Exercise 1: Basic visualization of LiDAR Digital Elevation Models using ArcGIS

Introduction

This exercise covers activities associated with basic visualization of LiDAR Digital Elevation Models using ArcGIS. Topics include a description of the standard tiled DEMs available from http://www.opentopography.org, loading them into ArcMap and mosaicking them, and producing color gradient maps, hillshades, slope maps and slopeshades, and contour maps.

Data included

We start with the uncompressed downloaded archives from http://www.opentopography.org -> Standard DEMs.

The DEMs in this example are for Sanborn Park area in the Santa Cruz Mountains, California (archive names are 583_4120, 583_4121, 582_4120 and 582_4121).

Data	Data format	Resolution (m)	Coordinate System
GeoEarthScope Lidar data tiles—unfiltered (all the data) and filtered (just ground returns) interpolated by kriging to make DEM. Includes hillshades	ArcGrid	0.5	UTM Zone 10N, WGS84 ellipsoid heights

Data source, type, and file naming convention

OpenTopography delivers the Standard DEMs as delivered from the National Center for Airborne Laser Mapping (http://www.ncalm.org/). In this demonstration, we will play with the filtered and unfiltered 1km x 1km ArcInfo grids @ 0.5m cell size and their shaded relief maps (NO overlap).

Due to ArcInfo file naming limitations, the grids contain only the significant digits from the lower left coordinate of their originating tile. For example, the ASCII tile named "f571000_4130000.xyz" corresponds to the ArcInfo elevation grid named "fg571_4130" and shaded relief map "fg571_4130shd". Filtered elevation grids are prefixed by "fg" and the hillshades end in "shd". Unfiltered elevation grids are prefixed by "ug" and the hillshades end in "shd."

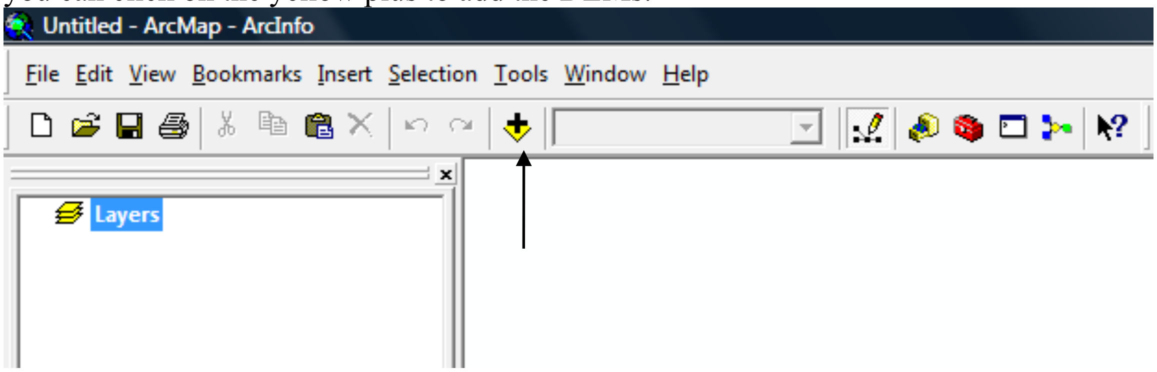
ArcGIS activities

Introduction

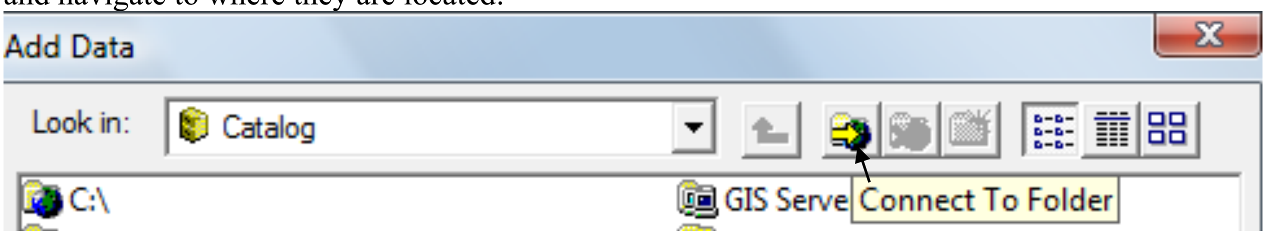
The ArcGIS software suite has many useful capabilities for handling geospatial data including LiDAR DEMs. We use ArcMap 9.3 (with its extensions Spatial Analyst and 3D Analyst) to produce map view visualizations. For some introductory lessons in ArcGIS, you should check the ESRI web sites (http://www.esri.com/ and http://www.esri.com/what-is-gis/index.html) and you may also try Ramon's lectures at http://arrowsmith410-598.asu.edu/GLG410_598--Lectures.html.

Launch ArcMap and load data

Under the Start Menu, navigate to ArcGIS and launch ArcMap. Once the software is launched, you can click on the yellow plus to add the DEMs:

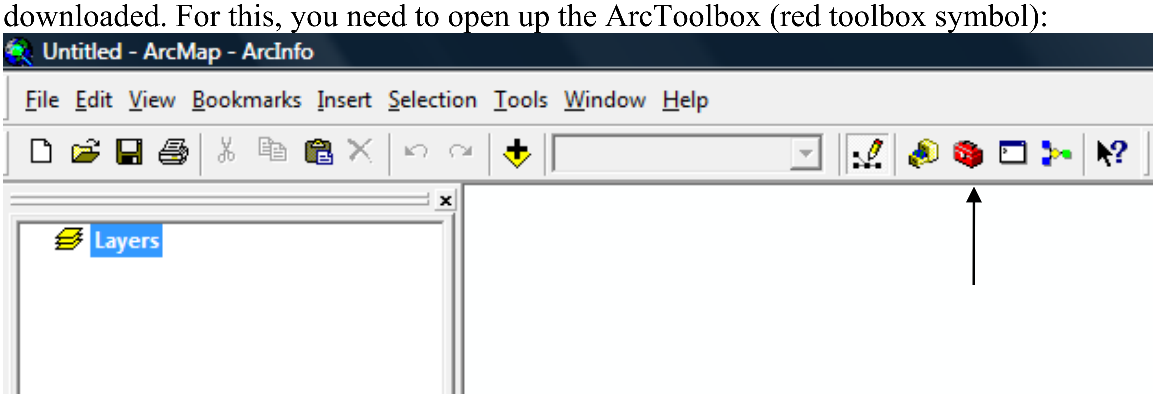


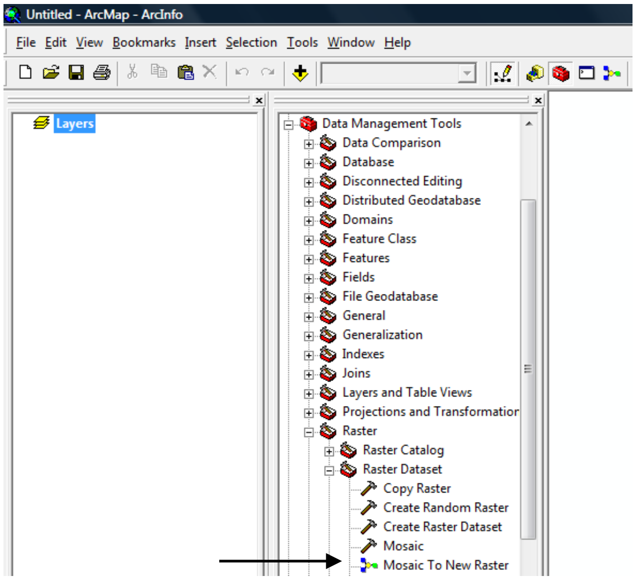
Note that the first time you navigate for the data, you may need to "Connect to the folder" and navigate to where they are located:



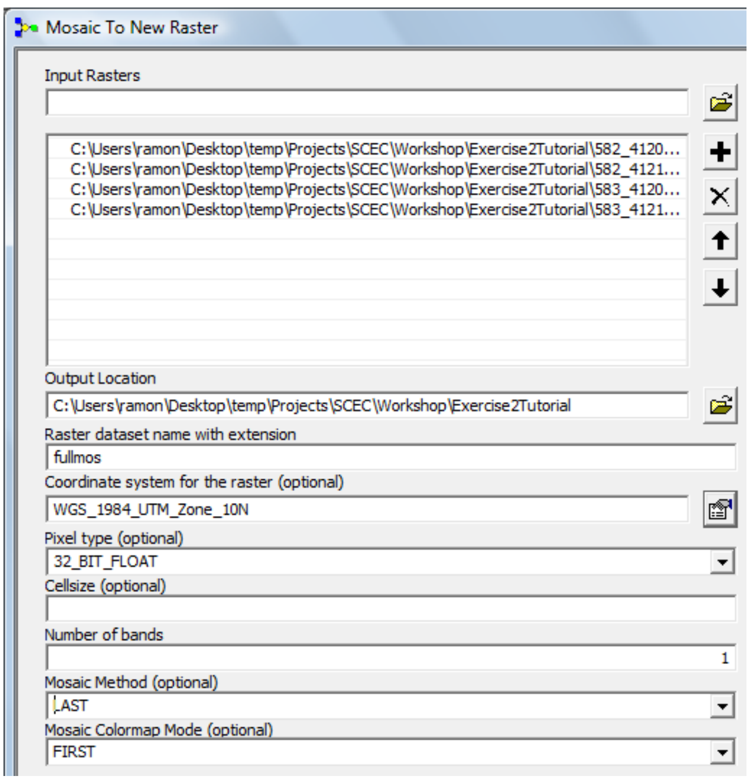
Mosaicking the DEM tiles

Before adding too many files, let's mosaic the 4 contiguous square kilometer tiles that we downloaded. For this, you need to open up the ArcToolbox (red toolbox symbol):





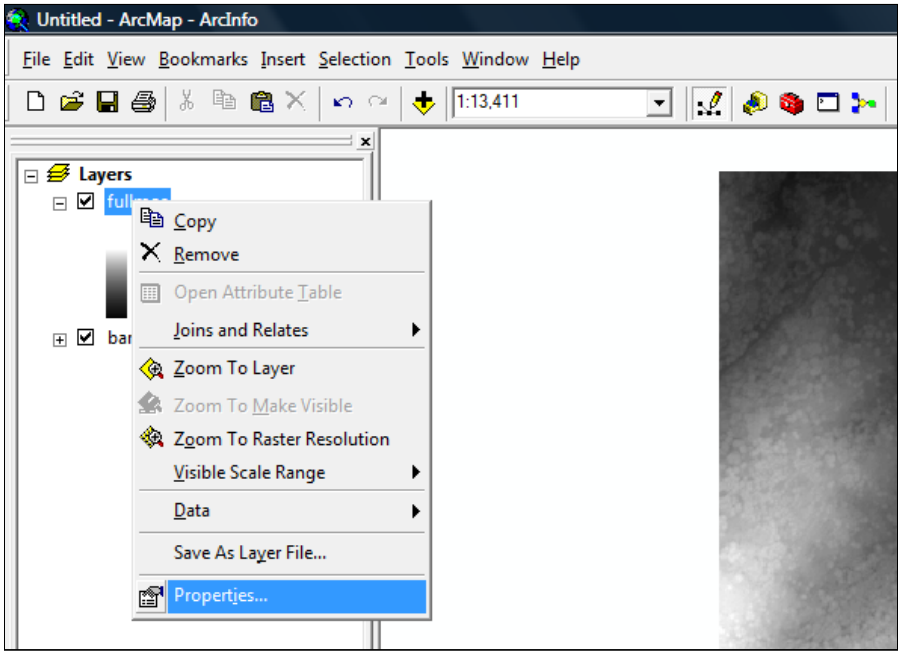
Open the toolboxes: Data Management Tools->Raster->Raster Dataset->Mosaic to New Raster.



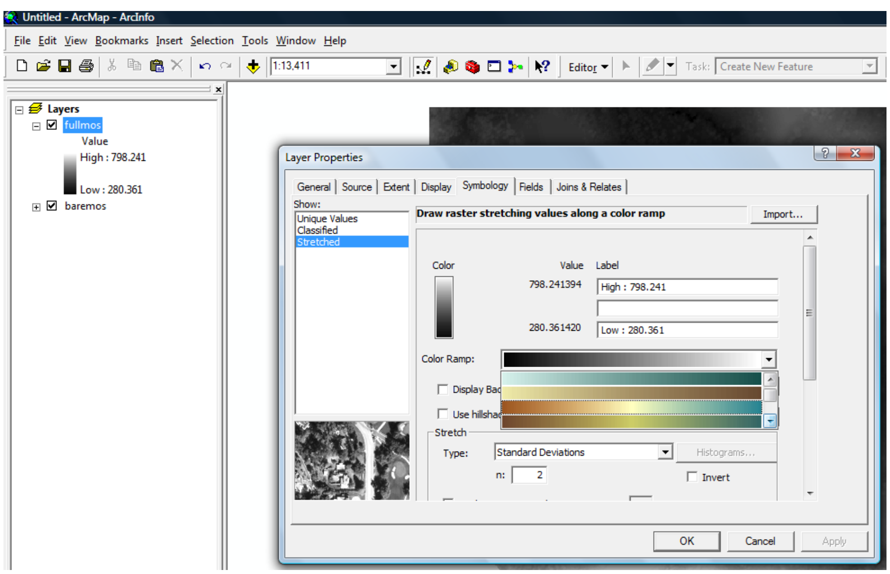
- Select the files to be mosaicked by clicking the open folder at the upper right and progressively select them.
- The Output Location is a directory (folder) into which the mosaic will go.
- Provide a mosaic name.
- The coordinate system can be defined by clicking the small button () and either Selecting by choosing the coordinate system into which you want the mosaic projected, or Importing which will pull the projection from an existing file (in this case, I used one of the DEM tiles) if you navigate to the file and select it.
- The Pixel Type should be 32 bit float.
- The other boxes can be left optional.
- Click OK to launch the mosaicking process and after a few seconds to minutes, you will have your mosaic added to the ArcMap project. Mosaic both the full feature and the bare earth DEMs.

How to visualize the DEM

Color gradients



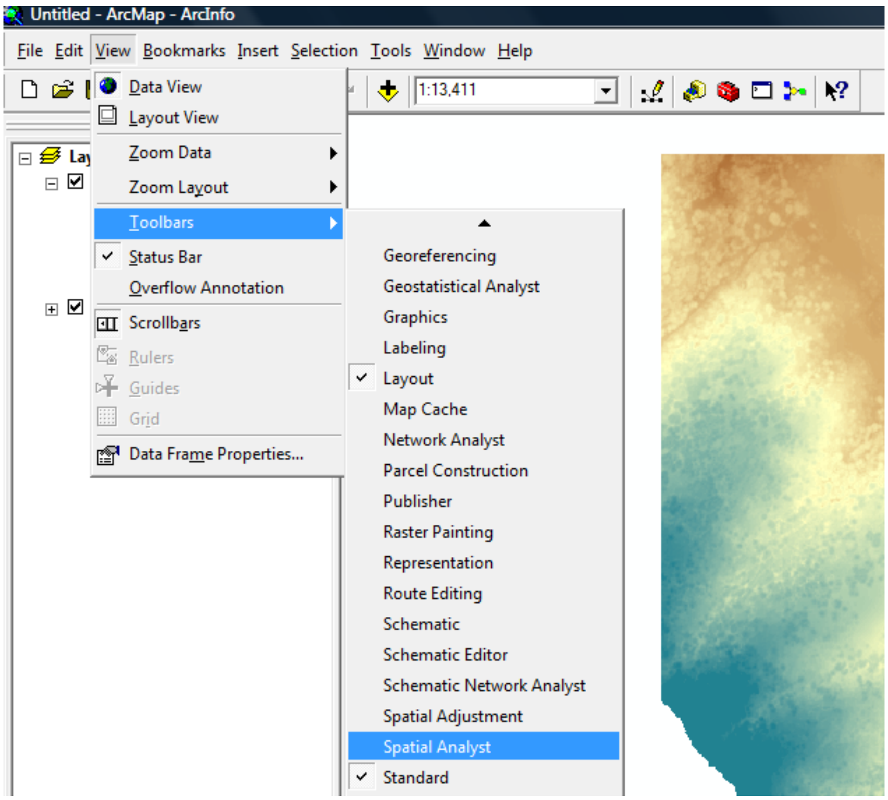
To visualize the topography color coded by elevation (with a different color ramp than the default grayscale), right click on the DEM file name in the Table of Contents (left portion of the ArcMap window) and choose Properties.



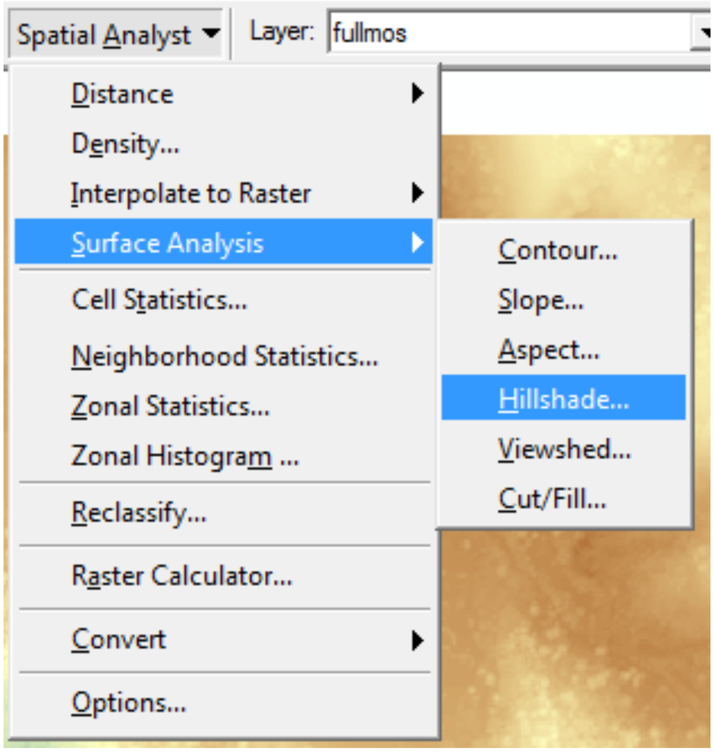
Choose the symbology tab and select the color ramp of interest

Hillshade

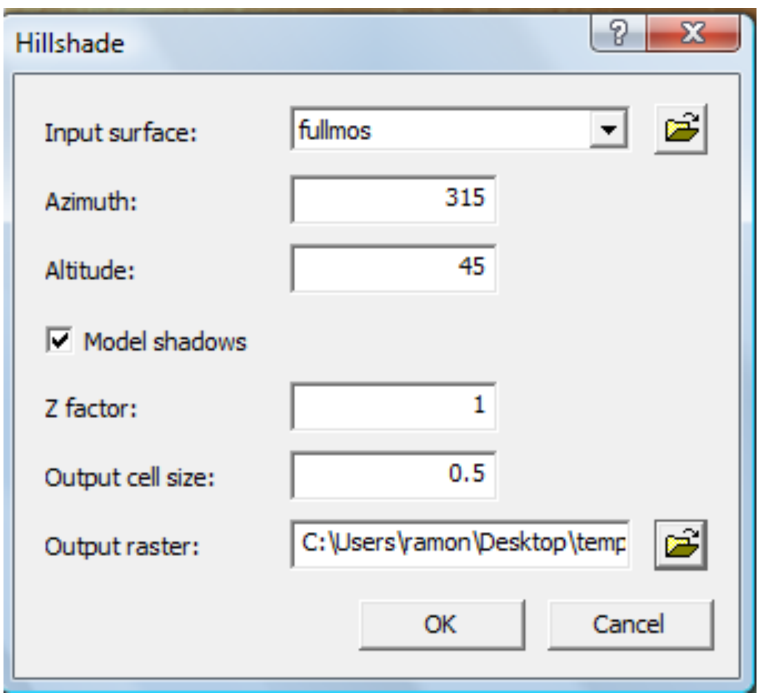
Hillshades are a commonly used visualization of topography. They are a simulated reflection of a light source of specified azimuth and zenith angles from the topography (with set reflective properties) toward the viewer who is looking straight down.



To produce the hillshade, you first may need to display the Spatial Analyst toolbar (View->Toolbars)



In Spatial Analyst, select Surface Analysis->Hillshade

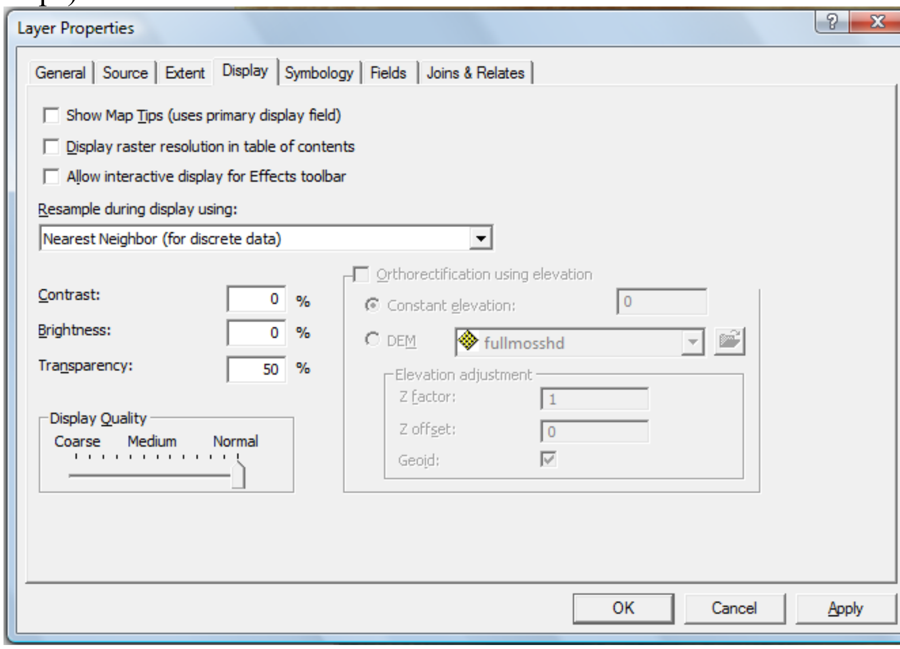


In the Hillshade dialogue box:

- define the input surface (one of your DEMs)
- select the azimuth (315 is default, but try 45 for some variety as well)
- specify the altitude (this is the zenith angle from vertical for the simulated light source)
- Choose Model Shadows (this does a fancier computation which can be annoying at times in LiDAR data with small and tall features). Experiment with this checked and not.
- We don't usually change the Z factor or output cell size.
- Provide a file name to make the hillshade permanent

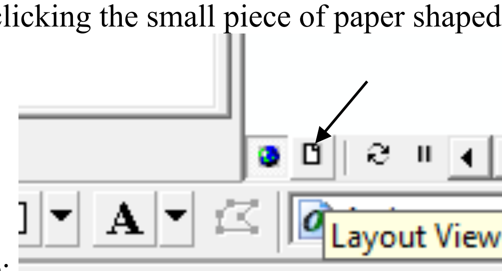
Combine color gradient and hillshade into a map

A nice visualization combines the colored elevations semi-transparently over the hillshade. Make sure that the hillshade is underneath the colored dem (both were produced in the last two steps).



Right click on the DEM file name in the Table of Contents (left portion of the ArcMap window) and choose Properties. Select the Display tab and type 25 or 50% (do some experimenting) in the transparency box and click ok.

Switch from the data view to layout view by clicking the small piece of paper shaped button at the lower right of the table of contents in ArcMap:

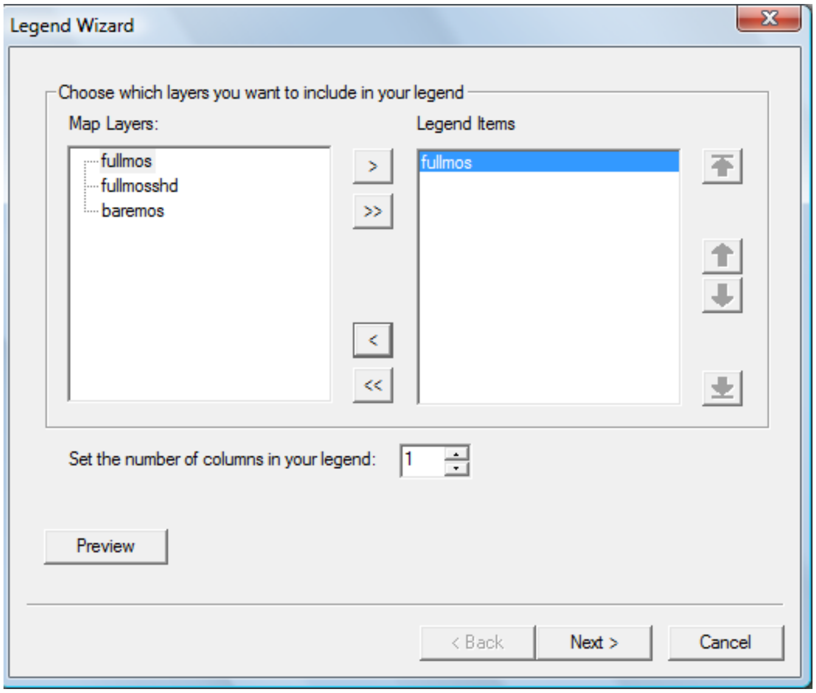


.
You now will see your view of the map as it would appear on a piece of paper once printed. Move the view around with the hand tool and zoom (Tools toolbar).

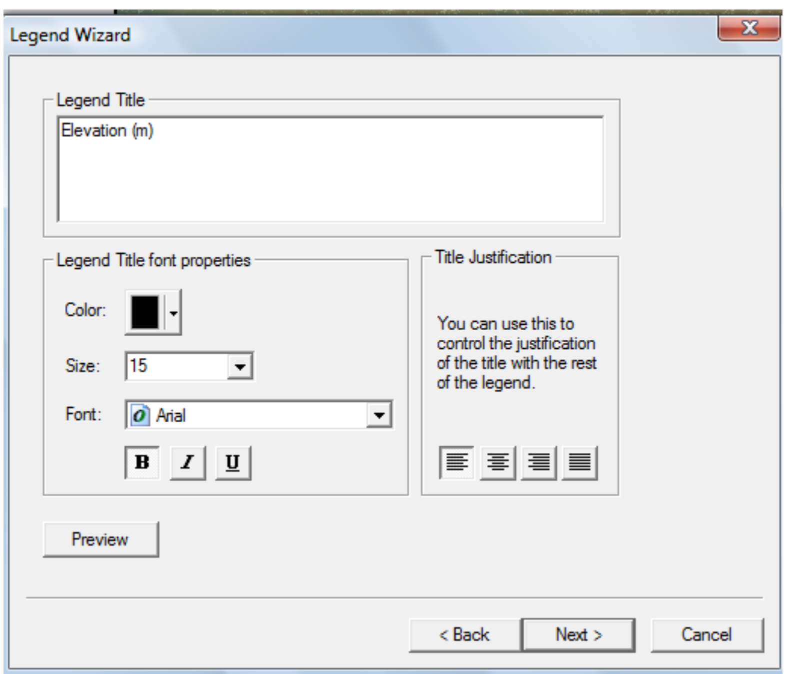
Add a north arrow (Menu->Insert->North Arrow). Move it and resize it as desired.

Add a scale bar (Menu->Insert->Scale bar [click on properties to change the units if necessary]). Move it and resize it as desired.

Add a text box and other annotation using the Drawing toolbar.

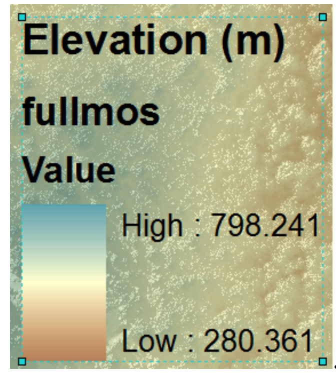


Add a legend (explanation): (Menu->Insert->Legend). Use the left pointing arrow to move all the layers except the DEM out of the Legend Items column. Click Next.

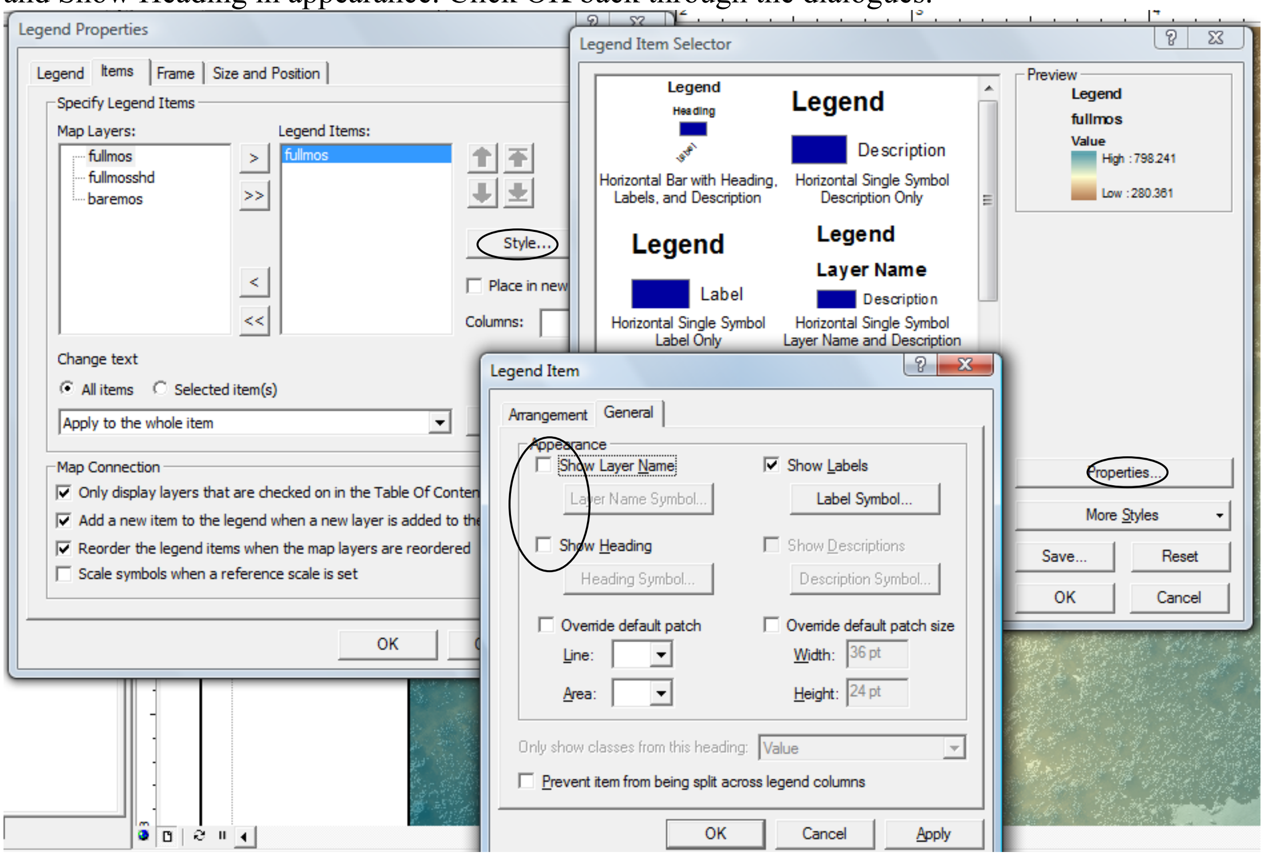


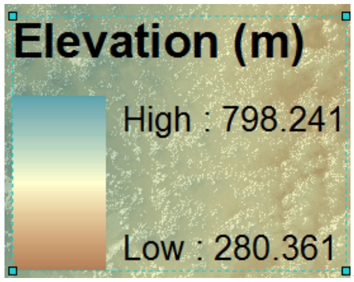
Rename it to Elevation (m). Click Next.

Click through the rest of the screens, leaving the defaults and finish.

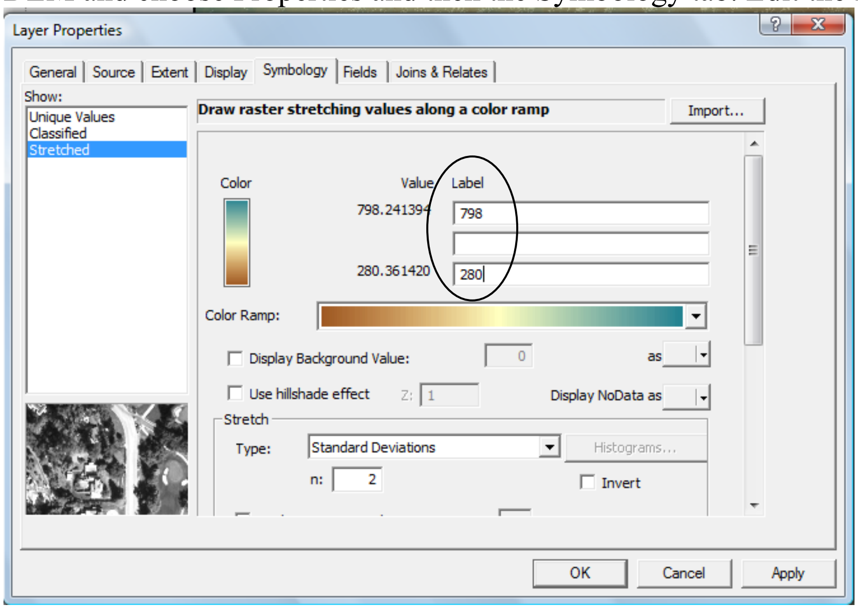
Now you have an Explanation/Legend, but it should be cleaned up: .

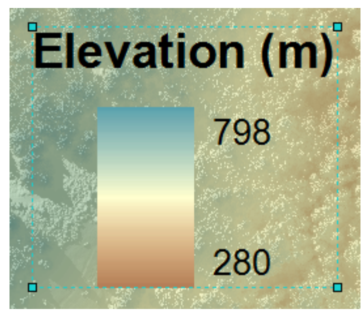
Right click on the Legend and choose Properties. Then click Style at the right of Legend Properties dialogue and then Properties in the Legend Item Selector. Turn off Show Layer Name and Show Heading in appearance. Click OK back through the dialogues.



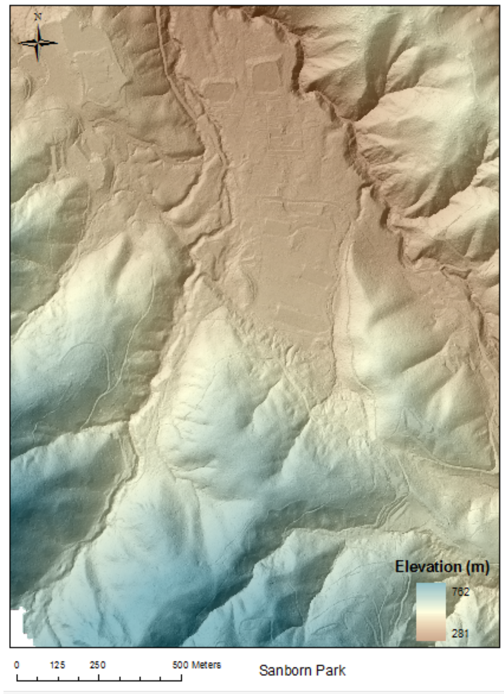
We are getting there 

. To finish off the labeling more cleanly, now go back to the Table of Contents in the left side of the main ArcMap Window and right click on the DEM and choose Properties and then the Symbology tab. Edit the labels to be more appropriate.





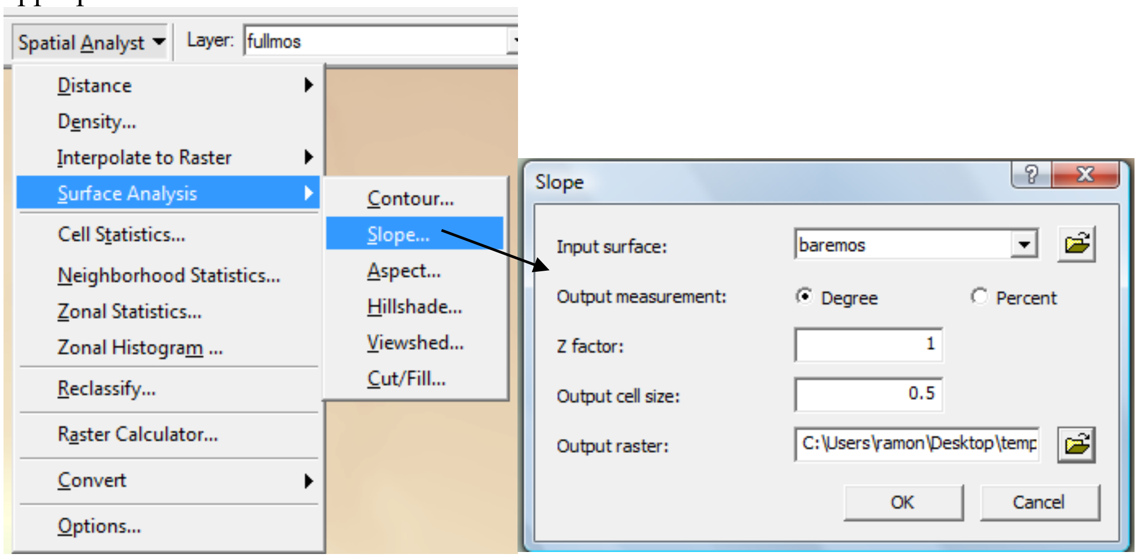
Export the map as a PDF file if desired for other documents.



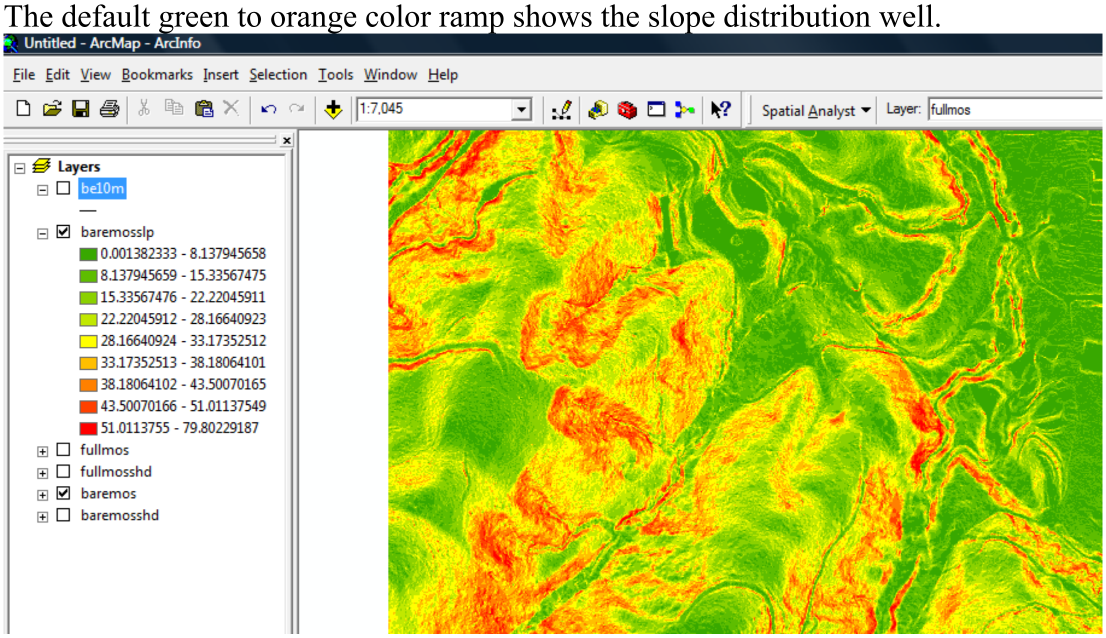
The final map showing the bare earth dataset with the San Andreas Fault trace clearly cutting from upper left to lower right..

Slope and slopeshade

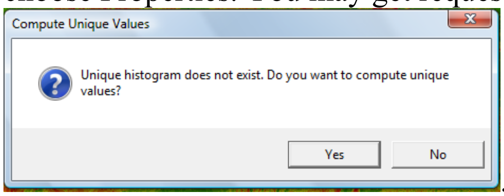
Computing the local slope of the DEM is done similarly as hillshade and contours: Spatial Analyst->Surface Analysis->Slope. Check that the input surface is correct. Usually we compute slope in Degrees. Don't change the Z factor or Output cell size. Give the Output raster an appropriate name and save it with related files.



The default green to orange color ramp shows the slope distribution well.

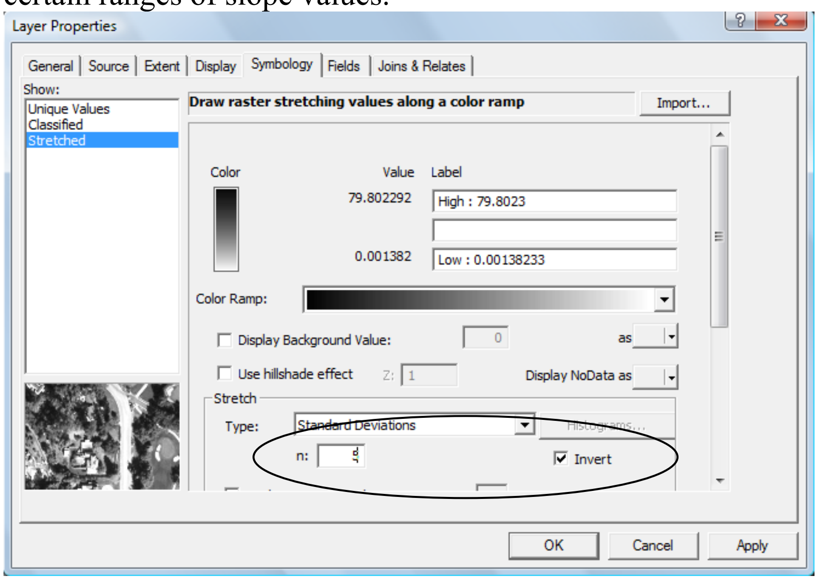


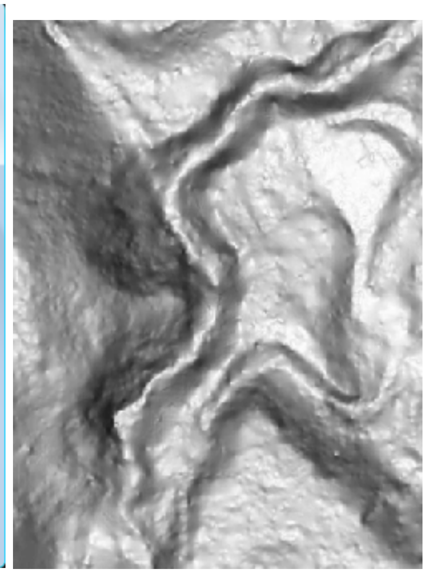
Visualizing the landscape as a "slopeshade" can be useful. Your brain treats it similarly as it does a hillshade, except here it looks as if the illumination comes from all directions. The slopeshade simply takes the slope map and colors it with steep slopes dark and low slopes white (black to white *inverted* color ramp) and stretches the range nonlinearly. Right click on the slope map and choose Properties. You may get request to compute unique values



. Click yes.

An error message about there being too many values may pop up. Click ok. In the Layer Properties, click the Symbology tab. Choose Stretched for what to Show and then choose a color ramp that goes black to white with the high slopes being white. Choose "Standard Deviations" - typically we start with n=5 (default is n=2), but a range of values work depending on what you want to emphasize. You can also tweak the curve on the histogram page to pull out details in certain ranges of slope values.

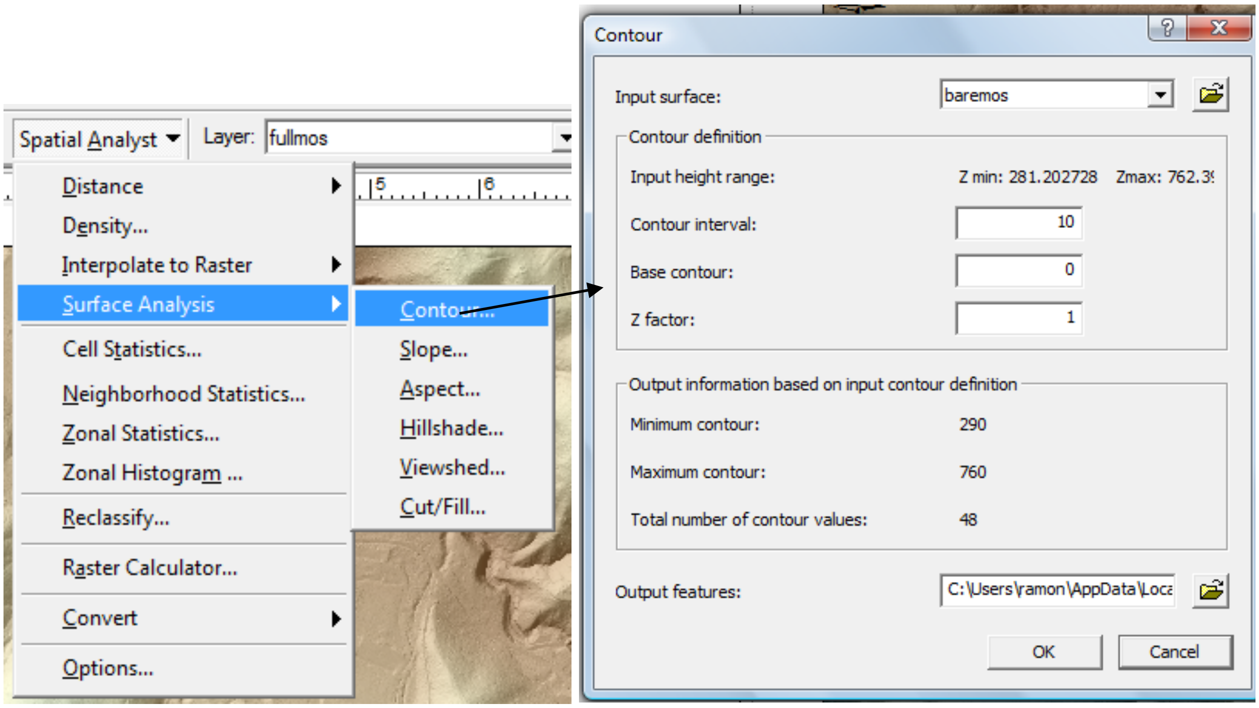




Contours

Use Spatial Analyst to compute contours from one of your DEMs: Surface Analysis->Contour.

In the Contour dialogue box (below right), make sure you choose the correct input surface. Specify the desired contour interval. The base contour should be 0 and keep the Z factor 1. The process will produce an Arc shapefile. You should save it in the same directory as your other DEM data.



To label the contours, right click on the contours shapefile and select Label Features. Usually, the contours will first be labeled by the feature number and not the elevation. To change the labeling to elevation, right click on the shapefile and click Properties. Select the Labels tab. Change the Label field to CONTOURS. Change other characteristics of the label display while you are there as well. For example, under Placement Properties, you can move the labels onto the contour lines.