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Linking mineral physics and geodynamic mantle models

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In the past two decades geophysical studies of deep Earth structure have become increasingly sophisticated and have provided considerable insight into the physical state of our planet. Notable advances include detailed seismic images of the Earth's interior, thermodynamically consistent density and elastic models of the mantle, and geodynamic models that simulate convection processes at high numerical resolution in two and three dimensions. Particularly the recent experimental and theoretical progress in Mineral Physics has made it possible to build self-consistent models of the (dry) phases of the Earth's mantle. The models are based exclusively on physical and thermodynamical measurements. They are thus entirely independent on seismological constraints. In light of this progress it is desireable to bring mineral physics model of elastic constants and densities to bear on mantle convection models, even more so since the mineral physics models provide thermodynamically self-consistent descriptions of important mantle phase reactions. Here we have constructed a new thermodynamic database for the mantle and have coupled the resulting density dynamically with mantle convection models. The database is build on a self-consistent Gibb's free energy minimisation of the system MgO-FeO-SiO2-CaO-Al2O3 that is appropriate for standard (dry) chemical models of the Earth's mantle for relevant high pressure and temperature phases. We have linked the database with a high-resolution 2-D convection code (2DTERRA), dynamically coupling the thermodynamic model (density) with the conservation equations of mantle flow. The coupled model is run for different parameterisations of viscosity, initial temperature conditions, and varying the internal vs. external heating. We compare the resulting flow and temperature fields to cases with the Boussinesq approximation and other classical descriptions of the equation of state in mantle dynamics to assess the influence of realistic mineralogical density on mantle convection