



Rocky Mountain Mapping Center

Analyzing Tornadoes Across the USA with GIS

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Lesson: Analyzing the Pattern and Characteristics of USA Tornadoes Over Time

Skills:

1. Analyzing spatial point and polygon data.
2. Symbolizing data.
3. Data and file management.
4. Selection, sorting, querying data in maps and in tables.
5. Map Projections.
6. Creating summary tables.
7. Creating and analyzing graphs.
8. Creating raster grids from point data.
9. Analyzing raster grids.

Data Management

Create a folder on your computer to hold the data with an appropriate name, such as tornadoes.

Click [here to download the data](#) that you will need for this lab exercise, and download into the folder you created.

This file is named tornadolesson.zip and totals approximately 3.6 MB.

Next, unzip the file using the Winzip program.

You now should have the following **20** files:

elevcent.avl
elevcent.dbf
elevcent.shp
elevcent.shx
states.dbf
states.prj
states.sbn
states.sbx
states.shp
states.shx
tornados.dbf
tornados.doc
tornados.pdf

tornados.sbn
tornados.sbx
tornados.shp
tornados.shx
torncent.dbf
torncent.shp
torncent.shx

You are a scientist with the [National Oceanic and Atmospheric Administration's \(NOAA\) National Climatic Data Center](#). You need to analyze the distribution and patterns of tornado over a period of 40 years so that you can better plan your human and scientific resources to respond and provide aid for these types of events.

First, you need to become familiar with your *metadata*, a description of the data.

Examine either the tornados.doc file or the tornados.pdf using MS Word or a web browser.

- 1) What *company* was involved with putting this data set together?
- 2) What *government organization* was involved with putting this data set together?
- 3) How many tornadoes are in the data set?
- 4) What is the time period that the data set covers?
- 5) What field name in the table contains the width of the tornado track?
- 6) What field name in the table that contains the intensity of the tornadoes?
- 7) How is the date of the tornado encoded in the data?
- 8) How is the time of the tornado encoded in the data?
- 9) Which file of the above is the largest?

10) Why is this file is the largest? Is it the "G", the "I" or the "S" part of GIS?

11) How many files are inside your data folder?

12) How many *shape* files are inside this folder? Are the shape files the "G", the "I" or the "S" part of GIS?

Tornado Analysis

Access ArcView GIS.

Add Theme: States and Tornadoes.

Using File--> Save Project, save your project as tornadoes in the same folder where your data is located.

Minimize ArcView and use Windows Explorer to examine at your folder's contents.

13) What file extension does your saved project have? What does this extension stand for?

In Windows Explorer, notice that you have an "avl" file named elevcent.avl. This is an **ArcView Legend**, and you will use it later in this lesson.

Minimize Windows Explorer and Restore ArcView.

In ArcView, double-click on state outlines to change the legend. Make all state outlines with a thickness of 2, and with a transparent color.

14) How did you accomplish this?

15) What is the legend *type* that you had to choose in order to obtain transparent state polygons for every state?

See the table of contents on the left, which is your list of all of the map themes. Move the state outlines above the tornado touchdown points in the table of contents in your view so you can see both the tornado3s and the state outlines.


Notice the coordinates to the upper right of the view as you scroll the mouse in this file.

16) What coordinate system is your data in?

You need to change the projection and coordinate system of your map, as follows. Go to View--> Properties and change the View's Map Projection. Click on "Projection" and select "Projections of the United States" and then "Albers Equal Area North America"

17) Scroll the mouse and observe the coordinates. Are they the same or different than earlier?

18) Using the zoom and pan buttons, indicate the state where the origin (0,0) of the Albers Equal Area North America projection is located.

Make the tornados theme active and access the table of tornado touchdowns. 

19) How many tornado touchdowns are in this file? How does this compare with what you wrote based on your analysis of the metadata?

20) State 3 observations about the pattern and distribution of tornadoes across the USA.


21) Name two things about the pattern of tornadoes that across the USA that surprises you.


Change the legend to **graduated symbol** and use the field you identified earlier that indicates the intensity of the tornadoes. Symbolize the tornadoes with the highest intensity with a large red target.

22) Make at least two observations about the pattern of the intensity of the largest tornadoes.




Change the legend and use the field you identified earlier that indicates the track width of the tornadoes. Make the tornado with the widest track width a large red target.

23) Make at least two observations about the pattern of the track width of the tornadoes.

Open the table for the tornadoes theme. 

Highlight the fatalities field and sort the data on this field. 


Highlight (make yellow) the record in the table where the most fatalities occurred.

Exit the table and return to the map. Use the "zoom to selected"  function to center this tornado on the map. Use the zoom into center  and the identify  buttons until you can answer the following questions.

24) In what state did this tornado occur?

25) How many fatalities occurred during this event?

26) When did the tornado occur?

Clear your selection  and repeat your process above to answer the following questions about the tornado with the most *injuries*.

27) What state did this tornado occur in?

28) How many injuries occurred? How many fatalities occurred?

29) When did the tornado occur?

You have probably observed that the sheer number of tornadoes in the data set makes detecting patterns difficult. One way to reduce the set you are analyzing is to apply a definition query on the data. Go to Theme--> Properties and in the query box (with the hammer and question mark symbol), use the following definition query: ([Fujita] >= 2)


State in your own words what this query means.


30) Access the table. How many tornadoes are you now analyzing?

31) On the map, what do you observe about certain states such as Indiana and Colorado? Why do you suppose that this occurred? Discuss issues of data quality in your statements.


In Theme--> Properties, clear your definition query.

A GIS also allows the user to create *new* data. This data may be a summary set of data, as you will do next.

Access the tornadoes table  and make "state" the selected field.

Go to Field-->Summarize. Sort the summary table  on "count."

32) Which state code is listed as having the most tornadoes?

Using the "identify"  button, and after making your states theme active, move around in your view, identifying the state, to determine the name of this state.

33) In which state (the **name** this time) were the most tornadoes between 1950 and 1990?

34) Which state had the fewest tornadoes in the list but still had **some** tornadoes?

35) How many tornadoes occurred in South Dakota?

36) Where are you likely to recommend that NOAA not direct any tornado relief and research funds? In other words, which states had no tornadoes?

Use the pan and zoom functions in the view, table sort function, identify button, and the query tool that you used in this and previous lessons, and build a summary table using month as the selected field, to answer the following questions.

37) During which month did more tornadoes occur than any other month?

38) During which month did fewer tornadoes occur than any other month?

39) During which month did the extent of tornadoes across the USA reach what you observe to be the maximum spatial extent?

Use Theme-->Convert to Shapefile, and create a shapefile that includes just the April tornadoes, named aprilorn.shp.

40) How many tornadoes exist in aprilorn? Why?

41) Create a layout showing all April tornadoes throughout the USA. Print the layout. Include your name, a legend, a north arrow, and a scale. Attach it to these lab sheets.

In August 1999, during the Outdoor Retailers conference where the USGS and other organizations were operating an exhibit, a tornado raced through downtown Salt Lake City, Utah, killing one person and devastating parts of the downtown urban area. The newspaper reported that until that day, no fatalities from a tornado had ever occurred in Utah.

42) According to the data set that you are analyzing, was this newspaper report correct? Why or why not?

43) How did you find the answer to the previous question?

44) How many tornadoes have occurred in Utah during the years covered by this dataset?

45) Have there ever been any injuries due to tornadoes in Utah? If so, during what years did injuries occur?

Next, examine the relationship of elevation and tornado occurrence for the central part of the USA.

Turn off the themes in your view and add the themes: elevcent and torncent. Access the legend for the theme elevcent. Press "Load" and find the file "elevcent.avl". Apply this legend to the gridcode field.

Look at the table.

46) What does the field *gridcode* represent?

47) Do you have information that can tell you how many tornadoes occurred in each elevation category?

Therefore, you need to join the tornado information to the elevation data so that you can determine which tornadoes were inside each elevation category.

Access the File-->Extensions menu.


Add the "GeoProcessing" extension. This adds the Geoprocessing Wizard choice to the "View" menu.

Access the GeoProcessing Extension by selecting: View--> GeoProcessing Wizard. This is the new menu

choice that you added by accessing the Geoprocessing extension.

Go to: Assign Data by Location.

Next: Assign data **to** torncent.shp **from** elevcent.shp. Be patient. The GIS has to assign an elevation to all tornadoes in the central USA.

48) When complete, examine the tornadoes central region table.  What new field(s) have been added?

Next, summarize the new data to solve the problem of how many tornadoes occurred in each elevation zone, as follows:

First, click on the field "gridcode".

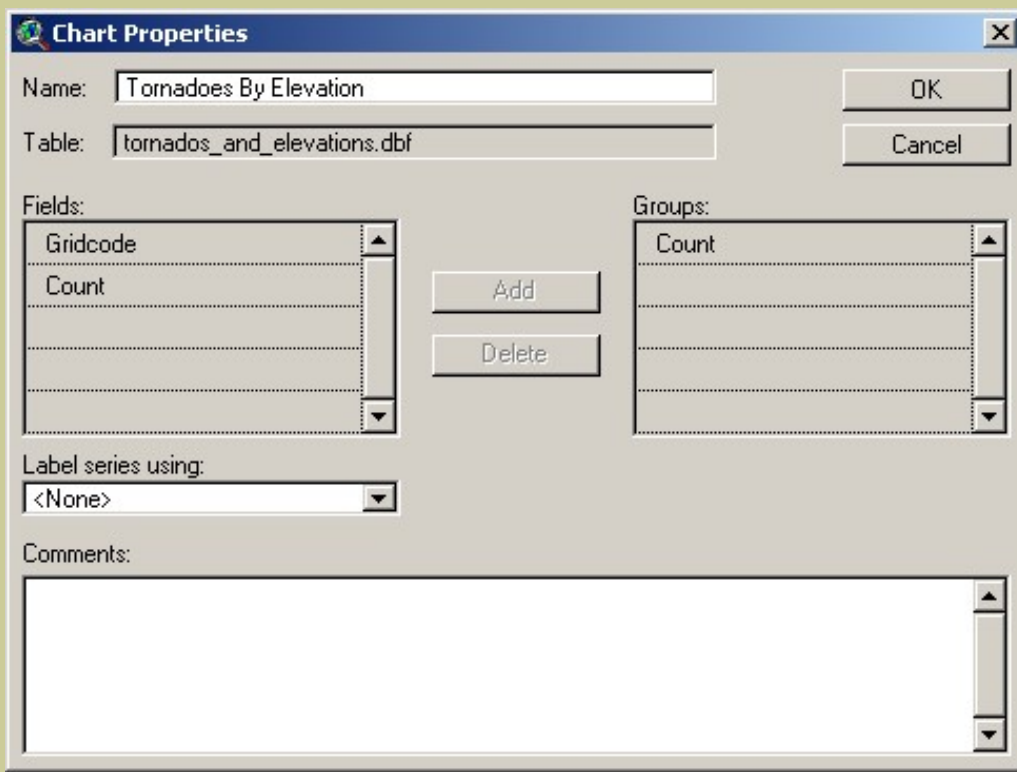
Second, Go to Field --> Summarize.

Third, save to a table in your folder. Give it an appropriate name.

Fourth, sort the new table on "count".

49) What does the count in the FIRST row of the summary table represent?

Go to the Project window -- the one with views, tables, charts, layouts, and scripts on the left hand side. Select charts and click on "New". Make a chart (graph) based on the SUMMARY table that you just created. Give it an appropriate name in the "name" column. Use "count" as the field and "add" it to the chart, as shown below.



50) Print the chart and attach it to these lab sheets.

51) Which elevation *category* had the most tornadoes? What is the elevation of this category?

52) Which elevation category had the least tornadoes? What is the elevation of this category?

53) Is this what you expected? Why or why not?

The following section requires the Spatial Analyst extension to ArcView GIS.

You have been analyzing tornadoes as a vector (point) theme. Sometimes, it is better to analyze data as continuous surfaces, or raster grids. Elevations are typically analyzed as rasters, but other data is just as suitable to analyze as rasters. For example, you may wish to convert field test points for water quality data in wells or soils to a raster. In this section, you will convert the tornado points to a surface and analyze using raster tools.

Using File-->Extensions, turn on the Spatial Analyst extension.

54) What two new menu choices do you now have at the top?

Make the *torncent.shp* theme active (raised up) and clear any selections in the theme.

Access Surface--> Interpolate Grid. Make your output grid the same as *torncent.shp*. Make the output cell size 5000 meters. Leave the method as IDW (Inverse Distance Weighting) and make sure the field is "Fujita."

55) Make two observations about your new tornadoes raster grid. Examine the table of the raster grid and also the table of `torncent.shp`. Why are there so many negative values?

56) Why did the new grid place data in Minnesota, Iowa, Utah, Arizona, and in other states?

57) What is the reliability of this data?

58) Why is the pattern for Colorado radically different than the other Central Region states? Recall your observations earlier about missing values in the Fujita attribute.

59) Now, select the tornadoes from the Central Region where the Fujita is greater than or equal to 0. How many tornadoes are selected?

Next, interpolate a different new grid as you did, above, using the `torncent.shp` as the input theme. This time, the grid will reflect only recorded Fujita values. Double-click on the new theme to access the legend editor and re-classify with a red monochromatic color scheme.

60) Make two observations about the pattern of tornado intensity across the Central USA based on the Fujita grid, comparing it to the original Fujita point data.

61) In what part of the Central USA is the pattern of Fujita most intense?

62) Change the classification to standard deviation. Which part of Texas contains lower-intensity tornadoes based on this map--the East half or the West half?

63) Which state is characterized by the largest land area with higher intensity tornadoes--Oklahoma, Kansas, or South Dakota?

64) What did the high Fujita reading on a tornado south of Yellowstone National Park in northwest Wyoming do to the resulting raster grid?

Save your project, close your project, and exit ArcView.

65) Summarize in a few sentences what you have learned about tornadoes in this lesson.

66) Summarize in a few sentences what you have learned about ArcView GIS in this lesson.

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URL: <http://rockyweb.cr.usgs.gov/outreach/sgu/tornadolesson.html>

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