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MARS EXPRESS HRSC HIGH ALTITUDE COLOUR MOSAIC PRODUCT USER GUIDE

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CHANGE RECORD

Issue 1	Revision 1		
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1. INTRODUCTION

1.1 Executive Summary

A high-altitude observation campaign with the Mars Express High Resolution Stereo Camera was used to construct five global mosaics of Mars from images captured through each of its five different spectral filters: panchromatic, red, green, blue and infra-red.

The substantial overlaps of high-altitude images enable the calculation of a global colour model yielding mosaics which both retain long range colour information and maintain high relative colour accuracy. The mosaics are currently processed at 2 km/pixel.

1.2 Extended introduction

Colour images of Mars are strongly affected by the planet's varying atmospheric scattering such that colour shifts between images may be comparable in magnitude to the actual surface colour variation within an image. The processing of this product addresses this problem by making use only of relative colour information within single images, used iteratively to derive a global colour model, offering absolute colour brightness estimates at all locations (Michael et al, *in review*).

The current processing iteration uses around 90 images with pixel scales greater than 200 m, selected for minimal influence of atmospheric dust while clipping out any significant areas of cloud, and processed to 2 km/pixel. There remain a small number of coverage gaps which we hope to fill during the 2023-2026 mission extension.

1.3 Mars Express High Resolution Stereo Camera high-altitude observations introduction

Since 2019, the Mars Express High Resolution Stereo Camera (Neukum & Jaumann, 2004; Jaumann et al. 2007; Gwinner et al, 2016) has been carrying out a high-altitude observation campaign, acquiring images from altitudes between 4 000 and 10 500 km above the surface to permit the compilation of the mosaics described here. It was desirable to obtain high quality, low atmospheric scattering images with as wide as possible single-image coverage, capturing colour variations over large distances on the surface.

1.4 Abbreviations and Acronyms

HRSC – High Resolution Stereo Camera

1.5 Reference and Applicable Documents

G. G. Michael, D. Tirsch, K.-D. Matz, W. Zuschneid, E. Hauber, K. Gwinner, S. Walter, R. Jaumann, T. Roatsch, F. Postberg. *A global colour mosaic of Mars from high altitude observations (in review)* https://doi.org/10.48550/arXiv.2307.14238

Neukum, G. & Jaumann, R. *HRSC: the High Resolution Stereo Camera of Mars Express*. Mars Express: the Scientific Payload 1240, 17–35 (2004).

Jaumann, R. et al. *The high-resolution stereo camera (HRSC) experiment on Mars Express: Instrument aspects and experiment conduct from interplanetary cruise through the nominal mission.* Planetary and Space Science 55, 928–952 (2007).

Gwinner, K. et al. *The High Resolution Stereo Camera (HRSC) of Mars Express and its approach to science analysis and mapping for Mars and its satellites*. Planetary and Space Science 126, 93–138 (2016).

Michael, G. G. et al. *Systematic processing of Mars Express HRSC panchromatic and colour image mosaics: Image equalisation using an external brightness reference*. Planetary and Space Science 121, 18–26 (2016).

2. SCIENTIFIC OBJECTIVES

The compensation of atmospheric scattering effects has been a long standing problem in the compilation of Mars image mosaics. Reflection and scattering off dust particles changes the absolute brightness and contrast of individual images. For colour products, rather than monochromatic mosaics, the problem is compounded.

The systematic colour processing of high resolution HRSC colour mosaics has involved a form of high-pass filtering: colour variations on distance scales greater than typical image strip widths had to be discarded. This meant that high resolution colour details could be studied – as would be seen in a single colour image - but regional colour properties were averaged away (Michael et al, 2016).

Mars Express operates in an elliptical orbit with its altitude above the surface varying from about 250 km to over 10 000 km. High resolution mapping images are acquired close to the minimum altitude; images acquired from high altitude show colour variations over much greater distances. A mosaic from such images could thus retain more long-range colour information, which motivated the high altitude observation campaign (Michael et al, *in review*). Such a mosaic may also be used to colour-reference high resolution images and thus feed the long range information back into the high resolution product.

2.1 Acknowledgements

The high altitude images used were level 3 HRSC data products up to image hn091_0000. Those which are already released can be found here:

https://archives.esac.esa.int/psa/ftp/MARS-EXPRESS/HRSC/MEX-M-HRSC-3-RDR-V3.0/

It is appreciated if use of the dataset is acknowledged by citing:

G. G. Michael, D. Tirsch, K.-D. Matz, W. Zuschneid, E. Hauber, K. Gwinner, S. Walter, R. Jaumann, T. Roatsch, F. Postberg. *A global colour mosaic of Mars from high altitude observations (in review)* https://doi.org/10.48550/arXiv.2307.14238

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3. DATA PRODUCT GENERATION

The techniques for processing this dataset are described in Michael et al (*in review*).

4. ARCHIVE FORMAT AND CONTENT

The data are provided as geotiff format 4-byte/pixel floating point images. Blank areas have the value nodata=-1e32. Files are arranged in two directories,

DATA/

contains the complete dataset in its original processing. For each camera filter (nd – panchromatic nadir, re – red; gr – green; bl – blue; ir – infrared) there are six planetary face mosaics in orthographic projection centred on the two poles and equatorial points at 0°, 90°, 180°, 270°E, each extending to 2800 km radius.

The files are named

<ii-ff>-face_<lbl>.tif

where

<ii-ff> is the filter index number and label combination (00-nd, 01-re, 02-gr, 03-bl, 04-ir)

<lbl> is the face label (N, S, 000, 090, 180, 270)

EXTRA/

Contains the same dataset, but reprojected to equicylindrical for convenience.

The files are named

<ii-ff>-eqc.tif

where

<ii-ff> is the filter index number and label combination (00-nd, 01-re, 02-gr, 03-bl, 04-ir)

Typical software packages for viewing these data include QGIS and ArcGIS. GDAL is recommended for reprojecting and combining the data from different faces. Note that projection artefacts will generally be minimised when starting from the orthographic faces (DATA directory), particularly when interested in the polar areas.

5. KNOWN ISSUES

There are a few small coverage gaps around the north polar cap and elsewhere. Note that these appear in the data as featureless areas rather than holes as a consequence of the processing methods. It is hoped to fill them during the 2023-2027 mission extension.

6. SOFTWARE

Recommended software for working with the data:

QGIS or ArcGIS

Image viewing

GDAL

Available from https://gdal.org/

For performing reprojections, combining faces, constructing colour composites.

The following are examples of potentially useful commands, but see GDAL documentation for further details:

To reproject:

```
gdalwarp -t_srs "+proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0
+R=3396000 +units=m +no_defs" 00-nd-face_000.tif 00-nd-
face_000_eqc.tif
```

To merge (after creating `00-nd-face_000_eqc.tif` above and analogously `00-nd-face_090_eqc.tif`):

```
gdalwarp -t_srs "+proj=eqc +lat_ts=0 +lat_0=0 +lon_0=0 +x_0=0 +y_0=0
+R=3396000 +units=m +no_defs" 00-nd-face_000_eqc.tif 00-nd-
face_090_eqc.tif merged_eqc.tif
```

To create RGB composite:

```
gdal_merge -init -1e32 -a_nodata -1e32 -tap -o rgb.tif -separate 01-
re-eqc.tif 01-gr-eqc.tif 03-bl-eqc.tif
```