The HRSC Level 3 Mosaic of Mars: Equatorial regions, Mid-Latitudes - Improvements and Outlook.

W. Zuschneid, G.G. Michael, S.H.G.Walter, F. Postberg
Institute of Geological Sciences, Planetary Sciences and Remote Sensing Group, Freie Universität Berlin, Germany
(w.zuschneid@fu-berlin.de).

Introduction: The HRSC camera onboard ESA's Mars Express spacecraft has been operational in Mars Orbit since January 2004. Since then, it has been acquiring image data of the surface in colour and photogrammetric stereo, achieving a near-complete coverage at resolutions better than 50 m, and a complete coverage at lower resolutions.

One of the main mission goals is the creation of a global high-resolution image mosaic, using the HRSC global Digital Elevation Model (DEM) as a basis for geometric correction. These highly precise image mosaics are known as Level 5 products [1]. 5 of these mosaics have already been published, and more will be created in the coming years as the bundle-block-adjusted DEMs become available.

In addition, we are creating a mosaic based on the Level 3 images, which are orthorectified using the MOLA DEM. These images are created automatically after data acquisition, while they possess a significantly lower geometric accuracy than the latter HRSC DEM based level 5 images, they are available much earlier.

The idea of the Level 3 image mosaics is to use this independent processing chain to produce a high-quality image product - with lower resolution - at a much faster pace [2,3,4]. Using Level 3 data, a complete HRSC mosaic of Mars Chart 30 (MC-30) quadrangle can be finished within one month.

Mosaic Updating: After finishing the equatorial quadrangles, it was decided to update them all to integrate images acquired in the meanwhile. This also allowed to apply the experience gained and new methods developed to the older mosaics, including the use of stereo images for gap-filling, as well as applying a new brightness reference map which improves the brightness adjustments, especially in the high-contrast regions in the northern lowlands. The new brightness reference is based on recently acquired HRSC high altitude imagery.

As a result, the updated Level 3 image mosaics provide an improved visual impression and a better view into details at first glance. Also, the coverage has been improved, and some critical gaps in some quadrangles could be filled with new data.

Approach:
Mosaic creation follows a series of steps from the individual image to the completed mosaic. The process is a combination of scripted and interactive steps, and the creation of a mosaic from the first selection of images to the final mosaic requires several iterations, the exact number depending on the quality of the input images [2,3,4].

Image selection: Images are selected for a working area, initially, these areas were based on the extent of the MC-30 scheme. Later, we changed the approach for the equatorial quadrangles to two half quadrangles (north and south of the equator), as the overlap in north-south-direction is much more significant. This reduces redundancies in the mosaic processing and also allows more consistent contrast adjustment of images crossing the equator. For updating the equatorial mosaics, we used a scheme of 8 mosaic tiles, each consisting of 2 MC-30 quadrangles north and south of the equator. While the total number of images per mosaic is large, only a small number of new images was actually added
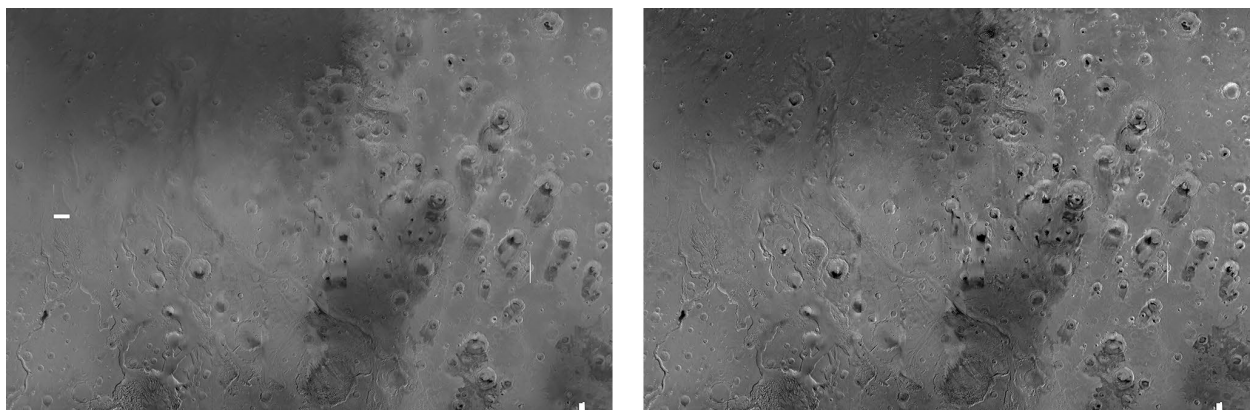

Fig. 1 Comparison of the old (left) and updated versions of the MC-11 (Oxia Palus) quadrangle. Please note that this quadrangle has a better coverage than average, with a much higher number of images compared to other MC quadrangles already early in the mission. The updated MC-11 also now uses a stretch range similar to other quadrangles, as well as the improved brightness reference.

for the updating. New images were highlighted for easier assessment and integration into the mosaic.

The mid-latitude mosaics also follow the MC-30 scheme. To reduce the geometric distortion and improve the image assessment and handling, images are projected to a Lambert conformal conic projection for the mid-latitude mosaic creation.

Lambert correction: In the first step, a Lambert correction is applied to the single images to correct the different lighting conditions and planetary curvature.

Brightness adjustment: For the brightness adjustment, an external brightness reference is used. This ensures a consistent brightness for all images of a location regardless of imaging conditions.

Sorting and Adjustment: Initially, all images are sorted by projected resolution / best ground resolution. As the resolution does not necessarily reflect image quality, a parameter "effective ground resolution" was introduced [2,3]. Using QGIS, images are sorted according to their perceived quality, and if necessary, a different, lower effective resolution is assigned. Using QGIS, a contrast adjustment factor is also assigned, to ensure a good usability of the mosaic for visual interpretation. Along-track, different contrast adjustment can be assigned. All these changes are recorded in the QGIS project file, which can be read out by the processing software to provide both image sequencing and contrast adjustments for the next iteration.

Finalizing: The process of sorting and adjustment takes several iterations. For the final version, a full-resolution mosaic is produced, where the image borders are processed with a feathering algorithm to further minimize the visual differences. The final image mosaics are then uploaded to the HRSC mapserver at Freie Universität Berlin and are also made available as a COG file (cloud-optimized GeoTIFFs [6]) for direct integration in a GIS without download.

Mapserver: The Mapserver at Freie Universität Berlin is the central instrument for the distribution of the HRSC level 3 image mosaics. The mosaics as well as many individual HRSC datasets can be selected and downloaded here [5].

Outlook: The creation of the mid-latitude mosaics proceeds as planned. We look forward for the Level 5 DEMs and individual orthoimages to continue our work there. We are currently also preparing for the mosaicking of the Martian polar areas.

References: [1] Gwinner et al. (2016), P&SS 126, DOI: 10.1016/j.pss.2016.02.014; [2] Michael, G.G. et al. (2016), P&SS 121, DOI: 10.1016/j.pss.2015.12.002; [3] Zuschneid, W. et al. [2021], 52nd LPSC, LPI Contrib. No. 2548, id.2049; [4] Zuschneid, W. et al. (2022), 53rd LPSC, LPI Contrib. No. 2678, id.2227; [5] Walter et al., (2018), ESS 5, DOI: 10.1029/2018EA000389; [6] https://www.cogeo.org/

Data availability: Work on the HRSC level 3 mosaics is ongoing. Data and the current coverage are available on the HRSC Mapserver at Freie Universität Berlin via the following links:
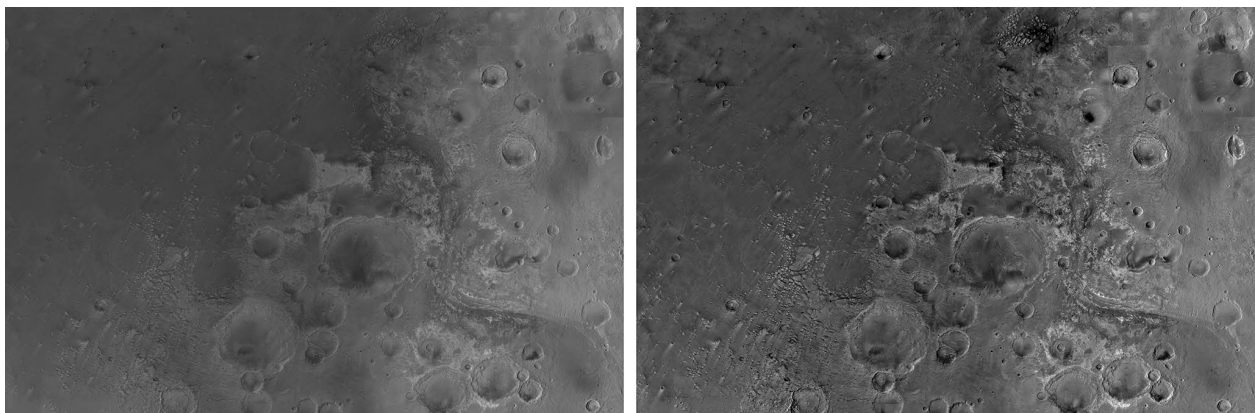
COG file (QGIS and others):

https://maps.planet.fu-berlin.de/level3/hrsc3-mos.tif

ArcGIS VRT file:

https://maps.planet.fu-berlin.de/level3/hrsc3-mos.vrt

(Total download size of the dataset is currently around 80 GB)

Mapserver web adress: https://maps.planet.fu-berlin.de/

Fig. 2: Detail view of the Mawrth Vallis Region in MC-11. The updated version on the right provides much better contrast in the darker and less detail-rich regions, improving the visual interpretation of the image mosaic.