MULTISCALE ROUGHNESS OF TERRESTRIAL PATTERNED GROUND AS A MARS ANALOG

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Introduction: Periglacial patterned ground has been utilized extensively in Earth-Mars analog research [1, 2, et al.]. Thermal contraction and sublimation-driven modification of patterned ground is thought to be possible under current climate climate conditions on Mars [3 et al.]. It has been proposed that periglacial modification of patterned ground (via wet active layers) could be possible during periods of high obliquity [4 et. al], suggesting such features would be relict today. Patterned ground expresses a wide range of morphological forms (stone circles, stone stripes, hummocks, polygons, etc.) such that differences between active and relict variants of the same feature type are likely to occur at the micromorphological level. Collecting such measurements would be at or beyond the detection limits of the High Resolution Imaging and Science Experiment (HiRISE) on the Mars Reconnaissance Orbiter, so understanding what types of features and information can be analyzed using existing HiRISE imagery and digital terrain models (DTMs) is important.

Methods: The objective of this research is to establish the types of features that might be detectable in HiRISE DTMs by using a small uncrewed aerial system (sUAS) to conduct high-resolution imaging surveys of relict alpine patterned ground at a site in the Icelandic Westfjords [5]. The images were generated into DTMs using Agisoft Metashape. The Whitebox Toolkit was utilized to interpret resulting DTMs and imagery using a combination of ArcGIS and QGIS.

Surface roughness can be used as a metric to quantify small-scale terrain variations across patterned ground corresponding to the positioning, sorting, and distribution of gravels and rocks across each feature, as well as detecting small-scale topographic variations across feature centers and margins. The Multiscale Roughness (MSR) tool in Whitebox calculates the surface roughness over a range of spatial scales by modifying the minimum and maximum neighborhood search radius (in grid cells) of DTM rasters in ArcGIS or QGIS [6]. When used to compare terrestrial and Martian patterned ground, the MSR tool generates surface roughness profiles that can be adapted to variations in sensor resolution and to distinguish between feature types, centers, and margins.

Results: The MSR tool was used to quantify the surface roughness of sUAS-acquired DTMs at the Westfjords site. The maximum search neighborhood radius parameter was set incrementally to scales ranging from 10 to 100 grid cells. Orthoimages were characterized by feature type and further subdivided by feature margins and centers.

A search radius between 25-100 was required to clearly resolve feature boundaries. A larger search radius typically worked well for higher resolution DTMs and a smaller radius was suitable for lower resolution DTMs. There was a correlation between feature detection in the MSR output and feature composition. For example, stone circles and nets with heterogeneous distributions of gravel between the centers (fine grained) and margins (coarse grained) had a higher rate of detection across the selected search radii, in contrast to hummocks that were less discernible due to homogeneous distributions of gravel across the entire feature.

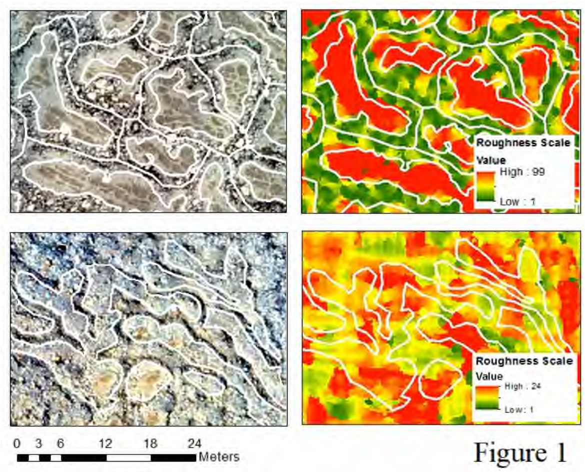

Figure 1

Figure 1 provides an example of MSR output highlighting differences between patterned ground centers and margins at the Icelandic site. This method was effective at detecting and analyzing high relief features with heterogeneous compositions. An expanded application of this technique is enabling assessments of HiRISE DTMs to establish detection limits based on feature size, morphology, and composition for patterned ground sites on Mars.

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