EPSC Abstracts
Vol. 12, EPSC2018-221, 2018
European Planetary Science Congress 2018

Combined retrieval of the lunar body tide and a global topographic grid from LOLA data

R. Thor (1, 2), R. Kallenbach (3), P. Gläser (2), A. Stark (3), U. Christensen (1), and J. Oberst (2,3)
(1) Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, D-37077 Göttingen, (2) Technische Universität Berlin, Institute of Geodesy and Geoinformation Science, Straße des 17. Juni 135, D-10623 Berlin, (3) DLR Institute of Planetary Research, Rutherfordstraße 2, D-12489 Berlin

Abstract

We use data from the Lunar Orbiter Laser Altimeter (LOLA) to retrieve the h_2 tidal Love number of the Moon and find $0.040 < h_2 < 0.044$. The applied algorithm solves simultaneously for h_2 and the shape of the Moon, parametrized using cubic splines on a global rectangular grid. The result can give valuable constraints for the Moon's interior and validates the method for application to other bodies.

1 Introduction

Tides from the Earth and the Sun cause periodic radial displacements on the surface of the Moon which are described by the tidal Love number h_2. The Love number is a function of the materials in a planet's interior and their distribution and an important constraint for models of the interior structure. The small amplitude of the displacements of only up to ~10 cm makes their detection very challenging. Previous estimates of the lunar h_2 have been achieved by LOLA [2] and by Lunar Laser Ranging (LLR) [3]. However, significant discrepancies exist between these two h_2 results and those achieved by modelling [3]. In this study, we present a method for retrieving h_2 from LOLA data which is different from the one used by [2]. Instead of analyzing cross-overs of the ground tracks, we simultaneously solve for h_2 and the global shape of the Moon. This serves two purposes: reconciling the results from laser altimetry with those from LLR and modelling; and validating the method for future applications to other solar system bodies, such as Mercury and Ganymede.

2 Methods

Coregistration of single LOLA tracks with a LOLA-generated DEM removes gross outliers in the data. Then, each remaining measurement can be decomposed into a time-invariable part and the radial displacement due to tides. The time-invariable part of the shape is represented by a set of 2D cubic B-spline basis functions and their coefficients, defined on a rectangular grid. This set of basis functions allows for a much higher resolution than for example an expansion in spherical harmonics. The application of splines in both directions provides an improvement over previous studies which used splines only in longitude direction [1]. The parameters of this inverse problem are the coefficients of the spline functions and h_2. We solve for these parameters using least squares, while also minimizing the second derivative of the shape coefficients as a smoothing constraint.

3 Results and Discussion

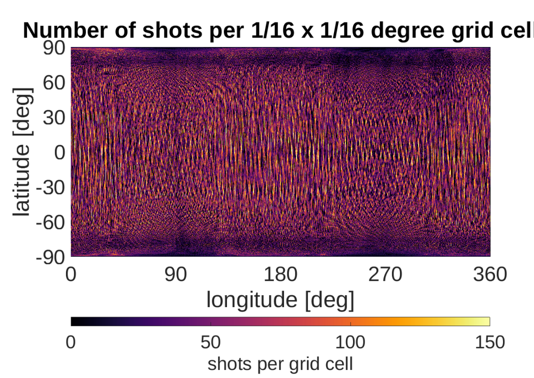

Figure 1: Number of measurements per grid cell used in this study. Color scale is truncated at 150, the highest value is 481.

LOLA has been producing more than $7 \cdot 10^9$ laser altimeter measurements since 2009. We focus on data obtained between September 2009 and December 2011 when the Lunar Reconnaissance Orbiter (LRO) was in its near-circular orbit phase. This ensures a homogeneous coverage of the entire lunar surface (Fig. 1). Furthermore, we limit the amount of data by only using data from one of LOLA's five receiver channels. This leaves a total of ∼10000 orbits with $\sim 7.7 \cdot 10^8$ measurements.
We observe that the solution for h_2 depends on the exact parametrization, i.e. the number and spatial distribution of the spline functions. Within this limitation we can constrain that $0.040 < h_2 < 0.044$. Furthermore, we note that the same results can still be achieved when omitting large numbers of measurements by decreasing the sampling rate in time by a factor of 4. This is promising with respect to future laser altimeter experiments whose coverage will not be as dense as LOLA's.

Acknowledgements

R. Thor is supported by grant 50 QW 1401 on behalf of the DLR Space Administration while preparing his PhD thesis in the framework of the International Max Planck Research School on Solar System Science at the University of Göttingen.

References

[1] Koch, C., Kallenbach, R., and Christensen, U.: Mercury's global topography and tidal signal from laser altimetry by using a rectangular grid, Planetary and Space Science, Vol. 58(14), pp. 2022-2030, 2010.

[2] Mazarico, E., Barker, M. K., Neumann, G. A., Zuber, M. T., and Smith, D. E.: Detection of the lunar body tide by the Lunar Orbiter Laser Altimeter, Geophysical Research Letters, Vol. 41(7), pp. 2282-2288, 2014.

[3] Williams, J. G., and Boggs, D. H.: Tides on the Moon: Theory and determination of dissipation, Journal of Geophysical Research: Planets, Vol. 120, pp. 689–724, 2015.