Tidal-librational dissipation within volcanic and cryovolcanic worlds

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Tidal dissipation is thought to power volcanism or cryovolcanism on a number of moons, most notably Io and Enceladus. The amount and distribution of tidal heating within the moon are however still misunderstood, and intricately related to surface observations like heat flow and distribution of volcanic activity. From an extensive benchmark between a set of numerical and semi-analytical models, we show that, in the presence of a subsurface (magma or water) ocean, librations (i.e. spin rate variations) along the orbit trigger additional deformation mechanisms, enhancing the amount of dissipation compared to traditional tidal dissipation (by at least 25% for Enceladus), and affecting the distribution of dissipation within the moon. We illustrate these mechanisms with numerous animations, and identify librational loading as the most relevant process.