EPSC Abstracts
Vol. 9, EPSC2014-315, 2014
European Planetary Science Congress 2014

Multi-temporal database of High Resolution Stereo Camera (HRSC) images – Alpha version

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Introduction

Image data transmitted to Earth by Martian spacecraft since the 1970s, for example by Mariner and Viking, Mars Global Surveyor (MGS), Mars Express (MEx) and the Mars Reconnaissance Orbiter (MRO) showed, that the surface of Mars has changed dramatically and actually is continually changing [e.g., 1-8]. The changes are attributed to a large variety of atmospherical, geological and morphological processes, including eolian processes [9,10], mass wasting processes [11], changes of the polar caps [12] and impact cratering processes [13]. In addition, comparisons between Mariner, Viking and Mars Global Surveyor images suggest that more than one third of the Martian surface has brightened or darkened by at least 10% [6]. Albedo changes can have effects on the global heat balance and the circulation of winds, which can result in further surface changes [14-15].

The High Resolution Stereo Camera (HRSC) [16,17] on board Mars Express (MEx) covers large areas at high resolution and is therefore suited to detect the frequency, extent and origin of Martian surface changes. Since 2003 HRSC acquires high-resolution images of the Martian surface and contributes to Martian research, with focus on the surface morphology, the geology and mineralogy, the role of liquid water on the surface and in the atmosphere, on volcanism, as well as on the proposed climate change throughout the Martian history and has improved our understanding of the evolution of Mars significantly [18-21]. The HRSC data are available at ESA's Planetary Science Archive (PSA) as well as through the NASA Planetary Data System (PDS). Both data platforms are frequently used by the scientific community and provide additional software and environments to further generate map-projected and geometrically calibrated HRSC data. However, while previews of the images are available, there is no possibility to quickly and conveniently see the spatial and temporal availability of HRSC images in a specific region, which is important to detect the surface changes that occurred between two or more images.

Multi-temporal HRSC database

We contribute to the systematic processing of High Resolution Stereo Camera (HRSC) nadir (ND) image data with the development of a multi-temporal database of High Resolution Stereo Camera (HRSC) ND images and other planetary ND image data. The multi-temporal database is a new approach and one of our contributions to the HRSC team. The HRSC database will help to globally identify areas with multi-temporal HRSC ND coverage and will give researchers the option to conveniently and easily detect surface changes in planetary image data.

We developed an algorithm that automatically creates color-coded polygons to provide information about the location and number of overlapping HRSC ND images. The routine is based on the latitude (Lat) and longitude (Lon) coordinates of the vertices of each HRSC image and the vertices of the 100 sections each HRSC ND image consists of, respectively. Our preliminary color-coded ranking system provides a quick overview of overlapping HRSC ND (level-4) image data (Fig. 1). The polygons are based on GIS shapefiles and are created automatically with our routine. Such ranking is commonly used for a large variability of tasks, for example to show the availability of entries in any kind of databases. It is self-explanatory for most users and therefore suitable for use in the multi-temporal HRSC database. The current alpha version of the multi-temporal HRSC image database allows showing the total number of overlapping images of an entire HRSC orbit (Fig. 2). The improved beta version will use the Lat/Lon coordinates of overlapping images to calculate the intersection between the images.

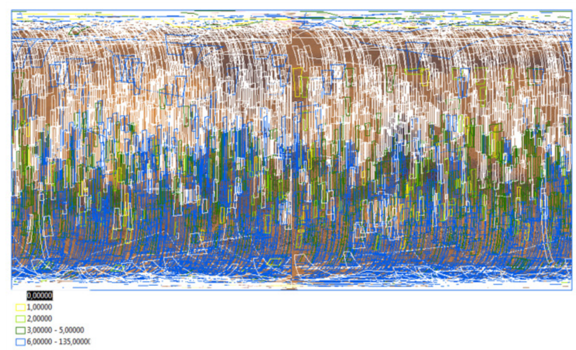

Fig. 1: Preliminary global multi-temporal coverage and availability of HRSC nadir orbits. Preliminary color-coded ranking: yellow: 1 HRSC orbit (no overlap of HRSC nadir images), light green: 2 HRSC orbits, dark green: 3 – 5 HRSC orbits, blue: more than 6 HRSC orbits, white: HRSC orbits which are in progress.

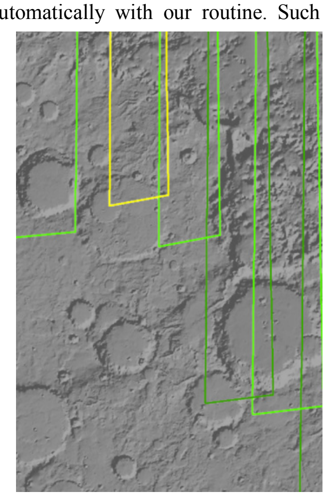

Fig. 2: GIS output of the multi-temporal HRSC image database with a color coded ranking showing the total number of overlapping HRSC images. Preliminary color-coded ranking: yellow: 1 HRSC orbit (no overlap of HRSC nadir images), light green: 2 HRSC orbits.

Compilation of multi-temporal HRSC database

The multi-temporal HRSC database is generated by the integration of different planetary image datasets into a Microsoft Access database management system. Microsoft Access also serves as user interface (Fig. 3). The calculation of overlapping and the modification of the datasets are done by using VBA and SQL routines.

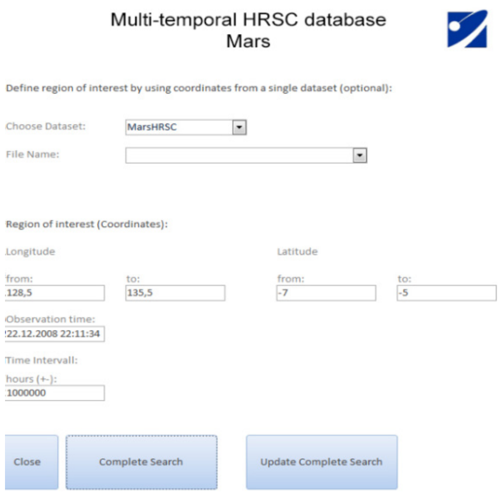

Fig. 3: User interface of the multi-temporal HRSC image database showing input parameters of a first usability test for a region of interest in Aeolis Terra, Mars [22].

In the input mask, the parameters for Lat/Lon can be set freely or based on the footprints of a specific image. The compiled tables of overlapping images from different datasets appear in the output mask (Fig. 4). Additionally to the manual search of images for a requested area, the program automatically calculates overlaps for all images and stores them along with their respective relationships. This summed number of overlapping images enables a color coded ranking. In order to display the calculated results in GIS, a *.dbf- and *.prn-file is generated. These files are required to create GIS executable shapefiles by using free ShapeLib tools, which are based on Linux. The resulting *.shp- and *.shx-files can then be integrated into GIS. The integration into GIS will contain the development of shapefiles for each color-coded class. We will create shapefiles for a variety of HRSC data products, for example HRSC ND (level-4) images (Fig. 1), digital terrain models (DTMs) or stereo color data.

Integration of additional datasets

We added additional planetary image datasets to our database. Context Camera (CTX) and Mars Orbiter Camera (MOC) images are already included into the database. In particular, CTX images cover areas of an extent comparable to HRSC and also have comparable resolution. Together with HRSC, CTX images are best suited for the detection of surface changes. The addition of other planetary datasets such as CTX images will not only improve the spatial coverage of multi-temporal images, but will also extend the time period of observation.

Release of database

An alpha version of the multi-temporal HRSC image database is currently available on request via the Institut für Planetologie. The database is in working condition but major features are not fully tested. A beta version of the database will be released to the HRSC team for usability tests and internal reviews. Users will have access to the database including the HRSC-ND, CTX, MOC-WA and THEMIS-VIS dataset. The database will finally be available at the Institut für Planetologie webpage, where the Microsoft Access file and the calculated shapefiles can be downloaded. We will provide a compressed file for download due to the large file size of the Access-based multi-temporal HRSC image database (>1GB).

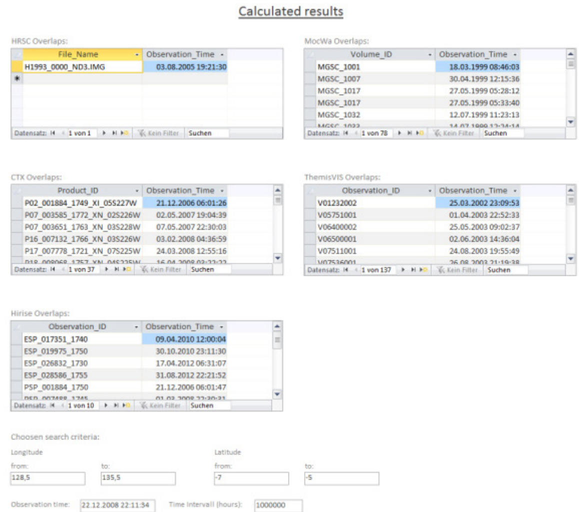

Fig. 4: Output mask of the multi-temporal HRSC database with the query results of a first usability test showing overlapping images of the HRSC, MOC-WA, CTX and THEMIS VIS image datasets. A preliminary HiRISE image dataset has been included into the calculation. The output tables are showing the number, the location and observation time of overlapping images. The scientific results of this research are published by [22].

Scientific objectives

Our objectives are (1) to study examples of surface changes based on multi-temporal HRSC ND image data caused by eolian processes, mass wasting and polar processes, as well as impact cratering processes, and (2) to document examples of surface changes through the comparison of multi-temporal HRSC ND image data with other past, current and future missions of Mars exploration, e.g., CTX and MOC, and (3) to investigate the causes of the selected examples of Martian surface changes by seeking correlations between morphologic, geologic and atmospherical processes and surface parameters such as topography, relief, elevation, thermal inertia, rock abundance, surface roughness, geologic properties and wind regimes.

Summary

The multi-temporal database will be available for the HRSC team as well as the scientific community and will show the distribution of High Resolution Stereo Camera (HRSC) and other planetary image data and, in particular, how many images cover the same terrain at different times. The database will be suitable for further scientific investigations of temporal and multi-temporal processes that cause surface changes on Mars. In conclusion, using the multi-temporal HRSC database, researchers will be able to easier and faster detect and investigate surface changes on Mars and will better understand what surface changes can tell us about the interactions between the Martian surface and external forces, including the atmosphere: Why do variable features occur at certain locations and seasons? Do surface changes occur diurnally, daily, seasonally or annually? In conclusion, the temporal and multi-temporal High Resolution Stereo Camera (HRSC) image database is intended to further expand our knowledge about correlations between morphologic, geologic and atmospherical processes and the surface.

References: [1] Sagan et al. (1972), Icarus 17, 346-372 [2] Sagan et al. (1973), JGR 78, 4163-4196 [3] Thomas and Veverka (1979), JGR 84, 8131-8146 [4] Chaikin et al. (1981), Icarus 45, 167-178. [5] Zurek and Martin (1993), JGR 98, 3247-3259.[6] Geissler (2005), JGR 110 [7] Raack et al. (2012) Icarus 219, 129-141 [8] Hayward et al. (2013), Icarus in press. [9] Bourke et al. (2008), Geomorphology 94, 247-255 [10] Reiss et al. (2011), Icarus 215, 358-369. [11] Quantin et al. (2004), Icarus 172, 555-572. [12] Piqueux and Christensen (2008), JGR 113 E02006. [13] Daubar et al. (2013), Icarus in press. [14] Gurwell (2005), Icarus 175, 23-31. [15] Fenton et al. (2007), Nature 446, 646-649. [16] Neukum et al. (2004), Photo. Eng. Rem. Sens. 75, 1127-1142 [17] Jaumann et al. (2007), PSS 55, 7-8. [18] Mangold et al. (2004), Science 305, 78-81 [19] Jaumann et al. (2005), GRL 32, 16. [20] Hauber et al. (2009), PSS 57, 944-957. [21] Erkeling et al. (2010), EPSL 294, 291-305. [22] Ruesch et al. (2013), LPSC abstract #1719.