EPSC Abstracts
Vol. 11, EPSC2017-667-2, 2017
European Planetary Science Congress 2017

Revised coordinates of the Mars Orbiter Laser Altimeter (MOLA) footprints

Serena Annibali (1), Alexander Stark (1), Klaus Gwinner (1), Hauke Hussmann (1), Jürgen Oberst (1,2)
(1) Deutsches Zentrum für Luft- und Raumfahrt, Berlin, Germany (Alexander.Stark@dlr.de), (2) Technische Universität Berlin, Germany

Abstract

We revised the Mars Orbiter Laser Altimeter (MOLA) footprint locations (i.e. areocentric body-fixed latitude and longitude), using updated trajectory models for the Mars Global Surveyor and updated rotation parameters of Mars, including precession, nutation and length-of-day variation [1]. We assess the impact of these updates on the gridded MOLA maps. Ultimately, we aim at independent measurements of the rotation parameters of Mars. Using the method presented by Stark et al. [2], we co-register MOLA profiles to digital terrain models from stereo images (stereo DTMs) and measure offsets of the two data sets. At the same time we wish to assess the accuracy of the stereo DTMs and detect possible unidentified false returns in the MOLA data.

1. Introduction

The MOLA data greatly improved our knowledge about Mars morphology and became an extensively used reference for Mars. In the last decade, data from several space missions improved our knowledge on shape, gravity, and rotational state of the planet. With the improved knowledge of the gravity field of Mars, the trajectory of the Mars Global Surveyor (MGS) spacecraft has been reconstructed with better accuracy [3, 4]. However the MOLA data, released in 2003, remains to be based on an outdated spacecraft orbit and Mars rotation model (the so called IAU2000 Mars rotation model) neglecting the precession and nutation of the rotation axis as well as seasonal spin variations. The present work contains a comparison of the Mars parameters given in the IAU2000 reference frame [5] and in the more complete orientation model of Mars [3]. Assessing the discrepancy between old and new values of the planet's rotational parameters gives a first evaluation of the difference to be expected between old and recomputed MOLA footprint locations.

2. Data sources

2.1 MOLA measurements

The MOLA instrument on Mars Global Surveyor operated as an active altimeter from February 1999 until June 2001. Short Laser pulses at the Laser wavelength of 1.064 µm are sent to the surface [6]. From an average spacecraft altitude of 400 km the emitted pulse produces a footprint of about 75 m diameter [7]. A small portion of the reflected laser pulse is detected at the spacecraft and by measuring the time of flight of the laser pulses, precise measurements of spacecraft ranges are obtained. A single range measurement has a vertical precision in the order of 40 cm (over smooth terrain); the location of the laser footprints was corrected for spacecraft trajectory errors through an adjustment using height differences at cross-over points [8]. At the given shot frequency of 10 Hz, consecutive measurements are separated by 300 m and form topographic profiles, which ultimately yield global coverage. Interpolation is performed where data are missing and a gridded topographic model based on over 333 million surface measurements has been devised. Final registration of profiles and images are obtained with an uncertainty of < 100 m [9]. The complete data set is archived at the Planetary Data System [10].

2.2 Rotation parameters

The rotation parameters of Mars were recently improved based on all available tracking of spacecraft in orbit around Mars and of landers on the surface of Mars [1]. The model includes seasonal variations of the rotation rate, as well as precession and nutation terms of the rotation axis. A comparison of the Euler angles (right ascension, declination and prime meridian angle) of the previous IAU2000 rotation model and the new model from [1] is shown in Figure 1 over the time span of eight years.

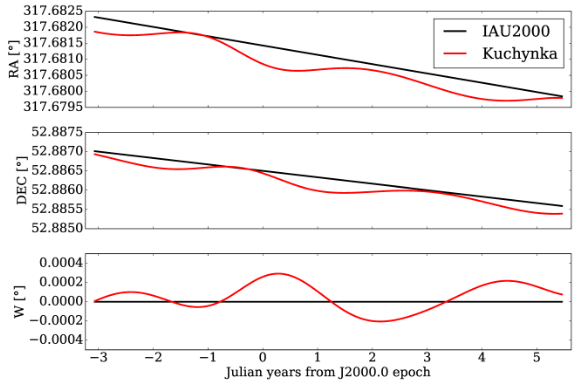

Figure 1: Variation of right ascension (RA), declination (DEC) and prime meridian (W) angles for the IAU2000 (black) and the Kuchynka et al. [1] (red) rotation models. For the prime meridian angle the rotation rate of the IAU2000 [5] model was subtracted from both models. Further, an offset of 0.0018° has been applied to the prime meridian angle of the Kuchynka et al. model in order to better notice its variations in time.

2.3 MGS orbit solutions

The accuracy of the laser altimeter profiles depends on the knowledge of the spacecraft position and attitude at the firing time. Any offset of the spacecraft directly translates to lateral and vertical offsets of the Laser spots on the ground. After completion of the MGS mission in November 2006, the Inner Planet Navigation and Gravity Group (IPNG) from JPL NASA performed an orbit determination for MGS using the complete set of available radio science observations based on the gravity model described by Konopliv et al. [3]. More recently, Genova et al. [4] determined the gravity field of Mars considering radio science data from MGS, Mars Odyssey and Mars Reconnaissance Orbiter. The orbits of the three spacecraft were updated in the process. However, the MOLA data itself was processed using the outdated MGS orbit solution by the Goddard Space Flight Center dating back to 2003.

3. Results

The locations of the MOLA footprints in the region within (337.5°, 360°) longitude and (15°, 30°) latitude have been recomputed according to the rotation model of Mars given by Kuchynka et al. [1] (Figure 2) and to the IAU2000 model. The obtained maps have been compared in terms of height differences (Figure 3).

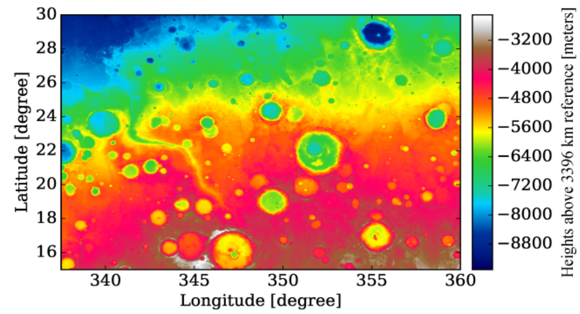

Figure 2: Example of a gridded terrain model for a small region of Mars from MOLA profiles computed using the Kuchynka et al. [1] rotation model. Interpolation was performed on regions without MOLA measurements.

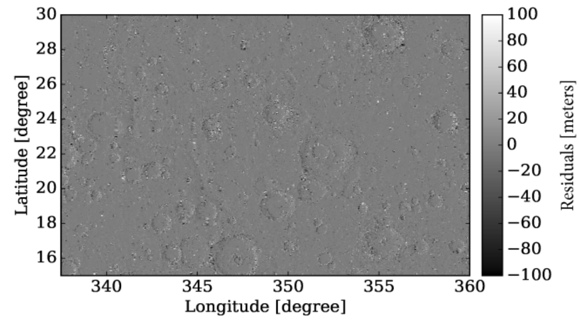

Figure 3: Difference between the nominal (IAU2000) MOLA data set and the terrain model computed using the Kuchynka et al. [1] rotation model.

The comparison reveals that even slight corrections to the rotational state of Mars can lead to height differences up to 100 m (in particular in regions with high slopes, where large interpolation effects are expected). Further work will assess the impact of the MGS orbit solutions on the MOLA data set.

Acknowledgements

This work was supported by a research grant from the Helmholtz Association and German Aerospace Center (DLR).

References

[1] Kuchynka et al. 2014, Icarus, 229, 340–347. **[2]** Stark et al. 2015, *GRL*, 42, 7881-7889. **[3]** Konopliv et al., 2006, *Icarus*, 182, 23-50. **[4]** Genova et al. 2016, *Icarus*, 272, 228-245. **[5]** Seidelmann et al. 2002, *Celest. Mech. Dyn. Astron.*, 82, 83-111. **[6]** Smith et al. 2001, *JGR-Planets*, 106, 23689-23722. **[7]** Neumann et al. 2003, *GRL* 30-11, 1561. **[8]** Neumann et al. 2001, *JGR-Planets*, 106, 23, 753-768. **[9]** Neumann et al. 2003, Lunar and Pl. Science XXXIV. **[10]** MOLA on *PDS* ftp://pds-geosciences.wustl.edu/mgs/mgs-m-mola-3-pedr-l1a-v1/mgsl_21xx/