**Lab: Hypsometry in Fluvial and Glacial Terrains**

This week we will be exploring the topographic signature of active tectonics and glaciation as reflected in basin hypsometry. As you analyze your data, I want you to think about the following questions:

1. What does the altitudinal distribution of area (hypsometry) tell you about the processes that formed each landscape? How does the hypsometry vary between landscapes? Does it vary?
2. Is there any evidence for a “glacial buzzsaw” in the datasets you are comparing? Can you estimate the ELA given the latitude for the datasets we have? How does it compare with hypsometric maxima (per Egholm et al. (2009))?
3. Do you think these topographic metrics are useful?

There are two parts to this lab. In part 1, each individual will be responsible for producing data compilations for one particular area. I will pool all of the datasets and distribute them for your analysis and report. In part 2, you will compare datasets. You do not need to include all locations, although you can if you want to. You should plan to focus on comparisons between at least 4 or 5. You should discuss the questions above in under 4 pages, figures included. Include any other insightful observations and comments, too.

The data from your area need to be posted to Moodle by the end of Wednesday, March 5th. I will get the compiled dataset back to you by Friday, March 7th. Your report describing and comparing a subset of the data is due Wednesday, March 12th.

In class on Wednesday, each of you selected a different mountain range covering a wide variety of tectonic and climatic settings. I have already downloaded data, merged individual lat-long tiles into broader areas, and they are located in individual folders on the Z drive. *I would suggest you start by copying the DEM data for your location onto a USB drive first before starting any analyses.*

**Step 1: Data prepping (This is already done for you!)**

We downloaded SRTM (Shuttle Radar Topography Mission) DEM data. They are at 90 meters resolution. Although we have better data available for the continental United States, I wanted all the datasets to be consistent. The data have been stitched together, cleaned up a little, and reprojected to be in a more useful coordinate system. The directions are in the Appendix at the end if you would like to download your own SRTM data. Otherwise, skip on to Step 2.

**Step 2: Data Extraction and Analyses**

**Hypsometry (standard):**

Basin hypsometry reflects the altitudinal distribution of area within a landscape. The data you need for hypsometry are remarkably easy to extract from Arc. We will once again be crunching those data in Excel.

Basically, you want to extract the elevation at each pixel. More specifically (and more usefully), you want to know how many pixels are at an elevation of 1 masl (meters above sea level), 2 masl, 3 masl, and on up to the maximum elevation in your landscape. To get at this information, you need to turn your DEM into an integer file. (ArcToolbox 🡪 Spatial Analyst 🡪 Math 🡪 Int). Then right-click on the new integer DEM file and open the attribute table. You can export the data by finding the “Options” tab in the lower right corner of the attribute table and selecting “Export”. Bring those data into Excel.

Let’s start by plotting a standard normalized hypsometric plot, similar to what Montgomery et al. (2001) used in the Andes. Basically, we want to develop a cumulative distribution function of elevation. Start at the highest elevation and then calculate the sum of the # of pixels at that location plus all of the ones higher than it. Go ahead and plot that cumulative distribution curve vs. elevation. This is plot #1.

Now, normalize it. Figure out the total number of pixels and divide each entry on your cumulative curve by the total # of pixels. (Think: Total # pixels is really total area (\* 90m x 90m) so you are normalizing by area.) Next make the elevation run from 0 to 1 where 1 is the max elevation and 0 is the min elevation. I will let you figure out how to do this. In order to standardize across different locations, I recommend we set the minimum elevation = sea level in all plots, even if you do not have data extending to sea level in your dataset.

Now plot normalized elevation vs. normalized area. Your plot should run from 0 to 1 on both axes. By convention, put cumulative elevation along the y-axis and cumulative area along the x-axis. At your highest elevation, the cumulative area curve should be 0 (nothing higher than it). At your lowest elevation, the cumulative area curve will read 1 (everything higher than it). This is plot #2.

**Elevation distributions (non-cumulative):**

For our third plot, we will create a curve similar to the ones analyzed by Egholm et al. (2009). For this, you need to bin the data in 100m increments and plot each bin as a % of the total area. The easiest way to bin your data is to actually go back into Arc and turn your elevation data from meters into 100s of meters. Go back to Arc. Take your DEM and divide it by 100 (in ArcToolbox find Spatial Analyst Tools 🡪 Math 🡪 Divide). Then turn that into an integer file. Extract the data (which are now in elevations of 100s of meters) and pull them into Excel to plot. Create a plot a la Egholm et al., with elevation on the y-axis and % area in each bin on the x-axis. See if you can figure out what your hypsometric maxima is.

**Step 2: ELA Estimations**

It would really help to know where the modern and LGM (Last Glacial Maximum) snowline is location in order to compare with your data. You have the global curve from Egholm et al. (2009). Use Figure 1, coupled with your latitude to estimate the modern and LGM snowlines.

**Step 3: Data Compilation**

Please turn in one (1) (!) Excel file. In that Excel file, please include your first cumulative hypsometry plot, your normalized cumulative hypsometry plot, your binned histogram of elevation data, and your best estimate of the modern and LGM snowlines in your area. Include the raw data, not just the plots on your Excel file that you post to the moodle site.

Once received, I will double-check and then distribute data sets to the class so that you can analyze and compare multiple datasets for your write-up.

The data need to be posted to Moodle by the end of Wednesday, March 5th. I will get the compiled dataset back to you by Friday, March 7th. Your report describing and comparing a subset of the data is due Wednesday, March 12th.

A reminder that your write-up should focus on comparisons between at least 4 or 5 locations, but you do not need to include all datasets. You should discuss the questions listed at the beginning of this handout in under 4 pages, figures included. Include any other insightful observations and comments, too.

**Appendix**

**How to download and clean up your own SRTM data**

Here are the directions (for future reference): Go to http://earthexplorer.usgs.gov and go to Search Criteria. Click on “Use map”. Select an area by outlining it with a box. Click on Data Sets, and choose Digital Elevation 🡪 SRTM. Click Results and it shows you all of the lat\_long tiles in your selected area. Each file covers 1 degree lat and 1 degree long. I downloaded 6 in each area we decided on in class by clicking the download button under the coordinates. I opened up all 6 tiles for each area in Arc and then merged them into one file (Here’s how: Data Management Tools 🡪 Raster 🡪 Raster Dataset 🡪 Mosaic to New Raster). These are the files you see in the class folder. If you want a new area to work in, go get the data yourself…

When you open the data files up, you will see that values extend all the way down to -32768 which is the code for “no data”. To strip out these values, here is what I suggest. First, make a file showing where the no data pixels are located. Use Spatial Analyst Tools 🡪 Math 🡪 Logical 🡪 Greater Than. Input Raster 1 should be your DEM. Input 2 should be the number “0”. This will produce a file with 0s where there are no data and 1s where there are data. Now take this file and use it to strip the no data cells out using the “Conditional” command (Spatial Analyst Tools 🡪 Conditional 🡪 Con). Enter your raster with 0s and 1s as the “Input conditional raster” and the original DEM as the “Input true raster or constant value”. This will create a new raster with positive elevations remaining and negative values removed from the dataset.

You also may want to put your dataset into a more useful coordinate system. I would recommend the Albers projection. To reproject either the raw files or the files with the “no data” stripped out, you want to use the project raster function (Data Management Tools 🡪 Projections and Transformations 🡪 Raster 🡪 Project Raster). For the new projection, click on the box on the right next to “Output Coordinate System”. This allows you to specify a new projection. Click on “select”. I would suggest you use one of the “Projected Coordinate Systems”, click on “Continental”, and then on the location information for your data (right continent, etc.). You want a version of the Albers Equal Area projection for large data spatial extents or a UTM projection for smaller spatial extents. You will need to go on-line and figure out what UTM section you are in first if you want to use this.