A NEW TOPOGRAPHY MODEL OF MERCURY'S SOUTH POLE FROM MESSENGER MDIS-NAC. Stefano Bertone[1,2], E. Mazarico [2], M. K. Barker [2], M. Siegler [3], J. M. Martinez Camacho [3], C. Hamill [4], N. L. Chabot [5] [1] Center for Research and Exploration in Space Science and Technology, University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore MD, USA [2] NASA Goddard Space Flight Center (GSFC), Code 698, 8800 Greenbelt Road, Greenbelt, MD 20771, USA [3] University of Arizona [4] University of Purdue [5] Johns Hopkins Applied Physics Laboratory

Introduction: Mercury's South Polar regions are of particular interest since Arecibo radar measurements show many high-reflectance regions consistent with ice deposits (see Fig. 1 from [1]). Detailed modeling of the illumination and thermal conditions at these radar-bright locations would allow the first constraints on the volatiles potentially residing there. However, the resolution of current terrain models at Mercury's South Polar areas is not sufficient for such detailed analyses. Because of MESSENGER's [2] very eccentric orbit with periapsis over northern latitudes, its observations of southern regions were limited by the spacecraft distance from the planet. For instance, no Mercury Laser Altimeter ranges to the surface are available lower than $10°$ South, so that elevation information in the southern hemisphere is limited to what can be recovered from the Mercury Dual Imaging System (MDIS) [3] supplemented by radio occultations [4]. Past studies have used stereo-photogrammetry (SPG) with MDIS data to produce elevation maps of Mercury's surface, both global ones [5] at 665 m/pix or focusing on several Mercury quadrangles [6]. However, this technique is difficult to use in polar regions, where strong shadowing hinders SPG. With

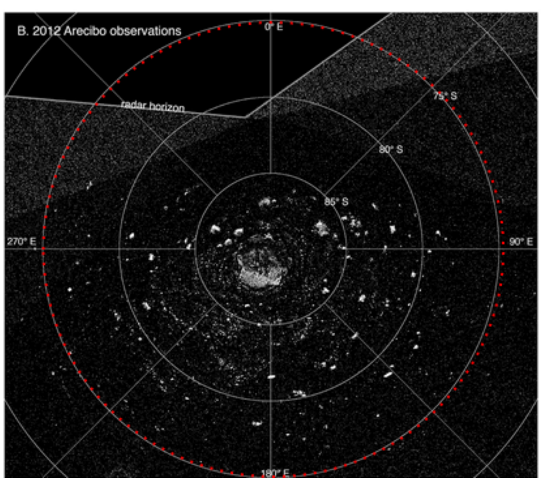

Figure 1: Map of radar bright areas from [1]. Our detailed elevation maps (covering the region $75°$-$90°$ S indicated by the red dots) allow the first detailed simulations of illumination and thermal conditions in these regions to constrain their nature and composition.

BepiColombo still several years away from entering orbit, it is important to further exploit MESSENGER's extensive datasets to retrieve additional information about the planet, for both geophysical analysis and preparation for the upcoming mission. In this study, we use an approach called photoclinometry [7], or Shape-from-Shading (SfS), to provide higher resolution topographic maps of the South Pole. In particular, we apply tools available within the Ames Stereo Pipeline (ASP [8]) to MDIS Narrow Angle Camera (NAC) images, to resolve topography with a resolution of 250 m/pix at latitudes below $75°$ South (an area covering $\sim 1.3 \times 10^6$ km^2).

New Topographic model from photoclinometry and MDIS-NAC images: In recent years, SfS has been successfully applied to many terrestrial bodies [see, *e.g.*, 9, 10, 11, 12]. In this method, the terrain slope is inferred from the shading variations in images caused by variations in illumination and observation geometry, and topography is obtained from the reconstructed slopes. SfS works best when multiple images per scene are available, sampling a wide range of solar azimuths. We first select (among the $\geq 270,000$ geolocated MDIS images available on the PDS for the whole planet) NAC images with a pixel scale better than 250 m/pix, off-nadir angle $\leq 45°$, incidence angle $\leq 85°$ (so that the image is taken on the day-side of Mercury), and a 20% overlap with the latitudes of interest. Still, using all images satisfying the above criteria would not be computationally practical. Thus, we use a custom Python tool to select a reduced set of images ensuring optimal surface coverage and Sun azimuth range at each surface point below $75°$ South. SfS has been shown to recover topography at or near the native image pixel scale [11]. We thus use ASP to build elevation models with a pixel scale of 250 m/pix for overlapping square tiles ~ 200 km on a side (in stereographic projection) covering the whole area of interest. We carefully align them with a bundle adjustment before building up a seamless mosaic using ASP's suite of tools. A final check against the USGS DEM [5] does not reveal any evident craters misalignment or broad-scale elevation discrepancies. As permanently shadowed regions are not visible in regular NAC images, and with no MLA altimetry information available, we assume a bowl-shaped radial profile to fill in shadowed parts of Mercury's craters. Slopes derived from both the USGS and our elevation models are shown in Fig. 2, with the latter showing a much higher level of detail. This is especially

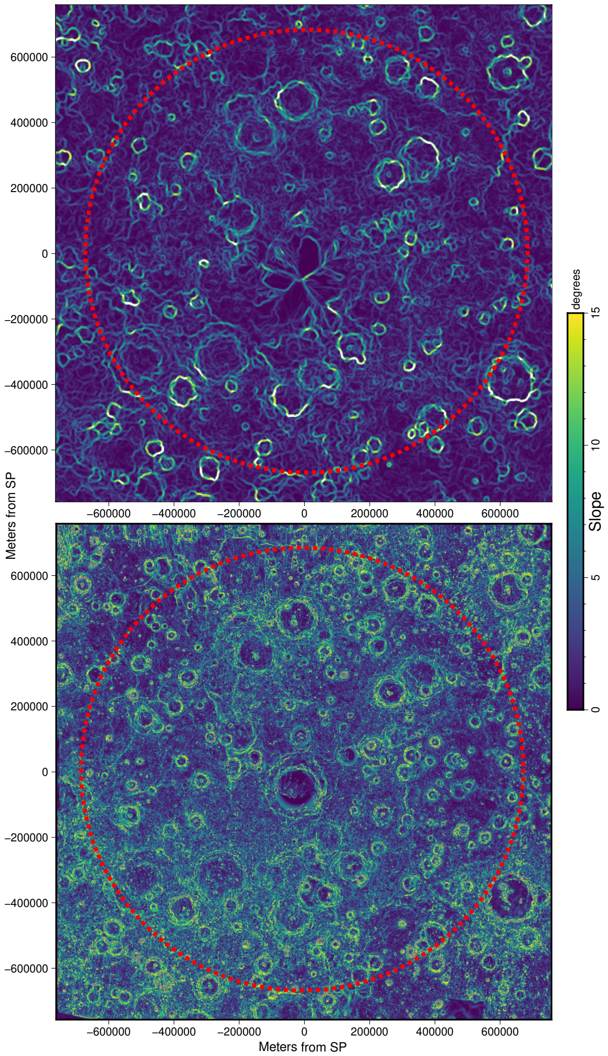

Figure 2: Slopes of USGS stereo elevation model [5] at 665 m/pix (top) and of our new 250 m/pix model based on Shape-from-Shading (bottom). Much more details and smaller craters are resolved in the latter, which is key to determine illumination conditions at the surface. The dotted red circles indicate 75°S latitude, as in Fig. 1.

true close to the South Pole and for the Chao-Meng-Fu crater (87.6° S), where the USGS map only shows interpolation artifacts for lack of proper stereo pairs.

A key advance for illumination analyses at Mercury South Pole: The increased resolution and level of detail provided by our new elevation model opens the door to a realistic recovery of illumination and thermal conditions at Mercury's South polar regions, and specifically at potential volatiles deposits. We use our modeling tools (e.g., the IllumNG software [13]) to render the elevation models and compare them to MDIS NAC images of the same regions. Fig. 3 shows the increased potential of our new model to realistically represent illumination con-

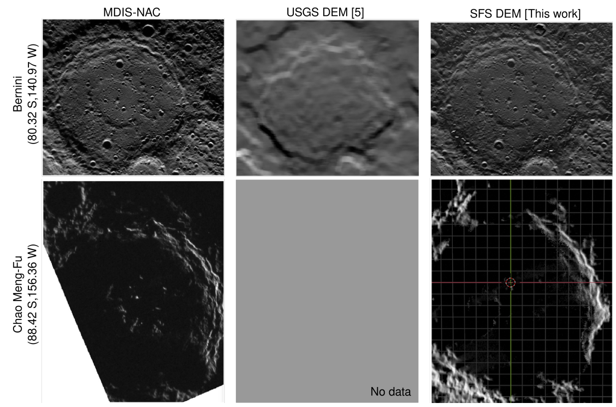

Figure 3: Left, MDIS-NAC capture of the Bernini (top, EN0215554941M) and Chao Meng-Fu (bottom, EN1052520846M) craters; center, USGS DEM [5] clip of the same region, consistently rendered ; right, rendering of our SfS DEM, showing a much better consistency with the NAC images.

ditions within several craters. A detailed knowledge of both direct and scattered illumination at the surface over a Mercury year is then the basis to recover thermal conditions and assess the possibility and nature of volatiles present at Mercury's South polar regions.

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