MESSENGER MASCS VIRS UPDATED GEOMETRY. Mario D'Amore[1], Jörn Helbert[1], Alessandro Maturilli[1], and Deborah L. Domingue[2] [1] Institute for Planetary Research, DLR, Rutherfordstrasse 2, Berlin, Germany,[2] Planetary Science Institute, 1700 E. Ft. Lowell Road, Suite 106, Tucson, AZ 85719 USA (mario.damore@dlr.de)

Introduction: The Mercury Atmospheric and Surface Composition Spectrometer (MASCS) [1] instrument was onboard the NASA MESSENGER mission which operated between 2004 and 2011, when the spacecraft was crashed onto Mercury's surface. MASCS contained two detectors, an Ultraviolet-Visible Spectrometer (UVVS) and a Visible-Infrared Spectrograph (VIRS). VIRS covered the wavelength ranges of the visible (300-1050 nm) and near infrared (850-1450 nm), with an average spectral resolution of 5 nm. MASCS investigated the composition and structure of Mercury's exosphere and globally mapped the surface reflectance on spatial scales of 5 km. We recomputed MASCS geometries using the NAIF SPICE toolkit python implementation spiceypy [2]. The code and the output dataset will be publicly available following FAIR principles (see www.go-fair.org/fair-principles/ too).

Method: MASCS calibrated data records (CDR) in the PDS archive already contain some geometrical information, but omits some key parameters, such as local time, which is a useful proxy for the surface temperature, due to Mercury's slow rotation.

Moreover, at the time of observation, a detailed digital elevation model (DTM) of the whole planet was not available, so calculations were done approximating the planet as an ellipsoid. Even though this was the best approach at the time, we currently have better datasets, thanks to analyses of the MESSENGER instruments suite observations. In particular, the Mercury Laser Altimeter (MLA) derived data are now available within ESA's SPICE kernel archive.

NASA's Navigation and Ancillary Information Facility (NAIF), the source for position and orientation for solar system bodies and spacecraft, maintains SPICE, an information system describing position and orientation to assist scientists in interpreting scientific observations from space-borne instruments.

Each MASCS/VIRS observation has a timestamp giving the exact UTC time of the observation, that is used to compute the position and orientation of the MESSENGER spacecraft and planet Mercury relative to the SUN (J2000 reference system) at the moment of data acquisition. The relative position of the spacecraft and the planet can then be easily calculated, in addition to several other variables like: local time, sub-spacecraft and sub-solar location, and altitude. The latter is calculated using the model from ESA SPICE Service (ESS) repository (see Acknowledgements) and contains MESSENGER derived Mercury's shape data, downsized to 7 pixels per degree.

MASCS FOV is defined via its instrument boresight vector ([0,0,1] in the instrument's reference system) and a ray on the FOV, defining an cone of 0.015 deg of aperture. The ray is rotated in 72 steps around the boresight. Each vector intersection with the planetary surface is calculated, along all other parameters (see Fig1.a , the red spots). This is done at the measurement's start and stop times, over a the detector integration interval, producing a initial and final instantaneous FOV (Fig1.a, red shapes). Those instantaneous FOVs are fused calculating the convex hull containing them, giving the final shape of an elongated FOV (Fig1.b, green shape).

Resuts: Spacecraft orbit 11224, taken on 2011-08-12, was used as test (dataset ID VIRSVD_ORB_11224_214005_DAT). The datafile has 421 single spectral observations in the southern hemisphere. One example of the recalculated FOV is given in Fig1.b. This shows the mismatch between the final FOV and the PDS archived data. The final position of the FOV differs because we are taking in account Mercury's local shape and elevation. This in turn changes the incidence/emission angles calculated by ~6 deg with opposite sign, leaving the phase angle almost unchanged (see Table 1). Because we are calculating 72 points per FOV over 2 timesteps and fusing them, we don't have an unique number for the calculated quantities over the FOV. We provide mean, median and standard deviation for each quantity to have an idea of the sub-FOV distribution. Small standard deviation means homogeneous sub-FOV values, while higher values indicates more variability in the FOV. The differences between PDS data and this work output will be more pronounced for more extreme viewing geometries and larger FOV (higher spacecraft altitude). The sub-FOV variations will be bigger for larger FOV too.

Acknowledgments: MESSENGER MASCS VIRS data are publicly available at the Planetary Data System (PDS) Geoscience node, DOI 10.17189/b2cw-pq73. SPICE compatible DTM model (DSK kernels) is available at in the ESA Generic SPICE Kernel Dataset https://s2e2.cosmos.esa.int/bitbucket/projects/spice_kernels/repos/esa_generic/browse

References:

[1] McClintock, W. E. and M. R. Lankton, Space Science Reviews, 131, 481-521, doi: 10.1007/s11214-007-9264-5 (2007). [2] Annex et al., Journal of Open Source Software, 5(46), 2050, doi:10.21105/joss.02050 (2020). [3] Wilkinson, M., *et al.* , *Sci Data* **3**, 160018, doi:10.1038/sdata.2016.18, (2016). [4] Acton, C.H., Planetary and Space Science, 44, 1, 65-70. doi:10.1016/0032-0633(95)00107-7 (1996).

		Calculated		PDS
		Mean	Standard Deviation	
Intercept	longitude	61.57	0.01	61.56
	latitude	-20.38	0.01	-20.38
	altitude	-0.02	0.07	NA
	distance	3,235.24	0.36	NA
	phase	77.86	0.01	77.86
	incidence	40.58	0.17	33.96
	emission	37.40	0.20	43.91
Local time	hour	13.00	0.00	NA
	minute	51.00	0.00	NA
	second	11.94	3.29	NA
Sub-Spacecraft	longitude	86.83	0.00	NA
	latitude	-31.79	0.00	NA
	altitude	-2.13	0.00	NA
Sub-Solar	longitude	33.77	0.00	NA
	latitude	-0.03	0.00	NA
	altitude	0.14	0.00	NA

Table 1. Example of calculated param3ters, their mean and standard deviation over the FOV and PDS data for observation in Fig.1. NA values are not defined in PDS.

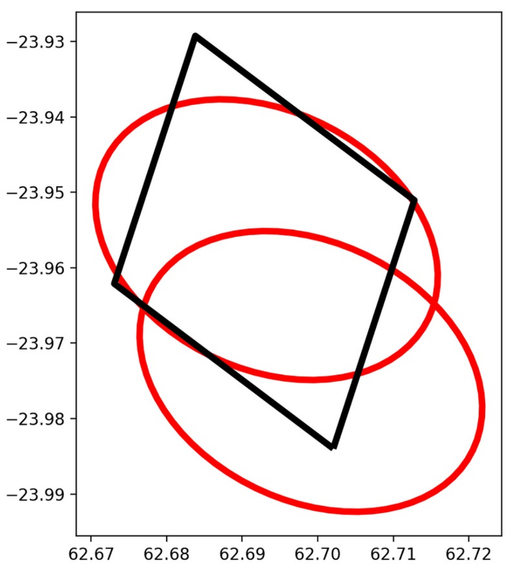

Figure 1: Fig. 1 Example FOV. Diamond black shape: data from PDS. a. (left) Red circles: instantaneous FOV. b. (right) Green shape: convex hull of the instantaneous FOVs.