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A comparison of finite-frequency and ray approaches in local tomography

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We determined detailed 3-D P and S wave velocity models of the crust in the 1995 Kobe earthquake (M 7.2) area in Southwest Japan using both finite-frequency and ray tomography methods. Our finite-frequency tomography technique is based on the single-scattering theory (Tong et al., 2011). The finite-frequency sensitivity kernel derived in this study reflects correctly the sensitivity of the heterogeneity off the geometrical ray path and the existence of Fresnel volume, and the kernel depends on the dominant frequency of the observed wave. The dominant frequency is estimated directly from the earthquake magnitude based on a relation that is obtained by regressively analyzing the displacement spectra of 20 earthquakes in the study area. We used a great number of P and S wave high-quality arrival-time data from the Kobe aftershocks and other local earthquakes during 2002 to 2010. Our tomographic images obtained with the finite-frequency and ray tomography methods show a high level of similarity, which is verified quantitatively by adopting the structural similarity index. Similar to the previous studies (e.g., Zhao et al., 1996), the present results show that the Kobe mainshock hypocenter is located in a distinctive zone characterized by a high Poisson's ratio and a low product of P- and S-wave velocities, which is interpreted as a fluid-filled, fractured rock matrix that may have triggered the 1995 Kobe earthquake. The crustal fluids in the Kobe hypocenter are considered to originate from the dehydration of the subducting PHS slab beneath Southwest Japan (Zhao et al., 2002, 2010).

Keywords: ray theory, finite-frequency, tomography, crustal structure, earthquakes