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Roughness Analysis of Martian Landforms and its Analogues on Earth, Moon and Other Solar System Bodies

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One of the uttermost goals of planetary science is to understand the history and forming the surfaces of the solid Solar System bodies. This can be accomplished through qualitative and quantitative analysis of the surface, where for the latter, a range of surface parameters has to be estimated first. Since the direct measurements are almost not possible, remote sensing (RS) appears as a feasible alternative. Surface roughness, as a descriptive and dynamic physical parameter of solid surfaces, figures in both RS and physical processes. Roughness provides the evidence how the surface was altered through physical processes, and affects the backscatter signals recorded by RS instruments. Therefore, understanding and description of surface roughness is a prerequisite for a successful evolution reconstruction in planetary science.

Our study utilizes existing and introduces new methods for analyzing and comparing roughness of landform analogues within and over different solid bodies. The analysis is focused only on the bodies where digital terrain models (DTM) are available. These DTMs mainly come from photogrammetry (e.g. HRSC), laser (e.g. MOLA) or radar (e.g. SRTM) RS technique.

Landform patterns of planet Mars were selected as a basis for roughness analysis. Reasons for that lie in large coverage with good quality DTMs, wide range of processes and no vegetation that may hamper the roughness analysis. After selecting the initial set of landform patterns, their analogues are searched on other bodies, e.g. Earth, Mars, etc. This was done primarily on surface features present within the pattern. In other words, the selected analogues contains similar features, but not necessary at similar scales. This also provides a possibility to analyze similar features in different environments. Finally, several sets of analogues where created which covers: (a) features present on canyon banks, (b) Martian chaos areas, (c) erosion features, (d) glacial features and (e) lava flow features.

The roughness analysis of the analogues is performed at three different levels using several roughness indices (standard deviation of elevation, topographic prominence, openness, etc.). In first level, the overall roughness is estimated for each landscape. This is done by modeling the transition of the roughness indices over estimation scales with power law, i.e. estimating the fractal dimension for each roughness index. These results are then used for the roughness comparison and identification of important scales. In second level, at each important scale the patterns are analysed spatially using variogram, and correlation length. Finally, in third level, the roughness pattern is analysed with respect to the local topography, i.e. trend.

The proposed approach for roughness analysis aims at systematic categorization and estimation of extremes of planetary roughness. These results can be then related to corresponding backscatter magnitude domains, geomorphic units or to other parameters that controls physical processes on those bodies.