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Gravity fields of the Moon derived from GRAIL Primary and Extended Mission Data

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The twin Gravity Recovery and Interior Laboratory (GRAIL) spacecraft were launched in September 2011 on a Discovery-class NASA mission to study the gravitational field of the Moon. Extremely accurate range-rate observations between the two spacecraft at the Ka-band radio wavelength (KBRR) enable the determination of the gravity field of the Moon to very high degree since the data are acquired continuously, even when the spacecraft are not tracked from the Earth.

The primary mapping mission for GRAIL commenced on March 1, 2012 and continued until May 29, 2012. During the primary mission, the altitude of the spacecraft was on average 55 km above lunar surface. This allowed the determination of a lunar gravity field model of degree and order 420 in spherical harmonics (equivalent to a spatial block-size resolution of 13 km) (Zuber et al., 2012). GRAIL's extended mission initiated on August 30, 2012, and was successfully completed on December 14, 2012. The average altitude during the extended mission was 23 km above lunar surface, half of the altitude during the primary mission, allowing gravity field models at even finer resolution.

In this paper, we discuss the analysis of the primary and the extended mission data. With the primary mission data, we have developed solutions to 540x540 in spherical harmonics, and using the extended mission data through December 5, 2012, before the extremely low Orientale campaign, we have developed solutions to 720x720 in spherical harmonics. The solutions were developed using the supercomputers at NASA GSFC of the NASA Center for Climate Simulation (NCCS). The solution development methodology is described, including the precision force modeling, and inversion strategy. The solutions are evaluated using RMS of fit tests, calculation of the global and nearside vs. farside coherence with topography, and analysis of the derived Bouguer coefficients. In addition, we evaluate these new selenopotential models by applying them to Lunar Prospector and the Lunar Reconnaissance Orbiter.