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Exploring hemispheric tectonics on tidally-locked super-Earths

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Super-Earth LHS 3844b is a rocky exoplanet with a radius around 1.3 Earth radii. Its thermal phase curve suggests that the dayside temperature is around 1040 K and the nightside temperature is around 0 - 700 K, indicating inefficient atmospheric heat circulation. Therefore, this planet most likely lacks an atmosphere. In a previous study, we have shown that such a strong surface temperature dichotomy can lead to a so-called hemispheric tectonic regime. In such a regime, a cold downwelling forms preferentially on one side and hot upwellings are getting pushed towards the other hemisphere.
GJ 486b is a super-Earth that is very similar to LHS 3844b in terms of size and it is currently unknown whether this planet has an atmosphere. In this study, we are investigating under which circumstances hemispheric tectonics can operate on GJ 486b. We also investigate the stability of hemispheric tectonics.

We run 2D geodynamic simulations of the interior mantle flow using the mantle convection code StagYY. The models are fully compressible with an Arrhenius-type viscosity law where the mantle is mostly composed of perovskite and post-perovskite. The lithospheric strength is modelled through a plastic yielding criteria and the heating mode is either basal heating only or mixed heating (basal and internal heating).
We use general circulation models (GCMs) of potential atmospheres to constrain the surface temperature assuming different efficiencies of atmospheric heat circulation.

We find that a hemispheric tectonic regime is also possible for surface temperature contrasts with moderate heat redistribution. The location of the strong downwelling depends on several factors such as the surface temperature contrast and strength of the lithosphere. By reducing the temperature contrast, the location of the downwelling becomes less stable and it can start to move from one side towards the other over very long timescales (Gyrs). Our results show that hemispheric tectonics could operate on tidally-locked super-Earths, even if the surface temperature contrast between the dayside and nightside is not as strong as for LHS 3844b. Upwellings that rise preferentially on one hemisphere could lead to generation of melt and subsequent outgassing of volatiles on that side. Imprints of such outgassing on the atmospheric composition could possibly be probed by current and future observations such as JWST, ARIEL or the ELT.