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A new lunar gravity field model from SELENE and historical satellite tracking data

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The SELENE (Kaguya) mission has successfully completed its nominal mission phase at the end of October 2008. The tracking data of the three satellites of Main, Rstar, and Vstar have also been accumulated and are to be still increased during its extended mission phase. This presentation reports the current status of lunar gravity field estimation including the acquisition status of the tracking data and the latest gravity field model estimated from the Kaguya and the historical satellite tracking data. Classification and compensation mechanism of impact basins are discussed based on the gravity and topography data.

One year of Kaguya tracking data (from 20 October, 2007, until 30 October, 2008) have been combined with pre-Kaguya tracking data to create a spherical harmonics model of degree and order 100, named SGM100g (SELENE Gravity Model). The new model successfully reveals the ring-shaped free-air gravity anomalies in the far-side which correspond well to the topographic features of impact basins. There are still some 4-way Doppler data gaps in the far-side northern hemisphere, but some of them will be filled by the end of Rstar's lifetime (around 12 Feb. 2009). The large gravity error in the far-side which existed in pre-SELENE model such as LP100K is drastically reduced and asymmetric error distribution between the near-side and the far-side is mitigated. Mainly thanks to the 4-way Doppler measurements the gravity coefficients below degree and order 55 are now determined by observations with more than 90% of contribution factor. Although differential VLBI data between Rstar and Vstar are not yet included in SGM100g, we will present a preliminary result of including about 4 months of same-beam VLBI data.

Solutions for the polar moment of inertia C/MR^2 and the lunar degree 2 Love number k_2 for SGM100g are 0.3934 $\pm$ 0.00008 and 0.0230 $\pm$ 0.0016, respectively. The error for C/MR^2 is based on five times the formal error, and the error for k_2 is ten times the formal error. They are compared with recent LLR estimates of (0.3935$\pm$0.0002, 0.020$\pm$0.003) (Williams, 2008) and those from Lunar Prospector data (0.3932 $\pm$ 0.0002, 0.0244 $\pm$ 0.0008) (Goossens and Matsumoto, 2008; the case without estimating one cycle per revolution acceleration).

It is suggested that there are three types of lunar impact basins depending on their location and the magnitude of free-air anomalies relative to Bouguer anomalies, i.e., Type I, Type II, and primary mascon basins. The Type I and II basins are distributed on the far-side and limb, while the primary mascon basins are located on the near-side. Central gravity high of Type I basin is considered to be due to mantle uplift at the time of its formation which is elastically supported. The magnitude of free-air anomalies at the center of Type II basins is lower than the Bouguer anomalies, which indicates brittle deformation of the basins. Plateau-like signature of gravity anomalies for the primary mascon basins implies viscous relaxation at the crust-mantle boundary beneath the basins.

References

Williams, J.G., 16th International Workshop of Laser Ranging, 2008.
Goossens, S. and K. Matsumoto, GRL, 35, L02204, 2008.