How well can mantle plumes be imaged by global tomography?

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Hotspot volcanoes such as Hawaii and Iceland exist on the Earth, which are either active intraplate volcanoes or exceptionally large volcanoes located on the mid-ocean ridges. The mantle-plume hypothesis was proposed about forty years ago to explain the origin of hotspot volcanoes (Wilson, 1963; Morgan, 1971). A mantle plume is thought to be a hot upwelling flow from the deep mantle. Its maximum temperature seems to be 250 to 500 K higher than that of the normal mantle. However, it is still a debating issue whether mantle plumes actually exist, and even if they exist, many questions remain such as their depth origin, number, distribution and so on.

In this work, we have tried to investigate mantle plumes in detail using our whole-mantle P-wave tomographic model (Tohoku-model). The Tohoku-model was determined by using about 2.5 million arrival times from 21,752 earthquakes selected from the EHB-ISC catalog during 1964 to 2004. We used five kinds of P-wave data: direct P, pP, PP, PcP and P-diff waves. A flexible-grid parameterization is adopted to express the 3-D velocity structure of the crust and mantle. The grid interval is ˜200 km in the lateral direction and 50-200 km in depth.

Mantle plumes are hard to detect because most of them are located in oceanic regions where few seismic stations exist, though the use of reflected waves in the mantle (PP, PcP, etc.) in this work has improved the ray-path coverage in the mantle under oceanic regions. In this work, we conducted many synthetic tests on the resolvability of mantle plumes which should show up as low-velocity anomalies. In the synthetic models, we put low-velocity anomalies with different thicknesses and depth ranges under the possible hotspots on Earth. Then we calculate and invert the synthetic arrival-time data, and then we compare the inverted results with the input models. Our results show that mantle plumes under some hotspots like Iceland, Easter and Afar can be well reconstructed with a resolution of about 200 km, while other plumes like the Hawaiian plume have poor resolution in the middle mantle. The tests results for many plumes will be shown in the presentation. We will also discuss whether super-plumes or plume-clusters exist under the South Pacific and Africa.