The Multi-temporal Database of High Resolution Stereo Camera (HRSC) Images: A Tool to Support the Identification of Surface Changes and Short-lived Surface Processes 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 from Mars transmitted to Earth by 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].

The High Resolution Stereo Camera (HRSC) [14,15] on board Mars Express (MEx) covers large areas at high resolution and thus is particularly 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. Thus, MEx has significantly improved our understanding of the evolution of Mars [16-19]. 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.

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 (Fig. 1). 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.

Scientific objectives: Our objectives are (1) to study examples of surface changes 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.

Multi-temporal HRSC database: 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 subsections of each HRSC ND image. In the case of an overlap of two HRSC ND images, the Lat/Lon coordinates of both images are used to calculate the intersection, which is color-coded in the ranking. The multi-temporal HRSC database is generated by the integration of different planetary image datasets into a Microsoft Access database management system. The calculation of overlaps and the modifications of the datasets are done with VBA and SQL routines.

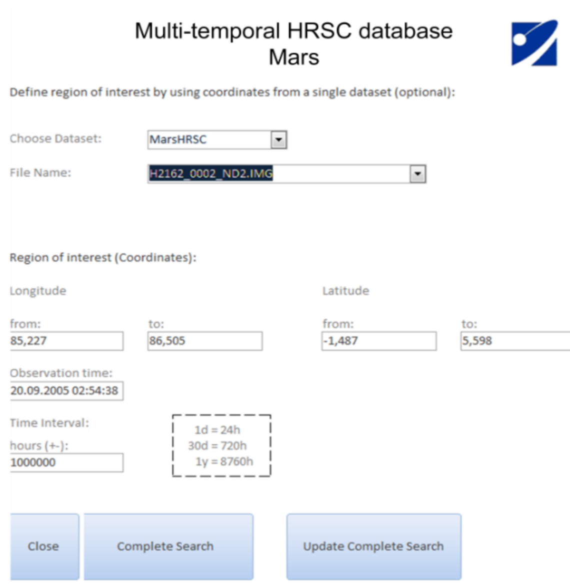

Fig. 1: User interface of the multi-temporal HRSC image database. Calculation of the overlap based on latitude/longitude of region of interest or corner coordinates of selected HRSC orbits.

In the input mask, the parameters for Lat/Lon can be set freely or based on the footprints of a specific image. As an output, the compiled tables of overlapping HRSC images appear in a new mask. Additionally, 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.

GIS shapefiles: Figures 2A-D show examples of GIS shapefiles created with the multi-temporal database of HRSC images. A global view of all available HRSC images and a color-coded ranking based on the number of overlaps is shown in the GIS shapefile of Figure 2A. There are only a few gaps on the surface left (red), where only one HRSC image is available. Multi-temporal observations based on HRSC images only cannot be performed at these sites. Multi-temporal observations can be done at sites showing HRSC orbits outlined in orange, yellow or green. However, particularly for investigations of recent and short-term processes on the surface of Mars, such as dust devil movement, it is important to identify those sites that have been monitored within days, hours or minutes. This is only possible with additional planetary image data such as those from the Context Camera (CTX), which are already included into the database. 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. Figure 2B shows a global view of all available HRSC and CTX images and a color-coded ranking based on the number of overlaps. Although multi-temporal observations are possible using nearly all imaging orbits, researchers that are searching for short-lived dust devils need to quickly identify those overlaps between HRSC and CTX, that have been acquired within a short time, for example within one day (Fig. 2C) or within 3 hours (Fig. 2D). While there are ~60 sites on Mars that have been monitored by HRSC and CTX within one day, there are only 19 locations on Mars that have been monitored by HRSC and CTX within 3 hours. The GIS shapefiles created by the multi-temporal database of HRSC images, in particular those that show images acquired within a short timespan (hours) give researchers the option to conveniently and easily identify those sites on Mars, where investigations of recent and / or short-term surface processes are possible.

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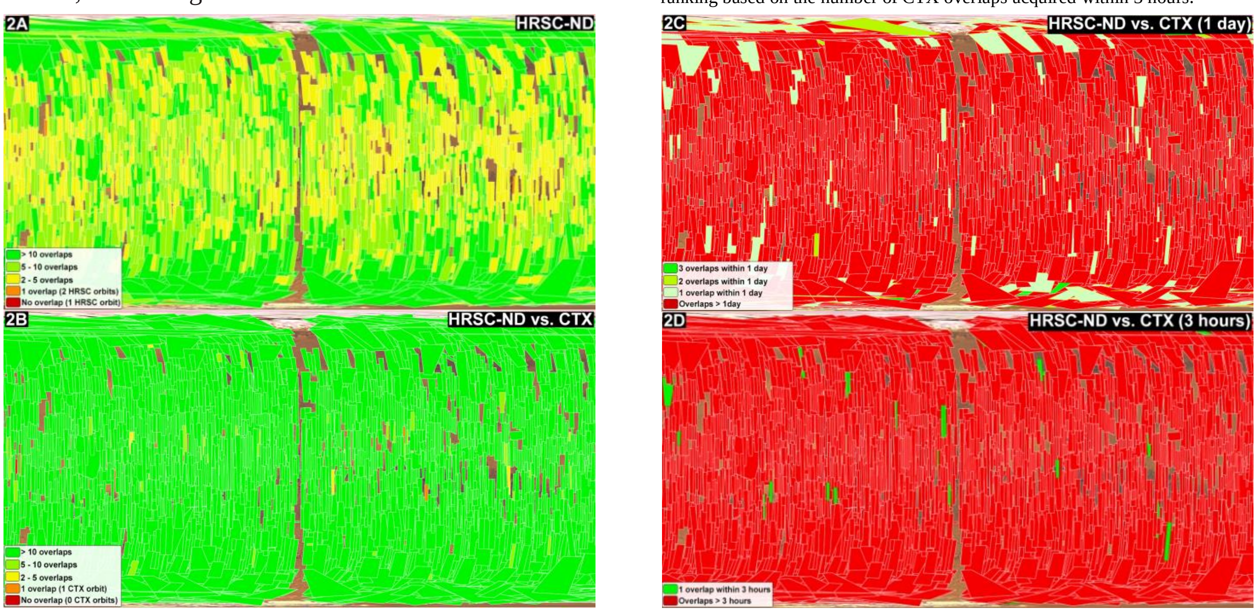

Fig. 2: Examples of GIS shapefiles created with the multi-temporal database of HRSC images. Data gap at Longitude boundary is an artefact related to the Beta version of the database. **A.** Global view of all available HRSC images and a color-coded ranking based on the number of overlaps **B.** Global view of all available HRSC images and a color-coded ranking based on the number of overlaps with CTX images. **C.** Global view of all available HRSC images and a color-coded ranking based on the number of CTX overlaps acquired within 1 day. **D.** Global view of all available HRSC images and a color-coded ranking based on the number of CTX overlaps acquired within 3 hours.