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Updated Outer Core Reference Model from a Bayesian Inversion of Normal Mode Eigenfrequencies

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The outer core is arguably Earth's most dynamic region, and consists of an iron-nickel liquid with an unknown combination of lighter alloying elements. Frequencies of Earth's normal modes provide the strongest constraints on the radial profiles of compressional wavespeed, VΦ, and density, , in the outer core. Recent great earthquakes have yielded new normal mode measurements; however, mineral physics experiments and calculations are often compared to the Preliminary Reference Earth model (PREM), which is 35 years old and does not provide uncertainties. Here we investigate the thermo-elastic properties of the outer core using Earth's free oscillations and a Bayesian framework.

To estimate radial structure of the outer core and its uncertainties, we choose to exploit recent datasets of normal mode centre frequencies. Under the self-coupling approximation, centre frequencies are unaffected by lateral heterogeneities in the Earth, for example in the mantle. Normal modes are sensitive to both VΦ and in the outer core, with each mode's specific sensitivity depending on its eigenfunctions. We include a priori bounds on outer core models that ensure compatibility with measurements of mass and moment of inertia as well as satisfying other physical requirements.

We use Bayesian Monte Carlo Markov Chain techniques to explore different choices in parameterizing the outer core, each of which represents different a priori constraints. We test how results vary assuming a smooth polynomial parametrization (similar to PREM), or assuming an Equation-of-State and adiabaticity and inverting directly for thermo-elastic parameters. Independent of the parameterisation we find that the top of the outer core is denser and has a steeper velocity profile than suggested by PREM. The velocity model we propose from our inversion of normal modes is in good agreement with velocity models based purely on body waves.