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Correlation between mobile continents and elevated temperatures in the subcontinental mantle

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Rolf et al. (EPSL, 2012) and Coltice et al. (Science, 2012) have previously shown that continents exert a first order influence on Earth's mantle flow by affecting convective wavelength and surface heat flow. With stationary continents, Heron and Lowman (JGR, 2014) highlighted the decreasing role of continental insulation on subcontinental temperatures with higher Rayleigh number (Ra). However, the question whether there exists a correlation between mobile continents and elevated temperatures in the subcontinental mantle or not remains to be answered.

By systematically varying parameters like core-mantle boundary (CMB) temperature, continental size, and mantle heating modes (basal and internal); we model thermo-chemical mantle convection with 2D spherical annulus geometry (Hernlund and Tackley, PEPI 2008) using StagYY (Tackley, PEPI 2008). Starting with a simple incompressible model having mobile continents, we observe this correlation. Furthermore, this correlation still holds when the model complexity is gradually increased by introducing internal heating, compressibility, and melting.

In general, downwellings reduce the mantle temperature away from the continents, thereby resulting in correlation between mobile continents and elevated temperatures in the subcontinental mantle. For incompressible models (Boussinesq approximation), correlation exists and the dominant degree of convection varies with the continental distribution. When internal heating is switched on, correlation is observed but it is reduced as there are less cold regions in the mantle. Even for compressible models with melting, big continents are able to focus the heat underneath them. The dominant degree of convection changes with continental breakup. Additionally, correlation is observed to be higher in the upper mantle (300 - 1000 km) compared to the lower mantle (1000 - 2890 km).

At present, mobile continents in StagYY are simplified into a compositionally distinct field drifting at the top of the mantle; thereby lacking the complexities of real Earth. We aim to implement another step in the code where the newly generated basalt melts again to form continental crust thus allowing for realistic continental growth and destruction.