Storm Mapping Tutorial

Step-by-step guide for using GIS to create maps of weather conditions before, during, and after hurricanes.

NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

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GIS Support Tutorial: Introduction

The National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center developed this GIS Support Tutorial for members of the Federal Emergency Management Agency (FEMA) and their contractors. The tutorial provides guidance to those using ArcGIS for map production before, during, and after hurricanes.

Though this tutorial focuses on novice users of geographic information systems, or GIS, those users who have not taken the Environmental Systems Research Institute's (ESRI) *Introduction to ArcGIS I* course (or similar introductory ArcGIS training) should first familiarize themselves with basic GIS concepts and cartographic principles.

This tutorial provides guidance in the following ways:

- Discussion of where to find NOAA National Weather Service data and other related resources
- Basic direction on how to use ArcGIS for cartographic production
- Standard cartographic principles in designing specific presentation-quality maps for FEMA's use

GIS Support Tutorial: Mapping Timeline

A general timeline is provided to show when each product may be created, but timing of products can be altered based on specific characteristics of an event.

	Chapter/Product	Pre-Landfall			Landfall	Post-Landfall
		Day -3	Day -2	Day -1	Day 0	Day 1
1	**6-Hour Quantitative Precipitation Forecast**		✓	✓	✓	✓
2	**Forecast Waveheight**	✓	✓	✓	✓	
3	**Forecast Windspeed**	✓	✓	✓	✓	
4	**120-Hour Quantitative Precipitation Forecast**	✓	✓	✓	✓	✓
5	**NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast**	✓	✓	✓	✓	✓
6	**24-Hour Stage III Rainfall**				✓	✓
7	**Cumulative Rainfall - Stage III Multi-Sensor Precipitation Estimate**				✓	✓
8	**SLOSH Model Run - hypothetical (h), or real-time (r)**	✓ h	✓ h	✓ r	✓ r	
9	**6 Hour Flash Flood Guidance**		✓	✓	✓	✓
10	**120-Hour QPF / 6-Hour Flash Flood Guidance Difference**		✓	✓	✓	✓
11	**Stage III Rainfall / 6-Hour Flash Flood Guidance Difference**				✓	✓
12	**Significant River Flood Outlook**	✓	✓	✓	✓	✓
13	**Tropical Cyclone Wind Speed Probabilities**	✓	✓	✓	✓	

GIS Support Tutorial: Requirements

To complete this tutorial, you will need the following tools:

❑ ArcGIS, ArcView version 8.x or higher with the Spatial Analyst extension
Contact Information

Environmental Systems Research Institute (ESRI)
www.esri.com

❑ HURREVAC
Contact Information

John F. Townsend
Sea Island Software Inc.
(843) 881-0593
www.hurrevac.com
support@hurrevac.com

❑ SLOSH Display Program – with GIS shapefile export capability enabled
Contact Information

Arthur Taylor	Wilson (Wil) Shaffer
Arthur.Taylor@noaa.gov	Wilson.Shaffer@noaa.gov
(301) 713-1613, x163	(301) 713-1613, x167

Continued on next page…

GIS Support Tutorial: Requirements

❑ National Digital Forecast Database (NDFD) GRIB2 Decoder

Contact Information

Arthur Taylor
Arthur.Taylor@noaa.gov
(301) 713-1613, x163
www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/howto.php

❑ A file decompression utility such as WinZip or PKZIP – This software allows you to extract compressed shapefiles that are used throughout the tutorial.

WinZip – www.winzip.com/downwzeval.htm
PKZIP – http://nct.digitalriver.com/fulfill/0018.18

❑ Adobe PDF – Finished maps are exported to .pdf format for easy exchange and printing. This software allows you to create these files.

www.adobe.com/products/acrobatpro/tryout.html

Other Resources

❑ NOAA Coastal Services Center Storm Info Web site – This site provides links to many of the data sources listed in the tutorial.

www.csc.noaa.gov/storm_info/guide.html

❑ FEMA's floodmaps.net – This site is for use by those actively engaged in flood hazard mapping, maintenance, and update. This site's Easy FTP page allows you to share large files with others.

www.floodmaps.net/eftp/

6-Hour Quantitative Precipitation Forecast

Purpose: This type of map presents a 6-hour estimate of the amount of expected rainfall for a given area. The information is displayed as a summary of total predicted rainfall, measured in inches, for that period of time.

Source Data: This type of map uses the NOAA National Weather Service's National Digital Forecast Database (NDFD), found at *www.nws.noaa.gov/ndfd/*. The National Weather Service (NWS) provides access to gridded forecasts of weather elements (e.g., cloud cover, maximum temperature) through the NDFD. This database contains a seamless mosaic of digital forecasts from NWS field offices working with the National Centers for Environmental Prediction (NCEP). The database uses a 5-kilometer national grid that covers the continental U.S. and separate grids that cover Hawaii, Alaska, the U.S. Virgin Islands, and Puerto Rico. Each 5-kilometer grid cell has forecast information, allowing users to retrieve specific forecasts by entering geographic coordinates.

The World Meteorological Organization (WMO) has adopted Edition 2 of the gridded binary data (GRIB) code as a standard for sharing information. GRIB, Edition 2 (GRIB2), is involved in the NDFD in two ways. First, GRIB2 is the code form used to transmit gridded forecasts from contributing offices to the NDFD. Second, GRIB2 is one of the primary forms used to transmit the NDFD grids to NWS customers and partners. Users should note that this should be considered an experimental product at the time of this writing (March 2006).

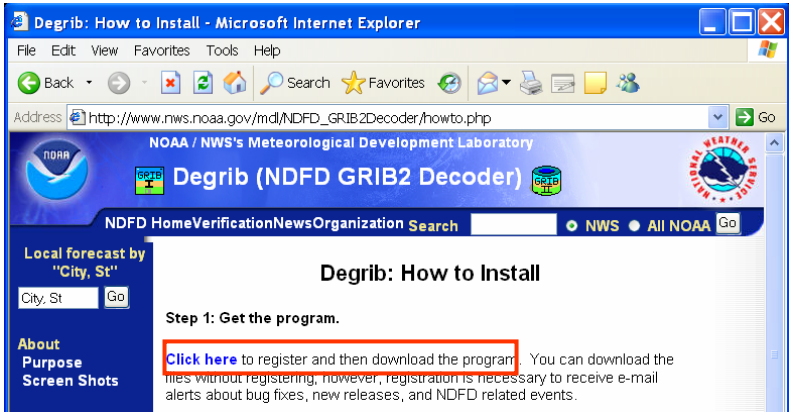
Download: Before working with NDFD data, users must first download the GRIB2 Decoder tool that allows access to the data. Learn more about GRIB2 Decoder by visiting this site: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/*

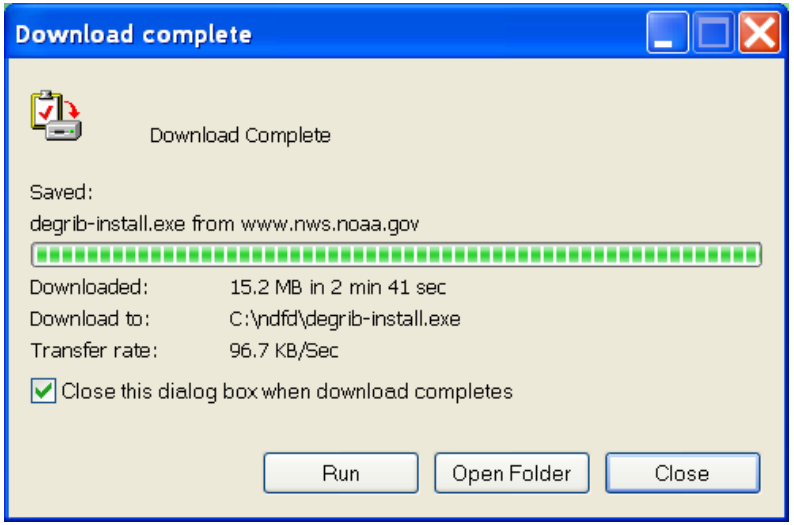
6-Hour Quantitative Precipitation Forecast

Download: Register for the DEGRIB program here: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/howto.php*
At the top of the page, under step 1, click on the highlighted link to register and download the program.

Once done, download the program from here:
www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/download.php

This page provides several different versions of the same product. For this tutorial, you will focus on the Microsoft Windows version. Click on **degrib-install.exe** and select **Save**. Specify the directory path for the program as c:/ndfd and copy the .exe into that folder.





Double-click on **degrib-install.exe** to install the program. A window will appear; click on the **Install** button and accept the defaults for the installer.

6-Hour Quantitative Precipitation Forecast

Download: Double-click on **tkdegrib (aka NDFD GRIB2 Decoder)** to start the program.

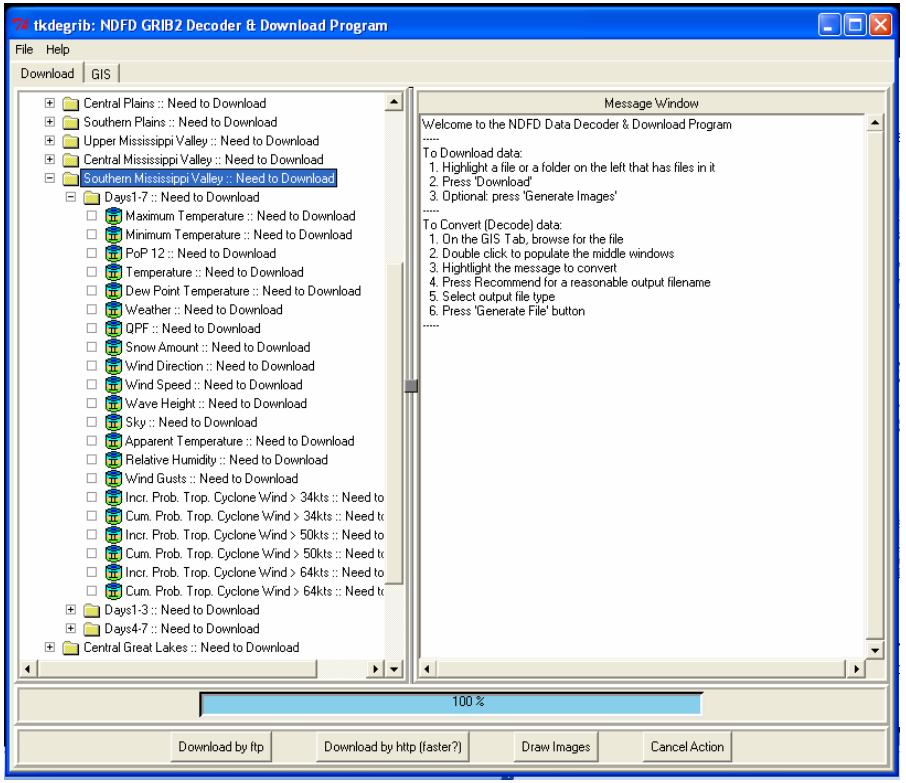
Then click on the **Download** tab and expand the NDFD data set folder if it is not already open.

Choose the region of interest and expand the file. Choose the days of interest and expand the folder.

Data for each weather element can be downloaded by highlighting the entire region folder, or individual weather elements can be downloaded by holding down the Control key on the keyboard and highlighting one or more elements.

Click on **QPF** (quantitative precipitation forecast), and then click on either the **Download by FTP** or the **Download by HTTP** button (either will work) at the bottom of the window.

Once downloading begins, there will be an indication in the Message Window that it is working. Also, after the download button is clicked, the light blue bar near the bottom of the window will show the progress of the data download.

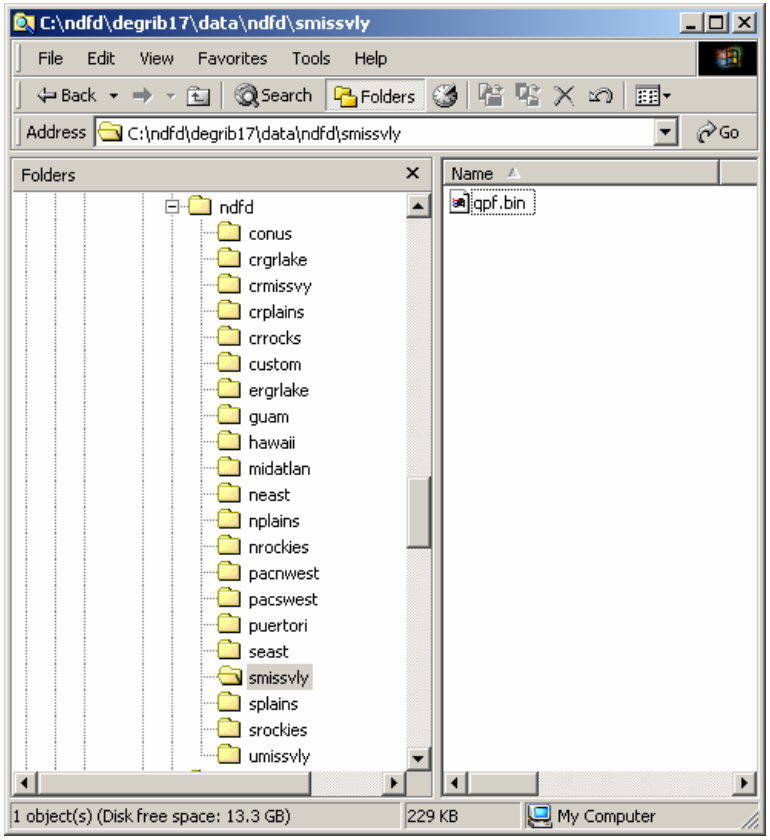


6-Hour Quantitative Precipitation Forecast

View the data: Minimize this program and open **Windows Explorer**. Navigate to C:\ndfd\degrib18\data\ndfd\smissvly and notice that qpf.bin is stored in that directory.

This file contains important data in a binary format. Unfortunately, ArcGIS is unable to read this format, so the data must be converted into a shapefile.

Close Windows Explorer and return to the **tkdegrib (aka NDFD GRIB2 Decoder)** program.



6-Hour Quantitative Precipitation Forecast

Convert the data: Click on the **GIS** tab. This window lets users choose a file to convert to various GIS-friendly formats. Navigate to the directory of your .bin file. Double-click on **qpf.bin** to see a series of precipitation forecasts.

Select the first in the list, which provides the 6-hour forecast.

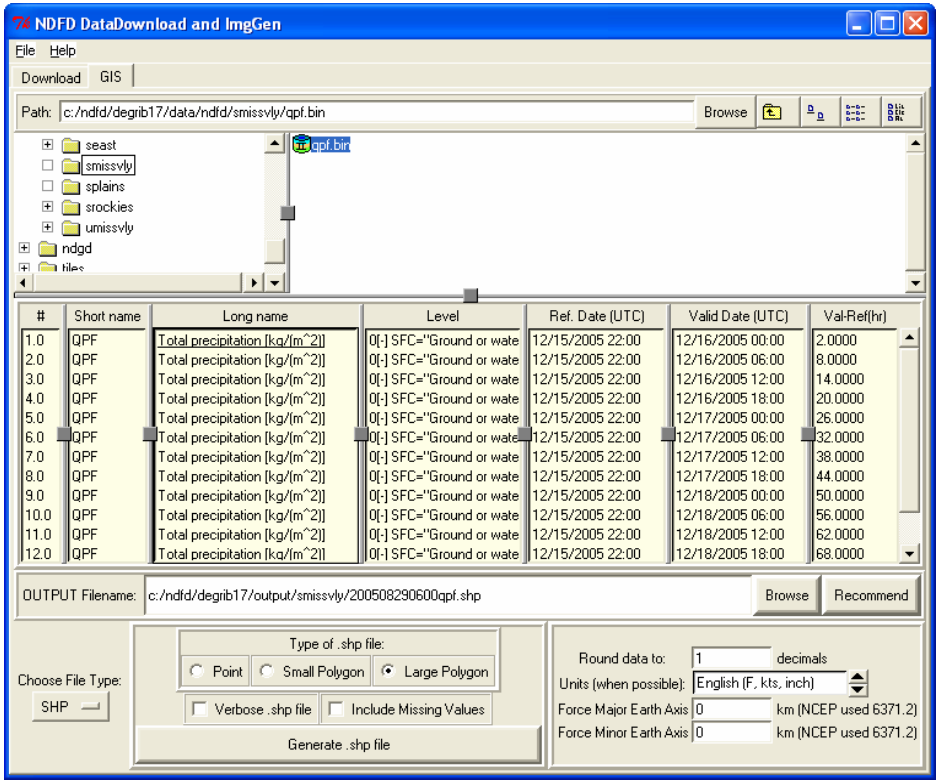
An easy way to create an output shapefile inside the Output Filename window is to simply click on the Recommend button. Ideally, you should keep all of your regional files in the same directory (i.e., smissvly).

Specify the File Type as **SHP** (shapefile).

Specify the type of shapefile to be **Large Polygon**.

Specify **Round data to: 1** decimal.

When finished, click the **Generate .shp file** button. This will create a new shapefile and copy it into your specified folder. Notice that it is in a different folder than the qpf.bin file.

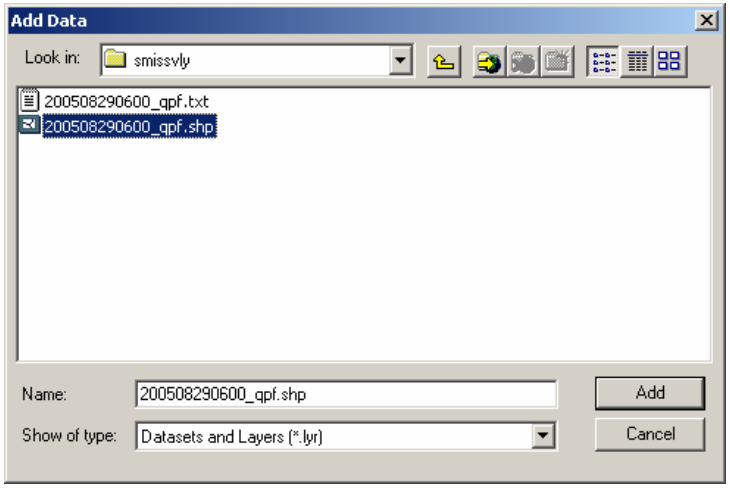


When finished, click on the window that reads **Done**. Minimize the program and open **ArcMap**.

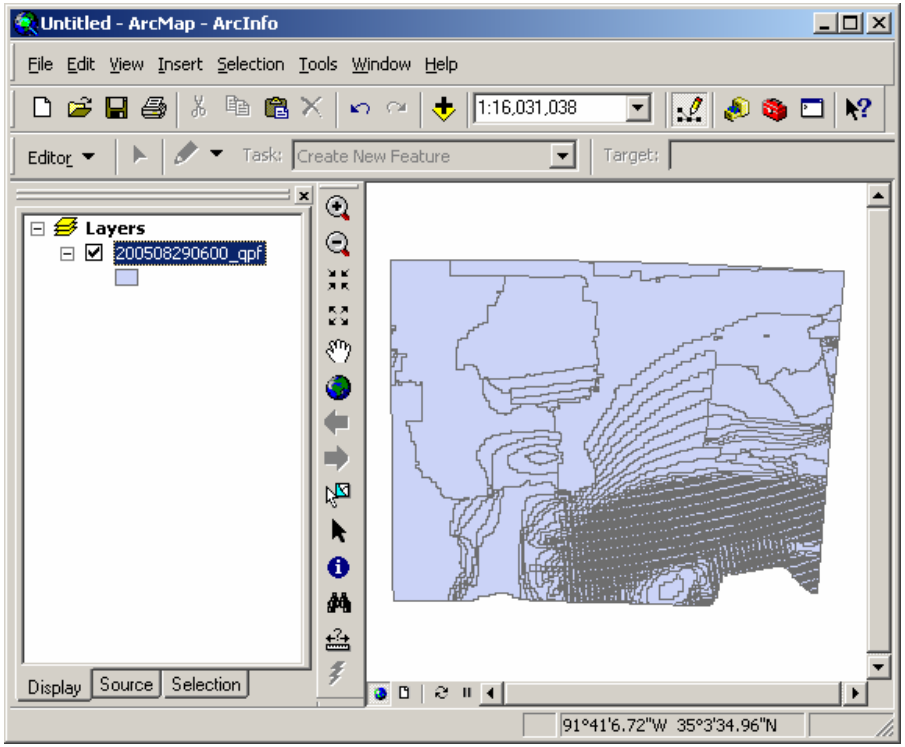
6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: ArcMap can be started by selecting **Start > Programs > ArcGIS > ArcMap**

Add data by clicking on the **Add Data** button found at the top of the ArcMap window. This will start a dialog window that lets users browse to their data.



Select the file and click **Add**. Notice the layer is now added to the top of the table of contents in ArcMap.



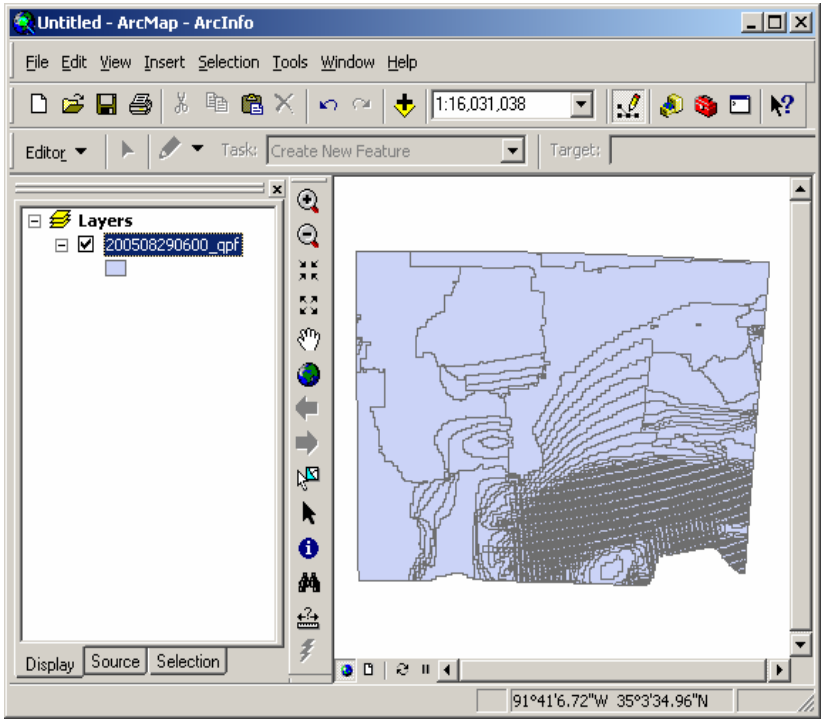
The data should now be symbolized to show the amounts of precipitation expected in the area.

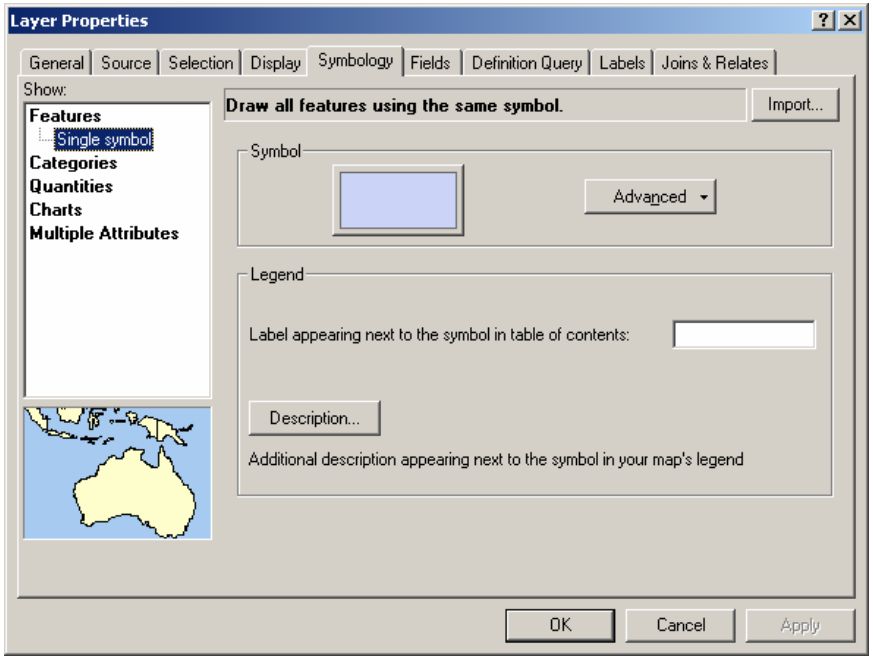
6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Double-click on the shapefile layer in ArcMap's table of contents. This opens the Layer Properties dialog box.

Click on the **Symbology** tab to specify a predefined legend.

Click on the **Import** button to browse to predefined layer files.

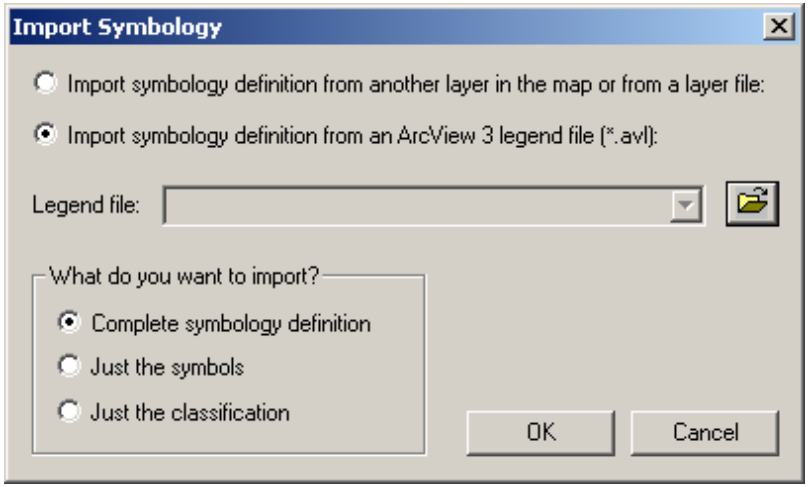


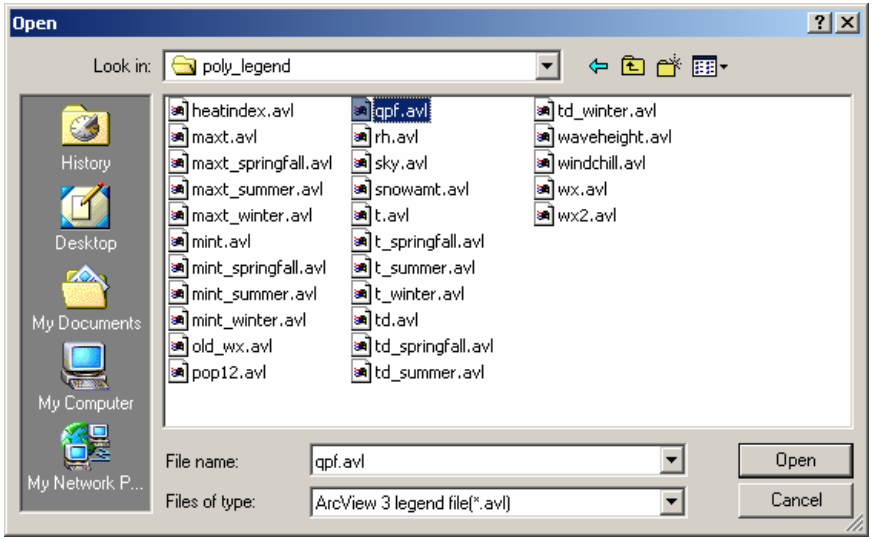


6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: In the Import Symbology dialog box, choose to **Import symbology definition from an ArcView 3 legend file (*.avl)**.

Click on the **Browse** button and navigate to C:\ndfd\degrib17\arcview\poly_legend.



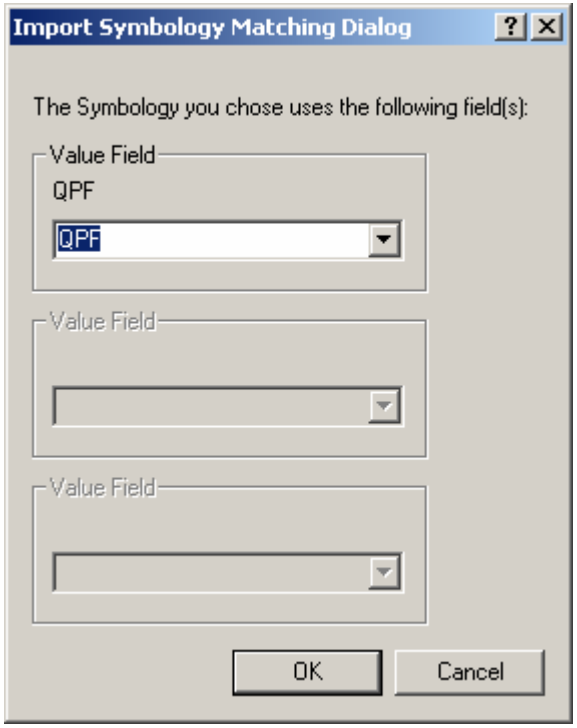


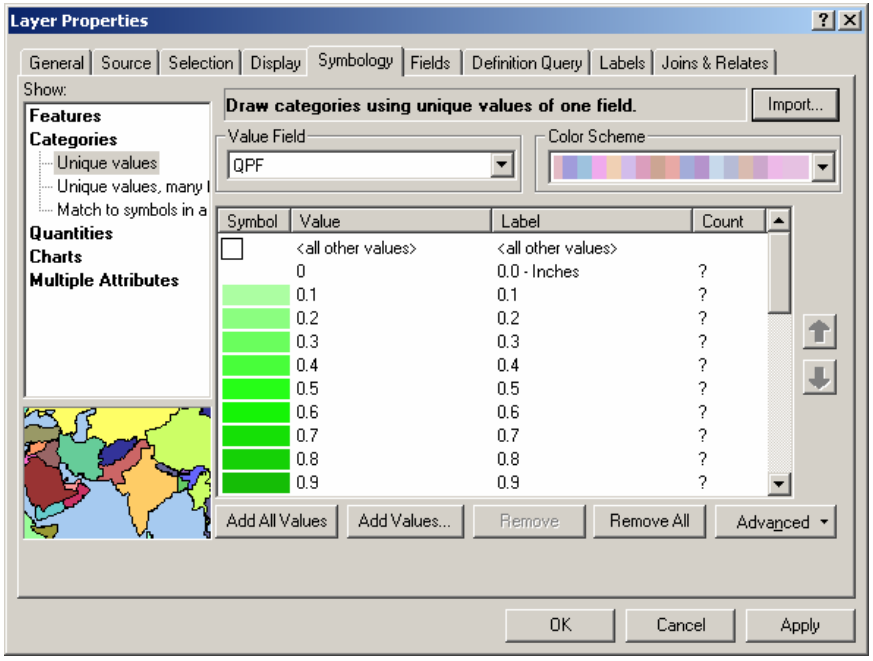
Select **qpf.avl** and click on the **Open** button.

6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: In the Import Symbology Matching Dialog window, take the default **QPF** values listed in the Value Field drop-down menu.

Click **OK**.





Notice that a predefined set of symbols and values has been added under the Symbology tab. Click **OK** to assign these to the data.

6-Hour Quantitative Precipitation Forecast

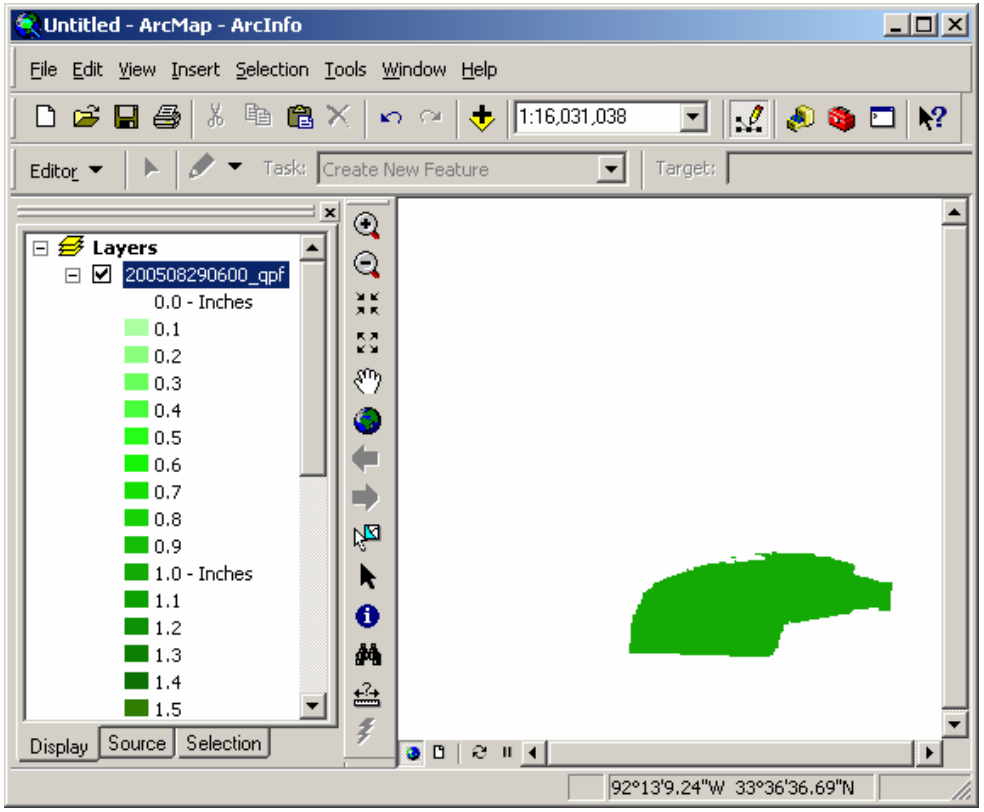
Add and symbolize the data: The resulting symbology color ramp will be assigned to the polygons of the QPF layer according to their predicted precipitation amounts for the next 6 hours.

Of course, you cannot tell where this area is located. To do so, add a layer of county boundaries.

A good resource for ancillary base map data is the NOAA Advanced Weather Information Processing System (AWIPS) Web site:
www.nws.noaa.gov/geodata/

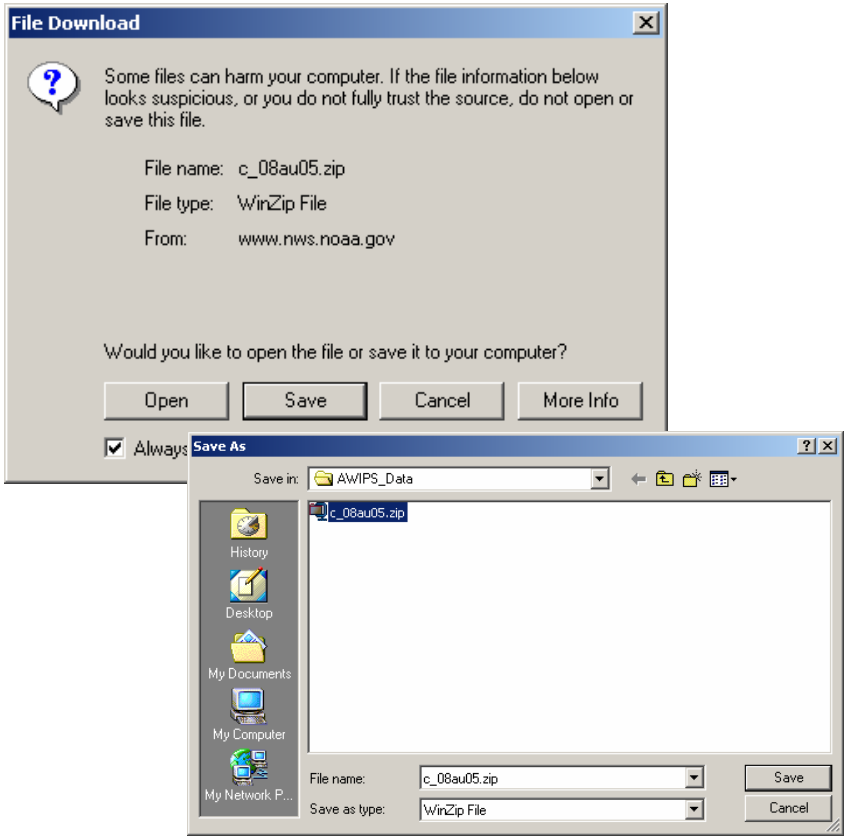
Open a Web browser and navigate to this site. Scroll down the Web page and look for a section called County Libraries.

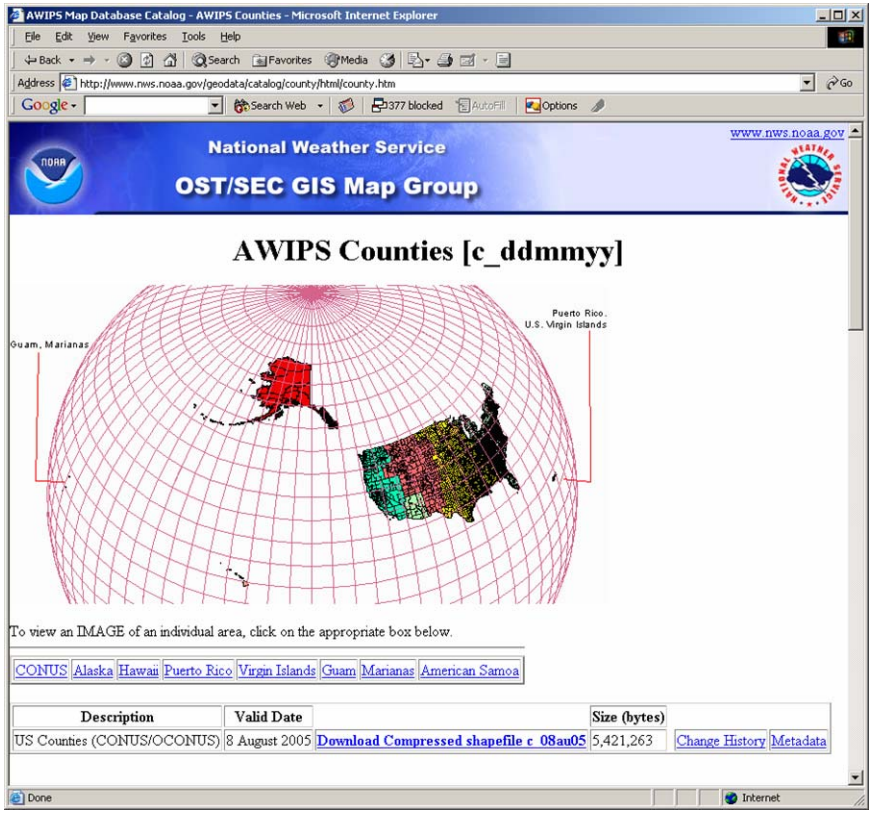
Click on the **AWIPS Counties** link. This is the most recent county boundary information.



6-Hour Quantitative Precipitation Forecast

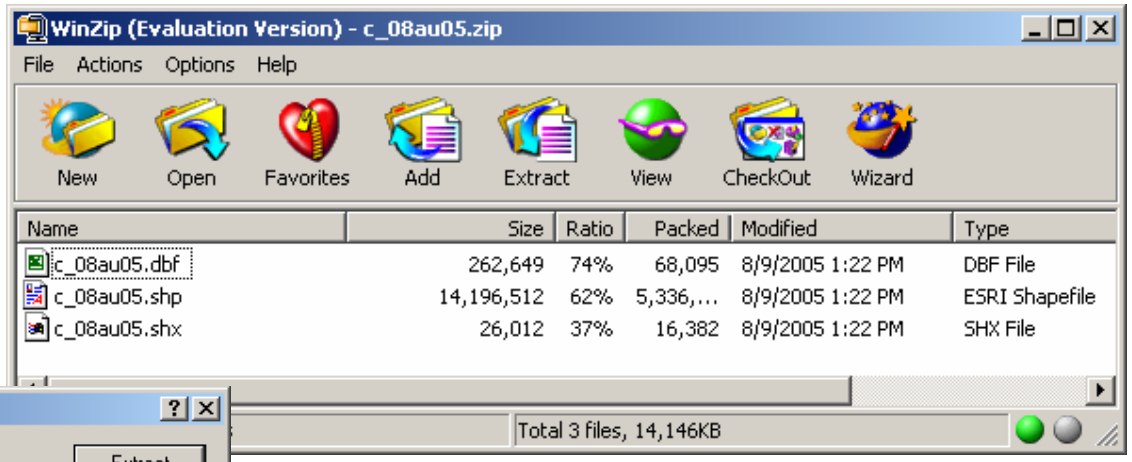
Add and symbolize the data: Click on the **Download Compressed Shapefile** link. This allows you to permanently save the file onto your system. Click on the **Save** button when prompted, and specify a new folder (i.e., c:\AWIPS_Data).

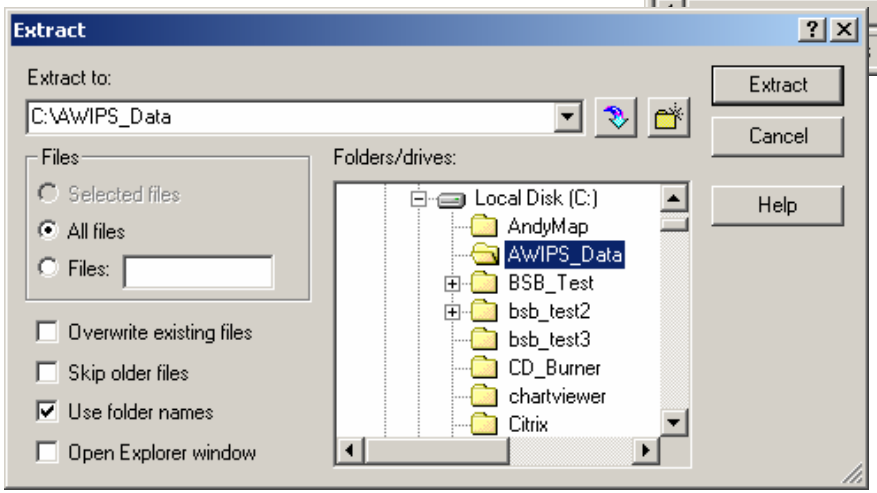




6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Using Windows Explorer, navigate to this new folder once the compressed .zip file is saved. Double-click on the file to use a zip utility to uncompress it.

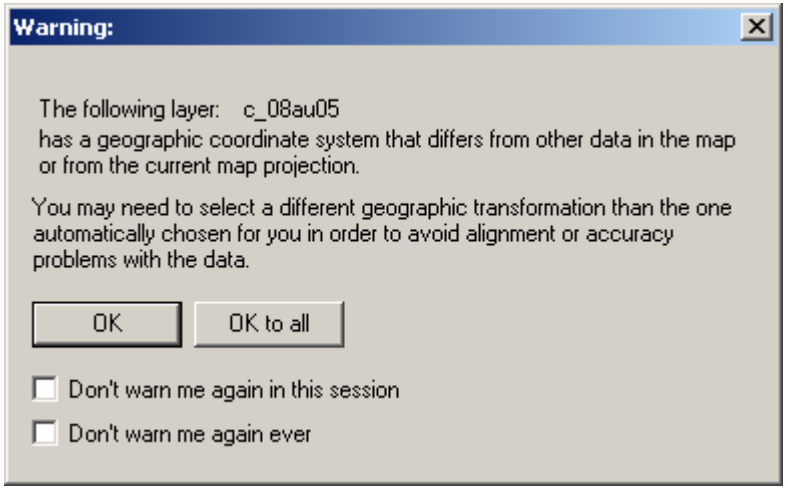


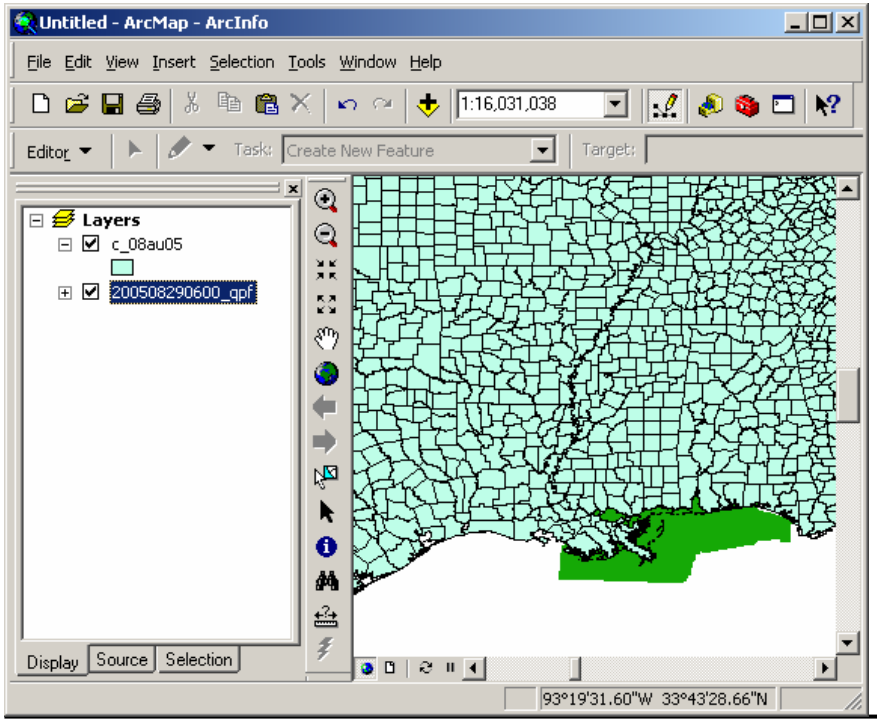


Save the uncompressed shapefile into the AWIPS_Data folder.

6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Once uncompressed, add the county boundary layer to ArcMap. You may receive a warning message alerting you that the county boundary layer does not contain spatial reference (projection properties). However, ArcMap is able to properly reconcile this layer with the QPF layer. Simply click **OK** to dismiss this window.





By default, the county boundary layer will be added at the top of the table of contents. As a result, it will obscure the QPF data. Rearrange the layers so you can see which counties will receive rain in the next 6 hours.

Collapse the classes of the QPF layer by clicking on the minus sign next to the name of the layer. Next, click and drag the county boundary layer below the QPF layer.

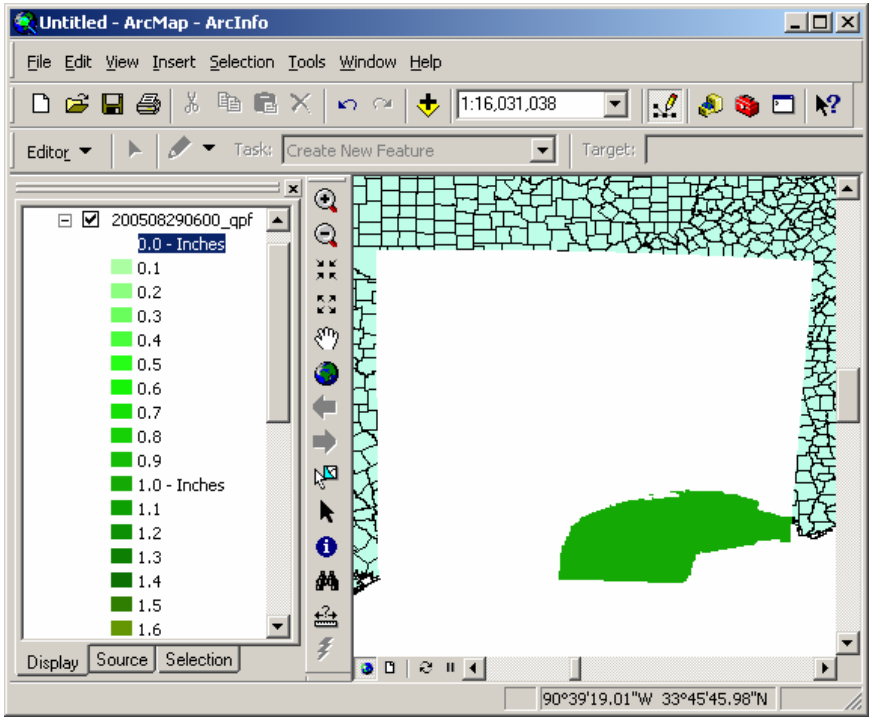
Note: The Display tab at the bottom of the table of contents must be selected before you can reorder the layers.

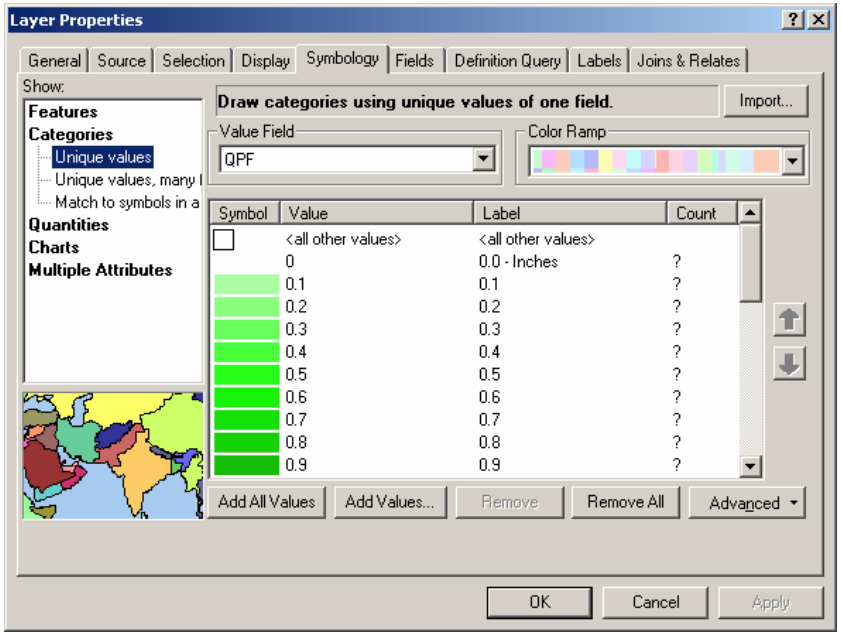
6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Unfortunately, the QPF layer has the color “white” assigned to polygons that will not receive precipitation (0.0 inches). This needs to be changed so other layers will be visible.

Double-click on the QPF layer to open its Layer Properties window.

Click on the **Symbology** tab to reveal the color ramp. Double-click on the “white” class that is assigned to the “0” value. This will open the Symbol Selector window.

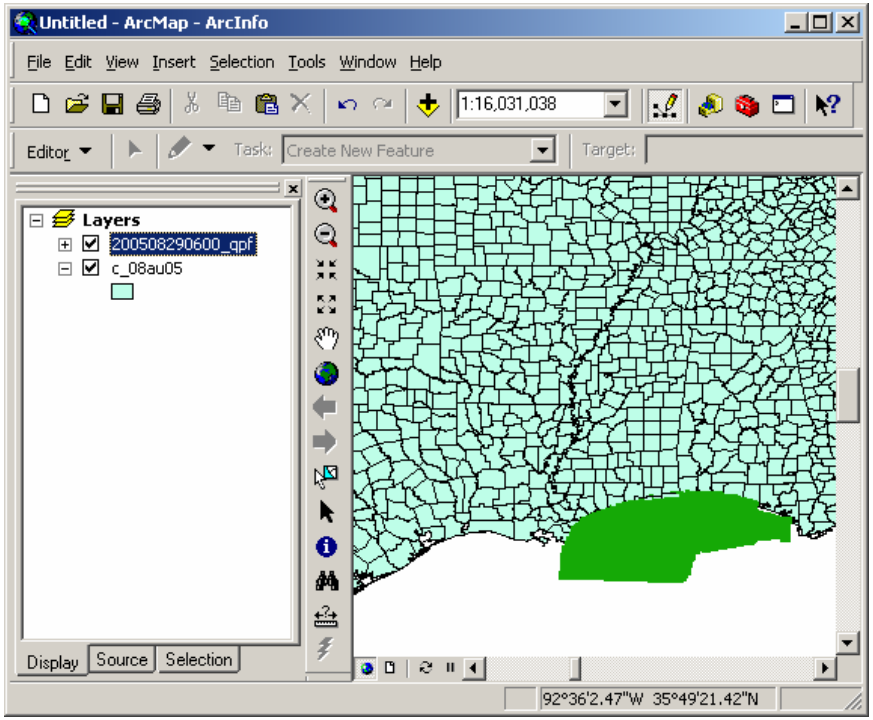


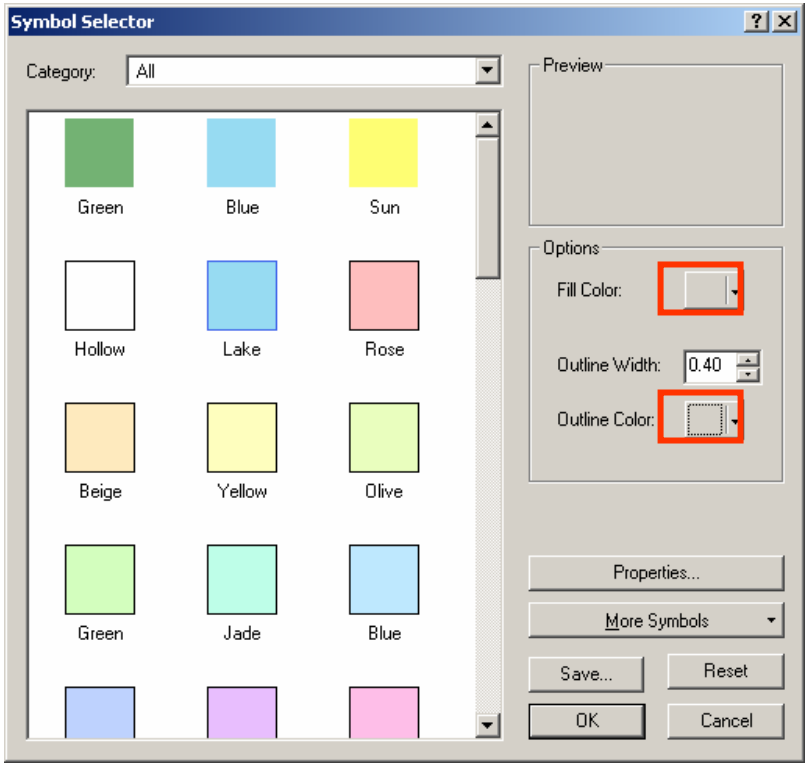


6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Click on the **Fill Color** button and specify **No Color** so a transparency can be set for these QPF polygons. Do the same for the **Outline Color** button so the polygons will not be outlined. Click **OK** to make the change.

Click **OK** in the Layer Properties window. The newly symbolized layer will display.



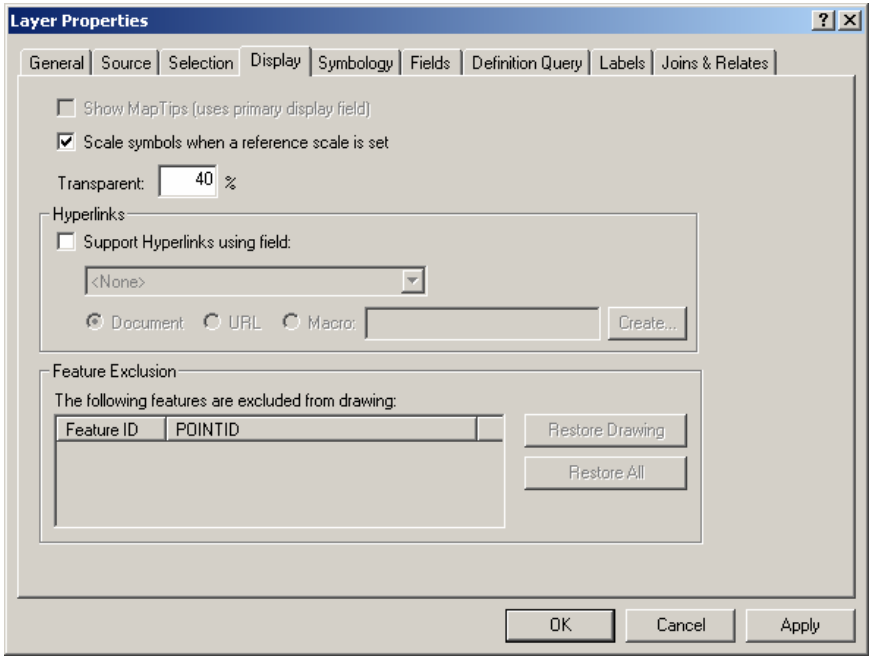


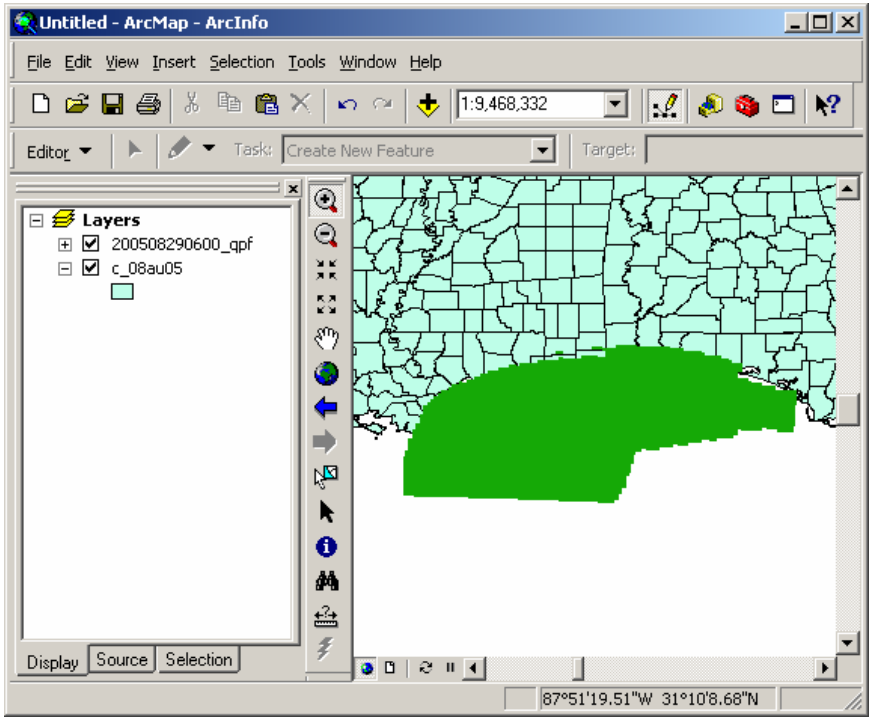
Use the Zoom In tool for a closer look at the area around this rain event.

6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Because the QPF data are a solid fill, you cannot see the counties that are going to be affected. Set a transparency for this layer by opening the Layer Properties window (remember how?).

Click on the **Display** tab and change the transparency amount from 0% to **40%**. Click **OK** to make the change.

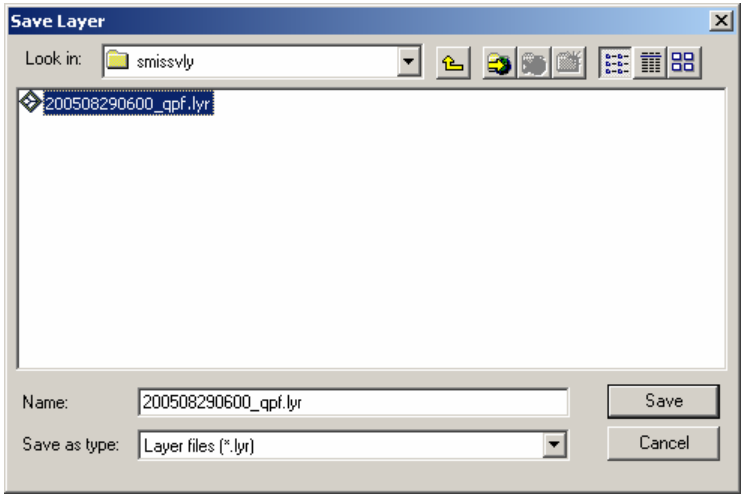


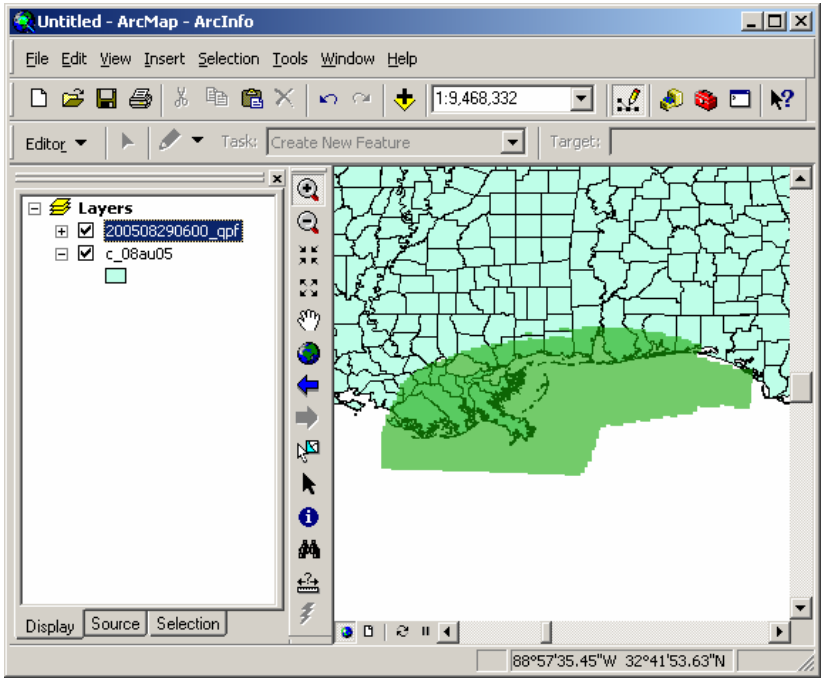


6-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Retain the colors and class assignments of the symbology for future mapping. This is done by making a "layer file" of the layer. Right-click on the QPF layer and select **Save As Layer File**.

The following dialog window allows you to navigate to a folder and specify a name for the new layer file. You should always create this inside the same folder as the layer itself. Notice the .lyr extension that is added to the file.

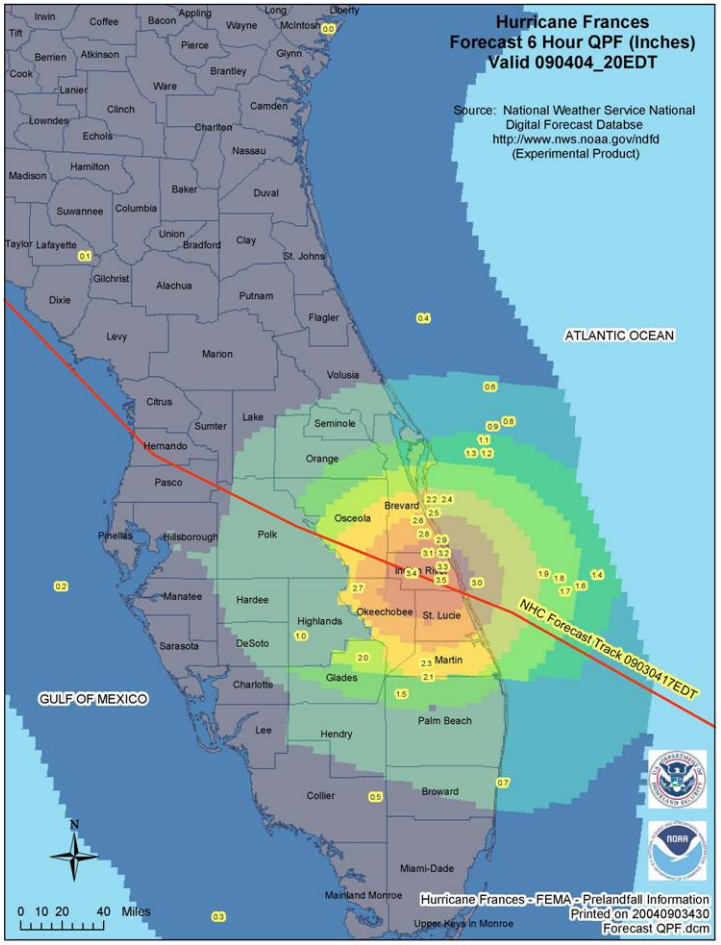




Click **Save** once you are done.

At this point, you are ready to begin making a map. Several examples have been included to give some guidance on what the NOAA Coastal Services Center has provided to members of FEMA in the past. Refer to the "Basics of Cartography" chapter at the end of this manual for additional information.

6-Hour Quantitative Precipitation Forecast



Forecast Waveheight

Purpose: This type of map presents an estimate of the significant wave height, measured in feet, for a given area. Significant wave height is approximately equal to the highest one-third of waves passing a certain point.

Source Data: This type of map uses the NOAA National Weather Service's National Digital Forecast Database (NDFD), found at *www.nws.noaa.gov/ndfd/*. The National Weather Service (NWS) provides access to gridded forecasts of weather elements (e.g., cloud cover, maximum temperature) through the NDFD. This database contains a seamless mosaic of digital forecasts from NWS field offices working with the National Centers for Environmental Prediction (NCEP). The database uses a 5-kilometer national grid that covers the continental U.S. and separate grids that cover Hawaii, Alaska, the U.S. Virgin Islands, and Puerto Rico. Each 5-kilometer grid cell has forecast information, allowing users to retrieve specific forecasts by entering geographic coordinates.

The World Meteorological Organization (WMO) has adopted Edition 2 of the gridded binary data (GRIB) code as a standard for sharing information. GRIB, Edition 2 (GRIB2), is involved in the NDFD in two ways. First, GRIB2 is the code form used to transmit gridded forecasts from contributing offices to the NDFD. Second, GRIB2 is one of the primary forms used to transmit the NDFD grids to NWS customers and partners. Users should note that this should be considered an experimental product at the time of this writing (March 2006).

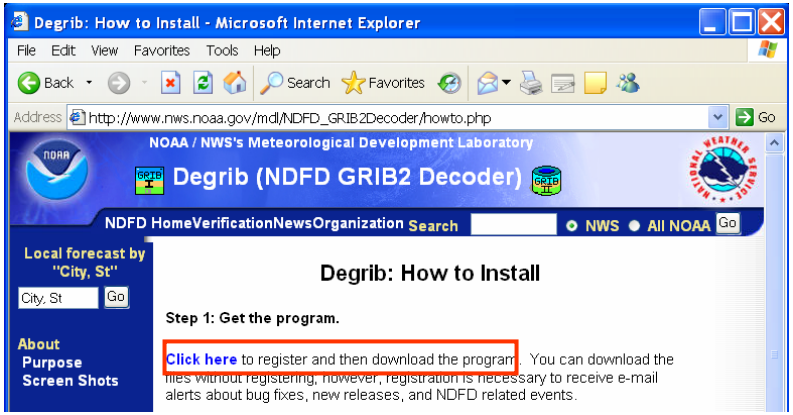
Download: Before working with NDFD data, users must first download the GRIB2 Decoder tool that allows access to the data. Learn more about GRIB2 Decoder by visiting this site: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/*

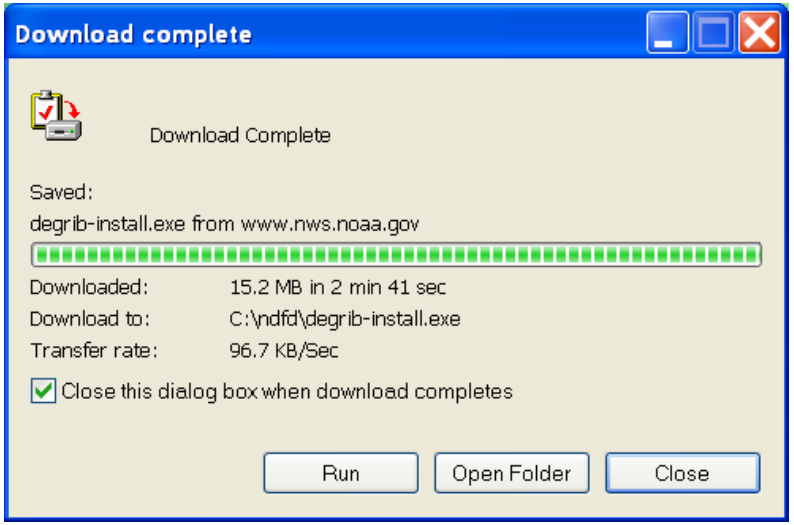
Forecast Waveheight

Download: Register for the DEGRIB program here: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/howto.php*
At the top of the page, under step 1, click on the highlighted link to register and download the program.

Once done, download the program from here:
www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/download.php

This page provides several different versions of the same product. For this tutorial, you will focus on the Microsoft Windows version. Click on **degrib-install.exe** and select **Save**. Specify the directory path for the program as c:/ndfd and copy the .exe into that folder.





Double-click on **degrib-install.exe** to install the program. A window will appear; click on the **Install** button and accept the defaults for the installer.

Forecast Waveheight

Download: Double-click on **tkdegrib (aka NDFD GRIB2 Decoder)** to start the program.

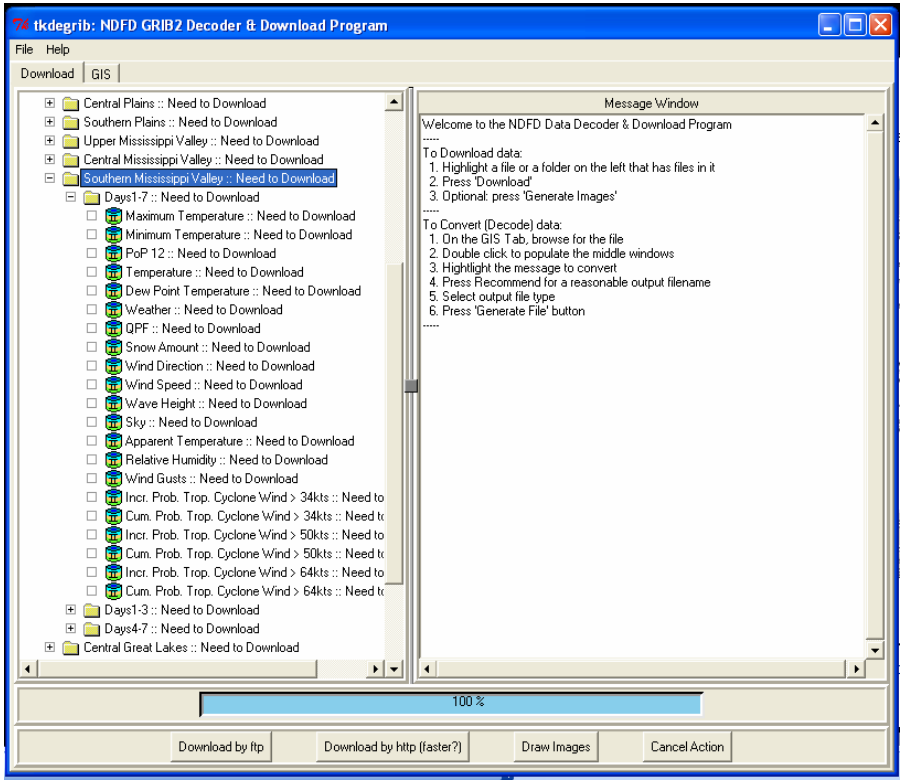
Then click on the **Download** tab and expand the NDFD data set folder if it is not already open.

Choose the region of interest and expand the folder.
Choose the days of interest and expand the folder.

Data for each weather element can be downloaded by highlighting the entire region folder, or individual weather elements can be downloaded by holding down the Control key on the keyboard and highlighting one or more elements.

Click on **Wave Height**, and then click on either the **Download by FTP** or the **Download by HTTP** button (either will work) at the bottom of the window.

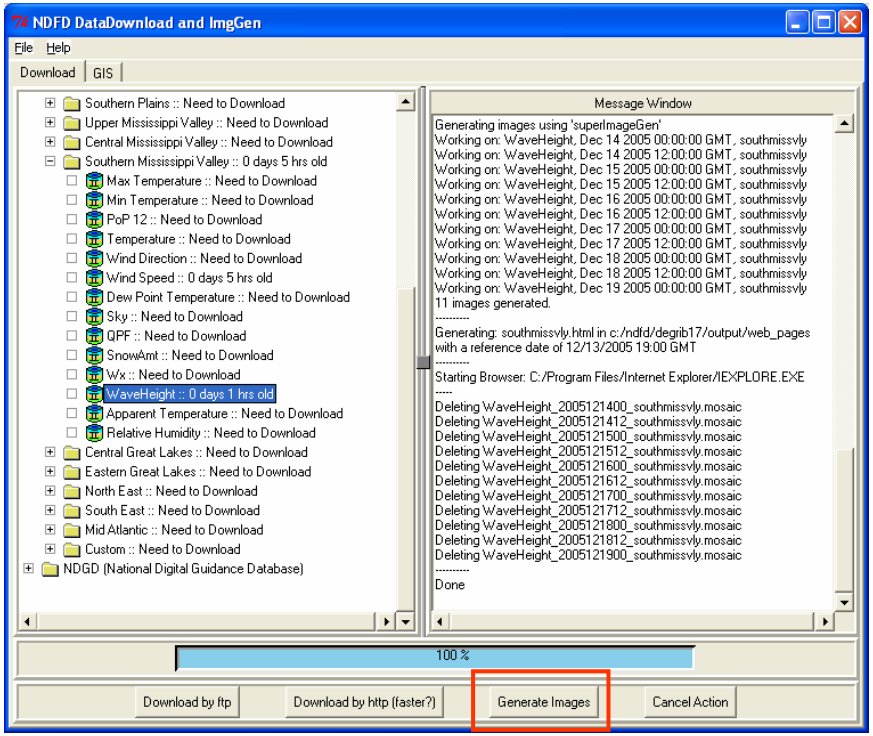
Once downloading begins, there will be an indication in the Message Window that it is working. Also, after the download button is clicked, the light blue bar near the bottom of the window will show the progress of the data download.

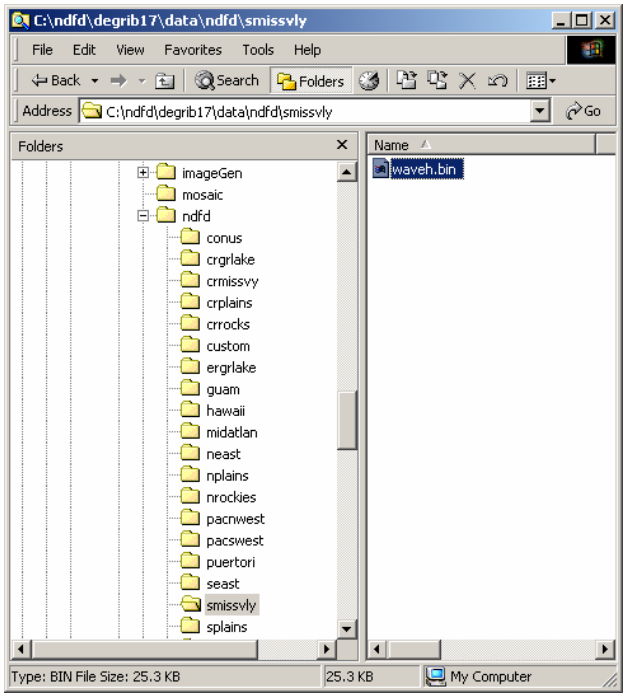


Forecast Waveheight

View the data: Minimize this program and open **Windows Explorer**. Navigate to C:\ndfd\degrib18\data\ndfd\smissvly and notice that waveh.bin is stored in that directory.

This file contains important data in a binary format. Unfortunately, ArcGIS is unable to read this format, so the data must be converted into ESRI's shapefile format, which you will do shortly.

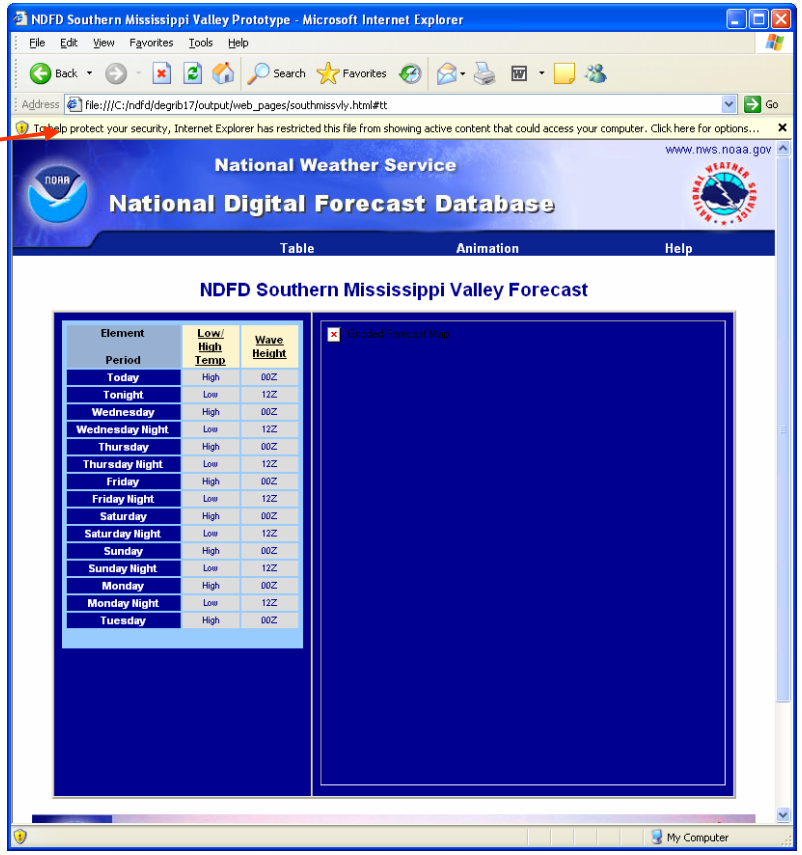


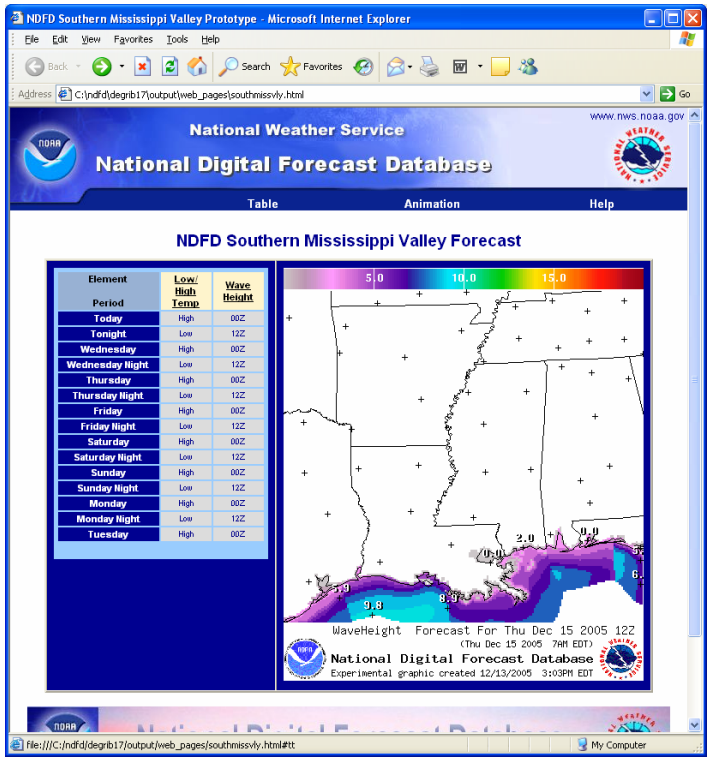


Close Windows Explorer and return to the **tkdegrib (aka NDFD GRIB2 Decoder)** program. At the bottom of the NDFD DataDownload and ImgGen program is a **Generate Images** button. Click on this button to see different waveheight predictions within the waveh.bin file.

Forecast Waveheight

View the data: Your default Web browser will open and reveal a site that shows the various wave height forecasts. To see the graphics, you may need to allow pop-ups to appear for this site. Simply click on the warning message at the top of the window and choose **Allow Blocked Content**.





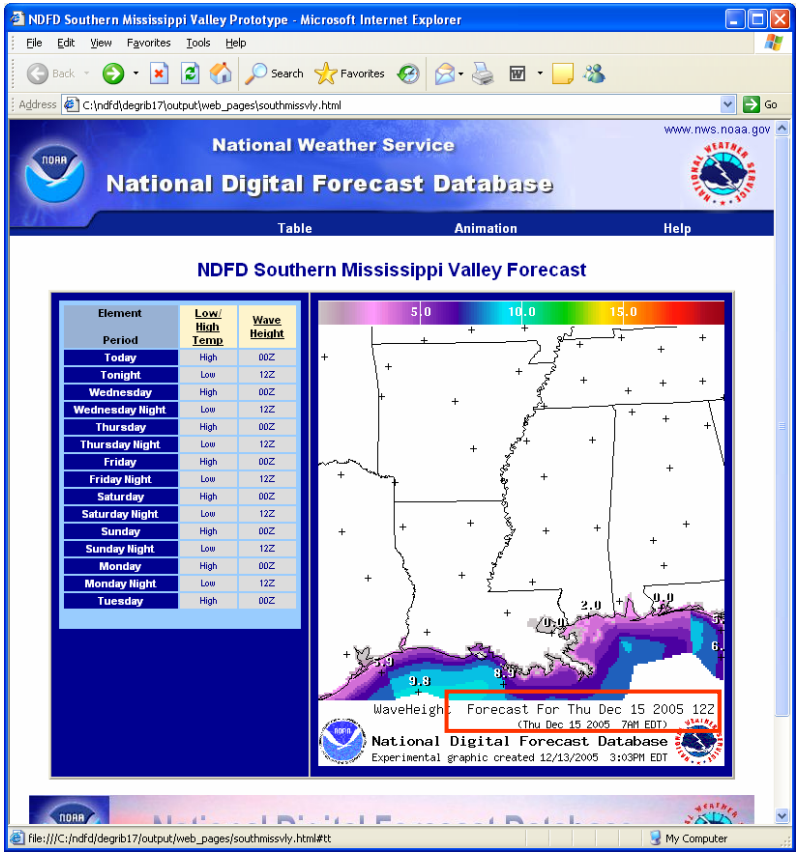
You should be able to mouse over the times listed in the Wave Height column to see a graphic of predicted heights.

Forecast Waveheight

View the data: Choose a day and time when the predicted storm position is close to landfall. This will probably reflect the highest waveheights (colors may display with reds and greens). Notice that the time values are expressed as “Zulu.” For guidance on how to convert to local time, refer to the appendix in the back of this tutorial.

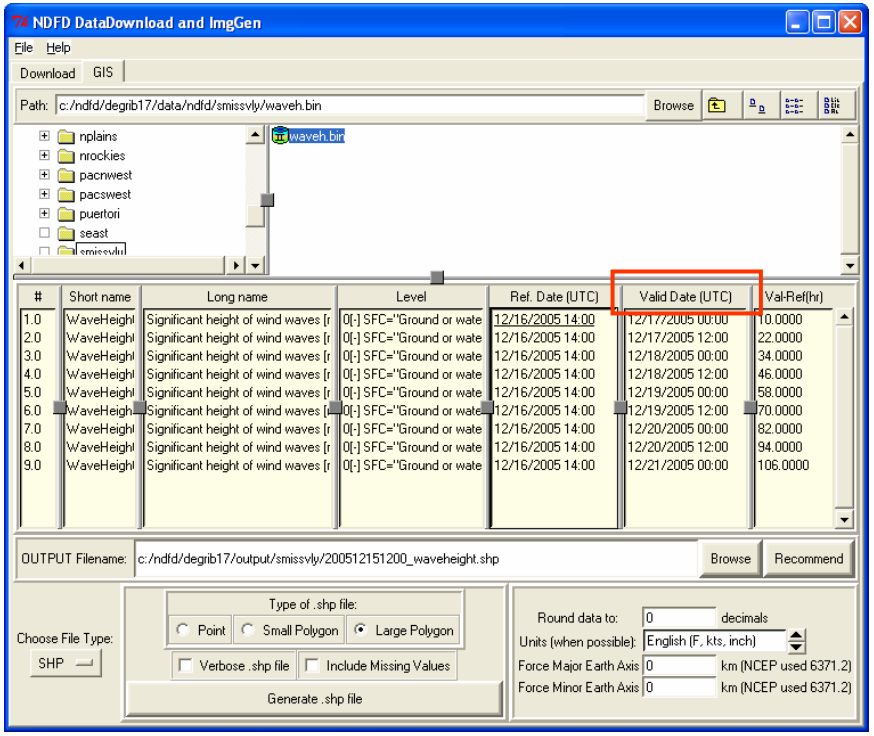
For your purposes, select the data for Wednesday (12Z). This equates to noon at the Prime Meridian, and 7 a.m. in Eastern Daylight Time. Notice the red outline in the graphic.

Close the Web browser and return to the **tkdegrib (aka NDFD GRIB2 Decoder)** program again.



Forecast Waveheight

Convert the data: Click on the **GIS** tab. This window lets users choose a file to convert to various GIS-friendly formats. Navigate to the directory of your .bin file. Double-click the **waveh.bin** file, and view the forecast times that match the graphics you just saw.



Choose the time under the Valid Date field that will be closest to the forecasted landfall of the storm.

An easy way to create an output shapefile inside the Output Filename window is to simply click on the Recommend button. Ideally, you should keep all of your regional files in the same directory (i.e., smissvly).

Specify the File Type as **SHP** (shapefile).

Specify the type of shapefile to be **Large Polygon**.

Specify **Round data to: 0** decimals.

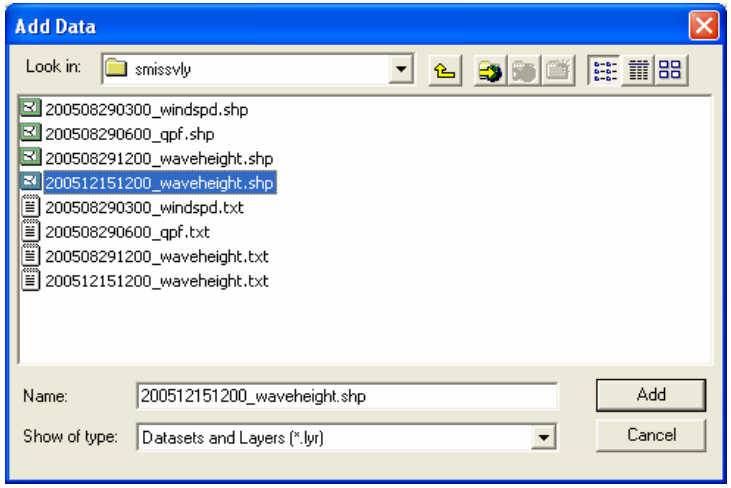
Click the **Generate .shp file** button. This will create a new shapefile and copy it into your specified folder. Notice that it is in a different folder than the waveh.bin file.

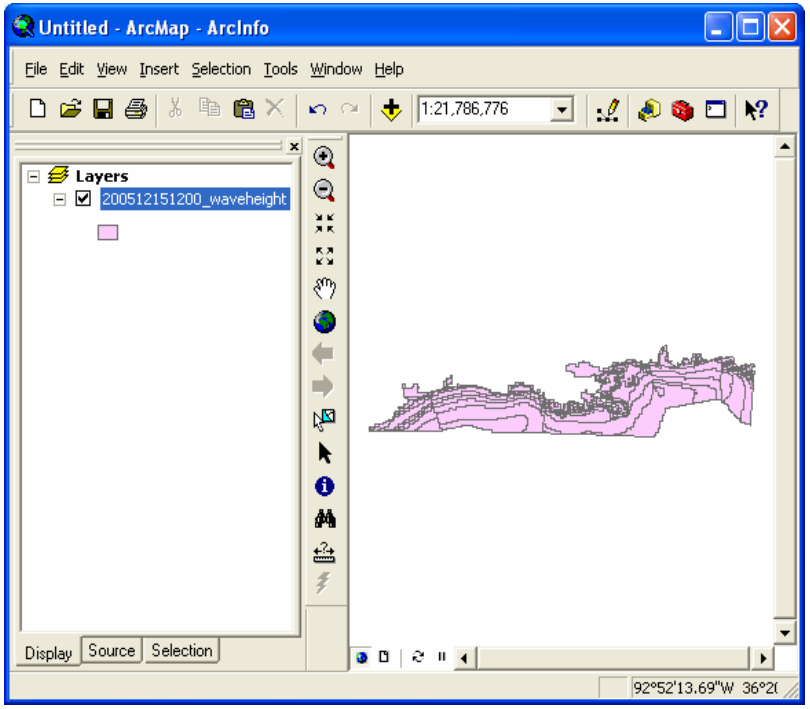
When finished, click on the window that reads **Done**. Minimize the program and open **ArcMap**.

Forecast Waveheight

Add and symbolize the data: Start ArcMap by selecting **Start > Programs > ArcGIS > ArcMap**

Add data by clicking on the **Add Data** button found at the top of the ArcMap window.
This will open a dialog window that lets users browse to their data.



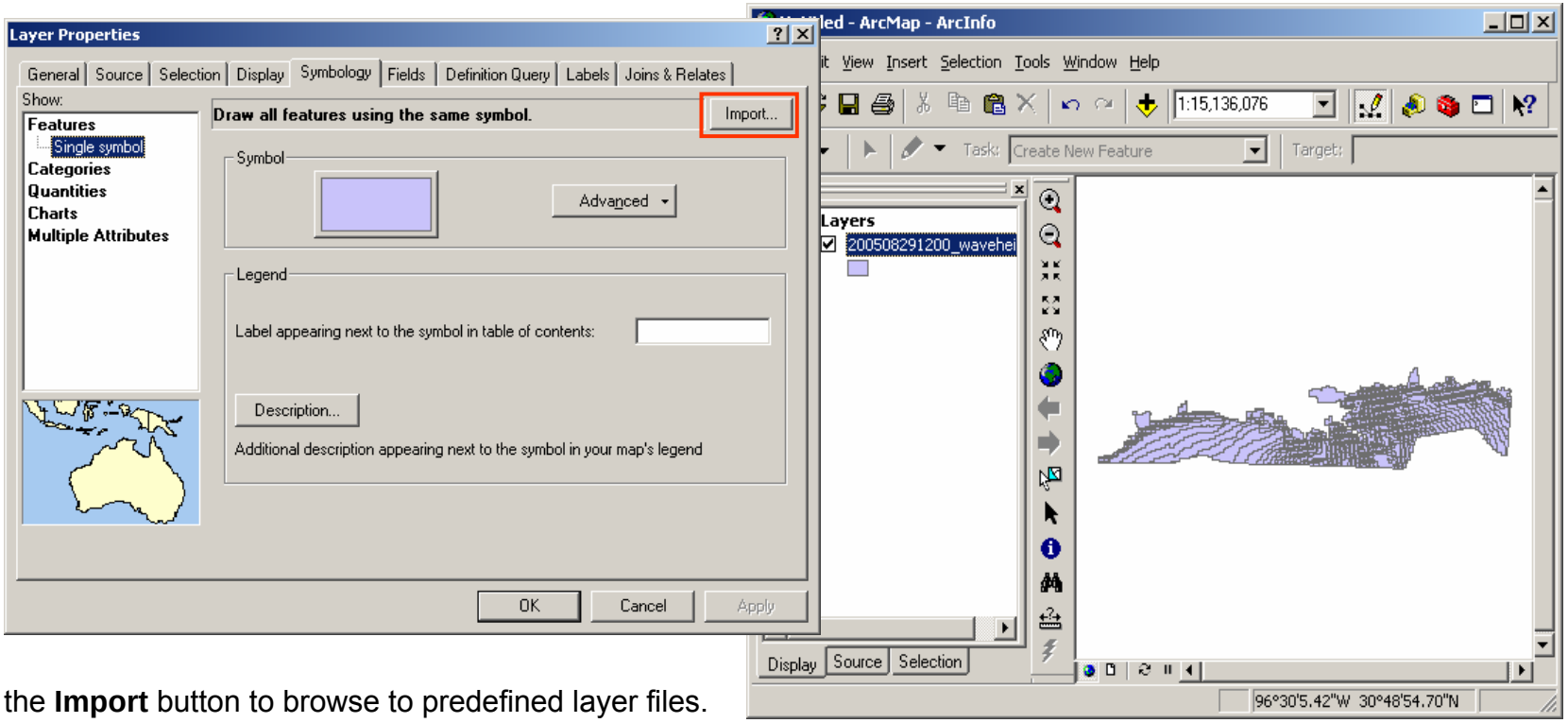


Select the file and click **Add**. Notice the layer is now added to the top of the table of contents in ArcMap.

The data should now be symbolized to show the different forecasted waveheights.

Forecast Waveheight

Add and symbolize the data: Double-click on the shapefile layer in ArcMap's table of contents. This opens the Layer Properties dialog window. Select the **Symbology** tab to specify a predefined legend.

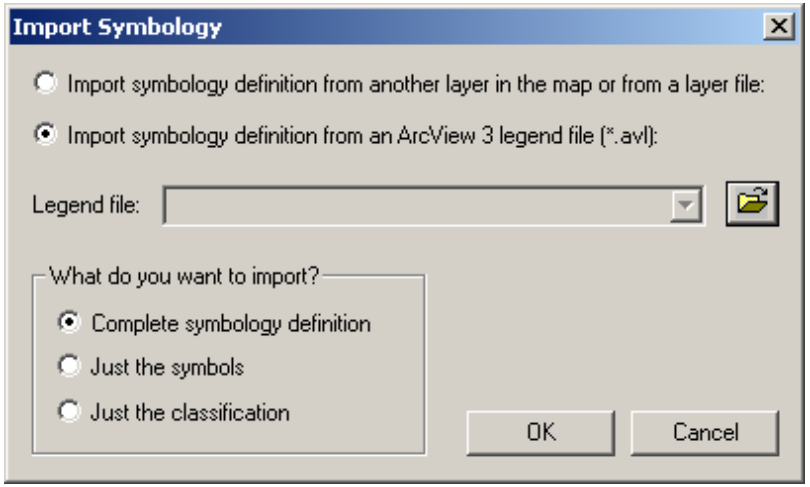


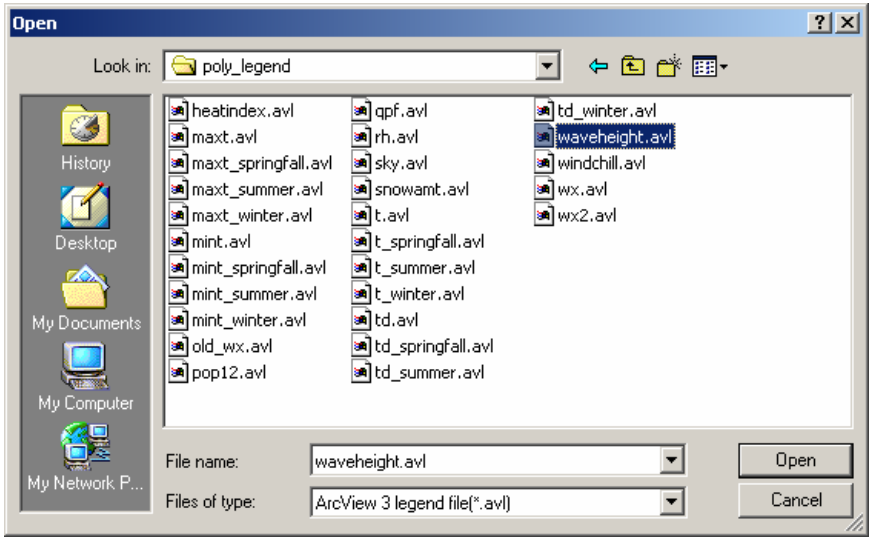
Click on the **Import** button to browse to predefined layer files.

Forecast Waveheight

Add and symbolize the data: In the Import Symbology dialog window, choose to **Import symbology definition from an ArcView 3 legend file (*.avl)**.

Click on the **Browse** button and navigate to C:\ndfd\degrib17\arcview\poly_legend.

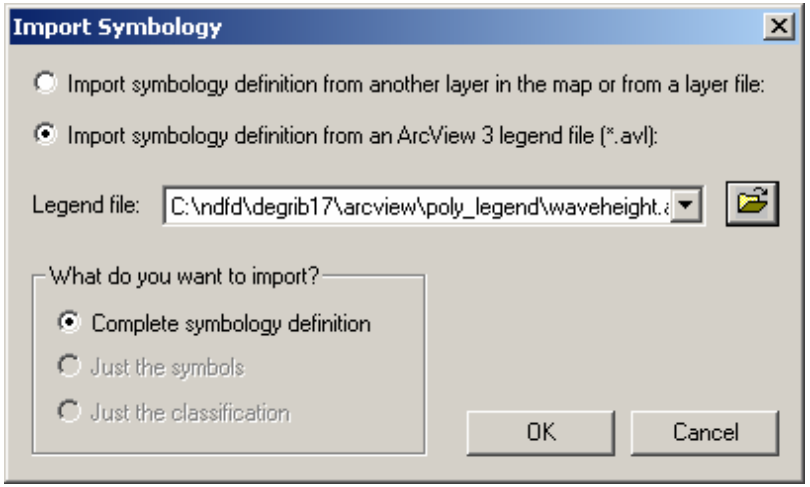


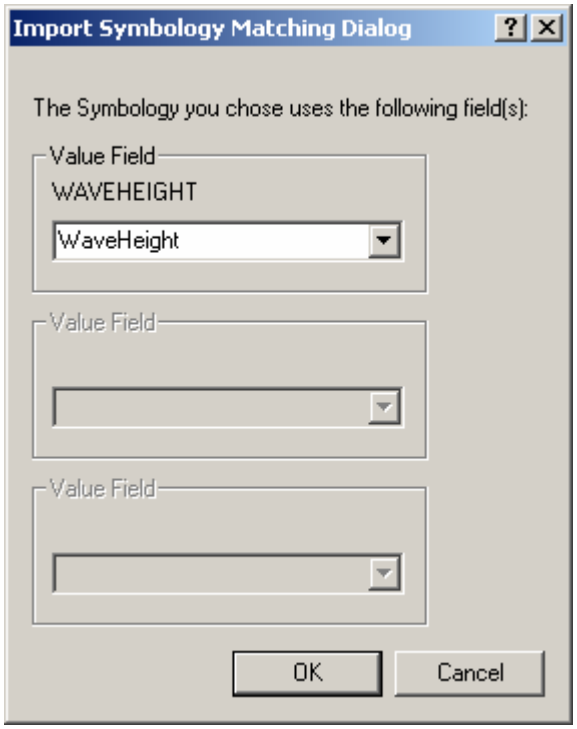


Select **waveheight.avl** and click on the **Open** button.

Forecast Waveheight

Add and symbolize the data: In the Import Symbology dialog window, the path to the .avl file will display. Click **OK**.



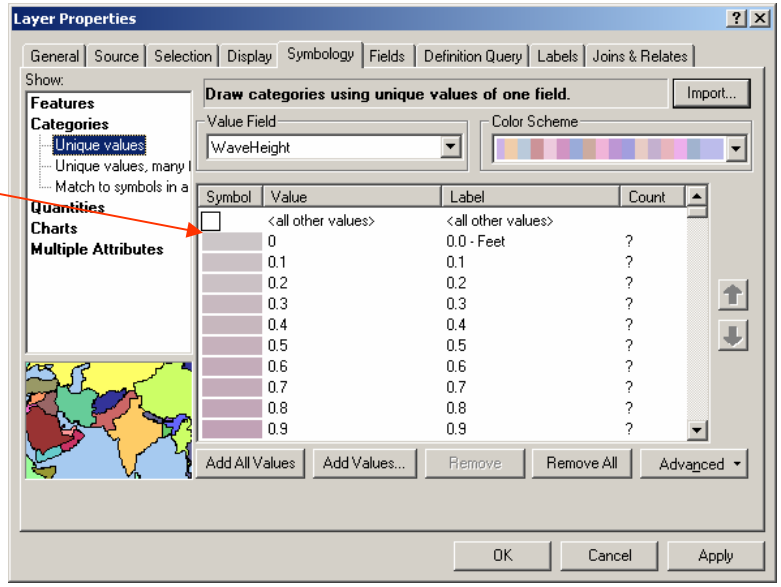


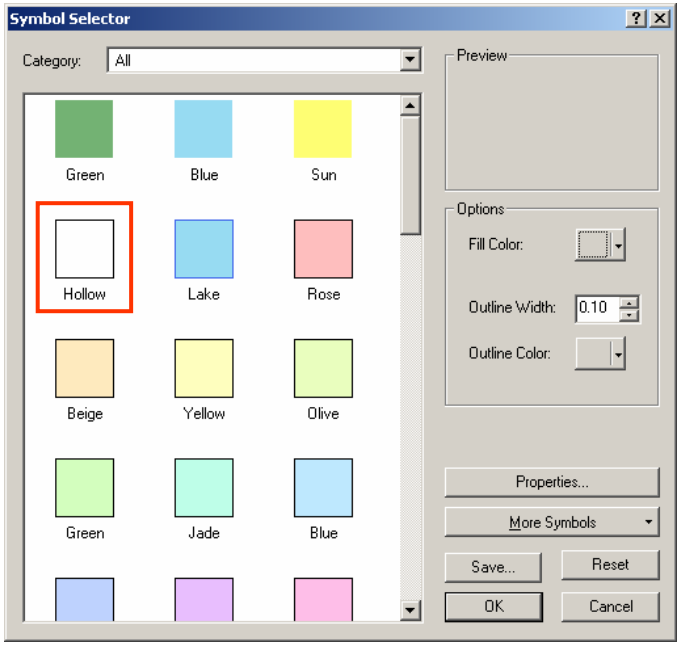
Take the default **WaveHeight** values listed in the Value Field drop-down menu.

Click **OK**.

Forecast Waveheight

Add and symbolize the data: Notice that a predefined set of symbols and values has been added under the Symbology tab. Values of “0” need to be set to transparent. Double-click on the symbol that is assigned to “0”.





The Symbol Selector dialog window opens to reveal different types of symbology to assign this symbol. Click on the **Hollow** symbol.

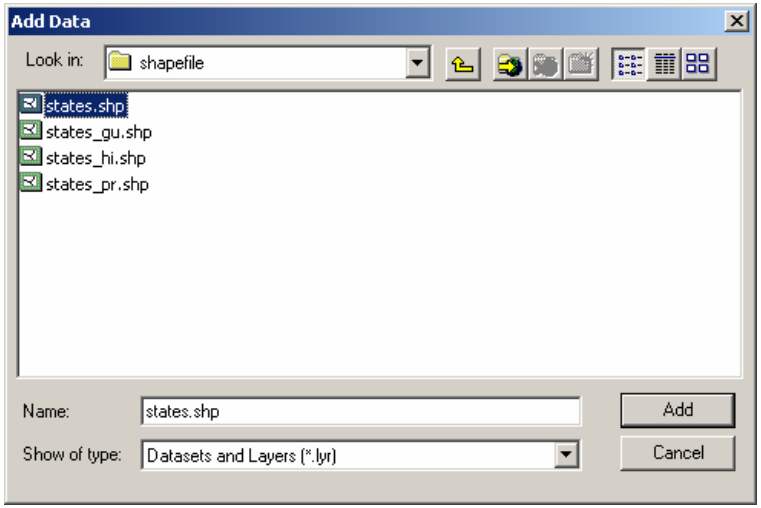
Click **OK** to assign this transparency setting to “0” values.

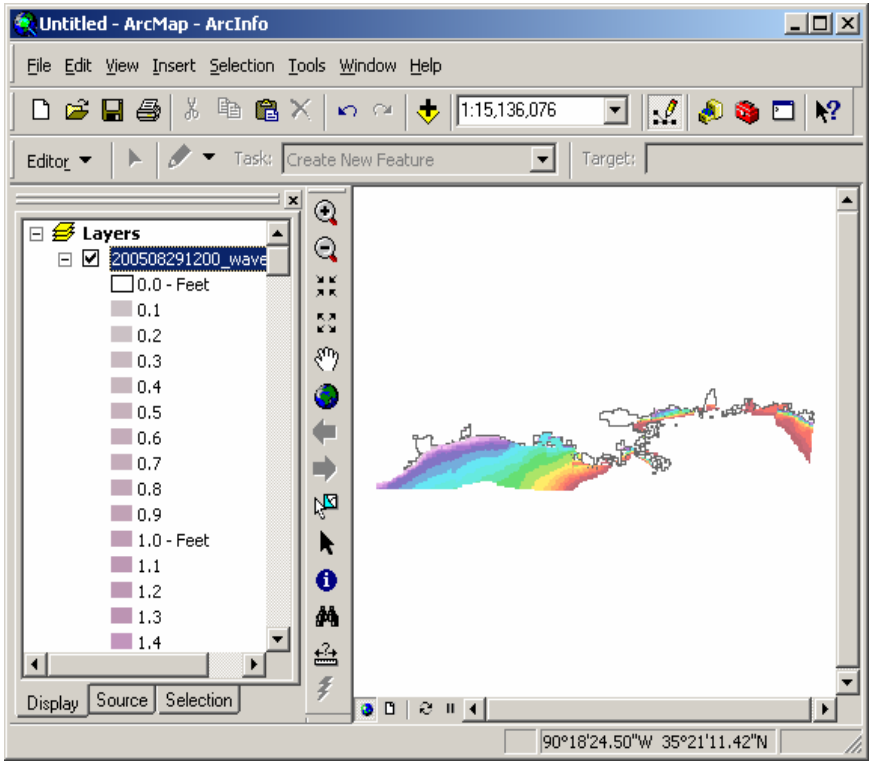
Forecast Waveheight

Add and symbolize the data: Collapse the symbols for this layer by clicking on the minus sign next to the layer's name.

Add a state boundary layer for reference purposes. Click on the **Add Data** button and browse to the following directory:
C:\ndfd\degrib17\data\imageGen\shapefile

Select the **states.shp** layer for this example.

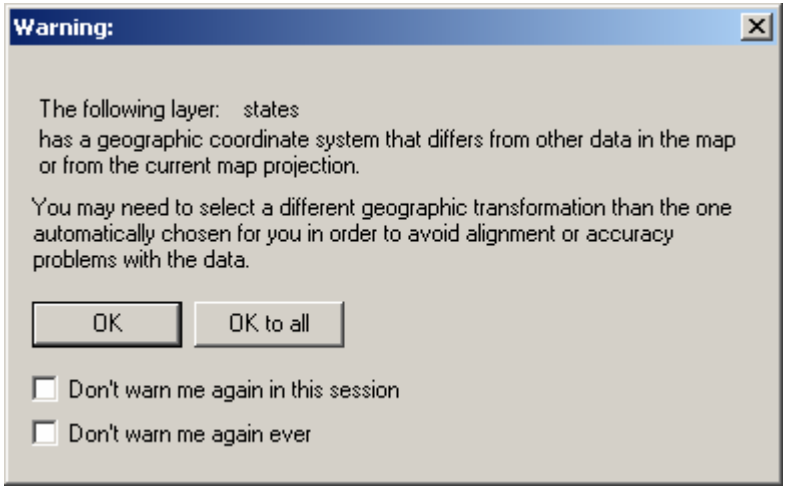


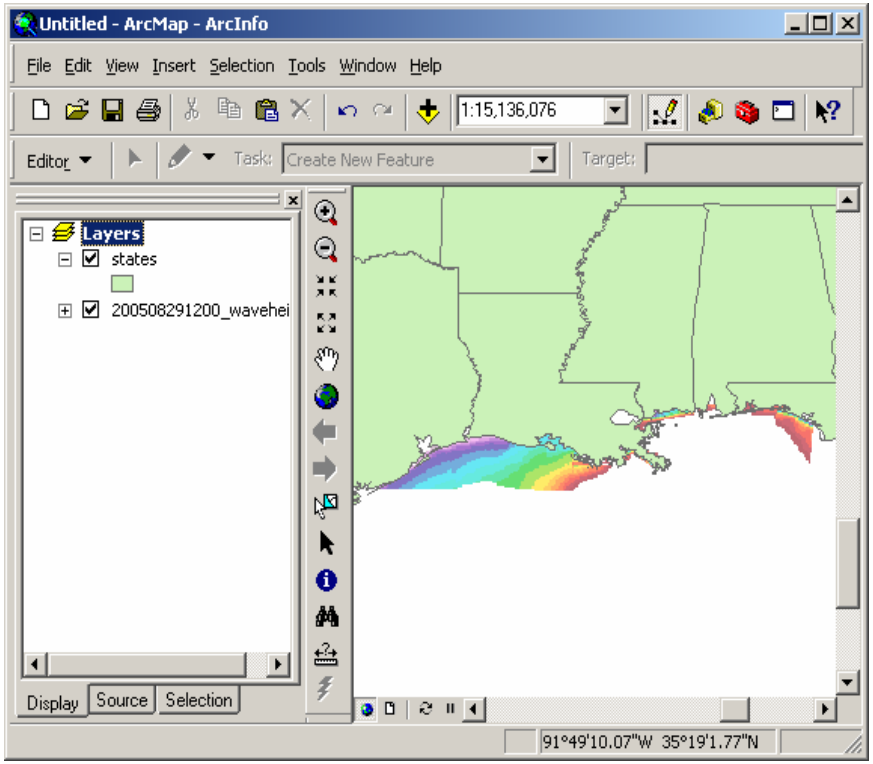


Click **Add**.

Forecast Waveheight

Add and symbolize the data: The following Warning dialog will appear.





This warning alerts the user that the data being added has a different spatial reference (projection system) than the NDFD layer currently in the table of contents. ArcMap's data frame defaults to the spatial reference of the first layer added; however, other added layers having different spatial reference will automatically reproject to the original layer.

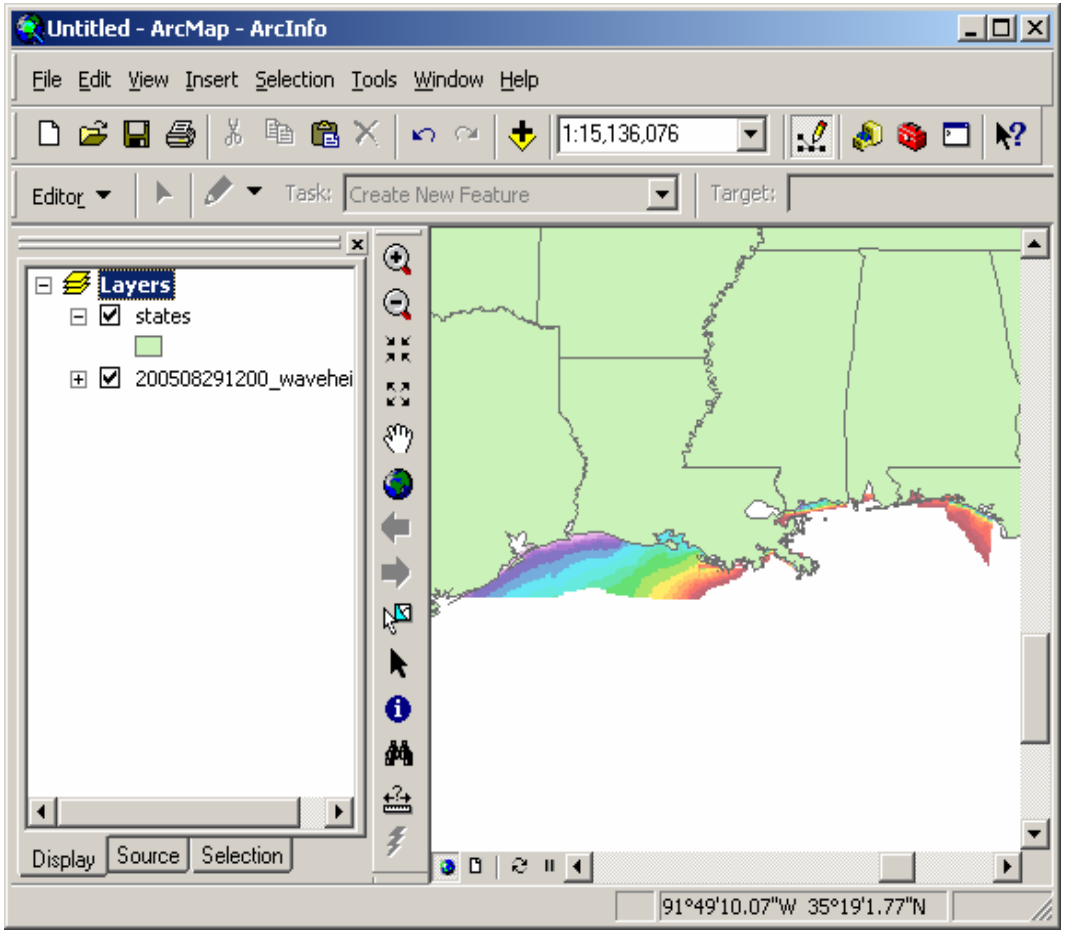
This is known as "projection on the fly." This message is normal and can be dismissed by clicking **OK**.

Forecast Waveheight

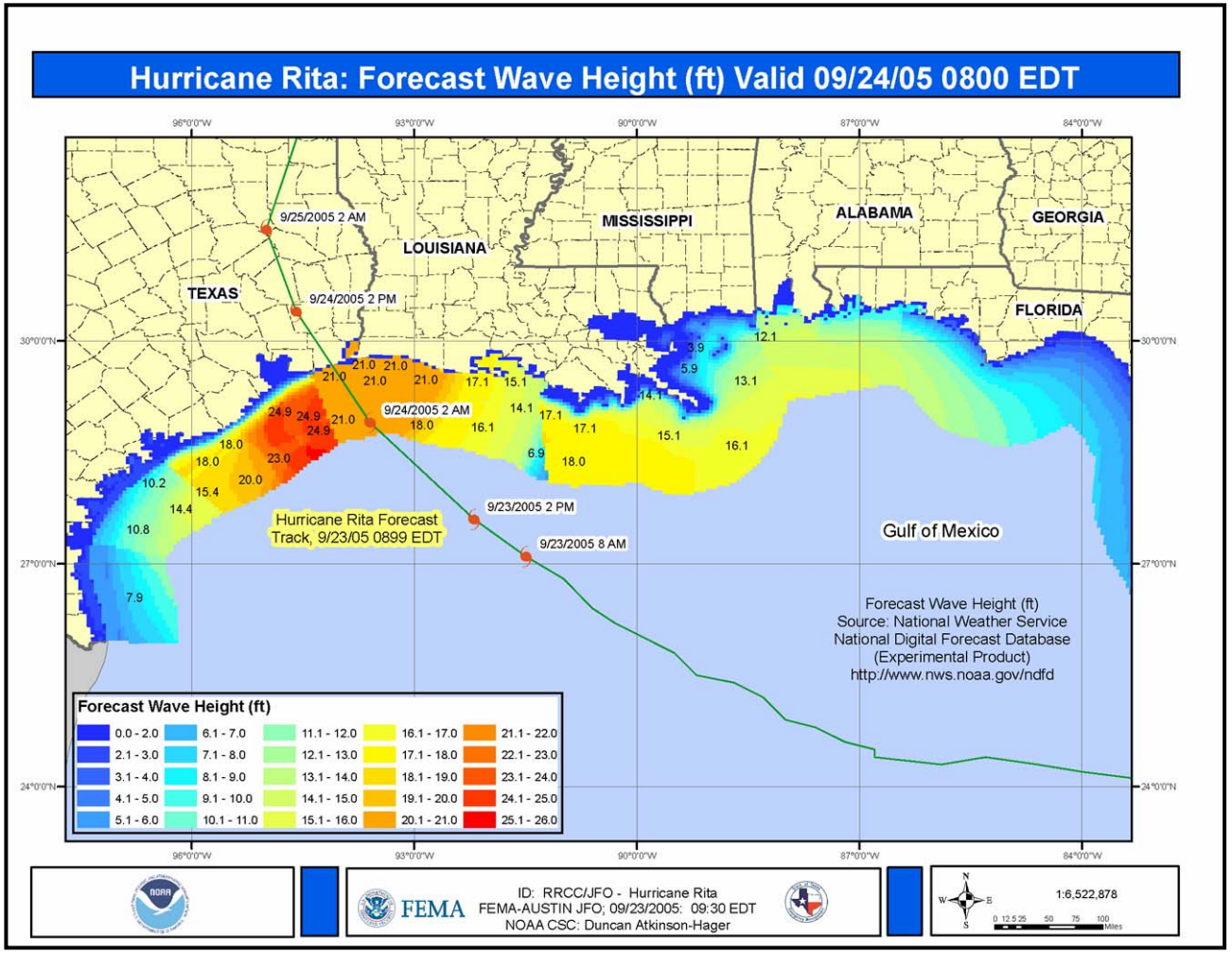
Add and symbolize the data: At this point, you are ready to begin making maps of these data.

Examples of maps that the NOAA Coastal Services Center has provided to members of FEMA in the past have been included.

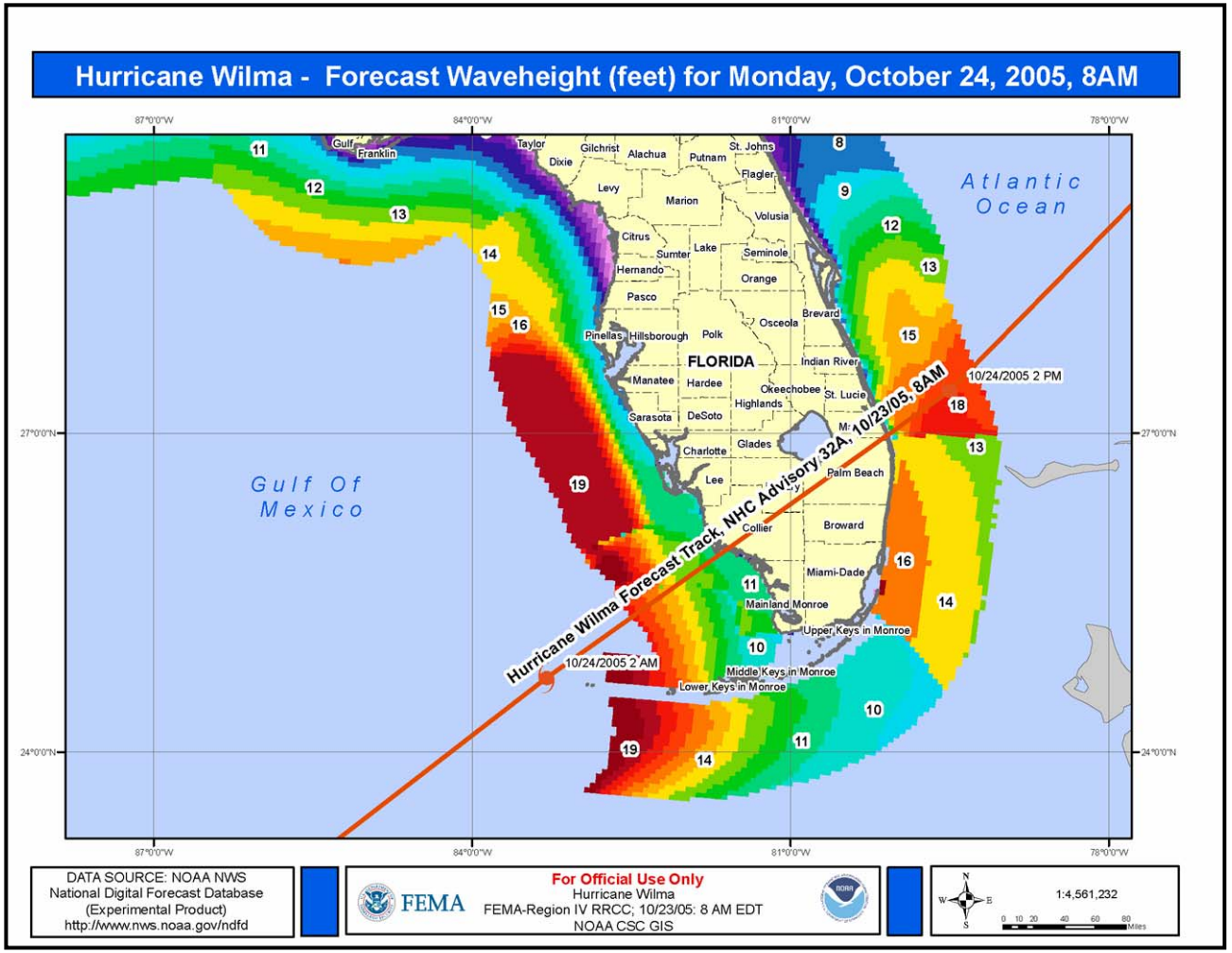
Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.



Forecast Waveheight



Forecast Waveheight



Forecast Windspeed

Purpose: This type of map presents an estimate of the maximum wind speeds for a given area. Wind speed is measured in miles per hour.

Source Data: This type of map uses the NOAA National Weather Service's National Digital Forecast Database (NDFD), found at *www.nws.noaa.gov/ndfd/*. The National Weather Service (NWS) provides access to gridded forecasts of weather elements (e.g., cloud cover, maximum temperature) through the NDFD. This database contains a seamless mosaic of digital forecasts from NWS field offices working with the National Centers for Environmental Prediction (NCEP). The database uses a 5-kilometer national grid that covers the continental U.S. and separate grids that cover Hawaii, Alaska, the U.S. Virgin Islands, and Puerto Rico. Each 5-kilometer grid cell has forecast information, allowing users to retrieve specific forecasts by entering geographic coordinates.

The World Meteorological Organization (WMO) has adopted Edition 2 of the gridded binary data (GRIB) code as a standard for sharing information. GRIB, Edition 2 (GRIB2), is involved in the NDFD in two ways. First, GRIB2 is the code form used to transmit gridded forecasts from contributing offices to the NDFD. Second, GRIB2 is one of the primary forms used to transmit the NDFD grids to NWS customers and partners.

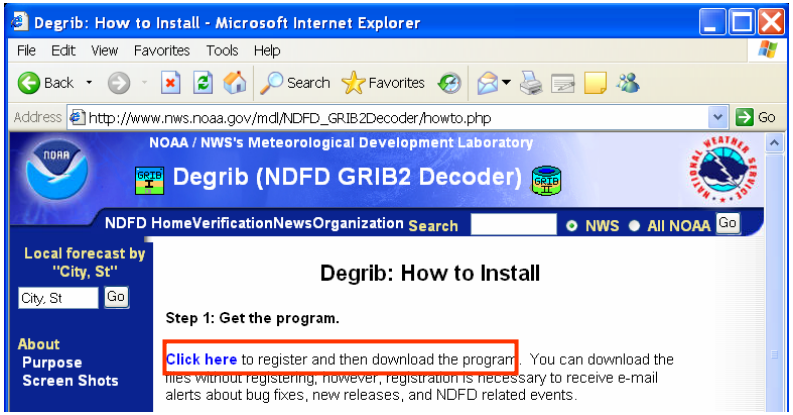
Download: Before working with NDFD data, users must first download the GRIB2 Decoder tool that allows access to the data. Learn more about GRIB2 Decoder by visiting this site: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/*

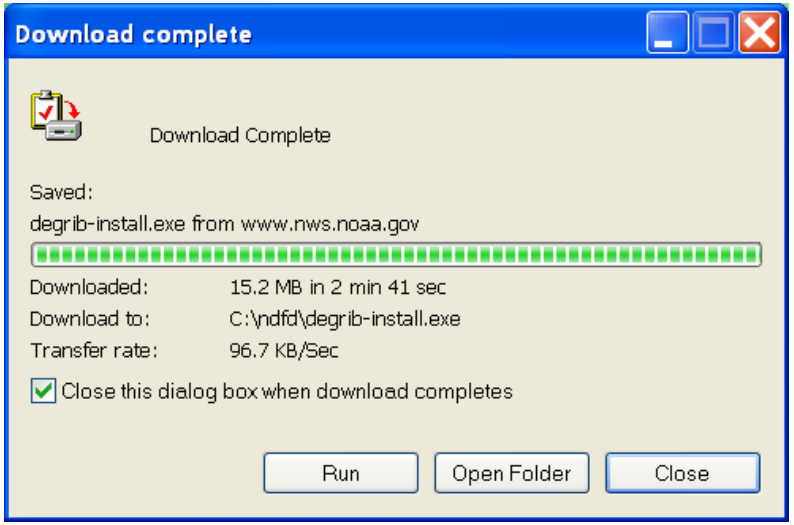
Forecast Windspeed

Download: Register for the DEGRIB program here: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/howto.php*
At the top of the page, under step 1, click on the highlighted link to register and download the program.

Once done, download the program from here:
www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/download.php

This page provides several different versions of the same product. For this tutorial, you will focus on the Microsoft Windows version. Click on **degrib-install.exe** and select **Save**. Specify the directory path for the program as c:/ndfd and copy the .exe into that folder.





Double-click on **degrib-install.exe** to install the program. A window will appear; click on the **Install** button and accept the defaults for the installer.

Forecast Windspeed

Download: Double-click on **tkdegrib (aka NDFD GRIB2 Decoder)** to start the program.

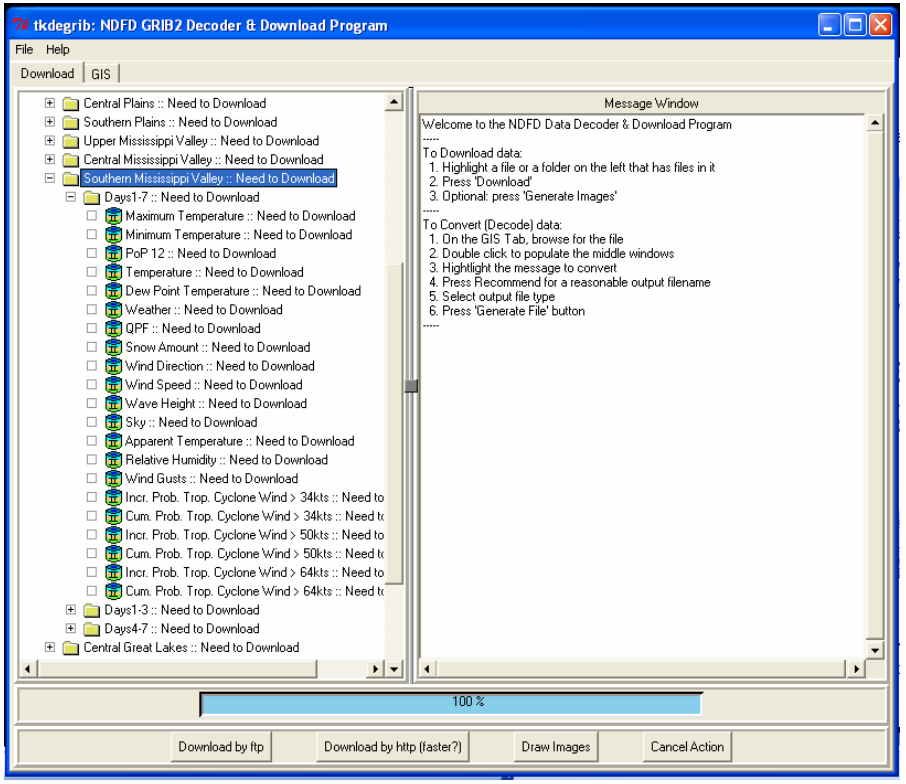
Then click on the **Download** tab and expand the NDFD data set folder if it is not already open.

Choose the region of interest and expand the folder.
Choose the days of interest and expand the folder.

Data for each weather element can be downloaded by highlighting the entire region folder, or individual weather elements can be downloaded by holding down the Control key on the keyboard and highlighting one or more elements.

Click on **Wind Speed**, and then click on either the **Download by FTP** or the **Download by HTTP** button (either will work) at the bottom of the window.

Once downloading begins, there will be an indication in the Message Window that it is working. Also, after the download button is clicked, the light blue bar near the bottom of the window will show the progress of the data download.

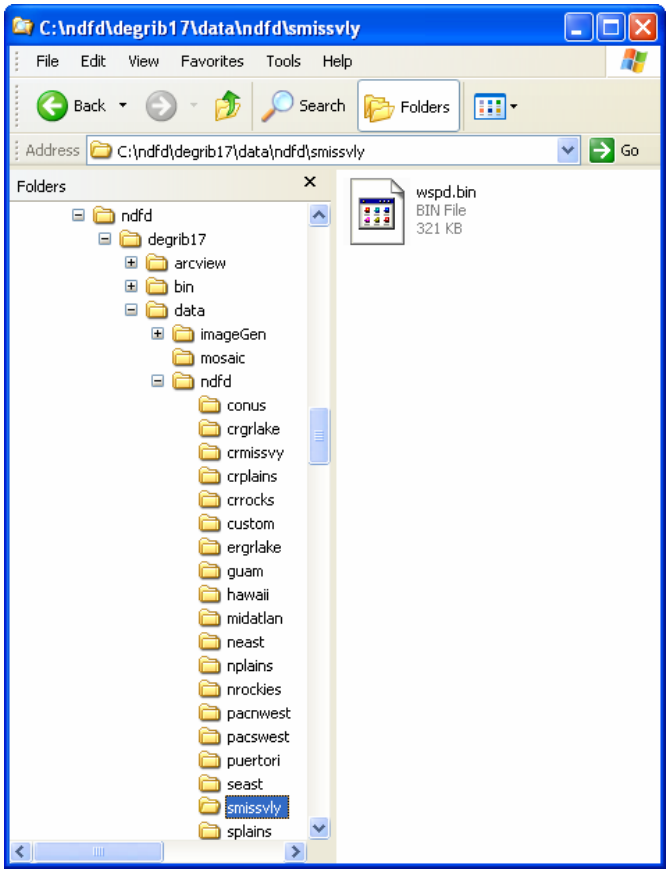


Forecast Windspeed

View the data: Minimize this program and open **Windows Explorer**. Navigate to C:\ndfd\degrib18\data\ndfd\smissvly and notice that wspd.bin is stored in that directory.

This file contains important data in a binary format. Unfortunately, ArcGIS is unable to read this format, so the data must be converted into a shapefile.

Close Windows Explorer and return to the **tkdegrib (aka NDFD GRIB2 Decoder)** program.



Forecast Windspeed

Convert the data: Click on the **GIS** tab. This window lets users choose a file to convert to various GIS-friendly formats. Navigate to the directory of your .bin file. Double-click on the **wspd.bin** file to see a series of wind speed forecasts.

Choose the time under the Valid Date field that will be closest to the forecasted landfall of the storm. You may want to have this Windspeed map correspond to the same day and time of the Waveheight map in the previous module.

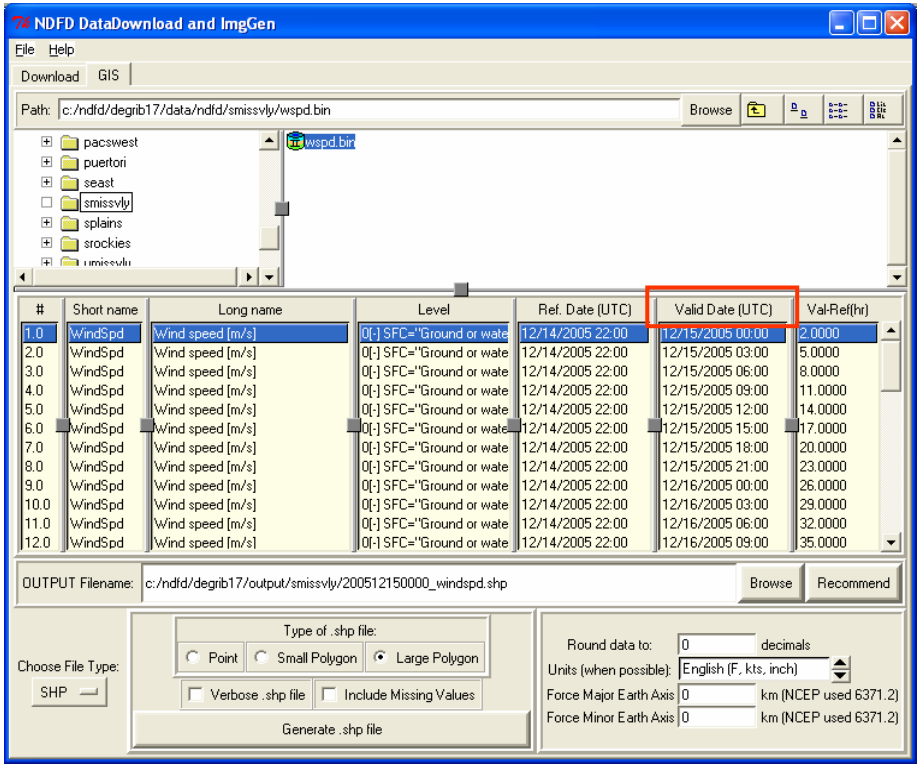
An easy way to name an output shapefile inside the Output Filename window is to simply click on the Recommend button. Ideally, you should keep all of your regional files in the same directory (i.e., smissvly).

Specify the File Type as **SHP** (shapefile).

Specify the type of shapefile to be **Large Polygon**.

Specify **Round data to: 0** decimals.

Click the **Generate .shp file** button. This will create a new shapefile and copy it into your specified folder. Notice that it is in a different folder than the wspd.bin file.

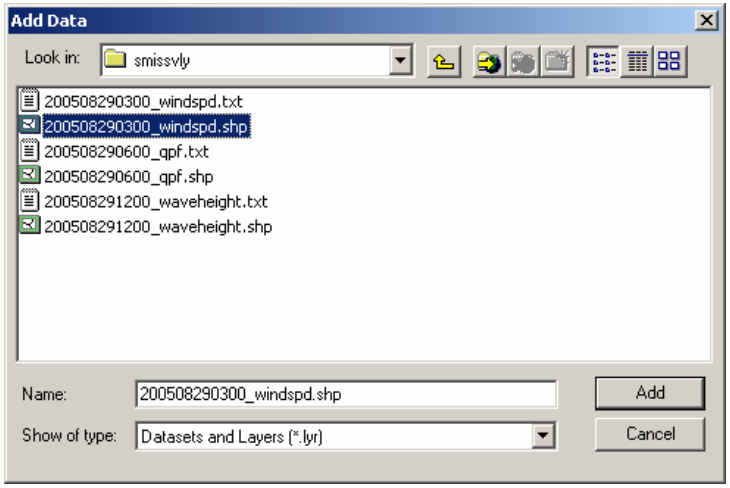


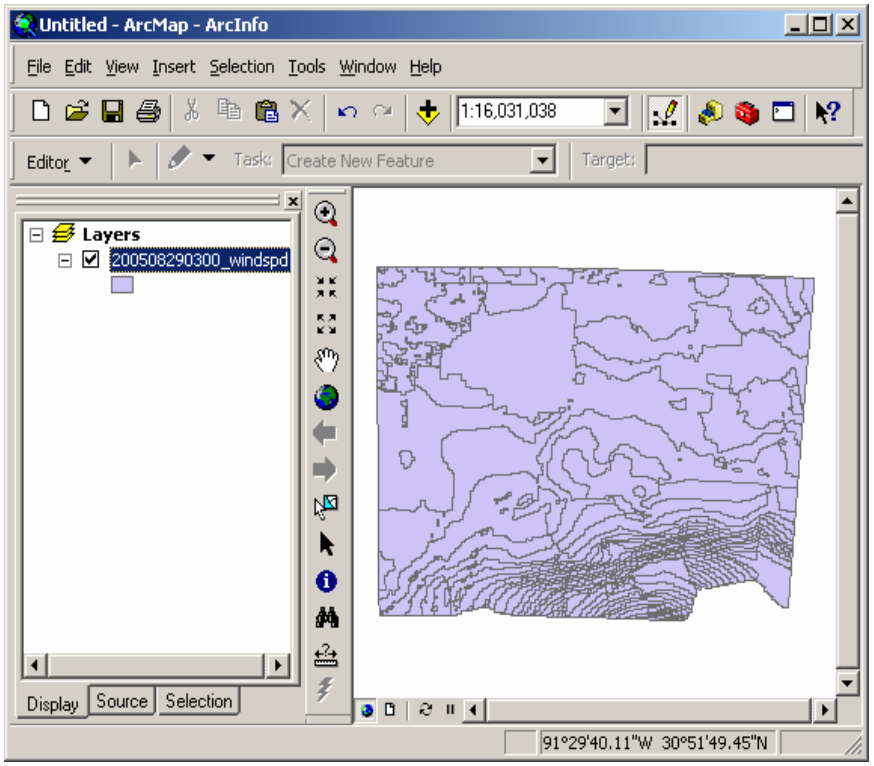
When finished, click on the window that reads **Done**. Minimize the program and open **ArcMap**.

Forecast Windspeed

Add and symbolize the data: Start ArcMap by selecting **Start > Programs > ArcGIS > ArcMap**

Add data by clicking on the **Add Data** button found at the top of the ArcMap window.
This will open a dialog window that lets users browse to their data.





Select the file and click **Add**. Notice the layer is now added to the top of the table of contents in ArcMap.

The data should now be symbolized to show the different forecasted wind speeds.

Forecast Windspeed

Add and symbolize the data: Open the attribute table to see the records for this layer (right-click on the name of the layer and select **Open Attribute Table**).

The values represented in the WindSpd field are wind speeds measured in meters per second. A new field will be added and calculated for wind speeds measured in miles per hour.

Attributes of 200508290300_windspd

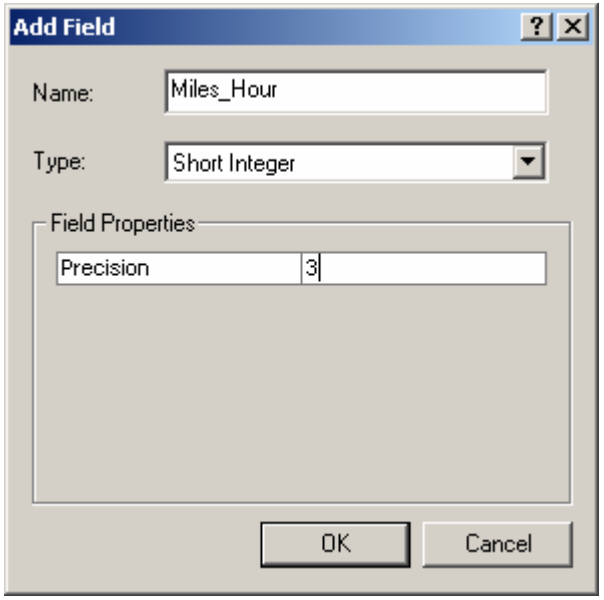
FID	Shape	POINTID	WindSpd
0	Polygon	1	0
1	Polygon	2	2
2	Polygon	3	4
3	Polygon	4	6
4	Polygon	5	8
5	Polygon	6	10
6	Polygon	7	12
7	Polygon	8	14
8	Polygon	9	16
9	Polygon	10	17
10	Polygon	11	19
11	Polygon	12	21
12	Polygon	13	23
13	Polygon	14	25
14	Polygon	15	27
15	Polygon	16	29
16	Polygon	17	31
17	Polygon	18	33
18	Polygon	19	35
19	Polygon	20	37

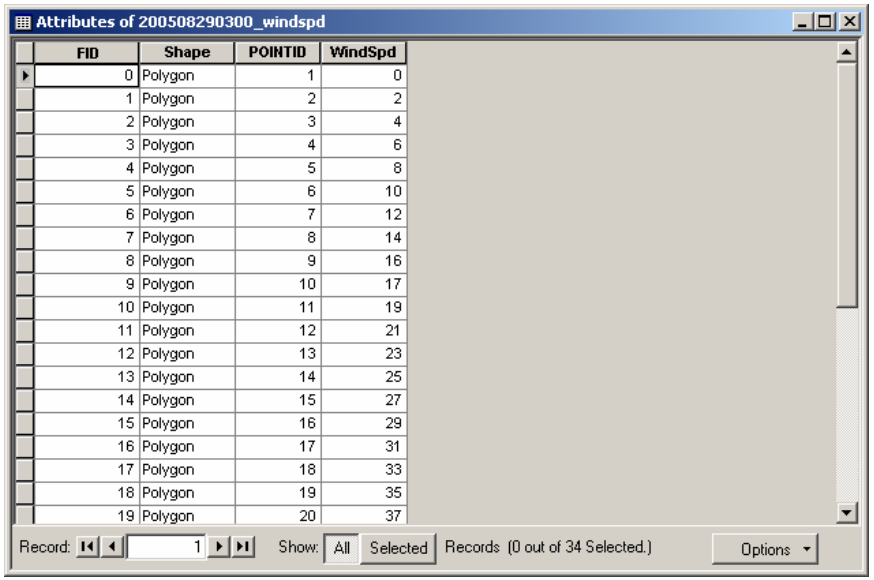
Record: 1 Show: All Selected Records (0 out of 34 Selected.) Options

Forecast Windspeed

Add and symbolize the data: Click on the **Options** button at the bottom right of the table and select **Add Field**. This opens a dialog window that allows you to specify the schema for the new field.

Specify the name of the new field as **Miles_Hour** and set the type of field to be **Short Integer** with a **Precision** of **3**. Click **OK** to add the field.



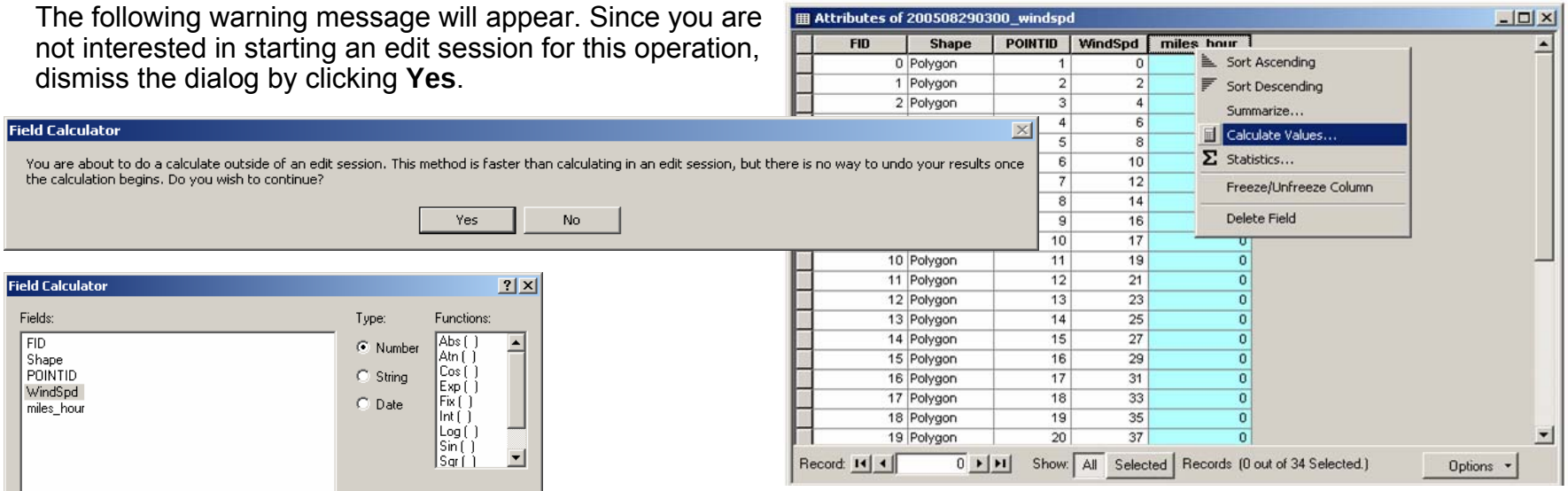


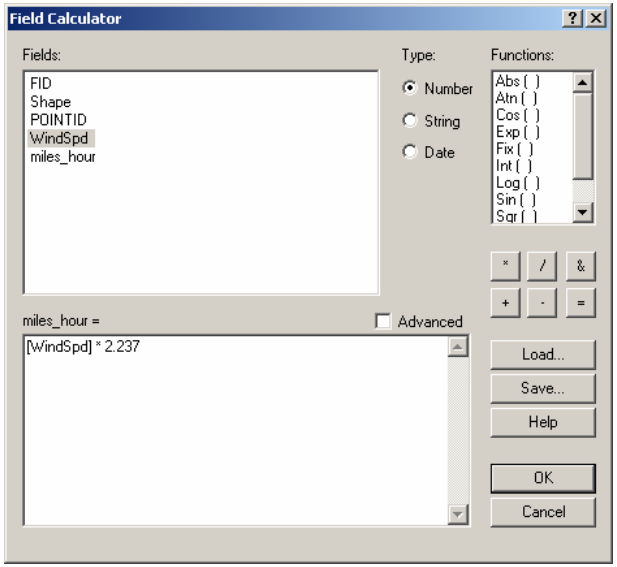
FID	Shape	POINTID	WindSpd
0	Polygon	1	0
1	Polygon	2	2
2	Polygon	3	4
3	Polygon	4	6
4	Polygon	5	8
5	Polygon	6	10
6	Polygon	7	12
7	Polygon	8	14
8	Polygon	9	16
9	Polygon	10	17
10	Polygon	11	19
11	Polygon	12	21
12	Polygon	13	23
13	Polygon	14	25
14	Polygon	15	27
15	Polygon	16	29
16	Polygon	17	31
17	Polygon	18	33
18	Polygon	19	35
19	Polygon	20	37

Forecast Windspeed

Add and symbolize the data: The new field is added, but it is empty. Right-click on the field name and select **Calculate Values…**

The following warning message will appear. Since you are not interested in starting an edit session for this operation, dismiss the dialog by clicking **Yes**.





Notice that the calculation expression is started within the Field Calculator dialog. Complete the formula as it is given in this example:

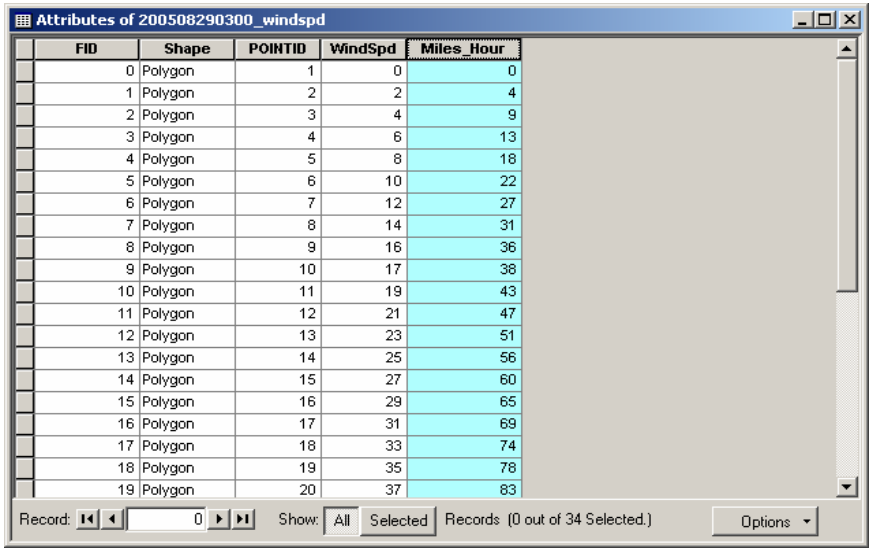
[WindSpd] * 2.237

Click **OK** to calculate the field.

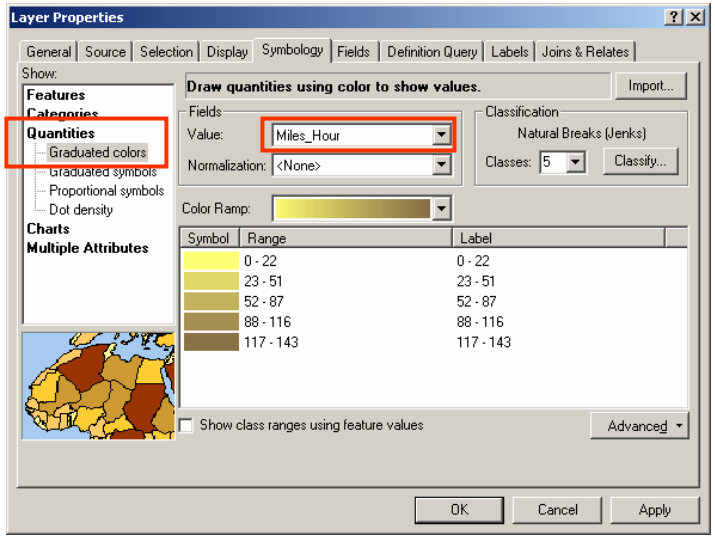
Forecast Windspeed

Add and symbolize the data: The values appear in the table and are now ready to be symbolized. Scroll through the table to see the range of wind speeds for this layer. Close the table when finished.

Double-click on the layer name in the table of contents. This will open the Layer Properties window. Click on the **Symbology** tab to assign wind speed ranges to the polygons.



FID	Shape	POINTID	WindSpd	Miles_Hour
0	Polygon	1	0	0
1	Polygon	2	2	4
2	Polygon	3	4	9
3	Polygon	4	6	13
4	Polygon	5	8	18
5	Polygon	6	10	22
6	Polygon	7	12	27
7	Polygon	8	14	31
8	Polygon	9	16	36
9	Polygon	10	17	38
10	Polygon	11	19	43
11	Polygon	12	21	47
12	Polygon	13	23	51
13	Polygon	14	25	56
14	Polygon	15	27	60
15	Polygon	16	29	65
16	Polygon	17	31	69
17	Polygon	18	33	74
18	Polygon	19	35	78
19	Polygon	20	37	83



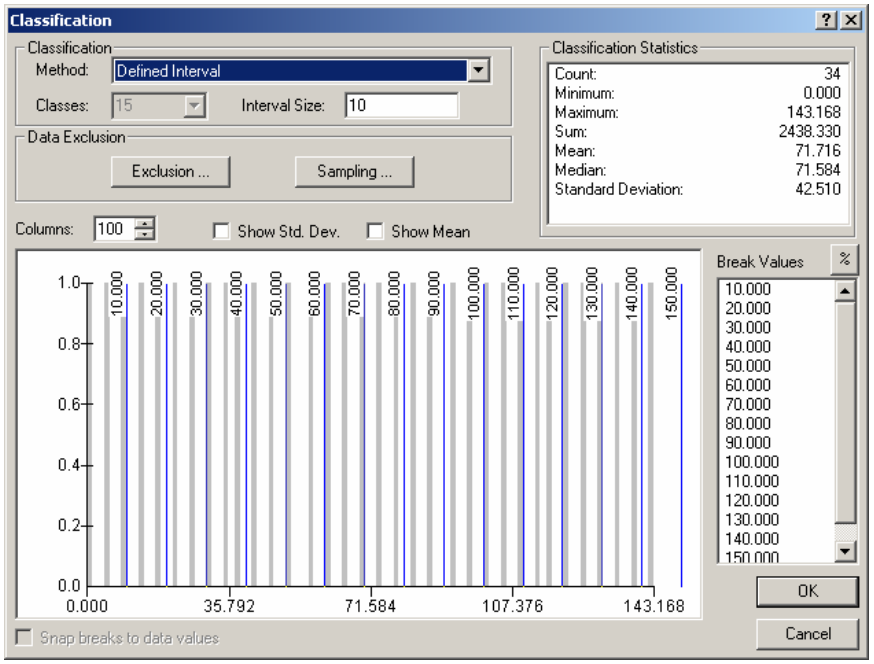
Change the “Show” group on the left of the window to the **Quantities > Graduated colors** category. Specify the Value field as **Miles_Hour**. Notice that a default classification is given.

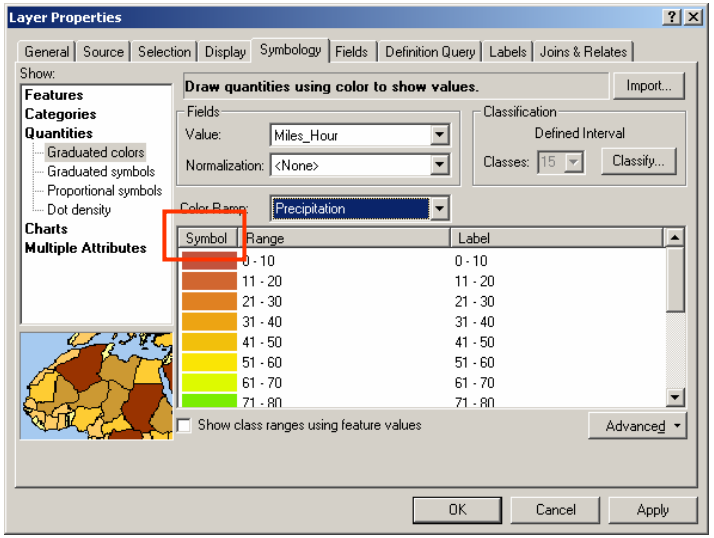
Forecast Windspeed

Add and symbolize the data: Click on the **Classify** button to open the Classification dialog window. Set the Classification Method to **Defined Interval**. Change the Interval Size to **10**. Click **OK**.

Choose a color ramp that is a logical progression from light to dark colors or, as in the example below, hot to cold colors.

Since you want the most dangerous wind speeds to be red, you need to reverse the order of these colors.



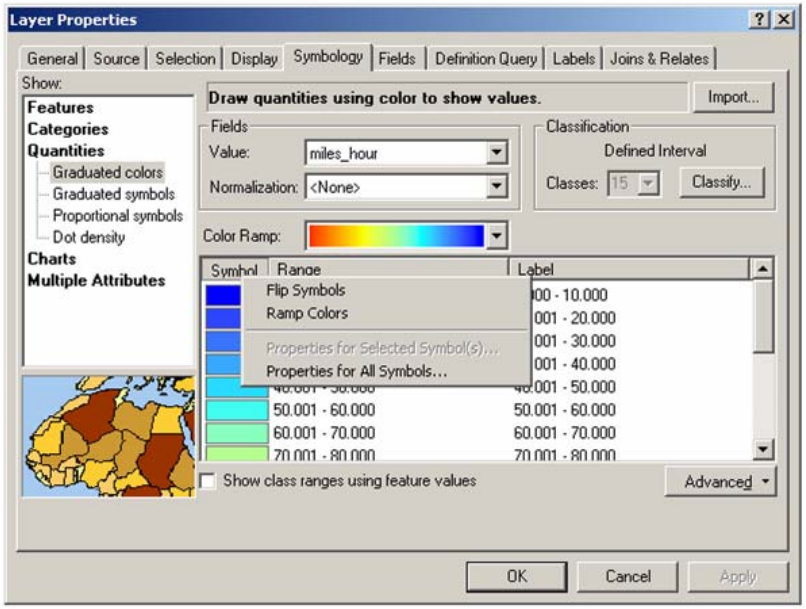


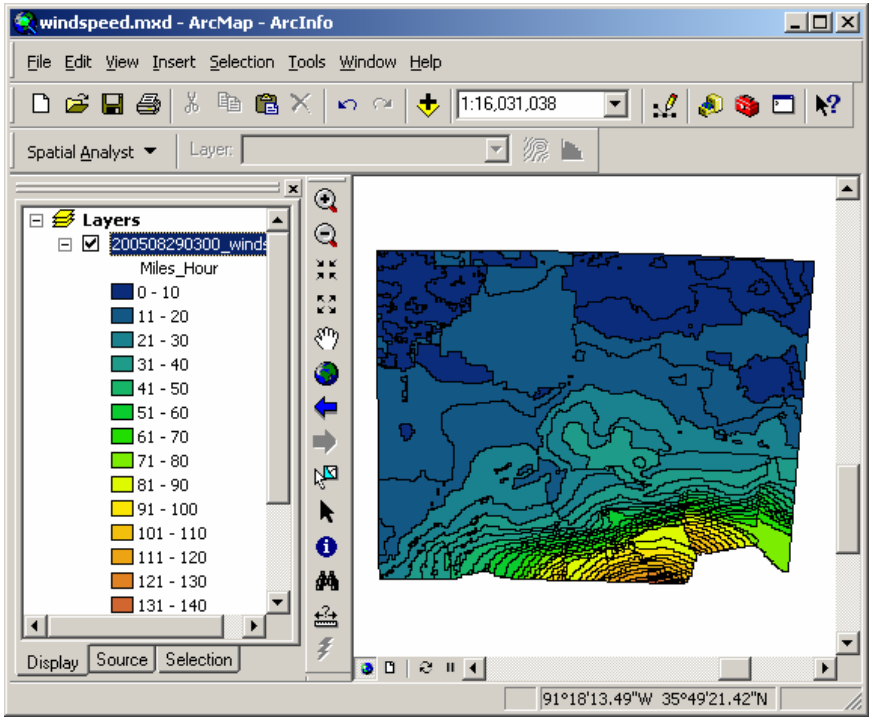
Click on the **Symbol** field and select **Flip Symbols**. Click **OK** to see the new colors.

Forecast Windspeed

Add and symbolize the data: Notice that the outline of the polygons appear distracting. Turn these off to see the wind speeds better.

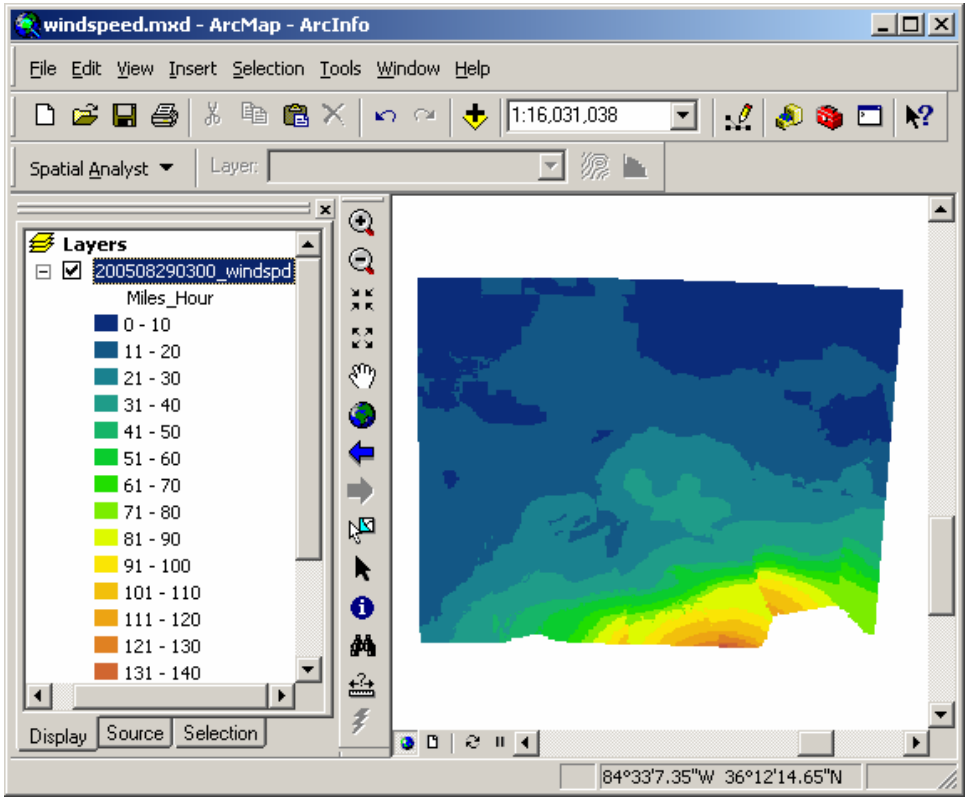
Double-click on the layer to open its Layer Properties.
Click on the **Symbol** header and select **Properties for All Symbols**.

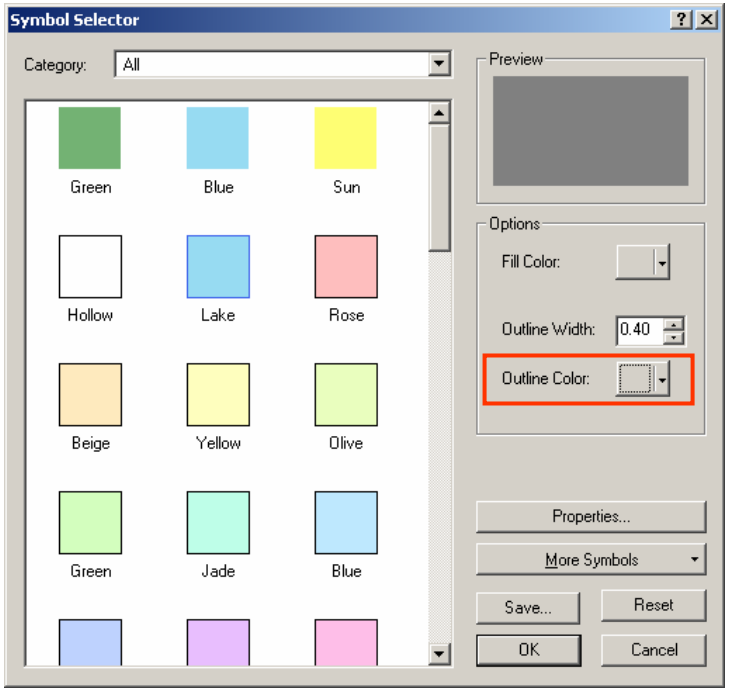




Forecast Windspeed

Add and symbolize the data: Change the Outline Color to **No Color** and click **OK**. Click **OK** in the Layer Properties window to assign the change.





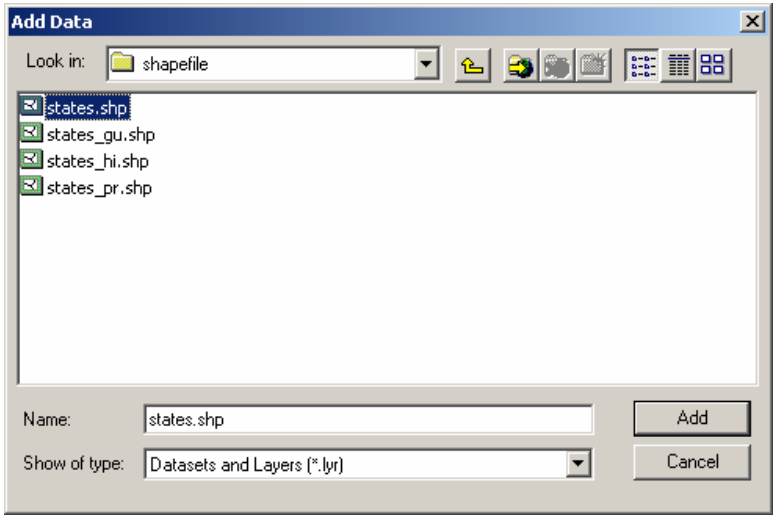
Notice that the different wind speeds are now easier to see.

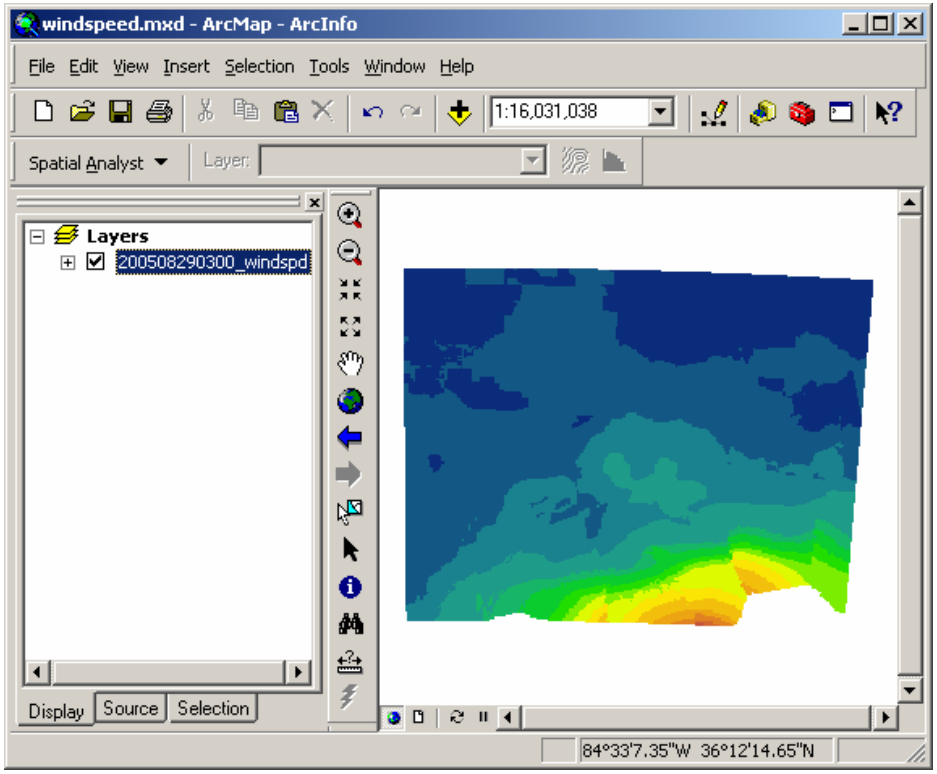
Forecast Windspeed

Add and symbolize the data: Collapse the symbols for this layer by clicking on the minus sign next to the layer's name.

Add a state boundary layer for reference purposes. Click on the **Add Data** button and browse to the following directory:
C:\ndfd\degrib17\data\imageGen\shapefile

Select the **states.shp** layer for this example.





Click **Add**.

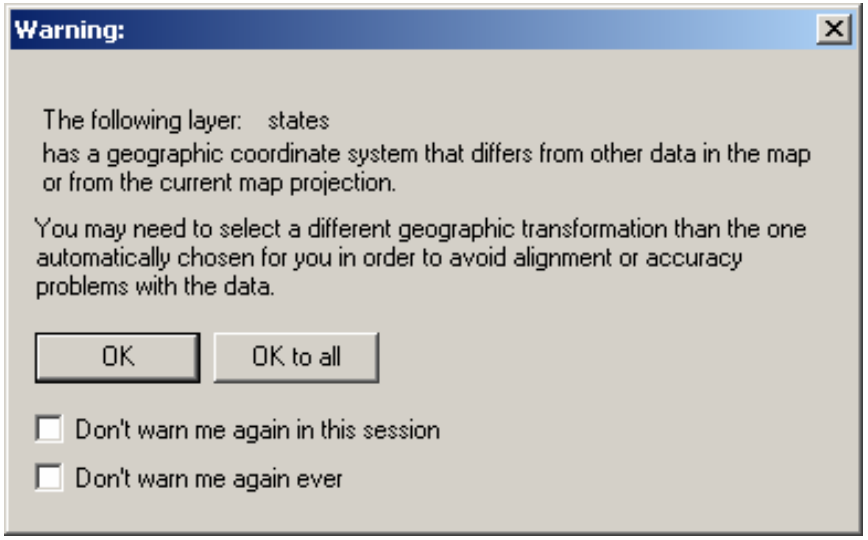
Forecast Windspeed

Add and symbolize the data: The following Warning dialog will appear.

This alerts the user that the data being added have a different spatial reference (projection system) than the NDFD layer currently in the table of contents.

ArcMap's data frame defaults the spatial reference to the first layer added; however, other added layers having different spatial reference will automatically reproject to the original layer.

This is known as "projection on the fly." This message is normal and can be dismissed by clicking **OK**.

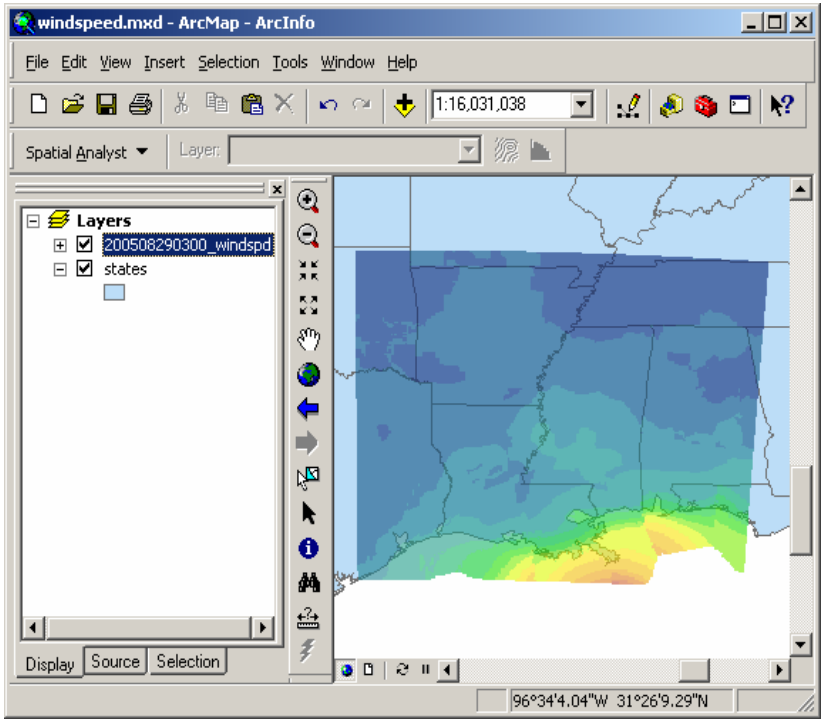


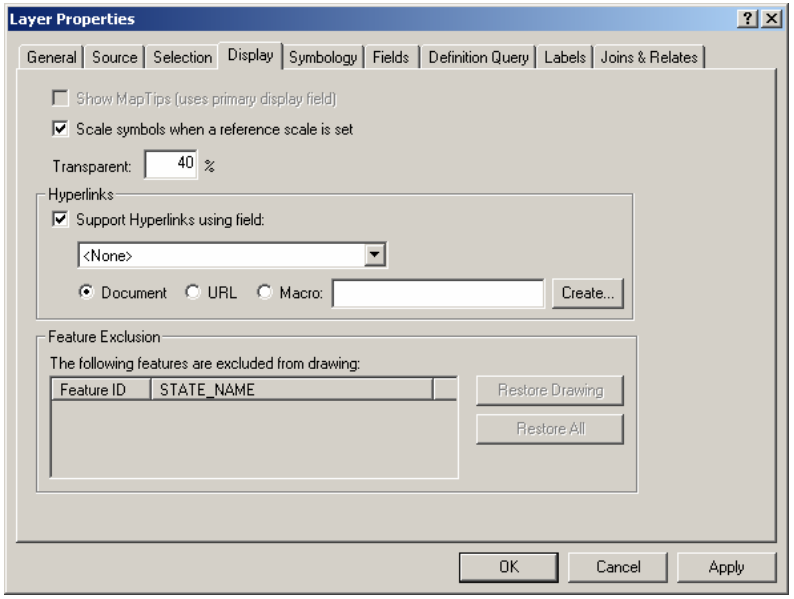
Forecast Windspeed

Add and symbolize the data: Click and drag the windspeed layer to the top. Double-click on the layer to open its Layer Properties window, and set the transparency so that you can see the state layer below it.

Click on the **Display** tab, and change the Transparency to **40%**.

Click **OK** to see the change take effect.

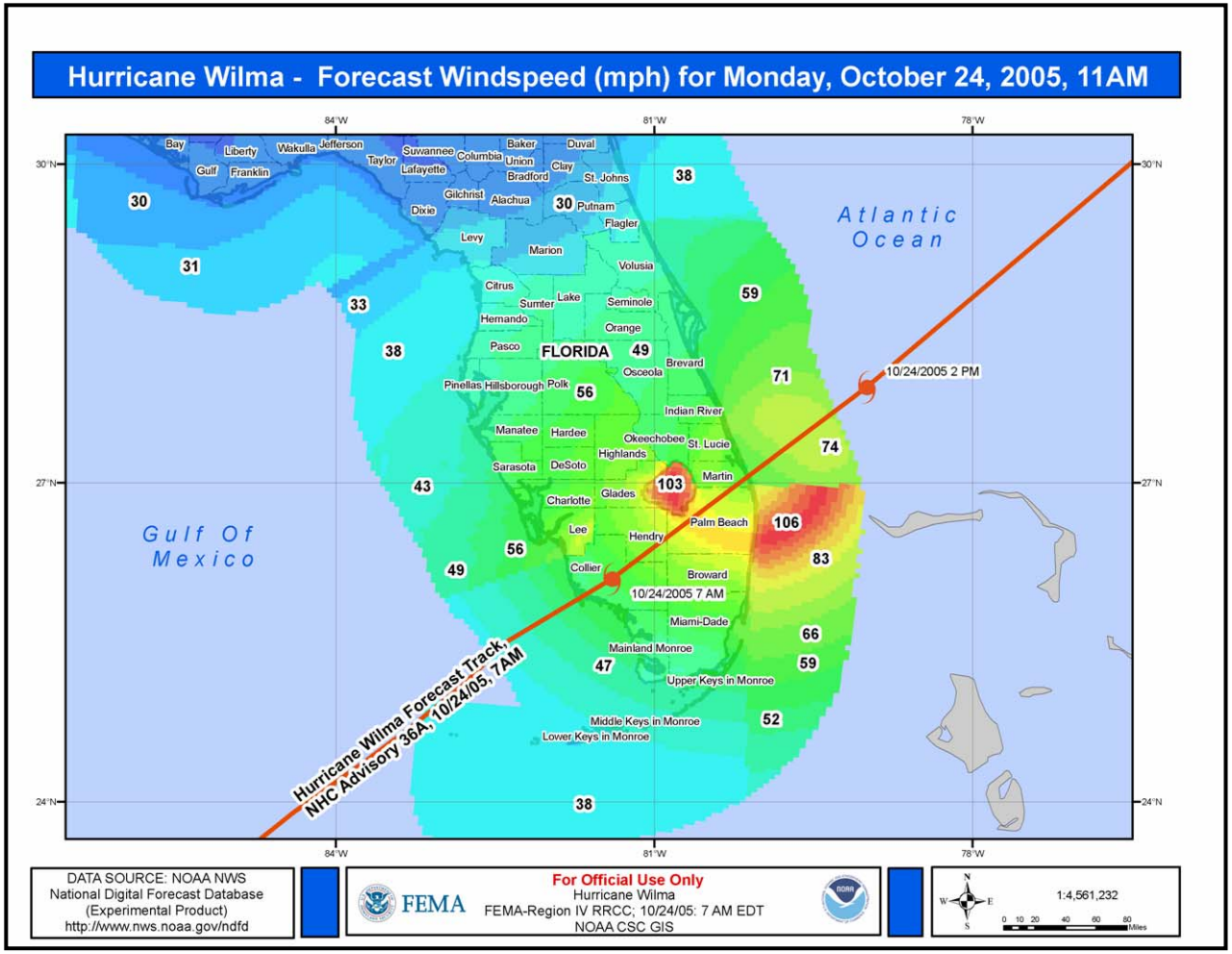




At this point you are ready to begin making a map. The following example shows what the NOAA Coastal Services Center has provided to members of FEMA in the past.

Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.

Forecast Windspeed



120-Hour Quantitative Precipitation Forecast

Purpose: This type of map presents a spatial and temporal precipitation forecast that predicts the potential amount of future precipitation for a specified region. The Southeast River Forecast Center (SERFC) uses the National Weather Service (NWS) Hydrometeorlogical Prediction Center's 5-day quantitative precipitation forecast (QPF) and makes minor changes based on the knowledge of local forecasters. QPF products are created by adding the prediction center's 6-hour QPFs for Days 1-3 (a total of 12 6-hour periods) to a 48-hour forecast for Days 4-5 prepared by NWS's medium-range forecasters. This forecast is issued twice per day, once at 7:00 a.m. Eastern Daylight Time/Eastern Standard Time (EDT/EST) (11Zulu time [Z]/12Z) and again at 7:00 p.m. EST/EDT (23Z/00Z). Both forecasts are valid from the beginning of Day 1 through the end of Day 5, with the later issuance offset by 12 hours. For example, a forecast prepared at 7:00 a.m. EDT/EST on September 2, 2004, would be valid for the 120-hour period from 12Z September 2, 2004, through 12Z September 7, 2004. For more information on Zulu Time see the Appendix.

Source Data: This type of map uses the NOAA National Weather Service's National Digital Forecast Database (NDFD), found at *www.nws.noaa.gov/ndfd/*. NWS provides access to gridded forecasts of weather elements (e.g., cloud cover, maximum temperature) through the NDFD. This database contains a seamless mosaic of digital forecasts from NWS field offices working with the National Centers for Environmental Prediction (NCEP). The database uses a 5-kilometer national grid that covers the continental U.S. and separate grids that cover Hawaii, Alaska, the U.S. Virgin Islands, and Puerto Rico. Each 5-kilometer grid cell has forecast information, allowing users to retrieve specific forecasts by entering geographic coordinates.

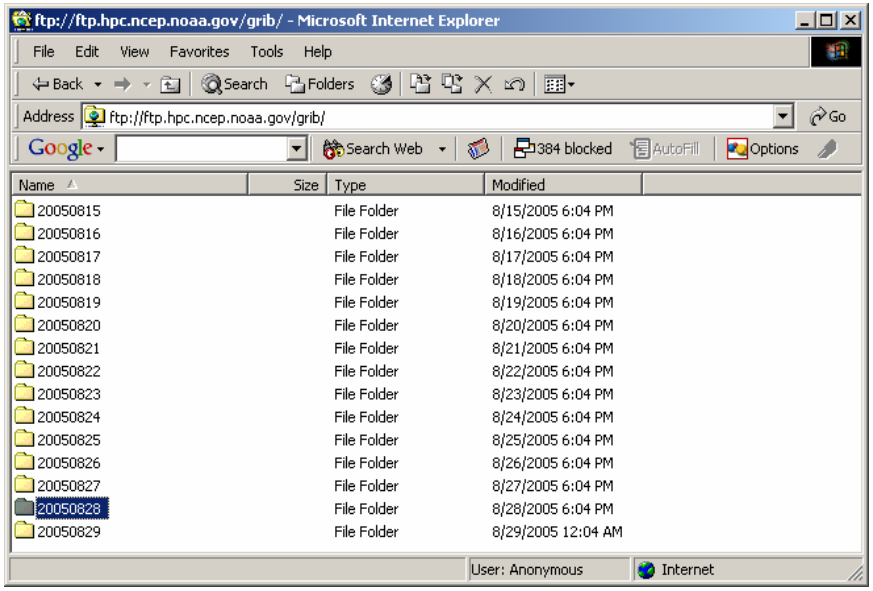
The World Meteorological Organization (WMO) has adopted Edition 2 of the gridded binary data (GRIB) code as a standard for sharing information. GRIB, Edition 2 (GRIB2), is involved in the NDFD in two ways. First, GRIB2 is the code form used to transmit gridded forecasts from contributing offices to the NDFD. Second, GRIB2 is one of the primary forms used to transmit the NDFD grids to NWS customers and partners. Users should note that this should be considered an experimental product at the time of this writing (March 2006).

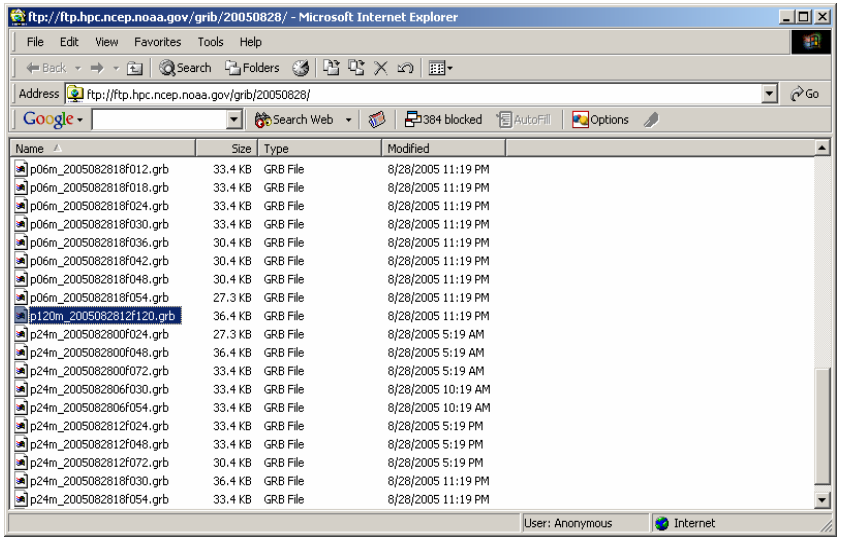
120-Hour Quantitative Precipitation Forecast

Download Data: Open a Web browser and connect to the FTP site that contains the GRIB data. Type the following address:

ftp://ftp.hpc.ncep.noaa.gov/grib/

Once you are connected, open a folder that corresponds with the date of QPF data you want to access.





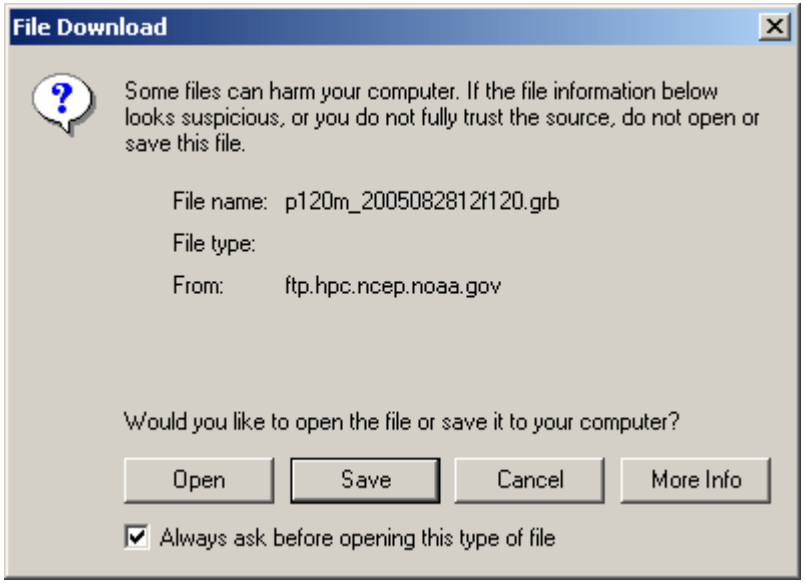
Scroll to the bottom of the list of GRIB files and select the one that begins with 120 (i.e., **p120_2005082812f120.grb**).

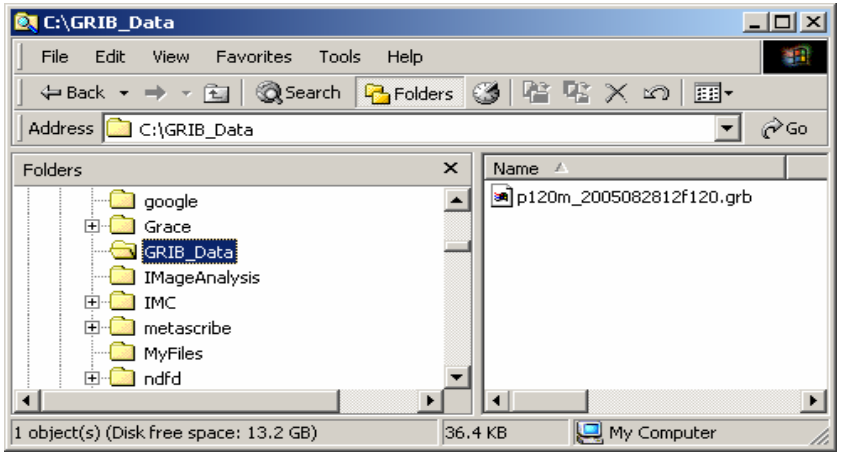
This represents the cumulative amount of rain for the next five days beginning at noon of August 28, 2005.

Double-click on the file to begin the download process.

120-Hour Quantitative Precipitation Forecast

Download Data: If using Microsoft's Internet Explorer, you will receive the following window. Click on the **Save** button and navigate to a folder on your hard drive (i.e., C:\GRIB_Data)





Open Windows Explorer to see the file. Because ArcGIS does not read this format, you must convert the file to the ESRI shapefile format.

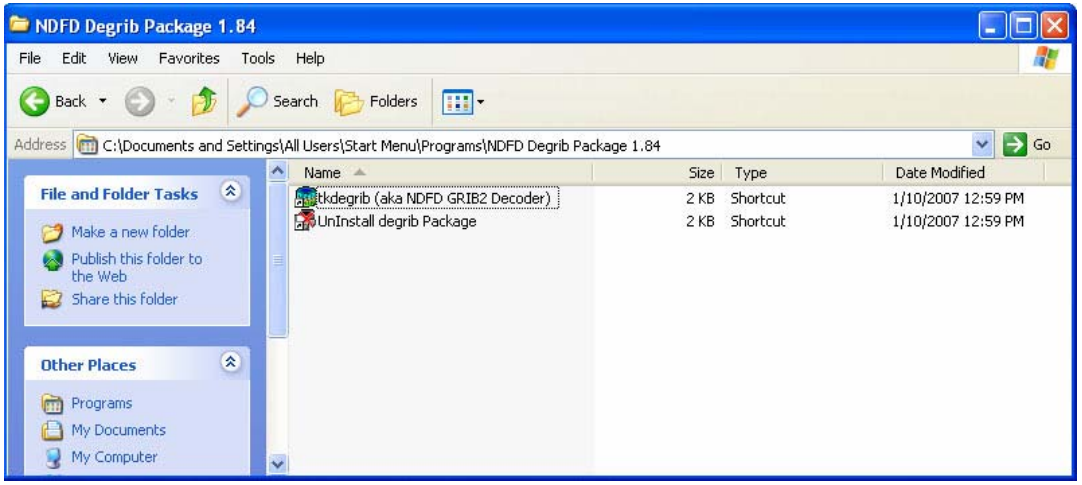
120-Hour Quantitative Precipitation Forecast

Download Software: Before working with NDFD data, you must first download the GRIB2 Decoder tool that allows access to the data. Learn more about GRIB2 Decoder by visiting this site: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/*

Register for the DEGRIB program here: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/howto.php*

Once finished, download the program: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/download.php*

This page provides several different versions of the same product. For this tutorial, you will focus on the Microsoft Windows version. Click on **degrib-install.exe** file and select **Save**. Specify the defaults to begin the installation. This program will create c:/ndfd and install the necessary files into that folder. Once the installation is finished, you should have a program group like the one below.

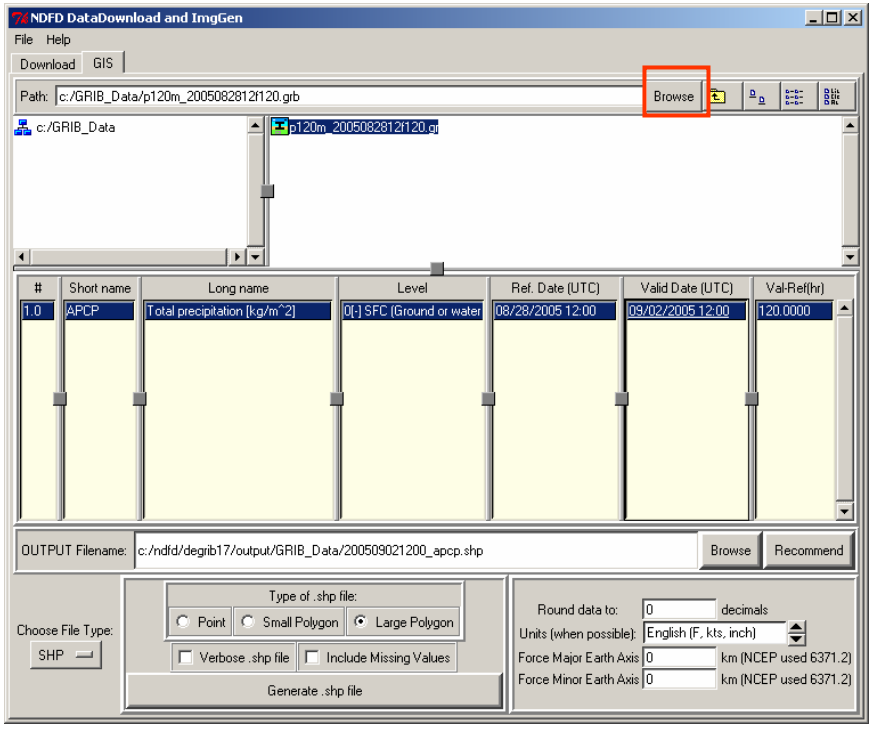


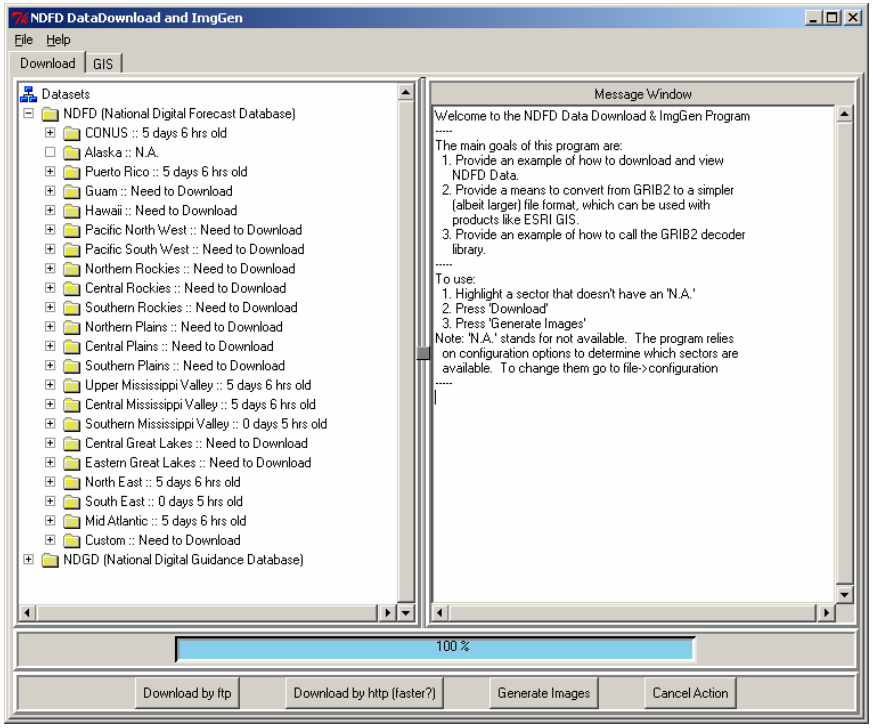
Double-click on **tkdegrib (aka NDFD GRIB2 Decoder)** to start the program.

120-Hour Quantitative Precipitation Forecast

Download: In the main program window shown on the right, click on the **GIS** tab.

Next, click on the **Browse** button at the top and navigate to the folder where you copied the GRIB data. Do you remember its name?





This file contains important Quantitative Precipitation Forecast (QPF) data in binary format. Unfortunately, ArcGIS is unable to read this format, so the data must be converted to a shapefile.

120-Hour Quantitative Precipitation Forecast

Convert the data: Select the .grb file that was created on August 28, 2005 (20050828), at noon (12) Greenwich Mean Time, forecasting (f) the cumulative precipitation amount in 120 hours.

Next, specify where you would like to have the converted shapefile written. In this example, you will click on the **Recommend** button and take the default directory and filename.

Specify that the new shapefile contains **Large Polygons**.

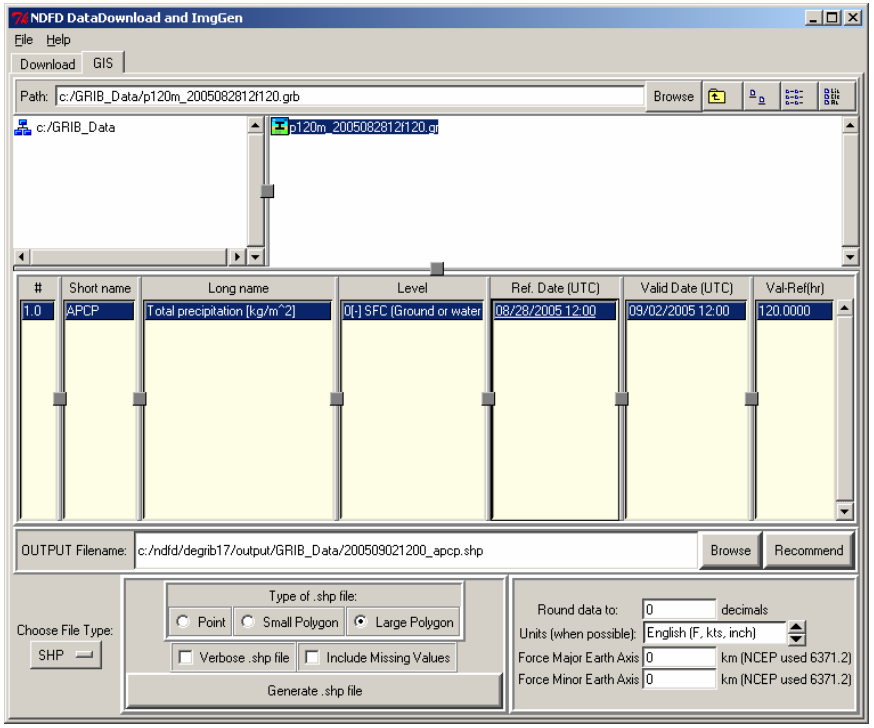
Specify **Round data to: 0** decimals.

Click on the **Generate .shp file** button.

Click on the message box when the conversion is **Done**.

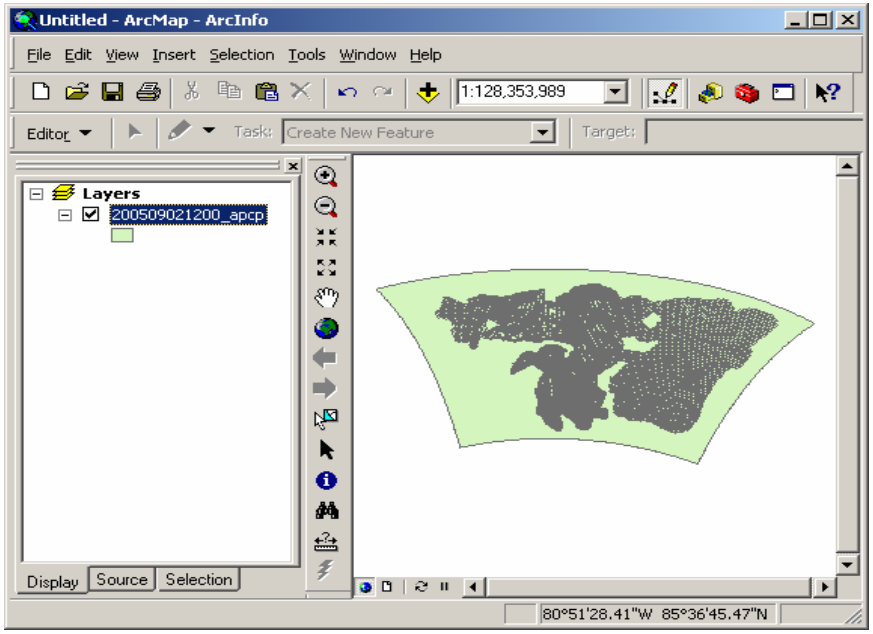
When finished, minimize the program and open ArcMap to add this layer and begin making a map that explains what the data are describing.

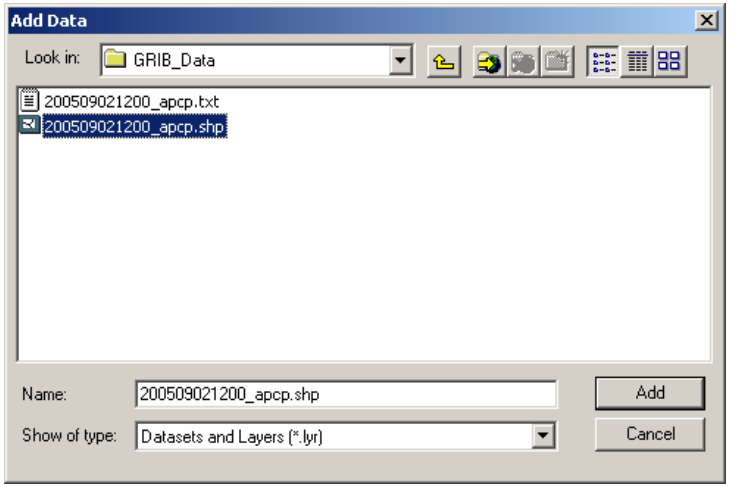
ArcMap can be started by selecting **Start > Programs > ArcGIS > ArcMap**.



120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Add the layer by clicking on the **Add Data** button found at the top of the ArcMap window. This starts a dialog box that lets users browse to their data. Click on the layer to select, and click the **Add** button.



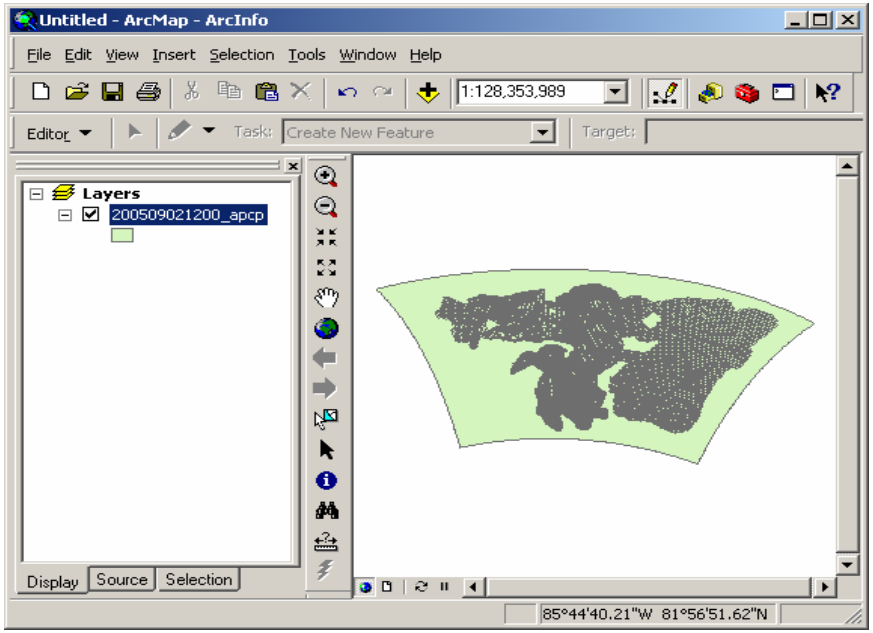


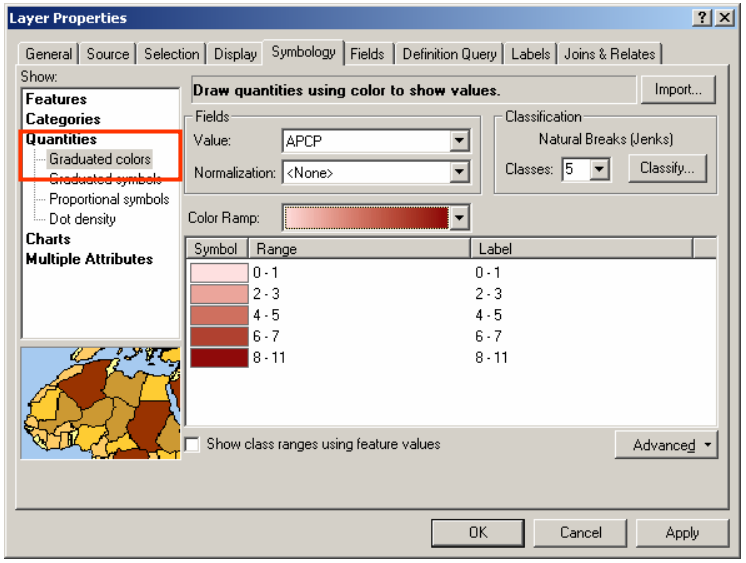
The data need to be symbolized to show the amount of precipitation expected in the area during the next 120 hours.

120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Double-click on the shapefile layer in ArcMap's table of contents. This opens the Layer Properties dialog box. Select the **Symbology** tab, and click on the **Quantities > Graduated Color** category to specify a classification system.

Set the field value to **APCP** (Accumulated Total Precipitation), and click on the **Classify** button.

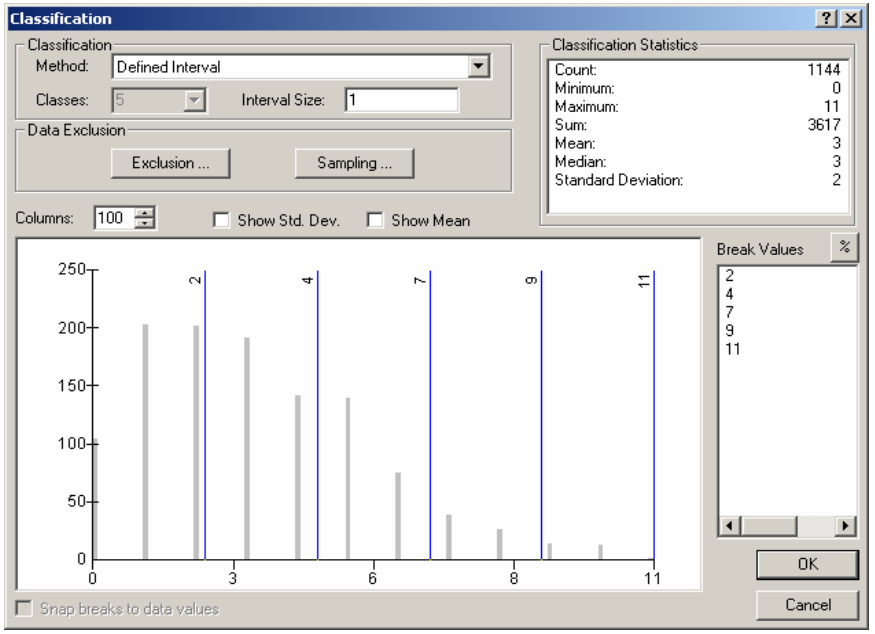


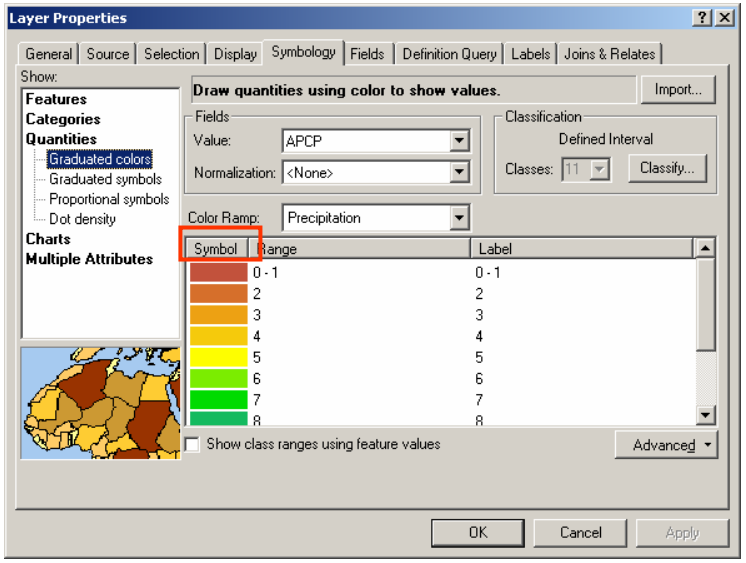


120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Change the classification method to **Defined Interval**. Set the Interval Size to **1** (inch of rain) and click **OK** to make the change.

Assign a logical color ramp to the rainfall amounts in the **Symbology** tab by right-clicking on the color ramp and choosing **Graphic View**. This gives a textual description of the color ramp.



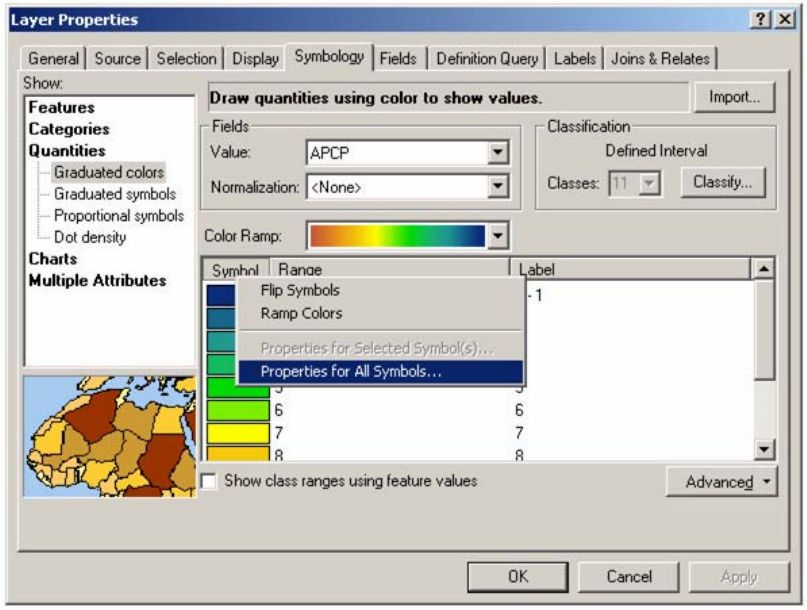


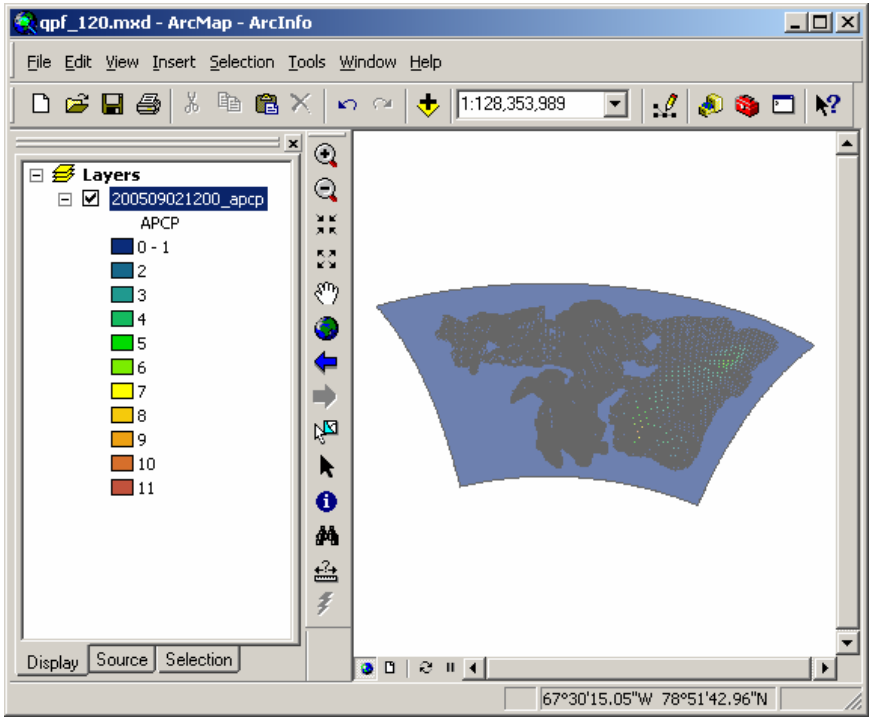
Select a color ramp that is a logical progression from light to dark colors, or, as in the example on the left, **Precipitation**. Next, flip the color of the symbols so that the reds are assigned to the higher values. Click on the **Symbol** field and select **Flip Symbols**. Click **OK**.

120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Notice that the outlines of the polygons appear distracting. Turn these off to see the precipitation amounts better.

Double-click on the layer to open its Layer Properties again. Click on the **Symbol** header and select **Properties for All Symbols**.

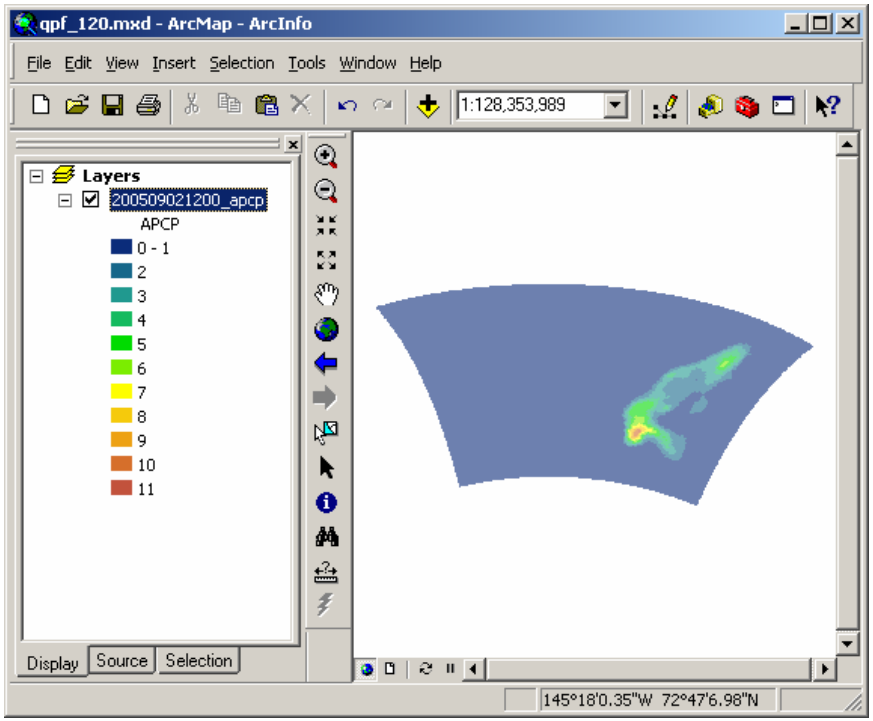


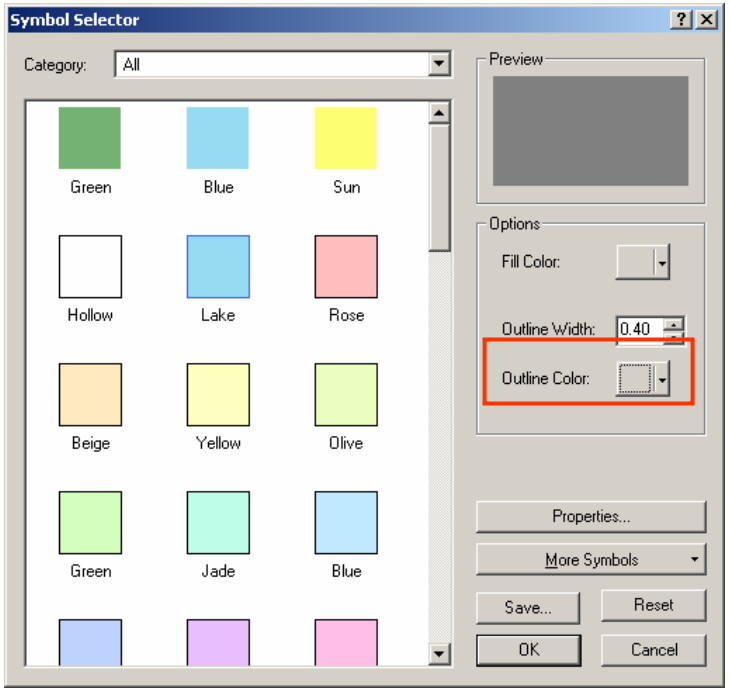


120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Change the Outline Color to no color and click **OK**. Click **OK** in the Layer Properties window to assign the change.

Notice that the different precipitation amounts are now easier to see.

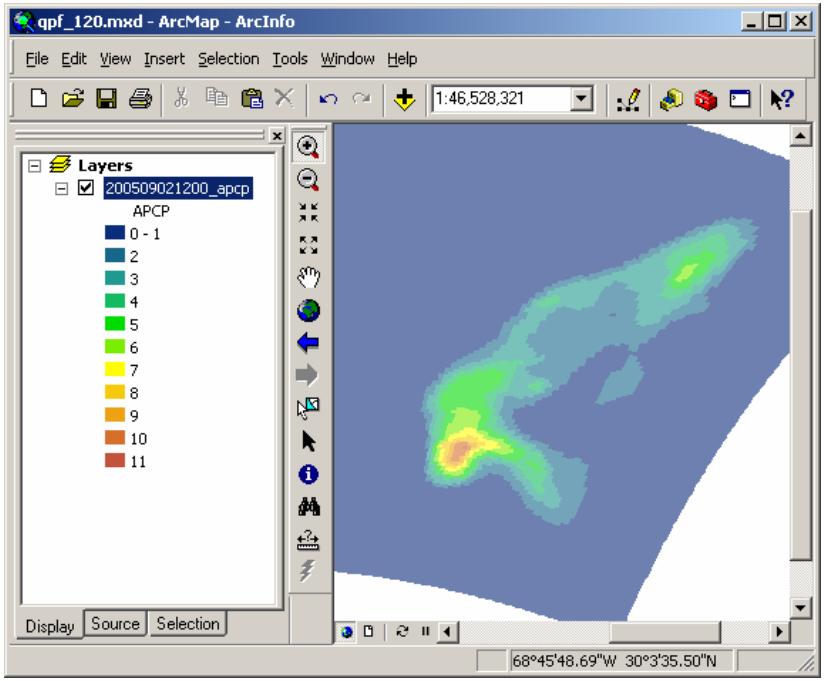




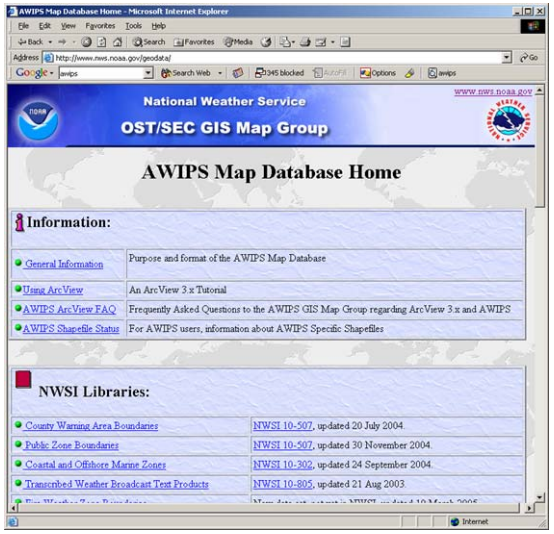
120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Collapse the symbols for this layer by clicking on the minus sign next to the layer's name. Zoom into an area of interest.

Notice that the layer is now properly symbolized with specific colors assigned to precipitation amounts. Also note that the units of measure is in inches.



To clearly see the political areas affected by this rainfall, you must add a new layer. Minimize ArcMap and open a Web browser. Visit the AWIPS homepage to download these data: *www.nws.noaa.gov/geodata/*



This site serves different base layer data for use in a GIS. Scroll down the page and find the County Libraries section.

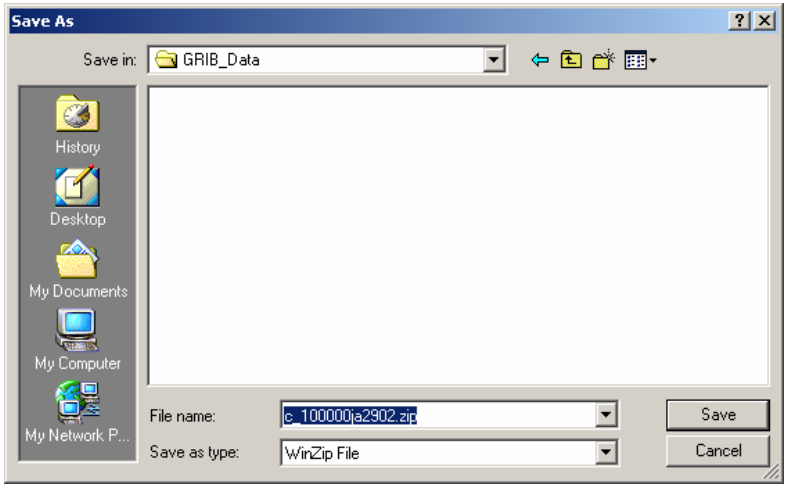
Click on the file named **Counties at 1:100k**.

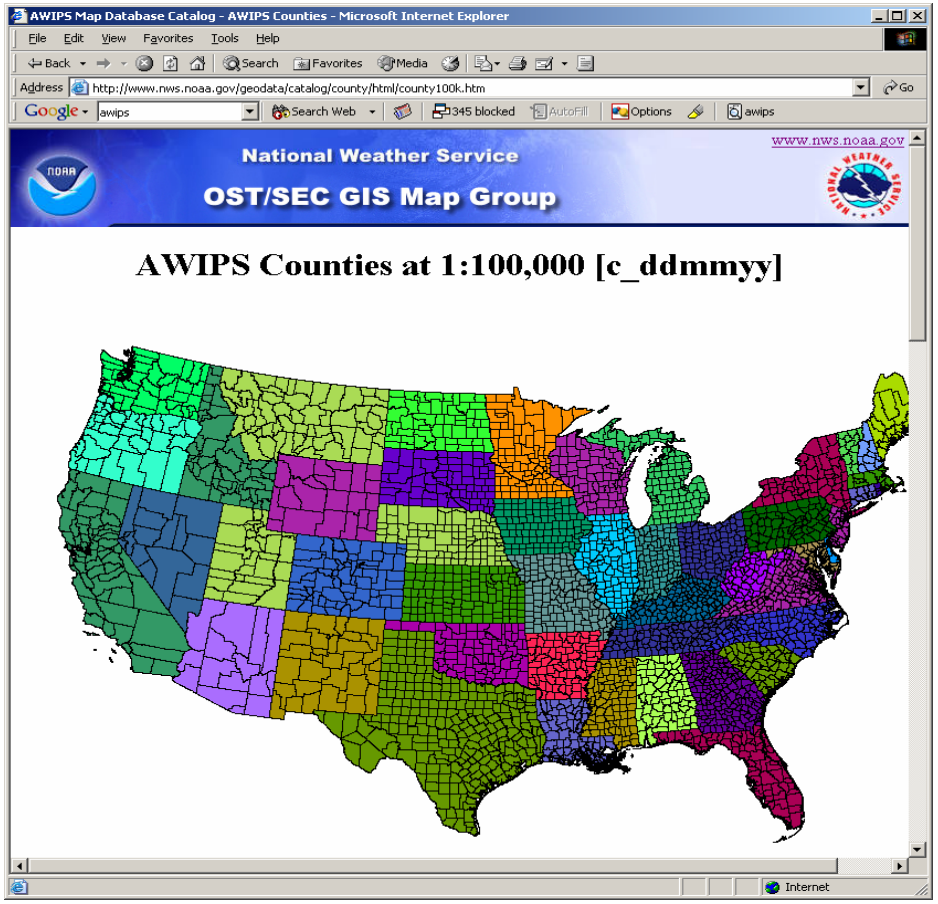
120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: This site provides free county boundary data at 1:100,000 scale, which will be suitable for our mapping purposes.

Scroll down and click on the **Download Compressed Shapefile** link. Save this file to your GRIB_Data folder. This 52 MB file is large and will take some time to save.

Description	Valid Date		Size (bytes)		
US Counties (CONUS)	14 January 2003	Download Compressed shapefile	51,731,681	Change History	Metadata



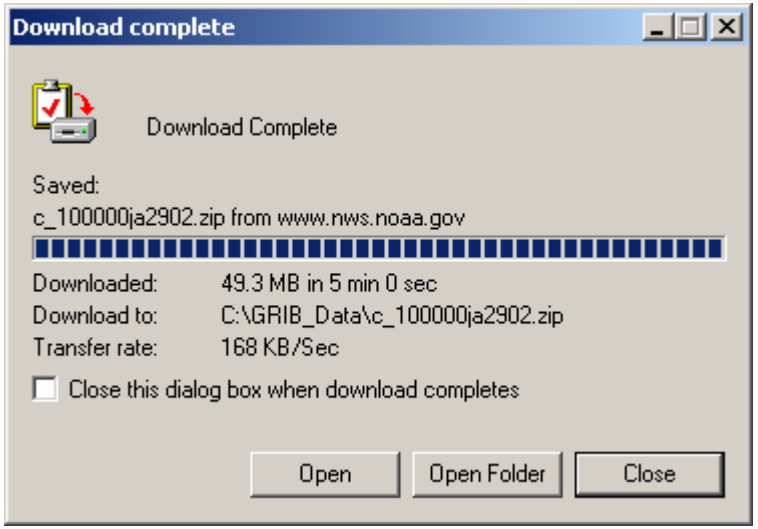


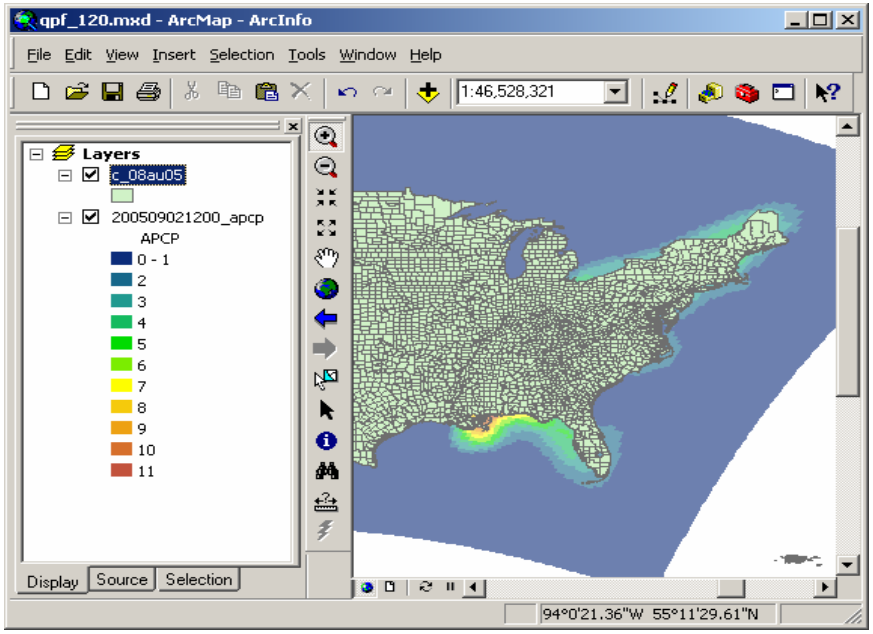
120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: Once the download finishes, you should open the .zip file with a compression utility package.

Extract all three files from the .zip file and save them to the c:\GRIB_Data folder.

Open **ArcMap** back up and add the new county boundary layer.





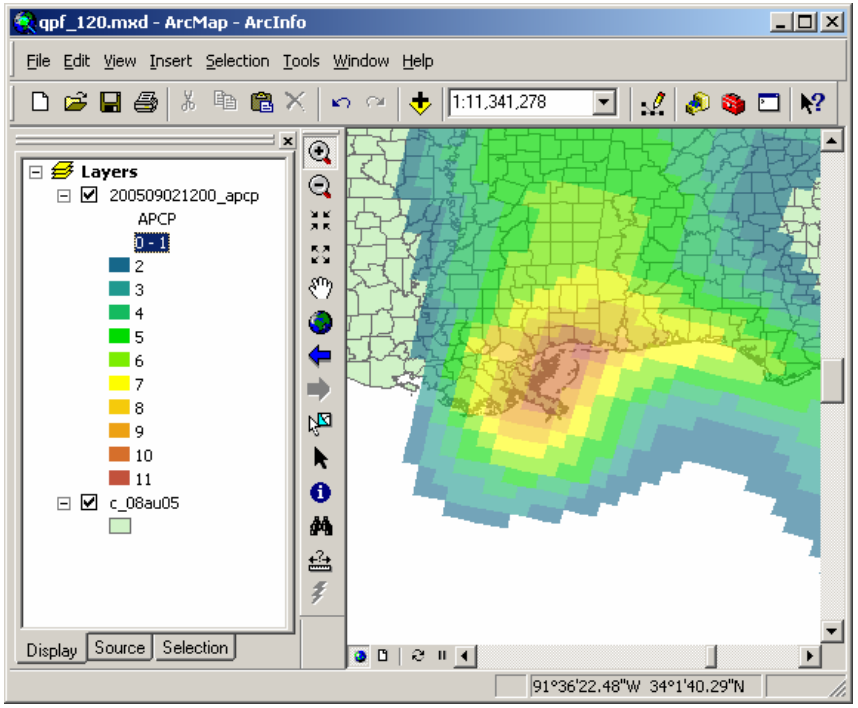
Drag the county boundary layer below the QPF layer. Make the QPF layer partially transparent so that both layers are visible.

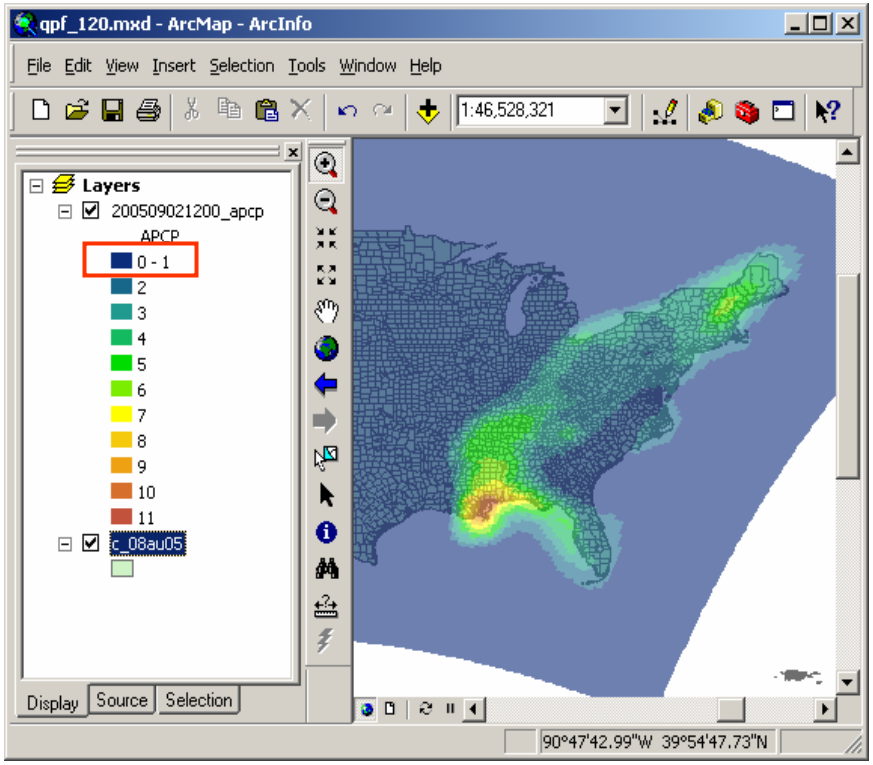
To do this, double-click on the QPF file to open Layer Properties. Select the **Display** tab and set the Transparency to **40%**. Click **OK** to make the change.

120-Hour Quantitative Precipitation Forecast

Add and symbolize the data: You may want to set the first class (0-1 inches) to be transparent. Right-click on the symbol that represents that class and select **No Color**.

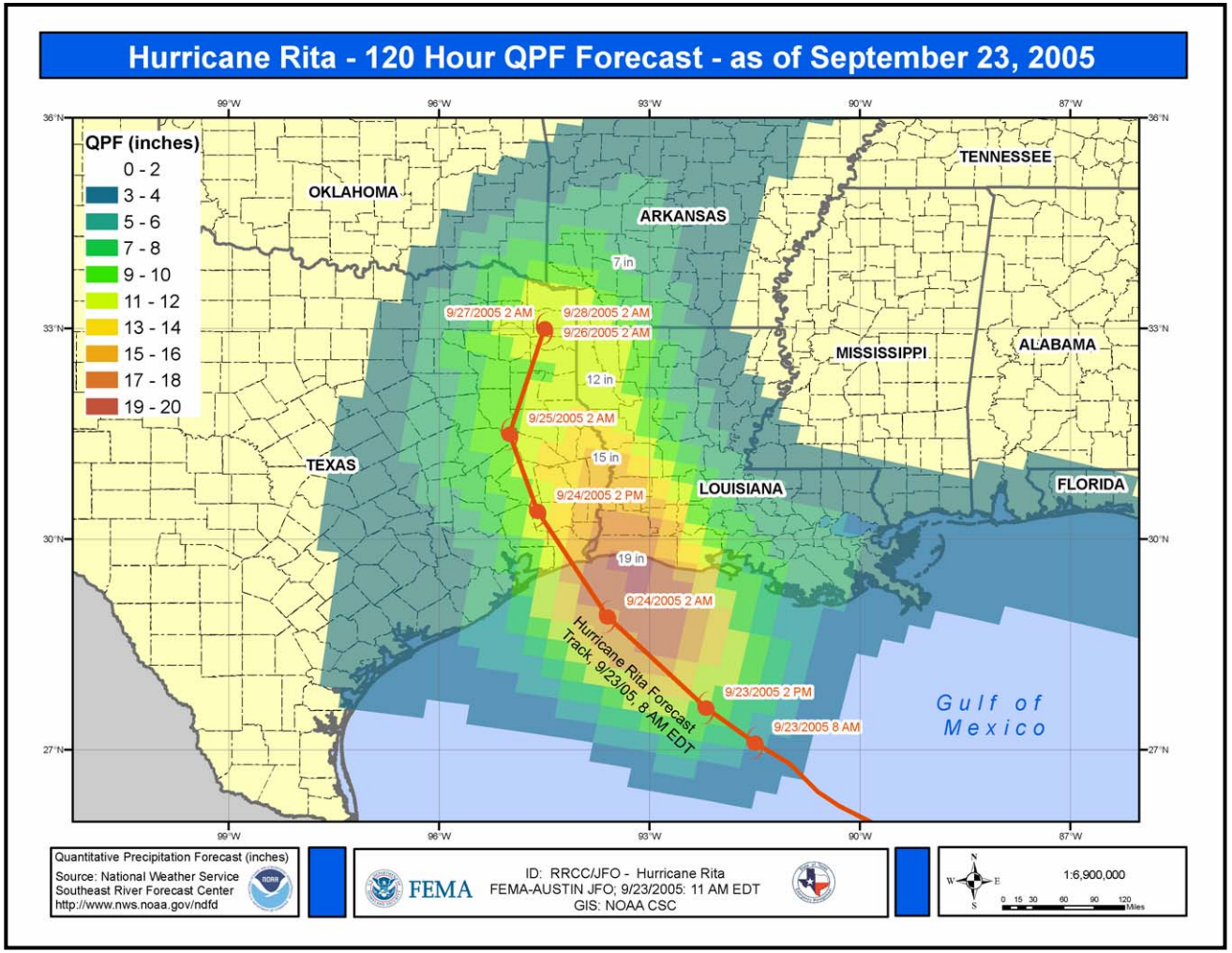
At this point you are ready to begin making a map. The following examples show what the NOAA Coastal Services Center has provided to members of FEMA in the past.



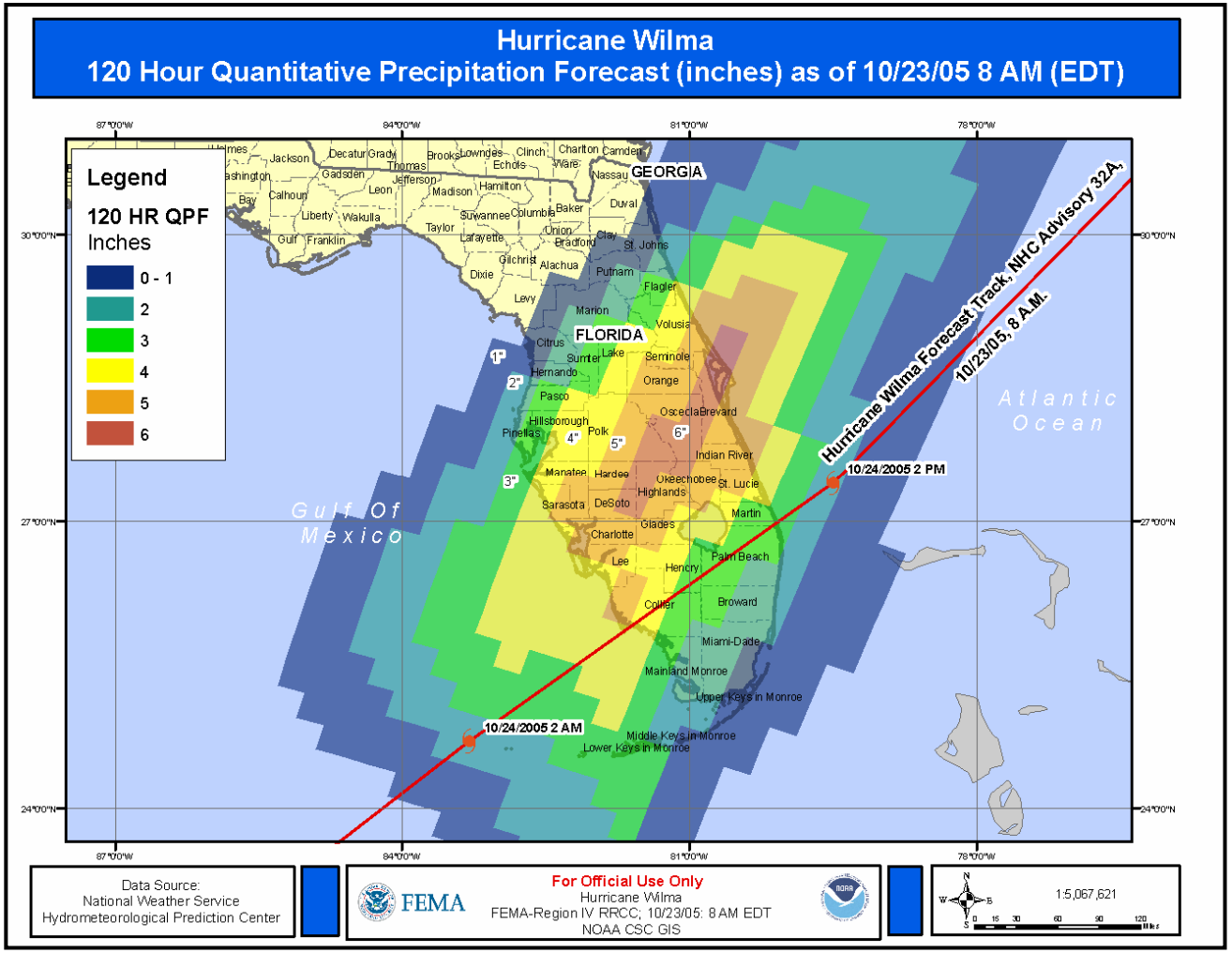


Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.

120-Hour Quantitative Precipitation Forecast



120-Hour Quantitative Precipitation Forecast



NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Purpose: This type of map presents an estimate of the amount of rainfall during one or more days. This amount is measured in inches.

Source Data: National Hurricane Center (NHC) and local weather information, forecast tracks, and evacuation time calculations can be plotted manually, but this can be an onerous task during an emergency. A computer program called HURREVAC automatically tracks this information and displays the results graphically. The computer program can be obtained from county, local, and state emergency management offices. **(Please note that this program is not available to the general public.)**

HURREVAC updates current and forecast storm data and then displays the track of the storm in various formats. Using Hurricane Evacuation Study (HES) data, it considers the potential for storm surge and calculates evacuation times by considering storm speed and intensity. HURREVAC can also be used as a "what if" tool to help emergency managers determine courses of action for different storm characteristics.

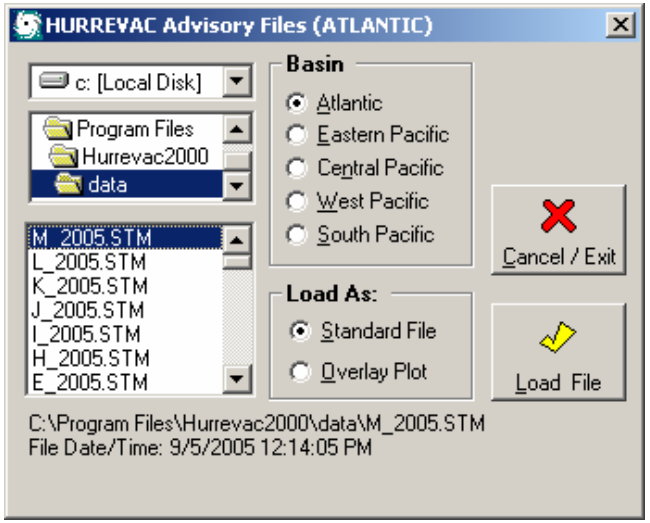
Download: This tutorial assumes that users of HURREVAC have already installed the software and have some idea of how it works.

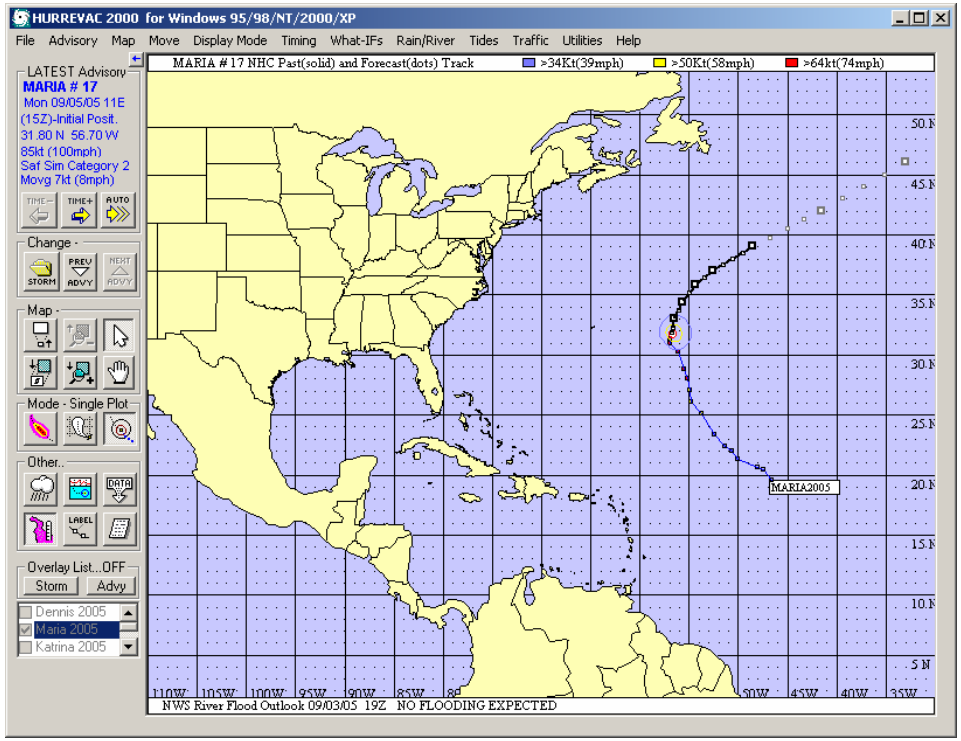
NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Access the data: Begin using HURREVAC by going to **Start > Programs > HURREVAC2000**. Once the program opens, click on the **Auto Download Latest** button.

Once the data finishes downloading, click **Exit** to close the window.

Click on the **Load Storm File** button to access data for a specific tropical storm.



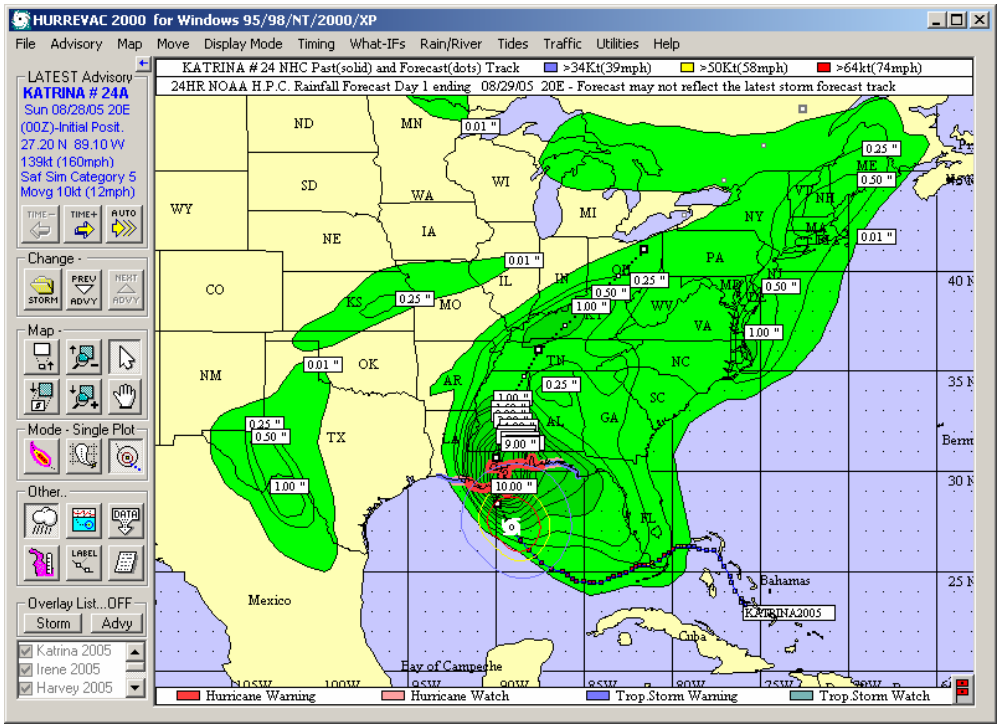


The following dialog window will open. Navigate to the c:\Program Files\Hurrevac2000\data folder. Click on the storm name (first letter in name_year of storm). Click on the **Load File** button.

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

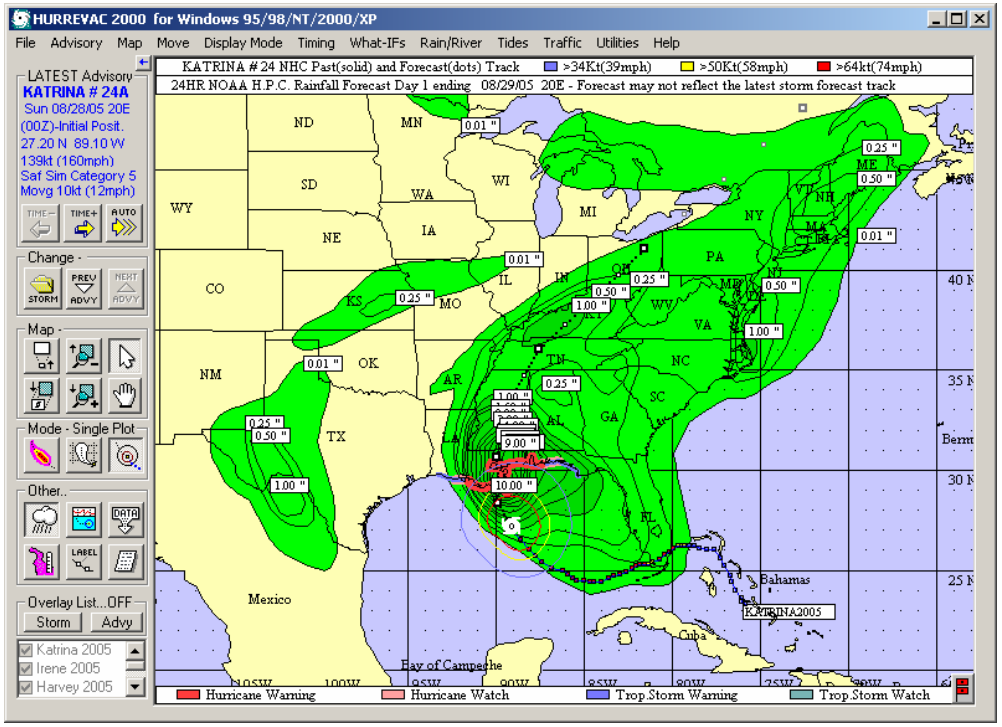
Access the data: To view HPC Rainfall forecasts for a given day, click on the **HPC Rain Forecast** button. This will display the areas expecting rain for that day.

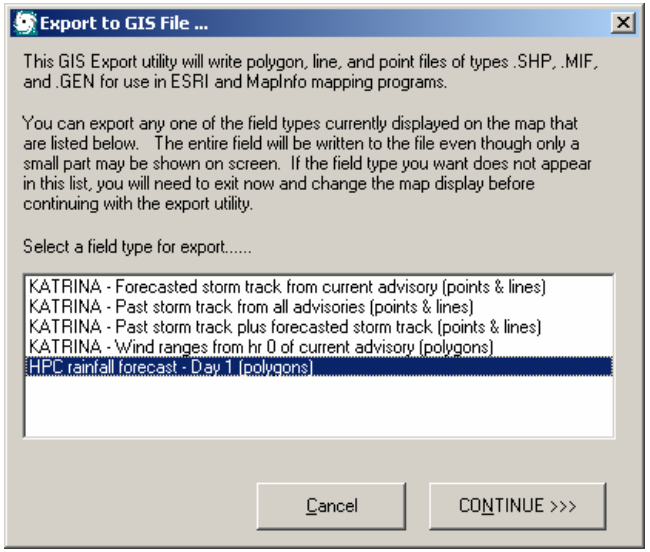
Right-click on this button to show additional days afterwards. To zoom in closer to an area of interest, simply click and drag your cursor to make a frame around the area.



NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Access the data: To select and output the data presented inside HURREVAC to an ESRI shapefile, simply select **File > Export Field(s) to GIS File**.



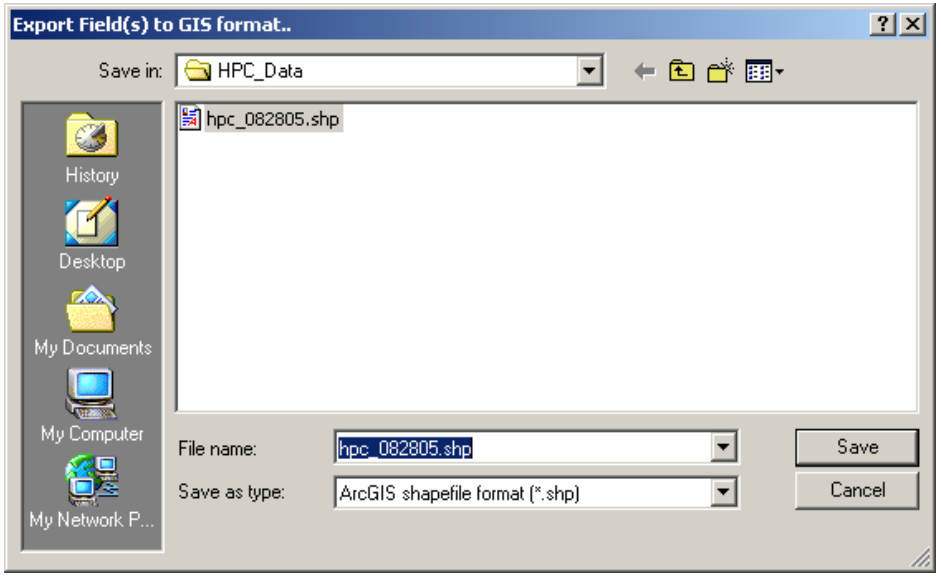


Click on a field type and click the **Continue** button. For this example, the HPC rainfall forecast for Day 1 will be selected.

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

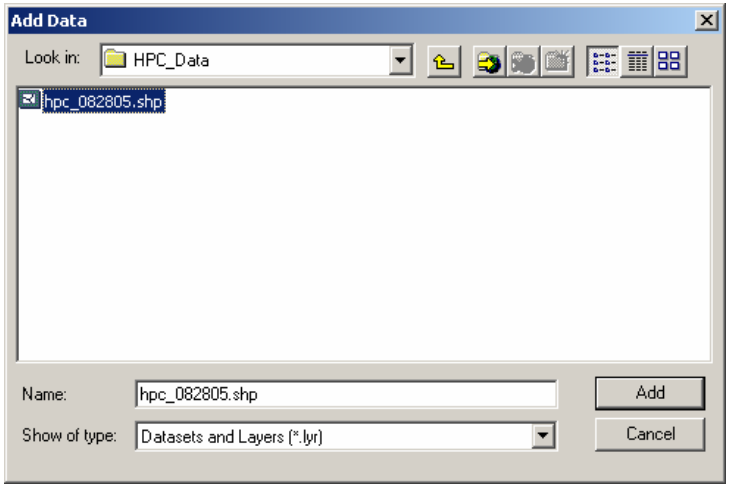
Access the data: A dialog window will appear that asks for the folder to save the downloaded shapefile. Specify an existing folder, or create a new one (i.e., C:\HPC_Data).

Provide a logical name for your shapefile and click **Save**. Ideally, you should try to record the date for which the HPC data are valid.

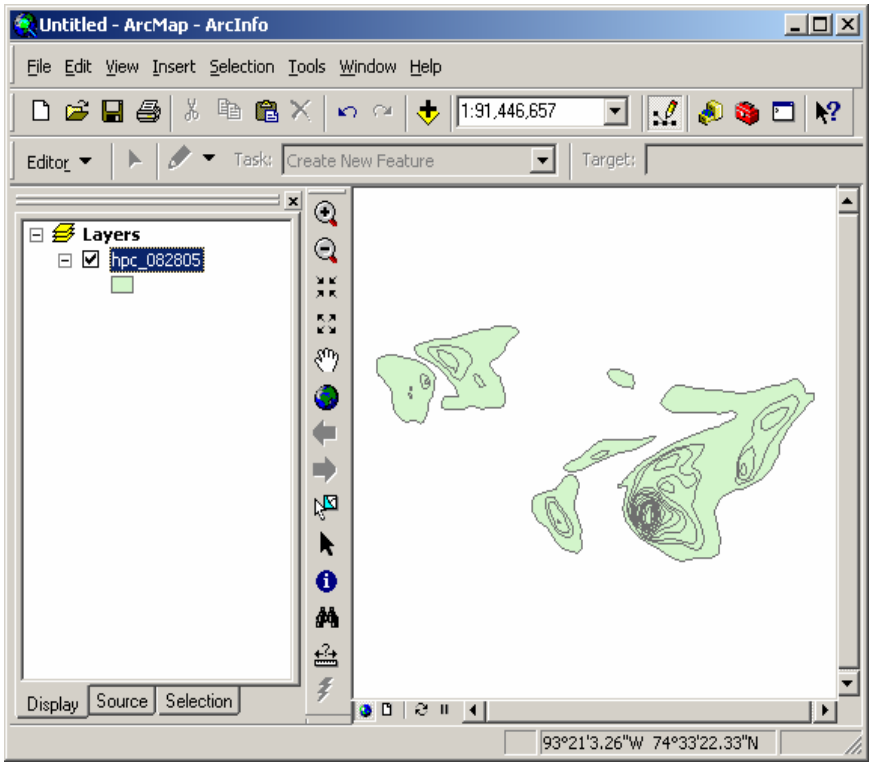


NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

View the data: Add the layer by clicking on the **Add Data** button found at the top of the ArcMap window. This brings up a dialog window that lets users browse to the data.

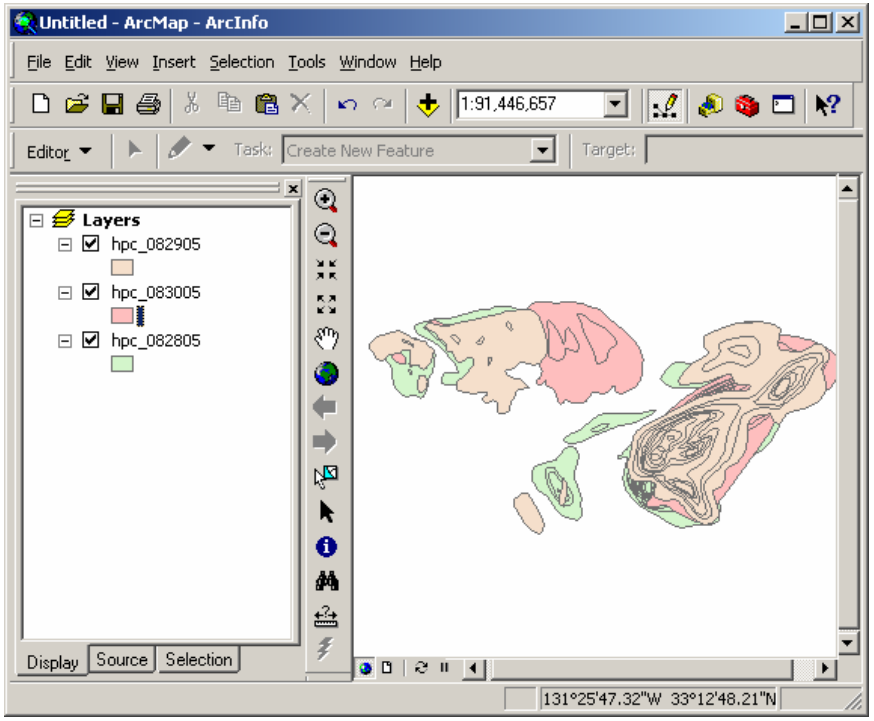


Select the HPC layer and click **Add**. The layer now appears at the top of ArcMap's table of contents.



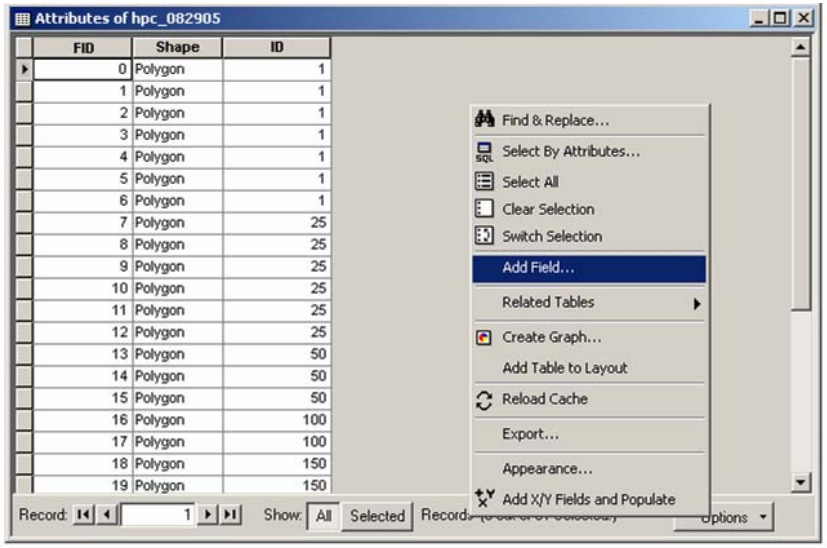
NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

View the data: Repeat this process for the other days you wish to display. Notice that three consecutive days have been displayed in the table of contents below.



To determine the amount of rain in inches that are predicted for these areas, you must add a new field to each layer and calculate them.

Right-click on the earliest layer and select **Open Attribute Table**.



When the table opens, look at the bottom right corner and select **Options > Add Field**.

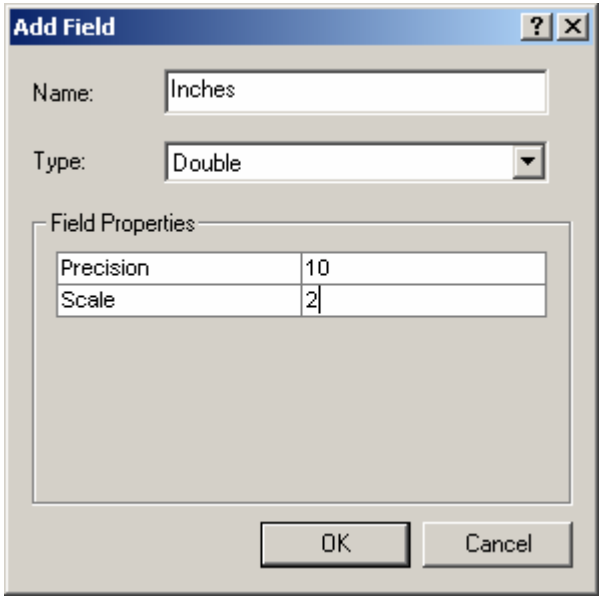
NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

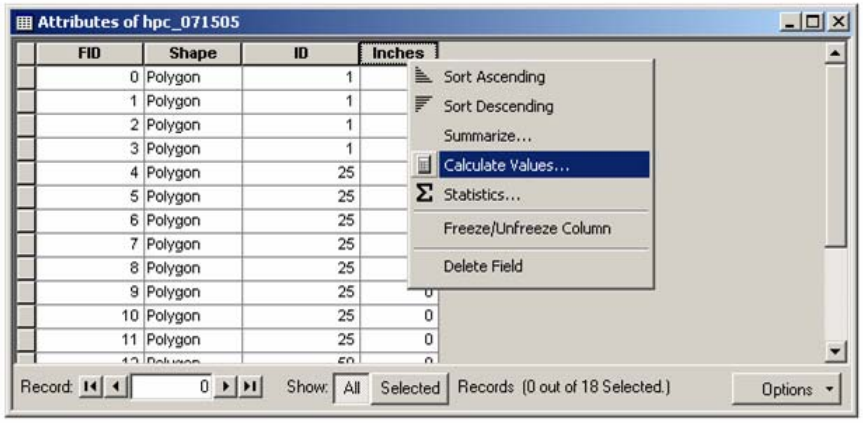
Calculate rainfall: The Add Field dialog window will appear. Specify the name of the field as **Inches**.

Specify the Field Type as **Double** (or “double precision”)

Specify the Precision (or the number of digits to be assigned for each number) to be **10**, and the Scale (or the number of decimal places) to be **2**.

Click **OK** to create the field.

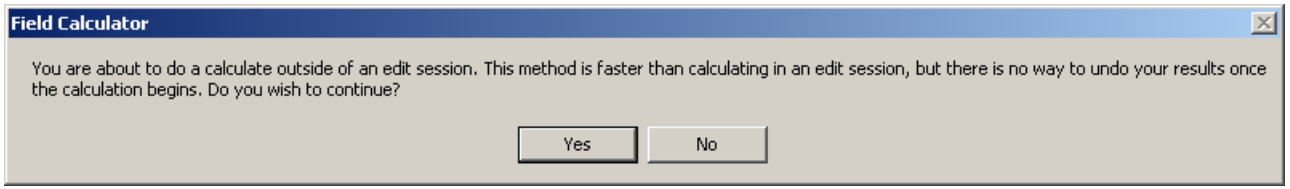


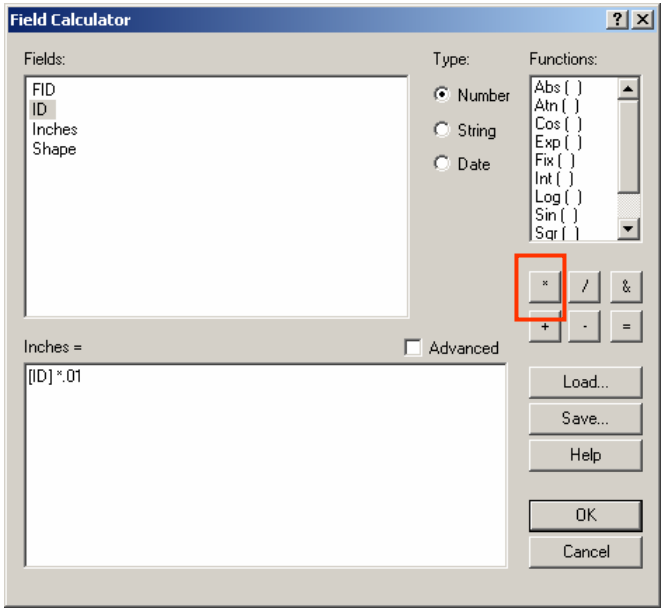


In the table, right-click on the **Inches** field. In the context menu, select **Calculate Values...**

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: A warning message will appear. This alerts you to the fact that any calculations made to this field will be permanent. Click **Yes** to dismiss this message.





In the Field Calculator dialog window, notice that the calculation expression is started for you: "Inches = "

Simply complete the expression by double-clicking on the field called **ID**, click on the "multiply by" mathematical operation that looks like an asterisk, and then type **.01**. This operation will multiply the ID value of each record by 0.01 to determine rainfall amounts in inches.

Once the expression is developed, click **OK**.

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: The rainfall values now appear in the table as amounts in inches. Close this layer's table and repeat the same steps for the two other layers.

Attributes of hpc_071505

FID	Shape	ID	Inches
0	Polygon	1	0.01
1	Polygon	1	0.01
2	Polygon	1	0.01
3	Polygon	1	0.01
4	Polygon	25	0.25
5	Polygon	25	0.25
6	Polygon	25	0.25
7	Polygon	25	0.25
8	Polygon	25	0.25
9	Polygon	25	0.25
10	Polygon	25	0.25
11	Polygon	25	0.25

Record: 0 Show: All Selected Records (0 out of 18 Selected.) Options

Once all three layers have a field named Inches in their attribute tables, you can add them together to find cumulative amounts of rainfall for given areas during those three days.

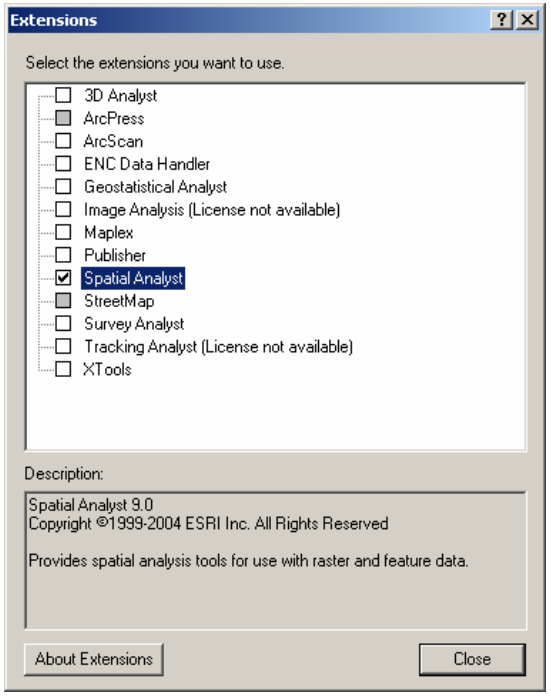
To perform this step, you must convert the polygon layers to raster layers using an ArcGIS extension known as Spatial Analyst.

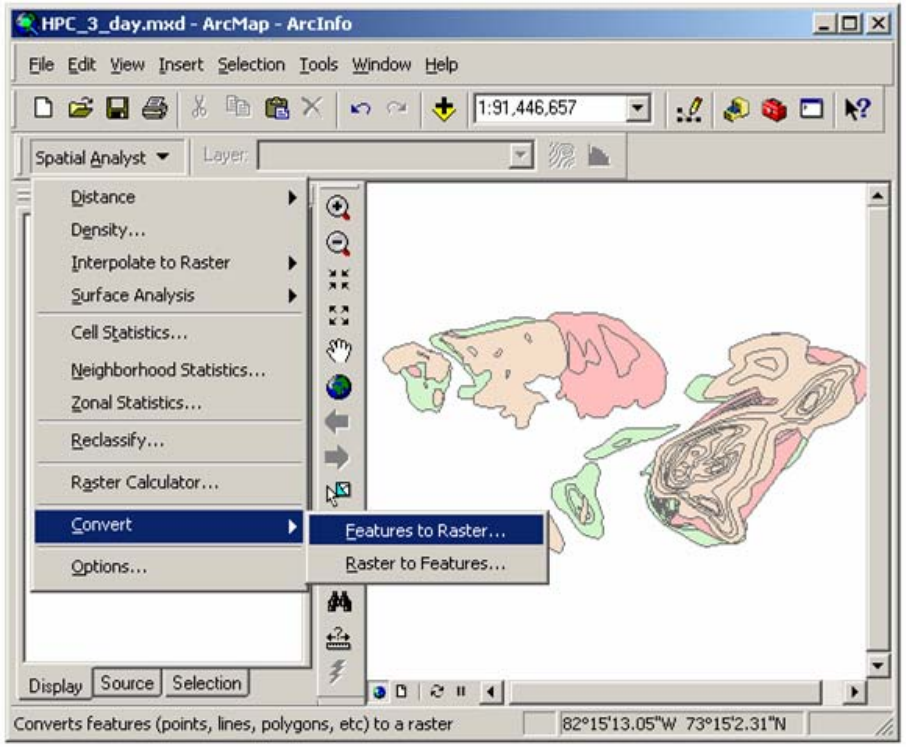
Begin by adding the Spatial Analyst toolbar. Click on **View > Toolbars > Spatial Analyst**. You will see the toolbar appear in the application.

You can drag and dock this toolbar to the ArcMap window or let it "float" around in ArcMap. You should now enable the extension by clicking on **Tools > Extensions**.

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: Once the Extensions window appears, check on **Spatial Analyst** to enable the extension. Click **Close**.

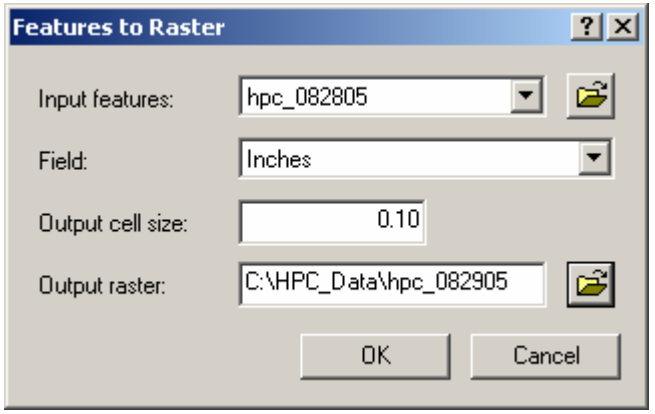




Click on the **Spatial Analyst** menu from the toolbar and select **Convert > Features to Raster**. This will convert the polygon layers to raster layers for analysis.

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: Each polygon layer will be converted into a raster. Select **Spatial Analyst > Convert > Features to Raster**. The following window will appear. Select one of the polygon layers from the Input Features drop-down menu.



Specify **Inches** in the Field drop-down menu, because these are the values we want to transfer over for our raster cells. Change the Output cell size to be **0.10**. These units are in geographic coordinates, since the source data are also unprojected. Specify an output folder and file name for the new raster. Ideally, you should consider using the same folder that is used for the feature layers. You should also consider keeping the same naming convention for the raster as was used for the feature data.

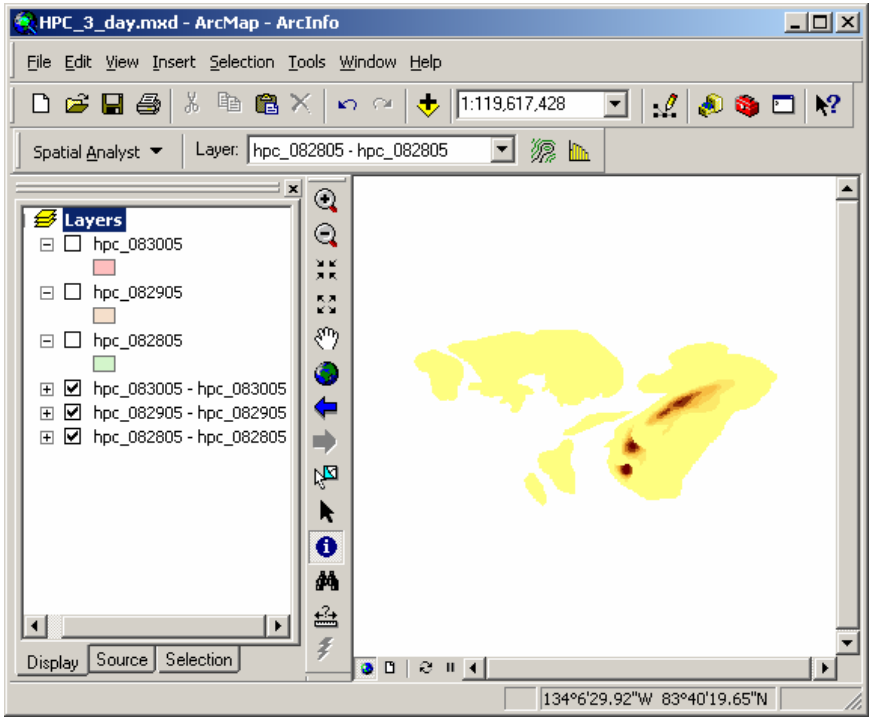
Click **OK**. The raster layer is created and added to ArcMap's table of contents.

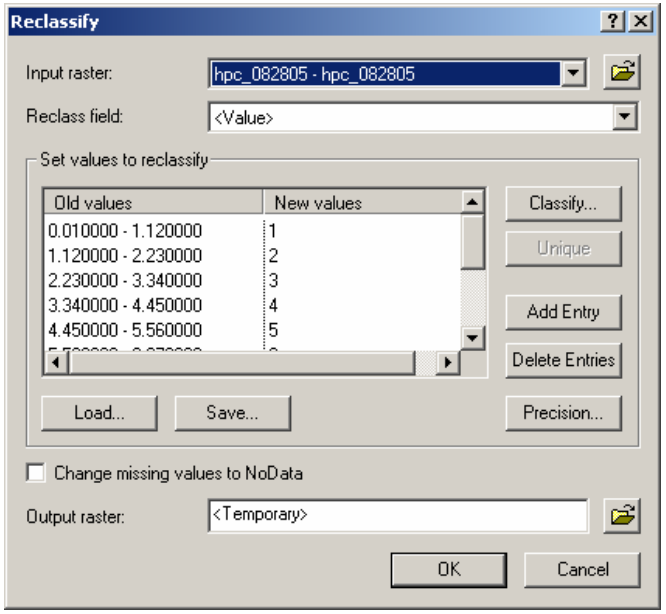
Repeat this process for the other two feature layers until all three have been converted.

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: Once the layers are converted, turn off the features and turn on all three rasters. Order them as shown below. Each can be considered a valuable layer, but you will add them together to determine how much rain will fall in the next three days.

Before you can add up the values of the cells, you have to reclassify them, or group them into classes of like value. Select **Spatial Analyst > Reclassify**. In the dialog box, select the earliest date as the input raster, and click on the **Classify** button.

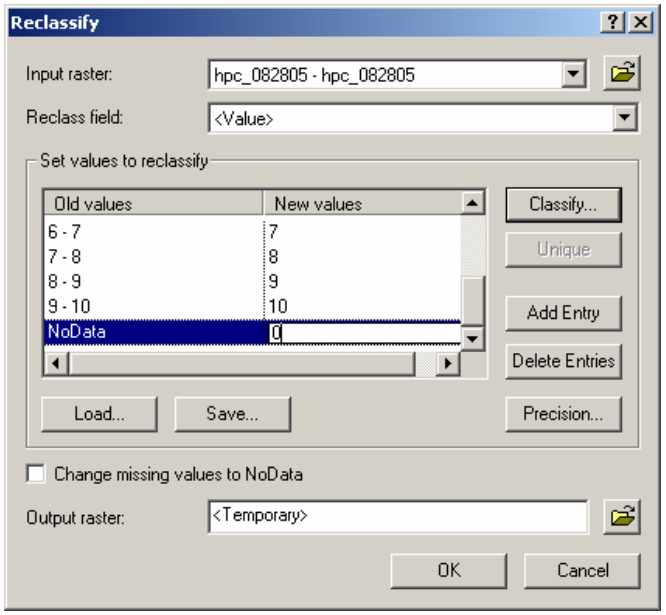


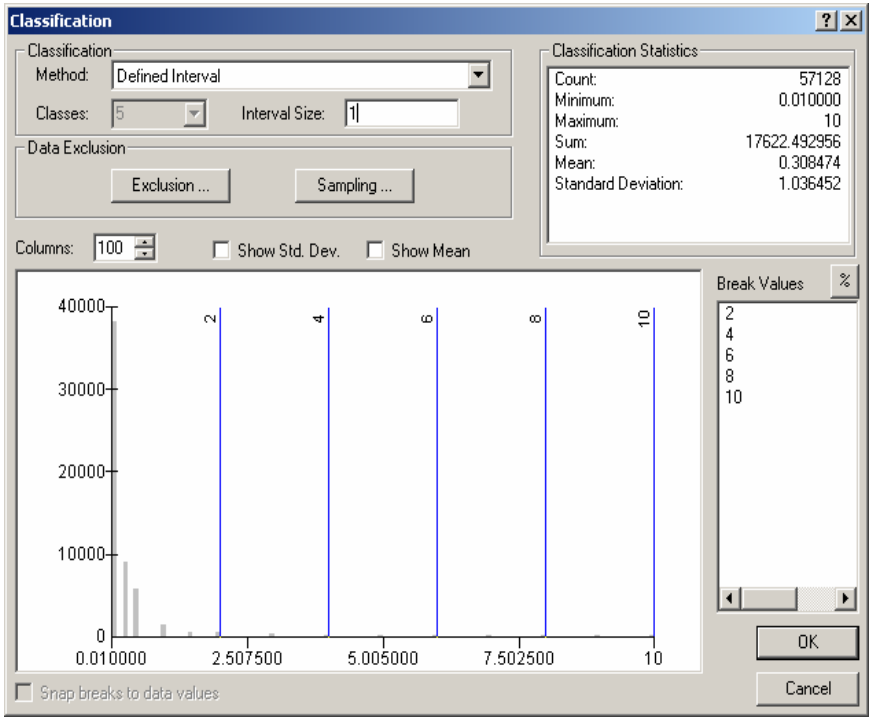


NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: Select **Defined Interval** as the classification method. Change the Interval Size to **1** (inch of rain). Click **OK** to set the classification.

Notice that the values have changed in the Reclassify window. Scroll down to the bottom and manually change the NoData value to **0** as in the example below. Click **OK** to create the temporary layer. It will be added to the table of contents.

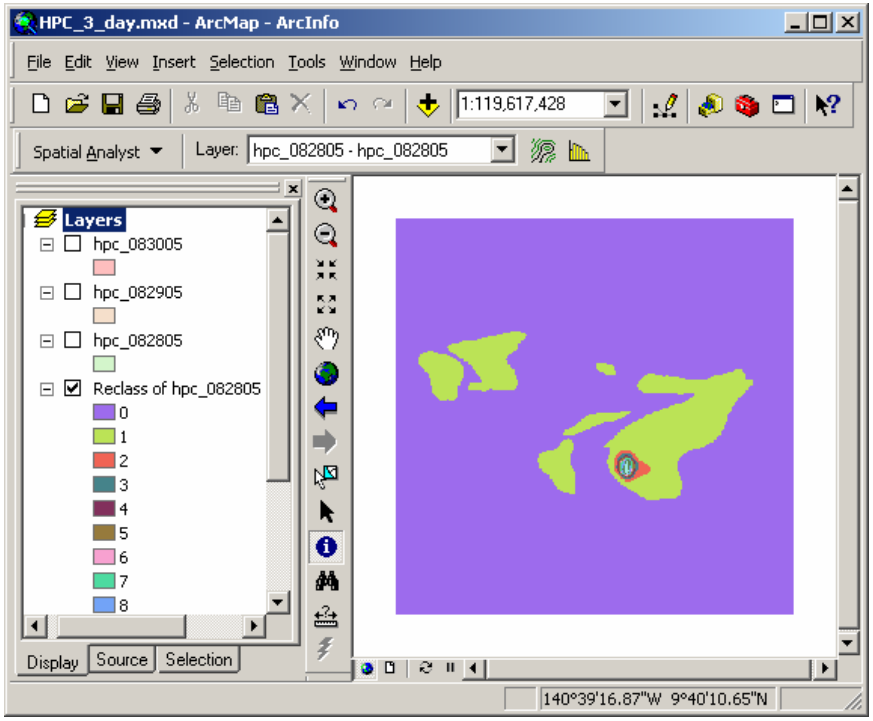




Repeat this process for the other two layers. Make sure whole values are present in the New Values column.

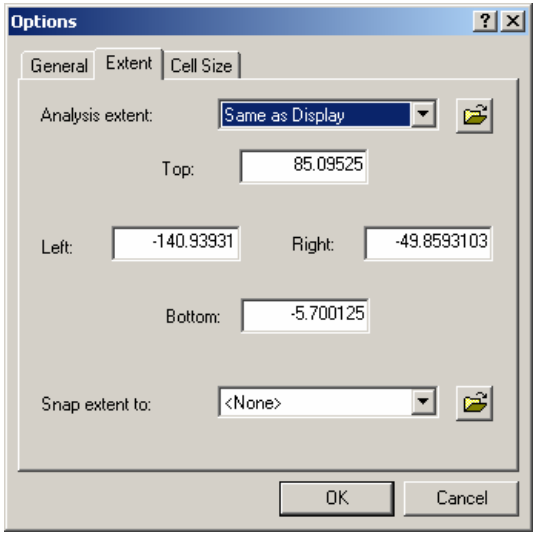
NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: Your reclassified layers will look similar to the example below. Don't be concerned with the colors at this time, since we will assign logical colors after the rasters are added.



Before the layers can be added, the Analysis Extent has to be set. This is what ArcMap determines to be the area that everything falls inside. If the extent is not set properly, data can be clipped off and omitted.

Select **Spatial Analyst > Options**. Click on the **Extent** tab and specify **Same as Display** for the Analysis Extent.



When finished, click **OK**.

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

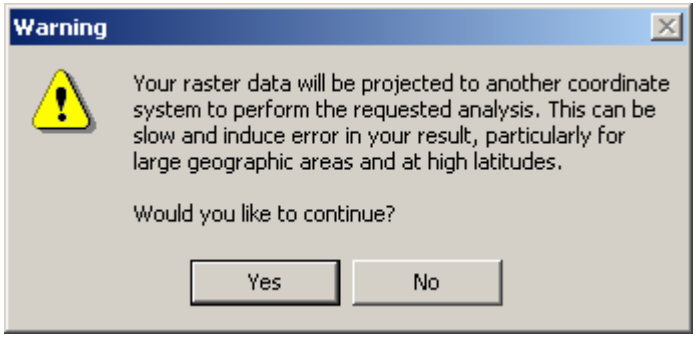
Calculate rainfall: Once all three layers have been reclassified, they are ready to be added.

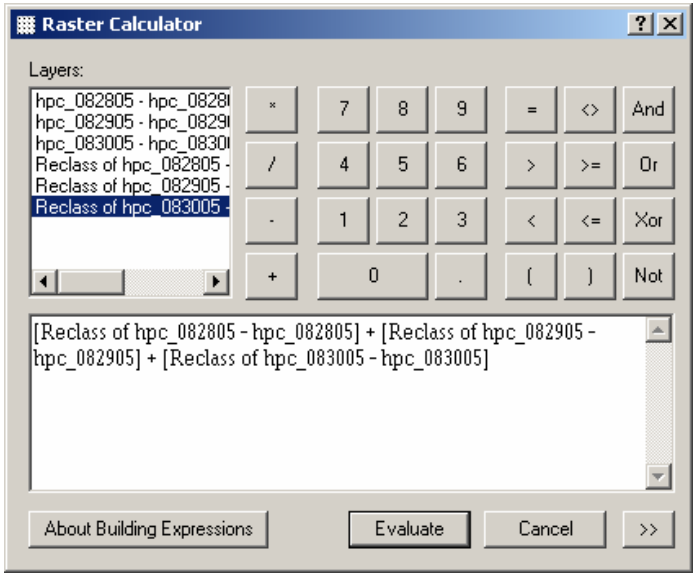
Select **Spatial Analyst > Raster Calculator**.

Double-click each layer to place it in the expression window, and separate each with a “plus sign” as shown to the right.

When finished, click on the **Evaluate** button to start the addition process.

The following message box may appear because your raster layers do not have a projection system assigned to them. For now, dismiss this message by clicking **Yes**.

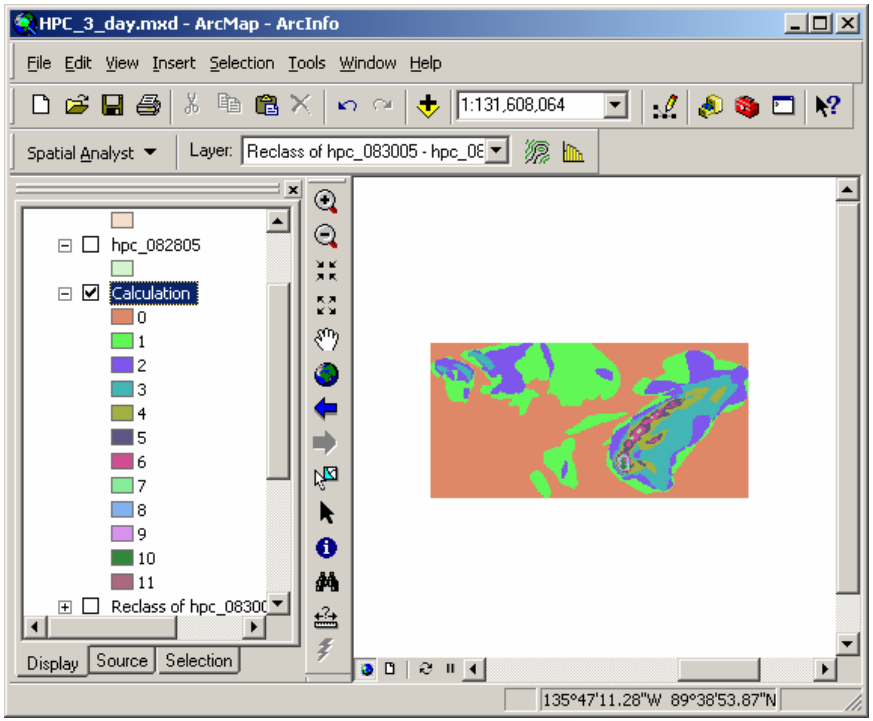


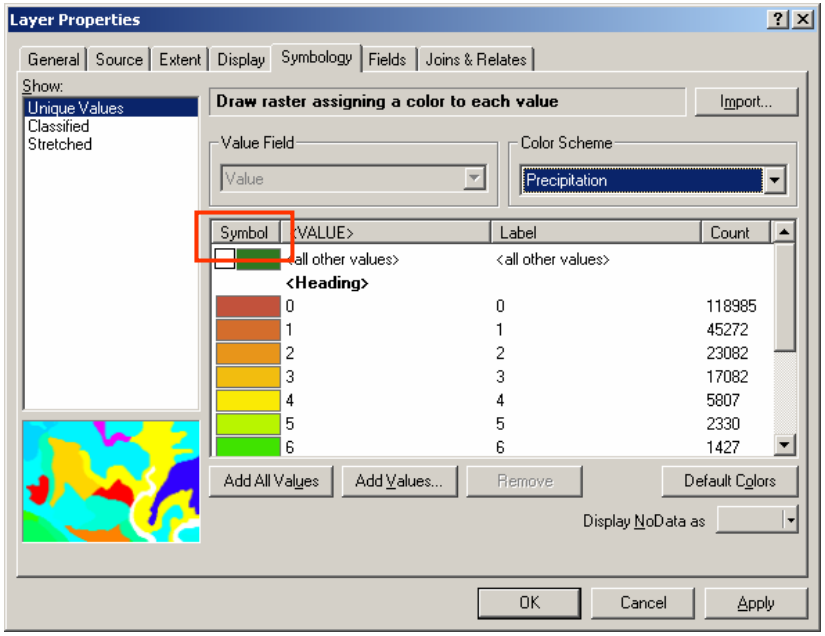


NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: The resulting Calculation layer may look something like the example below.

Assign a logical color ramp to the rainfall amounts by opening the Layer Property window for the Calculation layer. Select the **Symbology** tab and choose the **Unique Values** category listed on the left. Right-click on the color ramp and choose **Graphic View**. This gives a textual description of the color ramp.



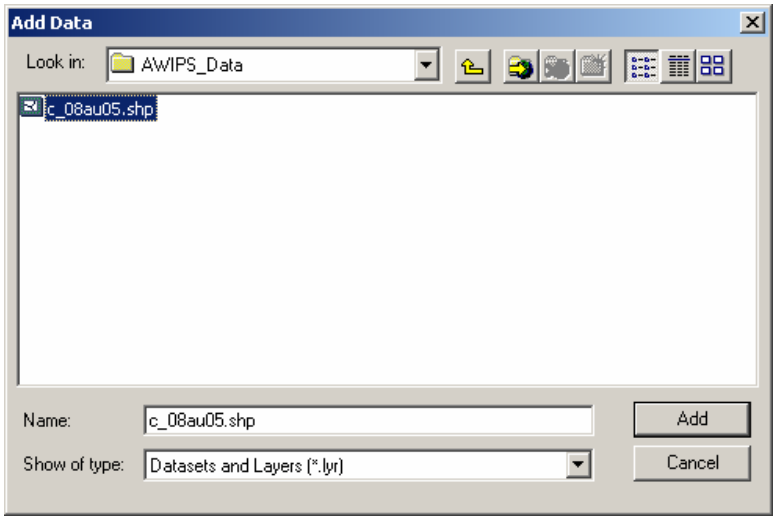


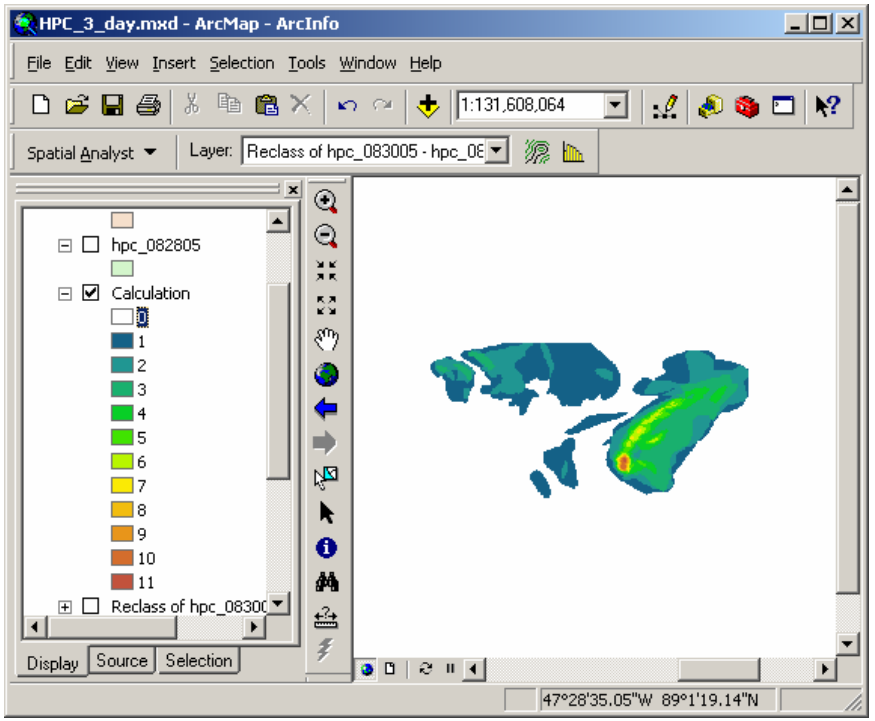
Select a color ramp that is a logical progression from light to dark colors, or, as in the example on the left, **Precipitation**. Next, flip the color of the symbols so that the reds are assigned to the higher values. Click on the **Symbol** field and select **Flip Symbols**. Click **OK**.

NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: Right-click on the first cell to change “0” from blue to No Color.

Add a county boundary layer from the AWIPS_Data folder.

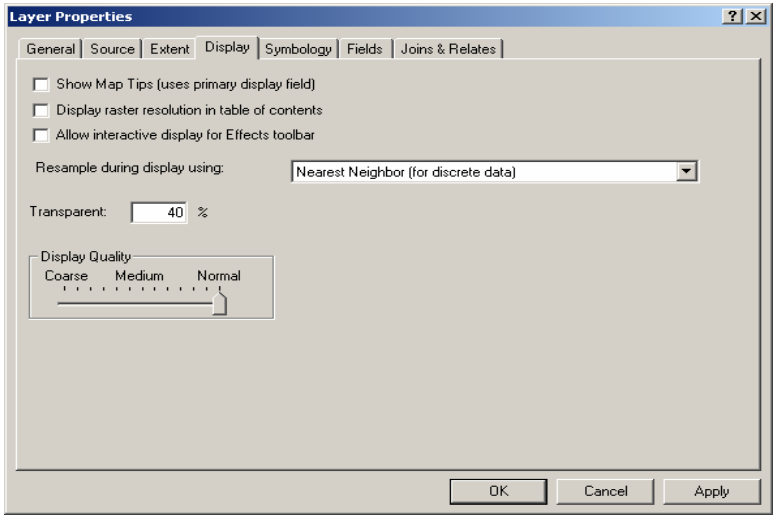


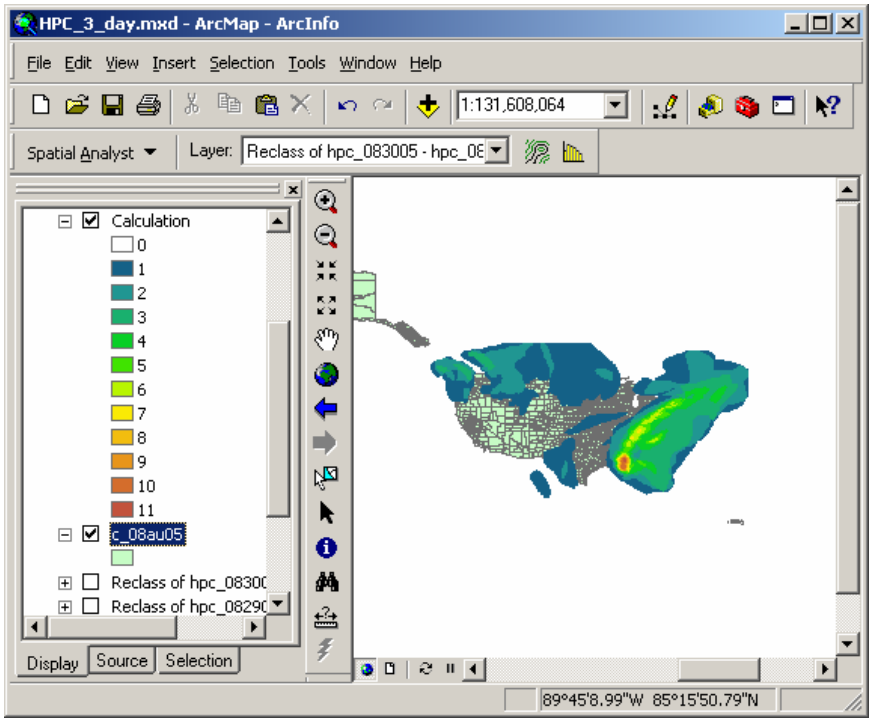


NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

Calculate rainfall: Move the county boundary layer below the three-day HPC Rainfall Forecast layer.

Make the HPC layer partially transparent so that both layers are visible. To do this, double-click on the layer to open its Properties window. Select the **Display** tab and specify the Transparency at **40%**. Click **OK** to see the result.



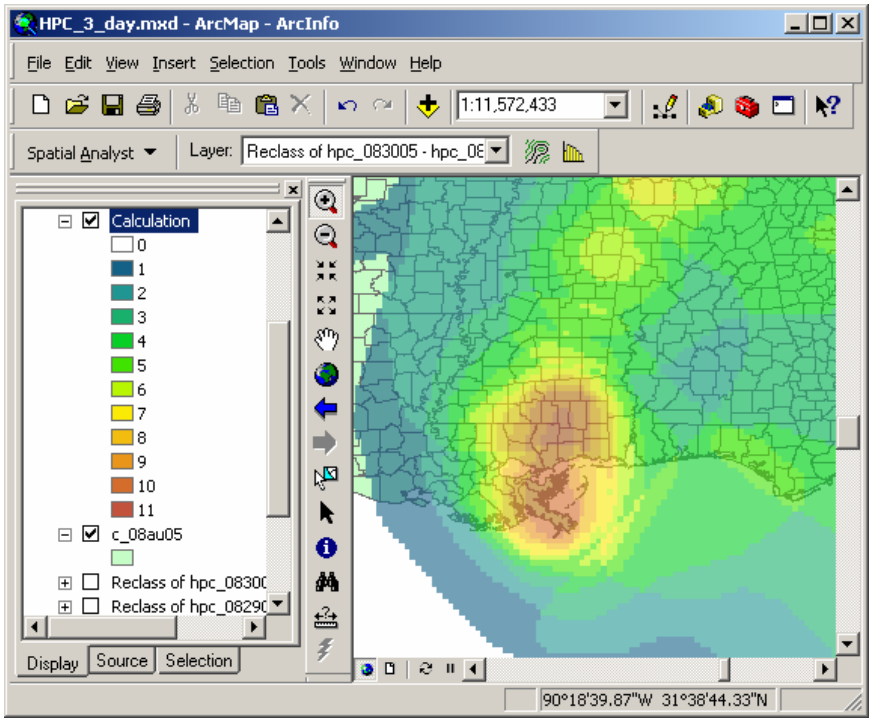


NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast

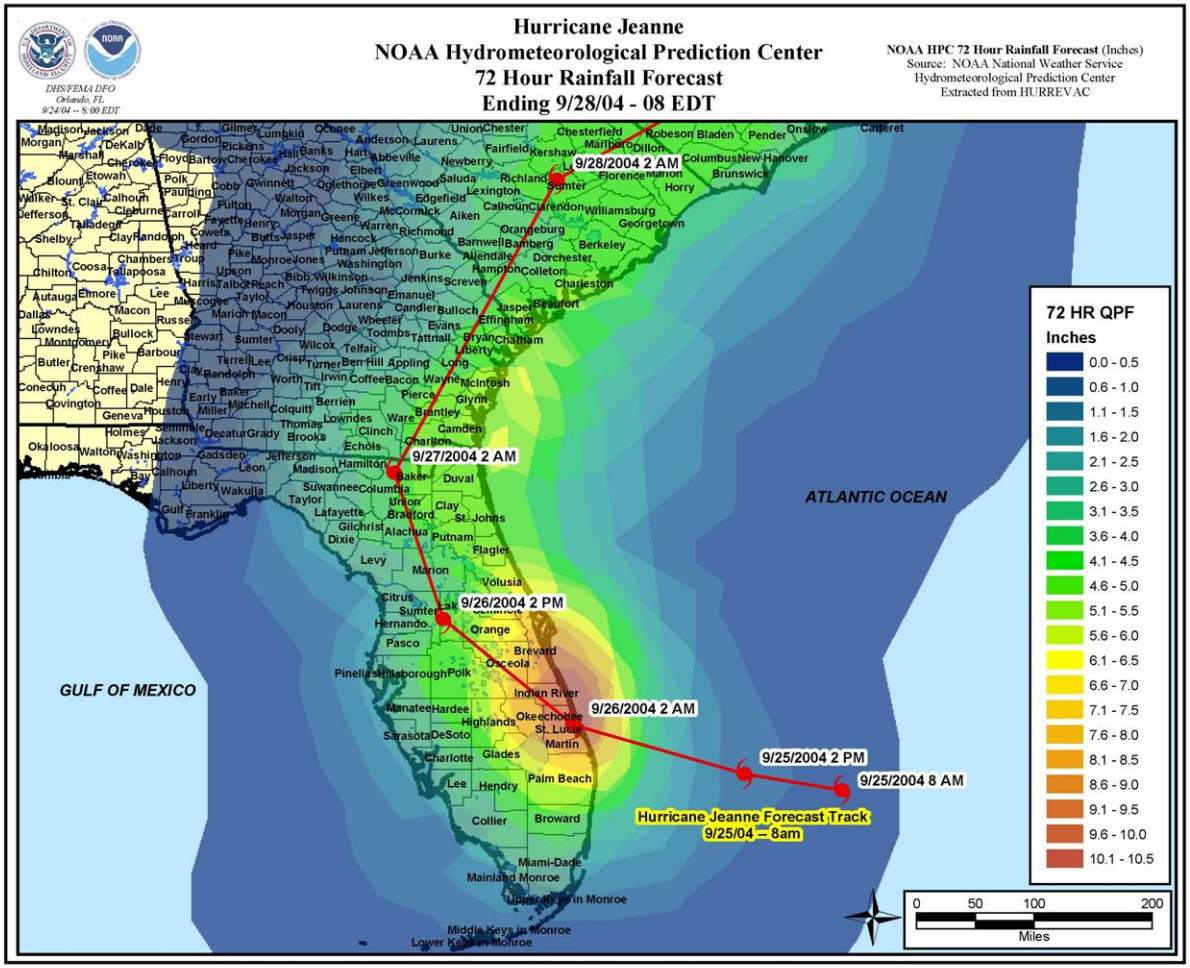
Calculate rainfall: Zoom to an area of interest and see the results.

At this point you are ready to begin making a map. An example has been included of what the NOAA Coastal Services Center has provided to members of FEMA in the past.

Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.



NOAA Hydrometeorological Prediction Center (HPC) Rainfall Forecast



24-Hour Stage III Rainfall

Purpose: This type of map displays precipitation estimates for given areas using multiple sensors.

Source Data: These data are created using multiple inputs that include the following:

- High-resolution Parameter-Elevation Regressions on Independent Slopes Model (PRISM) data derived from National Oceanic and Atmospheric Administration (NOAA) Cooperative Stations. These data are the most detailed, highest-quality spatial climate data sets currently available.
- Process 1 (P1) offers the best estimates of gridded precipitation fields currently available in an operational environment. When compared to one another, P1 and PRISM data offer detailed insights into the distribution of rainfall across a 4 x 4 kilometer scale. Using these products, users can capture localized departures that are often lost when using regionalized climate and drought maps.
- SNOTEL (for SNOwpack TELemetry), operated by the Natural Resources Conservation Service (NRCS). This automated system is used to collect snowpack and related climatic data in the Western United States. SNOTEL has reliably and efficiently collected the data needed to produce water supply forecasts and to support the resource management activities of NRCS and others.
- U.S. Geologic Survey (USGS) Digital Elevation Models (DEM).
- Sets of rules, decisions, and calculations used to simulate the thought process of a climatologist in generating spatial climate maps. These rules account for increased precipitation with elevation, rain shadows, and coastal locations. The further a given location is from an observation site, the more these rules influence a given climate parameter.

24-Hour Stage III Rainfall

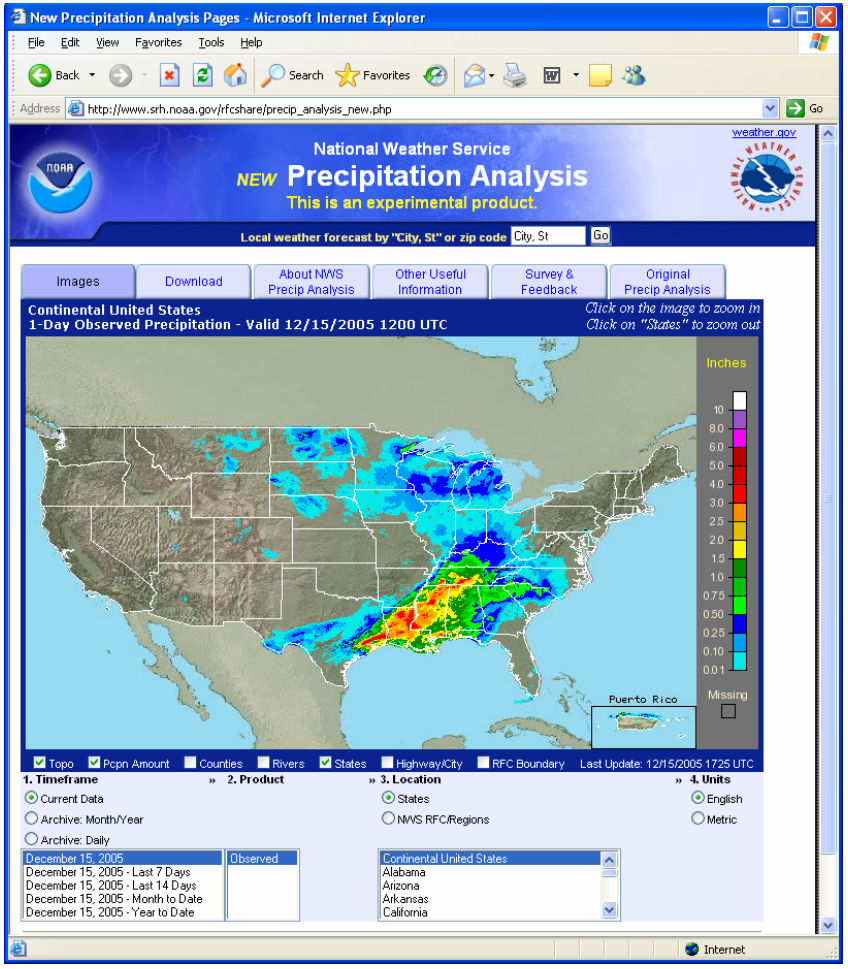
Download: Users wanting to download this kind of spatial data should visit the NWS Precipitation Analysis Web site at *www.srh.noaa.gov/rfcshare/precip_analysis_new.php*.

Begin by specifying the region of interest. You can either click on the map to zoom closer to an area or specify a state from the drop-down list at the bottom.

For this module, you will look at the observed precipitation amounts in the last 24 hours for Louisiana.

Specify that you want the **Current Data** for this day.

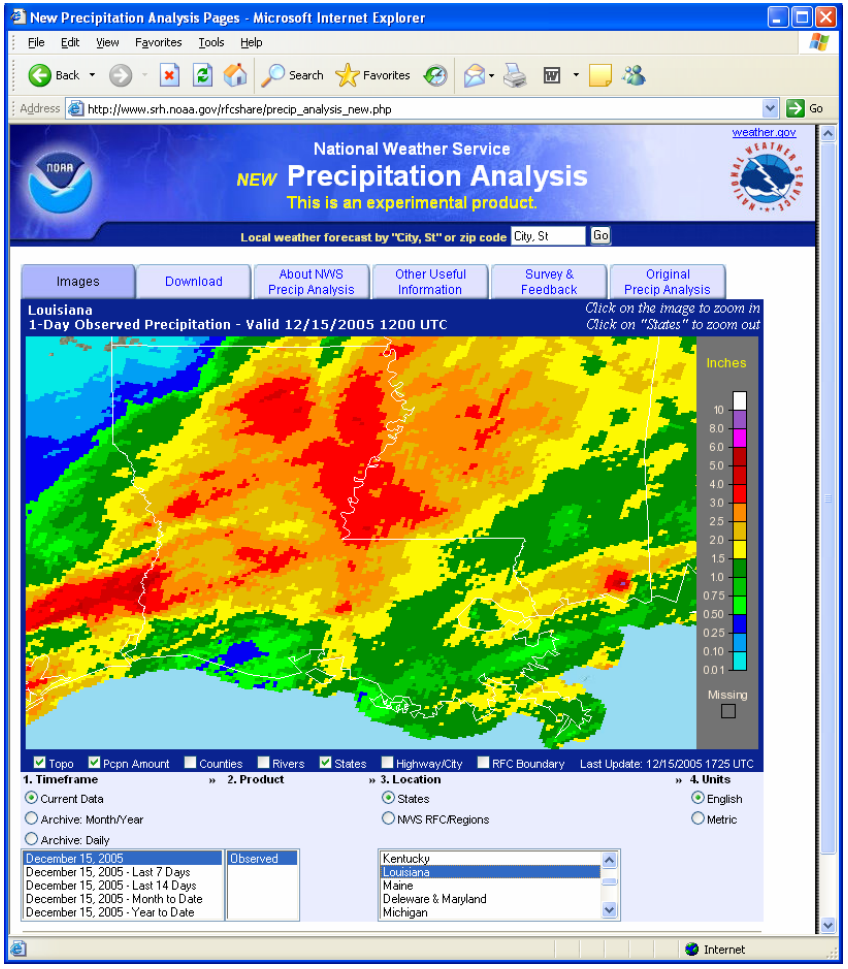
Select **Louisiana** from the drop-down list. The graphic map will change to reflect the data for this state.



24-Hour Stage III Rainfall

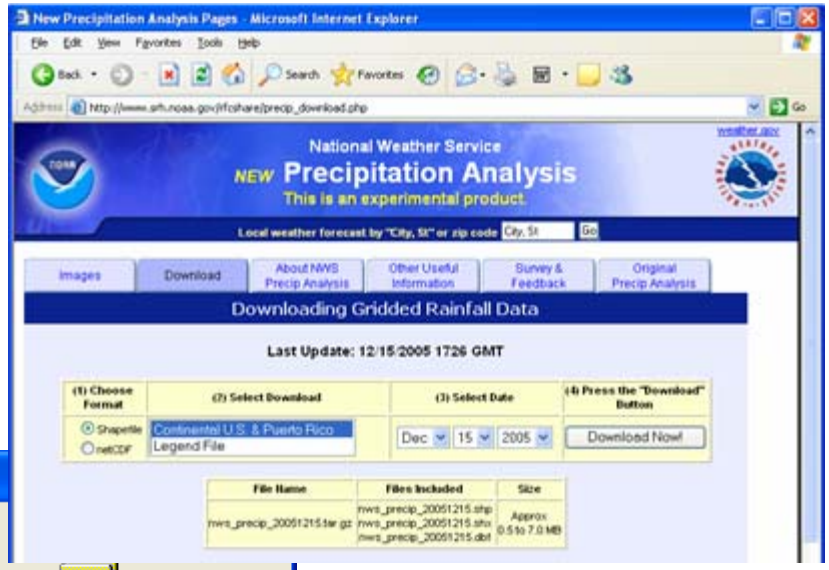
Download: Your display will change to show the state of interest and the amount of recorded precipitation from the last 24 hours.

You will download these data and bring them into your GIS for display. Click on the **Download** tab to begin this process.

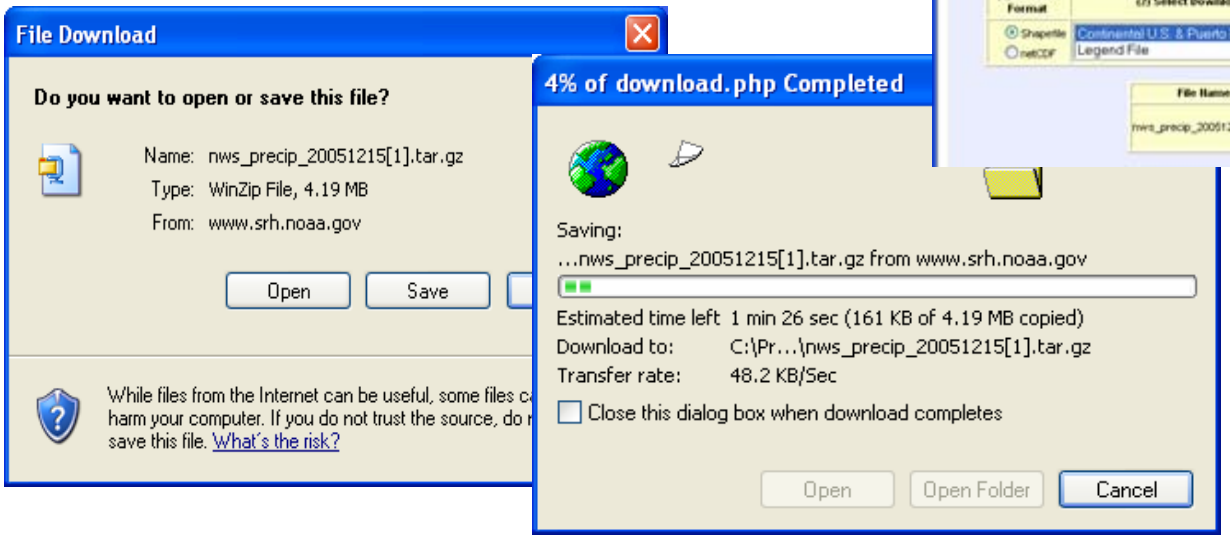


24-Hour Stage III Rainfall

Download: The following window should appear. Click the **Download Now** button to begin the process.



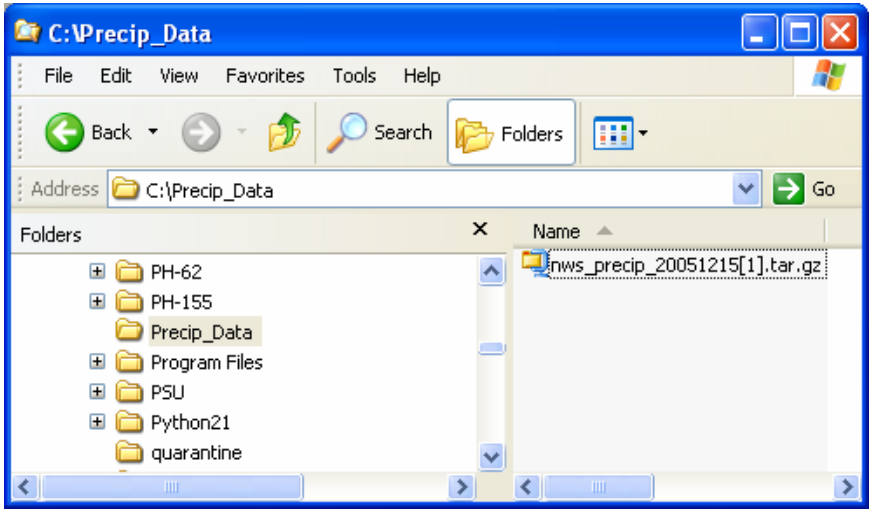
A File Download dialog window will prompt you to decide what to do with your data. Click the **Save** button. Create a new folder (i.e. C:\precip_data) and copy the file into that location.

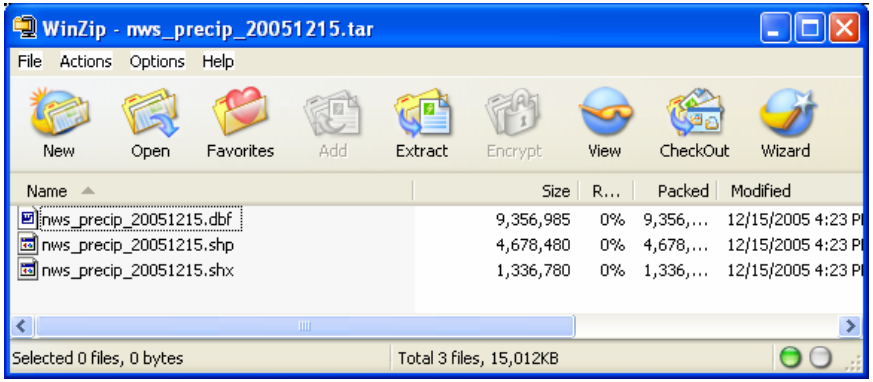


Once the download completes, click on the **Open** button.

24-Hour Stage III Rainfall

Download: You will now find a .tar file copied to this folder. This is a compressed file that contains other files. You will need to use a file uncompression software (such as Winzip or PKZip) to extract the other files.

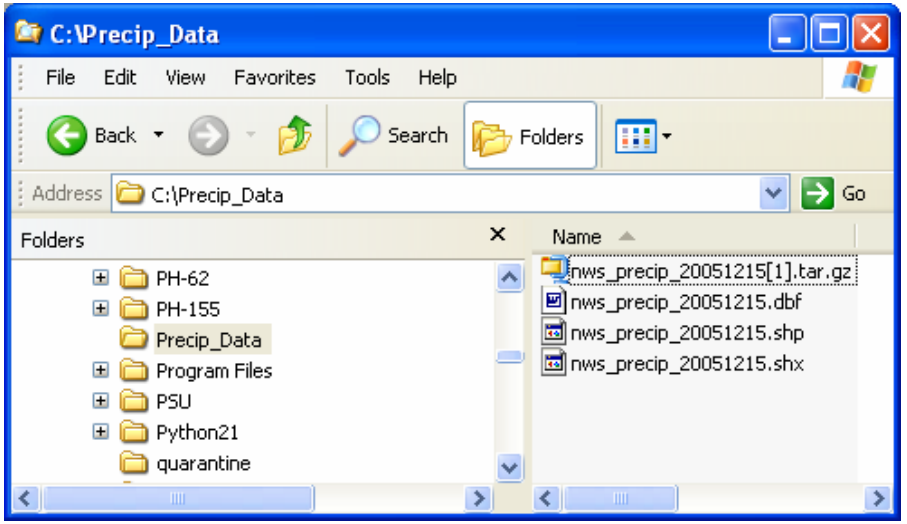




Once these files are extracted, they make up a “shapefile” (with .dbf, .shx, and .shp extensions).

24-Hour Stage III Rainfall

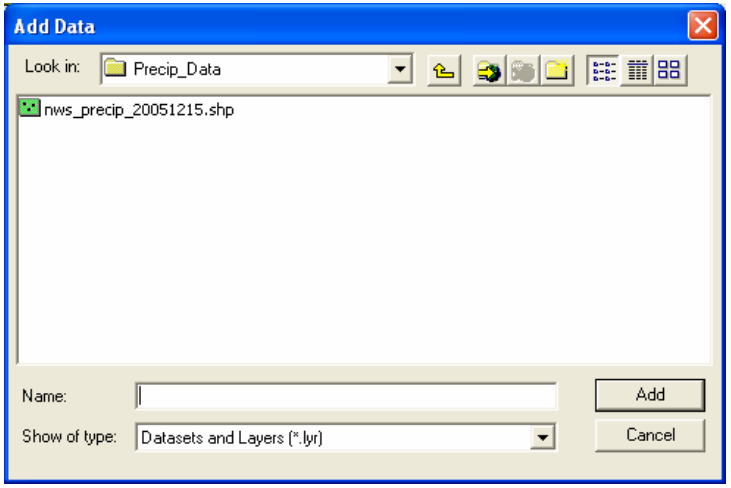
Download: You should now see the following files in your directory. Once the shapefiles are uncompressed, you can view them in ArcGIS.

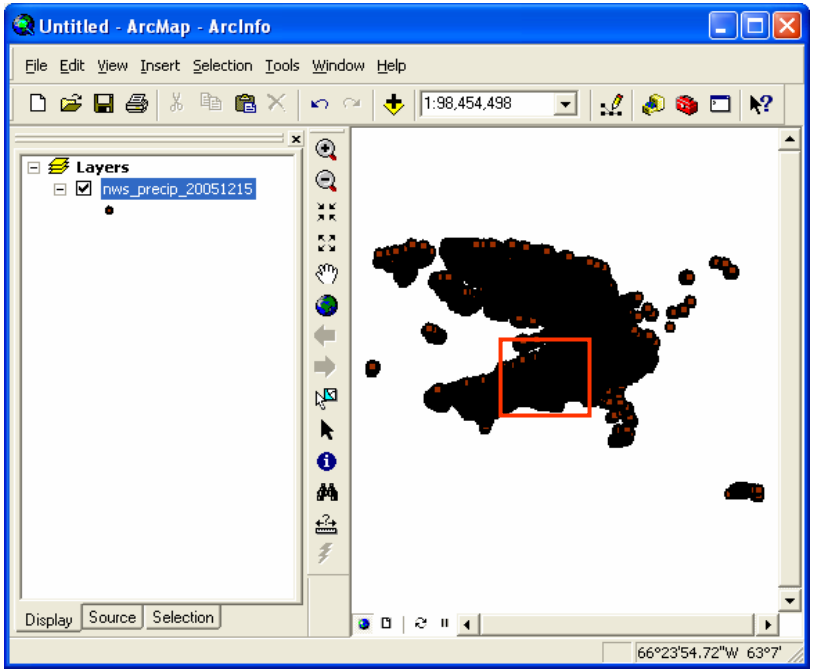


An important thing to note: there are two cycles of precipitation shapefiles. The first (preliminary) is updated between 9:30 and 10:00 a.m. Central Daylight Time (CDT) (1430 zulu [z]-1530z). The final version takes into account late rain gage reports and adjustments to radar data. This version comes out between 4:00 to 5:00 p.m. (CDT) (2100z – 2200z).

24-Hour Stage III Rainfall

Add and symbolize the data: Add the layer by clicking on the **Add Data** button found at the top of the ArcMap window. This opens a dialog box that lets users browse to their data.



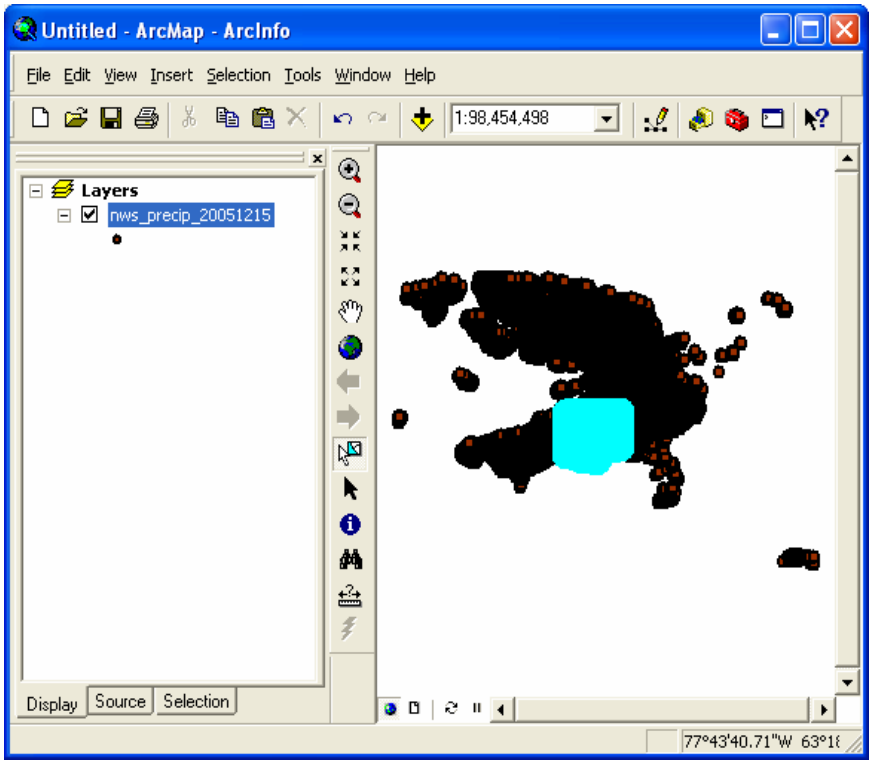


Once you have selected the shapefile, click **Add**.

Now select just the points in the study area. Use the **Feature Selection** tool to click and drag an area.

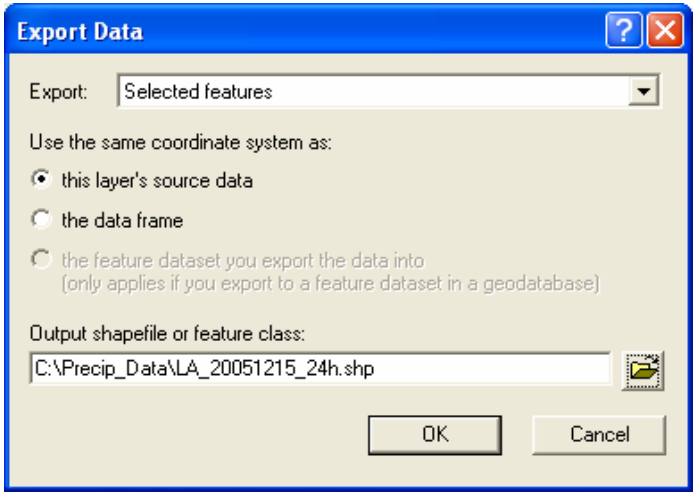
24-Hour Stage III Rainfall

Add and symbolize the data: After the points are selected, export them to a new layer. Right-click on the name of the shapefile and select **Data > Export Data**.



In the dialog window, specify that you will only export the **Selected features** (which is the default), use the same coordinate system as the shapefile (again, the default), and browse to a folder and specify a name for the new layer.

Please remember to include the date from the original layer in the name of the new layer so that others will know when the data were captured.

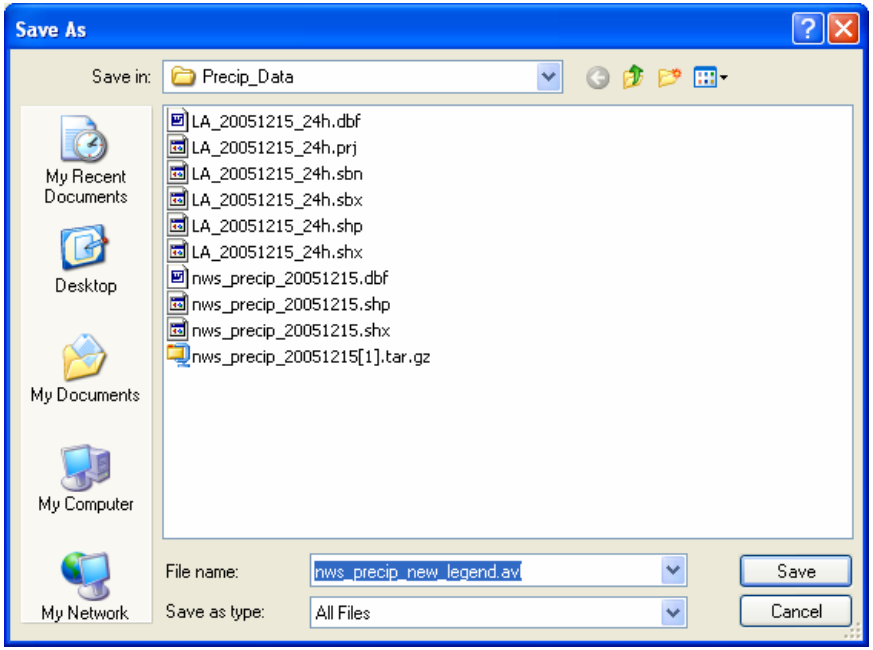


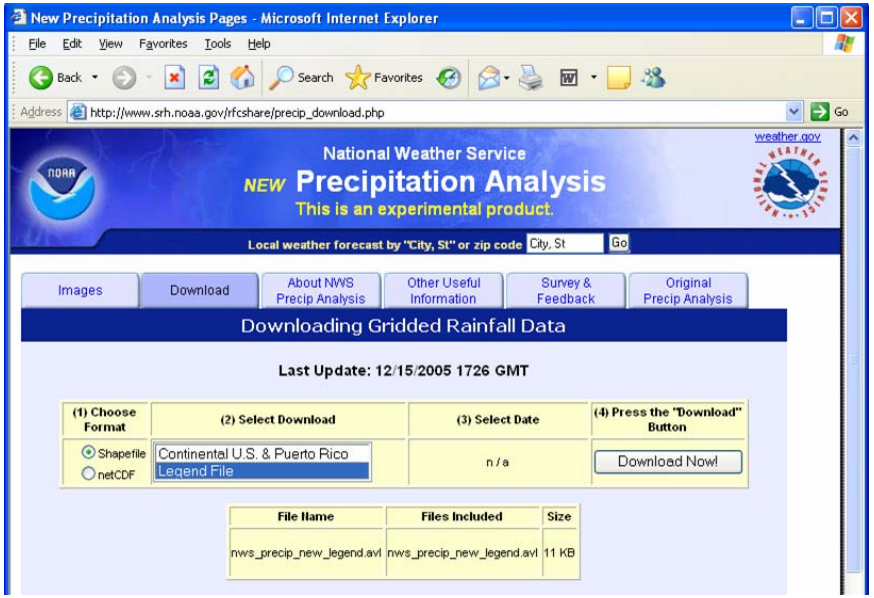
Click **OK** when finished. Add the new layer into ArcMap, and turn off the original one.

24-Hour Stage III Rainfall

Add and symbolize the data: The data should be symbolized to show precipitation amounts for the area. You will now download an associated ArcView Legend (.avl) file that will provide the proper symbology.

Going back to the Southern Region Headquarters Web site, you will specify the legend file containing symbology. Click on the **Download Now** button.





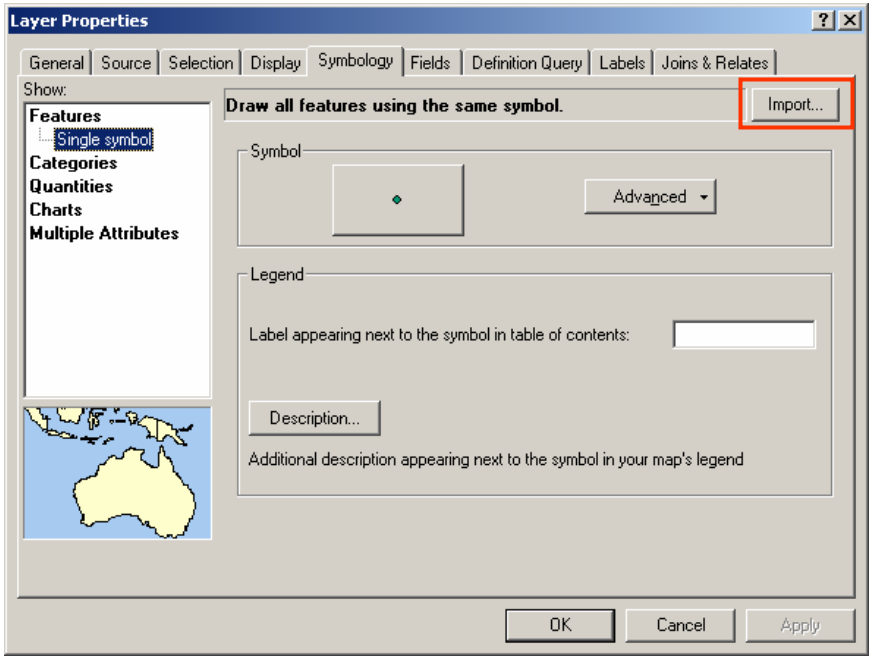
Save the .avl into the same Precip_Data folder and take the default name given to the .avl. Click **Save**. Once the download is complete, simply close the message window.

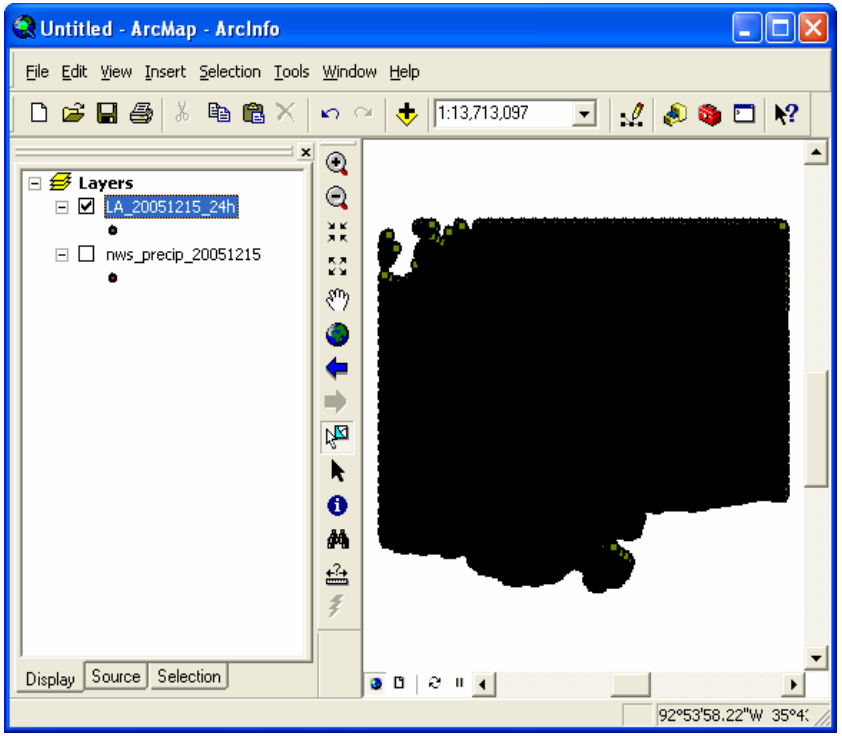
Open Windows Explorer and navigate to where the .avl file was saved. Notice that the zip utility may have appended ".txt" onto the end of your .avl file. Simply remove the ".txt" portion and ArcGIS will recognize the file as an ArcView legend file.

24-Hour Stage III Rainfall

Add and symbolize the data: Right-click on the exported layer and select **Zoom to Layer**. Double-click on the shapefile layer in ArcMap's table of contents. This opens the Layer Properties dialog window. Select the **Symbology** tab to specify a predefined legend.

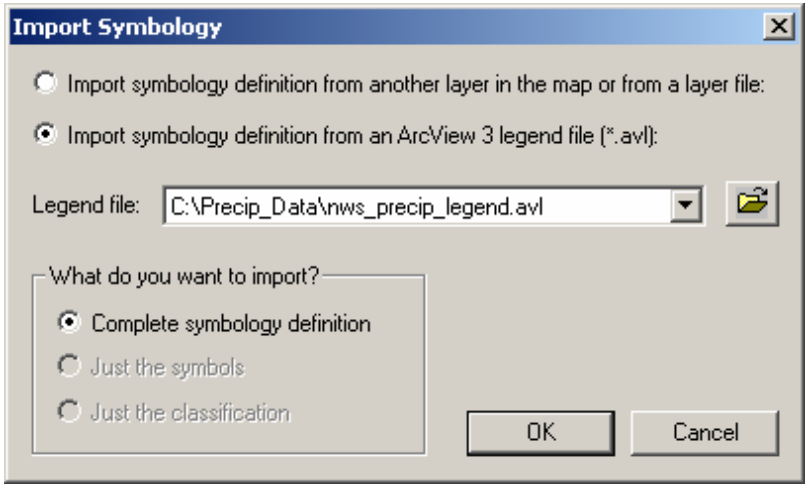
Click on the **Import** button to browse to the .avl file.

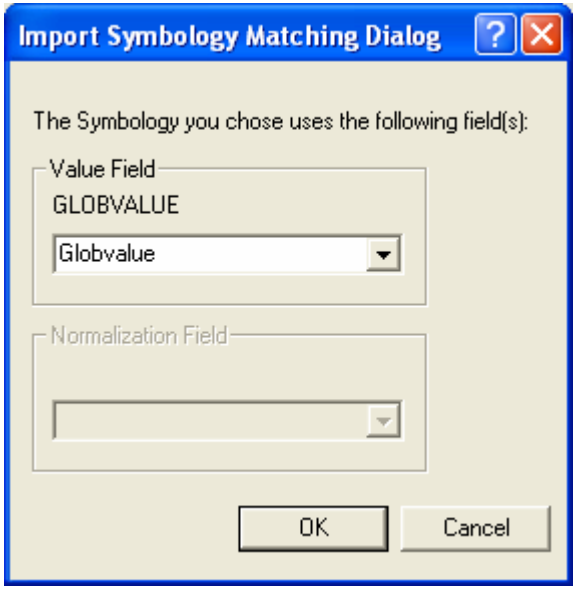




24-Hour Stage III Rainfall

Add and symbolize the data: In the Import Symbology dialog window, choose to **Import symbology definition from an ArcView 3 legend file (*.avl)**. Click on the **Browse** button and navigate to C:\Precip_Data. Select the **NWS_Precip_Legend.avl** file. Click **OK**.



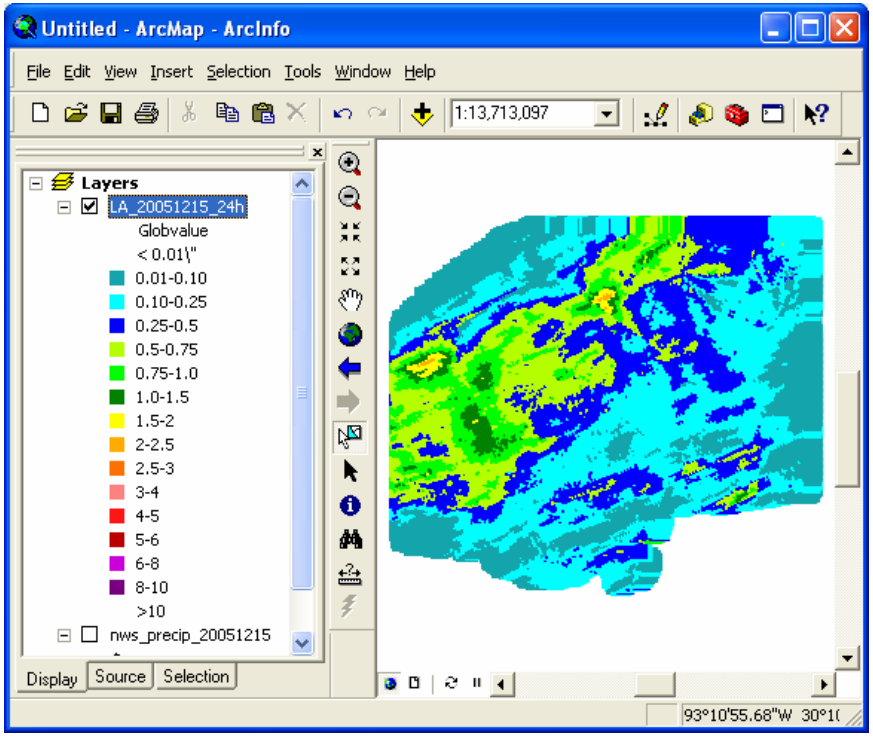


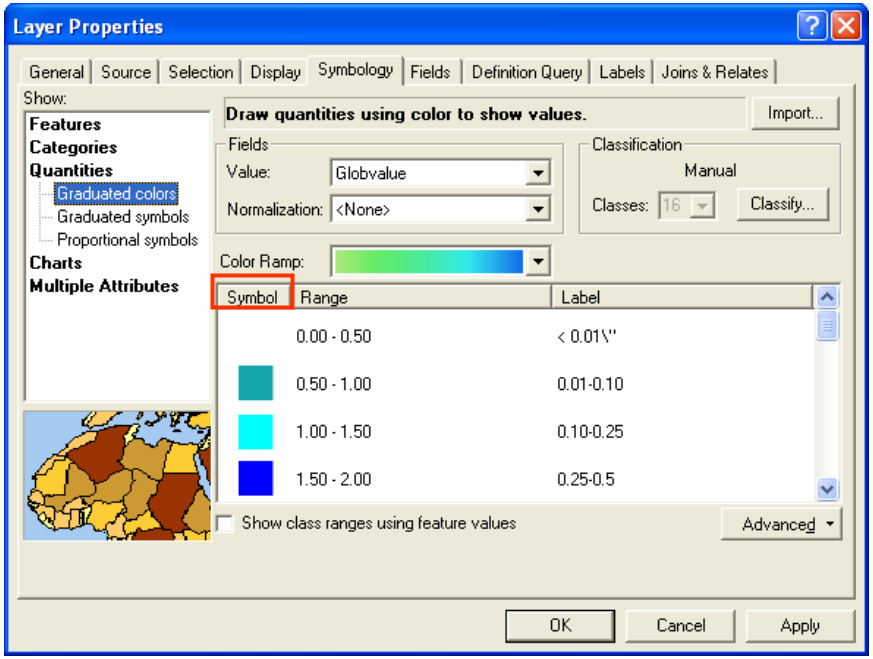
In the Import Symbology Matching Dialog window, change the Value Field to **GLOBVALUE**. Click **OK**. The points will now symbolize according to the rainfall amounts in the .avl.

24-Hour Stage III Rainfall

Add and symbolize the data: The predefined symbology will appear complete with rainfall amounts measured in inches. However, the size of each point is too great for your cartographic purposes. Click on the **Symbol** column heading and select **Properties for All Symbols**. Here you can reduce the size of all of the points. Select **10** and click **OK**.

Click **OK** to assign these values.





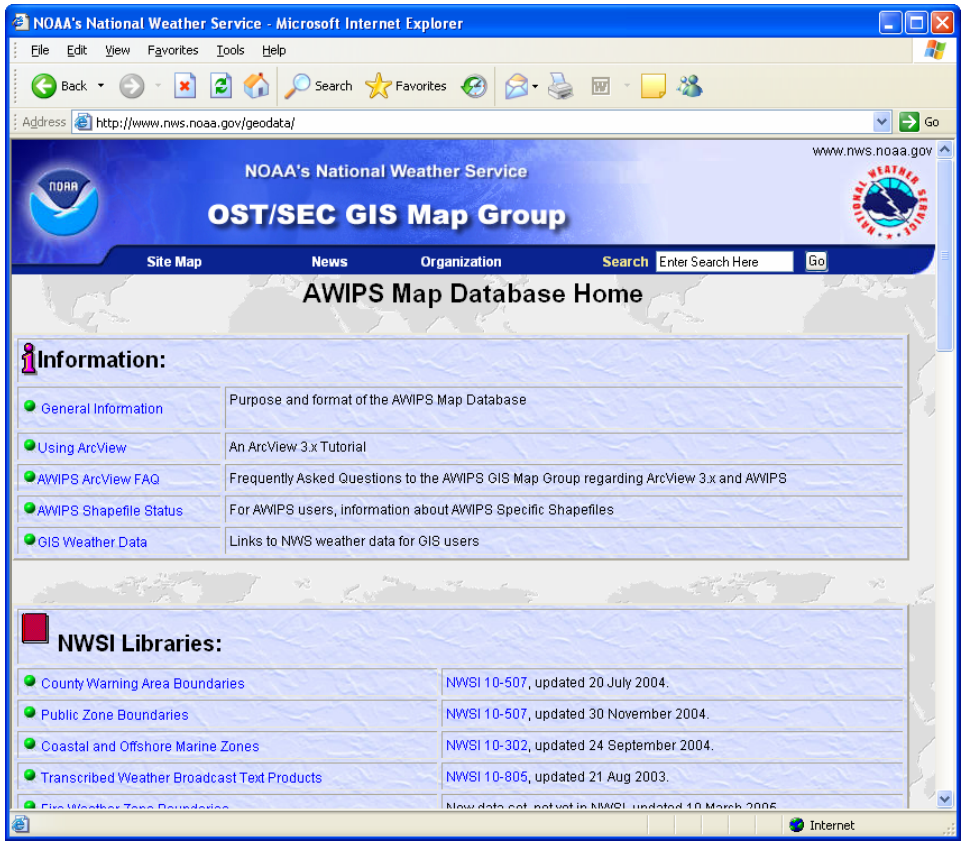
To clearly see the political areas affected by this rainfall, you must add a new layer. Minimize ArcMap and open a Web browser.

24-Hour Stage III Rainfall

Add and symbolize the data: Visit the AWIPS home page to download these data: *www.nws.noaa.gov/geodata/*

This site serves different base layer data for use in a GIS. Scroll down the page and find the County Libraries section.

Click on the file named **Counties at 1:100k**.

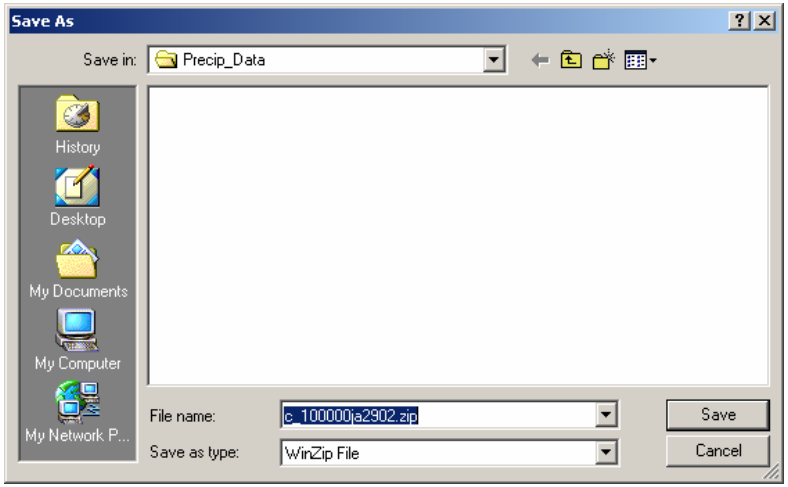


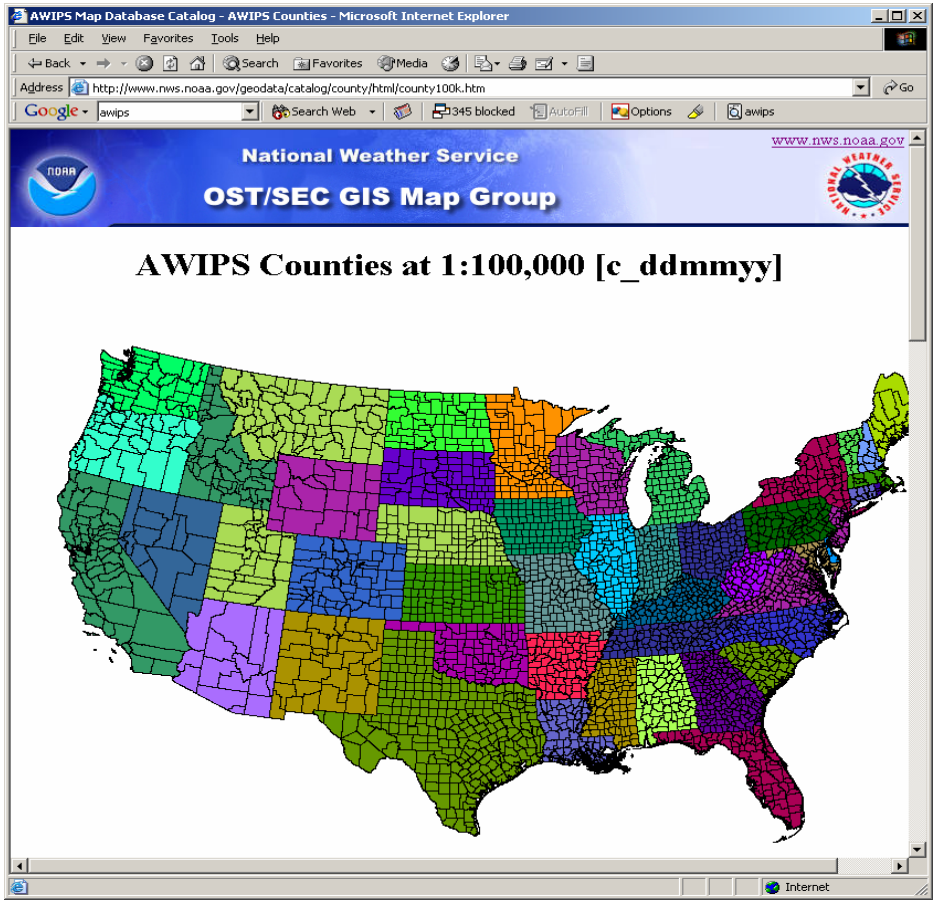
24-Hour Stage III Rainfall

Add and symbolize the data: This site provides free county boundary data at 1:100,000 scale, which will be suitable for our mapping purposes.

Scroll down and click on the **Download Compressed Shapefile** link. Save this file to your Precip_Data folder. This 52-megabyte file is large and will take some time to save.

Description	Valid Date		Size (bytes)		
US Counties (CONUS)	14 January 2003	Download Compressed shapefile	51,731,681	Change History	Metadata

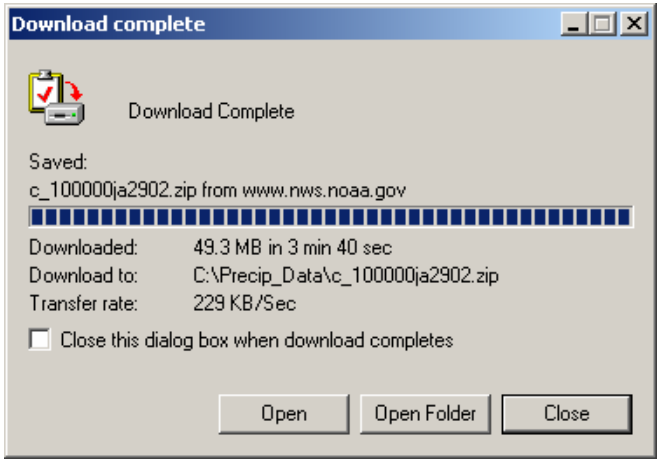


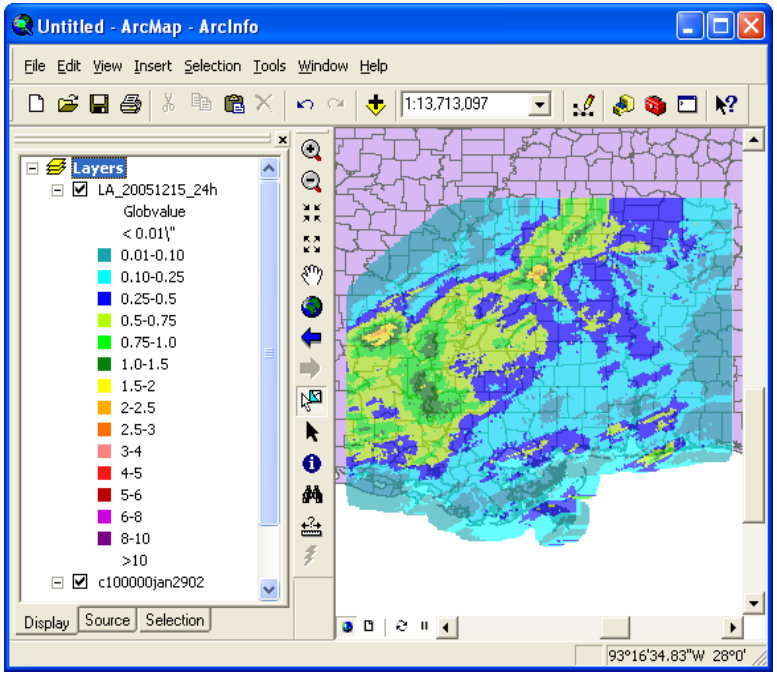


24-Hour Stage III Rainfall

Add and symbolize the data: Once the download finishes, you should open the .zip file with a compression utility package.

Extract all three files and save them to the c:\Precip_Data folder.



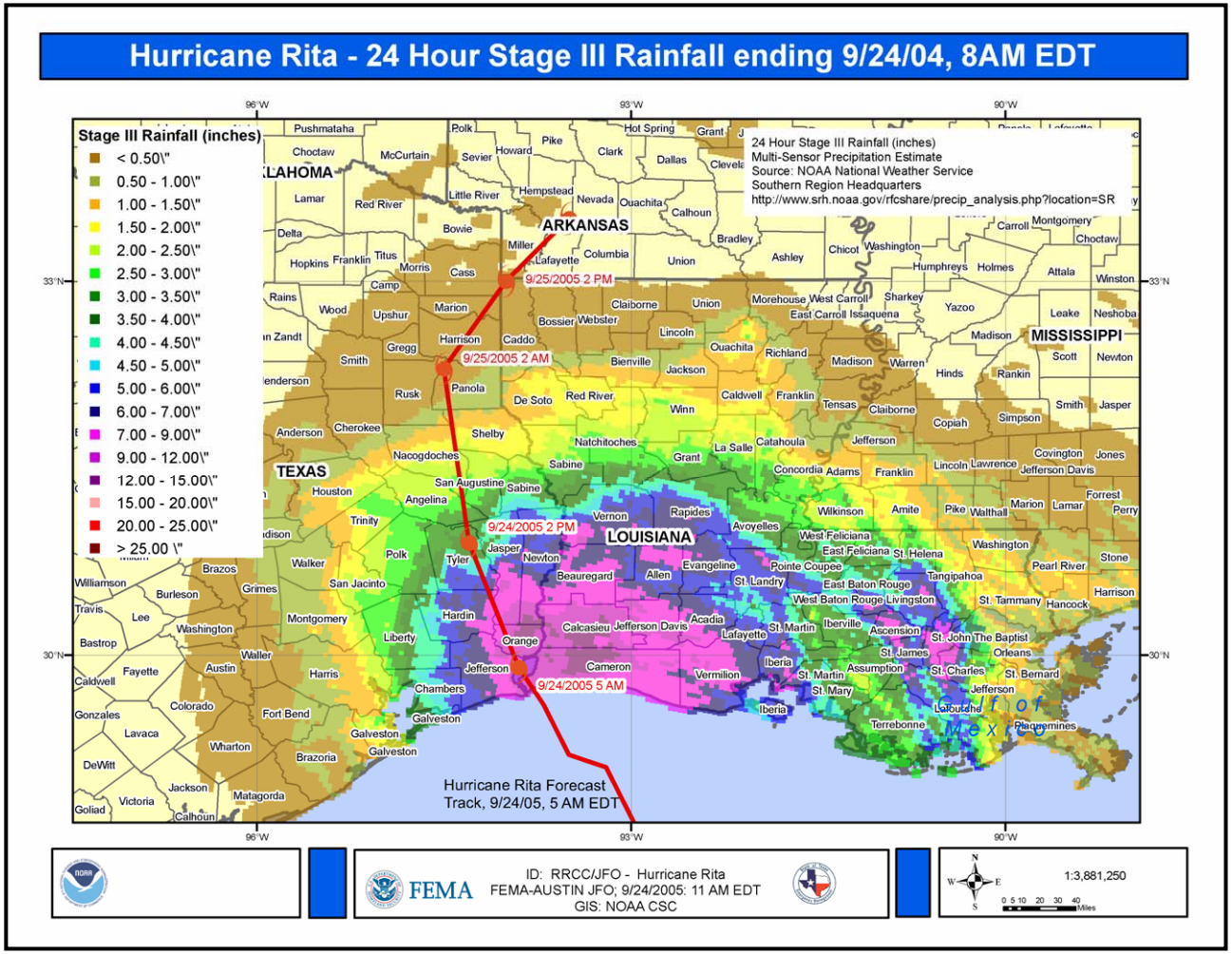


Open ArcMap back up and add the new county boundary layer.

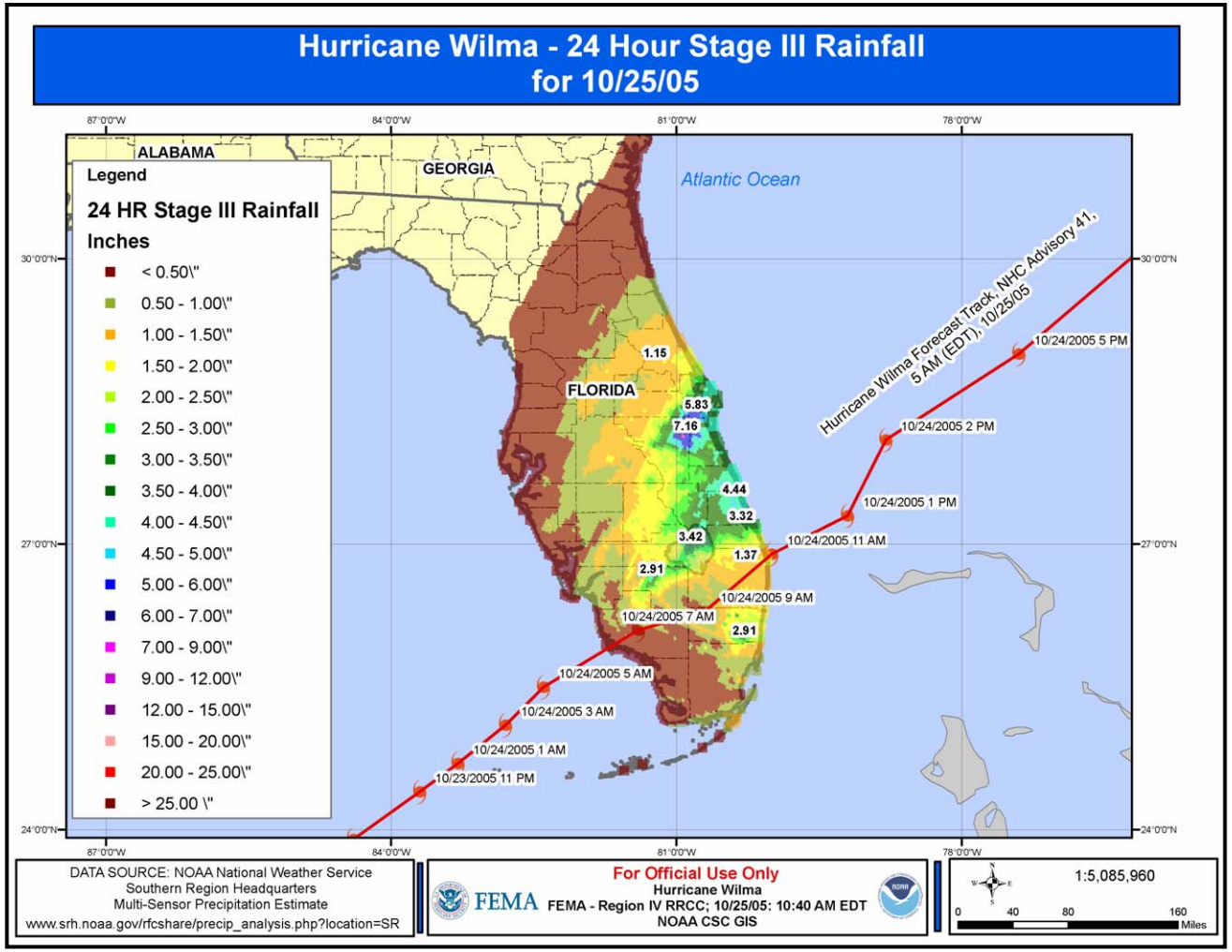
Move the county layer below the 24-hour precipitation layer. Make the precipitation layer partially transparent so that both layers are visible. To do this, double-click on the layer to open its Properties window. Select the **Display** tab and specify **40%**. Click **OK** to see the result.

At this point you are ready to begin making a map. Several examples have been included to show what the NOAA Coastal Services Center has provided to members of FEMA in the past. Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.

24-Hour Stage III Rainfall



24-Hour Stage III Rainfall



Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Purpose: This type of map displays cumulative precipitation estimates for a range of dates for given areas using multiple sensors.

Source Data: These data are created using multiple inputs that include the following:

- High-resolution Parameter-Elevation Regressions on Independent Slopes Model (PRISM) data derived from National Oceanic and Atmospheric Administration (NOAA) Cooperative Stations. These data are the most detailed, highest-quality spatial climate data sets currently available.
- Process 1 (P1) offers the best estimates of gridded precipitation fields currently available in an operational environment. When compared to one another, P1 and PRISM data offer detailed insights into the distribution of rainfall across a 4 x 4 kilometer scale. Using these products, users can capture localized departures that are often lost when using regionalized climate and drought maps.
- SNOTEL (for SNOwpack TELemetry), operated by the Natural Resources Conservation Service (NRCS). This automated system is used to collect snowpack and related climatic data in the Western United States. SNOTEL has reliably and efficiently collected the data needed to produce water supply forecasts and to support the resource management activities of NRCS and others.
- U.S. Geologic Survey (USGS) Digital Elevation Models (DEM).
- Sets of rules, decisions, and calculations used to simulate the thought process of a climatologist in generating spatial climate maps. These rules account for increased precipitation with elevation, rain shadows, and coastal locations. The further a given location is from an observation site, the more these rules influence a given climate parameter.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Download: Users wanting to download this kind of spatial data should visit the NWS Precipitation Analysis Web site at *www.srh.noaa.gov/rfcshare/precip_analysis_new.php*.

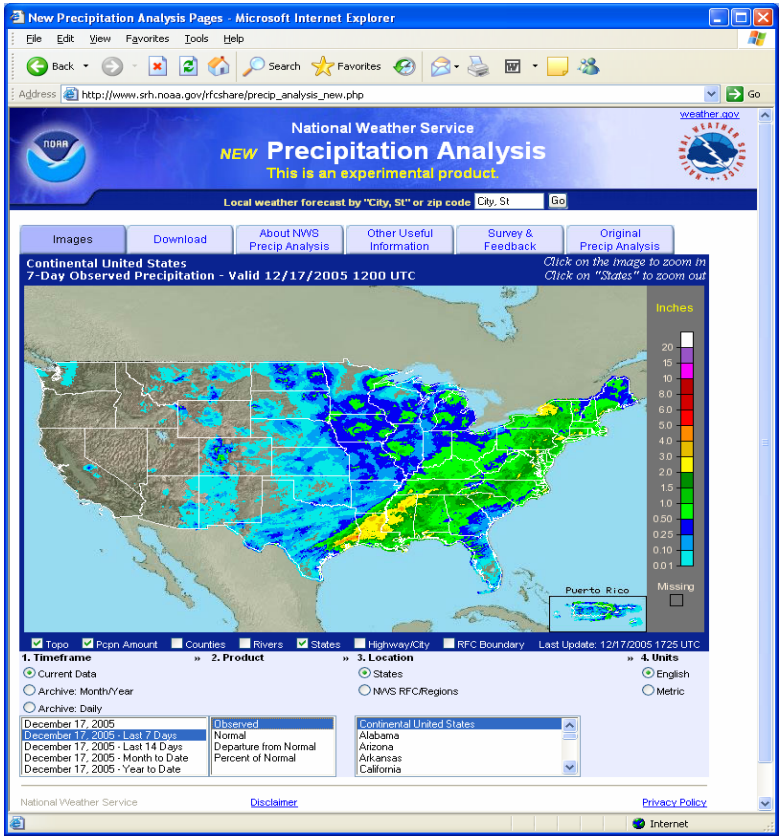
Begin by specifying the region of interest. You can either click on the map to zoom closer to an area or specify a state from the drop-down list at the bottom.

For this module, you will look at the observed precipitation amounts in the last seven days for Florida.

Change the timeframe of observation to **7** days. The graphic map will change to reflect the cumulative precipitation amounts.

Leave the Product as **Observed**.

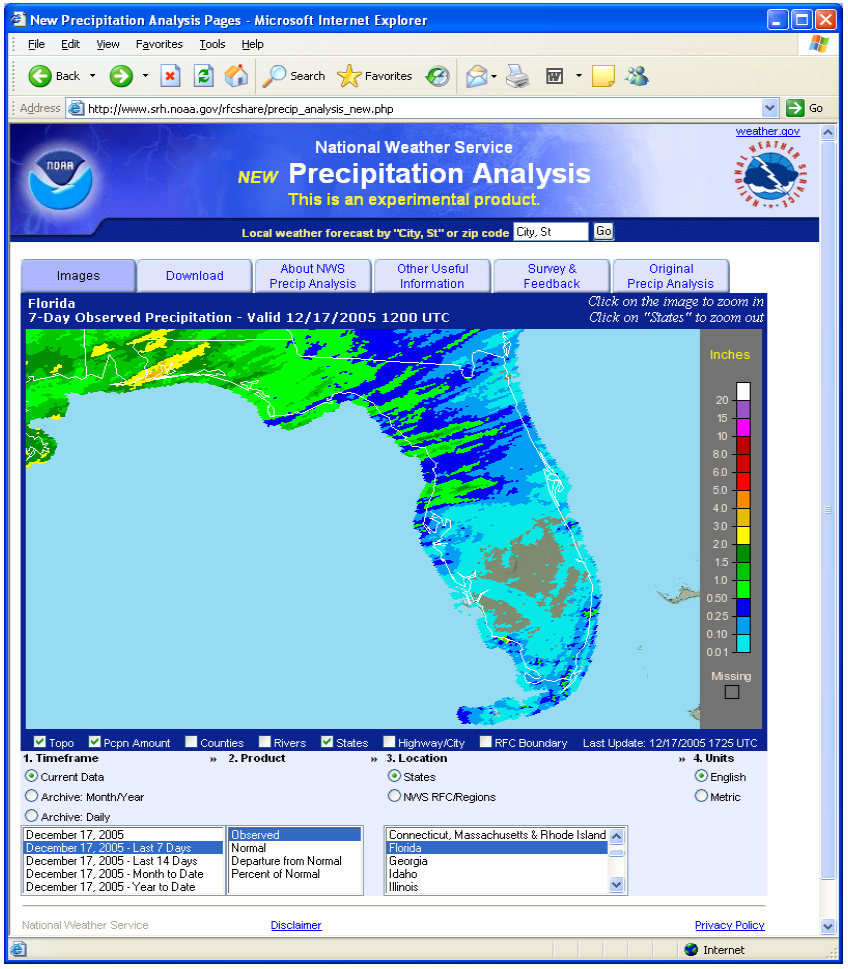
Select **Florida** from the drop-down list. Again, the map will change to reflect the data for that state.



Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

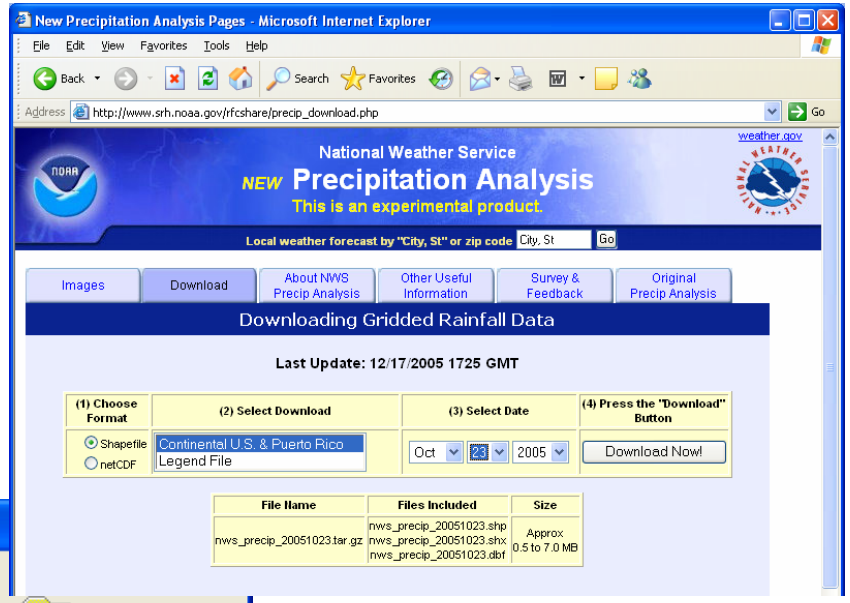
Download: Your display will show the state of interest and the amount of recorded precipitation from the last seven days.

To create a cumulative rainfall estimate, you will specify multiple dates for your study area. Hurricane Wilma made landfall on October 24, 2005. You will download historical data from this site and bring it into your GIS for display. Click on the **Download** tab to begin this process.

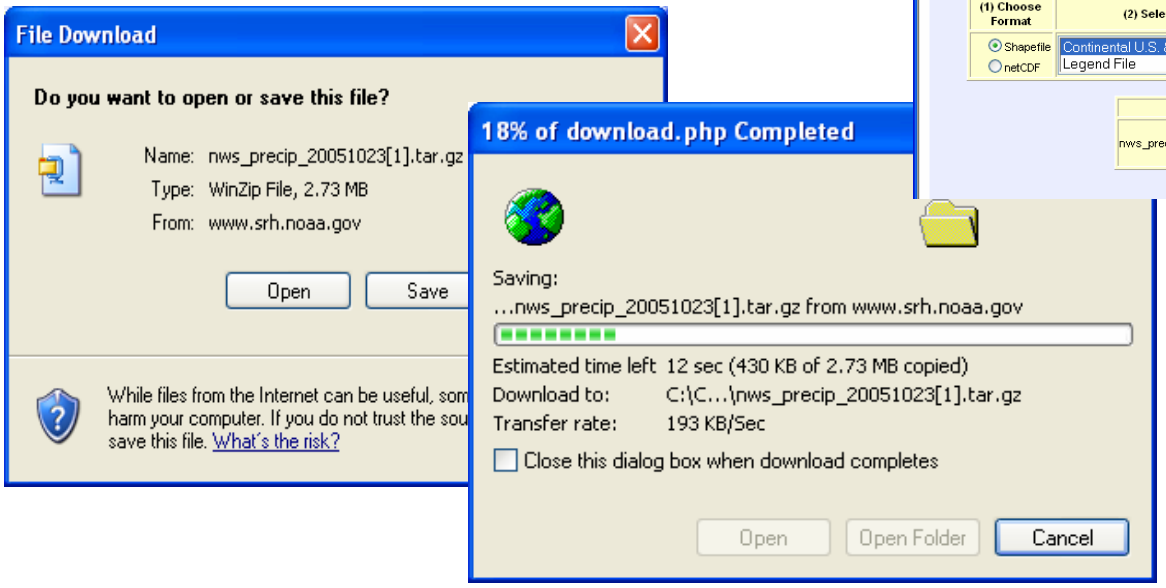


Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Download: The following window should appear. You will download a shapefile for the Continental U.S. for October 23, 2005. Click the **Download Now** button to begin the process.



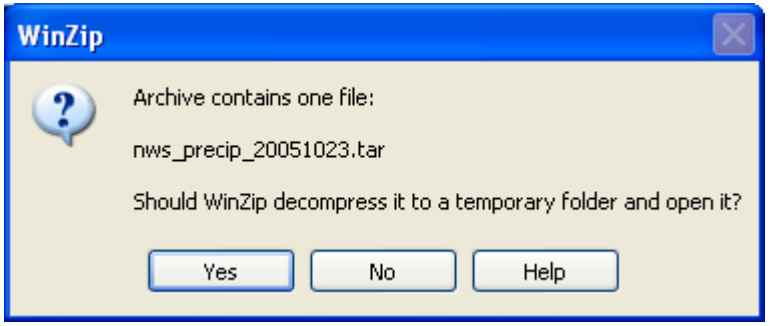
A File Download dialog window will prompt you to decide what to do with your data. Click the **Save** button. Create a new folder (i.e., C:\cumulative_rainfall), and copy the file into that location.



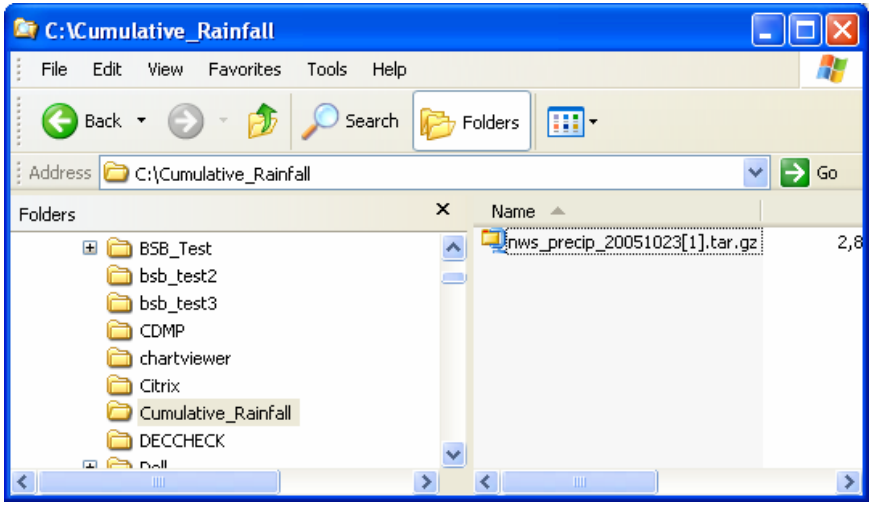
Once the download completes, click on the **Open** button.

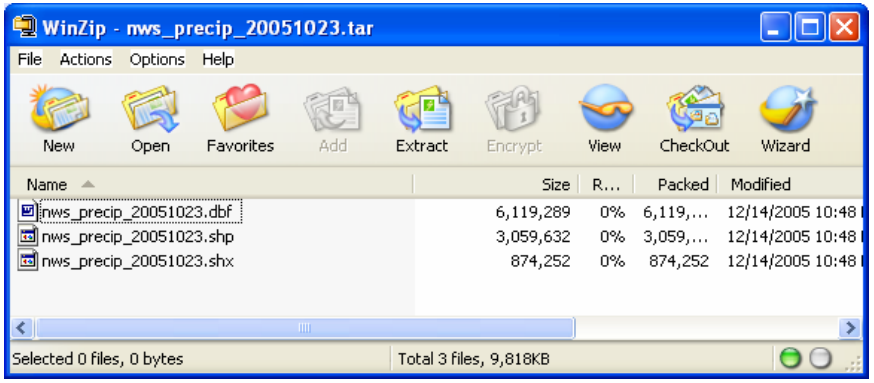
Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Download: You may receive the following dialog box. Click **Yes** to decompress the file into a temporary folder and open it.



You will now find a .tar file copied into this folder. This is a compressed file that contains other files. You will need to use a file uncompression software (such as Winzip or PKZip) to extract the other files.



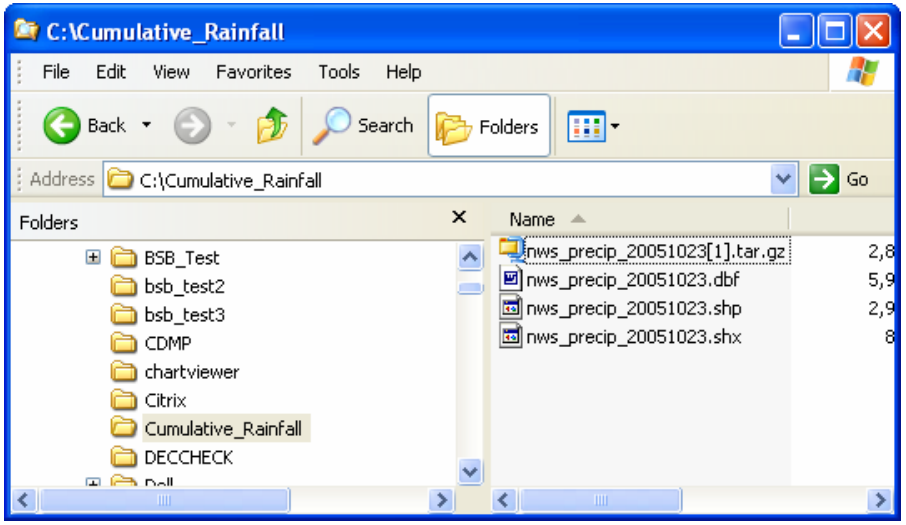


Once these are extracted, they make up a “shapefile” (with .dbf, .shx, and .shp extensions).

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Download: You should now see the following files in your directory. Once the shapefiles are uncompressed, you can view them in ArcGIS.

Repeat these steps for two other dates (i.e., October 24 and 25, 2005). Once these shapefiles are uncompressed, add them into ArcMap.

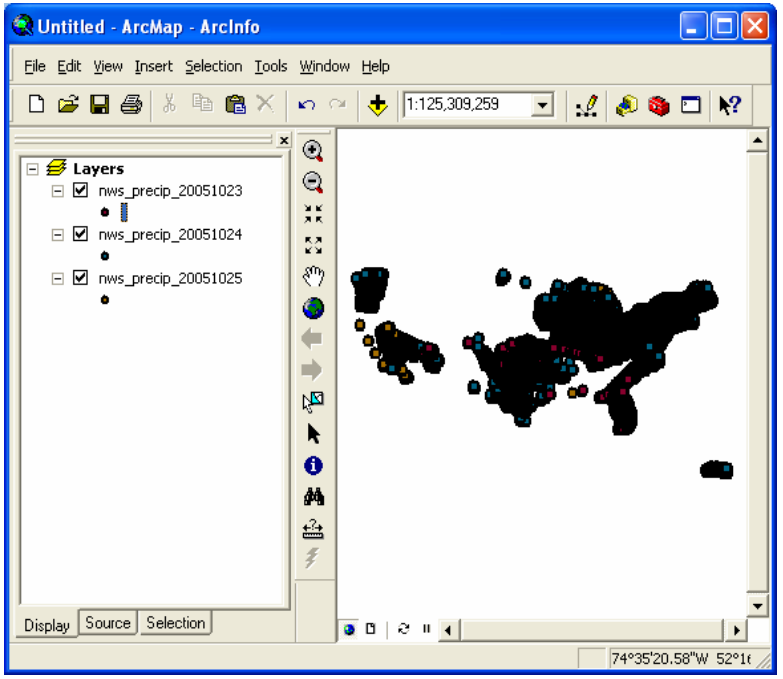


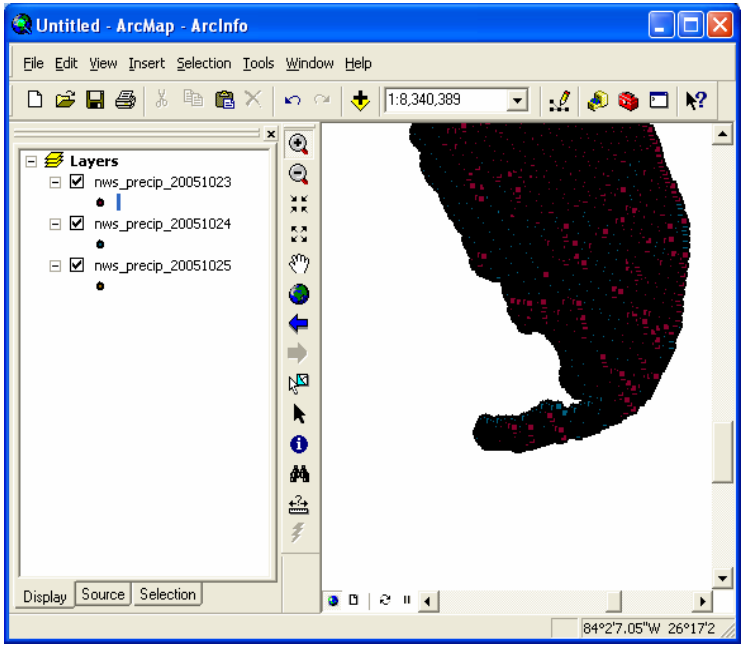
Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add the data: Open ArcMap by clicking on **Start > Programs > ArcGIS > ArcMap**.

Click on the **Add Data** button to add the three shapefiles.

Add a county boundary layer to see how these data overlay.



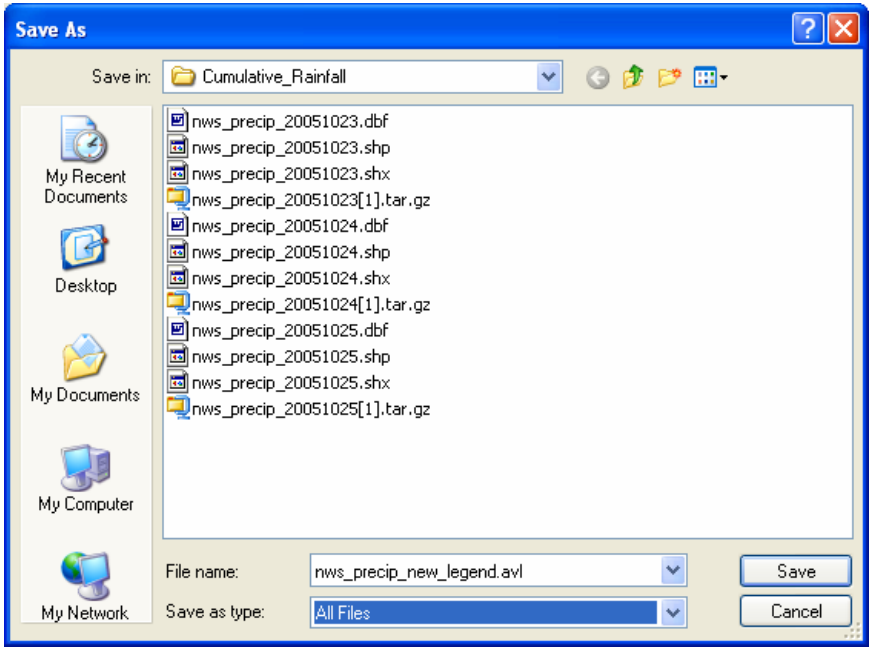


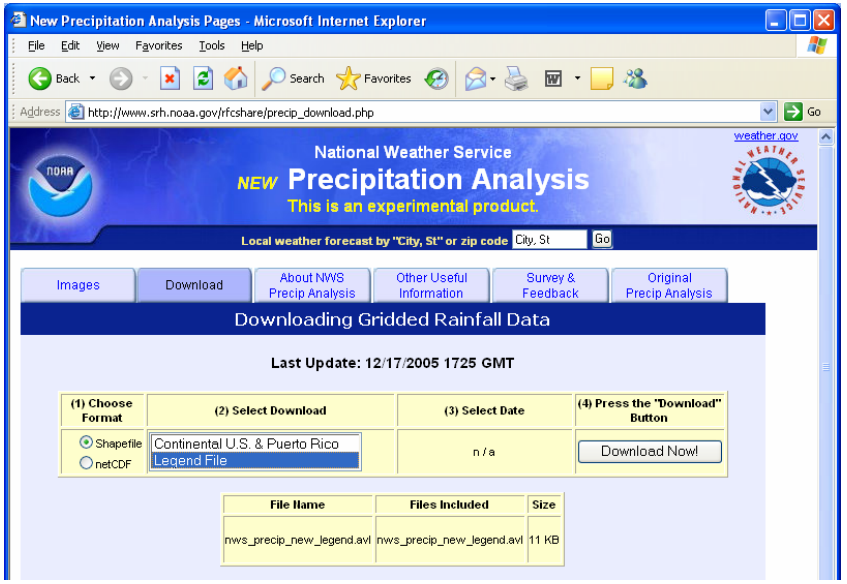
Zoom to an area of interest. In this example, you will look at the southwestern coast of Florida.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: The data should be symbolized to show precipitation amounts for the area. You will now download an associated ArcView Legend (.avl) file that will provide the proper symbology.

Going back to the NWS Precipitation Analysis Web site, you will specify the legend file containing symbology. Click on the **Download Now** button.





Save the .avl into the same Cumulative_Rainfall folder and take the default name given to the .avl. Click **Save**. Once the download is complete, simply close the message window.

Open Windows Explorer and navigate to the folder you saved the .avl file in. Notice that the zip utility may have appended ".txt" onto the end of your .avl file. Simply remove the ".txt" portion, and ArcGIS will recognize the file as an ArcView legend file.

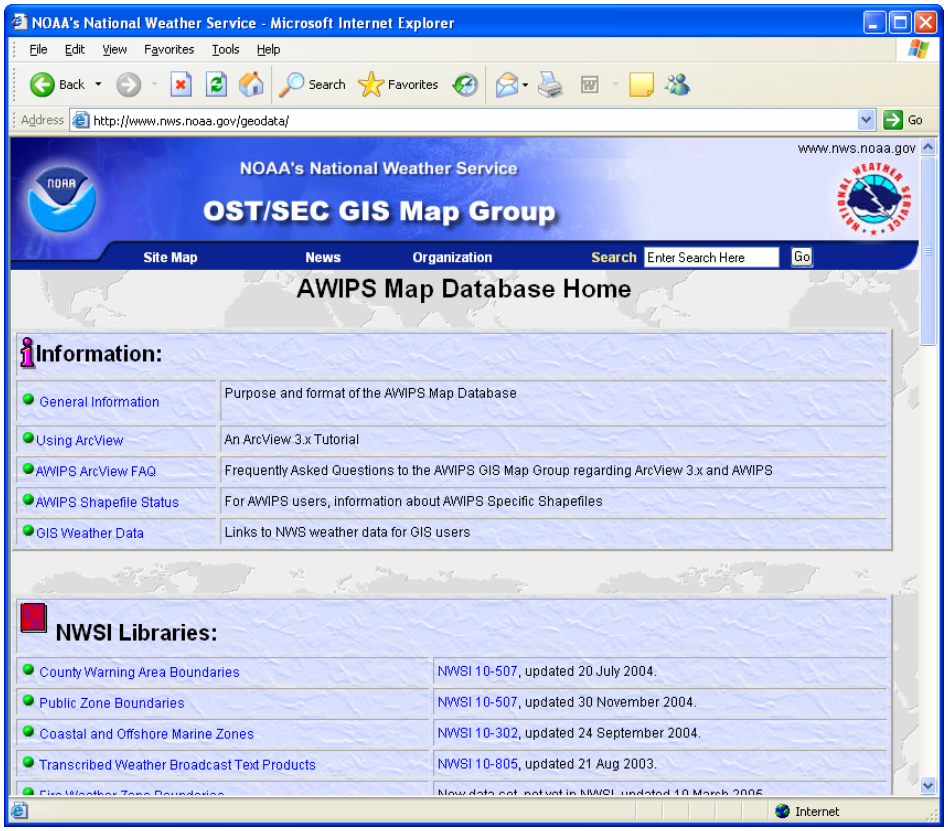
Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: To clearly see the political areas affected by this rainfall, you must add a new layer.

Open a Web browser and visit the AWIPS homepage: *www.nws.noaa.gov/geodata/*

This site serves different base layer data for use in a GIS. Scroll down the page and find the County Libraries section.

Click on the file named **Counties at 1:100k**.

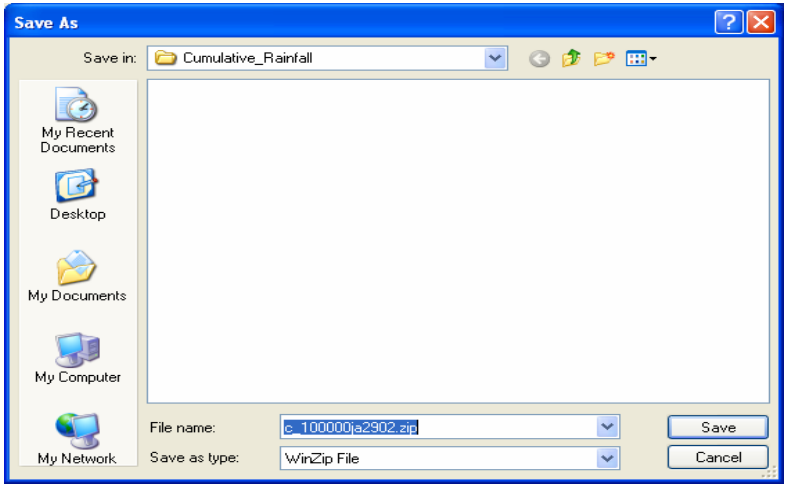


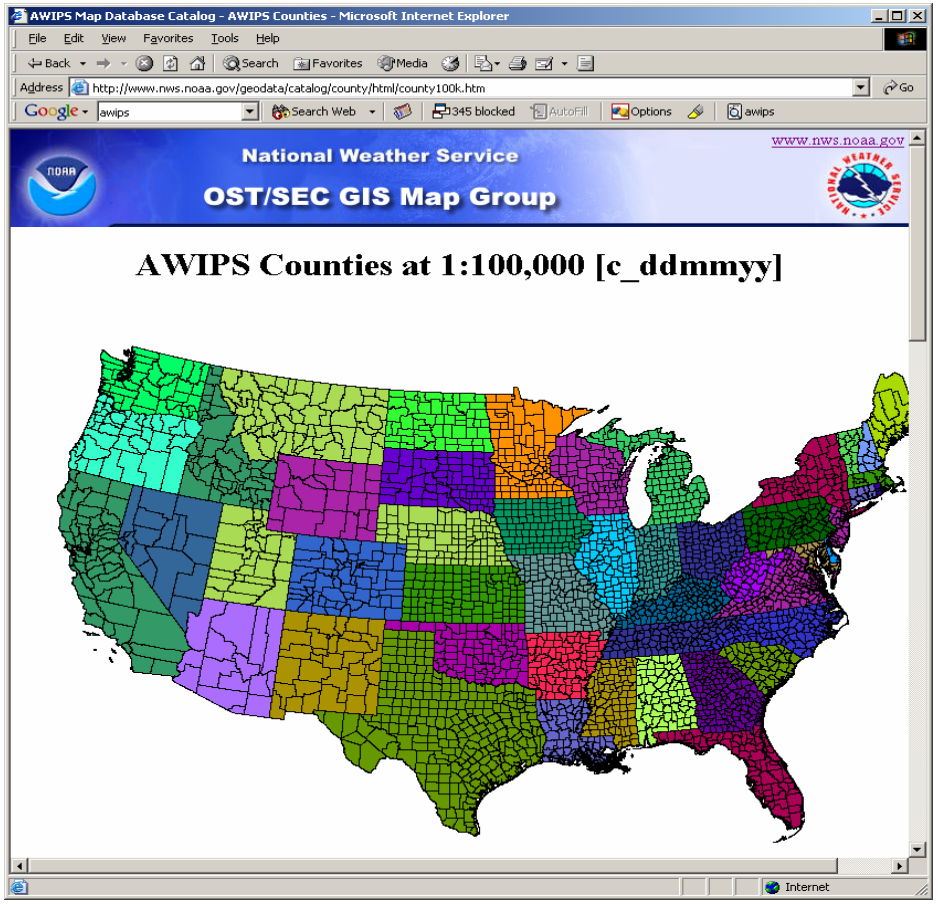
Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: This site provides free county boundary data at 1:100,000 scale, which will be suitable for your mapping purposes.

Scroll down and click on the **Download Compressed Shapefile** link. Save this file to your Cumulative_Rainfall folder. This 52-megabyte file is large and will take some time to save.

Description	Valid Date		Size (bytes)		
US Counties (CONUS)	14 January 2003	Download Compressed shapefile	51,731,681	Change History	Metadata

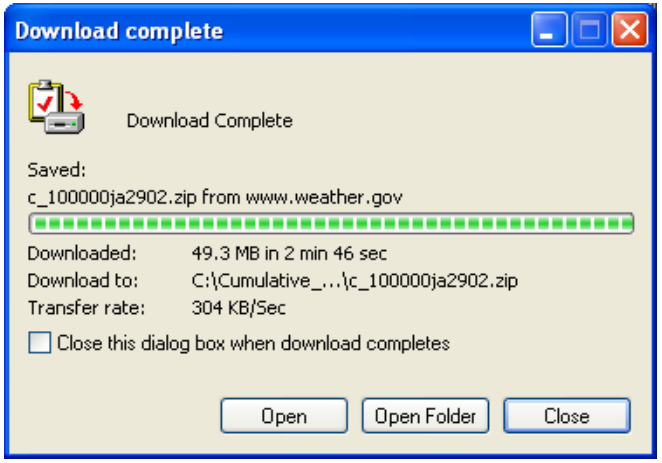


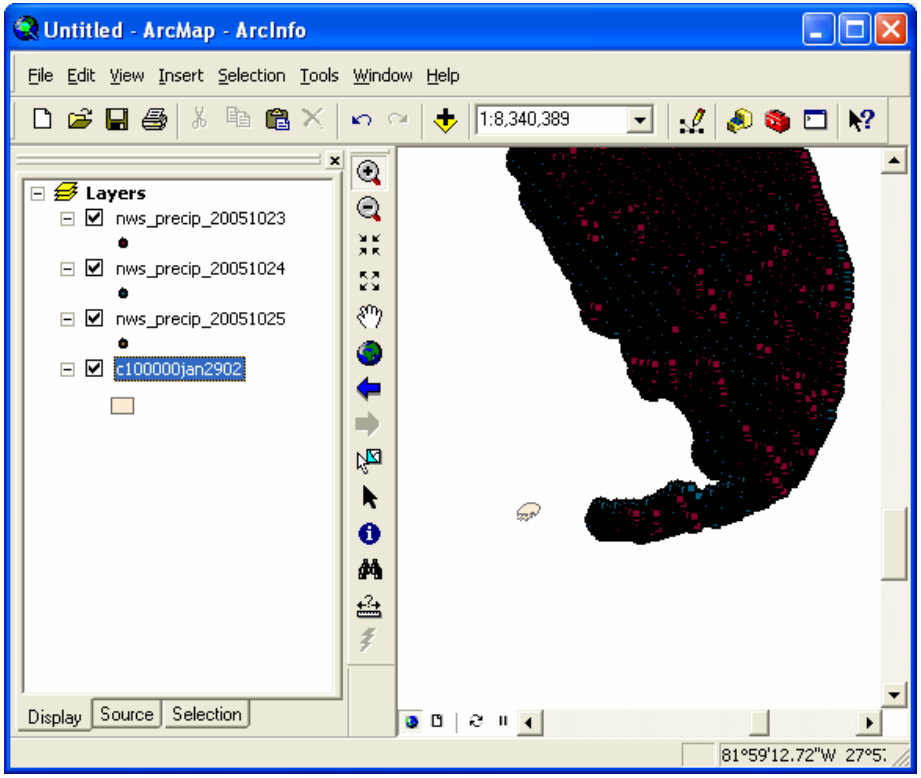


Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: Once the download finishes, you should open the .zip file with a compression utility package.

Extract all three files and save them to the c:\Cumulative_Rainfall folder.





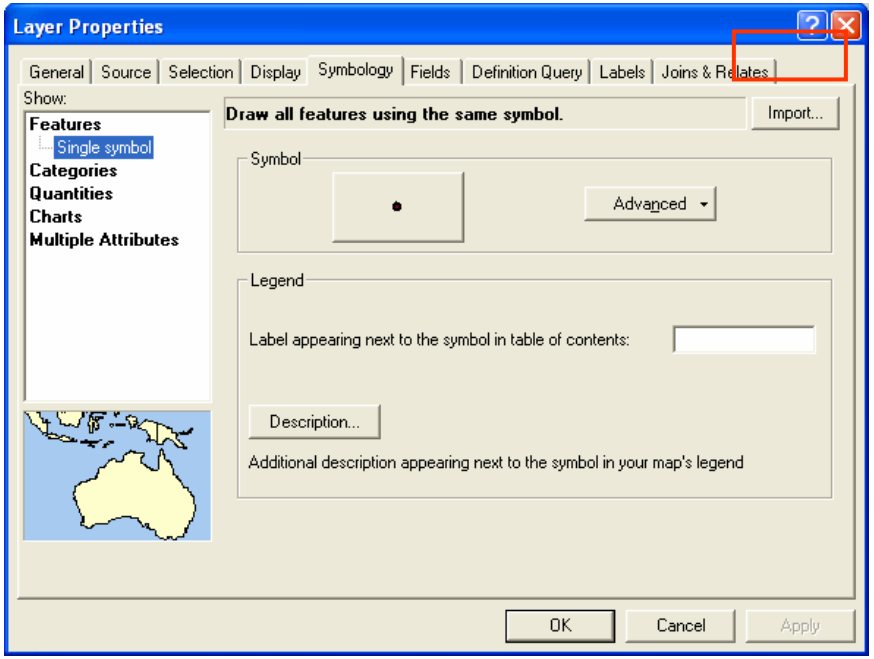
Open **ArcMap** back up and add the new county boundary layer.

Move the county layer below the cumulative rainfall layers.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

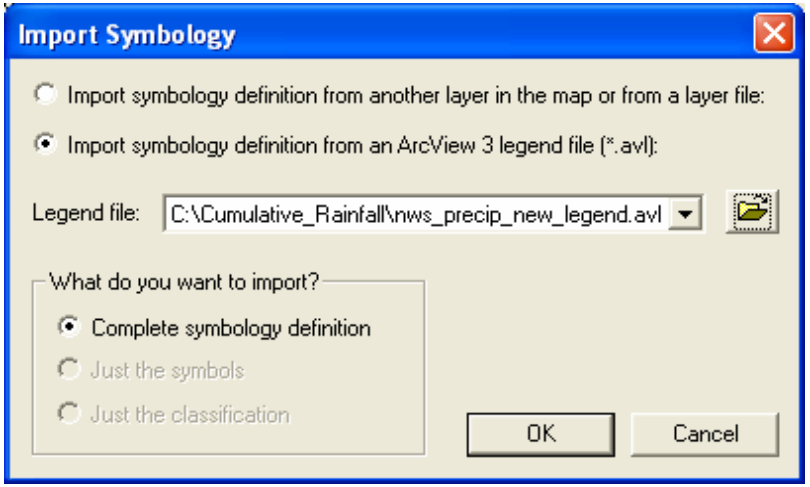
Add and symbolize the data: Double-click on one of the Stage III layers in ArcMap's table of contents. This opens the Layer Properties dialog window. Select the **Symbology** tab to specify a predefined legend.

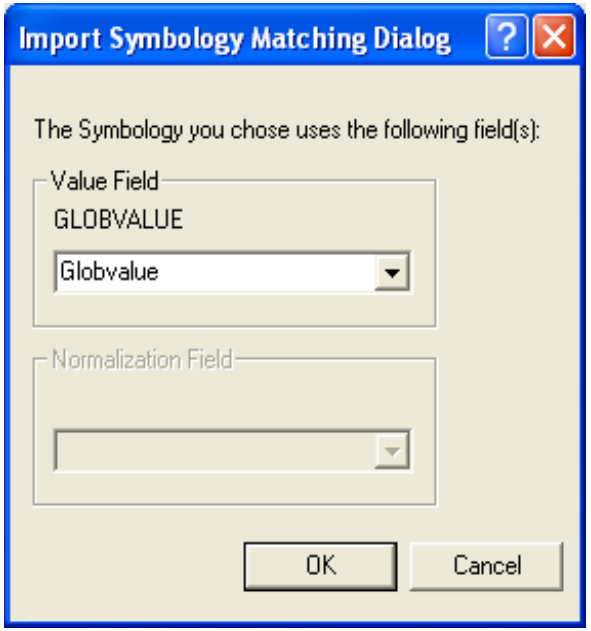
Click on the **Import** button to browse to the .avl file.



Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: In the Import Symbology dialog window, choose to **Import symbology definition from an ArcView 3 legend file (*.avl)**. Click on the **Browse** button and navigate to C:\Cumulative_Rainfall. Select the **nws_precip_new_legend.avl** file. Click **OK**.

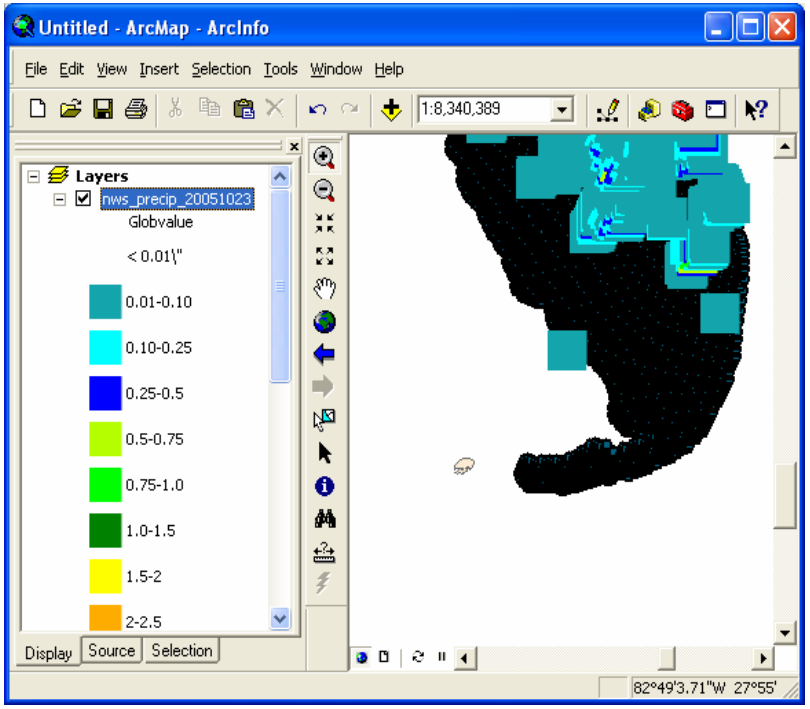


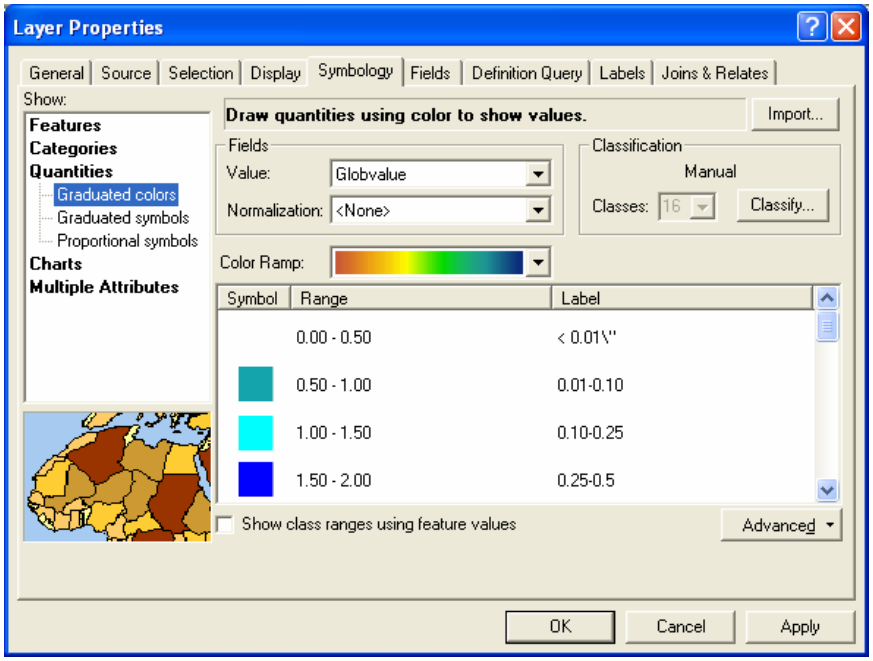


In the Import Symbology Matching Dialog window, the Value Field should read **Globvalue**. Click **OK**. The points will now symbolize according to the preset rainfall amounts contained in the .avl.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: The predefined symbology will appear complete with rainfall amounts measured in inches. Click **OK** to assign these values.

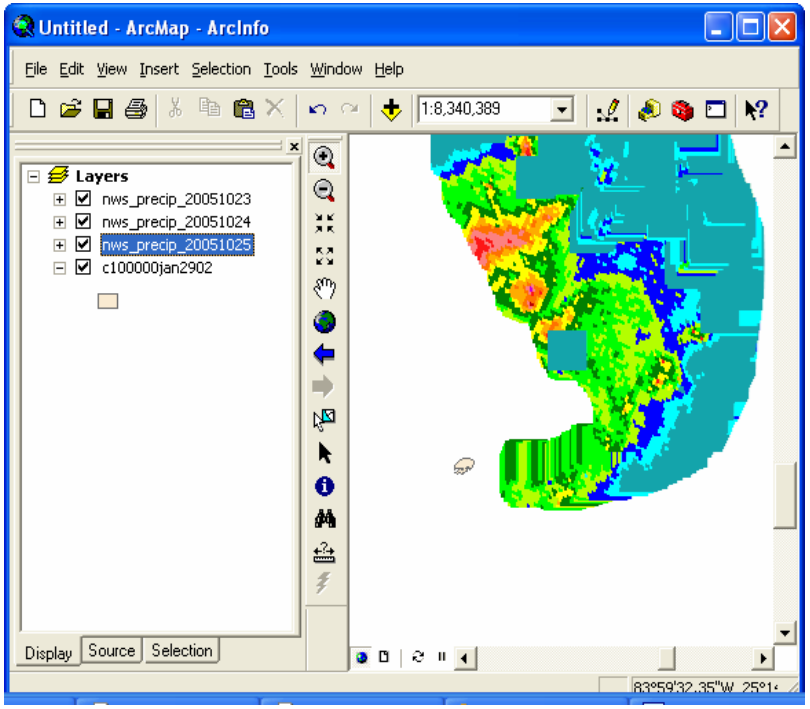




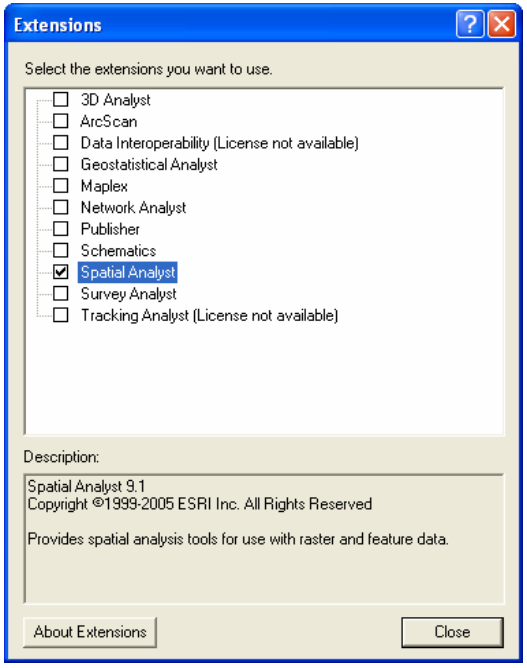
Repeat the symbolization operation for each of the Stage III shapefiles.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: To make visualization easier, minimize the symbology of each layer by checking on the minus ("-") sign next to each one.



To combine these three layers, you must first convert them into raster layers. This is done through the use of the Spatial Analyst extension. Enable Spatial Analyst by clicking on the **Tools** menu and selecting **Extensions…**



Turn on **Spatial Analyst** and **Close** the Extension window. Now add the Spatial Analyst toolbar by clicking on the **View** menu and selecting **Toolbars > Spatial Analyst**. The toolbar will appear and can be docked to the ArcMap window.

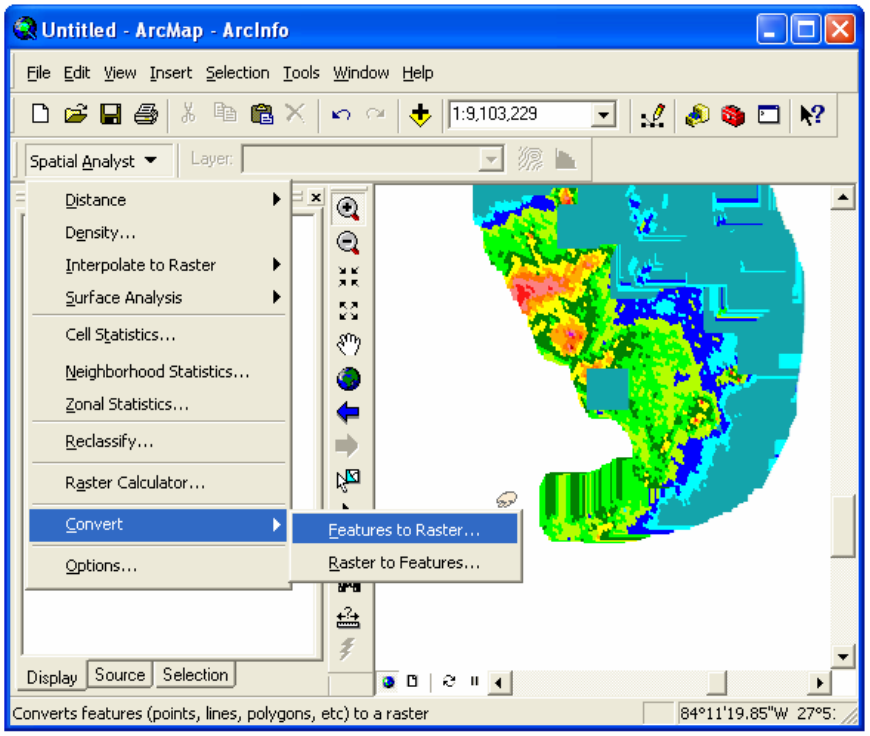
Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

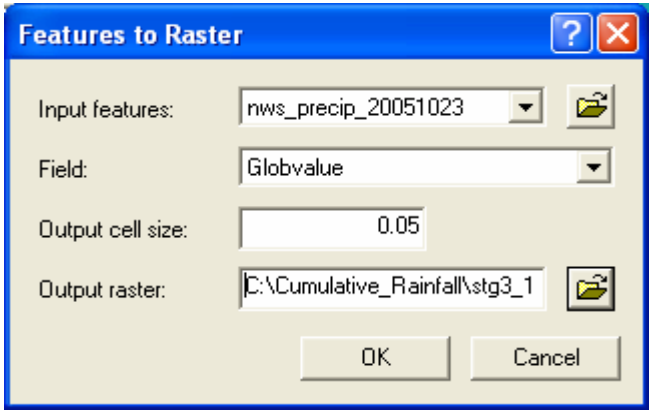
Add and symbolize the data: Click on one of the rainfall layers to highlight it. Click on the **Spatial Analyst** menu and select **Convert > Features to Raster…**

In the dialog box, specify the selected layer to convert. In the Field drop-down menu, retain **Globvalue**.

Change the Output cell size to **0.05**.

Specify a folder for the new raster layer. Remember that rasters are limited to 13 characters for their names—and that you should include the date of data capture in the name.



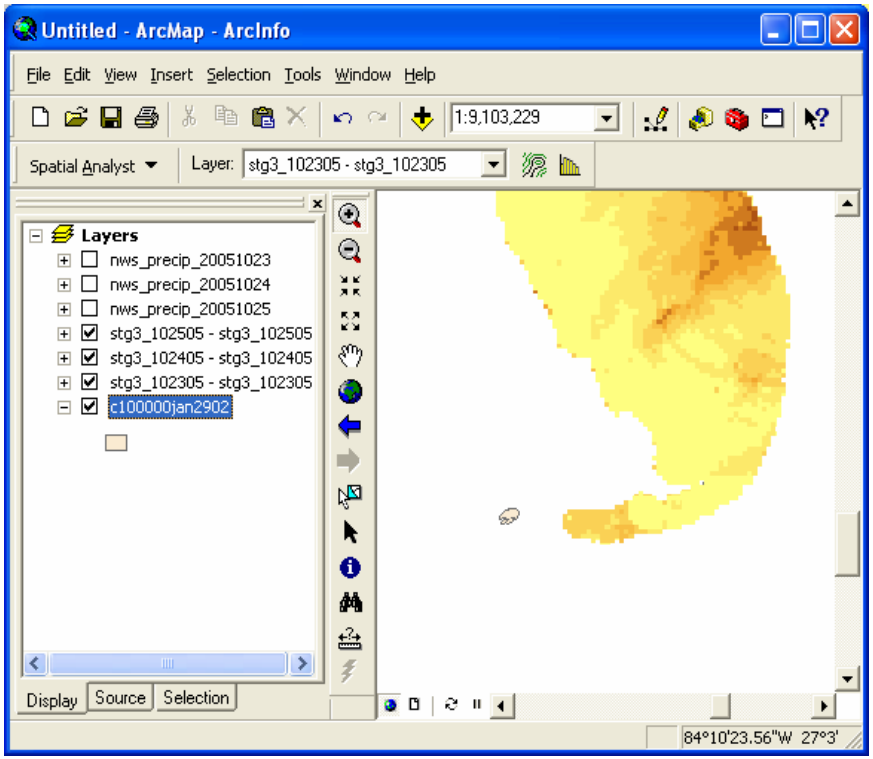


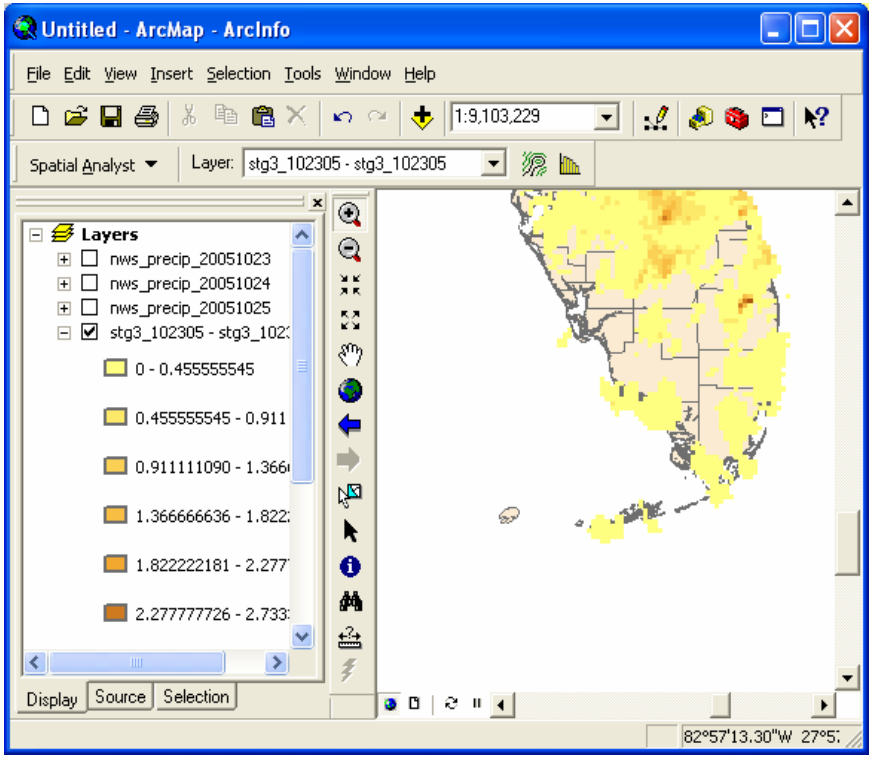
Click **OK** when you are finished. This will create the new raster from the shapefile, and ArcMap will add it automatically into the table of contents and turn it on.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: The converted raster layer should look like the example below. Turn off the point shapefiles to view the raster.

Repeat this conversion process for the other two layers. Be sure to specify the same cell size (0.05) for all rasters.





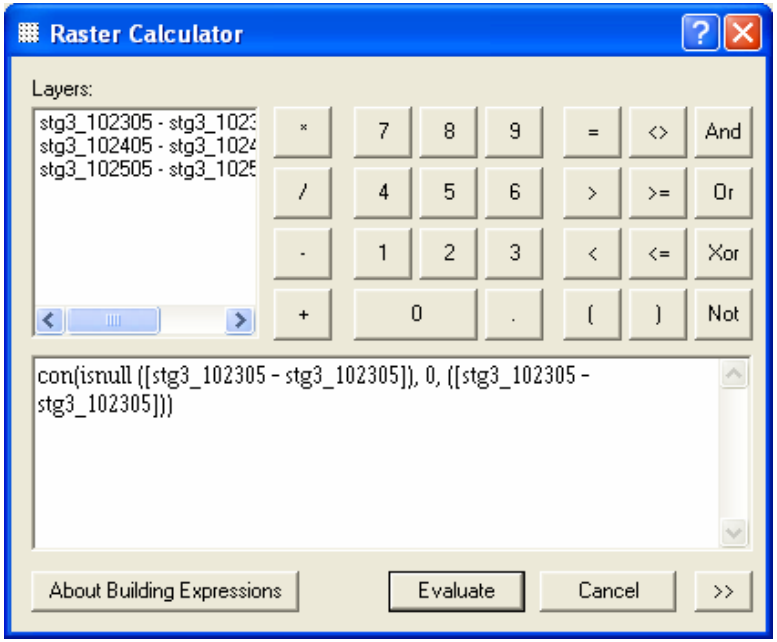
When this work is finished, the layers will probably not look very impressive. You need to remove any null values.

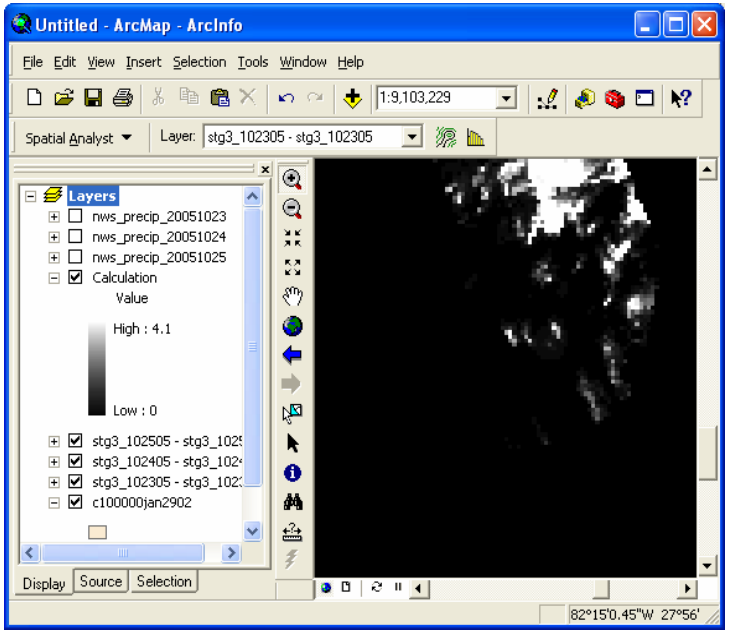
Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: Use the **Raster Calculator** found inside the Spatial Analyst menu and develop the following expression to remove null values:

con(isnull ([stg3_20051023 - stg3_20051023]), 0, ([stg3_20051023 - stg3_20051023]))

This is a pretty complicated expression to execute properly. Pay close attention to the parentheses, brackets, and spaces throughout. When you have the expression developed, click **Evaluate**.





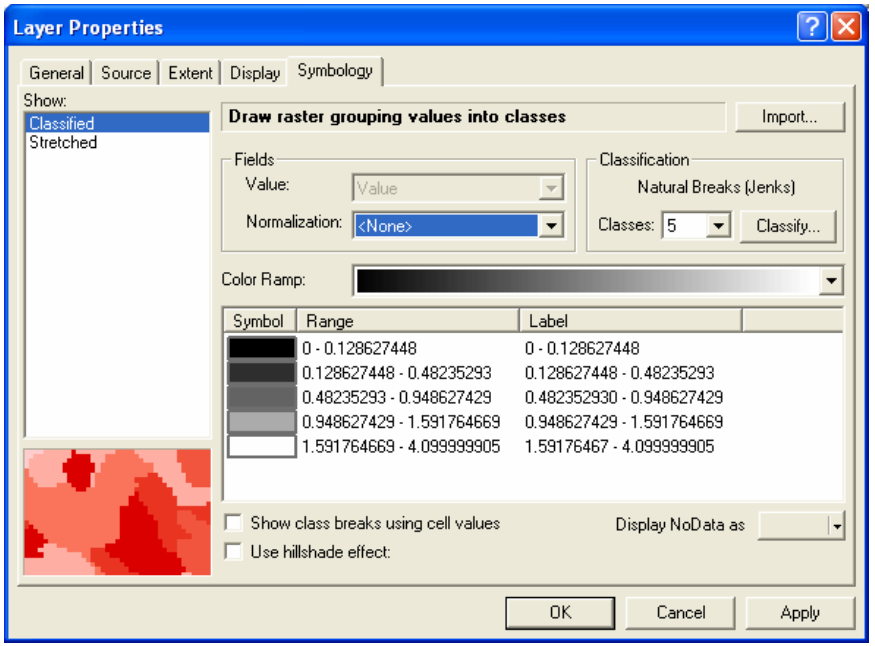
The resulting raster will look similar to this example. Open its Layer Properties window and select the **Symbology** tab.

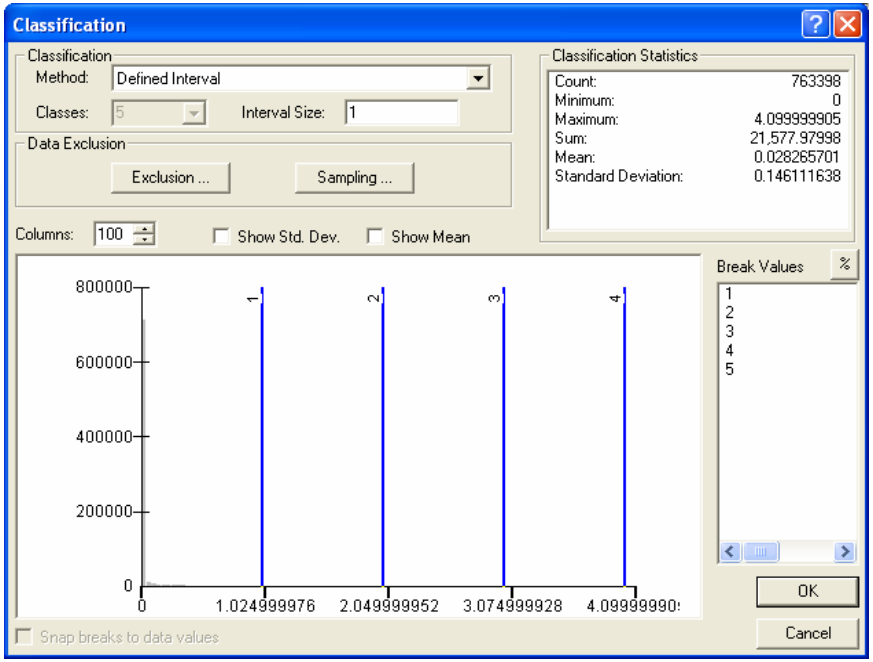
Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: Click on the **Classified** option under the Show field.

Change the Classification system from Natural Breaks to **Defined Interval** by clicking on the **Classify** button.

Change the Interval Size to **1**.



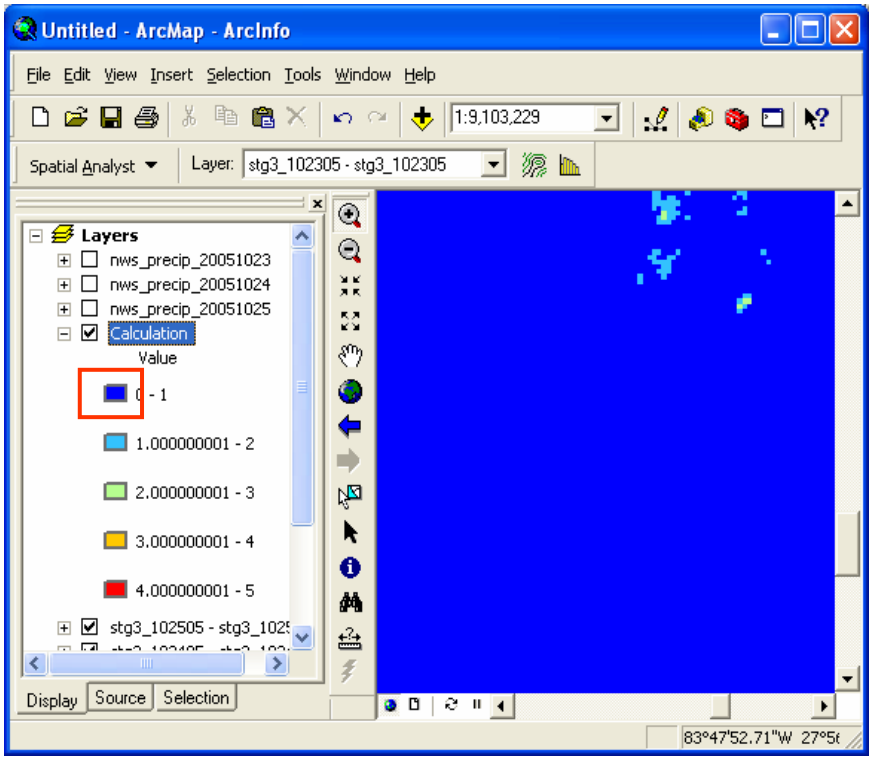


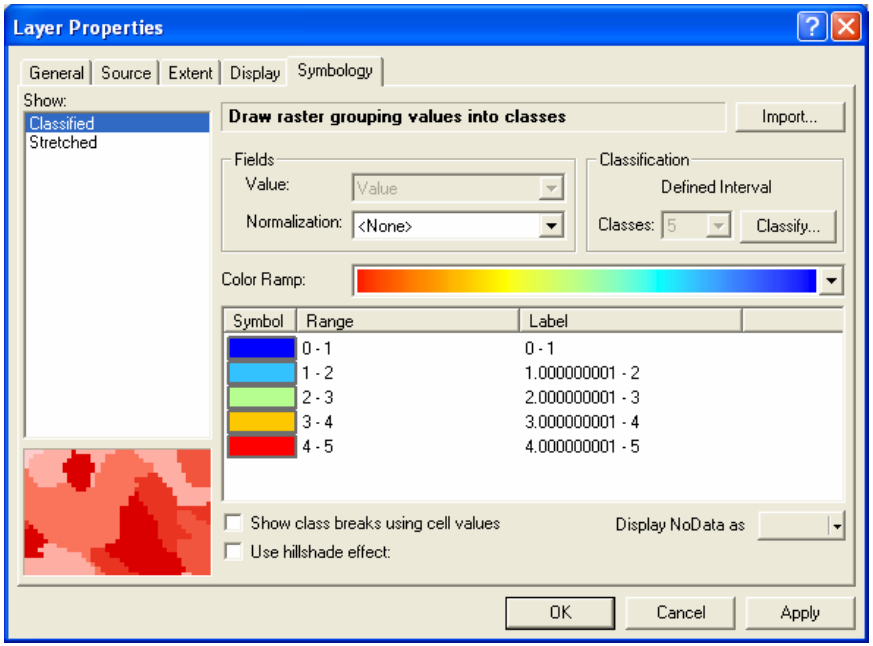
Click **OK** when finished.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: Change the color ramp to a red-to-blue graduation.

Flip the symbols so that the lowest rainfall amounts are coded blue and the highest areas are red. Click on the **Symbol** field and select **Flip Colors**. Click **OK**.



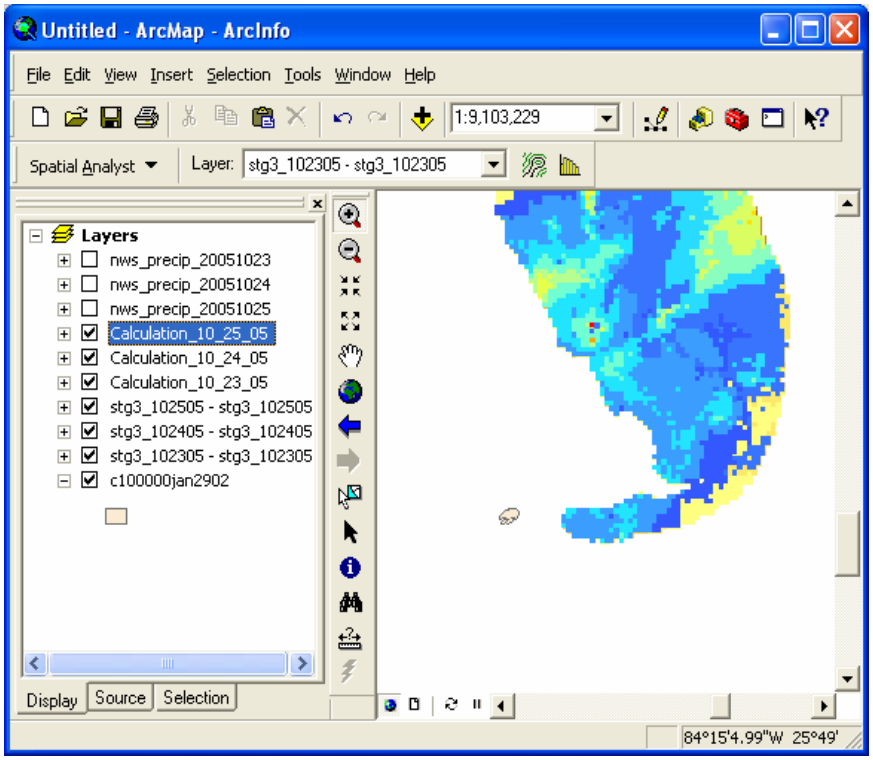


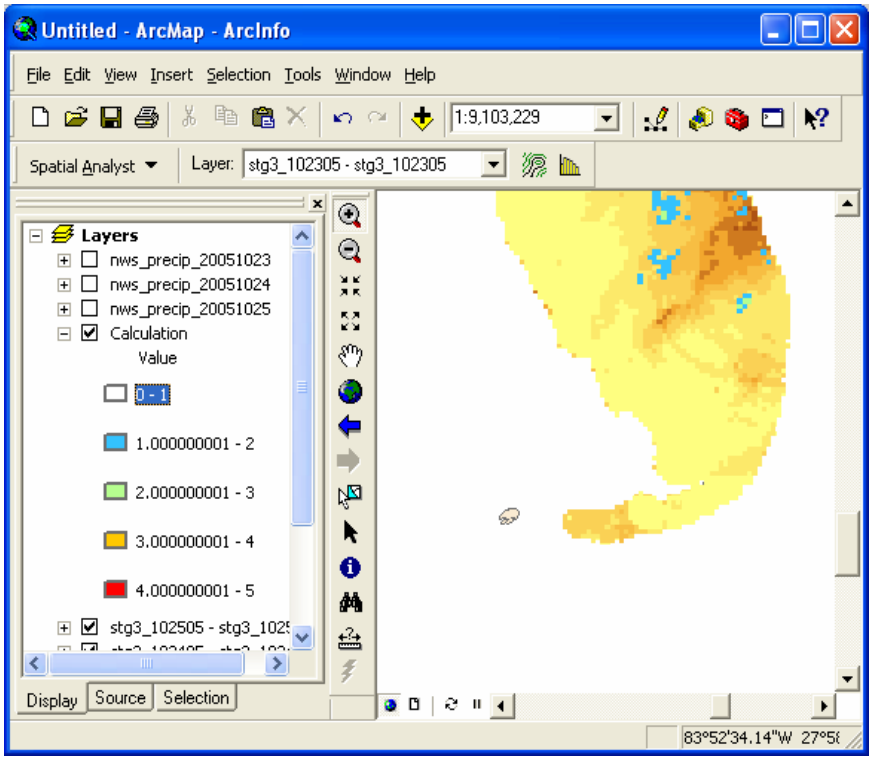
The raster should symbolize to look like the example to the left. Right-click on the class of values ranked **0 - 1** and set them to No Color.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: The resulting raster should look like the example below. Repeat the process for the other two layers until you have a series of "Calculation" rasters.

It makes sense to rename the calculated rasters by adding their collection dates.

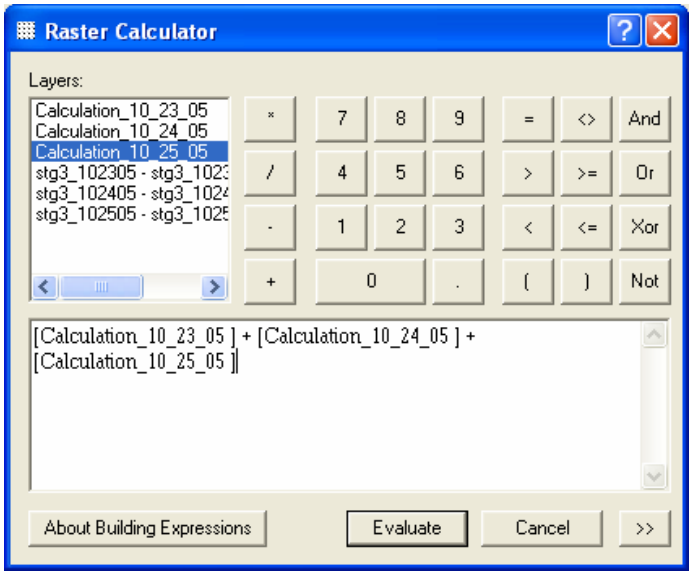


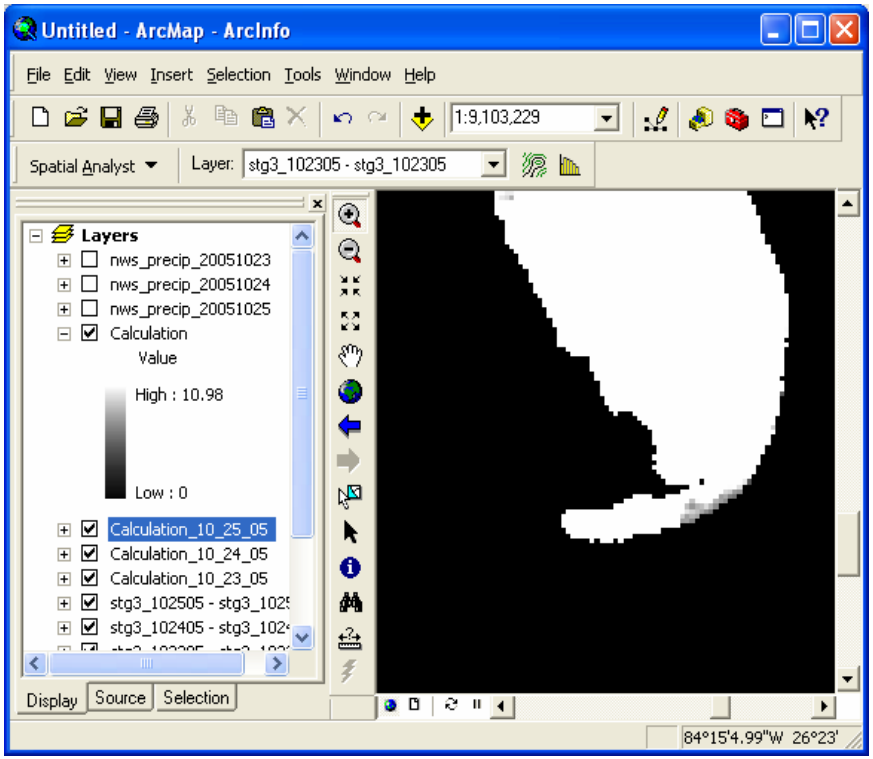


Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: Now add the individual rasters together by using the **Raster Calculator** again.

Build the expression to look like the example to the right, where each raster is added together. When finished, click **Evaluate**.



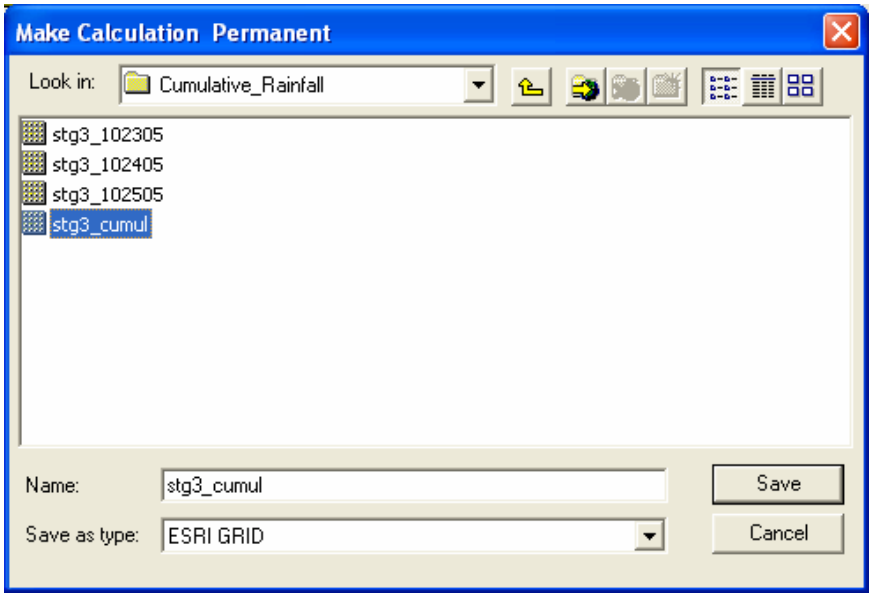


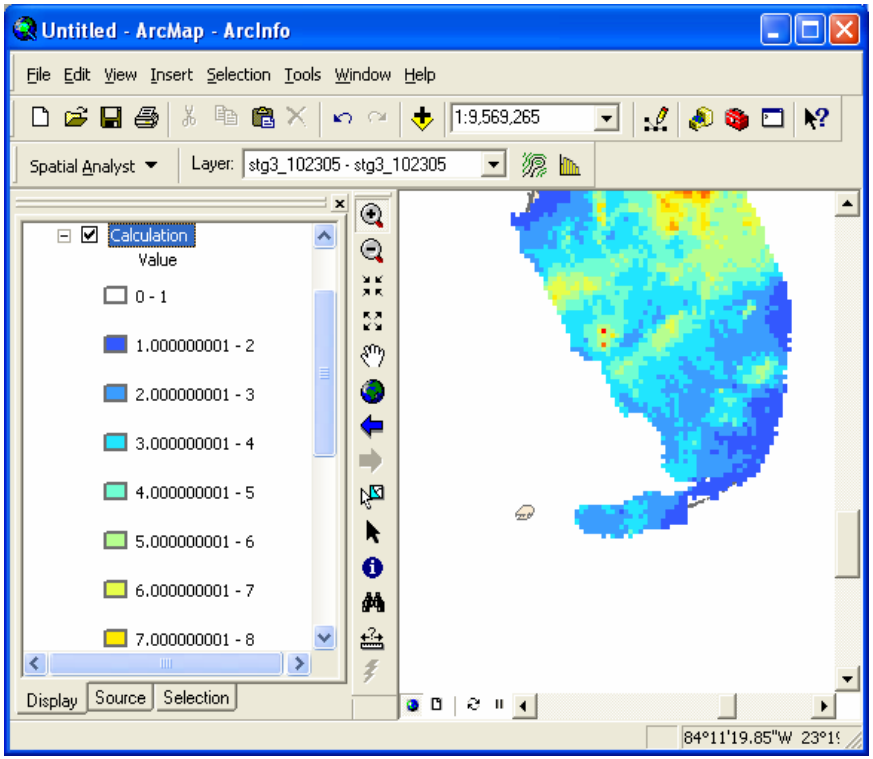
The resulting raster should look like this example. Go into its Layer Properties and **Symbolize** it like the others before.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate

Add and symbolize the data: Notice that all rainfall values for the rasters have been summed and the result appears in this example. You should now save this layer so that it becomes permanent.

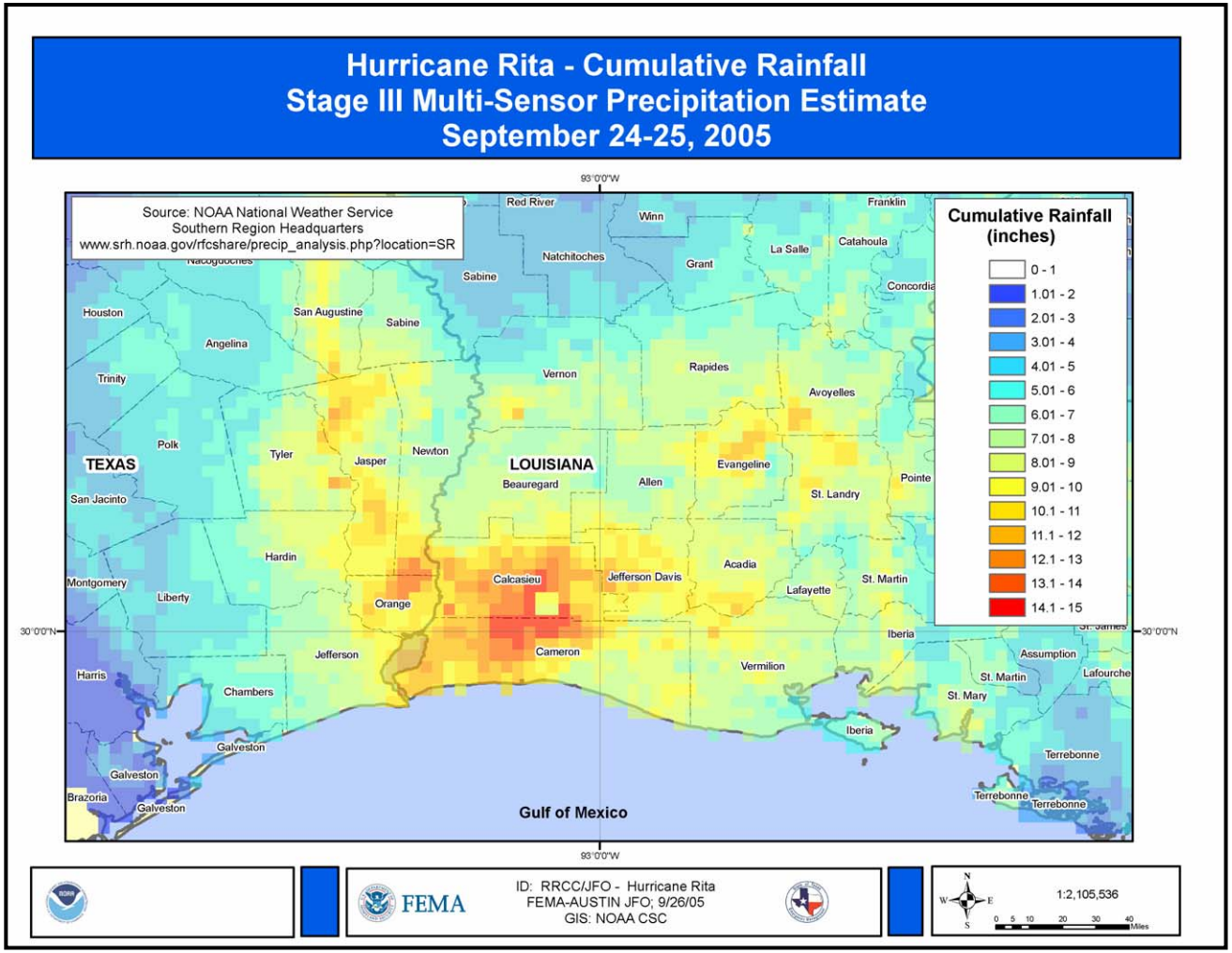
Right-click on the **Calculation** layer and select **Make Permanent**. In the dialog box, specify a new name for the raster, and save it into the Cumulative_Rainfall folder. Click **Save**.



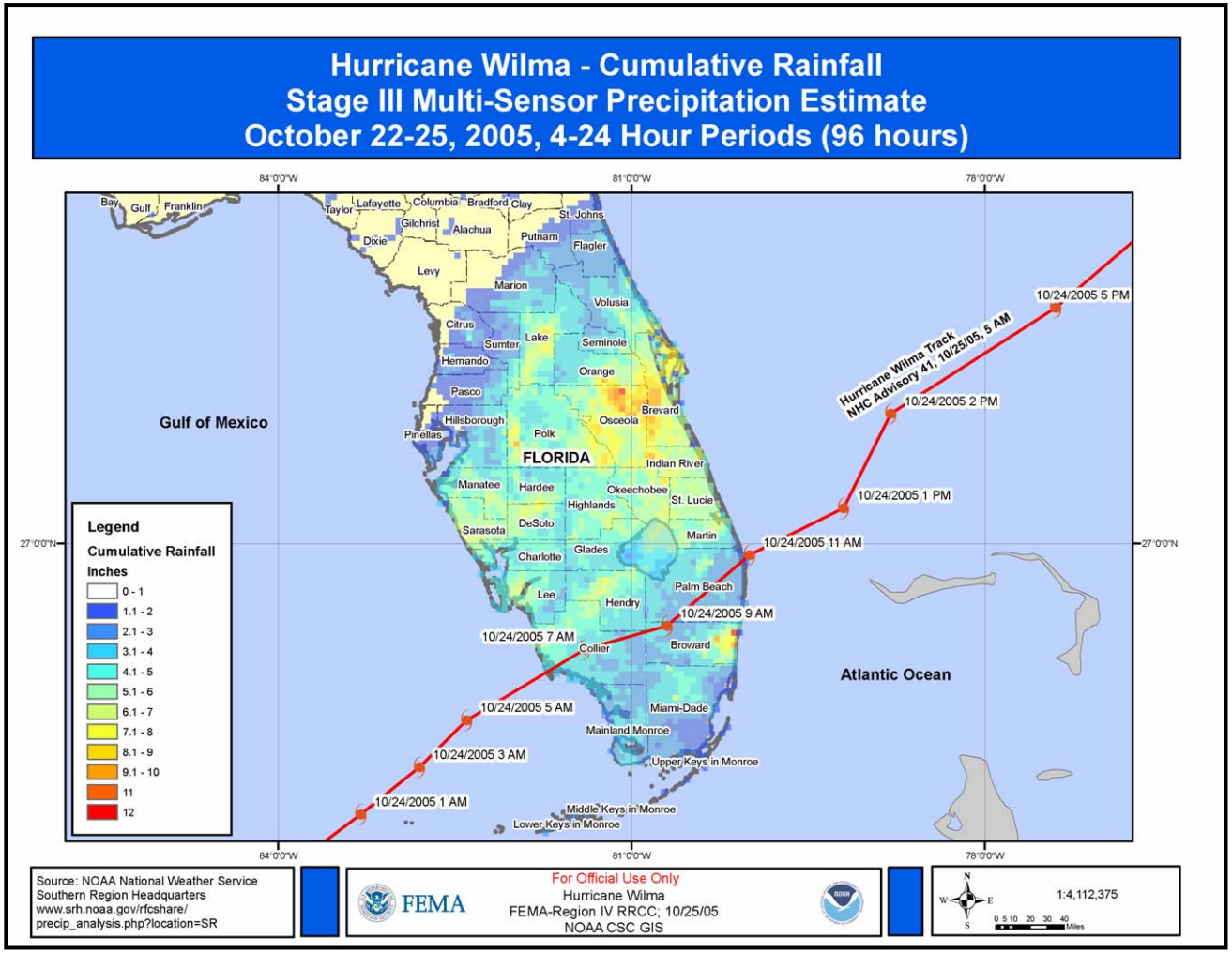


At this point you are ready to begin making a map. Several examples have been included to show what the NOAA Coastal Services Center has provided to members of FEMA in the past. Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.

Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate



Cumulative Rainfall – Stage III Multi-Sensor Precipitation Estimate



SLOSH Model Run

Purpose: This type of map presents the predicted amount of storm surge from a tropical cyclone event. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model is currently the primary tool used by the federal government to evaluate the threat from storm surge.

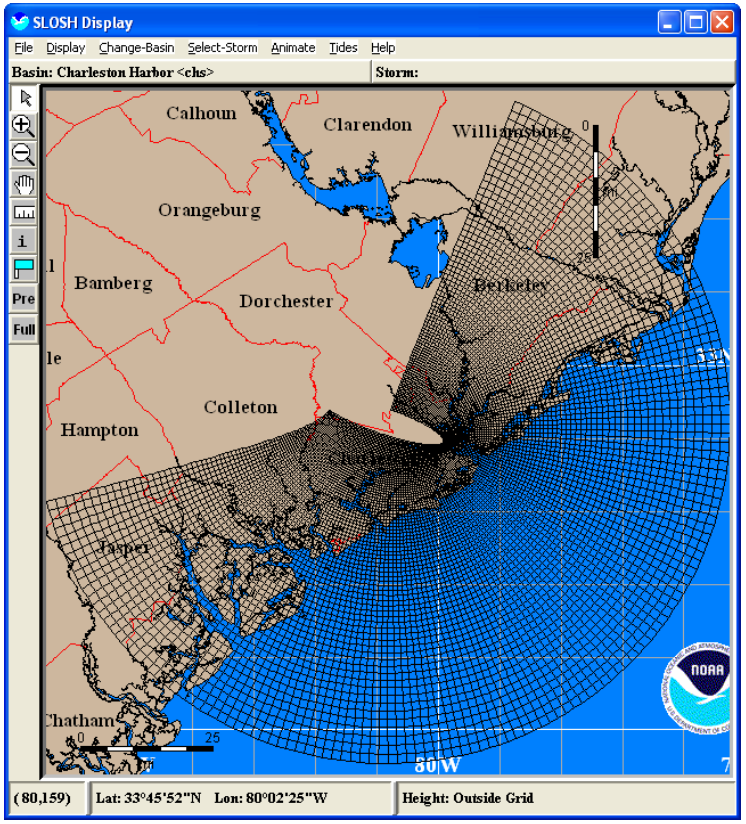
Source Data: SLOSH is a computerized model run by the National Weather Service to estimate storm surge heights from historical, hypothetical, or predicted hurricanes. The model creates its estimates by assessing the pressure, size, forward speed, track, and wind data from a storm. Graphical output from the model displays color-coded storm surge heights for a particular area. The calculations are applied to a specific locale's shoreline, incorporating the unique bay and river configurations, water depths, bridges, roads, and other physical features.

The geographic coverage of the SLOSH model currently includes all of the U.S. East and Gulf coasts, as well as parts of Hawaii, Guam, Puerto Rico, and the Virgin Islands. With the SLOSH Display Program, a user can generate and extract GIS shapefiles for various storm scenarios, which can be exported and used in a mapping environment such as ArcMap.

More information about the SLOSH program is found at *www.nhc.noaa.gov/HAW2/english/surge/slosh.shtml.*

SLOSH Model Run

SLOSH Display Instructions: Install the current SLOSH Display Program that is distributed through the NOAA National Weather Service's (NWS) Meteorological Development Lab (MDL). Once installation is complete, click on **Start > Programs > SLOSH Package 1.33 > SLOSH Display**.

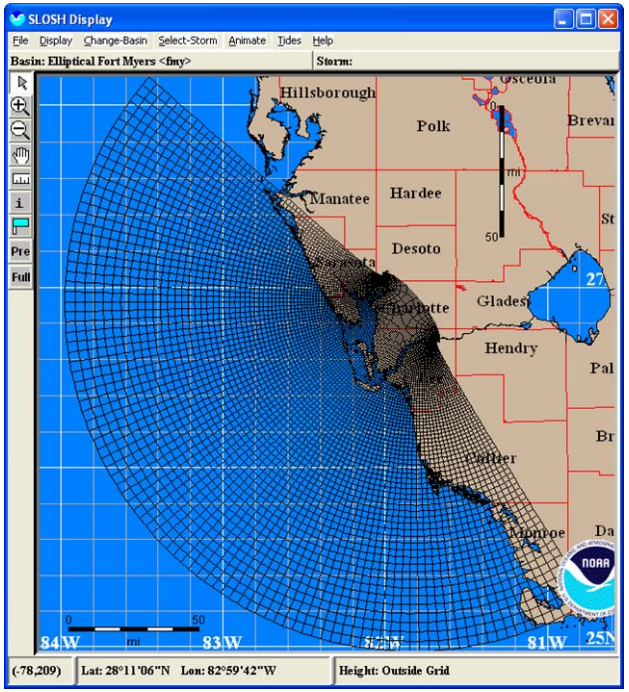


Once the program opens, click on the **Change Basin** menu and select **Change Basin**. Click on the basin that is forecast to be affected by the hurricane of concern. It may be necessary to step through this process for several adjoining basins because of forecast uncertainty.

Hurricane Wilma struck the southwestern Florida coast on October 24, 2005, as a Category 3 storm. For this tutorial, you will focus on this area.

SLOSH Model Run

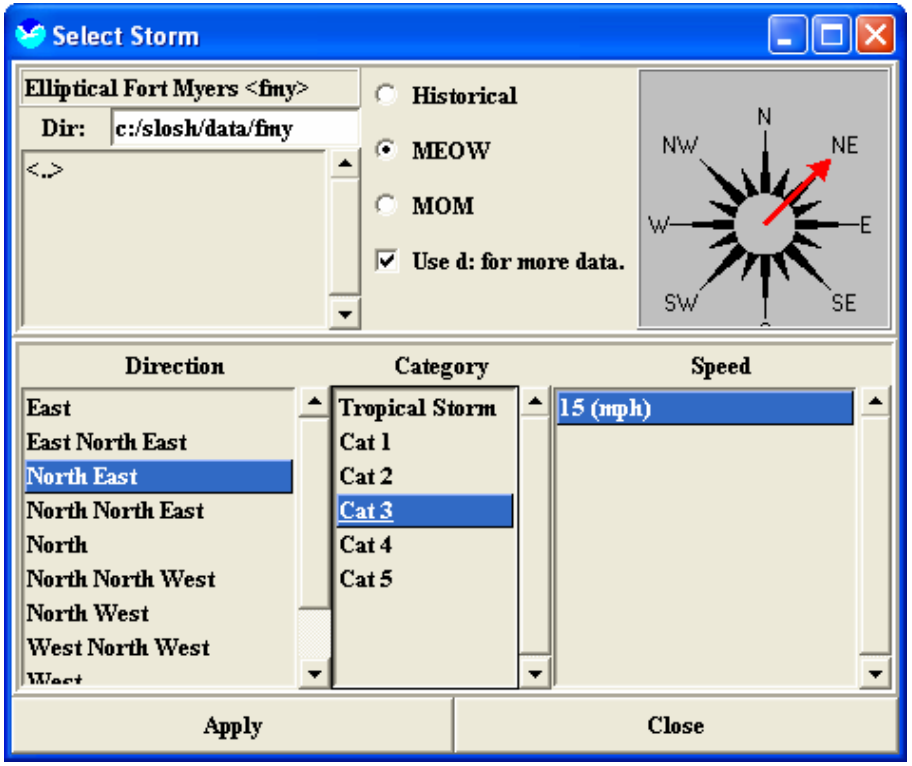
SLOSH Display Instructions: The following map will appear. Select the basin of interest by clicking on the elliptical graph on the map. You should see the corresponding basin name selected on the left (efmy Elliptical Fort Myers). Double-click on this name to change the appearance of the map.



The new basin appears for your study area.

SLOSH Model Run

SLOSH Display Instructions: After choosing a basin, click on the **Select Storm** menu and then on **Select Storm**. Once the dialog window appears, make sure the radio button for **MEOW** is selected. This will illustrate the "Maximum Envelope Of Winds" for the storm.



Under Direction, choose the direction in which the storm is forecast to be moving at the time of landfall.

For Category, select the category or intensity that the storm is forecast to be at landfall. Select the next *highest* category if the storm is forecast to be on the cusp of one category and another.

Finally, for Speed, select the closest speed at which the storm is forecast to be moving. Again, if necessary, round up if the storm is forecast to be moving at a speed somewhere in between the choices.

Click **Apply** and then **Close**.

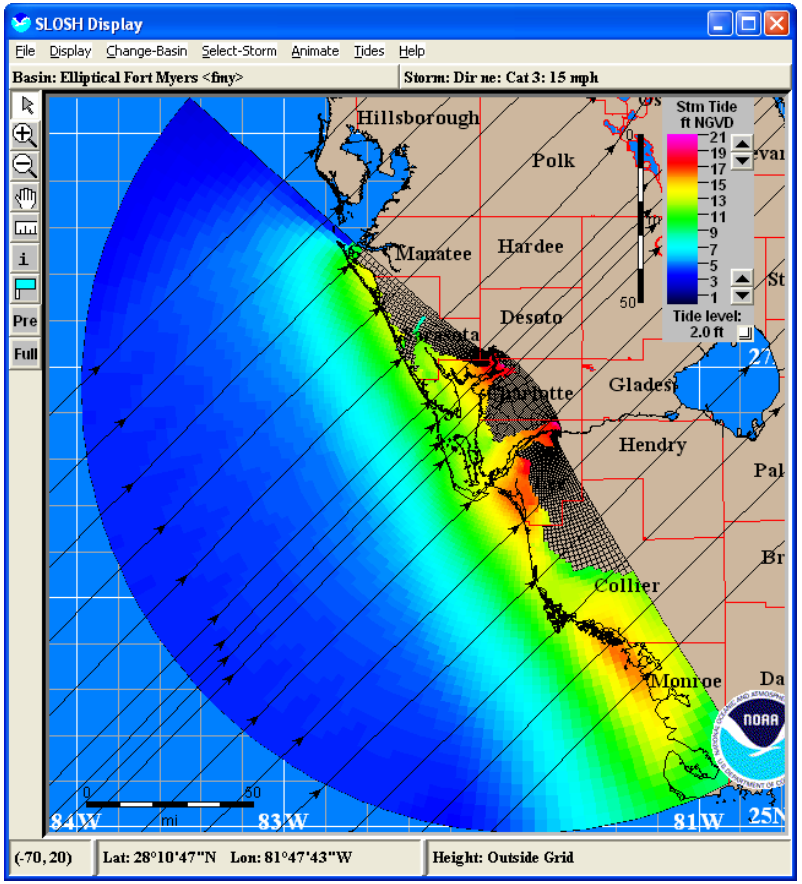
SLOSH Model Run

SLOSH Display Instructions: Once the surge heights are displayed in the map, click **File > Save to SHP**.

If this option is not available in your version of the SLOSH Display Program, please contact one of these developers:

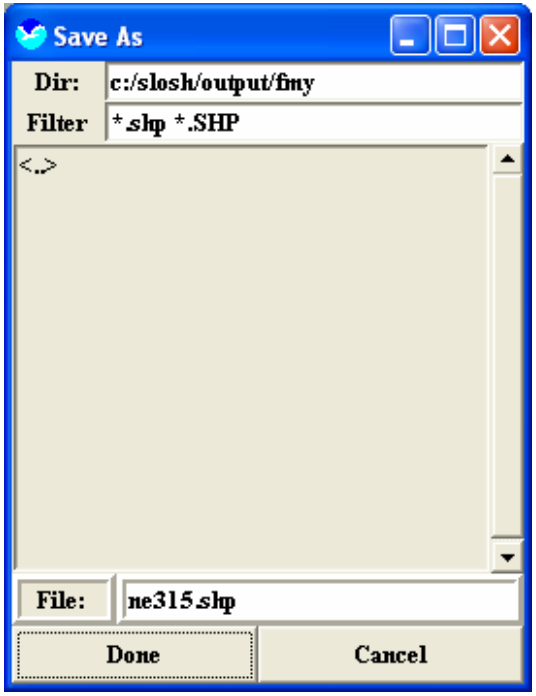
Arthur Taylor – (301) 713-1613, ext. 163 or
Arthur.Taylor@noaa.gov

Wilson (Wil) Shaffer – (301) 713-1613, ext. 167 or
Wilson.Shaffer@noaa.gov



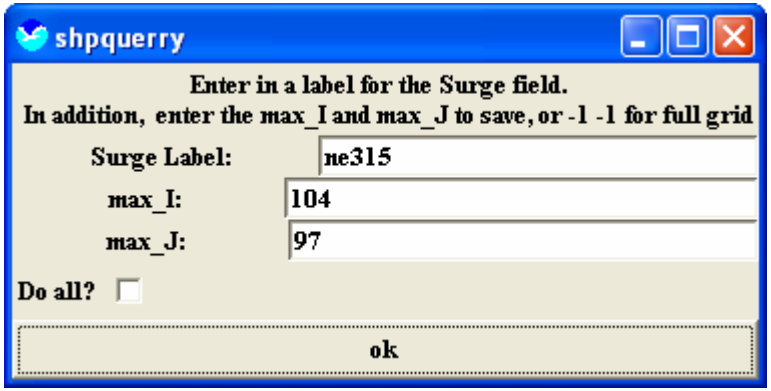
SLOSH Model Run

SLOSH Display Instructions: If you have enabled the SLOSH Display Program to save your data in the shapefile format, the following dialog box will open.



You have the ability to change the directory that the data will be saved to. Simply click on the **<..>** in the grey area and navigate to a new location. For the purposes of this module, you will take the default location. Notice the naming convention that will be used for the shapefile; “ne315” represents a storm heading toward the northeast that strikes the shore as a Category 3 moving at 15 miles per hour.

Click on the **Done** button. The next dialog window will open. You should simply take the default values given in the display and click **OK**. The shapefile of the SLOSH data for this area will copy into the given folder.



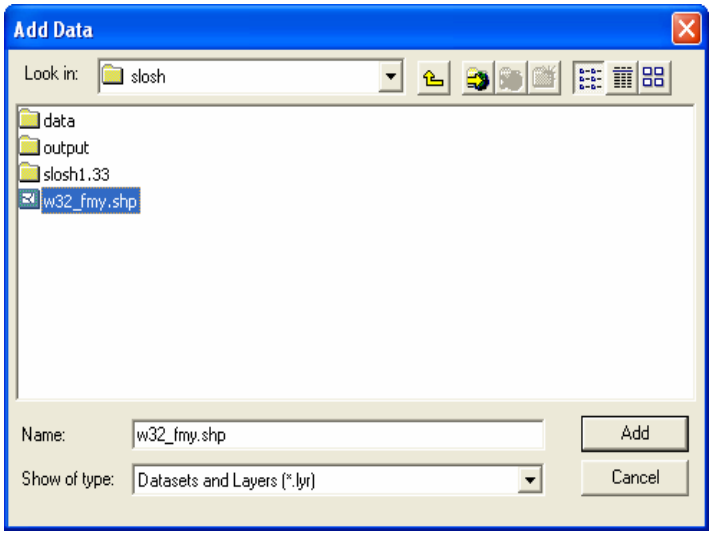
SLOSH Model Run

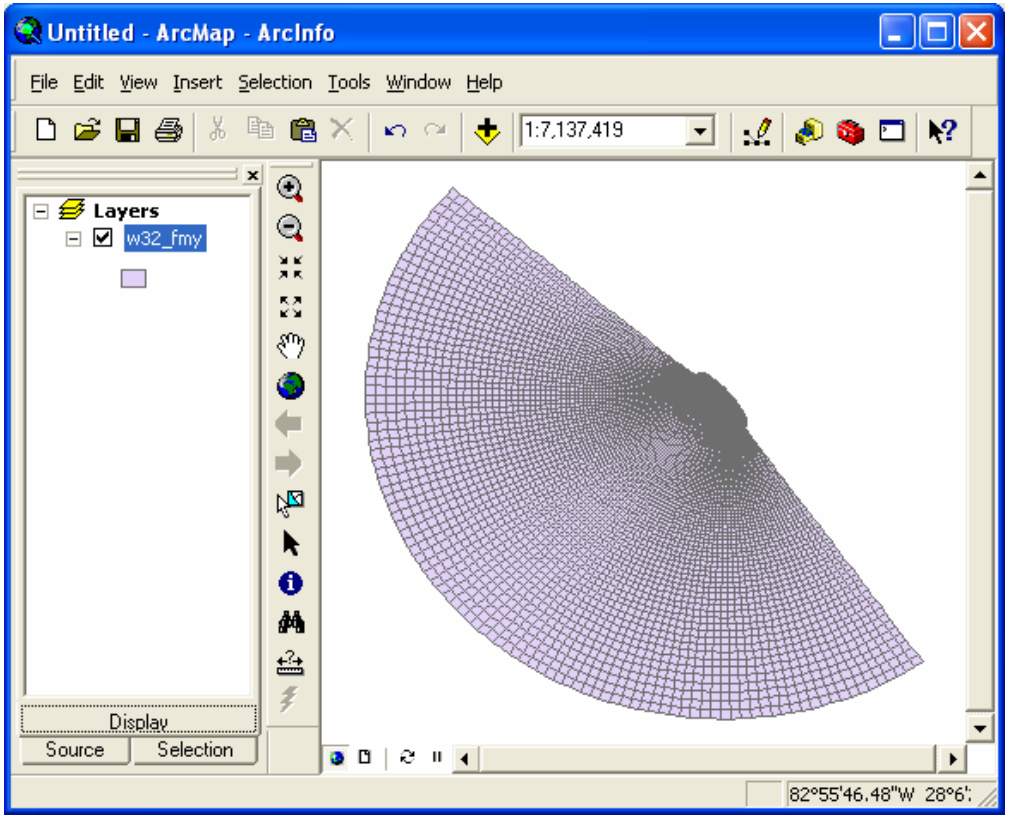
Download the data: Should you not have access to saving the SLOSH data as a shapefile, you can download the most recent shapefiles from *ftp://ftp.tpc.ncep.noaa.gov/users/surge*.

This page will provide shapefiles that depict the latest SLOSH model runs. The formatting of the shapefiles follows the convention [letter of storm][advisory number]_[basin abbreviation].[file extension]. Download all the files (.shp, .shx, .dbf) for the latest advisory for each affected basin to your hard drive or network drive with the exception of the .rex and .gif files. A map will need to be created for each of the latest SLOSH model runs for each basin.

SLOSH Model Run

View the data: Add the layer by clicking on the **Add Data** button found at the top of the ArcMap window. This brings up a dialog window that lets users browse to their data.

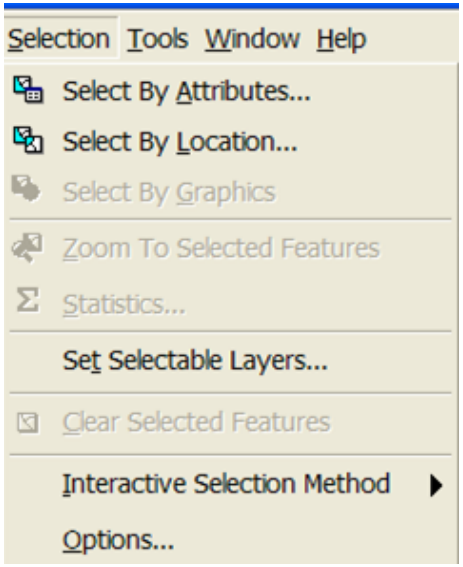




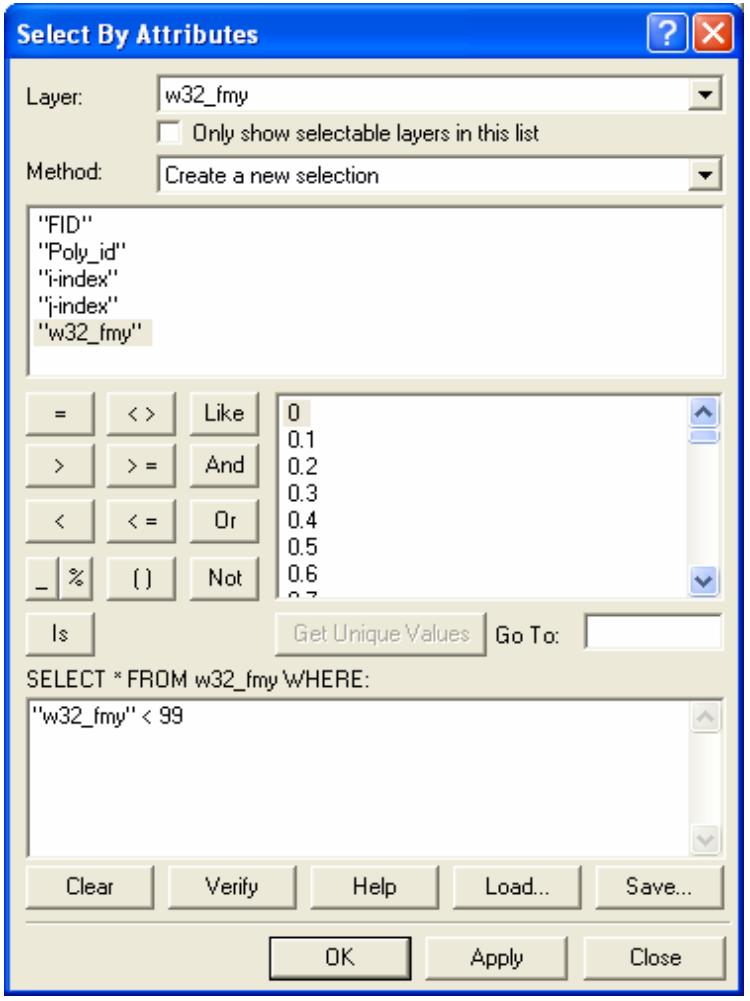
Select the SLOSH data that you want to work with and click **Add**. The layer now appears at the top of ArcMap's table of contents.

SLOSH Model Run

Work with the data: In ArcMap, go to the **Selection** pull-down menu and click on **Select by Attribute**.



1. Set the Layer to the SLOSH data that you are working on.
2. Make sure the Method is set to **Create a new selection**.
3. Under Fields, double-click on the field with the same name as your layer.
4. Single-click on the less than operator (**<**).
5. In the expression box, type in the number **99** at the end of the expression.
6. Make sure the Select by Attributes dialog box looks like the one pictured here and click **OK**.



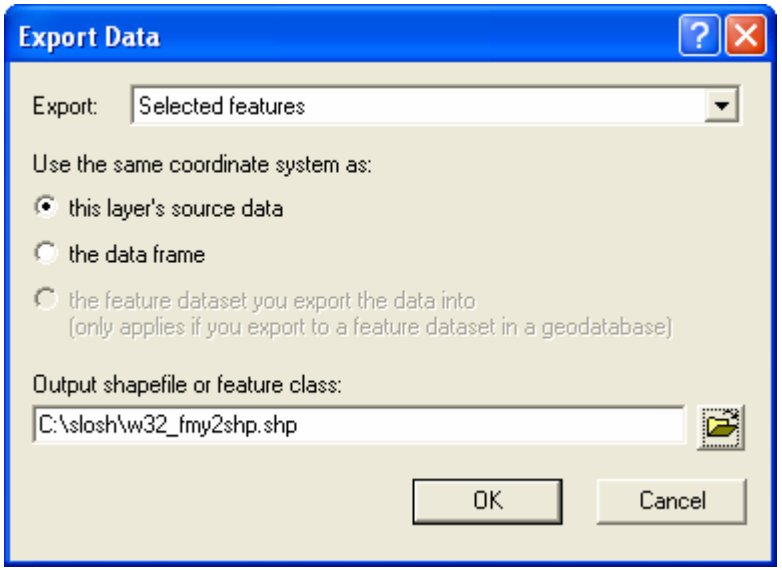
SLOSH Model Run

Add and symbolize the data: After the selection is made, right-click on the SLOSH layer and select the **Data** option from the context menu. From the Data menu select **Export**. Make sure **Selected features** is shown in the Export pull-down list. Use the same coordinate system as the layer's source data, and specify a name and location where you would like the new shapefile to be created. Click **OK**.

When asked if you want to add the exported data to the map as a layer, click **Yes**.

You have just created a new shapefile without the No Data value of 99.9 that was included in the original data downloaded from the National Hurricane Center.

Remove the original SLOSH data, leaving the layer you created in the last step.



SLOSH Model Run

Add and symbolize the data: Double-click on the new SLOSH data layer to open the Layer Properties dialog. Click on the **Symbology** tab.

In the Show menu, click on **Quantities**.

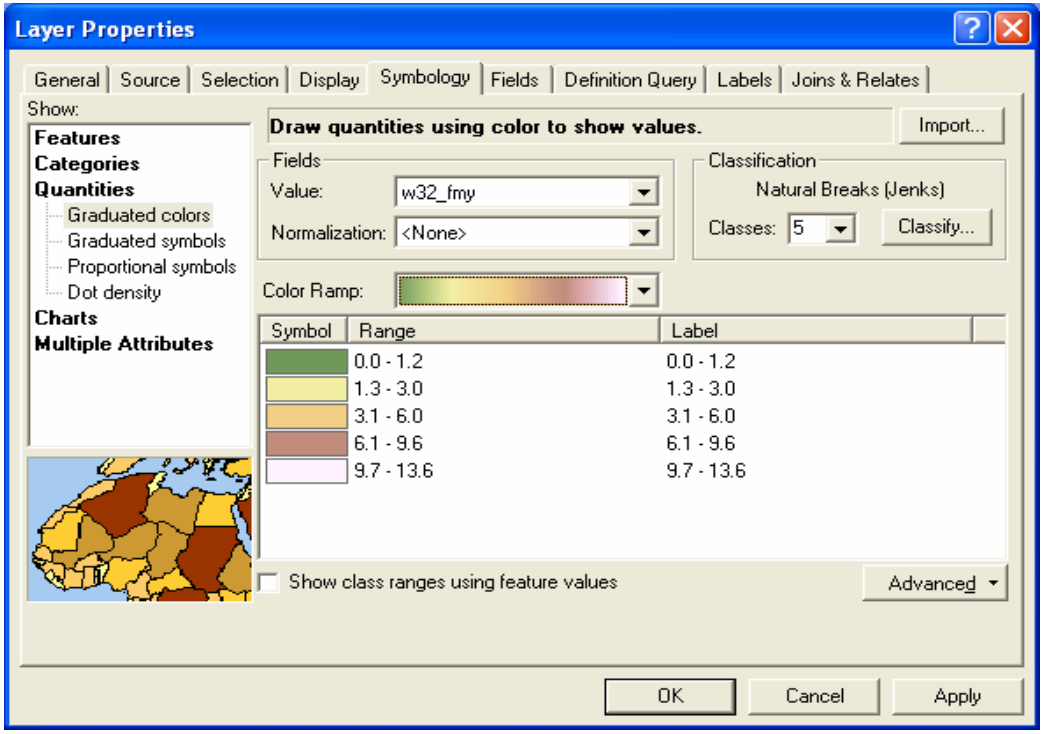
Under Quantities, make sure **Graduated colors** is selected.

Under Fields, change Value to the field that matches the name of your SLOSH layer.

You may get a dialog box that tells you that not all records are being used because the sample size is too small. Click **OK**.

Right-click on the Color Ramp. Click **Graphic View** from the available options. This changes the color ramp into a textual description of the color ramp.

Select the **Spectrum-Full Bright** color ramp.



SLOSH Model Run

Add and symbolize the data: Click on the **Symbol** header and select **Flip Symbols** so that higher amounts of inundation are assigned darker reds.

Click **Apply** to assign the new color ramp.

Click again on the **Symbol** header.

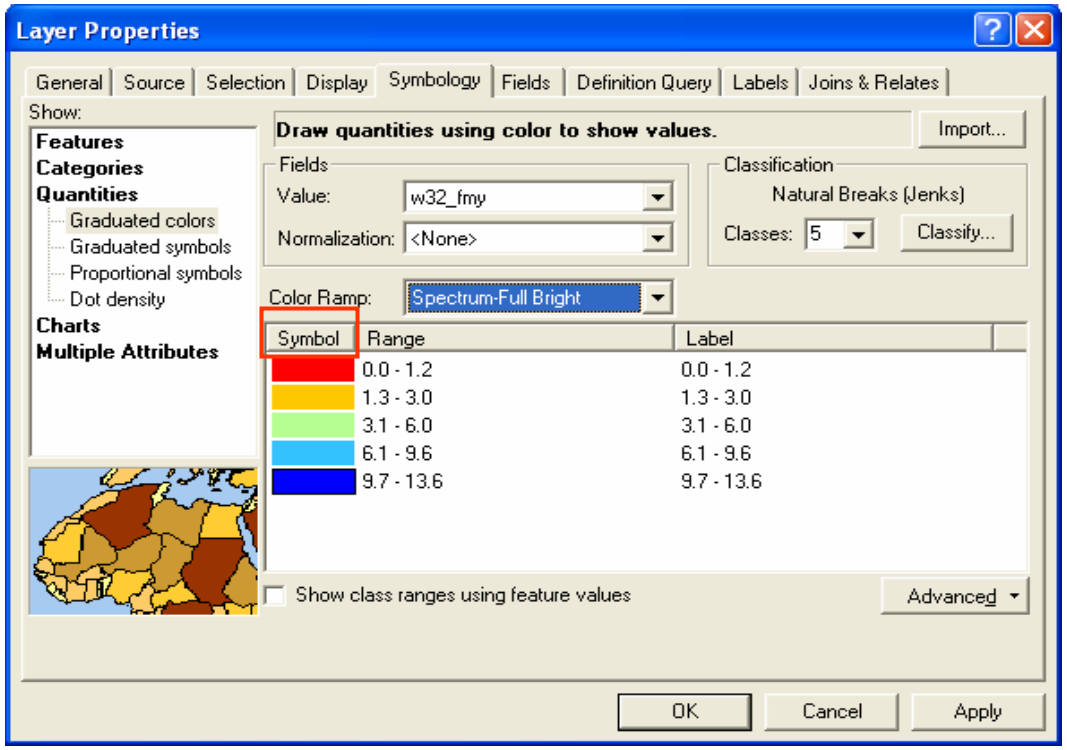
Select the **Properties for all Symbols** option.

In the Symbol Selector dialog box, under Options, click on the **Outline Color** pull-down menu and select **No Color**.

Click **OK** and **OK** again to close the Layer Properties box and apply all of the changes you have made to the symbology of the SLOSH data layer.

This will remove the outline around each polygon and make the SLOSH data appear more continuous.

Click **OK** to make these changes in the view.



SLOSH Model Run

Add and symbolize the data: You now have the SLOSH data symbolized in a meaningful way. You might want to add a state boundary layer for display purposes.

Click on the **Add Data** button and browse to the directory that houses your base layer shapefiles.

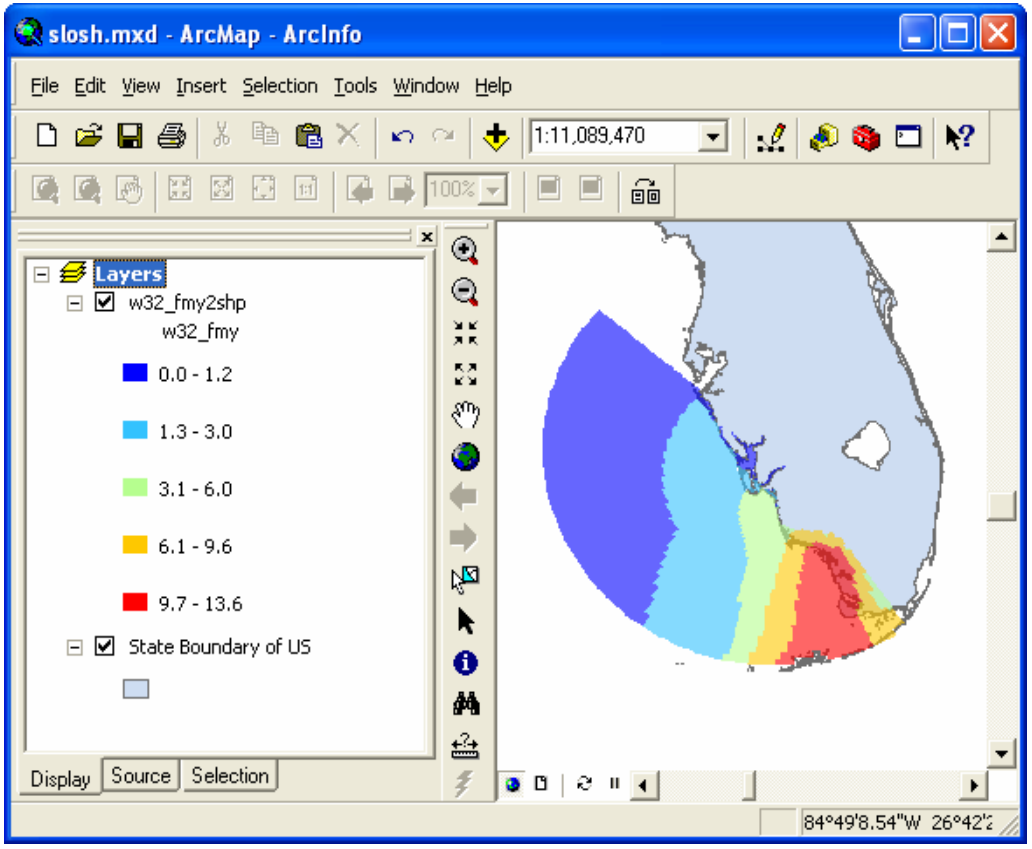
Add a states layer to your map.

Make sure that the SLOSH layer is on top of the state layer.

Open the SLOSH Layer Properties and click on the **Display** tab.

Set the transparency level to **40%** and click **OK**.

Save the symbology of the SLOSH layer. Right-click on the layer, and select **Save As Layer File**. Browse to the SLOSH folder on your hard drive, and click **OK** to accept the default name of the new .lyr file.



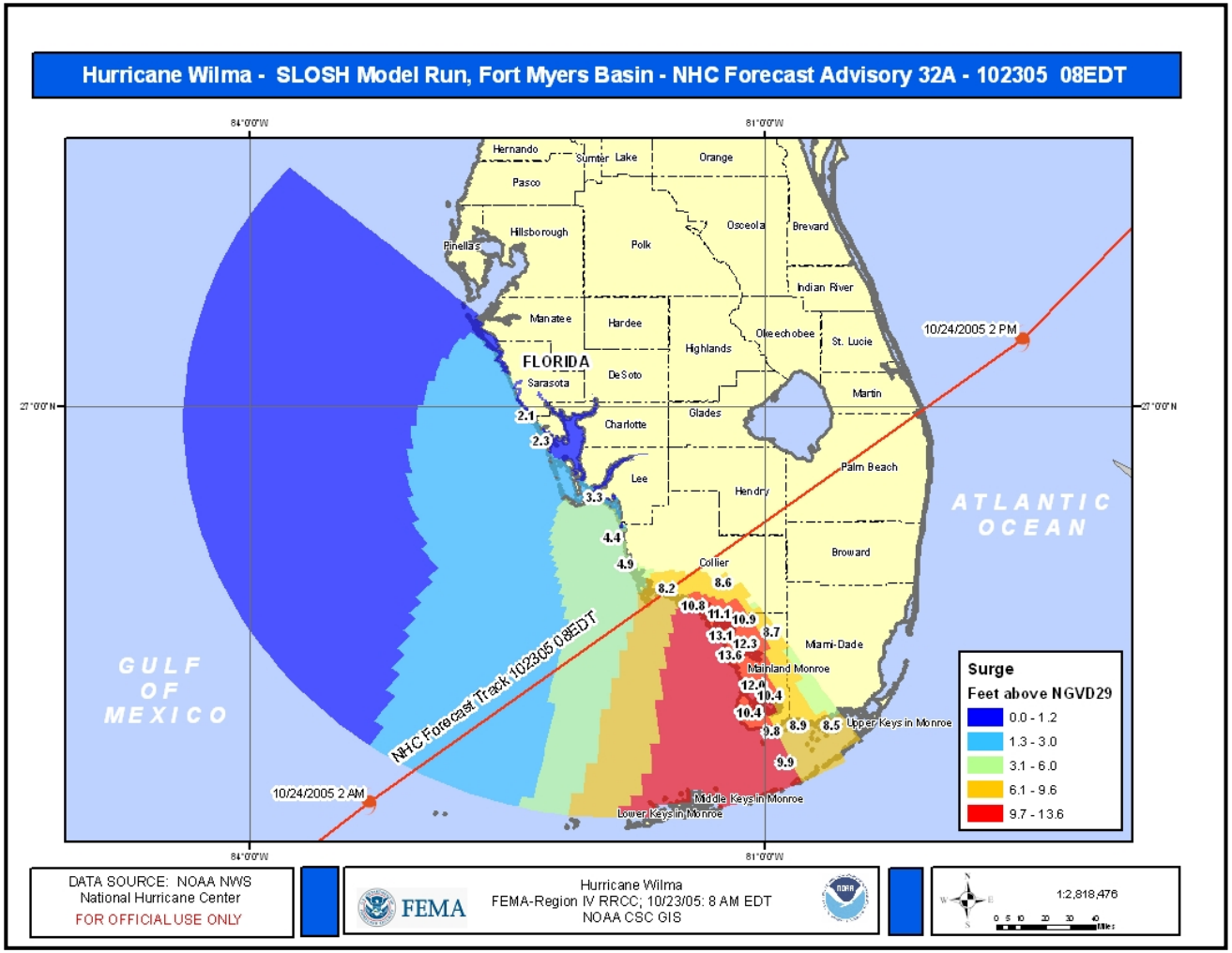
SLOSH Model Run

Add and symbolize the data: You now have symbolized SLOSH data and a state boundary displayed together.

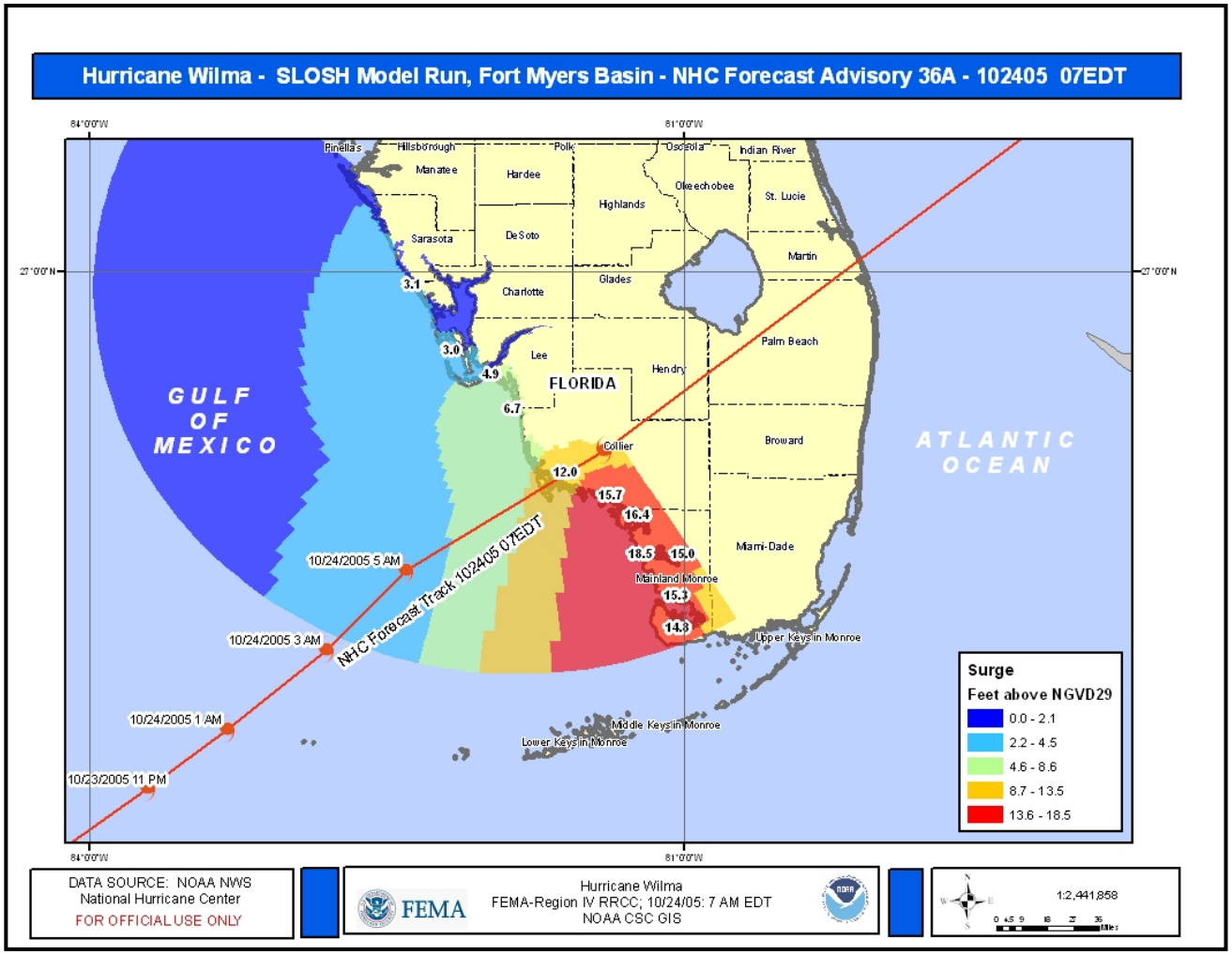
At this point you are ready to begin making a map of your SLOSH data. Several examples follow that show what the NOAA Coastal Services Center has provided to members of FEMA in the past.

Refer to the “Basics of Cartography” chapter at the end of this manual for addition information.

SLOSH Model Run



SLOSH Model Run



6-Hour Flash Flood Guidance

Purpose: This type of map presents a 6-hour estimate for flash flooding in given areas. National Weather Service River Forecast Centers (RFC) routinely issue flash flood guidance throughout the day for every county in their areas. Flash flood guidance estimates the average number of inches of rainfall for given durations required to produce flash flooding in an indicated county. These estimates are based on current soil moisture conditions. Note that in urban areas, less rainfall is required to produce flash flooding. The higher the flash flood guidance values, the more rainfall the soil will be able to absorb, and thus the less likelihood of flash flooding. The lower the values, the less rainfall the soil will be able to absorb, and thus the more likelihood of flash flooding. Areas that have received large amounts of antecedent rainfall will be more susceptible to flash flooding because the soil will not be able to absorb as much rainfall and will therefore have lower flash flooding guidance values. Keep in mind that flash flood watches and warnings are always issued by local weather forecast offices.

Source Data: This type of map uses data that originate from the NOAA National Weather Service's (NWS) Southern Region Headquarters.

Download: Open a Web browser and visit the NWS Flash Flood Guidance Web site:
www.srh.noaa.gov/rfcshare/ffg.php?location=SR

This tutorial will demonstrate how to download data from this Web site, bring it into ArcMap, and create a presentation map using other data sets.

6-Hour Flash Flood Guidance

Download the data: Once on the Web site (*www.srh.noaa.gov/rfcshare/ffg.php?location=SR*), select the specific product that you want to download. In this case, select **6 Hour Flash Flood Guidance**.

Choose which state has the flash flood guidance data you want. For this example, select Florida.

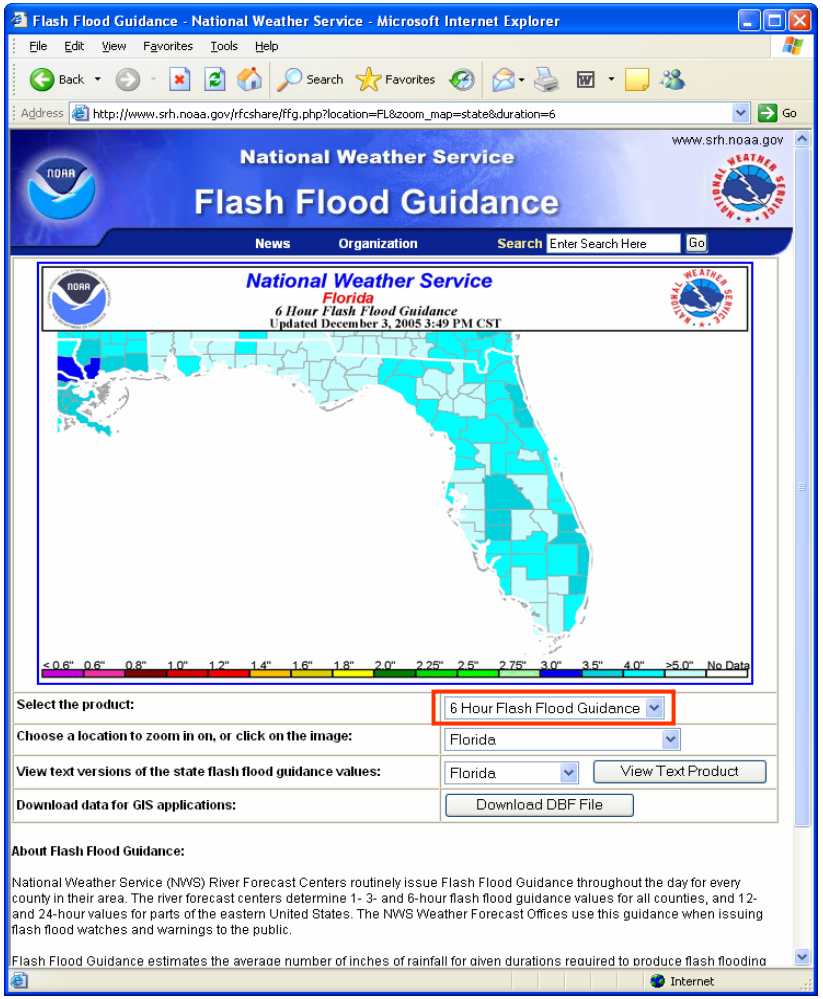
Begin the downloading process by clicking on the **Download DBF File** button.

This will open another window in your browser.

An important note: The flash flood guidance (FFG) shapefiles may be updated at 2:45, 7:45, 8:45, 9:45, and 10:45 a.m. – and 12:45, 1:45, 3:45, 7:45, 8:45, 9:45, and 10:45 p.m. These times are Eastern Standard Time (EST).

The frequency and times when each River Forecast Center (RFC) updates its FFG values will vary quite a bit. Some RFCs only update once daily, while others update four times a day.

The graphics and DBase (.dbf) files are run more frequently in the morning between 7:45 a.m. and 1:45 p.m. and then again during the evening hours around midnight to include the latest FFG possible from the RFCs.



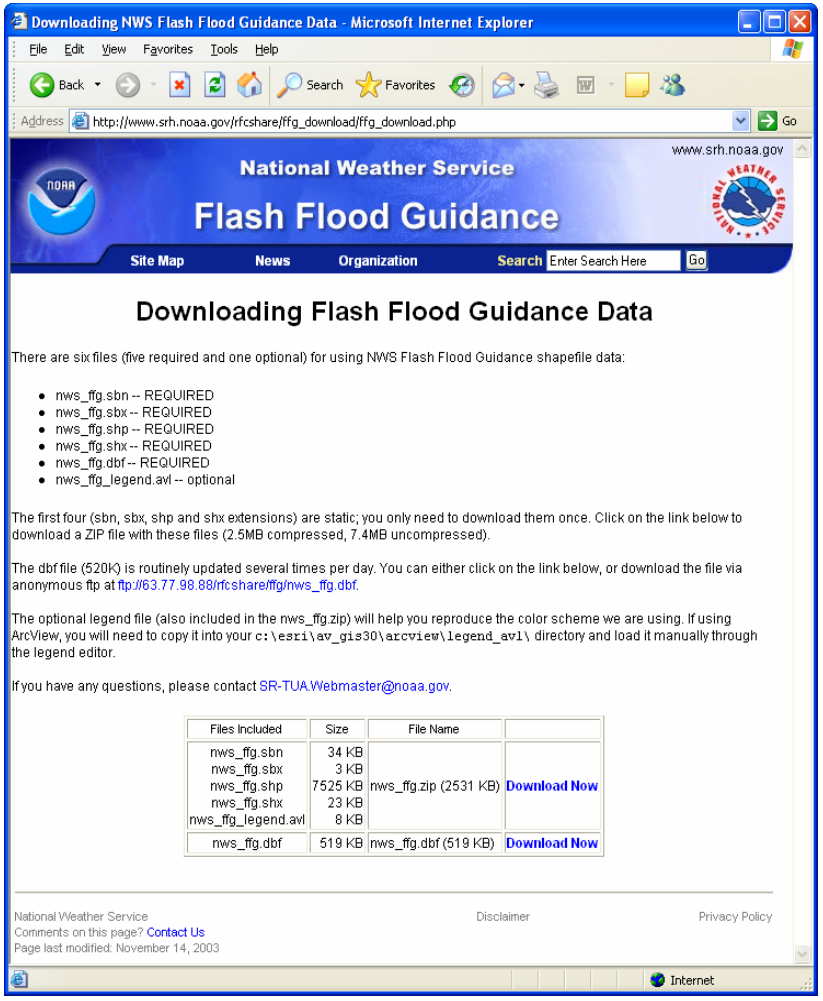
6-Hour Flash Flood Guidance

Download the data: There are two files to download.

The first is a .zip file that has a compressed ESRI shapefile for the state and its county boundaries. This shapefile is static in nature and does not change.

The second is a table of data values that are stored in DBase format (.dbf). The values in this table change several times a day. Keep in mind that this file will need to be downloaded each time you want to make a current map of flood forecast guidance values.

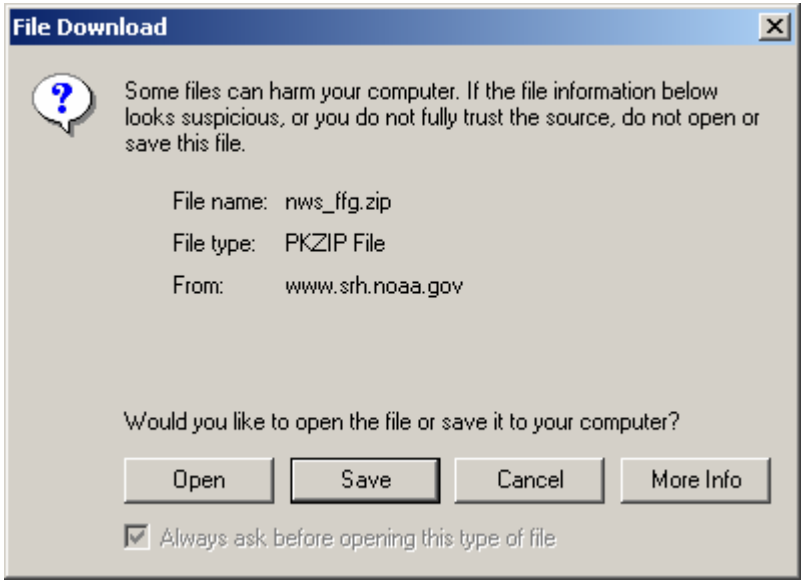
Click on the **Download Now** link for the shapefile that is compressed in the .zip format.

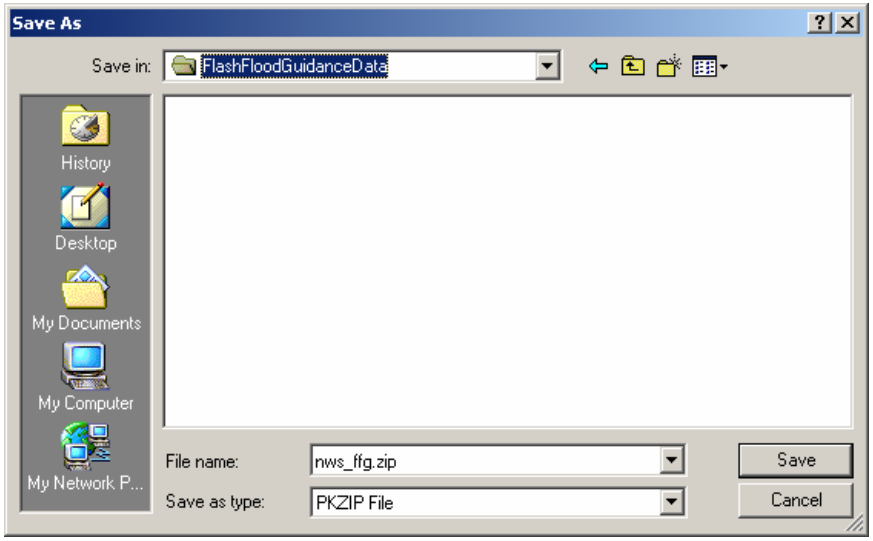


6-Hour Flash Flood Guidance

Download the data: When prompted in the File Download window, click on the **Save** button to browse to a folder on your hard drive where the data will reside.

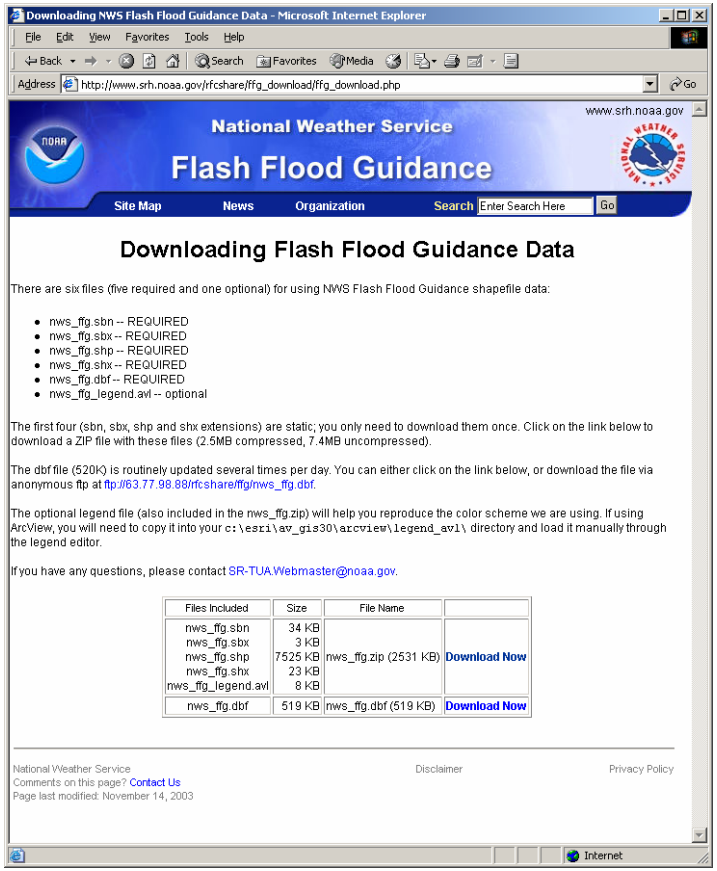
You should create an empty data folder that has a name which is easy to remember. Once created, click on the **Save** button.

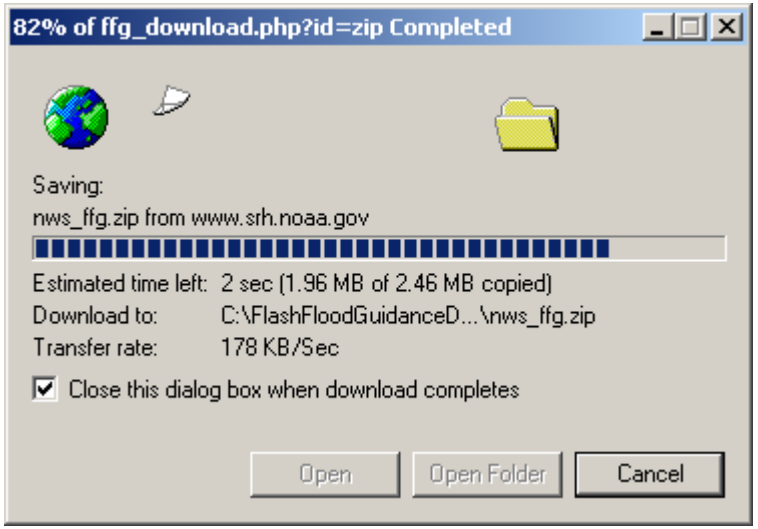




6-Hour Flash Flood Guidance

Download the data: After several moments, the data will download into your new data folder.

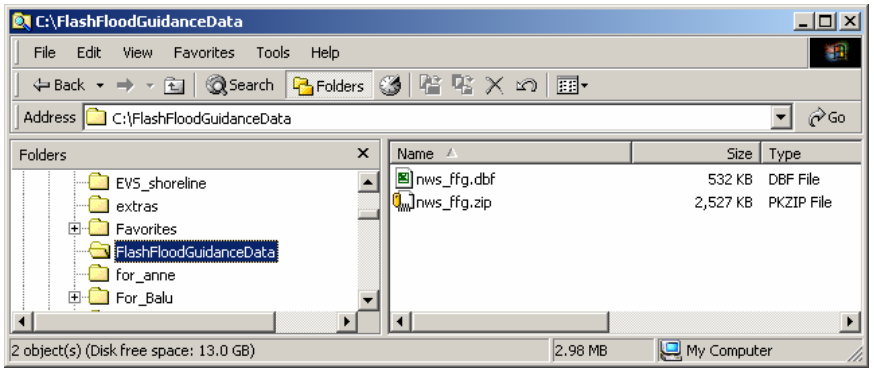




Return to the Web browser and repeat this process for the .dbf table. Remember to save the file into the same folder as the .zip file. This is a very important thing to remember: the shapefile will only work properly if it is coupled with the .dbf table. If they are not in the same folder, then the shapefile is not complete.

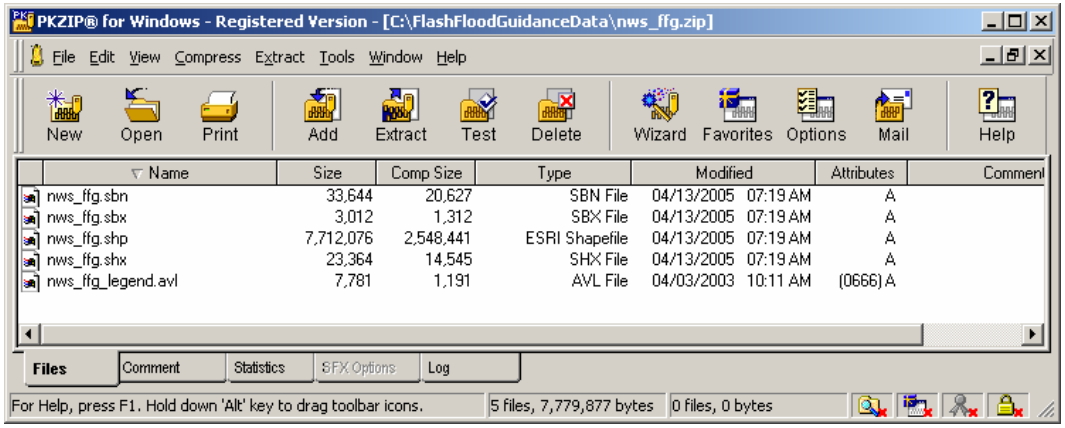
6-Hour Flash Flood Guidance

Download the data: Once the .dbf table is saved to your hard drive, open Windows Explorer to view the two files. Navigate to the data folder.



The individual files contained within the .zip file need to be uncompressed. Double-click on the .zip file to start a compression utility program on your PC. Examples may include WinZip or PKZip.

Once the program opens and loads the .zip file, you will see the individual files that comprise the shapefile (minus the .dbf table).



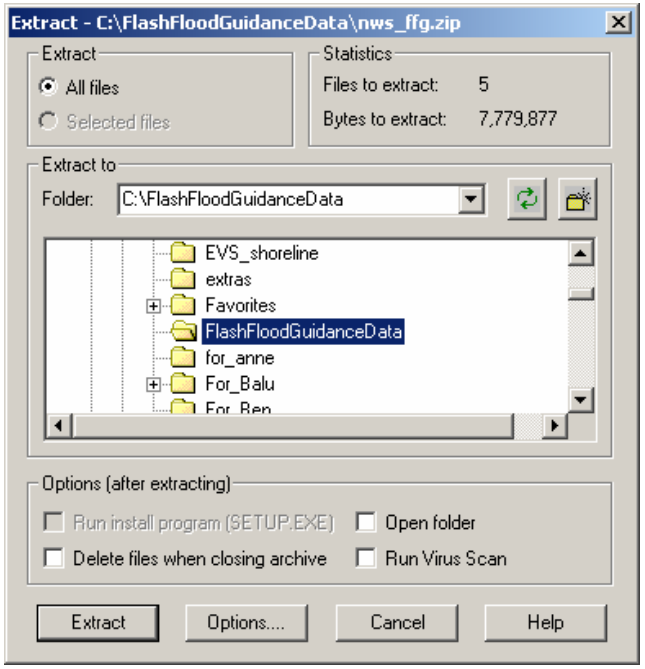
Click on the **Extract** button to specify where the data should be written.

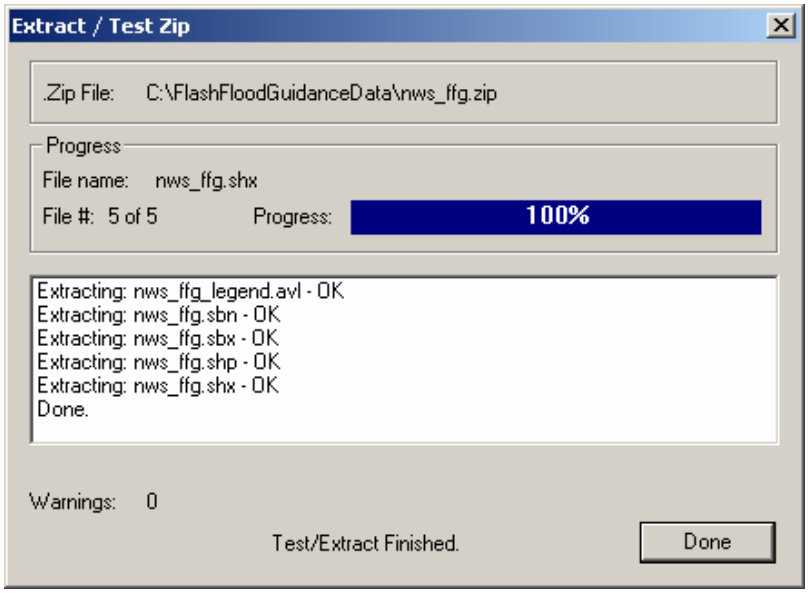
6-Hour Flash Flood Guidance

Download the data: In the Extract window, navigate to the data folder where the original downloaded files exist. You want to keep all of these files together. Click **Extract**.

You will now see the individual files uncompressing. Click **Done** when this process is complete.

Close the .zip utility program.



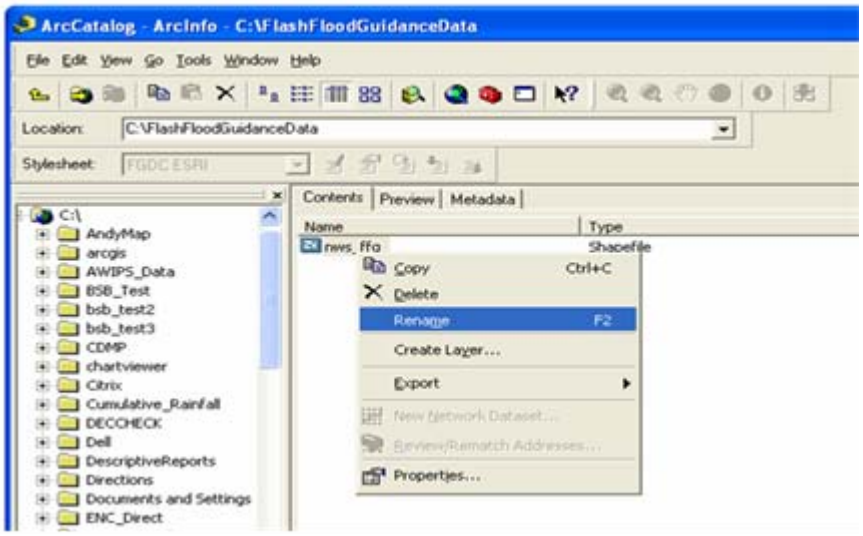


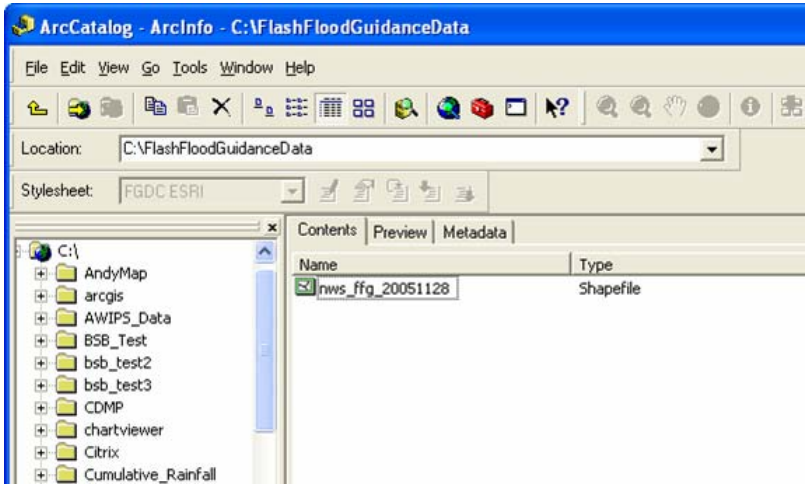
6-Hour Flash Flood Guidance

Rename the layer: Open ArcCatalog to rename the shapefile to include the date. Click on **Start > Programs > ArcGIS > ArcCatalog**.

Once the program opens, browse to the directory that contains the FFG layer. Right-click on the layer and select **Rename**. It will be a good idea to add the date of the data so the file can be distinguished from other FFG data.

Once the date has been added to the end of the file, you are ready to proceed to the next step.



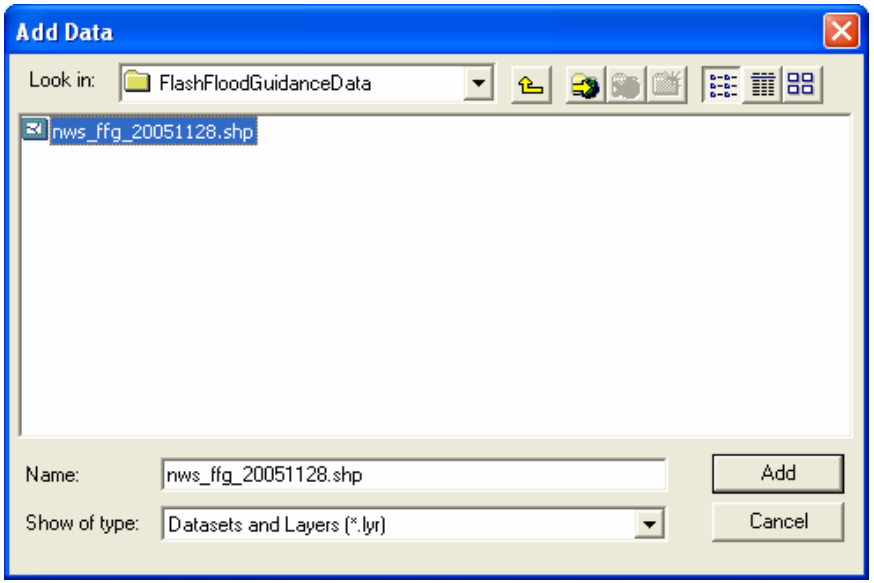


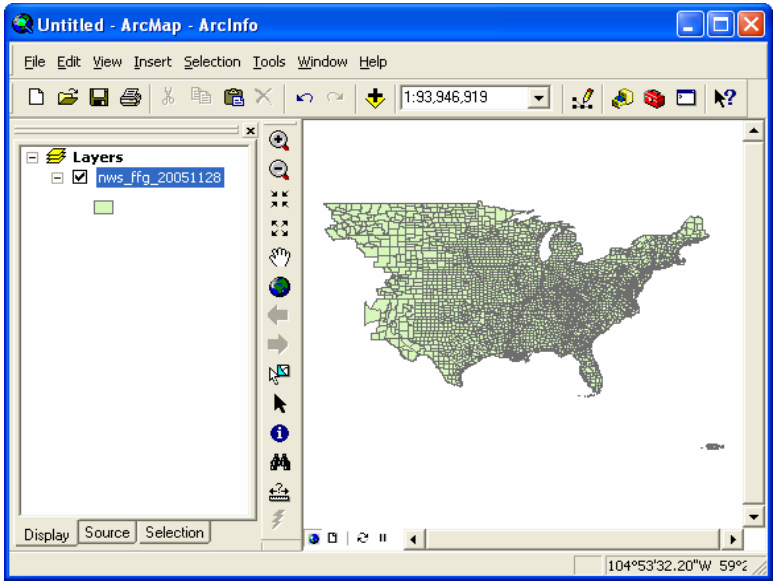
6-Hour Flash Flood Guidance

Add and symbolize the data: Open ArcMap to add the shapefile. Click on **Start > Programs > ArcGIS > ArcMap**.

Once the program opens, click on the **Add Data** button that is found at the top of ArcMap.

This will start the dialog window that lets users browse to their data. Navigate to the data folder and select the shapefile. Click **Add**.



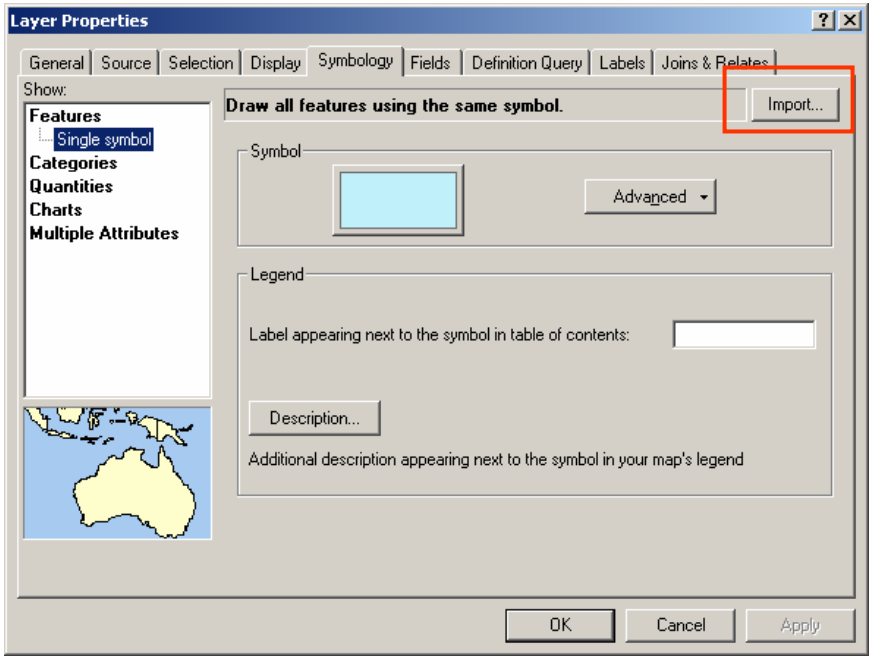


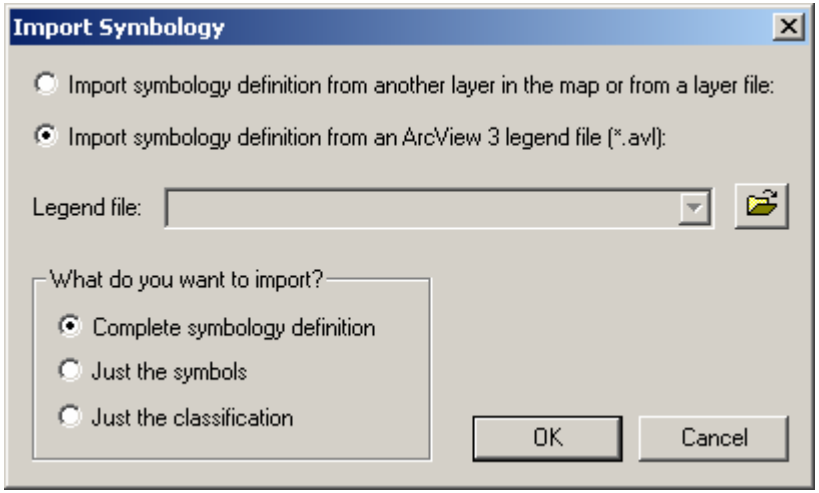
The shapefile is then added to ArcMap's table of contents. Notice that this shapefile contains only a portion of counties within the United States, so do not be alarmed if you see similar results.

6-Hour Flash Flood Guidance

Add and symbolize the data: You will symbolize these counties by their reported Flash Flood Guidance Value for the next 6 hours. Right-click on the name of the layer in the table of contents and select its **Properties** at the bottom of the context menu.

Included with the shapefile you downloaded is an ArcView Legend file (.avl). This will provide the proper symbology to assign to the counties. Select the **Symbology** tab and then click on the **Import** button to begin this process.



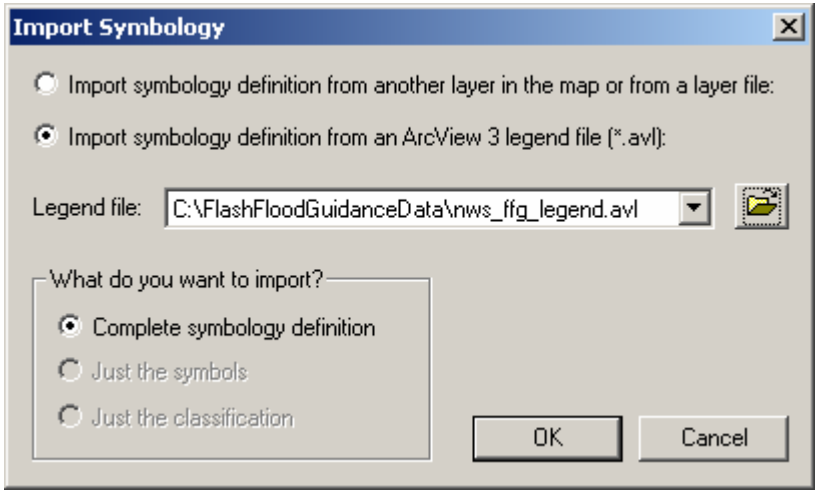


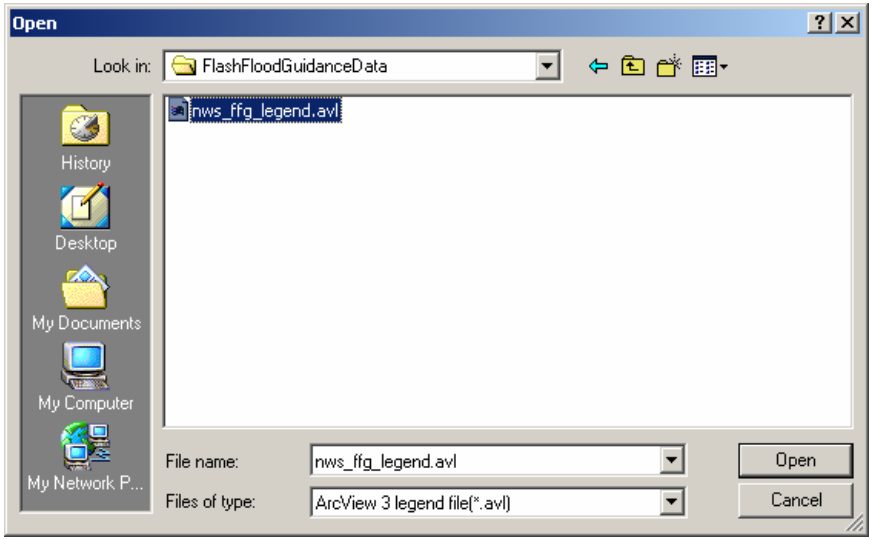
Once the Import Symbology window opens, select **Import symbology definition from an ArcView 3 legend file (.avl):**. Click on the **Browse** button (yellow folder).

6-Hour Flash Flood Guidance

Add and symbolize the data: Navigate to the data folder and select the .avl file that is saved there. Click on the **Open** button.

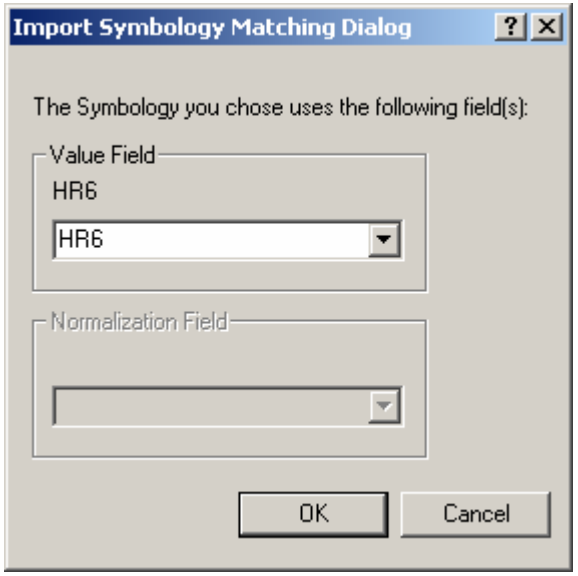
Once the path to the proper legend file is established, click **OK**.



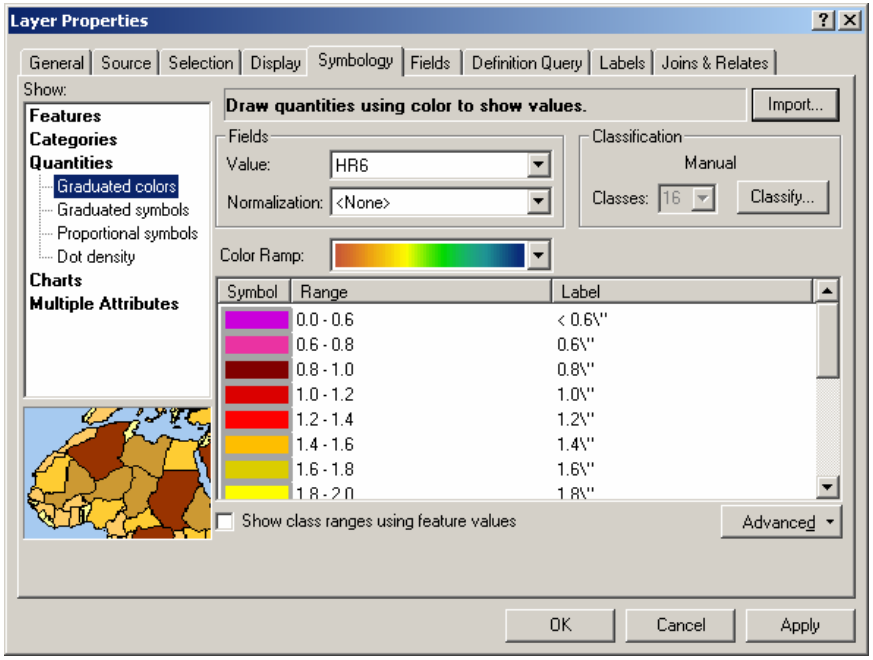


6-Hour Flash Flood Guidance

Add and symbolize the data: The following window will open and prompt you for the specific Value field in the attribute table you want to assign symbology. Click on the drop-down menu, select **HR6**, and then click **OK**.



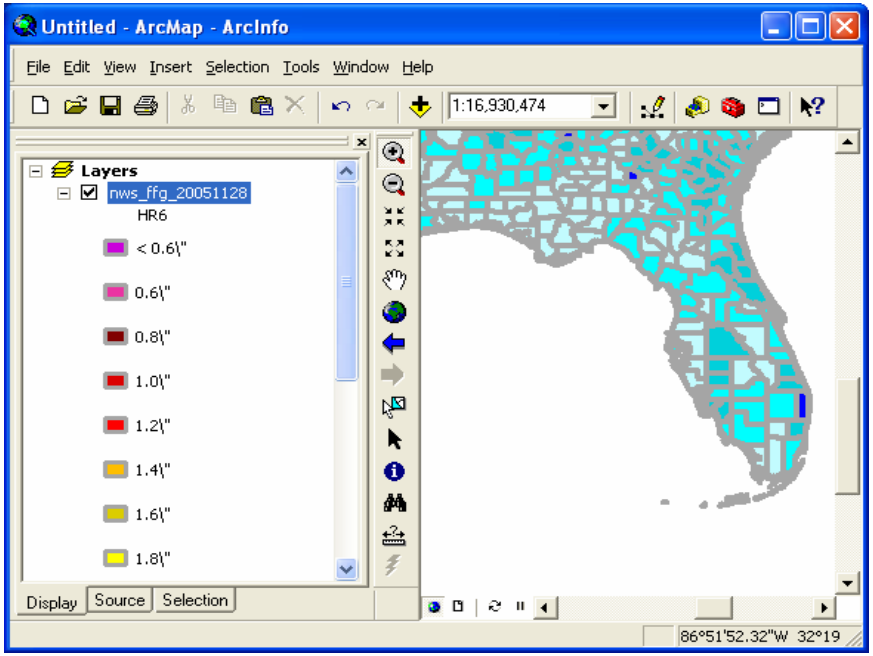
You will see the predefined symbology appear in the Layer Properties window. After you have reviewed the classes, click **OK** to assign the symbology.

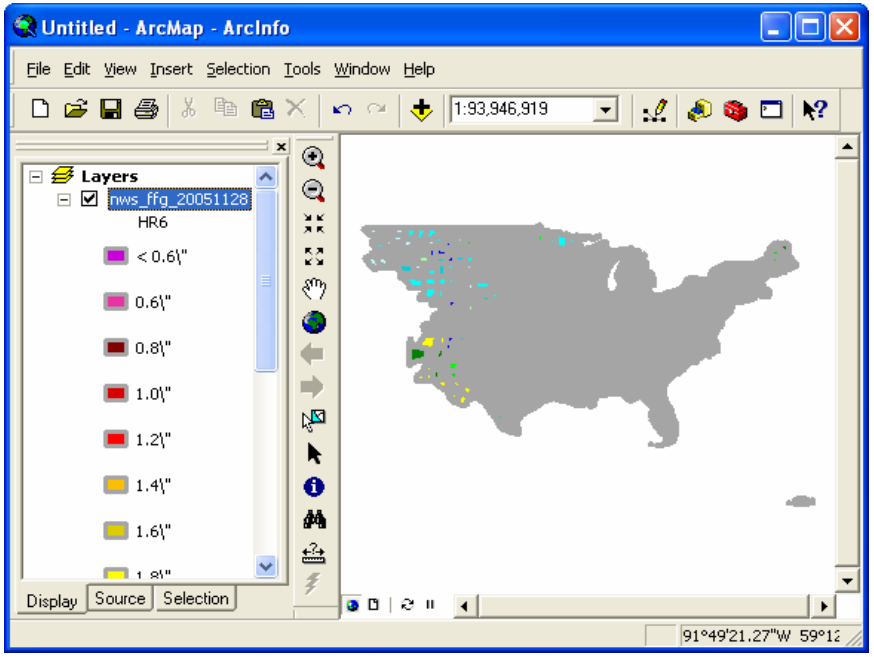


6-Hour Flash Flood Guidance

Add and symbolize the data: Notice that the symbology is now assigned to the layer. Zoom in to Florida to get a closer look at the data for that state.

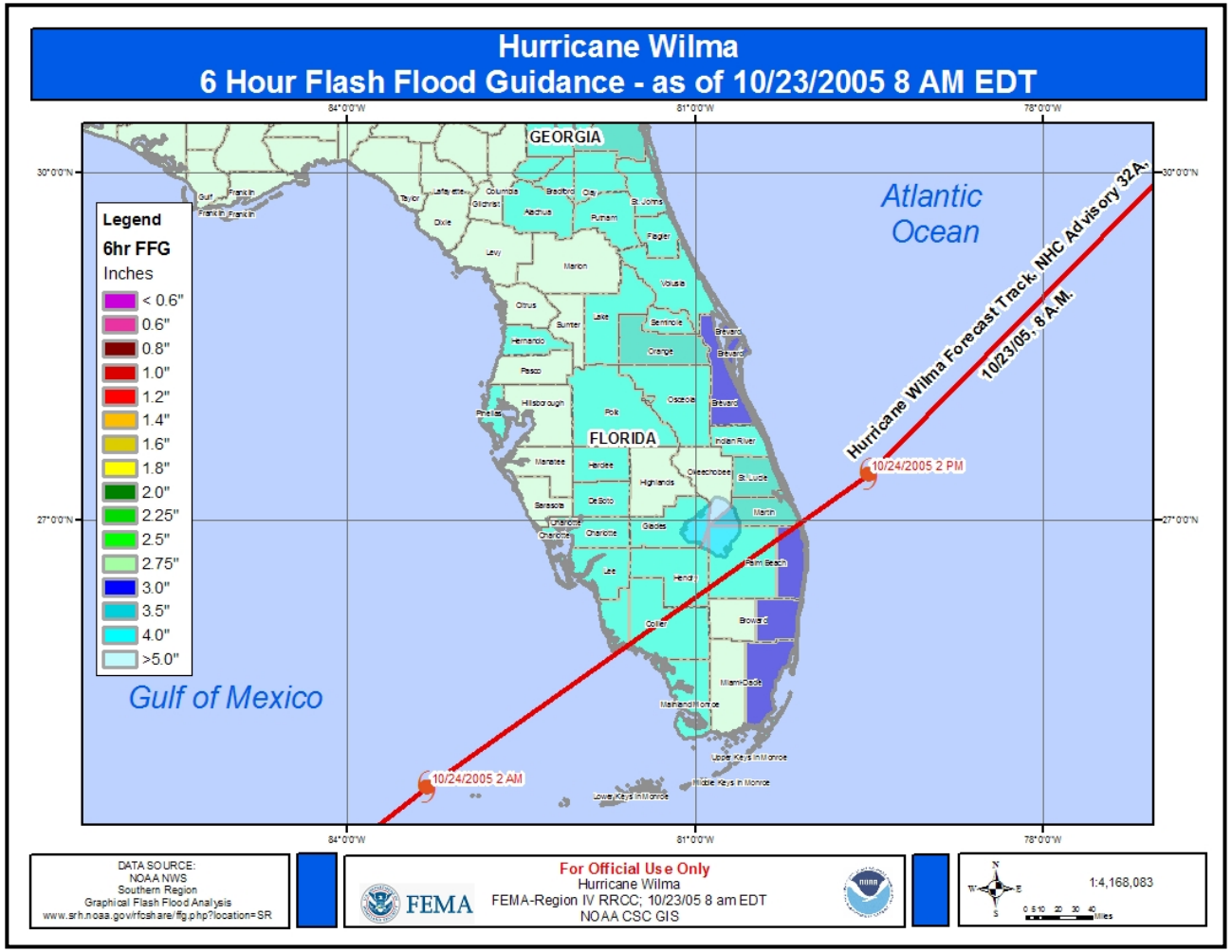
At this point you are ready to begin making a map. Several examples have been included of what the NOAA Coastal Services Center has provided to members of FEMA in the past.



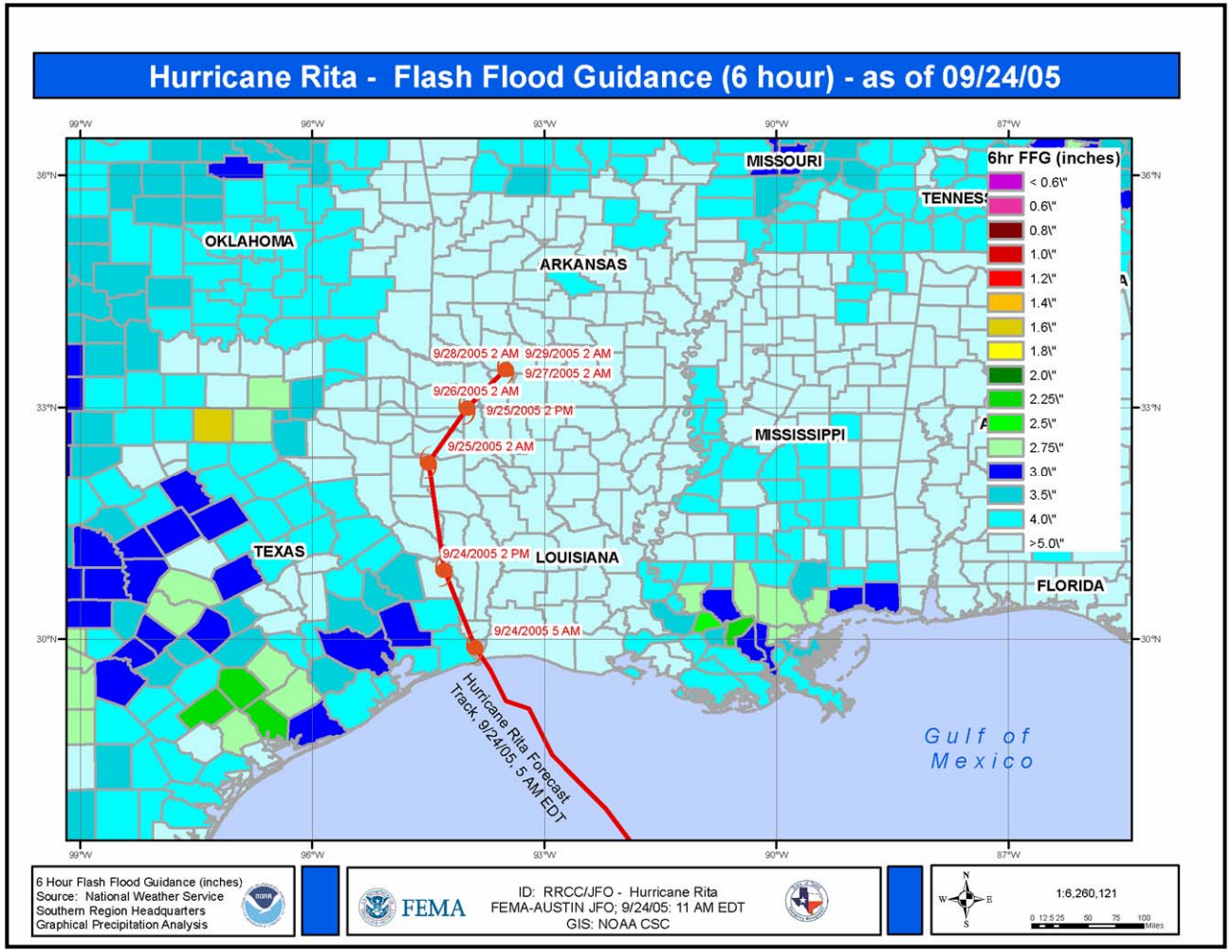


Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.

6-Hour Flash Flood Guidance



6-Hour Flash Flood Guidance



120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Purpose: See the definitions of the 120-Hour Quantitative Precipitation Forecast (QPF) and 6-Hour Flash Flood Guidance (FFG) products for individual product descriptions. This comparison takes the 120-hour QPF and 6-hour FFG values and converts them to rasters using the same grid cell sizes and subtracts the 6-hour FFG values from the 120-hour QPF. The result is a raster with positive and negative values. The positive values indicate amount of rainfall (inches) forecasted by the 120-hour QPF that is above the 6-hour FFG. This can be used to show the areas that will exceed the 6-hour FFG based on the rainfall predicted to occur over the next 120 hours. The resulting map shows (in inches) the amount of rain that is forecast to fall over 120 hours that will be above the 6-hour FFG values. Thus, one can infer that this amount will be available to become 100% runoff and that these areas are vulnerable to flash flooding.

CAUTION: The 120-hour QPF values are the total rainfall predicted over 120 hours. There is no indication of amount in smaller time increments, like 6 hours. Therefore, this comparison may not be accurate because the total QPF amount may not fall in a 6-hour period. This should only be used as guidance to determine where flash flooding potential is likely to occur over a 120 -our period.

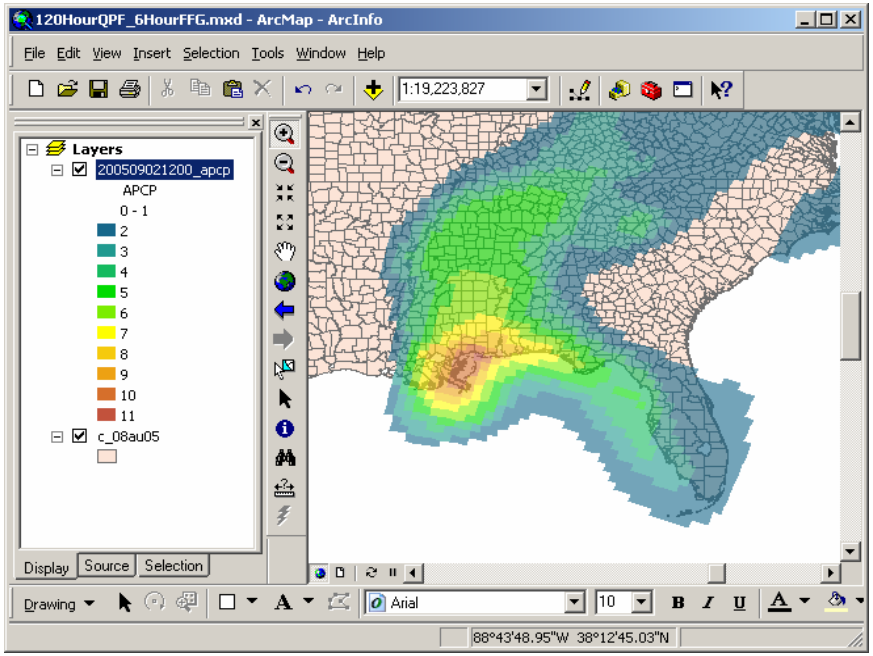
Source Data: This type of map uses data that originate from the NOAA National Weather Service's (NWS) Southern Region Headquarters.

Download: Refer to the 120-Hour QPF module for download instructions for those data.

Refer to the 6-Hour Flash Flood Guidance Value module for download instructions for those data.

120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Follow the directions to download and process the 120-Hour QPF data for a given study area. Your results should look like the following example. Be sure to add a state or county boundary layer to help identify the area of concern.



To compare the 120-hour QPF data to the 6-Hour Flash Flood Guidance layer you need to convert each to a raster with equal sized cells. Use the Spatial Analyst extension to perform the feature (shapefile) to raster conversion.

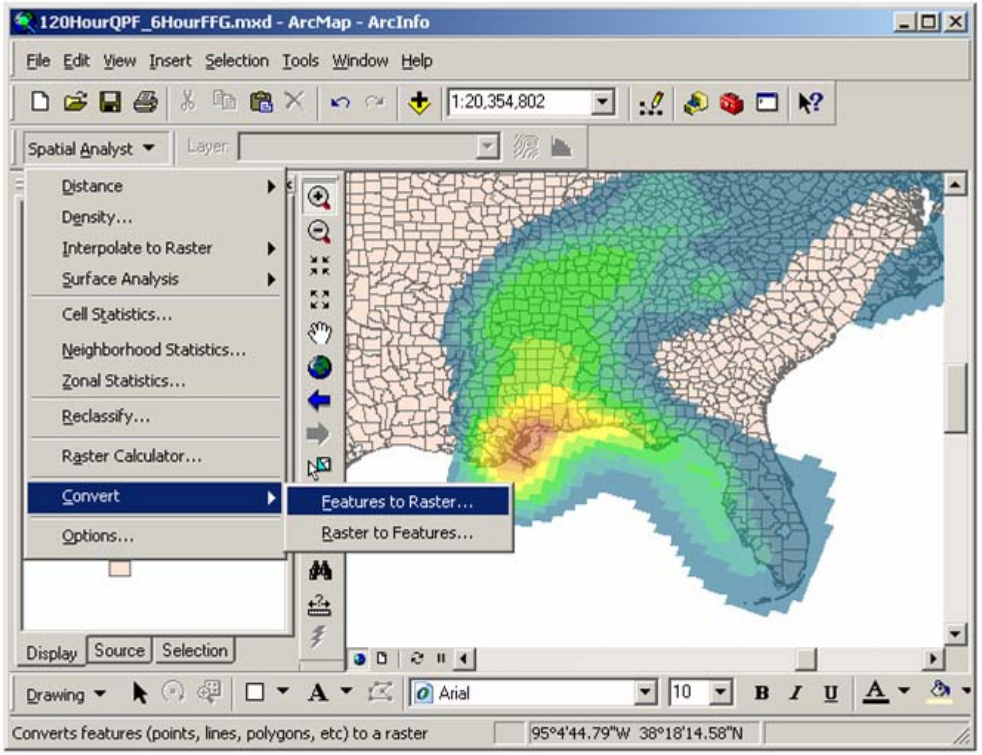
To use Spatial Analyst, click on **View > Toolbars > Spatial Analyst**. You will see the toolbar appear inside ArcMap.

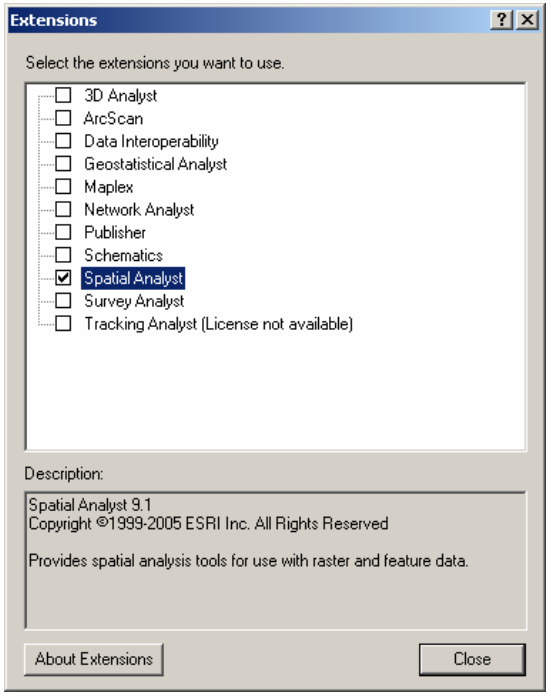
You can drag and dock this toolbar to the ArcMap window or let it “float” around in ArcMap. You should now enable the extension by clicking on **Tools > Extensions**.

120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Once the extension window appears, check on **Spatial Analyst** to enable the extension. Click **Close**.

Click on the **Spatial Analyst** menu and select **Convert > Features to Raster** as demonstrated in the graphic below.

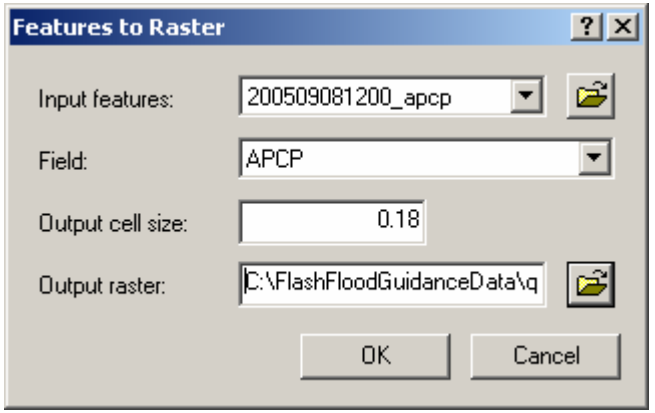




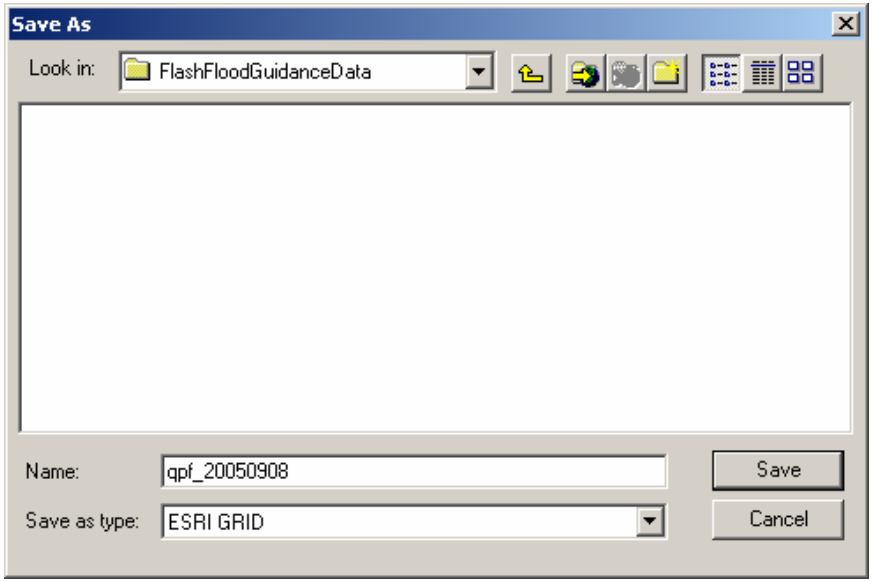
120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: In the Features to Raster dialog, set the Input features layer as the QPF layer. To ensure the correct attribute data are transferred from the polygon layer to the raster, set the Field drop-down to **APCP**.

Set the Output cell size as **0.18**. This should also be the same cell size used for the 6-Hour FFG layer.



Lastly, browse for a directory to write this new raster into. Remember that because this is a raster, there is a 13-character limitation in the file name. It is also a good idea to capture the cumulative date of the QPF.

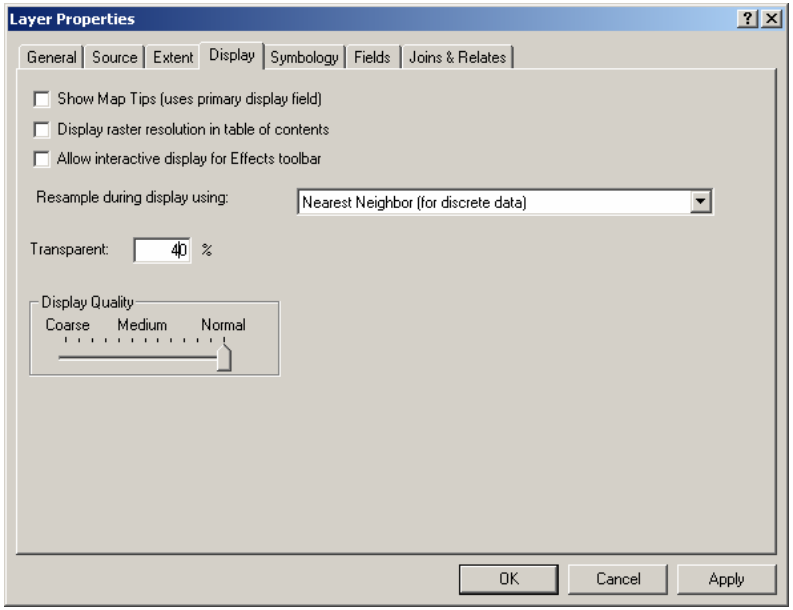


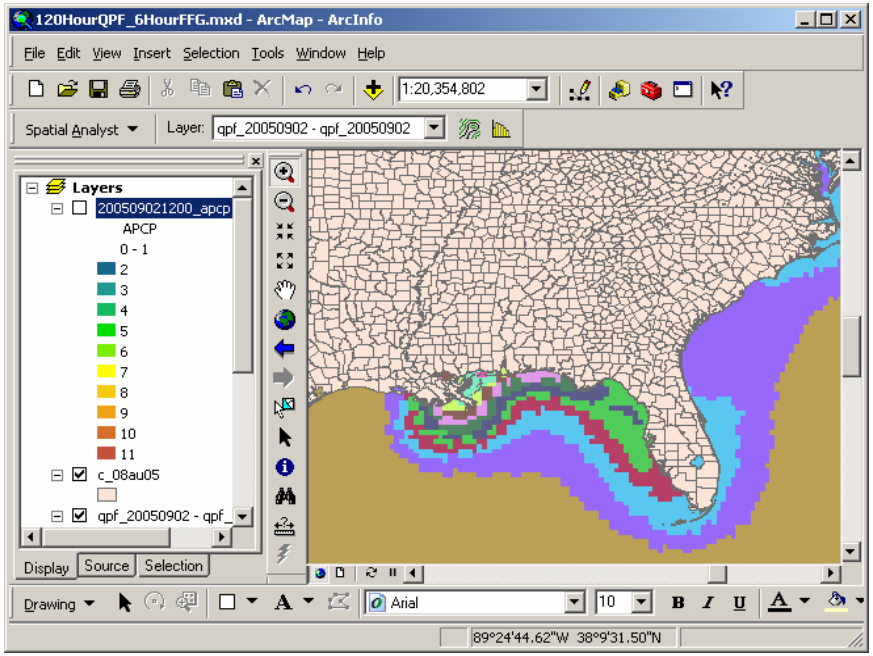
Click **Save** when you are done.

120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Notice that the raster is added at the bottom of the table of contents and looks similar to the original polygon layer. One big difference is that the cells are now in a horizontal/vertical orientation, whereas they were oriented diagonally in the polygon layer. This won't pose a problem since the spatial extent of the cells is basically the same.

View these data better by turning off the original polygon layer and dragging the new raster above the county boundary layer. Open the layer properties of the raster, click on the **Display** tab, and set the transparency to **40%**.





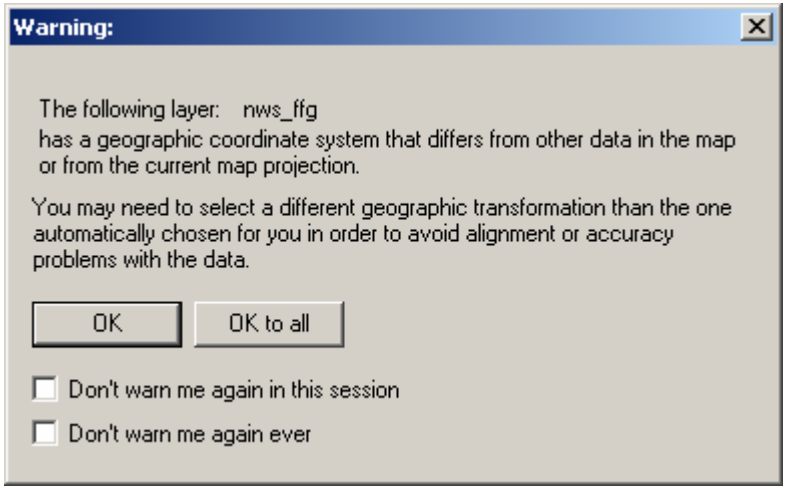
Click **OK** when you are done.

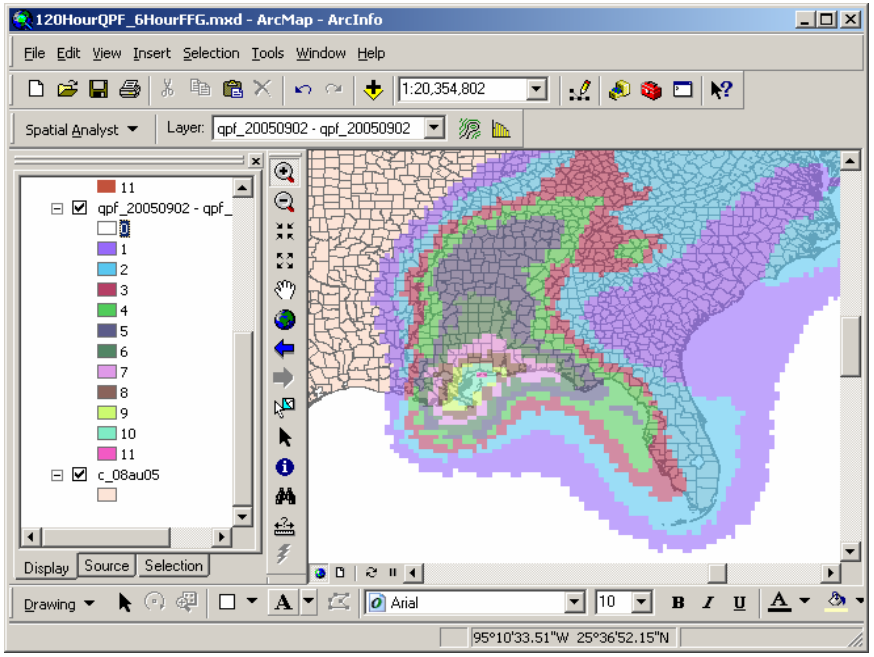
120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Right-click on the **0** class and set it to **No Color**. This allows you to see through to the counties.

Now add the 6-Hour FFG layer to ArcMap. You may receive the following warning message, which announces that the spatial reference (or projection) of the raster layer differs from that of the 6-Hour FFG layer. However, ArcMap is able to reconcile this through its ability to perform projections "on the fly."

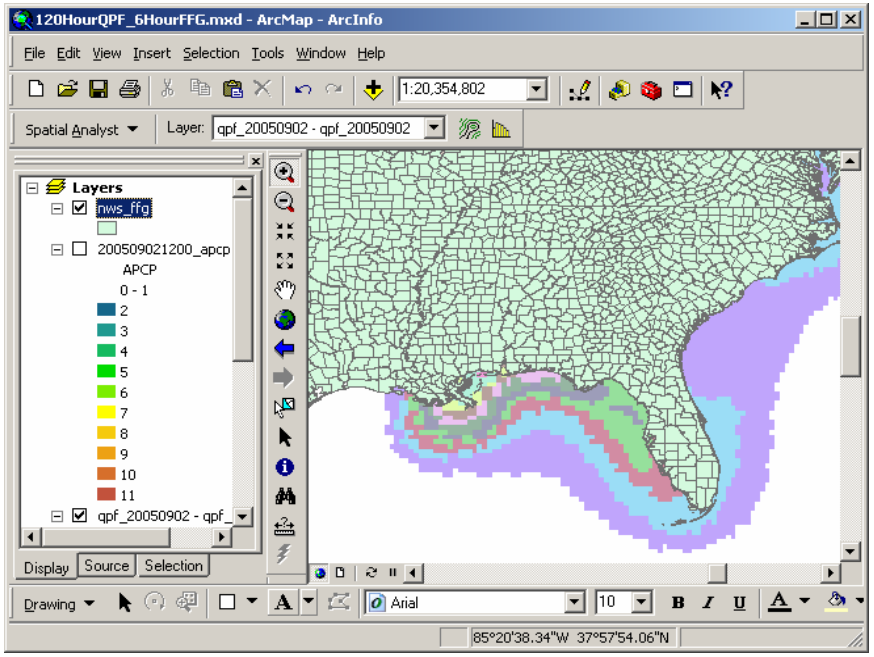
Click **OK** to dismiss this window.



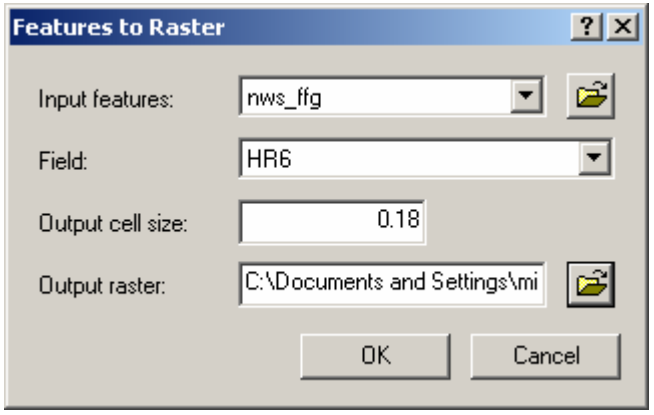


120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Once this polygon layer is added, it should be converted to a raster just like the 120-Hour QPF data. Again, using the Spatial Analyst menu, select **Convert > Features to Raster**.



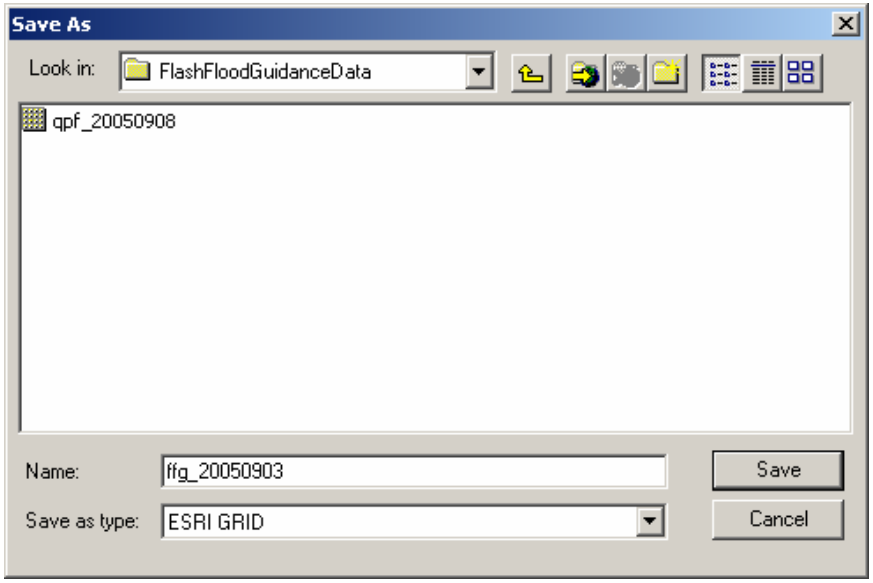
In the Features to Raster dialog, make sure the Input features drop-down is set to the FFG layer. Set the Field from which attributes will be transferred to **HR6** and change the Output Cell Size to match the size you specified for the 120-Hour QPF raster (**0.18** decimal degrees). This must be the same in order for the two rasters to be compared!



120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Specify the Output Raster folder and file name by clicking on the **Browse** button, and navigate to the same directory as the original 120-Hour QPF shapefile. Type the name of the raster while remembering the 13-character limitation and the need to retain the date of the data.

Click on **Save** when you are finished. Then click **OK** on the Features to Raster dialog window to begin the conversion process.

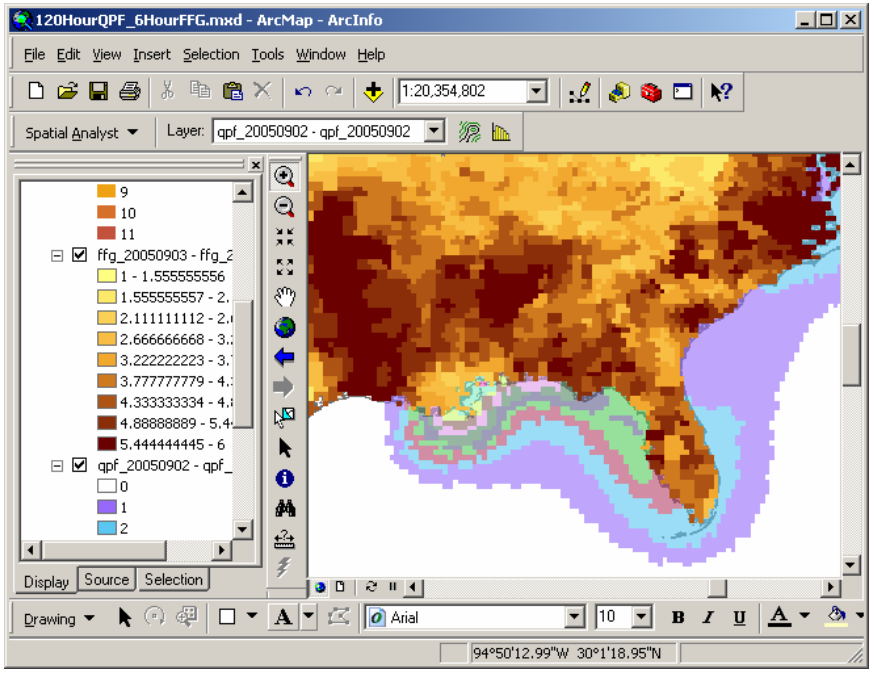


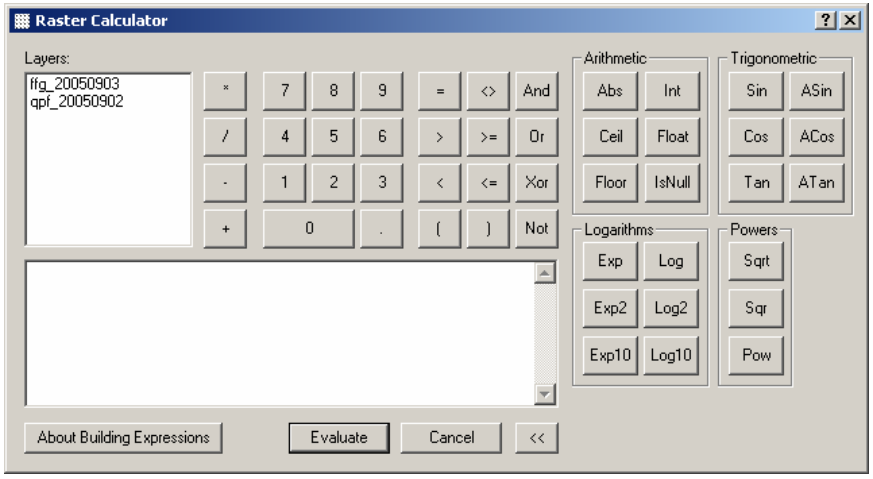
120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Turn off the 6-Hour FFG shapefile and review the converted FFG raster file.

To compare the difference between the two rasters, you will use the Raster Calculator within Spatial Analyst.

Click on **Spatial Analyst > Raster Calculator** to start the program.





120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Once you open the Calculator, you may want to expand its offerings by clicking on the >> button at the bottom of the window to reveal more advanced mathematical operators.

Build the calculation expression in the following manner:

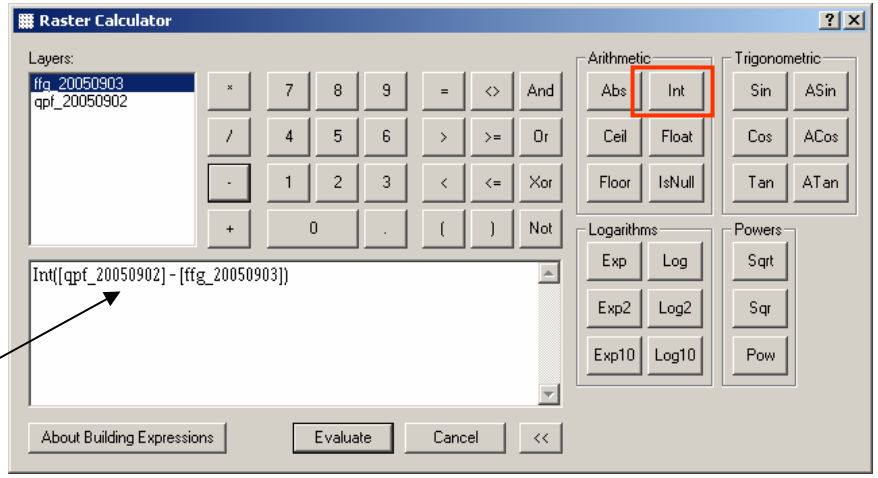
Click the Integer or **Int** button once to start the expression.

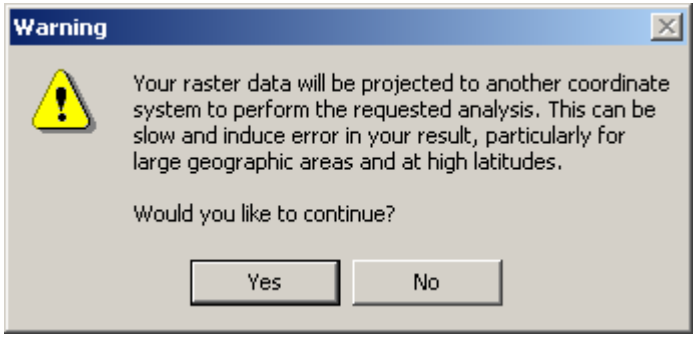
Double-click on the QPF raster.

Click on the minus (**-**) operator.

Double-click on the FFG raster.

Your expression should look like this example.





Click on the **Evaluate** button when finished.

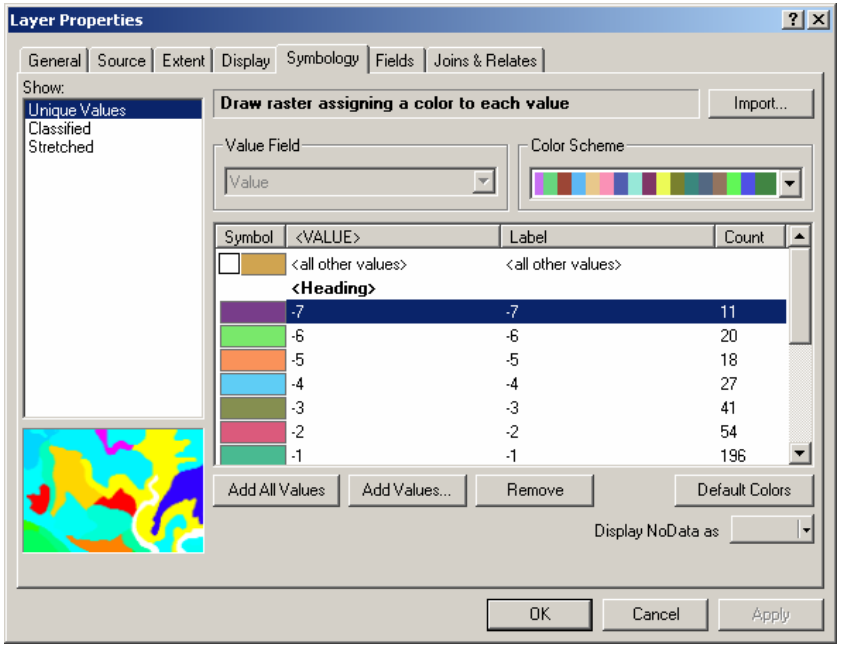
The calculation will take a few moments to complete.

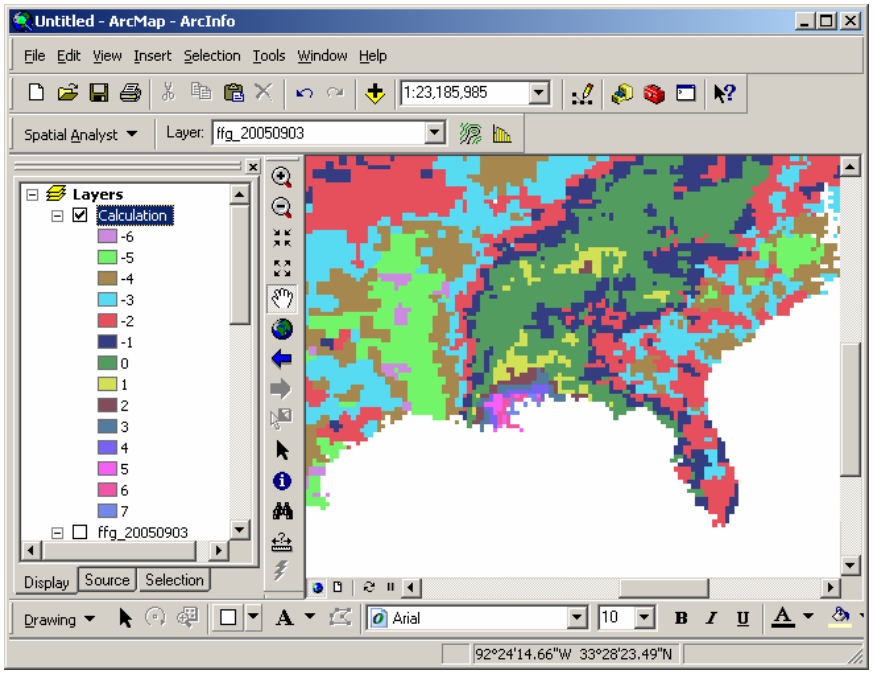
You may receive a warning message. This is normal and can be ignored. Click **Yes** to dismiss the window.

120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: The resulting difference raster may look like the example below. Notice that there are negative values. You are not interested in seeing those.

Open up the Calculation raster's Layer Properties. Click on the **Symbology** tab. Select all classes containing a negative value or "0" and delete them by clicking on the **Remove** button.





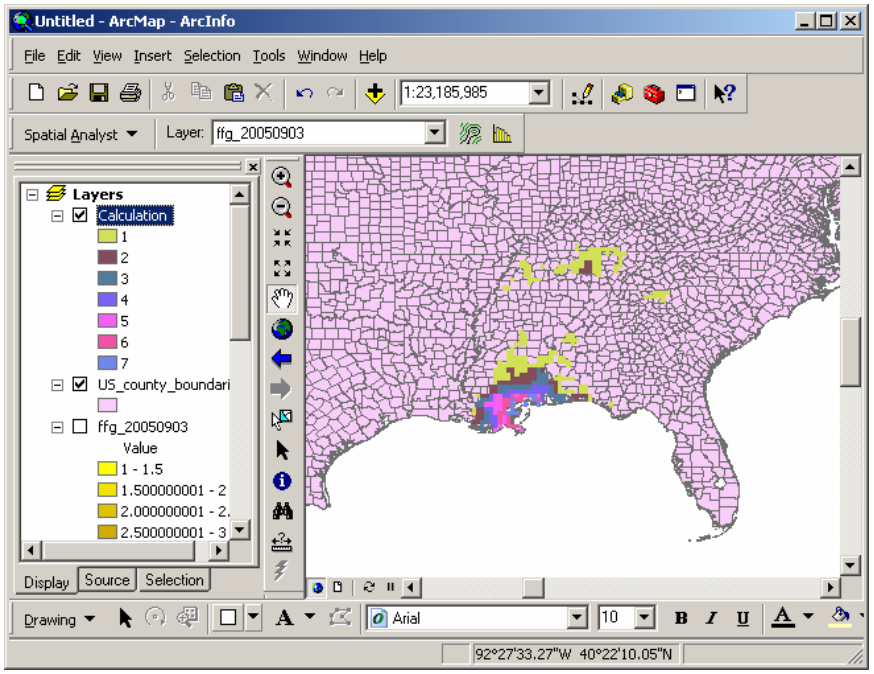
When the process is finished, click **OK** to see the changes.

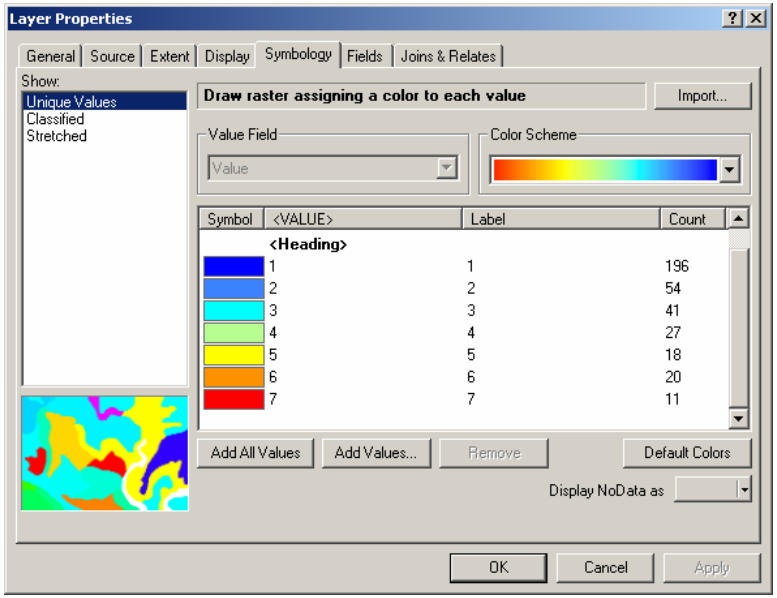
120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: You now want to symbolize the classes with a logical color ramp.

Open up the Calculation raster's Layer Properties again and click on the **Symbology** tab. Select a color ramp that is a logical progression from red to blue.

Since you want the highest amounts of rain to be red, you need to reverse the order of these colors.





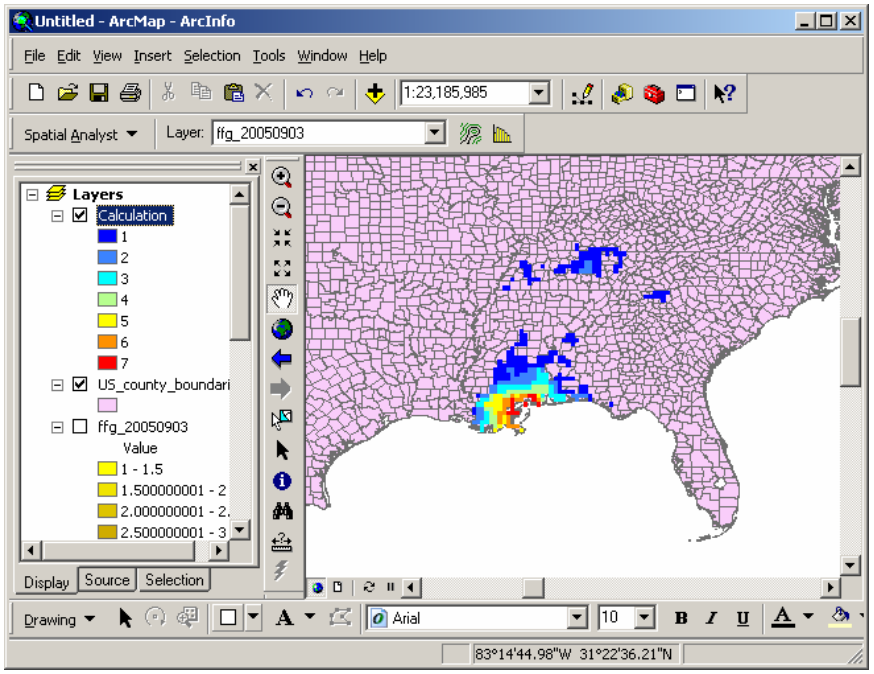
Click on the **Symbol** field and select **Flip Symbols**. Click **OK** to see the new symbolization.

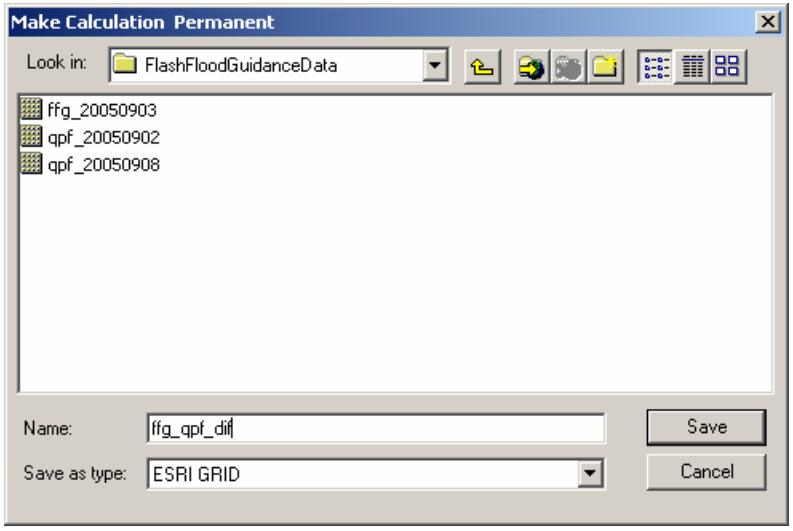
120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Since this layer is useful but at the moment considered "temporary," it should now be saved permanently.

Right-click on the layer and select **Make Permanent…**

The following dialog window will appear. Specify the new name of this raster, and click **Save** when finished.



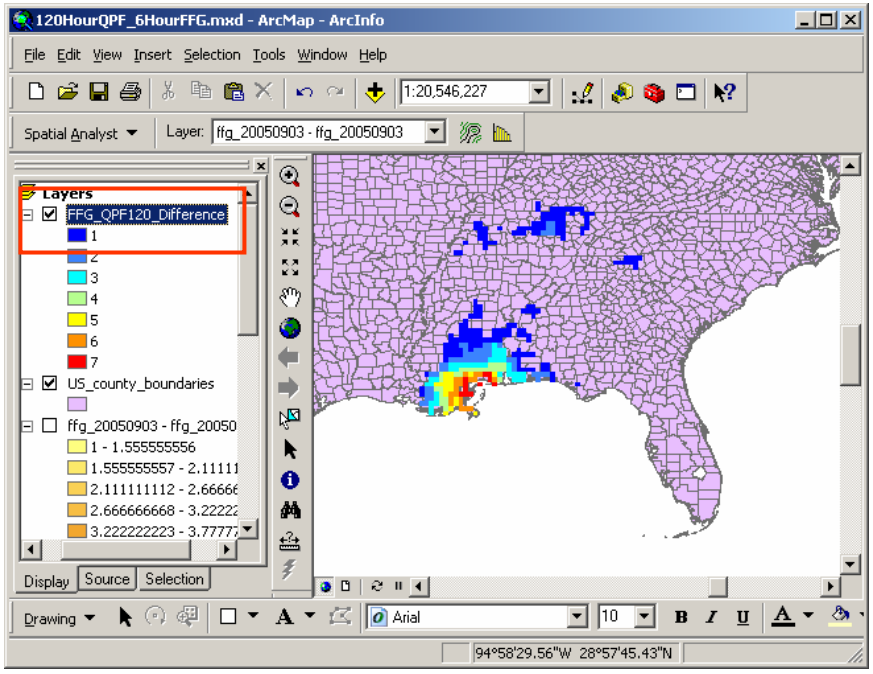


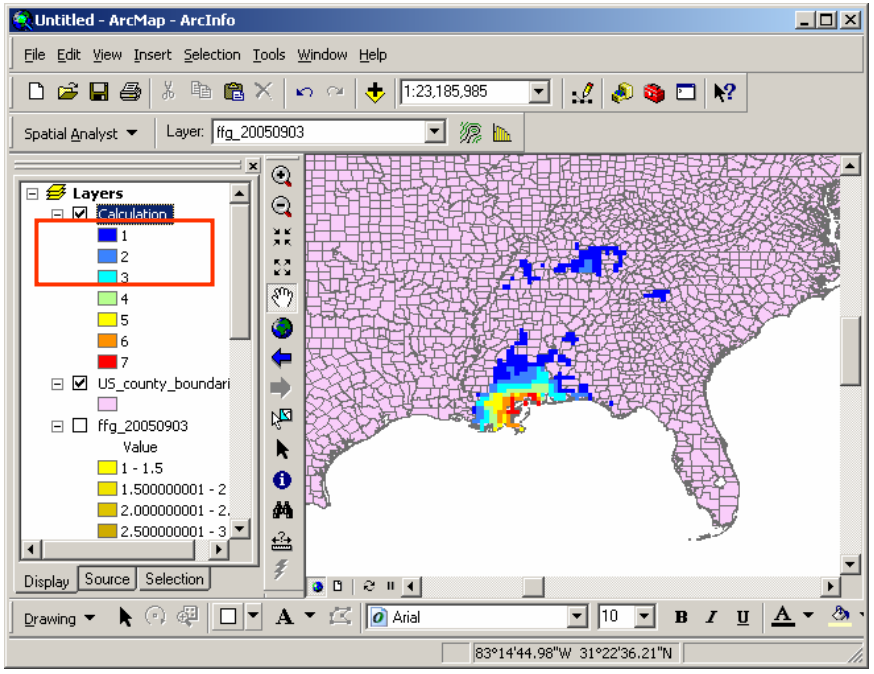
Now the layer can be reused at any time.

120-Hour QPF / 6-Hour Flash Flood Guidance Difference

Process the data: Although the name does not change in the table of contents, you can see that the new raster has been added to the folder you specified.

Additionally, you can see the new name specified inside the layer's properties window within the Source tab.

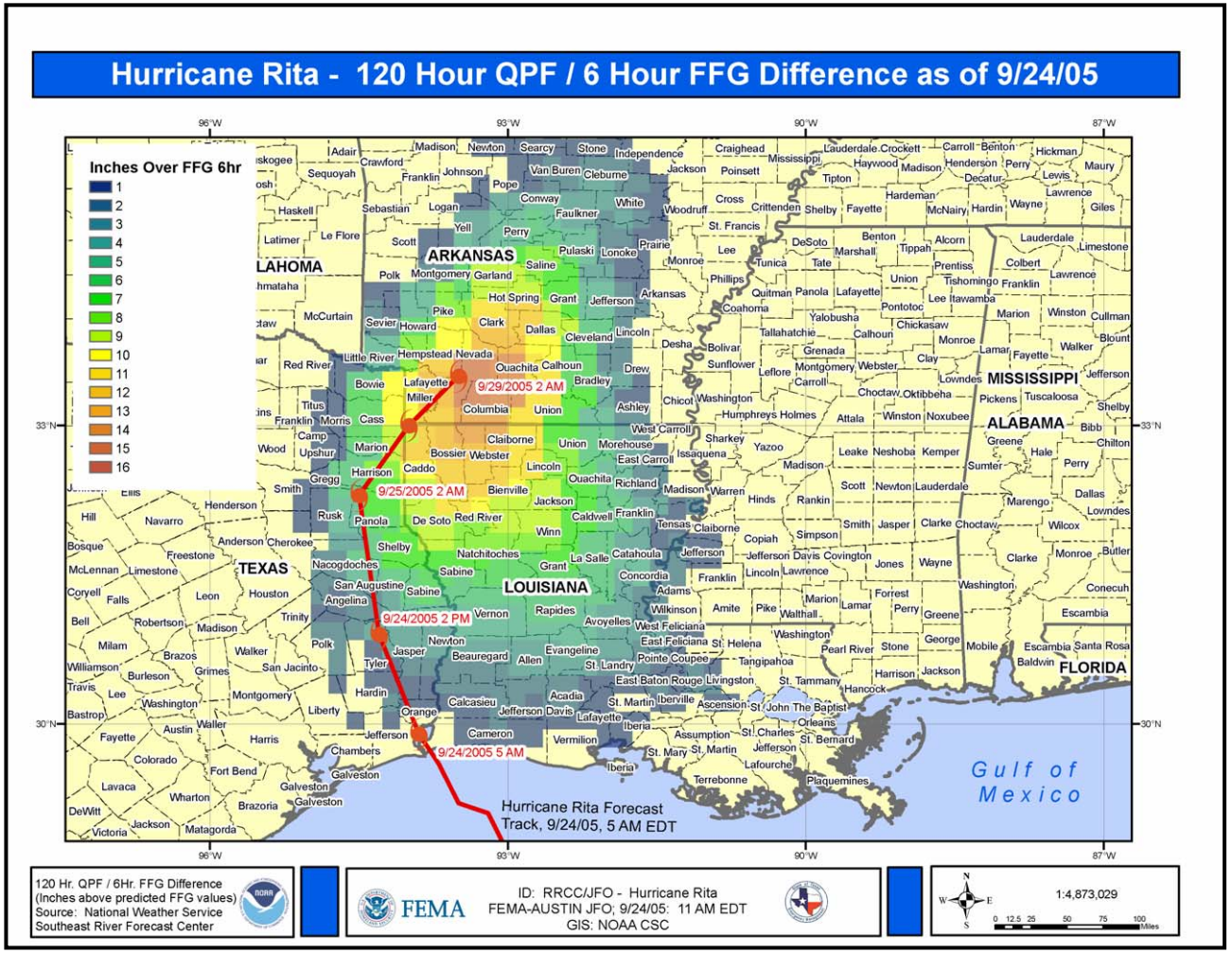




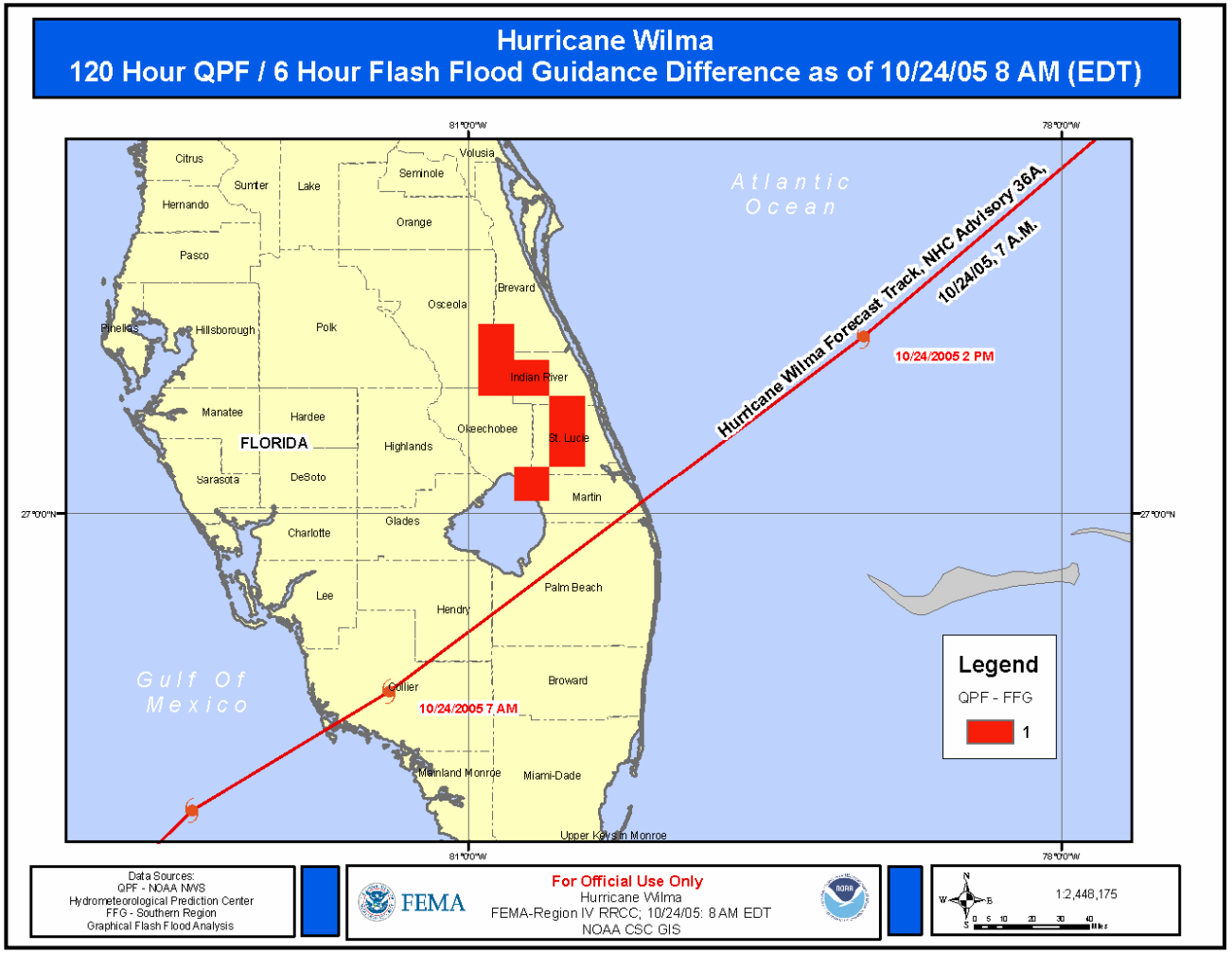
It might be helpful to rename the layer in the table of contents to help remember how it was developed.

At this point you are ready to begin making a map. Several examples have been included to show what the NOAA Coastal Services Center has provided to members of FEMA in the past. Refer to the "Basics of Cartography" chapter at the end of this manual for additional information.

120-Hour QPF / 6-Hour Flash Flood Guidance Difference



120-Hour QPF / 6-Hour Flash Flood Guidance Difference



Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Purpose: See the definitions of the Cumulative Rainfall Using Stage III Multi-Sensor Precipitation Estimates and 6-Hour Flash Flood Guidance (FFG) products for individual product descriptions. This comparison converts the Stage III Rainfall and 6-hour FFG values into rasters using the same grid cell sizes and subtracts the 6-hour FFG values from the Stage III Rainfall. The result is a raster with positive and negative values. The positive values show the amount of rainfall (inches) above the 6 hour FFG as indicated by the Stage III Rainfall estimation. This can be used to show the areas that will exceed the 6-hour FFG based on cumulative rainfall using Stage III Multi-Sensor Precipitation Estimates. The goal of this analysis is to show counties where flash flooding may have occurred.

Since Stage III data describe “past” rainfall and FFG data describe “forecast” conditions, it is not possible to perform a meaningful comparative analysis for the present day. Instead, the user should archive the present day’s (i.e., today) FFG data for comparison with Stage III data available on the second day (i.e., tomorrow). For example, an analyst wishing to create a map as outlined in this module would need to download the 6-hour FFG data for today, archive the file, and use it for comparison tomorrow, once today's Stage III data are available.

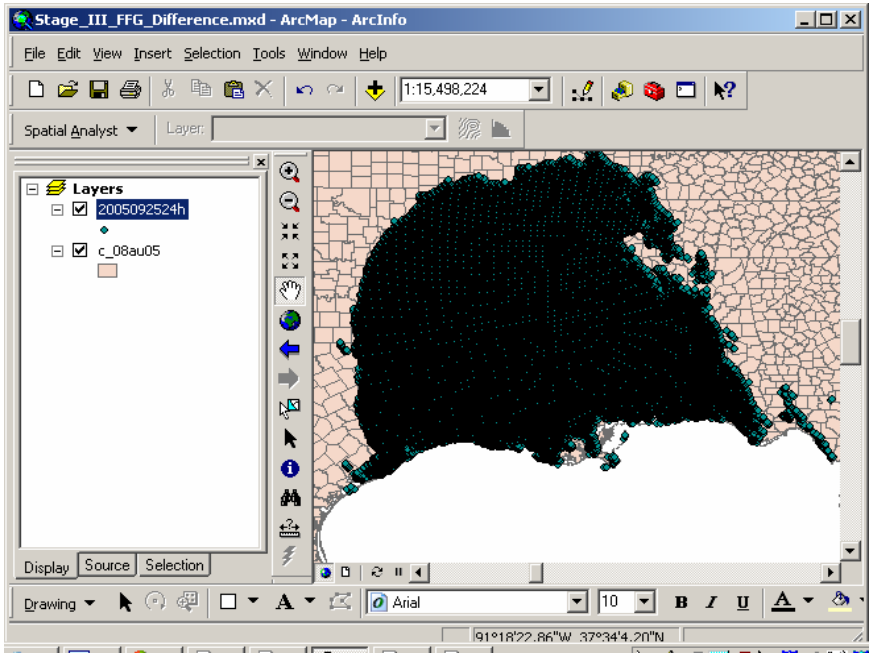
Source Data: This type of map uses data originating from NOAA’s National Weather Service’s (NWS) Southern Region Headquarters.

Download: Refer to the Cumulative Rainfall Using Stage III Multi-Sensor Precipitation Estimate module for download instructions for those data.

Refer to the 6-Hour Flash Flood Guidance Value module for download instructions for those data.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Follow the directions to download and process the Stage III Rainfall data for a given study area. Your results should look like the following example. Be sure to add a state or county boundary layer to help identify the area of concern.



To compare the Stage III Rainfall data to the 6-Hour Flash Flood Guidance data, you need to convert each to a raster with equal-sized cells. You need to use the Spatial Analyst extension to perform the feature (shapefile) to raster conversion.

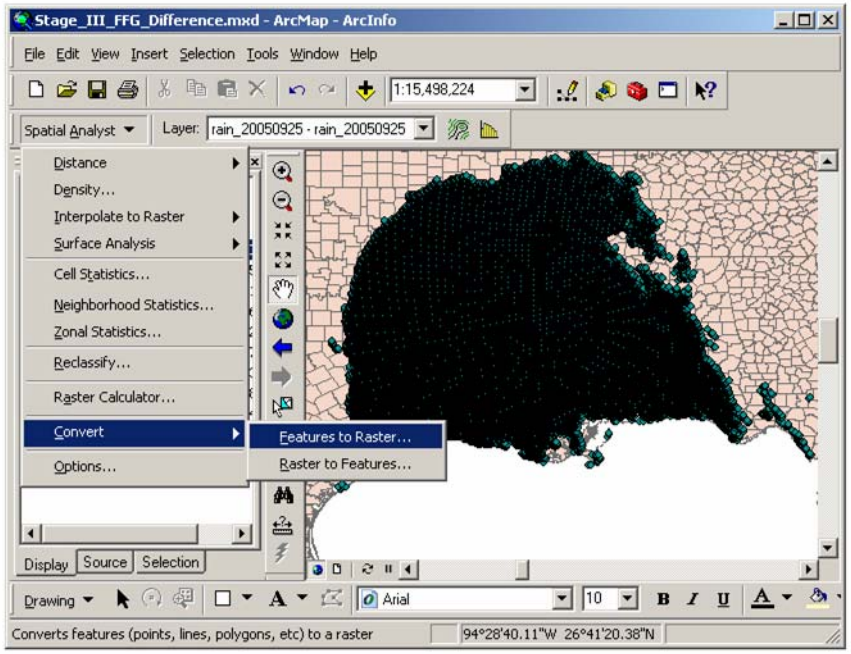
To use Spatial Analyst, click on **View > Toolbars > Spatial Analyst**. You will see the toolbar appear inside ArcMap.

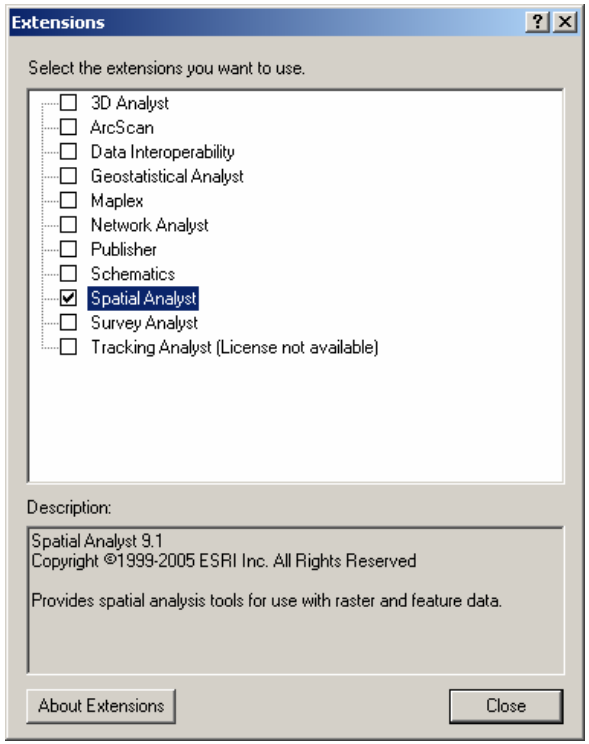
You can drag and dock this toolbar to the window or let it “float” around in ArcMap. You should now enable the extension by clicking on **Tools > Extensions**.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Once the extension window appears, check on **Spatial Analyst** to enable the extension. Click **Close**.

Click on the **Spatial Analyst** menu and select **Convert > Features to Raster** as demonstrated in the graphic below.

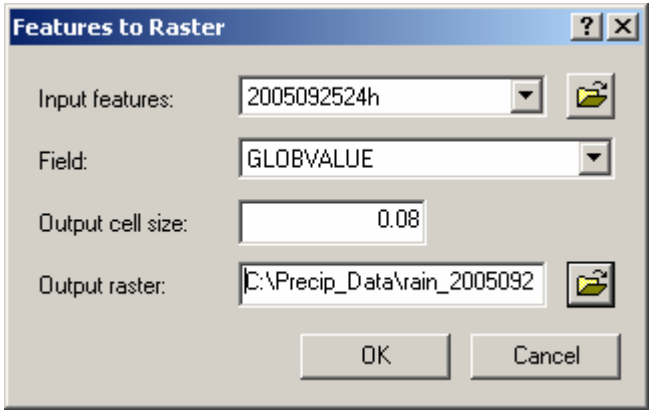


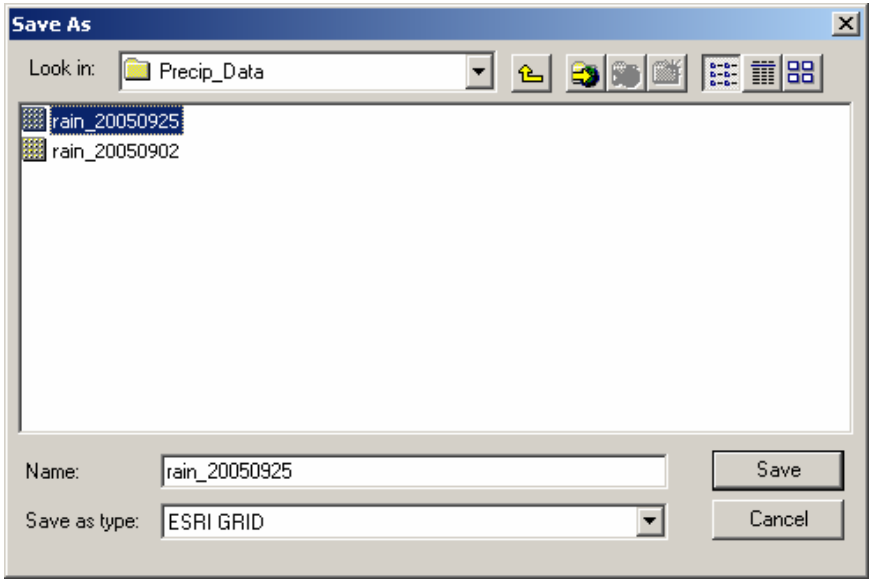


Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: In the Features to Raster dialog window, set the Input features layer to be the Stage III Rainfall layer. To ensure the correct attribute data are transferred from the polygon layer to the raster, set the Field drop-down menu to **GLOBVALUE**.

Set the Output cell size as **0.08**. This should also be the same cell size used for the 6-Hour FFG layer.





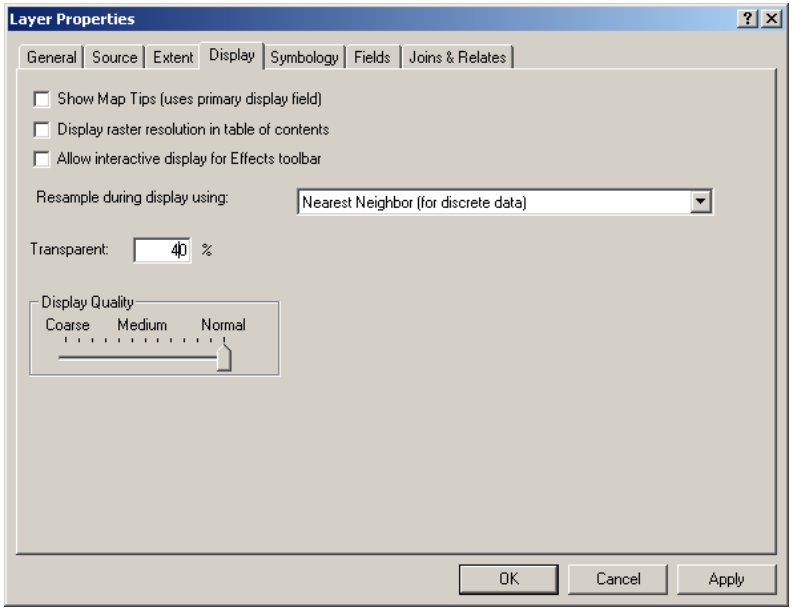
Lastly, browse for a directory to write this new raster into. Remember that because this is a raster, there is a 13-character limitation in the file name. It is also a good idea to capture the date of the Stage III Rainfall data.

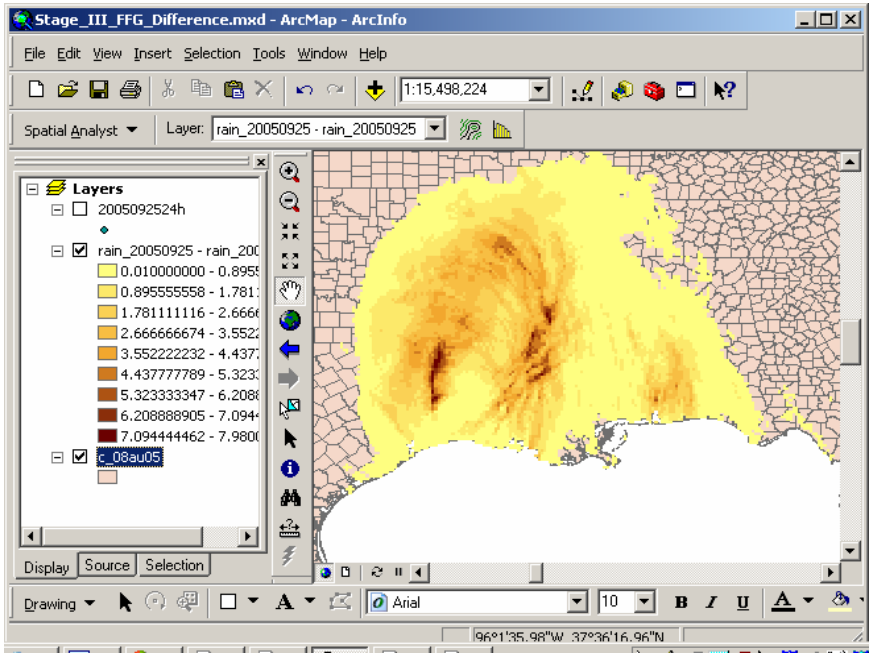
Click **Save** when you are done. Then click **OK** in the Features to Raster dialog to begin the conversion process.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Notice that the raster is added at the bottom of the table of contents and looks similar to the original shapefile layer. One big difference is that the rainfall values assigned to each cell of the raster is an averaging of the rainfall values of the original points in the shapefile (expressed in inches).

View these data better by turning off the original point layer and dragging the new raster above the county boundary layer. Open the Layer Properties of the raster, click on the **Display** tab, and set the transparency to **40%**.



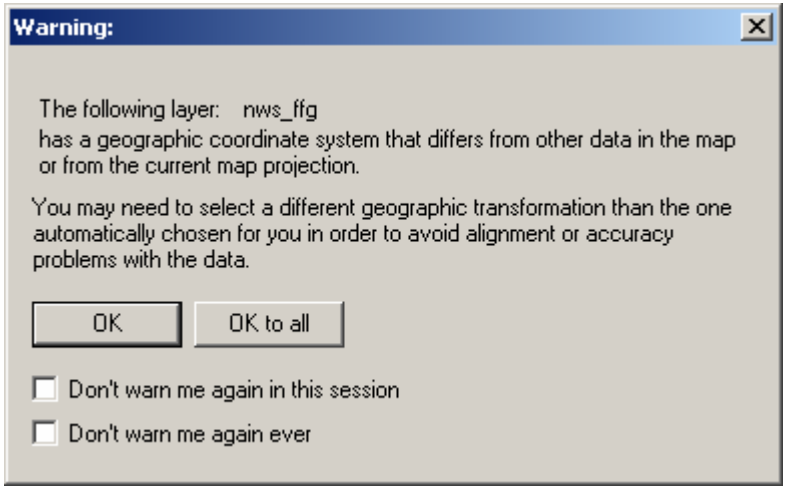


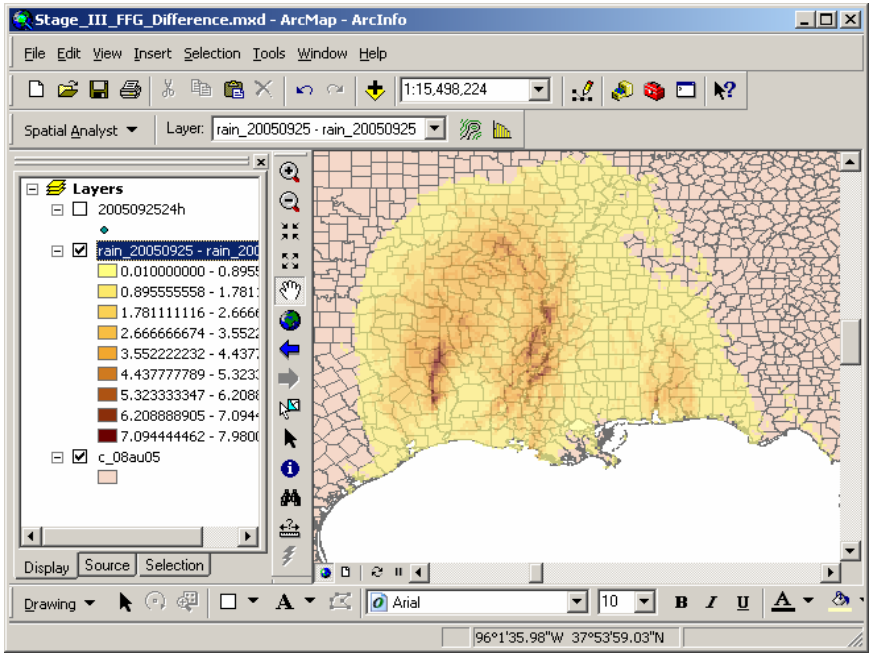
Click **OK** when you are done.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Now add the 6-Hour FFG layer to ArcMap. You may receive the Warning message shown below, which announces that the spatial reference (or projection) of the raster layer differs from that of the 6-Hour FFG layer. However, ArcMap is able to reconcile this through its ability to perform projections "on the fly."

Click **OK** to dismiss this window.

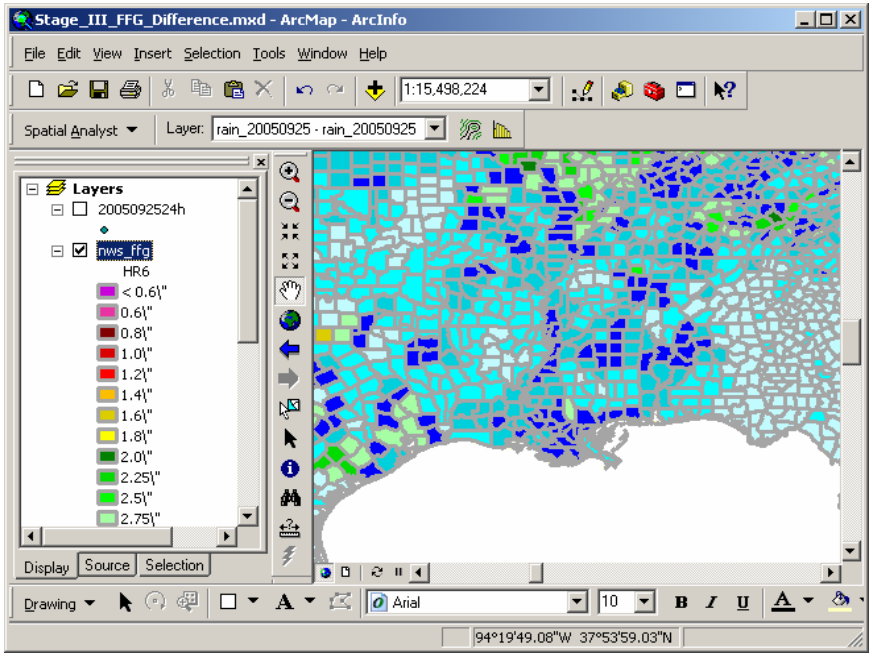


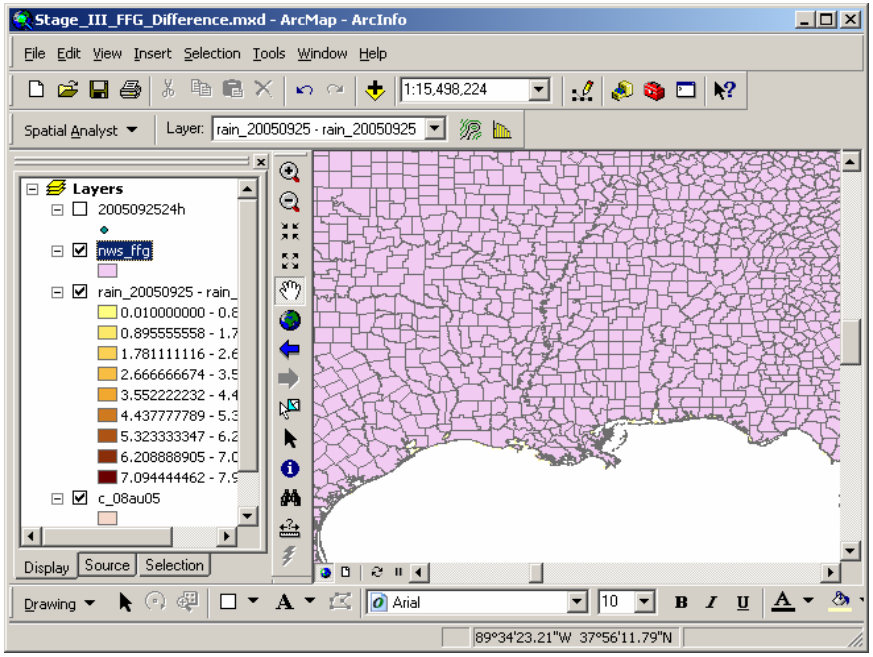


Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: The 6-Hour FFG layer is added but not symbolized as outlined in its module. Consult this module and follow the steps to symbolize the layer properly.

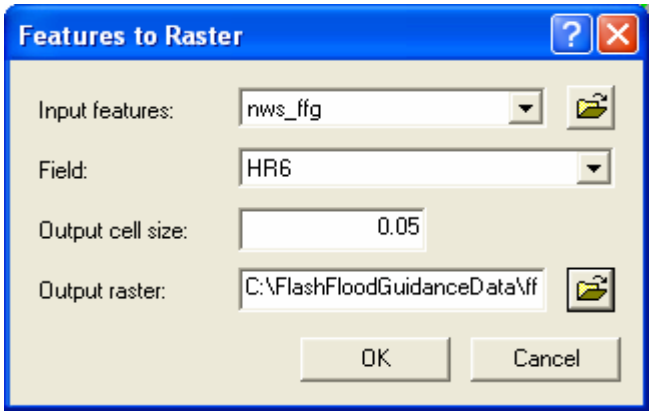
Once this polygon layer is symbolized, you will convert it to a raster. Again, using the Spatial Analyst menu, select **Convert > Features to Raster**.



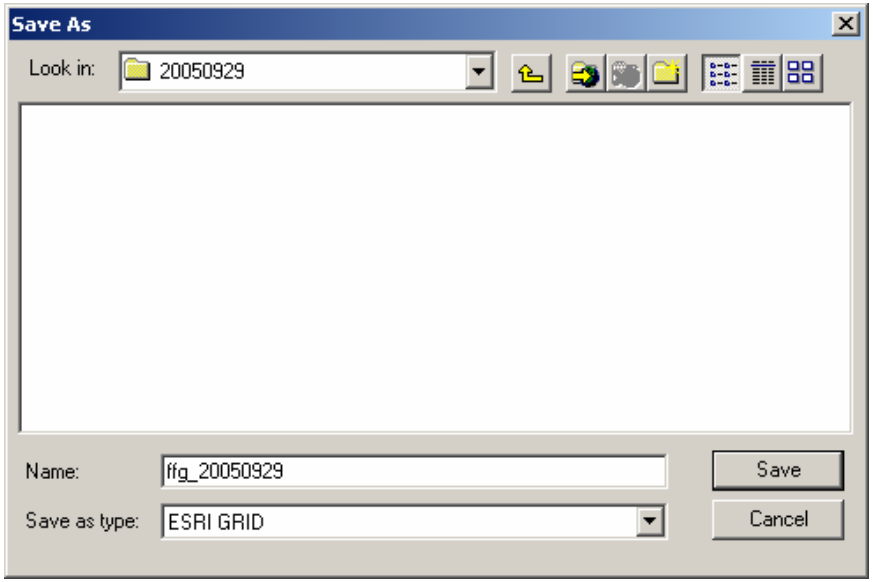


Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: In the Features to Raster dialog, make sure the Input features drop-down is set to the FFG layer. Set the Field from which attributes will be transferred to **HR6**, and change the Output Cell Size to match the size you specified for the Stage III Cumulative Rainfall raster (**0.05** decimal degrees).



Specify the Output Raster folder and file name by clicking on the **Browse** button, and navigate to the same directory as the original FFG shapefile. Type the name of the raster, while remembering the 13-character limitation and a need to retain the date of the data.

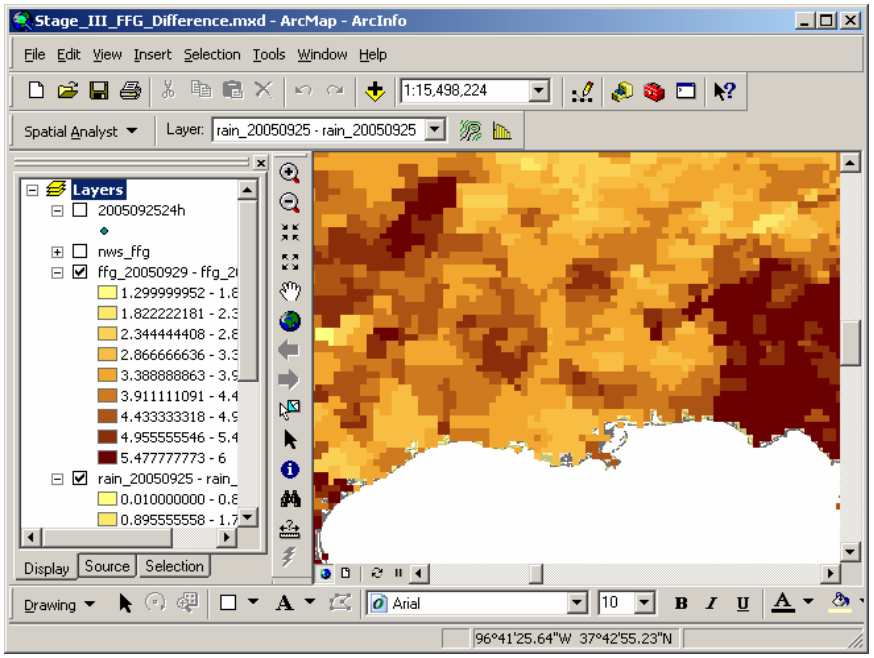


Click on **Save** when you are finished. Then click **OK** on the Features to Raster dialog window to begin the conversion process.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Turn off the 6-Hour FFG shapefile and review the converted raster file.

To compare the difference between the two rasters, you will use the Raster Calculator within Spatial Analyst. Once you open the Calculator, you may want to expand its offerings by clicking on the >> button at the bottom of the window to reveal more advanced mathematical operators.



For this particular map, you will compare the difference between the Stage II Rainfall values and the 6-Hour FFG values. Begin building the raster analysis expression by double-clicking on the **Int** button.

Double-click on the QPF raster.

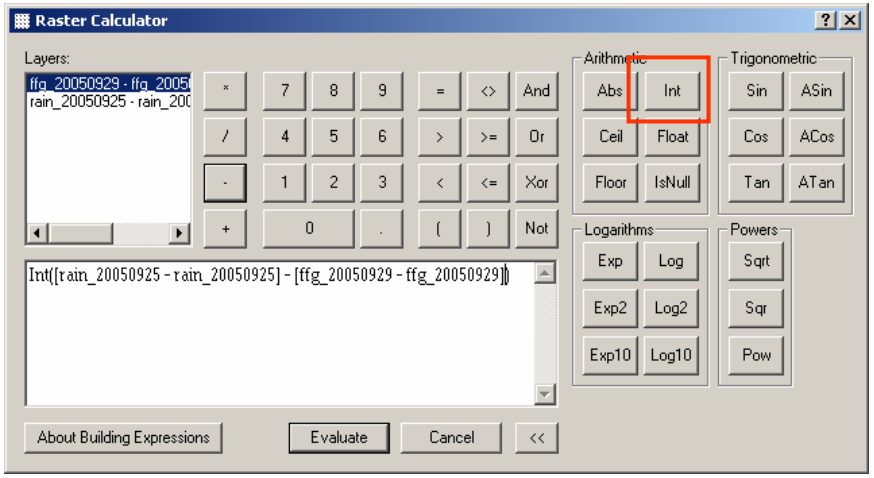
Click on the minus "**-**" operator.

Double-click on the FFG raster.

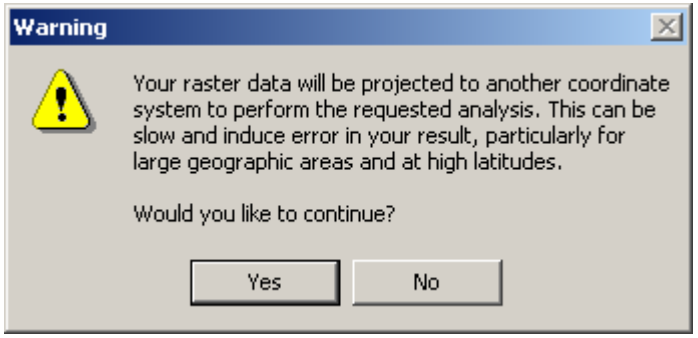
Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Your expression should look like the example below. Make sure there are spaces on either side of the minus sign "-" that separates the two rasters. Click on the **Evaluate** button when finished.

The calculation will take a few moments to run.



You may receive the following message.

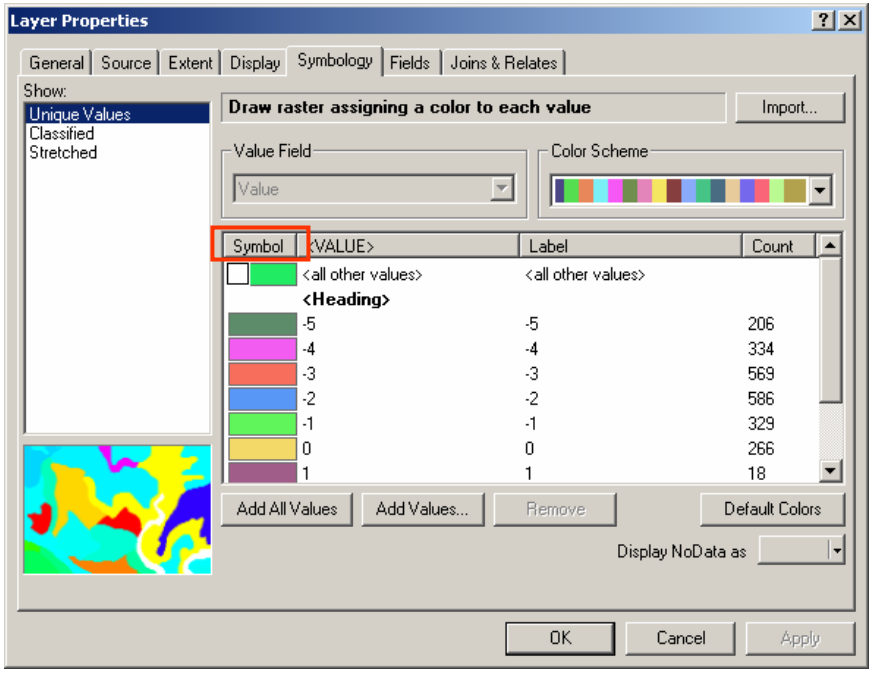


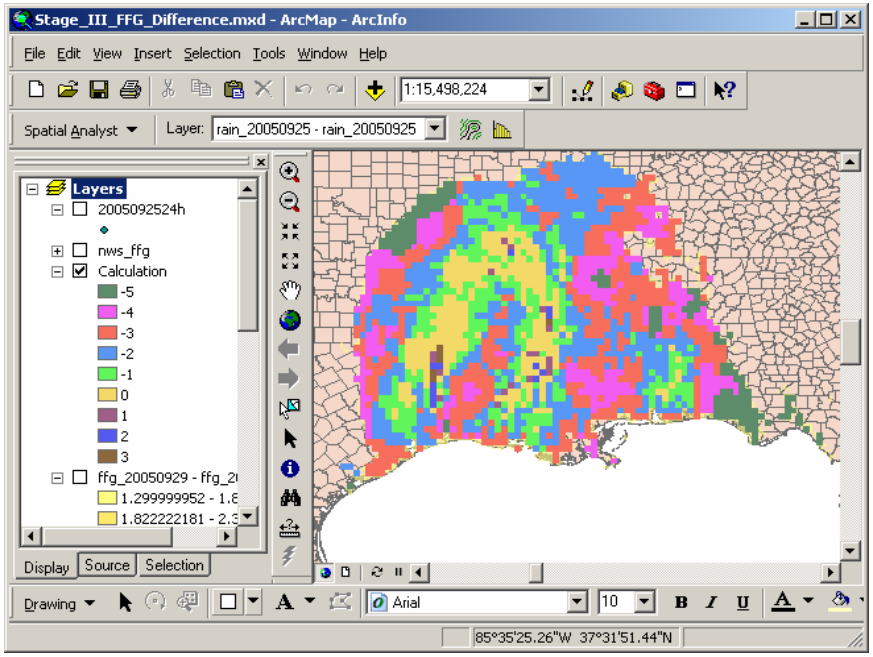
This is normal and can be ignored. Click **Yes** to dismiss the window. Turn off the 6-Hour FFG shapefile, and review the converted raster file.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Notice the Calculation raster layer is added to the table of contents. Turn off all other layers to review the results.

The colors assigned to the classes of the raster are not meaningful. Therefore, open the raster's Layer Properties window, and click on the **Symbology** tab.



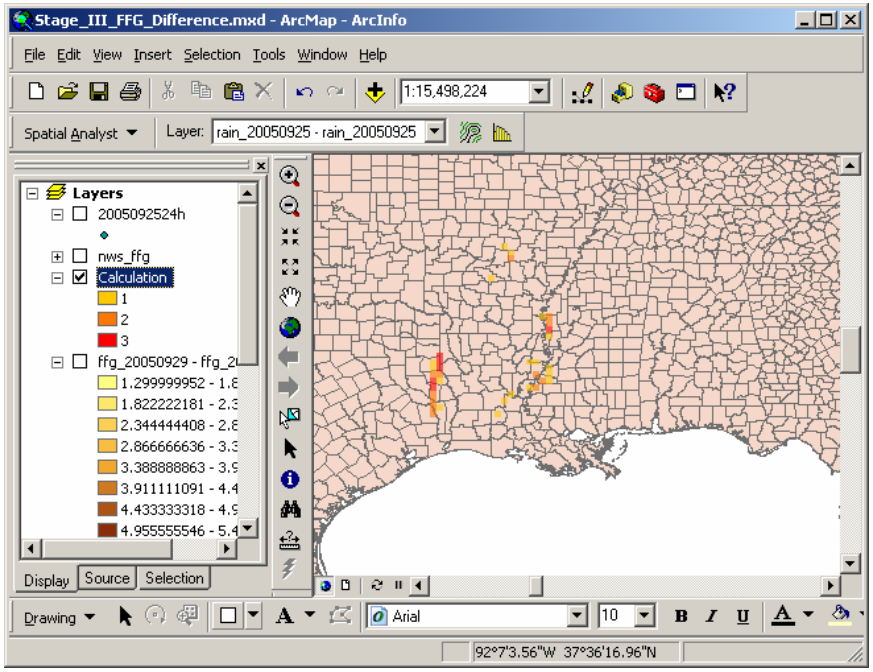


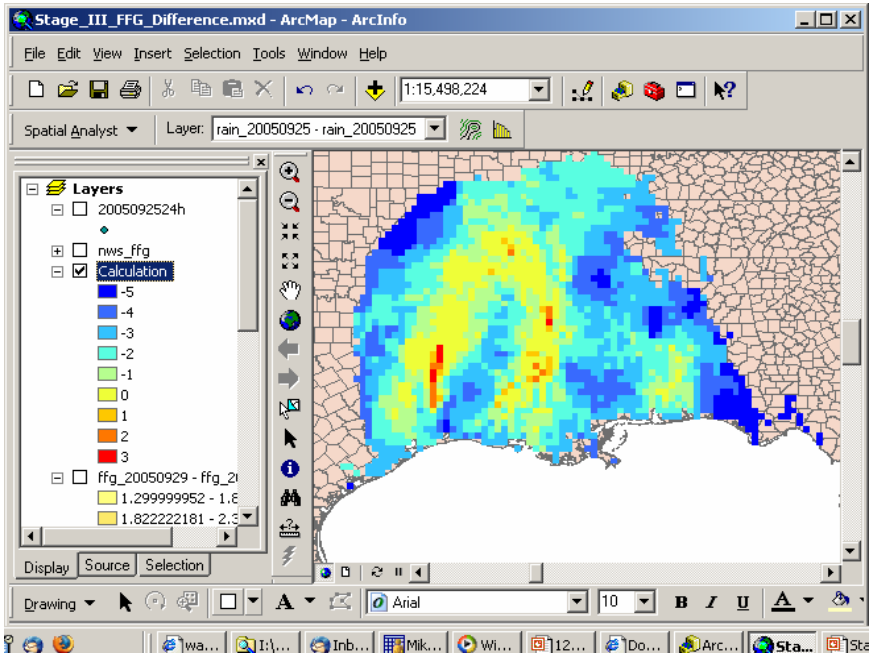
Change the Color Scheme to the Red to Blue ramp. Change the order of the colors by clicking on the **Symbol** field, and select **Flip Colors**. Click **OK**.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: The resulting difference raster may look like the example below. Notice there are negative values. You are not interested in seeing those.

Open up the Calculation raster's Layer Properties window, and click on the **Symbology** tab. Select all classes containing a negative value or "0" and delete them by clicking on the **Remove** button.





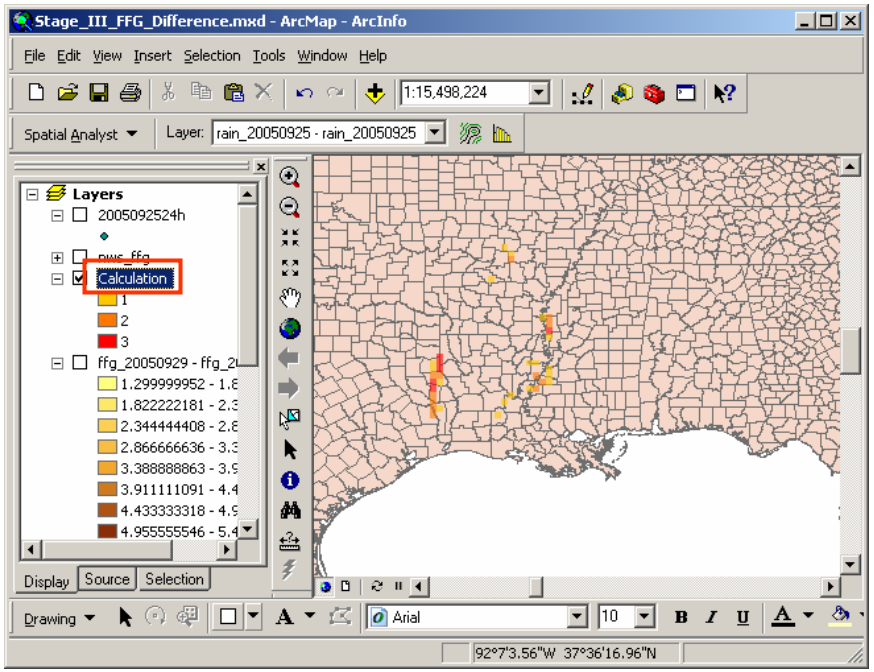
To see the counties below the raster, set the transparency of the raster to **40%** (do you remember how?)

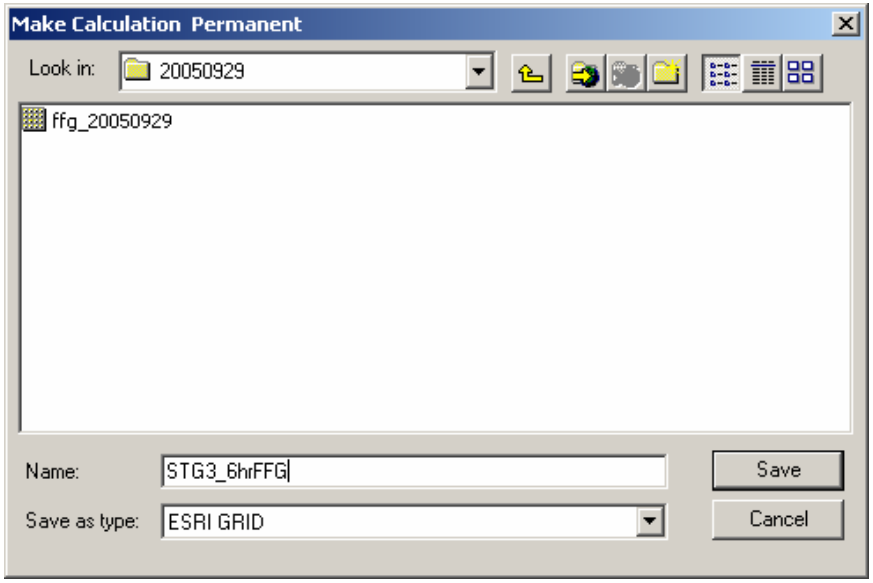
Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Since the Calculate layer is useful but at the moment is considered "temporary," it should now be saved permanently.

Right-click on the layer and select **Make Permanent…**

The following dialog window will appear. Specify the new name of this raster and click **Save** when finished.



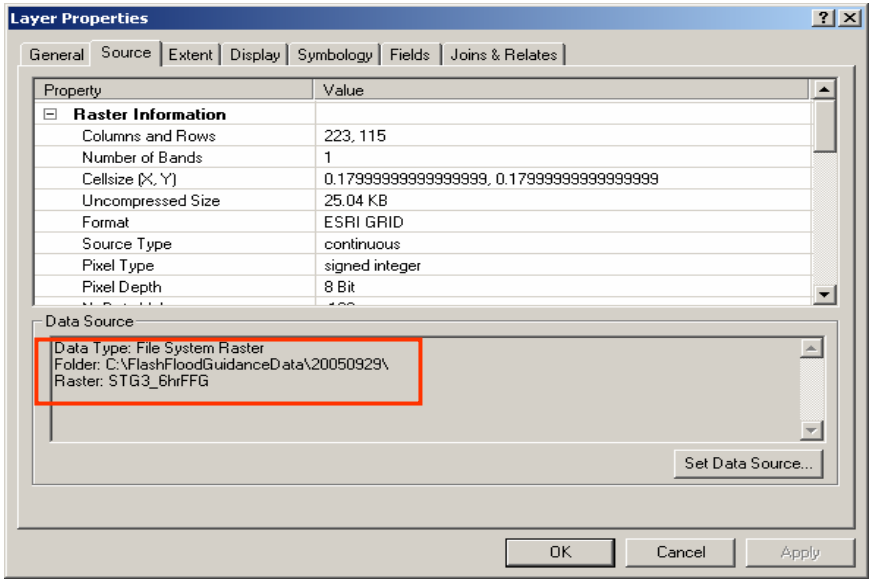


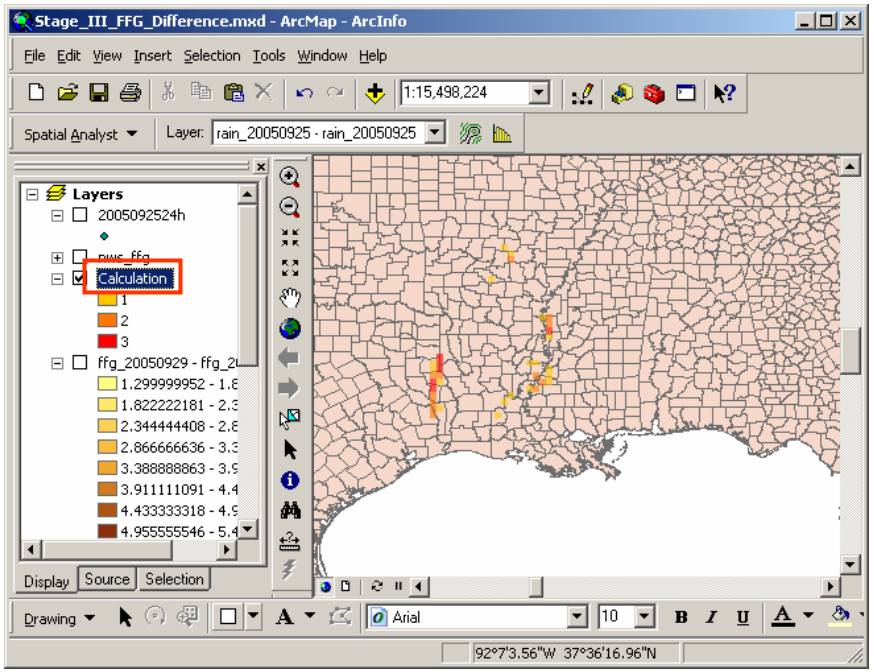
Now the layer can be reused at any time.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference

Process the data: Although the name does not change in the table of contents, you can see that the new raster has been added to the folder you specified.

Additionally, you can see the new name specified inside the Layer Properties window within the Source tab.



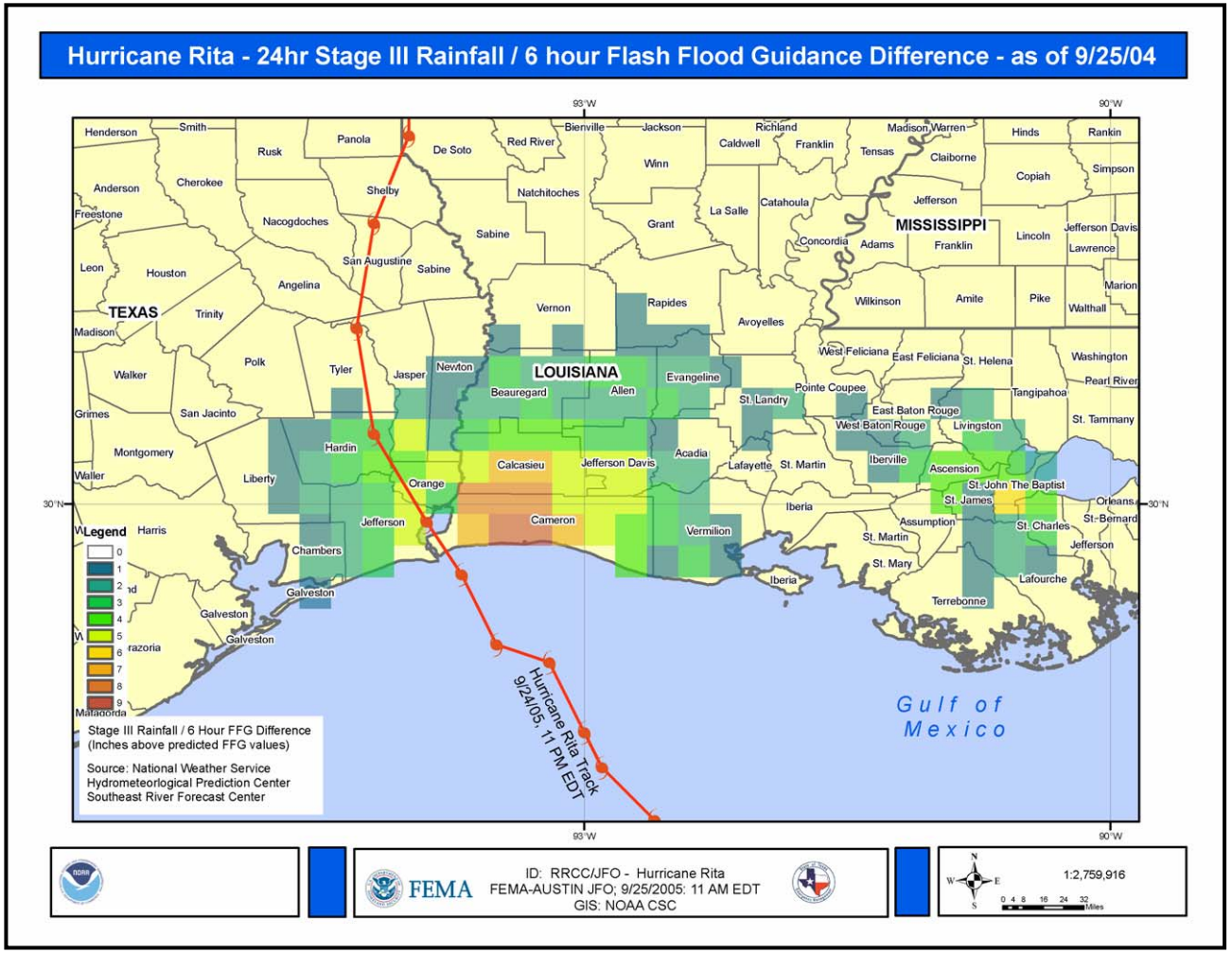


It would be useful to rename the layer in the table of contents to help remember how it was developed.

At this point you are ready to begin making a map. An example has been included that shows what the NOAA Coastal Services Center has provided to members of FEMA in the past.

Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.

Stage III Rainfall / 6-Hour Flash Flood Guidance Difference



Significant River Flood Outlook

Purpose: This type of map presents an estimate of the potential for inland flooding.

Source Data: National Hurricane Center (NHC) and local weather information, forecast tracks, and evacuation time calculations can be plotted manually, but this can be an onerous task during an emergency. A computer program called HURREVAC automatically tracks this information and displays the results graphically. The computer program can be obtained from county, local, and state emergency management offices. **(Please note that this program is not available to the general public.)**

HURREVAC updates current and forecast storm data and then displays the track of the storm in various formats. Using Hurricane Evacuation Study (HES) data, it considers the potential for storm surge and calculates evacuation times based on storm speed and intensity. HURREVAC can also be used as a "what-if" tool to help emergency managers determine courses of action for different storm characteristics.

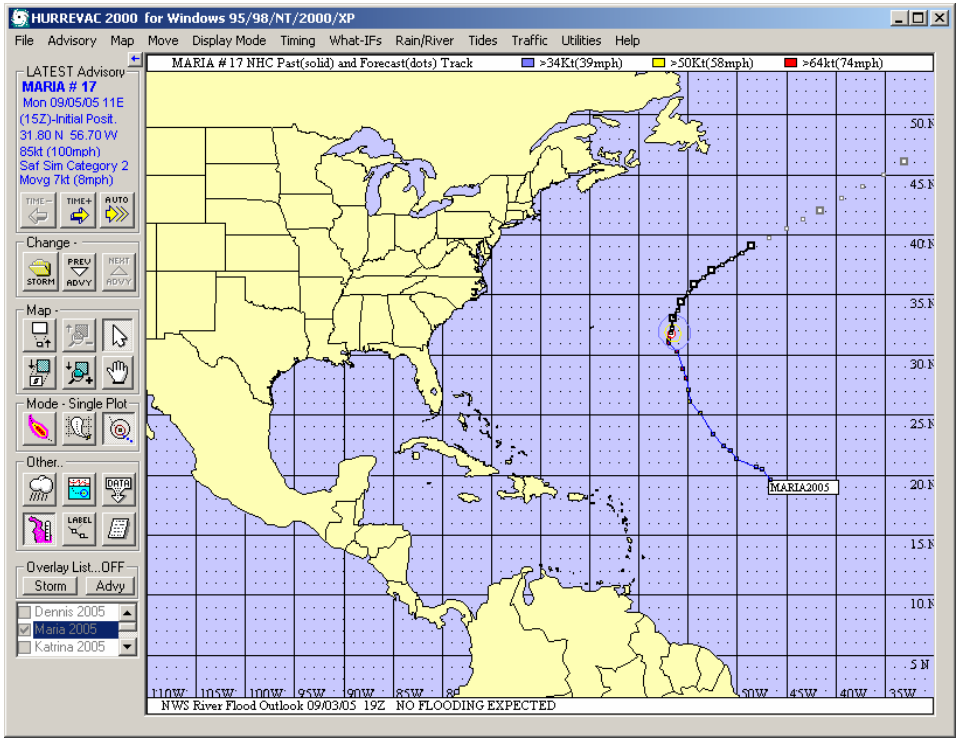
Download: This tutorial assumes that users of HURREVAC have already installed the software and have some idea of how it works.

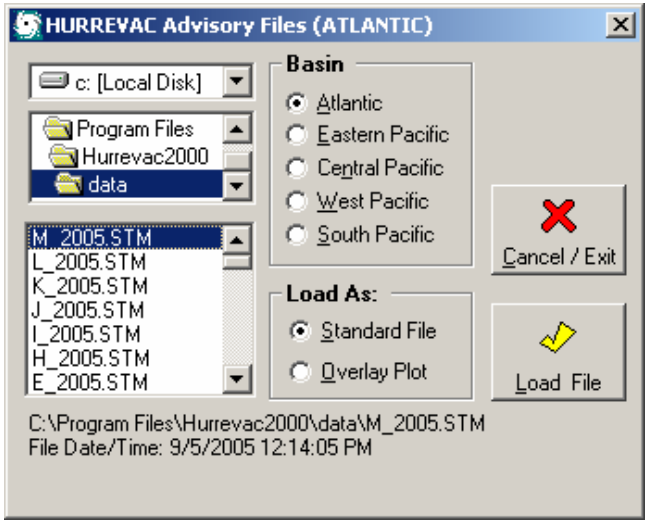
Significant River Flood Outlook

Access the data: Begin using HURREVAC by going to **Start > Programs > HURREVAC2000**. Once the program opens, click on the **Auto Download Latest** button.

Once the data finishes downloading, click **Exit** to close the window.

Click on the **Load Storm File** button to access the date for a specific tropical storm.

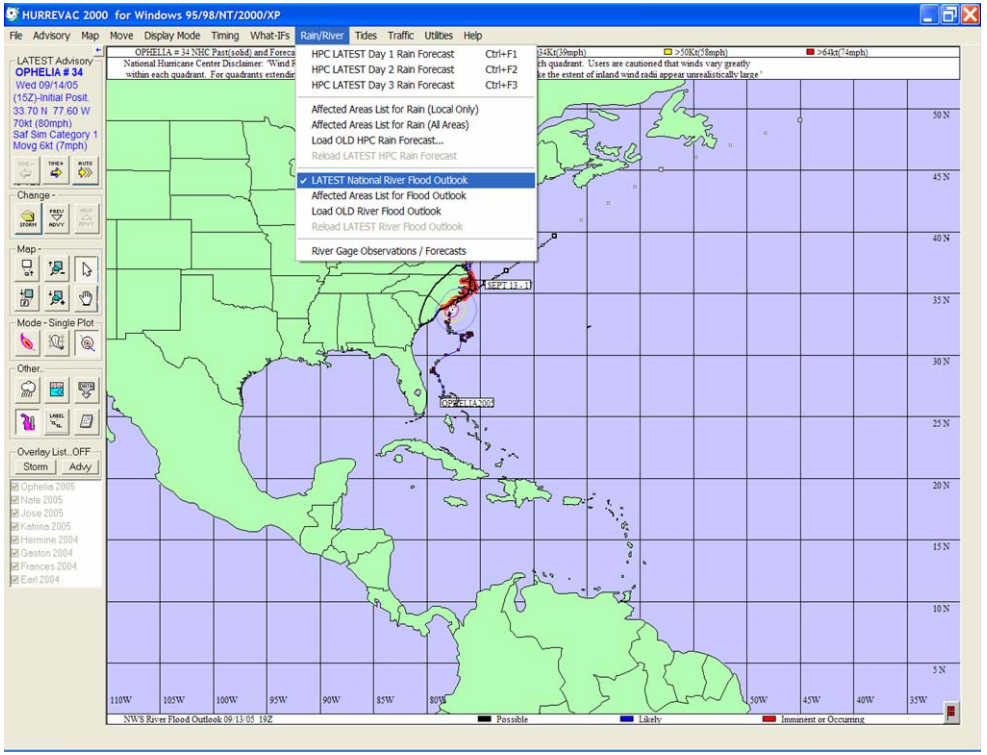




The HURREVAC Advisory Files dialog will open. Navigate to the c:\Program Files\Hurrevac2000\data folder. Click on the storm name (first letter in name_year of storm). Click on the **Load File** button.

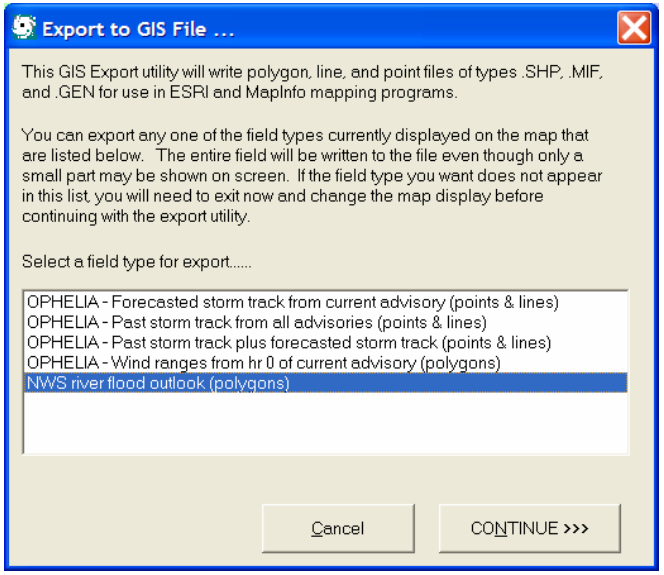
Significant River Flood Outlook

Access the data: To view Significant River Flood Outlooks (SRFOs), click on the **Rain/River** menu at the top of HURREVAC and select **LATEST National River Flood Outlook**. This will display the areas expecting inland flooding for that day.



Bring these areas that will experience flooding into ArcMap for mapping. Click on the **File** menu and select **Export Field(s) to GIS File…**

The window below will appear.

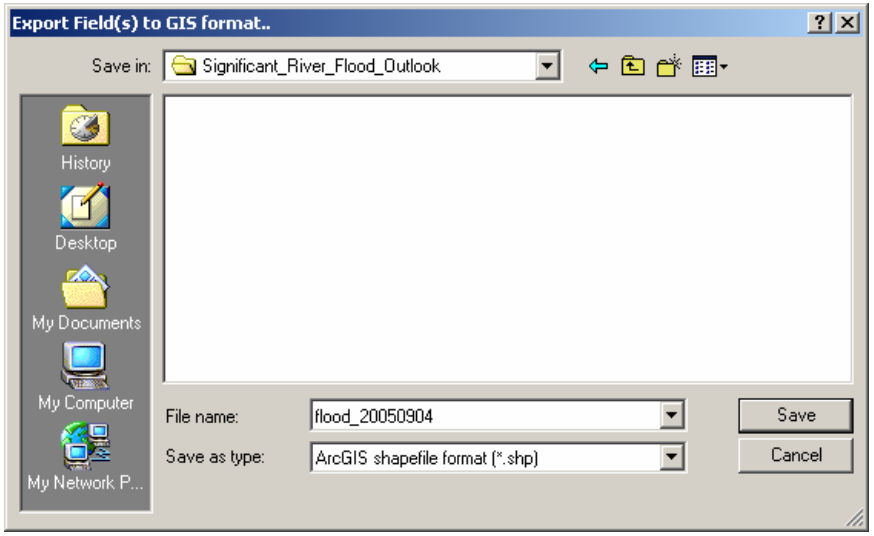


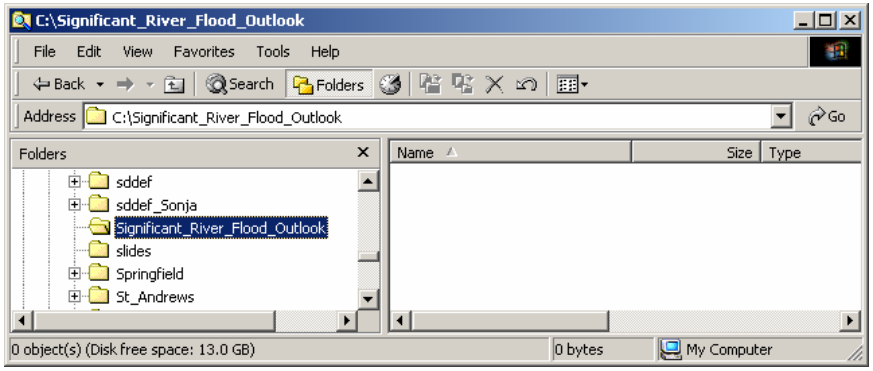
Select the field type named **NWS river flood outlook (polygons)** and click on the **Continue** button.

Significant River Flood Outlook

Access the data: A dialog window will appear that asks for the folder to save the downloaded shapefile. Specify an existing folder, or create a new one (e.g., c:\Significant_River_Flood_Outlook). Provide a logical name for your shapefile and click **Save**. Ideally, you should try to record the date for which the SRFO data are valid.

Open Windows Explorer and navigate to your new SRFO data folder. Notice that the shapefiles have been downloaded and saved to this location.



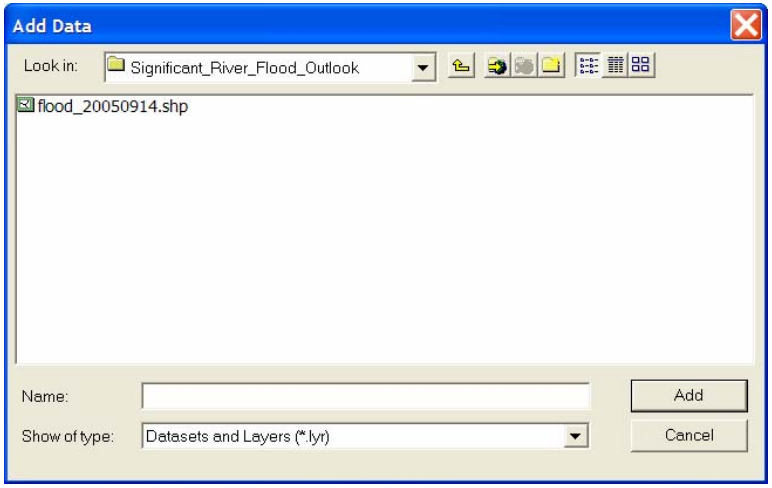


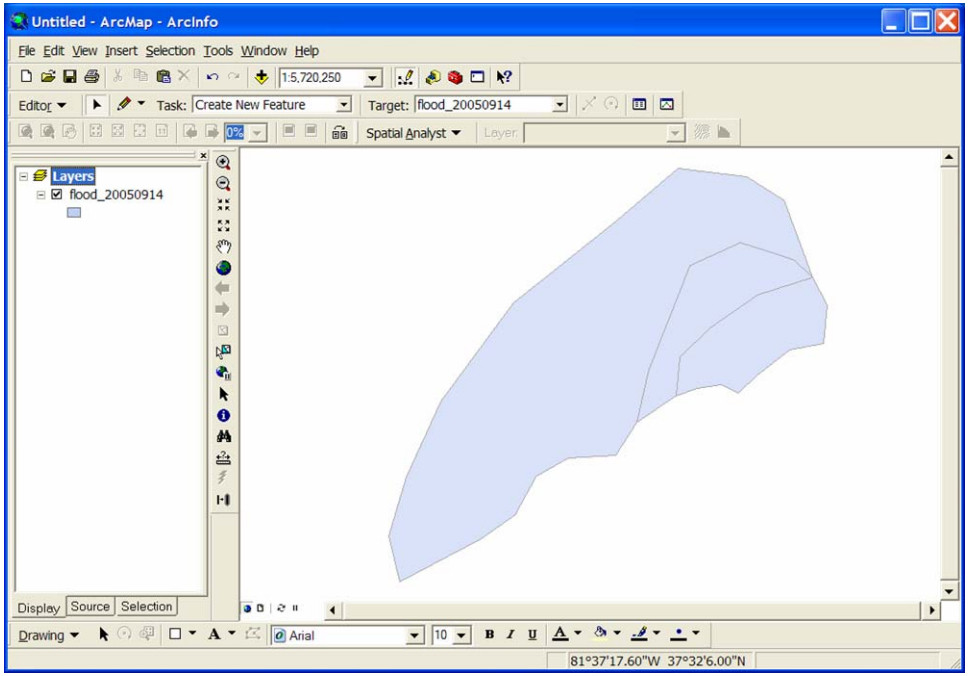
Open ArcMap to view these data. Select **Start > Programs > ArcGIS> ArcMap**.

Significant River Flood Outlook

View the data: Add the shapefile by clicking on the **Add Data** button found at the top of the ArcMap window. This brings up a dialog box that lets users browse to their data.

Select the SRFO layer and click **Add**. The layer now appears at the top of ArcMap's table of contents.





Significant River Flood Outlook

View the data: Double-click on the SRFO data layer to open the Layer Properties. Click on the **Symbology** tab.

Under the Show window, click on **Quantities**.

Under Quantities, select **Graduated Colors**.

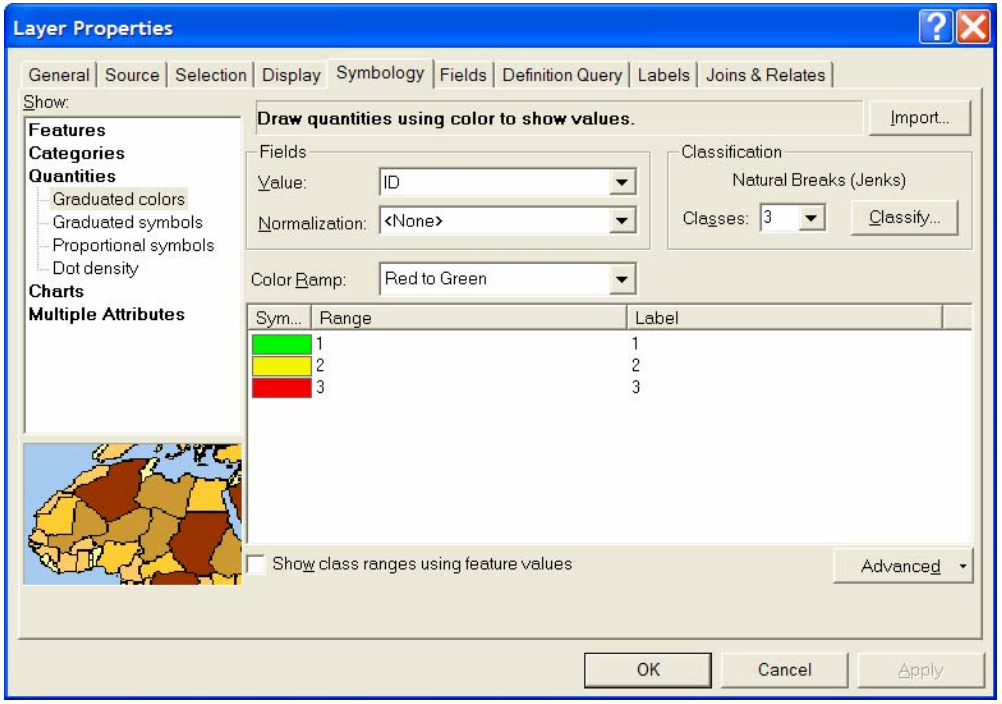
Under Fields change Value to **ID**.

Right-click on the Color Ramp.

Click **Graphic View** from the available options. This changes the color ramp into a textual description of the color ramp.

Use the **Red to Green** ramp to display the SRFO data. You may have to right-click on the symbols and select **Flip Symbols** to have value 1 equal green and value 3 equal red.

Once you have decided on a color ramp, click **Apply** to make the changes to the symbology.



Significant River Flood Outlook

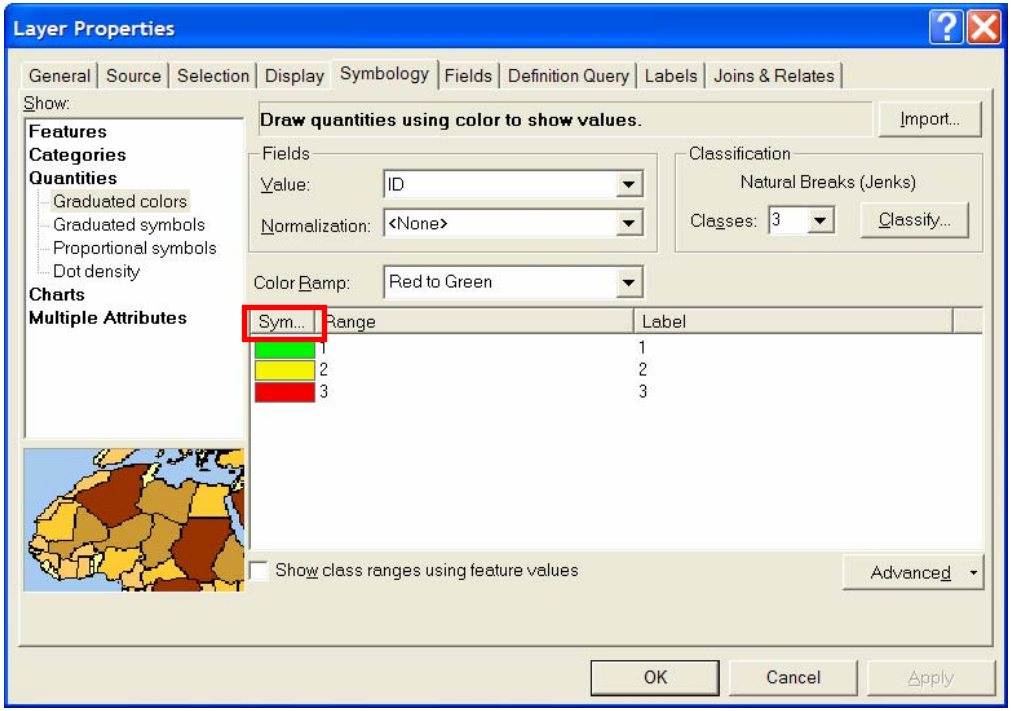
View the data: Before closing the Layer Properties dialog box to return to your map, click on the **Symbol** header (indicated in the graphic).

Select the **Properties for All Symbols** option.

In the Symbol Selector dialog box, under **Options**, click on the **Outline Color** pull-down menu and select **No Color**.

Click **OK** and **OK** again to close the Layer Properties box and apply the changes you have made to the symbology of the SRFO data layer.

This will remove the outline around each polygon and make the SRFO data appear more continuous.



Significant River Flood Outlook

View the data: You now have the SRFO data symbolized in a meaningful way. Next you will need to add some additional base data like state boundaries.

Click on the **Add Data** button and browse to the directory that houses your base layer shapefiles.

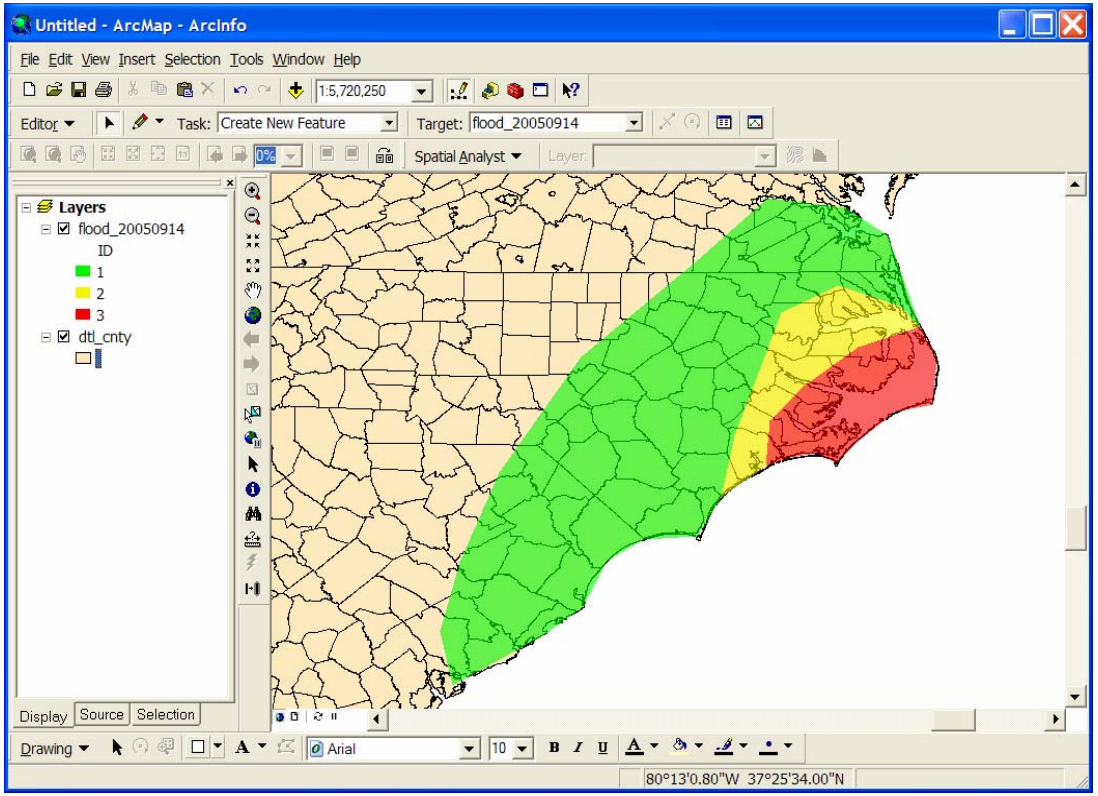
Add a counties layer to you map.

Make sure that the SRFO layer is on top of the counties layer.

Open the SRFO Layer Properties and click on the **Display** tab.

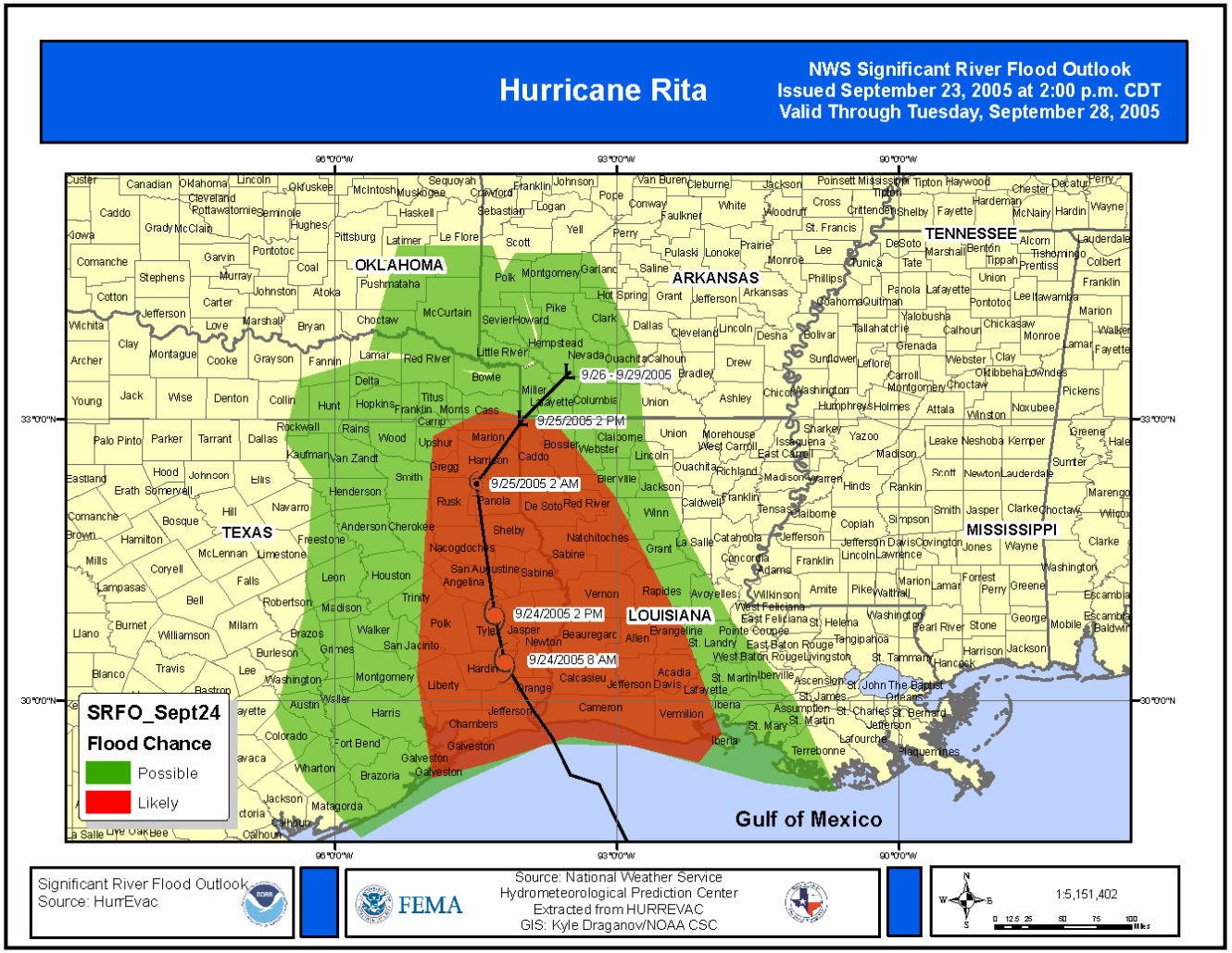
Set the transparency level to **40%** and click **OK**.

At this point you are ready to begin making a map. An example has been included of what the NOAA Coastal Services Center has provided to members of FEMA in the past.



Refer to the “Basics of Cartography” chapter at the end of this manual for additional information.

Significant River Flood Outlook



Tropical Cyclone Wind Speed Probabilities

Purpose: This type of map depicts probabilities of sustained tropical-cyclone surface wind speeds. These probabilities are expressed in percent for wind speed thresholds equal to or exceeding 34, 50, and 64 knots. The probabilities are based on the track, intensity, and wind structure (size in terms of radii) uncertainties in the official National Hurricane Center forecasts.

Source Data: This type of map uses the NOAA National Weather Service's National Digital Forecast Database (NDFD), found at *www.nws.noaa.gov/ndfd/*. The National Weather Service (NWS) provides access to gridded forecasts of weather elements (e.g., cloud cover, maximum temperature) through the NDFD. This database contains a seamless mosaic of digital forecasts from NWS field offices working with the National Centers for Environmental Prediction (NCEP). The database uses a 5-kilometer national grid that covers the continental U.S. and separate grids that cover Hawaii, Alaska, the U.S. Virgin Islands, and Puerto Rico. Each 5-kilometer grid cell has forecast information, allowing users to retrieve specific forecasts by entering geographic coordinates.

The World Meteorological Organization (WMO) has adopted Edition 2 of the gridded binary data (GRIB) code as a standard for sharing information. GRIB, Edition 2 (GRIB2), is involved in the NDFD in two ways. First, GRIB2 is the code form used to transmit gridded forecasts from contributing offices to the NDFD. Second, GRIB2 is one of the primary forms used to transmit the NDFD grids to NWS customers and partners.

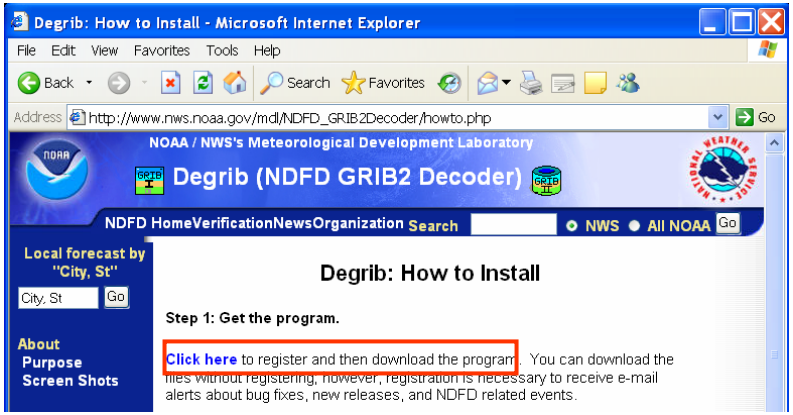
Download: Before working with NDFD data, users must first download the GRIB2 Decoder tool that allows access to the data. Learn more about GRIB2 Decoder by visiting this site: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/*

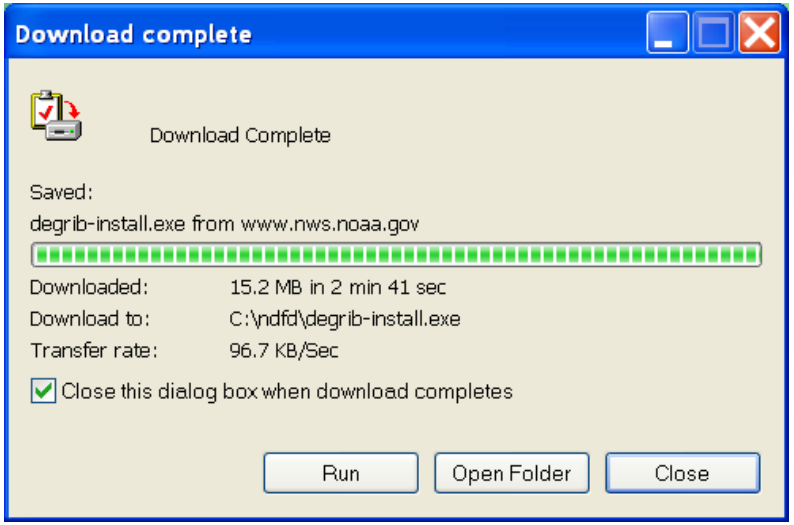
Tropical Cyclone Wind Speed Probabilities

Download: Register for the DEGRIB program here: *www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/howto.php*
At the top of the page, under step 1, click on the highlighted link to register and download the program.

Once done, download the program from here:
www.nws.noaa.gov/mdl/NDFD_GRIB2Decoder/download.php

This page provides several different versions of the same product. For this tutorial, you will focus on the Microsoft Windows version. Click on **degrib-install.exe** and select **Save**. Specify the directory path for the program as c:/ndfd and copy the .exe into that folder.





Double-click on **degrib-install.exe** to install the program. A window will appear; click on the **Install** button and accept the defaults for the installer.

Tropical Cyclone Wind Speed Probabilities

Download: Double-click on **tkdegrib (aka NDFD GRIB2 Decoder)** to start the program.

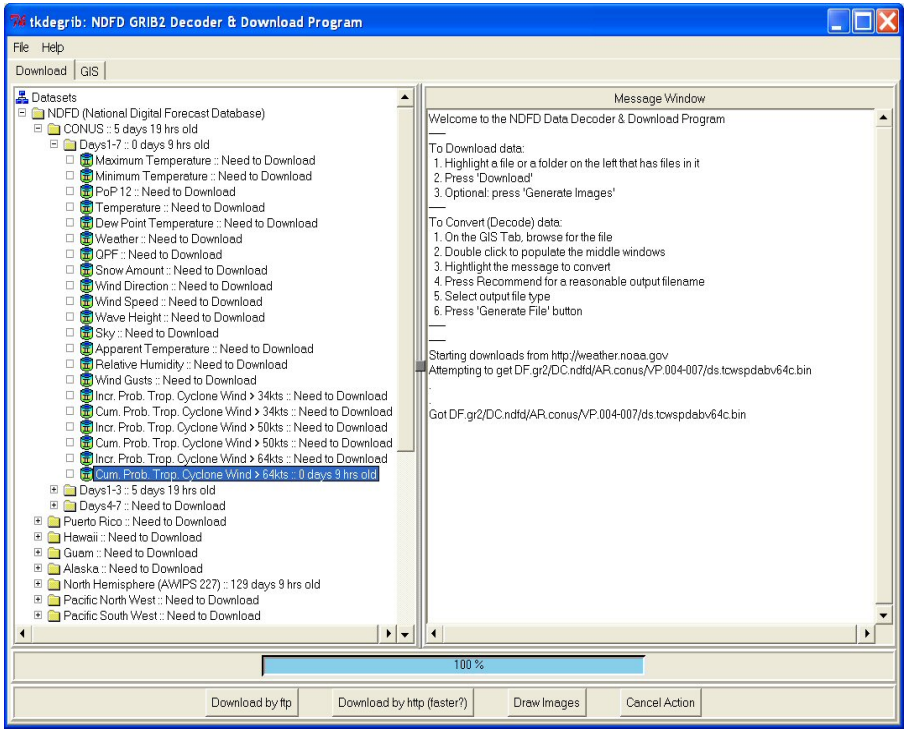
Then click on the **Download** tab and expand the NDFD data set folder if it is not already open.

Choose the region of interest and expand the folder.
Choose the days of interest and expand the folder.

Data for each weather element can be downloaded by highlighting the entire region folder, or individual weather elements can be downloaded by holding down the Control key on the keyboard and highlighting one or more elements.

Click on the **Cum. Prob. Trop. Cyclone Wind > 64kts (knots)***, and then click on either the **Download by FTP** or the **Download by HTTP** button (either will work) at the bottom of the window.

Once downloading begins, there will be an indication in the Message Window that it is working. Also, after the download button is clicked, the light blue bar near the bottom of the window will show the progress of the data download.



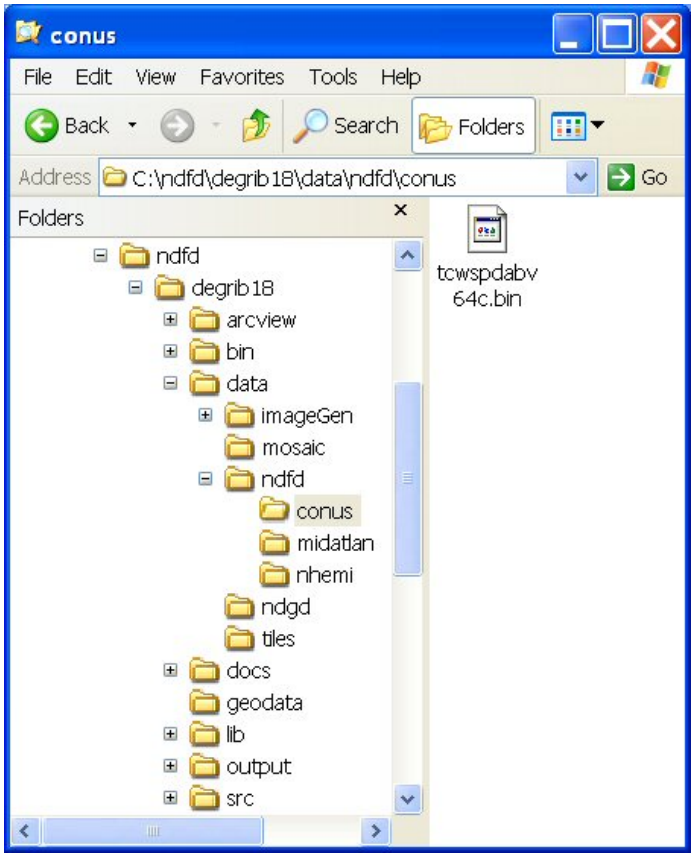
***Note:** In most cases, the file(s) of greatest use will be the Cum. Prob. Trop. Cyclone Wind > 34kts or Cum. Prob. Trop. Cyclone Wind > 64kts, which include the cumulative probability (out to 120 hours) of an area experiencing tropical-storm-force or hurricane-force winds, respectively.*

Tropical Cyclone Wind Speed Probabilities

View the data: Minimize this program and open **Windows Explorer**. Navigate to C:\ndfd\degrib18\data\ndfd\conus and notice that tcwspdabv64c.bin is stored in that directory.

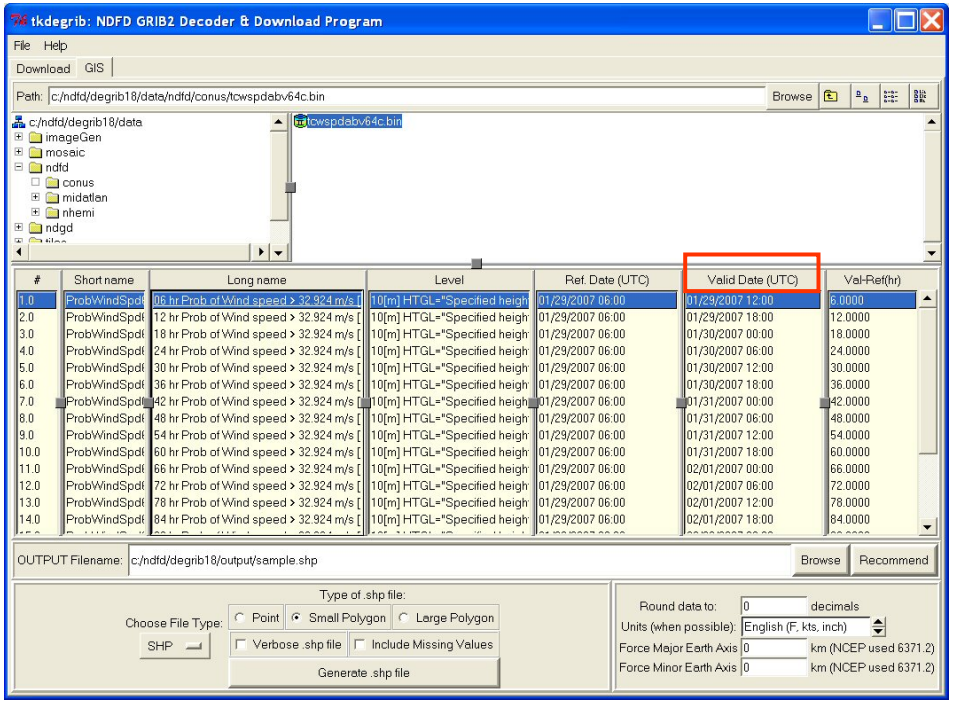
This file contains important data in a binary format. Unfortunately, ArcGIS is unable to read this format, so the data must be converted into a shapefile.

Close Windows Explorer and return to the **tkdegrib (aka NDFD GRIB2 Decoder)** program.



Tropical Cyclone Wind Speed Probabilities

Convert the data: Click on the **GIS** tab. This window lets users choose a file to convert to various GIS-friendly formats. Navigate to the directory of your .bin file. Double-click on **tcwspdabv64c.bin** to see a series of wind speed probability forecasts.



Choose the time under the Valid Date field that will be closest to the forecasted landfall of the storm. You may want to have these data correspond to the same day and time of data in previous modules.

An easy way to name an output file inside the Output Filename window is to simply click on the Recommend button. Ideally, you should keep all of your regional files in the same directory.

Specify the File Type as **SHP** (shapefile).

Specify the type of shapefile to be **Large Polygon**.

Specify **Round data to: 0** decimals.

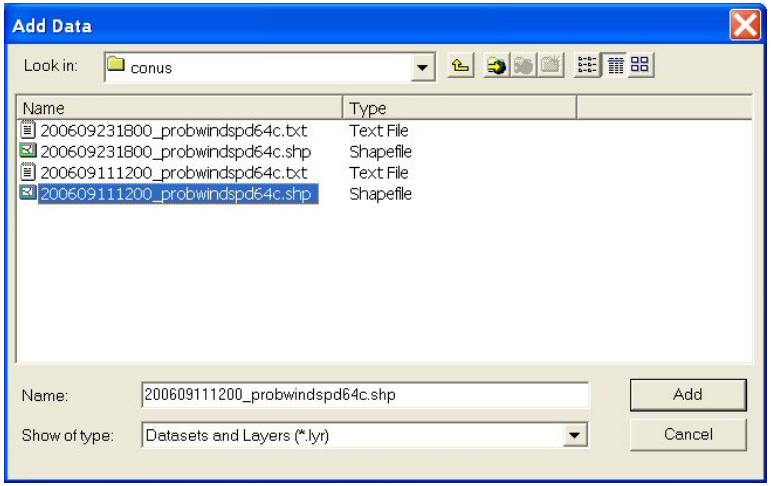
When finished, click the **Generate .shp file** button. This will create a new shapefile and copy it into the specified folder. Notice that it is in a different folder than the tcwspdabv64c.bin file.

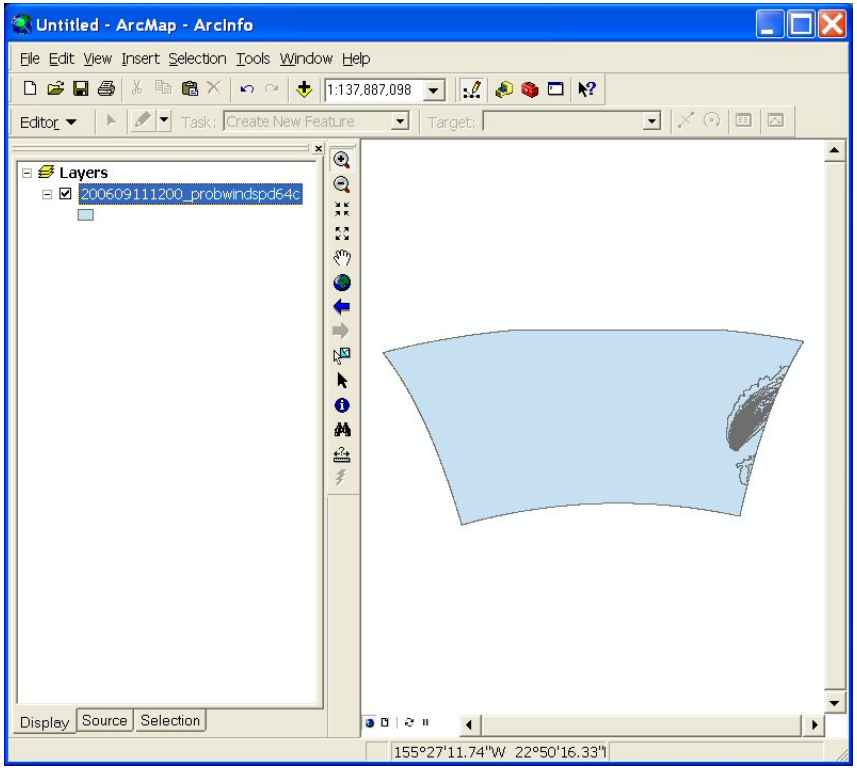
When finished, click on the window that reads **Done**. Minimize the program and open **ArcMap**.

Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: Start ArcMap by selecting **Start > Programs > ArcGIS > ArcMap**

Add data by clicking on the **Add Data** button found at the top of the ArcMap window.
This will open a dialog window that lets users browse to their data.





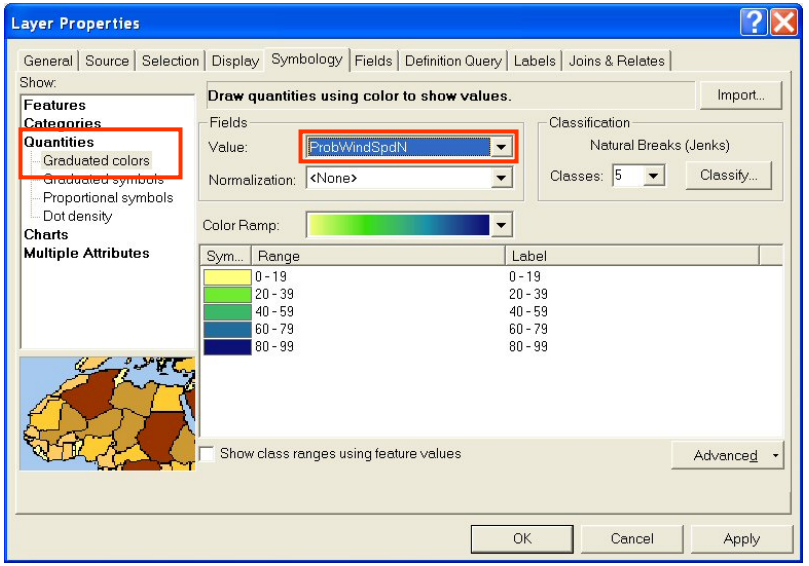
Select the file and click **Add**. Notice the layer is now added to the top of the table of contents in ArcMap.

The data should now be symbolized to show the different forecasted wind speed probabilities.

Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: Double-click on the layer name in the table of contents. This will open the Layer Properties window. Click on the **Symbology** tab to assign probability ranges to the polygons.

Change the Show group on the left-hand side of the window to the **Quantities > Graduated Colors** category. Specify the value field as **ProbWindSpdN.** Notice that a default classification is given.

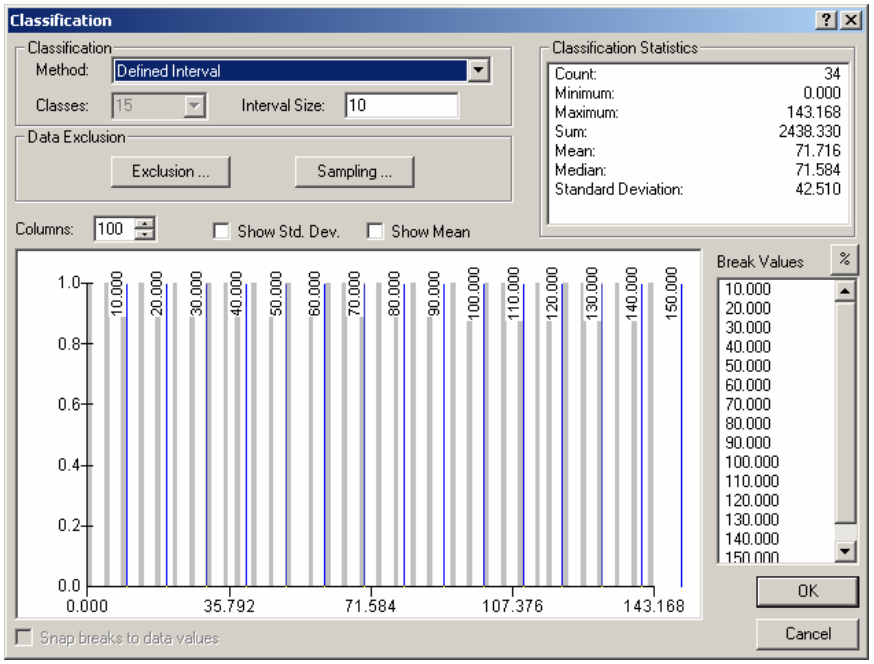


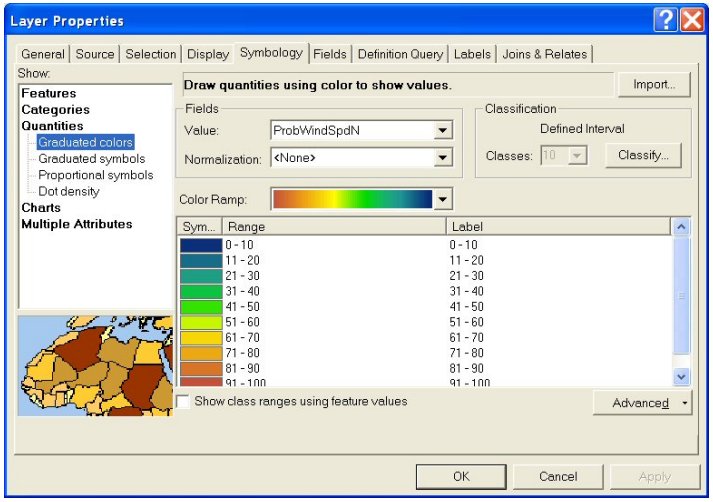
Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: Click on the **Classify** button to open the Classification dialog window. Set the Classification Method to **Defined Interval**. Change the Interval Size to **10**. Click **OK**.

Choose a color ramp that is a logical progression from light to dark colors or, as in the example below, hot to cold colors.

Since you want the highest probability for tropical cyclone wind speeds to be red, you need to reverse the order of these colors.



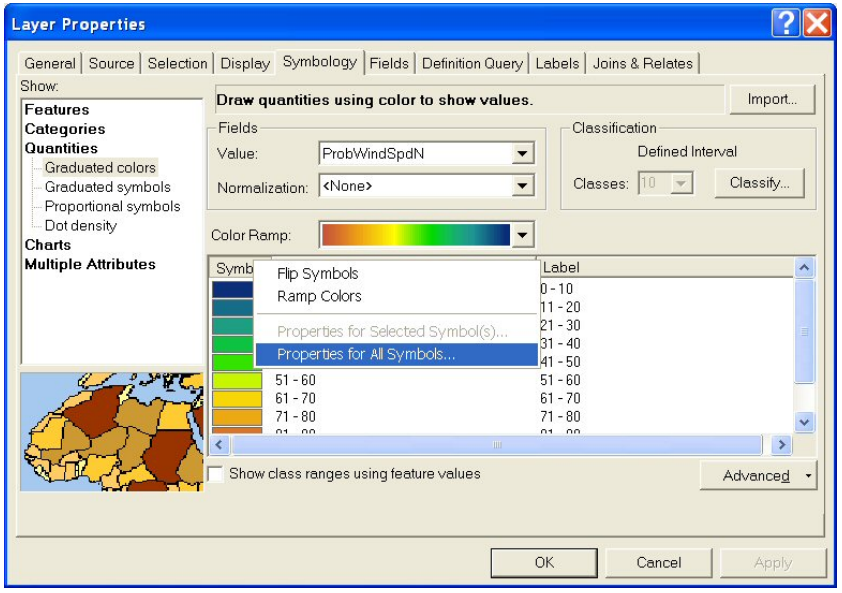


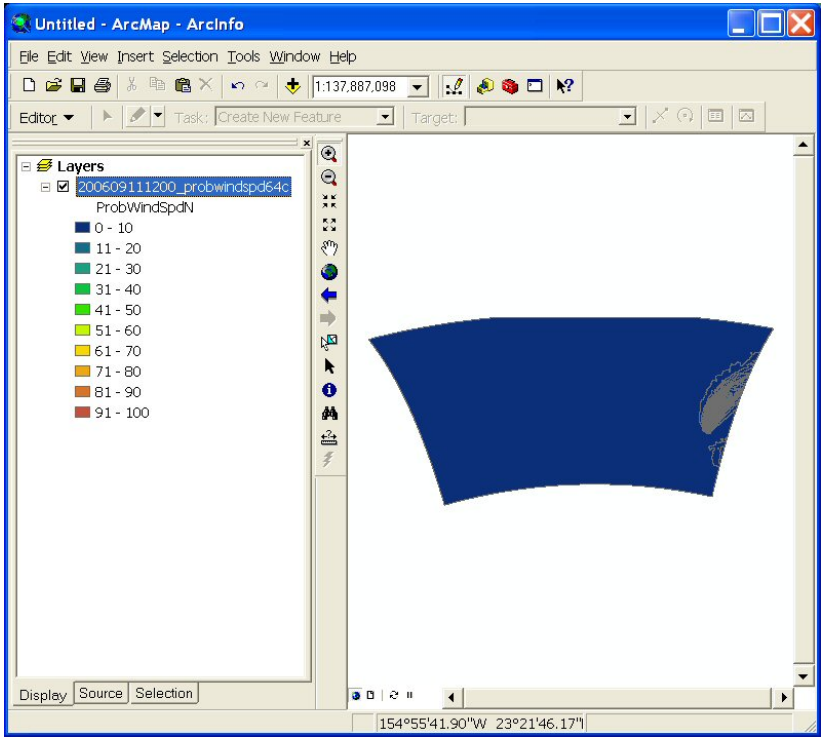
Click on the **Symbol** field and select **Flip Symbols**. Click **OK** to see the new colors.

Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: Notice that the outline of the polygons is distracting.

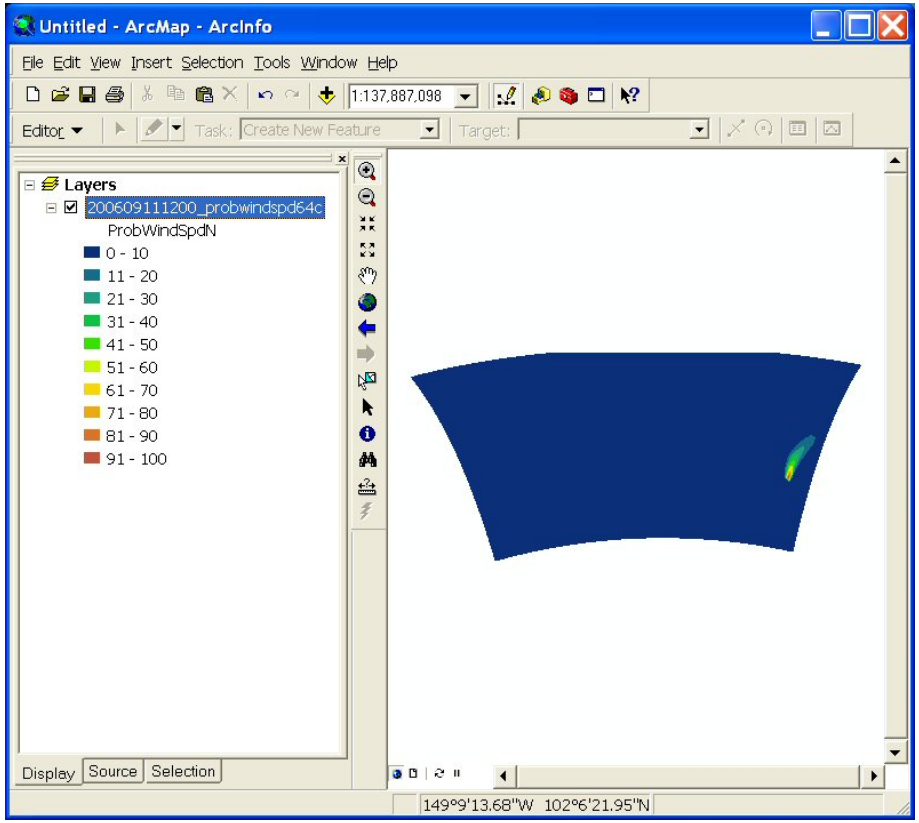
To better display the data, turn the outline off by double-clicking on the layer to open its Layer Properties. Click on the **Symbol** header and select **Properties for All Symbols**.

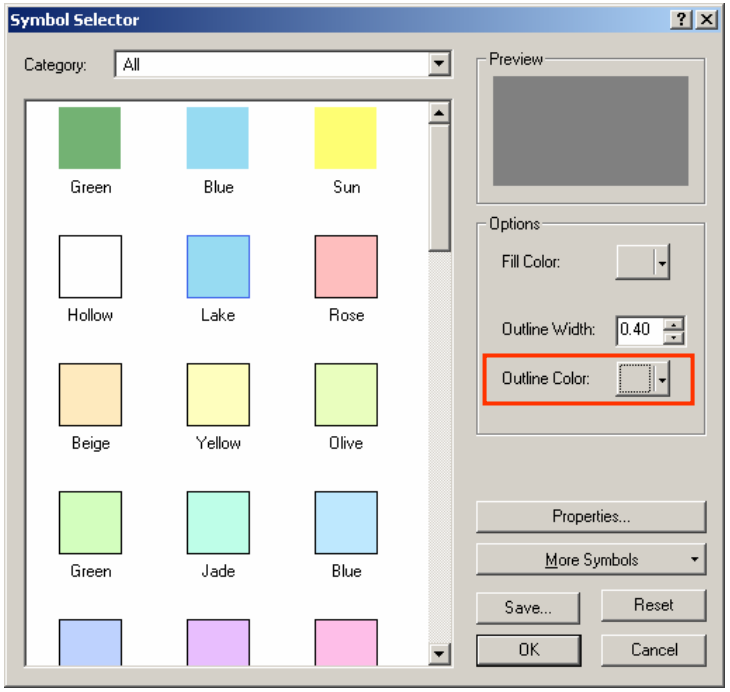




Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: Change the Outline Color to **No Color** and click **OK**. Click **OK** in the Layer Properties window to assign the change.





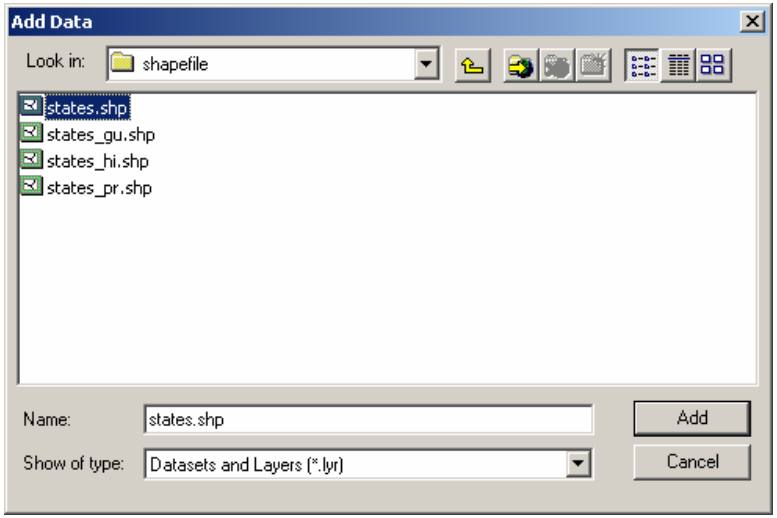
Notice that the different wind speed probabilities are now easier to see.

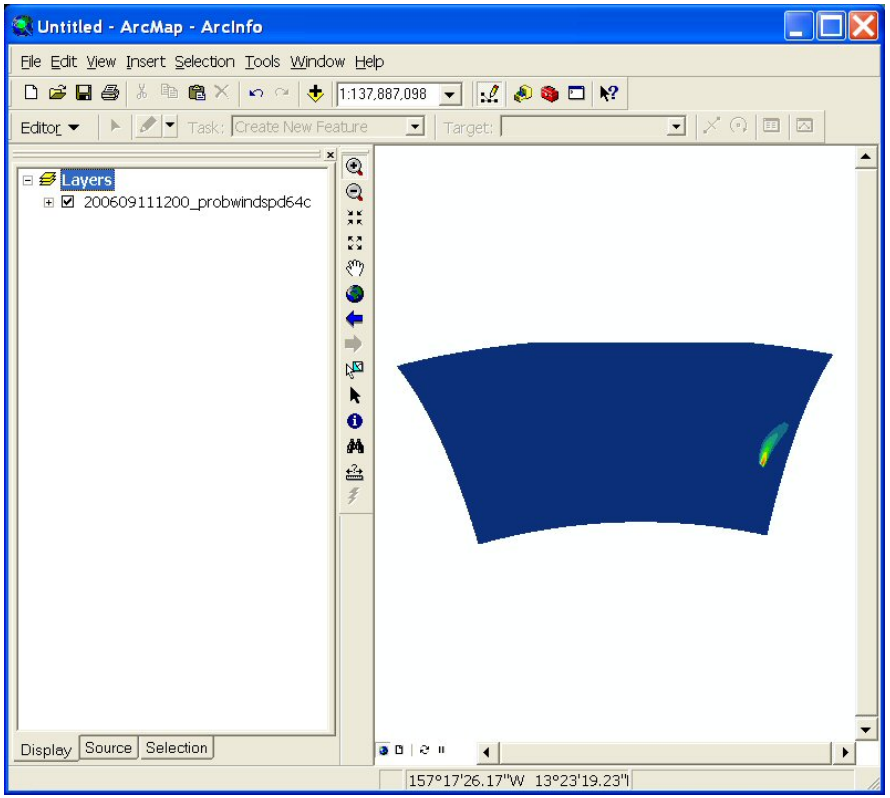
Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: Collapse the symbols for this layer by clicking on the minus sign next to the layer's name.

Add a state boundary layer for reference purposes. Click on the **Add Data** button and browse to the following directory: C:\ndfd\degrib18\data\imageGen\shapefile

Select the **states.shp** layer for this example and click **Add**.





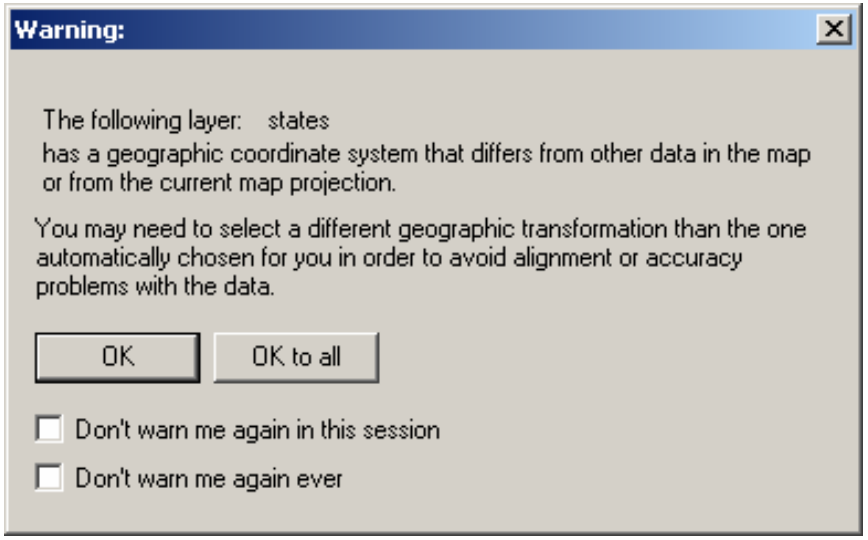
Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: The following Warning dialog will appear.

This alerts the user that the data being added have a different spatial reference (projection system) than the NDFD layer currently in the table of contents.

ArcMap's data frame defaults to the spatial reference of the first layer added; however, as other layers having a different spatial reference are added, they will be automatically reprojected to the original layer.

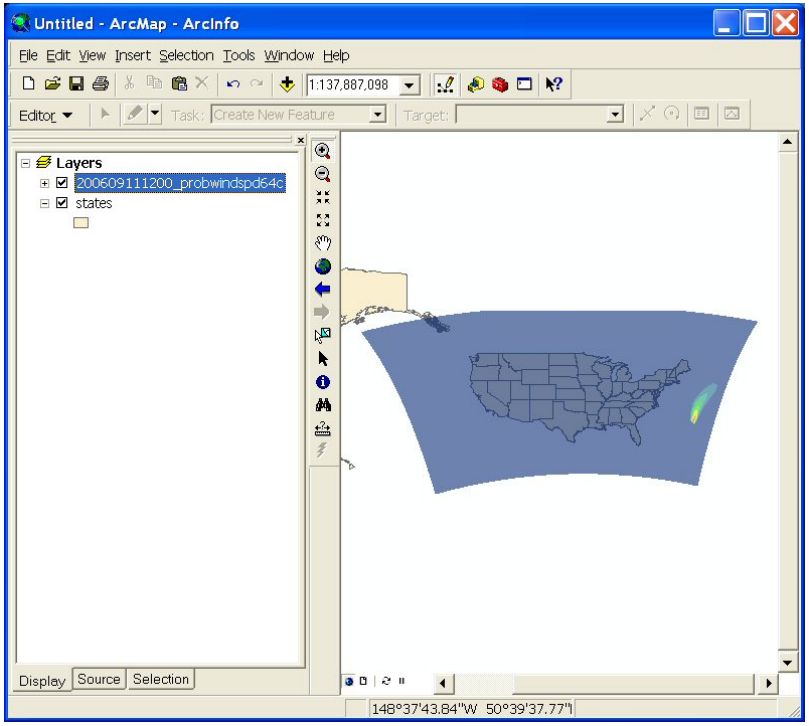
This is known as "projection on the fly." This message is normal and can be dismissed by clicking **OK**.

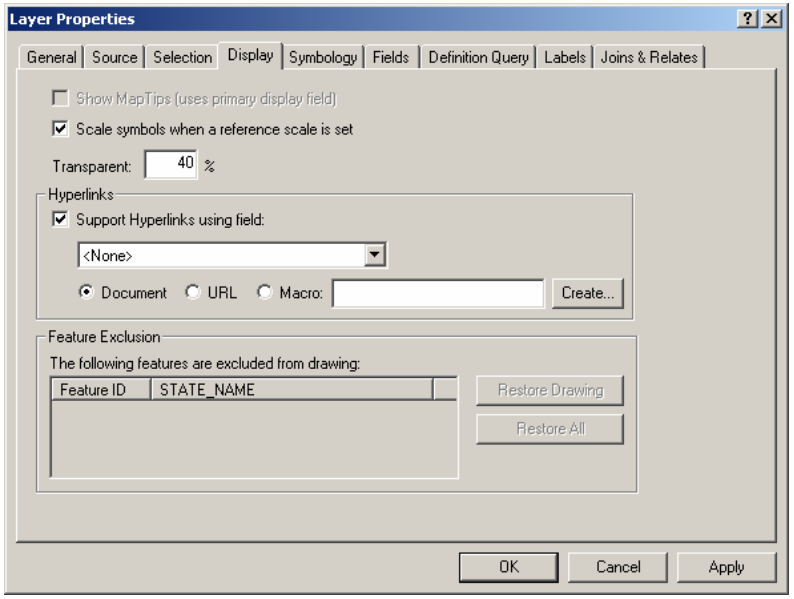


Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: Click and drag the wind speed probability layer to the top. Double-click on the layer to open its Layer Properties window, click on the **Display** tab, and set the transparency to **40%** so you can see the state layer below it.

Click **OK** to see the change take effect.



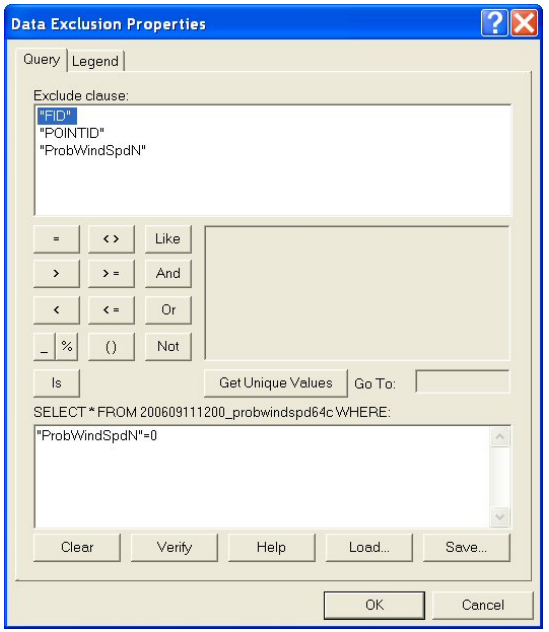


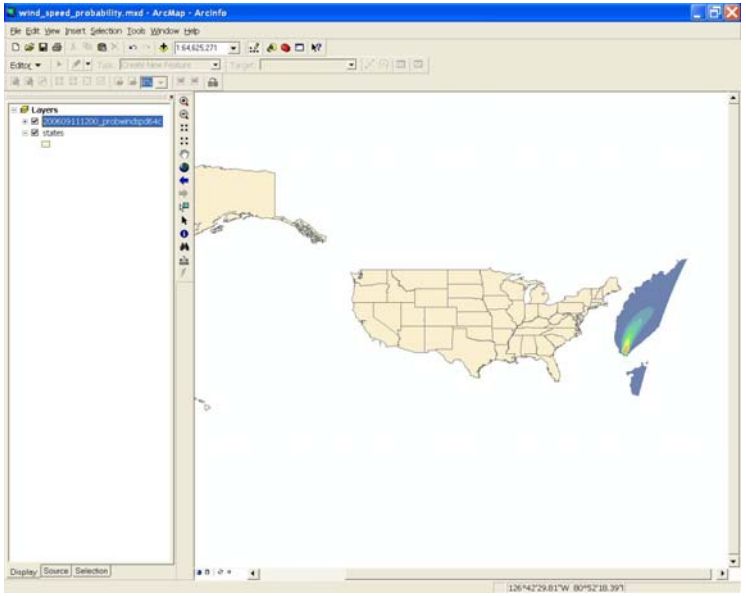
Tropical Cyclone Wind Speed Probabilities

Add and symbolize the data: You may also wish to exclude the value for zero probability of experiencing winds up to 64 knots. Double-click on the layer to re-open its Layer Properties window.

Click on the **Symbology** tab, and then click on the **Classify** button to open the Classification dialog window. Click on the **Exclusion** button to open the Data Exclusion Properties dialog.

Create an exclusion statement. In the white space at the bottom of the window, type **"ProbWindSpdN"=0**.



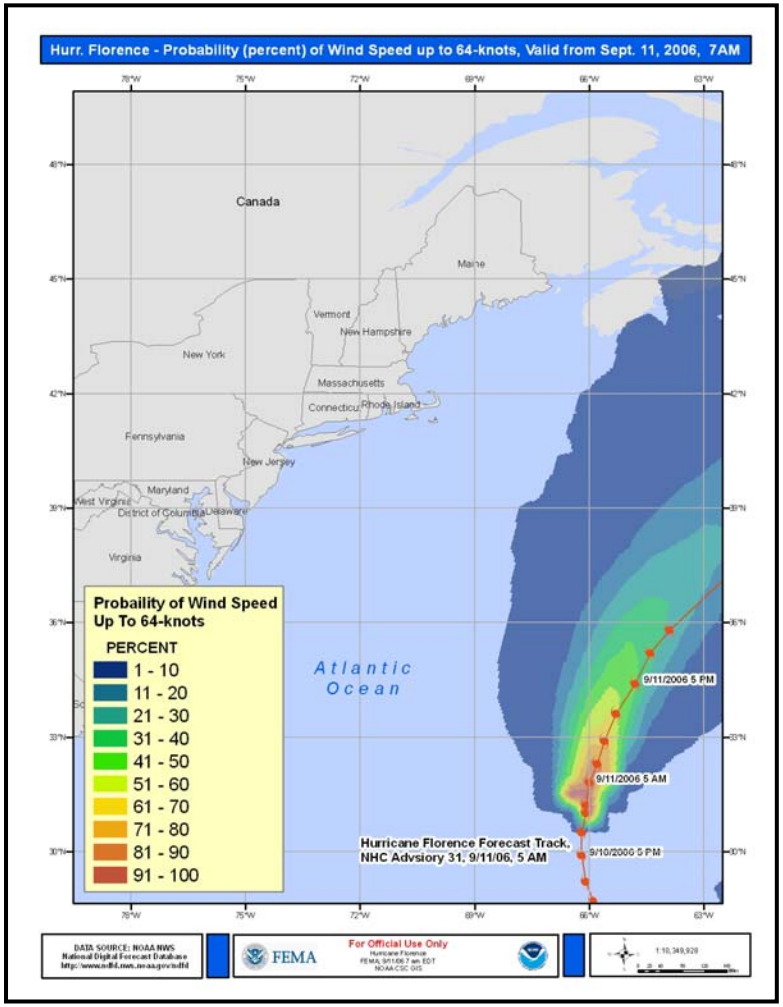


Click **OK** three times to see the change take effect.

At this point you are ready to begin making a map. The following is an example.

Refer to the "Basics of Cartography" chapter at the end of this manual for additional information.

Tropical Cyclone Wind Speed Probabilities



Basics of Cartography

Purpose: This chapter discusses how to display the data you have processed in previous chapters through the use of cartography, which is defined as the art and science of making maps. Though there are many ways to represent your data cartographically, this chapter will discuss “conventions” you should consider for all FEMA-produced maps and look at specific elements that should appear for each.

All maps should include several common map elements:

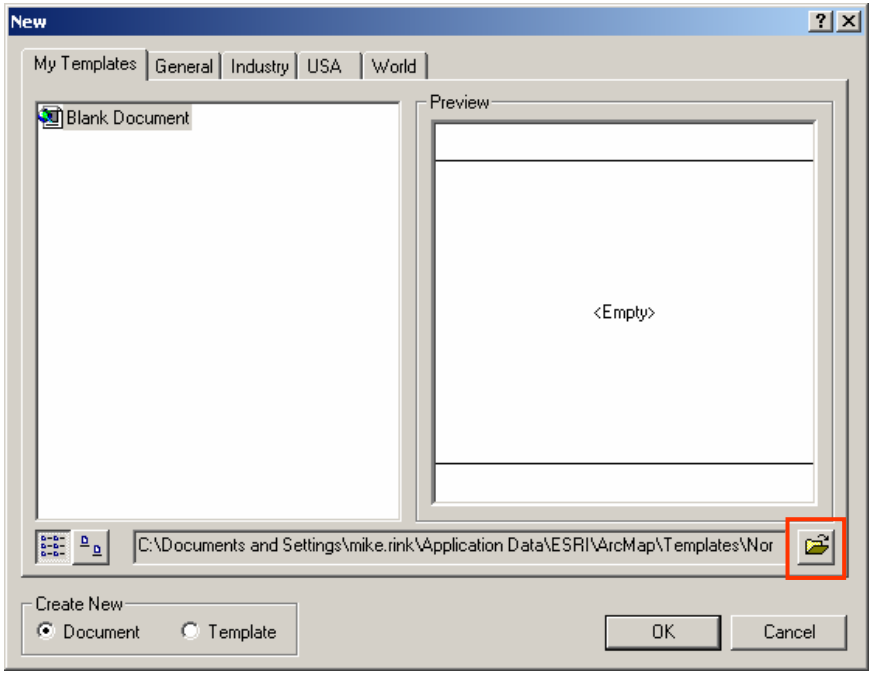
- The map body (in this case, your data frame)
- A well-structured title
- A legend
- A north arrow or graticule (lines of latitude and longitude with labels)
- A scale bar
- Explanatory text (date of map, source of data, any disclaimers, etc.)
- Agency logos
- Hurricane track and category symbols
- Other FEMA- or NOAA-specific information

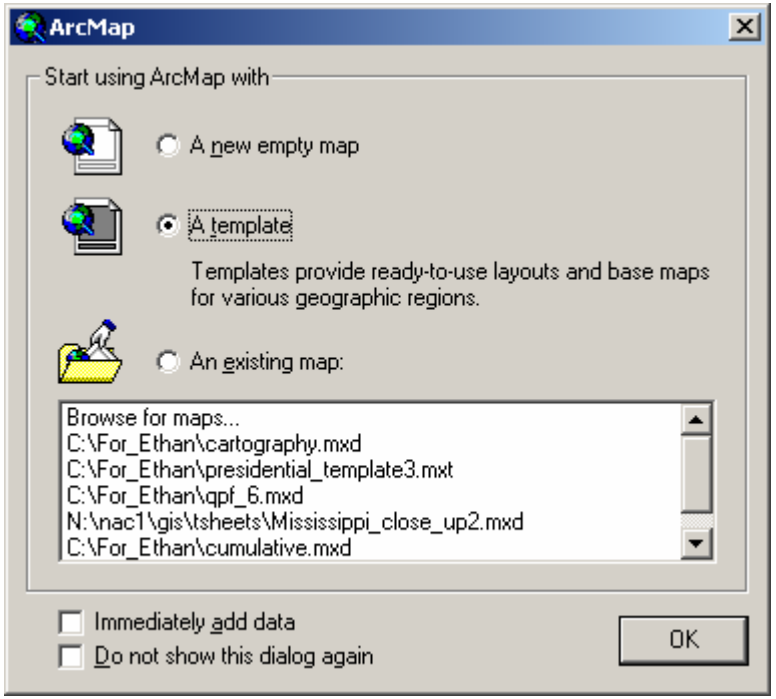
Each of these topics will be discussed at length in this chapter.

Basics of Cartography

The Presidential Template: A map template is a pre-structured map that contains many (but not all) of the necessary map elements for a complete presentation of the data. A special template has been developed that provides a uniform look to all the FEMA-produced maps in this chapter. The idea of the template is to help assist users in the cartography process.

Open a new ArcMap session, and when prompted, specify that you want to open **A template** file (.mxt). Click **OK**.





When the dialog window opens, browse to the folder that contains the Presidential_template.mxt.

Basics of Cartography

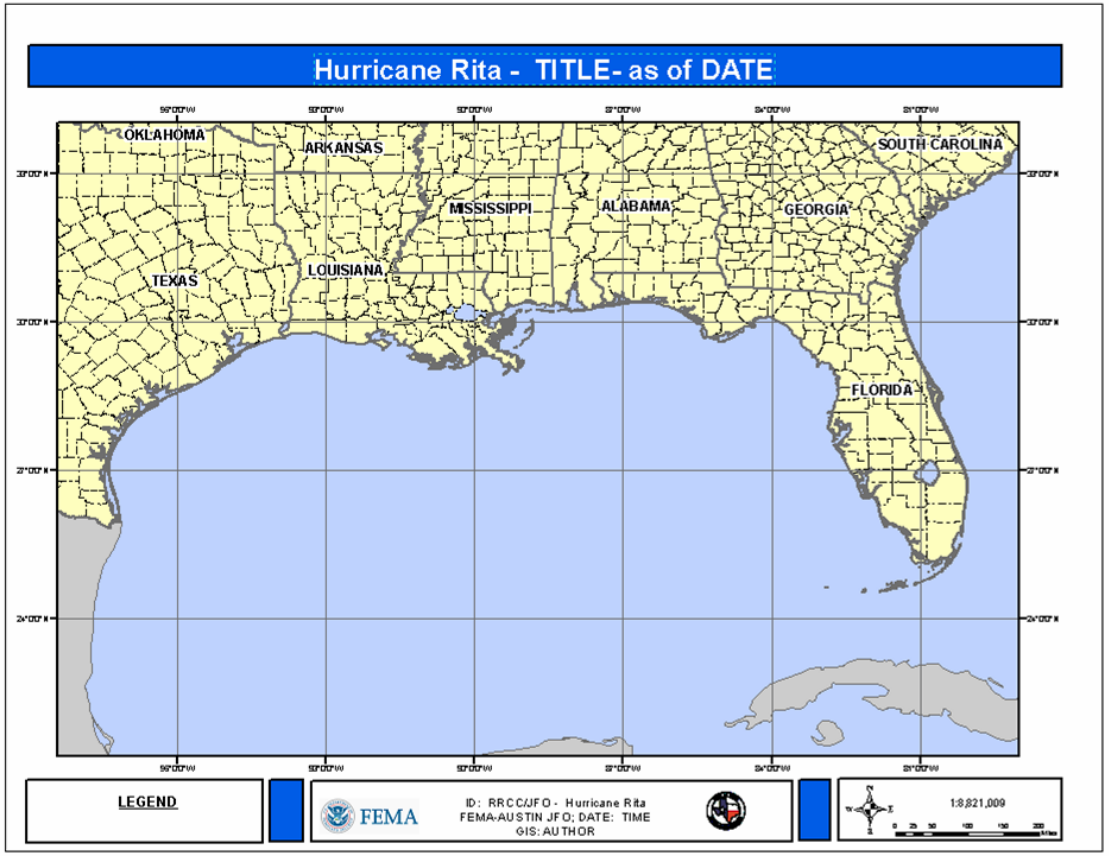
The Presidential Template: In the Open dialog window, specify the name of the .mxt and click **Open**. Select the **FEMA_Template_Landscape.mxt**. The following map will appear.

Notice that several data layers and standard map element conventions are provided to give your maps the same appearance and structure.

Ideally, you would not need to modify these elements, but in cartography, that is seldom the case. Instead, think of the placement and properties of these elements as merely a suggested guide for you to follow.

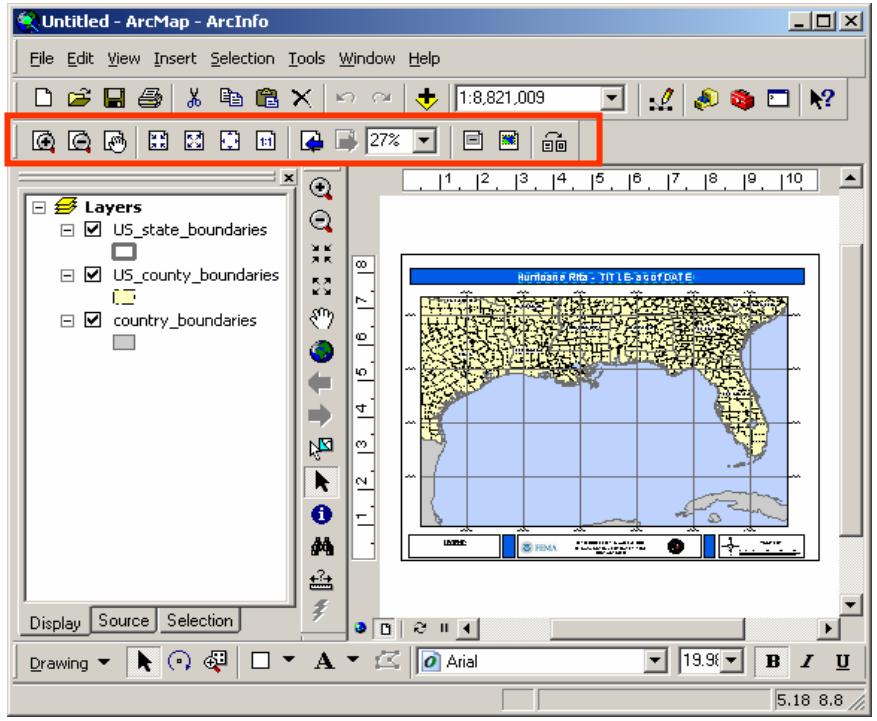
You'll notice that there is a graticule (lines of latitude and longitude) provided that demarks intersecting lines every 3 degrees. These will properly resize as you zoom in to a specific area of interest.

You will need to look at modifying the title, legend, source text, and possibly scale bar for each map produced.



Basics of Cartography

The Presidential Template: All the work thus far inside ArcMap has been performed within the Data View. The cartography component occurs within the Layout View. When the template is open, you will see that it is automatically set to the Layout View. At any time, you can change into the Layout View by clicking on the **View** menu and selecting **Layout View.**



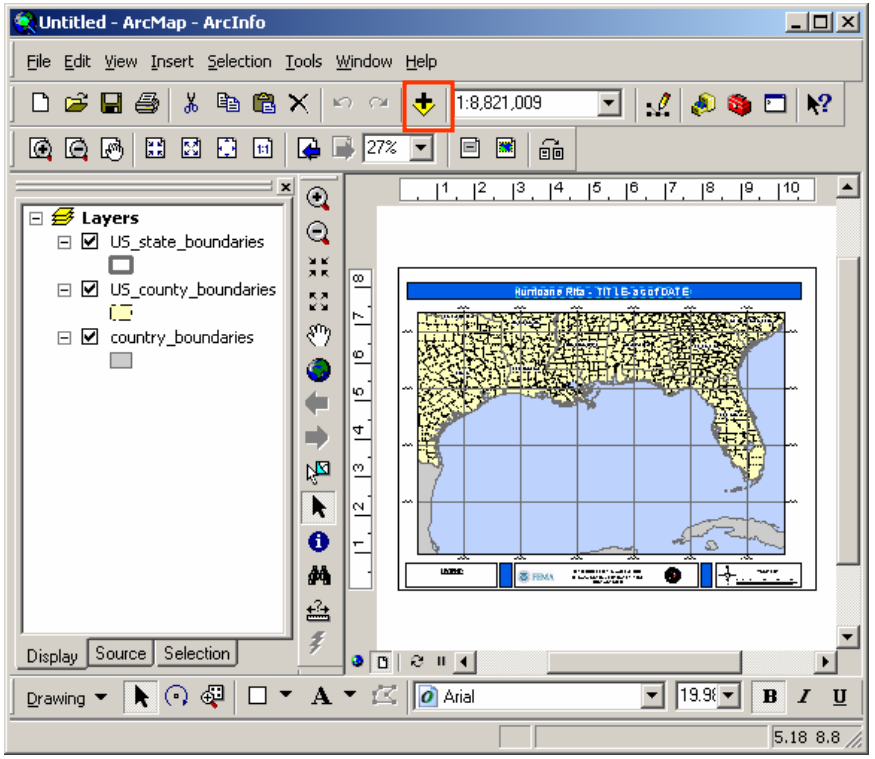
You'll notice that the layout toolbar is added to the view. These tools are used exclusively when working in layouts.

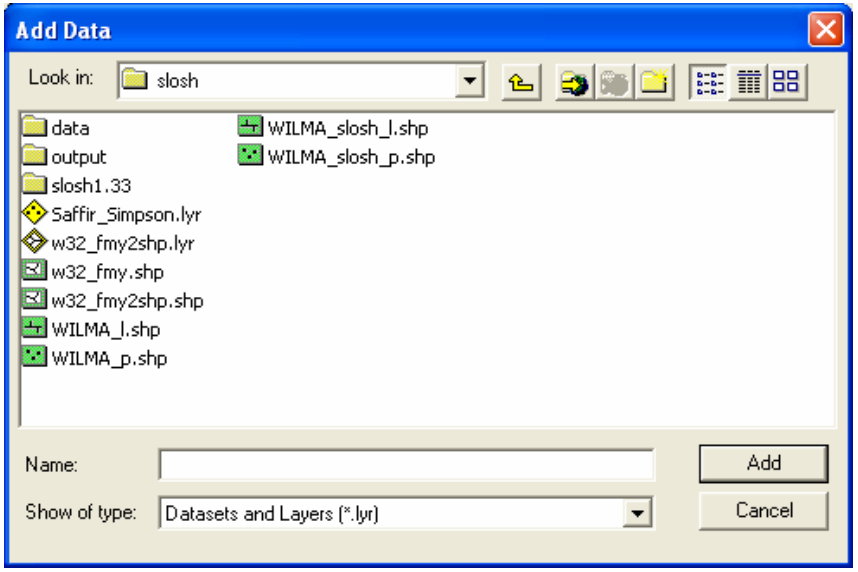
Each module in this chapter focuses on a specific type of data set. As a result, each data set will have its own type of map that starts with one of the FEMA templates. Examples for each type of map are given throughout this tutorial as a guide to show how your maps may look.

We are using the landscape template at this time since the data we will map have an east-west trend. As a result, the data are ideally suited for a landscape orientation. Data with a north-south trend should be mapped with the portrait template.

Basics of Cartography

Map Production: This example map shows a SLOSH model run. Once the template is open, click on the **Add Data** button and navigate to the folder that contains the SLOSH .lyr file you saved earlier.

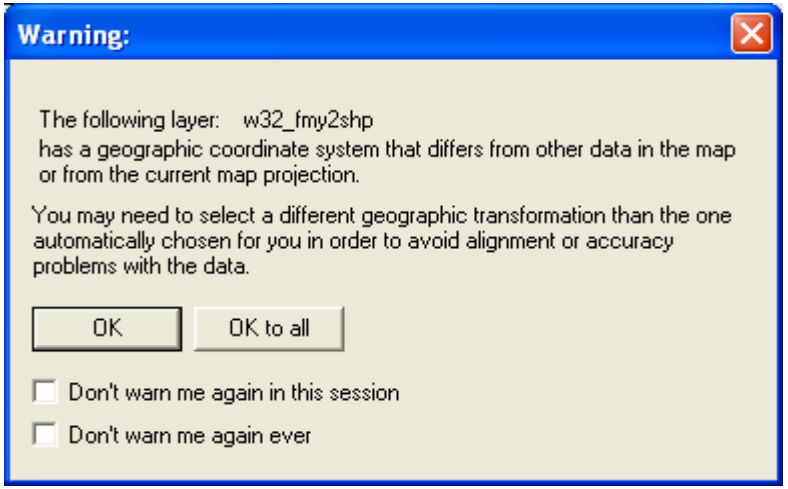


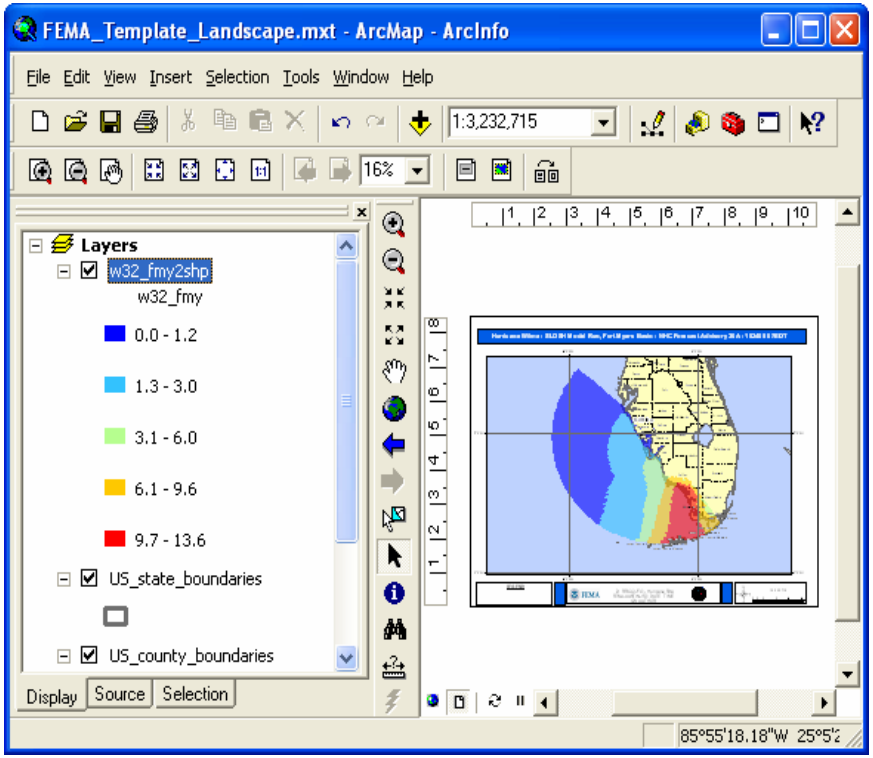


Select the .lyr file and click **Add**. The symbolized SLOSH layer is now added to ArcMap's table of contents.

Basics of Cartography

Map Production: You will probably receive the following warning message. This is normal, because it describes how the coordinate system of the layer you added is different from those layers already present in the table of contents. Dismiss this window by clicking **OK**. ArcMap's ability to perform projection "on the fly" resolves this problem.





The SLOSH data are now added to the table of contents. Rename the layer in the table of contents to read **Feet above NGVD29**. Zoom in to your area of interest to see the full extent of the data.

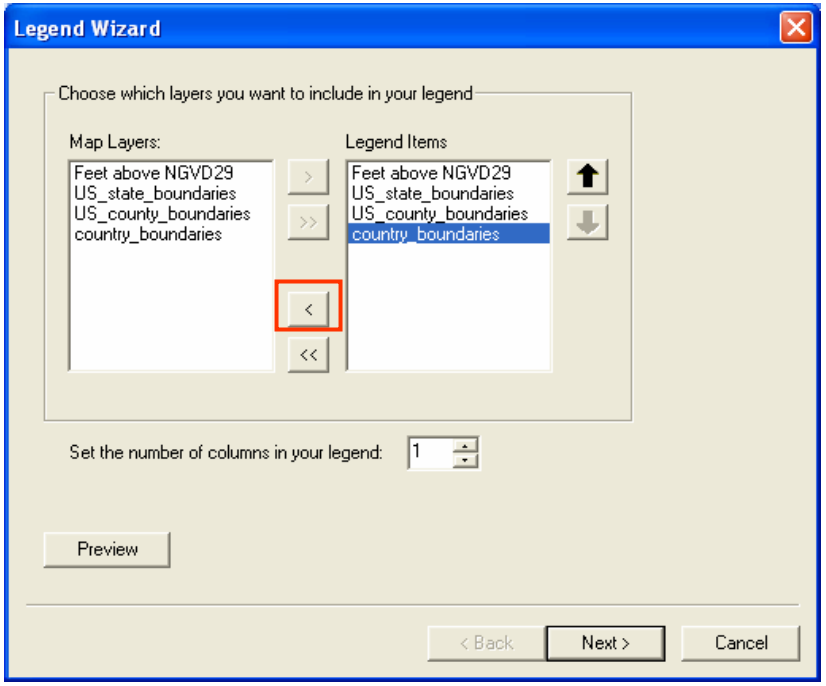
You will now add a legend to the layout.

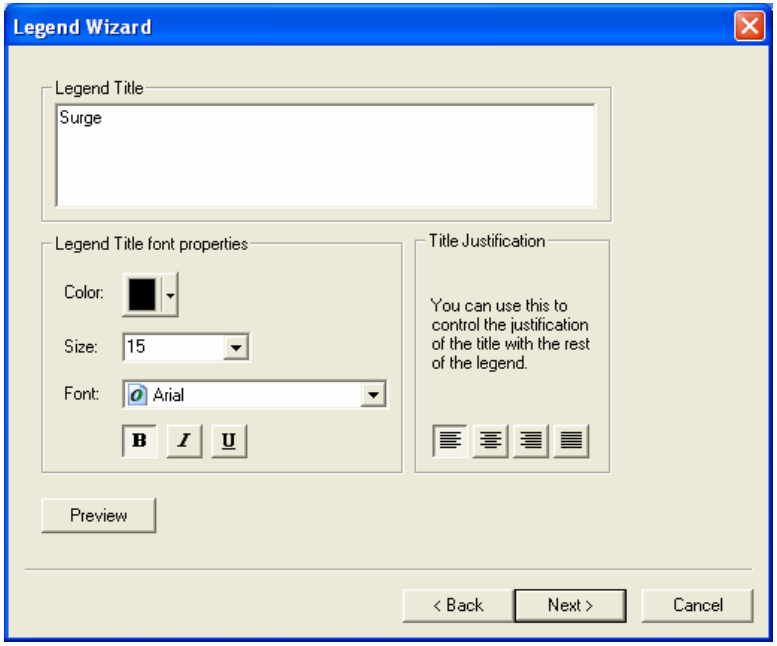
Click **Insert > Legend** to start the wizard.

Basics of Cartography

Map Production: The SLOSH layer has too many classes to fit inside the legend box provided on the template. For this reason the legend will appear in the map body. Remove all other layers (not Feet above NGVD29) from the legend by selecting the name of each one in the Legend Items field. Click on the **Move** button to remove the layers from the legend. Click **OK**.

In the next window, select and delete the word Legend and replace it with **Surge**. Click **Next**.

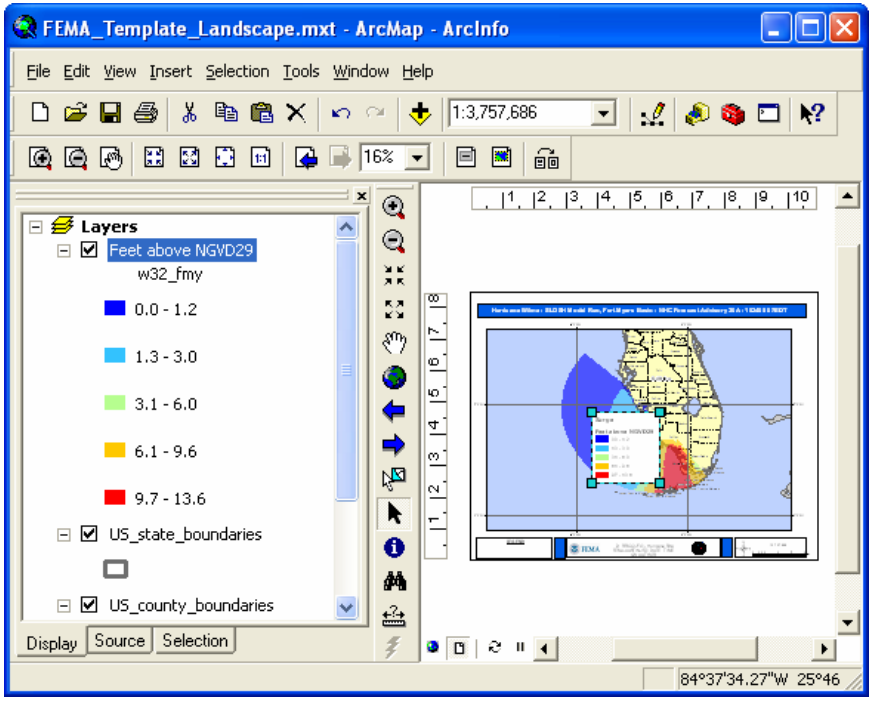


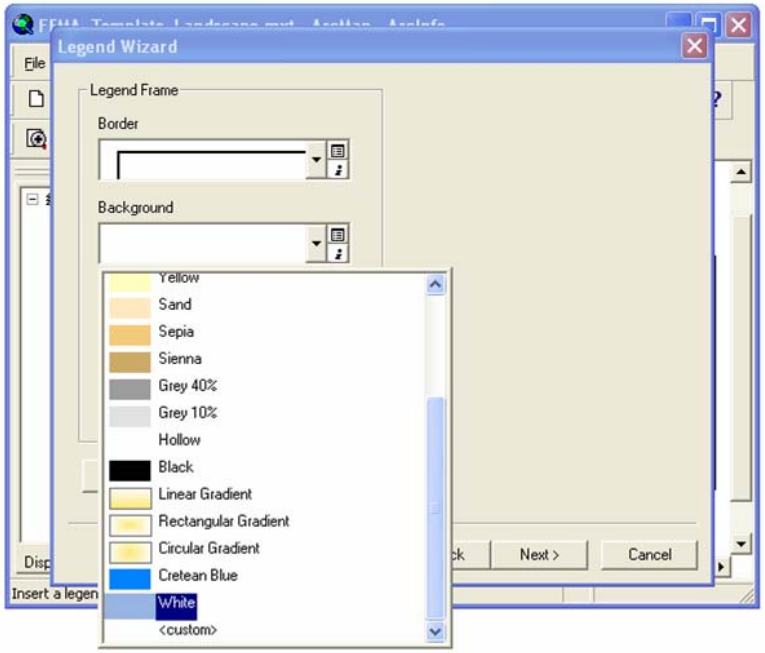


Basics of Cartography

Map Production: In the next window, change the Border to **1.0 Point** and the Background color of the legend box from transparent (default) to **White**. Click **Next** on the remaining windows. Click **Finish** to create the legend.

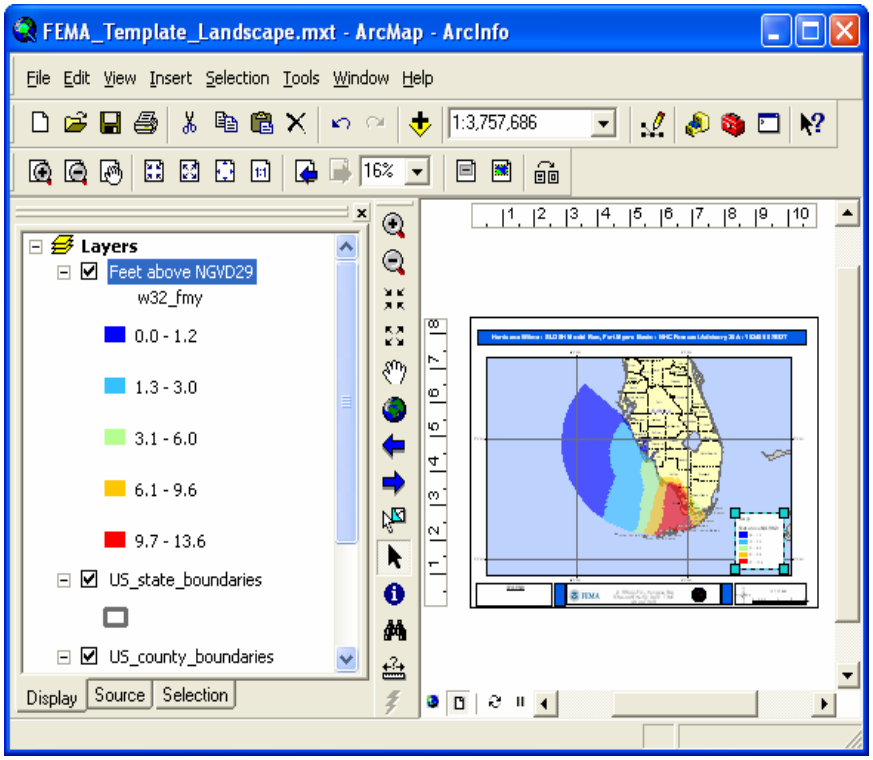
The legend is generated and added to the layout view. If you do not like its appearance, you can simply hit the Delete key to remove it and start again.

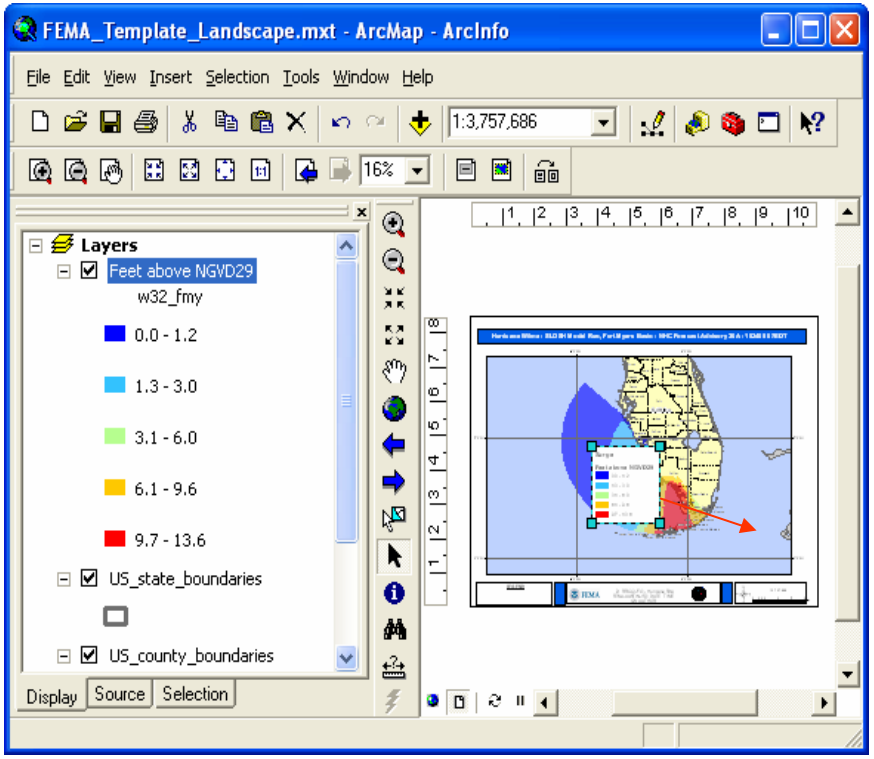




Basics of Cartography

Map Production: Move the legend off to the side so it does not obscure the map. You may want to use the Zoom In tool on the layout toolbar to get a closer look at where it will be placed. You might also need to change the size of the legend appropriately. To do this, simply click and drag the blue squares on the corners of the legend frame.

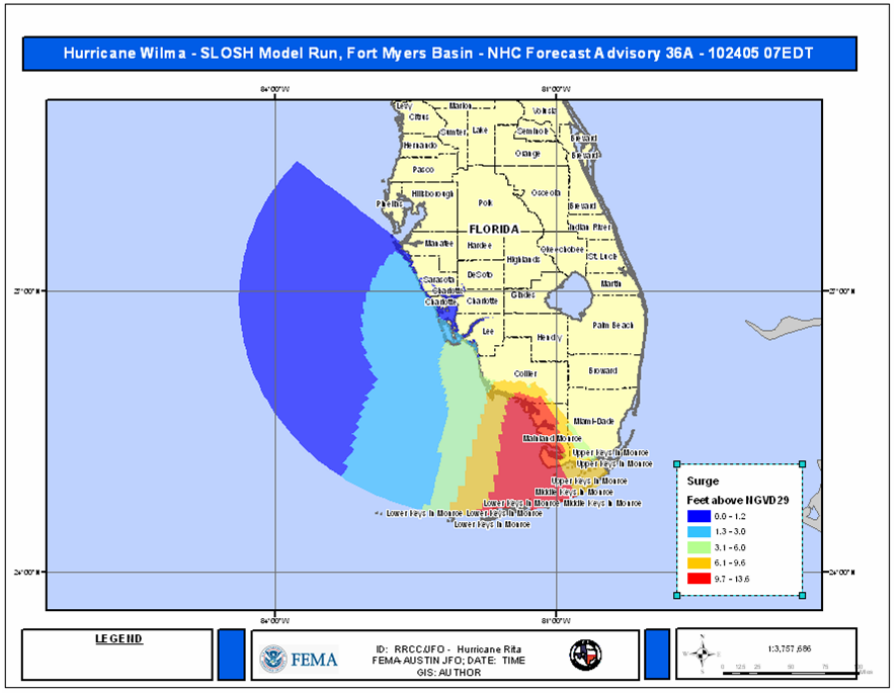


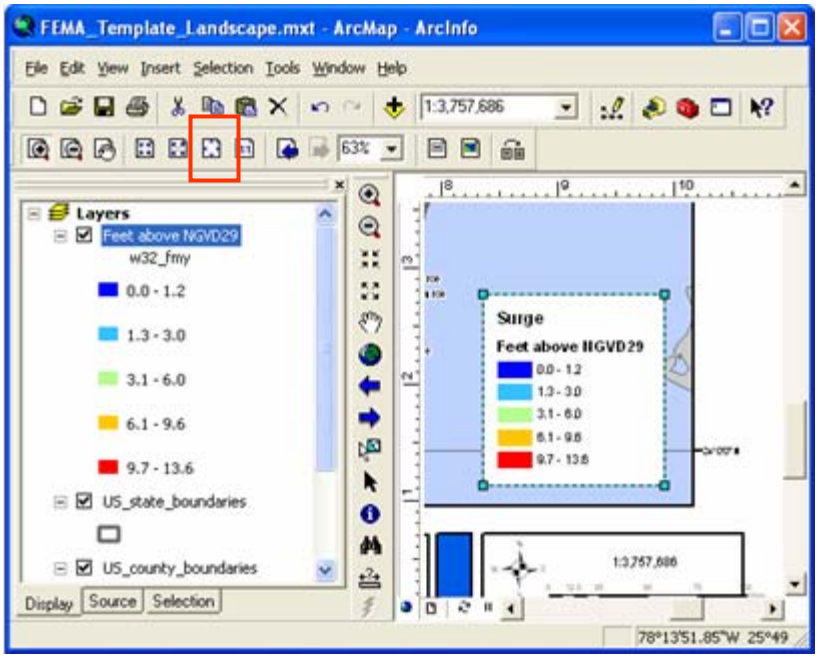


Basics of Cartography

Map Production: Once you are satisfied with the results, click on the **Zoom Whole Page** button to return to the entire layout.

Change the title so it relates to the data you are displaying. Double-click on the existing template title to open a text box. For all SLOSH model run maps, the title should be structured in the following manner:



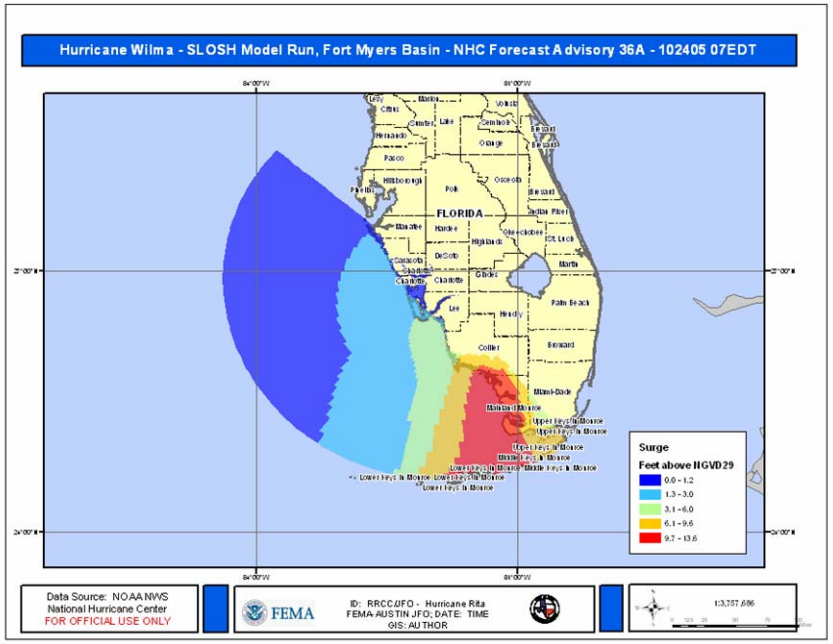


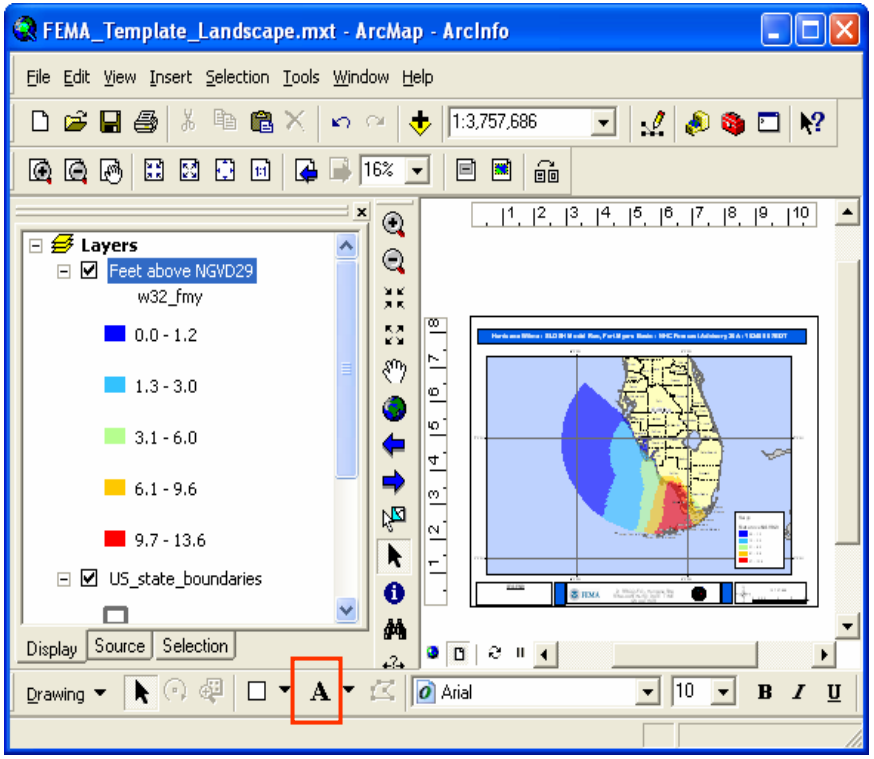
Storm Name
SLOSH Model Run
Basin Name
NHC Forecast Advisory Number
Date of Model Run (MMDDYY)
Hour of Model Run (HourEDT)

Basics of Cartography

Map Production: Use the Text tool located on the draw toolbar to add the source information to the map so readers will know where the data originated. If the draw toolbar is not installed, simply select **View > Toolbars > Draw**. For all SLOSH model run maps, structure the source text in the following manner:

Data Source: NOAA NWS
National Hurricane Center
For Official Use Only [in red]





Place this text into the legend box. Delete the Legend text.

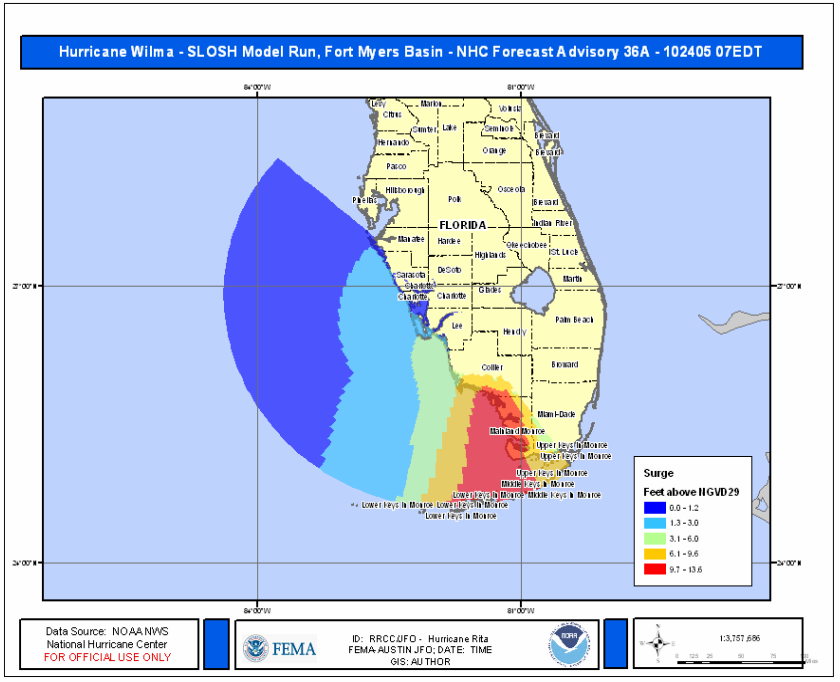
Basics of Cartography

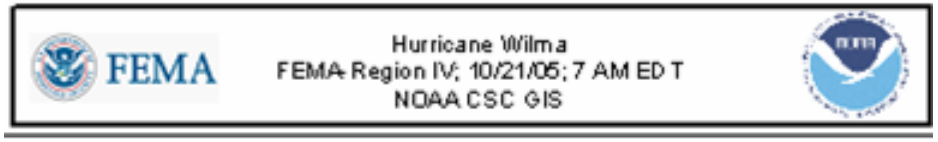
Map Production: Since the source SLOSH data (and other data discussed in this tutorial) originate from a NOAA Web site or product, this agency's logo should accompany all maps.

Add the NOAA logo to the template (**Insert > Picture...**) Ideally, it should be placed inside the credit box.

Structure the credit box text in the following manner:

Hurricane Name
FEMA Region Number
Date (MM/DD/YY)
Time (Hour EDT)
Author Agency

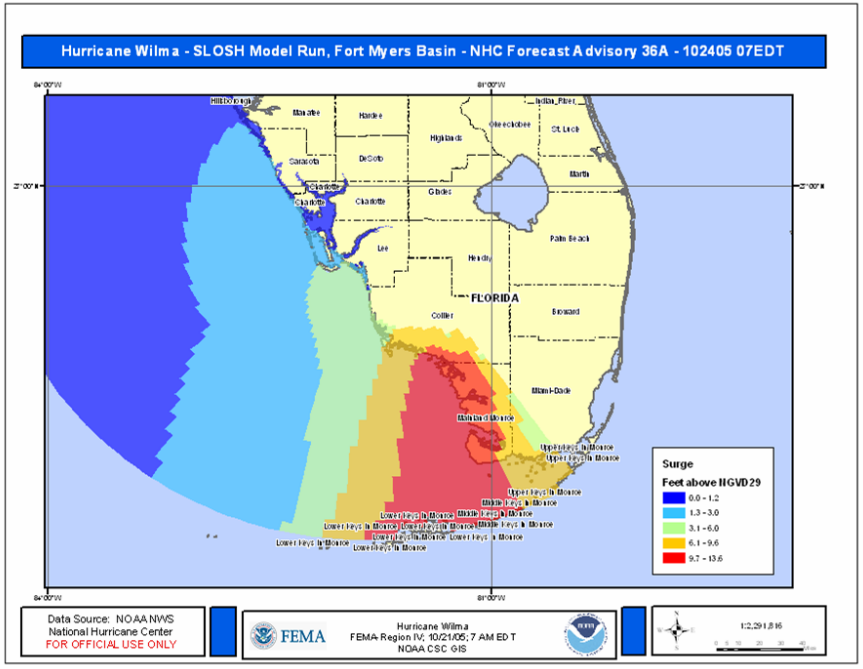




Basics of Cartography

Map Production: Occasionally, it is necessary to resize the default scale bar that is provided in the template. Before adjusting the scale bar, ensure that the map is positioned so that all salient data are clearly visible. In this example, you will zoom in further to see your surge data better.

Notice that when you do so, the scale bar adjusts automatically. Feel free to move it so that it appears centered within the box.



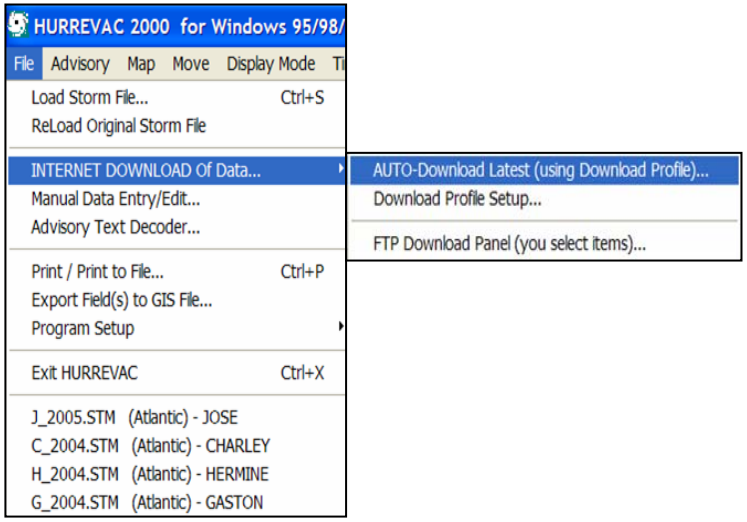
A default north arrow is provided for visual effect. Technically, it is considered redundant since a graticule is present that conveys the same information more precisely.

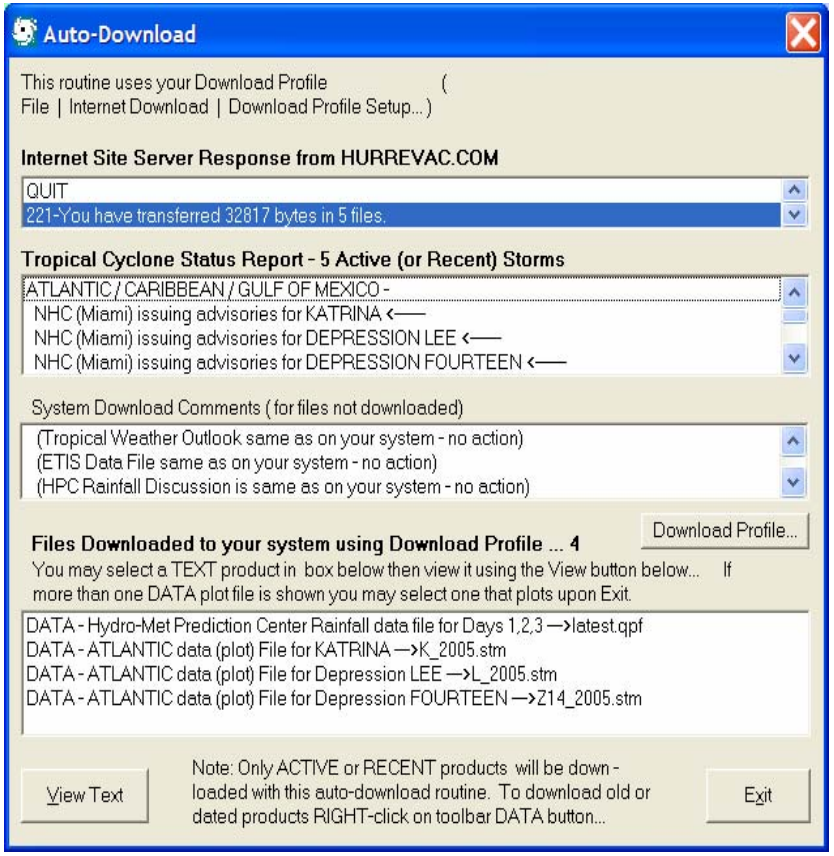
Nevertheless, you should consider leaving the north arrow to help orient those unfamiliar with the study area and to give the map additional cartographic flair.

Basics of Cartography

Map Production: Always add the past and predicted path of the storm. The following steps show how to obtain this from the HURREVAC program.

1. Open Hurrevac2000
2. Once the program is open, select the **File** pull-down menu and click on **INTERNET DOWNLOAD of Data** and then **AUTO-Download Latest**.
3. After several moments, the text will stop scrolling through the dialog boxes.
4. Once this happens, click on the **Exit** button.





Basics of Cartography

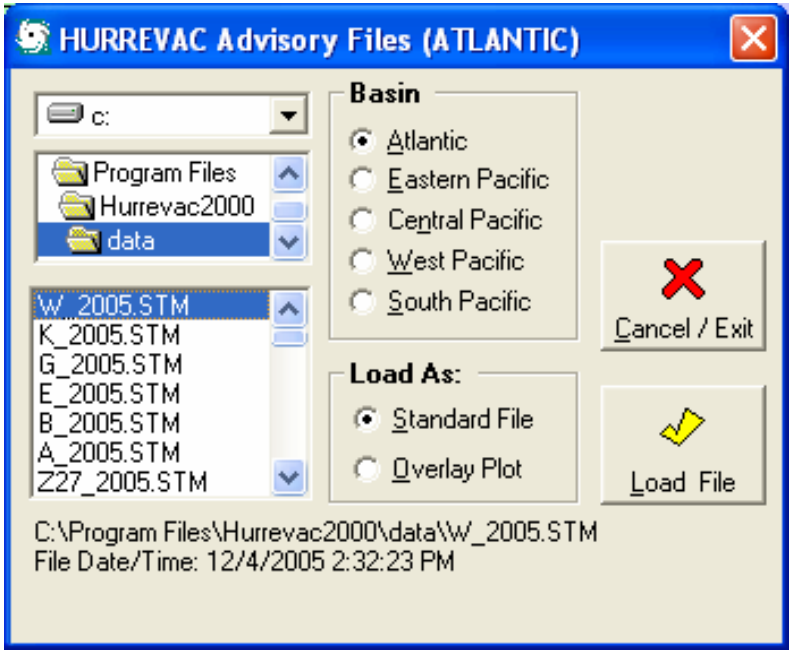
Map Production: Go to the **File** pull-down menu and select **Load Storm File**.

Browse to Program Files\Hurrevac2000\data and select the letter of the storm you are interested in.

In the Load As: box, make sure **Standard File** is selected.

Click on the **Load File** button.

The track of the storm should now display inside HURREVAC.



Basics of Cartography

Map Production: With the track of the hurricane now loaded, click on the **File** menu and select **Export Field(s) to GIS File**.

You may select to export a storm track to a shapefile for use in ArcGIS based on

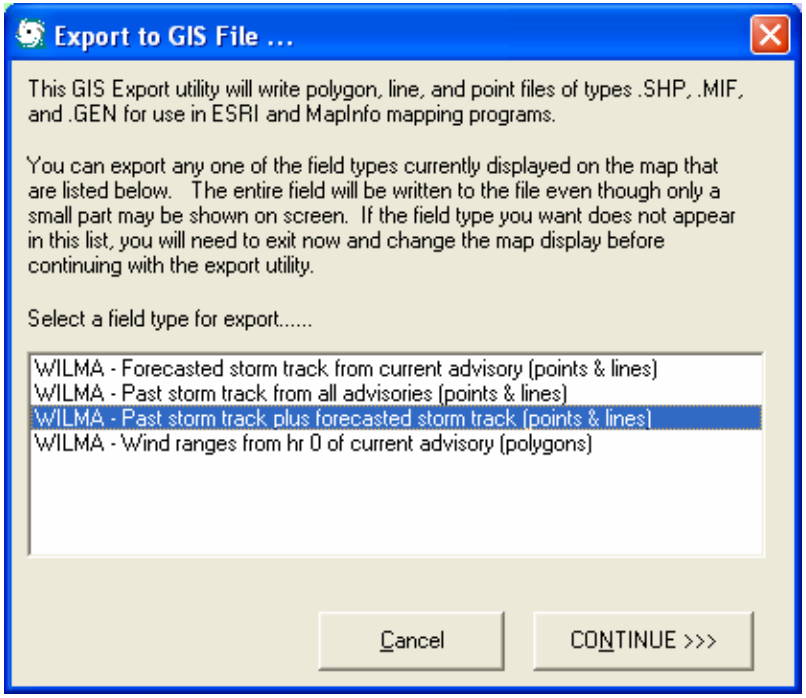
- Forecast from current advisory
- Past storm track from all advisories
- Past storm track plus forecast track
- Wind ranges from current advisories

For your map, choose the third option, which shows the past and forecast storm track.

Click **Continue>>>**

Browse to a folder on your hard drive and click **Save**.

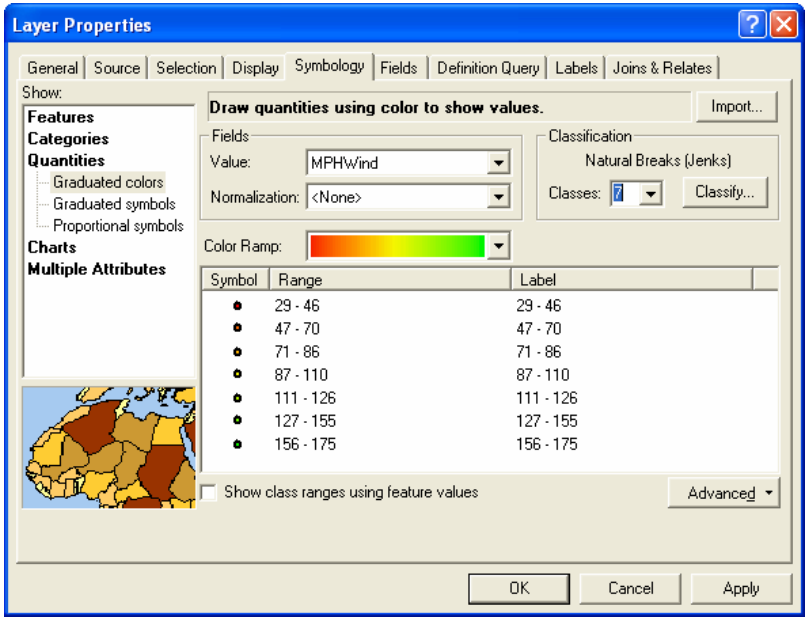
In ArcMap, click on the **Add Data** button and browse to your data folder to load the shapefiles.

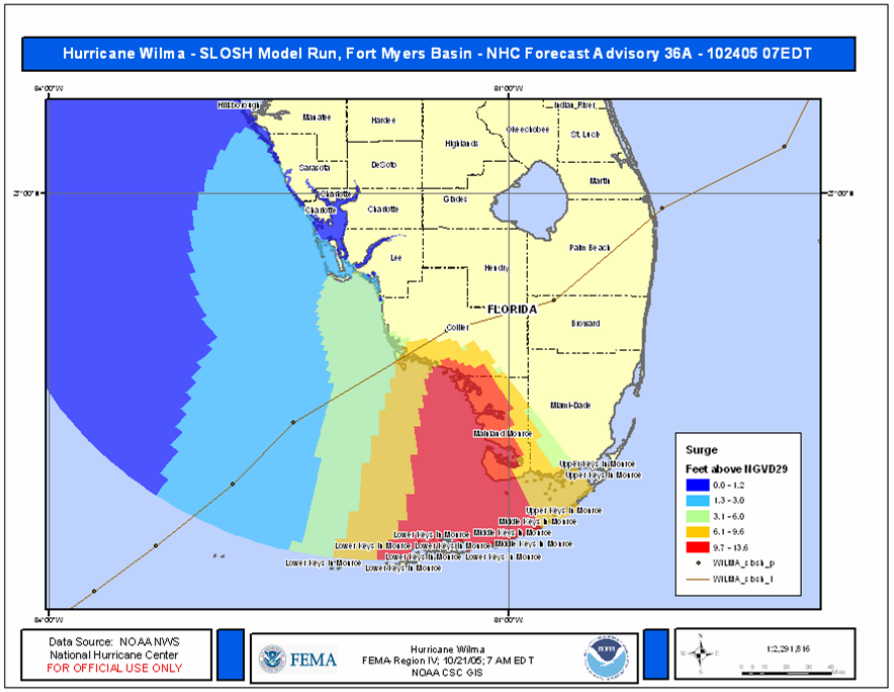


Basics of Cartography

Map Production: Notice that a past and forecast storm track line appears along with the predicted locations of the storm.

Double-click on the point layer name to change its symbology. The Layer Properties dialog will open. Click on the **Symbology** tab.





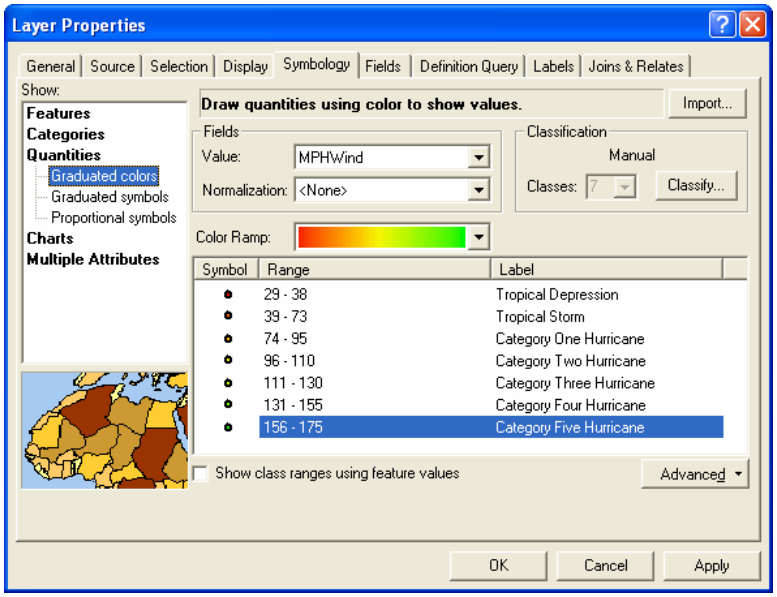
Click on **Quantities > Graduated Colors**.

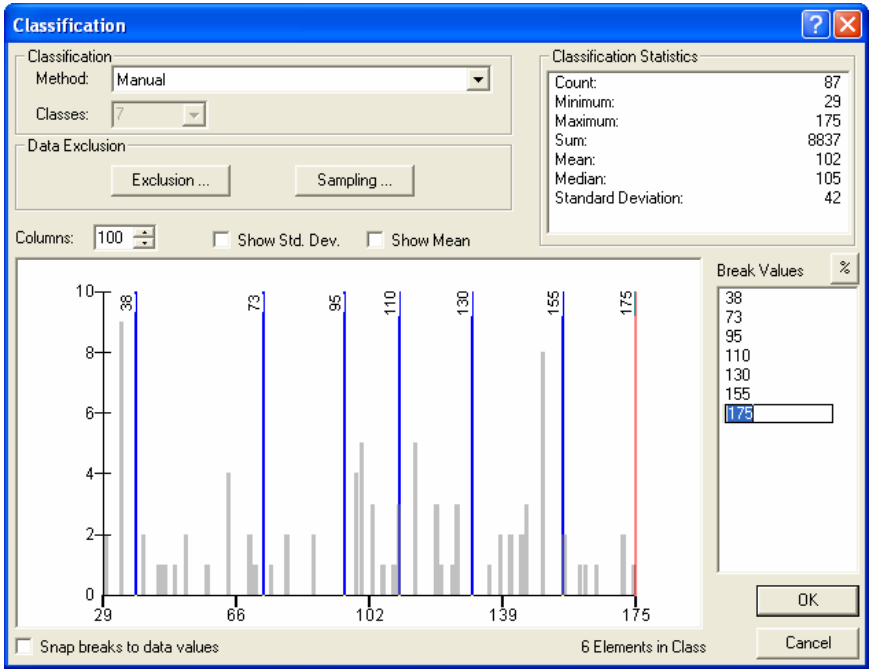
Change the Value field you want to display to **MPHWind**. Set the number of classes to **7**.

Basics of Cartography

Map Production: You need to change the range of values for your hurricane categories. Click on the **Classify** button. When the Classification dialog opens, change the Classification Method to **Manual**. Update the Break Values to match the values provided in this screen capture. These numbers represent the upper limits of various storm categories. Click **OK** when finished.

The results of the new break values will appear. Change the labels for each one to match the storm category as shown in the screen capture below.



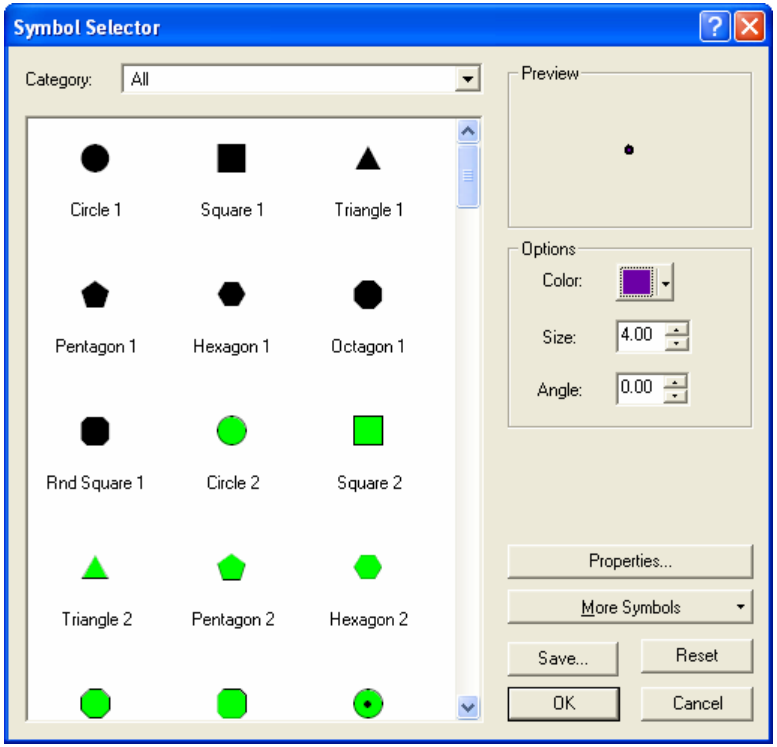


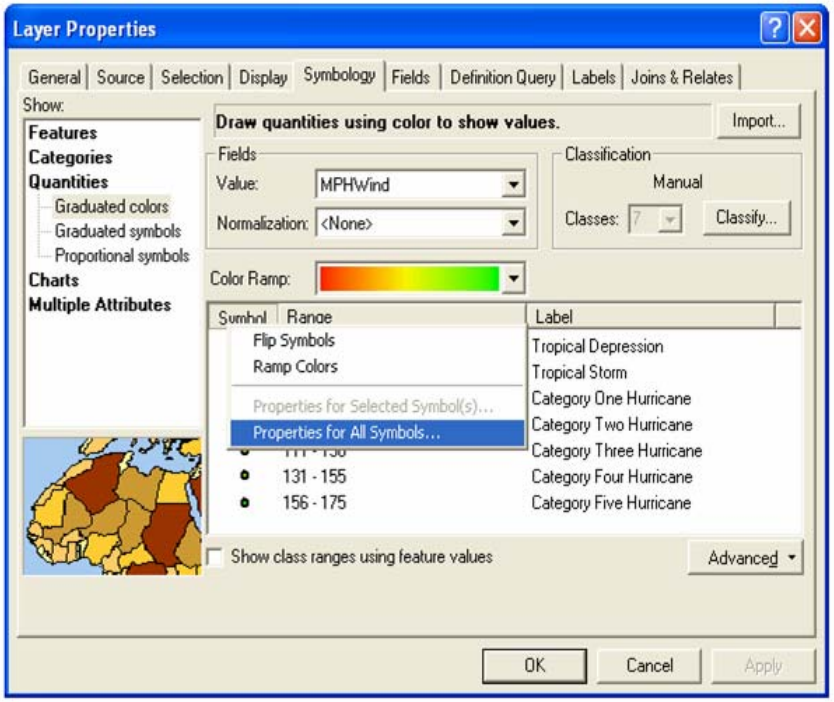
You now need to change the symbol of each point to look like a standard hurricane symbol used in cartography.

Basics of Cartography

Map Production: Click on the **Symbol** header and select **Properties for All Symbols**.

Click on the **More Symbols** button to select a special set of symbols for your hurricane layer.



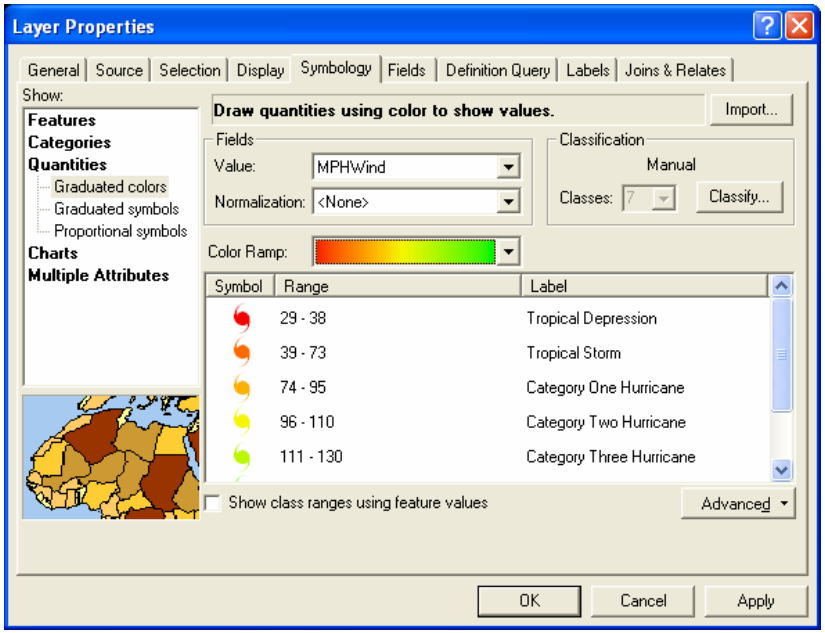


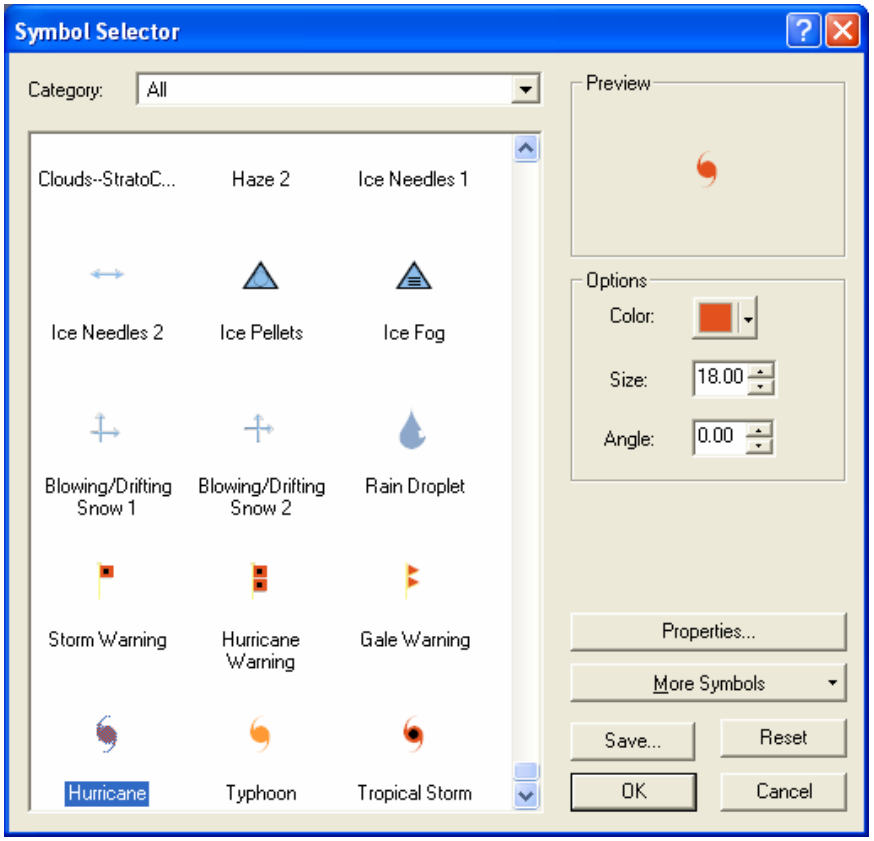
Find the symbol set named **Weather** at the bottom of the list and select it. This will add additional point symbols specific to meteorology to your Symbol Selector.

Basics of Cartography

Map Production: Scroll to the bottom of the symbol list and select the **Hurricane** symbol. Click **OK**.

Change the color ramp to a red to green (divergent) color scheme. Since the lowest wind values are assigned darker colors, you will need to flip the symbols around.

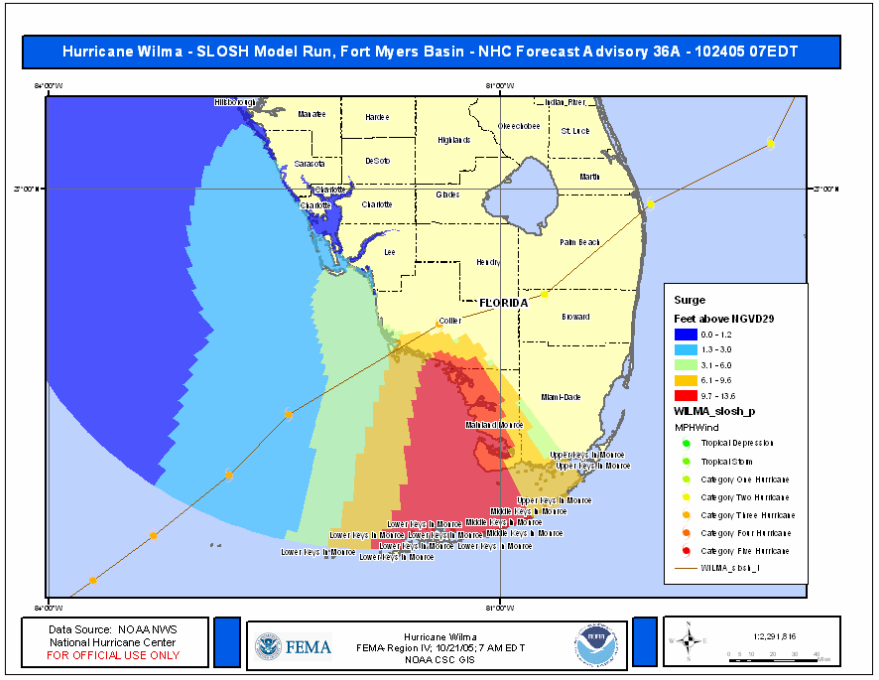


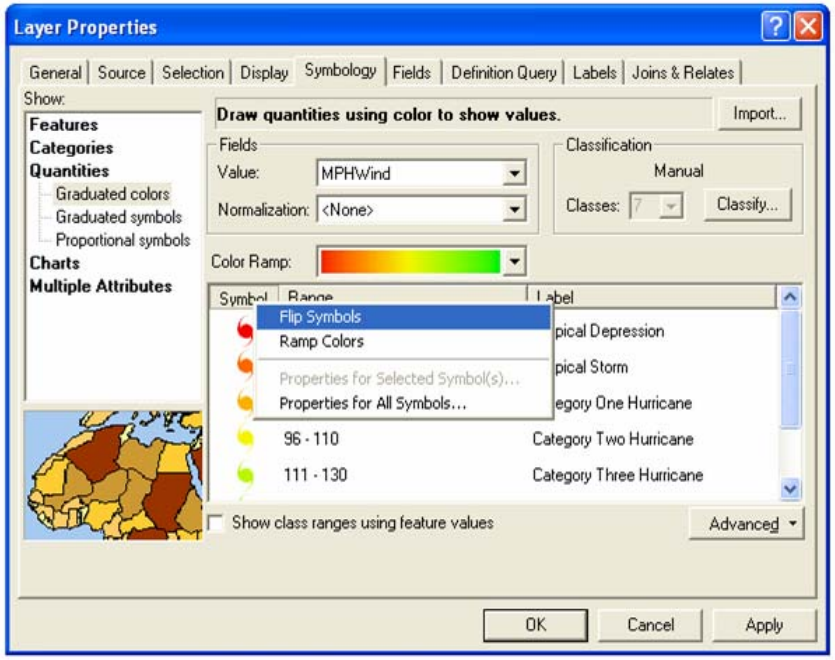


Basics of Cartography

Map Production: Click on the **Symbol** header again, and select the **Flip Symbol** option. The highest winds will now have darker reds. Click **OK** to assign these changes and see the difference in the display.

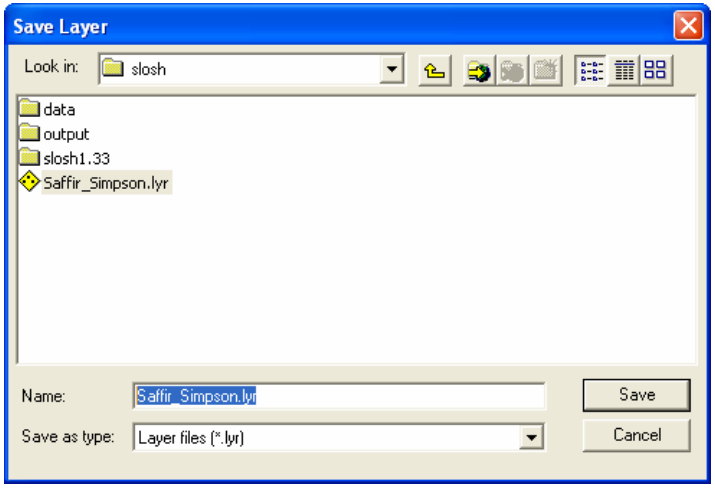
At this time, it would be wise to save these symbol settings to a layer file. This provides quick recall of these settings for future hurricane point layers.





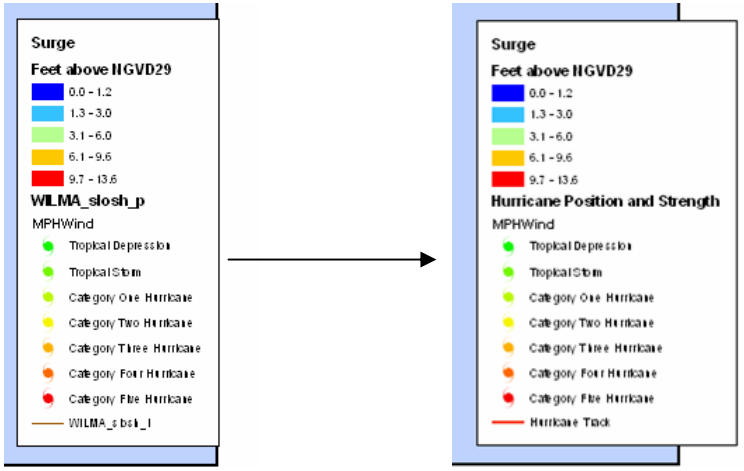
Basics of Cartography

Map Production: Right-click on the layer name and select **Save as Layer File**. Browse to a folder and name your layer file **Saffir_Simpson.lyr** as shown in the screen capture below. Click **Save** to create the file.



When you want to reuse this layer file, simply right-click on another hurricane point layer, select **Properties**, select the **Symbology** tab, and click on the **Import** button. Browse to the location of the Saffir_Simpson.lyr file and click **OK** to retrieve the predefined symbology.

You may want to modify the legend since the hurricane point and line layers have been added. If you want to leave them in the legend, you should rename the layers in the table of contents to something that makes sense.



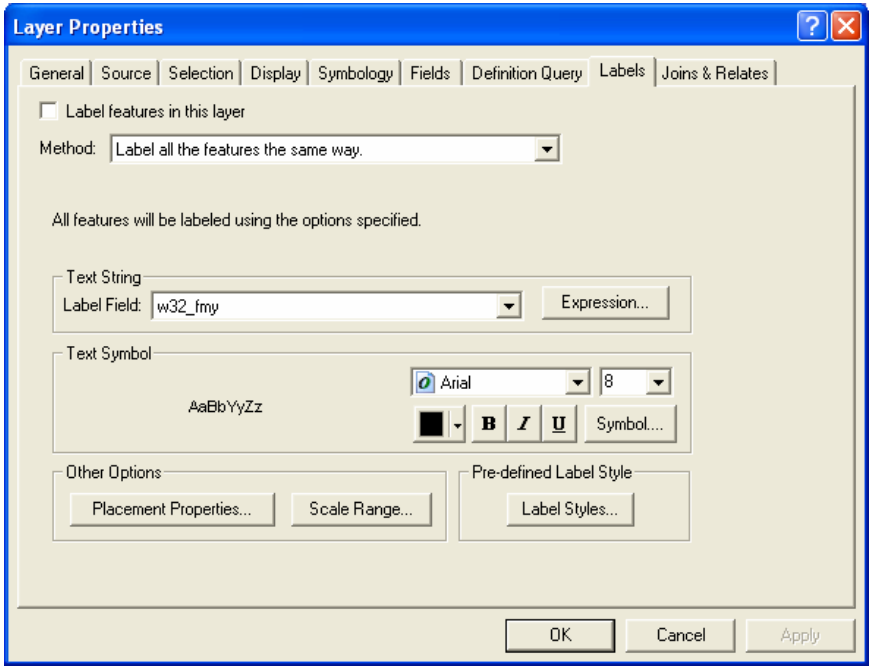
You should also note that the Hurricane Track layer symbol has been changed to a thick red line to help it stand out.

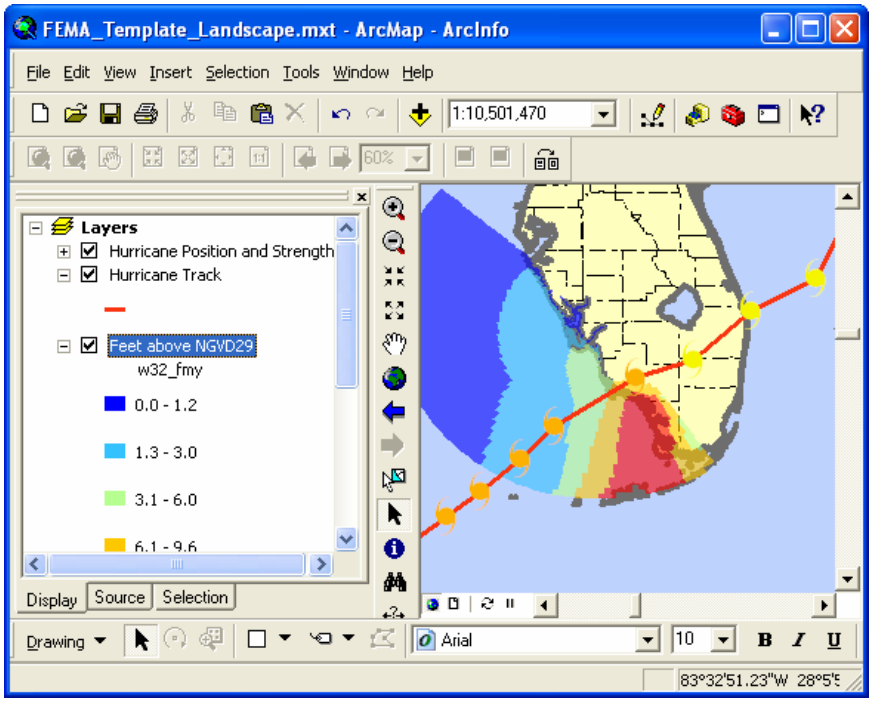
Basics of Cartography

Map Production: Add surge values onto the map by placing labels at specific points of interest. To add labels, return to the data view (**View > Data View**).

Click on the name of the surge layer in the table of contents. Open its Layer Properties and select the **Label** tab.

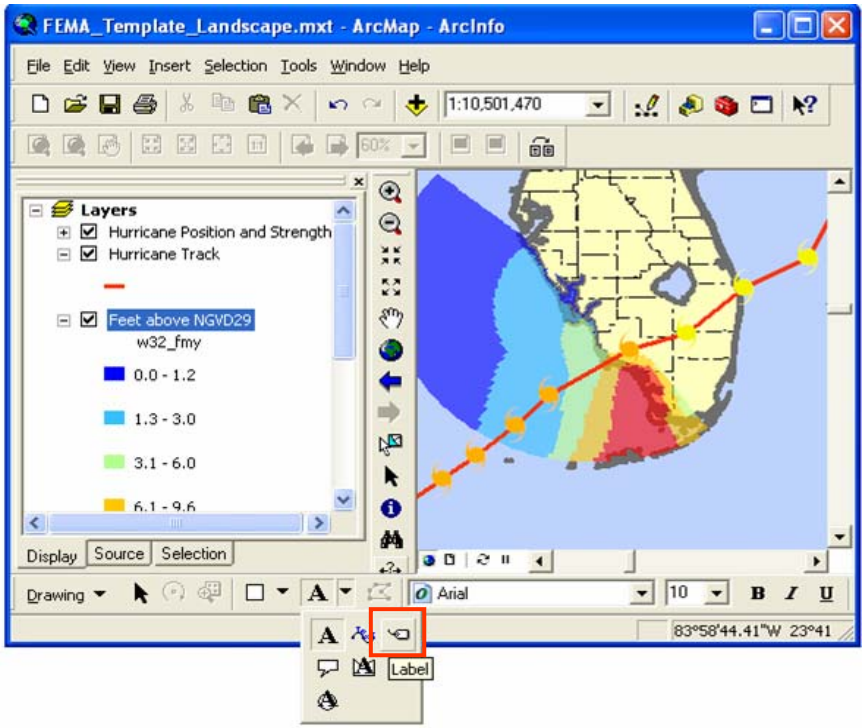
Set the Label Field to be equal to the original name of the layer. In your case it is **w32_fmy**. Click **OK**.

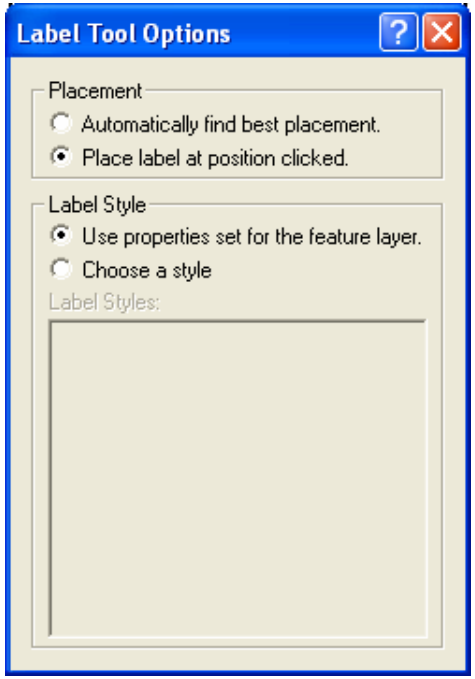




Basics of Cartography

Map Production: Click on the drop-down arrow on the text tool located on the draw toolbar. A group of text tools will appear. Select the **Label** text tool (looks like a shopping tag).

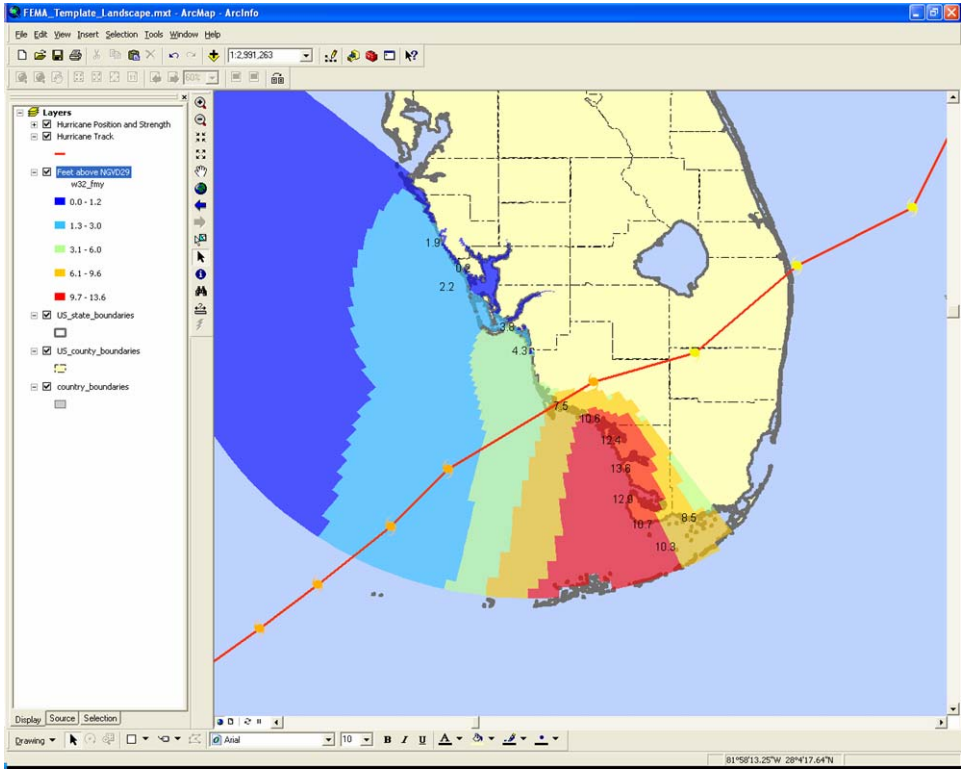




The Label Tool Options dialog will open. Select **Place label at position clicked** and close the dialog.

Basics of Cartography

Map Production: Click various locations along the coastline where you want to illustrate the amount of surge. Unfortunately, the text does not stand out very well with the colored background.



To improve visibility, select the text values and assign a halo background behind them.

Click on **Edit > Select All Elements**. You will notice faint dashed blue boxes around each of the values.

Right-click on one of the selected values. Select the **Properties** option. The changes you make for this one element will affect all elements selected.

Select the **Text** tab and click on the **Change Symbol** button at the bottom of the window.

In the Symbol Selector dialog window, click on the **Properties** button to open the Editor dialog window.

Select the **Mask** tab. Click on the **Halo** style, and set the size of halo to **1**. Click **OK** three times.

You should clearly see the values appear with a white halo background.

Basics of Cartography

Map Production: Add hurricane position values onto the map by automatically labeling each point.

Right-click on the hurricane point layer and open its Layer Properties dialog window.

Select the **Labels** tab.

Change the Label Field to **Date**.

Click on the **Symbol** button to open the Symbol Selector dialog window.

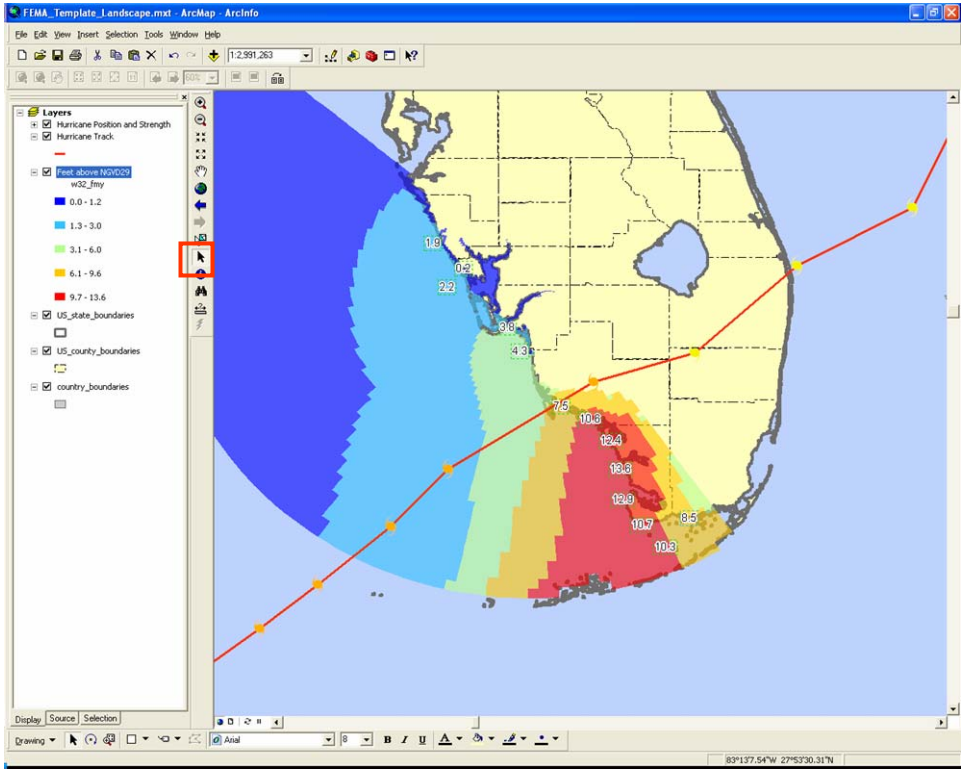
Click on the **Properties** button to open the Editor dialog window.

Click on the **Mask** tab, select **Halo**, and resize to **1**.

Click **OK** three times.

Right-click on the layer again. Select **Label Features**.

Each point will now label with the day and time the storm will be present at that location with a halo background.



Basics of Cartography

Map Production: Add the time of the hurricane forecast track onto the map with free text.

Click on the the **Text** tool drop-down and select the **New Text** tool.

Click anywhere inside the Data View to start a text string. Type supporting text for the track in the following manner:

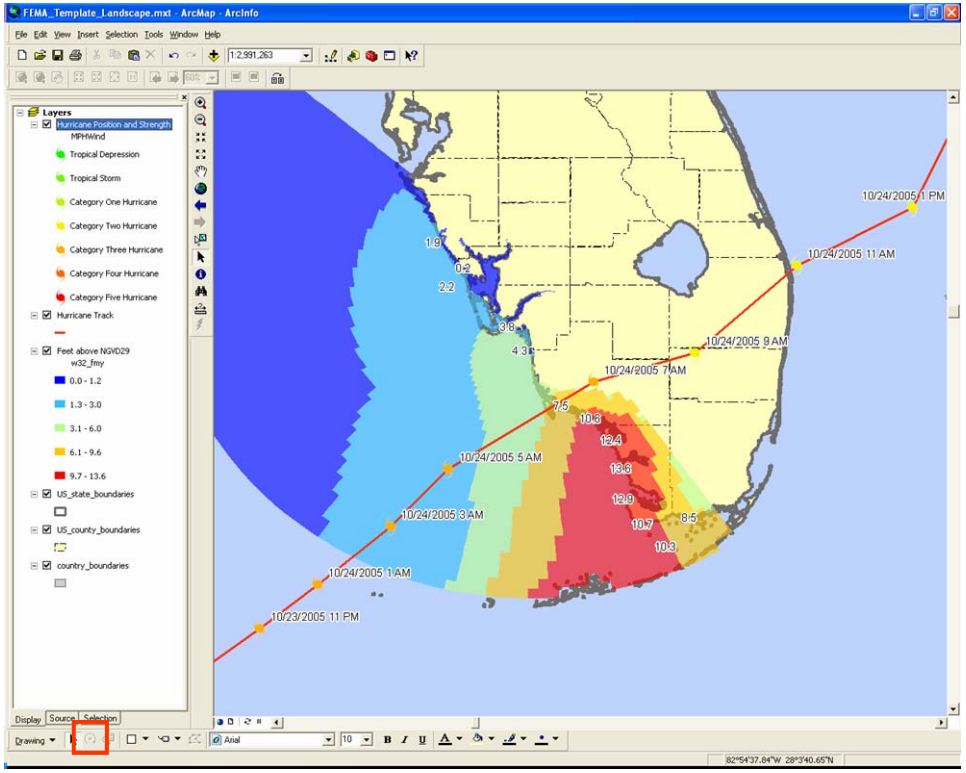
NHC Forecast Track
Date (MM/DD/YY)
Time (Hour EDT)

Once it is added, move the text string to run parallel to the storm track.

Use the **Rotate** tool found on the draw toolbar to angle the text appropriately.

Create a halo around the text in the same way as the other text elements (remember how?).

Hint: Right-click on the **Text > Properties**.



Basics of Cartography

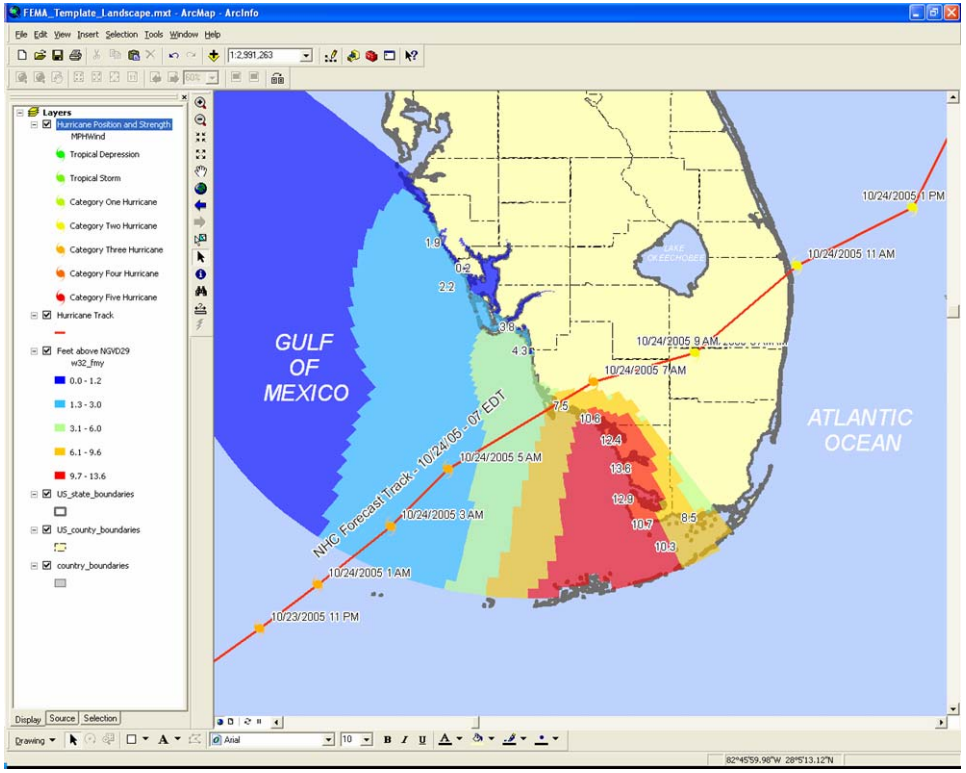
Map Production: Lastly, add text to denote water bodies in the study area. A few cartographic conventions should be observed for water body text:

- Use uppercase text
- Use italics text style
- Use blue or white text color

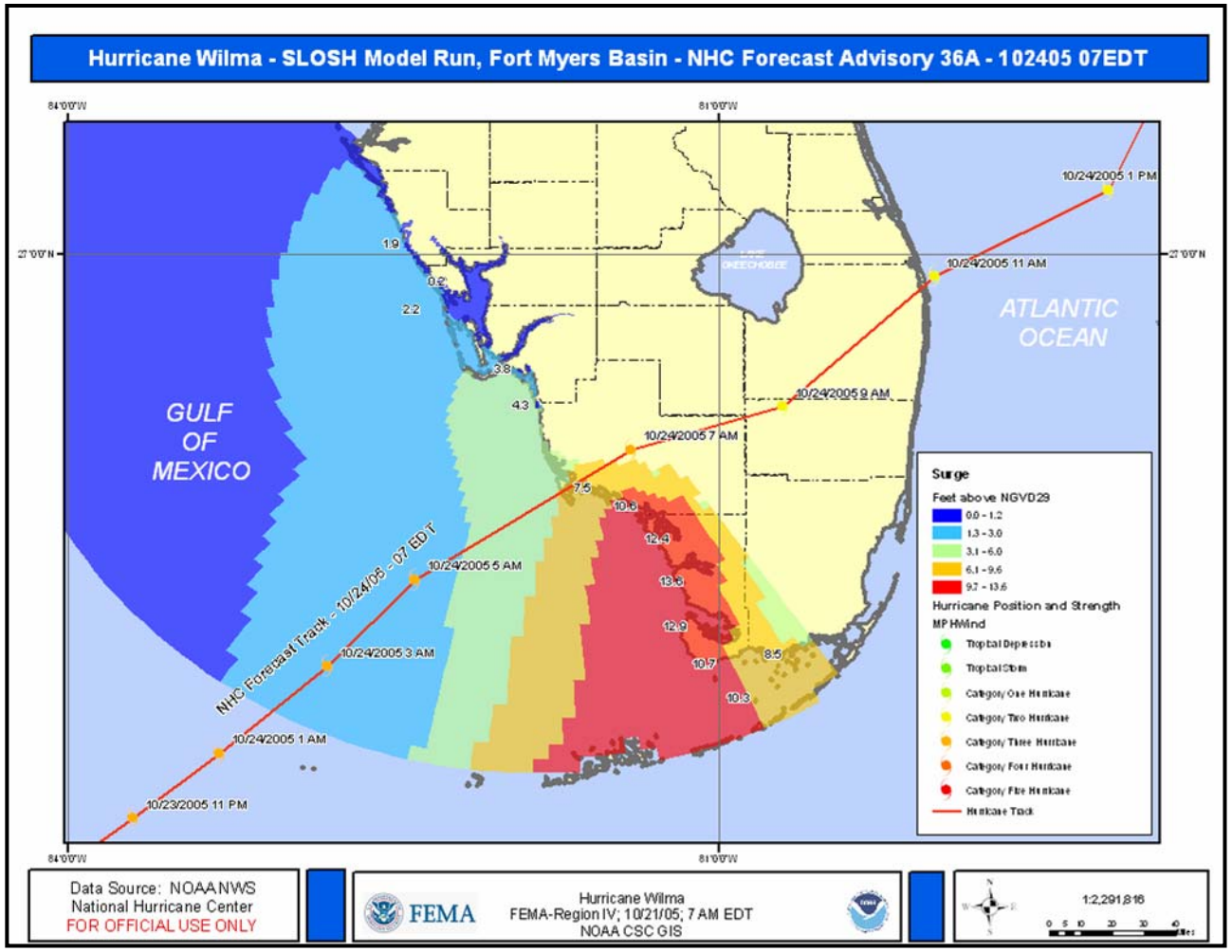
In this example, add text for the Gulf of Mexico and Atlantic Ocean. Extra credit will be given for Lake Okeechobee!

Once you are finished adding text, go back to the Layout View to see the results.

The following page is an example of what you should try to achieve.



Basics of Cartography



Appendix

Zulu Time: The world is divided into 24 time zones. The "clock" at Greenwich, England, is used as the standard clock for international reference of time in communications, military, aviation, maritime, and other activities that cross time zones. The letter designator for this clock is **Z**, for **Zulu**.

Times written in military time (24 hour format) are four digits, such as 1830**Z** (6:30 pm), with the Zulu suffix. Zulu Time is officially named Coordinated Universal Time or UTC. This time zone had previously been called Greenwich Mean Time (GMT) but was replaced with UTC in 1972 as the official world time standard changed.

Table: Converting Local Time to Zulu Time
Use the table on the right to convert local time to Zulu time, and vice versa. Find your local time in the first column (in blue) and then use the corresponding Zulu time (in red) listed under your time zone.

LOCAL	EDT	EST	CDT	CST	MDT	MST	PDT	PST
Midnight	0400	0500	0500	0600	0600	0700	0700	0800
1 a.m.	0500	0600	0600	0700	0700	0800	0800	0900
2 a.m.	0600	0700	0700	0800	0800	0900	0900	1000
3 a.m.	0700	0800	0800	0900	0900	1000	1000	1100
4 a.m.	0800	0900	0900	1000	1000	1100	1100	1200
5 a.m.	0900	1000	1000	1100	1100	1200	1200	1300
6 a.m.	1000	1100	1100	1200	1200	1300	1300	1400
7 a.m.	1100	1200	1200	1300	1300	1400	1400	1500
8 a.m.	1200	1300	1300	1400	1400	1500	1500	1600
9 a.m.	1300	1400	1400	1500	1500	1600	1600	1700
10 a.m.	1400	1500	1500	1600	1600	1700	1700	1800
11 a.m.	1500	1600	1600	1700	1700	1800	1800	1900
NOON	1600	1700	1700	1800	1800	1900	1900	2000
1 p.m.	1700	1800	1800	1900	1900	2000	2000	2100
2 p.m.	1800	1900	1900	2000	2000	2100	2100	2200
3 p.m.	1900	2000	2000	2100	2100	2200	2200	2300
4 p.m.	2000	2100	2100	2200	2200	2300	2300	2400
5 p.m.	2100	2200	2200	2300	2300	2400	2400	0100
6 p.m.	2200	2300	2300	2400	2400	0100	0100	0200
7 p.m.	2300	2400	2400	0100	0100	0200	0200	0300
8 p.m.	2400	0100	0100	0200	0200	0300	0300	0400
9 p.m.	0100	0200	0200	0300	0300	0400	0400	0500
10 p.m.	0200	0300	0300	0400	0400	0500	0500	0600
11 p.m.	0300	0400	0400	0500	0500	0600	0600	0700
LOCAL	EDT	EST	CDT	CST	MDT	MST	PDT	PST

LEGEND:
EDT = Eastern Daylight Saving Time
EST = Eastern Standard Time
CDT = Central Daylight Saving Time
CST = Central Standard Time
MDT = Mountain Daylight Saving Time
MST = Mountain Standard Time
PDT = Pacific Daylight Saving Time
PST = Pacific Standard Time

Sources:
Zulu Chart – *http://hurricanes.noaa.gov/zulu-utc.html*

Explanatory Text – Mobile Aeronautics Education Laboratory, accessed on 19 November 2005, *www.lerc.nasa.gov/WWW/MAEL/ag/zulu.htm*