EPSC Abstracts
Vol. 14, EPSC2020-506, 2020
https://doi.org/10.5194/epsc2020-506
Europlanet Science Congress 2020
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Stopping Super-Earths from growing into Jupiters

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Super-Earths are by far the most dominant type of exoplanet, yet their formation is still not well understood. In particular, planet formation models predict that many of them should have accreted enough gas to become gas giants. Here we examine the role of the protoplanetary disk in the cooling and contraction of the protoplanetary envelope. In particular, we investigate the effects of 1) the thermal state of the disk as set by the relative size of heating by accretion or irradiation, and whether its energy is transported by radiation or convection, and 2) advection of entropy into the outer envelope by disk flows that penetrate the Hill sphere, as found in 3D global simulations.
We find that, at 0.1 AU, the envelope quickly becomes fully radiative, nearly isothermal, and thus cannot cool down, stalling gas accretion. This effect is significantly more pronounced in convective disks, leading to envelope mass orders of magnitude lower. Entropy advection at 0.1 AU in either radiative or convective disks could therefore explain why super-Earths failed to undergo runaway accretion.

Ali-Dib, Cumming, & Lin (MNRAS 2020)