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Feedback between tidal dissipation and temperature-dependent mantle viscosity: Implications for Jupiter's moon Io

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Recent Earth-based observations of Io reveal a specific distribution of persistent hotspots and sudden high-intensity events. The volcanic pattern is commonly associated with the heat flux originating from Io's tidally heated mantle and asthenosphere. Io's interior state is a complex system of heat production, heat transport, melt, and temperature-dependent rheology. The spatial pattern of dissipated heat, for example, depends on the interior rheology but at the same time the heating influences the rheology, in particular due to the temperature-dependence of the mantle viscosity.

We present an iterative procedure to investigate the strength and characteristics of this specific feedback. The tidal dissipation is calculated by a viscoelastic model of a spherical body disturbed by a tidal force. The model is based on finite elements so it can deal with lateral variations of the viscosity. We use simple scaling laws to relate the temperature-dependent viscosity distribution to the spatial heat production and heat transport by mantle convection. In an iterative procedure, the viscosity distribution is updated and a new heat dissipation pattern is calculated until convergence is found. The results show that the heat in Io's interior and consequently the heat flux at the surface are strongly smoothed. The comparison of the converged models and the initial models of different Rayleigh numbers and types of mantle rheology reveals a diverge characteristics of the feedback. This possibly changes the way the observed distribution of volcanos on Io's surface is related to Io's interior properties.