Annual Report for 2002 SCEC Grant

"Large-scale 3D Crust and Upper Mantle Structure in Southern California from TriNet Broadband Data Set"

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Primary Focus Group: Structural Representation

The purpose of the project was to develop a seismic model that constrains the long-wavelength components in seismic velocity variations, and satisfies surface waves and body-wave data from TriNet. During 2002, we collected further data and performed separate inversions for surface waves and body waves.

(1) Analysis Technique Development: We first fine-tuned our phase velocity measurement technique for the dense seismological data set from TriNet. The technique is basically a two-station method of phase velocity measurement. The best approach we arrived at was a type of waveform inversion approach performed in the frequency domain. For the teleseismic body waves, we began collecting teleseismic data recorded by TriNet from 2000-2001. We found that events with magnitudes _ 6.5 displayed very good signal-to-noise for picking S-wave phases. We selected events with distances <~95_ and picked S-wave arrival times from the radial component for 17 events, resulting in about 1200 arrival time measurements. The preliminary inversions were carried out using the travel-time anomaly approach for velocity perturbations described in Kohler et al. (2002). Crustal effects were removed using the SCEC CVM 2.0.

(2) Surface Wave Phase Velocity Maps: We expanded our data set and derived phase velocity maps from Rayleigh and Love wave data. Path coverage and the number of measurements at various frequencies are shown in Figure 1. The frequency range for Love waves was smaller because of low signal/noise ratio as well as higher mode contaminations (at lower frequencies). We measured Rayleigh wave phase velocity from 98 events and Love wave phase velocity from 73 events. Resulting phase velocity maps at selected frequencies are shown in Figure 2.

(3) Surface-wave Inversion: The phase velocity measurements for Rayleigh and Love waves were inverted for S-wave velocity variations with depth. As a preliminary attempt, we used the SCEC 3D velocity model version 2.0 as the starting model (Magistrale et al., 2000) and obtained the model shown in Figure 3. Some of the notable observations are that:

- The velocity contrast across this plate boundary region is apparent and extends beyond the Moho. A contrast in the crust was reported, for example, by Hauksson (2000), and Helmberger et al. (2001). The velocity contrast in the mantle is confirmed in depth slices A and B in Figure 3. We have performed different cases of the inversion, one perturbing the crustal parameters (away from SCEC 2.0) and the other fixing the crustal parameters. In either case, the structural contrast in the mantle persisted and seems to be a robust feature. There is a hint that the boundary (zero line) of this velocity contrast is close to the San Andreas in the northern region but tends to shift to the west of the San Andreas in the southern region, closer to the San Jacinto fault.
- The crust in the Mojave Desert is characterized by very low anomalies in the mid to lower crust. These anomalies are distributed in the northwest-southeast direction and seem to lie under the major faults in the Eastern California Shear Zone.
- Two major low-velocity anomalies exist, one under the Salton Sea (Slice B in Figure 3) and the other under the Southern Sierra.
- There is a distinct high-velocity anomaly under the Peninsular Range in the area just north of San Diego (slices B and C). This anomaly is almost as distinct as the high-velocity anomaly under the Transverse Ranges (e.g., Humphreys and Clayton, 1990), as the slice C in Figure 3 shows

(4) Body-wave Inversion: The teleseismic body-wave S-wave travel-time anomalies were inverted for velocity perturbations for varying depth in the uppermost mantle. Unlike the phase-velocity approach, we assumed that the CVM contains the full crustal effect and placed all remaining travel-time anomaly in the mantle. Figure 4 shows preliminary tomographic images from the inversion of S-wave body-wave travel-time anomalies. The images show large-scale features both similar and different from the P-wave and surface-wave results. There is a large high-velocity region beneath the eastern Transverse Ranges extending to at least 170 km depth. However, there is no such distinct feature beneath the westernmost Transverse Ranges or the Peninsular Ranges. It remains to be determined if this is just due to our relatively small initial data set, or if there are differences in the sources of P- and S-wave anomalies or crustal corrections.

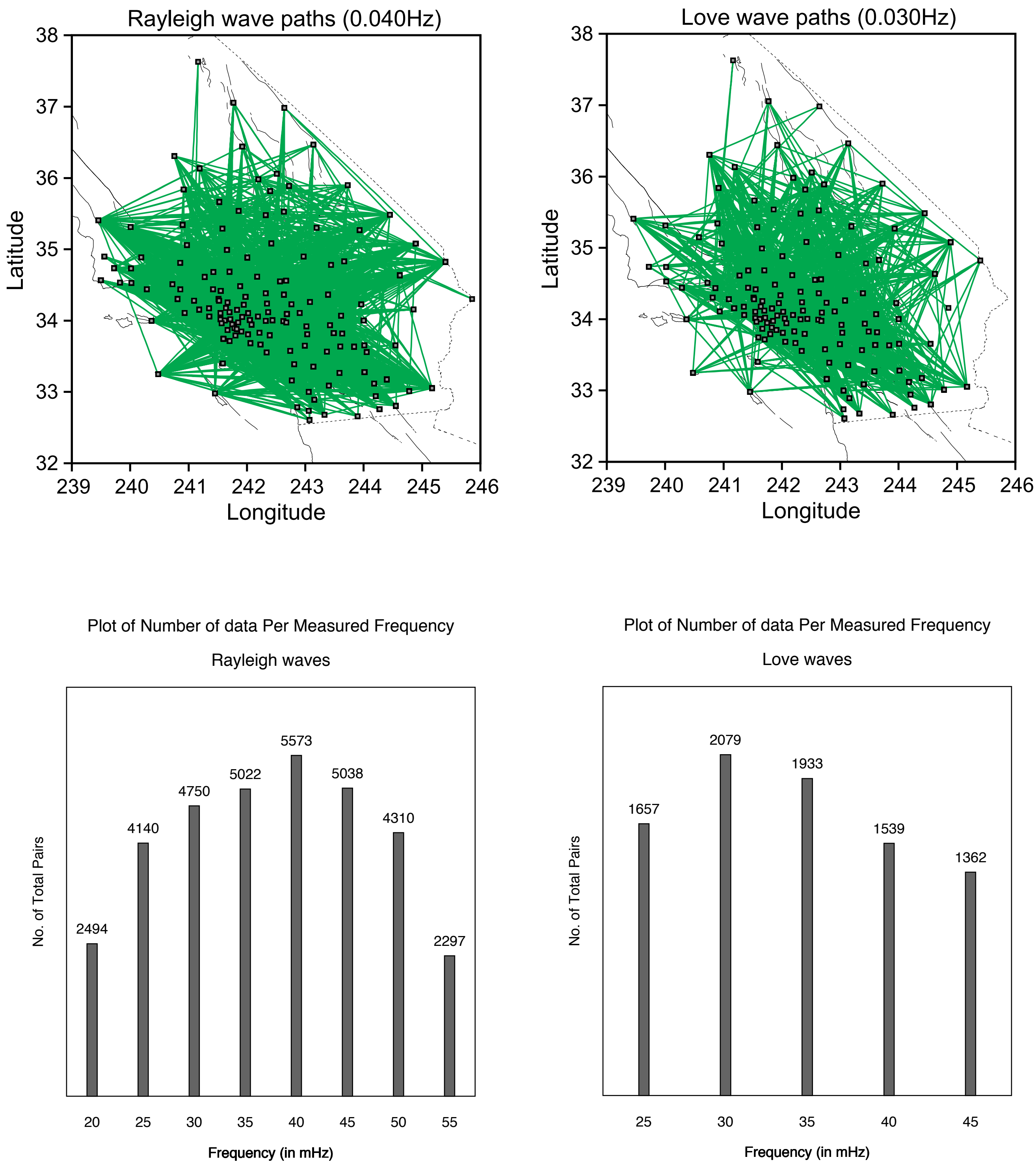

Figure 1: Path coverage for Rayleigh (40 mHz) and Love (30 mHz) waves, The bottom figures show the number of measurements at each frequency.

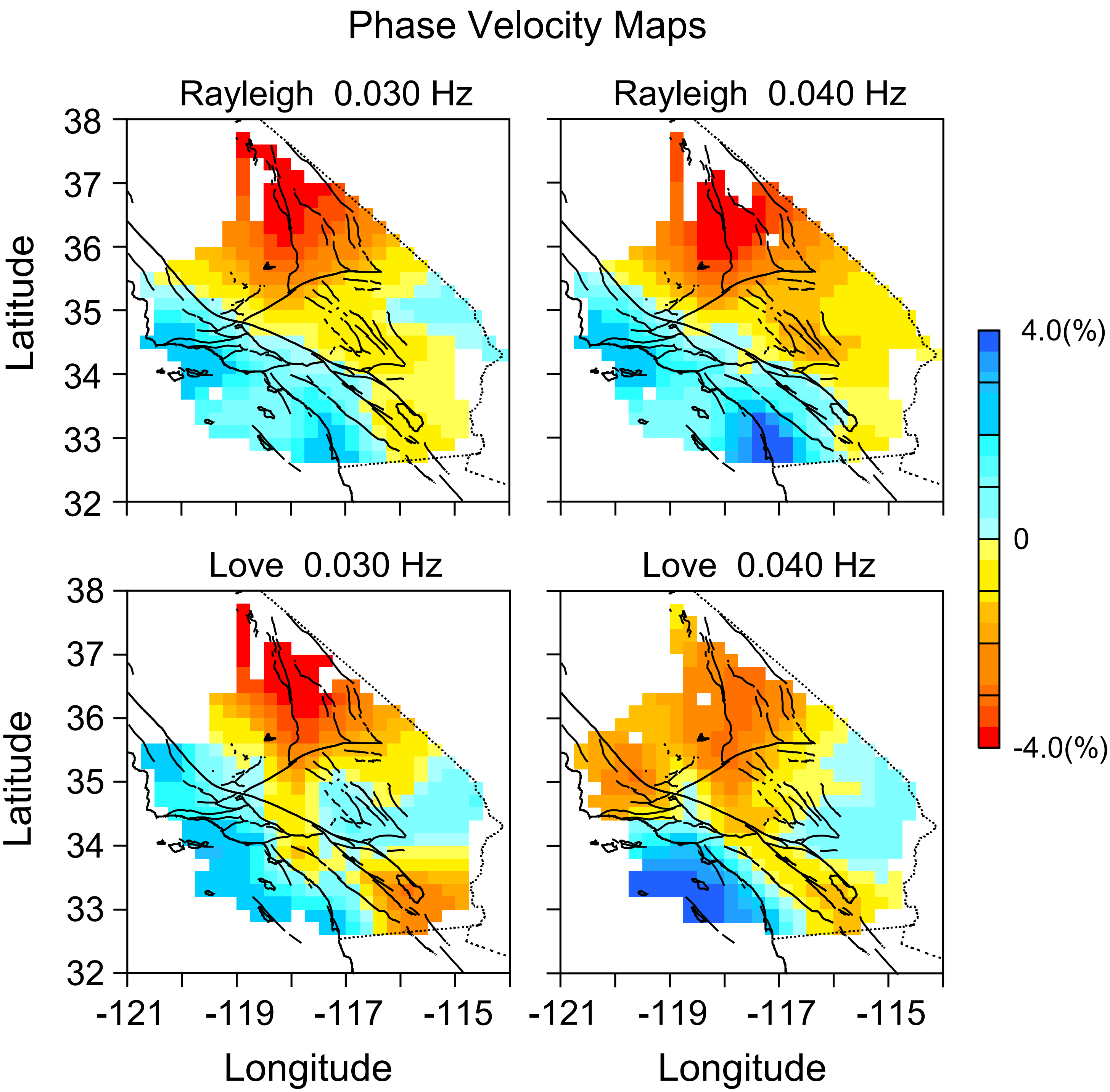

Figure 2: Phase velocity maps for Rayleigh and Love waves. Velocity contrast across San Andreas is clear in Rayleigh wave maps. Data from 98 earthquakes were used to create Rayleigh wave maps and data from 73 earthquakes were used for Love wave maps.

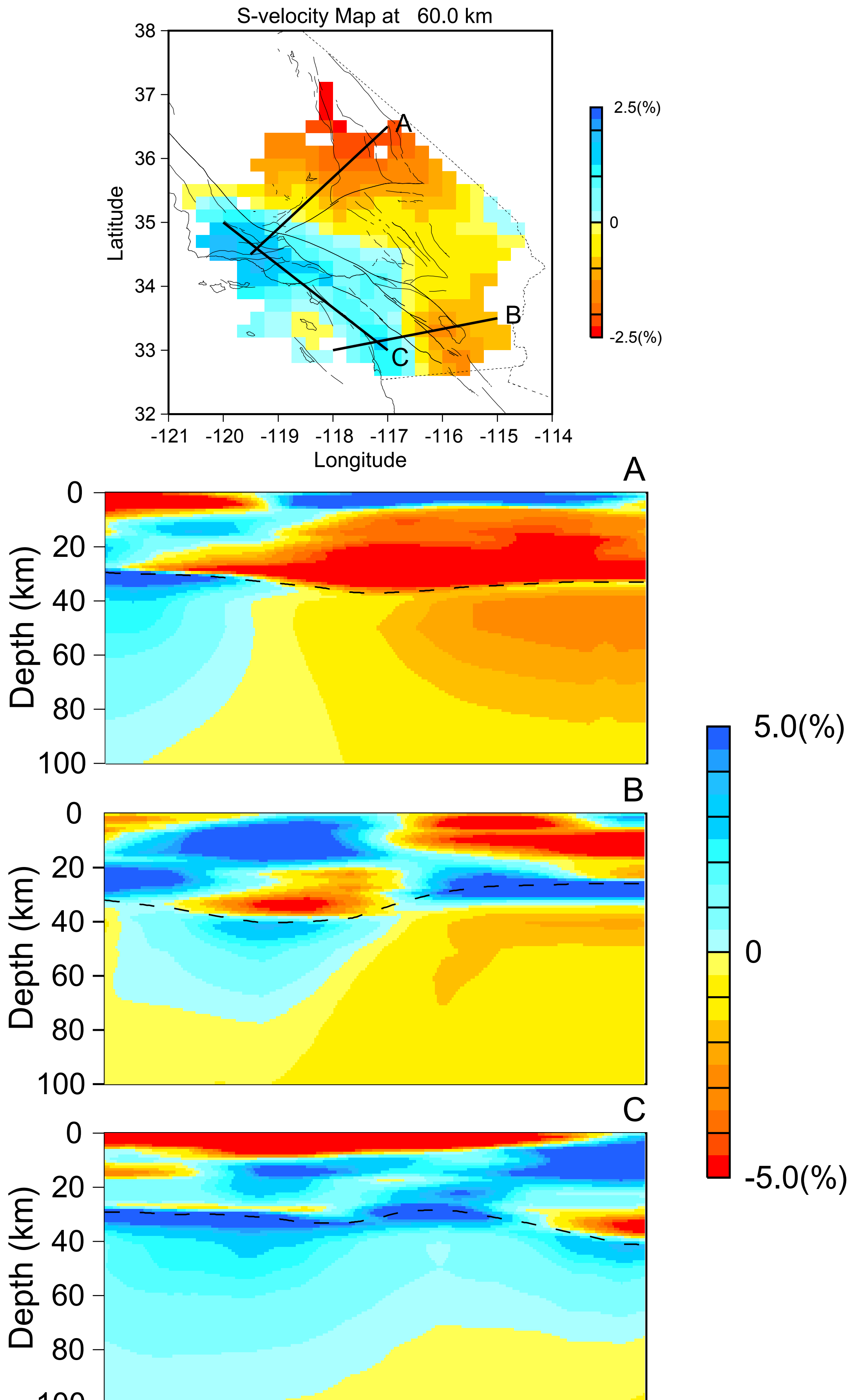

Figure 3: Depth slices along the profiles shown in the top figure.

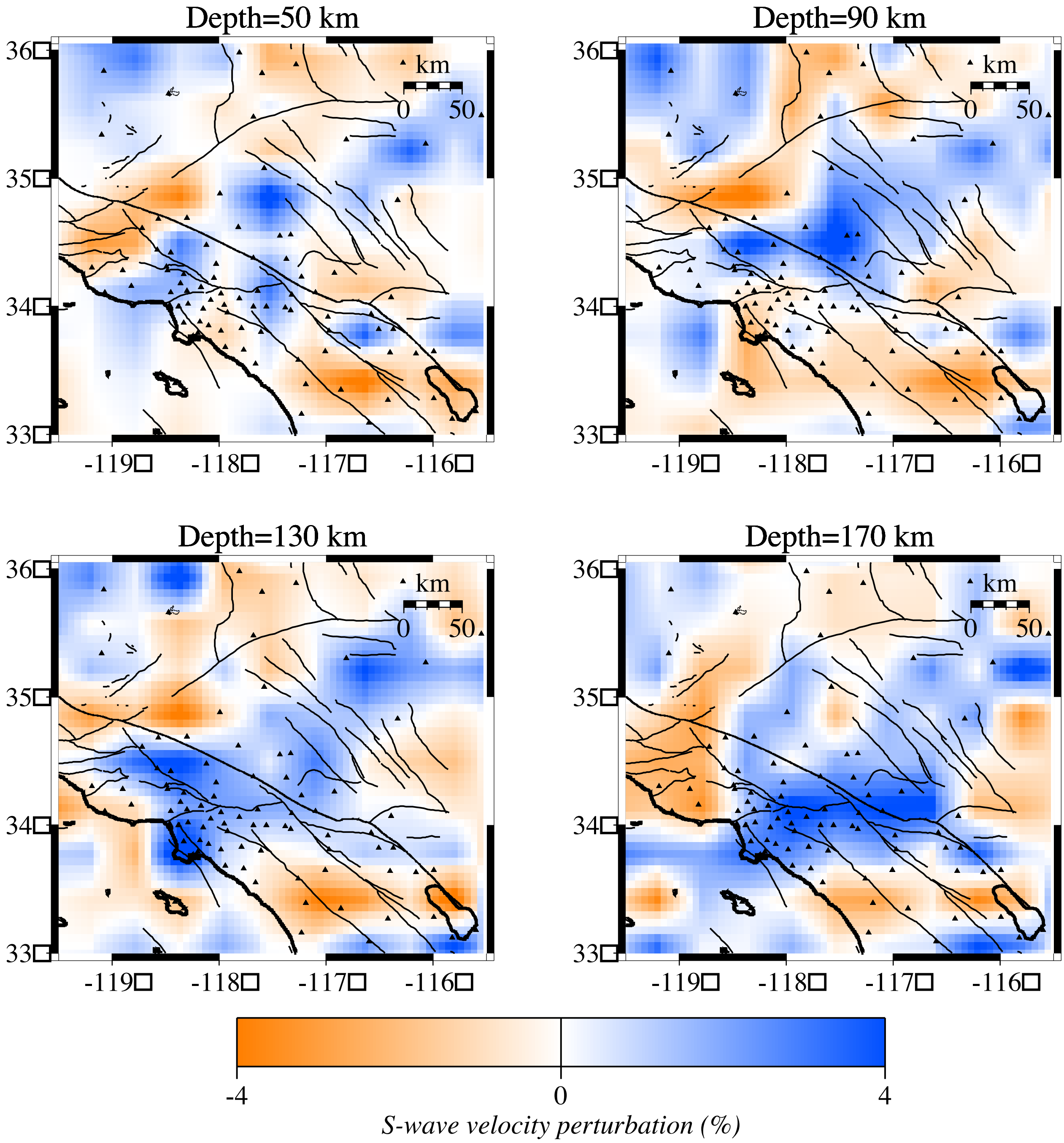

Figure 4: S-wave velocity variations from travel-time inversion of radial component S waves.