BRIGHTNESS EQUALIZATION FOR MARS IMAGES AS APPLIED TO HRSC IMAGE MOSAICS G. Michael[1], S. Walter[1], W. Zuschneid[1], C. Gross[1], B. Schreiner[1], K. Gwinner[2]. [1]Planetary Sciences and Remote Sensing, Institute of Geological Sciences, Freie Universitaet Berlin, Malteser Strasse 74-100, Haus D, Berlin 12249, Germany. [2]DLR Institute of Planetary Research, German Aerospace Center, Rutherfordstr. 2, 12489 Berlin, Germany.

Introduction: Mars Express HRSC image strips show varying brightnesses caused by differing illumination and atmospheric conditions. Lambert correction improves the situation [1], but not sufficiently for a visually consistent mosaic (Fig 1).

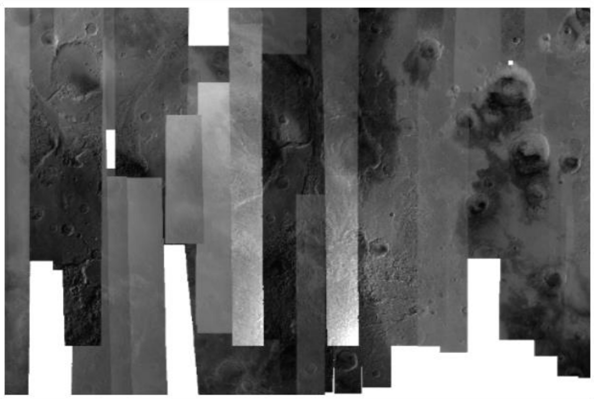

Fig 1. After Lambert correction: strips generally have good internal illumination consistency, but atmospheric variability between strips remains strongly visible (the area shown is particularly difficult)

There is not yet a systematically applicable correction for atmospheric effects for HRSC, which means that it cannot provide accurate information on surface albedo variations on scales greater than the image strip width. HRSC was conceived as a *high resolution* instrument, so this is not necessarily a problem: the global albedo of Mars at lower resolution is already well known, e.g. from TES [2], and if this is utilised as a brightness reference for individual HRSC strips, they can be brought into mutual consistency.

HRSC multi-orbit data products: characteristics and status

The problem of integrating many individual HRSC image strips into a single, visually consistent image mosaic (while fully preserving the local brightnes variability) has become of major importance when the HRSC science team initiated a systematic mapping program based on the MC-30 system few years ago [3]. This includes regional DTMs (50 m grid sapcing) and image mosaics (12.5 m pixel size for panchromatic images, 50 m pixel size for colour) for MC half-tiles (East and West) as the basic subdivision. Each half-tile comprises on the order of 100 block-adjusted individual image strips. Currently, the two half-tiles for MC-11 are being completed. The focus in designing the HRSC mosaic products was laid on homogeneity of visual appearance, in spite of large differences in illumination and atmospheric conditions (related to the orbit characteristics of Mars Express). As the overlapping patterns of HRSC image strips are quite irregular, resulting image mosaics are often heavily disturbed by strong contrasts across image borders without adequate brightness equalisation. Apart from their differing radiometric transformation, HRSC image mosaics share the geometric characteristics of the high-level orthorectified images of single-strip HRSC products (orthorectification using HRSC DTM).

Method: We construct the mosaic according to the following scheme:

Step 1: Apply Lambert correction and map-project image strips (see [1])

Step 2: Create intermediate resolution brightness reference map (Fig 2). Divide HRSC strip into cells and tie local mean of HRSC pixels to local mean of equivalent area in albedo map (using a continuous interpolation). Mosaic at moderate resolution to obtain higher resolution brightness reference map with same average brightness characteristics as source albedo map. Eliminate remaining image edge artefacts by applying a gaussian blur (without changing average spatial brightness characteristic).

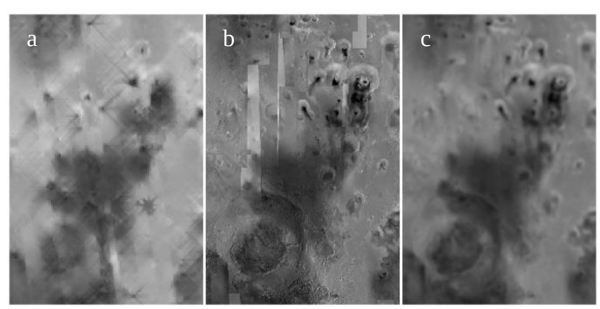

Fig 2. a) TES b) Tied HRSC over TES c) Intermediate brightness reference

Step 3: Create full resolution mosaic, tied to intermediate brightness reference map (Fig 3). Process images at full resolution, tying locally (and continuously) to intermediate brightness reference map, this time measured over smaller patches over each strip.

Place into mosaic, feathering (i.e. fading from 0% to 100% transparency) over a narrow range of pixels. Note that feathering helps to hide the image boundary, but is only effective if the image brightnesses are well matched.

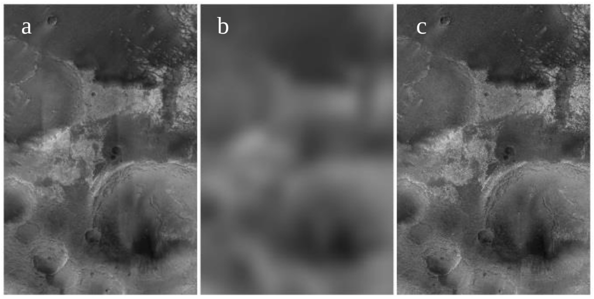

Fig 3. a) Tied HRSC over TES b) Intermediate brightness reference c) Final mosaic, 12.5 m/pix

Step 4: Image sequence optimisation. Images are put into the mosaic in order of best ground sampling resolution (lowest to highest). In cases where this is not the optimal sequence (for reasons of quality or consistency) we manually construct a list of ordering relations. This is done by comparison of the assembled mosaic with individual image strips.

Step 5: Contrast recovery. A significant number of images show reduced contrast caused by increased atmospheric scattering, appearing in the processed mosaic as relatively flat bands. Contrast is recovered by stretching the histogram width by a factor of typically 1.5-6, the amount being adjusted iteratively after inspection of the assembled mosaic (Fig 4).

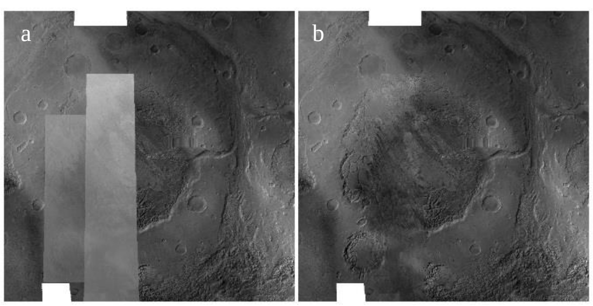

Fig 4. a) Mosaic with overlaid very low contrast images 1903_0000 (left), 1892_0000 (centre) b) Mosaic including images 1903_0000, 1892_0000 with contrast increases of 6x, 5x

Step 6: Colour processing. We have achieved some preliminary results in systematic processing of the colour channels using a similar technique, using a constant value for each colour channel instead of the brightness reference map, and restoring the larger scale brightness features by pan-sharpening the colour mosaic with that of the nadir channel (Fig 5). This means that colour differences are retained at local scales (less than the strip width), but not over longer distances, which may be sufficient for geomorphological interpretations at scales close to the resolution of the HRSC instrument.

Conclusion: We have shown that it is possible to produce a visually consistent image mosaic for geomorphological studies in the absence of a full correction of atmospheric effects [4]. We have begun systematic processing of the complete HRSC dataset, working according to the USGS MC-30 quadrangle scheme.

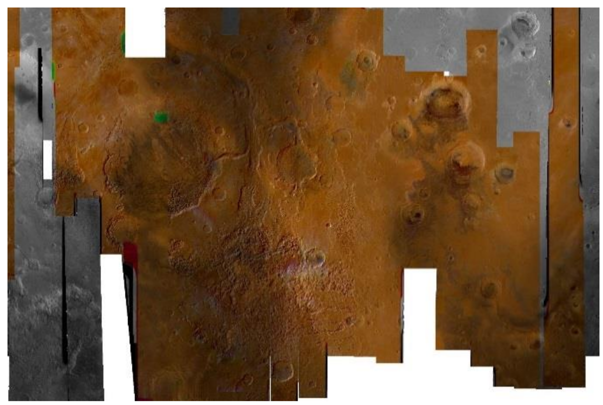

Fig 5. A colour mosaic including about 20 image strips in the Aram Chaos region

Acknowledgement: We thank the HRSC experiment team at DLR Berlin and the Mars Express operations team at ESOC for their successful planning, acquisition and processing of the HRSC data. The work was supported by the German Space Agency (DLR Bonn), grant 50QM1301 (HRSC on Mars Express), on behalf of the German Federal Ministry for Economic Affairs and Energy.

References: [1] Walter et al. LPSC 2015, abs. #1434 [2] Christensen et al., J. Geophys. Res., 106, 23823-23871, 2001. [3] Gwinner et al., Planet. Space Sc., 126, 93-138, 2016. [4] Michael et al., Planet. Space Sc., 121, 18–26, 2016.