THE GRAVITY FIELD OF MERCURY FROM MESSENGER. Erwan Mazarico[1], Antonio Genova[1], Sander J. Goossens[2], Frank G. Lemoine[3], David E. Smith[1], Maria T. Zuber[1], Gregory A. Neumann[3] and Sean C. Solomon[4,5]. [1]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA (mazarico@mit.edu); [2]Center for Research and Exploration in Space Science and Technology, University of Maryland, Baltimore County, Baltimore, MD 21250, USA; [3]Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA; [4]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, USA; [5]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015, USA.

Introduction: The MESSENGER spacecraft [1] is the first to orbit Mercury, and radiometric tracking data collected by the Deep Space Network since March 2011 have enabled the estimation of Mercury's gravity field and moments of inertia [2], important constraints on the planet's internal structure [2,3]. Here we present a successor solution to HgM002 [2] and HgM004 [4] for Mercury's global gravity field.

Data and Modeling: The new solution, HgM005, incorporates additional tracking data, including observations to October 2013. During MESSENGER's primary mission, the periapsis altitude increased rapidly between successive orbits from ~200 to 500 km, requiring frequent large orbit-correction maneuvers. During its second extended mission, in contrast, the orbit has been allowed to drift naturally without any propulsive maneuvers, and the periapsis has slowly drifted downward from ~450 km. As a result, the tracking data coverage has been relatively uniform over the course of several Mercury rotations. Such uninterrupted data coverage has been beneficial to the determination of the low-degree harmonic coefficients of the gravity field. In addition to incorporating new data, we have conducted a detailed re-analysis of the spacecraft modeling, such as center-of-mass position (important during rapid slews to account for the apparent line-of-sight movement of the active spacecraft antenna) and the radiation pressure acceleration. The surface areas of several key individual spacecraft panels are estimated regularly to account for changes in thermal properties and shadowing geometry. The Mercury orientation model of Margot et al. [5] is now used *a priori*.

Table 1. Low-degree coefficients for gravity fields derived from MESSENGER data.

	HGM002 (L=20)	HGM004 (L=20)	HGM005 (L=50)
GM (10^7) -2.203×10^{12}	178.05	183.92	187.169 ± 0.011
C_{20} (10^{-5})	-2.2555	-2.2515	-2.25108 ± 0.00008
C_{22} (10^{-5})	1.2537	1.2420	1.24489 ± 0.00006
C_{21} (10^{-8})	-4.641	-2.367	1.01132 ± 0.00005
S_{21} (10^{-8})	1.353	-0.251	-0.44340 ± 0.00005
S_{22} (10^{-8})	5.175	-2.951	-0.21771 ± 0.00004
C_{30} (10^{-5})	-0.4493	-0.4500	-0.47635 ± 0.00019

Results: The new solution, HgM005, is complete to harmonic degree and order 50 and is generally very consistent with the gravity fields to degree and order 20 previously obtained from MESSENGER data. The gravity anomaly map (Figure 1) shows greater detail at the northernmost latitudes, where MESSENGER is most sensitive because of its orbital eccentricity and high northern periapsis. The low-degree coefficients (Table 1) do not change significantly, except for the C_{30} term (important for secular orbit evolution), which has likely benefited from our improved radiation pressure modeling. The quality of the field is further confirmed by the fact that the C_{21}, S_{21}, and S_{22} values are very small, as expected in the principal axes frame. The pole position was co-estimated, and our obliquity estimate (2.03±0.02 arcmin) is compatible with the *a priori* value (2.04±0.08 arcmin) [5]. Our formal estimate of the tidal Love number k_2 is 0.437±0.002, but

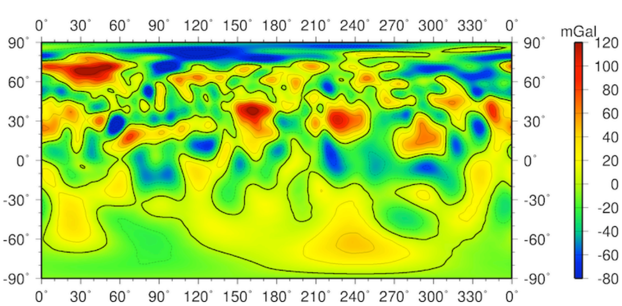

Figure 1. Map of the HgM005 gravity anomalies to harmonic degree and order 50 derived from ~2.5 years of tracking data. Cylindrical projection.

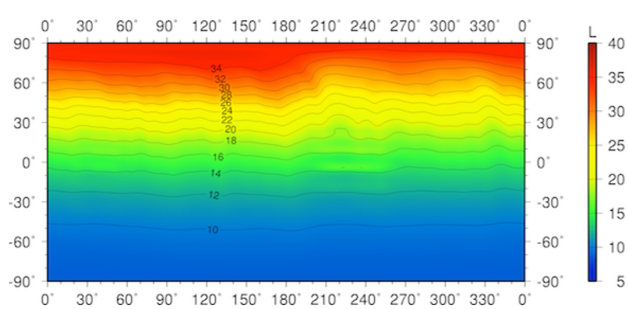

Figure 2. Degree strength of the HgM005 gravity field. Cylindrical projection.

because of higher sensitivity to the radiation modeling and inversion strategy, the range 0.4–0.5 is preferred. The full covariance matrix can be used to obtain spatial estimates of the gravity anomaly errors (not shown). Following earlier methodology [6], we calculated the degree strength of the gravity field (Figure 2). As expected, the degree strength is primarily zonal, dominated by the spacecraft altitude sensitivity. Figure 3 shows the HgM005 field expanded at each location up to only the calculated degree strength. Such a plot can be useful in determining those gravity anomalies from Figure 1 that are most likely to be robust.

References: [1] Solomon, S.C. et al. (2007) *Space Sci. Rev.* 131, 3-39. [2] Smith, D.E. et al. (2012) *Science*, 336, 214-217. [3] Hauck II, S.A. et al. (2013), *JGR Planets*, 118, 1204-1220. [4] Mazarico, E. et al. (2012), *AGU Fall Meeting*, abstract P31D-02. [5] Margot, J.-L. et al. (2012), *JGR*, 117, E00L09. [6] Konopliv, A.S. et al. (1999), *Icarus*, 139, 3-18.

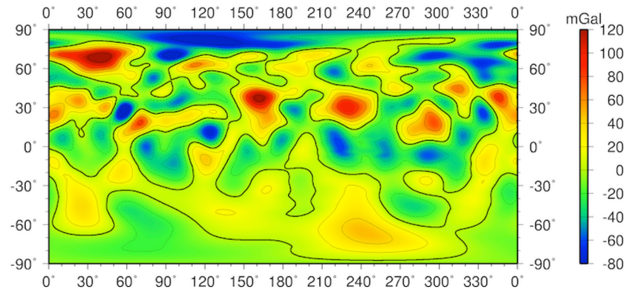

Figure 3. Map of the HgM005 gravity anomalies expanded only up to the degree strength at each location. Cylindrical projection.