Tutorials for Introducing ArcGIS into Introductory Geoscience Courses

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Brief Description: This set of three sequential modular exercises first introduces geoscience students to the power of GIS and then gives them experience with the kinds of GIS raster image analysis tasks commonly used by geoscientists.

Context: These exercises are part of a GIS Across the Curriculum effort in the Geology Department at Hamilton College. We use these core exercises in most of our introductory geoscience courses, and we also use them as refresher tutorials and introductory workshops for students in our upper level courses. Completion of the first three exercises is considered a base level of GIS knowledge for students entering the core courses for the major.

Prerequisite skills: None.

Where situated in the course: Because these GIS modules are not content-specific, they can be used at any point in the semester.

Concept goals: Students will become familiar with a suite of GIS tasks that they will use in other GIS assignments. These include working with DEMs and DRGs, creating and working with hillshades, 3D scenes in ArcScene, and shape files (point, line and polygon), and creating and managing attribute tables. Datums, coordinate systems and file management are addressed as well.

Higher order thinking skills goals: Rather than teaching students point-and-click GIS, or techniques without analysis, these exercises teach GIS in the context of solving a geoscience problem or addressing a geoscience question.

Description: The following three sequential tutorial exercises provide students with an introduction to and experience with GIS analysis of raster image data sets.
Mt. St. Helens exercise: Modified from an ESRI Canada activity, this exercise is designed primarily to be a "hook". It quickly gets students into ArcMap and gives them a first hand experience in the power of ArcGIS without bogging them down in background details.
Clinton exercise: Students gain experience in using ArcCatalog, creating hillshades of DEMs, and working with orthoquads. Although this exercise is built around the Clinton, NY 7.5' quad, it could be easily modified for any other quadrangle.
Adirondacks exercise: Students practice skills that they have learned in previous tutorials and gain experience in working with shape files. The primary emphasis of the exercise is to analyze the correlation between topography and bedrock geology in the Adirondacks region. The tutorial also teaches students how to create a finished map view. Although the exercise is built around the Adirondack region, it could be easily modified for any other area where bedrock resistance is correlated with topography.
All three tutorials are contained in the assignment/activity document that can be downloaded below. The data sets can be individually downloaded below; even though the data sets are in zipped folders, they are still large and may take awhile to download).

Evaluation: These tutorials do not have any accompanying assessment. Students are ultimately assessed in later activities and assignments on the basis of whether they can apply what they have learned in the tutorials to new assignments.

NOTE: Occasional blank pages are deliberate and allow the document to be printed double-sided and still have the first page of each tutorial start on an odd-numbered page.

Exploring ArcGIS: Mt. St. Helens Volcano[1]

Launching ArcGIS, opening an ArcMap

- Go to Start and click on All Programs. Click ArcGIS, and select ArcMap.
- In the dialog box, select **An existing map**, and click on **Browse to maps**.
- Navigate to the Academic Software Server, expand the **Geology** folder, expand the folder for your geo course (**GeoscXXX**), expand the folder with your user name, expand the **Mt_St_Helens** folder. Select the file **st_helens.mxd**.
- You will now see an ArcMap window with two portions, the map window on the right and the Table of Contents (TOC) on the left. Both are blank, because you haven't added any data yet.

Adding data to your ArcMap

- You now need to tell ArcMap what data you want it to plot on your map.
- Click on the **add data icon** (yellow diamond with a plus sign), and, in the **Add Data** dialog box, navigate to the **Mt_St_Helens** folder. Shift-click to select both **hafter** and **hbefore**, and click Add.
- You'll now see **hafter** and **hbefore** under Layers in the TOC and a view of one of the data layers in the map window.

Adding the 3D Analyst and Spatial Analyst Extensions and making the toolbars visible

- Go to the Tools menus, and select Extensions. 3D Analyst and Spatial Analyst must be turned on. If the two boxes are not checked, check them both. If they are checked, leave them checked. Click Close.
- We now need to make the 3D Analyst and Spatial Analyst toolbars active. In the **View** menu, scroll down to **Toolbars** and select **3D Analyst**. The 3D analyst toolbar will appear as a floating toolbar that can be repositioned by clicking in the blue bar and dragging the toolbar around. Repeat for the **Spatial Analyst** toolbar.
- Toolbars can be docked out of the way by clicking in the blue bar and dragging the toolbar to the gray area above the main white map window. Dock both toolbars to get them out of the way.

Deleting a layer if you screw up

- If you need to get rid of a layer, right click on the layer name in the Table of Contents (TOC), and choose **Remove**. **This does not delete the original data file from the folder where it is stored**. It simply removes it from your map. ArcGIS has a storage system that is like a filing cabinet. When you add a map layer to an ArcMap, it's like going to the filing cabinet and pulling out a copy of a map to look at. When you remove a layer from your ArcMap, it's like putting the copy of the map back into your filing cabinet, **not** like throwing it away.

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[1] This exercise was modified from one developed by ESRI Canada and posted at http://www.esricanada.com/english/5722.asp

Managing the data layers

- **To hide and show layers:** Next to each layer name in the TOC, you'll see a box with a check mark. Clicking in that box allows you to toggle the visibility of a layer. Toggle the top layer on and off to show the layer underneath.
- **Rearranging the order of layers:** If you decide that you want to have the layers in a different order, simply click and hold on the name of the layer and drag it above or below any other layer in order to switch its position. **Remember that the check box must be checked in order for you to actually see a layer, regardless of its position.**
- Before going on, be sure that **hbefore** is at the top of the list, and make sure that both layers have check marks in the TOC.

You have just added two data layers that don't look like much. Let's do something to make the data easier to visualize.

Making a hillshade of your data layers

- Check to be sure that your **Spatial Analyst toolbar** is visible. If it isn't, repeat the instructions on the previous page under **Making the 3D Analyst and Spatial Analyst toolbars visible**.
- Click on the word **Spatial Analyst** in the toolbar, select **Surface Analysis**, and then **Hillshade**. In the Hillshade dialog box, choose **hbefore** from the Input Surface pulldown, and leave all but the last setting at the default values (315, 45, no model shadows, 1, 30). Click the folder icon next to the Output raster box, and navigate to your **Mt_St_Helens** folder. Call this new file **hshbefore** (for hillshade before). ***Make sure that there are NO SPACES in the name when you type it!!*** Click OK, and be patient while ArcMap does the calculation. Be sure to save.
- Ooooh – wow!! This is what Mt. St. Helens looked like before the eruption of 1981.
- In the TOC, you'll see your new layer (with the name you called the file) appear at the top of the list. You'll also see the map view of your layer, this time as a shaded relief image. You can toggle this layer on and off, and you can move it around just like you did with the other layers.
- Create a hillshade for **hafter** as well, basing the new hillshade on **hafter** and naming the new file **hshafter**. Again, don't put any spaces in the name. Be sure to save!! This is what Mt. St. Helens looked like after the eruption of 1981.

Toggle the top hillshade on off so that you can see the before and after view of Mt. St. Helens? What happened to the mountain as a result of the eruption in 1981?

Viewing your hillshade in 3D

- The extension 3D Analyst allows us to view a hillshade in 3D and rotate the 3D view.
- Check to be sure that your **3D Analyst toolbar** is visible. If it isn't, repeat the instructions on the previous page under **Making the 3D Analyst and Spatial Analyst toolbars visible**.

- Locate the ArcScene icon in the 3D Analyst toolbar. It's the one second from the right hand end of the toolbar and looks like a circle with two yellow Post-Its (if you hold the cursor over an icon without clicking, a box will appear telling you what the icon does – if you have the right one, the box will say **ArcScene**).
- Click the **ArcScene** icon, which launches ArcScene and brings up a new window that has elements that look a lot like ArcMap except that the TOC is headed by the words **Scene layers**, and the menu bar is a bit different.
- Use the **Add Data** icon to add your two hillshades from the **Mt_St-Helens** folder. Remember that you can shift-click to add both at once.
- Save your new ArcScene to your data folder.
- Locate the icon in the ArcScene toolbar that looks like a globe with four arrows. This is the **Navigate** icon. Click on it. The cursor will now look like the Navigate icon, and clicking and dragging the cursor across the map window will tilt and rotate the hillshade that you've added. Right-clicking and dragging will let you zoom the image in and out. The center wheel of the mouse also zooms the image in the map window.
- You can rearrange the two hillshade layers or toggle them on and off. Notice that whatever tilts and rotations you do to one layer automatically happens to the other layer as well.
- Notice, though, that you only have the *illusion* of 3D. Although the hillshade makes it look 3D, the scene is a flat sheet when you rotate it to look at it edge on. So, we need to extrude each pixel according to its real elevation.
- Return the scene to the original orientation by clicking on the globe in the toolbar.
- Right click on a layer name in the TOC, and select **Properties**. Choose the **Base Heights** tab, and click the radio button next to **Obtain heights for layer from surface**. You want ArcScene to get the elevations from your original DEM, so you a have to direct ArcScene to find the right file that has the original elevations for your hillshade. Click the folder icon, and navigate to the original raster image data file (**hafter**, if you have chosen the after hillshade, or **hbefore** if you have chosen the before hillshade). Click **Add.** Don't change the other defaults, and click OK.
- Now, get the **Navigate** tool from the toolbar, and tilt and rotate. You can even view it from below!! If you do both layers, you can toggle before and after eruption to see the effects. Just be sure that you obtain the heights from the correct **original data** layers, not from one of the hillshade layers in your own data folder.
- If you want to increase the vertical exaggeration, right click on **Scene Layers** at the top of the TOC (not on one of your individual layers). Choose **Scene Properties**, and click the **General** tab. Under vertical exaggeration, choose something other than **None**. Click OK. If the scene disappears from view, you've chosen a vertical exaggeration that is too great. If that happens, go back and select a vertical exaggeration of 1.5 or 2. If the vertical exaggeration creeps you out, repeat the process, and change it back to **None**.
- Quit ArcScene.

Back to ArcMap

The data that you originally added to your ArcMap is a set of digital elevation data called a Digital Elevation Model (or DEM for short). Let's explore the data for a minute.

- Turn off the hillshade layers so that only the original hafter and hbefore layers are showing.
- Use the magnifier tool to zoom in on the map until you can see individual squares. Each square is called a **pixel** (short for "picture element" – a digital image is made up a collection of picture elements). The data for this layer includes the geographic location for each pixel, plus its elevation. The shade of gray of the pixel reflects its elevation, with darker pixels having lower elevations than lighter pixels.

ArcMap then electronically manipulates the pixels so that you see the data in different ways. When you asked ArcGIS to hillshade the data, it placed each pixel at its proper elevation, illuminated the scene with an artificial Sun, and showed you which pixels would be brightly lit because they are on slopes that face the Sun and which would be in the shadows because they are on slopes that face away from the Sun. This gives the illusion of 3D because your brain is used to seeing 3D objects with shadows. ArcScene, on the other hand, actually allowed you to extrude each pixel to its appropriate elevation so that the image had shape. Pretty marvelous program, huh?

The kind of data behind a DEM is called *raster data*. In raster data, information is stored for every pixel in the area of interest. Resolution is governed by the size of each pixel footprint. If each pixel represents the average elevation of a 10 m x 10 m square, the resolution of the image (ability to see fine detail) is better than if each pixel represents the average elevation of a 1 km x 1 km square. As resolution goes up for a given area, so does file size, because the number of pixels increases.

Let's explore the issue of spatial resolution.

- Add one more data layer, **lidar_dem**, to your ArcMap.
- Be sure that the two hillshades that you created are turned off.
- Zoom in on the LIDAR data layer until you can just begin to see individual pixels.
- Now we'll use a slick ArcMap trick to compare layers. Go to the main menu bar and select **View**, **Toolbars**, and **Effects**. You'll have a new toolbar with a layer pulldown plus some icons. Choose your LIDAR layer in the pulldown, and then click on the icon that has a horizontal line with a down arrow. This is the **Sweep** tool.
- Click the mouse on the image, and wait until the hour glass disappears. Click on the LIDAR image, and slide the sweep tool from side to side or from top to bottom, revealing the original DEM layer beneath the LIDAR layer. What difference do you see between the two DEMs?
- The resolution of your original DEM layers is 30 m/pixel. In other words, the elevations over a square 30 m by 30 m on the ground were averaged to one elevation value. The LIDAR data has a spatial resolution of **2 m/pixel**!
- Let's see what a difference this makes in what we can see in a hillshade.

- Last, add one more data layer (**lidar_hlsd**). This is a hillshade of the LIDAR DEM data. Zoom in and see what kind of detail you can see! **Remember that this is not an aerial photograph – this is simply elevation data!!**
- Turn your two other hillshades back on, and turn off the LIDAR data layer (leaving the LIDAR hillshade on). Use the swipe tool to compare the LIDAR resolution with the other DEM resolution. If it's not working, check to make sure that the layers are in the right order and that that you've selected the correct layer in the pulldown. You can zoom in and swipe as well.

Nuts and bolts of using ArcGIS and ArcCatalog
Clinton Quadrangle Exercise

In the first part of this exercise, you explored ArcGIS using a ready-made ArcMap file stored in your own folder on the server. In the second part of this exercise, you'll learn how to manage data files (create new files, copy files, etc), get more practice in adding data layers and creating cool views, and working with topographic map layers.

ArcGIS consists of two parts, **ArcMap**, which you have already used to create maps, and **ArcCatalog**, which is the way that ArcGIS let's you see the organization and storage for data files and the maps that you create.

Launching ArcCatalog

- Go to Start and click on All Programs. Click ArcGIS, and select ArcCatalog.
- Much like ArcMap, ArcCatalog has a window divided into two parts, with a Table of Contents (TOC) on the left.
- The Table of Contents (TOC) shows you the organization of folders and files and allows you to copy, paste, rename, and remove files (see sections below).

Creating a folder for your data and maps on the C:\ drive

- For every project the you do, you should create a new folder to organize all of the data and map files that you will create. If you don't do this, you will rapidly have long lists of files that are difficult to organize after the fact.
- Although you will get data from the Academic Software Server and copy your work folder to the server at the end of a work session, ***you should do your work on files that are located on the C drive***, otherwise processing times can be glacially slow.
- In the left hand window (the ArcCatalog TOC), **click on the C:\ drive listing to highlight it.** Go the main menu bar and click on **File, New,** and **Folder.** You'll now see a new folder on the C:\ drive.
- Right click on the new folder, and select Rename. In the file list, change the name to **Clinton**. This name is short, with no spaces. ***Remember that ArcGIS is very picky about file names.*** The name must be short, and you must ***be absolutely certain that there are NO SPACES in any name that you use for files and folders, and there are no oddball characters.*** If you want a space in the name, you must put in an underscore, not a space. ***MAC USERS BEWARE.*** Spaces are OK in Mac file and folder names. They are ***not*** OK in ArcGIS. If you have trouble getting something to work in ArcGIS, the very first troubleshooting thing you should do is check all of your file/folder names to make sure that they have ***no spaces and no long names.***
- When working ArcGIS, it is crucially important to set up new folders that are ***not*** in the Documents and Settings folder and that have **no spaces in the names** into which you can save your files. In Windows Explorer, the default location for saving files is a folder titled Documents and Settings, which, unfortunately, has spaces in the name. Even if you are careful to eliminate

spaces in your file names, saving to the default folder means that you are dead in the water. Make your own new folder where you can save your work.

- And, **don't make a folder on the Desktop** – ArcGIS does not like folders or files on the desktop.

Getting data for this exercise and copying it into your folder

- Be sure that you have ArcCatalog open. You will need to navigate to the Academic Software Server in order to get the data you need for this exercise.
- Scroll toward the bottom of the TOC, and check to see whether the Academic Software Server already appears in the list. If so, skip to the next step.
  - If the Academic Software Server isn't listed, click on the "connect to folder" icon (the one with the horizontal yellow arrow).
  - In the dialog box that comes up, replace the words **My Computer** with **\\software\academic\geology\\.** Be sure to use back slashes, rather than forward slashes. Click OK.
- In the ArcCatalog Table of Contents column at left, expand **\\software\academic\geology**, and choose the folder for your Geo course.
- Expand the Geosc_Data folder. This is the place where you will find all of the GIS data and files for this course.
- Right click on the **Clinton** folder, and select **Copy.**
- Expand the C:\ drive in the TOC. Right click on your new data folder, and select **Paste**. You should now have a folder inside your own folder on the C:\ drive that is titled **Clinton**.

Preview data

- Be sure that ArcCatalog is open.
- In the TOC window, expand your folder on the C: drive. Expand the **Clinton** folder, and **Clinton_Data.** Inside Clinton_Data, and you'll find two folders, **Clinton DEM** and **Clinton DOQ**.
- Highlight the Clinton DEM in the TOC window by clicking once on the name. Click on the **Preview** tab in the right hand window. If a dialog box comes up asking whether you want to create pyramids, say **yes**, and wait while pyramids are created.
- Make sure that the pulldown menu at the bottom is set to **Geography**. In the Preview window, you will see a preview of what the DEM looks like, although you won't be able to do anything with it. Then preview the **o43075a4.tif** file in the **Clinton DOQ folder.** This is a digital version of the Clinton topographic quadrangle map.
- To see the digital orthoquad better, select the **magnifier** from the toolbar, and enlarge the view by either repeatedly clicking or by dragging a rectangle of what you want to see. Then select the **hand** tool and drag the image around to see other parts. To return to the full-frame view, just click on the **globe** to the right of the hand.

Creating a new ArcMap file and adding the Clinton DEM

- Launch ArcMap from ArcCatalog by clicking on the globe in the tool bar immediately to the left of the red toolbox. OK a new empty map. Toggle the window expansion so that the ArcMap window fills the screen.
- *******Saving Relative Pathways in ArcMap.** Before saving an ArcMap .mxd file to your folder, make sure that you will be saving **relative**, rather than absolute, path names. Go to File, Document Properties, Data Source Options, and select "Make relative pathways the default for new map documents that I create." *******This is absolutely crucial. When you start a new session in the GIS lab, you should always check this in case the computer you are working at has been reimaged or in case someone has changed the default.**
- **Save your map file.** Select **Save** from the File menu. Navigate to the C:\ drive, and select your data folder. Name your new map **clintonmap. NO SPACES!!!** ArcMap will automatically add the suffix .mxd when you click Save.
- **Add the Clinton DEM that you previewed in the previous step.**

Coordinate systems and projections

Translating a curved surface to a planar (flat) view results in distortions. Different coordinate systems and projections have been developed to minimize these distortions.

When you bring a data set into an ArcMap document, the map document takes on the coordinate system and projection of the first data set added to the map (assuming that the data set has a defined coordinate system and projection). The map will retain this coordinate system and projection even if you delete all the layers you have added to a map.

- Now that you've added the Clinton DEM to your ArcMap, let's check the coordinate system and projection that you're working in.
- Right click on the word **Layers** at the top of the ArcMap TOC, and select **Properties.** choose the **Coordinate Systems** tab, and write down the coordinate system and projection (e.g, NAD_1927_UTM_Zone_18N).

Renaming the Data Frame with the projection name

- It's a good idea to get into the habit of renaming the Data Frame with the coordinate system and projection name so that you don't lose track of what the coordinate system and projection in which you are working.
- Click on the word **Layers** at the top of the TOC to highlight it. Click again, and change the name., typing in the projection as the Data Frame name (*e.g.,* NAD_1927_UTM_10N).

Renaming a layer

- If your layer names are a bit cryptic, you can rename any layer by highlighting the layer name, clicking again (not a fast double-click), and typing in a new name.
- You can also do this by bringing up **Layer Properties** (either by double-clicking on the layer name in the TOC or by right-clicking on the layer name and selecting **Layer Properties**. Click the

General tab, and type a new name in the layer name box, and click OK. TOC layer names (and legend items) are about the only things in ArcGIS that are OK with spaces in the names.

- Just as deleting a layer doesn't delete the original data file, renaming the layer doesn't change the name of the original data file in ArcCatalog. If you rename something and can't remember what the file was originally, just double-click on the new layer name to bring up the Layer Properties dialog box (or right-click and select **Layer Properties**), and click the **Source** tab. Under **Data Source**, you'll see the location and name of the file that your layer is made from.

Changing the display coordinate system to lat/lon

- Move the cursor around in the map window, and watch the numbers changing in the lower right hand corner of the map window. These numbers give the exact location on the surface of the Earth of the tip of the cursor. The default coordinate system isn't easy for us to visualize, so we'll switch it to the familiar latitude and longitude coordinate system.
- Right click on the word **Layers** in the TOC, and select **Properties** to open the **Data Frame Properties** window. Click on the **General** tab, and, under Units/Display, select **Degrees Minutes Seconds**. Click OK.
- Moving the cursor over the map will now give coordinates in degrees, minutes, and seconds, with longitude first.

DEMs (such as the ones you worked with for Mt. St. Helens) do not have geographic or cultural information, and, unless you are really familiar with an area, you may not recognize individual geographic features just by looking at the DEM. We can combine a DEM with other kinds of map data to create a composite map with different layers contributing various components to the final map. What we'll do next is to take a DEM from the Clinton, NY quad and combine it with what's known as a digital orthoquad – a digital version of the standard USGS topographic map. The composite map, with variably transparent layers, will let us locate geographic features while still being able to visualize the three dimensional shape of the land surface. Combining the DEM with a quadrangle map is made possible because the data files are ***georeferenced***. In other words, there is information in the files (the metadata) that can tell ArcMap exactly where in the world the map is, what its scale is, and what technique was used to project that portion of the Earth's sphere to a flat map surface. If any of these pieces is missing, or if the projection method of the DEM doesn't match the projection method of the orthquad, you can't combine the maps successfully. This is not a trivial issue. We have Dave Tewksbury to thank for all the work he did to make sure that these files would work for us in this exercise.

Superimposed topo features on a DEM hillshade

- Add the **Clinton orthoquad**. For the orthoquad, be sure to select the raster file in the list (the one with the raster file icon and the .tif extension). Rename the orthoquad layer as **Clinton orthoquad**. Save.
- Add the Spatial Analyst extension, and make the toolbar visible.
- Make a hillshade from the DEM layer (****remember to select the Clinton_DEM as the Input Surface!!!)**. **Be sure to save the hillshade to your data folder in the Clinton example.** Again,

you'll need to navigate, because the default folder that will likely come up will be your data folder for the Mt. St. Helens example.

- You'll now see the hillshade layer in the TOC. Rename it, if you like.
- Re-order the layers in the TOC so that the Clinton orthoquad is the top layer (click, drag, and drop).
- An orthoquad is a raster image. Zoom in until you can see individual pixels in your orthoquad layer. Because this is a raster file, ArcMap knows what color every pixel is in the file, and we can selectively replace pixels of a particular color with a new color or, as we will do in this exercise, with no color, in order to make the pixel transparent.
- The first thing we'll do is make the white background of the map disappear. Zoom out using the globe tool. Expand the Clinton orthoquad layer by clicking on the plus sign next to the layer name. Right click in color box #1, and select **No color**. Zoom in, and admire how you can now see a whole lot of the hillshade below. But, there are still some patches we'd like to get rid of, while still keeping some of the geographic features on the map.
- **Remember if you screw up, you can always remove the layer and add it again from the Clinton data file folder.**
- Do the same for color boxes 5, 6, 7, 9, 10, and 11. Don't do 4, 8, and 12!!! This will turn off all of the aspects of the map that are colored any other color except brown (topo lines), red (roads), blue (water), and black (labels, buildings, etc.). Use the magnifier tool (you can dock the floating tool bar, if you want) to browse around and check out how beautifully the streams lie in the bottoms of the valleys on the DEM and how beautifully the steep slopes correspond with the closely-spaced topo lines! Check out the College, and find Root Glen on the DEM. Ditto Kirkland Glen.

Proving to yourself that the orthoquad is in the right place

- Did ArcMap put the digital orthoquad in the right place geographically? You can easily check this. Zoom in on the lower right hand corner of the image until you can read the lat/lon coordinates on the digital orthoquad. Position the cursor so that it lies right at the corner of the quad, and check to see if the lat lon value for the cursor (shown in the information box at lower right) matches the values printed on the map. They should!!

Adding character by colorizing your hillshade

- Make sure that the order of layers in the TOC is, from top to bottom, Clinton orthoquad, hillshade, and Clinton DEM. If that's not the order you have, rearrange by dragging and dropping.
- Go to the orthoquad layer and get rid of the brown topo lines by selecting **no color** for colors 4 and 12 (right click on the color box, and select **no color**).
- Right click the **hillshade** layer, and scroll down to Properties. Click the **Display tab,** and change transparency to 50% by typing in **50**. **Do NOT click OK.** Drag the properties window partly out of the way so that you can see most of the map. Click **apply**, rather than OK. This allows you to try out various transparencies before committing yourself. You can also play with contrast and brightness – try a contrast of 30 and a brightness of 5 for starters. Once you have what you like,

and can see the DEM through the hillshade, click **OK**. You can always go back and change this later, if you change your mind as you go along.

- This is a better image, but it's still a little blah. Let's colorize it!
- Right click on the Clinton DEM, and select **Properties**. Click on the **Symbology** tab. Make sure that **Stretched** is highlighted in the left column, and right-click on the black-to-white color bar. Select **Graphic View** to uncheck it, and the color ramp should now have text instead of a color gradation in it.
- Scroll down to **Elevation #1**, and select it. Set the **Stretch type** to **None**.
- Click **apply**, and drag the Layer Properties window out of the way to see what you've done. Wowee! You can check out other color ramps as well. When you have what you like, click **OK**, and save.
- To see what the DEM looks like all by itself, you can turn off the hillshade. If you do this, you'll see why both the hillshade and the colorized DEM are necessary for the full 3D effect.
- Your map may look a little faded with the transparency of the hillshade set to 30%. That's because you're looking through a hillshade that is only 30% transparent. You can adjust the transparency of the hillshade so that you can see more of the color of the DEM through it.
- Zoom in and pan around the Clinton area!!

One more super-fun thing to try: creating a 3D topo map and viewing it in 3D

- Start a new ArcMap document.
- Add the Clinton digital orthoquad (DOQ) and the Clinton DEM.
- Hillshade the DEM. With the hillshade **above** the DOQ in the TOC, adjust the transparency of the hillshade by right clicking on the hillshade layer in the TOC, selecting Properties, and then the Display tab.
- Enter contrast 30, brightness 5, transparency 50. Be sure that the display quality slider is set to **Normal**. Click **Apply**. You can experiment with contrast, brightness and transparency if you want to before clicking OK.
- This is how shaded relief maps like you see in *National Geographic* are made. The key to making them is to be sure that the hillshade is the top layer.
- To look at the map in 3D, go to ArcScene as before. Add the Clinton DOQ, and right click on the DOQ, select **Properties**, and the **Base heights** tab.
- Click the radio button next to **Obtain base heights from..**, and browse to the Clinton **DEM** (not one of the hillshades), and select it. Click OK.
- Right click on the DOQ layer, and open **Properties.** Click on the **Rendering** tab. Under the **Effects** box, check "Shade areal features relative to the scene's light position". Under **Optimize**, drag the **Quality Enhancement Slider** to high. Click OK.
- The screen re-draw will take a few minutes, because it is rendering a nice, less pixelated version. You should now have a smooth map but without much appearance of relief.
- Right click the **Scene Layers** at the top of the TOC, go to **Properties**, and select the **General** tab. In the vertical exaggeration, highlight the zero in the box, and type in 2.5. Click OK.
- You'll now have a 3D topo map that you can view from multiple angles.

- For extra super fun, right click on **Scene Layers**, select **Properties**, and select the **Illumination** tab. Drag the dialog box to the upper left corner so that you can see your scene. Drag the contrast slider to 100%. Click on the Sun in the Azimuth Box, and drag the Sun around the compass rose and watch how the illumination in your scene changes. Oooooooh!
- This is a technique that people use to highlight features that would never be shaded that way in the natural world.

Adirondack Geology Exercise
DEMs and Geologic Maps

DEMs can be made in a variety of ways. Elevation data can be digitized from existing topographic maps, with elevations interpolated between contour lines. That's how the DEM was created for the Clinton exercise that we just did. In the Adirondack exercise that we're about to do, the DEM was created from surface elevation data measured from space by the Shuttle Radar Topography Mission (SRTM).

The SRTM data base is a remarkable worldwide digital elevation data set for about 80% of the Earth's land surface. It took 10 days (only 10 days!!) to collect all of the data! The data set covers all land areas between 60°N and 56°S latitude (higher latitudes were excluded because of the inclination of the Shuttle orbit, which was 56°. The resolution of SRTM data is 30 m/pixel for the highest resolution data. The mission was flown in February of 2000, and one of the mission specialists, Janet Kavandi, was also on the mission that flew in July 2001 that flew the Hamilton College banner that's hanging in the Geo Department.

Previewing the files for the Adirondacks

- Go to ArcCatalog, and navigate to the **Adk_Tutorial** folder in your class Data folder on the server. Copy the folder to your C:/drive. Expand the Adk_Tutorial folder. In that folder, you'll see a number of items that contain data that we have available to add to the map that we'll make in ArcMap.
- Open the **Adk_Data** folder inside the **Adk_Tutorial** folder. Preview the **Adk_mosaic** file. It has a familiar icon – you should recognize this by now as a raster image. In the **Preview** window, the DEM should look familiar! If you are familiar with New York State geography, you will recognize the dark-colored (low elevation) strips: the St. Lawrence River Valley to the northwest, Oneida Lake and the Mohawk River Valley to the south, and the Champlain and Hudson River Valleys to the east. Clinton is on this DEM, but it's hard to locate unless you're really familiar with the geography.
- Most of the rest of the files in this folder are **shape files**. Preview **roads**, **rivers**, and **faults**. These are all **line** shape files. Preview the rock units shape files. These are **polygon** shape files. **Preview** the towns file. It's also a shape file, but the data are **point data** (hence the dots in the icon).
- Shape files can consist of data as points, lines, or polygons, but an individual shape file cannot have more than one kind of shape data. So, the roads (lines) and towns (points) have to be in separate shape file. This is useful, because you might not want to have both on your map at the same time.
- Go back to the Adk_Tutorial Folder, and preview the **LF_orthoquad.tif** file. This is like the Clinton orthoquad that you worked with in Part I of this tutorial.
- Go back to the Adk_Tutorial Folder, and open the **LF_ortho_phot** folder. Preview LF_orthEUTM, and use the zoom tool to zoom in and look around a bit. It's an aerial photograph, another type of raster image.

Making an ArcMap

- Launch ArcMap, and open a new empty map. **Before you save, make sure to check under File, Document Properties, Data Source Options to be sure that you are saving relative pathways.** Save the map to your C:/drive. **Remember! No spaces in the name! Short name!**
- Add the Spatial Analyst Extension, open and dock the toolbar for Spatial Analyst, if it is not visible (View, Toolbars, etc.).
- Add the **Adk_mosaic** raster file.
- Create a hillshade for the Adk_mosaic layer. Change the **Z factor** to 2 to increase vertical exaggeration, and **be sure to click on the folder next to <Temporary> to save the hillshade** (otherwise, it will go away).

Adding bedrock faults

- Add the **nyfaults.shp** shape file.
- Zoom out to show the entire map (click in the globe on the toolbar), and you'll see that the layer has faults mapped for the entire state. Zoom back in on the portion that has the bedrock geology (select a box with the magnifier tool, or right click on the bedrock layer and select zoom to layer).
- ArcMap assigned an arbitrary color to the faults, but you can change the color if you don't like it or it's hard to see. Right click on the line **in the TOC** below nyfaults, and choose whatever color you'd like better. You may want to zoom in to check your choice. You can also make this layer a bit transparent, if you want.
- Zoom in on the Adirondack region, and pan around, looking at the faults and the topography as shown on the hillshade.

What general correlation exists between features in the topography and the locations of faults in the bedrock in the Adirondacks?

Offer and defend and explanation for the correlation.

Adding information about bedrock geology

- Now we're going to have a look at the influence of bedrock type on topography.
- Go to the **rock_units** folder, and add the **marbles.shp** and **gneisses.shp** shape files. Make them both 50% transparent. Then, change the colors for each. Right click on the color box for **gneisses** in the TOC, and choose **cantaloupe** (2^{nd} row, 3^{rd} from left). Change the color of **marbles** to **light vert** (3^{rd} row from bottom, 5^{th} from right). Save your work.
- **Before going on, answer the following background questions.** These questions will help you think about the differences between marble and gneiss.

  Marble is a carbonate rock, the metamorphic version of limestone. Given what you know about limestone, what would you predict about the dominant mechanism of weathering of marble in a wet climate like ours? Explain.

  Given what you know about limestone and what you have predicted about weathering of marble, what would you predict about the relative resistance of weathering of marble and gneiss? Explain.

- Add the **zoombx1.shp** shape file, and right click to change the fill to **no fill** and left click to change the outline to **black**. Zoom in to the box in the NW. You'll see that the bedrock geology is dominated by gneisses (peach) and marbles (green).
- Turn off the **gneisses** layer so that you can see the topography clearly. Now, toggle the marble layer on and off, and look for correlations between the topography and where the bedrock is marble and where it is gneiss (in this area, virtually everything that isn't marble is gneiss). Zoom out and then zoom in to the box in the central Adirondacks. Turn on the both the **gneisses** and **marbles** layers to see where they are, then turn off **gneisses** and toggle the **marbles** on and off.

  What correlation exists between topographic features and the location of marble vs. gneiss in the bedrock of the Adirondacks? Is this consistent with what you predicted? Why? Explain.

- Hide the zoombox layer, and turn the **gneisses** layer back on again.
- Add all of the remaining rock unit layers **except** bedrock.shp. Change colors, if you find that some look too much alike. Make each one partially transparent so that you can see the hillshade underneath.

Determining scale

- How big are things on this map? Right click on the word **Layers** at the top of the TOC, and choose Properties. Click the **General** tab, and change **Display** to **Kilometers**. Click OK.
- Find the measure tool in the toolbar (looks like a ruler). Click at one end/side of what you want to measure on the map (center the cross), and drag to the other. Double click to end. The length in kilometers appears in the lower left of the screen.

Adding towns

- Add the towns shape file. A dot appears on your map for each town.
- To find out the name of a town, you can select the **Get Info** tool in the toolbar (the blue circle with the "i" in it), and click on any town dot. Make sure that the **towns** layer is the one selected or you will get info on a shape in a different layer. When you click on a town, you'll see all the information in the data base for that feature.
- You can also see the data behind what appears on the map. Right click on the towns layer, and select **Open Attribute Table**. Look at all of the information that's stored behind the scenes!!
- Because the town names are in the attribute table, we can add the labels for the towns to the map. Navigate to properties for the **towns** layer, and click the **Labels** tab. Click **Label Features in this layer**. Make sure that **Label all the features the same way** is selected in the **Method** scrolling menu. Scroll the field next to **Label Field**, and you'll see all of the possibilities for labeling each town (the list represents all of the columns in the attribute table that you just looked at). You can label the dots in the towns layer with any one of these attributes , but we'll choose **NAME**.
- Use the default font, size, and color, although you can change these later if you want. Click OK. Be sure to save!
- Zoom in to a portion of the geologic map. If you don't like the symbol and symbol color for towns, you can change it easily. Left click on the town symbol **in the TOC**, and you'll see a menu where you can change symbol size, color, and shape. Play around, if you want. Click OK.
- **Remember that you can always hide a layer by clicking in the check box in the TOC.**
- **Locate Lyons Falls.** Remember on the field trip that we were wondering why the falls at Lyons Falls was there? Add the **Black_R_dem_tif** and hillshade it. You can also add the Port Leyden topo map, if you want (**pleyd_topo.**tif). Move layers around, and turn things off, if you need to in order to check your various layers.

Why are there falls at Lyons Falls? Explain, citing evidence from your ArcMap.

Adding streams

- Add the streams shape file. Change the colors so that streams are blue. Be sure to save!

Locating the Hudson River

- We could add all of the river names if we wanted to, just as we added names for the towns. But, this would make our map too messy. We could also find the Hudson by using the Get Info tool and clicking rivers in the area where we think the Hudson is until we find the right river. But, ArcMap makes it easy to find the Hudson. Basically, we'll ask ArcMap to find the Hudson for us and show us where it is. This is called querying the database.
- Right click on the **streams** layer in the TOC, and choose **Selection** and then **Make this the only selectable layer.** In the main ArcMap menu at the top of the screen, go to **Selection**, and **Select by Attributes.** You've now told ArcMap that you want to search only the streams layer and that you want to search by some attribute (in this case, river name) that is stored in the database.
- The **Select by Attributes** window is basically a database search engine that has a calculator-like interface where you ask ArcMap to search for values that meet specific criteria.
- Click **Only show selectable layers in this list**, to limit your choices to what's stored in the streams database. Be sure that **Method** is set to **Create new selection**.
- The scrollable box list, in alpha order, all of the attributes of streams that you can search the database for. You want to search by name, so scroll down to **NAME**, and double click on it to add it to the box below.
- In order to find the Hudson River, we want to search the database for the line whose name is Hudson River, so click the **=** box to add an = sign after NAME, and then click the box **Get Unique Values**. Scroll down and double click on Hudson River. What you should now have in the box is the following: "NAME"='HudsonRiver'. If this isn't what you have, try again, following the instructions carefully. Click OK.
- Zoom your map until you see a bright blue line, identifying the Hudson River. You can use the Get Info tool to check to see if it's right.
- You can deselect the Hudson and return it to normal by going to **Selection** and choosing **Clear Selected Features**. You can always select it again, if you need to.
- Be sure to save!!

Finishing the bedrock geology and colorizing by rock type

- If we want to see the full bedrock geology, we'll need to add a new layer and turn off a few. Start by turning off **rivers and towns.** Add the **bedrock.shp** file.

- **In the TOC**, move the bedrock layer so that it lies below streams, towns, and faults in the list, but above the individual rock units in the list.
- Zoom all the way out by clicking on the globe in the navigation bar. Notice that, even though the geologic map and the DEM don't cover the same area, ArcMap knew where to put each and how to scale them because both files are appropriately *georeferenced*.
- We can zoom in right to the bedrock layer by right clicking on **bedrock** in the TOC and selecting **Zoom To Layer**. That will fill the screen with just the bedrock layer.
- The default setting is for ArcMap to assign a single, randomly-selected color to all of the polygons in this file, so the map is all one color. We'll now ask ArcMap to assign colors to various areas on the map based on their bedrock types as contained in the database.
- Right click on the bedrock layer, and choose Properties. Click the Symbology tab. In the left hand column, select **Categories**. In the **Value Field**, scroll down and select **Material** (i.e., rock type). Now we need to add values for materials.
- Below the white window, click **Add All Values**. By doing this, you have asked ArcMap to make a list of all of the polygons with different rock type attributes. ArcMap arbitrarily assigns a different color to each rock type, which is coded in the list by abbreviations such as Cbk, Op, etc.
- Before clicking OK, **uncheck** "All Other Values" at the very top of the list. Click OK. ArcMap redraws the geology layer with colors based on the type of rock represented by each polygon.
- Let's change the color of the layer that shows the rock type *anorthosite*. Scroll down the list under the bedrock layer header, and locate the color box labeled "a" (for "anorthosite"). Right click in the color box, and select a bright yellow. ArcMap will redraw the geo map with bright yellow wherever there is anorthosite on the map. You can change colors of any of the other fields, if you want.
- Turn on the zoombox1 layer, and zoom into the central Adirondacks box. Make sure that the gneisses and marbles layers are turned on as well. Toggle the bedrock layer off and on, and you'll see that the bedrock geology is more complicated than it first appeared. When I created the **gneisses** layer for you, I lumped several different types of gneisses together to simplify things.
- You can collapse all of the color boxes in the TOC by clicking the minus (minimize box) next to the layer name. Save your work!

Adding the Little Falls Orthoquad and Orthophotos

- Click on the Globe in the toolbar to zoom out to full map view.
- Add the Little Falls topographic quadrangle (LF_orthoquad), located one level up from the Adk_Data folder in the Adk_Tutorial folder. Right click on the bedrock layer and select zoom to layer. **Remember that, once you've added this layer, you can change color boxes 1, 4-7, and 9-12 to "No color", leaving color boxes 0, 2, and 8 the way they are (black for 0, red for 4, and blue for 2 and 8).** If you mess up the colors, you can always add the orthoquad again. Remember that changing the colors in ArcMap doesn't change the original file.
- Add the two orthophotos, which are located in the LF_ortho_phot folder. Zoom in and look at them.

- Did the orthophotos register perfectly with the orthoquads? How about with the DEM? Remember that you can make layers partially transparent as well as drag them around in the TOC so that you can have them in the order that you want.

Creating a swell-looking map in ArcMap

Simple printout – just what you see on the map screen

- Start by turning off the layers you don't want to have on your printout. ArcMap will print only the layers that are visible (i.e., that have check marks next to the layer names)
- Then, zoom in or out to what you want to have on the printed page. ArcMap will print whatever shows in the map window.
- From the main **File** menu, select **Page and Print Set-up**. Make sure that the paper size is set to **Letter**, and choose either **Portrait** or **Landscape**. Be sure that the box **Scale Map Elements…** at the bottom is checked. Click OK.
- Under **File**, you can **Preview** the page, if you want.
- When you are ready to print, select **Print** from either the **Preview** window or from the main **File** menu.
- If you want to print in color, export your map as a jpeg or pdf (under the main File menu) (see page 6 for details), and insert it into a Word file or open it in Acrobat Reader.

Map with north arrows, scale bars, etc.

You can make a labeled map from any section of your document. Here's how.

Selecting what will appear in Layout View

- Whatever appears in the ArcMap window will be what you'll see in Layout view.
- Zoom to the portion of the file that you want to show, or zoom all the way out to include the entire file in the view.

Viewing the layout

- Below the regular ArcMap window, you will see two icons, a globe icon and a page icon. The globe icon takes you to the regular global view where you add and modify layers in ArcMap. The page icon takes you to the Layout view.
- Toggle back and forth to see the difference.
- In Layout view, clicking on your map will bring up a **Data Frame**. The colored outline and boxes of the Data Frame must be visible any time you want to modify the Data Frame.

Moving around in the layout view

- **If you use the regular zoom and pan tools in the layout view, you will change what appears in the Data Frame.** Remember that only what appears in the data frame will print.

- If you want to zoom your layout view **without** changing what's in the Data Frame, you have to uses the layout Zoom and Pan tools in the layout menu bar (the ones with the little page icon under the Zoom and Pan icons).

Setting the Page Set-up for your Layout View

- Go to the **File** menu and select **Page and Print Set-up.**
- In this dialog box, you can select a printer, page orientation (landscape or portrait), and paper size. **Be sure to check the box labeled *Scale Map elements proportionally to changes in Page Size*** (this is at the bottom of the dialog box). For your Nile map, select 11x17 paper size (at the very top of the list). And **be sure to also click Use Printer Page Settings** in the Map Page Size.
- Click OK.

Change the size and position of your Data Frame

- Be sure that your data frame is selected. Clicking and dragging will **move** the data frame.
- Clicking and dragging a side handle will make the data frame shorter/taller or wider/skinnier (e.,g., if you want to bring the border closer to the object inside the frame)..
- Clicking and dragging a corner handle will scale both height and width of the frame and what is in the frame.

Adding scale, north arrow, etc. to your Data Frame

Any of the items that you add below can be removed by selecting them a hitting the delete key. **Start by selecting the data frame in the layout view using the selection tool (black arrow) in the main toolbar.**

- **Adding a neat line**
    - From the **Insert** menu, select **Neatline**. Choose the kind of border you want, and click OK.

- **If you don't want to have either a neat line or a frame around the object.**
    - Even if you don't add a neat line, the default setting will put a black frame around the data frame. If you don't want this, right click on Layers in the TOC, and select **Frame**. Under **Border**, scroll up to None. Click OK.

- **Adding a north arrow**
    - From the **Insert** menu, select **North arrow**. Choose the kind of north arrow you want, and click OK.
    - The north arrow appears in your Data Frame. To move it around, click on it to highlight it, and move it or scale it by dragging the handles.
    - To modify your north arrow, double-click on it, and choose a new color or a new style.

- **Adding a title**

- From the **Insert** menu, select **Title**.
- The easiest way to add and modify a title is to click anywhere outside the title to deselect it, and then double-click on it to bring up the properties box.
- Type your title into the text box.
- To select fonts, sizes, and colors, go to the bottom of the main screen to make selections.. Clicking apply instead of OK lets you test out options.
- When you're happy with what you have, click OK.
- To move the title around, click on it to highlight it, and move it where you want it to be.

- **Adding a scale bar**
  - Go to the Layer Properties, and select the General tab. Choose the display units that you want. Choose something practical, because this is what will appear on your scale bar.
  - From the **Insert** menu, select **scale bar**. Choose the kind of scale bar you want, and click OK.
  - The scale bar appears in your Data Frame. To move it around, click on it to highlight it, and move it or scale it by dragging the handles.
  - To modify your scale bar, double-click on it, and make new choices.

- **Adding a callout box**
  - In the drawing menu, click on the down arrow next to the Text tool (the A). Select the callout box (looks like a cartoon caption). Click on the map layout and drag. Type your text into the textbox, and format it using the text formatting tools in the Drawing toolbar.
  - Hit Enter.
  - To move the end point, select the callout box, and click and drag the end point. Ditto for the box.
  - If you want to change the text in the box, double click on the text in the box, and enter the text in the dialog box.

- **Adding a text box (this kind of a box won't have a leader)**
  - From the **Insert** menu, select **Text**. Again, it's easiest to click outside to deselect it and then double click to bring up the options box.
  - **Text does not wrap in this option**. You will have to add returns where you want them.
  - Type what you want in the **text** box, and use the bar at the bottom of the main window to make choices about text font, size, and color. Click OK.
  - The text appears in your Data Frame. To move it around, click on it to highlight it, and move it or scale it by dragging the handles.
  - To modify your text, double-click on it, and make new choices.

- **Adding a leader or a line with an arrow**

- Find the Drawing icons at the bottom of the main window. Click on the line icon, and select the line tool.
- Draw your line, and double-click to end the line. Double-click on the line to bring up the properties box, and, if you want an arrow, go to **Change Symbol** and scroll to the bottom. Click OK.

- **Adding the Hamilton GIS logo**
  - If you want to add the Hamilton GIS logo to your map, from the **Insert** menu, select **Insert Picture**. Navigate to the main level of the Geosc103_Data folder, and find geoGIS.tif. Select it.
  - It's big, and you can modify its size by click on it and dragging the handles.

Map with multiple windows (Data Frames)

You can make a map with multiple windows that show zoomed-in portions of your main map, and you can even link the windows together!! Very fancy. **Save often as you are doing this!! It's easy to do something that you will regret.**

Creating the base map

- Zoom in to whatever you want to have on your main base map.
- Switch to layout view.
- Add scale bar, north arrow, neat line, title, key, whatever you want.

Adding new windows (Data Frames)

- The new windows are called **Data Frames**.
- If you want to have a second data frame, go to the **Insert** menu, and select **Data Frame.** You'll see a new listing in the TOC, and you'll see that your new Data Frame doesn't have anything in it. Go to your TOC, and left click and hold on the title of the layer you want to have in the new data frame, and drag it and drop it in your new data frame. You can drag as many layers as you want from the original menu. If you select the magnifier or pan tools from the **regular menu** (not the layout menu), you can zoom in to what you want in the new data frame. Pretty cool!!!
- **Rename your new data frame with a descriptive name.**

Linking your new Data Frame to the original window

- Right click on the **original Layers** in the TOC, and get the Data Frame Properties. Select the **Extent Rectangles** tab. Click on your original Layers in the Other Data Frames, and click the right arrow to move it to the right hand list.
  - Click the Frame button, and choose the color and size of the framing rectangle. You can always change this if you don't like it. You can see what it looks like by clicking Apply before you OK everything.

- To connect your new frame to the extent rectangle with a leader, check the Show Leader box, and choose Leader Symbols. When you're happy, click OK. You should now have a rectangle on your original map window that is connect to your new data frame.
- If you move your new data frame, just click the refresh icon (next to the page layout icon), and the leader will re-draw.
- If you don't like the frame or leader, just go back to the Properties again and change them.

- If you use the regular zoom and pan tools (not the ones for the layout view), you'll see that the rectangle changes size and location as you pan and zoom. Extra cool!!!
- You can add separate titles and neat lines for your new data frame.
- You can add as many new data frames as you want and link them to the original window. Just remember that you need to go to Layer Properties for the **original Layers** to make the extent rectangle show up on the original window. If you add several, you'll see why it's so important to rename each one!

Exporting your map

- When you are happy with your map, go to the File menu, and select **Export Map**. Under **Option,** click the **General** tab, and set the resolution to 200 (the width and height should automatically set to 2200 x 3400 pixels if your page setup is for 11x17 paper.)
- You can select either jpeg format or pdf. For best printing, select **pdf** format. Then, click the **Format** tab, and click in the box to **Embed all document fonts.**
- Name your map file. Navigate to your own data folder, and click Save.