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Constraining lowermost mantle structure using seismic observations of Earth's long period free oscillations

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The Earth's lowermost mantle (also called D") is bounded by a thermal boundary layer forming a discontinuous interface with the core. The range of seismic structures found in this region, including ultra low velocity zones, anisotropy, discontinuities and anti-correlations between shear and bulk sound velocity, rival the structures found in the lithosphere, the mantle's top thermal boundary layer. The majority of these structures have been found using body wave observations, but normal mode observations have been lacking. Even though seismic body wave studies of the core mantle boundary region have revealed a range of structures, many fundamental questions remain unanswered, including: Is there partial melting or compositional heterogeneity? What causes ultra low velocity layers? Which is the importance of post-perovskite?

Here, we will use long period whole Earth oscillations to study structures that have only been studied using short period body waves before. The splitting of Earth's free-oscillation spectra is especially interesting, because they place important constraints not only on the wave speed but also on the density structure of the Earth's mantle. We present a new set of splitting functions for mantle sensitive modes, of which almost half had not been measured before. In particular, we have made measurements of Stoneley modes which are uniquely sensitive to the core mantle boundary region, and have also added over 30 new modes which are predominantly sensitive to compressional velocity. Our observations are derived from modal spectra up to 10 mHz for 91 events with Mw $\geq$ 7.4 from the last 34 years (1976–2010). Our data include the 23 June 2001 Peru event (Mw=8.4), the Sumatra events of 2004 (Mw=9.0) and 2005 (Mw=8.6), the 2008 Wenchuan, China event (Mw=7.9) and the 2010 Chile event (Mw=8.8). The new events provide significant improvement of data coverage particularly in continental areas.

We are using our new measurements in a tomographic inversion for mantle shear and compressional velocity, especially focussing on the lower most mantle region and D". The addition of compressional sensitive modes provides improved constraints on the large scale compressional structure, and on the scaling ratio between $\delta v_s/v_s$ and $\delta v_p/v_p$, allowing us to estimate the amount of compositional heterogeneity in the lowermost mantle.