VALLES MARINERIS, MARS: HIGH-RESOLUTION DIGITAL TERRAIN MODEL ON THE BASIS OF MARS-EXPRESS HRSC DATA. A. Dumke, M. Spiegel, S. van Gasselt, G. Neukum. Institute of Geosciences, Freie Universität Berlin, Malteserstr. 74-100, 12249 Berlin, Germany. dumke@zedat.fu-berlin.de

Introduction: Since December 2003, the European Space Agency's (ESA) Mars Express (MEX) orbiter has been investigating Mars. The High Resolution Stereo Camera (HRSC), one of the scientific experiments onboard MEX, is a pushbroom stereo color scanning instrument with nine line detectors, each equipped with 5176 CCD sensor elements. Five CCD lines operate with panchromatic filters and four lines with red, green, blue and infrared filters at different observation angles [1]. MEX has a highly elliptical near-polar orbit and reaches a distance of 270 km at periapsis. Ground resolution of image data predominantly varies with respect to spacecraft altitude and the chosen macropixel format. Usually, although not exclusively, the nadir channel provides full resolution of up to 10 m per pixel. Stereo-, photometry and color channels generally have a coarser resolution. One of the goals for MEX HRSC is to cover Mars globally in color and stereoscopically at high-resolution. So far, HRSC has covered almost half of the surface of Mars at a resolution better than 20 meters per pixel. Such data are utilized to derive high resolution digital terrain models (DTM), ortho-image mosaics and additionally higher-level 3D data products such as 3D views.

Standardized high-resolution single-strip digital terrain models (using improved orientation data) have been derived at the German Aerospace Center (DLR) in Berlin-Adlershof [2]. Those datasets, i.e. high-resolution digital terrain models as well as ortho-image data, are distributed as Vicar image files (http://www-mipl.jpl.nasa.gov/external/vicar.html) via the HRSCview web-interface [3], accessible at http://hrscview.fu-berlin.de. A systematic processing workflow is described in detail in [4,5].

In consideration of the scientific interest, the processing of the Valles Marineris region will be discussed in this paper. The DTM mosaic (see Fig. 1) was derived from 82 HRSC orbits at approximately -22° S to 1° N and 250° to 311° E.

Methods: Apart from the DTM quality, image mosaicking also depends on the quality of exterior orientation data, and in order to generate high resolution DTMs and ortho-images, these data have to be corrected. For this purpose, new exterior and interior orientation data, based on tie-point matching and bundle adjustment have been used. The automated determination of tie points by software provided by the Leibniz Universität Hannover [6] are used as input in the bundle adjustment, provided by the Technische Universität München and Freie Universität Berlin.

The bundle adjustment approach for photogrammetric point determination with a three-line camera is a least squares adjustment based on the well known collinearity equations. The approach estimates the parameters of the exterior orientation only at a few selected image lines. Because of Doppler shift measurements to estimate the position of the orbiter there are systematic effects in the observed exterior orientation. To model these effects in the bundle adjustment, additional observation equations for bias (offset) and drift have to be introduced. To use the MOLA DTM as control information, the least squares adjustment has to be extended with an additional observation equation for each HRSC point. These observations describe a relation between the MOLA DTM and these HRSC points. This approach is described in more detail in [7,8].

Derivation of DTMs and ortho-image mosaics are basically performed using software developed at the German Aerospace Center (DLR), Berlin and is using the Vicar environment developed at JPL. For the DTM derivation, the main processing tasks are first a pre-rectification of image data using the global MOLA-based DTM, then a least-squares area-based matching between nadir and the other channels (stereo and photometry) in a pyramidal approach and finally, DTM raster generation.

Iterative low-pass image filtering (Gauss and mean filtering) is applied in order to improve the image matching process by increasing the amount and quality of object points and in order to reduce possible misdetections caused by image compression artifacts and noise.

Results and Outlook: The exterior orientation parameters can be improved for single orbits and for image blocks using the bundle adjustment which is essential for high-resolution digital terrain models and ortho-image mosaics. The exterior orientation data that were adjusted for single orbits can be used for ortho-image mosaics and DTMs, and provides good results apart from the elevation differences from the MOLA DTM. The results of bundle block adjustment provided the best accuracy and adapt the HRSC-derived data to the global Mars-reference system very well. These results are needed for the derivation of a high resolution DTM with a ground resolution of 100 m per pixel.

When compared to the MOLA DTM, the photogrammetrically derived HRSC DTM mosaic shows significantly more detail and is well defined (when compared to the MOLA tracks). Therefore it allows more detailed geoscientific studies of Mars. This is a first step to a global Mars HRSC DTM when MEX HRSC will cover Mars globally in the coming years. These data will furthermore be used for an atmospheric correction and even allow special data treatments, such as a de- and re-shading and to derive proper seamless color images in the near future.

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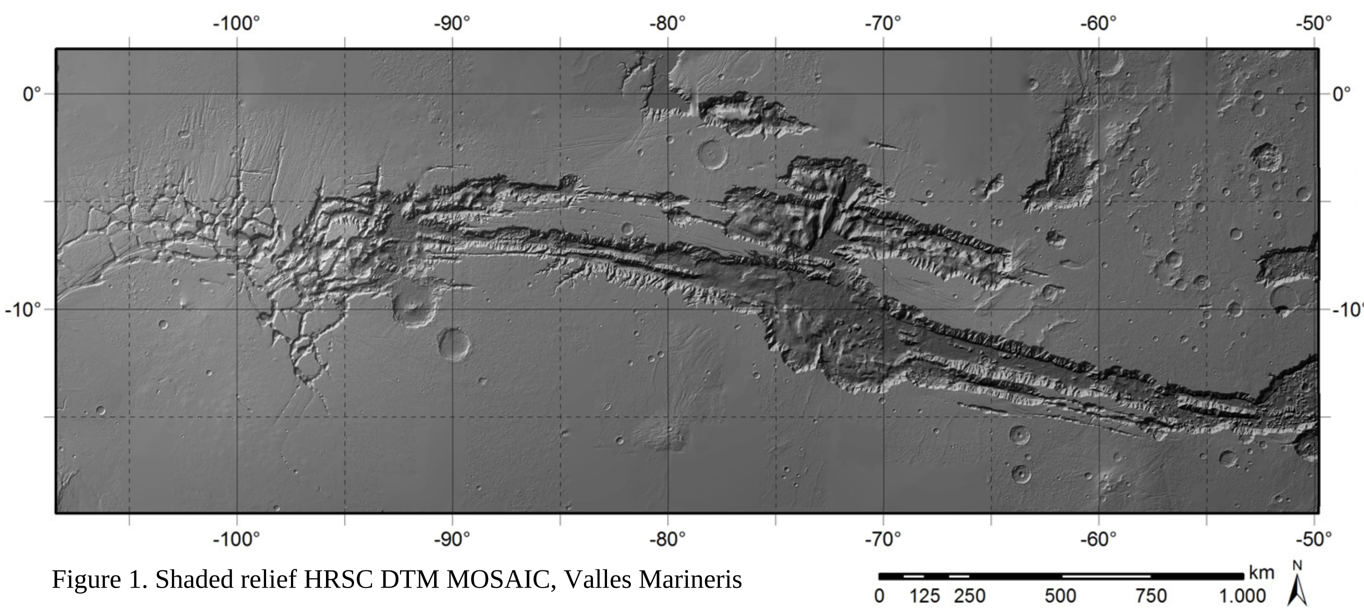

Figure 1. Shaded relief HRSC DTM MOSAIC, Valles Marineris