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Enceladus's south polar thermal anomaly in light of weak thermal convection

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The south polar thermal anomaly of Enceladus, contrasting with older and colder northern regions, suggests an asymmetrical heat transfer in the satellite's ice shell. Most of the current models that explain such a distribution prescribe an a priori asymmetry by mean of a mechanical or topographical anomaly in or below the south polar ice shell.

We present here a series of simulations with a 2D-spherical convection model to investigate the possibility of self-consistently generating a localized mechanical anomaly in the ice shell. We focus on the non-Newtonian character of ice rheology, and on the stability of a single-plume (i.e. localized convection) and low-degree convection regimes. We show that the non-Newtonian rheology favors a localized (tidally heated) convection surrounded by a conductive ice mantle, even with a global, liquid water ocean at the base of the ice shell. We find that the single-plume state is very unlikely to remain stable if the rheology is Newtonian.

The proposed thermal regime for Enceladus's ice shell is therefore weak, single-plume thermal convection focused at the south pole (e.g., remnant of a formerly more vigorous convection). Such weak-to-sub-critical regimes may be important for icy satellites, as recently pointed out by Solomatov (2012, PEPI). We will discuss the effects of ice plasticity on heat focusing in Enceladus's South Polar Terrain, together with the possibility of an ice shell a factor $\sim$2 thinner than previously thought (Hemingway et al., AGU 2013; Stevenson et al., AGU 2013).