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3D Path Calibration for the 12/30/2009 Imperial Valley Earthquake

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The source mechanism of 12/30/2009 earthquake in Imperial Valley is well determined by the teleseismic P and SH waves. The best point source mechanism we obtained is 60°/90°/11° (strike/dip/rake) with Mw of 5.9 and depth of 7km (*Tian et. al.*, 2010). Although regional stations are all to the north of the epicenter, we still can model one of the nodal directions of the P-SV radiation pattern. This event is also recorded by the InSAR data, using which we can obtain the location. 3D basin structure complicates waveform records when compared to the 1D synthetics at the frequency bands we usually use for CAP inversion (said 0.2~0.02Hz for Pnl waves and 0.01~0.1Hz for surface waves). Because the TriNet stations are all located to the north of the US-Mexico border, the station azimuthal coverage for earthquakes becomes worse as epicenters move further to the south, thus source parameters are less constrained as well. Here, we test the CMV-4m 3D velocity model by comparing 3D Finite-Difference synthetics with the real data at difference frequency bands, as well as 1D synthetics. We found that at 20sec and longer, the records are not much different from the 1D synthetics, but at higher frequency bands, 3D synthetics fit the data much better than 1D synthetics, especially along some paths. In the future effort, we will use these well calibrated paths to study earthquakes at higher frequency, not only for point source mechanism inversions but also for distributed slip models such as for the recent El Mayor-Cucapah Earthquake.

Teleseismic Inversion

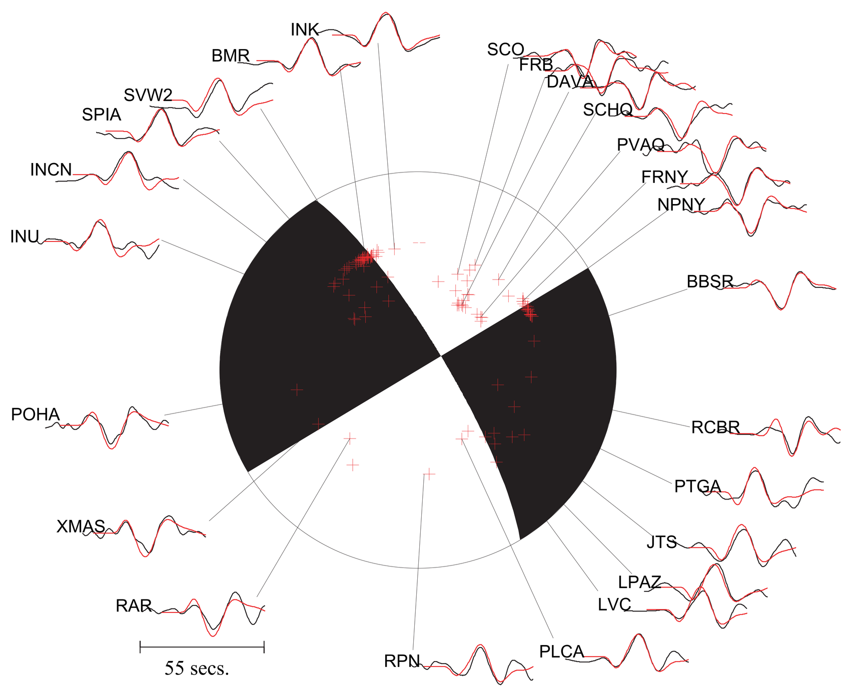

Figure 1. Teleseismic P and SH wave mechanism for the 12/30/2009 Mw5.9 Imperial Valley event. Red crosses indicate the projection of teleseismic stations on to the lower hemisphere of beachball. Representative SH waveforms are shown, data are in black and synthetic are red, both are displacement records and filtered to 0.02~0.1Hz. The best point source mechanism we get is 60°/90°/11°(strike/dip/rake) with Mw of 5.9 and depth of 7km.

Regional Seismic Inversion

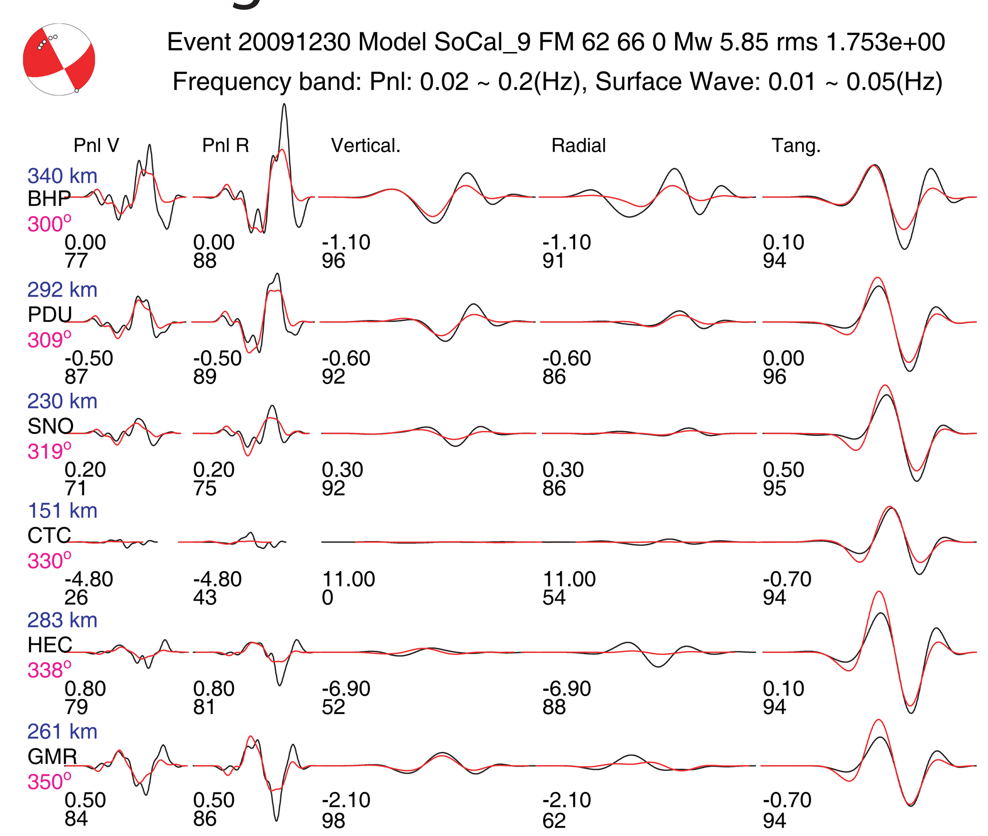

Figure 2. Regional seismic waveform inversion to obtain the source mechanism. Waveforms at each station are broken into Pnl (vertical and radial) waves and surface waves (vertical, radial and tangential). Station name is indicated at the left side of each wave train, with epicenter distance above and azimuth below. The first number below each waveform pair is the time shift necessary to align them and the second number is the cross-correlation coefficient in percentage. Here we show only a portion of fits in which we can see clearly the nodal direction of P-SV radiation pattern.

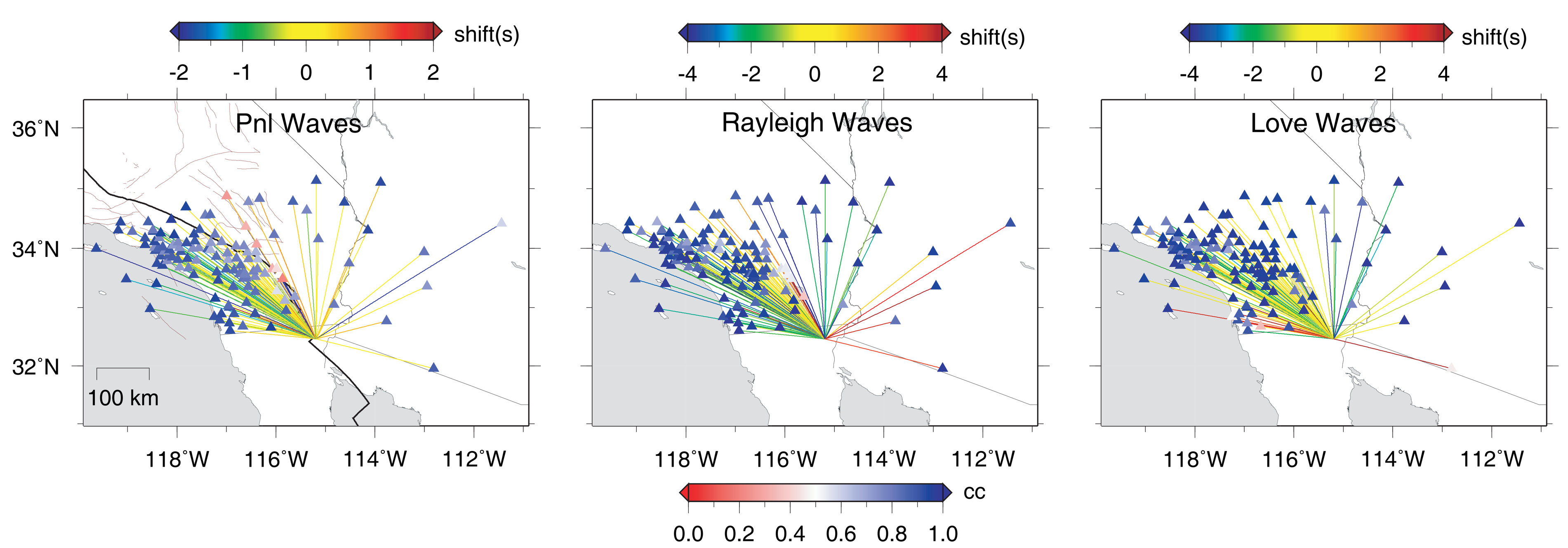

Figure 3. Time shifts between displacement data and synthetic.See fig.2 for filter bands. The stations(triangles) are colored by the cross-correlation coefficients and lines are colored by the time shifts needed to align up data and synthetic. Here we used the source location determined by the InSAR data. We can see one of the P-wave nodal direction from low cross-correlation coefficents.

InSAR Data and Static Inversion

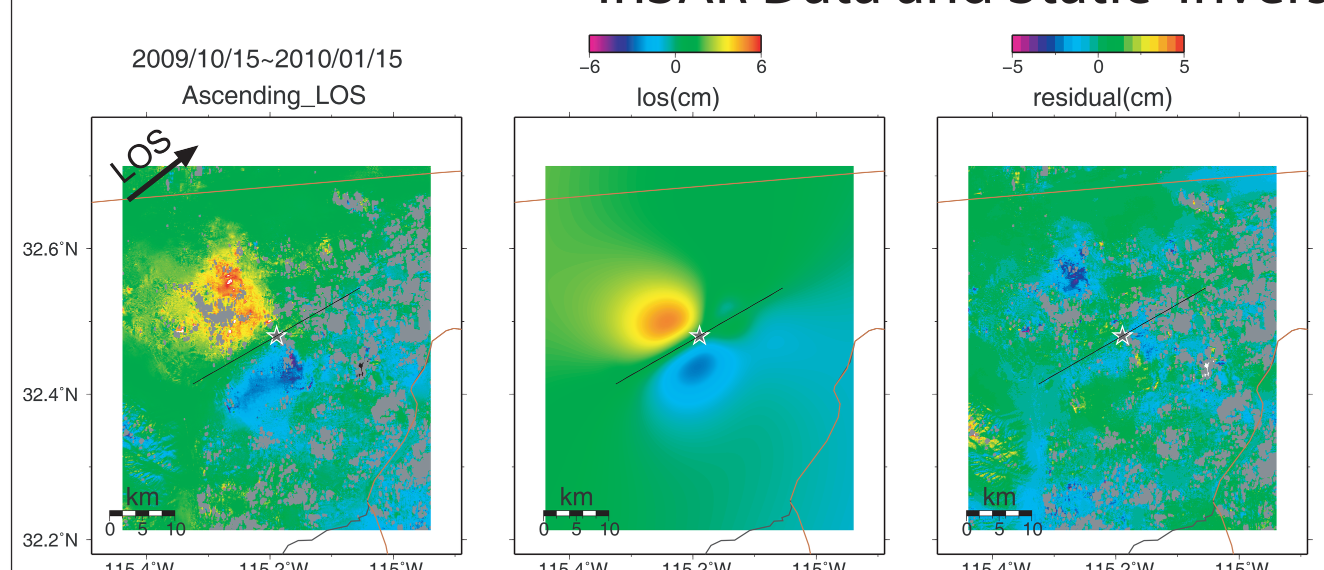

Figure 4. Left column is InSAR data for the 12/30/2009 Mw5.9 Earthquake in Imperial Valley. The line of sight(LOS) angle is indicated as the black arrow. The black star is the epicenter used in the static inversion, and the black thin line is the projection of the fault plane. Here we use one of the fault plane (strike=60°, dip=90°) for the static inversion. The middle is the prediction from the best model (Fig.5) obtained by inverting the InSAR data. The right panel shows the misfit between data and synthetic.

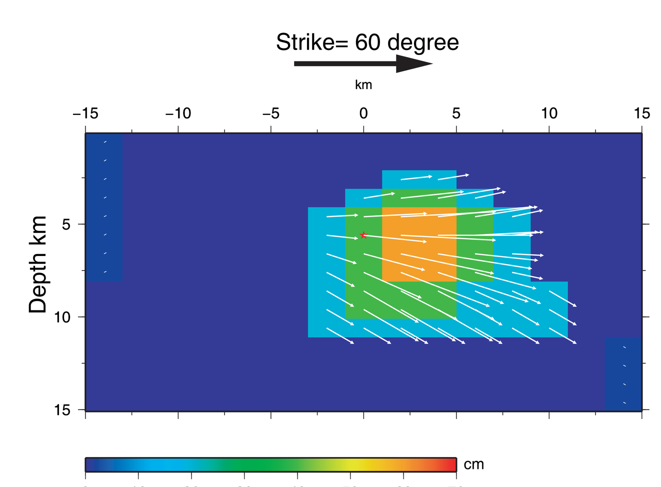

Figure 5. Distributed slip model obtain by inverting the InSAR data in Fig.4. The slip amplitude is colored coded and the rake angles are indicated by white arrows. The black arrow above indicates the strike of the fault plane we used.

Compare data with 3D and 1D Synthetics

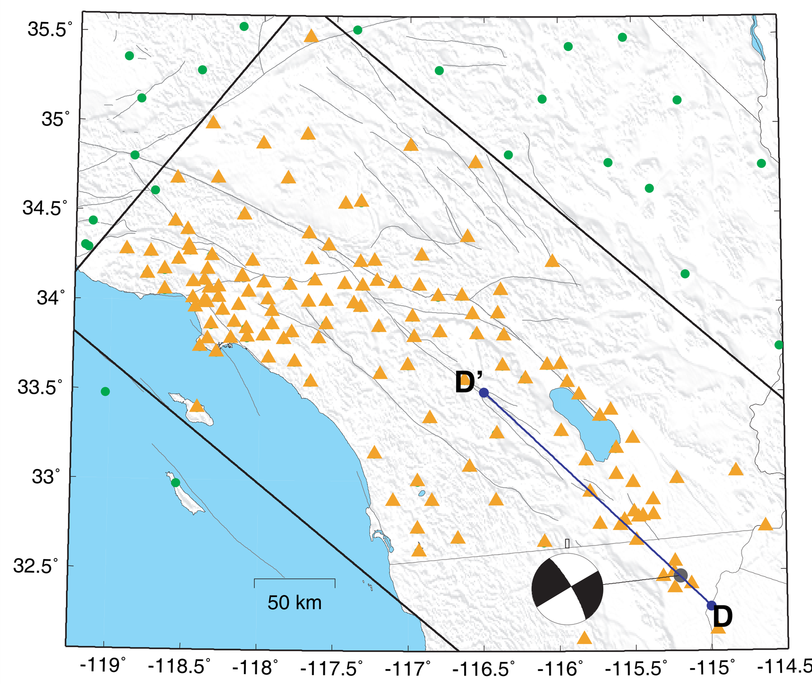

Figure 6. 3D CVM-4m model calculation region (regtangle region shown by thick black lines) and station distribution (triangles). The location of the source is indicated by the black circle and teleseismic mechanism and depth is used. The blue line connects D and D' indicates the 2D profile in Fig.8. Green dots out of the rectangle region are broadband TriNet stations not used in the simulation.

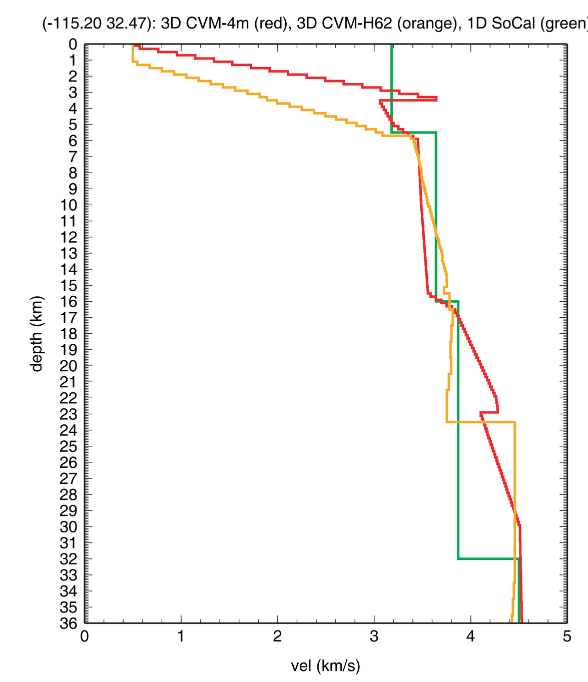

Figure 7. 1D velocity model sampled at the location of the earthquake. 1D SoCal model and sample of 3D CVM-H62 models are also plotted for comparison.

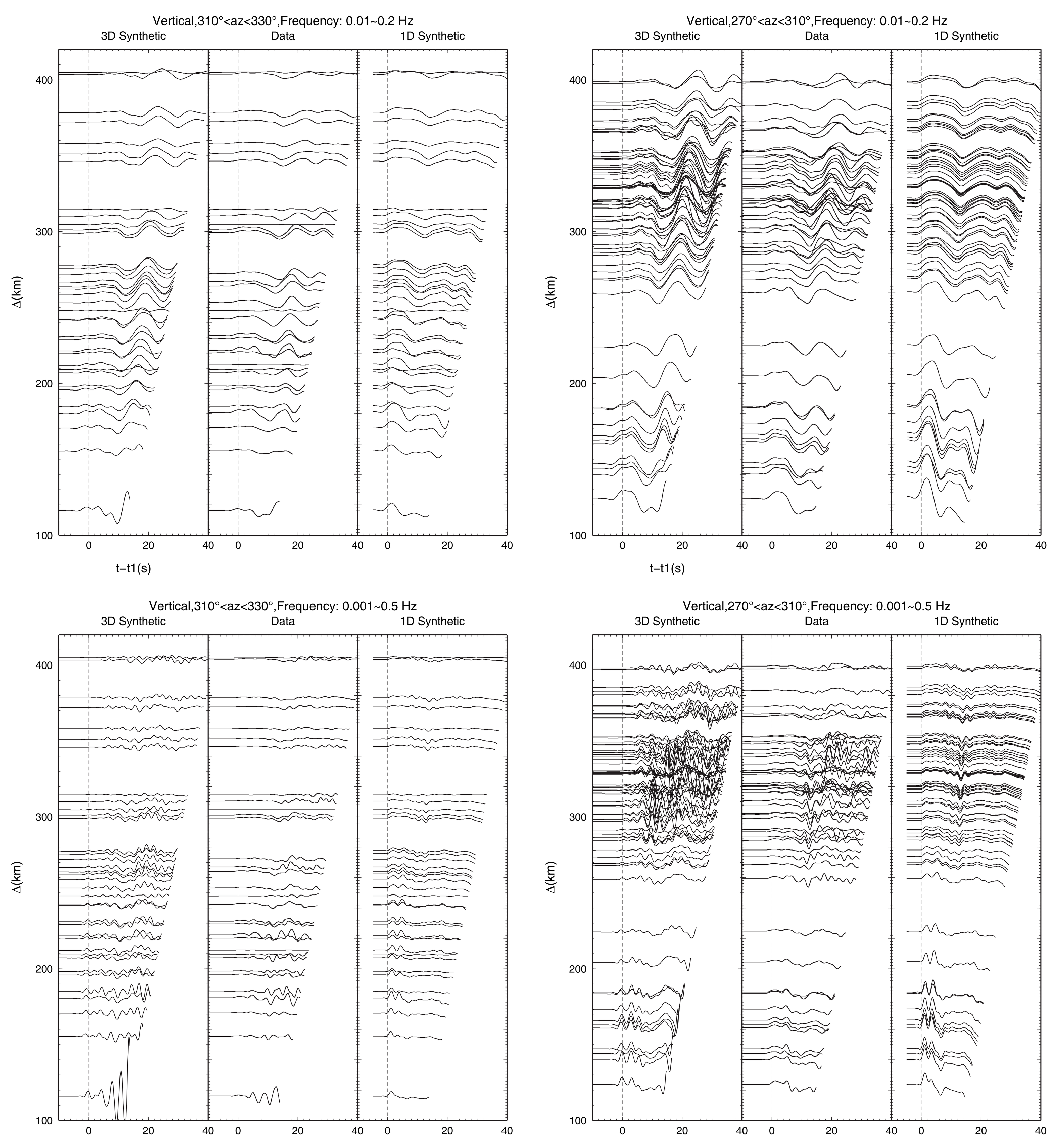

Figure 9. Comparison of record sections at different frequency bands, for the Dec. 30, 2009 strike-slip event (see Fig.1), along two corridors; 310°~330°, and 270°~310° crossing the LA basin. Both the data and synthetics are multiplied by (r/r_o) for plot with r_o as a reference distance and r as epicenter distance. All the records are aligned by the theoritic first arrival of SoCal model.

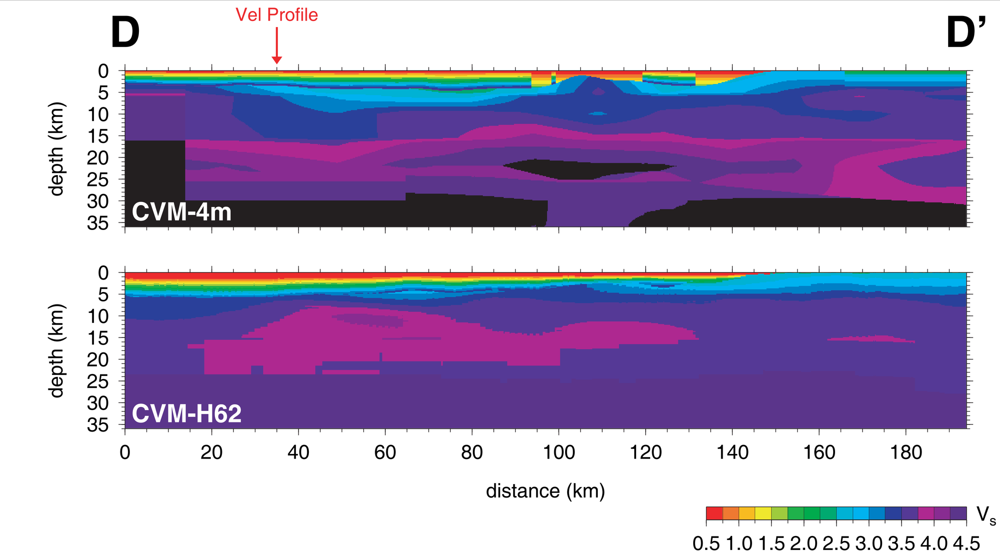

Figure 8. 2D velocity profile along the DD' as in figure 6. Similar profile from 3D CVM-H62 models is also presented below for comparison. the red arrow points out the location of the earthquake.

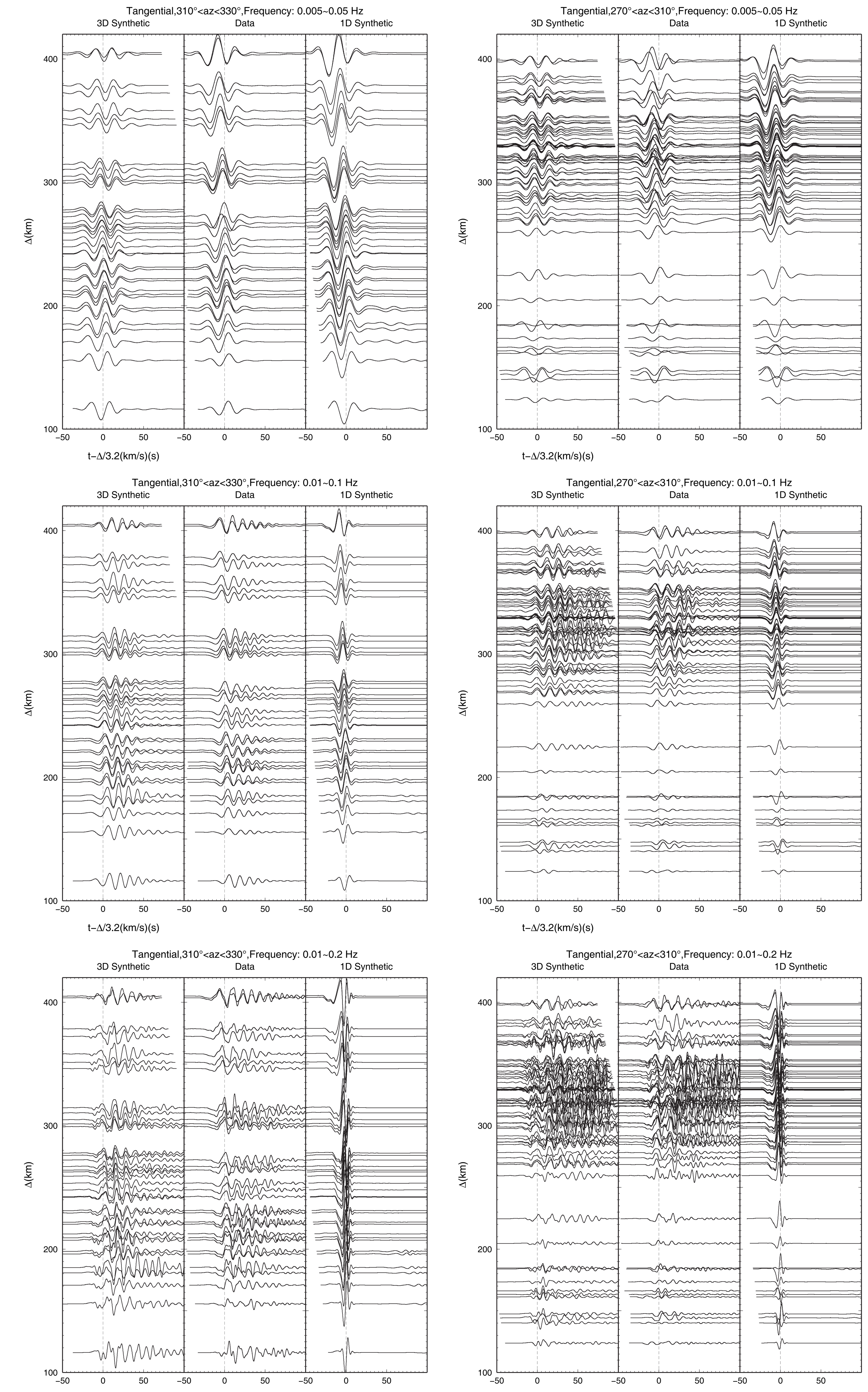

Figure 10. Similar as Fig.9, all waveforms are aligned by reduced velocity of 3.2km/s.

Future Work

1, Use 3D Green's Functions to obtain source mechanism of the 12/30/2009 earthquake along well calibrated paths.
2, Study source process of the El Mayor-Cucapah Earthquake and aftersocks using higher frequency waveform data.
3, To study source mechanisms of history events which are located south of the network.