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Interior dynamics of super-Earth 55 Cancri e constrained by general circulation models

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Close-in and tidally-locked super-Earths feature a day-side that always faces the host star and are thus subject to intense insolation. The thermal phase curve of 55 Cancri e, one of the best studied super-Earths, reveals a hotspot shift (offset of the maximum temperature from the substellar point) and a large day-night temperature contrast. Recent general circulation models (GCMs) aiming to explain these observations determine the spatial variability of the surface temperature of 55 Cnc e for different atmospheric masses and compositions. Here, we use constraints from the GCMs to infer the planet's interior dynamics using a numerical geodynamic model of mantle flow. The geodynamic model is devised to be relatively simple due to uncertainties in the interior composition and structure of 55 Cnc e (and super-Earths in general), which preclude a detailed treatment of thermophysical parameters or rheology. We focus on several end-member models inspired by the GCM results to map the variety of interior regimes relevant to understand the present-state and evolution of 55 Cnc e. In particular, we investigate differences in heat transport and convective style between the day- and night-sides, and find that the thermal structure close to the surface and core-mantle boundary exhibits the largest deviations. On the night-side, buoyancy driven downwellings from the colder near-surface lid descend to the core-mantle boundary and promote the growth of mantle plumes that preferentially rise on the day-side. Using a temperature-dependent proxy for melt production we investigate the distribution of regions where degassing is likely to be most pronounced and hence constrain the possible exchange of volatiles between the mantle and atmosphere. With the ever-growing number of close-in super-Earths detected from current and near-future space missions, such as TESS, inferences on the interplay between interior and atmospheric dynamics will enable a deeper understanding of the nature of rocky exoplanets.