Figure 5 is interactive and can be activated by clicking on the figure. Move mouse across hemisphere map (in the lower right) to display results from a particular back azimuth (Baz). If you are reading the full-text html version of the paper, please view the PDF of this paper or visit https://doi.org/10.1130/GES02093.5i to interact with Figure 5.

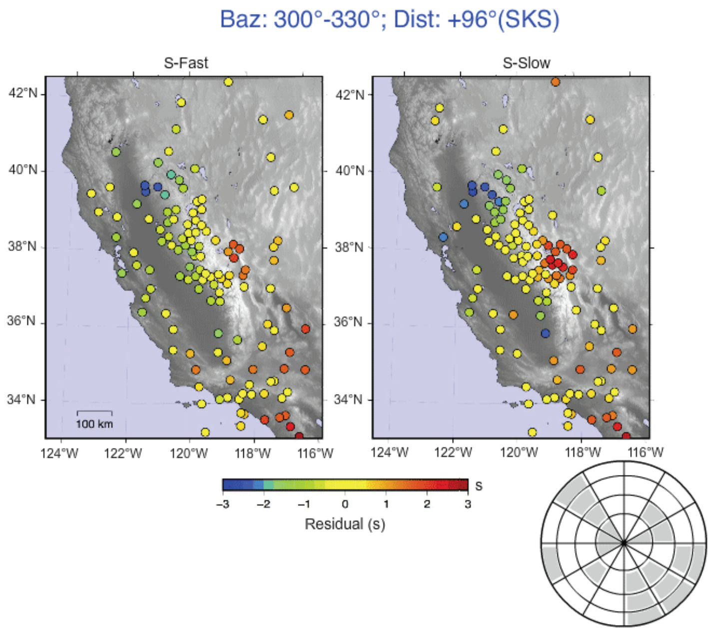

Figure 5. Map of S_{Fast} and S_{Slow} residuals with respect to a predicted arrival time using the one-dimensional (1-D) IASP91 seismic model (Kennett and Engdahl, 1991; interactive). Early (late) arrivals are denoted in cooler (warmer) colors. To interact with figure, click on figure to activate. Move mouse across hemisphere map (in the lower right) to display results from a particular back azimuth (Baz). If you are reading the full-text html version of the paper, please view the PDF of this paper or visit https://doi.org/10.1130/GES02093.5i to interact with Figure 5.

with incidence angle and back azimuth. Delays were most significant and coherent for SKS phases (epicentral distances greater than 96°; Fig. 5I). Variations in these delayed arrivals with back azimuth and distance were not as prominent as those related to the Isabella anomaly, suggesting a shallower source. However, the slight azimuthal variations are sufficient to preclude a purely crustal origin for this feature.

Inversion Parameterization

We modified an existing iterative, spherical, finite-difference (FD) tomography code, *sphfd* (Roecker et al., 2006), to include separate fast and slow shear-wave arrival times. This code performs a weighted, damped least squares inversion designed to optimize the trade-off between data and model misfit through appropriate damping and smoothing parameters. Our model space was parameterized by a set of nodes laid on a rectangular grid at specified depths. This inversion scheme incorporated the use of coarse and fine grids, where the coarse grid was used for the traveltime inversion, and the finer grid was used for calculating raypaths and traveltimes. The coarse grid spacing was an integer multiple of the fine grid's spacing. Similar to Jones et al. (2014), our coarse interval was set to ~25 km within our region of interest. Grid spacing increased toward the edges of our model to allow for teleseisms to enter at the base of our model and not on the sides. Nodes were placed at depths of −30, 0, 20, 40, 70, 120, 170, 220, 270, 320, and 430 km below sea level. P-, S_{Fast}-, and S_{Slow}-wave arrival times were inverted to obtain 3-D perturbations in Vp, Vp/Vs_{Mean}, and anisotropy, defined in this study as:

$$R \equiv V_P / V_{S_{Mean}} = \frac{2V_P}{V_{S_{Fast}} + V_{S_{Slow}}}, \tag{1}$$

$$A = \frac{V_{S_{Mean}} - V_{S_{Slow}}}{V_{S_{Mean}}}, \tag{2}$$

$$V_{S_{Fast}} = \frac{V_P}{R} * (1 + A), \tag{3}$$

$$V_{S_{Slow}} = \frac{V_P}{R} * (1 - A), \tag{4}$$

where A is anisotropy (though half of a more common definition of anisotropy). S_{Fast} and S_{Slow} velocities were determined from Equations 3 and 4. Note that we inverted for Vp/Vs_{Mean} instead of Vs, a choice that avoids spurious Vp/Vs anomalies where either Vp or Vs observations are insufficient to constrain that wave-speed model.

Iterative Scheme

Traveltimes were computed using a finite difference solution to the eikonal equation modified from Hole and Zelt (1995). Two sets of traveltimes were calculated. First, times from each station to the bottom edge of the model space were calculated. Next, traveltimes from each earthquake to the base of the model were computed and then added to the previous times. The earliest arrivals were used as the predicted P- and S-wave arrival times. The partial derivatives of traveltime with respect to slowness were determined separately for S_{Fast} and S_{Slow} and related changes in slowness, Vp/Vs_{Mean}, and anisotropy to traveltime residuals. S_{Fast} and S_{Slow} partial derivatives relating our traveltime observables to our model parameters at each grid point, i, along a raypath were calculated as:

$$\sum \frac{\partial t}{\partial \psi_{S_{Fast_i}}} \Delta\psi_{S_{Fast_i}} = \sum \frac{\partial t}{\partial \psi_{S_{Fast_i}}} \Delta\left[\frac{R_i \psi_{P_i}}{1 + A_i}\right]$$
$$= \sum \frac{\partial t}{\partial \psi_{S_{Fast_i}}} \left[\frac{R_i}{1 + A_i}\Delta\psi_{P_i} + \frac{\psi_{P_i}}{1 + A_i}\Delta R_i - \frac{\psi_{P_i} R_i}{(1 + A_i)^2}\Delta A_i\right], \tag{5}$$