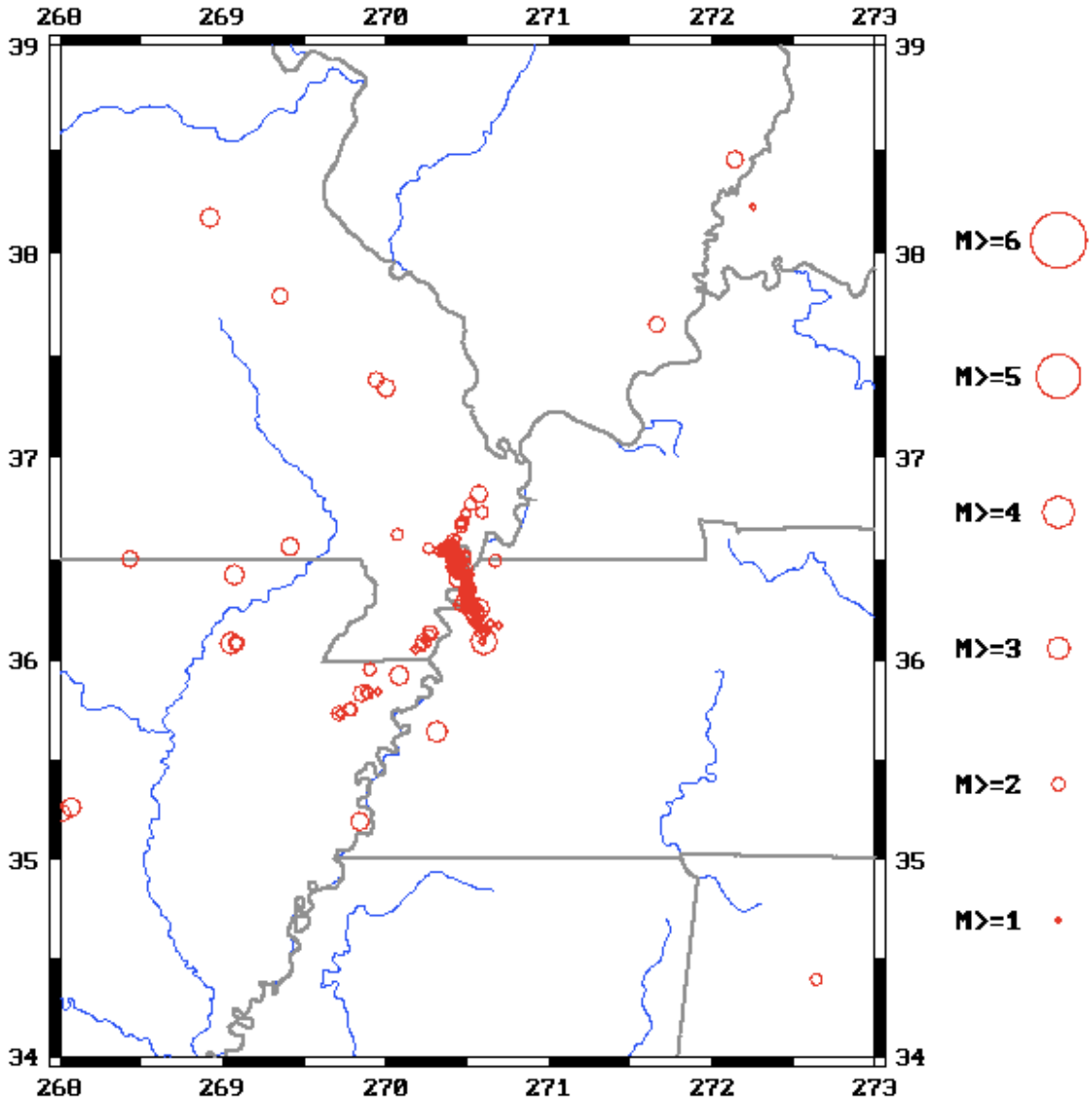
EARTH 501
Lesson 4: Earthquake Catalog problem set

Your Name: ELIZA'S KEY
Your PSU Access ID:

Here's my map of one year of earthquakes in the NMSZ (2009).



Part 1 Questions

1. How many earthquakes are in your catalog?

   There are 180 earthquakes in the 2009 catalog.

2. What is the largest magnitude earthquake in your catalog? How many earthquakes are there of this magnitude in your catalog? The largest earthquake is magnitude 3.4 and there is one of this size.

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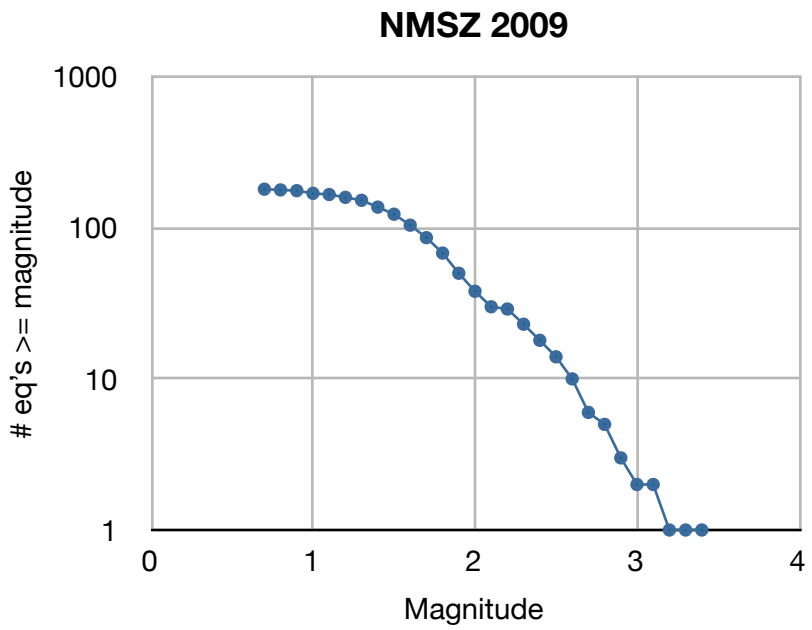
3. What's the smallest magnitude earthquake in your catalog? How many earthquakes are there of this magnitude in your catalog? The smallest earthquake is magnitude 0.7 and there are two of this size.
4. Describe your map in a few sentences. (What part of the country is it? Are the earthquakes sprinkled randomly about or do they cluster in patterns? If the latter, describe what the patterns look like) There are a few earthquakes in the background that seem randomly located, but most of the earthquakes in this catalog cluster along two lines. One small (about 25 km long) line is in the bootheel of southern Missouri and is more or less parallel to the Mississippi River. The other line is nearly normal to the first line. It is between 50-75 km long and runs almost north-south (maybe 5-10 degrees west of north to 5-10 degrees east of south).

Paste your three frequency-magnitude plots from the NMSZ here



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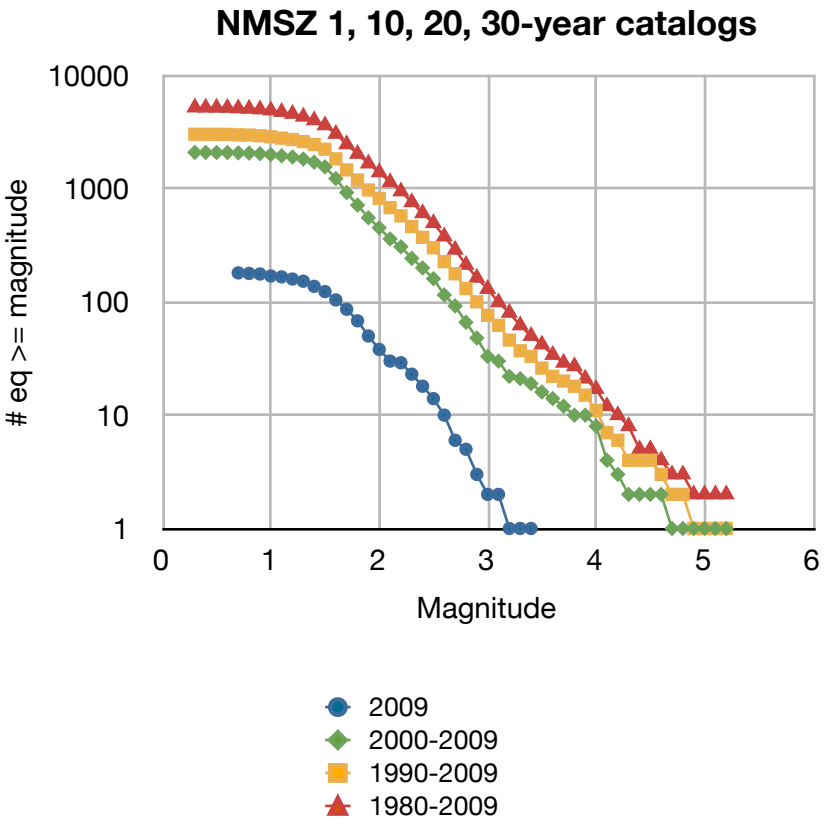

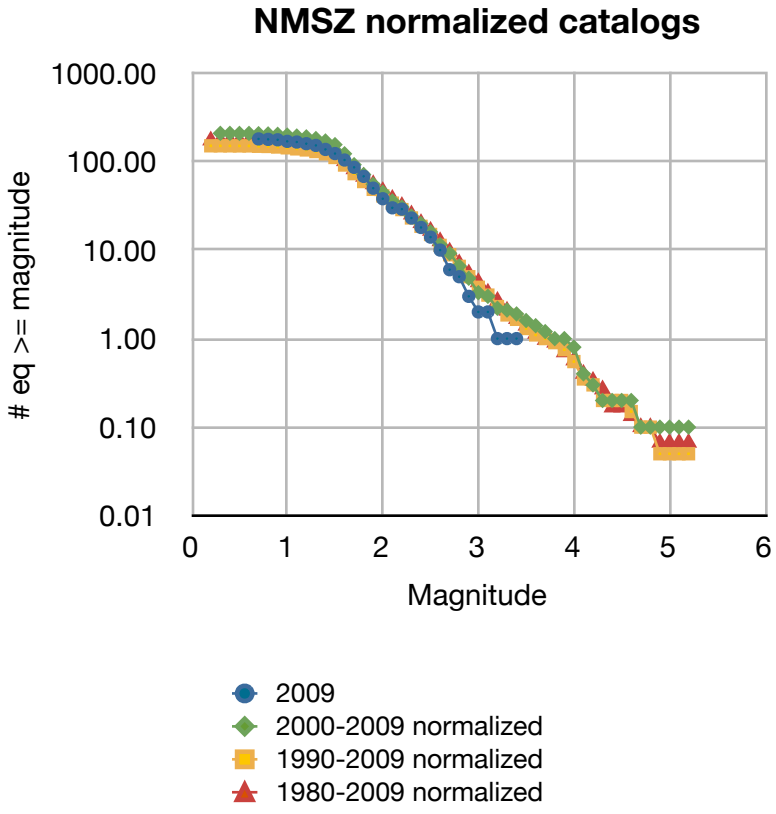

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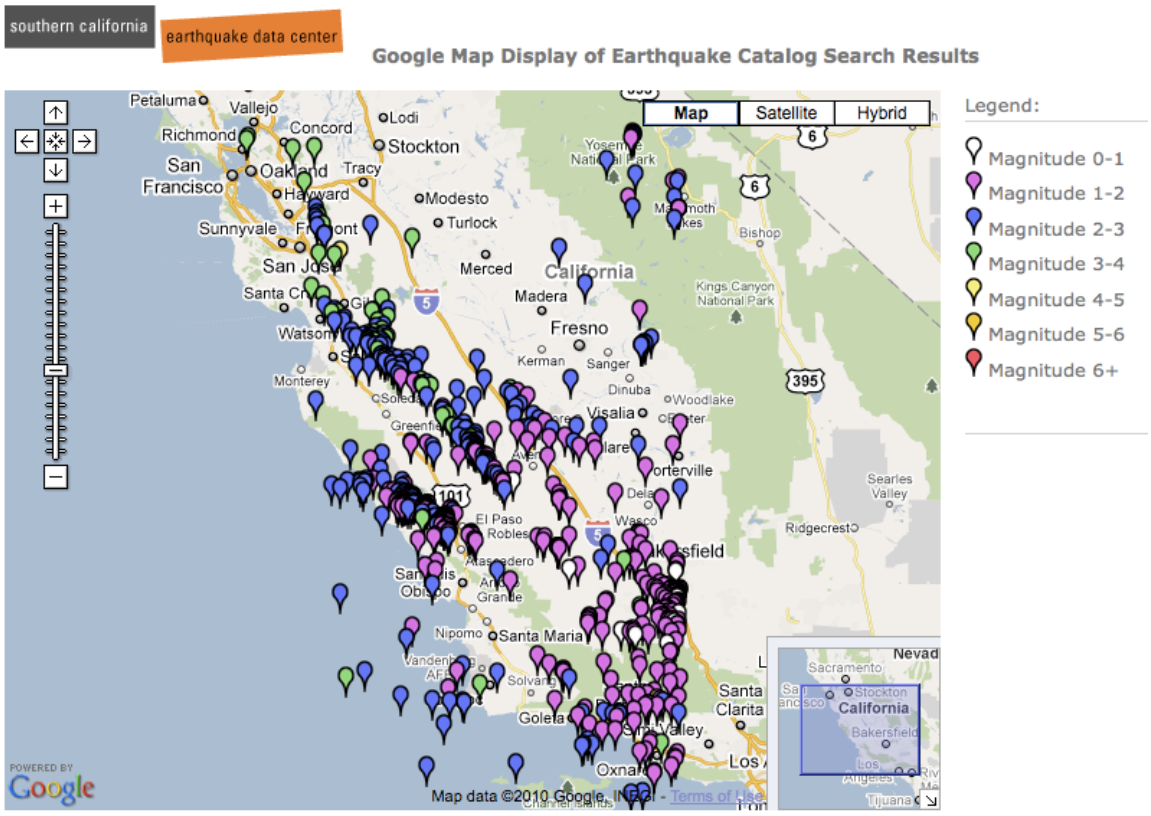
Part 2 Questions

1. Look at the first frequency-magnitude plot you made of the one-year catalog. Approximately what is the lower magnitude threshold for this catalog? (At about what magnitude does the slope of the line begin to deviate from -1?) The lower magnitude threshold is at about 1.5.
2. Now look at the other two plots you made. Do the other curves show a significantly different lower magnitude threshold? From this observation, what do you conclude about the relationship between catalog timespan and lower magnitude sensitivity? The lower magnitude threshold is pretty much the same for all of the curves. Catalog timespan should not affect the lower magnitude threshold. Lower magnitude threshold is controlled by the instrument sensitivity (how small an earthquake can the seismometer record) and by how closely spaced the seismometers are. (If the seismometers are too far apart, some earthquakes won't get recorded because they will happen too far away from the closest seismometers.)
3. Look at the second plot you made. Describe the differences and similarities among the four curves in a few sentences. For example, are the curves of the same shape? Where are the x and y intercepts relative to each other? What makes the y intercepts different? What causes the x intercepts to be different? The four curves are basically the same shape, but they are offset from each other. As catalog timespan increases, the y intercept gets higher. This is simply because a longer catalog has more total earthquakes in it. The ten year catalog has a higher x intercept than the one year catalog curve. The twenty and thirty year catalog curves have incrementally larger x intercepts also. The x intercept represents the largest earthquake in a catalog. There is a higher probability to get a big earthquake in a long catalog rather than a short catalog since big earthquakes happen less frequently, so this result is not unexpected.
4. Look at the second plot you made. Imagine having a catalog that spans 100 years. Using the four curves you made as a guide, imagine where the x and y intercepts would be for a 100-year catalog. What is the largest earthquake you would expect for a 100-year catalog? The y intercept relates to the total number of earthquakes in the catalog so it is directly controlled by catalog timespan. The one-year catalog has a y intercept of 180 because there are 180 earthquakes in the catalog. The ten-year catalog has 2082 earthquakes in it, the twenty year catalog has 3010 and the thirty-year catalog has 5190. Note that the ten-year catalog has about ten times the number of earthquakes as the one-year catalog. This is not surprising; during the 30-year interval of time over which this catalog data spans, there are about the same number of events in the NMSZ every year: between 180 and 200 or so. Therefore I would expect a 100-year catalog to have a y-intercept of about 20,000. Imagining where the x axis intercept would be is trickier. I imagine I am drawing a curve that is parallel to the other ones but starts at about y=20,000. The x intercept for a curve like this would be somewhere between magnitude 5.5 and 6.0.
5. Look at the second and third plots you made. Extrapolate your curves to predict how often a magnitude 7 earthquake will occur in this region. How often will a magnitude 8 occur in this region? You have just used frequency-magnitude relationships to calculate a recurrence interval for a large New Madrid earthquake. Cool! What are the sources of uncertainty in this estimate? (One way to realize just how much uncertainty there is in an extrapolation like this one is to try making several slightly different fits to the data that all look "pretty good" to you and see how different your final answers end up being) I used plot number three. When all the catalogs are normalized, the curves overlie each other except at the large magnitude end where we run into the problem of random chance causing a few unexpectedly large earthquakes, especially in the one-year catalog. By extending the line where the slopes all match I find that in one year, we can expect 10^{-3} magnitude 7s and about 10^{-4} magnitude 8s. This translates into 1 magnitude 7 about every 1000 years and 1 magnitude 8 every 10000 years. The main source

of uncertainty in this estimate is my eyeballing and extrapolating the curves. By using a curve with even a slightly different slope, you can end up calculating a recurrence interval that is different by hundreds of years. This is one of the limitations of seismic data. The catalogs we have are always too short to do anything but extrapolate. The recurrence interval for a large earthquake on even the most active faults is usually hundreds to thousands of years, but good digital seismometers have been around for less than 50 years.

Paste your two maps from SCEC and the USGS here



Search Parameters: magnitude between 0.0 and 9.0
date/time between 2009/01/01 00:00:00 and 2010/01/01 00:00:00
Number of events on map: **607**

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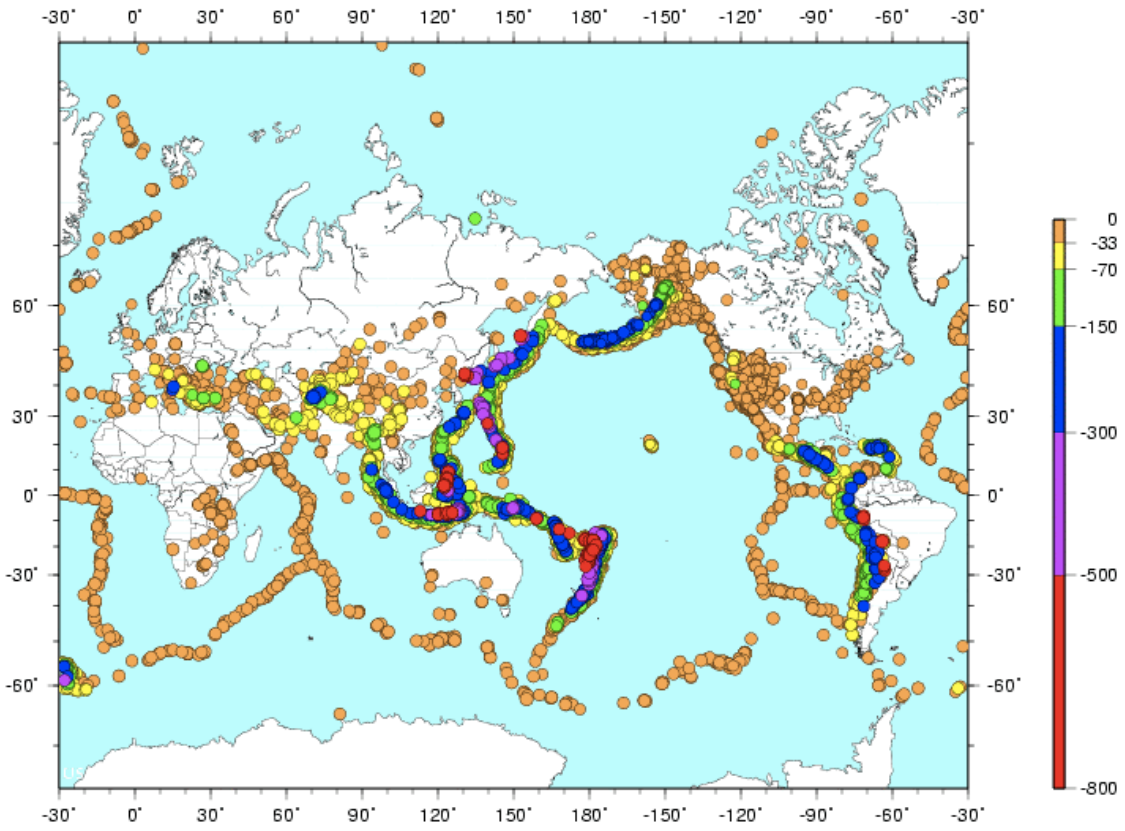
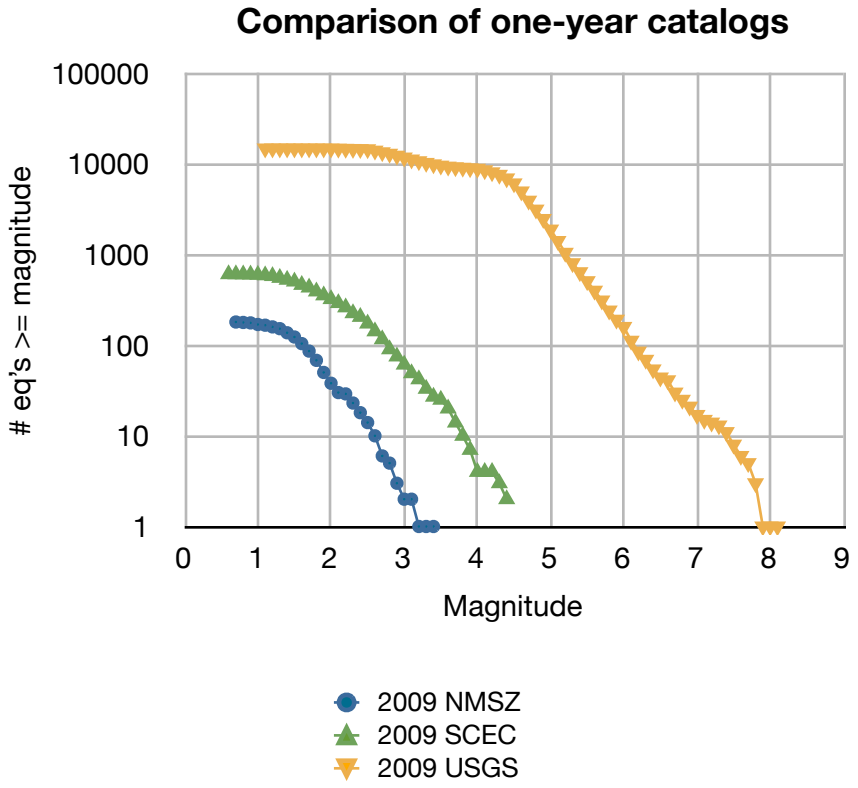


Paste your frequency-magnitude plot with the NMSZ, SCEC, and USGS data here



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Part 3 Questions

1. How many earthquakes are in your one-year catalog for Southern California? What is the largest magnitude earthquake in the catalog? How many earthquakes are there of this magnitude? There are 607 earthquakes in my 2009 SCSN catalog. There is 1 magnitude 0.5 earthquake and two earthquakes with magnitude 4.4. These are the smallest and largest earthquakes, respectively.
2. How many earthquakes are in your one-year catalog for the world? Are you surprised by this number? What is the largest magnitude earthquake in the world catalog? How many earthquakes are there of this magnitude? There are 14769 events in my global one-year catalog. I think the average person does not realize how many earthquakes happen around the world every day. The largest earthquake is a magnitude 8.1 and there is one of this size.
3. Look at your map of Southern Californian earthquakes. Describe it in a few sentences (i.e., Where are the earthquakes? Do they cluster in space? Beware of artificial clustering that we induced by where we set our search parameters.). Seismicity here is much more widespread than in the New Madrid region. There are some broad northwest – southeast linear clusters of seismicity, roughly subparallel to the San Andreas fault. There appears to be a north-south linear cluster running through Bakersfield, but this is really an artifact of the way we limited our search parameters to a smallish box. Those earthquakes are all at the eastern edge of our search box.
4. Look at your map of global earthquakes and describe it in a few sentences. How do the earthquakes cluster? The global earthquake map basically shows where the plate boundaries are. These boundaries are defined by the seismicity at them.
5. Compare the frequency-magnitude curves for New Madrid and Southern California. Which one of the two catalogs is more sensitive to small earthquakes? Which region is more seismically active in terms of number of earthquakes? Which region is more seismically active in terms of earthquake magnitude? Southern California has more total earthquakes in one year than New Madrid. This should not be surprising since Southern California is an active plate boundary area. The network around New Madrid actually has a lower minimum magnitude threshold. It is sensitive down to about magnitude 1.5 whereas the SCEC network is sensitive down to about magnitude 2.1 or so. Southern California had larger events than New Madrid during 2000. This should not be too surprising, either. Again, at an active plate boundary more earthquakes and bigger ones are expected.
6. Compare all three frequency-magnitude curves. Is the global catalog more or less sensitive to small earthquakes than the other two? Why do you think this is? The global catalog is much less sensitive to small earthquakes. Its lower magnitude threshold is at about 4.2 or so. This is because seismometer spacing is necessarily bigger at the global scale than at the regional scale. The other two catalogs are taken from areas where a small densely-spaced array has been set out deliberately to record seismicity accurately in a small area, whereas the global catalog is looking at the world. Some earthquakes smaller than magnitude 4 just get missed by a global network even though they are there.
7. How often does a big earthquake ($M > 7$ or so) happen in the global catalog vs. in the two regional catalogs? Why is this? Of course the global catalog has many more large earthquakes in it. There's a magnitude 8+ somewhere in the world every year, pretty much. There are usually between 10 and 20 earthquakes at about mag 7+ every year in the world. However, the odds that one of these large earthquakes would happen to be in our one-year catalogs of two small regions is small (and in fact there is not a magnitude 7 in my 1 year catalogs of the two regions we looked at).