
Practical: Hydrological Analysis of DEMs

After completing this practical you should be able to:

- Fill sinks in your DTM
- Perform a flow direction and flow accumulation analysis
- Create a drainage area raster dataset
- Delineate a river channel network

Adding Your SRTM DTM to ArcMap

Firstly, we are going to add in the DTM (Digital Terrain Model) into ArcGIS. The SRTM data you have been provided with has a resolution of 30m.

1. Open ArcMap from the Start Menu.
2. Close the Getting Started window
3. Add your SRTM DTM into ArcMap by selecting the 'Add Data' icon in the taskbar 
4. Use the interface to navigate to the 'Catchment_Data' folder you have been provided with on your USB drive.
5. Select the folder named 'SRTM_DTM' and enter the 'SRTM_DTM.gdb' (geodatabase).
6. Double click the 'SRTM_DTM_All' dataset to add it into ArcMap.
7. You should now see a black/white DTM of the whole study area (the combination of all of your groups study catchments).

Filling Sinks

In order to identify the drainage area for each raster cell in the river catchment it is first necessary to make sure the DTM is 'hydrologically correct', that is, water can flow downhill from the high areas to low areas without getting caught in an 'sinks' (low areas where water would enter but not leave).

1. Open the ArcToolbox 
2. Double click 'Spatial Analyst'
3. Double click 'Hydrology'
4. Open the 'Fill' tool by double clicking it.
5. Set the 'Input Raster' to be 'SRTM_DTM_All'.
6. Next to the 'Output Raster' box, use the folder icon to navigate to your 'SRTM_DTM.gbd'.
7. Save the output as 'SRTM_DTM_All_Filled' in the geodatabase.
8. Click ok to run the tool.
9. You should now see a new version of your DTM in the 'Table of Contents' which has been 'filled' to make it hydrologically correct.

Flow Direction Analysis

In order to calculate what the drainage area is for each raster cell, it is first necessary to work out which direction water would flow out of each cell.

1. Open the ArcToolbox
2. Double click 'Spatial Analyst'
3. Double click 'Hydrology'
4. Open the 'Flow Direction' tool by double clicking it.
5. Set the 'Input Raster' to be 'SRTM_DTM_All_Filled'.
6. Next to the 'Output Raster' box, use the folder icon to navigate to your 'SRTM_DTM.gbd'.
7. Save the output as 'SRTM_DTM_All_FlowDir' in the geodatabase.
8. Click ok to run the tool.
9. This may take a moment to complete. But you should see a new raster dataset where the values relate to the direction of water flow for that cell.

Flow Accumulation Analysis

Using the direction that water would flow out of each cell it is possible for the software to calculate how many other cells worth of rainfall will end up routing into each cell.

1. Open the ArcToolbox
2. Double click 'Spatial Analyst'
3. Double click 'Hydrology'
4. Open the 'Flow Accumulation' tool by double clicking it.
5. Set the 'Input Flow Direction Raster' to be 'SRTM_DTM_All_FlowDir'.
6. Next to the 'Output Raster' box, use the folder icon to navigate to your 'SRTM_DTM.gbd'.
7. Save the output as 'SRTM_DTM_All_FlowAcc' in the geodatabase.
8. Click ok to run the tool.
9. This may take a moment to complete. But you should see a new raster dataset where the values relate to the number of other cells which flow into that cell. The river channels should start to become clear at this point (shaded white).

Drainage Area Analysis

Finally, you need to multiply the number of cells that flow into each cell by the area of one cell to find the drainage area for each cell.

1. Open the ArcToolbox
2. Double click 'Spatial Analyst'
3. Double click 'Math'
4. Double click the 'Times' tool to open it.
5. Set the 'Input raster or constant value 1' to be 'SRTM_DTM_All_FlowAcc'.
6. Set the 'Input raster or constant value 2' to be the area of one DTM cell in km². (30m x 30m = 0.03km x 0.03km = 0.0009km²).
7. Next to the 'Output Raster' box, use the folder icon to navigate to your 'SRTM_DTM.gbd'.
8. Save the output as 'SRTM_DTM_All_DrArea' in the geodatabase.
9. Click ok to run the tool.
10. Explore the drainage area raster that has been created. By default, cells with high drainage area are light and cells with low drainage area are dark. What would you expect to find in cells of high drainage area?

Delineating the River Network

Rivers form where there is sufficient drainage area and rainfall to generate flow that is sufficient to erode a channel. We can identify all of the cells where a river channel is likely to form by highlighting just those cells that have a drainage area above a certain threshold.

1. Open the ArcToolbox
2. Double click 'Spatial Analyst'
3. Double click 'Math'
4. Double click 'Logical'
5. Double click the 'Greater Than Equal to' tool to open it.
6. Set the 'Input raster or constant value 1' to be 'SRTM_DTM_All_DrArea'.
7. Set the 'Input raster or constant value 2' to be 0.5
8. Next to the 'Output Raster' box, use the folder icon to navigate to your 'SRTM_DTM.gbd'.
9. Save the output as 'SRTM_DTM_All_Channels1' in the geodatabase.
10. Click ok to run the tool.

As an important processing step is to reclassify the way that the streams are represented in the raster layer.

11. Open the ArcToolbox
12. Double click 'Spatial Analyst'
13. Double click 'Reclass'
14. Double click the 'Reclassify' tool to open it.
15. Use your 'SRTM_DTM_All_Channels1' raster as 'Input raster'. Under the 'New Values' column type 'NoData' next to the '0' value in the 'Old Values' column, and '1' next to the '1' value in the 'Old Values' column. This changes all values of 0 to NoData and keeps all values of 1 as they are.
16. Next to the 'Output Raster' box, use the folder icon to navigate to your 'SRTM_DTM.gbd'.
17. Save the output as 'SRTM_DTM_All_Channels2' in the geodatabase.
18. Click ok to run the tool.

Finally, you can convert your raster representation into a more suitable vector representation

19. Open the ArcToolbox, Double click 'Spatial Analyst'.
20. Double click 'Hydrology', Double click the 'Stream to Feature' tool to open it.
21. Set the 'Input Stream Raster' as 'SRTM_DTM_All_Channels2'
22. Set the 'Input Flow Direction Raster' to be 'SRTM_DTM_All_FlowDir'.
22. Next to the 'Output Polyline Features' box, use the folder icon to navigate to your 'SRTM_DTM.gbd'.
23. Save the output as 'SRTM_DTM_All_Channels3' in the geodatabase.
24. Click ok to run the tool.
25. You should now have a new feature class dataset representing channels derived from the DTM.