TauDEM 5.3

QUICK START GUIDE TO USING THE TAUDEM ARCGIS TOOLBOX

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QUICK START

Purpose

The purpose of this document is to introduce Hydrologic Terrain Analysis in ArcGIS using the TauDEM toolbox. This guide is not intended to be comprehensive in documenting the use and functionality of TauDEM. Rather it is intended as a brief introduction to guide a reader through the initial steps of installing TauDEM obtaining data and running some of the more important functions required to delineate a stream network. Comprehensive documentation on the use of each TauDEM function is given in the online help that is part of the program (that will be introduced in this quick start guide) and is online in the TauDEM website http://hydrology.usu.edu/taudem in the Documentation section.

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/.

In this guide, you will perform the following tasks:

- TauDEM Installation
- Basic Grid Analysis using TauDEM functions, including.
 - o Pit Remove
 - D8 Flow Directions
 - o D8 Contributing Area
 - o Grid Network
 - D-Infinity flow direction
 - D-infinity Contributing Area
- Stream Network Analysis using TauDEM functions, including
 - Stream Definition by threshold
 - Move Outlets to Streams
 - Stream Reach and Watershed
 - Peuker Douglas
 - Peuker Douglas Stream Definition
- Specialized Grid Analysis using TauDEM functions, including
 - D-Infinity Distance Down
 - D-Infinity Distance Up
- Basic Grid Analysis using TauDEM functions, for geographic coordinate data including.
 - o Pit Remove
 - D8 Flow Directions

The Cub River watershed draining to USGS streamflow gauge #100096000 located just north of Preston, Idaho is used as an example. The Eno River watershed located near Durham, North Carolina is also used as an example for the geographic coordinate data.

Computer Requirements

To complete this guide, you will need to use ArcGIS 10.0 or higher and TauDEM 5.3. TauDEM 5.3 has the following dependencies that are installed when you install TauDEM.

- GDAL Geospatial Data Abstraction Library from <u>http://www.gdal.org/</u>.
- Microsoft HPC Pack 2012 MS-MPI Redistributable Package for parallel processing.
- Microsoft Visual C++ run time libraries for 32 and 64 bit windows platforms.

The ArcGIS software should be installed on your computer prior to starting this quick start guide, but we detail the steps involved in installing TauDEM and MPI libraries.

TauDEM 5.3 Installation

TauDEM 5.3 needs to be installed using the TauDEM530.exe program. This setup application can install TauDEM both on Windows 32-bit and 64-bit computers. Download this setup program from http://hydrology.usu.edu/taudem/taudem5/downloads.html.

TauDEM setup program will install the following applications and libraries:

- TauDEM version 5.3.
- GDAL 111 (MSVC 2010 Win64): Only on 64 bit computers.
- GDAL 111 (MSVC 2010): Only on 32 bit computers.
- Microsoft Visual C++ 2010 x64 Redistributable: Only on x64 computers.
- Microsoft Visual C++ 2010 x86 Redistributable: Used on both 32 and 64 bit computers.
- Microsoft HPC Pack 2012 MS-MPI Redistributable Package.

By default, TauDEM will be installed at C:\Program Files\TauDEM. GDAL related libraries will be installed at C:\GDAL. GDAL applications will be installed at C:\Program Files\GDAL. MS HPC Pack will be installed at C:\Program Files\Microsoft HPC Pack 2012. Path entries are added to these locations.

NOTE: If you have previously installed an earlier version of TauDEM you should uninstall it. You don't need to uninstall other TauDEM dependencies.

Procedure for Installing TauDEM:

1. Run (double click) TauDEM530.exe. You will need to click through all the prompts agreeing to the licenses of the various components. At the prompt to install GDAL select Typical.

🛃 GDAL 111 (MSVC 2010 Win64) Setup	- • •
Choose Setup Type Choose the setup type that best suits your needs	GDAL
Typical Installs the most common program features. Recommended for	most users.
Custom Allows users to choose which program features will be installed a they will be installed. Recommended for advanced users.	and where
Complete All program features will be installed. Requires the most disk spa	ace.
Back Next	Cancel

2. Eventually you get to click on "Finish" to finish installation of TauDEM. At this point you have successfully installed TauDEM 5.3.

Note that the redistributables libraries listed above that TauDEM depends on will only be installed if they are required for your platform and are not already installed. Note that the installer will also add firewall exceptions to allow TauDEM programs to run. These allow MPI interprocess communication used in the parallel computations. This is communication within your computer and not over any external network. The installer will also add the following path entries:

- C:\Program Files\Microsoft HPC Pack 2012\Bin\
- C:\GDAL
- C:\Program Files\GDAL
- C:\Program Files\TauDEM\TauDEM5Exe

The TauDEM Tools.tbx ArcGIS toolbox is included with the install and should work for ArcGIS 10.0 or higher (tested for versions 10.0, 10.2.2 and 10.3.1). Note that the installation does not require ArcGIS. Without ArcGIS you will be able to run all the functions from the command line, but will not be able to use the ArcGIS toolbox.

Activate the TauDEM Toolbox in ArcGIS:

- Open ArcMap/ArcCatalog. If the ArcToolbox Window is not open, click on the "Show/Hide ArcToolbox Window" icon in the Standard Toolbar.
- Right click on ArcToolbox at the top of the window. Select Add Toolbox.
- Browse to the TauDEM install directory (by default, this is: C:\Program Files\TauDEM\TauDEM5Arc).

• Click on the TauDEM Tools.tbx file, and click Open.

The TauDEM Toolbox should now be visible in the list of toolboxes.

NOTE: Activation of TauDEM ArcGIS Tools is only needed if you want to run TauDEM functionality from within ArcGIS.

The TauDEM Toolbox should now be visible in the list of toolboxes.

If you wish to save this configuration, right click on ArcToolbox, select Save to Default. This needs to be done for each user who wishes to use TauDEM. See below how we added TauDEM tools to Arc Toolbox:



Basic Grid Analysis using TauDEM functions

In this section we illustrate the TauDEM basic grid analysis functions. We start with a DEM in ESRI grid format and lead you through the steps of running the necessary TauDEM commands.

 Download the Cub River example data zip file from the Documentation folder at <u>http://hydrology.usu.edu/taudem/</u>. Extract all files from the zip file and load cubdem into ArcMAP. This data was obtained from the National Elevation Dataset data server.



2. TauDEM 5.3 read all raster data that supported by GDAL (e.g. tiff, ESRI grid, and img) but writes in tiff format. The first TauDEM function used is **Pit Remove**. Pits are grid cells surrounded by higher terrain that do not drain. Pit Remove creates a hydrologically correct DEM by raising the elevation of pits to the point where they overflow their confining pour point and can drain to the edge of the domain. Open (by double clicking on) the TauDEM Pit Remove Tool (in the Basic Grid Analysis) set.



3. At the Pit Remove Tool dialog select Show Help to expand the embedded function help information.

I Pit Remove	<u>- 🗆 ×</u>
 Input Elevation Grid 	<u>^</u>
	<u></u>
Fill Considering only 4 way neighbors (optional)	
Input Depression Mask Grid (optional)	
Input Number of Processes	8
Output Pit Removed Elevation Grid	
	2
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OK Cancel Environments Show	Help >>

I Pit Remove	<u>_ 0 ×</u>
	Pit Remove Identifies all pits in the DEM and raises their elevation to the level of the lowest pour point around their edge. Pits are low elevation areas in digital elevation models (DEMs) that are completely surrounded by higher terrain. They are generally taken to be artifacts that interfere with the routing of flow across DEMs, so are removed by raising their elevation to the point where they drain off the edge of the domain. The pour point is the lowest point on the boundary of the "watershed" draining to the pit. This step is not essential if you have reason to believe that the pits in your DEM are real. This step can be circumvented by copying the raw DEM source data onto the file with suffix "fel" to simulate the output of "Pit Remove" without actually removing the pits. Also, if a few pits actually exist and so should not be removed, the actual pits should have "no data" elevation values inserted at their lowest point. "No data" values serve to define edges in the domain, and elevations are only raised to where flow is off an edge, so an internal "no data" value will stop a pit from being removed, if necessary.
OK Cancel Environments	Tool Help

4. Click within each input field to obtain embedded context sensitive help for each input.

💐 Pit Remove	
Input Elevation Grid Fill Considering only 4 way neighbors (optional) Input Depression Mask Grid (optional) Input Number of Processes Output Pit Removed Elevation Grid Output Pit Removed Elevation Grid	A digital elevation Grid A digital elevation model (DEM) grid to serve as the base input for the terrain analysis and stream delineation. Pits are generally assumed to be artifacts of the digitation process that interfere with the processing of flow across DEMs, and so are removed by raising their elevation to the point where they just drain. However, if a few actual pits are known, but others need to be removed, the actual pits should have "no data" elevation values inserted at their lowest point. "No data" values serve to define edges in the flow field, and elevations are only raised to where flow is off an edge, so an internal "no data" value will stop a pit from being removed, if necessary.
OK Cancel Environments	Tool Help
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Input Elevation Grid Fill Considering only 4 way neighbors (optional) Input Depression Mask Grid (optional) Input Number of Processes 8 Output Pit Removed Elevation Grid	Input Depression Mask Grid (optional) Indicator grid to identify cells that are real sinks and should not be filled
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Input Number of Processes Output Pit Removed Elevation Grid Image: Concelements OK Cancelements
Output Pit Removed Elevation Grid
OK Cancel Environments << Hide Help
Input Elevation Grid
A grid of elevation values with pits removed so that flow is routed off of the domain.
Fill Considering only 4 way neighbors (optional) Pits are low elevation areas in digital elevation models (DEMs) that are completely surrounded by biother terrain. They are generally taken to be artifacts of the digitation
Input Depression Mask Grid (optional) process that interfere with the processing of flow across DEMs. So, they are removed by raising their elevation to the point where they just drain.
Input Number of Processes 8
Output Pit Removed Elevation Grid
OK Cancel Environments << Hide Help

5. Click on Tool Help at the bottom to open the more detailed html help generated by ArcGIS for the Toolbox.

Pit Remove

Title Pit Remove

Summary

Identifies all pits in the DEM and raises their elevation to the level of the lowest pour point around their edge. Pits are low elevation areas in digital elevation models (DEMs) that are completely surrounded by higher terrain. They are generally taken to be artifacts that interfere with the routing of flow across DEMs, so are removed by raising their elevation to the point where they drain off the edge of the domain. The pour point is the lowest point on the boundary of the "watershed" draining to the pit. This step is not essential if you have reason to believe that the pits in your DEM are real. This step can be circumvented by copying the raw DEM source data onto the file with suffix "fel" to simulate the output of "Pit Remove" without actually removing the pits. Also, if a few pits actually exist and so should not be removed, while at the same time others are believed to be artifacts that need to be removed, the actual pits should have "no data" elevation values inserted at their lowest point. "No data" values serve to define edges in the domain, and elevations are only raised to where flow is off an edge, so an internal "no data" value will stop a pit from being removed, if necessary.

Usage There is no usage for this tool.

Syntax

PitRemove (Input Elev, {Fill_Considering_only_4_way_neighbors}, {Input_Depression_Mask_Grid}, Input_Number_of_Processes, Output_Pit_Removed_Elevation_Grid)

Parameter	Explanation	Data Type
Input Elev	Dialog Reference A digital elevation model (DEM) grid to serve as the base input for the terrain analysis and stream delineation. Pits are generally assumed to be artifacts of the digitation process that interfere with the processing of flow across DEMs, and so are removed by raising their elevation to the point where they just drain. However, if a few actual pits are known, but others need to be removed, the actual pits should have "no data" elevation values inserted at their lowest point. "No data" values serve to define edges in the flow field, and elevations are only raised to where flow is off an edge, so an internal "no data" value will stop a pit from being removed, if necessary. There is no python reference for this parameter.	Raster Layer
Fill_Considering_only_4_way_neighbors (Optional)	Dialog Reference If this option is selected Fill ensures that the grid is hydrologically conditioned with cell to cell connectivity in only 4 directions (N, S, E or W neighbors). Each grid cell is conditioned to drain to one of these adjacent, but not diagonal neighbors. There is no python reference for this parameter.	Boolean
Input_Depression_Mask_Grid (Optional)	Dialog Reference Indicator grid to identify cells that are real sinks and should not be filled There is no python reference for this parameter.	Raster Layer
Input_Number_of_Processes	Dialog Reference The number of stripes that the domain will be divided into and the number of MPI parallel processes that will be spawned to evaluate each of the stripes. There is no python reference for this parameter.	Long
Output_Pit_Removed_Elevation_Grid	Dialog Reference A grid of elevation values with pits removed so that flow is routed off of the domain. Pits are low elevation areas in digital elevation models (DEMs) that are completely surrounded by higher terrain. They are generally taken to be artifacts of the digitation process that interfere with the processing of flow across DEMs. So, they are removed by raising their elevation to the point where they just drain. There is no python reference for this parameter.	Raster Dataset

6. This TauDEM Documentation website contains an overview of the tools, data formats used and file naming conventions suggested for working with TauDEM. There is a detailed description of the functionality and parameters of each function. The tools are configured to, by default assign output file names following the naming convention given here. You do not have to use these names, but it is strongly recommended to aid in keeping track of the results.

 Select cubdem for the Input Elevation Grid. Note that the Output Pit Removed Elevation Grid is automatically filled with cubdemfel.tif following the file naming convention. Select the Input Number of Processes (I used 8 for a dual quad core PC). Notice that input elevation (cubdem) is in ESRI grid but output Pitremove file (cubdemfel) is in tif format.

💐 Pit Remove	<u>_ 🗆 ×</u>
Input Elevation Grid	<u> </u>
cubdem 💌	2
Fill Considering only 4 way neighbors (optional)	
Input Depression Mask Grid (optional)	
_	2
Input Number of Processes	8
I Output Pit Removed Elevation Grid	0
D:\Scratch\CubDemo\cubdemfel.tif	2
	_
	-
OK Cancel Environments Show	Help >>

The parallel approach used by TauDEM is illustrated below. The domain is subdivided into row oriented partitions that are each processed independently by separate processes. When the algorithms reach a point where they can proceed no further within the partitions there is a swap step that exchanges information along the boundaries. The algorithms then proceed working within the partitions using new boundary information. This process is iterated until completion. The strategies for sharing information across boundaries and iterating are specific to each algorithm.



The number of processes does not have to be the same as the number of processors on your computer, although generally should be the same order of magnitude. The operating system (and MPI) takes care

of time sharing between processes, so in cases where some processes are likely to be waiting for other processes to complete there may be a benefit in selecting more processes than physical processors on the computer. However, message passing across the borders are increased. For large datasets, some experimentation as to the number of processes that works best (fastest) is suggested.

8. Click OK on the Pit Remove tool to run the Pit Remove function for the cub river DEM. The output dialog reports run statistics that include timing, as well as any error or warning messages.

<pre> Close this dialog when completed successfully Executing: PitRemove cubdem # # 8 D:\Scratch\CubDemo\cubdemfel.tif Start Time: Sat Oct 10 15:41:07 2015 Running script PitRemove Input Elevation file: D:\Scratch\CubDemo\cubdem Considering4way: Input Number of Processes: 8 </pre>	Close
Close this dialog when completed successfully Executing: PitRemove cubdem # # 8 D:\Scratch\CubDemo\cubdemfel.tif Start Time: Sat Oct 10 15:41:07 2015 Running script PitRemove Input Elevation file: D:\Scratch\CubDemo\cubdem Considering4way: Input Number of Processes: 8	< Details
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Output Pit Removed Elevation file: D:\Scratch\CubDemo\cubdemfel.tif	
Command Line: mpiexec -n 8 pitremove -z "D:\Scratch\CubDemo\cubdem" -fel "D:\Scratch\CubDemo\cubdemfel.t:	if"
Process started:	
PitRemove version 5.3	
Input file has projected coordinate system.	
Processes: 8	
Header read time: 0.321091	
Data read time: 0.007342	
Compute time: 0.356093	
Write time: 0.034495	
Total time: 0.719021	
Executing: Calculate Statistics	
Completed script PitRemove	
Succeeded at Sat Oct 10 15:41:11 2015 (Elapsed Time: 4.55 seconds)	

Note also in this output that timing information is reported for this run.

9. The next function to run is **D8 Flow Direction**. This takes as input the hydrologically correct elevation grid and outputs D8 flow direction and slope for each grid cell.

💐 D8 Flow Directions 📃 🗖	×
Input Pit Filled Elevation Grid (must be .tif)	-
Input Number of Processes	
8 Output D8 Flow Direction Grid (must be .tif)	
D:\Scratch\CubDemo\cubdemp.tif	
Output D8 Slope Grid (must be .tif) D:\Scratch\CubDemo\cubdemsd8.tif	
OK Cancel Environments Show Help >>	

The resulting D8 flow direction grid (grid has suffix p) is illustrated. This is an encoding of the direction of steepest descent from each grid cell using the numbers 1 to 8. This is the simplest model of the direction water would flow over the terrain.



10. The next function to run is **D8 Contributing Area**. This count the number of grid cells draining through (out of) each grid cell based on D8 flow directions.

💐 D8 Contributing Area	
Input D8 Flow Direction Grid (must be .tif)	D8 Contributing Area
cubdemp.tif Input Outlets Shapefile (must be .shp) (optional) Input Weight Grid (must be .tif) (optional)	Calculates a grid of contributing areas using the single direction D8 flow model. The contribution of each grid cell is taken as one (or when the optional weight grid is used, the value from the weight grid). The contributing area for each grid cell is taken as its own contribution plus the contribution from upslope neighbors that drain in to it according to the D8 flow model.
Check for edge contamination Input Number of Processes	If the optional outlet point shapefile is used, only the outlet cells and the cells upslope (by the D8 flow model) of them are in the domain to be evaluated.
8 Output D8 Contributing Area Grid (must be .tif) D:\Scratch\CubDemo\cubdemad8.tif	By default, the tool checks for edge contamination. This is defined as the possibility that a contributing area value may be underestimated due to grid cells outside of the domain not being counted. This occurs when drainage is inwards from the boundaries or areas with no data values for elevation. The algorithm recognizes this and reacts "no data" for the contributing area. It is common to see stroke of "no
OK Cancel Environments << Hide Help	Tool Help

There are options to specify outlets and an input weight grid that were not used here. These are detailed in the tool help and allow calculations to be restricted to the area upstream of designated outlets (specified as a shapefile) and to accumulate an input weight field, rather than just counting contributing area as a number of grid cells. There is also an option to check for edge contamination. Edge contamination is a problem that can occur in the calculation of contributing area when flow is inwards from the boundary of the terrain. The computer does not know what the inflowing contributing area at the edge is, so evaluates the contributing area that may be impacted by this unknown area as no data. The result is streaks that enter the domain along flow paths. This is a desired result as it guards against missing parts of the watershed, but it can and should be turned off if the DEM has been clipped to a watershed boundary. A logarithmic scale is often best to render contributing area values as in the illustration below. Red has been used to display no data to illustrate edge contamination.



11. The **Grid Network** function outputs three grids: (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.

💐 Grid Network	
Input D8 Flow Direction Grid (must be .tif)	Grid Network
cubdemp.tif 💌 🖻	
Input Number of Processes 8	Creates 3 grids that contain for each grid cell: 1) the longest path, 2) the total path, and 3) the Strahler order number. These values are derived from the network defined by the D8 flow model.
Input Outlets Shapefile (must be .shp) (optional)	by the bollow model.
Input Mask Grid (must be .tif) (optional)	The longest upslope length is the length of the flow path from the furthest cell that drains to each cell. The total upslope path length is the length of the entire grid
Input Mask Threshold Value (optional)	network upslope of each grid cell. Lengths are measured between cell centers taking into account cell size and whether the direction is adjacent or diagonal.
	Strahler order is defined as follows: A network of flow paths is defined by the D8
Output Strahler Network Order Grid (must be .tif)	Flow Direction grid. Source flow paths have a Strahler order number of one. When
D:\Scratch\CubDemo\cubdemgord.tif	two flow paths of different order join the order of the downstream flow path is the
Output Longest Upslope Length Grid (must be .tif)	order of the highest incoming flow path. When two flow paths of equal order join the downstream flow path order is increased by 1. When more than two flow paths join
D: \Scratch \CubDemo \cubdemplen.tif	the downstream flow path order is calculated as the maximum of the highest
Output Total Upslope Length Grid (must be .tif)	incoming flow path order or the second highest incoming flow path order + 1. This
D:\Scratch\CubDemo\cubdemtlen.tif	generalizes the common definition to cases where more than two flow paths join at a point.
	Where the optional mask grid and threshold value are input, the function is evaluated
OK Cancel Environments << Hide Help	Tool Help

Grid Network Order (file name suffix gord) output from Grid Network is illustrated:



The functions above used the D8 flow model that represents flow from each grid cell to one neighbor. TauDEM also uses the $D\infty$ (D-Infinity) flow model that calculates the steepest outwards flow direction using triangular facets centered on each grid cell and apportions flow between neighboring grid cells based on flow direction angles.

12. The **D-Infinity Flow Direction** function is starting point for all D-Infinity work. It calculates D-Infinity flow directions for use in other TauDEM functions requiring D-infinity flow direction input

💐 D-Infinity Flow Directions	- D X	(
Input Pit FIlled Elevation Grid cubdemfel.tif Imput Number of Processes Input Number of Processes 8 Output D-Infinity Flow Direction Grid Imput Numentation \CubDemo \Demo \cubdemang.tif Output D-Infinity Slope Grid Imput Numentation \CubDemo \Demo \cubdemslp.tif	Output D-Infinity Flow Direction Grid A grid of flow directions based on the D-infinity flow method using the steepest slope of a triangular facet (Tarboton, 1997, "A New Method for the Determination of Flow Directions and Contributing Areas in Grid Digital Elevation Models," Water Resources Research, 33(2): 309- 319). Flow direction is determined as the direction of the steepest downward slope on the 8 triangular facets of a 3 x 3 block centered grid. Flow direction is encoded as an angle in radians, counter-clockwise from east as a continuous (floating point) quantity between 0 and 2 pi. The resulting flow in a grid is then usually interpreted as being proportioned between the two neighboring cells that define the triangular facet with the steepest downward slope.	^
<		~
OK Cancel Environments << Hide Help	Tool Help	

D-Infinity flow directions (encoded as angles counter clockwise from East in Radians) render similar to a hillshading.

Q Untitled - ArcMap		
File Edit View Bookmarks Insert	Selection Geoprocessing Customize Window	vs Help
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13. **The D-Infinity Contributing Area** function evaluates contributing area using the D-Infinity model based on flow being shared between grid cells proportional to the angle to the steepest downslope direction. This is designed to represent specific catchment area within dispersed flow over a smooth topographic surface.



The result from running this is specific catchment area obtained from the D-Infinity contributing area function illustrated below



Stream Network Analysis using TauDEM functions

TauDEM provides a number of methods for delineating and analyzing stream networks and watersheds. The simplest stream network delineation method uses a threshold on contributing area.

14. Stream Definition by Threshold. This function defines a stream raster grid (src suffix) by applying a threshold to the input. In this case the input is a D8 contributing area grid and a threshold of 100 grid cells has been used.

Input Accumulated Stream Source Grid		Stream Definition By Threshold	1
cubdemad8.tif 🖻		-	
Input Mask Grid (optional)		Operates on any grid and outputs an indicator (1,0) grid identifing cells with input values >= the threshold value. The standard use is to use an accumulater source area grid to as the input grid to generate a stream raster grid as the	ł
Threshold 100		output. If you use the optional input mask grid, it limits the domain being evaluated to cells with mask values >= 0. When you use a D-infinity	
Input Number of Processes 8		contributing area grid (*sca) as the mask grid, it functions as an edge contamination mask. The threshold logic is: src = ((ssa >= thresh) & (mask >=0)) ? 1:0 .	
Output Stream Raster Grid		>=0)) ? 1.0 .	
T\TauDEM_Project\Documentation\CubDemo\Demo\cubdemsrc.tif			
	\sim		1

The result depicts the stream network (but is not logically connected as a network shapefile yet).



It is common to want to delineate watersheds upstream of an outlet, say a USGS stream gauge. This requires that gauge locations be precisely located on streams as rendered from the DEM. Due to

inaccuracies in gauge locations and DEM stream delineation it is common for gauge locations not to be precisely on streams delineated from the DEM. The move Outlets to streams function slides gauge locations downslope following D8 flow directions until a stream (as defined by a stream raster grid) is encountered. The shapefile CubGauge in the example data is used to illustrate this.



15. Add the **CubGauge.shp** file to ArcMap and zoom in to the area around it.

16. Open Move Outlets to Streams and select the following input and click OK

		Output Outlet Shanefile (must be sha)	Т
Input D8 Flow Direction Grid cubdemp.tif Input Stream Raster Grid E:\USU_Research_work\MMW_PROJECT\TauDEM_Project\I Input Outlets Shapefile (must be .shp) CubGauge Input Maximum Distance Input Maximum Distance 50 Input Number of Processes	^	Output Outlet Shapefile (must be .shp) A point shape file defining points of interest or outlets. This file has one point in it for each point in the input outlet shapefile. If the original point was located on a stream, then the point was not moved. If the original point was not on a stream, the point was moved downslope according to the D8 flow direction until it reached a stream or the maximum distance had been reached. This file has an additional field "dist_moved" added to it which is the number of cells that the point was moved. This field is 0 if the cell was originally on a stream, -1 if it was not moved becuase there was not a stream within the maximum distance, or some positive value if it was moved.	
8 Output Outlet Shapefile (must be .shp) M_Project\Documentation\CubDemo\Demo\CubGauge_moved.shp	~		

Notice (below) how the outlet has been moved to coincide with the stream.



It is somewhat overkill to use 8 processors to move one outlet point, but this is illustrative of how this could be used for many more points. Upon adding the moved outlet you may have received an ArcMAP unknown spatial reference warning. Be aware in using TauDEM that TauDEM does not do any spatial reference (projection) conversions. Therefore all data needs to be in the same spatial reference system. TauDEM does copy the spatial reference information from input grids to output grids, but does not do this for shapefiles.

With the outlet positioned on the stream the stream network upstream of the outlet can be delineated.

🛐 D8 Contributing Area	- 🗆 X
Input D8 Flow Direction Grid	D8 Contributing Area
cubdemp.tif 💽 🖆	
Input Outlets Shapefile (must be .shp) (optional)	Calculates a grid of contributing areas using the single direction D8 flow model. The contribution of each grid cell is taken as one (or when the optional weight
CubGauge_moved 💌 🖻	grid is used, the value from the weight grid). The contributing area for each grid
Input Weight Grid (optional)	cell is taken as its own contribution plus the contribution from upslope neighbors that drain in to it according to the D8 flow model.
Check for edge contamination	If the optional outlet point shapefile is used, only the outlet cells and the cells upslope (by the D8 flow model) of them are in the domain to be evaluated.
Input Number of Processes	
Output D8 Contributing Area Grid T\TauDEM_Project\Documentation\CubDemo\Demo\cubdemssa.tif	By default, the tool checks for edge contamination. This is defined as the possibility that a contributing area value may be underestimated due to grid cells outside of the domain not being counted. This occurs when drainage is inwards from the boundaries or areas with no data values for elevation. The algorithm recognizes this and reports "no data" for the contributing area. It is common to see streaks of "no data" values extending inwards from boundaries along flow paths that enter the domain at a boundary. This is the desired effect and indicates that contributing area for these grid cells is unknown due to it being dependent on terrain outside of the domain of data available. Edge contamination checking may be turned off in cases where you know this is not an issue or want to ignore these problems, if for example, the DEM has been clipped along a watershed outline.
OK Cancel Environments << Hide Help	Tool Help

17. Open **D8 Contributing Area** and select the following inputs and click OK

The result is contributing area only for the watershed upstream of the outlet.



18. Open **Stream Definition By Threshold** and select the following inputs and click OK to define a stream raster for this area upstream of the outlet

Stream Definition By Threshold		- D X	:
Stream Definition By Threshold Input Accumulated Stream Source Grid Cubdemssa.tif Input Mask Grid (optional) Threshold Input Number of Processes Dutput Stream Raster Grid [T\TauDEM_Project\Documentation\CubDemo\Demo\cubdemsrc2.tif]	^	Control Contro Control Control Control Control Control Control Control Control Co	^
	<		~
OK Cancel Environments << Hide Help		Tool Help	

19. Open Stream Reach and Watershed and select the following inputs and click OK

Input Pit Filled Elevation Grid	Stream Reach And Watershed
cubdemfel.tif 🗾 🖻	
Input D8 Flow Direction Grid	This tool produces a vector network and shapefile from the
cubdemp.tif	stream raster grid. The flow direction grid is used to connect flow paths along the stream raster. The Strahler order of each
nput D8 Drainage Area	stream segment is computed. The subwatershed draining to
cubdemad8.tif 🗾 🚰	each stream segment (reach) is also delineated and labeled
nput Stream Raster Grid	with the value identifier that corresponds to the WSNO (watershed number) attribute in the Stream Reach Shapefile.
cubdemsrc2.tif 🗾 🖻	(watershed humber) attribute in the Otream Reach Onapellie.
nput Outlets Shapefile as Network Nodes (must be .shp) (optional)	This tool orders the stream network according to the Strahler
CubGauge_moved 🗾 🚰	ordering system. Streams that don't have any other streams
Delineate Single Watershed	draining in to them are order 1. When two stream reaches of different order join the order of the downstream reach is the
	order of the highest incoming reach. When two reaches of equal
Input Number of Processes	order join the downstream reach order is increased by 1. When
Dutput Stream Order Grid	more than two reaches join the downstream reach order is calculated as the maximum of the highest incoming reach order
vork\MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\Demo\cubdemord.tif	or the second highest incoming reach order + 1. This
Dutput Network Connectivity Tree (must be .bxt)	generalizes the common definition to cases where more than two reaches join at a point. The network topological connectivity
»rk\MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\Demo\cubdemtree.txt	is stored in the Stream Network Tree file, and coordinates and
Dutput Network Coordinates (must be .txt)	attributes from each grid cell along the network are stored in the
k\MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\Demo\cubdemcoord.txt	Network Coordinates file.
Dutput Stream Reach Shapefile (must be .shp)	The stream raster grid is used as the source for the stream
>rk\/MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\Demo\cubdemnet.shp	network, and the flow direction grid is used to trace connections
Dutput Watershed Grid	within the stream network. Elevations and contributing area are
_work\/MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\Demo\cubdemw.tif	used to determine the elevation and contributing area attributes in the network coordinate file. Points in the outlets shapefile are
	used to logically split stream reaches to facilitate representing
	watersheds upstream and downstream of monitoring points. The
	program uses the attribute field "id" in the outlets shapefile as identifiers in the Network Tree file. This tool then translates the
	text file vector network representation in the Network Tree and
	Coordinates files into a shapefile. Further attributes are also

The result is 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 is referenced in terms of the stream network 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.



An important question in stream network delineation is what stream delineation threshold to use. The above used arbitrary thresholds of 100 and 200 grid cells. TauDEM also provides ways to do select stream delineation threshold objectively using a stream drop test following theory described in Tarboton et al. (Tarboton et al., 1991; 1992) and Tarboton and Ames (2001). This may be combined with more geomorphologically based methods for channel definition that attempt to capture topographic texture and spatial variability in drainage density. These will be illustrated next.

20. Open the **Peuker Douglas** function and select the following inputs and click OK.

out Elevation Grid	Peuker Douglas
ubdemfel.tif 🗾 🖻	Creates an indicator grid (1,0) of upward curved grid cells
nter Smoothing Weight 0.4	according to the Peuker and Douglas algorithm.
e Smoothing Weight 0.1	With this tool, the DEM is first smoothed by a kernel with weights at the center, sides, and diagonals. The Peuker and
gonal Smoothing Weight 0.05	Douglas (1975) method (also explained in Band, 1986), is then used to identify upwardly curving grid cells. This technique flags
out Number of Processes 8	the entire grid, then examines in a single pass each quadrant of 4 grid cells, and unflags the highest. The remaining flagged
tput Stream Source Grid	cells are deemed 'upwardly curved', and when viewed, resemble
ork\/MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\Demo\cubdemss.tif	a channel network. This proto-channel network generally lacks connectivity and requires thinning, issues that were discussed
	in detail by Band (1986).
	Band, L. E., (1986), "Topographic partition of watersheds with digital elevation models," Water Resources Research, 22(1): 15-24.
	Peuker, T. K. and D. H. Douglas, (1975), "Detection of surface- specific points by local parallel processing of discrete terrain elevation data," Comput. Graphics Image Process., 4: 375-387.
U	

The result, derived entirely from a local filter applied to the topography is a skeleton of a stream network illustrated below



21. Open the **Peuker Douglas Stream Definition** function and select the following inputs and click OK.

nput Elevation Grid	Peuker Douglas Stream Definition
cubdemfel.tif	
nput D8 Flow Direction Grid	This tool combines the functionality of the "Peuker Douglas,"
cubdemp.tif	"D8 Contributing Area," "Stream Drop Analysis," and "Stream
/eight Center	Definition by Threshold" tools in order to generate a stream indicator grid (1,0) where the streams are located using a DEM
0.4	curvature-based method. With this method, the DEM is first
Veight Side	smoothed by a kernel with weights at the center, sides, and
0.1	diagonals. The Peuker and Douglas (1975) method (also explained in Band, 1986), is then used to identify upwardly
Veight Diagonal	curving grid cells. This technique flags the entire grid, then
0.05	examines in a single pass each quadrant of 4 grid cells, and
Accumulation Threshold	unflags the highest. The remaining flagged cells are deemed 'upwardly curved', and when viewed, resemble a channel
	network. This proto-channel network sometimes lacks
Check for Edge Contamination	connectivity, and/or requires thinning, issues that were
nput Outlets Shapefile (must be .shp) (optional)	discussed in detail by Band (1986). The thinning and connecting of these grid cells is achieved here by computing
CubGauge_moved 🗾 🖻	the D8 contributing area using only these upwardly curving
nput Mask Grid (optional)	cells. An accumulation threshold on the number of these cells
I 🖻	is then used to map the channel network where this threshold i optionally set by the user, or determined via drop analysis.
nput D8 Contributing Area for Drop Analysis (optional)	optionally set by the user, of determined via drop analysis.
E:\USU_Research_work\MMW_PROJECT\TauDEM_Project\Documentation\C 🗾 📂	If drop analysis is used, then instead of providing a value for the
nput Number of Processes	accumulation threshold, the accumulation threshold value is
8	determined by searching the range between the Drop Analysis Parameters "Lowest" and "Highest", using the number of steps
Dutput Stream Source Grid E:\USU_Research_work\MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\D	in the parameter "Number". For the science behind drop
Dutput Accumulated Stream Source Grid	analysis, see Tarboton, et al. (1991, 1992), and Tarboton and
E: \USU_Research_work\MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\D	Ames (2001). The value of accumulation threshold that is selected is the smallest value where the absolute value of the t
Dutput Stream Raster Grid	statistic is less than 2. This is written to the drop analysis table
E:\USU_Research_work\MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\D	text file. Drop analysis is only possible when outlets have been specified, because if an entire grid domain is analyzed, as the
Dutput Drop Analysis Table (must be .txt) (optional)	threshold varies, shorter streams draining off the edge may not
E: \USU_Research_work\MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\D	meet the threshold criterion and be excluded from the analysis.
_	This makes defining drainage density problematic and it is somewhat inconsistent to compare statistics evaluated over
Use the range below to automatically select threshold by drop analysis	differing domains.
/inimum Threshold Value	
5	
Aaximum Threshold Value 500	
Number of Threshold Values	
10	
Use Logarithmic spacing for threshold values	
	×

This rather extensive set of inputs configures TauDEM to run Peuker Douglas, then use the Peuker Douglas stream skeleton as a weighted input to a D8 contributing area calculation. The result is then thresholded using a range of thresholds (the drop analysis thresholds at the bottom of the input) 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 that reports the stream drop statistics for each threshold examined. This is included in the completion dialog below as well as written to the drop analysis table file. 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 39 is chosen in this case as the objective stream delineation threshold.

💭 cubdemdrp.txt - Notepad
File Edit Format View Help
Threshold, DrainDen, NoFirstOrd,NoHighOrd, MeanDFirstOrd, MeanDHighOrd, StdDevFirstOrd, StdDevHighOrd, T
5.000000, 3.390493e-003, 1161, 349, 58.920692, 93.768005, 71.145126, 103.846100, -7.145377
8.340503, 2.600175e-003, 666, 203, 71.861404, 99.472878, 79.649048, 105.396080, -3.989054
13.912798, 2.148775e-003, 467, 132, 77.414116, 111.667526, 86.321220, 119.500938, -3.673055
23.207947, 1.666109e-003, 280, 80, 82.343758, 112.537766, 88.536217, 129.004654, -2.408210
38.713192, 1.334998e-003, 178, 47, 89.589325, 104.373589, 98.205269, 107.218628, -0.900324
64.577499, 1.038978e-003, 107, 27, 93.351128, 143.111740, 93.126717, 149.685410, -2.166116
107.721756, 8.146343e-004, 70, 21, 85.222809, 136.654785, 92.401611, 175.115128, -1.778427
179.690720, 6.057229e-004, 41, 15, 80.675217, 116.890854, 103.964249, 181.045517, -0.934205
299.742218, 4.902572e-004, 20, 4, 127.070969, 206.569214, 157.293503, 266.500153, -0.823664
500.000183, 4.304635e-004, 15, 4, 126.531258, 186.585266, 162.728027, 273.645569, -0.570258
Optimum Threshold Value: 38.713192

22. Open the Stream Reach and Watershed function and select the following inputs and click OK.

💐 Stream Reach And Watershed	- 🗆 ×
Stream Reach And Watershed Input Pit Filled Elevation Grid (cubdemfel.tif Input D8 Flow Direction Grid (cubdemp.tif (cubdemad8.tif (cubdemad8.tif (cubdemsrc1.tif (cubdemsrc2.tif (cubdemsrc2.tif <t< th=""><th>Output Watershed Grid This output grid identified each reach watershed with a unique ID number, or in the case where the delineate single watershed option was checked, the entire area draining to the stream network is identified with a single ID.</th></t<>	Output Watershed Grid This output grid identified each reach watershed with a unique ID number, or in the case where the delineate single watershed option was checked, the entire area draining to the stream network is identified with a single ID.
OK Cancel Environments << Hide Help	Tool Help

Following is an illustration of the result. Notice how the stream network has been delineated more or less consistently with the contour crenulations depicting the texture of the topography



Specialized Grid Analysis using TauDEM functions

TauDEM also includes a number of specialized grid analysis functions. Only a few are illustrated here as they are all detailed in the system help.

23. Open the **D-Infinity Distance Down** function and select the following inputs and click OK

D-Infinity Distance Down	- 0 ×
Input D-Infinity Flow Direction Grid	D-Infinity Distance Down
cubdemang.tif 🗾 🖻	
nput Pit Filled Elevation Grid	Calculates the distance downslope to a stream using the D-
cubdemfel.tif 🗾 🔁	infinity flow model. The D-infinity flow model is a multiple flow direction model, because the outflow from each grid cell is
input Stream Raster Grid	proportioned between up to 2 downslope grid cells. As such,
cubdemsrc1.tif 🗾 🖻	the distance from any grid cell to a stream is not uniquely
tatistical Method	defined. Flow that originates at a particular grid cell may enter the stream at a number of different cells. The statistical method
Average 🗸 🗸	may be selected as the longest, shortest or weighted average of
Distance Method	the flow path distance to the stream. Also one of several ways
Vertical V	of measuring distance may be selected: the total straight line
Check for edge contamination	path (Pythagoras), the horizontal component of the straight line path, the vertical component of the straight line path, or the total
Input Weight Path Grid (optional)	surface flow path.
	F
Input Number of Processes	
8	
Output D-Infinity Drop to Stream Grid	
work\MMW_PROJECT\TauDEM_Project\Documentation\CubDemo\Demo\cubdemdd.tif	
Ý	
,	
OK Cancel Environments << Hide Help	Tool Help

By selecting Vertical as the distance method the result is the vertical drop from each point, to a point on the stream as illustrated below



24. Open the D-Infinity Distance Up function and select the following inputs and click OK

🛐 D-Infinity Distance Up	– 🗆 X
Input D-Infinity Flow Direction Grid cubdemang.tif Input Pit Filled Elevation Grid cubdemfel.tif Input Slope Grid cubdemslp.tif Input Proportion Threshold 0 Statistical Method Average Distance Method Horizontal Check for Edge Contamination Input Number of Processes 8 Output D-Infinity Distance Up work\/MMW_PROJECT\TauDEM_Project\/Documentation\CubDemo\cubdemdu.tif C	D-Infinity Distance Up This tool calculates the distance from each grid cell up to the ridge cells along the reverse D-infinity flow directions. Ridge cells are defined to be grid cells that have no contribution from grid cells further upslope. Given the convergence of multiple flow paths at any grid cell, any given grid cell can have multiple upslope ridge cells. There are three statictical methods that this tool can use: maximum distance, minimum distance and waited flow average over these flow paths. A variant on the above is to consider only grid cells that contribute flow with a proportion greater than a user specified threshold (t) to be considered as upslope of any given grid cell. Setting t=0.5 would result in only one flow path from any grid cell and would give the result equivalent to a D8 flow model, rather than D-infinity flow model, where flow is proportioned between two downslope grid cells. Finally there are several different optional paths that can be measured: the total straight line path (Pythagoras), the horizontal component of the straight line path, the vertical component of the straight line path, or the total surface flow path.
OK Cancel Environments << Hide Help	Tool Help

The result in this case is the average horizontal distance moving upslope along D-Infinity flow directions to a ridge, defined as a grid cell that has no other grid cells flowing in to it.



Basic Grid Analysis using TauDEM functions for Geographic data:

25. Download the Eno River example data file from the Documentation page in <u>http://hydrology.usu.edu/taudem</u>. Unzip the folder and load enogeo.tif into ArcMAP.



Click on the lay	ver prop	erties of e	nogeo.tif y	which shov	s that dat	a is in the	geographic (coordinate sys	stem.
ener on the la			100001011		o that aat		8008.48.100	soon annate sys	

	Source	Key Metadata	Extent Dis	play	Symbology	
Proper	ty		Value			~
	Right		-78.80	060285	5766	
	Bottom		35.99	45648	856	
Spatial Reference			GCS_N	North_	American_1983	
	Linear Uni	t				
	Angular U	nit	Degre	e (0.0	174532925199433)	
	Datum		D_Nor	th_Am	nerican_1983	
	itatistics					
-	Band_1		Statist	tics hav	ve not been calculated.	
	Build Par	ameters				× .
Data S	Source					
Data		E:\U		n_work	Results\GEO_TEST\Start_geo\	^
Fold	DEM_Geo	_benverableb_in	neo tif			
Fold		eno	yeo.ui			
Fold \Tau			yeo.ui		Set Data Source	~
Fold \Tau			yeo. ui		Set Data Source	~

26. TauDEM 5.3 supports both geographic and projected coordinate data. Open the **PitRemove** function and select the following inputs and click OK

j Pit Remove	×
Input Elevation Grid enogeo.tif Input Number of Processes Output Pit Removed Elevation Grid ect\TauDEM_Geo_Deliverables_my_all_work\Tested_Results\GEO_TEST\enogeofel.tif	A grid of elevation values with pits removed so that flow is routed off of the domain. Pits are low elevation areas in digital elevation models (DEMs) that are completely surrounded by higher terrain. They are generally taken to be artifacts of the digitation process that interfere with the processing of flow across DEMs. So, they are removed by raising their elevation to the point where they just drain.
OK Cancel Environments << Hide Help	Tool Help

Click on the layer properties of enogeofel.tif which shows that it is also in the geographic coordinate system.

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Of Contents 7 ×			
🗦 🐟 🖳 🗉			
Layers E\USU_Research_work\MMW_PR ✓ enogeofel.tif Value High : 261.463 Low : 74.8443 E\USU_Research_work\MMW_PR enogeo.tif Value High : 226.593			
Low : 122.699	Layer Properties		×
	Concert Source Kay Matadata	Educt Direlay Cardedon	
	General Source Key Metadata	Extent Display Symbology	
	Property	Value	^
	Тор	36.2539167374	
	Left	-79.2596396877	
	Right	-78.8060285766	
		-78.8060285766 35.9945648856	_
	Right Bottom Spatial Reference		- 11
	Right Bottom Spatial Reference Linear Unit	35.9945648856 GCS_North_American_1983	- 11
	Right Bottom Spatial Reference Linear Unit Angular Unit	35.9945648856 GCS_North_American_1983 Degree (0.0174532925199433)	- 11
	Right Bottom Spatial Reference Linear Unit Angular Unit Datum	35.9945648856 GCS_North_American_1983	
	Right Bottom Spatial Reference Linear Unit Angular Unit	35.9945648856 GCS_North_American_1983 Degree (0.0174532925199433)	
	Right Bottom Spatial Reference Linear Unit Angular Unit Datum	35.9945648856 GCS_North_American_1983 Degree (0.0174532925199433)	v
	Right Bottom Spatial Reference Linear Unit Angular Unit Datum Statistics Data Source Data Type: File Folder: E:\L \(\TauDEM_Geo_Deliverables_m	35.9945648856 GCS_North_American_1983 Degree (0.0174532925199433)	×
	Right Bottom Spatial Reference Linear Unit Angular Unit Datum Statistics Data Source Data Type: File Folder: E:\L \(\TauDEM_Geo_Deliverables_m	35.9945648856 GCS_North_American_1983 Degree (0.0174532925199433) D_North_American_1983 System Raster SU_Research_work\MMW_PROJECT\TauDEM_Project y_all_work\Tested_Results\GEO_TEST\	~
	Right Bottom Spatial Reference Linear Unit Angular Unit Datum Statistics Data Source Data Type: File Folder: E:\L \(\TauDEM_Geo_Deliverables_m	35.9945648856 GCS_North_American_1983 Degree (0.0174532925199433) D_North_American_1983 System Raster ISU_Research_work\MMW_PROJECT\TauDEM_Project y_all_work\Tested_Results\GEO_TEST\ geofel.tif	~

27. Open the **D8flow direction** function and select the following inputs and click OK.

S D8 Flow Directions	- 0	\times
Input Pit Filled Elevation Grid enogeofel.tif Input Number of Processes Output D8 Flow Direction Grid	s measured	as
>ject\TauDEM_Geo_Deliverables_my_all_work\Tested_Results\GEO_TEST\enogeop.tif Output D8 Slope Grid :ct\TauDEM_Geo_Deliverables_my_all_work\Tested_Results\GEO_TEST\enogeosd8.tif		
		~
OK Cancel Environments << Hide Help Tool Help		

The resulting D8 flow direction grid (grid has suffix p) is illustrated which is also in geographic coordinate system.



Similarly, other TauDEM functions can be applied for the geographic coordinate system data.

References

- Broscoe, A. J., (1959), "Quantitative analysis of longitudinal stream profiles of small watersheds," Office of Naval Research, Project NR 389-042, Technical Report No. 18, Department of Geology, Columbia University, New York.
- Tarboton, D. G. and D. P. Ames, (2001), "Advances in the mapping of flow networks from digital elevation data," <u>World Water and Environmental Resources Congress</u>, Orlando, Florida, May 20-24, ASCE, <u>http://www.engineering.usu.edu/dtarb/asce2001.pdf</u>.
- Tarboton, D. G., R. L. Bras and I. Rodriguez-Iturbe, (1991), "On the Extraction of Channel Networks from Digital Elevation Data," <u>Hydrologic Processes</u>, 5(1): 81-100.
- Tarboton, D. G., R. L. Bras and I. Rodriguez-Iturbe, (1992), "A Physical Basis for Drainage Density," <u>Geomorphology</u>, 5(1/2): 59-76.