



Rocky Mountain Mapping Center

Earthquakes Everyday: Exploring Earthquakes with GIS

Author: Joseph J. Kerski, Geographer, jjkerski@usgs.gov, 303-202-4315.

Overview: In this lesson, you will have the opportunity to analyze historical and current information within a GIS. You will download current earthquake information from the Internet and import it into a GIS so that you can analyze it. You will create new data to analyze the number of earthquakes near plate boundaries and earthquakes by country.

Skills Involved:

- 1) Tabular sort and query.
- 2) Changing map legends and creating layouts.
- 3) Spatial sort and query.
- 4) Downloading and formatting data from the Internet for use in GIS.
- 5) Changing map projections.
- 6) Creating new data.

Data Management

During the last lab, you created a folder on your computer. Do the same thing for this lesson, naming the folder earthquakes.

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

This file is named worldearthquakeslesson.zip and the size is approximately 3.4 MB.

After downloading, unzip the file using the Winzip program.

You now should have the following **29** files:

- cntry95.dbf
- cntry95.sbn
- cntry95.sbx
- cntry95.shp
- cntry95.shx
- plat_lin.dbf
- plat_lin.sbn
- plat_lin.sbx
- plat_lin.shp
- plat_lin.shx
- plat_pol.dbf
- plat_pol.sbn

plat_pol.sbx
plat_pol.shp
plat_pol.shx
plates_4types.avl
plates_4types.dbf
plates_4types.shp
plates_4types.shx
quakes2001.dbf
quakes2001.sbn
quakes2001.sbx
quakes2001.shp
quakes2001.shx
world30.dbf
world30.sbn
world30.sbx
world30.shp
world30.shx

- 1) Recall last week's readings. In Windows Explorer, examine the file extensions for the files containing the map geometry. What extension do these files have?
- 2) Do these files represent the "G" or the "I" or the "S" part of GIS?
- 3) From last week's lesson, what extension do the files that contain the tables have?
- 4) Do these files represent the "G" or the "I" or the "S" part of GIS?
- 5) What role do the files that have the other extensions play in GIS?

Accessing Earthquake Data for Spatial Analysis

In this section, you will download information about earthquakes from the USGS National Earthquake Information Center that have occurred over the last several days. After you have the data, you will map these earthquake epicenters as point data. Before uploading the data into your GIS, you will need to edit the epicenters file.

Make sure to save all your Internet data in your own folder that you created for this lesson, called earthquakes.

Go to the USGS National Earthquake Information Center by typing in this address:

<http://neic.usgs.gov/neis/bulletin/>

- 6) What is the time period covered by this current earthquake bulletin?

7) How recent is the latest earthquake in this list?

8) What is the largest earthquake that appears in the list?

9) How many earthquakes appear in the list?

10) Does the number of earthquakes in the list surprise you? Why or why not?

At the end of the list, but above the map, click on **comma-delimited earthquake list**. It will appear as follows in your browser window:

```
Date, TimeUTC, Latitude, Longitude, Magnitude, Depth
04/01/01,00:32:01,37.76,21.07,3.4,5.0
04/01/01,00:51:07,-31.85,-69.77,2.9,138.7
04/01/01,00:56:52,51.39,-177.61,4.2,33.0
04/01/01,01:06:22,71.04,-13.72,4.2,10.0
<more records will exist>
```

The URL for the above list will be on:

<http://neic.cr.usgs.gov/neis/gis/bulletin.asc>

Go to File--> Save as and save your earthquake list as a **plain text file** named earthquakes.txt in your earthquake folder.

11) How many records of data (epicenters) does your file contain? **[a]**

Your data is now ready to bring to *ArcView* GIS.

Access *ArcView* GIS with a new project and new view.

Add the following 2 themes:

world30.shp

cntry95.shp

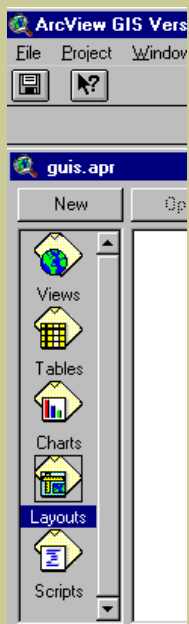
Make the themes visible and move cntry95 to the top of the list.

File-->Save Project OR Press Ctrl+S (saves project)

Important: Name your project as earthquake.apr in your earthquake folder.



Add your earthquake data.



Click once on Tables (shown at left) in the **project** window. The project window will be named "earthquake.apr."

Click Add.

12) What kind of file did you edit above (.dbf, INFO, or .txt?) _____ **[b]**.

In the lower left of the window, change the field to your answer in **[b]**.

Find your text file in your earthquakes folder and click OK.

Your table name (earthquakes.txt) should now appear in the list of tables along with a window with the data.

Click on the view window to make it active.

Go to the View menu on the top and select *Add Event Theme*.

Your text file should appear.

Think of the Cartesian coordinate system from mathematics. Examine this coordinate system on:

http://www.npac.syr.edu/REU/reu94/williams/ch1/subsection3_1_1.html

or

<http://www.csun.edu/~math095/schedule/notes/geo/Cartesian/Cartesian.html>


Now think of the Cartesian coordinate system in terms of latitude and longitude.

13) Which axis is "x" - longitude or latitude?

14) Which axis is "y" - longitude or latitude?

In the dialog box, indicate the correct fields for latitude and longitude based on your answers above.

Make the new theme appear by clicking on the small check box next to it.

15) Access the table for your new theme . How many epicenters are in your view?

16) How does this compare to your answer to **[a]** above? Why?

If your table does not have the correct number of rows and columns, you probably have a misplaced or

missing comma, a blank line at the beginning of your file, HTML tags in your file, or some other character that should not be there. If so, you'll need to delete the table from the project, open the table in WordPad or NotePad, make the changes, re-add the table to your project window, and re-add it as an event theme.

Analyzing Earthquake Patterns and Relationships

Now you are ready to analyze the data you have mapped and draw some conclusions about it.

17) Examine the earthquakes and describe at least two characteristics of your pattern of earthquakes over the past several days.

Note how all the earthquake epicenters are the same color. Change this so that each day's earthquakes are mapped with a different color, as follows:


Double click on the theme earthquakes.txt to bring up the legend editor.

Change the legend type from "single symbol" to "unique value."

Change the values field from "none" to "date".

18) Look at the 'count' to the right of each category. Which day witnessed the most earthquakes?


19) Apply changes and examine your map. What changed?

20) Add the theme  plat_lin.shp. What features are contained in this file?

21) What is the pattern of earthquakes related to plate boundaries?

22) What is the reason for the pattern of earthquakes related to plate boundaries?

23) Are some plate boundaries more active than others? If so, which ones? Why are they more active?

24) Add the theme  plat_pol.shp. What are the features in this file? How is this different from the plat_lin map? Recall our discussion about point, line, and polygon vector data.

25) What plate are you living on?

26) What plate are citizens of Brazil living on?

27) Double click on the **earthquakes.txt** theme in the table of contents to call up the legend editor. On which field do you need to classify to generate a map showing magnitude? Generate this map.

28) Move the order that the themes appear in the table of contents on the left side of the view so that you can see the plate lines on top of the earthquake epicenters. What is the relationship of the **magnitude** of earthquakes related to plate boundaries?

29) Where did the largest earthquake of the week occur?

30) Was it on land or offshore?

31) What was its magnitude?

32) How can you determine if earthquake aftershocks occurred this week?

33) If any aftershocks occurred, where are they and how many aftershocks occurred?


Change the legend to examine at the **depth** of earthquakes related to plate boundaries. This is the depth under the surface of the Earth at which the movement occurred, in kilometers.

34) Make at least two observations about the pattern of the depth of earthquakes across the world.

35) Is there a relationship between magnitude and depth? Why or why not?

Now you are ready to create a final plot of your data. All the information you wish to include in the final plot will be in a "layout." Zoom to the full extent of the data and determine which themes you would like shown in your plot.

Click on View --> Layout.

Use the "T" button  to add text to your layout.

Type in text. You should include the following items of text:

Your name(s).

Title of Map.

Date the map was created.

36) Print your layout to a printer by going to File--> Print.

37) Save your project. What is your project's name?

38) What is the full path name where your project resides on your computer?

Analyzing Earthquakes from 2001

Next, you'll examine all earthquakes from 2001. Add the quakes2001 theme.

39) What is the relationship of the pattern of the most recent earthquakes you examined earlier to the 2001 earthquakes? Why?


40) According to this theme, how many earthquakes occurred in 2001?

41) What is the relationship of earthquakes to plate boundaries? Why?

Let's investigate this relationship further. You will investigate how many epicenters are within a certain distance of the plate boundaries.

42) First access View --> Properties. Note the map units. What are the map units?

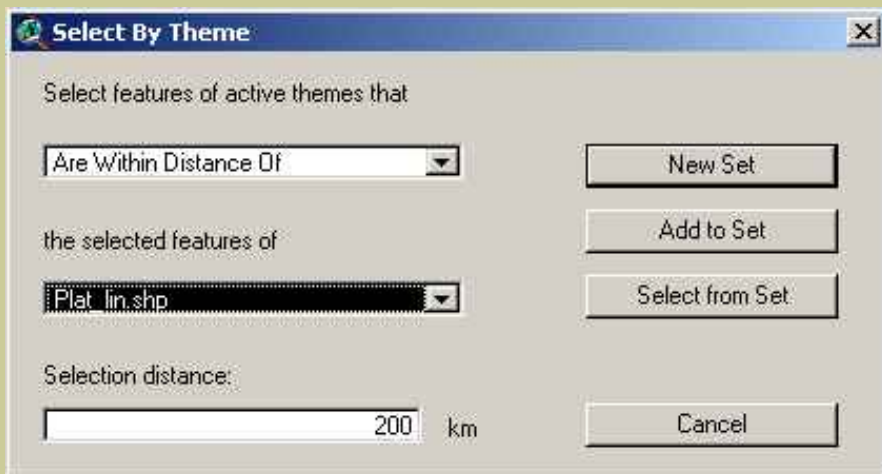
Set the distance units to *kilometers* so that everything you measure will be in kilometers.

Because you will perform a spatial query next, clear any and all selected features in each theme with the button that looks like a blank piece of notebook paper. 


Make the earthquake epicenters your active theme.

Theme-->Select By Theme.

Select epicenters that are within 200 km of plate boundaries (plat_lin), as shown below:



Select **New Set**.

Examine the table of your 2001 earthquakes. 

43) Approximately what percentage of epicenters during 2001 were within 200 km of plate boundaries? Show your work.

44) Clear the selection and repeat the above procedures to select earthquakes within **50 km** of plate boundaries. Approximately what percentage of epicenters during 2001 were within 50 km of plate boundaries? Show your work.

45) Does this percentage surprise you? Why or why not?

46) How much more likely would you say that an earthquake will strike within 200 km of the plate boundaries versus further away from the plate boundaries?


47) Look at all earthquakes again by clearing your selected set. Make a map of earthquake magnitude. What was the magnitude of the largest earthquake?

48) In what country or countries was this largest earthquake located in or near?

49) Zoom in. Did it occur on land or underwater?

50) Examine the sites: <http://pubs.usgs.gov/publications/text/understanding.html>, or

http://www.whfreeman.com/bolt/con_index.htm?07, or other plate tectonics site. Ridges, or Spreading Centers are those such as in the East African Rift Zone and the middle of the Atlantic Ocean, where new crust is built, spreading the old crust apart. Converging boundaries represent areas where one plate is subducting, or moving underneath, another plate. Would you predict the largest earthquakes on your map near ridges or converging boundaries? Why?

Add  plates_4types.shp. It should map by the *type* of plate boundary. If it does not, change the legend to create a unique value map on the field *type*.

51) Examine the statistics in the legend. What is the most common type of plate boundary? Remember, this is only "most common" in terms of the number of line segments, not necessarily its total length.

52) This plates_4types data is different from the other plate boundaries file you examined earlier both in terms of its attributes and its spatial locations. Identify these two differences--how is this file different from the other plate boundaries file?

53) Turn off the other plate boundaries and make two observations about the spatial relationship between earthquakes and the plates_4types data.

Map this week's earthquakes and the plates_4types data to answer the following question:

54) Which type of plate boundary would you say was most active *this week*?

Map the 2001 earthquakes and the plates_4types data to answer the following question:

55) Which type of plate boundary would you say was most active *in 2001*?

56) Which type of plate boundary is closest to where you live? Use the measure tool to measure how far away you are from it. The measure tool looks like a ruler with a question mark over it.

57) Which type of plate boundary runs along the west part of California?

58) How much of the California plate boundary is on land versus in the ocean?

59) Would you say that the land or the water portion of the California plate boundary is most active?

60) Which *type* of plate boundary is associated with the *most* earthquakes? Does this match your earlier prediction?

Examine earthquake *depth* from 2001.

61) In or near what country was the deepest earthquake during that year?

62) How deep was it?

63) Examine the West coast of North and South America. What type of plate boundary is this?

64) In North and South America, where do the deepest earthquakes occur? Why?

65) Which *type* of plate boundary is associated with the *deepest* earthquakes? Why?

66) Which *type* of plate boundary is associated with the *largest* earthquakes? Why?

Changing Map Projections

Your organization needs to examine the Pacific Ocean "Ring of Fire"--the ring of earthquakes that surround the Pacific Plate.

67) What is the problem with examining the Pacific Ocean using the current map that you are examining?

Therefore, you will change the map projection to effectively view the Pacific Ocean. This is difficult using paper maps but is easy within a GIS.

Under the View pull-down menu, under Properties, change the map projection. Change it to projections of the world, orthographic. Click on **custom** to make a custom projection, with a central meridian of 170 west longitude and a reference latitude of 20 degrees south. Remember to enter them as -170 and -20, respectively.

68) Apply the changes and describe what changed on your map.

Using this new projection, answer the following questions.

Scroll your mouse in the view.


69) Are the coordinates in the upper right still in latitude and longitude?

70) Why or why not?

71) What are the new “map units?” [look under View-->Properties]

72) How many earthquakes were recorded in or near Hawaii in 2001 according to this data set?

73) Does your data support the theory that Hawaii is a "hot spot" in the Pacific Ocean crust?

Clear all selections.  Zoom to the extent of the ring of fire.

74) Create a layout as you did in the above section that includes the following (you don't need to turn this in):

- 2001 Earthquake epicenters with the orthographic projection.
- Plate boundaries.
- 30 degree grid
- your name(s)
- title,
- legend.

Change the map projection back to geographic.

Examining Earthquakes By Country

You work for the US Aid Disaster Relief team. You need to focus your program on the top 3 countries that suffered the most earthquakes in 2001.

75) To solve this problem, first examine the table associated with the 2001 earthquakes. Does this table indicate which country the earthquakes occurred in?

Therefore, you need to join the country information from the country shape file to the earthquakes data so that you can determine which earthquakes were inside each country.

Go to File-->Extensions


Add the “GeoProcessing” extension.

This adds a new choice--the GeoProcessing Wizard--at the bottom of the “View” pull-down menu.

Select the Geoprocessing wizard: View--> GeoProcessing Wizard.

Go to: Assign Data by Location.

Next: Assign data **to** quakes2001.shp **from** cntry95.shp. Select Finish.

76) Examine the 2001 earthquakes table.  What new fields have been added?

77) In this table, do you have the country information for each earthquake?

78) Do you have the sum of earthquakes in each country?

Therefore, you need to create a summary table. Do to this, first click on and select the field "cntry_name".

Go to Field --> Summarize.

Save to the table quakessum.dbf in your folder.

Note that your new table has been added to the list of tables in the "table" portion of your project window.

Sort the new table on "count".

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

80) Which country had the most earthquakes in 2001? Why?

81) How many were there in that country?

82) What region of the country contributed the most to its total number of earthquakes?

83) How many earthquakes did Chile experience in 2001?

84) What 3 countries will you list in your report for the US Aid Disaster Relief Team that will receive the most

attention for future education and relief efforts?

85) After examining the population (field name is pop_cntry) in the cntry95 theme for each of these 3 countries, and considering what you know about the distribution of population within these countries, make two recommendations to your US Aid Disaster Relief Team about the vulnerability of these countries to earthquakes.

86) Did any country experience **no** earthquakes in 2001? If so, how many countries experienced none?

87) How did you determine your answer above?

88) Examine the area field sqkm_country in the cntry95 theme to determine the three largest countries in area with no earthquakes. Which ones are they?

89) Knowing what you do about the distribution of population within the three largest countries where **no** earthquakes occurred in 2001, make two recommendations to your US Aid Disaster Relief Team about the vulnerability of these countries to earthquakes.

90) Using your summary table, calculate the number of earthquakes on land. Show your work.

91) Compare the number of earthquakes on land versus the number of earthquakes under the oceans. Which had more earthquakes? Show your work.

92) What is the major hazard from earthquakes under the oceans to cities? Consult an atlas, OR add cities as a theme (may be found under c: \ esridata) to your table of contents. Which cities in the world would you say would be the 10 most vulnerable to this type of hazard?

93) Think of the countries in which these cities exist. Which countries would you say would be the 10 most vulnerable to this same type of hazard?

94) How many earthquakes occurred in **your** country?

You could run a spatial join of earthquakes to a state boundary map, if you have time, using the procedures that you used earlier to calculate the number of earthquakes in each country. The states.shp file may be found under c:\esridata.

95) Did any of the 2001 earthquakes occur in South Dakota? If so, how many? Compare the seismic activity of South Dakota to surrounding areas and other parts of the USA.


Use the dot tool at the top of the following menu.



Add a dot  at the location of Rosebud, South Dakota, at latitude 43.40 North and longitude 100.65 West.

It is unlikely that you were able to "eyeball" the exact location by clicking on the map. *Right click* on the point you just added, go to Shape Properties, and then Edit. Adjust the latitude and longitude coordinates to reflect those written above for Rosebud. Your point should move slightly to the exact coordinates.



Next, use the circle tool  to band a circle outward from your new point at Rosebud, South Dakota, until the perimeter of the circle reaches the first earthquake.

96) In what direction was the closest earthquake to Rosebud in 2001? In what state did it occur?

97) How far was it from Rosebud, and when did it occur?

98) What was its magnitude and what can you surmise about the damage it caused?

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

99) Summarize in a few sentences what you have learned about the frequency and distribution of earthquakes, and their relationships to continents, mountains, cities, and plate boundaries in this lesson.

100) Summarize in a few sentences what you have learned about GIS-based analysis this lesson.

[Back to SGU GIS Course Home](#)

[U.S. Department of the Interior](#)

[U.S. Geological Survey](#)

[Rocky Mountain Mapping Center](#)

Maintainer: webmaster@rockyweb.cr.usgs.gov

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

Last modified: 2 March 2004