

Lunar Satellite Orbit Determination Analysis and Quality Assessment from Lunar Prospector Tracking Data and SELENE Simulations

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In the near future a number of satellite missions are planned to be launched to the Moon. These missions include initiatives by China, India and the USA, as well as the Japanese SELENE mission. These missions will collect a wealth of lunar data, which will improve the knowledge of the Moon. One of the main topics that will be addressed is the lunar gravity field. The SELENE mission will especially contribute to improving the knowledge of this, by employing 4-way Doppler tracking and a differential VLBI experiment. This will improve the determination of the global lunar gravity field, especially for the lower degree spherical harmonics. This will also mean an improvement for the precision of the determination of orbits around the Moon.

This work focuses on the current status of lunar satellite orbit determination, as well as lunar gravity field determination. From a subset of Lunar Prospector tracking data from the nominal mission, a lunar gravity field model has been created. This model shows a data fit for (in)dependent data at a level comparable to that of a JPL model. Despite relatively large differences in gravity anomalies over the far side, both models perform equally well in terms of data fit and overlap statistics. The use and impact of historical data, as well as Clementine data, is also commented on. The extended mission data have been processed using the latest Lunar Prospector gravity field model LP150Q in order to assess orbit quality in terms of data fit and overlap statistics, showing the current status of low-lunar orbit determination precision.

Using covariance analysis, errors in the gravity field are propagated in order to show the expected orbit accuracy. This is done for current models as well as for combinations with SELENE simulations to show the expected improvement in orbit determination from SELENE data. The radial orbit accuracy for a polar orbit at 100 km altitude is expected to be below the 1 m level. It should be noted that current gravity field models are tuned towards the polar orbit, leading to expected orbit errors of several orders of magnitude larger for different inclinations, especially in the mid-range.

Orbit analysis is a powerful tool to assess the quality of the gravity field model. Furthermore, for a mission like SELENE, instruments such as the laser altimeter require precise orbits in order to maximize the retrieval of information from these data.