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A mega Ultra Low Velocity Zone at the Base of the Iceland Plume: a Target for Tomographic Telescope Implementation

Barbara Romanowicz (1), Kaiqing Yuan (2), Yder Masson (3), and Sevan Adourian (2)

(1) College de France, Paris - U.C. Berkeley, Berkeley Seismological Laboratory, Berkeley, CA, United States (barbara.romanowicz@gmail.com), (2) Berkeley Seismological Laboratory, U.C. Berkeley, (3) Institut de Physique du Globe, Paris, France

We have recently constructed the first global whole mantle radially anisotropic shear wave velocity model based on time domain full waveform inversion and numerical wavefield computations using the Spectral Element Method (French et al., 2013; French and Romanowicz, 2014). This model's most salient features are broad chimney-like low velocity conduits, rooted within the large-low-shear-velocity provinces (LLSVPs) at the base of the mantle, and extending from the core-mantle boundary up through most of the lower mantle, projecting to the earth's surface in the vicinity of major hotspots. The robustness of these features is confirmed through several non-linear synthetic tests, which we present here, including several iterations of inversion using a different starting model than that which served for the published model.

The roots of these not-so-classical "plumes" are regions of more pronounced low shear velocity. While the detailed structure is not yet resolvable tomographically, at least two of them contain large (>800 km diameter) ultra-low-velocity zones (ULVZs), one under Hawaii (Cottaar and Romanowicz, 2012) and the other one under Samoa (Thorne et al., 2013). Through 3D numerical forward modelling of Sdiff phases down to 10s period, using data from broadband arrays illuminating the base of the Iceland plume from different directions, we show that such a large ULVZ also exists at the root of this plume, embedded within a taller region of moderately reduced low shear velocity, such as proposed by He et al. (2015). We also show that such a wide, but localized ULVZ is unique in a broad region around the base of the Iceland Plume. Because of the intense computational effort required for forward modelling of trial structures, to first order this ULVZ is represented by a cylindrical structure of diameter $\sim$900 km, height $\sim$20 km and velocity reduction $\sim$20%.

To further refine the model, we have developed a technique which we call "tomographic telescope", in which we are able to compute the teleseismic wavefield down to periods of 10s only once, while subsequent iterations require numerical wavefield computations only within the target region, in this case, around the base of the Iceland plume. We describe the method and preliminary results of its implementation.