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Is there any correlation between 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. However, how continents influence the development and location of mantle plumes (upwellings) remains a topic of considerable debate. While Heron and Lowman (GRL, 2010; Tectonophysics, 2011) propose regions where downwelling has ceased (irrespective of overlying plate) as the preferred location for plumes, O'Neill et al. (Gondwana Research, 2009) show an anti-correlation between the average positions of subducting slabs at continental margins, and mantle plumes at continental/oceanic interiors.

Continental motion is attributed to the viscous stresses imparted by the convecting mantle and the extent of this motion depends on the heat budget of the mantle. Core-mantle boundary (CMB) heat flux, internal heating from decay of radioactive elements, and mantle cooling contribute to this heat budget. Out of these sources, CMB heat flux is not well defined. However, the recent determination of core's high thermal conductivity requires a CMB heat flow of at least 12 TW (de Koker et al., PNAS 2012; Pozzo et al., Nature 2012; Gomi et al., PEPI 2013). Thus it is necessary to characterize the impact of basal heating on mantle dynamics with continents and self-consistent plate tectonics.

By systematically varying parameters like CMB temperature, continental size, mantle heating modes (basal and internal), and Rayleigh number; we model Boussinesq, incompressible, thermo-chemical mantle convection in 2D spherical annulus geometry using StagYY (Tackley, PEPI 2008). We observe correlation between continents and elevated temperatures in the subcontinental mantle irrespective of the variations in basal heating and continental size (except for very small continents). Moreover, we see episodicity between correlation and anti-correlation with increasing Rayleigh number. Furthermore, the effect of radioactivity in the continental crust on this correlation is investigated. 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 further develop the code to allow for realistic continental growth and destruction.