FINITE FREQUENCY AND REGIONAL TOMOGRAPHY

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Abstract
One of the primary tools for investigation of deep Earth structure is seismic tomography. Most methods use ray-theory, which is a good approximation for 1 Hz seismic data but becomes problematic at longer periods. Oceanic noise levels are relatively high between 0.5 and ~10 seconds, preventing detection of seismic arrivals at these periods. Instead, we must use data with periods below ~10 seconds where the noise levels are significantly reduced. It is therefore important to consider finite frequency effects when interpreting the longer period datasets collected during ocean bottom experiments.

Here, we report the results of an investigation designed to test the significance of finite frequency effects for a hundreds-of-kilometers scale geological object in the upper mantle as imaged with a regional-scale seismic deployment. We use the broadband HOTSPOT dataset from the recent PASSCAL deployment across Iceland and investigate the nature of finite frequency effects on the structure of the low-velocity anomaly imaged beneath the array. The array is capable of imaging to ~400 km depth.

The ray theoretical image of mantle structure can be approximated as a low-velocity vertical cylinder extending from 400 to 200 km depth with a Gaussian-shaped cross-section and a Gaussian diameter of 200 km. Above 200 km the low velocity region spreads out horizontally. Using the Spectral Element Method (SEM) to investigate full 3D waveform propagation effects we derive traveltime delay maps for synthetic Gaussian cylinders of various diameters and compare them with ray-theoretical delay maps. When using ~20 second data, the delay map footprints on the SEM maps are much broader than the ray-theoretical ones, implying that the cylindrical anomaly beneath Iceland is narrower than ray-theoretical tomography suggests. Also, the SEM delay maps generated from 100 and 200 km diameter anomalies are similar in width, suggesting a lack of sensitivity to variations in mantle structure on this scale. We use these tests to present bounds on the geometry of the anomaly beneath Iceland.