LABORATORY 5 - SEISMOLOGY, PLATE BOUNDARIES, PLATE MOTIONS, AND SUBDUCTION ZONE FEATURES

OBJECTIVES: *Interpret regional data for Southeast Asia (including topography/bathymetry, volcano locations, earthquake locations and focal mechanisms) in terms of the location of plate boundaries, relative plate motions, subduction zone characteristics and possible back arc spreading in the Banda Sea.*

Overview: Plate boundaries were first identified as the locus of earthquake activity and the relative motions of plates were determined by earthquake focal mechanisms. The trend in the depth of earthquakes (the Benioff zone) is a guide to the location of the subducting plate. The active volcanic arc of subduction zones is located above the Benioff zone . In the fore-arc region one may find a trench, a fore arc bulge, a fore arc basin, and a back arc region that may be undergoing extension (back-arc spreading).

Your task will be to explore these concepts in the context of a particularly interesting (and complex) region stretching from Indonesia around to the Philippines. The rectangular area to be studied is bounded by the following coordinates: latitudes from 20S to 40 N and longitudes from 80E to 160 E).

You will create maps and cross sections to give you a basis for the requested interpretations.

Here are web data sources:

NOAA Data Center – ETOPO2 bathymetry:
http://www.ngdc.noaa.gov/mgg/fliers/01mgg04.html
Smithsonian volcano catalog: http://www.volcano.si.edu/world/
ANSS catalog: http://www.ncedc.org/anss/catalog-search.html
Can generate a file that plots in Google Earth
Also makes Google maps
NEIC catalog: http://neic.usgs.gov/neis/epic/epic_rect.html
Can download file or make maps
NEIC moment tensor (focal mechanisms) catalog: http://neic.usgs.gov/neis/sopar/
There are maps of recent events but mostly this is a source of data files
CMT Moment tensor catalog: http://www.globalcmt.org/CMTsearch.html
Another database without an attached mapping function
IRIS Earthquake Browser:
http://www.iris.washington.edu/servlet/eventserver/map.do
This has a GoogleMap interface

These catalogs provide data files in several formats. I have experienced frustration in trying to import the data into other applications like MATLAB. To help you, I've downloaded several data products and turned them into MATLAB readable files.

- VolcanoData.mat. Load into MATLAB with the command "load VolcanoData". This loads a matrix with two columns (latitudes and longitudes) that lists locations of every known volcano in the world.

- IndoEQ (.mat, .cvs) has as large set of earthquakes from the NEIC database. Search criteria: 1983 to 10/09. Latitude range: 20S to 40N, Longitude range: 80E to 160E. Magnitude range: >M=4, all depths.

- IndoEQFM (.mat, .cvs, and .xls) I provide several formats for this data set (MATLAB, Excel) that has earthquake focal mechanisms and locations for almost 2000 earthquakes in the study area. These data were obtained from the Harvard CMT catalog. The events are larger than M-6 and shallower than 100 km for the time period from 1977 to 2008.

- EHBdata – Centenial Earthquake Catalog: a special collection of large worldwide earthquake events from 1900 to 2002 that have been re-analyzed to provide a global perspective on earthquake activity; see http://earthquake.usgs.gov/research/data/centennial.php for more detail.

This project is fundamentally different from the previous labs. The expectation is that you will create and examine several maps. You will work with (play with) the data, plotting it in order to gain a better understanding of the study area.

Final data products should include
- Maps of seismicity and focal mechanisms
- cross sections showing topography/bathymetry across subduction zones
- cross sections showing earthquakes in the Benioff zone and volcano locations
- a summary map you create that shows the location of the plate boundaries and the relative motions of the plates at the boundaries.
- any other figures, cross sections, maps from any source that you think adds information for your interpretation.

Here is a suggested roadmap for your work:
(a) Use the seismicity pattern to draw in major plate boundaries. Label the four plates.

(b) Use orientations of the focal mechanisms to infer relative plate motions. Draw in slip vectors for some representative mechanisms on each plate boundary. Describe the variation in these slip vector directions along the boundaries.

(c) use a topography/bathymetry cross section to identify subduction zone features of trenches, forarc bulges, forarc basins, volcanic arc, and back arc basins. Identify regions/geographic names associated with these features.

(d) Comment on trends of earthquakes in subduction zone along the Indonesian coastline. At what angle does the slab subduct beneath Indonesia? How deep do

earthquakes go? How deep is the Benioff zone below the volcanic arc? Is there any along arc variation?

(c) Comment on the hypothesis that the normal fault mechanisms in the Banda Sea arise from 'Back Arc Spreading'.

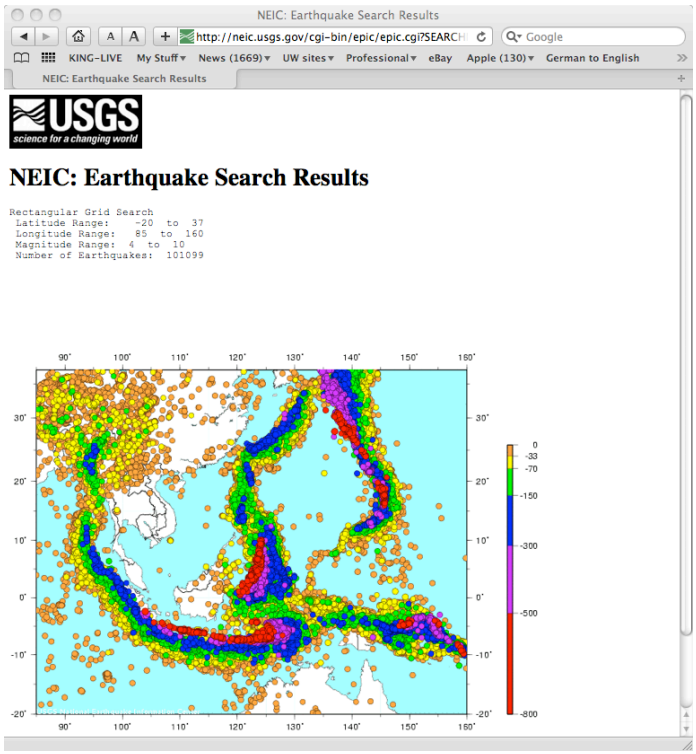
As always, make sure that all figures (plots, graphs, maps, etc.) are appropriately titled, labeled, and if necessary have keys and scales.

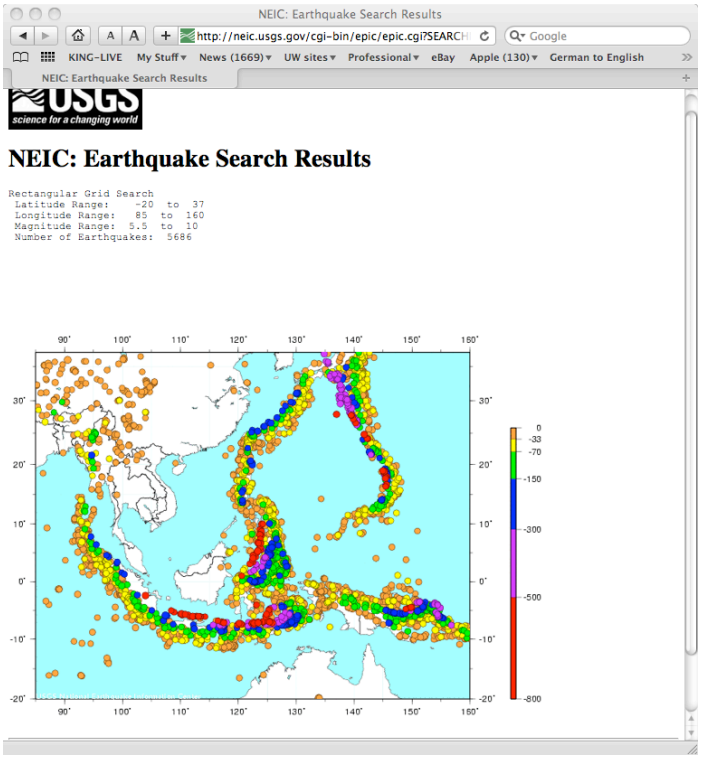
Elevation profiles (including bathymetry) can be made in Google Earth if you first load "global_topo_1min_v13.1_terra.kmz" found in the course download site. These profiles will nee to be saved as screen grabs.

You can also make elevation profiles in MATLAB, the following returns rectangular matrices with elevations/depths, latitudes, and longitudes for a box defined by latitude/longitude corners using the ETOPO2 database.

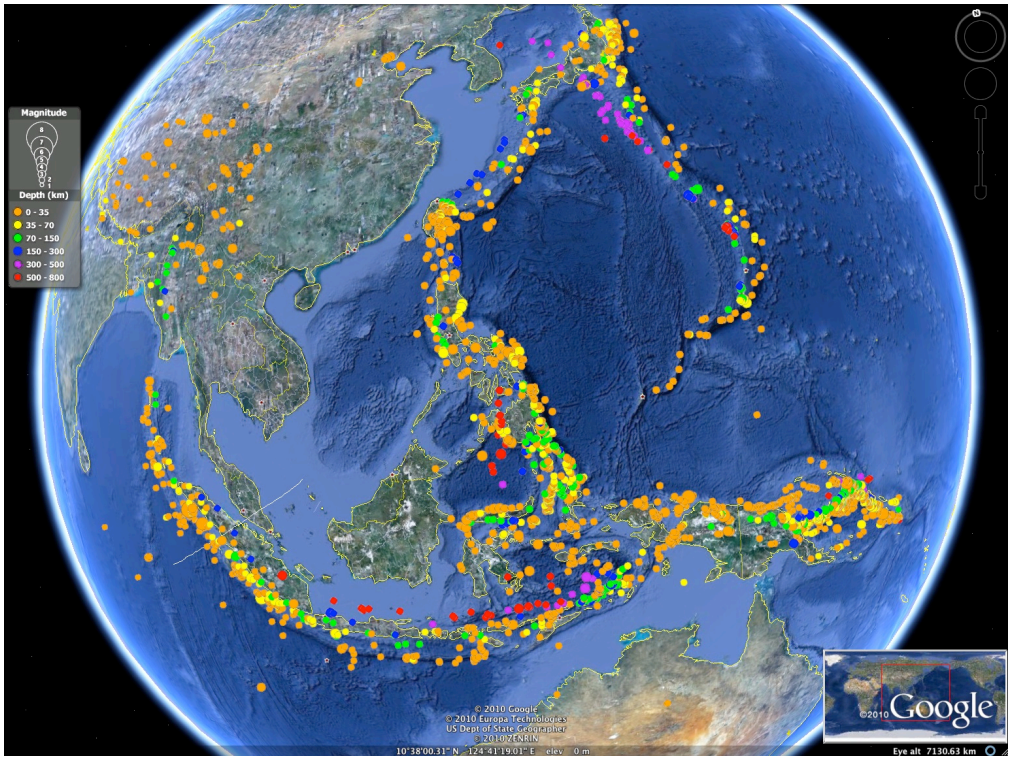
```
[Z,LONG,LAT]=m_etopo2([LONG_MIN LONG_MAX LAT_MIN LAT_MAX]);
```

Here are some example maps made using the NEIC plotting feature. Note that depending on what feature you are trying to illustrate, you may chose to plot fewer or more events

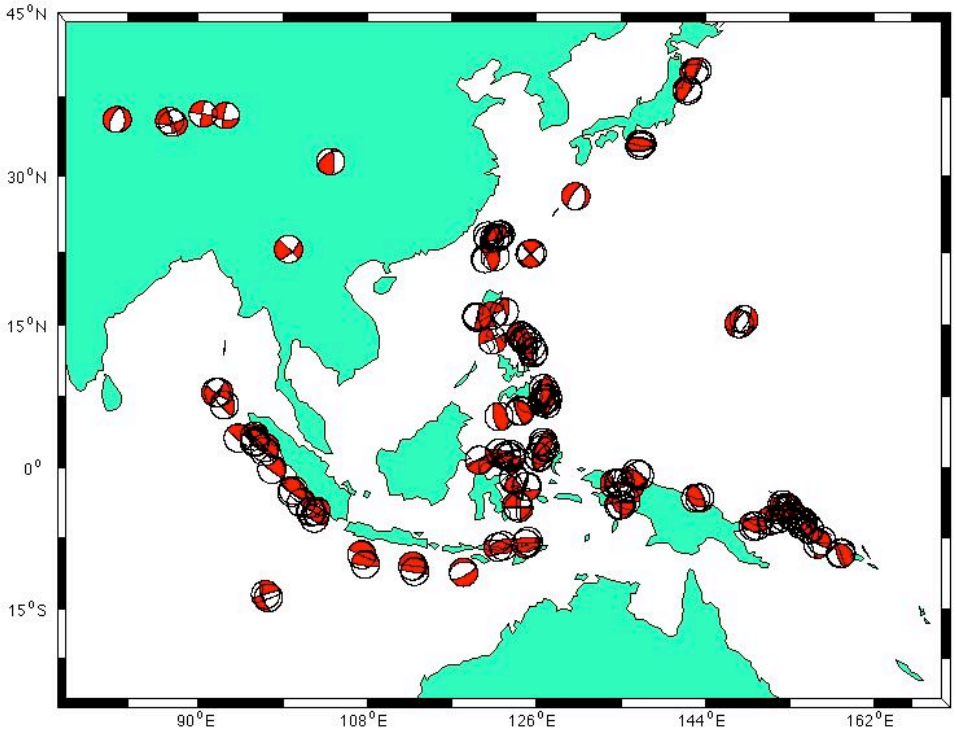




Please download a data set from ANSS in Google Earth KML format and try creating your own version of the following:



Making a suitable plot of focal mechanisms is a challenge both in getting adequate coverage but not having too cluttered a plot. I include the plot below made using the lab hints. There are other focal mechanism plots in the papers provided on the class site.



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