Behavior at the boundaries of our world: What can we learn about core and mantle dynamics from long and short period seismology?

Jessica C.E. Irving,[1] Alexander L. Burky,[1] Wenbo Wu,[2]
Sanne Cottaar,[3] Vedran Lekic,[4] Sidao Ni,[5] Frederik J. Simons[1]

Seismology provides 'snapshot' images of the current state of Earth's interior. Seismologists can detect arrivals of high frequency signals from waves traveling along simple or complicated paths from an earthquake to a seismometer, and also sense the frequency of whole Earth vibrations, or normal modes, after particularly large earthquakes. Both of these kinds of observations can be used to probe the Earth's physical properties, including the location of seismic discontinuities and their nature, and the bulk properties of its constituent layers. This information can then be used provide insights into its dynamical behavior, allowing us to interpret our 'snapshots' as part of the evolution of Earth's interior.

The outer core turbulently convects to provide Earth's magnetic field, thus the bulk outer core is expected to be very well-mixed and have a uniform composition. However, it is possible that the uppermost outer core hosts a stratified layer, which may be enriched in 'light' elements relative to the rest of the outer core. We use the frequencies of normal mode oscillations to assess whether a stratified layer, termed the E' layer, is required by these globally sensitive data, and consider the dynamic implications of such a layer.

The mantle transition zone (MTZ) occupies a ~250km thick span of the mantle, separating the upper mantle composed predominantly of olivine from the perovskite-dominated lower mantle. The interfaces at the top and bottom of the MTZ can be imaged using both reflected and converted seismic waves. We use asymmetrically reflected high frequency seismic waves to assess the amount of scattering at the base of the MTZ, and make a spot measurement of the transition zone thickness using converted seismic waves. We interpret both of these observations in the context of material flow in the mantle as it convects.

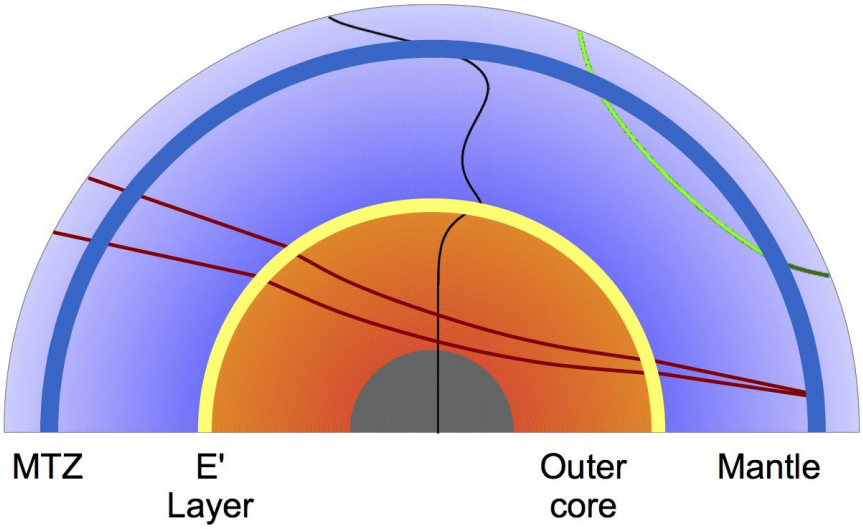

Figure: A schematic cross section of the Earth, indicating the approximate locations of the mantle transition zone (MTZ) and E' layer, together with a normal mode eigenfunction (black) and body wave paths (red and green).

[1] Princeton University, [2] Caltech, [3] University of Cambridge, [4] University of Maryland College Park,
[5] Institute of Geodesy and Geophysics, Chinese Academy of Sciences, Wuhan