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MarsExpress High Resolution Stereo Camera (HRSC) Multi-orbit Data Products: Methodology, Mapping Concepts and Performance for the first Quadrangle (MC-11E)

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The High Resolution Stereo Camera (HRSC) of ESA's Mars Express mission is designed to map and investigate the topography of Mars. As the surface areas with contiguous coverage by stereo data are increasingly abundant, the HRSC team has recently started a coordinated effort for the systematic mapping of Mars by multi-orbit digital terrain models (DTMs) and image mosaics, using the complete HRSC mission data record. We present the DTM and orthoimage mosaic obtained for the first half-tile, MC-11E (Eastern Oxia Palus), together with results of a performance analysis for this data set.

The geomorphological analysis of surface features observed by HRSC has allowed to characterize major surface modifications by endogenic and exogenic processes at different scales. Such studies (in the field of geomorphology, but also compositional mapping and atmospheric science) have been based on joint analysis of DTM and orthoimage information, and have benefitted from the high accuracy of co-registration between multiple datasets, which is particularly important for multi-temporal and multi-angular observations. HRSC is unique because it bridges the gap between laser altimetry and topography data derived from other stereo imaging instruments, and provides geodetic reference data and geological context to a variety of stereo and non-stereo datasets.

As HRSC is a push broom scanning instrument with nine CCD line detectors mounted in parallel, its unique feature is the ability to obtain along-track stereo images and four colors during a single orbital pass. The sub-pixel accuracy of 3D points derived from stereo analysis allows producing DTMs with grid sizes of up to 50 m and a height accuracy on the order of one pixel on the ground and better, as well as corresponding orthoimages. Such data products have been produced for individual HRSC strips covering approximately 40% of the surface of Mars so far. After more than 10 years of operation, HRSC covered about 70% of the surface by panchromatic images with 10-20 m/pixel, and about 98% with better than 100 m/pixel.

The new global mapping program is based on the USGS MC-30 quadrangle scheme, where quadrangles are split into eastern and western parts to limit data volumes. We provide an overview of relevant methods and standards applied for 3D reconstruction, block adjustment and mapping, including radiometric image processing. We demonstrate that multi-orbit DTMs with grid spacing of 50 m are feasible for large surface areas in spite of the existing variation of ground pixel size. After bundle block adjustment, image mosaics and DTMs can demonstrably benefit from co-registration accuracy of adjacent strips on the order of one pixel, and at the highest image resolution available. On average, the adjustment to Mars Orbiter Laser Altimeter (MOLA) heights used as global geodetic reference is achieved at the same accuracy as for single-strip DTMs. After a photometric normalization and by using Thermal Emission Spectrometer (TES) albedo as a brightness standard, it is possible to produce visually consistent image mosaics from HRSC images acquired under very different illumination and atmospheric conditions due to seasonal and day-time variation.