Introduction to Geospatial Technology

Hosted By:

Tidewater Community College

Provided by:

Virginia Space Grant Consortium

Geospatial Technician Education

through Virginia's

Community Colleges (GTEVCC) Project

June 28, 29, and 30, 2010

Advanced Technological Education (ATE) Program
NSF-ATE Project DUE-0903270

Virginia Space Grant Consortium
600 Butler Farm Road
Hampton, VA 23666

Author:

Wendy Stout
Virginia Space Grant Consortium
Education Program Specialist
wstout@odu.edu

Introduction to Geospatial Technology

Virginia Space Grant Consortium

Geospatial Technician Education

through Virginia's

Community Colleges (GTEVCC) Project

Funded by a grant from the National Science Foundation (NSF)
Advanced Technological Education (ATE) Program
NSF-ATE Project DUE-0903270

Table of Contents

OVERspace

Introduction to Geospatial Technology

Lesson Overview:

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.

Skills:

1. Learn about what GIS is and how it is used
2. Learn the components of a GIS
3. Use Google searches to find information about how GIS is used

Standards Of Learning:

Virginia Standards of Learning: Earth Science (ES.3); World Geography (WG. 1); Computer Technology (C/T8.1, C/T8.4)

National Science Standards: Content Standard A (Science as Inquiry); Content Standard D (Earth and Space Science); Content Standard E (Science and Technology)

References:

Caplan, J. M. (2010). *GIS for Public Safety: An Annotated Guide to ArcGIS Tools and Procedures*. Newark, NJ: Rutgers Center on Public Security.

www.esri.com

Questions to be answered:

1. What is a GIS?
2. What are the five components of GIS?
3. What are three fields that use or rely on GIS information?
4. What job positions frequently use GIS?
5. How is a GIS professional educated?

What is a GIS?

A geographic information system (GIS) is a computer software application for managing, editing, analyzing and displaying data which is spatially referenced to the Earth. GIS is a tool with which data can be layered with base maps that represent the landscape of the area where the data is associated. Base maps could represent the street network, buildings, census tracts, or local land use patterns.

Imagine GIS as a high tech overhead projector from the "old days" that used transparent plastic sheets and dry erase markers as inputs that were then projected on a wall. If you think of each transparent sheet as a separate map layer, and you place all of the transparent sheets (map layers) on top of each other, you can see through all of them at once. In this way, you can see relationships among the data that overlap in certain areas. Essentially, GIS does this in much more sophisticated ways.

Visualizing multiple map layers offers a means of exploring relationships among different data variables. For example, a map that only shows burglary points and absolutely no other data may not be particularly helpful. But, the burglary data can be layered with base map data that displays the street network to show where these burglaries were committed. A third layer could display all the properties across the area (e.g. owner occupied, rented, vacant buildings). These three layers might suggest that burglary incidents are highest on side streets—not major roadways—and in the areas where there is also a high percentage of vacant properties.

GIS Components

A GIS has five components: hardware, software, people, data and storage:

The bare minimum for **hardware** is a computer. GIS hardware requirements might also include peripherals such as a printer, plotter, or scanner. PDAs or GPS technology may also be used to synchronize data captured in the field to a central database. Off the shelf GIS **software** products possess a wide range of functionality; though, software extensions can be added for advanced analysis and map production. Operating a GIS involves bringing together the computer files that contain the data to be used, and possibly editing them, querying against them, linking them, adding new data and generating a display for output. A GIS requires trained **people** to perform these technical skills, as well as to ask spatial questions and interpret and communicate findings. **Data** must have a geographic reference such as ZIP codes, street addresses, or x,y coordinates that can be used to link it to a map. Data collected via Excel, Access, Oracle, or any other type of spreadsheet or database management system has potential for use in a GIS. Digital **storage** drives are also needed to keep large amounts of data.

*What is GPS?**

Trying to figure out where you are is probably one of humankind's oldest problems. Navigation and positioning are crucial to so many activities and yet the process has always been quite cumbersome and inexact. Over the years all kinds of technologies have tried to simplify the task but everyone has had some disadvantage. Finally, the U.S. Department of Defense decided that the military had to have a precise form of worldwide positioning. The result is the Global Positioning System, a system that's changed navigation forever.

The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. GPS uses these "man-made stars" as reference points to calculate positions accurate to a matter of meters. In fact, with advanced forms of GPS you can make measurements to better than a centimeter! In a sense it's like giving every square meter on the planet a unique address. GPS receivers have been miniaturized to just a few integrated circuits and so are becoming very economical. And that makes the technology accessible to virtually everyone. These days GPS is finding its way into cars, boats, planes, construction equipment, movie making gear, farm machinery, even laptop computers. Soon GPS will become almost as basic as the cell telephone. In fact, GPS technology is being used now in cell phones to implement the emergency ('911') location system.

How GPS Works

Here's how GPS works in six logical steps:

1. The basis of GPS is "triangulation" from satellites. To "triangulate," a GPS receiver measures distance using the travel time of radio signals.
2. To measure travel time, GPS needs very accurate timing.
3. Along with distance, you need to know exactly where the satellites are in space. High orbits and careful monitoring are the secret.
4. You must correct for any delays the signal experiences as it travels through the atmosphere.
5. Finally (for us), you can now obtain the precise time from the GPS satellites.

Improbable as it may seem, the whole idea behind GPS is to use satellites in space as reference points for locations here on earth. That's right, by very, very accurately measuring our distance from three satellites we can find our position anywhere on earth.

*This page was adapted from Todd Ensign's article "Understanding GPS Terminology"
From www.beaglesoft.com/gpstechnology.htm

What is a "GIS career"?

GIS careers exist in every imaginable discipline, from environmental science to mining to urban planning to commercial businesses to defense and beyond. As a result, there is no one definition of a career in GIS. A GIS career path has many origins, but there are some core skills required. The broad range of GIS opportunities available gives you the ability to combine your passions or interests with GIS for a satisfying and successful career.

What do GIS professionals do?

GIS professionals use GIS to visualize, analyze, and model systems to help in the planning and decision-making processes of their organizations. They make geographic information accessible to scientists, planners, decision makers, and the public.

GIS careers typically include positions such as

- Cartographic designer
- Computer programmer
- Database administrator
- Project manager
- System administrator

They also encompass business development, managerial, and administrative roles.

GIS is often associated with making maps, but GIS professionals do much more than that. GIS is used to manage human activities. The ESRI Map Book Gallery illustrates through real-world examples the range of topics, activities, and locales to which GIS can be applied.

GIS jobs range from part-time to full-time posts, and salary varies widely by region, nation, discipline, and experience. Salary.com reports the range in the United States as between $31,387 for an entry-level analyst to $83,333 for a GIS supervisor as of January 2006.

How are GIS professionals educated?

GIS professionals are educated in three main ways.

- Through special certificate programs at colleges and universities (most common)
- Through degree programs at colleges and universities
- As part of their curriculum in other specialties such as while pursuing an urban planning degree

Exploring NASA Centers

Lesson Overview:

Geography is defined as the study of the Earth and its lands, features, inhabitants, and phenomena. It is important to know how the location of something influences people, the environment, the economy, and how they are all connected. Geographic Information Systems (GIS) can help decision makers choose the right locations for businesses, government agencies, even satellite and space exploration mission launches. This lesson demonstrates how geography influences where NASA Centers across the United States are located.

Skills:

1. Explore a GIS map and get information about map features
2. Use common tools (identify/zoom/zoom to full extent, clear selected features, zoom layer, select features).
3. Access attribute table and look at its available features.
4. Change display properties, such as transparency, color, outline, label symbols.
5. Label features.
6. Create a layout.

Standards Of Learning:

Virginia Standards of Learning: Earth Science (ES.3); World Geography (WG. 1); Computer Technology (C/T8.1, C/T8.4)

National Science Standards: Content Standard A (Science as Inquiry); Content Standard D (Earth and Space Science); Content Standard E (Science and Technology)

References:

Original lesson developed by Gregory Overkamp; Adapted by Wendy Stout. Extension activity and experienced user activity developed by Lisa McCray.

Questions to be answered:

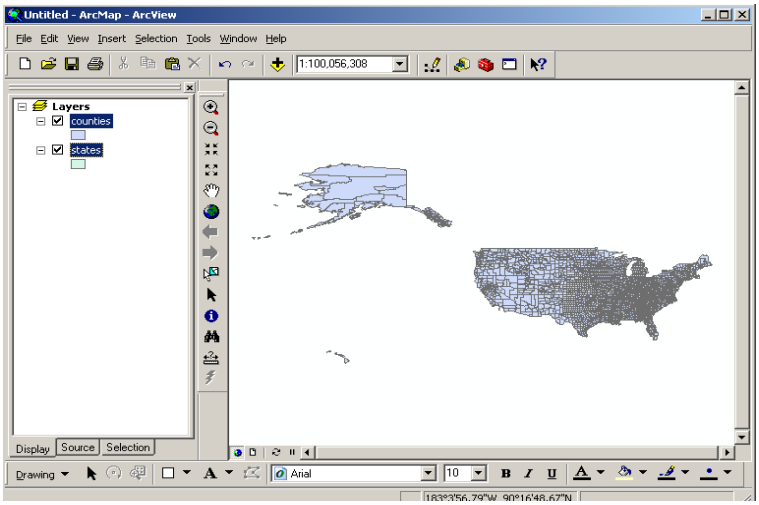
1. Which US states have NASA centers?
2. What geographic factors should NASA consider when choosing a location for a NASA Center?
3. Why do you think the Kennedy Space Center is a good location for the Space Shuttle launch pad?

1. *Start ArcMap*

- Double-click the **ArcMap desktop shortcut icon** or by clicking your Start menu, then clicking **Programs > ArcGIS > ArcMap.**
- Choose the option to start using ArcMap with an existing map and double-click **Browse for maps**.
- If you don't see the dialog, click the **Open button**  .
- Navigate to the **Overspace\ExploreUSA** folder on your flash drive.
- Double-click **USA.mxd** to open the map document.

2. *Adding and Preparing Data*

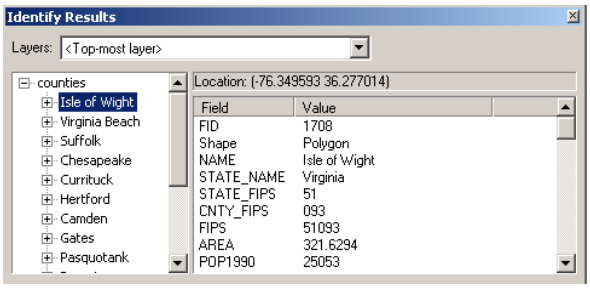
- Click on the **Add Data icon**  and go to the **OverspaceData\ExploreUSA\USAData** folder**.**
- Click on  . Click **Add**. You should now see the following after this layer is added:



You now have a map that shows all the counties in the US. The colors may be different from the colors in this picture.

3. *Identify Features*

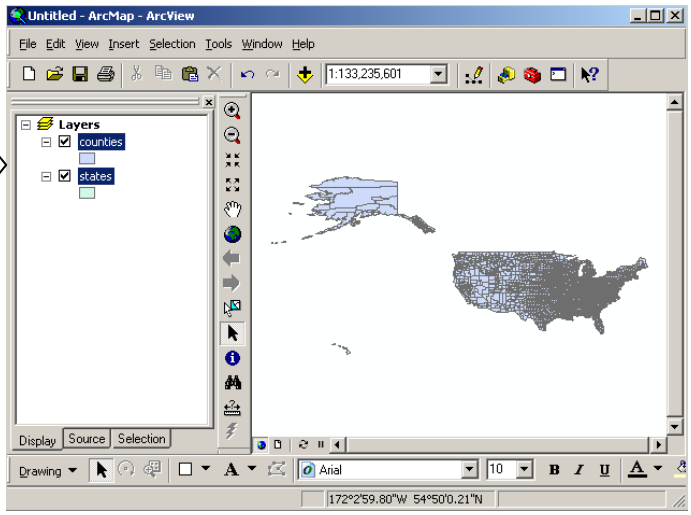
- Select the **Identify icon**  and click on an area of the US.
- An **Identify Results window** pops up which gives you information listed in the data table for that particular spot on the map.
- Scroll down through the data and see what information is listed in the data table for that particular spot on the map.



We want to see the outlines of the states with the counties inside them.

- Close the **Identify Results window**.
- Turn off the **Identify icon** by clicking on the **Select Elements icon**  .

This is the **Table of Contents** with both shapefiles selected.



- Click on a blank section in the **Table of Contents** to deselect both shapefiles.
- Click on the *states layer* and drag and drop it above the *counties layer*. Notice how the layer on top hides the layers below it, although bottom layers are still active.

4. *Transparency*

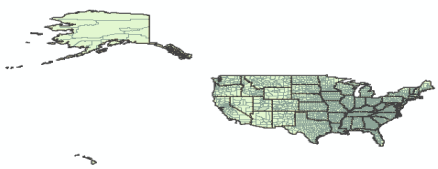
Now we will make the top layer semi-transparent so the counties layer will be visible on our map and corresponding counties will appear within state boundaries.

- Make sure the *states layer* is selected and right-click on it and choose **Properties**.
- In the **Layer Properties window**, select the **Display tab.** Change the **transparency to 60%** and **click OK**.

Your map now shows the outline of the states with the counties layer showing through. The outlines of the states are a little faint so we need to make them thicker.

5. *Symbology*

- Click on the small colored box below the states layer in the table of contents. A **Symbol Selector box** will open.
- Choose **Hollow** as the background color. Change the outline width to 1.5 and the outline color to black.
- Click OK.



Your map should now look like the map at right.

6. *Adding Imagery Data*

- **Add** the LaunchComplex39.jpg file
- **Drag to the top of the table of contents**

Note: for this file, you will have to highlight it and click Add rather than double clicking on it. This file is an aerial photo of the launch complex at Kennedy Space Center.

- In the **Table of Contents**, right click LaunchComplex39.jpg and click **Zoom to Layer**. This will fill your screen with the information in that file.
- The *Counties* and *States* layers may be on top of the aerial photo. Turn these layers off by removing the check mark next to them in the **Table of Contents**.
- Notice that the boundaries of the *Counties* and *States* layers do not align with the aerial photo. Why is that?

Layers can be turned on and off by the boxes next to them. When files are added to your map they are automatically turned on.

7. *Using Tools (Zoom, Pan, and Full Extent)*

- Launch Complex 39 is famous for its use in the Mercury, Gemini, and Apollo programs as well as being the launch site for the space shuttle. Take a few minutes to look at the area around the launch pads.

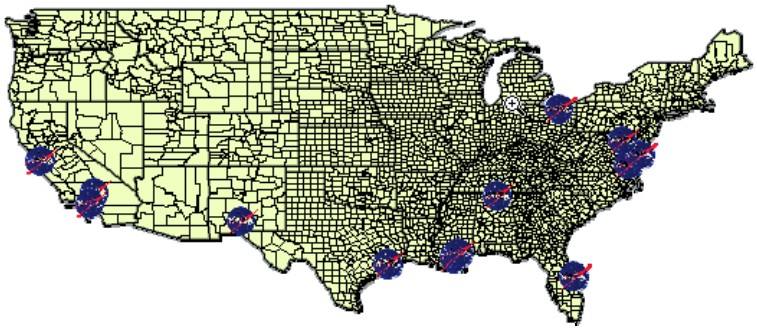
- Zoom into the aerial photo using the **Zoom tool**. Position your magnifying glass cursor at the top left corner of one of the launch sites and, while holding down the left mouse button, draw a box around the site. Your view will now be zoomed into the launch site. You can move the image to see the surrounding area by using the **pan tool**. You can go back to a previous view by using the **Previous Extent** tool.
- Look closely at the image and try to answer these questions:
  - ✓ How many launch pads are there at Launch Complex 39?
  - ✓ Describe the terrain that the Launch Complex was built in.
  - ✓ Rockets are launched in an eastward direction to take advantage of the rotation of the earth to help them into orbit. Launching in a westward direction requires much more energy. Knowing this and after examining the terrain around the launch complex, can you explain why NASA chose this location to launch from?
- When you are done, return to the view of the United States by clicking the **Full Extent button**. We no longer need the aerial photo, so remove it from your map by right-clicking on LaunchComplex39.jpg and clicking **Remove**.
- Turn on the *Counties* and *States* layers.

8. *Creating a Map of NASA Centers*

Next we will create a map of the NASA centers throughout the country.

- First, select the **Zoom tool** and draw a box around the contiguous United States.
- **Add** the NasaCenters.lyr file. This file contains information about NASA centers.

Your map should now look similar to the one below:



9. *Exploring the Attribute Table*

Layers in GIS have a table attached to them that provides additional information about the layer. The NasaCenters **attributes table** contains the name of each center, an important landmark, and the center's location.

- Right-Click on the *NasaCenters layer* in the **Table of Contents** and click **Open Attributes Table.**
- Look at the landmarks column.
  - ✓ Which state is the Hubble Space Telescope Operation Center located in?
- Close the attributes table when you are done viewing.

10. *Labels*

- Add labels to the centers by right clicking the NasaCenters in the **Table of Contents** and clicking **Label Features**. The NASA centers will now be labeled, but the labels are difficult to read.
- Right-click NasaCenters and click **properties.** Go to the **Labels tab**. Under the **Text Symbol section**, change the **font to size 9** and **Bold**. Click **OK**

The labels are a little easier to read, but the county lines make the map look cluttered.

- Click on the little box under the *counties layer*. The **Symbol Selector window** will appear. Change the outline color to **Gray 20%**. Click **OK**.

11. *Close ArcMap*

- From the **File menu**, choose **Exit**. Click **Yes** when asked if you want to save changes.
- **Save as nasa.mxd on your Flash Drive. Click OK.**

Note: .mxd is the file extension for saved arcview map files.
.shp is the extension for shapefiles.

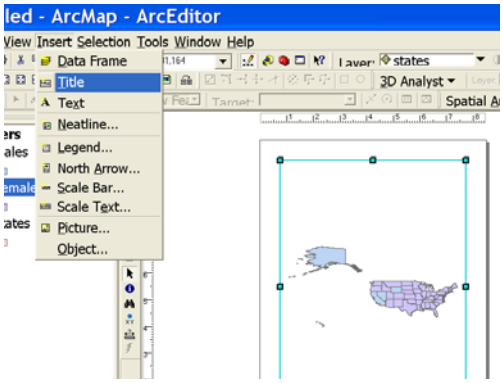
Exploring USA Data – Demographics Extension

1. *Make a population map.*

- Start a new blank map. (**File>New**)
- Add counties.shp from the **OverspaceData\ExploreUSA\USAData** folder.
- Right-click counties in the Table of Contents and click **Properties**.
- Click the Symbology tab.
- Select **Quantities>Graduated Colors**.
- Select POP2000 as the value.
- Select a color ramp that you like.
- Click OK.

Your map will now show population by county. ArcMap contains a mode called layout view that helps you to create an attractive map for printing or sharing on the computer.

2. *Use the layout view.*



- Click on the small **layout view** icon at the bottom of your map.
- Go to **Insert/Title** on the **menu bar**.
- Type in a title for your map. You may experiment with colors, etc, of the tile by double clicking in the title box.
- Insert a compass rose (of your choice). **Insert/North Arrow**.
- Insert the scale of your map. Options such as division units can be changed by double clicking it.
- **Insert/Legend**. Use the Legend Wizard to set up your legend.
- You may experiment with inserting other map elements, such as a neatline or text.

3. *Save.*

- You may save this map as a jpeg for use in a PowerPoint or to print out.
- **File/export map**.
- Navigate to the folder you want to save it in.
- Give it a title and save it in preferred format: jpeg, tiff, etc.

Exploring Virginia

Lesson Overview:

In this lesson students will explore the physiographic provinces and the major watersheds in Virginia. They will map the natural resources. By doing so, students will develop a greater awareness of their watershed and the natural resources available in Virginia.

Skills:

1. Define map properties (coordinate system/units/projection, relative path names)
2. Access attribute table and look at its available features
3. Use the query tool: select by attribute
4. Label features
5. Add imagery (raster)
6. Change symbology quantities

Standards Of Learning:

Virginia Standards of Learning: Life Sciences (LS.12); Earth Science (ES.1, ES.3, ES.9); Biology (BIO.1, BIO.9); Computer Technology (C/T 8.1, C/T 8.4)

National Science Standards: Use technology to investigate and communicate, formulate and revise models, human modifications of ecosystems.

References:

Lesson developed by Lisa McCray, adapted by Wendy Stout.

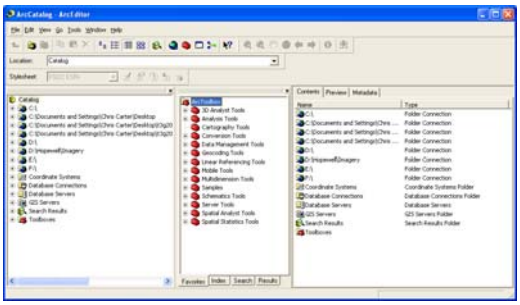
Questions to be answered:

1. How are the highest elevations in the state represented on the map? Where are the highest and lowest places in Virginia?
2. What is the length of the Cowpasture River?
3. What watershed do you live in?
4. Which river is closest to your house?
5. Which rivers are in your watershed?

1. Using ArcCatolog

ArcCatalog is the ArcGIS application designed for browsing, managing, and documenting geographic data. **ArcCatalog** and **ArcMap** work together. You can find and preview data in ArcCatalog, then drag and drop the data into ArcMap to work with it.
The ArcCatalog interface consists of the **Catalog tree** on the left and a preview pane on the right. You use the Catalog tree to navigate and browse data.

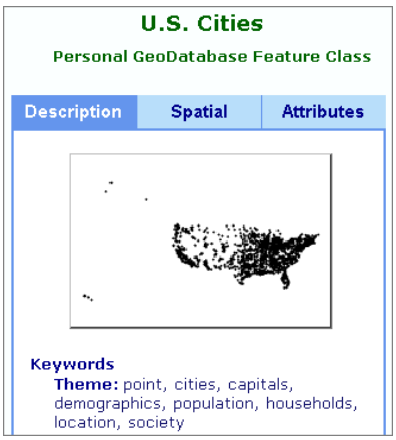
- Open **ArcCatalog** by clicking on the  icon on the menu bar.
  Navigate to **ExploreVirginia/VirginiaData.**



The preview pane in ArcCatalog has three tabs which provide different views of your data. The **Contents tab** shows a list or thumbnail graphics of folders and files. The **Metadata tab** shows information that has been documented for a dataset. The **Preview tab** shows the geographic and tabular information for a dataset.

2. Metadata

Metadata is commonly called "data about data." More precisely, metadata is information that describes, or documents, a geographic dataset. It typically includes information about why the data was collected (its purpose), what geographic area the data covers (its geographic extent), who collected the data, when the data was collected, what processes were performed on the data, and who should be contacted for more details about the data.



- In the **Catalog tree in ArcCatalog**, click cities, then click the **Metadata tab**. Green text is clickable – clicking green text displays or hides information about the data.
- Click the **Attributes tab** to see the total number of records in this dataset.
- Click the attribute names and explore their definitions. Look at the metadata for AREAWATER.
  - Which city has the most water?
  - What is the source for the AREAWATER data?
- Click on the **Description tab**. Click the Publication Information.
  - Locate the contact info for ESRI.

- Close ArcCatalog

3. *Creating a New Map*

- Click on ArcMap
- Select a new empty map
- Click OK for an empty map

4. *Coordinate systems*

Types of coordinate systems:

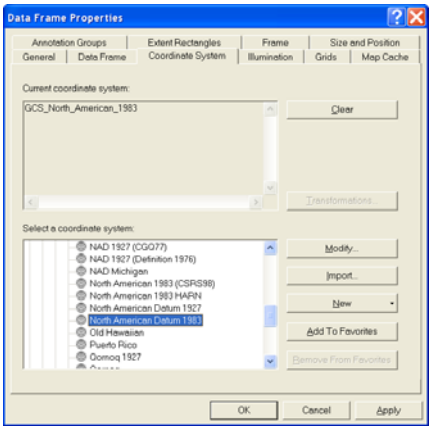
Coordinate systems (either geographic or projected) provide a framework for defining real-world locations. In ArcGIS, the coordinate system is used as the method to automatically integrate the geographic locations from different datasets into a common coordinate framework for display and analysis. There are two common types of coordinate systems used in GIS:

1. A global or spherical coordinate system such as latitude-longitude. These are often referred to as geographic coordinate systems.
2. A projected coordinate system based on a map projection such as transverse Mercator, Albers equal area, or Robinson, all of which (along with numerous other map projection models) provide various mechanisms to project maps of the earth's spherical surface onto a two-dimensional Cartesian coordinate plane. Projected coordinate systems are sometimes referred to as map projections.

5. *Set coordinate system for the map*

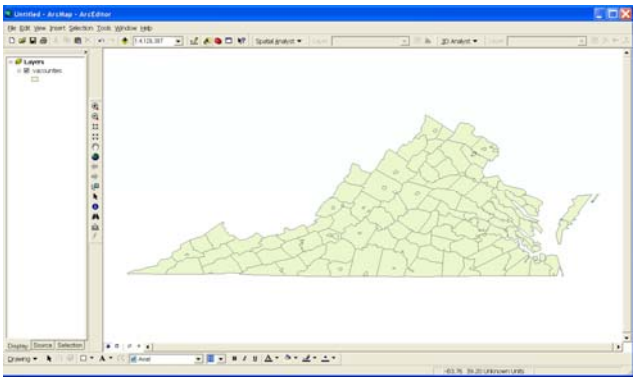
- Right click on **Layers** click on **Properties**
- Select the **Coordinate system tab**
- Select predefined/geographic coordinate systems/North America/North American Datum 1983.

Note: If the layers don't overlap properly, the coordinate system of the two layers does not match. Either set your coordinate system when you begin a new map or check to make certain that your data layers have the same coordinate system.



6. *Adding Layers Using ArcCatalog*

- Add vacounties.shp from **ExploreVirginia/VirginiaData** to the map.



In the last lesson we added data to ArcMap using the Add Data button. You can also add data by dragging and dropping data from ArcCatalog into ArcMap.

- **Dragging and Dropping**: In the Catalog tree in ArcCatalog, click and drag the following layers into the map. Click OK to any warnings:
  - *vacities*
  - *Lakes_va*
  - *Physio*
  - *Va_elev*
  - *rivers_va*
  - *va_watersheds*

- **Layers** are turned on when the small box in front of the name is checked. Practice turning the layers on and off.

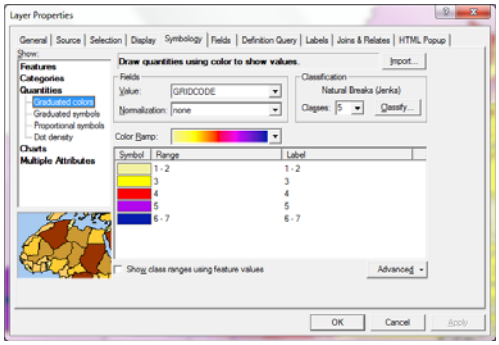
7. *Attribute Table*

- Make sure *va_elev* open its Attribute Table. (**right-click>Open Attribute** Table)
- Right-click on the heading **gridcod**e and choose **sort ascendin**g. This rearranges the records in the layer.
- Scroll down the table.
  - ✓ What is the range for the gridcode?

  The gridcode represents elevation.
  - ✓ What gridcode represents the highest elevation? 1 or 7

8. *Symbology*

- Turn off all layers except the va_elev layer.
- Close the attribute table and right-click *va_elev* and select **properties**.
- Click on the **symbology tab**
- Under **quantities**, choose **graduated colors**
- Under **fields**, select **grid code** for the value
- Change the **classes to 7,** choose a color ramp that goes from **tan to dark blue** called partial spectrum. If you right-click on the arrow next to **Color Ramp** and click on **Graphic View**, the colors will change to words.



- Click **OK**
  - ✓ In what part of Virginia do you find the highest elevations? The lowest elevations?
  - ✓ What is the elevation of the Atlantic Ocean? What is this commonly called?

9. *Transparency*

- Turn on the *physio* layer and drag it above the *elevation layer*.
- Right-click physio and go to **Properties>Display Tab**.
- Change the **transparency to 50%.**
- Click **Apply**, but not OK.
- Move the properties box so you can see the map.
  - ✓ Which regions have the highest elevation? The lowest?
- Select the **labels tab** on the **properties box**.
- Check the **Label features in this layer** box.
- Select **province** from the **drop-down menu** in the **label field box.**
- Click **OK.**
  - ✓ Were your regions correct?

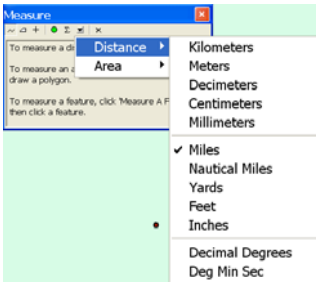
10. *Play with Color*

- Turn off the *physio* and *elev* layers.
- Turn on the *vacounties* layer. Change the color to **green.**
- Click on the colored box under *vacounties* in the Table of Contents to get the **symbol selector.** Choose **yellow** and change the **outline width to 1**. Click **OK**.

11. Select by Attributes and the Measure tool

- Turn on the *rivers_va layer* and make the rivers a dark blue.
- On the tool bar, select **Selection/Select by Attributes.** Make sure the layer is *rivers_va* and method is **Create a New Selection**.
- Under **Fields**, double-click **Name**, single click on **=**, click **Get Unique Values**, and double-click on **'Cowpasture River'**. Click **OK.** Cowpasture River is selected on the map.

  - ✓ How long is the river as the crow flies (a straight line from source to mouth)?
- Right-click anywhere on the map and click **Zoom to Selected Features**.
- Click on the **"measure" tool**  .
- The **measure box** appears. Click on the down arrow icon, click on **distance**, click **miles**.Change the distance measurement to **Mile**s clicking on the first point you want to measure from.



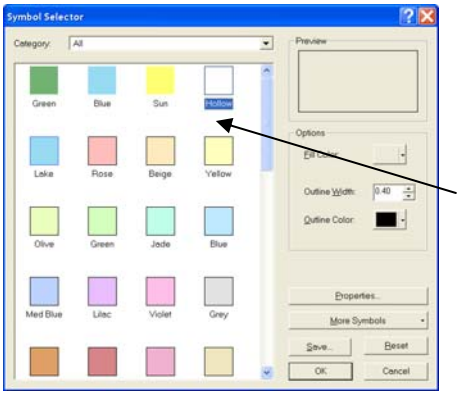
- On the map, click on one end of the river, then hold down the left mouse button and drag to the other end.
  - ✓ What is the distance? (Look in the measure window to see the distance.)
- Click on "**Zoom to Full Extent**"  to restore your map to its original scale. Unselect the river by using the **Clear Selected Features** tool. 

12. Labels

- Turn on *va_watersheds*. Make sure the other layers are off.

There are several ways to **label** these watersheds:

- Right-click on the **layer name** in the Table of Contents, scroll down to and click **Label Features**. Turn them off the same way.
- Right-click on the **layer name** and go down to **properties**. Select the **labels tab**. Check the box to label features in this layer. Method should be "Label all the features the same way", next to **Label Field**, select **NAME.** Click **OK.**
  - ✓ Which rivers are in your watershed?
- Turn on the *rivers layer* and zoom in on one *watershed*. You may **label** the rivers or use the **identify tool**.
- Turn on the elevation layer. Can you make any comments about the relationship between rivers, watersheds, and elevation? In order to see elevation better we will make the watershed layer transparent. Click on the color box under *va_watersheds* to get the symbol selector. Choose Hollow and make the outline 2.



13. Imagery and another way to add data

Satellite imagery

- Click on the **add data icon** .
- Select the *c321_halifax…tiff file* and click **Add**.
- Zoom in on the satellite image. Make sure the *rivers layer* is on. Notice how the rivers line up with the image.

Save your lesson and close ArcMap.

1. *Census Data*

- Right-click on *vacounties*.
- Click on the **attribute table** and scroll right to see the data available. Look at the data for **Roanoke.**

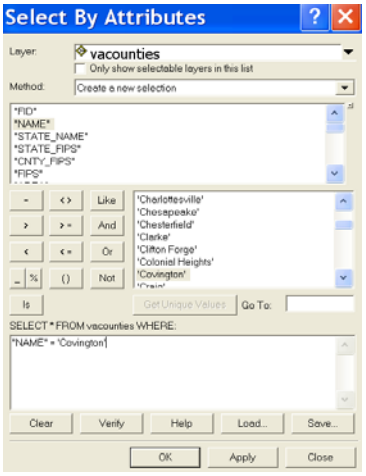
Hint: You might want to **sort the Name field** to find Roanoke.

- Right click on the column heading **Name**. Use the slide to see the census data included for Roanoke.
  - ✓ How many Hispanics?
  - ✓ How many 65 or older?
- Click on the box to the left of FID in line with Roanoke. The line with Roanoke information should now be highlighted in blue. Move the attribute table so you can see the map. Roanoke has been selected.
- Close the attribute table.

Go to the **Menu bar** to **Selection** and scroll down to **clear selected features**.

2. *Query*

Here's another way to locate a county:



- On the tool bar, select **Selection/Select by Attribute.** Make sure the layer is *vacounties* and method is **Create a New Selection**.
- Under **Fields**, double-click **Name**, single click on **=**, click **Get Unique Values**, and double-click on **Covington**. Click **OK.** Covington is outlined on the map.
- Go to **Selection/Clear Selected Features**.

Use a query with other fields on the attribute table.

- Activate the *cities layer*. Drag it on top if it is not already there.
- **Selection/Select by Attribute**.
- This time make the query population "**POP2000>=100000"** (make sure the layer is *vacities*). Click **Apply.**
- Add to the query **"and" "med_age" < 30**.
  - ✓ What are the results?

3. Exporting as a New Shapefile

Suppose the only cities we wanted to work with were the cities with a large population with a median age less than 30. We can isolate it and save it as a separate **shapefile**. We will accomplish this by performing the following steps:

- You have already **isolated (selected)** the cities of interest in step 2. You can now export them as a separate **shapefile.**
- Right-click the vacities layer and select **Data>Export Data...**
- You want to put your new file in a location that is easily found.
- Browse to the **ExploreVirginia** folder in your flash drive and create a new folder. Name it new data.
- Open the data folder and click **Save**.
- This should direct ArcGIS to save your new shape file in the new folder and will be reflected in the "Output shapefile of feature class:" box.
- Replace the default name (**Export_Output.shp**) with a name you choose for the new shapefile, such as *LargeCities.shp*.
- Click **OK.** You will be asked if you want to add the exported data to your map as a new layer. Choose **Yes.**

Now let's look at what you have created

- Keep ArcMap open
- Right-click on start at the bottom of your screen
- Go to Explore
- Find your NewData folder inside Exploring Virginia
- Notice the number of files that have the name "LargeCities"
- Close Explore and go back to ArcMap

You now have your new shapefile listed in the Table of Contents.

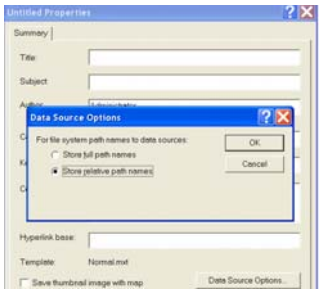
- Deselect your selection on the vacities layer by clicking on Selection on the top menu bar and choose Clear Selected Features.
- Turn off the vacities layer and you will see only large cities displayed on your map.
- Right-click on LargeCities in the Table of Contents and choose Zoom to Layer.

Your newly created shapefile is centered and enlarged.

- Open the Attributes Table (right click on LargeCities layer and then Open Attributes Table) and explore the data that you have in your new shapefile.

Now try selecting features manually by selecting the **Select feature tool**  from the standard toolbar. Hold down the shift key while selecting multiple cities and then follow the steps above to create a new shapefile.

4. How to End



At this point, you have several options:

1. If this is a project you want to save, or work on it without having to add the layers, go to File/Document Properties/Data Source Options and select "Store relative path names to data sources". This makes the file more transportable. Now do File/Save and put it in an appropriate folder.
2. If you want a picture of this map in JPEG format to import into a Word document or PowerPoint, use File/Export Map and save as a JPEG file.
3. Or exit without saving.

Google Earth - Volcanoes

Lesson Overview:

In this lesson, students will use Google Earth to identify the type of several volcanoes, including **Tristan de Cunha** in the South Atlantic, **Mt Rainier** in Washington, **Lava Butte** in Oregon, and **Olympus Mons** on Mars. These volcanoes represent one of the three main types of volcanoes. Each type has its own characteristics. Below is a table explaining the differences between the three types of volcanoes:

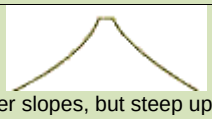
Three Main Types of Volcanoes				
The three main types of volcanoes differ in shape, size, and make-up; the differences partly result from the different types of eruptions.				
Volcano Type	**Volcano Shape**	**Volcano Size**	**Volcano Materials**	**Eruption Type**
Cinder Cone	 Steep conical hill with straight sides	Small less than 300m high	cinders	Explosive
Shield Volcano	 Very gentle slopes; convex upward (shaped like a warrior's shield)	Large over 10s of kms across	fluid lava flows (basalt)	Quiet
Stratovolcano	 Gentle lower slopes, but steep upper slopes; concave upward	Large 1-10 km in diameter	numerous layers of lava and pyroclastics	Explosive

Table from the Utah Geological Survey - http://geology.utah.gov/utahgeo/geo/volcanoes/volcano_type.htm

Use the table above to determine the category that each volcano belongs to.

Skills:

1. Locate volcanoes using geographic coordinates
2. Find height and width of volcanoes using tools in Google Earth
3. Analyze 3D models of terrain using vertical exaggeration

Standards:

Virginia Standards of Learning: Math (M6.2); Earth Science (ES.2, ES.3, ES.8, ES.11): World Geography (WG. 1); Computer Technology (C/T8.1, C/T8.4)

National Science Standards: Content Standard A (Science as Inquiry); Content Standard D (Earth and Space Science); Content Standard E (Science and Technology)

References:

Lesson developed by Wendy Stout, Andrea Geyer, and Daniel Fourquet.

Questions to be answered: Identify the type of the following volcanoes: Lava Butte, Mt Rainier, Tristan de Cunha, Olympus Mons

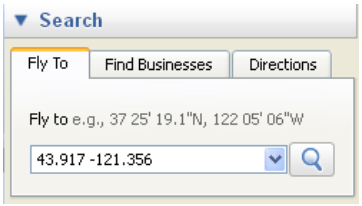
1. *Identify volcanoes in Google Earth*

- Open **Google Earth**.

The following is a list of the volcanoes you will find and where they are located:

Volcano Name, Location	Coordinates
Lava Butte, Oregon	43.917 -121.356
Mt Rainier, Washington	46.851 -121.758
Tristan de Cunha, South Atlantic	-37.108 -12.275

The volcanoes can easily be found in Google Earth by searching for the coordinates in the **Fly To box** in the top left hand side of the screen, as seen in the picture to the right. (Don't worry about "N" or "W" shown in the example in Google Earth.)



✓ Why is there a negative sign in front of the longitude?

2. *Identifying the Volcano in Google Earth*

There are three properties that can be used to identify the type of volcano: **height, width,** the **height/width ratio**. Repeat the following steps with all three volcanoes to identify them. Use the table provided below to help:

- First, **determine the height of the volcano**. To do this, find the elevation of the summit and the base, then subtract.
- Hover the mouse over the **rim** of the **crater** and look at the bottom of the screen to see the **elevation in feet**.

Note: make sure that terrain is turned on in the Layers box on the left hand side of the screen. If it is turned off, everything will be at an elevation of 0ft.

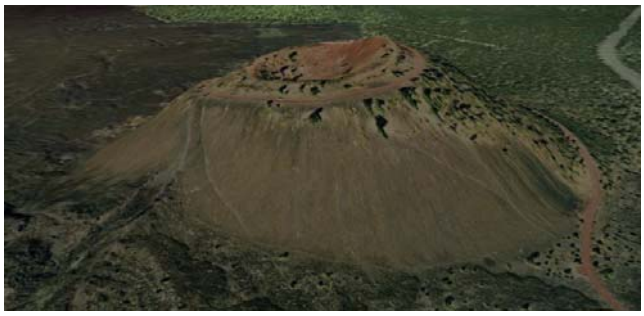
- Do the same from the base of the volcano. Then subtract the two values to find the height of the volcano.
- Next, **find the diameter (width) of the volcano** using the ruler tool.
- Using the **ruler tool**, click on the base of the volcano, then click on the base directly opposite, so that you draw a line across the volcano. The line should cross the center of the crater.

The **height/width ratio** can be found by dividing the height by the diameter. A value of 1 means that the volcano is about as tall as it is wide. A number lower than 1 means the volcano is wider than it is tall. A number above 1 means the volcano is taller than it is wide.

Volcano Name	Height	Width	H/W Ratio	Type of Volcano
Lava Butte				
Mt Rainier				
Tristan de Cunha				
Olympus Mons				

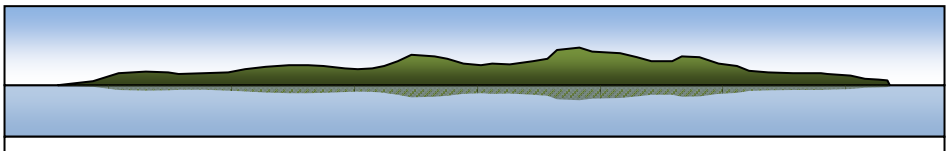
3. Vertical Exaggeration

If you are finding difficulty identifying the volcano type based on the information you just collected, then it might be helpful to look at the 3D model of the volcano and compare it to the profile picture in the table.

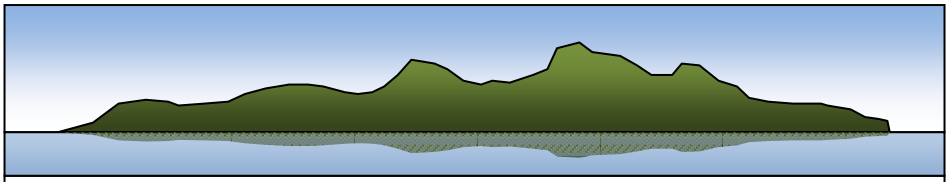


This view is similar to what the volcano would look like in real life. Sometimes it is easier to see the details of features if you distort the surface. If the vertical scale is larger than the horizontal scale, small differences in elevation become easier to see. This is called vertical exaggeration because the vertical features are stretched so that they're easier to see.

For an example of **vertical exaggeration**, look at the drawings below. The first drawing represents the profile of an island where the vertical scale and horizontal scale are the same – the way it would look from a nearby boat. The second drawing represents the profile of the same island where the vertical scale is greater than the horizontal scale. As a result, differences in elevation are much clearer in the second drawing.



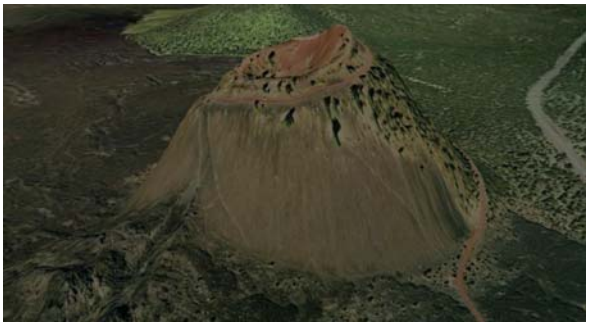
Profile of an island – no vertical exaggeration



Profile of the same island – with vertical exaggeration

The same concept can be used in Google Earth to help identify volcano types.

- In **Google Earth**, click **Tools, Options**…
- In the **3D tab**, change the **Elevation Exaggeration** option to **2.** Click **OK.**

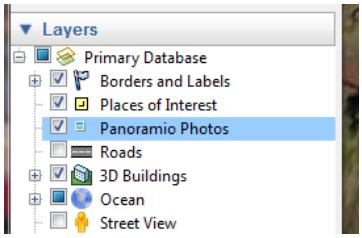


The terrain around the volcano will now have vertical exaggeration.
Note: Holding the Shift key while you work the hand will allow you to "tilt" the image

- Try changing the **Elevation Exaggeration to 3**.
- When you are done, **return the value to 1.**

4. Panoramio Photos

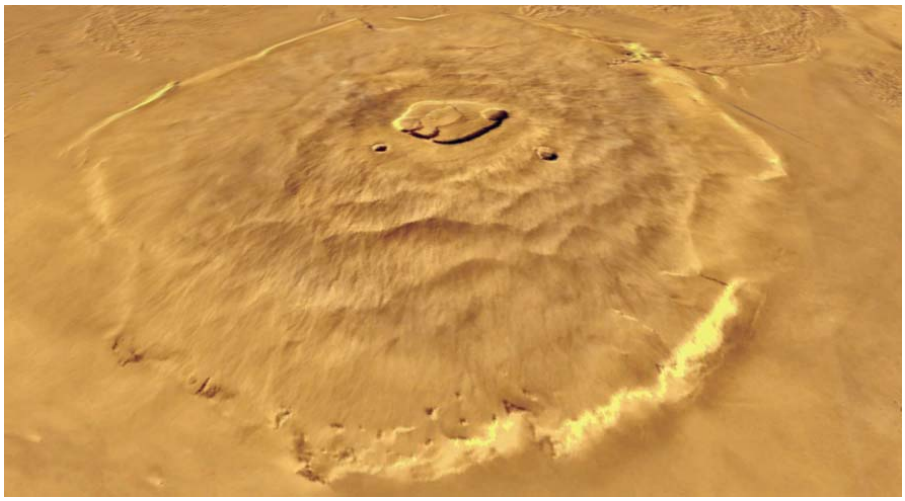
Google Earth users are able to post georeferenced (associated with geographic coordinates) photos to Google Earth through a website called panoramio.com. The photos appear on the screen as a small picture icon that you can click. You may need to turn on the Panoramio Photos layer on to see them. Spend a couple minutes looking at pictures of the volcanoes that people posted.



5. Volcanoes on Mars

Volcanoes also occur on other planets. After you have identified the type of the first three volcanoes, try identifying the type of the largest volcano in the solar system, Olympus Mons.

- In **Google Earth**, click **View**, **Explore, Mars.**
- Enter the coordinates of **Olympus Mons**: **18.4 -134.0**
- Take the same measurements of this volcano as you did on the Earth volcanoes.



Earthquakes and Volcanoes

Lesson Overview:

GIS can be used to investigate and visualize earthquake and volcano data by looking for patterns and comparing events that took place at different times. By analyzing earthquakes and volcanoes in this way, GIS offers a way to predict where increases in earthquakes may next threaten populations.

Skills:

1. Compare different map layers and identify relationships between them
2. Identify spatial patterns and give reasons to explain them
3. Change symbology for data layers: categories, group values
4. Open an attribute table for an active layer
5. Use a query to select features and records in a layer
6. Create and export new shapefiles

Standards:

Virginia Standards of Learning: Earth Science (ES.2, ES.3, ES.8, ES.11): World Geography (WG. 1); Computer Technology (C/T8.1, C/T8.4)

National Science Standards: Content Standard A (Science as Inquiry); Content Standard D (Earth and Space Science); Content Standard E (Science and Technology)

References:

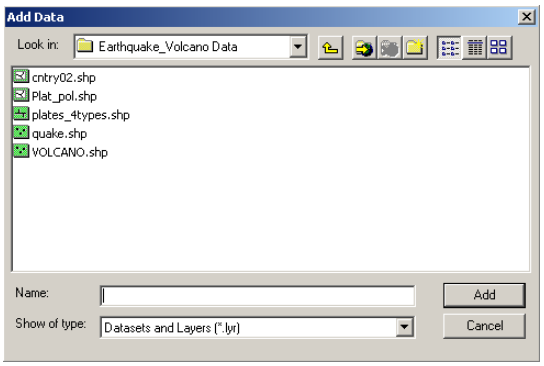
Lesson developed by: Gregory Overkamp; adapted by Wendy Stout.

Questions to be answered:

1. Where do most of the world's earthquakes take place?
2. How can GIS data be used to plan for natural disasters?
3. What GIS data would be useful to assist officials in making decisions?
4. Which countries had the greatest number of people affected by Earthquakes/ Volcanoes?
5. What is the relationship between coastal plate boundaries and the concentration of volcanoes and earthquakes on Earth?

1. *Add Data*

- Open ArcMap and start with a blank map.
- Click on the **Add Data icon** and go to the **Earthquake_Volcano Data** folder. In this folder you will see the following files:
  - Click on cntry02.shp.
  - While holding down the ctrl key, click on Plat_pol.shp and plates_4types.shp.
- Click **Add** and **OK** to the warning messages



Notice how all shapefiles added are selected (in blue) and turned on (small boxes next to shapefile name are checked) in the Table of Contents.

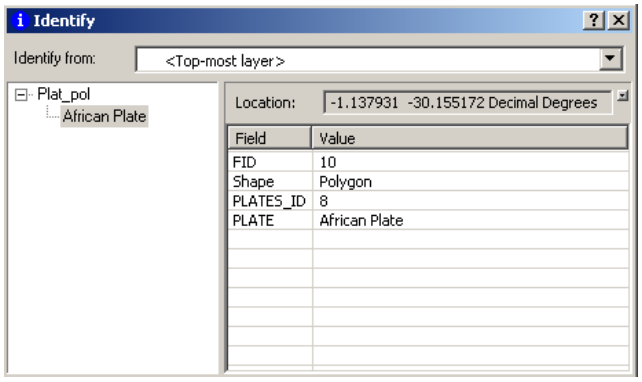
You now have a map that shows the *world countries, crust plates,* and *plate boundaries*.

2. *Identify Results*

- Click on the **Identify icon** and click on an area of the map. An **Identify Results window** pops up which gives you information listed in the attribute table for that particular spot on the map. Scroll down through the data and see what information is listed.
- Make sure the layer you want info on is selected.

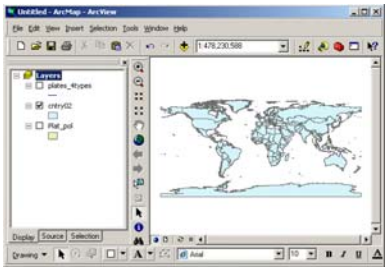
The **Identify Results window** displays the information contained in the Attribute Table.

- Close the Identify Results window. Turn off the Identify icon by clicking on the **Select Elements icon**.



3. *Working with Layers*

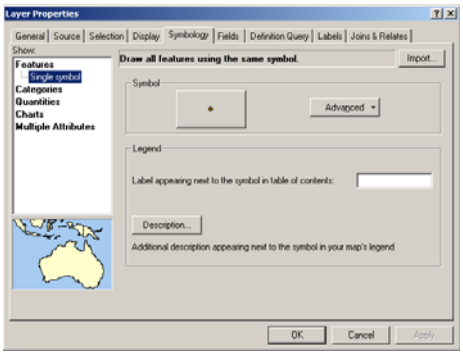
- Turn off all layers except the *cntry02 layer*. Click the small box next to the shapefiles you want turned off (this will uncheck the box) and leave the *cntry02 layer* turned on.
- Click on a **blank** section in the Table of Contents to deselect all the shapefiles.



Your map should now show only the world countries.

4. *Symbology*

- Change the color of the **world countries** by clicking on the small colored box below the shapefile you want to work with. Clicking the small box below a layer will enable you to manipulate symbol styles, colors, sizes, etc.
- A **Symbol Selector box** will open. Click on the color you want features in your shapefile displayed.
- **Features** can be outlined in different colors and different widths.
- Open the **Outline Color box** and choose **No Color**. Click **OK**.
- Add more layers. **Add**  the quake.shp and VOLCANO.shp shapefiles.



Your map now shows earthquake and volcano data around the world. This appears very congested so let's turn off the *volcanoes layer* and make the symbols for earthquakes smaller.

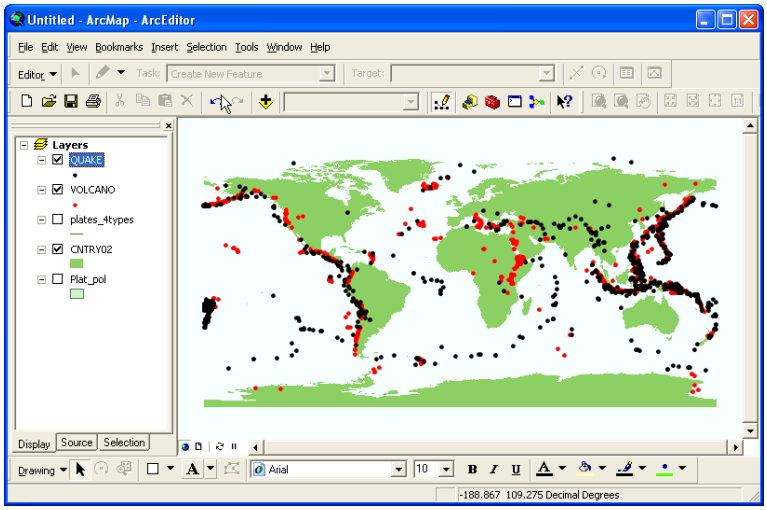
- Double click on the *quakes layer* and a **Layer Properties window** pops up. Click on the **Symbology tab.**
- Single symbols can be selected by clicking on the **Symbol button.**
- A **symbol selector window** pops up in which you can click on any symbol you want. Select a symbol and adjust the size and color you want.

More symbols are available and are grouped by category. Click the **More Symbols** button and select the category you want. The symbols will be added to the end of the current symbols display.

- Click **OK.**

Your map now has earthquakes displayed using the symbol you chose.

- Turn on the *volcanoes shapefile* (check box next to shapefile name in Table of Contents) and select a size and color you want them displayed in. After selecting the symbology for *volcanoes* your map will look something like this:

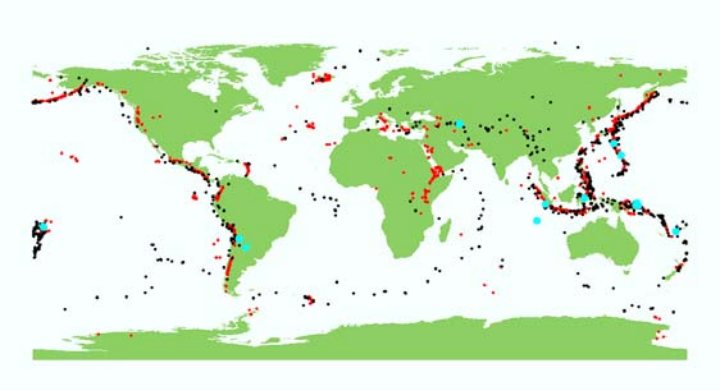


5. *Select by Attribute*

Let's identify earthquakes that have a **magnitude of 7.0** or greater on the Richter Scale.

- In the menu bar, click **Selection**, **Select by Attribute**
- Change **Layer** to *quake*.
- Change Method to **"Create a new selection."**
- The large box on top lists all of the fields of the *quake layer*. Double click on **"MAG".** The **"MAG" attribute** will be added to the **query box** on the bottom.
- Click the **>= sign** button.

We want to list all the choices possible for the field we are working with (in this case, magnitudes of earthquakes in our data set).



- Click on the **Get Unique Values** box.

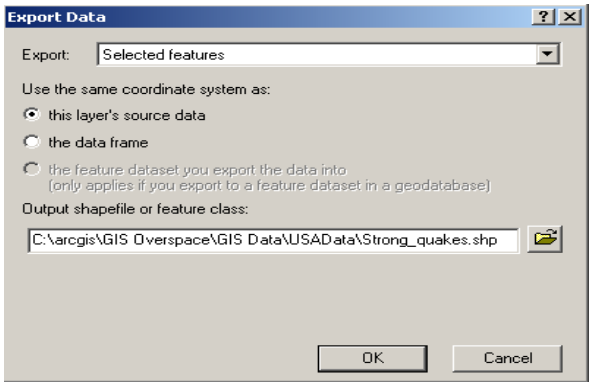
Notice how all the possible choices pop up in the large middle box.

- **Select the number 7** by double-clicking on it.
- Execute the query by clicking **OK**. After completing a successful query you will find the results highlighted (selected) in a light blue color on your map, as shown:

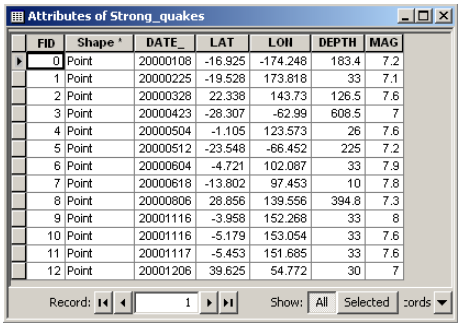
6. *Exporting Data*

Now that your desired data is isolated (selected) you can export it as a separate shapefile.

- Right-click on the *quake layer* in the Table of Contents, select **Data, then Export Data.**
- Chose a location to save your file on your flash drive and name your new shapefile *Strong_quakes.shp*. Use the following figure as a reference, then click **OK**:



- When you click OK, you will be asked if you want to **add the exported data to your map as a new layer**. Choose **Yes.** Click **OK** to any messages that pop up.
- Deselect your selection on the *quake layer* by clicking on **Selection** on the top menu bar and choose **Clear Selected Features**. Alternatively, you can click the button in the tools window.
- Turn off the *quake layer* and you will see only *earthquakes with a magnitude of >= 7* displayed in your map.
- Right-click on *Strong_quakes* in the Table of Contents and choose **Zoom to Layer**. Your newly created shapefile is centered and enlarged.
- Open the **Attributes Table** (right click on the *Strong_quake layer* and click **Open Attributes Table**) and explore the data that you have for these earthquakes in your new shapefile.



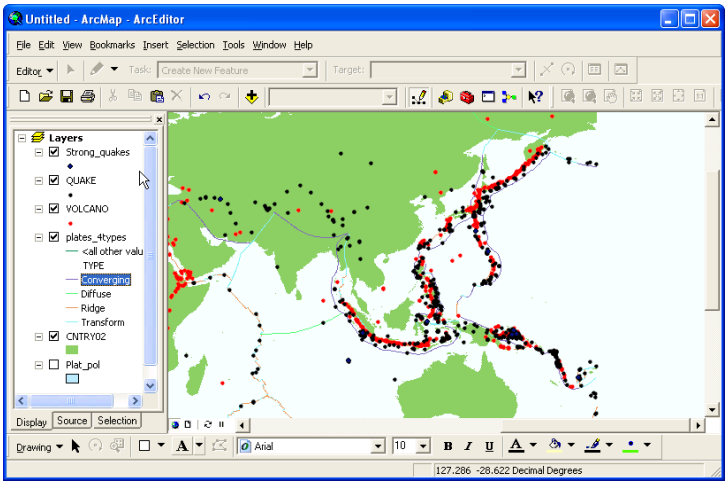
FID	Shape *	DATE_	LAT	LON	DEPTH	MAG
0	Point	20000108	-16.925	-174.248	183.4	7.2
1	Point	20000225	-19.528	173.818	33	7.1
2	Point	20000328	22.338	143.73	126.5	7.6
3	Point	20000423	-28.307	-62.99	608.5	7
4	Point	20000504	-1.105	123.573	26	7.6
5	Point	20000512	-23.548	-66.452	225	7.2
6	Point	20000604	-4.721	102.087	33	7.9
7	Point	20000618	-13.802	97.453	10	7.8
8	Point	20000806	28.856	139.556	394.8	7.3
9	Point	20001116	-3.958	152.268	33	8
10	Point	20001116	-5.179	153.054	33	7.6
11	Point	20001117	-5.453	151.685	33	7.6
12	Point	20001206	39.625	54.772	30	7

- You can sort the data in the Attribute table. Put your cursor on the column header MAG and right click. **Choose Sort Ascending**. Notice how the records are sorted from lowest to highest magnitude earthquakes. Try it on the Date_ field.

7. More Symbology

- Turn the *quake* and *VOLCANO layers* back on and zoom in on the area of the world with the most earthquake activity using the **zoom tool**.
- Turn on the *plates_4types layer* to display the **plate boundaries** on your map. They all look the same, so let's categorize them with unique colors so we can see which types are associated with the most activity.
- Double-click the *plates_4types layer* in the Table of Contents and the **Layer Properties** window will pop up. Click on the **Symbology tab** and select **Categories>Unique Values**.
- Change the **Value Field** to TYPE and click on **Add All Values**. Click **OK.**

Your map should now show the different types of plate boundaries by color, as shown in the figure.



We can see that most earthquakes and volcanoes occur near **convergent boundaries**. Let's make this even more obvious by making the convergent boundary lines thicker.

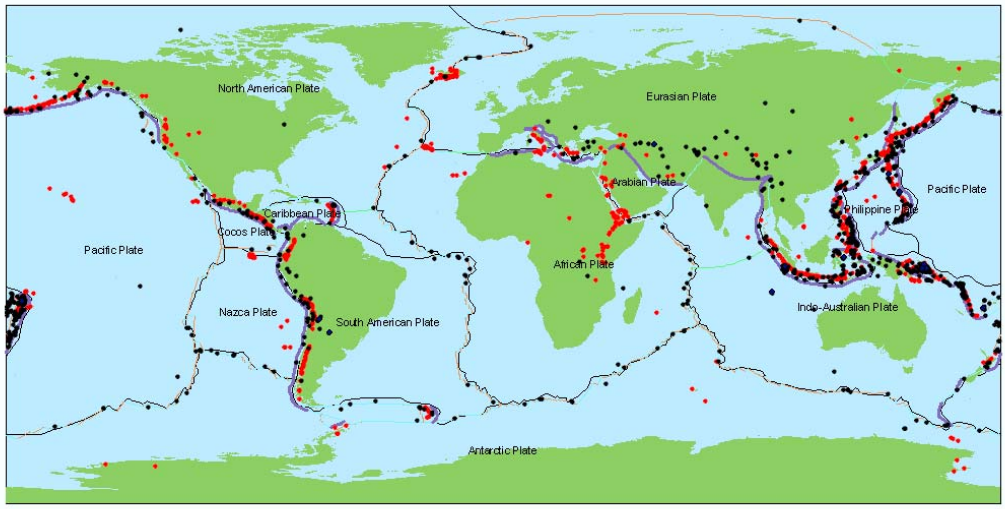
- Left-click on the line next to **Converging** in the Table of Contents and the **Symbol Selector window** will appear.
- Change the **width to 2** and click **OK**.
- Click the **Full Extent tool**  to show the worldwide view.

8. *Labeling the Plates*

- Make the *Plat_pol layer* active and click on the square below it to change the color of the *plates layer*.
- Choose a **blue** color and click **OK.**
- To label the plates, right-click on the *Plat_pol layer* in the Table of Contents and select **Label Features**.

Your map is now complete. Try zooming in on different spots on your map.

✓ Which plate contains the greatest number of earthquakes?



Hurricanes

Lesson Overview:

In 2005, Hurricane Katrina hit the Gulf and Atlantic coasts destroying homes, businesses, infrastructure, and natural resources. In the aftermath, federal, state, and local governments, service agencies, and the private sector responded to help rebuild. GIS aided critical tasks including assessing the damage, monitoring the weather, coordinating relief efforts, and tracking health hazards. GIS specialists provided relevant and readily available data, maps, and images to the responders in the field. In this module, you will map the path of the hurricane and understand how data helped federal officials decide where to allocate disaster aid in the counties most affected by Hurricane Katrina.

Skills:

1. Identify the path of Hurricane Katrina
2. Interpret thematic maps to answer questions and draw conclusions
3. Change symbology for data layers: categories, group values
4. Change display properties
5. Use analysis tools (buffer, clip) to find answers and make decisions
6. Interpret wind speed data using graphs

Standards Of Learning:

Virginia Standards of Learning: Earth Science (ES.3, ES.13); World Geography (WG.1, WG.2); Computer Technology (C/T8.1, C/T8.4)

National Science Standards: Content Standard A (Science as Inquiry); Content Standard D (Earth and Space Science); Content Standard E (Science and Technology)

References:

Lesson developed by Gregory Overkamp; adapted by Wendy Stout. Extension activities and experience user lesson developed by Lisa McCray and Wendy Stout.

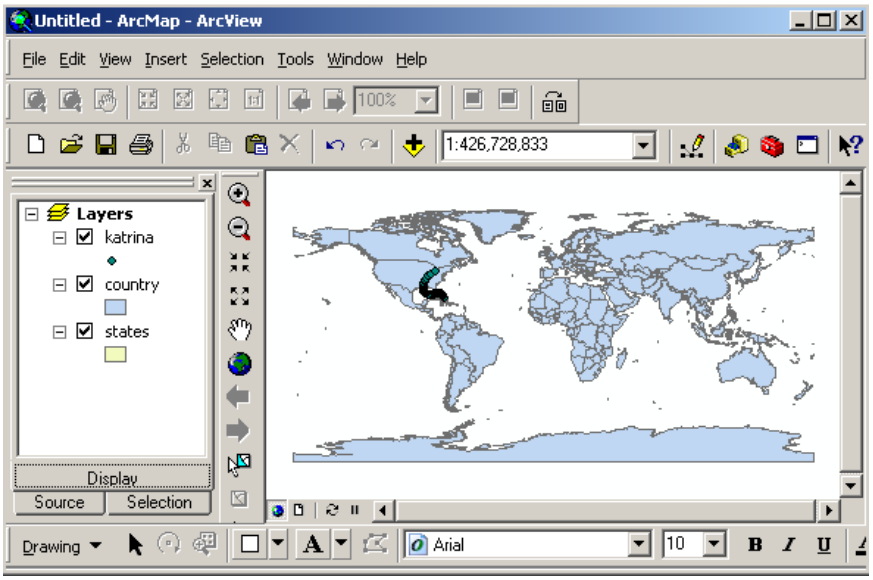
Questions to be answered:

1. What geographic area was impacted?
2. How can GIS data be used in emergency response decisions?
3. Which counties had the greatest number of people that were affected?
4. What additional data layers would you add to your map to help you to provide information to aid in the decision-making process?

1. *Add Data*

- Open **ArcMap**.
- Select a **new** empty map.
- Click **OK** for an empty map.
- Click on the **Add Data icon** and go to the **OverspaceData/Hurricanes/HurricaneData** folder.
- Click on country.shp and, while holding down the ctrl key, click on states.shp and katrina.shp .
- Click **Add**.

You should now see the following after those three layers are added (your default colors may be different):

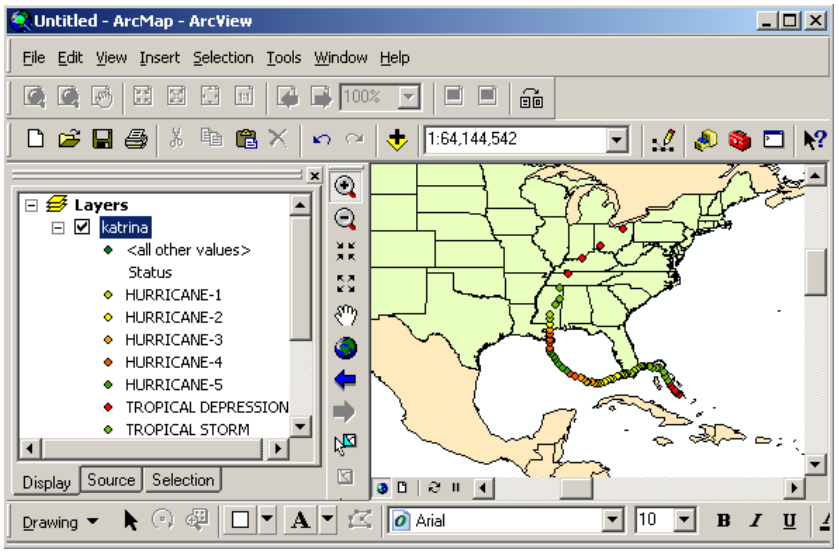


You now have a map that shows the world countries and the path of Hurricane Katrina. The states layer is not visible because the country layer is on top and masking it.

- Deselect all layers by clicking on a blank spot in the Table of Contents and drag the country layer below the states layer. You will see the US States displayed on your map.
- Click the **Identify icon** and click on different features of the map to see what data is listed for the different layers.
- Close the **Identify Results window**.
- Turn off the Identify icon by clicking on the **Select Elements icon** .
- Change the colors of the *world countries* to **beige** and the *states layer* to **olive**. Make the **outline width .40** and the **outline color black**.

2. *Symbolize the Path and Strength of Hurricane Katrina*

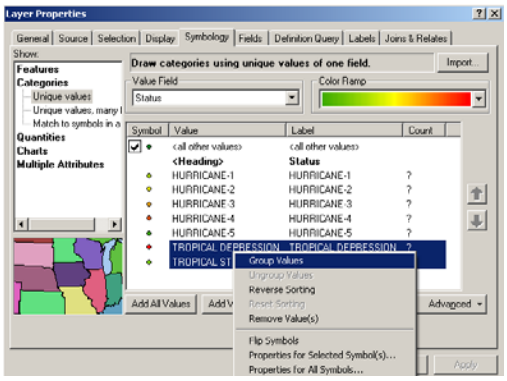
- Right-click on the Katrina layer, click **Properties**, then click **Categories** under the **Symbology tab**. Select **Unique Values** since we want the different stages of the hurricane to be displayed in unique colors.
- The **Value Field** should be changed to the feature you are working with. In this case, it should be status.
- Click **Add All Values** to add all of the attributes (hurricane strengths).
- Click **OK.** The stages of Hurricane Katrina now display in color:



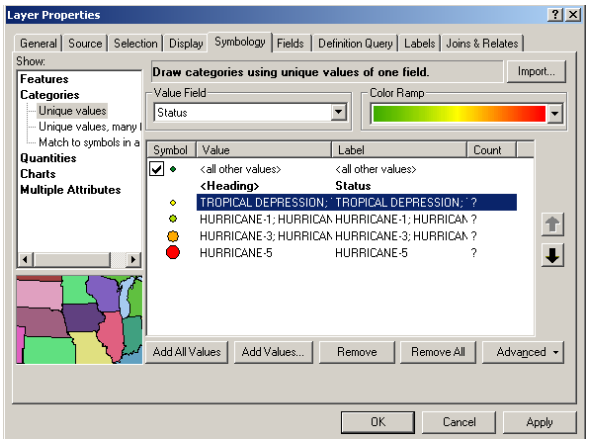
To make decisions about the impact of Hurricane Katrina, it is useful to reduce the number of groups. Let's group the storms strength into four groups; tropical depressions and storms, weak, intermediate, and strong hurricanes.

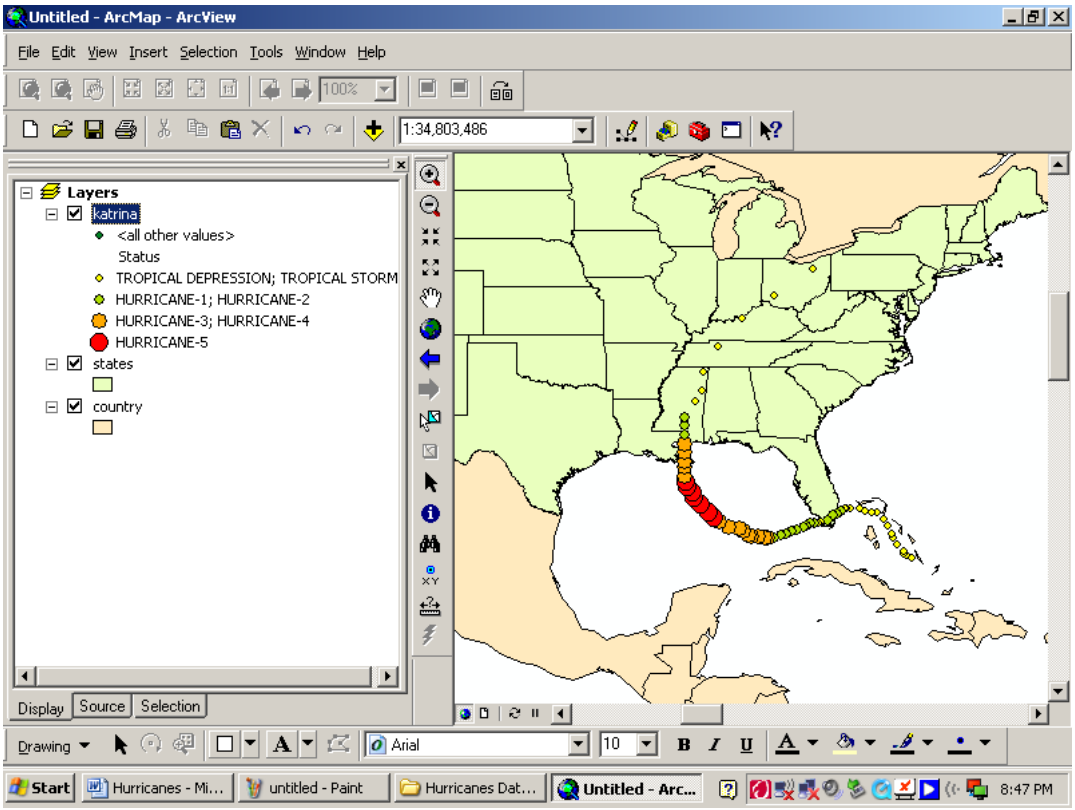
- Go back into **Layer Properties** in the **Symbology tab**.
- While holding the Ctrl key, select **tropical depressions** and **tropical storms.**
- Right-clicking on either while they are selected will bring up a menu. Select **Group Values** as shown in the following diagram.

Attributes can be grouped together and displayed on a map as one class.



- Group the HURRICANE-1 and HURRICANE-2 together and the HURRICANE-3 and HURRICANE-4 together. Leave HURRICANE-5 alone.
- Move the Tropical Depression group to the top of the list by highlighting it and clicking the **up arrow**  .
- Change the sizes of the symbols as follows: Make the **sizes 4, 6, 8, and 10** respectively. Make the colors as shown at right.
- Click **OK** and your map should look like the one below.

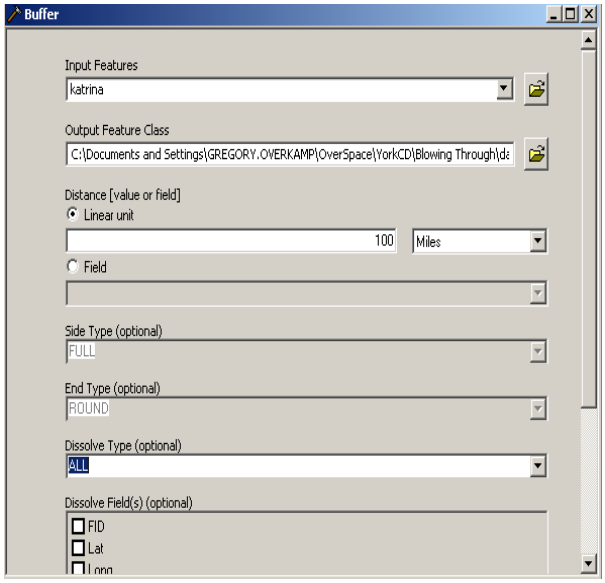




3. *Buffer*

In the case of a hurricane, it is helpful to identify an area within a 100 mile distance from the path so preparation, rescue, and relief plans can be made. To do this, we will need to identify an area within proximity of another feature, the hurricanes. We can accomplish this by creating a buffer. A **buffer** in GIS is a zone around a map feature measured in units of distance.

- Click on the **ArcToolbox icon**  near the top of the display window. Select **Analysis Tools, Proximity,** and then double-click on **Buffer.** A **buffer window** will appear.
- The **Input Features** are what you want to buffer around. This should be Katrina.
- The **Output Feature Class** will be the name of the buffered shapefile you want saved. Name the new shapefile and save it in your **Hurricanes** folder.
- Make the **linear unit 100**. Select **Miles** as the unit.
- We want to dissolve individual buffers around each point on our hurricane path, so choose **ALL** for **Dissolve Type**.
- The Buffer window should look like the figure below. Click **OK**. Ignore the datum conflict that you get.

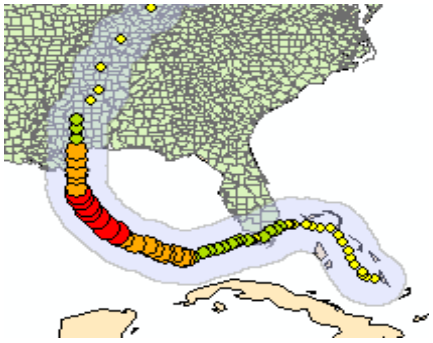


Notice that the buffer is a separate shapefile and is added to the Table of Contents. It does not include the data points for the hurricane. Turn the *Katrina layer* off and you will see the buffer alone.

4. *Clip*

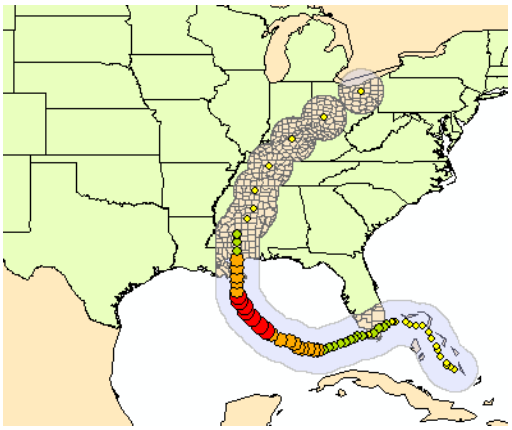
The **clip tool** extracts any features that are entirely within the boundaries that are defined. Clipping works much like a cookie cutter.

- **Add Data** the counties.shp and drag it in the Table of Contents below the katrina_Buffer layer. We want to see the counties below the buffer so we will make the buffer somewhat transparent.
- Double-click on katrina_Buffer and the **Layer Properties window** pops up. Select the **Display tab** and change the transparency to 60.
- Click **OK**. You can now see the counties below the hurricane buffer.

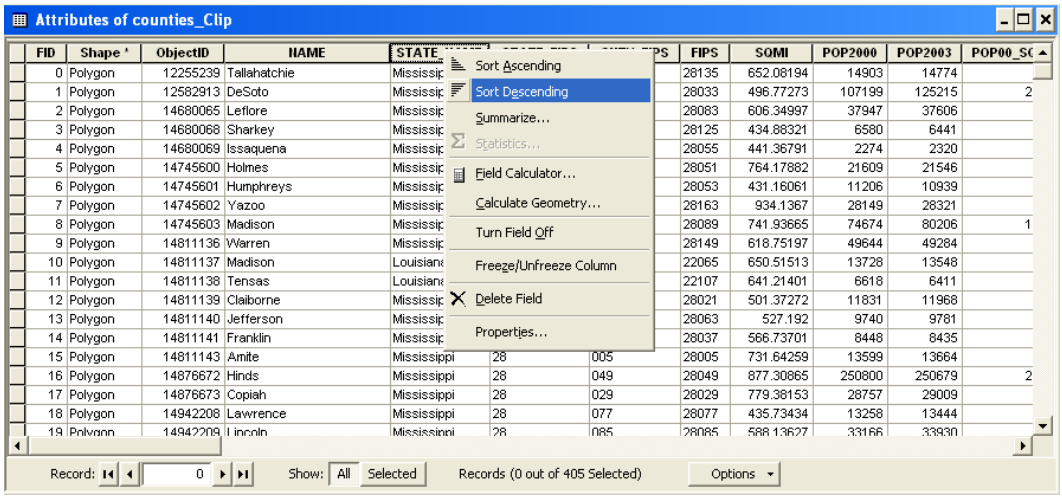


We are concerned only with the counties that are within the buffered area of the hurricane's path, so we will separate them from the rest by Clipping.

- Open **ArcToolbox** if it isn't already open and select **Analysis Tools, Extract,** and then double-click on **Clip**. A **Clip window** will pop up.
- The **Input features** is the layer you want clipped. In our case, we want the counties within the buffered area separated from the others. Enter counties.
- The **Clip Features** is the layer you want clipped to. In our case we want the counties within the buffered area clipped to the buffered area. Select your buffer shapefile.
- The **Output Feature Class** is the default name ArcMap gives to the shapefile to be created. Accept the default name for this exercise.
- Click **OK.** Close ArcToolbox by clicking the X in the top right corner.
- Turn off the counties layer and you can see your clipped shapefile.

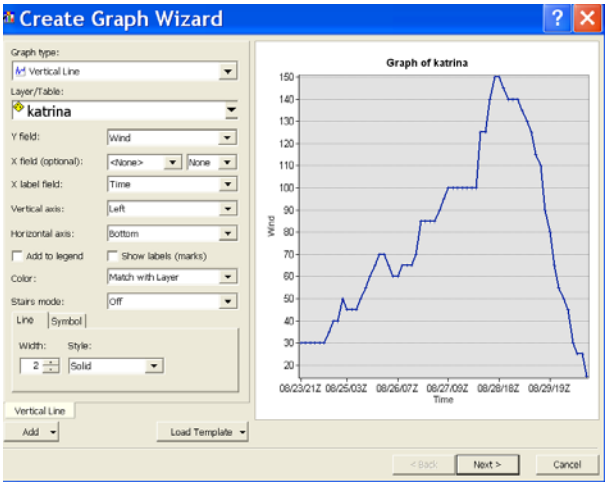


- Right-click on counties_Clip and select **Open Attribute Table**. The Attribute Table lists all the counties that fall within the buffered area of the Katrina path. Using the data in the table we can determine how many people will be most affected by the storm.
- The **Attributes Table** can be sorted in various ways by placing the cursor above the column to sort and right-clicking. **Sort Descending** the column for the **STATE_NAME** and scroll down to **Louisiana** to see the **population data** for the counties most affected by Katrina. Do the same for Mississippi.



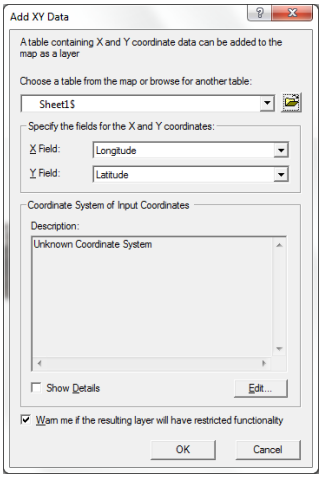
5. *Create a graph to show the wind speed of Katrina over time.*

- Go to **Tools/Graph/Create**
- Select **vertical line graph**
- Make sure that *Katrina* is the layer
- Y field is **Wind**
- X field is **Time**
- Uncheck Add to Legend



Add X/Y Data Hurricane Extension

1. *Adding X/Y Data*



- Open a new map.
- Add the *States* and *Counties* layers from the hurricane data folder.
- To add Hurricane Fred data, click **Tools/Add X/Y Data**
- Browse to Hurricane Fred folder
- Click on the **excel spreadsheet** and **Add**
- Click on **Sheet1** and Add
- The **X field** should be longitude
- The **Y field** should be latitude
- Click **OK** to all messages

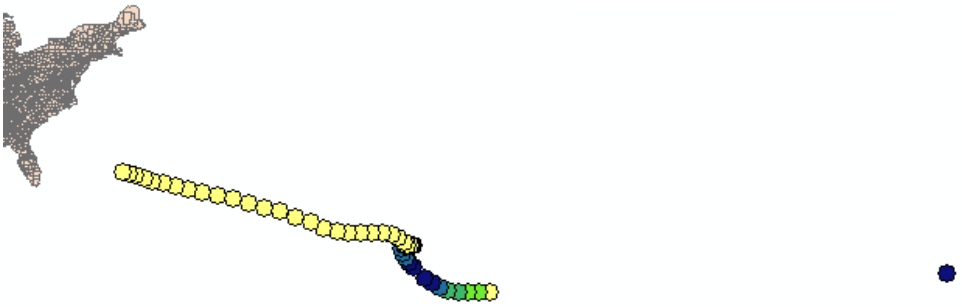
2. *Exporting a Shapefile*

The path of Hurricane Fred is now shown on your map, but in its current form its use is limited. It must be exported as a shapefile.

- Right-click on **Sheet1$events,** Choose **Data,** Choose **Export Data**
- Navigate to the Hurricane Fred folder
- Name the file *Fred.shp*
- Click **OK**
- Symbolize the track by wind speed using **quantities/graduated symbols**

(Hint: right-click on Fred and click Properties).

✓ OOPS! Where is that extraneous point coming from?



- Select the point in Sudan, Africa using the **Select Features tool** .
- Open the attribute table of Fred and compare the data of the selected point to the rest of the points.

✓ Can you find out what went wrong?

Solution: Notice that the longitude value of all of the points are negative (indicating that they are located in the western hemisphere) except for the selected point.

Use the Internet to get Hurricane Data Extension

1. Get Hurricane Isabel Data from the Internet

Now locate Hurricane Isabel data from the NOAA website in a table format and display it in ArcMap. Some basic knowledge of the use of Microsoft Excel is helpful for this section.

- *Go to www.nhc.noaa.gov*.
- On the **navigation bar** on the left hand side of the website, click on **Seasons Archive** under the **Hurricane History** section.
- In the middle of the page, there is a section that says **Atlantic, Caribbean, and the Gulf of Mexico**. Choose the **2003 season** and **click Go.**
- Click **Hurricane Isabel**
- About a quarter of the way down the page, there is a table that shows information about the hurricane, such as its location, pressure, and wind speed. **Highlight and copy it (Ctrl + C).**

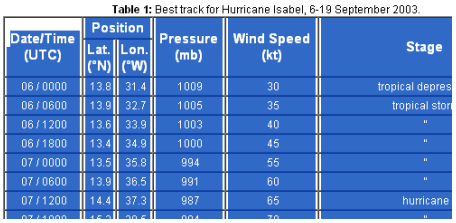


Table 1: Best track for Hurricane Isabel, 6-19 September 2003.

Date/Time (UTC)	Position		Pressure (mb)	Wind Speed (kt)	Stage
	Lat. (°N)	Lon. (°W)			
06 / 0000	13.8	31.4	1009	30	tropical depres
06 / 0600	13.9	32.7	1005	35	tropical stor
06 / 1200	13.6	33.9	1003	40	"
06 / 1800	13.4	34.9	1000	45	"
07 / 0000	13.5	35.8	994	55	"
07 / 0600	13.9	36.5	991	60	"
07 / 1200	14.4	37.3	987	65	hurricane

Before we can import the data to ArcMap, we must put it into a format that it will recognize. This will be a slightly complicated task. The easiest way to do this is to turn it into an Excel file. We cannot simply paste the table into Excel because it will recognize the numbers as text. The way around this is to first paste the table in **Notepad,** then import it into Excel.

2. Using Excel for Data

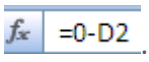
- Open Notepad (**Start>All Programs>Accessories>Notepad**) and click **Edit>Paste**.
- Save the file as **Isabel.txt**.
- Open Microsoft Excel. And click **Open**. Change **Files of Type** to **Text Files**. Open **Isabel.txt.**
- The **Text Import Wizard window** will pop up. Under **Original data type**, choose **Delimited**. Click Next.
- Under Delimiters, check the box that says **Space**.

This section lets Excel know where one cell ends and the next begins. Every time there is a space in the numbers, Excel will put the next set of numbers in the next cell. Nothing needs to be changed in step 3 of the wizard.

- Click **Finish**.

The result will not look very pretty. It will need to be cleaned up before it is useful to us.

Date/Time (UTC)	Position (mb)	Pressure (kt)						
	Wind Stage	Speed						
Lat. (~N)	Lon. (~W)							
6	/	0	13.8	31.4	1009	30	tropical	depression
6	/	600	13.9	32.7	1005	35	tropical	storm
6	/	1200	13.6	33.9	1003	40		
6	/	1800	13.4	34.9	1000	45		
7	/	0	13.5	35.8	994	55		

- Perform the following steps to set up the data: Delete rows 1-7 and 65. (Be careful. Select and delete all of these at the same time by using the Ctrl key. If you delete them one at a time, the numbers or letters will change) Delete columns A, C, and I-N. Insert a line above row 1 to create new headings for each column. The headings should be as follows: **Date, Time, Lat, Lon, Pressure, Wind.**
- Remember that the Lon values must be negative to show that they are in the western hemisphere. Insert a new column between Lon and Pressure and call it LonW. In cell E1 (the first row in the LonW column), type in the formula = 0-D2 

.
- Copy the value of E2. Highlight cells E3 to E60 and click Paste.
- Your table should now look like the figure at right.
- Save the table as an Excel Workbook. You may now import it in the same way as you imported the Hurricane Fred data above.

Date	Time	Lat	Lon	LonW	Pressure	Wind
6	0	13.8	31.4	-31.4	1009	30
6	600	13.9	32.7	-32.7	1005	35
6	1200	13.6	33.9	-33.9	1003	40
6	1800	13.4	34.9	-34.9	1000	45
7	0	13.5	35.8	-35.8	994	55
7	600	13.9	36.5	-36.5	991	60
7	1200	14.4	37.3	-37.3	987	65
7	1800	15.2	38.5	-38.5	984	70
8	0	15.8	39.7	-39.7	976	80
8	600	16.5	40.9	-40.9	966	95
8	1200	17.1	42	-42	952	110
8	1800	17.6	43.1	-43.1	952	110
9	0	18.2	44.1	-44.1	948	115
9	600	18.9	45.2	-45.2	948	115
9	1200	19.4	46.3	-46.3	948	115
9	1800	20	47.3	-47.3	948	115
10	0	20.5	48.3	-48.3	952	110
10	600	20.9	49.4	-49.4	952	110
10	1200	21.1	50.4	-50.4	948	115
10	1800	21.1	51.4	-51.4	942	120
11	0	21.2	52.3	-52.3	935	125
11	600	21.3	53.2	-53.2	935	125
11	1200	21.4	54	-54	925	135
11	1800	21.5	54.8	-54.8	915	145
12	0	21.6	55.7	-55.7	920	140

(Note, make sure you use the LonW data for longitude rather than the Lon data)

- Set Coordinate System
  - ✓ Can you find a relationship between the pressure and the wind speed?

Drill for Skill

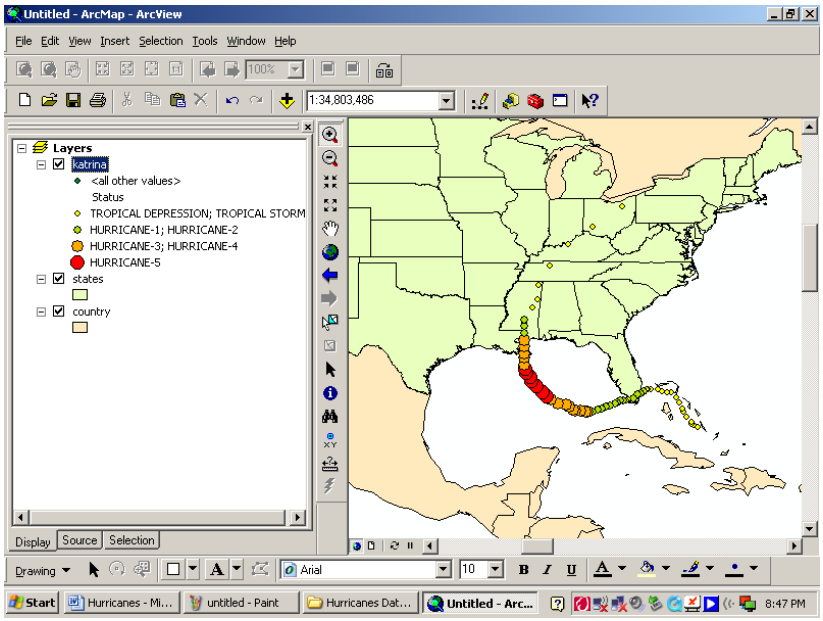
Create a new map that shows a 100 mile buffer around Hurricane Isabel.

- ✓ How many Virginia counties are within the 100 mile buffer?

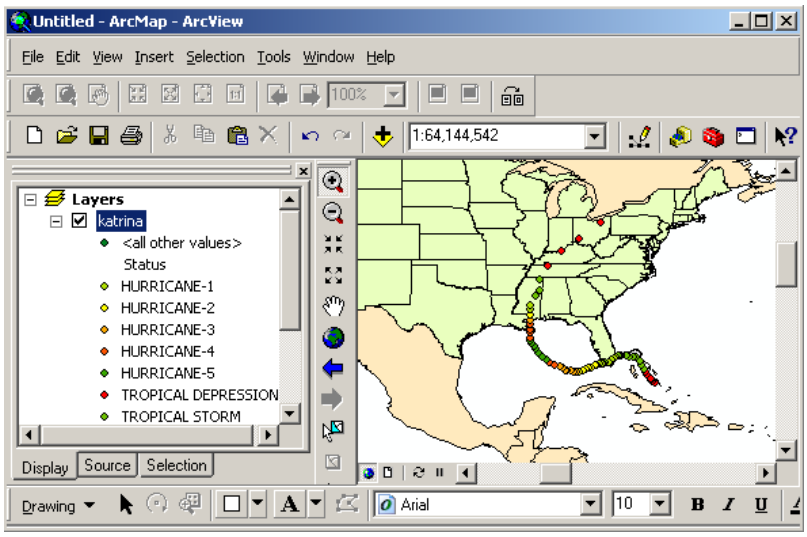
Hurricanes Extension for Experienced Users

1. *Perform the following tasks to complete this assignment:*

Use the data in the "hurricanes" folder to create this map:

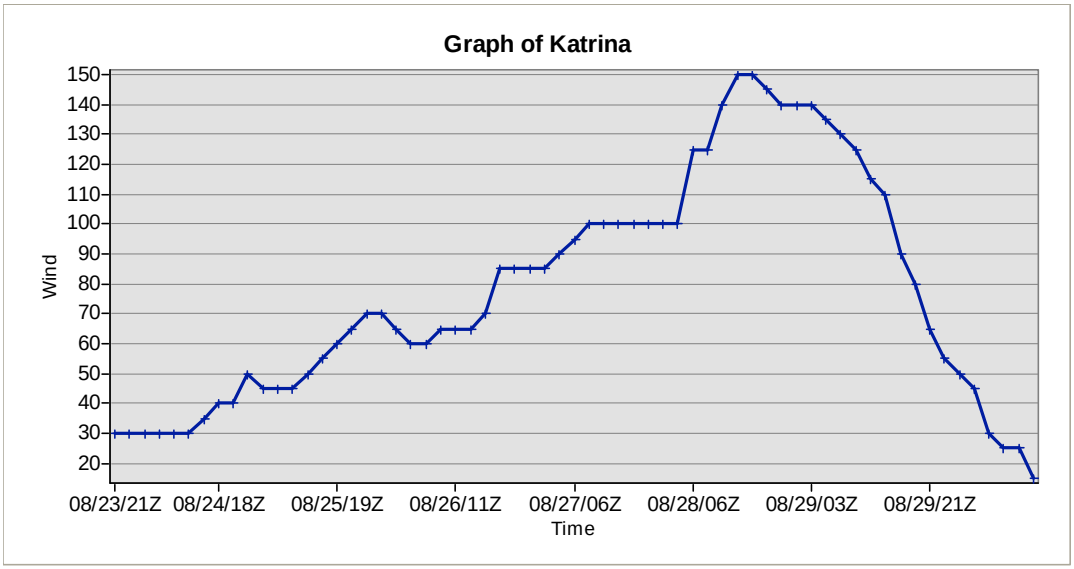


- Group the storms into four groups: tropical depression and storms; weak (categories 1 and 2), intermediate (categories 3 and 4); and strong (category 5).
- Change the symbols of the new categories to create the following map:



- Create a 100mi buffer around the path of Katrina. Save it in your hurricane folder.
- Create a new layer that includes the counties in that buffer zone. (Hint: Clip)

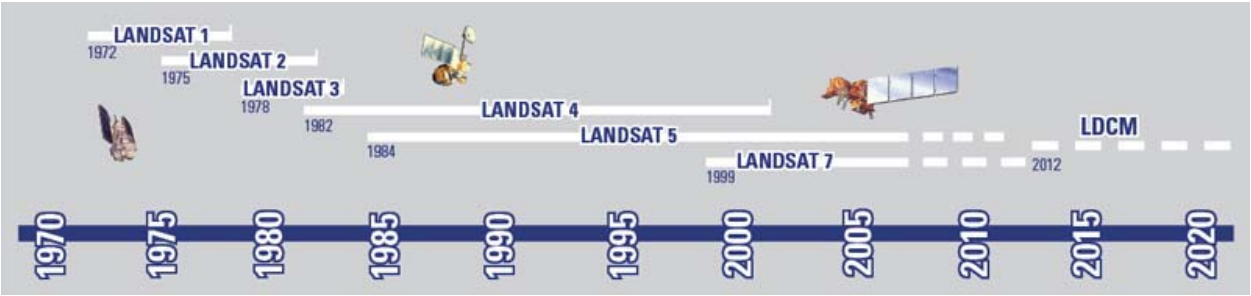
- Which two counties were most affected by Katrina in Louisiana? In Mississippi?
- Create a graph of wind speed/time for Hurricane Katrina.



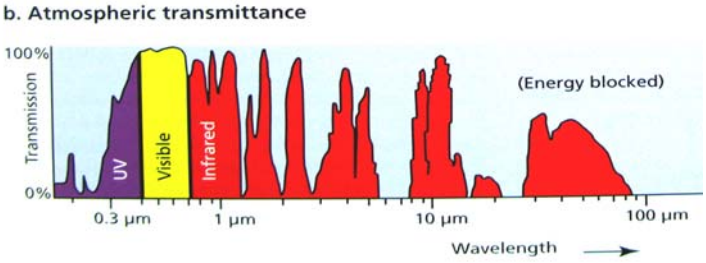
Remote Sensing Overview

Aerial photography was the beginning of being able to get images of large areas of our planet. The use of satellites has drastically improved that task. At the same time, a pixel (picture element) in the satellite image covers a large area (e.g. 170 km x 185 km for the whole image) and therefore is considered lower resolution than most aerial photos. In addition, most satellite images use multiple sensors and therefore you are able to put together many different images of the same area. Those different images give us different information about the area you might want to study.

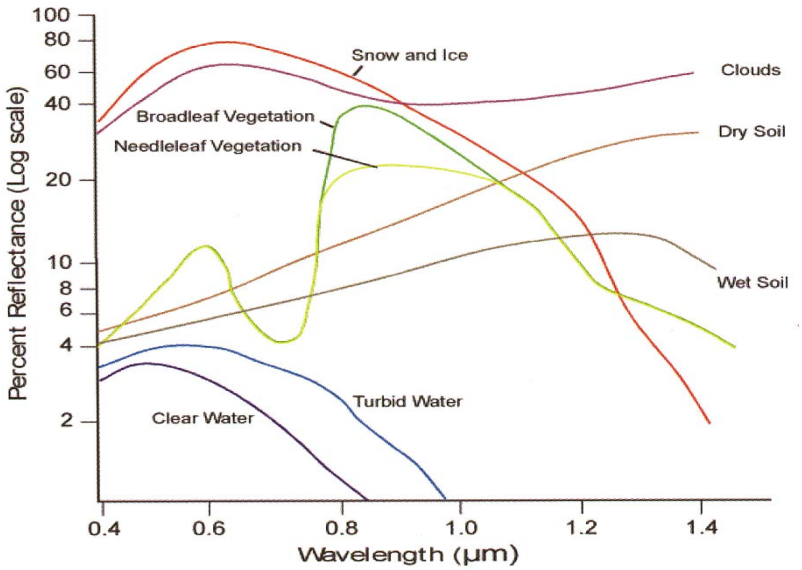
For our purposes, we will use images from the Landsat program as representative of this technology. The program has been around since 1971 and has used many different satellites. Landsat 5 has been the most prolific, by collecting images for more than 25 years. In addition, each satellite returns to any point on the earth approximately each 16 days



Light can interact with objects in different ways depending on the wavelength of the light and the properties of the object. Objects can interact with light in three different ways: the light can be reflected by the object, it can move through the object, or it can be absorbed. The following graph shows which wavelengths are transmitted (move through) and which are blocked by the earth's atmosphere. Notice that the visible wavelengths (what you can see with your eyes) makes up a small portion of the graph.



The next graph shows which wavelengths are important for viewing different objects. Notice that you would use different combinations of Landsat bands to certain types of objects due to these wavelength "signatures."



The following list describes the wavelengths used by seven different sensors on Landsat 5. Notice that they fit in the windows of "light" that can go through the atmosphere.

Band 1 (0.45-0.52 µm, blue-green): Since this short wavelength of light penetrates better than the other bands it is often the band of choice for aquatic ecosystems. It is used to monitor sediment in water, mapping coral reefs, and water depth. Unfortunately this is the noisiest of the Landsat bands since short wavelength blue light is scattered more than the other bands. For this reason it is rarely used for "pretty picture" type images.
Band 2 (0.52-0.60 µm, green): This has similar qualities to band 1 but not as extreme. The band was selected because it matches the wavelength for the green we see when looking at vegetation.
Band 3 (0.63-0.69 µm, red): Since vegetation absorbs nearly all red light (it is sometimes called the chlorophyll absorption band) this band can be useful for distinguishing between vegetation and soil and in monitoring vegetation health.
Band 4 (0.76-0.90 µm, near infrared): Since water absorbs nearly all light at this wavelength water bodies appear very dark. This contrasts with bright reflectance for soil and vegetation so it is a good band for defining the water/land interface.
Band 5 (1.55-1.75 µm, mid-infrared): This band is very sensitive to moisture and is therefore used to monitor vegetation and soil moisture. It is also good at differentiating between clouds and snow.
Band 6 (10.40-12.50 µm, thermal infrared): This is a thermal band, which means it can be used to measure surface temperature. This is primarily used for geological applications but it is

sometime used to measure plant heat stress. This is also used to differentiate clouds from bright soils since clouds tend to be very cold. One other difference between this band and the other multispectral ETM bands is that the resolution is half of the other bands (60 m instead of 30 m).
Band 7 (2.08-2.35 µm mid-infrared): This band is also used for vegetation moisture although generally band 5 is preferred for that application, as well as for soil and geology mapping.

To create an image on your computer screen you are using combinations of red, green, and blue. Therefore to create a normal looking (true color) picture you would choose bands 3, 2, 1. Because vegetation is more "visible" in band 4 (NIR), many people will use bands 4, 2, 1. As an alternative, most vegetation is green and some people will do 3, 4, 1. The following images are good examples of those combinations.

Hue, Vietnam

23 April, 2003

Landsat image

Using the Band Combination Tool
http://biodiversityinformatics.amnh.org/tool.php?content_id=141

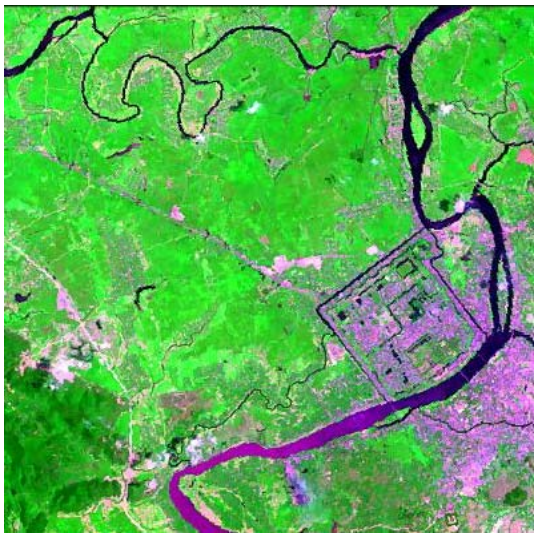
bands 3, 2, 1

true color

This and the next two images are taken from American Museum of Natural History, Center for Biodiversity and Conservation. Available from http://biodiversityinformatics.amnh.org. They are used under the Creative Common license.

bands 4, 2, 1

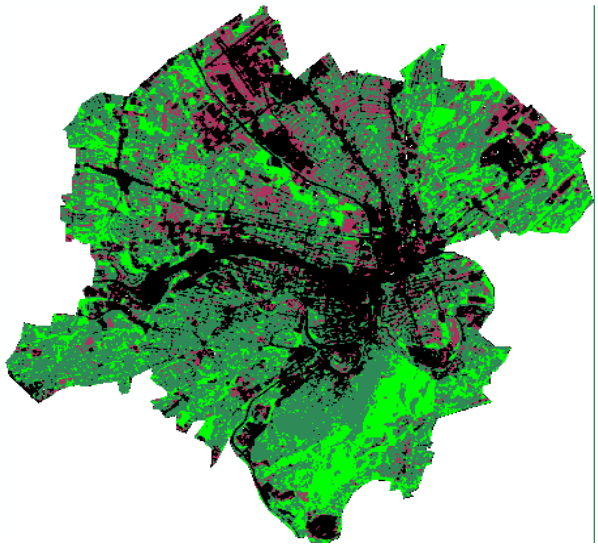
Note that in this false color image, band 4 (near infrared) is represented in red. Remember that vegetation strongly reflects near infrared light. As a result, vegetation in this image appears as bright red.



bands 3, 4, 1

false color, but many may think it is true

bands 4, 5, 7



Bands 3, 4, 1

Landsat image of Roanoke, VA

Done by author to help identify tree canopy within the city. Some additional band math was done to create this particular image.

Resources:

Landsat images: glovis. usgs.gov

Remote Sensing Tutorial , http://rst.gsfc.nasa.gov/

http://biodiversityinformatics.amnh.org.

Canadian Remote Sensing Tutorial, http://www.ccrs.nrcan.gc.ca/index_e.php

Remote Sensing in GIS

Lesson Overview

In this lesson, students will learn to download Landsat images from the USGS Global Visualization Viewer and import the images into ArcMap.

Skills:

1. Use the USGS Global Visualization Viewer.
2. Find and download Landsat images.
3. Decompress images.
4. Import Landsat images into ArcMap.

Standards:

Virginia Standards of Learning: Earth Science (ES3); Physical Science (PS9);.World Geography: (WG1)

References:

Lisa McCray and Heather Smith

Questions to be answered:

1. What services does GLOVIS provide?
2. What is Landsat?
3. How are Landsat images imported into ArcMap?

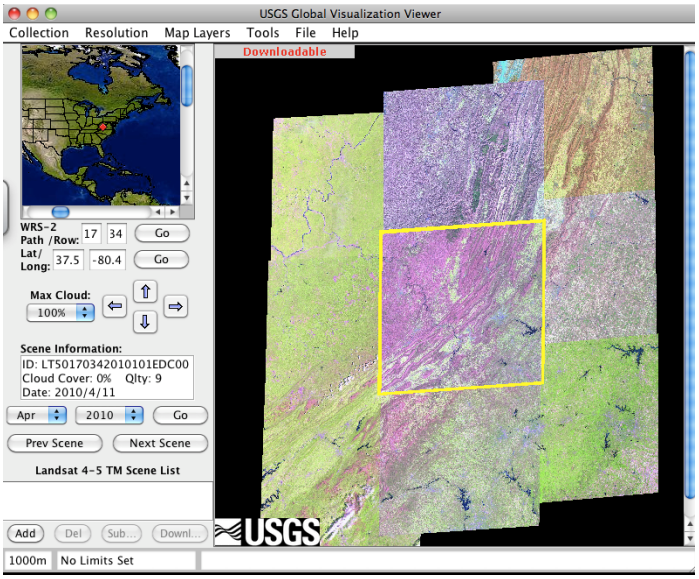
"The Landsat Program is a series of Earth-observing satellite missions jointly managed by NASA and the U.S. Geological Survey. Since 1972, Landsat satellites have collected information about Earth from space. This science, known as remote sensing, has matured with the Landsat Program.

Landsat satellites have taken specialized digital photographs of Earth's continents and surrounding coastal regions for over three decades, enabling people to study many aspects of our planet and to evaluate the dynamic changes caused by both natural processes and human practices."

http://landsat.gsfc.nasa.gov/

1. *Using the Global Visualization Viewer*

- In a web browser, go to glovis.usgs.gov. This will take you to a site that gives you access to remote sensing images from many different satellites.
- The glovis home page features a large world map. If you know the coordinates of the area you would like to download, you may enter them in the latitude and longitude boxes above the map. Alternatively, you can click the area directly on the map.
- After you have entered your request, a new java window will open showing a small preview of the landsat images available for the area.



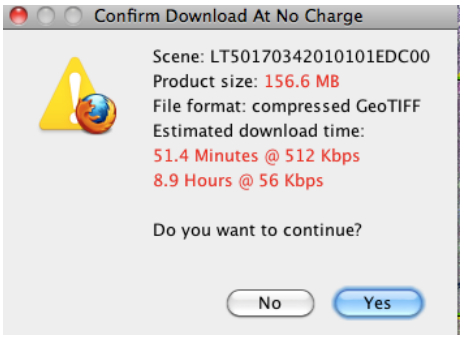
FYI: Landsat 7 has had image problems since 2003. You might appreciate using images from Landsat 5 since it has been collecting images for 25 years. That provides you with images over a wide variety of time to look at land use changes over time. The satellite returns to the same site every 16 days

The glovis viewer displays important information about the selected image on the left hand side

- Richmond is in the center image that is identified as Path 15 Row 34
- Scene Information shows that this image has no cloud cover (quality 9) and date of image

2. Downloading Landsat Images

- In the top of the window, the label DOWNLOADABLE indicates that the image is immediately.
- At the bottom left, click on the ADD button to the image to the window just above the ADD button. That will then activate the Download button. (If the image does not have the DOWNLOADABLE label, then you will have to click on the Sub(mit) button. This will start the process for the getting the image available for downloading.
- A small window will appear when you download an image. (Shown below) The file name tells you that it is a Landsat 5 image of path 17 row 34 on day 101 (April 11) of year 2010. The file is 156 MB.
- You will need to create an account if you don't already have one.



This is a compressed file that needs to be uncompressed with a good utility. It is double compressed. When you get the file uncompressed you will see why the download is so big.

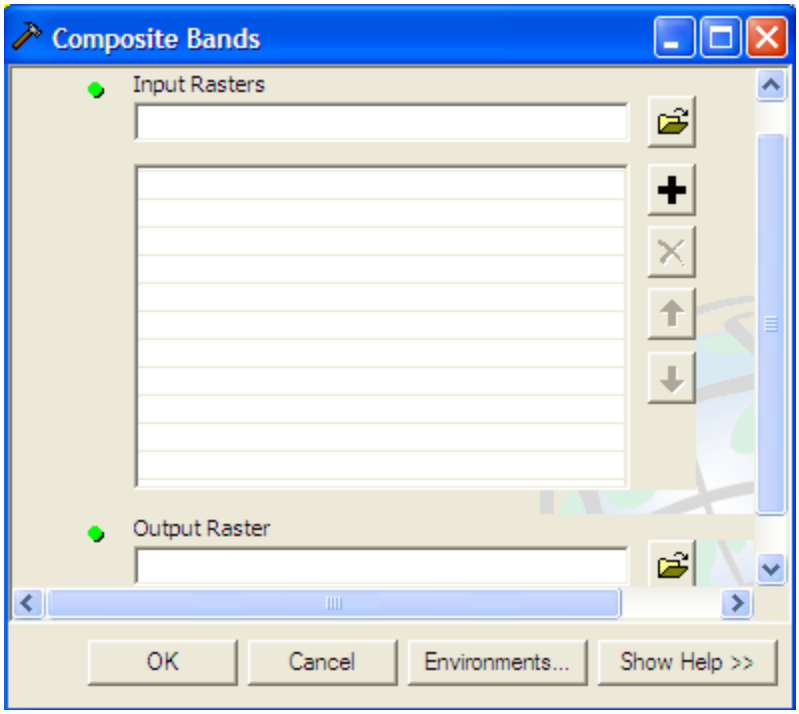
Name	Date Modi...	Size	Kind
L5017034_03420100411_B10.TIF	4/11/10	59.3 MB	TIFF image
L5017034_03420100411_B20.TIF	4/11/10	59.3 MB	TIFF image
L5017034_03420100411_B30.TIF	4/11/10	59.3 MB	TIFF image
L5017034_03420100411_B40.TIF	4/11/10	59.3 MB	TIFF image
L5017034_03420100411_B50.TIF	4/11/10	59.3 MB	TIFF image
L5017034_03420100411_B60.TIF	4/11/10	59.3 MB	TIFF image
L5017034_03420100411_B70.TIF	4/11/10	59.3 MB	TIFF image
L5017034_03420100411_GCP.txt	4/11/10	16 KB	Plain Text
L5017034_03420100411_MTL.txt	4/11/10	66 KB	Plain Text
README.GTF	4/11/10	12 KB	Document

Now you are ready to add your combination of bands to a ArcGIS map. ArcMap/ArcToolbox can allow you to work with multi-band images directly in ArcGIS

3. Using Landsat Images in ArcMap

- Open ArcMap with Toolbox available
- In Toolbox, expand DATA MANAGEMENT TOOLS: RASTER: COMPOSITE BANDS

- In the new window, you can import just the three bands you want to display in red-green-blue (notice that you can change the order of the bands in the middle section) and then save as an image (typically geotiff).



- You can also import all of the bands into a single image remembering that only the first3 bands will be displayed. The advantage here is that you can reorder the bands in ArcMap, under PROPERTIES: DISPLAY