Exercise 06: Comparing the D8 and D-infinity Methods

Introduction

In Exercise 05, we calculated the topographic moisture index (TMI) by making use of the D8 digital terrain analysis sequence in conjunction with a gridded digital elevation model. Recall that the D8 method only routes flow from one cell to a single neighbor. This has the effect of representing convergent flow (multiple cells flowing to a single cell), while precluding the representation of divergent flow (a single cell flowing to multiple cells). In real landscapes, flow probably converges and diverges at various places and times.

With that in mind, the D-infinity method of flow representation offers an alternative that allows for a limited representation of flow divergence. Unfortunately, such a non-convergent representation doesn't allow for some of the things D8 can do, like finding all the cells that flow to a given cell, and the products derived from that capability. However, D-infinity does provide an alternative method of calculating slopes, flow directions, and contributing area through the accumulation of converging and diverging flow directions. This, in turn, allow for the creation of a more physically realistic topographic moisture index (TMI).

Data

The exercises in the first half of the course will use spatial data from the vicinity of the Coldstream Creek catchment, a small watershed in Okanagan Valley of British Columbia, Canada. This exercise will use the following 2 datasets:

- coldstream – The Coldstream Creek watershed GRID
- d8slope – A slope GRID for Coldstream Creek, derived using D8 digital terrain analysis
- d8tmi – A topographic moisture index GRID for Coldstream Creek, derived using D8 digital terrain analysis
- dem – This digital elevation model GRID was produced by applying the *Fill* tool to our original DEM in Exercise 03.

Procedure and Questions

Comparing D8 Slope to D-infinity Slope

- Add the datasets listed above, except for dem, to your map document
- The D-infinity analysis capabilities required for this lab are provided by the TauDEM extendible component for ArcGIS (Tarboton, 2005). This software should be installed on all the computers in the Science, 3rd floor, room 20 lab. If you wish to use it on your own installation of ArcGIS, you can find a download and instructions for installing it at http://hydrology.neng.usu.edu/taudem/ (note that this software will not be available in the Science, 3rd floor, room 34 lab).

- As was the case with the *Spatial Analyst*, you will need to make sure that the *TauDEM* toolbar is activated in your map document. In the list of *Toolbars* inside the *View* menu, you should see *Terrain analysis using Digital Elevation Models (TauDEM)*. Check this item off to activate the *TauDEM* menu.
- *TauDEM* managed GRIDs a little differently from the *Hydrology* tools you have been using previously. Its convenient is to append a suffix to the name of an existing GRID, and save the new GRID in the same location. For this reason, it would be most convenient to save a copy of the dem to a sub-directory in your H:\ space. That is, make a sub-directory named H:\exercise06 and copy the dem GRID there (H:\exercise06\dem). You can perform both of these operations using *ArcCatalog*.
- Add your new copy of the dem GRID in your H:\ space to the map document.
- The first step in using *TauDEM* is to *Select Base DEM grid*. This is the first item in the *Basic Grid Analysis* pull-down menu. Set the base DEM grid to be dem.
- Next, fill any pits in the DEM using the *Fill pits* item from the *Basic Grid Analysis* pull-down menu. This will create a new GRID named demfel that will automatically be saved in the same directory where your dem GRID is located, and this GRID will also be added to your map document (provided you leave all the options in the *Fill Pits* dialog as their default values).
- You can now run *Dinf Flow Directions* (same pull-down menu), which will create both the *D-Inf Flow Directions* GRID (demang) and the *D-Inf Slope* GRID (demslp).
- The *D-Inf Slope* GRID is expressed as an actual slope (rise / run). To make a reasonable comparison to our D8 slope angle from Exercise 05, we will have to convert the D-infinity slope to being expressed in degrees of angle as well. We can do so using the *Raster Calculator*. We need to take the Arctan of the D-infinity slope, which will return the slope angle in radians, and then convert from radians to degrees (there are 2 pi radians and 360 degrees in a circle). The *Raster Calculator* expression ATan([demslp]) * DEG will do so (note that DEG is a built-in constant, with a precisely calculated value for degrees per radian). Rename the resulting *Calculation* GRID to the name dinfslope (also, use the *Data → Make Permanent* menu item, which can be found by right-clicking on the layer in the *Table of Contents*, if you wish to save this GRID to your H:\ space).
- Use the *Raster Calculator* to calculate the difference between the D8 slope and the D-infinity slope (in degrees, from the previous step), i.e. [d8slope] – [dinfslope] and rename the resulting *Calculation* GRID to slopediff (also, use the *Data → Make Permanent* menu item, which can be found by right-clicking on the layer in the *Table of Contents*, if you wish to save this GRID to your H:\ space).
- We can use the *Zonal Statistics* tool, found in the pull-down menu of the *Spatial Analyst* toolbar to collect some statistics on the differences between slope values. The *Zone dataset* must be coldstream, leave the *Zone field* as *Value*, and the *Value raster* must be your cropped difference calculated in the previous step. Set the *Output table* to be located within your H:\ space, leave *Ignore NoData in calculations* checked, and uncheck the *Chart statistic* option. After running the tool, the resulting DBF file automatically be opened.

Question 1 – What are the MIN and MAX differences between slopes produced by the two methods in Coldstream? Include a printed map of the difference GRID with your exercise, and make sure it has the following characteristics: It should have an appropriate title, north arrow, scale, and legend (be sure to use the Layout View for this). An ideal symbology would make it easy to distinguish between positive and negative differences.

Question 2 – What are the MEAN and STD (standard deviation) of the differences within Coldstream, and what does this indicate about the differences between the two methods of calculating slope in general?

<u>Creating the D-infinity Topographic Moisture Index GRID</u>

- Run *Dinf Contributing Area* (again in the *TauDEM Basic Grid Analysis* pull-down menu) to create the Specific Catchment Area GRID (demsca).
- We can now use the *Raster Calculator* to create the D-infinity TMI GRID. We have the required inputs (the D-infinity slope GRID in degrees from a previous step and Specific Catchment Area GRID). We can do this in a single step, including cropping the output to the Coldstream Creek catchment using the following *Raster Calculator* expression: Ln([demsca] / [dinfslope]) * [coldstream] and rename the resulting *Calculation* to dinftmi (also, use the *Data* → *Make Permanent* menu item, which can be found by right-clicking on the layer in the *Table of Contents*, if you wish to save this GRID to your H:\ space).

Question 3 – What are the lowest and highest values of the D-infinity topographic moisture index GRID you created? Include a printed map of the D-infinity topographic moisture index GRID with your exercise, and make sure it has the following characteristics: It should have an appropriate title, north arrow, scale, and legend (be sure to use the Layout View for this), and should use a symbology that makes the pattern of values easy to discern (I find it useful to symbolize high values of TMI with blue or green and low values with red or yellow, to denote wetness and dryness respectively).

- Zoom in to the D-infinity topographic moisture index GRID to have a closer look at it. You should find that there are some cells that do not have a value (to make this more apparent, alter the symbology of the GRID to draw *No Data* values as a color very different from any others used in your symbology).

*Question 4 – Why do these cells not have a topographic moisture index value, and instead have a No Data value (**Hint: use the Identify tool to check the D-infinity slope at these locations**)?*

*Question 5 – How many cells like this (cells with a No Data value) are there in your topographic moisture index GRID (**Hint: You can figure this out by using the Raster Calculator either on the D-infinity slope GRID or the D-infinity topographic moisture index GRID, provided you can think of a Raster Calculator Expression that will find these cells**)? You may recall answering similar questions in Exercise 05 about the D8 TMI GRID: Are there less or more No Data cells in the D-infinity TMI GRID, and why is this the case?*

Comparing Topographic Moisture Index Statistics for Coldstream Creek

- Change the symbology of the d8tmi GRID and the dinftmi GRID to *Classified*, using the *Natural Breaks (Jenks)* method with 20 classes (remember to choose appropriate color ramps and assign a distinct color to the *No Data* values as well).

Question 6 – *How do the distributions of TMI values generated by the two methods compare to one another? To help answer this question, produce histograms of the values by setting the Layer in the Spatial Analyst toolbar to each of the TMI GRIDs, and clicking on the Histogram button to produce a histograms. Print off a copy of both histograms and include them with your exercise, interpreting the shape of the histograms with respect to one another.*

- We can use the *Zonal Statistics* tool, found in the pull-down menu of the *Spatial Analyst* toolbar to collect some statistics on each of the two TMI GRIDs. The *Input Raster* must be coldstream, leave the *Zone field* as *Value*, and the *Input value raster* must be each of the TMI GRIDs respectively. Set the *Output table* to be located within your H:\ space, leave *Ignore NoData in calculations* checked, and uncheck the *Chart statistic* option. After running the tool, the resulting DBF files will automatically be opened.

Question 7 – *What are the means and standard deviations (STD in the table) of all the non-No Data TMI values in Coldstream Creek as determined by the two different methods? Do these values reflect what you would have expected from what differences you can see between the two histograms?*