The heterogeneous ice shell thickness of Enceladus

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Saturn's moon Enceladus is the smallest Solar System body that presents an intense geologic activity on its surface. Plumes erupting from Enceladus' South Polar terrain (SPT) provide direct evidence of a reservoir of liquid below the surface. Previous analysis of gravity data determined that the ice shell above the liquid ocean must be 30-40 km thick from the South Pole up to 50° S latitude (Iess et al., 2014), however, understand the global or regional nature of the ocean beneath the ice crust is still challenging. To infer the thickness of the outer ice shell and prove the global extent of the ocean, we used the self-similar clustering method (Bonnet et al., 2001; Bour et al., 2002) to analyze the widespread fractures of the Enceladus's surface. 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. Hence, this method allowed us to estimate the icy shell thickness values in different regions of Enceladus from SPT up to northern regions.

We mapped fractures in ESRI ArcGis environment in different regions of the satellite improving the recently published geological map (Crow-Willard and Pappalardo, 2015). On these regions we have taken into account the fractures, such as *wide troughs* and *narrow troughs*, located in well-defined geological units. Firstly, we analyzed the distribution of South Polar Region fracture patterns finding an ice shell thickness of ~ 31 km, in agreement with gravity measurements (Iess et al., 2014). Then, we applied the same approach to other four regions of the satellite inferring an increasing of the ice shell thickness from 31 to 70 km from the South Pole to northern regions. By these findings, we prove the global extent of the ocean underneath the ice crust of the satellite.