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A search for constraints on lithospheric net rotation in 2D convection simulations

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Net rotation is the process whereby the entire lithosphere can rotate with respect to the Earth's mantle. The plates and continents retain their location with respect to each other, but they change their position with respect to global reference frames such as the Earth's magnetic dipole, and structures in the Earth's mantle such as plumes and hotspots. Constraining lithospheric net rotation is therefore one factor in building an absolute plate motion model. However, the amount of net rotation occurring at present day is poorly contained, and the drivers of net rotation are very poorly understood. Many absolute plate motion models therefore attempt to minimise net rotation, because there is no way to constrain rotation in the geological past.

In previous geodynamical studies, the presence of thick continents and large viscosity contrasts were found to be controlling factors in the development of net rotation. We investigate the effects of different convection parameters and tectonic states on the magnitude and evolution of net rotation in 2D simulations. The use of 2D simulations allows us to run enough simulations to study a wide range of model parameters. We intend to compare our 2D conclusions with 3D simulations, to investigate how much of a difference the third dimension makes.

We find that net rotation varies on much shorter timescales than any other geodynamic feature. Net rotation is not cleanly correlated with any tectonic behaviours or settings, and that the magnitude and duration is unpredictable. We do however find that the distribution of net rotation within the lifetime of a particular simulation is Gaussian, with standard deviation dependent on the viscosity structure and contrasts of the simulation, in agreement with previous studies. However, in contrast to previous studies, the presence and thickness of continents makes very little difference to the speed of lithospheric rotation, although this may be because we are working in 2D. If the 2D results are also relevant in 3D, net rotation is a continuously varying and unpredictable value, but with a predictable statistical range. This may provide a way to better constrain net rotation for plate motion models.