

FNR 66 Lab 6

Hospital or Notspital

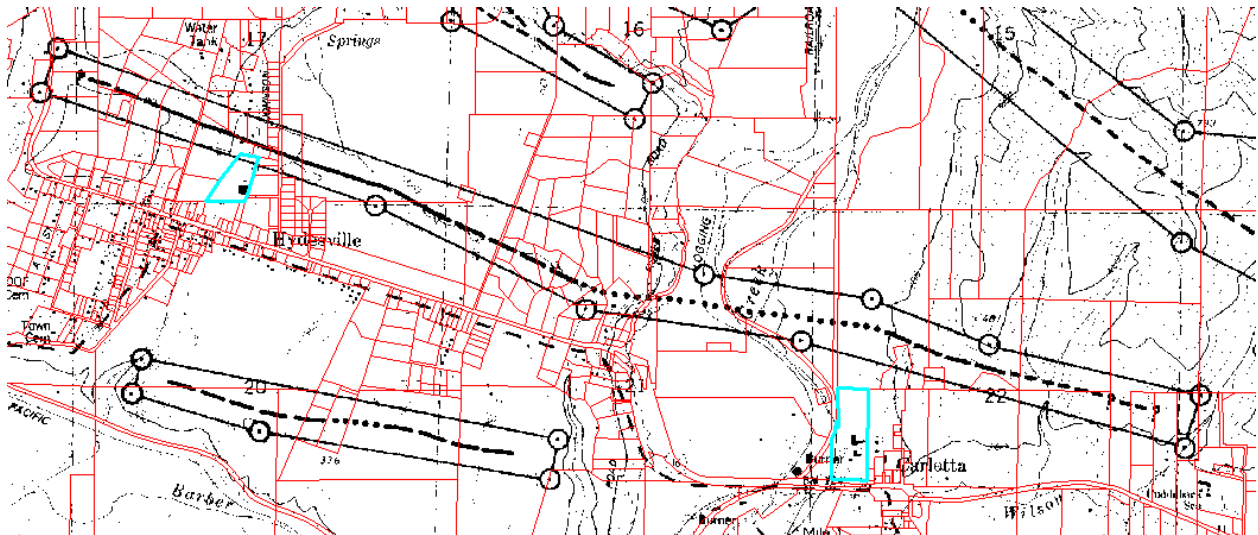
INTRODUCTION: This tutorial examines the calculation of ground motions expected from an earthquake on a fault mapped for the state of California as part of the Alquist-Priolo (AP) Law in preparation for building a hospital. There are several steps for this lab.

Background: Active faults have been mapped based upon the Alquist-Priolo Law, written after the human casualty devastating Sylmar, CA earthquake in 1971. Some basic background information is available here: <http://www.conservation.ca.gov/cgs/rghm/ap/Pages/main.aspx> Earthquake ground motions (like Peak Ground Acceleration, in percent g, or gravity) are largest nearest the fault where the earthquake ruptured. Based on thousands of measurements from hundreds of earthquakes, empirical relations between fault distance and ground motions have been developed (you will use one of these relations). Based on hundreds of measurements of fault ruptures and earthquake magnitude calculations, empirical equations have developed (you will use one of these equations). One may take a fault length and estimate the magnitude of earthquake one would expect on that fault.

Assignment: You have been hired by an engineering firm to calculate the peak ground acceleration (PGA) expected for a hospital that they are designing to be built nearby an active fault. You will be rubbersheeting a map, digitizing from that map, calculating lengths, creating a buffer raster, and using raster algebra to model ground shaking from an earthquake. The following are the **general** steps for your analysis:

- Step 1. Determine the location of the “AP” fault nearby the construction site. Acquire or digitize the fault and calculate the length of the fault.
- Step 2. Measure the fault and determine the largest possible earthquake magnitude, assuming the entire fault will rupture.
- Step 3. Create a raster that represents the ground shaking (PGA in % g) expected from an earthquake on this fault. This will be based largely on the distance to the fault (buffer = R in km) and the potential earthquake magnitude. You will need to make a raster that represents the distance from the earthquake fault.
- Step 4: Generate a report that lists the range in PGA for the proposed hospital site. The engineering firm has provided you with an alternative site. Does this alternative site have better chance to withstand ground shaking from an earthquake on this fault? Provide information about the alternate site in your report. Also, include a map (or maps) in your report that supports the conclusions in your report. The engineers will want to know the expected magnitude for this fault, how you determined that, the range of expected PGA for the two sites, how you determined that, and your final recommendation (build at primary or secondary site, given that all you have to make this decision is the ground motions that you model).

Here is the fault you are searching for (not a droid). The fault is the longest fault that is completely in this map. The fault begins and ends with question marks. There are other faults, but they are further away and are not of concern for your exercise. The 2 parcels are outlined in light blue.



Data Sources:

AP fault maps are available here:

<http://co.humboldt.ca.us/planning/maps/datainventory/gisdatalist.asp>

Scroll down to the Hazard Disclosure section, find the AP Scanned Maps, and download the TIFF images (they will be in a compressed folder called a “zip” file). Save these TIFF files onto your computer where you are storing your data for this lab. You are interested in the faults mapped on the Hydesville USGS quadrangle (screenshot above). You will need to rubbersheet this map to place it into a coordinate system (you are now an expert at this task). To simplify matters, use the USDA gateway DRG (7.5' USGS quadrangle) as a control for your rubbersheeting. The DRG for Humboldt County will be on the server for your convenience (too large to rapidly order and download from the data gateway). Use the coordinate system/projection that the DRG comes in (add the DRG first and define the data frame properties correctly). Once you rubbersheet the map, create a polyline shapefile, and digitize the entire fault length (from ? to ?). You will need to calculate the length of this fault in km (as evidenced by the formula listed below, from Wells and Coppersmith, 1994). In addition to calculating earthquake magnitude from your digitized fault, you will need to create a raster that represents the distance to the fault. The units for your buffer raster will need to be in km (so it matches the units in the Gregor et al., 2002 empirical formula).

The Humboldt County Parcel Map data layer is also available at the above site. Download the shapefile so you can identify the two parcels. The two parcels are identified by the APN number. The primary parcel is 20432113 and the secondary parcel is 20610124 and are located in Hydesville and Carlotta respectively.

Empirical Relations:

The Surface Rupture Length (km) – Moment Magnitude (Mw) relations you can use (Wells and Coppersmith, 1994) are here:

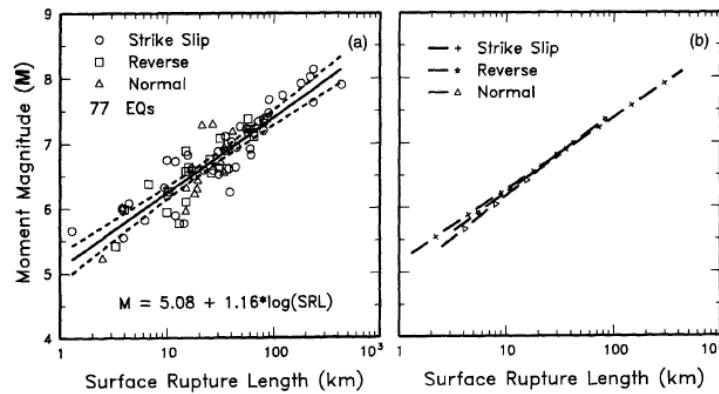


Figure 9. (a) Regression of surface rupture length on magnitude (M). Regression line shown for all-slip-type relationship. Short dashed line indicates 95% confidence interval. (b) Regression lines for strike-slip, reverse, and normal-slip relationships. See Table 2 for regression coefficients. Length of regression lines shows the range of data for each relationship.

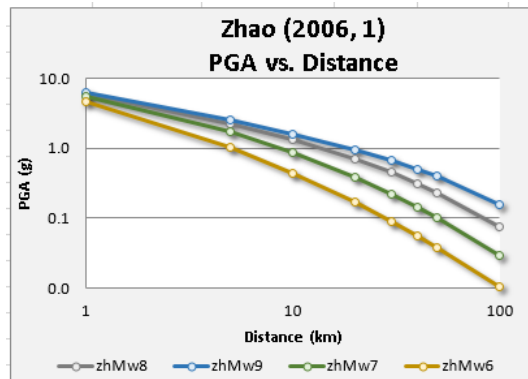
The formula you are interested in is $M_w = 5.08 + 1.16 * \log(\text{SRL})$. The magnitude you calculate will be the M in the ground motion calculation below.

The ground motion empirical relations you will use are published in Zhao et al. (2006). Here is the main formula (where Y = PGA, also plotted to the right):

$$\log_e(y_{i,j}) = aM_{wi} + bx_{i,j} - \log_e(r_{i,j}) + e(h - h_c) \delta_h + F_R + S_1 + S_S + S_{SL} \log_e(x_{i,j}) + C_k + \xi_{i,j} + \eta_i \quad (1)$$

$$r_{i,j} = x_{i,j} + c \exp(dM_{wi}), \quad (2)$$

where y is either PGA (in centimeters per second²) or 5% damped acceleration response spectrum (the geometric mean of two horizontal components in centimeters per second²) for a spectral period T, M_w is the moment magnitude, x is the source distance in kilometers, and h is the focal depth in kilometers. The reverse-fault parameter F_R applies only to crustal events with a reverse-faulting mechanism and is zero for all other events. The tectonic source-type parameter S₁ applies to interface events and is 0 for all other type events, and S_S applies to subduction slab events only and is zero for all other type events. S_{SL} is a magnitude-independent path modification term for slab events to account for the complex seismic wave travel path for slab events. C_k is the site-class term for a given site class. Subscript i denotes event number and j denotes record number from event i. Coefficient h_c is a depth constant. When h is larger than h_c, the depth term e(h - h_c) takes effect, with δ_h being a dummy variable that equals 0 for h < h_c and 1 for h ≥ h_c. When h is larger than 125 km, h = 125 km is selected so that a constant factor is used for deeper earthquakes (i.e., depth is capped at 125 km). Random variable η_{ij} is the intra-event error (error that represents the variability from the median predicted value for a



Log_eY gives one the natural log of ground motions, so you will need to solve this equation to use with the raster calculator to solve for Y. $Y = \text{Ln}Y^e$ (e is approximately = 2.71828)

http://en.wikipedia.org/wiki/Natural_logarithm

[http://en.wikipedia.org/wiki/E_\(mathematical_constant\)](http://en.wikipedia.org/wiki/E_(mathematical_constant))

$$\text{Loge}(y) = a * Mw + b * x - \text{loge}(x + (c * \exp(d * M))) + e(h - hc) * dh + FR + SI + SS + SSL * \text{loge}(x) + Ck + \xi + \eta$$

$$A = 1.101$$

$$B = -0.00564$$

$$C = 0.0055$$

$$D = 1.08$$

$$E = 0.01412$$

$$X = \text{Rdist}$$

$$H = \text{Rdist}$$

$$Hc = 15 \text{ km}$$

$$Dh = 0$$

$$FR = 1$$

$$SI = 1$$

$$SS = 0$$

$$SSL = 0$$

$$Ck = 1.355$$

Here is the raster algebra I got to work:

$$\frac{(\text{Exp}(1.101 * 5.07755 - 0.00564 * \text{"Rdist_km"} - \text{Ln}(\text{"Rdist_km"} + (0.0055 * \text{Exp}(1.08 * 5.07755)))) + 1 + 1)}{(100 * 9.80665)}$$