Integrating Geodesy and Seismology: 2008/10/6 Tibet M6.2 Event

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Ground truth locations using remote sensing with seismology only proves difficult. The recent event in southern Tibet (2008/10/06) is an example with reported epicentral differences of over 50 km. Here, we investigate the use of two new methods to help improve the situation. One is to use regional waveform data (CAPloc) and use the synergy with geodetic data(InSAR) to find the true locations and refine source property. We first obtain the point source mechanism by regional and teleseismic data seperately.During regional inversion we also search for horizontal centroid location which proved quite close to the maximum InSAR displacement.Source depth and moment magnitude are validated by comparing the miximum static displacement between data and prediction which shows a depth of 8km. And then we test the possibility to use one station to location an event in the case we really know its mechanism, this one station inversion works pretty well for the main event. Finite fault inversion is pursued by using regional and geodesy data together. The best location of the fault plane and epicenter is obtained in a grid search manner. The inversion prefers the north-south fault plane and a directivity from north to south.

Regional and Teleseismic Point Source Inversion

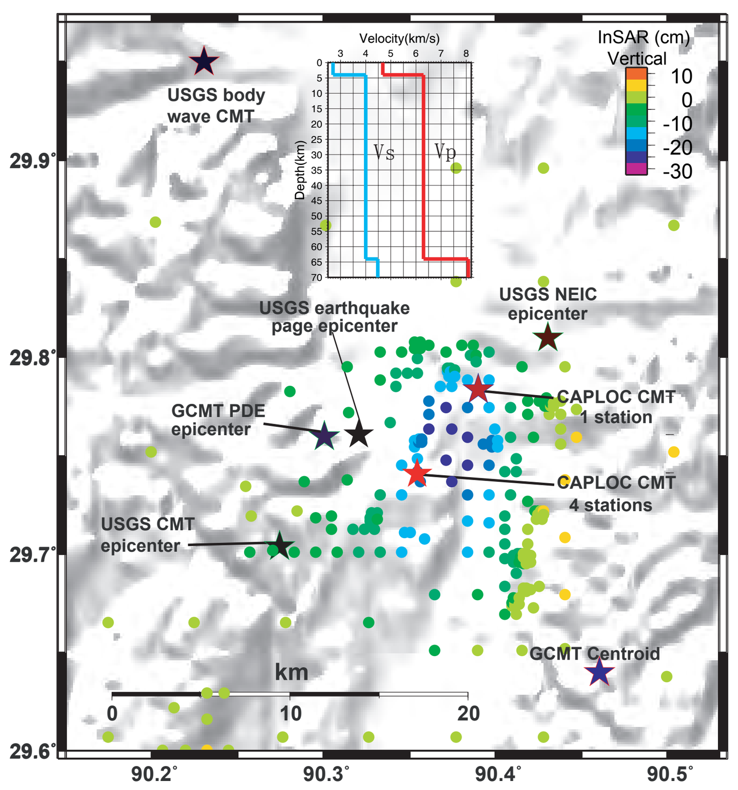


Figure 1: InSAR data along with locations from USGS CMT epicenter, GCMT centroid, USGS body wave centroid and USGE NEIC epicenter. Note that the vertical hole expected from a normal event. These locations are published within hours after the earthquake. One station(LSA) and four stations CAPloc solutions are also displayed as red stars. This plot clearly shows where the InSAR deformation is and how far the CAPloc and other CMT solutions are.

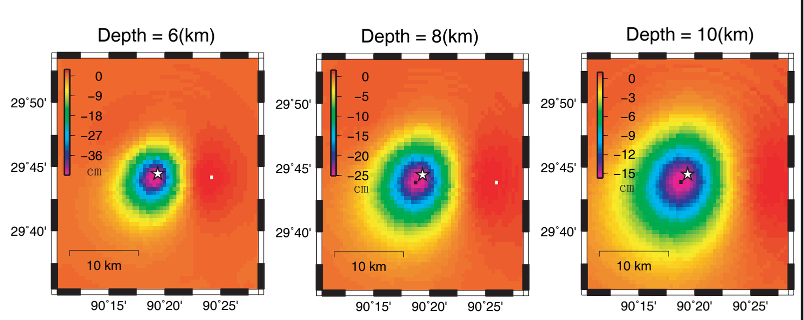


Figure 2, Forward static displacement(vertical) predicted from CAPloc point source solutions, the mechanism used is 43°/44°/-59° for strike/dip/rake and moment is 6.2. A depth of 8km gives the best fit, which is consistent with regional and teleseismic inversion.

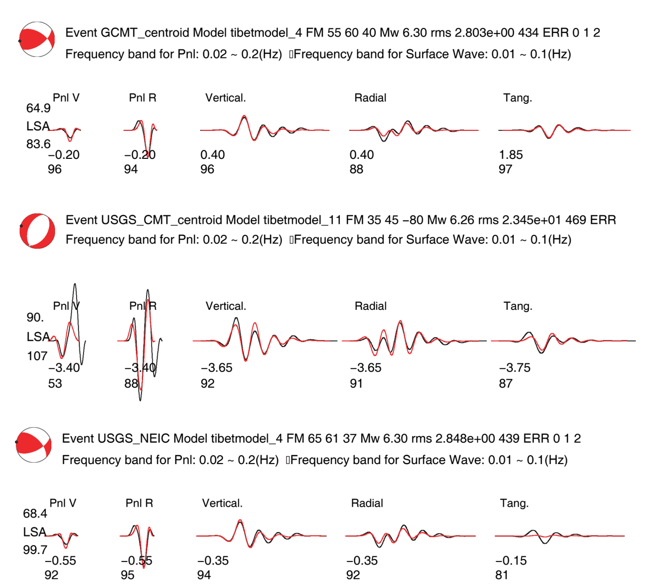


Figure 3, Waveform fits of one station CAP inversion (LSA),assuming various initial locations. The number above station name (LSA) is the distance and below the azimuth. If the mechanism is known, one station can locate the event as displayed below.

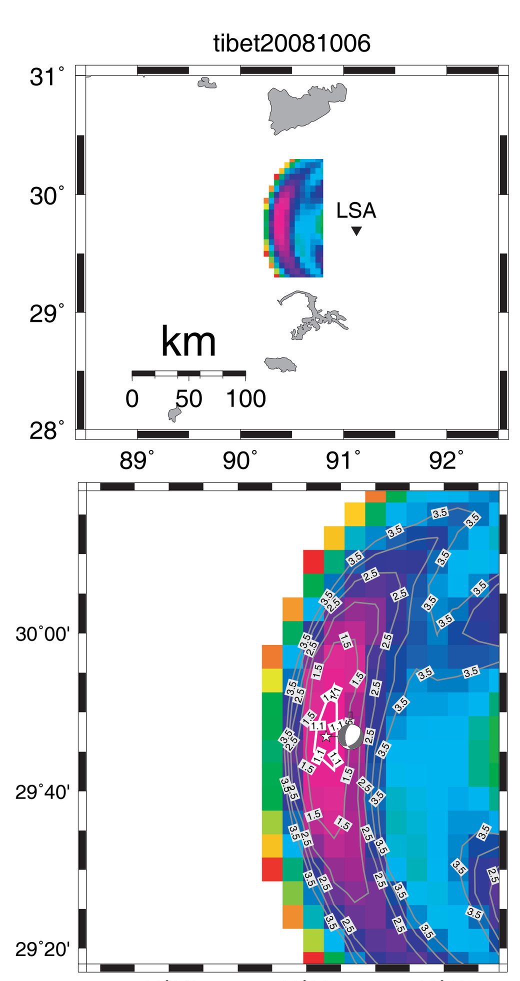
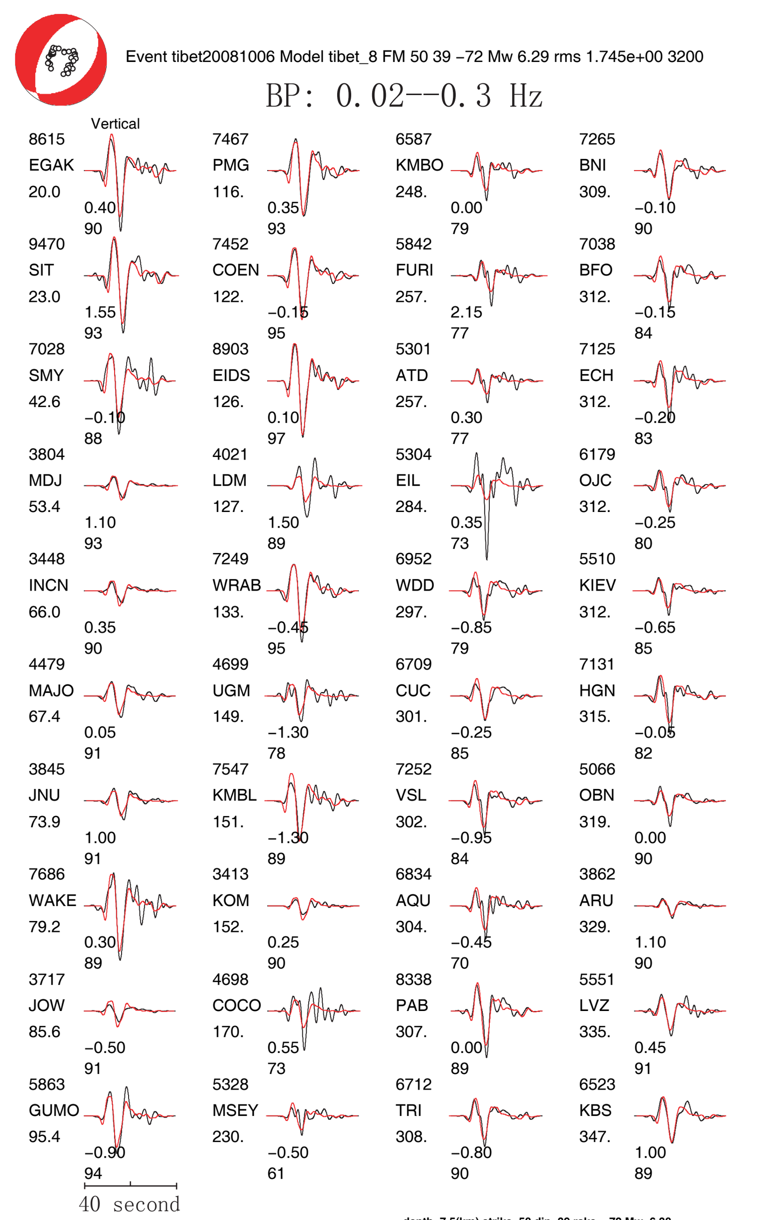


Figure 4. One station CAPloc inversion, in which mechanism and moment magnitude are fixed as discussed later.



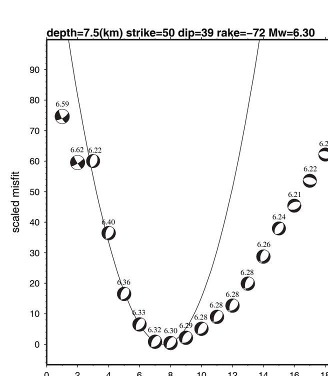
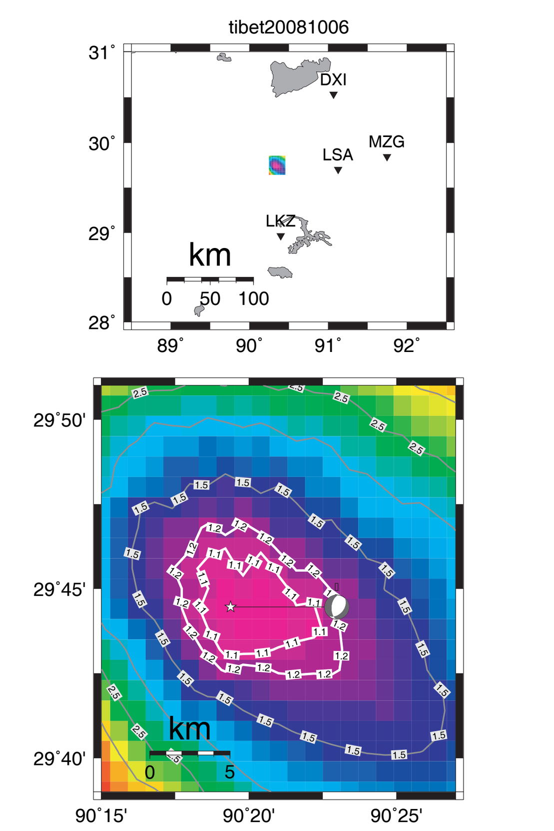


Figure 5. Teleseismic body-wave inversion, 40 vertical components of P-waves are selected for a grid search inversion(CAPt) to determine the mechanism, moment magnitude and source depth.A tp* = 1.0 is used and frequency band is 0.02~0.3Hz. The best solution is depth = 7.5km, Mw = 6.30, stike = 50°, dip = 39°, rake = 72°. As this is a normal event, all teleseismic P-waves have the same polarity, which implies that the inversion has a relative weak constrain on strike.



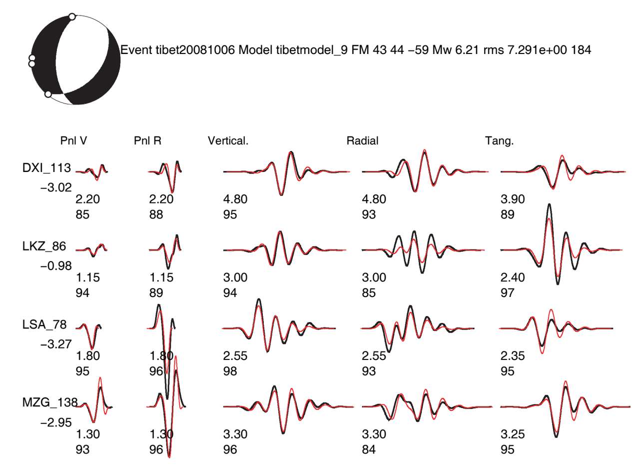
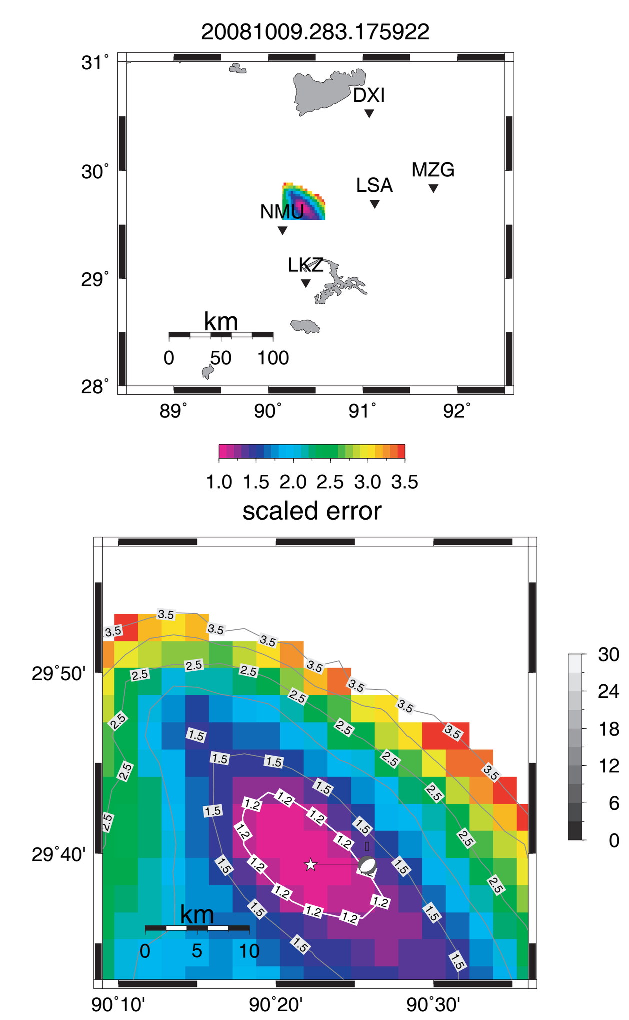
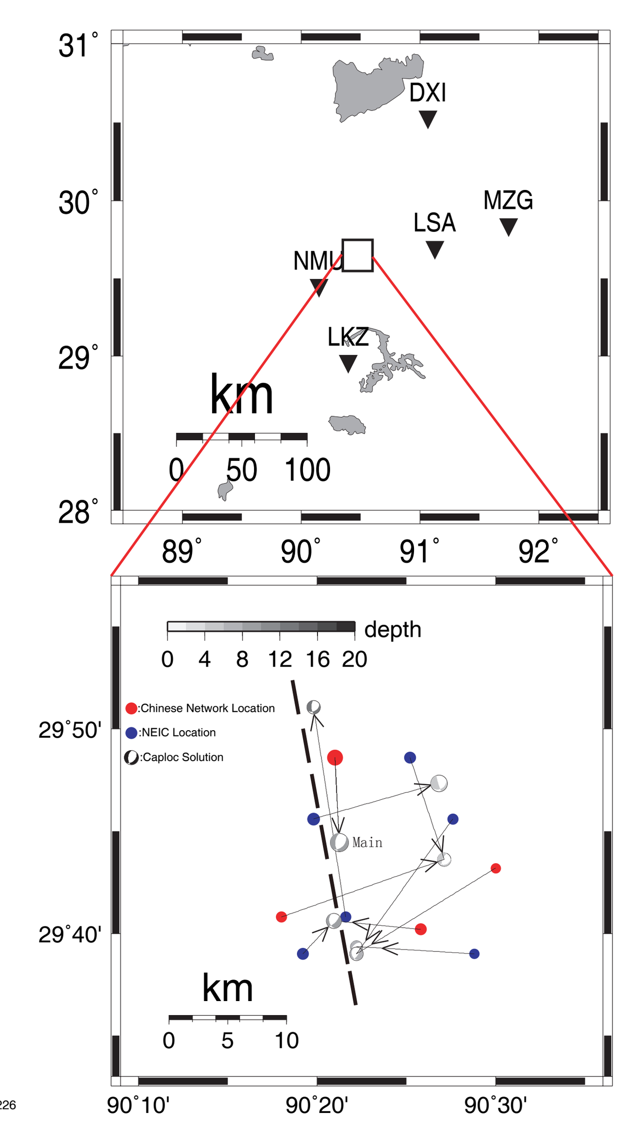


Figure 6, We use 4 regional broadband station and the CAPloc technique(Tan et al. 2006) to determin full point source solution. Mechanism, moment, source location (horizontal and vertical) are determined in a grid search manner.The best horizontal location is showed in Figure1. Waveform fits at the best location are showed above. Note that the relatively large lags are eliminated by a shift in origin time.





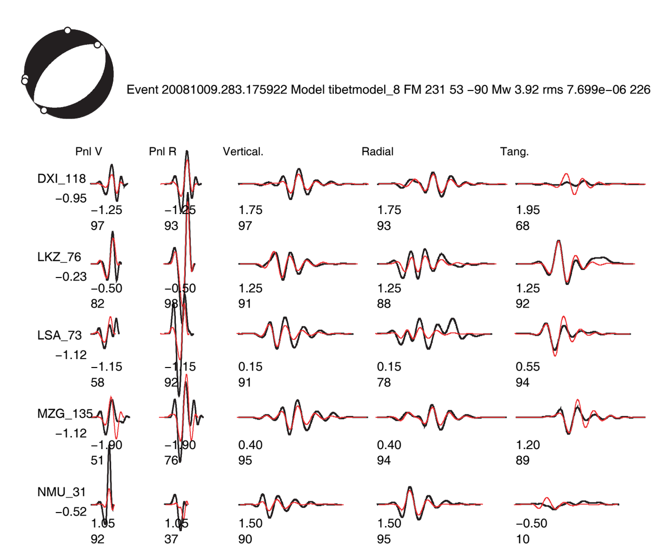


Figure 7, CAPloc inversion for other 6 large aftershocks. Location of stations and inversion results are show on the above. Detail result of the 20091009.283.175922 event are showed on the left, as an example. These data will be used todetermine directivilty in future effort.

Future Work

As we can determin locations and mechanisms for some of the aftershock, in the future, we will study directivity of the main event by Empirical Green's Function(EGF) method.

Finite Fault Inversion with InSAR and Regoinal Data

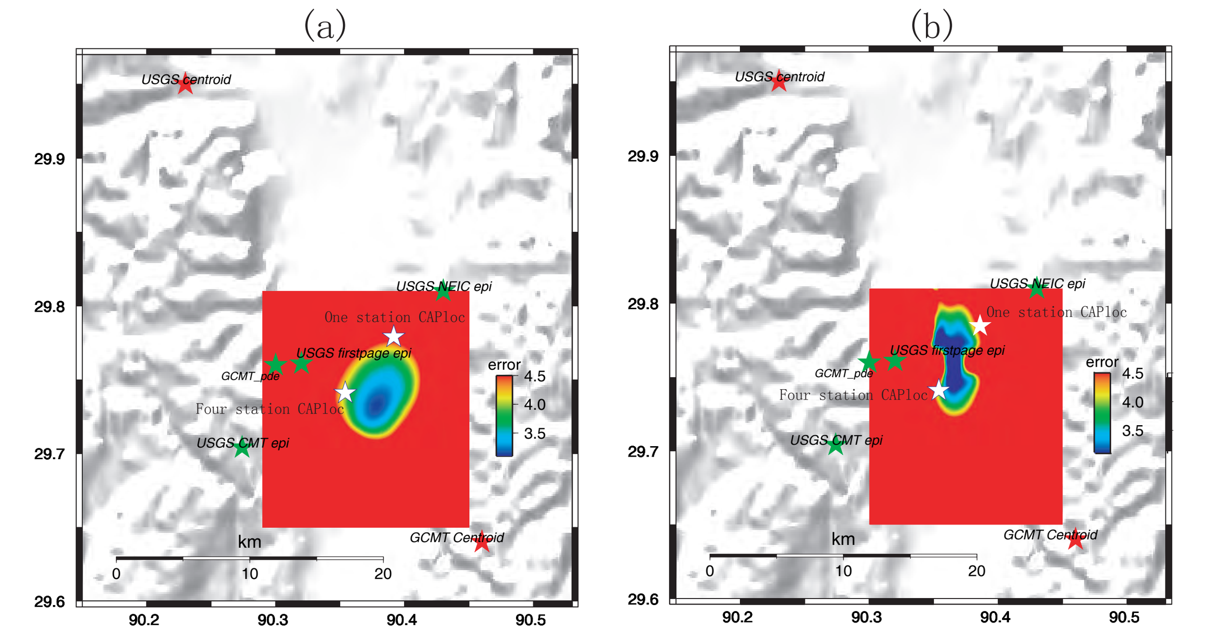


Figure 8: The result of grid search of best fit InSAR plane using the two possible planes of solutions (a) strike: 45°, dip: 43° (b) strike: 180°, dip: 56°. A 6 km along strike and 10 km along dip plane was moved around and a geodetic inversion to the InSAR data was performed. Fit to the InSAR data is recorded for the center point of the plane. The best fitting center point of plane locations are shown with the error scale. Various epicenter and CMT locations are also shown.

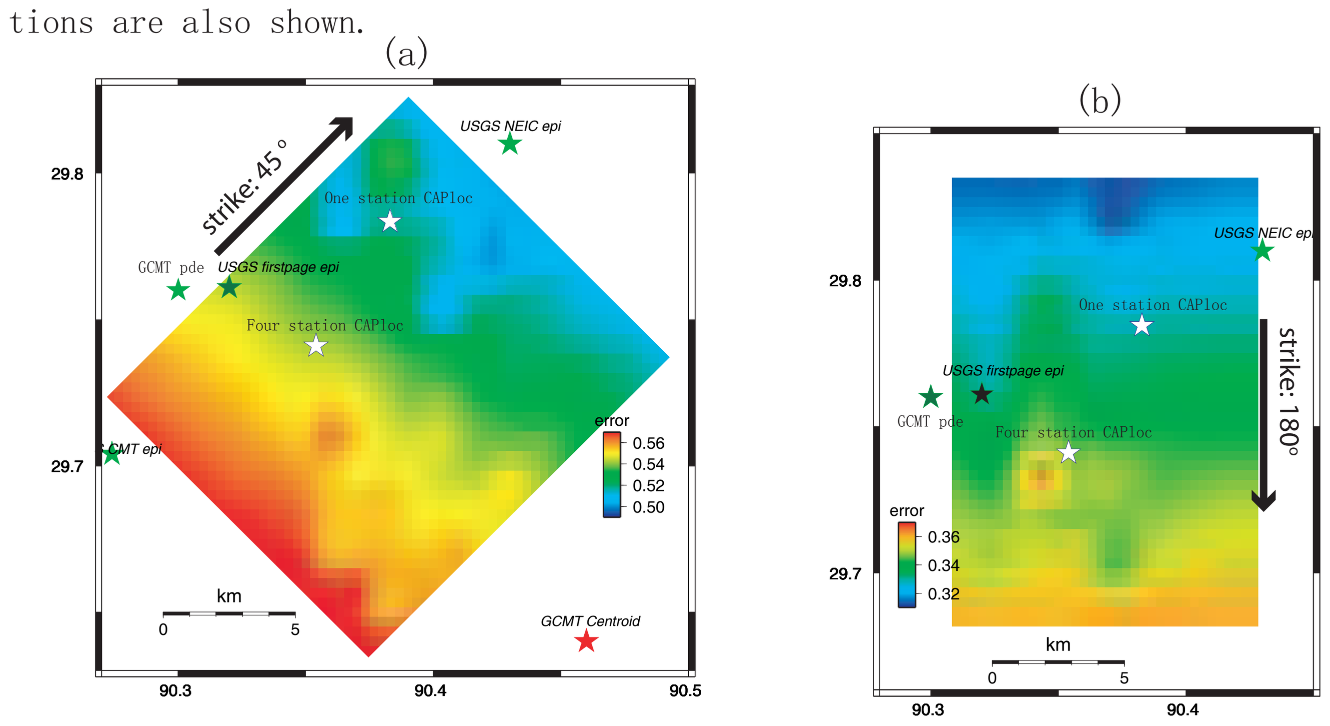


Figure 9: Determining the best fit plane and best fit hypocenter: Using the best fit fault plane locations from Figure 8 with two possible planes, now we extend these best fit planes to be a bit longer (16.5 km by 19.5 km along dip). Then we do a joint inversion to InSAR and regional broadband data using two possible fault planes (a) strike: 45°, dip: 43° (b) strike: 180°, dip: 56°. What is plotted on the fault plane is the joint error to InSAR+ seismic+ smoothness error for that particular hypocenter location. What is clear is that the error to the data is much better when strike:180 plane is used (check the ranges of error for both planes). Also what is clear that there is a directivity in the broadband data. The locations close to the north of the fault planes do a much better job of fitting the data.

So Fig8 and 9 clearly show that the best fitting plane is the one with strike: 180°, dip: 56°. Also the best fit hypocenter location is this: lon: 90.37 lat: 29.815 depth: 8.5 km

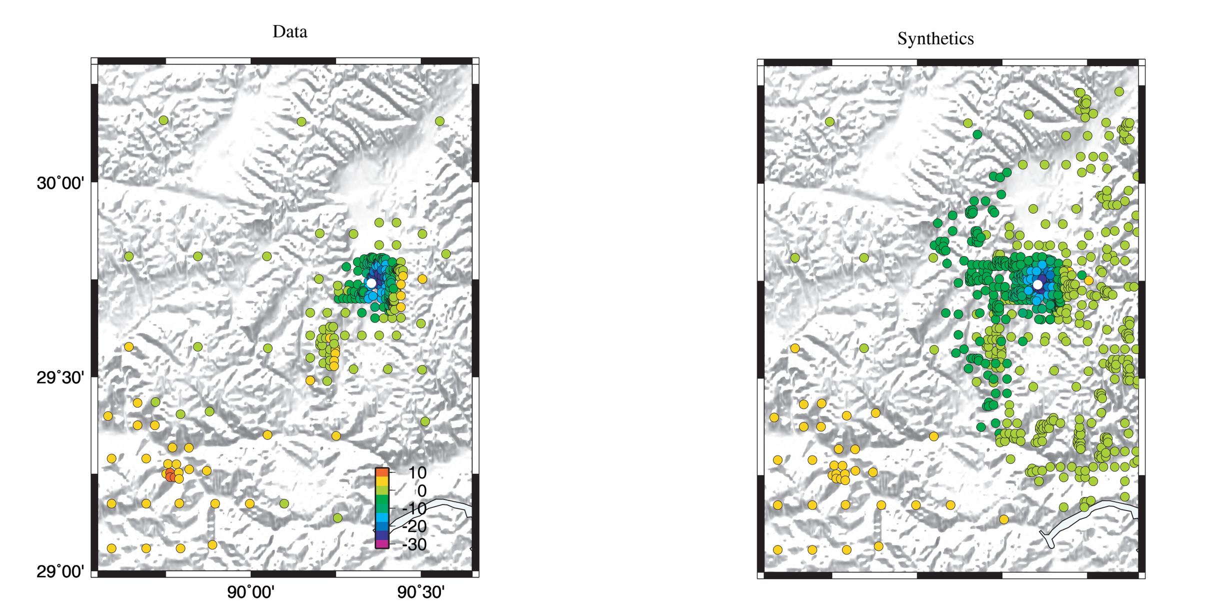
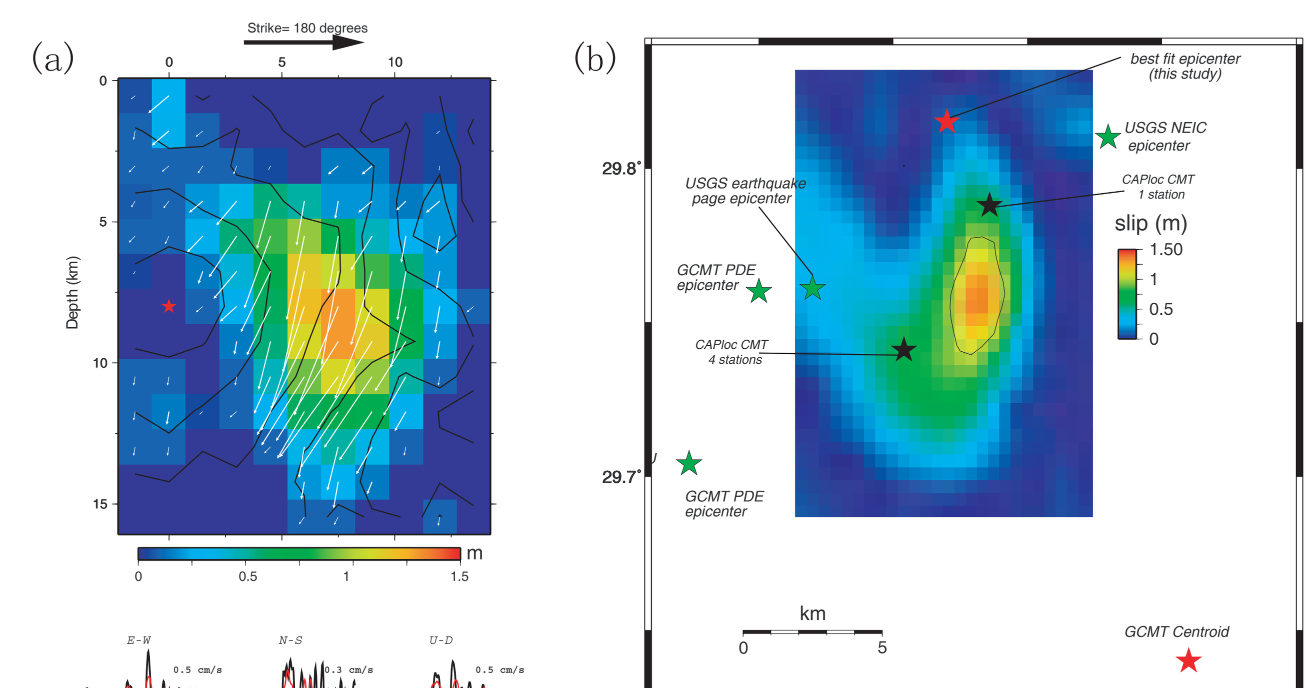


Figure 10: InSAR data(left) and synthetics using the joint model of Figure 11.



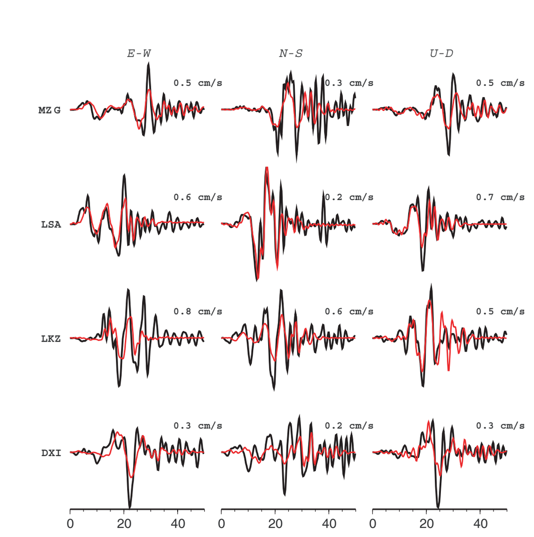


Figure 11: (a)slip distribution of the best fit finite fault model. (b) Map view of the same slip distribution along with various CMT and epicenter locations.

Figure 12:Regional broadband data (black) and synthetics for the frequency band of 50-1.75 seconds.