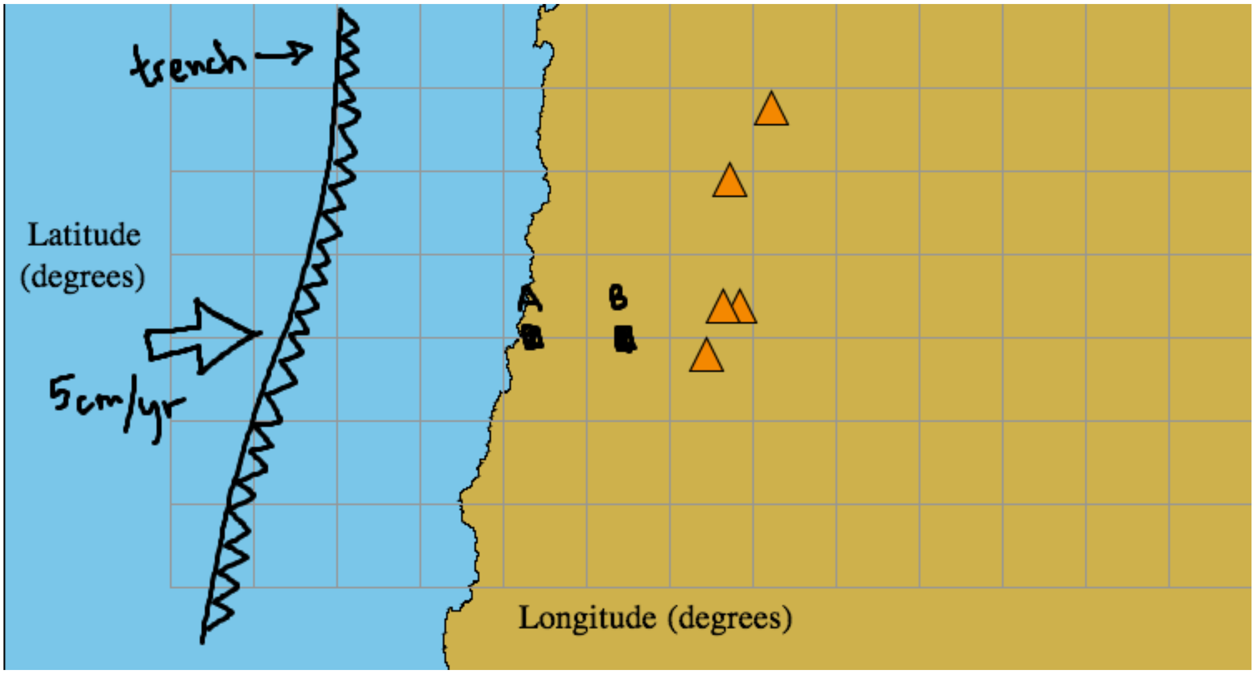
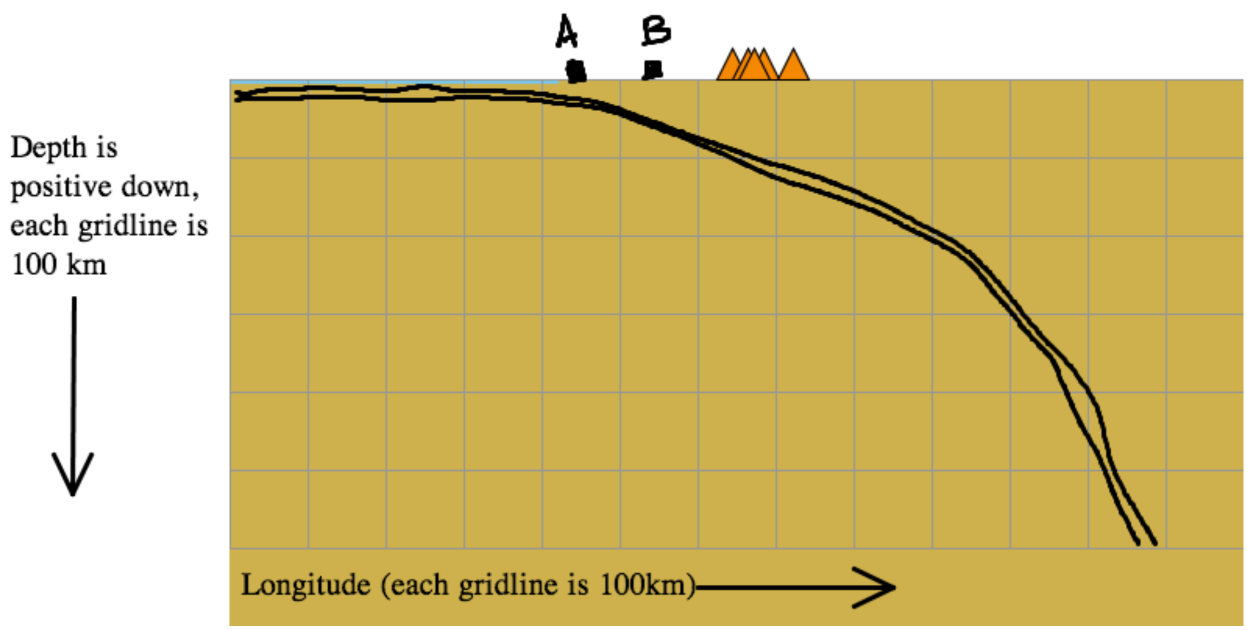
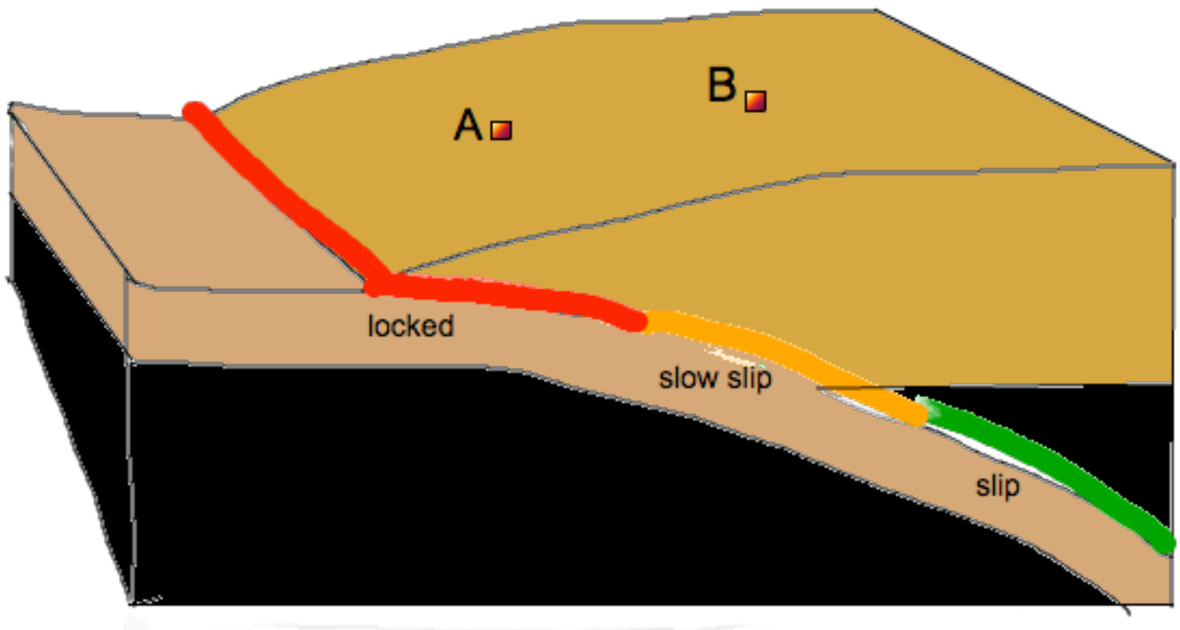
Slow Slip vs. Earthquakes problem set







1. Here is a hypothetical subduction zone. A and B are geodetic monuments. Orange triangles are volcanoes. Sketch what GPS timeseries data should look like for station A which is on the overriding plate above the locked zone. Assume for this sketch that nothing out of the ordinary is going on besides normal plate motion as indicated on the map. Assume station A records its location once per day.
2. Look at the same hypothetical subduction zone as in #1. A and B are geodetic monuments. Orange triangles are volcanoes. Sketch what GPS timeseries data should look like for station B which is on the overriding plate above the freely slipping zone. Assume for this sketch that nothing out of the ordinary is going on besides normal plate motion as indicated on the map. Assume station B records its location once per day
3. If a M7.0 earthquake happened on the plate interface directly below station A, how much average slip would be generated by such an earthquake? Use this simplified relationship: $M = \frac{\log_{10}(D) + 6.32}{0.9}$

where M = magnitude

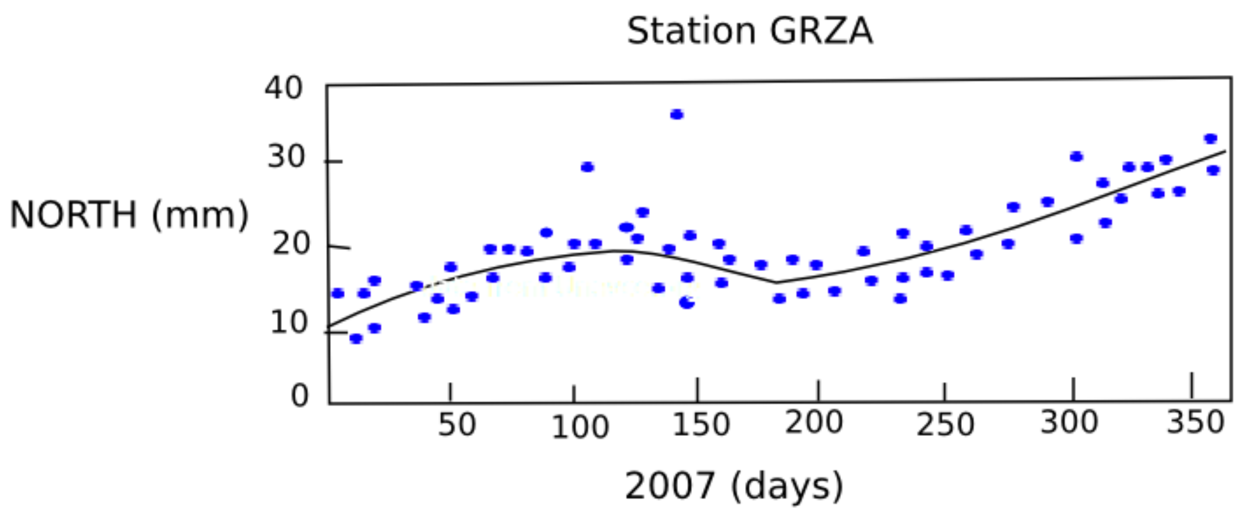
D= average slip in meters

4. Which direction will station A move during this earthquake?
5. Sketch the GPS time series you'd expect at station A. Write down your logic about how you drew it. label the axes.If a SSE event happened at the plate interface between stations A and B that took 6 months and was the equivalent of a M7.0

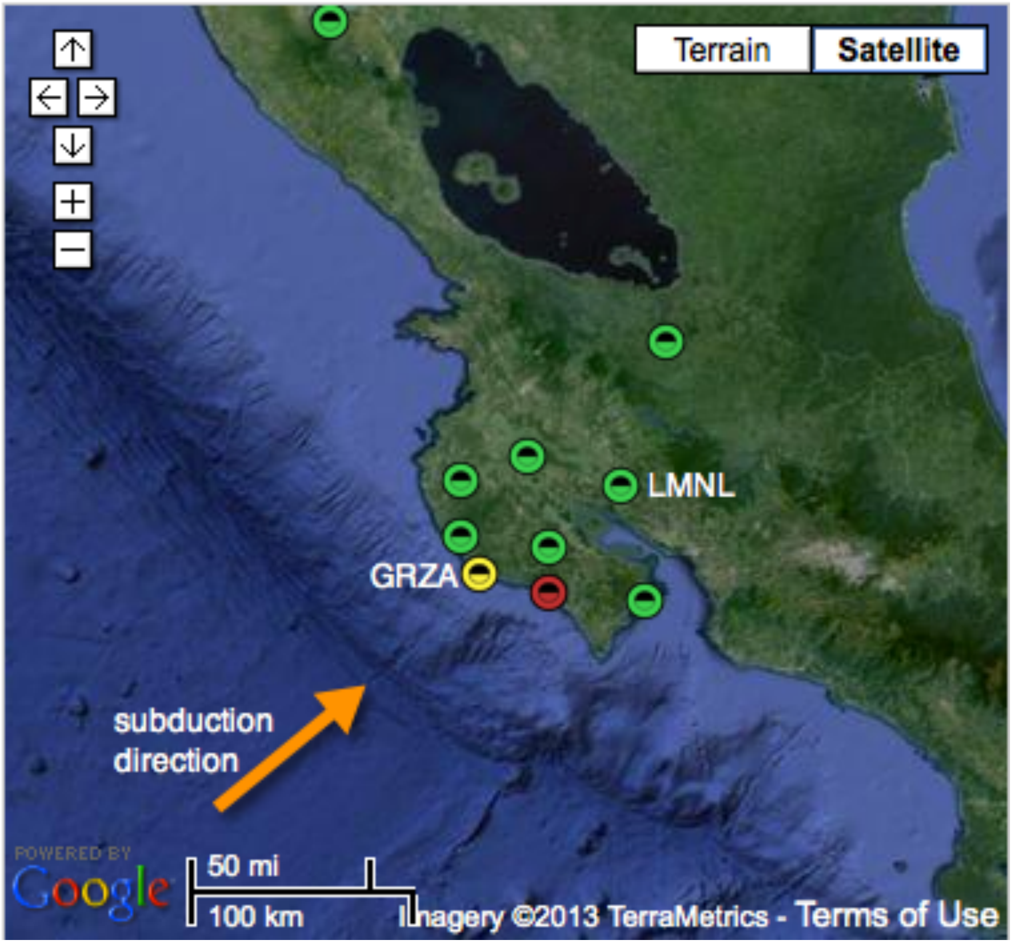
earthquake, how much average slip would be generated by such an event? What's the average rupture velocity for this event?
6. Which direction would station A move during the SSE?
7. Sketch the gps times series at station A for the SSE. label the axes.

Part 2: Interpreting actual data

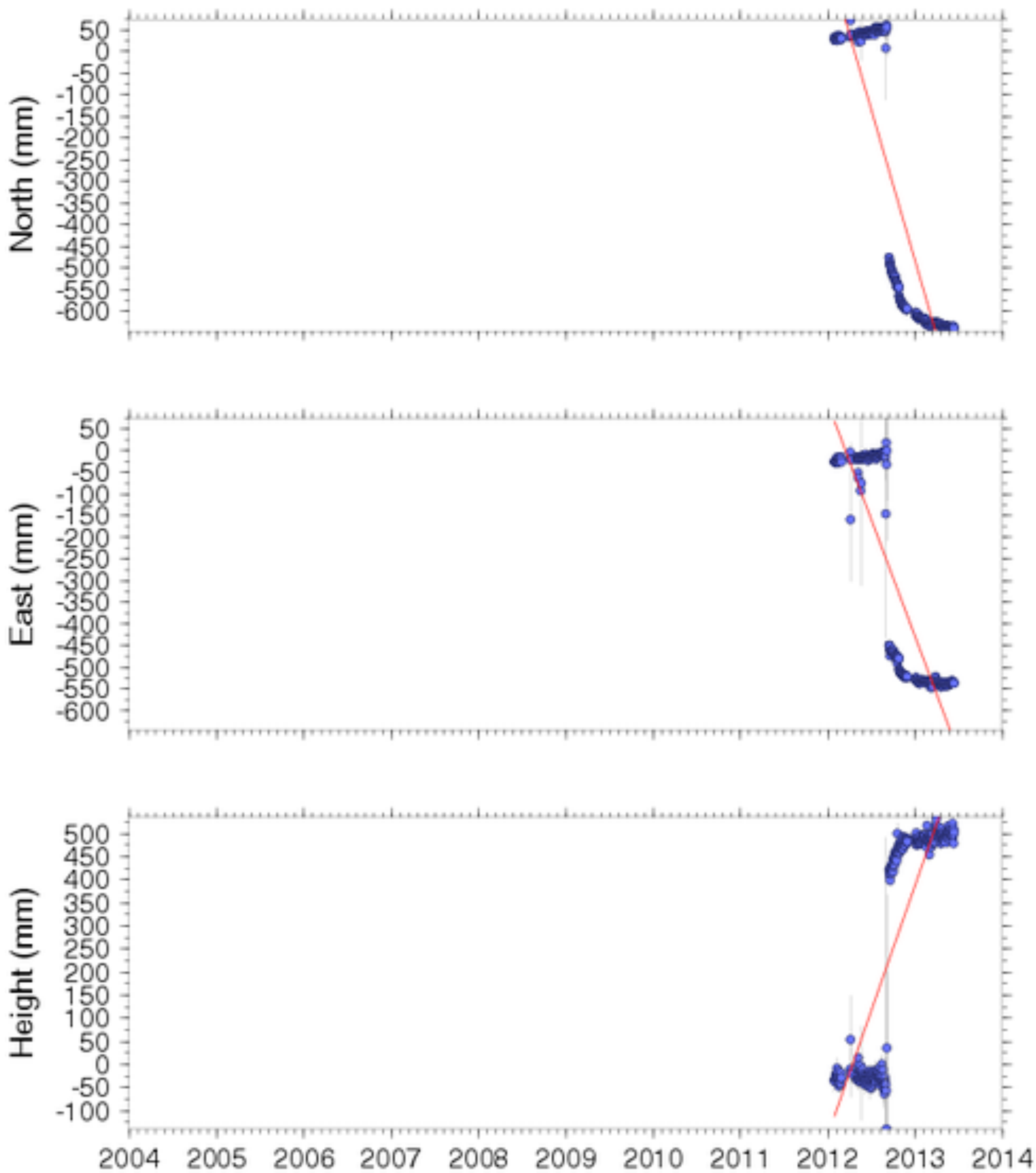
1. Given this data (plot modified from Outerbridge et al., 2010): what is the plate rate in the north component? when did the sse start and end? how much displacement?



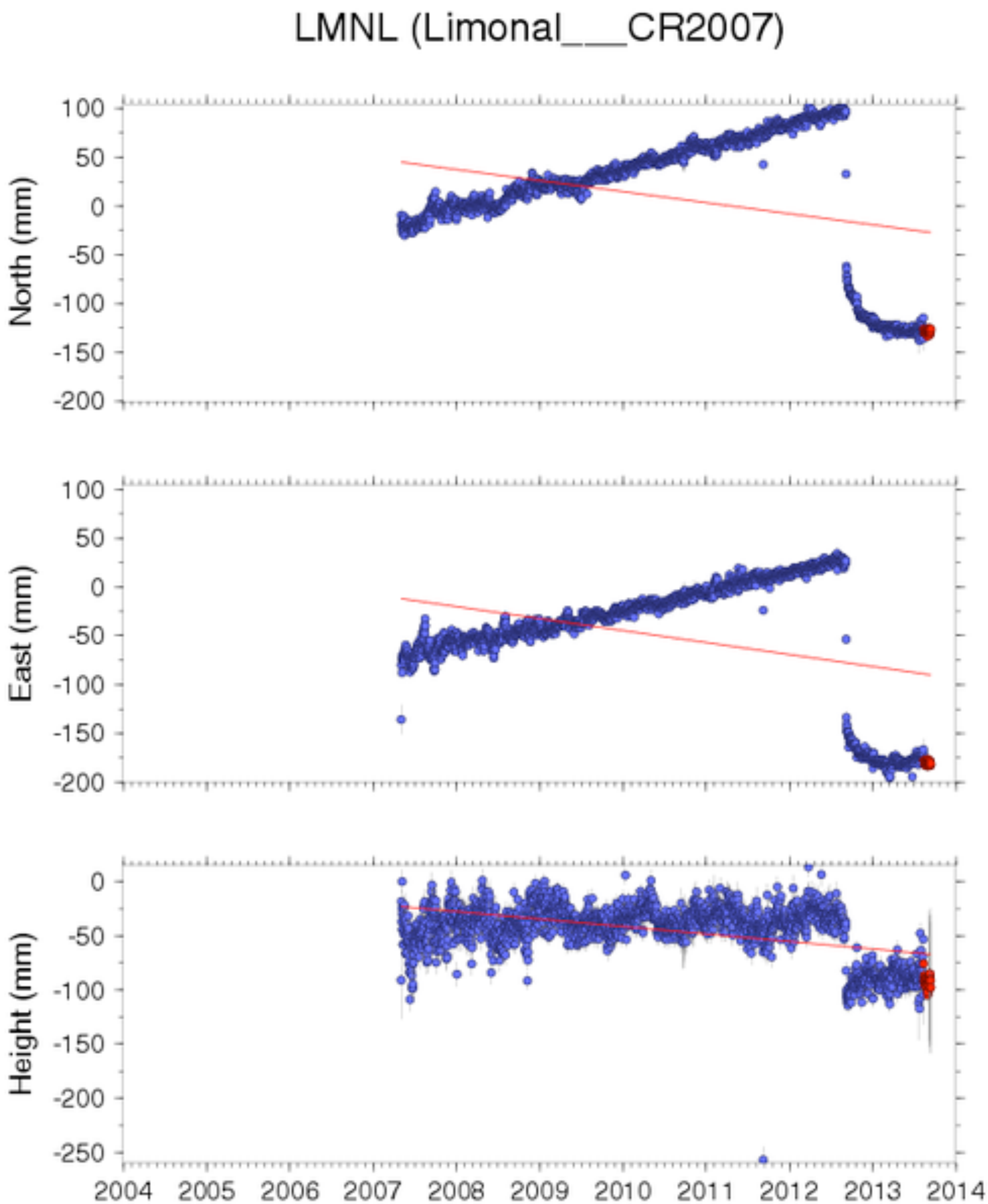
2. Use the map and the data from GRZA and LMNL to answer the next questions. GRZA's coordinates are: 9.92 N, -85.64 W, 39.77 m

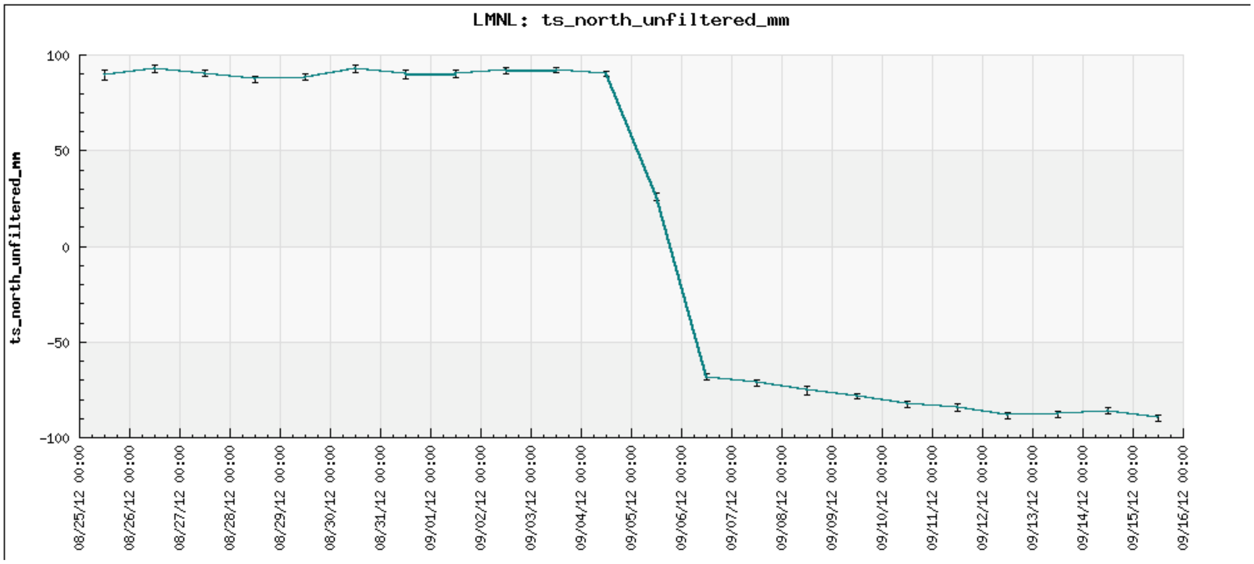

Terrain
Satellite
LMNL
GRZA
subduction
direction
POWERED BY
Google
50 mi
100 km
Imagery ©2013 TerraMetrics - Terms of Use

GRZA (Garza)

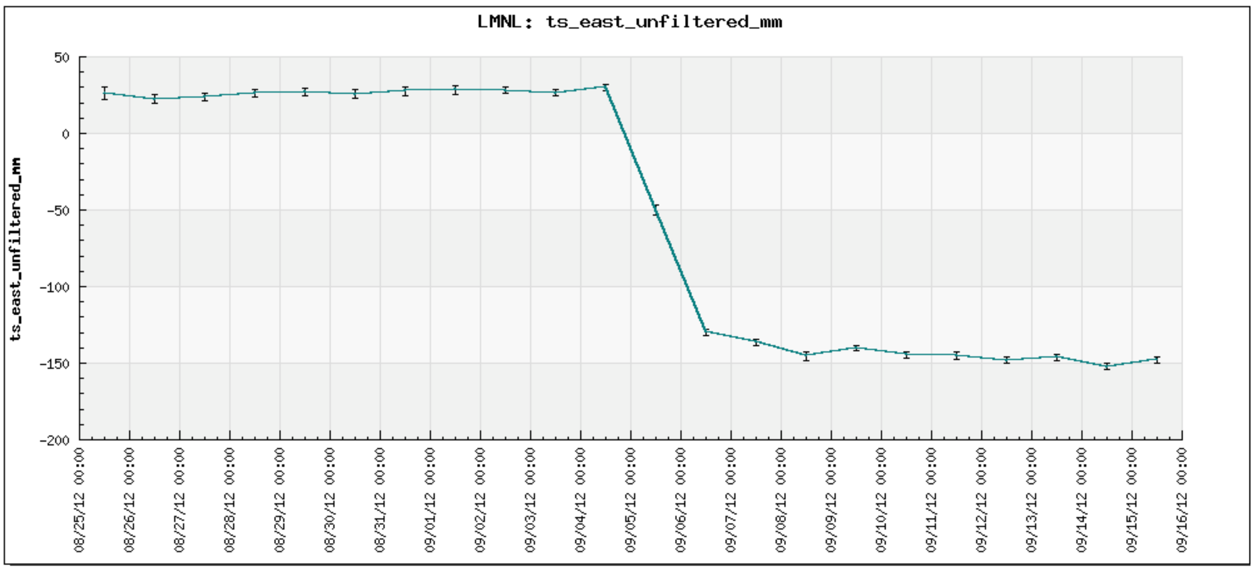


North (mm)
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
-550
-600
East (mm)
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
-550
-600
Height (mm)
500
450
400
350
300
250
200
150
100
50
0
-50
-100
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

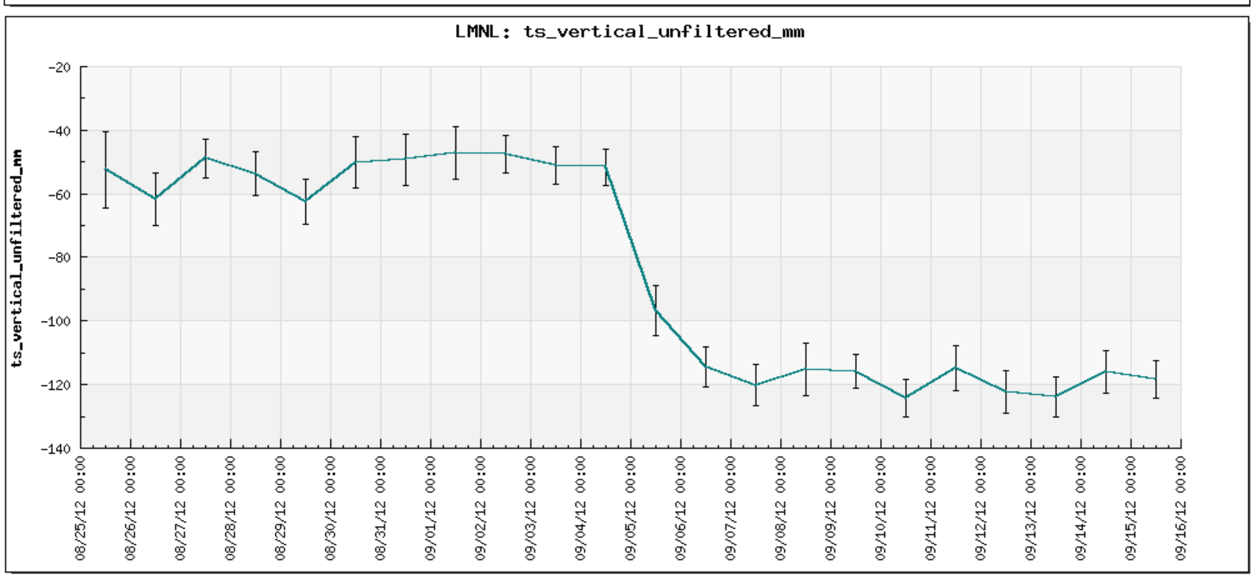

LMNL (Limonal___CR2007)
North (mm)
East (mm)
Height (mm)
100
50
0
-50
-100
-150
-200
-250
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014



LMNL: ts_north_unfiltered_mm
ts_north_unfiltered_mm



LMNL: ts_east_unfiltered_mm
ts_east_unfiltered_mm



LMNL: ts_vertical_unfiltered_mm
ts_vertical_unfiltered_mm

According to the data in the plots above, when did the earthquake occur?

2. How much slip on the fault occurred during the earthquake at the location of GRZA? according to its time series plots (it is okay to estimate to the nearest 25 mm. the point is to work through the method correctly. show your work and show your estimates so we can follow your logic)?

3. Describe how the GRZA GPS station's position changed during the earthquake.
4. Descrbie how the LMNL GPS station's position changed during the earthquake.
5. Using the equation below, which is a simplified estimate for the moment magnitude, what was the magnitude of the earthquake based on the slip that you calculated at GRZA?

$$M = \frac{\log_{10}(D) + 6.32}{0.9}$$

where M = magnitude

D= average slip in meters

6. Go to the [significant earthquake archive]() on the USGS site and find the details about this earthquake. (If this is printed out, here is the actual web address: http://earthquake.usgs.gov/earthquakes/eqinthenews/). What is the location, time, and magnitude of this earthquake according to the USGS? How well does this measured magnitude of the earthquake match your calculation based on slip? Explain discrepancies (Look at the maps to see where the GPS monument is and where the earthquake happened. This isn't meant to be a trick question).

In problems 7,8, and 9 we will work through a method to use geodetic data to calculate a recurrence interval, which will allow us to estimate how often an earthquake of that size might occur in this location.

7. Calculate the background rate of motion. This is its velocity vector before the earthquake happened. Use station LMNL for this calculation because we have a longer pre-earthquake timeseries at LMNL.
8. Calculate the amount of slip expected for an earthquake of this magnitude (use the magnitude determined by the USGS and rearrange the formula in #5 above).
9. How long will it take to build up that amount of strain energy (set it equal to slip) on the fault if the fault is locked? For this idealized calculation assume that no slip is resolved on the fault except in an earthquake, whereas far away from the fault, the ground moves at the plate rate you calculated.
10. We assumed in #9 that all the slip happens in earthquakes, but we know from the figure in #1 that there have been SSEs observed in this area. How does that alter your idea about the recurrence interval here?