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Plate tectonics on rocky exoplanets: Influence of initial conditions and mantle rheology

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Abstract

Several numerical studies have been published in the past years speculating about the existence of plate tectonics on large exoplanets. They focus on aspects like the mass of a planet, the interior heating rate and the occurrence of water in the mantle. Different trends in the propensity for plate tectonics have been observed in particular when varying the planetary mass: with increasing mass the surface mobilization is found to be either more, equally or less likely than on Earth. These studies and their implications are, however, difficult to compare as they assume different initial conditions and parameter sets, and either neglect the pressure effect on the viscosity or assume a rather small influence of the pressure on the rheology. Furthermore, the thermal evolution of the planets (i.e. cooling of core and decrease in radioactive heat sources with time) is typically neglected.

In our study, we use a 2D finite volume code and apply a pseudo-plastic rheology. We investigate how a strong pressure-dependence of the viscosity influences not only the convective regime in the lower mantle, but also in the upper mantle and hence the likelihood to obtain plate tectonics. We investigate how our results change when either assuming a wet or a dry rheology or when employing different initial conditions, focussing on the initial