NEW ULTRAVIOLET THROUGH NEAR INFRARED SURFACE REFLECTANCE DATA PRODUCTS FROM MESSENGER. N. R. Izenberg[1], and Gregory M. Holsclaw[2], [1]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723, USA, [2]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO 80303, USA. noam.izenberg@jhuapl.edu

Introduction: Surface reflectance data from ultraviolet through near-infrared wavelengths were obtained by the MESSENGER mission's Mercury Atmosphere and Surface Composition Spectrometer (MASCS) during its over 4-year orbital mission. The full global dataset of the MASCS Visible and InfraRed Spectrograph (VIRS) (wavelength range 300 nm – 1450 nm) was delivered to the planetary data system as part of the mission; this archive includes raw data, calibrated spectra, derived reflectance, photometrically normalized reflectance, and a monochrome reflectance map [2]. The Ultraviolet and Visible Spectrometer (UVVS), being a point spectrometer primarily designed for observation of the Mercury exosphere, had a much more limited surface dataset. Several observing campaigns of targeted surface observations using the middle ultraviolet (MUV; 210 nm - 300 nm) and far ultraviolet (FUV; 119.1 – 122.5 nm and 129.2 – 131.5 nm) ranges of the UVVS yelded around 4600 surface reflectance spectra each, located mostly in Mercury's southern hemisphere. The MUV data was delivered to PDS in reflectance (I/F) form, [3], but only the calibrated radiance-at-sensor values for the FUV data were derived and delivered at the end of mission.

The final extension of the MESSENGER mission after the end of orbital operations has allowed development of two new data products for use by the science community incorporating and improving utility of the UV data obtained. The first product is a combined UVVS+VIRS Derived Data Record (DDR) of MUV-through-Near-infrared reflectance spectrum (210 nm – 1450 nm) for each location targeted by the UVVS. The second product is a surface reflectance DDR integrated over a ~1 nm bandpass centered at wavelengths 121.6 nm and 103.4 nm for each targeted location on the planet.

UVVS+VIRS Combined Spectrum: The UVVS+VIRS DDRs consist of derived data from the UVVS middle-ultraviolet (MUV) photomultiplier tube, and VIRS. Spatially proximate UVVS and VIRS spectra are combined to create a single extended wavelength surface reflectance spectrum from 210 nm to 1450 nm. The combination is conducted by software that locates automatically or with human assistance, the closest best-matching VIRS spectrum to a given UVVS spectrum, and combines the two data sets into a single spectrum for that location.

The UVVS+VIRS combined DDR data product contains all the data from one observation pair (matched UVVS and VIRS observations). One observation pair is associated with one DDR data product showing derived science data (photometrically corrected surface reflectance), and location information for each wavelength bin of a UVVS surface observation and the corresponding VIRS observation. The DDRs are in binary table format, and each is described by a detached PDS label. The label files define source DDR files, the time of acquisition of the UVVS observation, product creation time, etc. The label points to an associated format file that defines the fields of the binary table contained within the data file.

The combined spectrum contains footprint information similar to that shown in Figure 1A, and spectrum information similar to that shown in Figure 1B.

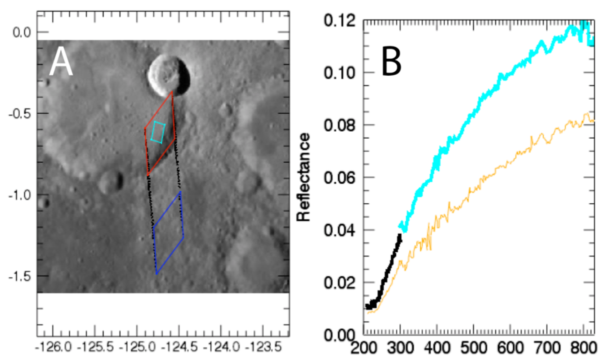

Figure 1. A) UVVS footprint of UVVS-VIRS Combined DDR is shown projected on an image mosaic background. The blue parallelogram represents the location of the first wavelength (210 nm) of the UVVS spectrum. The red shows the location of the last wavelength (300 nm). The cyan footprint represents the coordinate points of the VIRS footprint associated with the combined spectrum. Detailed information on the locations and ancillary data for the source observations for UVVS and VIRS are included in the DDR. B) Combined spectrum data from UVVS and VIRS. UVVS reflectance is shown in black, VIRS (up to 840 nm) is shown in cyan. A mean Mercury spectrum for the southern hemisphere is shown in orange.

FUV Surface Reflectance: The MASCS UVVS was capable of powering two of its three photomultiplier tubes for any given observation. During surface observations by the UVVS where the primary objective was to gather MUV surface reflectance with one tube, the instrument also gathered FUV data. There are only a few solar atomic emissions that are bright enough to be observed in the FUV channel; therefore, we restrict FUV DDRs to surface observations that have used an observation mode typically used for atmospheric scans of hydrogen Lyman alpha (121.6 nm) and oxygen (130.4 nm). For any single observation, there are two distinct scan ranges: a 31-step scan from 119.1 nm to 122.45 nm and a 21-step scan from 129.24 nm to 131.46 nm. Each of these two ranges consists of contiguous grating positions in 1-step increments. A notable difference from the MUV DDRs is that these FUV observations use the long (1°), atmospheric slit position in order to obtain sufficient signal. The measured radiance and the solar irradiance are integrated in the spectral ranges 121.6 ± 0.5 nm and 130.4 ± 0.5 nm. The reflectance (I/F) is otherwise calculated identically as that for the MUV DDRs, resulting in values at only these two wavelengths.

Because the solar irradiance can be highly variable at FUV wavelengths [4], we use the daily-averaged solar spectral irradiance provided by SORCE-SOLSTICE [5] and available from the LISIRD database (http://lasp.colorado.edu/lisird/). The SORCE spacecraft operates in a low-Earth orbit (LEO) and, in general, views a different hemisphere of the Sun than that which contributes to the solar irradiance seen at Mercury. This requires a temporal/spatial interpolation of the solar irradiance measured by SOLSTICE to the time of the UVVS observation and position of Mercury in its orbit.

The conversion and coadding process results in a ~4600 individual observations covering much of Mercury's southern hemisphere in grid-like fashion, similar to the extant grid of MUV observations. These products are under-explored to date, and their final correction and delivery to the PDS provides a potentially important data set for future Mercury research.

Science Potential: Near- to middle-ultraviolet observations have been shown to be are important for interpretation of Mercury's composition [6], especially with respect to iron and carbon compositions [7 - 9]. The creation of an expanded spectrum to combine MUV through near-infrared data should help maximize the mineralogical information interpretable from surface reflectance at Mercury.

Analysis of the extensive FUV spectral reflectance measurements of the dayside lunar surface by the Lunar Reconnaissance Orbiter (LRO) Lyman Alpha Mapping Project (LAMP) indicate that the data are sensitive to both composition and space weathering [10]. The FUV reflectance from MASCS may provide similar information for the Mercury surface, complementing results from longer wavelengths. We note that supporting laboratory data are very limited, and largely restricted to work published in 1987 [11]. Additional laboratory work will be needed to understand this unique dataset.

References: [1] W.E. McCLintock and M.R. Lankton (2007), *Space Sci. Rev*. 131, 481–521, [2] N.R. Izenberg and J. Ward (2014), VIRS SIS, PDS Geosciences Node [3] N.R. Izenberg and J. Ward (2014), MASCS UVVS SIS, PDS Geosciences Node [4] Rottman, G. (1999) J. Atm. Sol. Terr. Phys. 61, 37-44 [5] W. E. McClintock, G. J. Rottman, T. N. Woods (2005) Sol. Phys. 230, 225-258 [6] Izenberg et al. (2014), Icarus. 228, 364-374, [7] N. R. Izenberg (2015) 2015 AGU Fall Mtg., [8] Maxwell et al. (2016), *LPSC 47, LPI Contribution No. 1903*, #1606 [9] Trang et al. (2016), *LPSC 47, LPI Contribution No. 1903*, #1396 [10] Hendrix et al (2012) J. Geophys. Res., 117 [11] J. K. Wagner, B. W. Hapke, E. N. Wells (1987) Icarus 69, 14-28.