Module 4, Lesson 2
Analyzing historical tornadoes

Lesson overview

Students will analyze U.S. tornadoes to compare some of the most well-known tornado outbreaks in history. Students will work with more than 30 years of tornado data for the entire United States. In this lesson, students will use the Fujita Tornado Damage Scale to classify tornadoes and identify the amount and types of damage associated with tornadoes of different strengths. Finally, they will look for spatial patterns and compare three well-known tornado outbreaks.

Estimated time

Approximately 60 minutes

Materials

The student activity, handout, and worksheet can be found in the student workbook or on the Software and Data CD. Install the teacher resources on your computer to access them.

The student activity can be found at http://esri.com/geoinquiries.

Click on the Thinking Spatially Using GIS link and choose Module 4, Lesson 2.
Student activity: TS_M4L2_StudentDirections.pdf

Objectives

- After completing the lesson, a student is able to do the following:
- Identify and compare regions in the United States
- Compare different map layers and identify relationships between them
- Identify spatial patterns and give reasons to explain them
- Identify temporal patterns and give reasons to explain them
- Analyze and compare the frequency and intensity of tornadoes and learn the differences between them
- Compare the geographic extent of different layers

GIS Tools and Functions

- Open a map file
- Zoom to the geographic extent of a layer
- Add a data layer to a map

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- Identify to get information about a feature
- Use a filter to select features and records in a layer
- Open the attribute table for a layer

Functions

- Turn layers on and off
- Activate a layer
- Change style of a symbol
- Sort fields in a table
- Select records in a table
- Get statistics for selected records

National Geography Standards

Standard	K-4	5-8
5 That people create regions to interpret Earth's complexity	The concept of a region as an area of the Earth's surface with unifying geographic characteristics	The influences and effects of regional labels and images
7 The physical processes that shape the patterns of Earth's surface	How patterns (location, distribution, and association) of features on Earth's surface are shaped by physical processes	How to predict the consequences of physical processes on Earth's surface
15 How physical systems affect human systems	How variations within the physical environment produce spatial patterns that affect human adaptation	How natural hazards affect human activities

Teaching the lesson

Introducing the lesson

- Begin this lesson by reviewing or discussing the following concepts.
- Natural disasters: where they occur and how they affect people all over the country
- How natural disasters can cause a significant amount of damage
- How studying natural disasters can help you learn about weather, climate, landforms, and other aspects of geography
- Tornado dynamics
- Tetsuya Fujita and the Storm Prediction Center

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Student activity

We recommend that you complete this lesson yourself before completing it with students. This will allow you to modify the activity to accommodate the specific needs of your students.

Teacher Notes

- For younger grades, you can conduct the GIS activity as a teacher-led activity with students following along. You can lead students through the GIS steps and ask them the associated questions as a class.
- For older grades, ideally, students will have access to their own computers, but students can complete the activities in groups or under the direction of a teacher.
- Throughout the GIS activity, students are presented with questions. The GIS activity is designed so that students can mark their answers directly on these sheets. Alternatively, you can create a separate answer sheet.
- We recommend that students save their work as they progress through the GIS activity. Students can use either the Save command (to save their changes to the original map) or the Save As command (to save their changes to a new map). Please explain to students where and how they should save their work.
- Throughout this activity, students are asked to calculate percentages. Students can use either a handheld calculator or the calculator on their computer.
- The tornado data used in this lesson was downloaded from the National Atlas Web site (http://www.nationalatlas.com/mld/tornadx.html). The actual number of tornadoes and deaths from tornadoes recorded in this dataset may differ slightly from reports found on the Internet. For example, it is generally reported that 401–412 tornadoes occurred from May 1–10, 2003. In the tornado data used in this lesson, the number of tornadoes recorded for the May 1–10, 2003, event is 366.

The following are things to look for while the students are working on this set of activities:

- As students work through the steps, are they thinking about the underlying geographic concepts (e.g., are they looking for spatial patterns? Are they looking for relationships between features and layers? Are they relating the map to the information on their worksheet?)
- Are students answering the questions in the GIS activity as they work through the steps?
- Are students able to use the legends to interpret the map layers?
- Do students understand the concept of selecting features from a layer?
- Do students understand the difference between attribute query (selecting features based on an attribute value) and spatial query (selecting features based on location)?

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Concluding the lesson

- Engage students in a discussion about the observations and discoveries they made during their exploration of 30 years of U.S. tornadoes and noted tornado outbreaks.
- Ask students to characterize regions of the country based on what they have learned about U.S. tornadoes.
- Has this activity raised any questions that students would like to explore further?
- Ask students to research the terms “tornado watch” and “tornado warning.”
- Ask students if their community or school has a tornado plan and what it contains.
- How can GIS help students to learn about natural disasters?
- Has this activity changed students’ ideas about tornadoes?

Extending the lesson

- Have students create a graph comparing the characteristics of the three tornado outbreaks covered in this lesson, such as total number of tornadoes, number of states affected, and total number of strong and violent tornadoes.
- Ask students to determine the date and intensity of the tornado closest to where they live.
- Ask students to examine unexpected tornadoes, such as tornadoes occurring in the mountains of Colorado or the canyon lands of Utah.

References

- http://www.spc.noaa.gov/faq/tornado/f-scale.html
- http://www.noaanews.noaa.gov/stories/s345.htm
- http://www.nssl.noaa.gov/edu/safety/tornadoguide.html
- http://www.aon.com/us/busi/risk_management/risk_consulting/impact_forecast_files/UnitedStatesTornadoSeasonality.pdf

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Student activity answer key

Answers appear in blue.

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Meteorologists study storms that produce tornadoes. They use tools such as forecasting (predicting the weather), research (observing and trying to understand the weather), and storm chasing (following and watching storms close-up). Some tornadoes and tornado outbreaks may stick even in your memory. Some students grow up to study the science of tornadoes because of a personal experience or out of curiosity about a particular outbreak. Perhaps you will decide to be a meteorologist yourself one day!

In this GIS activity, you will see how tornadoes are classified into weak, strong, and violent categories. You will also take a close look at some of the memorable tornado outbreaks in history.
Let's explore Tornado Alley.

Task 1: Open the map

Task 2: Enlarge the ArcGIS Online window

Task 3: Tornadoes of the United States

Task 4: Thirty years of tornadoes.

Q1: Which region had the fewest tornadoes between 1974 and 2003?

a. ***Midwest***
b. ***Northeast***
c. ***South***
d. ***West***

Q2: Which state had no tornadoes between 1974 and 2003? Alaska

Q3: How many tornadoes occurred between 1974 and 2003? (Write the number here. You will use this number in the next step. 29,640

Task 5: Weak tornadoes.

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Q4: Which region had the fewest weak tornadoes between 1974 and 2003?

a. ***Midwest***
b. ***Northeast***
c. ***South***
d. ***West***

Q5: Look at your "Tornado F-scale" handout. Write down two examples of damage that occurs with F0 tornadoes. Answers may include the following:

- ***Chimney damage***
- ***Broken twigs and tree branches***
- ***Trees pushed over***
- ***Damage to signboards***
- ***Broken windows***

Q6: Look at your "Tornado F-scale" handout again. Write down two examples of damage that occurs with F1 tornadoes. Answers may include the following:

- ***Roof damage***
- ***Mobile homes pushed off foundations***
- ***Autos pushed off roads***
- ***Broken trees***

Q7: How many weak tornadoes occurred in the United States between 1974 and 2003? 24,858

Q8: What percentage of all tornadoes were weak? To answer this question, you will divide the number of weak tornadoes by the total number of tornadoes (you wrote this number down in Q3). Then you will multiply the answer by 100. You may need to use a calculator.

Weak tornadoes ÷ total tornadoes = 0.83 X 100 = 83 percent (without the decimal)

Task 6: Strong tornadoes.

Q9: Which region had the fewest strong tornadoes between 1974 and 2003?

a. ***Midwest***
b. ***Northeast***
c. ***South***
d. ***West***

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Q10: Look at the map. Does it look like there were more strong tornadoes or weak tornadoes from 1974 to 2003? (Hint: Turn the layers on and off to compare them.)

a. ***More strong tornadoes***
b. ***More weak tornadoes***

Q11: Look at your "Tornado F-scale" handout. Write down two examples of damage that occurs with F2 tornadoes. Answers may include the following:

- ***Roofs torn off***
- ***Mobile home destruction***
- ***Houses lifted and moved***
- ***Railroad cars pushed over***
- ***Large trees snapped or pulled out***
- ***Light objects take flight***

Q12: Look at your "Tornado F-scale" handout again. Write down two examples of damage that occurs with F3 tornadoes. Answers may include the following:

- ***Roofs and walls torn off***
- ***Trains turned over***
- ***Forest trees pulled out***
- ***Heavy cars lifted and thrown***
- ***Pavement blown off***

Q13: How many strong tornadoes occurred in the United States between 1974 and 2003? 4,517

Q14: What percentage of all tornadoes were strong? To answer this question, you will divide the number of strong tornadoes by the total number of tornadoes (you wrote this number down in Q3). Then you will multiply the answer by 100. You may need to use a calculator.

Strong tornadoes ÷ total tornadoes = 0.15 X 100 = 15 percent (without the decimal)

Task 7: Violent tornadoes.

Q15: Which region had the fewest violent tornadoes between 1974 and 2003?

a. ***Midwest***
b. ***Northeast***
c. ***South***
d. ***West***

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Q16: Which regions had the most violent tornadoes between 1974 and 2003? (Circle all the correct answers.)

a. ***Midwest***
b. ***Northeast***
c. ***South***
d. ***West***

Q17: Were there more violent tornadoes or strong tornadoes from 1974 to 2003? Hint: Turn the layers on and off to compare them.)

a. ***More violent tornadoes***
b. ***More strong tornadoes***

Q18: Look at your "Tornado F-scale" handout. Write down two examples of damage that occurs with F4 tornadoes. Answers may include the following:

- ***Flattened houses***
- ***Weak buildings blown away***
- ***Cars thrown***
- ***Large objects take flight***
- ***Forest trees blown away***

Q19: Look at your "Tornado F-scale" handout again. Write down two examples of damage that occurs with F5 tornadoes. Answers may include the following:

- ***Strong houses blown away***
- ***Very large objects (like cars) take flight***
- ***Bark blown off trees***
- ***Incredible things happen***

Q20: How many violent tornadoes occurred in the United States between 1974 and 2003? 265

Q21: What percentage of all tornadoes were violenHt? Your already calculated the percentage of weak and strong tornadoes. Write those down here.

Percentage of weak tornadoes: __ __percent (from Q8)
Percentage of strong tornadoes: __ __percent (from Q14)
Add these two numbers together: __ __percent
Subtract this number from 100%.
What is the percentage of violent tornadoes?

a. ***1 percent***
b. ***2 percent***
c. ***3 percent***
d. ***4 percent***

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Step 7: One of the most violent tornado outbreaks that we know about in History happened on April 3-4, 1974.

Q22: How many people lived in Xenia in 2000? 24,164

Q23: How many tornadoes occurred during this 24-hour period? 148

Q24: How many states were affected? 13

Q25: How many F5 tornadoes occurred on April 3 and 4? 7

Q26: How many tornadoes caused injuries? (Hint: Look at the number of selected records at the bottom of the table.) 83

Q27: What is the total number of injuries that occurred? Write this number on your "Historical tornadoes" worksheet. 5,454

Q28: How many tornadoes caused deaths? (Hint: Look at the number of selected records at the bottom of the table.) 48

Q29: What is the total number of deaths that occurred? Write this number on your "Historical tornadoes" worksheet. 310

Q30: Look at your map, and look at your "Historical tornadoes" worksheet. Why do you think the tornado outbreak of April 3–4, 1974, is considered the most violent tornado outbreak in history? List two reasons. Answers may include the following:

- ***The large number of tornadoes (148)***
- ***The large area affected (13 states and 3 regions)***
- ***The large number of strong (67) and violent (30) tornadoes***
- ***The large number of injuries (5,454) and deaths (310)***

Task 8: The most costly tornado of all time occurred on May 3, 1999

Q31: How many housing units (houses) are in Moore? 15,801

Q32: What is the F-scale of the strongest tornado on this day? 5

Q33: How far did this F5 tornado travel? Divide the answer by 10.
Length value in table = 370 ÷ 10 = 37.0 miles

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Q34: Did this F5 (highlighted) tornado have the longest track of any tornado that occurred that day (May 3, 1999)?

a. Yes
b. No

Q35: What was the width of the F5 tornado?
Multiply the answer by 10. (You can ignore the number after the decimal.)
Width value in table = 429 X 10 = 4290 feet

Q36: Was this F5 tornado you identified in Step 76 the widest tornado that occurred that day?

a. Yes
b. No

Q37: How many tornadoes were wider? 1

Q38: How many states were hit by tornadoes on May 3, 1999? Write your answer on your Historical tornadoes worksheet.

Q39: Look at the map and identify the region(s) that the tornadoes on May 3, 1999 were located in. Write your answer on your Historical tornadoes worksheet.

Task 9: More tornadoes occurred between May 1 and May 10, 2003, than any other ten-day period since record keeping began.

Q40: Look at your map. Describe in your own words how this tornado outbreak looks different from the other two outbreaks you have already looked at. (Hint: Turn the layers on and off to compare them. How far do the tornadoes extend in all directions? Which regions and states were hit?) This tornado outbreak is more widespread. It covers a bigger area (more stats). It stretches from Arizona in the West to New York an North Carolina in the East.

Q41: How many F2 tornadoes occurred between May 1 and May 10, 2003? Write the number on your "Historical tornadoes" worksheet. 37

Q42: How many F3 tornadoes occurred from May 1-10, 2003? Write the number on your "Historical tornadoes" worksheet. 17

Q43: How many F4 tornadoes occurred from May 1-10, 2003? Write the number on your "Historical tornadoes" worksheet. 6

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Q44: Add the number of F2 and F3 tornadoes together.

37 (number of F2s) + 17 (number of F3s) = 54 Strong tornadoes. Write this number on your "Historical tornadoes" worksheet.

Q45: Add the number of F4 and F5 tornadoes together.

6 (number of F4s) + 0 (number of F5s) = 6 Violent tornadoes. Write this number on your "Historical tornadoes" worksheet.

Q46: Look at your "Historical tornadoes" worksheet. Why do you think the 2003 tornado outbreak caused more damage than the other two outbreaks? Discuss this with your classmates, and write your answer here. The number of tornadoes from May 1-10 (more than 400 reported) far exceeded the other outbreaks. More cities were involved and more structures sustained damage.

Task 10: Save your work and exit ArcMap.

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Worksheet: Historical tornadoes

	Event 1	Event 2	Event 3
Date	April 3-4, 1974	May 3, 1999	May 1-10, 2003
Why is it remembered?	Largest outbreak	Most expensive single tornado	More tornadoes than any other 10-day period
Total number of tornadoes	148 tornadoes	71 tornadoes	401 – 412 tornadoes
Cities most affected	Xenia, Ohio	Moore, Oklahoma, (suburb of Oklahoma City)	Kansas City, Kansas; Oklahoma City, Oklahoma; Pierce City, Missouri; Jackson, Tennessee
Total number of states	13 states	5 states	26 states
Names of states	Alabama, Georgia, Illinois, Indiana, Kentucky, Michigan, Mississippi, New York, North Carolina, Ohio, Tennessee, Virginia, West Virginia	South Dakota Nebraska Kansas Oklahoma Texas	Alabama, Arizona, Arkansas, Colorado, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Missouri, Nebraska, New York, North Carolina, North Dakota, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Virginia, Wisconsin
Regions	Midwest, Northeast, South	Midwest South	Midwest, Northeast, South, West
F-scale	F2 = 34 F3 = 33 F4 = 23 F5 = 7	F2 = 7 F3 = 6 F4 = 3 F5 = 1	F2 = 37 F3 = 17 F4 = 6 F5 = 0
Total number of strong and violent tornadoes	Strong = 67 Violent = 30	Strong = 13 Violent = 4	Strong = 54 Violent = 6
Total number of injuries	5,454 injuries	825 injuries	637 injuries
Total number of deaths	310 deaths	46 deaths	40+ deaths
Total damage in dollars	>600 million	1.6 billion	3.4 billion

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Worksheet: Historical tornadoes

Tetsuya T. Fujita, also known as "Mr. Tornado," invented the Fujita Scale (F-scale) at the University of Chicago in the early 1970s. The F-scale describes different levels of damage caused by tornadoes based on their estimated wind speeds. The scale goes from light damage (F-0) to incredible damage (F-5).

F-scale	Wind speed (miles per hour)	Damage
F0	40-72 mph	**Light damage**—Some damage to chimneys; breaks twigs and tree branches; pushes over some trees; damages signboards; breaks some windows
F1	73-112 mph	**Moderate damage**—Peels surfaces off roofs; mobile homes pushed off foundations; moving autos pushed off the roads; trees snapped or broken
F2	113-157 mph	**Considerable damage**—Roofs torn off houses; mobile homes destroyed; some houses lifted and moved; railroad cars pushed over; large trees snapped or pulled out; light objects take flight
F3	158-206 mph	**Severe damage**—Roofs and walls torn off houses; whole trains turned over; most forest trees pulled out; heavy cars lifted off the ground and thrown; pavement blown off roads
F4	207-260 mph	**Devastating damage**—Houses flattened; weak buildings blown some distance; cars thrown and destroyed; large objects take flight; forest trees pulled out and blown away
F5	261-318 mph	**Incredible damage**—Strong houses lifted and blown away; objects the size of autos fly through the air; bark blown off trees; incredible things happen

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