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Mars Topography Investigated Through the Wavelet Leaders Method: a Multidimensional Study of its Fractal Structure

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This work examines the scaling properties of Mars topography through a wavelet-based formalism. We conduct exhaustive one-dimensional (both longitudinal and latitudinal) and two-dimensional studies based on Mars Orbiter Laser Altimeter (MOLA) data using the multifractal formalism called Wavelet Leaders Method (WLM). This approach shows that a scale break occurs at approximately 15 km, giving two scaling regimes in both 1D and 2D cases. At small scales, these topographic profiles mostly display a monofractal behavior while a switch to multifractality is observed in several areas at larger scales. The scaling exponents extracted from this framework tend to be greater at small scales. In the 1D context, these observations are in agreement with previous works and thus suggest that the WLM is well-suited for examining scaling properties of topographic fields. Moreover, the 2D analysis is the first such complete study to our knowledge. It gives both a local and global insight on the scaling regimes of the surface of Mars and allows to exhibit the link between the scaling exponents and several famous features of the Martian topography. These results may be used as a solid basis for further investigations of the scaling laws of the Red planet and show that the WLM could be used to perform systematic analyses of the surface roughness of other celestial bodies.