

## Global GIS Lesson: *Exploring North American Earthquakes*

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Loma Prieta, California, Earthquake 17 October 1989, Moss Landing. Damaged approach and abutment of the bridge linking the spit to the mainland. Liquefaction of the beach and Salinas River deposits caused ground cracking and differential settlement. Slide XV-2, USGS Open File Report 90-547 (<http://130.11.57.28/of90547.htm>), Digital File:tjc00009, ID. Tinsley, J.C. 9ct

### Description

In this lesson, students use Geographic Information Systems (GIS) together with the tools and data from the North America Global GIS CD to investigate earthquakes, volcanoes, and population from a local to global scale. The lessons can be used with other data in the Global GIS project to investigate earthquakes in other continents. Furthermore, the methods used here can be applied to other map themes contained within the North America Global GIS CD.

The lesson is organized into 7 parts. Parts 1 and 2 are in this booklet. The complete lesson is available on:

<http://rockyweb.cr.usgs.gov/public/outreach/globalgis/northamerica/earthquakes.html>

- Part 1—What's Shakin'?
- Part 2—Digging Deeper
- Part 3—The Loma Prieta Earthquake
- Part 4—Investigating Your Community
- Part 5—Earthquakes Everyday
- Part 6—Analyzing Recent Earthquakes
- Part 7—Earthquakes Respect No Boundaries

## **What is GIS?**

A GIS combines the power of maps, satellite images, and aerial photographs with databases that store information behind the maps and images. One way to think about GIS is to break it up into its three initials. The “G” part of GIS could be a map, a 3-D surface, or an image. The “I” part is Information such as the magnitude of an earthquake or a country’s population. The “S” part makes it possible to analyze the maps and attributes together. GIS is computer hardware, software, methods, and a human explorer. ArcReader and ArcView software from ESRI, Inc. will be used for this lesson. GIS involves procedures such as making thematic maps that students will have the opportunity to use. GIS also requires certain kinds of spatial data, produced by organizations such as the USGS, the US Census Bureau, NASA, tribal, state, and local government, nonprofit organizations, and private industry. However, the most important component of a GIS is the user, who must make sense of what the GIS tools and methods are saying, and what action to take.

## **Why Use GIS in Education?**

As the world becomes ever more monitored, mapped, and surveyed, students have the opportunity as never before to take advantage of the same tools that scientists are using. A GIS allows the user to create computerized maps, and to analyze patterns, linkages, and trends on the Earth’s surface. Oceanographers, geologists, geographers, seismologists, climatologists, biologists, chemists, and other scientists regularly use GIS to help them make wise decisions about the planet. Rather than being confined to the content, scale, and symbols of a paper map, a GIS allows the user to create and customize his or her own map to address the issues and problem at hand. Analyzing the Earth with a GIS in the classroom provides for inquiry-based, problem-solving learning. Students ask a question, acquire the necessary tools and data to address the question, analyze the data, and assess the results of their investigation, leading to further investigation and questions. Learning with GIS allows for relevant, exciting, interdisciplinary learning. Therefore, the lesson supports national science teaching science standards, professional development standards, and science content standards. Content standards are supported as students examine evidence and explain the distribution of phenomena across Earth’s surface. They measure phenomena and they analyze changes over time and space, becoming familiar with and also critical of the types of data they work with.

The emphasis on this CD and lesson is on investigation and analysis, rather than on demonstration. The multiple GIS skills of process, computer, and analysis the students are learning are in context with the lesson on seismicity. Instead of simply providing answers to questions, students are communicating science explanations about science content through their maps, tables, and charts from GIS. Their conclusions are backed by real-world data. The lesson supports the physical science standards because students learn about tectonic forces, motions, and patterns, and the structure of the earth system. The science and technology standards are addressed because students learn science *through GIS technology*. Natural hazards are a component in the science in personal and social perspectives standards, and with this lesson, students assess risks and benefits of living with earthquakes, and the relationship of earthquakes to cities and critical infrastructure such as roads, utility lines, and railroads.

## **Problem Setting**

For the past 25 years, the average cost of North American earthquakes has been approximately \$2.5 billion dollars per year in property and critical infrastructure, with an average of 1,000 people dying each year. "Critical infrastructure" includes roads, airports, powerlines, pipelines,

railroads, fiber optic cable, Internet and telephone lines, shipping docks, power stations, transmission towers, and canals. As the population grows and development expands to cover more and more of the land area of North America, the problems will grow as well. In this earthquakes lesson, students are given a scenario where they must report on the distribution and frequency of earthquakes in North America related to cities, political boundaries, volcanoes, and fault lines. They analyze current earthquakes from the Internet, and assess the hazards from a continental to a local scale, to their community.

### **Options for Running the Software:**

1. For users who have installed ArcView Data Publisher, start the "North America Global GIS" icon from the Windows start bar under the 'Global GIS' folder. ArcView Data Publisher users will not be able to complete parts 6 and 7 of this lesson.
2. Users who own a version ArcView 3.x can open the ArcView GIS project named "Namerica\_global\_gis5\_v3.apr" directly off the Global GIS CD. This will give the user the opportunity to save his/her project.
  - Notes: Before starting, please see <http://www.agiweb.org/pubs/globalgis/> under "support and downloads" for any data updates or project updates. The ArcView project delivered on this disk is not compatible with ArcView version 3.0 because of the use of the MrSid image format. ArcView version 3.1 and higher will work. Thus, for Macintosh ArcView version 3.0, users will need to download a compatible Macintosh project, which removes the MrSid image references from the AGI site mentioned above.

### **Investigation**

The U.S. Geological Survey was created in 1879 to help understand the geology, biology, hydrology, and geography of the Earth. To help assess where and why earthquakes occur in North America, the USGS has hired you as an earth systems scientist to provide them a report that will include the distribution, frequency, and causes of earthquakes in North America, specific regions of the continent, and the state where you attend school. Included in your report must be an analysis of the depth and magnitude of the earthquakes, and the locations and characteristics of cities, volcanoes, and faults in relationship to earthquakes.

0) List three kinds of critical infrastructure that could be destroyed or damaged during an earthquake. For each, describe why the destruction of these infrastructure resources is so disruptive to local, regional, and national government and commerce.

### **————— Part 1: What's Shakin'?**

In this part, you will examine earthquakes across North America, noting their distribution, magnitude, and depth, and also examining certain regions on the continent. Access the Global GIS interface. You will be viewing the "G" part of GIS with the map on the right side and a set of tools across the left and the top.

Turn off (uncheck) all themes except for the following:

- shaded relief base (at the bottom of the table of contents)
- earthquakes 1973-1994 (about 1/3 down on the table of contents)

Movies, 3D, ...

Access the Movies, 3D menu at the top and run nam\_eq\_anima.avi. Use the slider bar to position the movie at specific years you wish to investigate further.

- 1) What years do the earthquakes cover?
- 2) The USGS seismologists want you to make three observations about the *spatial pattern* of earthquakes that you notice as they occur across the North American continent. Consider the extent of the earthquakes, and specific areas of North America where earthquakes occur more often.
- 3) Make three observations about the *magnitude of earthquakes* and where earthquakes of certain magnitudes occur across North America. Do large earthquakes only occur in specific regions? If so, where are they?
- 4) Do any specific years seem to have more earthquakes than others, or would you say that about the same number of earthquakes occur each year?

Close the movie and return to your GIS. Now you can further analyze the earthquake theme and draw some conclusions.

- 5) Do more earthquakes occur near oceans or in the interior of the North American continent? Why?
- 6) Do more earthquakes occur near the Pacific Ocean to the west of North America or near the Atlantic Ocean to the east of North America? Why?
- 7) Compare the number of earthquakes that occur in the oceans versus land.
- 8) Compare the Atlantic versus Pacific Ocean earthquakes.
- 9) What feature runs down the middle of the Atlantic, and why is it so prone to earthquakes?
- 10) What particular hazard exists to people when an earthquake occurs in the ocean?
- 11) In what part(s) of North America would people need to be concerned about earthquakes occurring in the ocean?

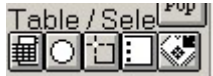
Make volcanoes visible by checking the box to the left of the theme name.



- 12) Make three observations about the pattern of volcanoes in North America.
- 13) The USGS wants you to determine the relationship of earthquakes and volcanoes. Examine at least three different places around North America and investigate the spatial relationship between earthquakes and volcanoes. Do volcanoes and earthquakes occur in the


same places? Include the three places you examined, your conclusions about the relationship, and why you believe the relationship either exists or does not exist.


Single click on the earthquakes theme so that it becomes raised up, or "active." Click on the tables tool in Global GIS Tools to access the table--the "I" part of GIS, that is, the information in

the table.  Each row in the table represents one earthquake in the dataset.


14) Look in the upper left part of your screen under ArcView GIS. How many earthquakes are recorded in this dataset?

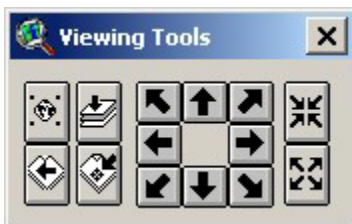
15) Approximately how many earthquakes are recorded during an average year? Show how you determined this answer.


Click on the "magnitude" field and sort it in descending order . Navigate to the top of the table and click on the row containing the earthquake with the highest magnitude to select it.

You may have to select the black selection arrow to select a row.  The row will appear in yellow.

16) What is the magnitude of this earthquake?



Close the table. In the Global GIS Tools box, on the right side of Viewing Tools, go to "More Tools." Select the "Zoom to Selected" tool  in the Global GIS Tools box:





Use the "zoom into center" button a number of times to zoom into your selected earthquake . Turn on the themes political boundaries, and political boundary labels.

17) In which country did the largest earthquake occur?

Access the earthquakes table again and clear your selection .


Select the field "km" in the table. This represents the depth of the earthquakes in kilometers underneath the surface. Click on the "km" field and sort it in descending order . Navigate to the top of the table and click on the row containing the earthquake with the greatest depth to select it.  The row will appear in yellow.

18) What is the depth of this earthquake?


Close the table and select the "Zoom to Selected" tool in the Global GIS Tools box . Use the "zoom into center" button  a number of times to zoom to your selected earthquake.

19) In which country has the deepest earthquake occurred?

20) In what continent is this country?


Pan  to the United States.

21) You are asked to list in your USGS report that states you consider to be most vulnerable to earthquakes. List the top three states, and your reasons for including them.

Pan  to the western side of the United States to the area of California. You could turn on the US Counties theme to see California counties all in the same color.

22) You receive an email from the USGS seismologists that ask you to determine four major areas of California where most earthquakes occur. What four areas will you list in your report?

Turn on major cities and turn off earthquakes. You might have to zoom in to see the labels. Zoom to the center of the Pacific Coast of the United States, central California and Nevada.

Use the "Create Profile" tool  and draw a line from Carson City, Nevada, southwest to San Francisco, California. Choose to profile the data set "elevation."

23) Describe how the land elevation changes from Carson City to San Francisco.

Turn earthquakes back on.

24) Examine the earthquakes across your profile. What kind of terrain is more prone to earthquakes—valleys or mountains? Why?

Zoom out to California, turn off earthquakes, and note the location and names of the 6 major cities. Turn earthquakes back on.


25) Of the 6 major cities in California, indicate in your report to the USGS the 2 cities that you consider to be the most vulnerable to an earthquake. Indicate why you consider them to be the most vulnerable.


26) Congratulations! You have completed the first part of the assignment and have contributed much to the understanding of earthquakes in North America. Indicate what you consider to be the most surprising thing you have learned in this part, the most interesting thing, and the most significant thing.

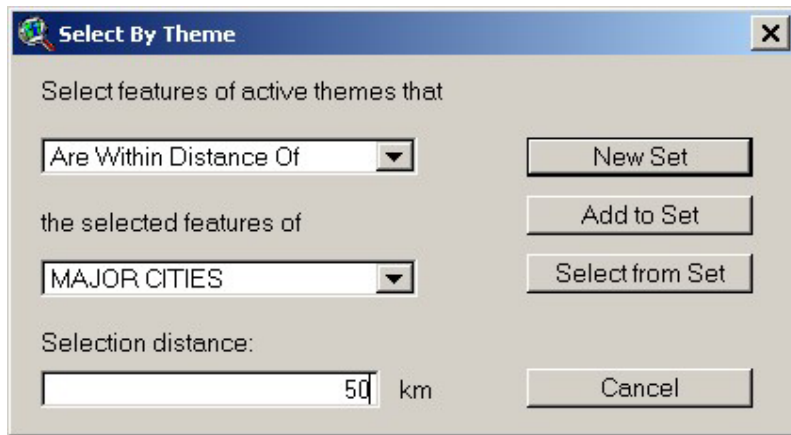
## ———— Part 2: Digging Deeper


In this part, you will examine the relationship between earthquakes and cities, and investigate earthquakes in a specific area in California.

Click on the Advanced Interface button at the bottom of the Global GIS Tools window. You will notice the additional tools now at the top of your computer screen.

Make major cities the active theme by clicking once on it. Clear any previous city selections . Make earthquakes the active theme by clicking once on it. Clear any previous

earthquake selections . Under the Theme pull-down menu, press "Select By Theme" to discover how many earthquakes are within 50 kilometers of major cities.



Examine the resulting earthquake table . Look in the upper left of your computer screen.

- 27) How many earthquakes resulted from your query of the data?
- 28) What percentage of North American earthquakes are within 50 kilometers of major cities? Show how you determined this answer.
- 29) Make 3 observations about the pattern of earthquakes near California cities.
- 30) Compare the amount of earthquakes in Alaska versus California. Which state would you say receives the most earthquakes?
- 31) Which state would you say receives the most publicity about earthquakes in newspapers, television, radio, and on the Internet?
- 32) Compare your answers to the two previous questions. Did you write a different answer for the two questions? If so, why do you suppose this is the case?

As you move around the map, notice the latitude and longitude values to the upper right of the view (map) window.

Zoom to the earthquakes at 36.91 north latitude and 121.65 west longitude. Set the scale to 1:10,000. There will be two earthquakes at this exact spot.

- 33) Identify  these earthquakes and indicate their magnitudes:

Click on "Global GIS Help"  in Global GIS Tools. Go to "Datasets" and select the earthquakes theme.

- 34) What field name contains the **time** when the earthquakes occurred?



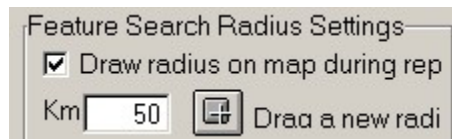
Based on this information, go back to your map and examine the time when the three earthquakes occurred. List the earthquakes below in the order of their occurrence.


35) Were these earthquakes associated with the same seismic event? Explain your answer.

36) What is an aftershock?

37) Do you think the earthquakes you are examining include an aftershock? If so, which earthquake was an *aftershock* of the first?

38) Notice the “feature search radius settings” near the bottom of the Global GIS Tools window.



Drag a new search radius – a circle -- from these two earthquakes until the circle just touches the Pacific coastline. This should be a 13 kilometer search radius, and the number 13 should appear in the kilometers field. Generate a map report  and click on the earthquake on the map again. Print the map report of this area.

39) Summarize what this report tells you in your own words.

You need to assess possible damage from future earthquakes in this region in your report, in terms of roads, airports, and population.

40) What is the 1998 population within 13km of these earthquakes?

41) Who, in your opinion, are the most vulnerable segments of the population to earthquakes?

42) How far is the nearest road from the earthquakes?

43) Do you think roads could be damaged by earthquakes? Name three ways roads could be damaged.

44) How could the disruption of transportation affect evacuation from an earthquake and rescue operations?

45) What is the name of the nearest airfield to these earthquakes? How far is it from the earthquakes?

46) Do you think an airfield could be damaged by an earthquake? Describe three ways air services could be disrupted.

47) Congratulations! You have completed the second part of your mission and have contributed much to the understanding of earthquakes in North America. Indicate what you consider to be the most surprising thing you have learned in this part, the most interesting thing, and the most significant thing.