THE GRAVITY FIELD OF MERCURY DERIVED FROM TWO YEARS OF MESSENGER DATA.

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Introduction: Since 18 March 2011, the MESSENGER spacecraft **[1]** has been operating successfully in Mercury orbit and collecting scientific data. During the yearlong primary mission, the spacecraft occupied a near-polar 12-hour orbit about Mercury. In April 2012, MESSENGER transitioned to an 8-hour orbit, providing more and higher-resolution mapping opportunities at low altitude for the various instruments. The altitude at apoapsis was reduced from ~15,000km to ~10,000km, but the periapsis altitude (which varies between 200 and 500 km) was not altered.

Data: We have processed the MESSENGER radiometric tracking data collected by the NASA Deep Space Network (DSN). The first global gravity field model HgM002 **[2]** was derived from measurements acquired between Mercury orbit insertion (MOI) and late August 2011. The new solution shown in Figure 1 adds nearly one year of data, extending the coverage to August 2012. The new observations result in six complete cycles of coverage of the northern hemisphere of Mercury with radiometric data, taking into account actual tracking schedules.

Gravity Field: The tracking data have the highest sensitivity to the gravity field in the northern hemisphere, but because of MESSENGER's eccentric orbit and the higher orbital altitude (> 1000 km south of the equator), the sensitivity to gravity anomalies is sharply reduced in the southern hemisphere. The maximum spherical harmonic degree and order (20) of HgM002 reflects the spatial resolution that was achievable after the first few months of Mercury orbital observations.

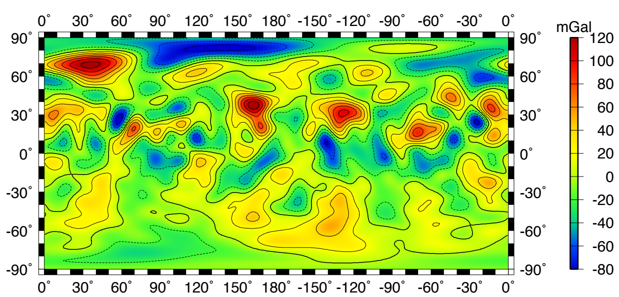

Figure 1. Map of the gravitaty anomalies on Mercury from the new solution to harmonic degree and order 20 derived from 1.5 years of tracking data. Cylindrical projection.

The map of the gravity anomalies obtained with the additional year of data (Figure 1) is broadly consistent with the earlier findings from HgM002 **[2]**. Although the sensitivity at southern latitudes has not changed, given that the periapsis latitude of the MESSENGER orbit has moved northward over the course of the orbital mission, shorter-wavelength features in the northern polar region are detectable with the additional data. For this reason, we have derived two solutions, expanded in spherical harmonics to degree and order 20 and 50, from the same set of data. Beyond finer spatial gravitational signatures, the larger solution also leads

	HGM002	L=20 solution	L=50 solution
GM (10^7) -2.203×10^{12}	178.05	183.92	184.17
C_{20} (10^{-5})	-2.2555	-2.2515	-2.2510
C_{22} (10^{-5})	1.2537	1.2420	1.2415
C_{21} (10^{-8})	-4.641	-2.367	-1.102
S_{21} (10^{-8})	1.353	-0.251	0.191
S_{22} (10^{-8})	5.175	-2.951	-3.569

Table 1. Central-body term and degree-2 gravity coefficients for the HgM002 field and the new solutions.

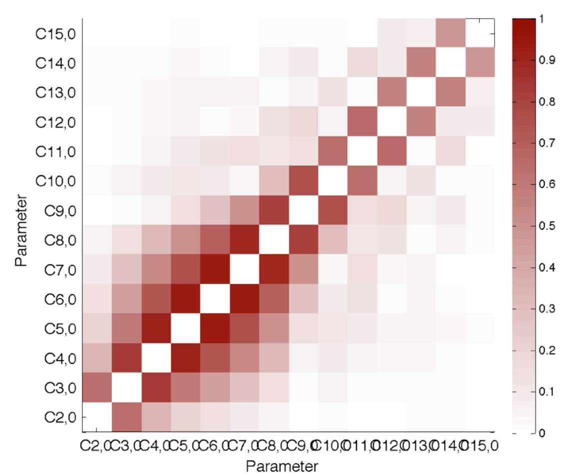

Figure 2. Correlations (absolute values) between the zonal coefficients between degrees 2 and 15, for the new solution to harmonic degree and order 20.

to improvements in the determination of the low-degree field, which have important implications for the internal structure of Mercury **[2]**. As with earlier solutions, low-degree zonal coefficients remain heavily correlated with each other even after the addition of the new data from the 8-hour orbit However, in the solution to degree and order 50, the degree-2 Stokes coefficients expected to be small in the principal axes frame (C_{21}, S_{21} and S_{22}) are reduced from both HgM002 and the degree and order 20 solution (Table 1), indicating overall improvement and better consistency.

References: [1] Solomon S. C. et al. (2007) *Space Sci. Rev.* 131(1-4), 3-39, doi:10.1007/s11214-007-9258-3. [2] Smith D. E. et al. (2012) *Science*, 336(6078), 214-217, doi: 10.1126/science.1218805.