Multi-temporal database of High Resolution Stereo Camera (HRSC) images G. Erkeling[1], D. Luesebrink[1], H. Hiesinger[1], D. Reiss[1], R. Jaumann[2] [1]Institut für Planetologie (IfP), WWU Münster, Wilhelm-Klemm-Straße 10, 48149 Münster, Germany [2]German Aerospace Center (DLR), Berlin, Germany (gino.erkeling@uni-muenster.de / +49-251-8336376)

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 thus is particularly therefore well 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 Martian history and has significantly improved our understanding of the evolution of Mars [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 coverage of HRSC images in a specific region, which is important to detect surface changes that occurred between two or more images.

Scientific objectives: Our objectives are (1) to study examples of surface changes based on multi-temporal HRSC ND image data caused by eolian processes (Fig. 3), 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.

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 gives 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 (Fig. 1). 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. In the case of an overlap of two HRSC ND images, the Lat/Lon coordinates of both images will be used to calculate the intersection, which is color-coded in the ranking. The example in Figure 1A shows a study area on Mars with multiple (and overlapping) HRSC ND images. The

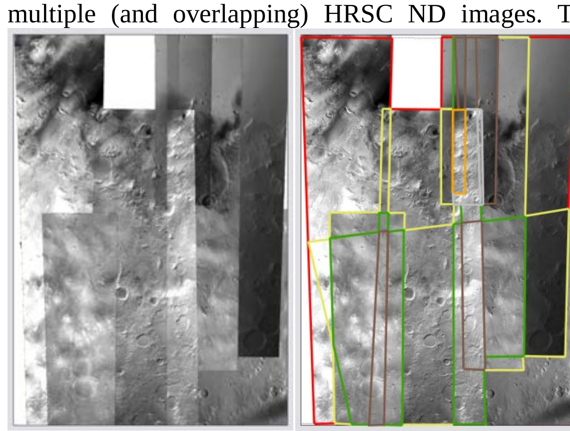

Fig. 1: A. Study area on Mars showing multiple HRSC ND images. Some parts of the study area are covered by two or more images. **B.** Study area on Mars with color-coded ranking showing all available HRSC ND images. Indicate how often a region of interest is covered by HRSC images/orbits (red: 1 orbit, yellow: 2 orbits, green: 3-5 orbits, orange/silver: 6-10 orbits, gold: more than 10 orbits). White sections are gaps in image coverage.

number of overlapping HRSC ND images is not clearly visible for researchers browsing for new image data. Our preliminary color-coded ranking system (Fig. 1B) implemented for the study area demonstrates the functionality of our HRSC database and provides a quick overview of overlapping HRSC ND image data. Here we used simple polygons stored in GIS layers. The polygons are based on GIS shapefiles and can be created automatically with our routine. The preliminary color-coded visualization for the coverage of all available HRSC ND images is based on a simple (traffic light) ranking with red showing areas with a coverage of 1 image, yellow indicating 2, green 3-5, silver 6-10 overlapping images and gold indicating more than 10 overlapping images. 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.

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. 2). The calculation of overlapping and the modification of the datasets are done by using VBA and SQL routines. 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 HRSC images appear in a new mask. Additionally to the manual search of images for a requested area, the program

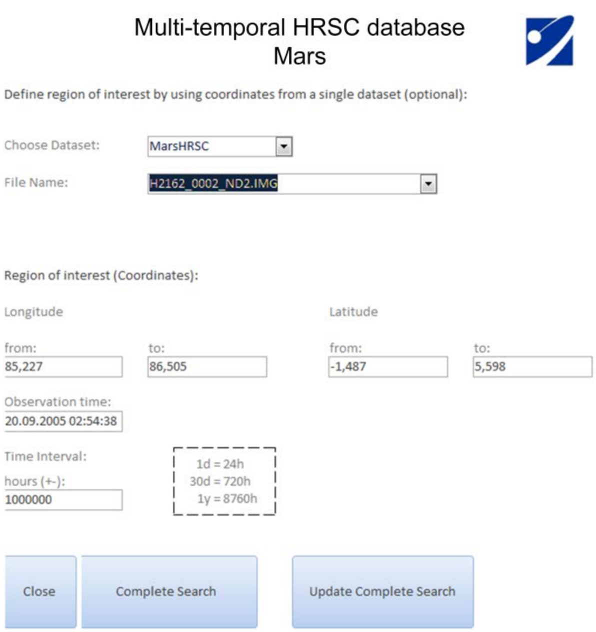

Fig. 2: User interface of the multi-temporal HRSC image database. Calculation of the overlap based on latitude/longitude of region of interest or corner coordinates of selected HRSC orbits.

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 (Fig. 3). We will create shapefiles for a variety of HRSC data products, for example HRSC ND (level-4) images, digital terrain models (DTMs) or stereo color data.

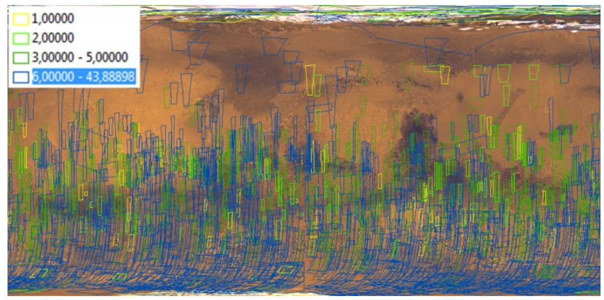

Fig. 3: Visualization of overlapping HRSC images in GIS (in progress).

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: After GIS integration and implementation of additional functions, we intend to release a first version of the multi-temporal HRSC image database for usability tests and internal reviews to the HRSC team and the scientific community. Users will have access to the database including HRSC, CTX and MOC datasets. The database will finally be available at the Institut für Planetologie webpage, where the Access file and the calculated shapefiles can be downloaded.

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.