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Thermal activity on Enceladus's south pole triggered by tidal forces: Toward a self-consistent model.

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Observations by Cassini have revealed that Enceladus' souh pole is highly active, with jets of icy particles and water vapour emanated from narrow tectonic ridges, called "tiger stripes". This jet activity is associated to a very high thermal emission mainly focused along the tectonic ridges. Heat power required to sustain such an activity is probably related to the dissipation of mechanical energy due to tidal forces exerted by Saturn. However, the dissipation process and its relation to the tectonic features are not clearly established.

Both shear heating along the tectonic ridges and viscous dissipation in the convective part of the ice shell could contribute to the energy budget (Nimmo et al. 2007, Tobie et al. 2008). Tobie et al. (2008) pointed out that only interior models with a liquid water layer at depth, covering at least $\tilde{2}/3$ of the southern hemisphere, can explain the observed magnitude of dissipation and its particular location at the south pole. However, the long term stability of such a liquid reservoir remains problematic (Roberts and Nimmo 2007) and the possible link between the liquid reservoir and the surface activities is unknown.

Concentration of tidal stresses along the tiger ridges have also been invoked as a mechanism to trigger the eruptive processes (Hurtford et al. 2007, Smith-Konter et al. 2008). However, those models do not take into account a realistic rheological structure for the ice shell when computing the fluctuating stress field. Moreover, the effect of the faults on the background tidal stress is neglected. In particular, low viscosity values are expected to be associated with the shear zone along the tiger stripes and may have a significant impact of the global tidal stress field.

In order to self-consistently determine the tidal deformation and its impact on the thermal activity on Enceladus, we are currently developing a 3D model that combines a thermal convection code in spherical geometry (Choblet et al. 2007) and a viscoelastic tidal deformation model (Tobie et al. 2008). The objective is to simultaneously determine the thermal structure of the whole ice shell and the corresponding tidal deformation field, including the effect of the shear zones. This approach allows us (i) to quantify the distribution of tidal heating and the contribution of heating along the tectonic ridges and within the convective part, (ii) to determine the heat transfer toward the tectonic ridges and the possible exchange between the deep liquid reservoir and the surface, (iii) to determine the thermal evolution of the south polar region and the evolution of the liquid reservoir, (iv) to assess the evolution of tidal stress field on both orbital and geological timescales.