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The effect of mantle internal heating and pressure-weakening on surface dynamics: implications for Super-Earths

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The quest of habitability of other planets has led to intensive investigations of the planets' surface dynamics. In this context Super-Earths (a new class of exoplanets) have become of special interest in the past decade. Scalings to their increased size compared to the Earth suggest an increase in convective stresses (mobility) but also in plate resistance. The latter is fundamentally determined by the mantle viscosity, which depends on temperature, stress and pressure. We conduct a systematic 2D study on parameters affecting the surface behaviour of mantle convection with strongly variable viscosity. For example, it is assumed that super-sized planets will have higher Rayleigh numbers and non-dimensional heating rates. Additionally, the viscosity will be affected by the increased temperature and pressure of super-sized planets. In particular, a pressure-weakening effect has been discussed as a consequence of the high pressures in Super-Earths. The main focus of our work considers the response of surface motion to the mantle's internal heating rate. Increasing the non-dimensional heating rates leads to the formation of a strong stagnant lid because the mantle heating effects thermally activated viscosity. Not even the surface weakening effect of a high pressure-dependent viscosity is sufficient to mobilise the surface. We find that plate resistance increases which leads to a reduced surface mobility on Super-Earths.