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Mars Global Digital Dune Database: MC-30

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Database Organization and Terminology

The Mars Global Digital Dune Database (MGD^3) is a catalog of nearly all medium to large-size dark dune fields between lat 90° S. to 90° N. This global database is divided into three regions. The equatorial region (EQ database), covering dune fields from lat 65° N. to 65° S., was finished in 2007 (http://pubs.usgs.gov/of/2007/1158). The north polar region (NP database), covering dune fields from lat 65° to 90° N., followed in 2010 (http://pubs.usgs.gov/of/2010/1170.) This report (http://pubs.usgs.gov/of/2012/1259) covers the south polar region (SP database), which covers dune fields from lat 65 to 90° S., and completes global coverage. We use the term MGD^3 to refer to the entire database and use a regional name, such as SP database, when referring to a particular region.

Abstract/Purpose/Process

SP Database Abstract

The SP database (http://pubs.usgs.gov/of/2012/1259) provides a comprehensive and quantitative view of the geographic distribution of dune fields from lat 65 to 90° S. Approximately 750 dune fields, covering a total area of ~75,000 km^2, have been mapped in the SP region. We estimate the volume of dune sediment to be between 300 km^3 and 2,100 km^3. The SP database consists of 9 layers (in shapefile format) that we created, as well as several publicly available background layers that are provided for the convenience of the user. Where availability and quality of higher resolution images allowed, (Mars Odyssey Thermal Emission Imaging System (THEMIS) visible (VIS), Mars Orbiter Camera narrow angle (MOC NA), Mars Express High Resolution Stereo Camera (HRSC), Mars Reconnaissance Orbiter (MRO) Context Camera (CTX), or MRO High Resolution Imaging Science Experiment (HiRISE)), we classified dunes and measured dune slipfaces. Dune classification follows McKee's Earth-based dune classifications (McKee, 1979). Slipface measurements were derived from gross dune morphology and represent the approximate prevailing wind direction at the last time of significant dune modification. It was beyond the scope of this report to look at the detail needed to discern subtle dune modification. It was also beyond the scope of this report to measure all slipfaces. We attempted to include enough slipface measurements to represent the general circulation (as implied by gross dune morphology) and to give a sense of the complex nature of aeolian activity on Mars. The absence of slipface measurements in a given direction should not be taken as evidence that winds in that

direction did not occur. For dune fields located within craters, the azimuth from crater centroid to dune-field centroid is calculated as another possible indicator of wind direction. These indicators of wind direction can be compared to the included NASA/Ames Mars general circulation model (GCM) output (Haberle and others, 1999). In addition to polygons identifying dune fields, the database includes over 700 of the THEMIS VIS and MOC NA images that were used to study the dunes. Other appropriate images are hyperlinked to dune fields in the ArcMap and ArcReader projects.

Mars Global Digital Dune Database Purpose

Sand dunes are among the most widespread aeolian features present on Mars, serving as unique indicators of the interaction between the atmosphere and surface. On a planetary body, dunes accumulate where a supply of sand-sized grains exists or may be abraded, is carried downwind by winds of saltation strength, and is subsequently deposited where these winds weaken below the threshold for sand transport. As a result, the study of dune processes contributes to both atmospheric and sedimentary science. Both the presence and morphologies of sand dunes are sensitive to subtle shifts in wind circulation patterns and wind strengths, which are thought to be influenced by changes in Martian orbital parameters. The spatial distribution of aeolian sand relates to patterns of sedimentary deposition and erosion of source materials, giving clues to the sedimentary history of the surrounding terrain. Dunes are particularly suited to comprehensive planetary studies in part because they are abundant on the Martian surface over a wide range of elevations and terrain types, and in part because they are large enough to be studied using the wide suite of spacecraft data now available. Thus a global-scale study of Martian dunes serves a dual purpose in furthering the understanding of both climatic and sedimentary processes, two fundamental topics currently driving Martian science.

MGD^3 makes it possible to look at dunes in a global context, comparing their geographic locations and attributes to other global-scale datasets, such as geologic maps, GCMs, Mars Orbiter Laser Altimeter (MOLA) and Thermal Emission Spectrometer (TES). Such comparisons provide significant perspective on local, regional, and global-scale aeolian processes that have shaped and continue to influence the surface of Mars.

Mars Global Digital Dune Database Process

MGD^3 consists of dune forms and (or) sand deposits that were initially located using calibrated THEMIS Infrared (IR) images (RDRs). Each THEMIS IR image is ~32 km in width, and can be greater than 6000 km long, providing an areal coverage greater than 180,000 km^2. For most daytime images, the sensor acquires nine bands ranging in wavelength from 6.8-14.9 μm. Nighttime IR images are usually acquired using only bands 4, 9 and 10 (bands centered on 8.56, 12.57, and 14.88 μm, respectively). Band 9 was chosen as the default image for this study because it offers the highest signal to noise ratio (SNR) at night, high SNR during the day, and is included in every acquisition. A subset of THEMIS band-9 images covering orbits 816-9601 (spanning 02/2002 - 02/2004 and L_s = 0.085°-358.531°), comprising more than 30,000 images planetwide, was chosen as the basis for construction of the database. This provided ~98% nighttime and ~75% daytime areal coverage of Mars. Images containing dunes were identified using THV (Interactive THEMIS IR Viewer written in Research Systems Incorporated's (RSI) IDL software at the U.S. Geological Survey (USGS) in Flagstaff, Arizona (www.mars-ice.org)). Despite better nighttime coverage, approximately 75% of the images identified as containing dunes were daytime images, where dunes appear brighter than the surrounding area, thus indicating a warmer relative temperature. On nighttime images, where dunes are often darker than the surrounding area and show less tonal variation within a dune field, the dunes were more difficult to locate. For the SP region we also used the THEMIS IR daytime mosaic and so had complete IR coverage for that region.

Polygons were drawn around all areas that were considered to be possible dune-field candidates based on the identification of dune form (where discernible) and tonal (relative thermal) contrast with surrounding material, commonly at a scale of ~1:75,000. While medium-to-large dune fields could often be identified at 100 m/px resolution, non-optimal image quality or small feature size sometimes precluded reliable feature identification. Questionable dune fields were verified using higher resolution images, THEMIS VIS and MOC NA, for the EQ region. For the NP region MRO CTX images were also available. For the SP region we also used MRO HiRISE and HRSC images. When review of higher resolution images revealed dunes that were too small to be seen on IR images or dunes that fell outside IR image boundaries, polygons were added to the database. Addition of dune-field polygons based on higher resolution imagery was minimal for the EQ and NP regions. In the SP region they accounted for ~25% of the total number of dune fields mapped.

Mars Global Digital Dune Database—Completeness of Database

This report (http://pubs.usgs.gov/of/2012/1259) covers lat 65° to 90° S. and completes dune database coverage of Mars. The EQ database, lat 65º N. to 65º S., was released in 2007 as USGS Open-File Report 2007-1158 (http://pubs.usgs.gov/of/2007/1158/). The NP database, lat 65º to 90º N, was released in 2010 as USGS Open-File Report 2010-1170 (http://pubs.usgs.gov/of/2010/1170/). Although developed using the same basic methods, the SP report differs from the two previous reports. The dune fields included in the EQ and NP databases were located using THEMIS IR images. In the previous two releases some dune fields may have been unintentionally excluded for two reasons: (1) incomplete THEMIS IR (daytime) coverage may have caused us to exclude some moderate- to large-size dune fields or (2) resolution of THEMIS IR imagery (100 m/pixel) certainly caused us to exclude smaller dune fields. In the SP, mapping is more complete. The Arizona State University THEMIS daytime IR mosaic provided complete IR coverage and so it is unlikely that we missed any large dune fields in the SP region. In addition, the SP report was part of a related study (Fenton and Hayward, 2010) that used higher resolution images to map more small (>1 km^2) sand dune fields and sand patches. Of the ~750 mapped features, ~550 are consistent with mapping done in earlier parts of MGD^3 and have been labeled as such. We acknowledge that our global database excludes numerous small dune fields and some moderate-to-large dune fields as well. Please note that the absence of mapped dune fields, especially between lat 65° S and 90° N, does not mean that such dune fields do not exist and is not intended to imply a lack of saltating sand in other areas.

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