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Tidal heating, liquid water and the origin of the South Polar Hot Spot on Enceladus.

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The CIRS instrument onboard Cassini detected 3 to 7 gigawatts of thermal emission over Enceladus' south polar regions, which corresponds to more than ten times the radiogenic power currently provided by the rocky interior (assuming chondritic composition). Here we investigate how subsolidus convection within the icy crust can explain such a large heat flux. For reasonable values of ice viscosity at the melting point ($\sim$1013-1014 Pa.s), classical models of thermal convection indicate that the amount of heat that can be released by convection is small compared to that power and cannot explain how a huge thermal anomaly can be generated at the South Pole. However, by incorporating a self-consistent treatment of tidal dissipation in 2D and 3D thermal convection models, we show how small heterogeneities in the radiogenic heat source distribution in the rocky core associated with localized tidal heating in the ice shell could have caused the formation of a large thermal plume. If the plume formed out of the polar region, Enceladus may have globally reoriented, moving the plume region toward the spin axis (Nimmo and Pappalardo 2006). Our models show that a localized pool of liquid water forms at the ice-rock interface below the thermal anomaly due to melting within the tidally heated plume. The presence of a liquid water zone at depth results in an enhanced tidal flexing of the above ice shell, and hence in a larger tidal dissipation rate. In addition, it stabilizes the active region at the South Pole by creating a negative gravity anomaly.