PHOTOMETRIC ANALYSIS OF SELECTED REGIONS ON MERCURY FROM MESSENGER ORBITAL OBSERVATIONS OF SPECTRAL REFLECTANCE.

Deborah L. Domingue[1], Gregory M. Holsclaw[2], Noam R. Izenberg[3], and Faith Vilas[1]. [1]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719-2395 (domingue@psi.edu, fvilas@psi.edu); [2]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80303 (greg.holsclaw@lasp.colorado.edu); [3]The Johns Hopkins University Applied Physics Laboratory, Laurel MD, 20723 (noam.izenberg@jhuapl.edu).

Introduction: The Mercury Atmospheric and Surface Composition Spectrometer (MASCS) on the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft has acquired photometric observations of several regions of Mercury during the orbital period of its mission with the Visible and Infrared Spectrograph (VIRS) portion of the instrument. These observations were acquired to provide the information needed to derive photometric corrections for the MASCS spectra of Mercury observed during the flybys and from orbit. They also provide a data set for examining variations in the physical properties of Mercury's surface.

Data Sets: Fifteen regions have been targeted and sampled by the MASCS/VIRS instrumentation (over the selected wavelength range 325 – 1450 nm) to date. Figure 1 displays an example of the data coverage, including incidence, emission, and phase angle ranges, for a typical plains unit. Each photometric region is being examined and compared with the global photometric properties derived from the Mercury Dual Imaging System (MDIS) disk-integrated photometric sequence acquired during MESSENGER's Mercury flybys [1]. The Hapke model [2,3] has been used to date to describe the photometric properties of Mercury [1] and is used here for consistency. This model has been shown to describe photometric measurements accurately, though the correlation between model parameters and surface physical properties has not been robustly demonstrated [4,5], and has been used to derive photometric corrections for the MDIS instrument [6]. Variations in parameters can indicate physical differences, if not uniquely identify them.

Data Analysis: Hapke model parameters representing the global properties of Mercury's surface were derived from MDIS disk-integrated photometric observations for each of the eleven spectral bandpass filters, which span the wavelength range 430 – 1050 nm, of the instrument's wide-angle camera (WAC) [1]. The disk-integrated study provides a means to normalize MDIS measurements to a common photometric geometry on the basis of global rather than regional properties of the surface. This study will investigate if the model derived from MDIS measurements is applicable for general corrections to the MASCS observations. Values of the Hapke parameters as functions of wavelength were established from their variations over the WAC spectral region. We used these trends to interpolate over the wavelength range common to VIRS and extrapolate to the longer wavelengths, deriving preliminary Hapke model parameter values for each of the 15 regions. Independent model fits, obtained with a least-squares grid search, were compared to the extrapolated values to test the veracity of the interpolations as well as the extrapolation technique.

From the least-squares grid search [1], we derived Hapke model parameters for 95 wavelengths spanning the MASCS spectral range. The parameter values resulting from these fits were then compared with the suggested values from the MDIS-derived parameters. Figure 2 shows example plots comparing the model and photometric measurements at three discrete wavelengths, one wavelength outside the MDIS spectral range and two inside, for the plains region shown in Figure 1. A goodness-of-fit metric was defined to be the ratio of the observed reflectance to the theoretical value from the model. On the basis of work by Cheng and Domingue [7], a set of model parameter values that accurately describes the photometric measurements should show ~5% or less difference between measurements and model-derived reflectances.

Preliminary Results: The median of the goodness-of-fit ratio at 325 nm wavelength is 1.01 and 0.97 for the least-squares and extrapolated values, respectively. The two results thus differ by 4%. The median ratio at 567 nm wavelength is 1.01 and 1.07 for the least-squares and interpolated values, respectively. These two results thus differ by 6%. The median ratio in the final example at 632 nm wavelength is 1.01 and 0.99 for the least-squares and interpolated values, respectively. The standard deviation of the ratio for all cases is ~0.1 (see table in the caption to Fig. 2). The single-scattering albedo (w) and surface roughness parameter (θ) values are higher at each wavelength in the least-squares results than in the extrapolated values. For example, at 567 nm the least-squares values for w and θ are 0.3 and 33°, respectively, whereas the extrapolated values are 0.22 and 15°. These differences could indicate that the plains region measured is different from the globally averaged surface. However the small differences in the goodness-of-fit metric may indicate issues with uniqueness of the model solutions. Comparisons with modeling results from MDIS should take into account that the photometric models will also compensate for any camera artifact issues, such as contribution from scattered light. Analyses of additional regions will help determine the source of these differences.

References: [1] Domingue, D. L. et al. (2011) PSS 59, 1853-1872. [2] Hapke, B. (1981) JGR 86, 3039-3054. [3] Hapke, B. (1984) Icarus 59, 41-59. [4] Shepard, M. K. and P. Helfenstein (2007) JGR 112, E03001. [5] Shepard, M. K. and P. Helfenstein (2011) Icarus 215, 526-533. [6] Domingue, D. L. et al. (2011) PSS 59, 1873-1887. [7] Cheng, A. F. and D. L. Domingue (2000) JGR 105, 9477-9482.

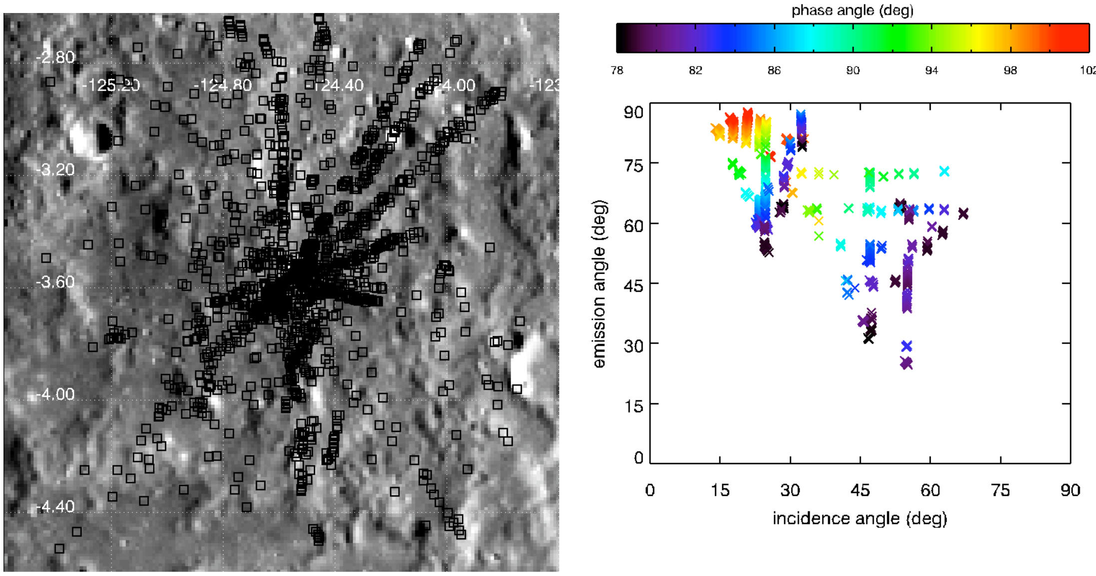
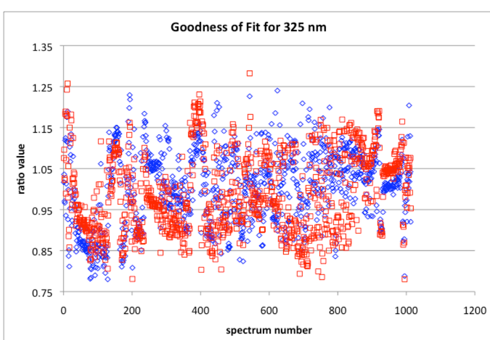
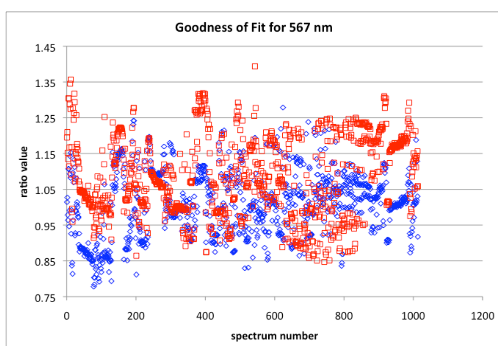


Figure 1. Example of photometrically sampled plains unit centered at 3.6°S, 235.6°E. The left panel shows an MDIS image of the region, and the centers of MASCS footprints are marked by black squares. The right panel shows the coverage in incidence, emission, and phase angle.





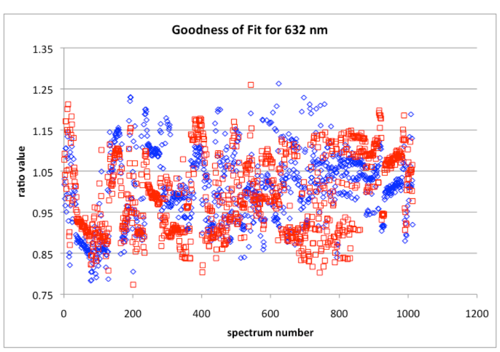


Figure 2. Goodness-of-fit ratios between the observations and the reflectance predicted from the least squares analysis (blue diamonds) and the extrapolated values (red squares) at 325 nm (top left), 567 nm (top right), and 632 nm (bottom) wavelength for the plains unit shown in Figure 1.

Wavelength (nm) /fit type	median	Standard deviation
325/least squares	1.01	0.091
325/extrapolated	0.97	0.096
567/least squares	1.01	0.091
567/extrapolated	1.07	0.111
632/least squares	1.01	0.089
632/extrapolated	0.99	0.095