A new 3-D mantle density model from recent normal-mode measurements

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Constraints on the 3-D density structure of Earth's mantle provide important insights into the nature of seismically observed features, such as the Large Low Shear Velocity Provinces (LLSVPs) in the lower mantle under Africa and the Pacific. The only seismic data directly sensitive to density variations throughout the entire mantle are normal modes: whole Earth oscillations that are induced by large earthquakes ($M_w > 7.5$). However, their sensitivity to density is weak compared to the sensitivity to velocity and different studies have presented conflicting density models of the lower mantle. For example, Ishii & Tromp (1999) and Trampert et al. (2004) have found that the LLSVPs have a larger density than the surrounding mantle, while Koelemeijer et al. (2017) used additional Stoneley-mode observations, which are particularly sensitive to the core-mantle boundary region, to show that the LLSVPs have a lower density. Recently, Lau et al. (2017) have used tidal tomography to show that Earth's body tides prefer dense LLSVPs.

A large number of new normal-mode splitting function measurements has become available since the last density models of the entire mantle were published. Here, we show the models from our inversion of these recent data and compare our results to previous studies. We find areas of high as well as low density at the base of the LLSVPs and we find that inside the LLSVPs density varies on a smaller scale than velocity, indicating the presence of compositionally distinct material. In fact, we find low correlations between the density and velocity structure throughout the entire mantle, revealing that compositional variations are required at all depths inside the mantle.