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Global scale numerical modelling of the transition to modern day plate tectonics

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The Earth's lithosphere, atmosphere, and biosphere interact with one another primarily at the surface of our planet, with the lithospheric coupling arising primarily from large-scale, long-period topographic evolution driven by deep mantle processes. Global numerical modelling of mantle convection in 3D with mobile continents in a modern plate tectonic regime has been previously demonstrated (Coltice et al., 2019). Improvements on such models can provide a useful tool for investigating the effects of large scale and long term changes in Earth's tectonic regime on the surface.

We present preliminary results in 2D spherical geometry using newly implemented additions to the existing mantle convection code StagYY (Tackley, 2008). A free surface representation using a marker chain enables higher surface resolution and the possibility of future implementation of surface processes on a global scale (Duretz et al., 2016). Initial conditions based on previous work on self-consistent continent generation enables modelling of continents with realistic rheology and structure (Jain et al., 2019).

The successful development of these tools enables further study of the evolution of the surface as a result of tectonic changes. A key goal is the modelling of the transition from a pre-plate tectonic regime to modern plate tectonics, as may have occurred in the Neoproterozoic (Stern, 2018). The tectonic changes of this period were also associated with other radical changes in the atmosphere and biosphere, such as the Cryogenian glaciations, and the Cambrian explosion. Models of topographic evolution may be used in conjunction with climate models or models of biological evolution to study the coupling between these systems as a part of the emerging field known as Biogeodynamics (Gerya et al., 2020).