EPSC Abstracts
Vol. 10, EPSC2015-685, 2015
European Planetary Science Congress 2015

GRAIL gravity field recovery using the short-arc integral equation technique: development of the latest Graz lunar gravity field model (GrazLGM)

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Abstract

We present an updated version of the lunar gravity field model GrazLGM300a,b [1,2] based on inter-satellite Ka-band ranging (KBR) observations collected by the GRAIL mission. We propose to exploit the ranging measurements by an integral equation approach using short orbital arcs [4]. Compared to the predecessor model we increase the spectral resolution to degree and order 450 and refined the parameterization. Validation shows that the applied technique is well suited to recover the lunar gravity field.

1. Introduction

The NASA lunar science mission Gravity Recovery And Interior Laboratory (GRAIL) uses Ka-band range-rate measurements between the two GRAIL satellites to resolve the lunar gravity field with unprecedented resolution and accuracy. This satellite-to-satellite tracking technique is independent of the tracking capability from Earth, thus allowing data acquisition on the near side and the far side of the Moon. The GRAIL mission plays a key role to improve our understanding of the Moon's interior structure and its thermal evolution, as well as the evolution of the terrestrial planets in the solar system. For our current gravity field investigations we focus on data from the primary mission (March 1 to May 29, 2012).

2. Methods & Results

To determine the lunar gravity field we analyze the KBR observations within an integral equation approach using short orbital arcs. This method has already successfully applied to the recovery of the Earth's gravity field from data provided by the GRACE mission [6]. The basic idea is to reformulate Newton's equation of motion in the inertial space as a boundary value problem:

$$\ddot{\boldsymbol{r}}(t) = \boldsymbol{g}(t) + \boldsymbol{a}(t) = \boldsymbol{g}(t) + \boldsymbol{a}_b(t) + \boldsymbol{a}_t(t) + \boldsymbol{a}_n(t) + \boldsymbol{a}_r(t)$$

In doing so, the total acceleration acting on both GRAIL satellites can be split into the Moon's gravitational attraction on the satellite $\boldsymbol{g}(t)$ and additional perturbing forces, including third-body accelerations $\boldsymbol{a}_b(t)$, accelerations due to solid Moon tides $\boldsymbol{a}_t(t)$, non-gravitational accelerations $\boldsymbol{a}_n(t)$ and relativistic effects $\boldsymbol{a}_r(t)$. In this contribution we pay particular attention to processing details associated with the error structure of the observations (covariance functions) and the spectral increase of the model. On this basis we computed a refined version of the lunar gravity field model GrazLGM300b [2]. Finally, a validation with recent GRAIL models computed at NASA-GSFC [1] and NASA-JPL [5] is performed.

Acknowledgement

The data used in this study were made freely available by NASA; GRAIL orbit and inter-satellite information was retrieved from the Planetary Data System (PDS, http://geo.pds.nasa.gov/missions/grail).

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