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Lunar Gravity Field Determination and Orbit Quality Assessment using Lunar Prospector tracking data: Preparing for SELENE

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In the near future a number of satellite missions are foreseen to be launched to the Moon. These missions include initiatives by China, India and the USA, as well as the Japanese SELENE mission. They will collect a wealth of lunar data, thus improving our knowledge of the Moon and address questions concerning origin and constitution of the Moon.

One of the main topics that will be addressed with these new data is the lunar gravity field. The SELENE mission will especially contribute to improving the knowledge of this, by employing 4-Way Doppler tracking between the main orbiter in a 100 km altitude circular orbit, and relay satellites in high-altitude, elliptical orbits. SELENE will obtain the first tracking data over the far side of the Moon, and thus the first truly global tracking data set of the Moon. Since the main orbiter of SELENE will fly in a 100 km altitude orbit, it will mainly be sensitive to the lower degrees of the spherical harmonical expansion of the gravity field. The Lunar Prospector spacecraft on the other hand flew at extremely low altitudes in its extended mission, making these data very valuable to extract the high-frequency gravity field information from them.

This work focuses on the use of Lunar Prospector tracking data for the purposes of gravity field determination and orbit determination. Tracking data from the first months of the Lunar Prospector mission have been processed in order to create a lunar gravity field model independent of JPL models. This model shows a data fit for dependent and independent data at a level comparable to that of JPL models. 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 from the Apollo and Lunar Orbiter missions, as well as Clementine data, is also commented on. All these data are to be processed in order to create a pre-SELENE lunar gravity field model at NAOJ.

The extended mission data have been processed using the latest Lunar Prospector gravity field model LP150Q in order to assess orbit quality. This is expressed in terms of data fit and overlap statistics, showing the current status of lunar orbit determination precision. Using covariance analysis, errors in the gravity field are propagated in order to show expected orbit accuracy. This is done for current models as well as for combinations with SELENE simulated covariance, in order to show the expected improvement from SELENE data. Results show that 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 all tuned towards the polar orbit, leading to expected orbit errors of several orders of magnitude larger for different inclinations, especially in the mid-range.