Influence of continents in mantle convection models with self-consistent plate tectonics

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It is now well accepted that mantle convection and plate tectonics form an integrated system and cannot be treated independently. Although this is a promising improvement in understanding Earth, there is still a striking feature, which is nowadays not yet included in this integrated system, namely the existence of a lithospheric heterogeneity - in other words - the difference between oceans and continents.

The present study focusses on the effect of continents in a model of self-consistent plate tectonics in spherical geometry. As a simplification these continents are realized as strong cratons with homogeneous composition and they differ from the rest of the mantle in buoyancy and rheology. In contrast to many former studies where continents are idealized as rigid and/or immovable units, we treat continents in the same manner as normal mantle, but with different physical properties. Numerically a tracer approach is used, which allows more consistent movement and deformation of the continents.

It has been shown before that continents might have a first-order effect on the dynamics of the Earth as they might modulate convective wavelength, surface heat loss and - due to thermal insulation - the internal temperature. Increasing the latter causes a decrease in convective stresses and we studied how this effect strengthens the lithospheric lid, what can finally lead to a transition from mobile lid to stagnant lid convection. Existence and timescale of this transition depend on the initial strength of the lithosphere and are most sensitive to internal temperature variations, but less sensitive to relative continental buoyancy.

The mentioned transition will be studied into more detail. A question of particular interest is, if the system behaviour changes, if the continents are no longer embedded in the thermal boundary layer. For answering this question it is necessary to modify the rheology of the continental material, namely to consider a viscosity, that depends on composition, and to make sure that continents are initially cold.