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Stereo data products of the HRSC Experiment onboard Mars Express for the PSA and PDS archives

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We present the specifications of high-level photogrammetric data products (digital elevation models and orthoimages) derived from data of the High Resolution Stereo Camera (HRSC), a pushbroom stereo camera operated onboard the ESA orbiter Mars Express. These data products are now derived systematically for all HRSC stereo datasets of the nominal mission and first mission extension and are made available to the public through the archives at the Planetary Science Archive (PSA, http://www.rssd.esa.int/PSA) at ESA and the Planetary Data System (PDS, http://pds-geosciences.wustl.edu/missions/mars_express/) at NASA. A joint website of Freie Universitaet Berlin and the German Aerospace Center (DLR) provides the ability of on-line vizualisation (http://hrscview.fu-berlin.de/). Up to now, only radiometrically corrected images were available from PSA and PDS, as well as map-projected images rectified without the use of DTMs derived from HRSC stereo data.

The data products (Level-4 products) comprise 8 Bit orthoimages for the panchromatic nadir channel and the 4 color channels and 16 Bit DTMs (1 m numeric height resolution), both in VICAR format. They are also formatted according to PDS specifications. The map scales of the orthoimages adhere to standard resolutions (12.5, 25, 50... m/pixel), depending on the ground resolution of the respective image. For the specification of the DTM spatial resolution, the quality of image and orientation data is also decisive. Usually, a grid spacing of about 2 times the mean stereo resolution is used (up to 50 m). Since Level-4 orthoimages are based on the Level-4 DTM, they are available exclusively for areas covered by the latter. The principal geometric reference

for both planimetry and height is a sphere of radius r=3396.0 km as defined by the MOLA team. In addition to the spheroid DTM, an areoid DTM is produced. Again in agreement with the datum used by the MOLA team, the areoid DTM represents heights above an equipotential surface described by potential model GMM3 (PDS dataset MGS-M-MOLA-5-MEGDR-L3-V1.0). The map projection is Sinusoidal for latitudes between $\pm 85^{\circ}$ and Polar-Stereographic for polar areas.

DTM generation is based on multi-image matching using pyramid-based least-squares correlation after pre-processing by adaptive Gaussian low pass filtering of the images to reduce the effects of compression. 3D points are determined by least-squares forward intersection. Raster DTMs are interpolated by distance weighted averaging. The DTMs and the ortho-images (the calculation of which uses the DTMs) are based on adjusted orbit and pointing data. Similarly, the Level-3 images (orthorectification based on MOLA) already available via PDS and PSA are successively re-calculated using the new orientation data and product specifications.

Quality assessment for the data products derived so far (corresponding to the first 6 months of the mission), based on internal quality parameters and on comparison to external terrain data, confirms the results of our earlier investigations. A typical 3D point accuracy of 10 m – 15 m is achieved (up to 5 m for the best datasets). This sub-pixel accuracy with respect to stereo image resolution allows us to derive raster DTMs at a spatial resolution of up to 50 m for large parts of the surface of Mars within a reasonable effort. Height differences with respect to MOLA topography data show near-zero offsets on average, testifying to the accurate co-registration of both datasets. However, local height deviations between the two datasets can be considerable (more than $\pm$100m; typical standard deviations for entire DTMs: $>$20m). They reflect the measurement uncertainties on both sides, but also differences in the representation of topographic detail (resulting e.g. from the difference in spatial resolution and coverage) and underline the complementarity of the two approaches.

The derivation of the data products (nominal mission and first extension) is expected to be finalized after 3 years, i.e. in early 2010. We plan to have seven further data releases, each encompassing the stereo data acquired within 6 months of the mission (i.e. orbits until #1224, #1863, #2529, #3160, #3795, #4479, #4917). The respective stereo imagery covers about 105 Mio km^2 or 72 percent of the surface of Mars. Thus, the goal of global coverage by HRSC high-level data products critically depends on the further progression of the mission, and in particular on the approval of the 3rd mission extension.