THE TOPOGRAPHY OF MERCURY DERIVED FROM TWO YEARS OF MESSENGER DATA. Gregory A. Neumann[1], John F. Cavanaugh[1], Xiaoli Sun[1], Erwan Mazarico[2,1], David E. Smith[2], Maria T. Zuber[2], Kopal Jha[3], James E. Golder[3], Mark H. Torrence[4], Carolyn M. Ernst[5], Olivier S. Barnouin[5], and Sean C. Solomon[6,7]. [1]Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA (Gregory.A.Neumann@nasa.gov); [2]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, USA; [3]Sigma Space Corporation, Lanham, MD 20706, USA; [4]Stinger Ghaffarian Technologies Inc., Greenbelt, MD 20770; [5]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA; [6]Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY 10964, USA; [7]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20015, USA.

Introduction: Since March 29, 2011, the Mercury Laser Altimeter (MLA) [1] onboard the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft [2] has operated successfully in Mercury orbit [3]. During the primary mission and the current extended mission, over 19 million laser shots have been fired in the course of 1,260 ranging orbits. As of the first week of January 2013, the MLA had produced 11.3 million validated planetary radii. More than 77.5% of the northern hemisphere of Mercury has been mapped after averaging into 0.5°×0.5° bins. In the current extended mission the MLA has also confirmed via radiometric measurements and thermal models [4, 5] that radar-bright deposits (discovered from Earth-based measurements) within near-polar impact craters contain both water ice and unusually dark material, postulated to include organic compounds.

Orbital Evolution and Coverage: MESSENGER's eccentric orbit permitted ranging from its initial 83°N maximum latitude to the equator during the dawn-dusk phases in continuous nadir operation while maintaining sunshade protection. During noon-midnight orbits, thermal protection requires offnadir operation, thus limiting coverage to 20°-30°N latitude (Fig. 1). As the instrument's laser output declined, the maximum range attainable decreased from >1500 km to less than 1200 km, also limiting coverage.

In April 2012, MESSENGER transitioned to an 8-hour orbit, allowing more frequent observation periods at low altitudes. During the second year of operation the orbital periapsis migrated northward from its initial 60°N and the periapsis altitude increased from its initial 200-400 km height. The sub-spacecraft latitude at or below 1200 km altitude increased to 25°N. Equatorial ranging is no longer possible so the focus of MLA in the extended mission has been to characterize tectonic processes while conducting targeted observations of the north polar region. Chief measurements are topographic profiles over broadly elevated regions within the northern hemisphere containing both volcanically flooded and unmodified impact craters, as well as offnadir ranging near the poles.

Topography and Reflectance of Permanently-Shadowed Regions (PSRs): The maximum latitude of the MESSENGER orbit has increased but still requires spacecraft maneuvers to range to the northernmost 6-7 degrees of latitude where most PSRs are found (Fig. 2). Reflectance at 1064 nm wavelength is calculated from multiple-threshold measurements of the returned pulse waveform when feasible. The 108-km-diameter crater Prokofiev contains a large radar-bright deposit in its permanently shadowed southern interior. Profiles obtained at favorable incidence and altitude during the extended mission have shown areas within this deposit with reflectance values 2-3 times brighter than surrounding regolith, suggesting exposure of surface ice. The remainder of the permanently shadowed crater interior is relatively dark. Likewise the interiors of most shadowed regions extending southward of Prokofiev contain radar-bright deposits that are covered by what is interpreted from Neutron Spectrometer measurements [6] as a decimeters-thick layer of dark organic residues insulating thicker deposits of water ice. Smaller highly-reflective deposits are observed in permanently shadowed regions extending southward that correlate with predictions of thermal models derived from MLA topography. Further reflectance observations together with refined thermal models will allow additional constraints on the characteristics of volatile emplacement and sequestration in Mercury's north-polar region.

Topography Archive: Altimetry and reflectance profiles through September 17, 2012 consisting of 20–80-m diameter footprints spaced ~400 m along-track, edited manually to remove extraneous noise returns, have been delivered to the Planetary Data System.

References: [1] Cavanaugh, J. F. et al. (2007) *Space Sci. Rev. 131*, 451-479. [2] Solomon S. C. et al. (2007) *Space Sci. Rev. 131*, 3-39, doi:10.1007/s11214-007-9258-3. [3] Zuber M. T. et al. (2012) *Science 336*, 217-220, doi: 10.1126/science.1218805. [4] Neumann G. A. et al. (2013) *Science 339*, doi:10.1126/science.1229764. [5] Paige, D. A. et al. (2013) *Science 339,* doi:10.1126/science.1231106. [6] Lawrence, D. J. et al. (2013) *Science 339*, doi: 10.1126/science.1229953.

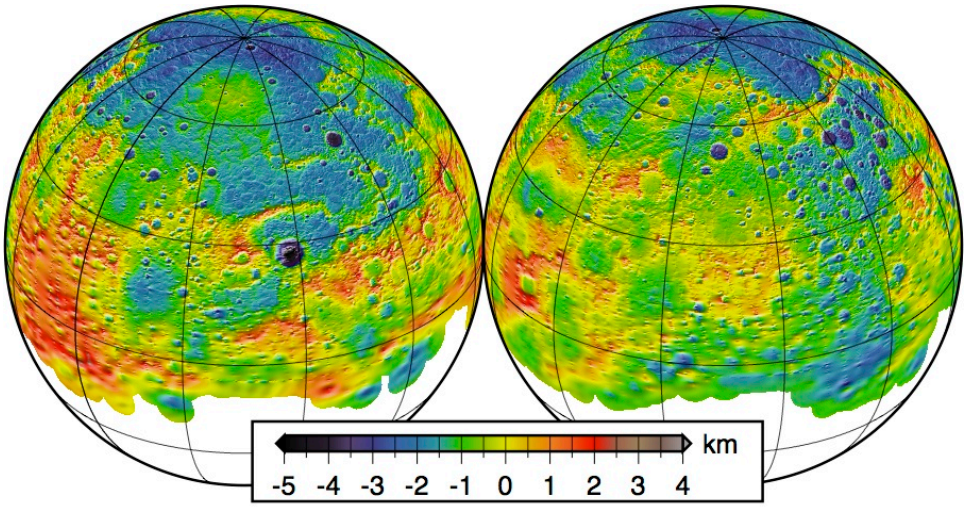

Figure 1. Topography of Mercury from two years of MLA altimetry, relative to a 2440-km spherical datum. Orthographic projections centered at 30°N latitude and 45°E (left) and 225°E (right) longitude. Blank areas are beyond the range of MLA.

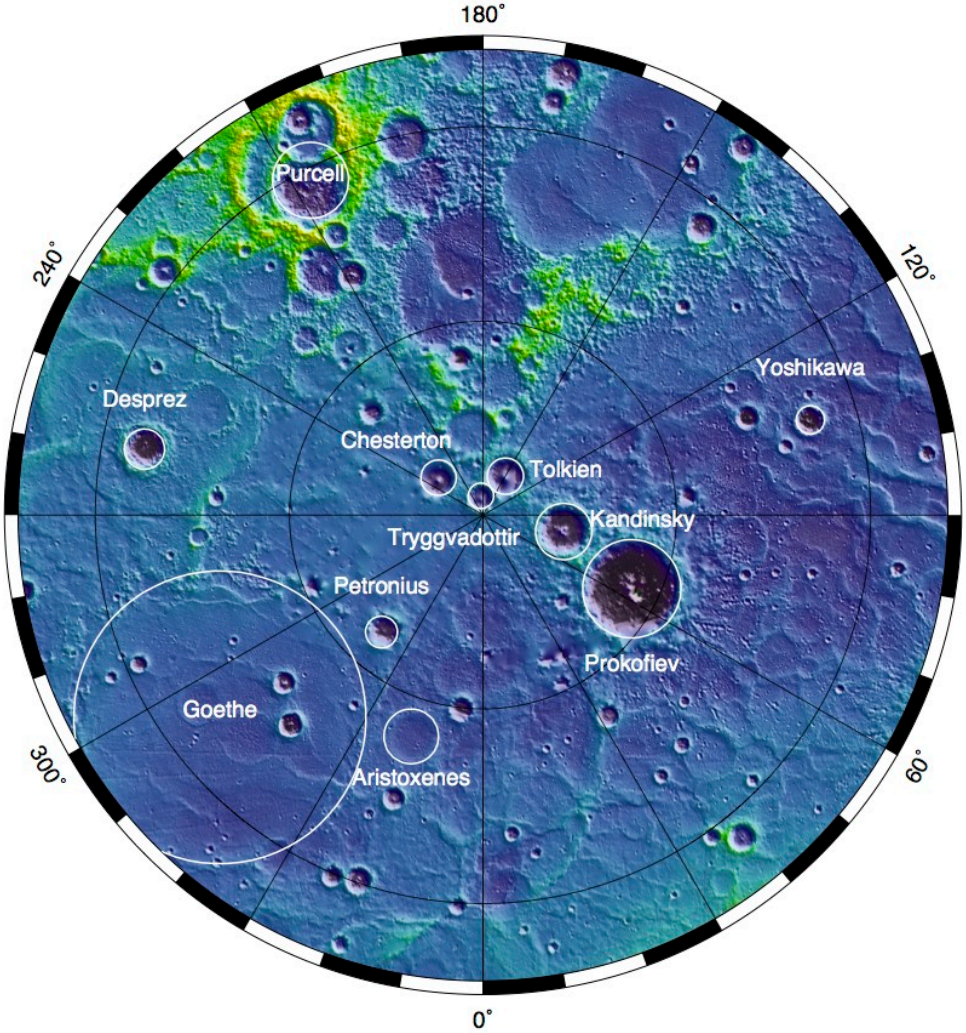

Figure 2. Topography and shaded relief from 78°N to the north pole, with false illumination from the upper right. Colors follow the elevation scale in Figure 1; stereographic projection. Crater names are those approved by the IAU.