TOWARDS AUTOMATED/GLOBAL COLOR MOSAICKING OF HRSC IMAGES OF MARS

P.C. McGuire[1,3], S.H.G. Walter[1], S. van Gasselt[1], A. Dumke[1], C. Gross[1], G. Michael[1], and L. Wendt[1,2],
[1]Planetary Science and Remote Sensing Group, Freie Universität Berlin, Germany
[2]Geoinformatics Group, Universität Salzburg, Austria
[3]Email: patrick.mcguire@fu-berlin.de

The High Resolution Stereo Camera (HRSC) on the Mars Express (MEx) orbiter has acquired over 3300 images (with 'preliminary level 4' processing) of the martian surface since arriving in orbit in 2003. At resolutions that can reach 10 meters/pixel, these MEx/HRSC images [1-2] are constructed in a push-broom manner from 9 different CCD line sensors, including a panchromatic nadir-looking (P) channel, 4 color channels (R,G,B,IR), and 4 other panchromatic channels for stereo imaging or photometric imaging.

Herein, we discuss our approach towards automatically mosaicking hundreds of the MEx/HRSC P or RGB images together.

The images were acquired under different atmospheric conditions over the entire mission and under different observation geometries. Therefore, the main challenge that we have addressed is the color matching of these images, which have varying colors due to the different observing conditions. We use a simple photometric correction (Lambertian, by dividing by the cosine of the incidence angle), which is currently used in the global mosaicking and map-tile creation of MRO/CRISM multispectral data [3-5]. However, due to the time and difficulty involved [3-5], we do not currently use atmospheric correction for mosaicking this data. The color-matching techniques that we have investigated include: 'dodging and burning' and 'histogram matching'. Dodging and burning is a local contrast-enhancment technique similar to high-pass filtering. One digital implementation of dodging and burning is Local Range Modification (LRM) [6-7], though we currently use the dodging option in the mosaicking tool of ArcGIS. We also have employed edge blending [8] in order to reduce the seam-line imbalances of the color-matched mosaics.

Thus far, we have constructed panchromatic P (nadir) and color RGB mosaics with over 600 images that cover about 25% of Mars (at the low-to-mid latitudes) at a resolution of 50 meters/pixel, including the canyons of Valles Marineris and the Argyre impact basin. This subset of over 600 images had already been 'cleaned': images from this region of sub-standard data quality were eliminated prior to the mosaicking.

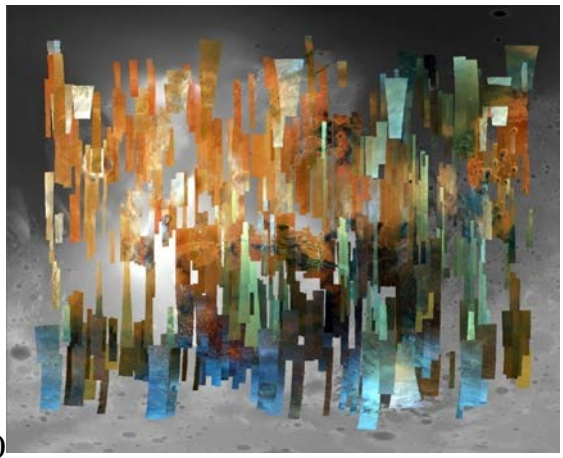
The resulting mosaics (see Fig. 1 on the next page) with both the Lambertian photometric correction and the dodging color-correction are much better when neither or only one of these corrections are applied. These are false-color mosaics, with a 0.5% clip, and the large-scale color-variations are absent in the final dodged mosaics due to the high-pass filtering. These mosaics are appropriate for crater-counting and geomorphological analysis across several HRSC images, without needing to change manually the contrast for each individual image.

Future: Using these techniques, we intend to make preliminary, non-archival, spatially-complete 'semi-global' mosaics (global mosaics, but excluding the polar regions, due to several factors, including the difficulty imposed by the changing polar atmosphere) available to the community in the next months (i.e., by a mapserver website), at a resolution of 50 m/pixel. We will work towards reducing the number of images that need to be completely eliminated during our cleaning step. We plan to develop our own code for dodging and burning, in order to gain more control over the process, as compared to the ArcGIS function. We also intend to create mosaics with more advanced techniques (some of which, for example, would allow us to produce mosaics with more-natural large-scale color variations): (i) low-pass/high-pass version, similar to the Viking MDIM [9]; (ii) Color Grading [10]; (iii) Color Histogram Warping [11]; (iv) Pan-sharpening; (v) with other photometric-correction techniques (Minnaert [12] and Lunar-Lambert [13]); (vi) with atmospheric correction; (vii) for the polar regions. Upcoming discussions are required to define science-data products to be potentially archived at PDS or PSA or which are going to be distributed via dedicated dissemination platforms

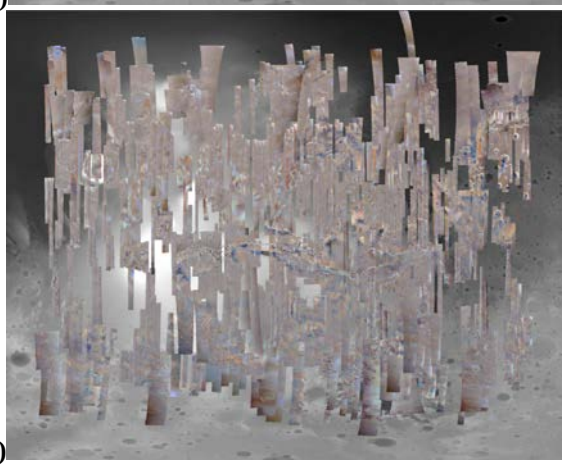
Acknowledgments: The work was supported by the German Space Agency (DLR Bonn), grant 50QM1301 (HRSC on Mars Express), on behalf of the German Federal Ministry of Economics and Technology. We acknowledge the entire HRSC team for their efforts in acquiring and processing the images used in this work.

References: [1] Neukum G. and Jaumann R. (2004) *Mars Express: the Scientific Payload, ESA Special Publication* **1240**, pp. 17–35. [2] Jaumann R. *et al.* (2007) *Planet. Space Sci.* **55**, pp. 928–952. [3]

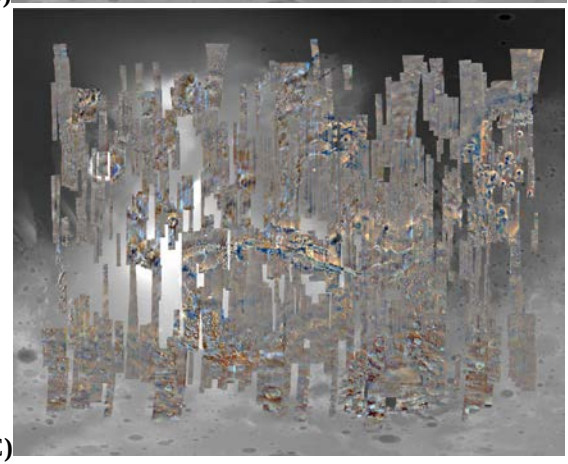
McGuire P.C. *et al* (2008) *Trans. Geosci. Remote Sensing,* **46**(12) 4020-4040. [4] McGuire P.C. *et al.* (2009) *Planet. Space Sci.* **57**, 809-815. [5] McGuire P. C. *et al.* (2013) *LPS XLIV*, extended abstract #1581. [6] Fahnestock J. D. and Schowengerdt R. A. (1983) *Opt. Eng.* 22, pp.378-381.[7] Nóbrega R. A. A. and Quintanilha J. A.(2001) *Joint ISPRS Workshop High Resolution Mapping from Space*, Hannover, Germany, pp. 153-159. [8] Kekre H. B. and Thepade S. D. (2008) *SPIT-IEEE Colloq. and Int'l. Conf.*, Mumbai, pp. 04-05. [9] Kirk, R. L. *et al.* (2000) *LPS XXXI*, extended abstract #2011. [10] Pitié, F., Kokaram, A. C., and Dahyot, R. (2007). *Computer Vision and Image Understanding*, **107**(1), pp. 123-137. [11] Grundland, M., & Dodgson, N. A. (2005*) Electronic Imaging 2005*, pp. 610-621. [12] Walter, S. *et al.* (2012\ *LPS XLIII*, extended abstract #2322. [13] McEwen, A. S. (1996). *LPS XXVII*, extended abstract #841.



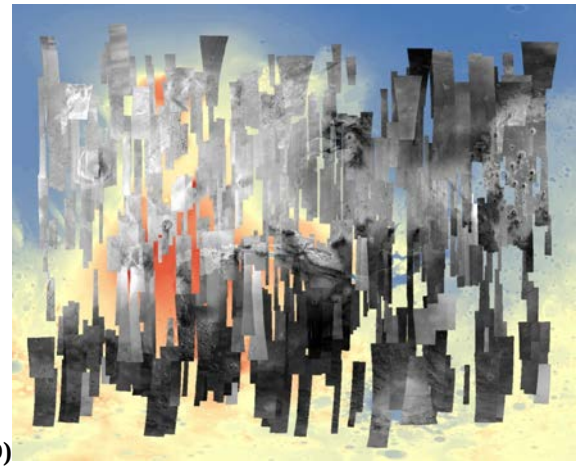
A)



B)

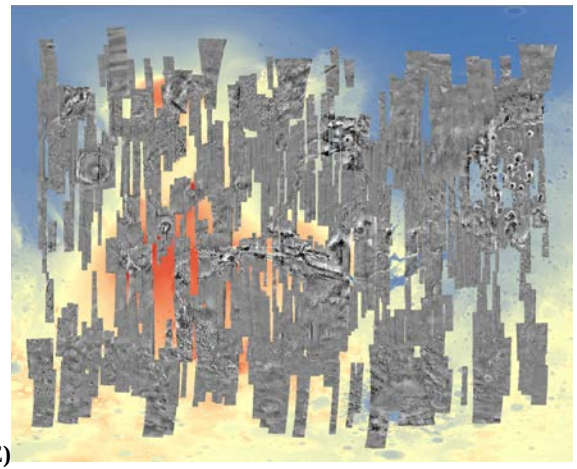


C)



D)

Figure 1: HRSC Color and Panchromatic Mosaics of Tharsis+Valles-Marineris+Argyre, etc. hemisphere; Background = MOLA; **A)** Color mosaic with photometric correction and without dodging color-correction; **B)** Color mosaic without photometric correction and with dodging color-correction; **C)** Color mosaic with photometric correction and with dodging color-correction; **D)** Panchromatic Nadir-Channel with photometric correction and without dodging color-correction; **E)** Panchromatic Nadir-Channel with photometric correction and with dodging color-correction; Note: We do not show the Panchromatic mosaic without the photometric correction and with the dodging color-correction.



E)