EPSC Abstracts
Vol. 13, EPSC-DPS2019-2006-1, 2019
EPSC-DPS Joint Meeting 2019
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EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Characteristics of the HRSC Mars Chart (HMC-30) and its Quality of Co-Registration with the MOLA Reference

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Abstract

We provide an overview of quality characteristics of the regional data products of the HRSC Mars Chart (HMC-30) series, and present new data on coordinate accuracy relative to the MOLA global reference, which were not available from previous HRSC DTMs. Finally, details of the HMC-30 global map layout and tiling scheme are reported.

1. Introduction

Digital terrain models (DTMs) and orthoimages for Mars have been produced from HRSC stereo and color images, so far, using data from individual orbits only [1,2]. Based on the entire mission data record, a coordinated effort for mapping Mars by multi-orbit DTMs and image mosaics has been initiated by the HRSC Team. The global layout of the HRSC Mars Chart (HMC-30) products is based on [3]. In addition to their higher user-friendliness, multi-orbit data products allow for significant improvements with respect to processing methodology (block adjustment, radiometric adjustment, surface reconstruction from overlapping point clouds) [4,5].

The High Resolution Stereo Camera (HRSC) of ESA Mars Express [6] is designed to map the topography of Mars and its satellites. As a push broom camera with 9 CCD line detectors, it acquires along-track stereo images and 4 colors during a single orbit. The sub-pixel accuracy of derived 3D points allows producing DTMs with grid sizes of up to 50 m and height accuracy on the order of one pixel and better (12.9 m, on average) [2,4]. HRSC has covered about 75% of the surface of Mars at 10-20 m/pixel, and achieved global coverage at better than 100 m/pixel.

2. Geometric Quality and Co-Registration with MOLA

3D surface points from HRSC stereo images are derived regularly using bundle adjustment to improve the position and pointing data of the instrument while minimizing residual offsets between overlapping images and the deviation of corresponding heights from MOLA control data [7]. In the case of image blocks, also offsets among images from adjacent orbits are adjusted. Residual strip-to-strip offsets provide information on the geometric consistency of the block. Average values of about 0.3 pixels for the horizontal coordinates and about 0.2 times the pixel size for height have been reported [4]. Vertical deviation from MOLA heights is well documented from single strip DTMs (±1.9 m for strip averages, 25-35m 1σ for individual height differences) [2]. Based on adjusted orientation, DTM heights at full resolution, and dense control meshes, orthoimages can be considered to share the same planimetric properties as the DTM (point accuracy and offsets).

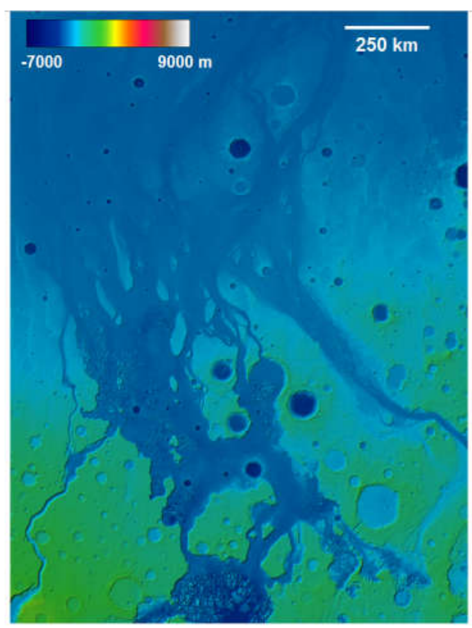

Figure 1. Relief map of the MC-11W quadrangle.

An important aspect of geometric quality not easily assessed using single-strip DTMs (due to limited extent) or from strip-to-strip offsets is the quality of lateral co-registration with MOLA, i.e. the accuracy of coordinates relative to the global reference dataset.

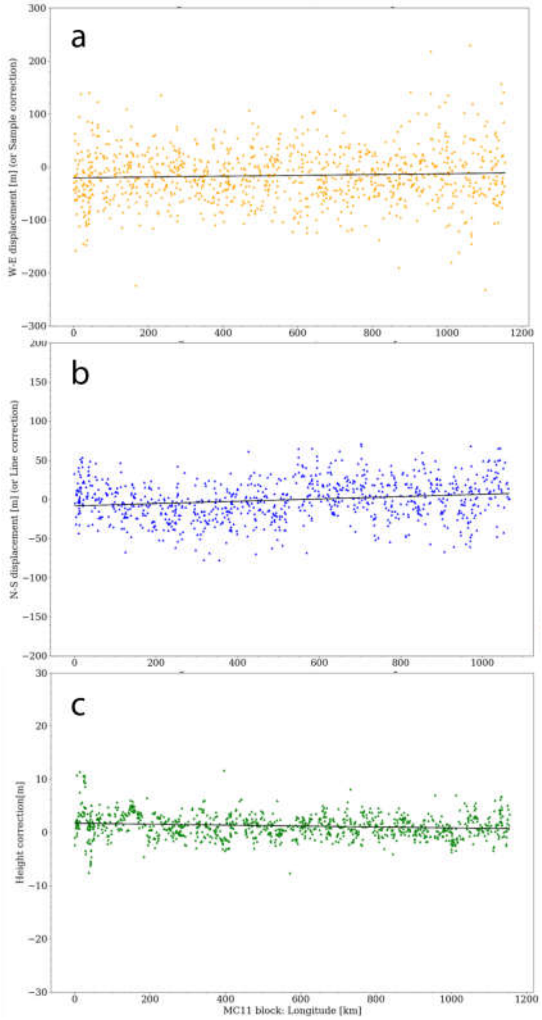

Figure 2. Average offsets of individual MOLA tracks from HRSC DTM of MC-11E quadrangle in a) E-W, b) N-S, and c) radial height direction, as determined from least-squares matching.

The regional DTMs, though, allow to examine large numbers of co-located MOLA tracks. We use least-squares matching to sub-pixel register MOLA profiles to the HRSC DTM [8,9]. The 3D translation determined for each profile can be interpreted in terms of uncertainty of the 3D coordinates of corresponding HRSC points.

Fig. 2 shows results of this analysis for MC-11E. The RMS deviation of the average MOLA track offsets for E-W and N-S directions (a and b) is 51 m and 28 m, respectively, i.e. within the grid spacing of the DTMs. Regression analysis suggests no dominant spatial trends across the DTM, i.e. absence of significant scale errors or shear (regression line slopes of 0.8±0.4 and 1.3±0.3 cm/km). The RMS for height deviation (2.3 m) agrees with the results from previous analysis. Average offsets are < ±5 m almost everywhere across the DTM, and no dominating trend indicative of distortion or tilt is observed.

3. Product types and Tiling scheme

As described elsewhere [4], the main purpose of the new regional HRSC products is to serve as a globally structured reference dataset and base map for Mars, with best-possible adjustment to MOLA and adjustment in terms of internal geometry and internal brightness/color variation. For applications relying on calibrated brightness values (e.g. image matching, photometry), use of single-strip ortho-images - after reprocessing using the block-adjusted orientation data - should still be considered.

Fig. 3 shows the tiling and naming conventions adopted for the HMC-30 products, with MC-30 half-quadrangles as the basic subdivision. With respect to resulting file size, the different product types (as documented in detail in [4], Tab. 6) are further subdivided into 4 sub-tiles (for DTM and color data sets), and 16 sub-tiles (for panchromatic mosaics at 12.5 m resolution). As supplementary data products, pan-sharpened color mosaics (12.5 m resolution), color coded shaded relief maps (Fig. 1), and topographic maps [10] are produced.

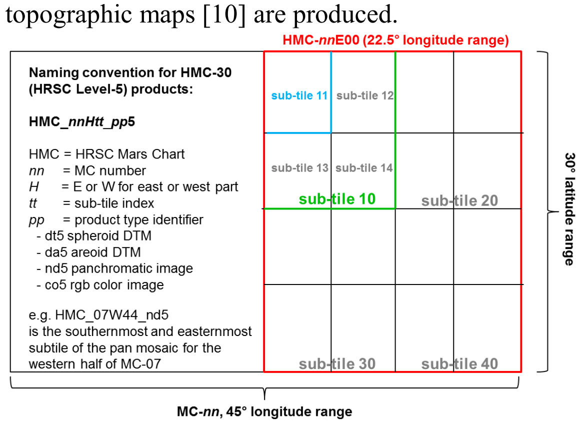

Figure 2. Tiling scheme and naming convention for HMC-30 data products.

References

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