THE MULTI-TEMPORAL DATABASE OF PLANETARY IMAGE DATA (MUTED): A TOOL TO SUPPORT THE IDENTIFICATION OF SURFACE CHANGES ON MARS. T. Heyer[1], G. Erkeling[1], H. Hiesinger[1], D. Reiss[1], D. Luesebrink[1], H. Bernhardt[1], and R. Jaumann[2], [1] Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany, [2]German Aerospace Center (DLR), Berlin, Germany (thomas.heyer@uni-muenster.de).

Introduction: Multi-temporal observations are key to detect and analyze surface changes and processes on Mars. Since the 1970s, spacecraft observations have revealed that the surface of Mars is changing [1-14]. The modifications are attributed to exogenic processes, including eolian activity [12-17], mass movement [18, 19], the growth and retreat of the polar caps [20-22], and crater-forming impacts [7, 23]. The observation of these variable features became possible by the increasing number of repeated image acquisitions of the same surface areas. Today more than one million images of Mars are available [24]. This increasing number highlights the importance of efficient and convenient tools for planetary image data management, search, and access.

MUTED comprises metadata of all major Mars missions and enables scientists to quickly identify the spatial and multi-temporal coverage of planetary image data from Mars [24, 25]. Images can be searched in temporal and spatial relation to other images on a global scale or for a specific region of interest (ROI). Additional information, e.g., data aquisiton, the temporal and spatial context, as well as preview images and raw data download links are available. MUTED has been released at http://muted.wwu.de.

Structure of MUTED: The database is based on free and open source software. Metadata of the planetary image datasets are included from the Planetary Data System (PDS) into a relational database. Additional information, e.g., the number and time span of overlapping images are derived for each image data respectively. A Geoserver translates the metadata stored in the relational database into web map services (WMS) and web features services (WFS). Together with image data footprints in vector format, base maps are integrated into the server. Global base maps provide a quick overview and allow the definition of an ROI based on spectral, topographical or geological information. All services are combined and visualized in the web-based user interface. The user interface was built using HTML, PhP, and JavaScript and provides several features for data and base map selection, spatial definition of the area of interest and data filtering. Another feature of the user interface is a timeline that displays all selected images in chronological order. The timeline serves as a quick overview of the data availability and their temporal context (Fig. 1).

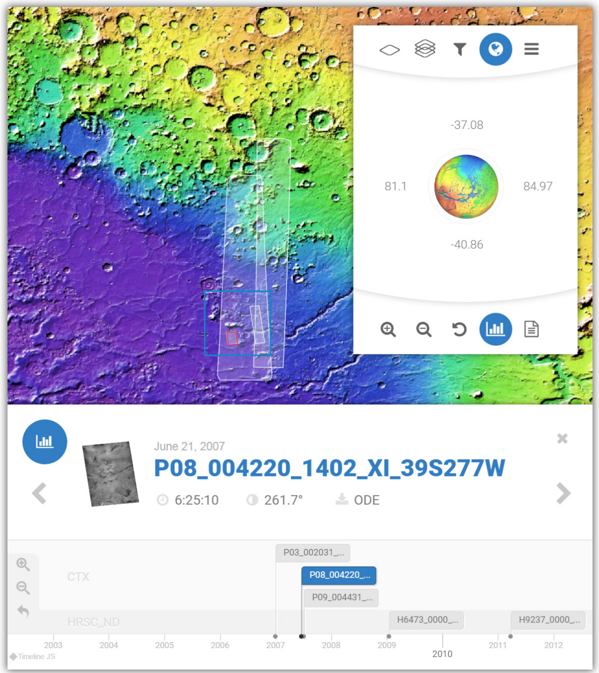

Figure 1: User interface of MUTED.

MUTED Datasets: At the current state, metadata pertaining to over 1.03 million images from various instruments including the Viking Orbiter (VO) [26], the Mars Orbiter Camera (MOC) [27] on board Mars Global Surveyor (MGS), the High Resolution Stereo Camera (HRSC) [28] on board Mars Express (MEx), the THermal EMission Imaging System (THEMIS) [29] on board Mars Odyssey, the Compact Reconnaissance Imaging Spectrometer of Mars (CRISM) [30], the Context Camera (CTX) [31], and the High Resolution Imaging Science Instrument (HiRISE) [32] on board the Mars Reconnaissance Orbiter (MRO) are integrated into the database. The spatial resolution of the integrated images varies from ~25 centimeters (HiRISE) to several kilometers per pixel (global observations of Viking and MOC-WA). Data analyses of all planetary image data integrated into MUTED showed that 52.3% of all images have a spatial resolution of < 50 m and cover about 99.98% of the surface of Mars. While some areas e.g., the landing sites or polar re-

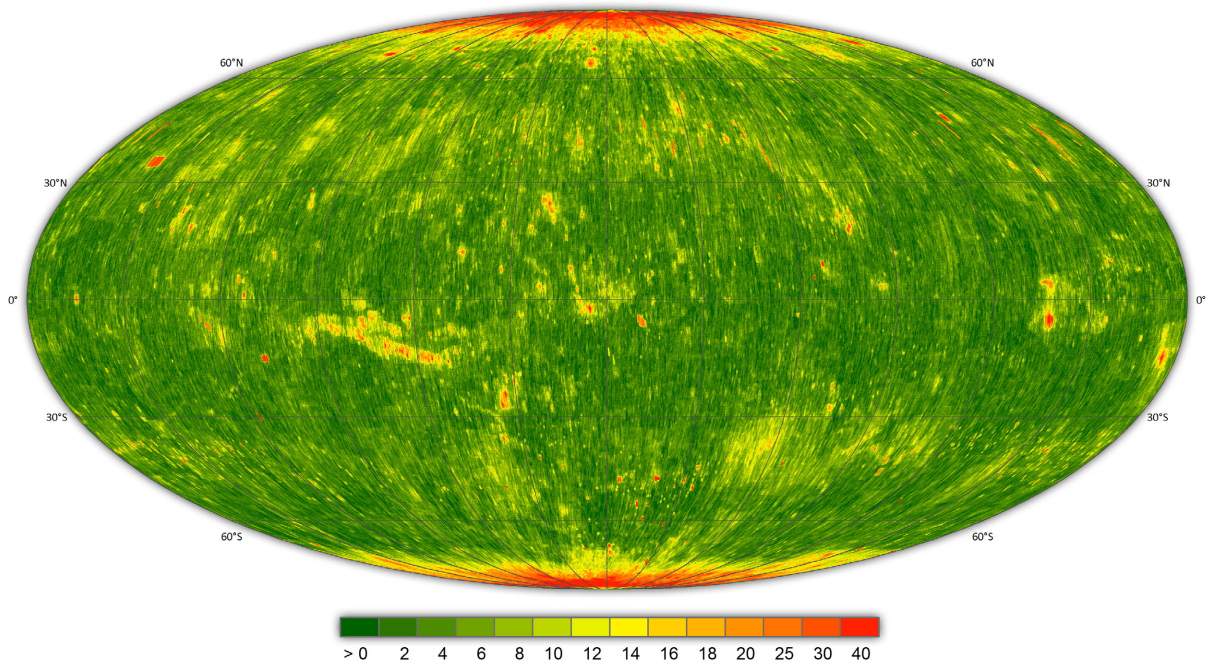

Figure 2: Number of images per 0.01° pixel derived from MUTED. A global view of all high resolution datasets integrated into MUTED, including CTX, HiRISE, HRSC-ND, MOC-NA, and THEMIS-VIS.

gions are covered with more than 200 images, a maximum of 50% of the surface of Mars is covered with at least 6 images (Fig. 2). These high to medium resolution multi-temporal observations are valuable sources to analyze various surface changes and processes on Mars from the 1970s to the present.

Scientific applications: MUTED enables planetary scientist, engineers, and mission planners to access multi-temporal observations of Mars and their spatial and temporal context. The database will assist and optimize image data searches as a basis for various change detection tasks:

(1) The time span between repeated images can be defined to discover surface changes caused by very short-term and temporal highly variable processes, e.g., dust devils.

(2) The number of images within a certain time period can be set according to solar longitude, for example to observe seasonal changes and processes, e.g., seasonal ice and frost cover.

(3) The minimum number of overlapping images can be defined to ensure data availability for certain multi-temporal data analyses, e.g., long term changes of the surface of Mars.

Due to long-term and continuous data acquisition by spacecraft, the amount of image data is steadily increasing and enables further comprehensive analyses of martian surface changes, caused by eolian, mass wasting, polar, as well as impact cratering processes.

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] Malin et al. (2006) Science 314, 1573-1577. [8] Stanzel et al. (2008) Icarus 197, 39–51. [9] Hayward et al. (2014) Icarus 230, 38–46. [10] Raack et al. (2015) Icarus 251, 226-243. [11] Vincendon et al. (2015) Icarus 251, 145–163. [12] Reiss et al. (2010b) GRL 30, L06203. [13] Reiss et al. (2011) Icarus 215, 358-369. [14] Reiss et al. (2014a) Icarus 227, 8-20. [15] Cantor et al. (2001) JGR 106. [16] Stanzel et al. (2006) GRL 33, L11202. [17] Bourke et al. (2008) Geomorphology 94, 247–255. [18] Squyres (1978) Icarus 34, 600–613. [19] Dundas and McEwen (2015) Icarus 254, 213–218. [20] Farmer et al. (1976) Science 194, 1339–1341. [21] Kieffer et al. (1976) Science 194, 1341–1344. [22] James et al. (2010) Icarus 208, 82–85. [23] Daubar et al. (2013) Icarus 225, 506–516. [24] Heyer et al. (2016) LPSC 2016 abstract #1852. [25] Erkeling et al. (2016) PSS 125, 43-61. [26] Carr et al. (1972) Icarus 16, 1, 17-33. [27] Malin et al. (2010) Mars 5, 1-60. [28] Jaumann et al. (2007) PSS 55, 928–952. [29] Christensen et al. (2004) SSR 110, 85–130. [30] Murchie et al. (2007) JGR 112, E05S03. [31] Malin et al. (2007) JGR 112, E05S04. [32] McEwen et al. (2007) JGR 112, E05S02.