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Global models of mantle flow and density from geodynamic considerations

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TOPO EUROPE will provide unprecedented linkages between deep-seated dynamic processes in the Earth's interior and their topographic response at the surface. Mass anomalies in the Earth's mantle are a key controlling factor in this effort, because they initiate up- and downwelling flow and thereby elevate or depress the surface over extended regions for prolonged periods of time. To trace, quantify and forecast topography evolution in response to deep-seated solid-earth processes, it is essential to combine detailed mass budget considerations of the mantle with the dynamic considerations embedded in modern models of the mantle circulation. There exists well-known a-priori information on the mass budget of the mantle in the form of density models derived from histories of subduction. Here we report on one such effort to directly quantify the thermally induced mantle density structure from a history of plate motion assimilated in global mantle circulation models. Key advances to the dynamic model include (1) a thermodynamically self-consistent formulation of the mantle mineralogy and (2) a very high numerical resolution sufficient to resolve (for the first time) global mantle flow at Earthlike convective vigour. The latter is needed to resolve thermal boundary layers at the appropriate time- and length-scales. We apply our model to gain better insight on the impact of hot thermal upwellings on the mantle density budget, which is important because recent geodynamic studies have favoured a larger heat flux across the core-mantle boundary than prior estimates. We test the sensitivity of mantle density models to a range of core heat flux values.