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Variation of the upper mantle velocity structure along the central-south Andes

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Background : The central-south Andes offers an excellent natural laboratory to study the effects of subducting oceanic plates (Nazca plate) underneath a continental margin and the associated mountain building. The history of the central Andes is dominated by subduction related magmatism, uplift related to contractional deformation and thermal uplift, and loss of the base of thickened crust and lithosphere by delamination. The mechanisms for uplift and crustal thickening along with the amount, timing and fate of removed continental crust and mantle lithosphere remain hotly debated. The subduction of Juan Fernandez Ridge might have led to flat slab subduction and gap in the volcanic arc, but the structure of the mantle wedge is unclear. At the same time the reason for the gap in intermediate depth seismicity gap is unclear. We are attempting to address the issues using the data recorded by the PUNA project between 2007-2009 which had 74 deployed stations, CHARGE project between 2000-2002 with 24 stations, SIEMBRA project between 2007-2009 with 45 stations, Chile RAMP project at 2010 with 58 stations and 5 permanent stations.

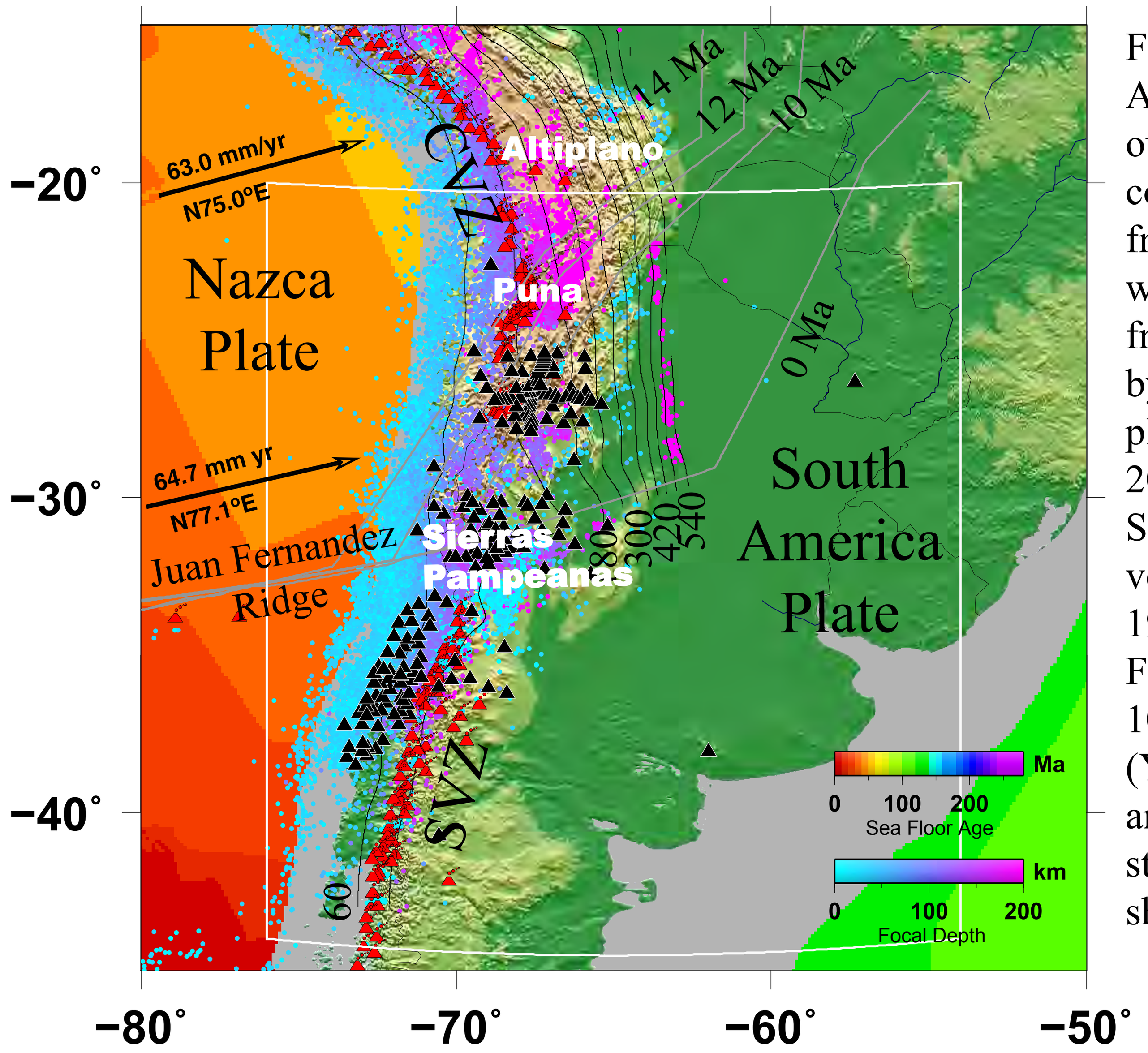

Figure 1. Location of the central-south Andes. The thin white rectangle shows our research region. The depth contours of subducted Nazca slab from USGS are plotted as black lines with 60 km interval. The seismicity is from PDE catalogue and color coded by depths. Sea floor age of Nazca plate is also color coded (Müller et al., 2008). CVZ: Central volcanic zone, SVZ: South volcanic zone. GPS velocities are from (Angermann et al., 1999). The positions of Juan Fernandez ridge at different times (0, 10, 12,14 Ma) are shown as grey lines (Yáñez et al., 2001). Volcanos data are from Smithsonian Institution. The stations used in our research are shown as triangles.

Method :

Following the improved approach outlined by Shen et al. (2012), very-broadband emperical Green's Functions (EGF, up to 300 s period) could be obtained from the ambient noise analysis between appropriate station pairs (Figure 3). Then we use these EGFs multiple with a theoretical source time function to get "emperical seismograms".

Using the finite difference waveform synthetic method developed by Zhang et al. (2012), we can simulate the seismic wave propogation in 3D media. By comparing these synthetic waveforms with our "empirical seismograms", we could measure the traveltime difference and then use these measurements to invert the corresponding velocity perturbations for the 3D input model.

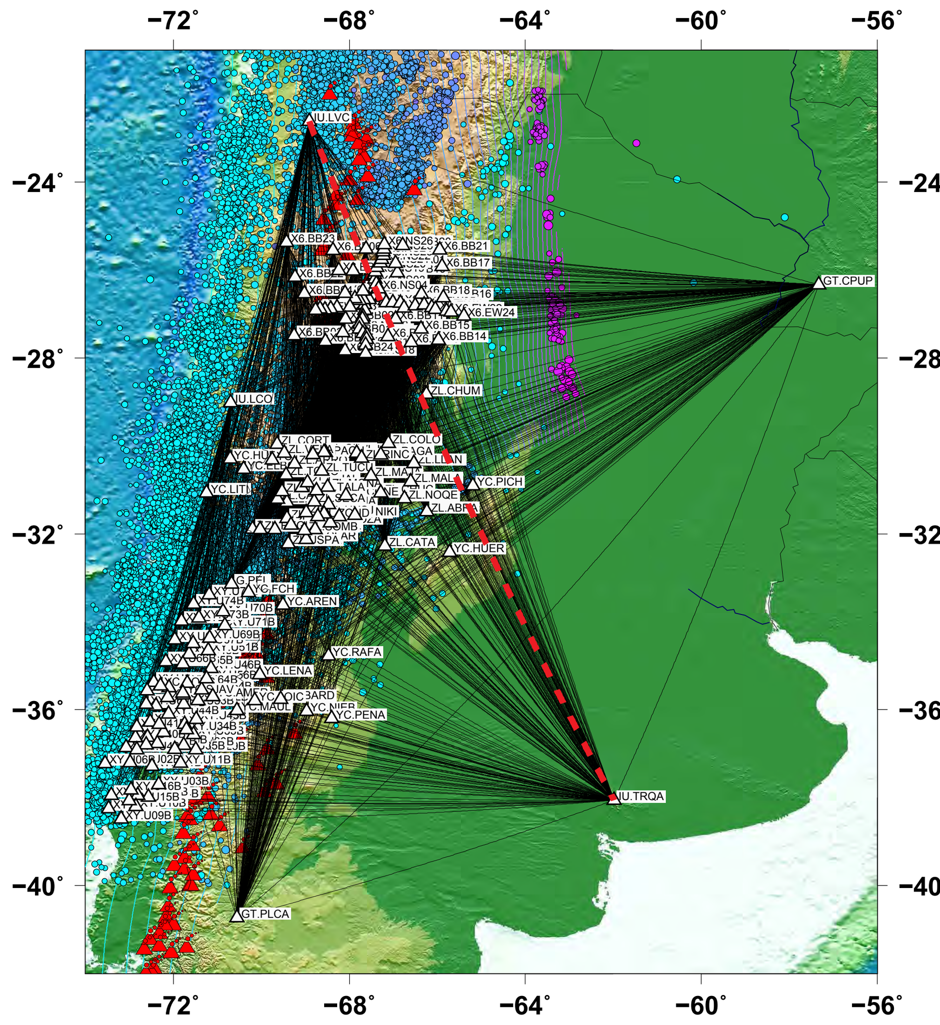

Figure 2. Station-pairs with distances longer than 500 km and at least 90 days overlapped continuous waveforms.

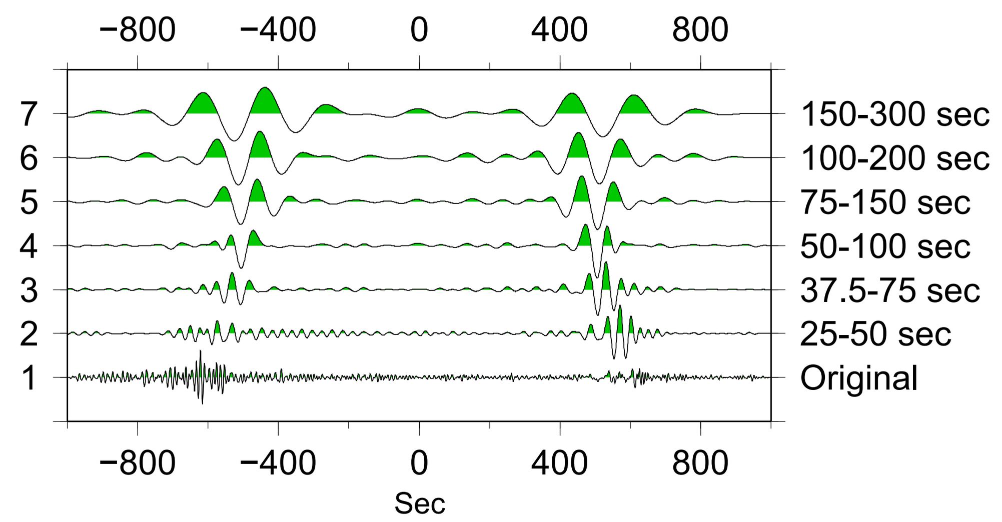

Figure 3. Very-broadband emperical Green's functions obtained between station IU.LVC and IU.TRQA (Red dash line on Figure 2).

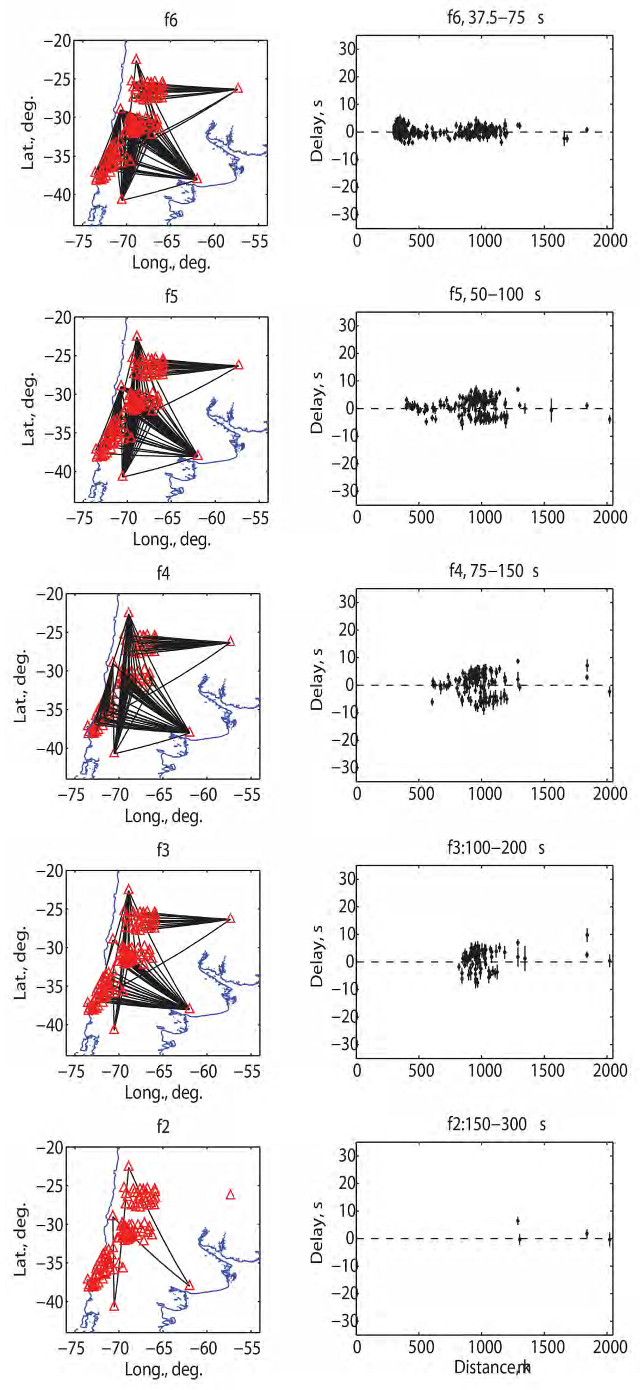

Figure 4. Traveltime residuals measurements of different frequency band between "empirical seismograms" and synthetic waveforms used in our inversion.

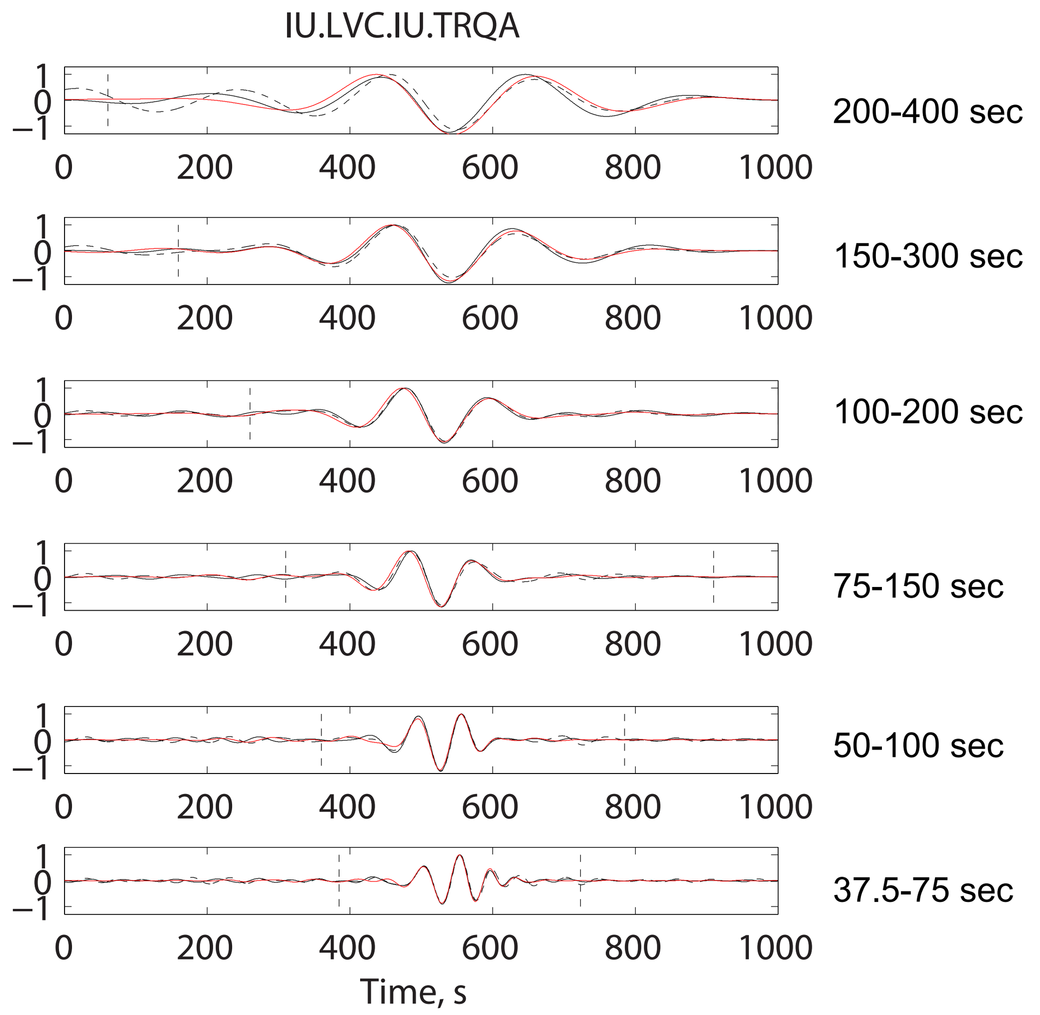

Figure 5. Cross-correlations for traveltime residuals between station pair IU.LVC and IU.TRQA. The red lines are the synthetic waveforms. Black solid and dash lines are the positive and negative parts of "empirical seismograms".

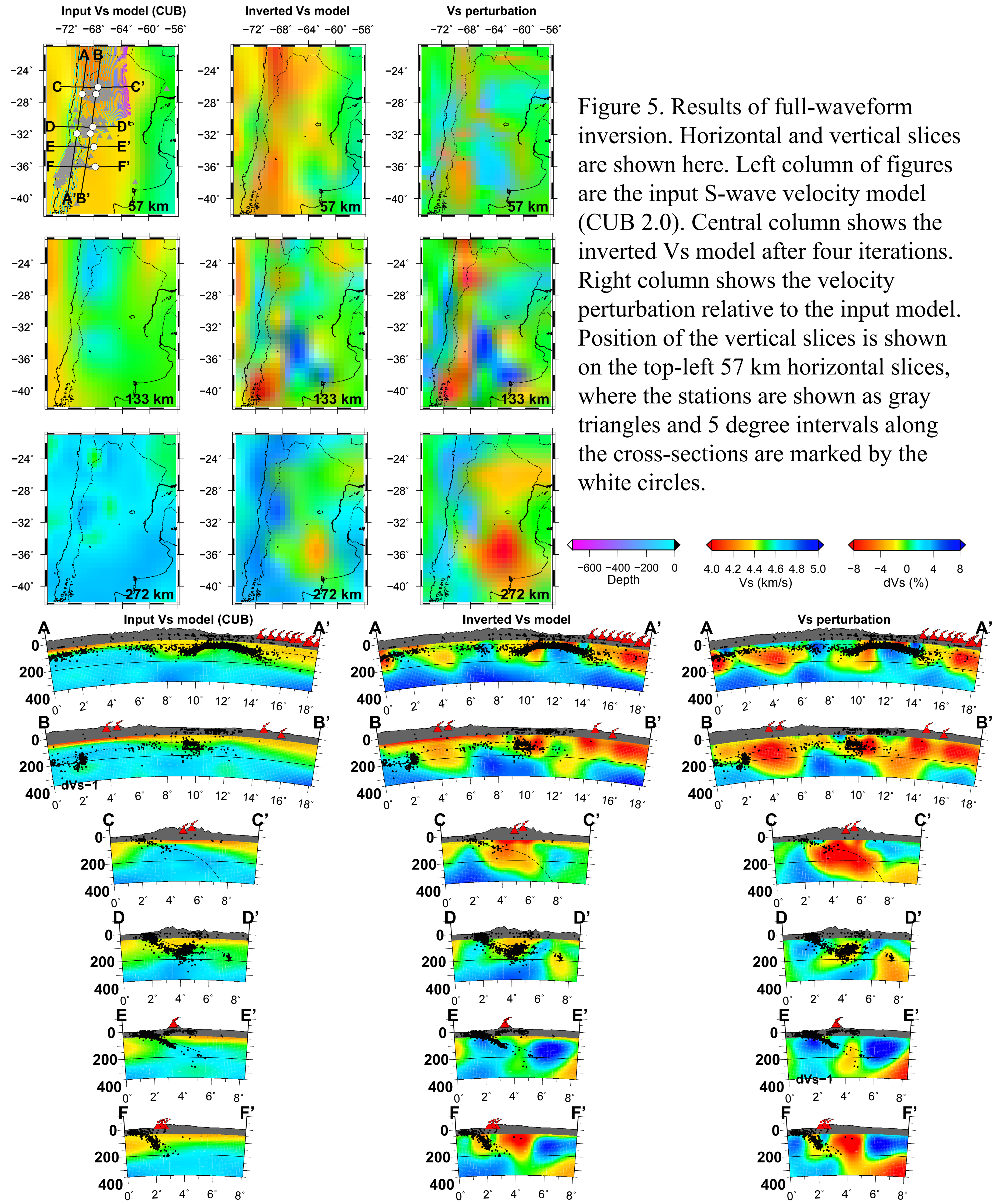

Figure 5. Results of full-waveform inversion. Horizontal and vertical slices are shown here. Left column of figures are the input S-wave velocity model (CUB 2.0). Central column shows the inverted Vs model after four iterations. Right column shows the velocity perturbation relative to the input model. Position of the vertical slices is shown on the top-left 57 km horizontal slices, where the stations are shown as gray triangles and 5 degree intervals along the cross-sections are marked by the white circles.

Take Home Messages :

1. We see Strong along-strike velocity variations within the mantle wedge and the subducting NAZCA slab.

2. Upper mantle velocity beneath the Sierras Pampeanas is faster than the upper mantle beneath SVZ and CVZ.

3. Resolution of shallow structure is limited by the minimum period of EGFs and minimum grid size of the finite difference calculation.