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Fractal analysis on Enceladus: a global ocean underneath the icy crust

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Plumes of water have been observed erupting from Enceladus' south polar terrain providing direct evidence of a reservoir of liquid below the surface, that could be considered global or just a small body of water concentrated at its south pole. Gravity data collected during the spacecraft's several close flyby over the south polar region determined that the icy shell above the liquid ocean must be 30-40 km thick extending from the south pole up to 50°S (Iess et al. 2014). The hypothesis of a global ocean beneath the icy crust has been raised even in a recent paper of Thomas et al. (2015) thanks to the measurements of the very slight wobble that Enceladus displays as it orbits Saturn. In this work we support the hypothesis of the presence of an ocean layer using the fractal percolation theory. This method allowed us to estimate the icy shell thickness values in different regions of Enceladus from the south polar terrain up to the north pole. The spatial distribution of fractures on Enceladus has been analyzed in terms of their self-similar clustering and a two-point correlation method was used to measure the fractal dimension of the fractures population (Mazzarini, 2004, 2010). A self-similar clustering of fractures is characterized by a correlation coefficient with a size range defined by a lower and upper cut-off, that represent a mechanical discontinuity and the thickness of the fractured icy crust, thus connected to the liquid reservoir.
We mapped the fractures on Enceladus surface based on April 2010 global mosaic from Cassini mission and applied the fractal method firstly to the south polar terrain finding indeed a fractal correlation of fractures and providing an ice shell thickness of ∼40 km. Then, we analyzed fractures of four different regions around the equator and around the north pole inferring an overall ice shell thickness ranging from 35 to 45 km. Our results are in agreement with the gravity observations (Iess et al., 2014) and the mechanical models (Yin and Pappalardo, 2015) of the south polar region and, in addition, they are consistent with the hypothesis of a global ocean beneath the icy shell.