sampled real function via a table of 8-coeff. sinc approximations.

Function Prototypes:

```
void shfs8r (float dx, int nxin, float fxin, float yin[],
float yinl, float yinr, int nxout, float fxout, float yout[]);
```

Input:

dx	x sampling interval for both input and output $y(x)$
nxin	number of x values at which $y(x)$ is input
fxin	x value of first sample input
yin	array[nxin] of input $y(x)$ values: $yin[0] = y(fxin)$ , etc.
yinl	value used to extrapolate yin values to left of $yin[0]$
yinr	value used to extrapolate yin values to right of $yin[nxin-1]$
nxout	number of x values a which $y(x)$ is output
fxout	x value of first sample output

Output:

yout array[nxout] of output  $y(x)$  values:  $yout[0] = y(fxout)$ , etc.

Notes:

Because extrapolation of the input function  $y(x)$  is defined by the left and right values yinl and yinr, the output samples defined by dx, nxout, and fxout are not restricted to lie within the range of input sample locations defined by dx, nxin, and fxin.

The maximum error for frequencies less than  $0.6 \cdot nyquist$  is less than one percent.

Author: Dave Hale, Colorado School of Mines, 06/02/89



SINC - Return SINC(x) for as floats or as doubles

fsinc return float value of sinc(x) for x input as a float

dsinc return double precision sinc(x) for double precision x

Function Prototype:

float fsinc (float x);

double dsinc (double x);

Input:

x value at which to evaluate sinc(x)

Returned: sinc(x)

Notes:

$$\text{sinc}(x) = \sin(\text{PI} * x) / (\text{PI} * x)$$

Author: Dave Hale, Colorado School of Mines, 06/02/89

**SORT** - Functions to sort arrays of data or arrays of indices

**hpsort** sort an array of floats by the heap sort method  
**qkisort** sort an array of indices `i[]` so that  
`a[i[0]] <= a[i[1]] <= ... <= a[i[n-1]]`  
uses the "quick sort" method  
**qkifind** partially sort an array of indices `i[]` so that the  
index `i[m]` has the value it would have if the entire  
array of indices were sorted such that  
`a[i[0]] <= a[i[1]] <= ... <= a[i[n-1]]`  
uses the "quick sort" method  
**qksort** sort an array of floats such that `a[0] <= a[1] <= ... <= a[n-1]`  
uses the "quick sort" method  
**qkfind** partially sort an array of floats so that the element `a[m]` has  
the value it would have if the entire array were sorted  
such that `a[0] <= a[1] <= ... <= a[n-1]`  
uses the "quick sort" method

Function Prototypes:

```
void hpsort (int n, float a[]);  
void qkisort (int n, float a[], int i[]);  
void qkifind (int m, int n, float a[], int i[]);  
void qksort (int n, float a[]);  
void qkfind (int m, int n, float a[]);
```

**hpsort:**

Input:

`n` number of elements in `a`  
`a` array[`n`] to be sorted

Output:

`a` array[`n`] sorted

**qkisort:**

Input:

`n` number of elements in array `a`  
`a` array[`n`] elements  
`i` array[`n`] indices to be sorted

Output:

`i` array[`n`] indices sorted

**qkifind:**

Input:  
m index of element to be found  
n number of elements in array a  
a array[n] elements  
i array[n] indices to be partially sorted

Output:  
i array[n] indices partially sorted sorted

qksort:  
Input:  
n number of elements in array a  
a array[n] containing elements to be sorted

Output:  
a array[n] containing sorted elements

qkfind:  
Input:  
m index of element to be found  
n number of elements in array a  
a array[n] to be partially sorted

Output:  
a array[n] partially sorted

Notes:  
hpsort:  
The heap sort algorithm is, at worst,  $N \log_2 N$ , and in most cases is 20% faster. Adapted from Standish.

qkisort, qkifind, qksort, qkfind:  
n must be less than  $2^{\text{NSTACK}}$ , where NSTACK is defined above.

qkisort:  
This function is adapted from procedure quicksort by Hoare, C.A.R., 1961, Communications of the ACM, v. 4, p. 321; the main difference is that recursion is accomplished explicitly via a stack array for efficiency; also, a simple insertion sort is used to sort subarrays too small to be partitioned efficiently.

qkfind:

This function is adapted from procedure find by  
Hoare, C.A.R., 1961, Communications of the ACM, v. 4, p. 321.

qksort:

This function is adapted from procedure quicksort by  
Hoare, C.A.R., 1961, Communications of the ACM, v. 4, p. 321;  
the main difference is that recursion is accomplished  
explicitly via a stack array for efficiency; also, a simple  
insertion sort is used to sort subarrays too small to be  
partitioned efficiently.

qkfind:

This function is adapted from procedure find by Hoare 1961.

Reference:

hpsort:

Standish, T. A., Data Structure Techniques, p. 91.

See also Press, W. A., et al., Numerical Recipes in C.

quick sort:

Hoare, C.A.R., 1961, Communications of the ACM, v. 4, p. 321.

Author: Dave Hale, Colorado School of Mines, 12/26/89

SQR - Single precision QR decomposition functions adapted from LINPACK FORTRAN:

sqrdc Compute QR decomposition of a matrix.

sqrsl Use QR decomposition to solve for coordinate transformations, projections, and least squares solutions.

sqrst Solve under-determined or over-determined least squares problems, with a user-specified tolerance.

Function Prototypes:

```
void sqrdc (float **x, int n, int p, float *qraux, int *jpvt,
float *work, int job);
void sqrsl (float **x, int n, int k, float *qraux,
float *y, float *qy, float *qty,
float *b, float *rsd, float *xb, int job, int *info);
void sqrst (float **x, int n, int p, float *y, float tol,
float *b, float *rsd, int *k,
int *jpvt, float *qraux, float *work);
```

sqrdc:

Input:

x matrix[p][n] to decompose (see notes below)

n number of rows in the matrix x

p number of columns in the matrix x

jpvt array[p] controlling the pivot columns (see notes below)

job =0 for no pivoting;

=1 for pivoting

Output:

x matrix[p][n] decomposed (see notes below)

qraux array[p] containing information required to recover the orthogonal part of the decomposition

jpvt array[p] with jpvt[k] containing the index of the original matrix that has been interchanged into the k-th column, if pivoting is requested.

Workspace:

work array[p] of workspace

sqrsl:

Input:

x matrix[p][n] containing output of sqrdc.

n number of rows in the matrix xk; same as in sqrdc.

k number of columns in the matrix xk; k must not be greater

than  $\text{MIN}(n,p)$ , where  $p$  is the same as in `sqrdc`.  
`qraux` array[p] containing auxiliary output from `sqrdc`.  
`y` array[n] to be manipulated by `sqrsl`.  
`job` specifies what is to be computed. `job` has the decimal expansion ABCDE, with the following meaning:  
 if A  $\neq 0$ , compute `qy`.  
 if B, C, D, or E  $\neq 0$ , compute `qty`.  
 if C  $\neq 0$ , compute `b`.  
 if D  $\neq 0$ , compute `rsd`.  
 if E  $\neq 0$ , compute `xb`.  
 Note that a request to compute `b`, `rsd`, or `xb` automatically triggers the computation of `qty`, for which an array must be provided.

Output:

`qy` array[n] containing  $Qy$ , if its computation has been requested.  
`qty` array[n] containing  $Q'y$ , if its computation has been requested. Here  $Q'$  denotes the transpose of  $Q$ .  
`b` array[k] containing solution of the least squares problem:  
 $\text{minimize } \text{norm2}(y - xk*b)$ ,  
 if its computation has been requested. (Note that if pivoting was requested in `sqrdc`, the  $j$ -th component of `b` will be associated with column `jpvt[j]` of the original matrix `x` that was input into `sqrdc`.)  
`rsd` array[n] containing the least squares residual  $y - xk*b$ , if its computation has been requested. `rsd` is also the orthogonal projection of `y` onto the orthogonal complement of the column space of `xk`.  
`xb` array[n] containing the least squares approximation  $xk*b$ , if its computation has been requested. `xb` is also the orthogonal projection of `y` onto the column space of `x`.  
`info` = 0 unless the computation of `b` has been requested and  $R$  is exactly singular. In this case, `info` is the index of the first zero diagonal element of  $R$  and `b` is left unaltered.

`sqrst`:

Input:

`x` matrix[p][n] of coefficients (`x` is destroyed by `sqrst`.)  
`n` number of rows in the matrix `x` (number of observations)  
`p` number of columns in the matrix `x` (number of parameters)  
`y` array[n] containing right-hand-side (observations)

tol relative tolerance used to determine the subset of columns of x included in the solution. If tol is zero, a full complement of the MIN(n,p) columns is used. If tol is non-zero, the problem should be scaled so that all the elements of X have roughly the same absolute accuracy eps. Then a reasonable value for tol is roughly eps divided by the magnitude of the largest element.

Output:

x matrix[p][n] containing output of sqrdc  
 b array[p] containing the solution (parameters); components corresponding to columns not used are set to zero.  
 rsd array[n] of residuals y - Xb  
 k number of columns of x used in the solution  
 jpvt array[p] containing pivot information from sqrdc.  
 qraux array[p] containing auxiliary information from sqrdc.

Workspace:

work array[p] of workspace.

Notes:

!!! WARNING !!!

These functions have many options, not all of which have been tested!  
 (Dave Hale, 12/31/89)

This function was adapted from LINPACK FORTRAN. Because two-dimensional arrays cannot be declared with variable dimensions in C, the matrix x is actually a pointer to an array of pointers to floats, as declared above and used below.

Elements of x are stored as follows:

x[0][0]	x[1][0]	x[2][0]	... x[p-1][0]
x[0][1]	x[1][1]	x[2][1]	... x[p-1][1]
x[0][2]	x[1][2]	x[2][2]	... x[p-1][2]
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
x[0][n-1]	x[1][n-1]	x[2][n-1]	... x[p-1][n-1]

sqrdc:

Uses Householder transformations to compute the QR decomposition of an n by p

matrix  $x$ . Column pivoting based on the 2-norms of the reduced columns may be performed at the user's option.

After decomposition,  $x$  contains in its upper triangular matrix  $R$  of the QR decomposition. Below its diagonal  $x$  contains information from which the orthogonal part of the decomposition can be recovered. Note that if pivoting has been requested, the decomposition is not that of the original matrix  $x$  but that of  $x$  with its columns permuted as described by  $jpvt$ .

The selection of pivot columns is controlled by  $jpvt$  as follows.

The  $k$ -th column  $x[k]$  of  $x$  is placed in one of three classes according to the value of  $jpvt[k]$ .

if  $jpvt[k] > 0$ , then  $x[k]$  is an initial column.

if  $jpvt[k] == 0$ , then  $x[k]$  is a free column.

if  $jpvt[k] < 0$ , then  $x[k]$  is a final column.

Before the decomposition is computed, initial columns are moved to the beginning of the array  $x$  and final columns to the end. Both initial and final columns are frozen in place during the computation and only free columns are moved. At the  $k$ -th stage of the reduction, if  $x[k]$  is occupied by a free column it is interchanged with the free column of largest reduced norm.  $jpvt$  is not referenced if  $job == 0$ .

**sqrsl:**

Uses the output of **sqrdc** to compute coordinate transformations, projections, and least squares solutions. For  $k \leq \text{MIN}(n,p)$ , let  $x_k$  be the matrix  $x_k = (x[jpvt[0]], x[jpvt[1]], \dots, x[jpvt[k-1]])$

formed from columns  $jpvt[0], jpvt[1], \dots, jpvt[k-1]$  of the original  $n$  by  $p$  matrix  $x$  that was input to **sqrdc**. (If no pivoting was done,  $x_k$  consists of the first  $k$  columns of  $x$  in their original order.) **sqrdc** produces a factored orthogonal matrix  $Q$  and an upper triangular matrix  $R$  such that

$$x_k = Q * (R) \\ (0)$$

This information is contained in coded form in the arrays  $x$  and  $qraux$ .

The parameters  $qy$ ,  $qty$ ,  $b$ ,  $rsd$ , and  $xb$  are not referenced if their computation is not requested and in this case can be replaced by NULL pointers in the calling program. To save storage, the user may in some cases use the same array for different parameters in the calling sequence. A frequently occurring example is when one wishes to compute any of  $b$ ,  $rsd$ , or  $xb$  and does not need  $y$  or  $qty$ . In this case one may equivalence  $y$ ,  $qty$ , and one of  $b$ ,  $rsd$ , or  $xb$ , while providing separate arrays for anything else that is to be computed. Thus the calling



sequence

`sqrsl(x,n,k,qraux,y,NULL,y,b,y,NULL,110,&info)`

will result in the computation of `b` and `rsd`, with `rsd` overwriting `y`.

More generally, each item in the following list contains groups of permissible equivalences for a single calling sequence.

1. `(y,qty,b) (rsd) (xb) (qy)`
2. `(y,qty,rsd) (b) (xb) (qy)`
3. `(y,qty,xb) (b) (rsd) (qy)`
4. `(y,qy) (qty,b) (rsd) (xb)`
5. `(y,qy) (qty,rsd) (b) (xb)`
6. `(y,qy) (qty,xb) (b) (rsd)`

In any group the value returned in the array allocated to the group corresponds to the last member of the group.

`sqrst:`

Computes least squares solutions to the system

$Xb = y$

which may be either under-determined or over-determined. The user may supply a tolerance to limit the columns of  $X$  used in computing the solution. In effect, a set of columns with a condition number approximately bounded by  $1/\text{tol}$  is used, the other components of  $b$  being set to zero.

On return, the arrays `x`, `jpvt`, and `qraux` contain the usual output from `sqrsl`, so that the QR decomposition of  $x$  with pivoting is fully available to the user. In particular, columns `jpvt[0]`, `jpvt[1]`, ..., `jpvt[k-1]` were used in the solution, and the condition number associated with those columns is estimated by  $\text{ABS}(x[0][0]/x[k-1][k-1])$ .

Author: Dave Hale, Colorado School of Mines, 12/29/89

STOEP - Functions to solve a symmetric Toeplitz linear system of equations  
 $Rf=g$  for  $f$

stoepd solve a symmetric Toeplitz system - doubles  
stoepf solve a symmetric Toeplitz system - floats

Function Prototypes:

```
void stoepd (int n, double r[], double g[], double f[], double a[]);  
void stoepf (int n, float r[], float g[], float f[], float a[]);
```

Input:

$n$  dimension of system  
 $r$  array[ $n$ ] of top row of Toeplitz matrix  
 $g$  array[ $n$ ] of right-hand-side column vector

Output:

$f$  array[ $n$ ] of solution (left-hand-side) column vector  
 $a$  array[ $n$ ] of solution to  $Ra=v$  (Claerbout, FGDP, p. 57)

Notes:

These routines do NOT solve the case when the main diagonal is zero, it just silently returns.

The left column of the Toeplitz matrix is assumed to be equal to the top row (as specified in  $r$ ); i.e., the Toeplitz matrix is assumed symmetric.

Author: Dave Hale, Colorado School of Mines, 06/02/89

STRSTUFF -- STRing manipulation subs

cwp\_strdup - duplicate a string

strchop - chop off the tail end of a string "s" after a "," returning  
the front part of "s" as "t".

cwp\_strrev - reverse a string

Input:

char \*str input string

Output:

none

Returns:

char \* duplicated string

Notes:

This local definition of strdup is necessary because some systems  
do not have it.

Author: John Stockwell, Spring 2000.

SWAPBYTE - Functions to SWAP the BYTE order of binary data

swap\_short\_2 swap a short integer  
swap\_u\_short\_2 swap an unsigned short integer  
swap\_int\_4 swap a 4 byte integer  
swap\_u\_int\_4 swap an unsigned integer  
swap\_long\_4 swap a long integer  
swap\_u\_long\_4 swap an unsigned long integer  
swap\_float\_4 swap a float  
swap\_double\_8 swap a double

Function Prototypes:

```
void swap_short_2(short *tni2);  
void swap_u_short_2(unsigned short *tni2);  
void swap_int_4(int *tni4);  
void swap_u_int_4(unsigned int *tni4);  
void swap_long_4(long *tni4);  
void swap_u_long_4(unsigned long *tni4);  
void swap_float_4(float *tnf4);  
void swap_double_8(double *tndd8);
```

Notes:

These routines are necessary for reversing the byte order of binary data for transportation between big-endian and little-endian machines. Examples of big-endian machines are IBM RS6000, SUN, NeXT. Examples of little endian machines are PC's and DEC.

These routines have been tested with PC data and run on PC's running several PC versions of UNIX, but have not been tested on DEC.

Also, the number appended to the name of the routine refers to the number of bytes that the item is assumed to be.

Authors: Jens Hartmann, Institut fur Geophysik, Hamburg, Jun 1993  
John Stockwell, CWP, Colorado School of Mines, Jan 1994

SYMEIGEN - Functions solving the eigenvalue problem for symmetric matrices  
 eig\_jacobi - find eigenvalues and corresponding eigenvectors via  
           the jacobi algorithm for symmetric matrices  
 sort\_eigenvalues - sort eigenvalues and corresponding eigenvectors  
 in descending order

Function Prototypes:

```
void eig_jacobi(float **a, float d[], float **v, int n);
void sort_eigenvalues(float d[], float **v, int n);
  (inspired by Press et. al., 1996)
```

Macro used internally

```
define ROTATE(a,i,j,k,l) g=a[i][j];h=a[k][l];a[i][j]=g-s*(h+g*tau);\
  a[k][l]=h+s*(g-h*tau);
```

```
void eig_jacobi(float **a, float d[], float **v, int n)
eig_jacobi - find eigenvalues and corresponding eigenvectors via
  the jacobi algorithm for symmetric matrices
```

Function Prototype:

```
void eig_jacobi(float **a, float d[], float **v, int n);
  (inspired by Press et. al., 1996)
{
```

```
  int j,iq,ip,i;
  float tresh,theta,tau,t,sm,s,h,g,c,*b,*z;
```

```
  /* allocate space temporarily
  b=alloc1float(n); b-=1;
  z=alloc1float(n); z-=1;
```

```
  /* initialize v to the identity matrix
  for (ip=1;ip<=n;ip++) {
    for (iq=1;iq<=n;iq++) v[ip][iq]=0.0;
    v[ip][ip]=1.0;
  }
```

```
  /* initialilize to the diagonal on matrix a
  for (ip=1;ip<=n;ip++) {
    b[ip]=d[ip]=a[ip][ip];
    z[ip]=0.0;
  }
```

```
  /* main iteration loop
  for (i=1;i<=50;i++) {
```

```

sm=0.0;
for (ip=1;ip<=n-1;ip++) {
    for (iq=ip+1;iq<=n;iq++)
        sm += fabs(a[ip][iq]);
}
/* normal return
if (sm == 0.0) {
    z+=1; free1float(z);
    b+=1; free1float(b);
    return;
}
/* tresh values for first 3 sweeps and thereafter
if (i < 4)
    tresh=0.2*sm/(n*n);
else
    tresh=0.0;
for (ip=1;ip<=n-1;ip++) {
    for (iq=ip+1;iq<=n;iq++) {
        g=100.0*fabs(a[ip][iq]);
        if (i > 4 && (float)(fabs(d[ip])+g) == (float)fabs(d[ip])
            && (float)(fabs(d[iq])+g) == (float)fabs(d[iq]))
            a[ip][iq]=0.0;
        else if (fabs(a[ip][iq]) > tresh) {
            h=d[iq]-d[ip];
            if ((float)(fabs(h)+g) == (float)fabs(h))
                t=(a[ip][iq])/h;
            else {
                theta=0.5*h/(a[ip][iq]);
                t=1.0/(fabs(theta)+sqrt(1.0+theta*theta));
                if (theta < 0.0) t = -t;
            }
            c=1.0/sqrt(1+t*t);
            s=t*c;
            tau=s/(1.0+c);
            h=t*a[ip][iq];
            z[ip] -= h;
            z[iq] += h;
            d[ip] -= h;
            d[iq] += h;
            a[ip][iq]=0.0;

            /* Jacobi rotations

```

```

        for (j=1;j<=ip-1;j++) {
            ROTATE(a,j,ip,j,iq)
        }
        for (j=ip+1;j<=iq-1;j++) {
            ROTATE(a,ip,j,j,iq)
        }
        for (j=iq+1;j<=n;j++) {
            ROTATE(a,ip,j,iq,j)
        }
        for (j=1;j<=n;j++) {
            ROTATE(v,j,ip,j,iq)
        }
    }
}
for (ip=1;ip<=n;ip++) {
    b[ip] += z[ip];
    d[ip]=b[ip];
    z[ip]=0.0;
}
}
/* this will not happen, hopefully
fprintf(stderr,"jacobi iteration does not converge\n");
}

```

void sort\_eigenvalues(float d[], float \*\*v, int n)  
 sort\_eigenvalues - sort eigenvalues and corresponding eigenvectors  
 in descending order

Function Prototypes:

```

void sort_eigenvalues(float d[], float **v, int n);
    (inspired by Press et. al., 1996)
{

```

```

    int k,j,i;
    float p;

    for (i=1;i<n;i++) {
        p=d[k=i];
        for (j=i+1;j<=n;j++)
            if (d[j] >= p) p=d[k=j];
        if (k != i) {
            d[k]=d[i];

```

```

        d[i]=p;
        for (j=1;j<=n;j++) {
            p=v[j][i];
            v[j][i]=v[j][k];
            v[j][k]=p;
        }
    }
}

```



```
include "cwp.h"
```

TEMPORARY\_FILENAME - Creates a file name in a user-specified directory.

Function prototypes:

```
FILE *temporary_stream (char *tempfile);  
char *temporary_filename(char *tempfile);
```

temporary\_stream:

Input:

tempfile pointer to directory prefix string (eg. /usr/tmp/)

Output:

filestream pointer to temporary file stream

temporary\_filename:

Input:

tempfile pointer to directory prefix string (eg. /usr/tmp/)

Output:

tempfile pointer to filename string (eg. /usr/tmp/1206aaa)

Notes:

temporary\_stream creates a file stream by appending a sequence of numbers and letters (which is created by mkstemp) to the prefix string passed as its argument.

Author: Andreas Klaedtke, 12/2/2009

temporary\_filename creates a file name by appending a sequence of numbers and letters (which is created by tmpnam) to the prefix string passed as its argument. On return the input argument points to the (now augmented) prefix string.

It is duty of the calling program to provide room for the augmented string. The resulting string is typically used as a name for a temporary file; in this case it is the calling program's job to make sure that the supplied prefix ends with a slash.

This routine was written to supplement the ANSI C function tmpnam which also creates a temporary filename, but within a fixed directory, usually the /tmp directory. Unfortunately, some /tmp directories are too small to hold typical seismic data sets, so this routine allows

the user to specify a directory with sufficient capacity. Also note that on many systems, the `tmpfile()` call avoids this problem by simulating a temporary file with a memory buffer. However, this is not a panacea as the file size might exceed available memory and on some systems this call does actually create a file (again, usually in `tmp`).

Author: Jack K. Cohen, Colorado School of Mines, 12/12/95

TRIDIAGONAL - Functions to solve tridiagonal systems of equations  $Tu=r$  for  $u$ .

tridif Solve a tridiagonal system of equations (float version)  
tridid Solve a tridiagonal system of equations (double version)  
tripd Solve a positive definite, symmetric tridiagonal system  
tripp Solve an unsymmetric tridiagonal system that uses  
Gaussian elimination with partial pivoting

Function Prototypes:

```
void tridif (int n, float a[], float b[], float c[], float r[], float u[]);
void tridid (int n, double a[], double b[], double c[], double r[], double u[]);
void tripd (float *d, float *e, float *b, int n);
void tripp(int n, float *d, float *e, float *c, float *b);
```

tridif, tridid:

Input:

n dimension of system  
a array[n] of lower sub-diagonal of T (a[0] ignored)  
b array[n] of diagonal of T  
c array[n] of upper super-diagonal of T (c[n-1] ignored)  
r array[n] of right-hand-side column vector

Output:

u array[n] of solution (left-hand-side) column vector

tripd:

Input:

d array[n], the diagonal of A  
e array[n], the superdiagonal of A  
b array[n], the rhs column vector of  $Ax=b$

Output:

b b is overwritten with the solution to  $Ax=b$

tripp:

Input:

d diagonal vector of matrix  
e upper-diagonal vector of matrix  
c lower-diagonal vector of matrix  
b right-hand vector  
n dimension of matrix

Output:

b solution vector

Notes:

For example, a tridiagonal system of dimension 4 is specified as:

$$\begin{array}{cccc|cccc} |b[0] & c[0] & 0 & 0 & | & |u[0]| & & |r[0]| \\ |a[1] & b[1] & c[1] & 0 & | & |u[1]| & = & |r[1]| \\ |0 & a[2] & b[2] & c[2] & | & |u[2]| & & |r[2]| \\ |0 & 0 & a[3] & b[3] & | & |u[3]| & & |r[3]| \end{array}$$

The tridiagonal matrix is assumed to be non-singular.

tripd:

Given an n-by-n symmetric, tridiagonal, positive definite matrix A and n-vector b, following algorithm overwrites b with the solution to  $Ax = b$

Authors: tridif, tridid: Dave Hale, Colorado School of Mines, 10/03/89

tripd, tripp: Zhenyue Liu, Colorado School of Mines, 1992-1993

UNWRAP\_PHASE - routines to UNWRAP phase of fourier transformed data

oppenheim\_unwrap\_phase - using the method of Oppenheim and Schafer (1975)

simple\_unwrap\_phase - by searching for phase jumps

Function Prototype:

```
void oppenheim_unwrap_phase(int n, int trend, int zeromean,  
float df, float *xr, float *xi, float *phase);
```

```
void simple_unwrap_phase(int n, int trend, int zeromean,  
float w, float *phase);
```

oppenheim\_unwrap\_phase:

Input:

n number of samples

df frequency sampling interval

trend remove linear trend from unwrapped phase

xr real part of signal

xi imaginary part of signal

Output:

phase array[n] of output unwrapped phase values

simple\_unwrap\_phase:

Input:

n number of samples

trend remove linear trend from phase

zeromean =0 assume phase(0)=0.0, else assume zero mean

w unwrapping parameter; returns an error if w=0

phase array[n] of input

Output:

phase array[n] of output phase values

oppenheim\_unwrap\_phase:

Notes:

- 1) The phase unwrapping method proposed by Oppenheim and Schaffer 1975 calculates the unwrapped phase by integrating the derivative with respect to frequency of the phase of a signal  $F(w)$  .

Let  $u(w) = \text{Re } F(w)$  and  $v(w) = \text{Im } F(w)$

$\text{phase}(w) = \arctan[v(w)/u(w)]$

Taking the derivative with respect to  $w$  of both sides

$$\begin{aligned} d/dw [ \text{phase}(w) ] &= d/dw ( \arctan (v/u) ) \\ &= [ 1 / (1 + (v/u)^2) ] ( v'/u - vu'/u^2 ) = ( v'u - vu' ) / (u^2 + v^2) \end{aligned}$$

- 2) Then, the  $d/dw$  phase is integrated with respect to  $w$  to produce the phase function

$$\text{phase}(w) = \int \text{phase}'(w) dw$$

- 3) the user has the option of removing the linear trend in the phase

The approach allows us to avoid the principle branch behavior of the arctangent function.

#### References:

Oppenheim A.V. and R.W. Schaffer, Digital Signal Processing, Prentice-Hall, Englewood Cliffs, New Jersey, 1975.

Tria M., M. Van Der Baan 2, A. Larue, J. Mars 1, 2007,  
Wavelet estimation in homomorphic domain by spectral  
averaging, for deconvolution of seismic data  
For the BLISS Project, Universit de Leeds,  
ITF Consorsium collaboration(s) (2007)

simple\_unwrap\_phase:

Notes:

The strategy is to look at the change in phase ( $d\text{phase}$ ) with each time step. If  $|d\text{phase}| > \pi/w$ , then use the previous value of  $d\text{phase}$ . No attempt is made at smoothing the  $d\text{phase}$  curve.

oppenheim\_unwrap\_phase:

Author: John Stockwell, CWP, 2010

simple\_unwrap\_phase

Author: John Stockwell, CWP, 2010

VANDERMONDE - Functions to solve Vandermonde system of equations  $Vx=b$

vanded solve Vandermonde system of doubles

vandef solve Vandermonde system of floats

Function Prototypes:

```
void vanded (int n, double v[], double b[], double x[]);
```

```
void vandef (int n, float v[], float b[], float x[]);
```

Input:

n dimension of system

v array[n] of 2nd row of Vandermonde matrix (1st row is all ones)

b array[n] of right-hand-side column vector

Output:

x array[n] of solution column vector

Notes:

The arrays b and x may be equivalenced.

Reference:

Adapted from Algorithm 5.6-2 in Golub, G. H., and Van Loan, C. F., 1983, Matrix Computations, John-Hopkins University Press.

Author: Dave Hale, Colorado School of Mines, 06/02/89

WAVEFORMS    Subroutines to define some wavelets for modeling of seismic data

ricker1\_wavelet    Compute the time response of a source function as a Ricker wavelet with peak frequency "fpeak" Hz.

ricker2\_wavelet    Compute a Ricker wavelet with a given period, amplitude and distortion factor

akb\_wavelet        Compute the time response of a source function as a wavelet based on a wavelet used by Alford, Kelly, and Boore.

spike\_wavelet      Compute the time response of a source function as a spike.

unit\_wavelet       Compute the time response of a source function as a constant unit shift.

zero\_wavelet       Compute the time response of a source function as zero everywhere.

berlage\_wavelet    Compute the time response of a source function as a Berlage wavelet with peak frequency "fpeak" Hz, exponential decay factor "decay", time exponent "tn", and initial phase angle "ipa".

gaussian\_wavelet   Compute the time response of a source function as a Gaussian wavelet with peak frequency "fpeak" in Hz.

gaussderiv\_wavelet Compute the time response of a source function as a Gaussian first derivative wavelet with peak frequency "fpeak" in Hz.

deriv\_n\_gauss      Compute the n-th derivative of a gaussian in double precision

#### Function Prototypes:

```
void ricker1_wavelet (int nt, float dt, float fpeak, float *wavelet);
void ricker2_wavelet (int hlw, float dt, float period, float ampl,
    float distort, float *wavelet);
void akb_wavelet (int nt, float dt, float fpeak, float *wavelet);
void spike_wavelet (int nt, int tindex, float *wavelet);
void unit_wavelet (int nt, float *wavelet);
void zero_wavelet (int nt, float *wavelet);
```



```
void berlage_wavelet (int nt, float dt, float fpeak, float ampl, float tn,  
                     float decay, float ipa, float *wavelet);  
void gaussian_wavelet (int nt, float dt, float fpeak, float *wavelet);  
void gaussderiv_wavelet (int nt, float dt, float fpeak, float *wavelet);
```

Authors: Tong Fei, Ken Larner

Author: Nils Maercklin, February 2007

WINDOW - windowing routines

hanningWindow - returns an n element long hanning window

Function prototypes:

```
void hanningWindow(int n,float *w);
```

Author: Potash Corporation, Saskatchewan: Balasz Nemeth given to CWP 2008

wrapArray - wrap an array

Function prototype:

```
void wrapArray(void *base,size_t nmemb,size_t size,int f)
```

Author: Potash Corporation: Balasz Nemeth, given to CWP 2008

XCOR - Compute  $z = x$  cross-correlated with  $y$

xcor compute  $z = x$  cross-correlated with  $y$

Function Prototype:

```
void xcor (int lx, int ifx, float *x, int ly, int ify, float *y ,
int lz, int ifz, float *z);
```

Input:

lx length of  $x$  array

ifx sample index of first  $x$

$x$  array[lx] to be cross-correlated with  $y$

ly length of  $y$  array

ify sample index of first  $y$

$y$  array[ly] with which  $x$  is to be cross-correlated

lz length of  $z$  array

ifz sample index of first  $z$

Output:

$z$  array[lz] containing  $x$  cross-correlated with  $y$

Notes:

See notes for convolution function convolve\_cwp().

The operation " $x$  cross correlated with  $y$ " is defined to be:

$$z[i] = \sum_{j=ifx}^{ifx+lx-1} x[j]*y[i+j] \quad ; \quad i = ifz, \dots, ifz+lz-1$$

This function performs cross-correlation by

(1) reversing the samples in the  $x$  array while copying them to a temporary array, and

(2) calling function convolve\_cwp() with ifx set to  $1-ifx-lx$ .

Assuming that the overhead of reversing the samples in  $x$  is negligible, this method enables cross-correlation to be performed as efficiently as convolution, while reducing the amount of code that must be optimized and maintained.

Author: Dave Hale, Colorado School of Mines, 11/23/91

XINDEX - determine index of x with respect to an array of x values

xindex determine index of x with respect to an array of x values

Input:

nx number of x values in array ax

ax array[nx] of monotonically increasing or decreasing x values

x the value for which index is to be determined

index index determined previously (used to begin search)

Output:

index for monotonically increasing ax values, the largest index

for which  $ax[index] \leq x$ , except index=0 if  $ax[0] > x$ ;

for monotonically decreasing ax values, the largest index

for which  $ax[index] \geq x$ , except index=0 if  $ax[0] < x$

Notes:

This function is designed to be particularly efficient when called repeatedly for slightly changing x values; in such cases, the index returned from one call should be used in the next.

Author: Dave Hale, Colorado School of Mines, 12/25/89

YCLIP - Clip a function  $y(x)$  defined by linear interpolation of the uniformly sampled values:  $y(fx)$ ,  $y(fx+dx)$ , ...,  $y(fx+(nx-1)*dx)$ . Returns the number of samples in the clipped function.

yclip clip a function  $y(x)$  defined by linear interpolation of uniformly sampled values

Function Prototype:

```
int yclip (int nx, float dx, float fx, float y[], float ymin, float ymax,
float xc[], float yc[]);
```

Input:

nx number of x (and y) values

dx x sampling interval

fx first x

y array[nx] of uniformly sampled  $y(x)$  values

ymin minimum y value; must not be greater than ymax

ymax maximum y value; must not be less than ymin

Output:

xc array[?] of x values for clipped  $y(x)$

yc array[?] of y values for clipped  $y(x)$

Returned: number of samples in output arrays xc and yc

Notes:

The output arrays xc and yc should contain space  $2*nx$  values, which is the maximum possible number (nc) of xc and yc returned.

Author: Dave Hale, Colorado School of Mines, 07/03/89

YXTOXY - Compute a regularly-sampled, monotonically increasing function  $x(y)$  from a regularly-sampled, monotonically increasing function  $y(x)$  by inverse linear interpolation.

yxtoxy compute a regularly sampled function  $x(y)$  from a regularly sampled, monotonically increasing function  $y(x)$

Function Prototype:

```
void yxtoxy (int nx, float dx, float fx, float y[],  
int ny, float dy, float fy, float xylo, float xyhi, float x[]);
```

Input:

nx number of samples of  $y(x)$

dx x sampling interval;  $dx > 0.0$  is required

fx first x

y array[nx] of  $y(x)$  values;  $y[0] < y[1] < \dots < y[nx-1]$  required

ny number of samples of  $x(y)$

dy y sampling interval;  $dy > 0.0$  is required

fy first y

xylo x value assigned to  $x(y)$  when y is less than smallest  $y(x)$

xyhi x value assigned to  $x(y)$  when y is greater than largest  $y(x)$

Output:

x array[ny] of  $x(y)$  values

Notes:

User must ensure that:

(1)  $dx > 0.0$  &&  $dy > 0.0$

(2)  $y[0] < y[1] < \dots < y[nx-1]$

Author: Dave Hale, Colorado School of Mines, 06/02/89

ZASC - routine to translate ncharacters from ebcdic to ascii

zasc - convert n characters from ebcdic to ascii format

Input:

nchar number of characters to be translated

ainput pointer to input characters

Output:

aoutput pointer to output characters

Function Prototype:

```
int zasc(char *ainput, char *aoutput, integer nchar);
```

Notes:

translated by f2c. Horribly inefficient, but little used

Author: Stew Levin of Mobil, 1997



ZEBC - routine to translate ncharacters from ascii to ebcdic

zebc - convert n characters from ascii to ebcdic format

Input:

nchar number of characters to be translated

ainput pointer to input characters

Output:

aoutput pointer to output characters

Function Prototype:

```
int zebc(char *ainput, char *aoutput, integer nchar);
```

Notes:

translated by f2c. Horribly inefficient, but little used

Author: Stew Levin of Mobil, 1997

CHECK - CHECK triangulated models

badModel bad Model flag  
checkVertexUse check Vertex Use  
checkEdgeUse check Edge Use  
checkFace check Face  
checkModel check Model

Function Prototypes:

void badModel(void);  
void checkVertexUse (VertexUse \*vu);  
void checkEdgeUse (EdgeUse \*eu);  
void checkFace (Face \*f);  
void checkModel (Model \*m);

checkVertexUse:

Input:  
vu Pointer to VertexUse

checkEdgeUse:

Input:  
eu pointer to EdgeUse

checkFace:

Input:  
f pointer to Face

checkModel:

Input:  
m pointer to Model

Notes: Routines for checking triangulated models.

Author: Dave Hale, Colorado School of Mines, 07/09/90

CIRCUM - define CIRCUMcircles for Delaunay triangulation

circum - compute center and radius-squared of circumcircle of 3 (x,y)  
locations

circumTri - compute center and radius-squared of circumcircle of  
triangular face

Function Prototypes:

```
void circum (float x1, float y1, float x2, float y2, float x3, float y3,  
float *xc, float *yc, float *rs);
```

```
void circumTri (Tri *t);
```

circum:

Input:

x1 x-coordinate of first point  
y1 y-coordinate of first point  
x2 x-coordinate of second point  
y2 y-coordinate of second point  
x3 x-coordinate of third point  
y3 y-coordinate of third point

Output:

xc pointer to x-coordinate of center of circumcircle  
yc pointer to y-coordinate of center of circumcircle  
rs pointer radius<sup>2</sup> of circumcircle

circumTri:

Input:

t Pointer to Tri

Returns:

xc x-coordinate of circumcircle  
yc y-coordinate of circumcircle  
rs radius<sup>2</sup> of circumcircle

Author: Dave Hale, Colorado School of Mines, Fall 1990.

COLINEAR - determine if edges or vertecies are COLINEAR in triangulated  
model

edgesColinear see whether or not two edges are colinear

vertexBetweenVertices determine whether or not a vertex is on a line  
between two other vertices

Function Prototypes:

```
int edgesColinear (Edge *e1, Edge *e2);
```

```
int vertexBetweenVertices (Vertex *v, Vertex *v1, Vertex *v2);
```

edgesColinear:

Input:

e1 pointer to first Edge

e2 pointer to second Edge

Returns: (int)

1 if colinear

vertexBetweenVertices:

Input:

v pointer to first Vertex in question

v1 pointer to first reference Vertex

v2 pointer to second reference Vertex

Returns: integer

1 if v=v1 or v=v2 or if v is between v1 and v2

0 otherwise

Author: Dave Hale, Colorado School of Mines, Fall 1990.

CREATE - create model, boundary edge triangles, edge face, edge vertex, add a vertex

makeModel Make and return a pointer to a new model

makeBoundaryEdgeTri Create a boundary edge and triangle

makeEdgeFace Create an edge by connecting two vertices

makeEdgeVertex Create an edge connecting an existing vertex (v1) to a new vertex

addVertexToModel Add a vertex to model, and return pointer to new vertex

insideTriInModel return pointer to triangle in model containing specified (x,y) coordinates

Function Prototypes:

```
Model *makeModel (float xmin, float ymin, float xmax, float ymax);
```

```
void makeBoundaryEdgeTri (Vertex *v, Edge **enew, Tri **tnew);
```

```
void makeEdgeFace (Vertex *v1, Vertex *v2, Edge **enew, Face **fnew);
```

```
Vertex* addVertexToModel (Model *m, float x, float y);
```

```
Tri* insideTriInModel (Model *m, Tri *start, float x, float y);
```

makeModel:

Input:

xmin minimum x-coordinate

ymin minimum y-coordinate

xmax maximum x-coordinate

ymax maximum y-coordinate

Returns: pointer to a new Model

makeBoundaryEdgeTri:

Input:

v specified boundary Vertex

Output:

enew new boundary Edge

tnew new boundary triangle

Notes:

The specified vertex and the adjacent vertices on the boundary are assumed to be colinear. Therefore, the resulting boundary triangle has zero area, and is intended to enable deletion of the specified vertex from the boundary.

makeEdgeFace:

Input:  
v1 First Vertex  
v2 second Vertex

Output:  
enew new Edge  
fnew new Face

Notes:  
The vertices must be adjacent to a single common face.  
This face is closed off by the new edge, and a new edge and  
a new face are made and returned.

addVertexToModel:  
Input:  
m model  
x x-coordinate of new vertex  
y y-coordinate of new vertex

Notes:  
If the new vertex is close to an existing vertex, this function returns NULL.

insideTriInModel:  
Input:  
m Model  
start triangle to look at first (NULL to begin looking anywhere)  
x x-coordinate  
y y-coordinate

Notes:  
Points on an edge of a triangle are assumed to be inside that triangle.  
An edge may be used by two triangles, so two triangles may "contain"  
a point that lies on an edge. The first triangle found to contain  
the specified point is returned.

Author: Dave Hale, Colorado School of Mines, Fall 1990.

DELETE - DELETE vertex, model, edge, or boundary edge from triangulated model

deleteVertexFromModel Delete a vertex from model

killModel Delete a model along with everything in it

killEdge Delete an edge

killBoundaryEdge Kill a boundary edge

Function Prototypes:

```
void deleteVertexFromModel (Model *m, Vertex *v);
```

```
void killModel (Model *m);
```

```
void killEdge (Edge *e, Face **fs);
```

```
void killBoundaryEdge (Edge *e);
```

deleteVertexFromModel:

Input:

m pointer to Model

v pointer to Vertex to be deleted

killModel:

Input:

m pointer to Model

killEdge:

Input:

e Edge to delete

Output:

fs surviving Face

killBoundaryEdge:

Input:

e boundary Edge

Notes:

Killing a boundary edge is typically done after a new boundary vertex is inserted on an existing boundary edge.

Author: Dave Hale, Colorado School of Mines, Fall 1990.

DTE - Distance to Edge

distanceToEdge - return distance to edge from specified (x,y) coordinates

Function Prototype:

```
float distanceToEdge (Edge *e, float x, float y);
```

distanceToEdge:

Input:

e edge to which distance is to be computed

x x-coordinate

y y-coordinate

Author: Dave Hale, Colorado School of Mines, 09/11/90



FIXEDGES - FIX or unFIX EDGES between verticies

fixEdgeBetweenVertices Fix edge(s) between vertices, creating new  
colinear edges as necessary.

unfixEdge unfix edge

fixEdgesBetweenVertices:

Input:

v1 pointer to first Vertex

v2 pointer to second Vertex

Returns:

0 if unable to fix edges

1 otherwise

unfixEdge:

Input:

e edge to be unfixed

Returns:

0 if unable to unfix edge

1 otherwise

Author: Dave Hale, Colorado School of Mines, 06/04/91

INSIDE - Is a vertex or point inside a circum circle, etc. of a triangulated model

inCircum determine whether or not a vertex is inside a circum circle

inCircumTri determine whether or not a vertex is inside a circum circle of a triangle

in3Vertices determine whether or not a vertex is inside triangle (v1,v2,v3)

inTri determine whether or not a vertex is inside a triangle

Function Prototypes:

```
int inCircum (float x, float y, float xc, float yc, float rs);
```

```
int inCircumTri (float x, float y, Tri *t);
```

```
int in3Vertices (float x, float y, Vertex *v1, Vertex *v2, Vertex *v3);
```

```
int inTri (float x, float y, Tri *t);
```

inCircum:

Input:

x x-coordinate of vertex

y y-coordinate of vertex

xc x-coordinate of center of circumcircle

yc y-coordinate of center of circumcircle

rs radius<sup>2</sup> of circumcircle

Returns:

1 if x,y inside of circumcircle

0 otherwise

Notes:

A vertex exactly on the edge of a circumcircle is taken as being outside

inCircumTri:

Input:

x x-coordinate of vertex

y y-coordinate of vertex

t pointer to Tri

Returns:

1 if x,y inside of circumcircle of a triangle

0 otherwise

Notes:

A vertex exactly on the edge of a circumcircle is taken as being outside

in3Vertices:

Input:

x x-coordinate of vertex  
y y-coordinate of vertex  
v1 pointer to first Vertex  
v2 pointer to second Vertex  
v3 pointer to third Vertex

Returns:

1 if x,y inside of v1,v2,v3  
0 otherwise

Notes:

A vertex exactly on an edge of the triangle is taken as being inside

inTri:

Input:

x x-coordinate of vertex  
y y-coordinate of vertex  
t pointer to Tri

Returns:

1 if x,y inside a triangle  
0 otherwise

Notes:

A vertex exactly on the edge of a triangle is inside

Author: Dave Hale, Colorado School of Mines, 06/04/91

NEAREST - NEAREST edge or vertex in triangulated model

nearestEdgeInModel Return pointer to edge in model nearest to  
specified (x,y) coordinates

nearestVertexInModel Return pointer to vertex in model nearest  
to specified (x,y) coordinates

Function Prototypes:

Vertex\* nearestVertexInModel (Model \*m, Vertex \*start, float x, float y);

Edge\* nearestEdgeInModel (Model \*m, Edge \*start, float x, float y);

nearestEdgeInModel:

Input:

m model

start edge to look at first (NULL to begin looking anywhere)

x x-coordinate

y y-coordinate

Returns: pointer to nearest Edge

nearestVertexInModel:

Input:

m model

start vertex to look at first (NULL to begin looking anywhere)

x x-coordinate

y y-coordinate

Returns: pointer to nearest Vertex

Author: Dave Hale, Colorado School of Mines, Fall 1990

PROJECT - project to edge in triangulated model

projectToEdge - Project point with specified (x,y) coordinates to specified  
edge

Function Prototype:

```
void projectToEdge (Edge *e, float *x, float *y)
```

Input:

e edge to which point is to be projected

x x-coordinate before projection

y y-coordinate before projection

Output:

x x-coordinate after projection

y y-coordinate after projection

Author: Dave Hale, Colorado School of Mines, 09/11/90

READWRITE - READ or WRITE a triangulated model

readModel Read a model in the form produced by writeModel

writeModel Write a model to a file

Function Prototypes:

Model \*readModel (FILE \*fp);

void writeModel (Model \*m, FILE \*fp);

readModel:

Input:

fp file pointer to file containing model

writeModel:

Input:

m pointer to Model

fp file pointer

Author: Jack K. Cohen, Center for Wave Phenomena, 09/21/90

Modified: Dave Hale, Center for Wave Phenomena, 11/30/90

Converted representation of model from ascii to binary for speed.

Added code to read attributes.

Modified (writeModel): Craig Artley, Center for Wave Phenomena, 04/08/94

Corrected bug; previously the edges and vertexes of the exterior face were not written.