University of Massachusetts Boston – Department of Environmental, Earth, and Ocean Sciences

EEOS 383 - GISCIENCE FOR WATER RESOURCES RESEARCH – Spring 2010

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Exercise 04: Stream Networks from DEMs

Introduction

In Exercise 03, we made use of the D8 digital terrain analysis sequence in conjunction with a gridded digital elevation model. We delineated a watershed for Upper Coldstream Creek by finding all grid cells that drained to a specified grid cell (co-located with the BCCOL06 sampling location) based upon a simple rule that drainage follows the direction of steepest descent. We were able to create the watershed delineation in this fashion, through the production of two very useful intermediate products that describe the movement of water through the watershed on a cell-by-cell basis, the flow direction and flow accumulation grids. Now, we will build on what we have done previously by using these products to create a representation of the stream network, which we can further analyze into a set of stream links, from which we can crate stream order and magnitude GRIDs.

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:

- flowacc – This flow accumulation GRID was produced by applying the *Flow Accumulation* tool to the flow direction GRID in Exercise 03.
- flowdir – This flow direction GRID was produced by applying the *Flow Direction* tool to the filled DEM GRID in Exercise 03.
- sampling3.shp – This point shapefile marks 8 sampling sites and channel characteristics at those locations
- streams.shp – This polyline shapefile maps the drainage network

Procedure and Questions

<u>Creating a Stream Network GRID</u>

- Add the datasets listed above to your map document
- Stream network GRIDs are created by selecting a threshold value of flow accumulation, and applying it to the flow accumulation GRID using the *Raster Calculator*. That is, by selecting a minimum level of accumulation to include in the stream network and by forming an appropriate *Raster Calculator* expression, one can create a GRID where cells are marked as being part of the stream network.
- The tricky part is identifying what the threshold value should be. Higher threshold values produce sparser, less detailed stream networks while lower threshold values produce denser, highly detailed stream networks. Recall Davis' (1899) metaphor of the river as a leaf: "one may extend the 'river' all over its basin and up to its very divides. Ordinarily treated, the river is like the veins of a leaf; broadly viewed, it is

like the entire leaf". This applies in the raster context as well, in terms of how many cells are included in the stream network (with the lowest possible threshold, all cells are included and the resulting 'stream network' is the watershed itself).

- To examine this, we will create stream networks using accumulation thresholds of 1000, 500, and 250 respectively. To create each of these, use the *Raster Calculator* to evaluate the appropriate expression: For example, the expression to find all cells in the flowacc GRID with values greater than 1000 would be [flowacc] > 1000
- Use this method to create each of the three specified stream networks. Rename each in the *Table of Contents* appropriately (e.g. change *Calculation* to *Streams1000* or something similar). Reorder them in the *Table of Contents* so the stream network with threshold 1000 is on top, above the one with threshold 500, in turn above the one with threshold 250. Change their symbologies so each has their 0 values set to *No Color* and their 1 values set to different colors so they can be distinguished from one another (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 these GRIDs to your H:\ space).

Question 1 – Describe the appearance of each of the three stream networks you have created, identifying which is the densest and which is the sparsest. Include a printed map of the stream network GRIDs with your exercise, and make sure it has the following characteristics: It should have an appropriate title, north arrow and scale (be sure to use the Layout View for this), as well as a legend that indicates the correspondence between raster cell symbologies and the various stream network thresholds.

- Now, overlay the streams.shp shapefile on top of your threshold-created stream networks so you can compare them (you may wish to zoom in and look at various portions of the stream network).

*Question 2 – Which of the three thresholds produces a stream network that is most similar to the one from the shapefile? Are any of them precisely the same as the shapefile's representation of the streams? Why or why not is this the case (**hint: what methods might have been used to produce the streams shapefile**)?*

<u>Creating the Stream Links GRID</u>

- We will select the stream network produced using the threshold of 500 cells to proceed with the remaining steps. We will use the *Stream Link* tool in the *Hydrology* sub-section of the *Spatial Analyst Tools* toolbox to create stream links.
- By reading the help associated with this tool, we find that it requires for input a stream network GRID where stream pixels have a value and non-stream pixels have a value of *No Data*. We can produce such a GRID by reclassifying our existing stream network with threshold 500, such that the 0 values are converted to *No Data* values by using the *Reclassify* capability of the *Spatial Analyst*. Set the *Old Values* of 0 to have *New Values* of *No Data* and keep the values of 1 the same.

Be sure to name and place the *Output raster* appropriately, saving it in your H:\ directory space.

- We are now ready to run the *Stream Link* tool. Use your newly created stream network grid with *No Data* values where there are non-stream cells for your *Input stream raster*, the flow direction GRID for the *Input flow direction raster*, and name and place the *Output raster* appropriately, again saving it in your H:\ directory space.

Question 3 – How many stream links were created as a result of the analysis? Include a printed map of the stream links GRIDs 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 it easy to distinguish between adjacent links (i.e. switch the symbology from stretched to unique values).

Creating the Stream Order GRID

- You can find the *Stream Order* tool just below the *Stream Link* tool. It works in a very similar fashion in terms of the inputs that it requires. The key difference is a pull down menu that allows you to select that the output be a GRID of *STRAHLER* order values, or *SHREVE* magnitude values.
- First we will generate the *STRAHLER* order GRID. Set the *Input stream raster, Input flow direction raster*, and *Output raster* appropriately, and leave the *Method of stream ordering* at its default setting of *STRAHLER* orders.

Question 4 – What is the highest value of the stream order GRID you created? Is that stream link part of the Coldstream Creek stream network (defined as the network that drains to the BCCOL01 sampling site)? What is the highest order link that is part of the Coldstream Creek stream network?

*Question 5 – Compare the stream order values in the GRID you just created to those found in the L_Order attribute of the streams.shp shapefile. What accounts for the difference in the highest order found in the Coldstream Creek stream network (**hint: Remember the rules for Strahler order values, namely that it takes two streams links of order n joining to produce a link downstream of order n + 1**)? Include a close-up map of a key portion of the stream networks (your GRID version and the shapefile version) that accounts for the difference. As always, include an appropriate title, north arrow, scale, and legend that describes the symbology, which should be appropriately selected to the order of various links can be clearly seen.*

Creating the Stream Magnitude GRID

- Use the *Stream Order* tool again, just as before, only this time, change the *Method of stream ordering* to *SHREVE* in order to produce Shreve magnitudes.

Question 6 – What is the highest Shreve magnitude produced by this analysis? Include a printed map of the stream magnitude 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 it easy to see the magnitude values (i.e. the symbology could be classified or stretched, but should show increasing magnitudes appropriately [and not have the highest magnitude be white on a white background!]).

Question 7 – Describe the difference between the rules that govern Shreve magnitudes versus Strahler orders. How does Shreve's scheme improve on the representation of the amount of upstream channel in the stream network? Is the Shreve approach vulnerable to the difference between our GRID stream network versus that in the streams.shp shapefile that you should have discussed in Question 5 as the Strahler approach is? Why or why not is this the case?