

ONLINE MARS DEM DERIVED FROM MOLA PROFILES

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Introduction: The topography of Mars is a key parameter for the understanding of the geological evolution of the planet [1]. Topographic data for most applications are represented as Digital Elevation Models (DEMs). DEMs are characterized by their spatial resolution (distance between neighbor points on the topographic grid) and the accuracy of elevations. The resolution and accuracy required depend on the geological applications from the global evolution of the whole planets to the study of small structures such as impact craters [2] or grabens [3,4]. DEMs of Mars at the local scale were mainly derived by stereophotogrammetric method during the Viking era [5]. High Topographic profiles have been recently acquired by Mars Orbiter Laser Altimeter (MOLA) launched in the frame of Mars Global Surveyor mission in 1997. In this paper we describe how to generate DEM's through an interactive Internet application.

Application server for the MOLA data : The Mars Orbiter Laser Altimeter has acquired more than 600 000 points over the whole surface of Mars. The precision of each measurement ranges from 3 to 5 meters due to uncertainties in orbit determination [1]. The altimeter has acquired topographic data along orbits with a spacing of 300 meters, while the distance between two neighbor topographic profiles is 2 km in average. Locally, the irregular ground tracks distribution can produce larger gaps up to 5-6 km. Thus, in order to make global topographic maps of Mars, the interpolation of these data is required. The best resolution of released DEMs produced by the MOLA team is up to 1/128th degrees which is equivalent to 0.5 km at the equator (<http://wufs.wustl.edu/missions/mgs/mola/>).

The calculation of the global full resolution DEM requires very intensive computation and large disk capacities. While the actual density of points depends on latitude, global DEMs have been computed with the same resolution. Furthermore, the excellent quality of individual measurement at the 300 meters resolution along tracks is not fully exploited using global maps. Thus, we propose an Internet application intended to local studies for the distribution of MOLA data, with adjustable parameters for the computation of DEMs, and access to individual measurements for any given area.

Processing steps : 44 CDROM containing MOLA points classed by profiles number over the whole planet are available from the following NASA website (<http://wufs.wustl.edu/missions/mgs/mola>). For any given area, topographic data are distributed over numerous files which are not located on the same CDROM. The first step consists to extract from all these files the relevant topographic information for DEM processing : geographic coordinates of each point, local radius of the planet, and elevation which is the local difference with the geoid given by up-to-date gravity models of Mars[6]. Then the extracted points are classed by area of 5°*5° corresponding to 2592 files for the whole surface. This step is fundamental for the improvement of speed access to the data. All the MOLA points for a given area are then grouped into files directly saved on the application server. After the request of a DEM computation on a selected area, the points belonging to the area are extracted and interpolated using the Delaunay triangulation method. During this step, the quality factor map (Q) is processed for each point of the final DEM. Q represents the minimum distance between each DEM's point and the three vertices of the triangles formed by the closest MOLA points obtained after the Delaunay triangulation. For visibility, Q is then arbitrary divided into 4 classes.

All the modules of the processing steps have been developed with IDL (Interactive Data Language by Research Systems, Inc., 2001a). IDL is a complete computing environment for the interactive analysis and visualization of data [7] integrating an array-oriented language with mathematical analysis.

The web application :

An internet net version of IDL, ION (IDL On the Net, Research Systems, Inc., 2001b) has been implemented on a web server (<http://image.univ-lyon1.fr>). All the computations through this web site are processed by IDL subroutines.

First of all, an identification step is required. A form including information (such as identity information and topic of interest) has to be filled in order to obtain an access to the server. The account is created upon 48 hours, login and password are sent to the user by E-mail. The access is totally free of charge.

The user can then connect to the server (<http://image.univ-lyon1.fr>) which is part of the WEB site of the " Laboratoire Dynamique de la Lithosphère

UMR 5570". The user clicks on the Mars section. At this step a tutorial section shows how to use the application with an example, then the user can move on the application section.

The parameters for the DEM computation can be set by two different ways. Either, directly on a map of Mars by clicking on the area of interest or by typing the coordinates of a rectangle of interest and the desired spatial resolution. In order to avoid irrelevant computations which may saturate the processor, the spatial resolution is limited to 0.3 km and the coverage is limited to $10^\circ \times 10^\circ$ which corresponds to 600 km by 600 km on Mars (at the equator).

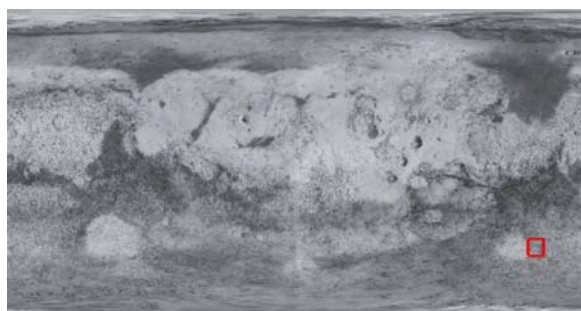


Figure 1. Selection of the DEM on a clickable map. The rectangle shows the selected area. (Longitude : $25^\circ W - 35^\circ W$, Latitude : $55^\circ S - 45^\circ S$, Resolution : 500 m).

Before the processing step, the user can check the localization of the selected area on map of Mars (figure 1).

Then the extracted MOLA measurement over the area of interest are immediately interpolated. The computation time to produce DEM and ancillary files does not exceed few minutes. Time can be saved by disabling the computation of the quality map. Finally, a color-coded map of the DEM is plotted (figure 2) and the user can check the result of his request before downloading the data files.

The download of the various files can be then performed (see table 2). A directory is created on the local server disks from where the user can download, rename and erase the created files.

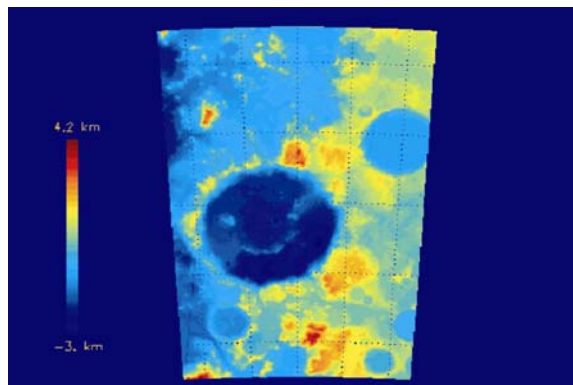


Figure 2. Color-coded map of the computed DEM displayed before the uploading step.






Name	Size	Type	Date
 mntmola.bin	7,03 Mo	Binary	10/01/2003
 mntmola.hdr	1,38 Ko	Text	10/01/2003
 mntmola.pts	29,2 Mo	Binary	10/01/2003
 mntmola.tif	0,19 Mo	Tiff	10/01/2003
 qmap.bin	7,03 Mo	Binary	10/01/2003

Table 2. The download window. *Mntmola.hdr* is the header file describing the format of the other files. *Mntmola.bin* contains the DEM data and *mntmola.pts* contains individual MOLA measurements on the area of interest. *Mntmola.tif* is an image file of the DEM, *qmap.bin* is the quality map of the DEM.

References: [1] Smith, D.E. et al., (1999), *Science*, 284, 1495-1503. [2] Garvin, J.B et al. (2000), *Icarus*, 144, 329-352. [3] Mangold, N et al. (1998), *Planetary and Space Science*, 46, 345-356. [4] Withers, P., and Neumann, G.A., 2001, *Nature*, 410, 651. [5] Baratoux, D. et al. (2001), *Journal of Geophysical Research*, 106, 32927-32941. [6] Smith, D.E et al. (1999), *Science*, 286, 94-97. [7] Marschallinger, R. (2001), *Computers and Geosciences*, 27, 419-426.

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