

Seismic ray path variations in a 3-D global velocity model with lateral depth variations of discontinuities

Jianshe Lei[1]; Dapeng Zhao[1]

[1] GRC, Ehime Univ

A new 3-D ray tracing technique of Zhao (2001) was applied to a global model with P wave velocity variations in three dimensions (Zhao, 2001) and with lateral depth variations of the Moho, 410, and 660 km discontinuities (Mooney et al., 1998; Flanagan and Shearer, 1998) to investigate ray path variations of P, PcP, pP, and PP waves. Although examining seismic rays along many cross sections, here we show examples for three profiles: West Pacific to East Asia, South Pacific, and Himalaya. From West Pacific to East Asia there is a pronounced high-velocity anomaly which corresponds to the subducting Pacific slab beneath the Eurasian plate. In South Pacific there is a strong low-velocity anomaly corresponding to the Pacific Super-plume. Under the Himalaya mountains the Moho discontinuity deepens from 39 to 60 km. Different effects of the velocity anomalies and undulations of the Moho, 410 and 660 km discontinuities on ray paths are investigated separately and compositively.

Our results show significant deviations of ray paths in the 3-D velocity model from those in the 1-D iasp91 Earth model. For a PcP wave in South Pacific, the ray path variation amounts to 77 km, while from West Pacific to East Asia it amounts to 27 km. In Himalaya a P-wave ray path with an epicenter distance of 10 degrees deviates about 17 km because of the Moho depth changes. Composite effects of the velocity anomalies and the Moho, 410 and 660 km discontinuities cause P-wave ray changes of about 50 km in South Pacific. Changes in travel times are as large as 3.9 s. These results suggest that although the maximum velocity anomalies of 1-2% and discontinuity undulations of tens of kilometers exist in the model, ray path and travel time change considerably when a ray passes through areas with significant velocity variations and with a large topography of discontinuities. Therefore, if the blocks or grid nodes adopted in the inversion are 3-5 degrees and only a low-resolution model is estimated, 1-D ray tracing is feasible. But if fine blocks or grid nodes are used to determine a high-resolution model, 3-D ray tracing becomes important and necessary for the global tomography.