**Processing MSBAS :**

Notes taken during working session with Sergey Samsonov

Walferdange, August 9-22, 2015.

* Code and scripts are copied in /PROCESS/MSBAS/Hawaii/3Dmsbas
* Dataset for test + results by Sergey are in Doris-Pro/PROCESS/MSBAS/Hawaii/msbas
* Reprocessed data on Doris-Pro are in Doris-Pro/PROCESS/MSBAS/Hawaii/msbas\_testWLF\_Aug11

**Script to prepare data: *make\_unw\_int\_msbas.sh* (contains Gamma command)**

* it reads info about modes (coord etc..)
* extract average coh for a given dataset for a given place. =>   
  Keep only data above a coh threshold. This is an additional selection after MSBAS eg to take into account also decorrelation related to seasonal vegetation or snow cover.
* For data that are coherent enough :
  + Transfo rad into meters
  + Re-grid the different modes into a common grid
  + Convert m to cm
  + Store as msbas binary files.

Note : it is possible in principle to select different time matrix for each pixel in order to keep time series for only the dates where data are coherent but it is much more computer-time consuming.

**Header for msbas : *header.txt***

1: BE\_SE = 1 #0 - small endian, 1 - big endian

2: FILE\_SIZE = 2001, 1851

3:WINDOW\_SIZE = 650, 2000, 0, 1570

4:HPF\_FLAG = 0

5:R\_FLAG = 0.2

6:TOPO\_FLAG = 0

7:C\_FLAG = 1, 860, 1380, 32,32

8:TAV\_FLAG = 0

9:I\_FLAG = 2, par.txt

10:DSET= 347.9123863, 19.7953, fq01.txt

11:DSET= 348.9440712, 40.1231, fq20.txt

12:DSET= 349.2513074, 45.1678, fq26.txt

13:DSET= -169.1360114, 41.9396, fq22.txt

14:DSET= -168.1188498, 22.3155, fq03.txt

line 1 = binary order

line 2 = size as: col and rows

line 3 = possible crop (attention first pixel = 0 ! and last is hence = max-1)

line 4 = flag for possible FFT high pass filtering to remove orbital residuals.   
 0 = no filter ; 1 = linear plane removed, 2 = quadratic ; 3 = cubic etc…

line 5 = R\_FLAG: Lambda factor for Tickhonov regularization. Best value is determined by running

multiple msbas processing using different values between 1 and 0 then plotting the L-curve

using results stored in lambda\_norm.txt file and selecting the Lambda that correspond to the

kink in the L-curve as Fig 2 in Vancouver paper by Samsonov et al. :

*lambda\_norm.txt* file contains a single line with the following values (non log!)

Lambda ||Ax-Y|| ||X||ew ||X||up ||X||combined up & ew

With all msbas runs operated with a different Lambda, create a **log** file with Lambda at

||Ax-Y|| value on X-axis and ||X||combined value on Y-axis. For each point, indicate the value of

Lambda next to the point on the curve.

Kink

Note : kink is not easily visible because NS is not taken into account so data are far from

ideal case, not to mention normal noise and uncertainties. Taking the second derivative of

the curve may help to spot the kink.

Line 6 : TOPO\_FLAG. If set to 0, do not solve for topo residual errors. If set to 1, it does.

It could be needed if works with srtm @ 90m and data @ 2m, but not needed if use

TDX DEM and data @ 5m.

Line 7 : C\_FLAG : coordinates of reference region(s) supposed stable.   
 Numbers are separated by comas. No coma at the end.   
 If first number is 0, it does consider reference region.

If first number is 2 for instance, it must be followed by coordinates ‘column’ and ‘rows’ of

two pixels supposed to be stable (or where GPS are installed and for which one can estimate

the velocity). The line is finished by two numbers that give the radius around the reference

pixel(s) that composes the reference region (in case the pixel(s) are noisy). The same radius

is used for each reference region.

Line 8 : TAV\_FLAG : temporal filtering. Not recommended and desactivated anyway because it

causes problems at compiling. Slower and less good than Tikhonov anyway. (If used, it would have contained the size of the temporal window, in year).

Line 9 : I\_FLAG : if 0 : run auto, without manual input.   
 If 1 : it asks for coordinates of point for which one want ascii time series to be created.

If 2 : it does it automatically by reading the coordinates of the points in the ***par.txt*** file.

The par.txt file contains for instance

AHUP.ts 1169 804 3

AINP.ts 209 836 3

BYRL.ts 1199 640 3

CNPK.ts 971 738 3

Where .ts files are GPS files followed by coordinates of the GPS pixel and the radius.

GPS files contain GPS data as follow (zero means no data):

2011.290405 0.000000 0.000000

2011.301392 0.002568 -0.000632

2011.323242 -0.008699 0.057749

That is Decimal year, ew (in input units), up (in input units)

Line 10-14 : info about the various data sets used for msbas (3 asc and 2 desc in present example):

Azimuth heading, incidence angle, filename.txt

Where filename.txt (eg fq01.txt) contain eg :

FQ1/20110420\_HH\_20110514\_HH.msbas -58.22120 20110420 20110514

FQ1/20110420\_HH\_20110818\_HH.msbas -164.49840 20110420 20110818

FQ1/20110420\_HH\_20111005\_HH.msbas -146.83830 20110420 20111005

That is path/name of msbas interfero, Bperp (in m) and dates of master and slaves. Time will be added later in the case of processing more than one image per day. Note that in that case, there is only one time per acquisition mode. Even Envisat, when desorbited, was only available as one pair at a time, which can be considered as a new acquisition mode each time.

Note : lines in the header file can be commented using #.

**Software 3Dmsbas:**

* compiled in c++ using the following command :  
   compile g++-mp-4.8 3Dsbas –llapack –o 3Dmsbas  
  If takes regular g++ it will emit warnings.   
  (If wanted to keep FFT filtering, add –lfftw2).   
  To remove the FFT option in the code, the following files have been changed as follow:
  + CDSet.h : comment line 127-232 using \*/ … /\*
  + 3Dsbas.cpp: comment line 374 with leading //
  + common.h: comment line 7 with leading //
* ATTENTION, msbas software output only one point per day. If more than one image is acquired on a given day by different satellites, values are combined. May be a problem if strong defo occurs in the mean time. May be improved in next version of software.

**PROCESSING:**

* In the dir where data.msbas data are stored (in sub dirs FQ1, FQ3 etc… in the present test), and where the file header.txt is stored, as well as –in the present case- the info about GPS stations and time series we want to extract for these pixels, launch the following cmd:   
   *path/3Dsbas header.txt*
* To plot the results, launch the script *plotall.sh* (that makes use of *plot.sh*):   
   *plotall.sh linear\_rate\_east.bin   
   plotall.sh linear\_rate\_up.bin*  
  Note: to change the color scale, modify line 56 in plot.sh.   
  ATTENTION : with GMT 5.0, each gmt command must start by “gmt”. Two versions of the scripts are made: for GMT V4 and V5.
* To plot the time series extracted for the given selected pixels, launch *plotgnu.sh* :   
   *plotgnu.sh gnuplot\_timeseries.txt*  
  Where gnuplot\_timeseries.txt contains the following

#load 'work.gnu'

set title ""

set xlabel "Time, year" font "Helvetica,24"

set ylabel "Displacement, cm" font "Helvetica,24"

#set zlabel ""geo\_920617-970111.unw.ch2\_1\_-117.7.prf

#set hidden3d

#set grid

set autoscale

#set xrange [2010:2014]

set yrange [-15:15]

#set logscale

set xtics 0.25

set ytics font "Helvetica,20"

set xtics font "Helvetica,20"

set size 1.2,1.2

set pointsize 1

set key bottom left

#set isosamples 50

#set polar

set output "data.eps"

set terminal postscript eps color enhanced "Helvetica,24"

# Actually Plot the Graph

#lines points linespoints impulses dots steps errorbars boxes boxerrorbars

plot 'data.dat' using 1:2 with linespoints title 'East-West' lw 4 lc rgb '#F15854', 'data.dat' using 1:3 with linespoints title 'Up-Down' lw 4 lc rgb '#5DA5DA'

#plot 'data.dat' using 1:3 with linespoints title 'Up-Down' linewidth 2 lt 1

* File *axy\_norm.bin* contains ||Ax-Y|| for each pixel. It allows to spot the reference pixel(s) as it is where the error will be the smallest.   
  Similarly, *x1\_norm.bin, x2\_norm.bin* and *x\_norm.bin* is the estimation of ew, up and ew&up absolute value of average velocity over time.