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Evolution Strategy-Based Approach for Joint Analysis of Laser Altimeter Tracks and Photogrammetric Stereo DTMs: MOLA and HRSC

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Introduction: Data by the MGS MOLA [1] instrument provide a dense global network of laser shots with unprecedented height precision for Mars. The extraction of planetary radii from laser pulses requires precise knowledge of spacecraft trajectory and the instrument's orientation in space. Limited knowledge of these extrinsic parameters causes deviating height information at cross-over points of the laser tracks and occasionally substantially offset outlier profiles. Applying adjustment techniques, the final mission data products [2] minimized the cross-over residuals while still showing considerable variability in height differences when compared to HRSC Mars quadrangle DTMs [3].

We accurately co-register MOLA profiles to existing HRSC DTMs allowing to increase the accuracy of the co-registration of the single laser tracks while providing similar internal a-posteriori cross-over accuracies as in [2]. The method applies Evolution Strategy (ES) [4] to directly solve for extrinsic observation parameters. Combined HRSC / MOLA DTMs will provide a most comprehensive, best resolved global data product currently available for Mars.

Method: Starting with a seed vector the ES repeatedly creates sets of random parameter vectors that are evaluated by the quality function. The latter is defined by the RMS of the height difference between DTM and corrected laser shots. The lowest RMS vector of each generation will be the seed for the next generation random vectors.

The optimization of the parameter vector for each laser data segment is performed on an equatorial HRSC half-quadrangle and parameters are applied to all data of a laser data segment reaching from North to South pole.

Results: ES-based adjustment of MOLA tracks was applied using two existing equatorial HRSC DTM half-quadrangles (MC-13E and MC-21E) and the laser track segments intersecting these quadrangles. The quality of the adjustment was evaluated by visual inspection of gridded DTM data products generated from the adjusted tracks and by analyzing the consistency of the results in terms of height residuals at cross-overs. Inspection of DTM products is sensitive to outlier track detection, that commonly occur in the uncorrected MOLA data but also appear in the ES adjusted DTMs. The average absolute residual height differences at cross-overs amount to 4.44 m for the nominal profile solutions, 4.58 m in the crossover-adjusted version [2], and to only 2.78 m with ES-

adjusted profiles. The same values are also derived eliminating globally the 3s-blunder height differences. The corresponding values are then 3.48 m (nominal case), 2.93 m [2], and 2.09 m (ES-adjusted). The method establishes a high-quality co-registration between MOLA and HRSC DTMs considered very promising for future joint HRSC/MOLA DTMs. We discuss the potential to re-assess temporal variation in the MOLA data record not uniquely resolved in the past, such as estimates of the seasonal deposition and sublimation in the polar areas.

References:

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