

TauDEM 5.2

**GUIDE TO USING THE TAUDEM COMMAND LINE
FUNCTIONS FOR TAUDEM MULTI-FILE**

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Purpose

The purpose of this document is to introduce Hydrologic Terrain Analysis using the TauDEM command line functionality for TauDEM multi-file.

TauDEM (Terrain Analysis Using Digital Elevation Models) is a set of Digital Elevation Model (DEM) tools for the extraction and analysis of hydrologic information from topography as represented by a DEM. This is software developed at Utah State University (USU) for hydrologic digital elevation model analysis and watershed delineation and may be obtained from <http://hydrology.usu.edu/taudem/taudem5/>.

TauDEM is available in two versions, the single-file with a graphical user interface to be used in the ArcGIS toolbox, and the multi-file command line executable versions. The single file version of TauDEM allows the user to perform analysis on a single input file. The multi-file version allows the user to specify a folder location and perform the analysis on multiple input files. This is beneficial when the area being processed is too big to fit in to a single TIFF file so needs to be represented using multiple TIFF files that logically comprise the domain. This guide is written to introduce the user to installation, setup, and usage of the command line multi-file version. The multi-file executables have been coded in C++ with the intention to be platform independent. It is helpful to have GIS software installed, such as ArcGIS, GRASS, MapWindow, etc., so that the user can view and inspect the results. In this guide we assume that you are working on a Windows PC, although much of the functionality is generic and can be (with knowledge of the other system) be transferred to other systems. To use TauDEM command line functions you need the TauDEM 5.2 multi-file software as well as MPI software. Our current Windows PC precompiled executables have been compiled using the Microsoft HPC Pack 2012 MS-MPI libraries from <http://www.microsoft.com/en-us/download/details.aspx?id=36045>. Earlier versions used MPICH2 from <http://www.mcs.anl.gov/research/projects/mpich2/>. MPICH2 libraries are suggested for non Windows installations.

Versions

TauDEM 5.1.x refers to the single file version

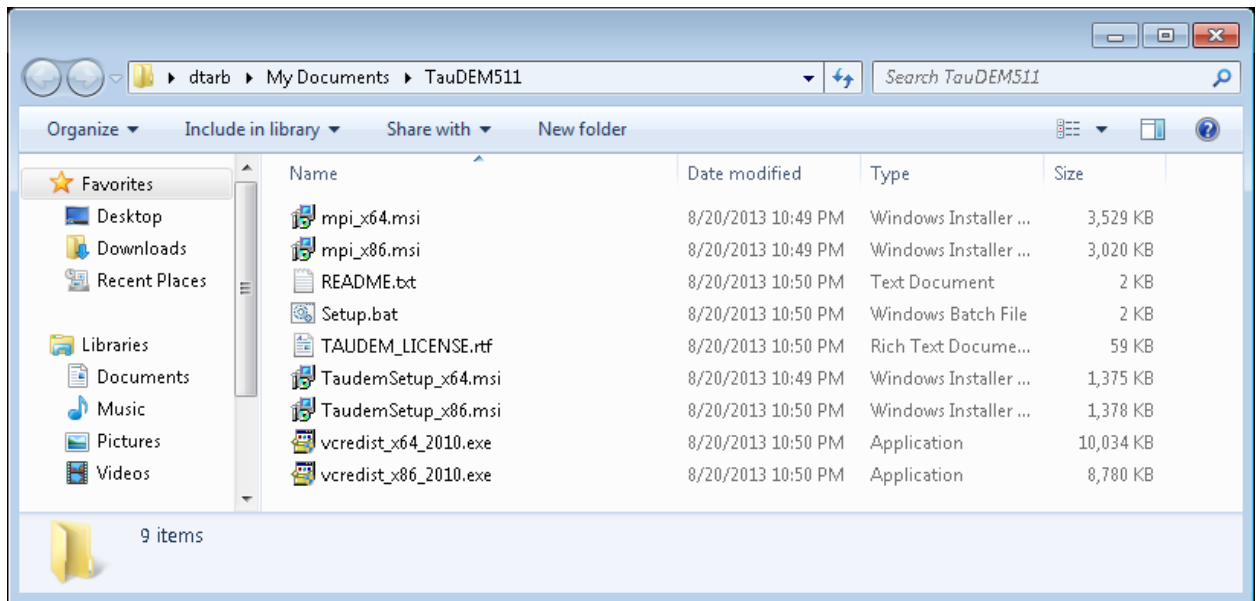
TauDEM 5.2.x refers to the multi file version described here

MPI and TauDEM Installation

For this guide we assume that the installation is done to the default locations on the C: drive of a 64-bit Windows PC:

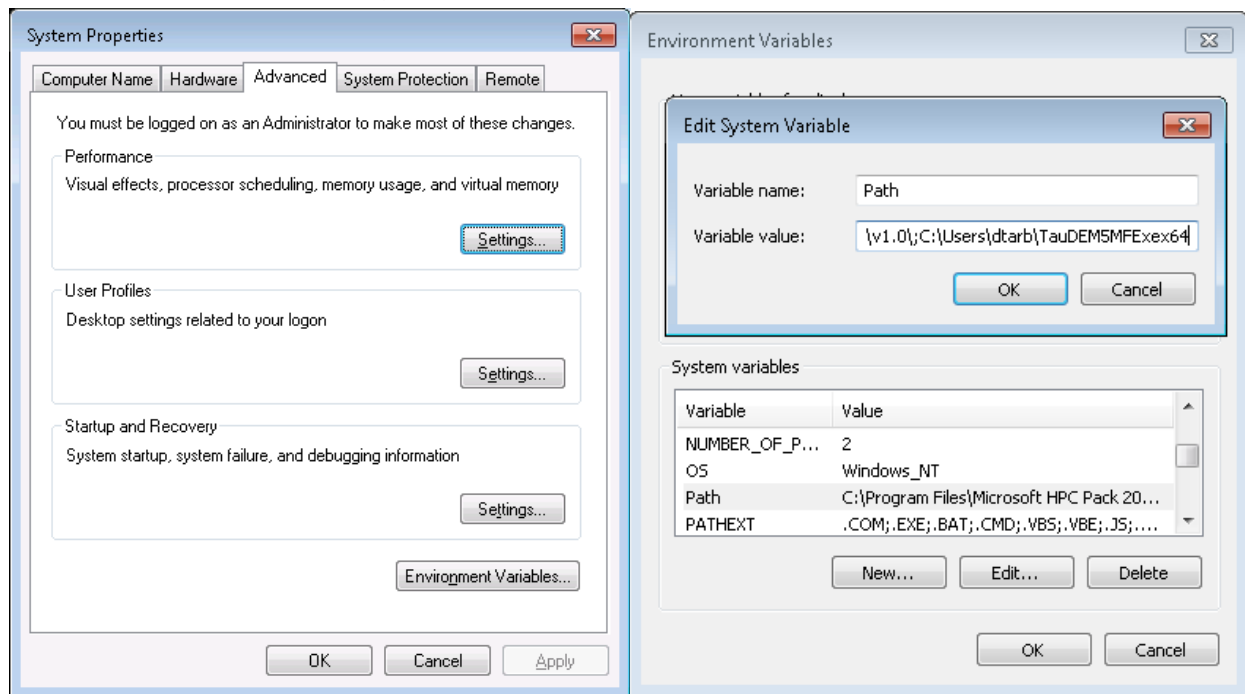
- Download TauDEM 5.2 Command Line Executable files for your platform (here TauDEM5MFExex64.zip)
- Download TauDEM zip file for customized installation TauDEM511.zip or more recent equivalent. This contains the necessary MPI and runtime libraries for TauDEM. It also contains the single file version of TauDEM, which will not be used here.

- Unzip TauDEM zip. The contents are:



- From the zipfile install the following
 - Visual Studio 2010 C++ runtime libraries vcredist_x86_2010.exe
 - Visual Studio 2010 C++ runtime libraries vcredist_x64_2010.exe if a 64 bit platform
 - Microsoft HPC Pack 2012 MS-MPI from mpi_x64.msi or mpi_x86.msi depending on your platform.
- Unzip the TauDEM 5.2 Command Line Executable files for your platform (here TauDEM5MFExex64.zip) and put them in a convenient location.

- Add the folder, here " C:\Users\dtarb\TauDEM5MFEEx64" to the system PATH environment variable. (Right click Computer->Properties->Advanced System Settings->Advanced->Environment variables). This should be done as shown below:



Quick Start Examples

Download and unzip the Logan River Multifile example data from <http://hydrology.usu.edu/taudem/taudem5>. For these examples we assume these files have been unzipped into a folder C:\Users\dtarb\Scratch\LoganMF. The folder C:\Users\dtarb\Scratch\LoganMF should contain a folder Logan that contains 45 TIFF files that together comprise the Logan DEM. If you display these using GIS software you should see that they are tiled to cover the domain (In ArcGIS you should use calculate statistics on each so that the display scale is set properly).

Open a command prompt.

1. Execute the following command to change to the directory with the data

```
cd C:\Users\dtarb\Scratch\loganMF
```

2. Remove Pits

```
mpiexec -n 8 PitRemove logan
```

This produces the output folder loganfel that contains files comprising the DEM with pits removed. These will be named felr0c0.tif, felr0c1.tif etc. The fel part of the name is the TauDEM code for that

file and r0c0 refers to row 0 and column 0 of the multi-file tiling of the domain into 9 rows and 5 columns (45 files). This output needs to be viewed in a GIS grid viewer, e.g. ArcGIS or MapWindow. The first time a TauDEM function is run, you may get a firewall warning.



You may select Cancel as TauDEM does not require smpl to use the network. It is used to communicate between processes on the same computer.

3. Flow Directions

```
mpiexec -n 4 D8Flowdir -p loganp -sd8 logansd8 -fel loganfel -mf 1 1
mpiexec -n 4 DinfFlowdir -ang loganang -slp loganslp -fel loganfel -
mf 1 1
```

These produce the output folders loganp, logansd8, loganang and loganslp that respectively contain D8 flow directions, D8 slopes, D-Infinity flow angles and D-Infinity slopes.

Note that in this case each of these folders only contains four files. This is because the `-mf` option was used. This specifies the number of rows and columns in the domain tiling to be used per processor. This option directs the programs not to have files overlapping processor boundaries on output and is useful when multiple processors on a cluster are writing to local disks. Assembly of the files created in this way into a single folder again results in a grid of tiles that cover the domain. Note that the files are named sd8p0r0co.tif for example, the sd8 being the TauDEM code, p0 referring to the processor that wrote it, and r0, c0 the row and column in the tiling from that processor. The two arguments that follow the `-mf` directive specify the number of rows and

columns to output for each processor. Single TIFF files cannot be larger than 4GB, so when processing very large domains the number of processors, and rows and columns for each processor should be coordinated so that no one file exceeds the 4GB limit.

4. Contributing area

```
mpiexec -n 2 AreaD8 -p loganp -ad8 loganad8 -mf 2 2
mpiexec -n 2 AreaDinf -ang loganang -sca logansca -mf 2 2
mpiexec -n 2 Aread8 -p loganp -o loganoutlet.shp -ad8 loganad8o -mf
2 2
```

The first two of these produce the outputs loganad8 and logansca that respectively contain D8 and D-Infinity contributing area. The last command produces the folder loganad8o that holds D8 contributing area evaluated upslope of outlets in the loganoutlet.shp shapefile.

Note that here, since the -mf 2 2 directive was used each processor output 2 rows and 2 columns of files, resulting in a total of 8 files in each folder, since there are 2 processors specified.

5. Gridnet

```
mpiexec -n 8 Gridnet -p loganp -plen loganplen -tlen logantlen -gord
logangord
```

This produces the output folders loganplen, logantlen and logangord, containing respectively (1) the longest flow path along D8 flow directions to each grid cell, (2) the total length of all flow paths that end at each grid cell, and (3) the grid network order. This is obtained by applying the Strahler stream ordering system to the network defined starting at each grid cell.

6. PeukerDouglas

```
mpiexec -n 8 PeukerDouglas -fel loganfel -ss loganss
```

This produces a skeleton of a stream network derived entirely from a local filter applied to the topography.

7. PeukerDouglas stream delineation

```
mpiexec -n 8 Aread8 -p loganp -o loganoutlet.shp -ad8 loganssa -wg
loganss
mpiexec -n 8 Dropanalysis -p loganp -fel loganfel -ad8 loganad8 -ssa
loganssa -drp logandrp.txt -o loganoutlet.shp -par 5 500 10 0
mpiexec -n 8 Threshold -ssa loganssa -src logansrc -thresh 300
```

These three commands evaluate the weighted contributing area of the PeukerDouglas stream network skeleton, then use stream drop analysis to apply a range of thresholds to this weighted contributing area grids to identify the smallest threshold for which the mean stream drop of first order streams is not significantly different from the mean stream drop of higher order streams. This is the constant drop law (Broscoe, 1959), and TauDEM uses it here to identify the highest resolution

stream network that complies with this law as an objective way of identifying the stream delineation threshold. The output results include a table (logandrp.txt) that reports the stream drop statistics for each threshold examined.

Threshold	Drain Den	No First Ord	No High Ord	Mean D First Ord	Mean D High Ord	Std Dev First Ord	Std Dev High Ord	T
5	2.46E-03	2256	688	66.5	125.0	76.2	131.9	-14.56
8	1.85E-03	1165	351	85.6	145.4	97.8	142.4	-8.94
14	1.54E-03	774	239	96.6	159.9	103.3	151.4	-7.35
23	1.23E-03	452	141	115.0	182.0	109.7	158.8	-5.64
39	9.99E-04	294	96	116.6	211.5	107.4	166.9	-6.48
65	7.90E-04	188	70	116.7	209.4	123.8	156.1	-4.97
108	6.35E-04	109	38	154.0	239.1	144.1	162.6	-3.03
180	5.24E-04	75	19	187.2	269.4	158.2	157.0	-2.03
300	4.12E-04	50	14	197.5	255.4	137.7	168.1	-1.32
500	3.04E-04	30	4	214.5	289.5	153.1	136.0	-0.93

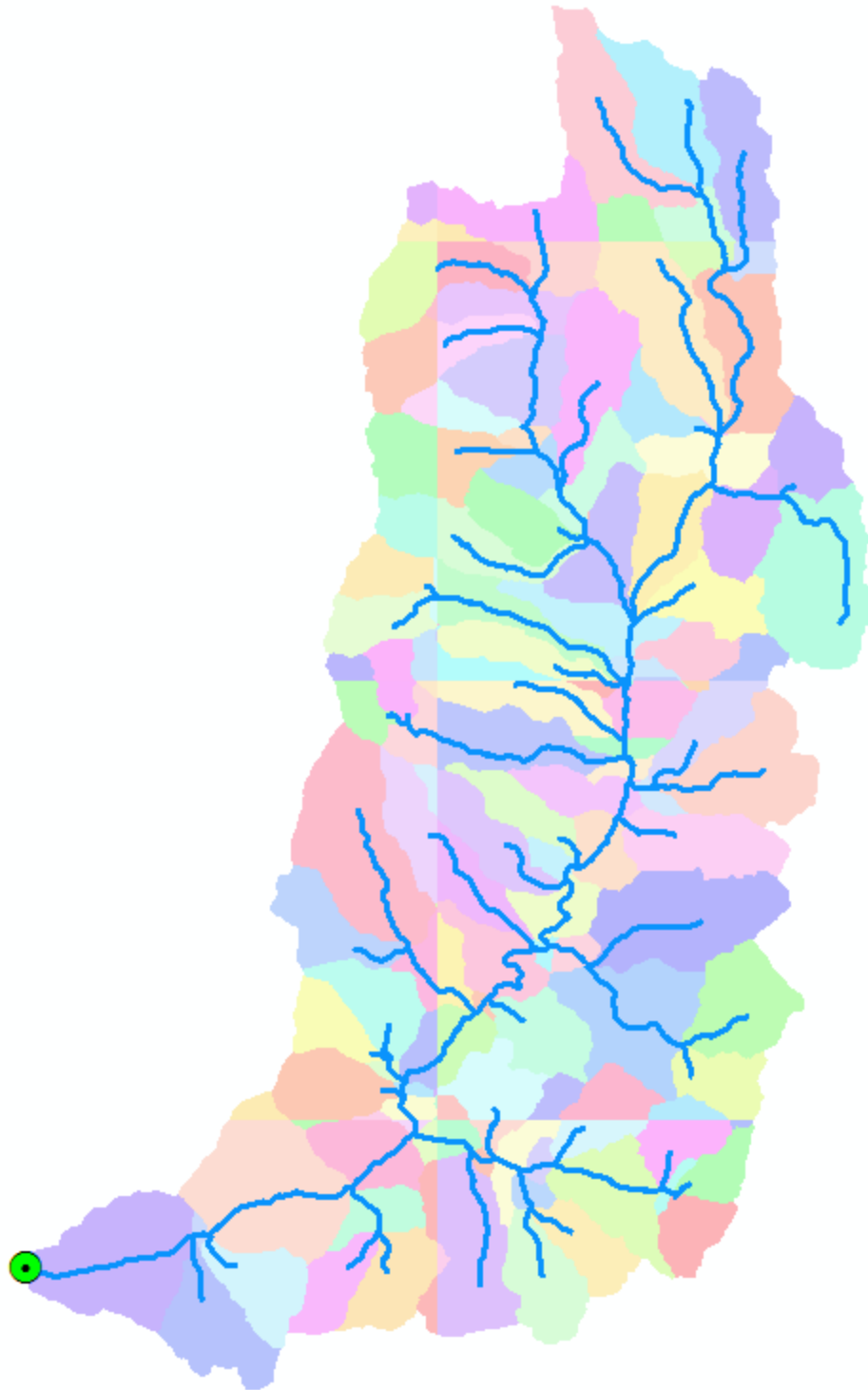
The last column of this gives T statistics for the differences of first and higher order streams. Using a threshold of $|2|$ as indicating significance in this T test the threshold of 300 is chosen in this case as the objective stream delineation threshold. This was used in the last command to output the logansrc stream raster grids

8. Stream Network

```
mpiexec -n 8 Streamnet -fel loganfel -p loganp -ad8 loganad8 -src
logansrc -ord loganord3 -tree logantree.dat -coord logancoord.dat
-net logannet.shp -w loganw -o loganoutlet.shp
```

- This produces a number of outputs illustrated below. These include a shapefile of the stream network and subwatersheds draining to each link of the stream network shapefile. This is one a key output from TauDEM. Each link in the stream network has a unique identifier that is linked to downstream and upstream links. Each subwatershed also has a unique identifier that allows it to be cross-referenced to the stream network link that it drains to. This information enables construction of a subwatershed based distributed hydrologic model with flow from subwatersheds being connected to, accumulated in, and routed along the appropriate stream reaches.

Note in the output illustrated below that the tiling due to the presence of multiple files is evident in the color symbolization. This is because the colors assigned to each file were random and not consistent across files. However the underlying grid values are consistent across the files to support the cross referencing mentioned above.



These examples have illustrated the use of key TauDEM multi-file command line functions to delineate watersheds. A summary of TauDEM command line functions with brief descriptions of their functionality is given below. Refer also to the TauDEM ArcGIS toolbox CHM help which provides more comprehensive information on what each function does and the full command line input specifications below.

	Function	Description
1. Basic Grid Analysis Functions		
	PitRemove	Pits are grid cells surrounded by higher terrain. A hydrologically correct DEM has no pits so that a drainage path can be defined from each grid cell to the edge of the domain. PitRemove takes as input elevation data grids and outputs hydrologically correct elevation grids with pits filled, using the flooding algorithm.
	D8FlowDir	Takes as input the hydrologically correct elevation grids and outputs D8 flow direction and slope for each grid cell. In flat areas flow directions are assigned away from higher ground and towards lower ground.
	DinfFlowDir	Assigns a flow direction based on steepest slope on a triangular facet following the D_{∞} model. This is recorded as an angle in radians anti-clockwise from east.
	AreaD8	Takes as input a D8 flow direction grids and outputs the contributing area as the number of grid cells draining through each grid cell. (Optionally accumulates input weight grids)
	AreaDinf	Takes as input D_{∞} flow direction grids and outputs the specific catchment area(s). Specific catchment area is defined as contributing area per unit contour length. (Optionally accumulates input weight grids)
	GridNet	Takes as input a D8 flow directions files and outputs three grid files: <ul style="list-style-type: none"> - plen contains the path length from the furthest cell that drains to each cell. - tlen contains the total length of all paths draining to each cell. - gord contains the Strahler order associated with that cell for a flow network defined using the D8 flow directions and including each grid cell.
2. Stream Network Functions		
	PeukerDouglas	Takes as input elevation grids and outputs an indicator (1,0) grid of candidate stream cells according to the Peuker and Douglas algorithm.
	Threshold	Takes as any grid and outputs an indicator (1,0) grid of grid cells that have values \geq the input threshold. This is used to delineate stream networks from contributing area and similar grids.
	D8FlowPathExtremeUp	Evaluates the extreme (either maximum or minimum) upslope value from input grids based on the D8 flow directions. Used in some stream delineation methods.
	SlopeArea	Evaluates $S^m a^n$ based on slope and specific catchment area grid inputs, and parameters m and n. Uses with slope-area stream delineation.

	LengthArea	Evaluates $A \geq M \cdot L_y$ and outputs an indicator (1,0) grid based on upslope path length and D8 contributing area grid inputs, and parameters M and y. Used with length-area stream delineation.
	DropAnalysis	Applies a series of thresholds and outputs a table of stream statistics used in objectively selecting the stream delineation threshold.
	StreamNet	Produces a vector network (shapefile) from stream raster grids. Outputs grids of subwatersheds draining to each stream network link
	MoveOutletsToStreams	Adjusts the position of outlets by moving them downslope along D8 flow directions until they reach a stream.
3. Specialized grid analysis functions		
	SlopeAreaRatio	Calculates ratio S/A where S is slope and A contributing area
	D8HDistToStrm	Calculates horizontal distance to stream along D8 flow directions
	DinfUpDependence	Calculates upslope dependence
	DinfDecayAccum	Calculates decay limited accumulation
	DinfConcLimAccum	Calculates concentration limited accumulation
	DinfTransLimAccum	Calculates transport limited accumulation
	DinfRevAccum	Calculates reverse accumulation
	DinfDistDown	Calculates distance downslope to a target zone (typically stream) using Dinf flow directions. Options include vertical, horizontal, along slope and pythagorus distances , computed using minimum, maximum, or flow weighted averaging along multiple Dinf flow paths.
	DinfDistUp	Calculates distance upslope to a ridge (grid cell with no inflow) using Dinf flow directions. Options include vertical, horizontal, along slope and pythagorus distances , computed using minimum, maximum, or flow weighted averaging along multiple Dinf flow paths.
	DinfAvalanche	Calculates avalanche runout zone and distance to avalanche source in avalanche runout zone
	SlopeAveDown	Calculates slope averaged over specified distance down D8 flow directions

Supported File Formats

TauDEM version 5 has been developed to read and write grid files in the GeoTiff (.tif) format only. It is up to users to convert their input files to this format before using TauDEM. ArcGIS as well as GDAL_Translate (http://www.gdal.org/gdal_translate.html) are options for producing GeoTiff files that TauDEM can read. In addition, TauDEM reads and writes ESRI shape files (multiple files with extensions .shp, .dbf, .shx etc.) for outlet points and stream networks and text files generally identified using the .dat extension.

TauDEM Codes

TauDEM works with numerous input and output file types, each of which contains data that needs to be interpreted differently. To manage this, a set of character TauDEM codes has been developed. The TauDEM codes are used both as suffixes in TauDEM's default file names and as flags in the syntax of the command line functions.

Naming Convention

In TauDEM's default naming convention, the name of the base digital elevation model is used as the base folder name for the default folder names of all of the different files generated based on that DEM. Many of the TauDEM codes are used as suffixes, where they are combined with the base folder name, followed by the extension, to identify each of the various file types used by TauDEM. For example, if "sss" is the TauDEM code for a particular type of file, and "dem" is the folder for base elevation grids, then the default folder name for grids of that type would be "demsss", the default file name of a shapefile would be "demsss.shp", and the default file name of a text file would be "demsss.dat".

Command Line Flags

TauDEM codes are also used as flags in the command line syntax to indicate the parameter being supplied to the function. When these codes are used as flags in the TauDEM command line syntax, they are preceded by a hyphen "-" followed by the parameter. For example, the suffix for the pit filled elevation folders is *fel* while its corresponding command line flag is *-fel*.

For the most part, the suffix codes and the flag codes are the same for each type of data file, but there are a few exceptions. **Table 1** lists the TauDEM codes used for grid data in TauDEM. The initial elevation folder does not have a suffix, however the code "z" is used on the command line as flag. **Table 2** lists the TauDEM codes used for shapefile and text data. Table 3 lists the non-file related TauDEM code flags.

Table 1 TauDEM codes for grids, their descriptions and input and output functions

Code	Description	Function Input	Function Output
ad8	D8 contributing area grid (area measured as number of grid cells)	Threshold, DropAnalysis, LengthArea, StreamNet	AreaD8
ang	D-infinity flow direction grid (flow direction grid measured in radians, counter clockwise from east)	AreaDinf, DinfUpDependence, DinfDecayAccum, DinfConcLimAccum, DinfTransLimAccum, DinfRevAccum, DinfDistDown, DinfDistUp, DinfAvalanche	DinfFlowDir
ass	avalanche source site grid, a required input for D-infinity avalanche runoff	DinfAvalanche	

Code	Description	Function Input	Function Output
cs	Concentration in supply grid, a grid giving the concentration of a compound of interest in the supply to the transport limited accumulation function	DinfTransLimAccum	
ctpt	Concentration grid, a grid giving the concentration of a compound of interest		DinfConcLimAccum, DinfTransLimAccum
dd	D-infinity distance to stream which can be average, minimum or maximum of horizontal, vertical, surface or Pythagoras distances to the stream.		DinfDistDown
dep	Upslope dependence grid, a grid giving at each grid cell the fraction of flow that contributes to any part of the target disturbance grid		DinfUpDependence
dfs	Distance from source grid		DinfAvalanche
dg	Disturbance indicator grid, an indicator grid that marks the target domain for various functions	DinfUpDependence, DinfConcLimAccum	
dist	D8 distance to stream grid		D8HDistDown
dm	Decay multiplier grid, a grid giving the factor by which flow leaving each grid cell is multiplied before accumulation on downslope grid cells. This may be used to simulate the movement of an attenuating substance.	DinfDecayAccum, DinfConcLimAccum	
dmax	Maximum downslope grid, a grid giving the maximum of the weight loading grid downslope from each grid cell		DinfRevAccum

Code	Description	Function Input	Function Output
dsca	Decayed specific catchment area grid (specific catchment area calculated by accumulating area but using the decay multipliers)		DinfDecayAccum
du	D-infinity distance to ridge which can be average, minimum or maximum of horizontal, vertical, surface or Pythagoras distances to the ridge.		DinfDistUp
fel	Hydrologically correct elevation grid with pits removed either by filling or carving	D8FlowDir, DinfFlowDir, StreamRaster, DropAnalysis, StreamNet, DinfDistUp, DinfDistDown, PeukerDouglas, DinfAvalanche	PitRemove
gord	Stahler network order grid (Strahler order for grid network defined from D8 flow directions)	Threshold, DropAnalysis	Gridnet
ord	Network order grid, a grid giving the Strahler stream order for each delineated stream grid cell		StreamNet
p	D8 flow direction grid obtained from the D8 flow direction function	AreaD8, D8HDistToStrm, D8FlowPathExtremeUp, PeukerDouglas, DropAnalysis, StreamNet,, Gridnet, SlopeAveDown	D8FlowDir
plen	Longest upslope length grid, a grid that gives the length of the longest upslope flow path terminating at each grid cell	Threshold, DropAnalysis, LengthArea	Gridnet
q	Specific discharge of the flow carrying the constituent being loaded at the concentration threshold specified	DinfConcLimAccum	

Code	Description	Function Input	Function Output
racc	Reverse accumulation grid, a grid giving the result of the "Reverse Accumulation" function		DinfRevAccum
rz	Runout zone grid, a runout zone indicator grid with value 0 to indicate that this grid cell is not in the runout zone and value > 0 to indicate that this grid cell is in the runout zone.		DinfAvalanche
sa	Slope-Area function output grid containing slope and area combined using $S^m A^n$	D8FlowPathExtremeUp	SlopeArea
sar	Slope/Area ratio grid used to evaluate wetness index		SlopeAreaRatio
sca	D-infinity contributing area grid (units in specific catchment area, i.e. area per unit contour width, using grid cell as the unit width and grid cell size squared as grid cell area)	SlopeAreaRatio, SlopeArea, Threshold, StreamNet	AreaDinf
sd8	D8 slope grid (slope measured as drop/distance)		D8FlowDir
slp	D-infinity slope grid	SlopeAreaRatio, SlopeArea, DinfDistDown, DinfDistUp	DinfFlowDir
slpd	D8 averaged slope distance grid, a grid of slope averaged over downslope distance		SlopeAveDown
src	Computed stream raster grid, a grid indicating streams, grid cell value 1 on streams and 0 off streams	DinfDistDown, DropAnalysis, D8HDistDown, StreamNet	Threshold

Code	Description	Function Input	Function Output
ss	A stream source grid derived through application of a function to identify potential stream sources to a set of inputs. Values should be 0 on non potential stream sources and >0, with a value that has relevance to the method being used for potential stream sources.	AreaD8	PeuckerDouglas, LengthArea
ssa	An accumulated stream source grid derived from a ss grid and is suitable for drop analysis. This needs to have the property that it is monotonically increasing downslope along D8 flow directions. This may be from an accumulation or maximum upslope function.	Threshold, DropAnalysis	D8FlowPathExtreme Up, AreaD8
tc	Transport capacity grid, a grid giving the transport capacity at each grid cell for the transport limited accumulation function	DinfTransLimAccum	
tdep	Deposition grid, a grid giving the deposition resulting from the transport limited accumulation		DinfTransLimAccum
tla	Transport limited accumulation grid		DinfTransLimAccum
tlen	Total upslope length grid, a grid that gives the total length of upslope flow paths terminating at each grid cell		Gridnet
tsup	Transport supply grid, a grid giving the supply (loading) of material to a transport limited accumulation function	DinfTransLimAccum	

Code	Description	Function Input	Function Output
w	Watershed grid demarcating each reach watershed mapped using Streamnet function		Streamnet
wg	Flag used to show weight grid, with the name of the weight grid as argument.	AreaD8, AreaDinf, DinfDecayAccum, DinfConcLimAccum, DinfRevAccum, DinfDistDown, DinfDistUp	

The following codes are used as command line flags but not necessarily as file suffixes because they only pertain to files used for input

-mask	Flag used to show mask file, with the name of the mask file as argument.	Threshold, Gridnet	
-z	Flag used to show elevation data before pit filling, with the name of the elevation file as argument	PitRemove	

Table 2 TauDEM codes for shape and text files their descriptions and input and output functions

Code	File Description	Input to	Output From
coord	Network coordinates file		StreamNet
drp	Stream drop analysis table		DropAnalysis
net	Stream network shapefile giving the links in a stream network		StreamNet
-o	Flag used to show outlets shapefile, with the name of name of the outlet shape file as argument.	AreaD8, AreaDinf, GridNet, StreamNet, DinfDecayAccum, DinfConcLimAccum, MoveOutletsToStreams	
-om	Flag used to show moved outlets shapefile name as argument.		MoveOutletsToStreams
tree	Stream Network tree text file		StreamNet

Table 3 Non-file TauDEM codes and their descriptions

Flags	Description	Arguments
-alpha	Flag for user selected input angle threshold used in avalanche runout function	Angle (degrees)
-csol	Solubility threshold in concentration limited accumulation function	Numeric value indicating substance solubility threshold
-direct	Flag to indicate direct rather than path distance to be used in avalanche runout function	No argument
-dn	Flag for user selected distance input in SlopeAveDown function	Downslope distance (in horizontal linear units of the DEM grid)
-m	Flag used as method indicator for computing horizontal, vertical, surface or Pythagoras distances to ridge and stream.	Two arguments are used with this flag: (1) The method type (horizontal as h, vertical as v, surface as s and Pythagoras as p); and (2) the method statistic (average as ave, minimum as min, and maximum as max). The default is h ave. (e.g. -m v ave)
-md	Flag used to indicate the maximum distance (in number of grid cells traversed) to move an outlet in the MoveOutletsToStreams function	Integer numeric value indicating the maximum number of grid cells to traverse when moving outlets
-mf	Flag used to indicate process specific multi-file output	Two integer numeric values specifying the number of rows and columns of files to be output from each processor
-nc	Flag for not checking edge contamination. The default is to check edge contamination.	No argument
-par	Flag to indicate that method parameters follow on the command line input.	Numerical method parameters, with method dependent interpretation and number
-sw	Flag used to indicate delineate single watershed only. Without the flag the default is to delineate multiple watersheds.	No argument
-thresh	Flag used to show threshold	Threshold value (number)

Command Line Interface Design Conventions

Command line interfaces may specify only the base name which is the name of the initial elevation file, for example dem, in which case the program will add the necessary suffixes for the folders it needs, or may specify the specific input and output files using the codes in tables 1 & 2 as command line flags. Specific command line interfaces conventions for each program are given in the following sections. The

function names are in italics; the required parameters are in normal font; the optional parameters are in normal font but in brackets []; outputs are underlined, and the flags and suffixes are in bold italics.

TauDEM Command Line Functions

Basic Grid Analysis Functions

PitRemove

This function takes as input an elevation data grid and outputs a hydrologically correct elevation grid file with pits filled, using the flooding algorithm.

Command line interfaces

Simple:

PitRemove dem (The output folder name is taken as demfel)

Specific folder names used:

PitRemove -z dem ***-fel*** demfel

demfile → input elevation grids

fel file → output elevations with pits filled

D8FlowDir

This function takes as input the hydrologically correct elevation grid and outputs D8 flow direction and slope for each grid cell. In flat areas flow directions are assigned away from higher ground and towards lower ground using the method of Garbrecht and Martz (Garbrecht and Martz, 1997).

Command line interfaces

Simple:

D8FlowDir dem (The flow direction and slope outputs are taken as demp and demsd8.tif)

Specific folder names used:

D8FlowDir -fel demfel ***-p*** demp ***-sd8*** demsd8

demfile → Pit filled elevation input folder

pointfile → D8 flow directions output folder

slopefile → D8 slopes output folder

DinfFlowDir

This function assigns a flow direction based on steepest slope on a triangular facet. This is recorded as an angle in radians anti-clockwise from east. In flat areas the D8 flow directions are converted to angles and used.

Command line interfaces

Simple:

DinfFlowDir dem (The flow direction and slope outputs are taken as demang and demslp)

Specific folder names used:

DinfFlowDir -fel demfel ***-ang*** demang ***-slp*** demslp

demfile → Pit filled elevation input datasets

angfile → Dinf flow directions output datasets

slopefile → Dinf slopes output files

AreaD8

This function takes as input a D8 flow directions file and outputs the contributing area. The result is the number of grid cells draining through each grid cell. The optional command line argument for the outlet shapefile results in only the area contributing to outlet points in the shapefile being calculated. The

optional weight grid input results in the output being the accumulation (sum) of the weights from upstream grid cells draining through each grid cell. By default the program checks for edge contamination. The edge contamination checking may be overridden with the optional command line argument -nc.

Command line interfaces

Simple:

AreaD8 dem (assume no outlets, no weight grid)

Specific file and folder names used:

AreaD8 -p demp.tif *-ad8* demad8 [-o outletfile.shp] [-wg demwg] [-nc]

pfile → input flow directions grids

ad8file → output contributing area grids

wgfile → input weight grid files

Outletfile → input outlets shapefile

AreaDinf

This function takes as input Dinf angle files and outputs the specific catchment area. Specific catchment area is defined as contributing area per unit contour length. Here the contour length is taken as the grid cell size. The result has length units the same as grid cell size. The optional command line argument for the outlet shapefile results in only the area contributing to outlet points in the shapefile being calculated. The optional weight grid input results in the output being the accumulation (sum) of the weights from upstream grid cells draining through each grid cell. By default the program checks for edge contamination. The edge contamination checking may be overridden with the optional command line argument -nc.

Command line interfaces

Simple:

AreaDinf dem (assume no outlets, without weight grid)

Specific file and folder names used:

AreaDinf -ang demang *-sca* demsca [-o outletfile.shp] [-wg demwg] [-nc]

scafile → Dinf contributing areas output files

angfile → Dinf angles input files

outletfile → Shapefile with outlet coordinates

wgfile → an optional weight file for area computations

Gridnet

This function takes as input a D8 flow directions file and outputs three grid files:

- plen → Each grid cell contains the path length from the furthest cell that drains to each cell.
- tlen → Each grid cell contains the total length of all paths draining to each cell.
- gord → Each grid cell contains the Strahler order associated with that cell for a flow network defined using the D8 flow directions and including each grid cell.

Strahler order is defined as follows. Cells that don't have any other grid cells draining in to them are order 1. For grid cells that have other cells draining into them the order of inflowing cells is used to determine the order, according to Strahler ordering rules. Because more than two flow paths may join at any grid cell, these are extended as follows. The order of inflowing grid cells is ranked from largest to smallest. Where there is one highest rank inflowing grid cell, the order is taken as the order of that inflowing grid cell. Where there are two or more inflowing grid cells with order equal to the order of the highest rank inflowing grid cell, then the order is taken as one plus the order of the highest rank inflowing grid cell. The optional mask file and threshold input results in lengths and order being

computed using only the domain defined by the mask grid greater than or equal to the threshold. The optional outlet shapefile input gives results only for the area contributing to the outlet points. [This function does not at present support edge contamination. This could be added in the future, but at present if edge contamination is needed a mask using output from a function like AreaD8 that does support edge contamination can be used.]

Command line interfaces

Simple:

Gridnet dem (assume no outlets, default folder suffixes used, no mask and threshold used)

Specific file and folder names used:

Gridnet **-p** demp **-plen** demplen **-tlen** demtlen **-gord** demgord [-o outletsfile.shp] [-mask demmask **-thresh** 100]

pfile → D8 flow directions input files

plenfile → grid of longest flow length upstream of each point output file

tlenfile → grid of total path length upstream of each point output file

gordfile → grid of strahler order output file

maskfile → mask file

outletsfile → Shapefile with outlet coordinates

thresh → the mask threshold used in >= test

Stream Delineation Functions

PeukerDouglas

This function operates on an elevation grid and outputs an indicator (1,0) grid of upward curved grid cells according to the Peuker and Douglas algorithm. This is to be based on code in [tardemlib.cpp/source](#).

Command line interfaces

Simple:

PeukerDouglas dem (default folder suffixes automatically appended and default parameters 0.4, 0.1, 0.05 used)

Specific folder names used:

PeukerDouglas **-fel** demfel **-ss** demss **-par** 0.4 0.1 0.05

felfile → Folder location for float grids of elevations (input)

ssfile → Folder location for short indicator grids of upward curved grid cells, by Peuker and Douglas

par → float array of parameters used to smooth DEM, p[0] being center weight, p[1] side weight, p[2] being diagonal weight.

Threshold

This function operates on any grid and outputs an indicator (1,0) grid of grid cells that have values >= the input threshold. The standard use is to threshold an accumulated source area grid to determine a stream raster. There is an option to include a mask input to replicate the functionality for using the sca file as an edge contamination mask. The threshold logic should be

$$\text{src} = ((\text{ssa} \geq \text{thresh}) \ \& \ (\text{mask} \geq 0)) \ ? \ 1:0$$

Command line interfaces

Simple:

Threshold dem (default folder suffixes automatically appended and threshold 100.0 used)

Specific folder names used:

Threshold **-ssa** demssa **-src** demsrc **-thresh** 100.0 [-mask demmask]

ssafile → Folder name for grids to be thresholded.

srcfile → Folder names for stream raster grid.

maskfile → Folder names for grid used to mask the output stream raster, or general thresholded grids.
thresh → Threshold parameter.
usemask → Flag to indicate whether maskfile has been input and is to be used (1 yes, 0 no)

D8FlowPathExtremeUp

This is a function that evaluates the extreme (either maximum or minimum) upslope value from an input grid based on the D8 flow directions. This is intended for use in stream raster generation to identify a threshold of slope x area product that results in an optimum (according to drop analysis) stream network. If an outlets shapefile is provided the function outputs results for the area upslope of the outlets.

Command line interfaces

Simple:

D8FlowPathExtremeUp dem (default file suffixes automatically appended and maximum used, no outlets, edge contamination checking)

Specific file and folder names used:

D8FlowPathExtremeUp -p demp *-sa* demsa *-ssa* demssa *[-min]* *[-nc]* *[-o* outlets.shp]

The default is maximum, that is switched to minimum if *-min* is specified.

pfile → File name for D8 flow direction grid (input)

safile → File name for slopearea file (input).

ssafile → File name for output grid with extreme upslope value

outletfile → File name for outlets shapefile (optional input)

SlopeArea

This is a function that evaluates $S^m a^n$ based on slope and specific catchment area grid inputs, and parameters m and n. This is intended for use with the slope-area stream raster delineation method.

Command line interfaces

Simple:

SlopeArea dem. (default file suffixes automatically appended and m=2, n=1 defaults used)

Specific folder names used:

SlopeArea -slp demslp *-sca* demsca *-sa* demsa *[-par 2 1]*

The default parameter values of 2 and 1 are assumed unless *-par* is specified.

slopefile → Folder name for slope grids (generally from DinfFlowDir) (input)

scafile → Folder name for contributing area files (generally from AreaDinf) (input).

safile → Folder name for output grids with $S^m A^n$. Float. (output)

par → Array of input parameters with p[0] being the slope exponent and p[1] being the area exponent

LengthArea

This is a function that evaluates $A \geq M L^y$? 1:0 based on upslope path length and D8 contributing area grid inputs, and parameters M and y. This is intended for use with the length-area stream raster delineation method.

Command line interfaces

Simple:

LengthArea dem (default file suffixes automatically appended and M=0.03, y=1.3 defaults used)

Specific folder names used:

LengthArea -plen demplen *-ad8* demad8 *-ss* demss *[-par 0.03 1.3]*

The default parameter values of 0.03 and 1.3 are assumed unless *-par* is specified.

plenfile → Folder location for longest upslope path grids (generally from Gridnet) (input)

ad8file → Folder location for contributing area files (generally from AreaD8) (input).
ssfile → File name for indicator (1,0) output grid with $A \geq M L^y$. Short. (output)
par → Array of input parameters with p[0] being M coefficient and p[1] being the y exponent on length

DropAnalysis

This function to be based on code in tardemlib.cpp/dropan. Applies a series of thresholds (determined from the input parameters) to the input ssa grid and outputs in the drp.txt file the stream drop statistics table.

Command line interfaces.

No simple interface because we do not have a default outlets shapefile name, and an outlets shapefile is required.

Specific file and folder names used:

DropAnalysis -ad8 demad8 -p dem -fel demfel -ssa demssa -o outlets.shp -drp demdrp.txt [-par 5 500 10 0]

The default parameter values of min=5, max=500, nthresh=10, steptype=0 are assumed unless **-par** is specified.

ad8file → Folder location for D8 contributing area grids 'ad8'

pfile → Folder location for D8 flow direction grids 'p'

fel file → Folder location for hydrologically correct elevation grids 'fel'

ssfile → Folder location for an accumulated stream source grids suitable for drop analysis. These need to have the property that it is monotonically increasing downslope along D8 flow directions.

dropfile → File name where stream drop analysis output is to be written as txt

outletfile → File name of outlets shape file (input). Note that unlike some other functions, for this function the outletfile is required.

par → Array of parameters consisting of:

- threshmin → Minimum value of threshold to be used in drop analysis
- threshmax → Maximum value of threshold to be used in drop analysis
- nthresh → Number of drop thresholds to be used in drop analysis
- steptype → Type of threshold step to be used in drop analysis (0 = log, 1=arithmetic)

StreamNet

This function produces a vector network from the Stream Raster grid by tracing down from each source grid cell. The network topological connectivity is stored in the output Stream Network Tree file, (suffix *tree.dat) and coordinates and attributes from each grid cell along the network are stored in the output Stream Network Coordinates file (suffix *coord.dat). A Strahler stream order grid is also produced as output. When an outlet shapefile is given, results are limited to the domain upslope of these outlets. Furthermore, internal "outlets", defined as points that have other outlets downstream of them are used to segment stream links. This function is also used to write a stream network shapefile and define subwatersheds draining to each link (stream segment) in a channel network. Output is a stream network shapefile (suffix 'net') and subwatershed grid (suffix 'w') that has a separate value for each subwatershed. The optional flag **-sw** is used to indicate that a single watershed, rather than separate subwatershed draining to each stream segment is to be delineated.

Command line interfaces

Simple:

StreamNet dem (assume no outlets)

Specific file and folder names used:

StreamNet -fel demfel -p demp -ad8 demad8 -src demsrc -ord demord -tree demtree.dat -coord demcoord.dat -net demnet.shp -w demw [-o outletfile.shp] [-sw]

pfile → Input D8 flow directions folder 'p'
 srcfile → Input stream raster folder 'src'
 ordfile → Output folder of channel network Strahler order 'ord'
 ad8file → Input folder with D8 contributing area 'ad8'
 felfile → Input pit filled elevation data folder 'fel'
 treefile → Output textfile with list of links in channel network tree
 coordfile → Output textfile with list of coordinates in channel network tree
 outletshapefile → Input shapefile with outlet locations. This must contain a field named "id" that is used to identify the links upstream of outlet points
 wfile → Output folder of watershed identifiers 'w'
 demnetshp → Output shape file of resultant channel network '*.shp'

MoveOutletsToStreams

This function moves outlet point that are off a stream raster grid down D8 flow directions until a stream raster grid is encountered. Input is a flow direction grid, stream raster grid and outlets shapefile. Output is a new outlets shapefile where each point has been moved to coincide with the stream raster grid if possible. A field 'dist_moved' is added to the new outlets shapefile to indicate the changes made to each point. Points that are already on the stream raster (src) grid are not moved and their 'dist_moved' field is assigned a value 0. Points that are initially not on the stream raster grid are moved by sliding them along D8 flow directions until one of the following occurs:

- A stream raster grid cell is encountered before traversing the max_dist number of grid cells. The point is moved and 'dist_moved' field is assigned a value indicating how many grid cells the point was moved.
- More than the max_number of grid cells are traversed, or the traversal ends up going out of the domain (encountering a no data D8 flow direction value). The point is not moved and the 'dist_moved' field is assigned a value of -1.

Command line interfaces

No simple interface because we have no outlet shape file default suffixes.

Specific file and folder names used:

MoveOutletsToStreams -p dem -src demsrc -o outlets.shp -om outletsmoved.shp [-md 50]

Note that if the -md flag and max_dist parameter is not given, the default of 50 is used.

pfile → Folder location for D8 flow direction grids (input)

srcfile → Folder location for stream raster grids (input)

maxdist → maximum number of grid cells to traverse in moving outlet points (input)

outletshapefile → File name for outlets shapefile (input)

movedoutletshapefile → File name for new shapefile where outlets have been moved

Specialized Grid Analysis Functions

SlopeAreaRatio

This function is used to calculate the ratio of slope to specific catchment area. Algebraically, it is related to the more common $\ln(a/\tan \beta)$ wetness index, but contributing area is in the denominator to avoid divide by 0 errors when slope is 0.

Command line interfaces

Simple:

SlopeAreaRatio dem (default folder suffixes used)

Specific folder names used:

SlopeAreaRatio -slp demslp -sca demsca -sar demsar

slopefile → input slope files

areafile → input specific catchment area files
sarfile → output slope area ratio files

D8HDistToStrm

This function computes the distance from each grid cell moving downstream until a stream grid cell as defined by the Stream Raster grid is encountered. The optional threshold input is to specify a threshold to be applied to the Stream Raster grids (src). Stream grid cells are defined as having src value \geq the threshold, or ≥ 1 if a threshold is not specified.

Command line interfaces

Simple:

D8HDistToStrm dem (default file suffixes used, without threshold)

Specific folder names used:

D8HDistToStrm -p dem *-src* demsrc *-dist* demdist [*-thresh* 50]

pfile → D8 flow direction input files

srcfile → stream channel definition input files

distfile → distance to stream channel output files

thresh → integer value used to define channels in srcfile (a greater or equal to test is used)

DinfUpDependence

This function calculates the amount of flow a cell contributes to a subset of cells using the Dinf flow model.

Command line interfaces

Simple:

DinfUpDependence dem (default file suffixes used)

Specific folder names used:

DinfUpDependence -ang demang *-dg* demdg *-dep* demdep

angfile → Dinf flow direction input files

dgfile → disturbance grid input files

depfile → flow dependence output files

DinfDecayAccum

This function calculates the weighted Dinf flow accumulation at each grid cell, where the flow is subject to first order decay.

Command line interfaces

Simple:

DinfDecayAccum dem (default folder suffixes used; without outlet shapefile and weight grid)

Specific folder names used:

DinfDecayAccum -ang demang *-dm* demdm [*-o* outletfile.shp] [*-wg* demwg] *-dsca* demdsca [*-nc*]

angfile → Folder of Dinf flow direction input fs

adecfile → Output decayed specific catchment area folder

dmfile → Input decay multiplier grids (distance down grid)

wgfile → Input weight files

outletshapefile → Outlet shape file.

DinfConcLimAccum

This function applies to the situation where an unlimited supply of a substance is loaded into flow at a concentration or solubility threshold Csol over an area demarcated by the (0,1) indicator grid (**dg**) that identifies (value 1) the area of the substance supply. The specific discharge grid gives the overland flow

calculated apriori (e.g. using the AreaDinf function) into which the substance is loaded at a solubility threshold over the area of the indicator grid. The concentration in the flow leaving the disturbance area is Csol. This is then attenuated due to decay and dilution downslope.

Command line interfaces

Simple:

DinfConcLimAccum dem (assume no outlets, default folder suffixes and solubility threshold of 1.0 used)

Specific file and folder names used:

DinfConcLimAccum -ang demang *-dg* demdg *-dm* demdm *-cpt* demcpt *-q* demq *[-o* outletfile.shp] *[-csol 1]* *[-nc]*
angfile → Dinf flow direction input grids
cptfile → Output concentration grids.
dmfile → decay multiplier grids
wgfile → Specific discharge grids
dgfile → Input disturbance indicator grids.
csol → Concentration threshold
qfile → Specific discharge grids.
outletfile → Outlet shapefile.

DinfTransLimAccum

This function applies to the situation where there is a supply of substance (e.g. erosion) and capacity for transport of the substance (e.g. sediment transport capacity). This function accumulates the substance flux subject to the rule that the transport out of any grid cell is the minimum of the transport in to that grid cell and the transport capacity.

Command line interfaces

Simple:

DinfTransLimAccum dem (assume no outlets, no input concentration files, default folder suffixes used)

Specific file and folder names used:

DinfTransLimAccum -ang demang *-tsup* demtsup *-tc* demtc *[-cs* demcs *-cpt* demcpt] *-tla* demtla *-tdep* demtdep *[-o* outletfile.shp] *[-nc]*
angfile → Dinf flow direction input grids
tsupfile → Input transport supply grids
tcfile → Input transport capacity grids
tlafile → Output transport limited accumulation grids
depfile → Output deposition grids
csfile → Input concentration grids (optional)
cptfile → Output concentration grids (optional)
outletfile → Outlet shapefile.

DinfRevAccum

This works in a similar way to evaluation of weighted Contributing area (AreaDinf), except that the accumulation is by propagating the weight loadings upslope along the reverse of the flow directions to accumulate the quantity of weight loading downslope from each grid cell. The function also reports the maximum value of the weight loading downslope from each grid cell in the Maximum Downslope grid.

Command line interfaces

Simple:

DinfRevAccum dem.tif (default file suffixes used without threshold value)

Specific folder names used:

DinfRevAccum **-ang** demang **-wg** demwg **-racc** demracc **-dmax** demdmax
angfile → Input Dinf flow direction grids
wgfile → Input weight grids
raccfile → Output reverse accumulation grids
dmaxfile → Output maximum downslope grids

DinfDistDown

This function was developed to calculate distance to stream using multiple methods: horizontal, vertical, Pythagoras and surface, each distance with average, maximum and minimum options, using the Dinf flow model. The distance between grid cells is defined as either:

- horizontal. The horizontal distance between grid cells, h .
- vertical. The difference in elevation between grid cells, v
- surface. The along the surface difference in elevation between grid cells defined as $s = h * \sqrt{1 + \text{slope}^2}$

These are then accumulated downslope from each point to the stream as defined by the stream raster grid. Since the flow from each grid cell is proportioned between multiple downslope cells the following options are used in accumulating distance between a grid cell and the stream.

- Average (ave). Here the proportions of flow going from one grid cell to the next are used as weights for weighted averaging
- Minimum (min). Here the shortest distance over multiple flow paths is accumulated.
- Maximum (max). Here the longest distance over multiple flow paths is accumulated.

In addition, a Pythagoras distance from the point in question to the stream calculated as $p = \sqrt{hs^2 + vs^2}$ where hs is the horizontal distance to the stream and vs is the vertical distance to the stream is defined. Further there is the option to specify a weight grid as input. If this is specified, the distance between grid cells indicated above is multiplied by $(w + w_d)/2$, the average of the weight along the path from a grid cell to its downslope neighbor.

Command line interfaces

Simple:

DinfDistDown dem (default folder suffixes used, default method = ave h, and without weight grid)

Specific folder names used:

DinfDistDown **-ang** demang **-fel** demfel **-src** demsrc **[-wg** demwg] **-dd** demdd **[-m** ave h] **[-nc]**

Note that two parameters need to follow -m, the first from ave, min, max to indicate the method statistic, and the second from h, v, s, p to indicate the method type. The default method 'ave' and 'h' are used if method is not specified.

angfile → Input Dinf flow direction grids

fel file → Input pit filled elevation grids

wgfile → Input weight path grids

srcfile → Input stream raster grids

ddfile → Output distance down grids

method → Method to be used (Encoding is h = horizontal, v = vertical, p = Pythagoras, s = surface, ave = average, min = minimum, and max = maximum)

DinfDistUp

This function was developed to calculate distance to ridge using four methods: horizontal, vertical, Pythagoras and surface, each distance with average, maximum and minimum variations, using the Dinf flow model. Distances between cells are defined the same as for the DinfDistDown function. Grid cells

that have no flow contribution from upslope grid cells are defined to be ridge grid cell and this function reports the distance from ridge cells to each grid cell. There is no weighting option, unlike DinfDistUp. There is an option to input a threshold, which if specified considers only grid cells with proportion more than the specified threshold contributing to a grid cell as being upslope of a grid cell for the calculation of distances to the ridge.

Command line interfaces

Simple:

DinfDistUp dem (default folder suffixes used, default method = ave h, without threshold)

Specific folder names used:

DinfDistUp -ang demang *-fel* demfel *-du* demdu [*-m* ave h] [*-thresh* 0.5] [*-nc*]

Note that two parameters need to follow *-m*, the first from ave, min, max to indicate the method statistic, and the second from h, v, s, p to indicate the method type. The default method 'ave' and 'h' are used if method is not specified.

angfile → Input Dinf flow direction grids

fel file → Input pit filled elevation grids

wgfile → Input weight path grids

dufile → Output Dinf rise to ridge grids

method → Method to be used (Encoding is h = horizontal, v = vertical, p = Pythagoras, s = surface, ave = average, min = minimum, and max = maximum)

thresh → Used to consider only grid cells that contribute flow with a proportion greater than a user specified threshold.

DinfAvalanche

In this function, avalanche runout zones are computed from input avalanche source zones. The rule for identifying runout zones is that all locations downslope from a source zone are potentially affected up until the energy from the avalanche is depleted. This depletion point is estimated when the slope between the source and the affected area is less than a threshold angle (alpha). The alpha angle is calculated using the distance from the highest point in the source zone to points within the potential runout zone. Distance may be measured either along a straight line or along a flow path. This alpha-angle model is a simple model for avalanche or debris flow runout that is used in practice to evaluate potential hazards (e.g. Schaerer, 1981; McClung and Schaerer, 1993; Iverson, 1997; Toyos et al., 2007).

Command line interfaces

Simple:

DinfAvalanche dem (default folder suffixes used, default path=1, default threshold=0.2, and default angle=18)

Specific folder names used:

DinfAvalanche -ang demang *-fel* demfel *-ass* demass *-rz* demrz *-dfs* demdfs [*-thresh* 0.2] [*-alpha* 20] [*-direct*]

angfile → Input Dinf flow direction grids

fel file → Input pit filled elevation grids

assfile → Input avalanche source site grids

rzfile → Output avalanche runout zone grids. The values output are actually the alpha angles from the source zone to each grid cell. All will be greater than the input alpha threshold angle.

dfsfile → Output distance down (path distance) grids

thresh → Input proportion threshold

alpha → Input angle threshold

directh → Flag to indicate whether distance is measured along flow path (default) or as a straight line from source to grid cell (if direct is given). Distances are horizontal distances in both cases.

SlopeAveDown

This function computes slope in a D8 downslope direction averaged over a user selected distance.

Command line interfaces

Simple:

SlopeAveDown dem (default folder suffixes used, default downslope distance taken as 50)

Specific folder names used:

SlopeAveDown -p dem *-fel* demfel *-slpd* demslpd [*-dn* 50]

pfile → Input D8 flow direction grids

fel file → Input pit filled elevation grids

slpd file → Output D8 slope distance averaged grids

dn → User selected downslope distance

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