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On the calibration of Mars Orbiter Laser Altimeter surface roughness estimates using high-resolution DTMs

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Planetary surface roughness is critical in the selection of suitable landing sites for robotic lander or roving missions. It has also been used in the identification of terrain, for better calibration of radar returns and improved understanding of aerodynamic roughness [1]. One of the secondary science goals of the Mars Orbiter Laser Altimeter (MOLA) was the study of surface roughness at 100 m, using the backscatter pulse width of the laser pulse, which has a footprint of 168 m in diameter [2]. The pulse width values in the final release (version L) of the MOLA Precision Experiment Data Record (PEDR) have been corrected for across track slopes and the removal of 'bad points', and footprint diameter was revised to 75 m, with a 35 m response length in [3]. We look here at comparing surface roughness values derived from the MOLA pulse-width data with surface roughness estimates derived at various scales from high-resolution digital terrain models (DTMs) to determine if these theoretically derived surface roughness lengths are physically meaningful.

The final four potential landing sites for Mars Science Laboratory were used in this study, as they have extensive HiRISE (1m) and HRSC (50m) DTM coverage [4]. Pulse width data from both the MOLA PEDR (version L) and the data used in [3] was collected and compared for each of the sites against surface roughness estimates at various scales from HiRISE, and HRSC, DTMs using the RMS height. This assumed a circular footprint for each MOLA footprint and that the horizontal geolocation of the PEDR MOLA footprints was sufficiently accurate to only extract those DTM points which lay inside the footprints.

Results from the MOLA PEDR data were extremely poor, and show no correlation with surface roughness measurements from DTMs. Results using the corrected data in [3] were mixed. Eberswalde and Holden Craters both show significantly improved correlations for a variety of surface roughness scales. The best correlations were found to be at surface roughness scales of 150 m diameter. Results from Gale Crater showed poorer correlations, the best correlation being at 300 m. Surface roughness measurements in the Mawrth area showed very poor correlations at all scales. As the best correlations were found at scales larger than the resolution of HRSC DTMs, we looked at trying to establish whether MOLA pulse width data is better correlated with this dataset. Gale Crater showed a slight improvement in correlation, with a best-fit scale at 200 m; other results were poorer.

These results suggest that surface roughness measurements from the MOLA instrument are not able to accurately determine surface roughness at the MOLA pulse locations given current models. It also calls into question previous global maps of surface roughness produced using these models as proposed in [5] and [6], as this work indicates the maps do not reflect actual physical phenomena.

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