THE MULTI-TEMPORAL DATABASE OF PLANETARY IMAGE DATA (MUTED): A TOOL TO STUDY DYNAMIC MARS. T. Heyer[1], H. Hiesinger[1], D. Reiss[1], G. Erkeling[2], H. Bernhardt[1], D. Luesebrink[1] and R. Jaumann[3], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany, [2]German National Library of Science and Technology (TIB), Hannover, Germany, [3]German Aerospace Center (DLR), Berlin, Germany. (thomas.heyer@uni-muenster.de)

Introduction: Multi-temporal observations are key to detect and study surface changes and time-critical processes on Mars. Since the 1970s, spacecraft observations have revealed that the martian surface is very dynamic [e.g., 1-3]. The observation of surface changes and processes, including eolian activity [e.g., 4, 5], mass movement [e.g., 6, 7], the growth and retreat of the polar caps [e.g., 8, 9], and crater-forming impacts [e.g., 10] became possible due to the increasing number of repeated image acquisitions of the same surface areas. Today more than one million orbital images of Mars are available [11]. This increasing number highlights the importance of efficient and comprehensive tools for planetary image data management, search, and access.

MUTED is a web-based tool to support the identification of surface changes and processes on Mars. The database enables scientists to quickly identify the spatial and multi-temporal coverage of orbital image data of all major Mars missions. In particular, images can be searched in temporal and spatial relation to other images on a global scale or for a specific region of interest. Additional information, e.g., data aquisiton time, the temporal and spatial context, as well as preview images and raw data download links are available. MUTED is accessible via web at muted.wwu.de and will assist and optimize image data searches to support the analyses and understanding of short-term, long-term and seasonal processes on the surface as well as in the atmosphere of Mars.

Structure: MUTED is based on a three-tier architecture (Fig 1). Metadata of planetary image datasets are integrated from the Planetary Data System (PDS) into a relational database (PostGreSQL) in combination with the PostGIS geospatial extension at the bottom data storage level. In order to provide the multi-temporal coverage, additional information, e.g., the geometry, the number and time span of overlapping images are derived for each image respectively. At the service level, a Geoserver translates the metadata stored in the relational database into web map services (WMS) and web feature services (WFS). WMS provides a global rasterized representation of image coverage. For a region of interest, WFS provides selectable vector representations of the images. Using Common Query Language (CQL), the web services can be filtered by date, solar longitude, spatial resolution, incidence angle, and spatial extend. A GeoWebCache is used to cache map tiles and accelerate as well as optimize the WMS delivery. At presentation level, all services are combined and visualized in the web-based user interface. The user interface was built using HTML, PhP, JavaScript, and Openlayers and provides several features for data selection, filtering, and visualization. A region of interest can be defined based on global spectral, topographic or geologic information. The multi-temporal coverage as well as meta data and the spatial and temporal context of the images are presented on the map, within a timeline or a downloadble feature list.

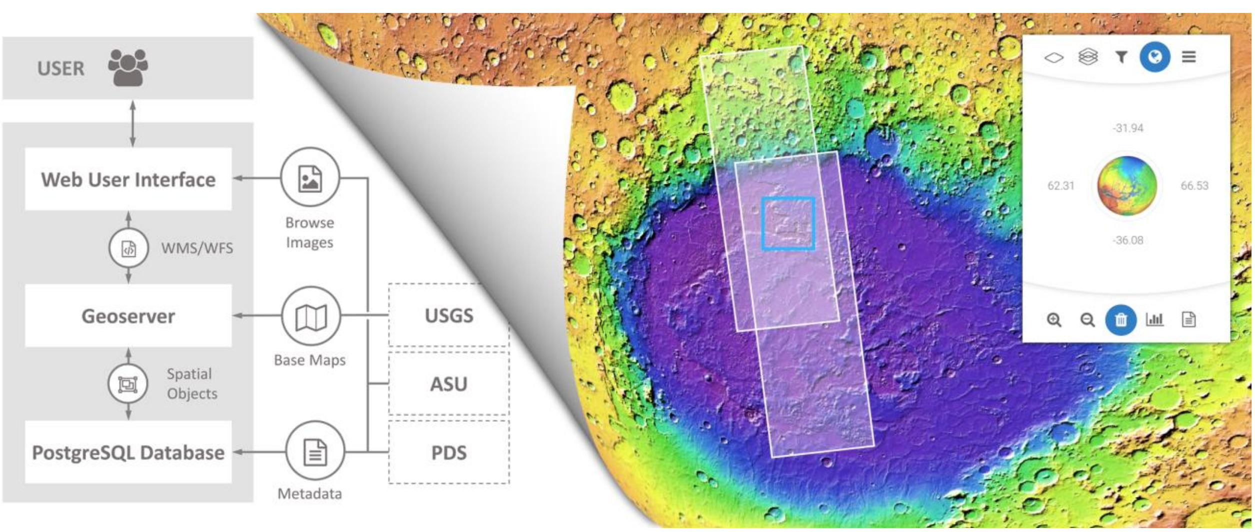

Fig 1.: Architecture of MUTED and corresponding data sources (left) and web-based user interface (right).

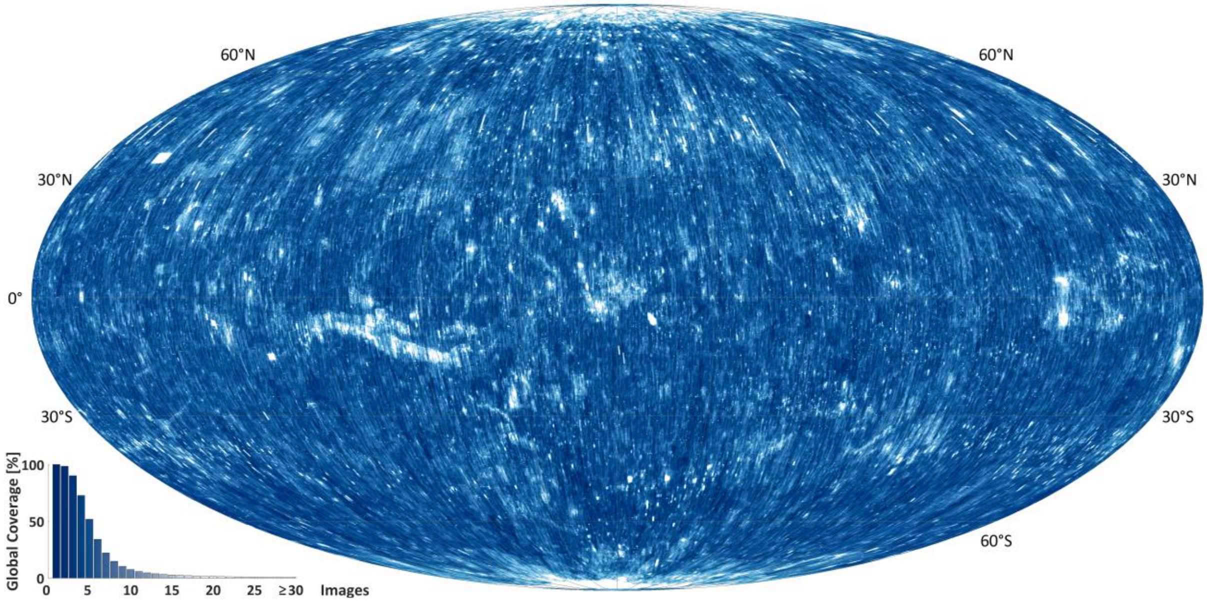

Fig 2.: Multi-temporal coverage of high-resolution orbital images (≤25 m/px) of Mars.

Datasets: At the current state, metadata pertaining to more than 1.27 million orbital images are integrated into the database. The images taken by various instruments including the Viking Orbiter (VO) [12], the Mars Orbiter Camera (MOC) [13] aboard Mars Global Surveyor (MGS), the High Resolution Stereo Camera (HRSC) [14] aboard Mars Express (MEx), the Thermal Emission Imaging System (THEMIS) [15] aboard Mars Odyssey, the Compact Reconnaissance Imaging Spectrometer of Mars (CRISM) [16], the Context Camera (CTX) [17], and the High Resolution Imaging Science Instrument (HiRISE) [18] aboard the Mars Reconnaissance Orbiter (MRO) covering a time range of four decades. The spatial resolution ranges from ~25 centimeters to several kilometers per pixel.

A global coverage analysis reveals that high-resolution images (≤25 m/px) cover 99.9% of the surface of Mars (Fig. 2). Areas with a maximum coverage of ~800 high-resolution images are within the polar regions. Over the last 10 Mars years almost 60,000 high-resolution images were acquired per Mars year with a mean annual coverage of 26.4% of the surface of Mars. While 50% of the surface are covered with at least 5 high-resolution images, the coverage analysis reveals a comprehensive data availability for various change detection tasks. The flexible structure of MUTED allows for a fast integration of upcoming data sets, e.g., from India's Mars Orbiter Mission (MOM) or ESA's ExoMars Trace Gas Orbiter (TGO) mission.

Scientific applications: MUTED enables scientists to explore the multi-temporal coverage of the surface of Mars. The database supports the identification of orbital images and their spatial and temporal context as a basis for various change detection analyses.

In particular, the time span between repeated images can be defined to discover surface changes caused by very short-term and temporally highly variable processes, e.g., dust devils. The difference in solar longitude between repeated images can be specified to observe seasonal changes and processes, e.g., seasonal ice and frost cover. The number of overlapping images can be selected to ensure data availability, e.g., long term changes of the surface of Mars. Due to 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.

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