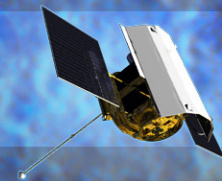




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Mercury Atmosphere and Surface Composition Spectrometer (MASCS) Visible and InfraRed Spectrograph (VIRS) Tutorial/User's Guide.

Noam Izenberg, Rachel Klima,
& the MESSENGER MASCS team

noam.izenberg@jhuapl.edu

rachel.klima@jhuapl.edu

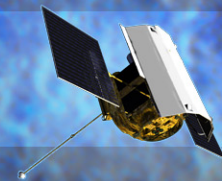
V2, March 13, 2017



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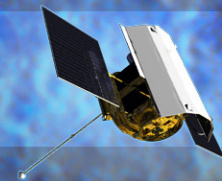
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Outline

- The MASCS instrument.....3
- VIRS Calibration.....6
- Data Products.....11
- MESSENGER Website and Tools.....17
- NASA PDS – Data Access.....43
- Data Readers.....61
- References.....64



Mercury Atmospheric and Surface Composition Spectrometer (MASCS)



- The Ultraviolet and Visible Spectrometer (UVVS)
 - 115-600 nm (split into FUV, MUV, Vis)
 - Primarily designed for exosphere measurements
 - Some surface scans being conducted
 - Surface data still being validated for science quality
- **Visible and Infrared Spectrograph (VIRS)**
 - **Surface measurements (300-1450 nm)**

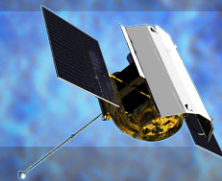


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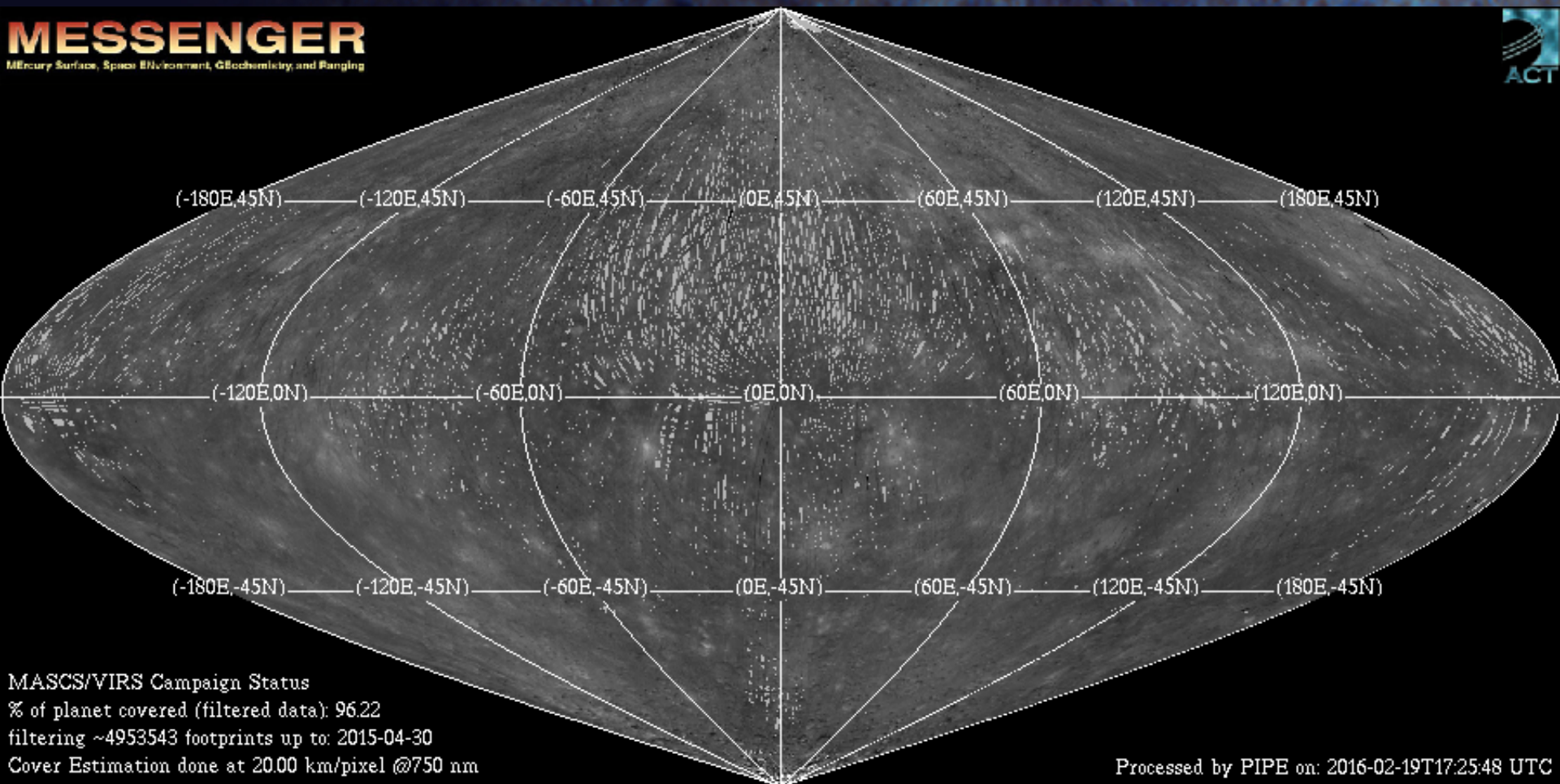
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VIRS Observations



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MASCS/VIRS Campaign Status

% of planet covered (filtered data): 96.22

filtering ~4953543 footprints up to: 2015-04-30

Cover Estimation done at 20.00 km/pixel @750 nm

Processed by PIPE on: 2016-02-19T17:25:48 UTC

From March 2011, to April, 2015 ~5 million reflectance spectra were collected (>96% surface coverage at 20 km spacing between footprints)

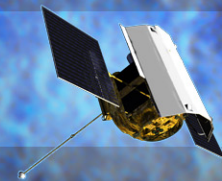
Observation geometry was restricted by spacecraft operational requirements. Between 70°N and 70°S data are limited to incidence <70°, emission <85°, Phase angles 78-102°.



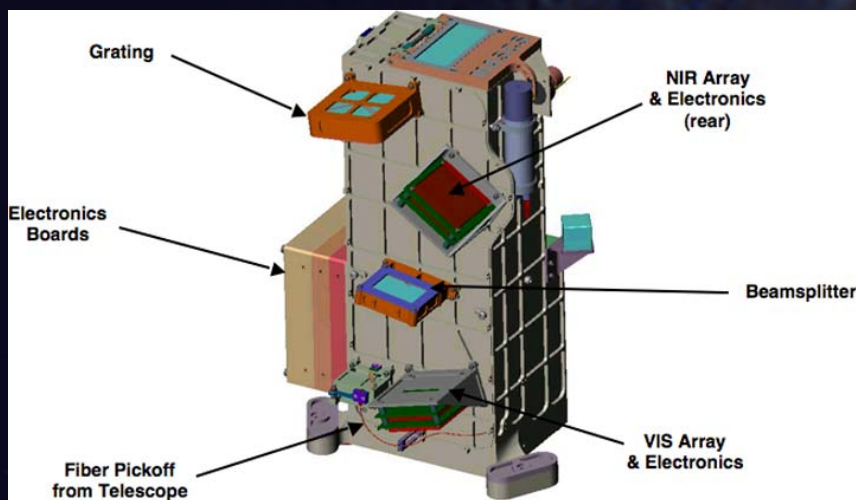
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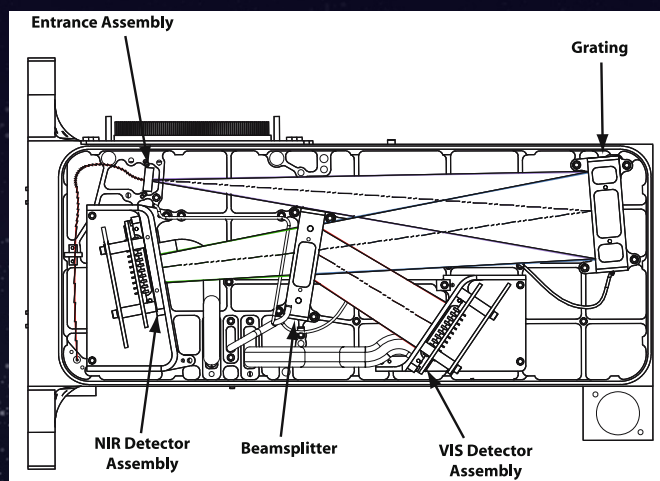
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VIRS Instrument Design



- Cassegrain Telescope (feeds both VIRS and UVVS)
- VIS detector: linear 512 element Si array
 - 300-900 nm
 - 5 nm spectral resolution
- IR detector: linear 256 element InGaAs array
 - 900-1450 nm
 - 5 nm spectral resolution
- No active detector cooling
- Shutter on VIRS entrance assembly
- Field of View 0.023° circular

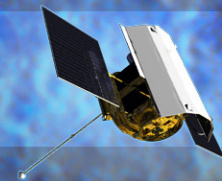




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VIRS Calibration

- Raw counts (data number, or DN) converted to corrected counts in DN.
- Shuttered dark measurements are interleaved with observations to monitor changes in dark current with temperature or other external conditions. A polynomial is fit to the shuttered darks in each data record to interpolate the dark level at the time of each observation.
- Corrected counts are converted to radiance.
- Noise spectrum – predicted standard deviation of observation based on dark measurements as a function of temperature (noise is in DN)
- Radiance-at-sensor is the data included in Calibrated Data Records (**CDRs**)

$$L = \left(\frac{(C - B_e - B_d - B_g)}{t} \right) \left(\frac{1}{S} \right)$$

L = radiance at the sensor

C = raw data value in DN,

B_e = background due to an electronic offset (in DN)

B_d = dark level (in DN)

B_g = grating-scattered light (in DN)

t = integration time (in s)

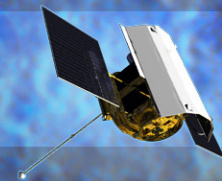
S = radiometric sensitivity measured in the laboratory in units of $\text{DN s}^{-1} (\text{W m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1})^{-1}$



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VIRS Data Calibration (Version 1)

$$r = \frac{L}{E_{\text{Sun}}/\pi}$$

$$f(i, e, \alpha) = \frac{\cos i}{\cos i + \cos e} p(\alpha)$$

$$p(\alpha) = a_0 + a_1 \alpha$$

$$r'(45, 45, 90) = r(i, e, \alpha) \frac{f(45, 45, 90)}{f(i, e, \alpha)}$$

L = radiance at the sensor ($\text{W m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$)

E_{Sun} = Solar spectrum irradiance ($\text{W m}^{-2} \mu\text{m}^{-1}$)

f = dependence of reflectance on viewing geometry

i = incidence angle

e = emission angle

α = phase angle

$p(\alpha)$ = phase function

$a_0 = 0.0576$

$a_1 = -3.52 \times 10^{-4}$

r' = normalized reflectance

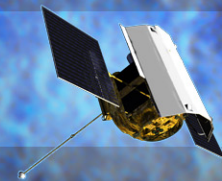
- Radiance divided by solar spectrum to get radiance factor
- Corrected for viewing geometry and phase dependence
 - V1 uses Lommel-Seeliger assumption ($f(i, e, \alpha)$) with empirical phase term
- Noise spectrum from CDR also converted to unitless reflectance
- Reflectance, and photometrically normalized reflectance are included in Derived Data Records (**DDRs**)



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New VIS Photometric Normalization (Version 2)

The Kaasalainen-Shkuratov model is given by:

$$f(i, e, \alpha) = A_N e^{-\alpha \mu} \left[c_l \left(\frac{2 \cos i}{\cos i + \cos e} \right) + (1 - c_l) \cos i \right]$$

where A_N is the normal albedo, c_l is a partition parameter between the Lommel-Seeliger $[2 \cos i / (\cos i + \cos e)]$ and Lambert $[(\cos i)]$ type scattering, and m is the disk-function parameter associated with surface roughness (Shkuratov et al. 2011)

- Based on analysis of VIS photometric observations acquired during orbit (NIR detector still uses V1 normalization)
- Uses same model as applied to MDIS data set
- Parameter values within the model are wavelength dependent, described using a polynomial function with coefficients shown

Coefficient	A_N	μ	C_l
A_4		1.04E-11	-6.20E-12
A_3	7.73E-10	-2.50E-08	1.52E-08
A_2	-1.57E-06	2.15E-05	-1.36E-05
A_1	1.17E-03	-7.86E-03	5.12E-03
A_0	-1.85E-01	1.54E+00	-3.25E-01

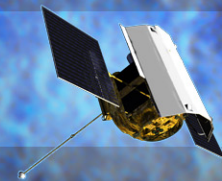
**Both Version 1 and Version 2
DDRs are preserved in the PDS.**



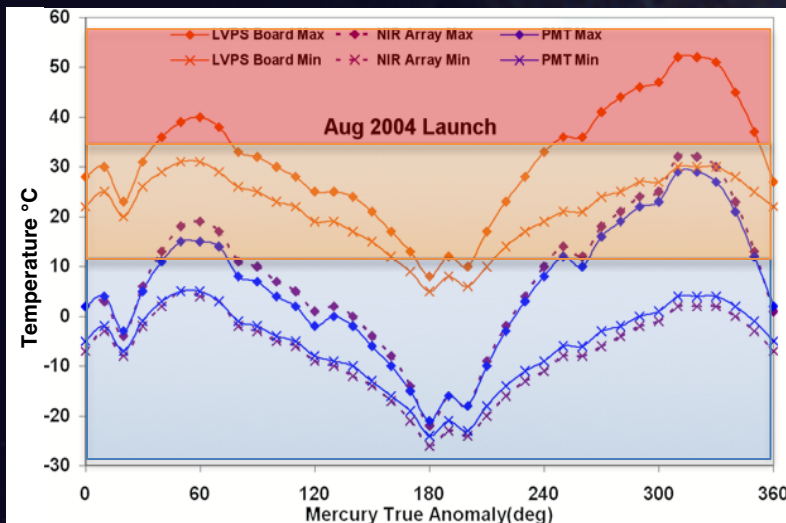
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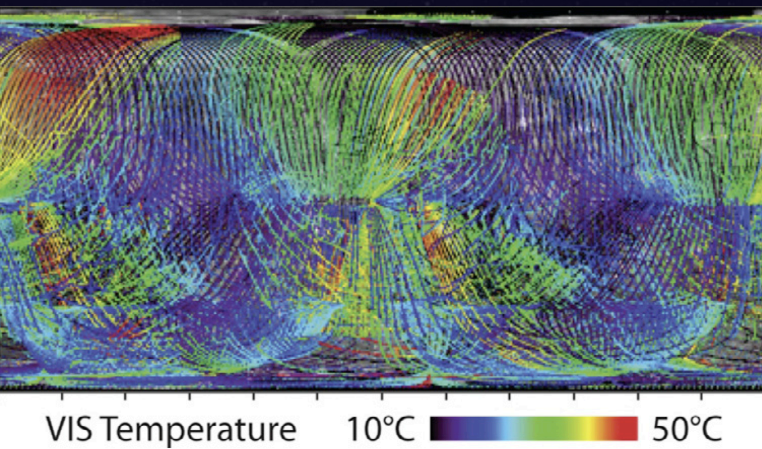
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High Temperature Data



- Instrument temperatures were predicted (pre-launch) to remain under $\sim 30^{\circ}\text{C}$ for most of the mission. (Figure from McClintock and Lankton, 2007). Data calibration was anticipated to be more challenging at $>10^{\circ}\text{C}$
- Actual temperatures exceeded 15°C for most of the orbital data. The bulk of data have been obtained at $10\text{--}35^{\circ}\text{C}$, but some reach $>50^{\circ}\text{C}$. NIR data noise became excessive $>35^{\circ}\text{C}$ and NIR pixels began to saturate in some cases. VIS data became increasingly noisy above 40°C . (Figure from Izenberg et al., 2014)

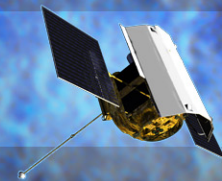




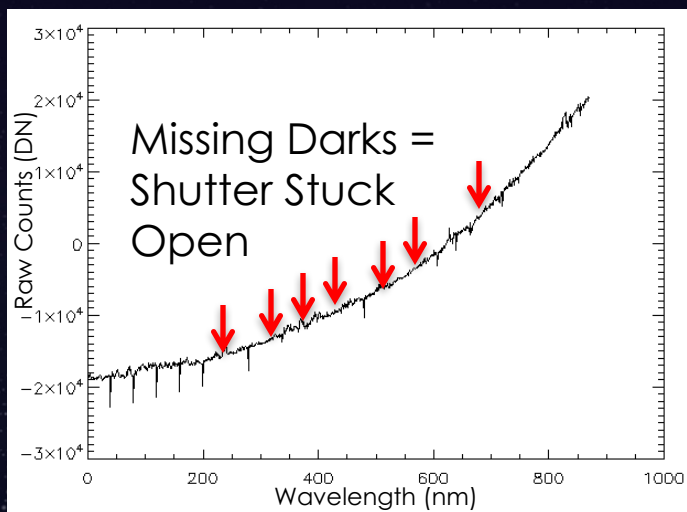
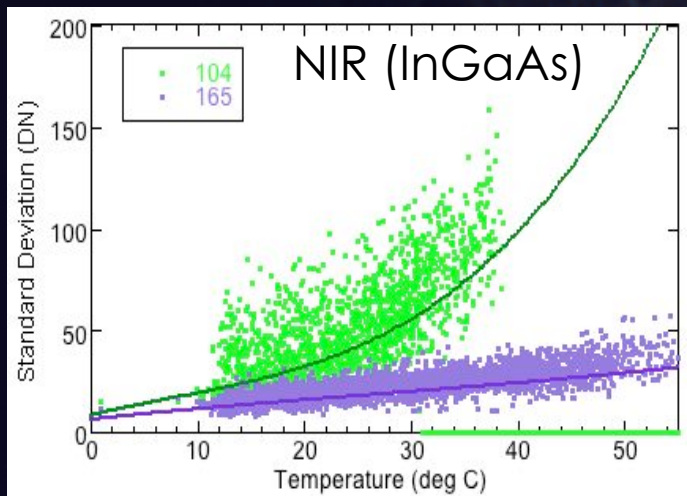
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High Temperature Issues



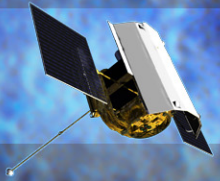
1. Saturation and increased noise in NIR
Some pixels were more sensitive to thermal noise than others. Spectra with saturated pixels are included in CDR and DDR PDS archived data.
2. 'Sticking' of the shutter mechanism (affects both VIS and NIR)
When the instrument got very hot, the shutter could stick in closed or open position, resulting in 'dark' observations used to perform background subtraction being light (or observations where shutter was supposed to be open being taken with the shutter stuck closed), and thus the radiance (light – light or dark – dark) being excessively low, or a total dark subtraction failure. Observations with stuck shutter were not processed from CDR to DDR.



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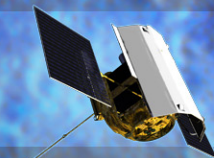
MASCS/VIRS Data Record Structures EDRs, CDRs, DDRs, DAP



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Experimental Data Records (EDRs)

- Experimental Data Records contain the raw data and spectrum metadata.
- Important information for filtering or checking the quality of the data, including the raw spectrum data is passed through to Calibrated Data Records (CDR) and also available there.
- Fields and number of bytes allocated to each field are described in the VIRS Software Interface Specification (SIS) available here from the PDS:
http://pds-geosciences.wustl.edu/messenger/mess-e_v_h-mascs-2-virs-edr-v1/messmas_1001/document/virsedrsis.pdf
- Important metadata includes: Dark Frequency, instrument temperature, integration time, gain, lamp on, binning, start and end pixel, spectrum number, spectrum mission elapsed time (MET). All of these are passed through to the CDRs.

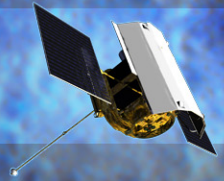
22 June 2011



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Calibrated Data Records (CDRs)

- Calibrated Data Records contain instrument status information necessary to filter and validate data quality
- UTC time translated from spacecraft time
- Spectra included (one row per spectrum):
 - Raw Spectrum – direct from EDR, uncompressed raw spectrum as 16-bit DN.
 - Corrected Counts – corrected for dark current and other instrument level corrections (DN/sec)
 - Calibrated Radiance – derived radiance at sensor ($\text{W m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$).
 - Noise Spectrum – estimated noise (in DN) based on noise measured during shuttered darks as a function of temperature plus shot noise.
 - Channel Wavelengths – wavelengths for each detector element
- Spice derived geometry information (lat, lon, viewing geometry, slant range, subspacecraft lat/lon, footprint size, etc.)
- Data Quality Index (described on next slide)
- CDR SIS at PDS:

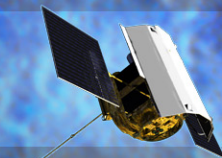
http://pds-geosciences.wustl.edu/messenger/mess-e_v_h-mascs-3-virs-cdr-caldata-v1/messmas_2001/document/virs_cdr_ddr_dap_sis.pdf



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Data Quality Index (in CDRs and DDRs)

19 character index of data quality. Each digit signifies quality factor of measurements.

Format: ABCD-EFGH-IJKL-MNOP

A: Dark Scan Flag, denotes shutter commanded closed for dark observation: 0 = shutter not engaged; 1 = shutter engaged.

B, C, D: Temperature 1,2, Grating Flags:

0 = Temperature does not exceed 15° C threshold

1 = Temperature exceeds 15° C threshold but less than 25° C threshold.

2 = Temperature exceeds 25° C threshold but less than 40° C threshold

3 = Temperature exceeds 40° C threshold.

E: Anomalous Pixels: Integer 0-9 = Indicates number of hot pixels found (the number of pixels with a noise spike (defined in DQI L, below).

F: Partial Data Flag: 0 = No partial data; 1 = Partial data exists.

G: Saturation Flag: 0 = No pixels saturated; 1 = Saturated pixels exist.

H: Low Signal Level Flag: 0 = Signal level not below -32768 threshold; 1 = Signal level below -32768 threshold.

I: Low VIS Wavelength Uncertainty Flag (not yet implemented, set to 0)

J: High VIS Wavelength Uncertainty Flag (not yet implemented, set to 0)

K: UVVS Operating Flag: 0 = UVVS is not scanning during readout; 1 = UVVS is scanning during readout.

L: UVVS Noise Spike Flag: 0 = No noise spike detected; 1 = Noise spike detected (A noise spike is a data value in 1 or 2 channels that exceeds 3 standard deviations of the average for a given channel in a given observation).

M: SPICE Version Epoch: Indicates what SPICE is used to determine pointing fields in CDR. 'Predict' SPICE may change one or more times before settling on 'Final' pointing solutions about 2 weeks from data acquisition.

0 = No SPICE

1 = Predict

2 = Actual

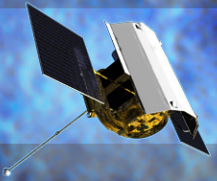
N-P: Spares



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Derived Data Records (DDRs)

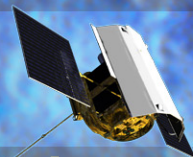
- Temperatures, dark frequency, integration time, spacecraft time from EDR; UTC, Data Quality Index, Spice derived geometry from CDR
- Spectra included (one row per spectrum):
 - IoF Spectrum – reflectance at sensor (radiance at sensor divided by solar irradiance) no correction for viewing geometry)
 - Photom IoF Spectrum (**V1**) – reflectance at sensor normalized to a viewing geometry of 45,45, 90 using a simple rough sphere assumption (see slide 7 and Izenberg et al., 2014)
 - Photom IoF Spectrum (**V2**) – reflectance at sensor normalized to a viewing geometry of 45,45, 90 using the KS photometric model (see slide 8)
 - IoF Noise Spectrum – noise spectrum propagated through to reflectance units
 - Photom IoF Noise Spectrum – noise spectrum propagated through to normalized reflectance units
 - Channel Wavelengths – wavelengths for each detector element



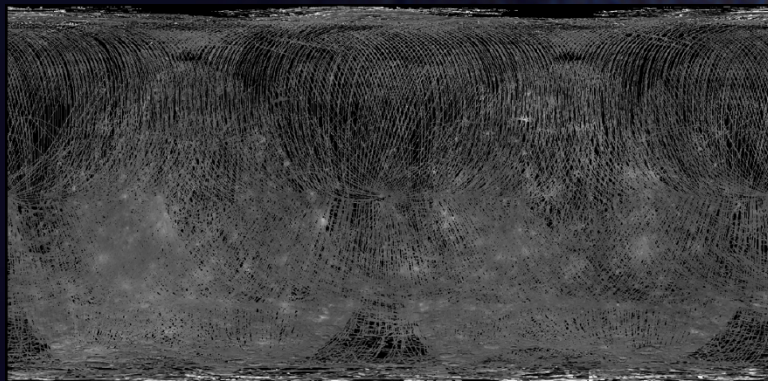
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Derived Analysis Product (DAP)



Mosaic

Interpolated
mosaic



The VIRS DAP is a map product of Mercury using 750 nm reflectance data from VIRS. The DAP is a series of nine map layers, each its own image (in .img format at PDS). The 500m per pixel layers :

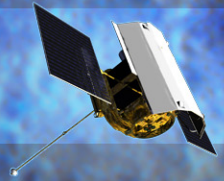
1. An image file containing the mosaic of MASCS/VIRS reflectance @750nm, taken from the DDRs
2. An image file containing the interpolated mosaic of MASCS/VIRS reflectance @750nm, where the gaps between individual footprints are filled in
3. An image file containing the incidence angle of MASCS/VIRS observations used in mosaic at the location of each footprint
4. An image file containing the emission angle of MASCS/VIRS observations used in mosaic at the location of each footprint
5. An image file containing the phase angle of MASCS/VIRS observations used in mosaic at the location of each footprint
6. An image file containing the area of MASCS/VIRS observations used in mosaic,
7. An image file containing the CDR Date of MASCS/VIRS observations used in mosaic,
8. An image file containing the CDR Time of MASCS/VIRS observations used in mosaic
9. An image file containing the spectrum number of MASCS/VIRS observations used in mosaic.¹⁶



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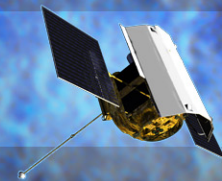
The MESSENGER Website and Tools MASCS/VIRS Data Access Using Quick Map



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MESSENGER Website: <http://messenger.jhuapl.edu>



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UNLOCKING THE MYSTERIES OF PLANET MERCURY

TOP 10 SCIENCE RESULTS AND TECHNOLOGY INNOVATIONS

After more than 10 years in operation, the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft impacted the surface of Mercury on April 30, 2015, at a speed of more than 3.91 kilometers per second (8,750 miles per hour), marking the end of operations for the hugely successful Mercury orbiter. At the *MESSENGER Nears End of Operations* media and public event, scientists and engineers discussed the mission's accomplishments, providing the top 10 scientific discoveries, as well as the technological innovations that grew out of the mission.

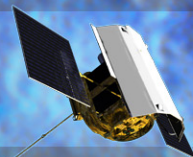




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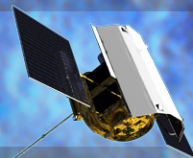




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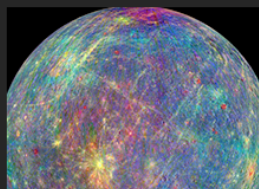
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EXPLORE

Explore maps, videos, images, and more that reveal Mercury's secrets and the discoveries of the MESSENGER mission



Images from MESSENGER

View images and other data acquired by MESSENGER and learn about the science they taught us about Mercury.

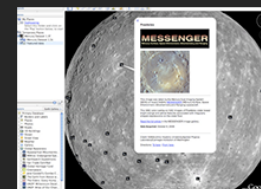
[Highlights Collection](#) | [Global Mosaics](#) | [Featured Image Database](#)



Multimedia

Watch videos, browse photos, and listen to podcasts!

[Videos](#) | [Graphics](#) | [Podcasts](#) | [Poetry and Music](#)



Interactive Maps

Explore Mercury your way, using interactive tools to visualize the MESSENGER datasets.

[Mercury on Google Earth](#) | [Quick Map Orbital Data](#)

Select "Quick Map
Orbital Data"

LEARN

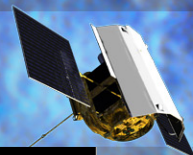




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Explore / Interactive Maps

QUICK MAP ORBITAL DATA

A simple, interactive Web interface for Mercury maps.

ACT-REACT Quick Map allows users to:

- Locate craters and other named Mercury features.
- Explore global mosaics and mini-mosaics of targeted regions. The global mosaics currently include a subset of images acquired during MESSENGER orbital operations and are updated when the corresponding map products delivered to the Planetary Data System (PDS) are updated. Global mosaics are available for download.
- Explore Mercury topography with elevation profile and 3-D interactive tools.
- Locate orbital images within user-defined regions of interest (ROI) and download those images from PDS. Also access spectra and observation meta-data.

[ACCESS QUICK MAP ▸](#)

[View Tutorial \(PDF\)](#)

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[Contact Us](#)

For Science Team Members (password required)

Starting Quick Map
and Accessing Tutorial

MESSENGER > Explore > Quick Map-Orbital-Data

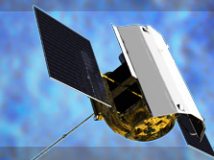




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VIRS-critical Quick Map Tutorial Pages

Direct link to tutorial pages:

https://messenger-act.actgate.com/msgr_public_released/act_docs/qmap.pdf

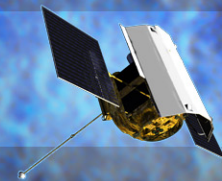
- P1-7 Intro and Controls
- P10 VIRS Global Mosaics
- P19-20 Probe tool & accessing spectra
 - Spectral Retrieval and Area Spectra are next steps



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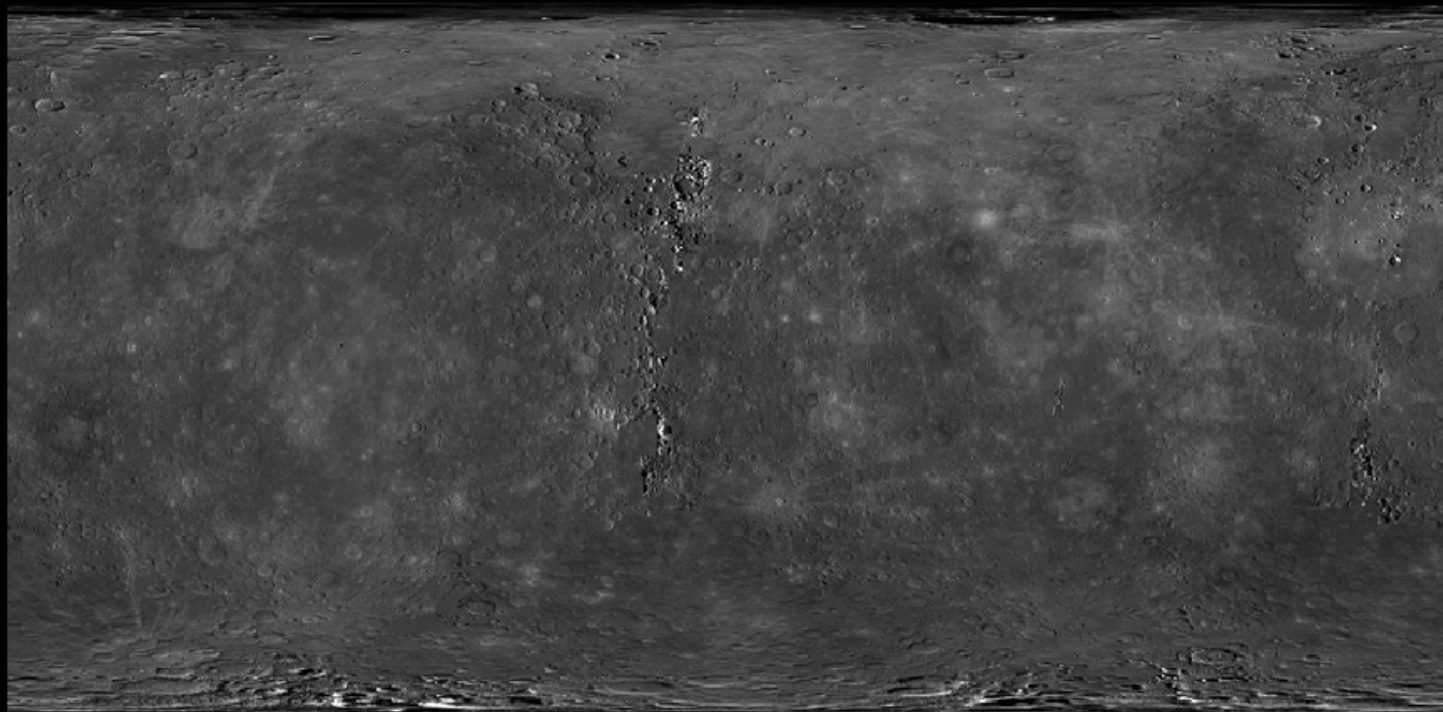
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Global Overview I

Mercury Layers

- ▼ Instrument Footprints
 - ☐ MDIS Color Coverage (total) ▶
 - ☐ MDIS Mono Coverage (total) ▶
 - ☐ MDIS Color Coverage (recent) ▶
 - ☐ MDIS Mono Coverage (recent) ▶
 - ☐ MASCS/VIRS Coverage ▶
 - ☐ XRS Coverage density ▶
 - ☐ NS Coverage density ▶
 - ☐ GRS Coverage density ▶
 - ☐ MLA Tracks ▶
- ▶ Location Overlays
- ▶ GRS Composition Maps
- ▶ Special Products
- ▶ Terrain Elevation
- ▼ MASCS/VIRS Global Mosaic
 - ☐ 750nm Mosaic (DAP PDS11) ▶
 - ☐ 750nm Mosaic Interpolated (DAP PDS11) ▶
 - ☐ Color Mosaic ▶
 - ☐ Color Mosaic Interpolated ▶
- ▼ MDIS Global Mosaic Campaigns
 - ☐ Multispectral (MDR updated) ▶
 - ☐ Multispectral 750nm (MDR updated) ▶
 - ☐ Multispectral 1000nm (MDR updated) ▶
 - ☐ Monochrome (BDR PDS9) ▶
 - ☒ Complete Monochrome ▶



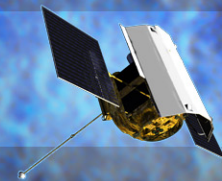
- MDIS basemap



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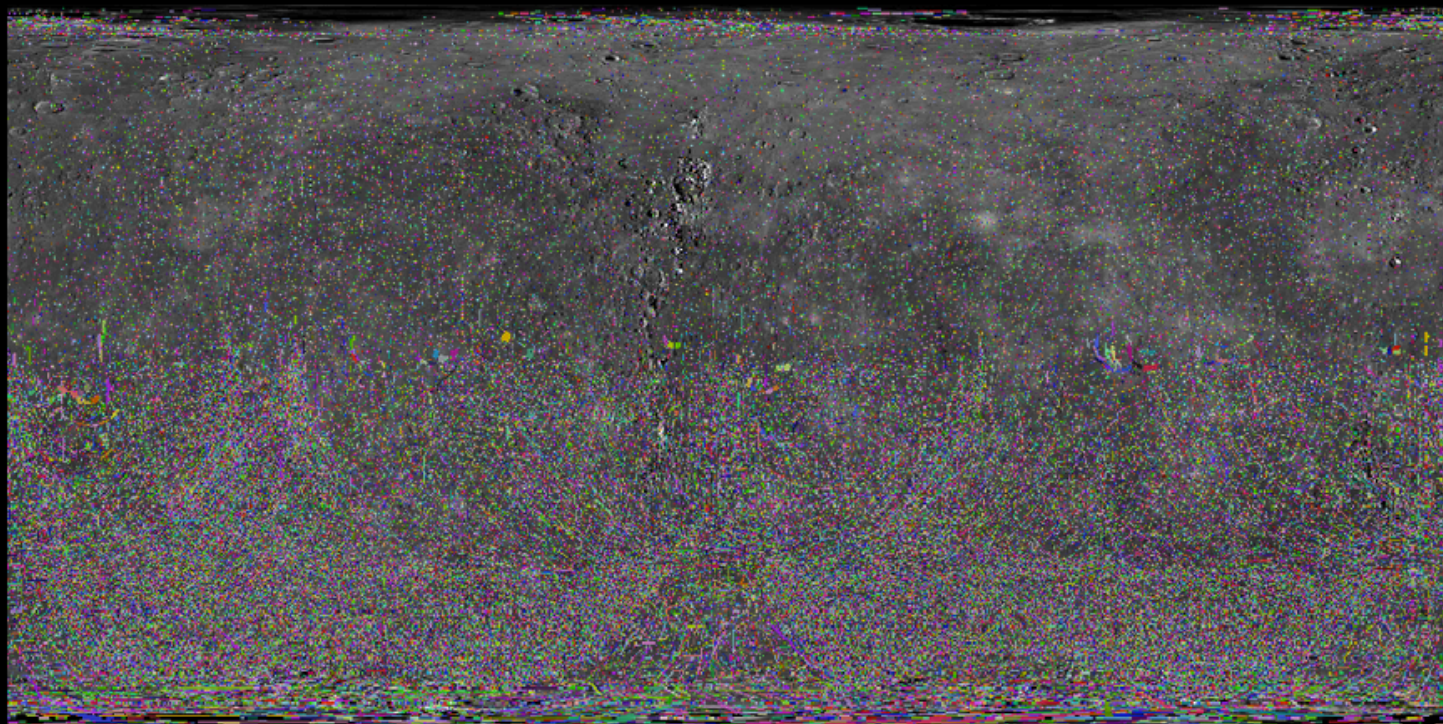
MERcury Surface, Space ENVIRONMENT, GEOchemistry, and Ranging



Global Overview II

Mercury Layers

- Instrument Footprints
 - ☐ MDIS Color Coverage (total)
 - ☐ MDIS Mono Coverage (total)
 - ☐ MDIS Color Coverage (recent)
 - ☐ MDIS Mono Coverage (recent)
 - ☒ MASCS/VIRS Coverage
 - ☐ XRS Coverage density
 - ☐ NS Coverage density
 - ☐ GRS Coverage density
 - ☐ MLA Tracks
- Location Overlays
 - GRS Composition Maps
 - Special Products
 - Terrain Elevation
- MASCS/VIRS Global Mosaic
 - ☐ 750nm Mosaic (DAP PDS11)
 - ☐ 750nm Mosaic Interpolated (DAP PDS11)
 - ☐ Color Mosaic
 - ☐ Color Mosaic Interpolated
- MDIS Global Mosaic Campaigns
 - ☐ Multispectral (MDR updated)
 - ☐ Multispectral 750nm (MDR updated)
 - ☐ Multispectral 1000nm (MDR updated)
 - ☐ Monochrome (BDR PDS9)
 - ☒ Complete Monochrome



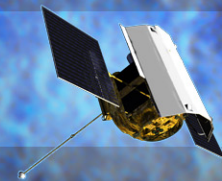
- VIRS Footprint map (All CDRs)



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Global Overview III

Mercury Layers

- Special Products
- Terrain Elevation
- MASCS/VIRS Global Mosaic
 - ☒ 750nm Mosaic

Info

Opacity: 100%

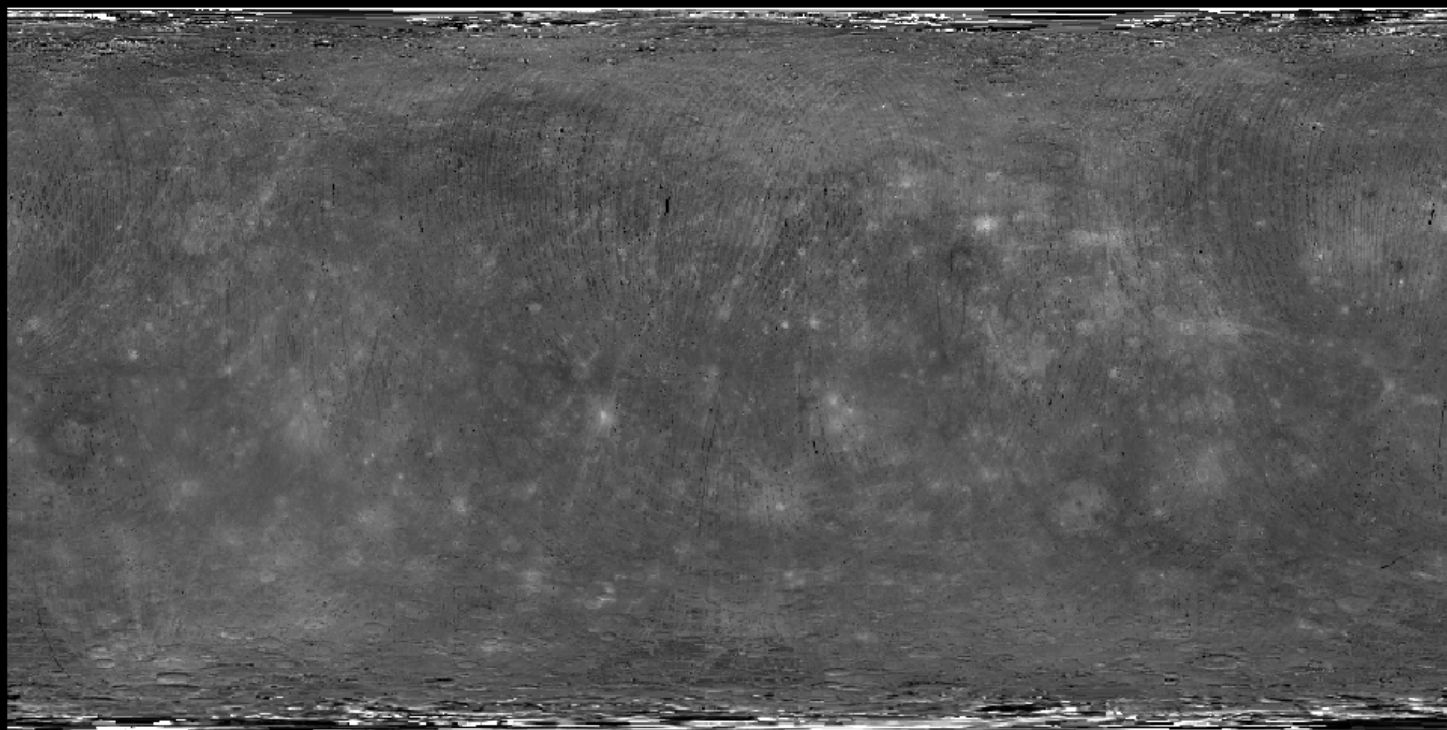
0.005 0.128 0.250
reflectance

Description:
MASCS/VIRS 750 nm Apparent Reflectance Mosaic - including MASCS/VIRS footprints collected after orbit insertion.
A metric defined as $M = \text{footprint_area} / (\cos(e) * \cos(i))$ is computed for each observation. Observations with the lowest metric value are stacked on top.
The observations accepted have $M > 0$, emission angle < 80 degrees and incidence angle < 70 degrees for footprints with latitude in $[-65, 65]$ or incidence angle $< \text{footprints latitude} + 5$ degrees for other footprints.

The grayscale image shows from black to white the 750 nm Reflectance between 0.005 and 0.25

Data provided by MESSENGER team

- ☐ 750nm Interpolated
- ☐ Color Mosaic
- ☐ Color Mosaic Interpolated
- MDIS Regional Targeted Mosaics
- MDIS Global Mosaic Campaigns
- 8-Color Global Map



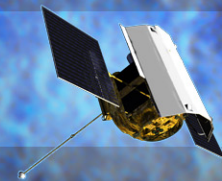
- VIRS 750nm Mosaic



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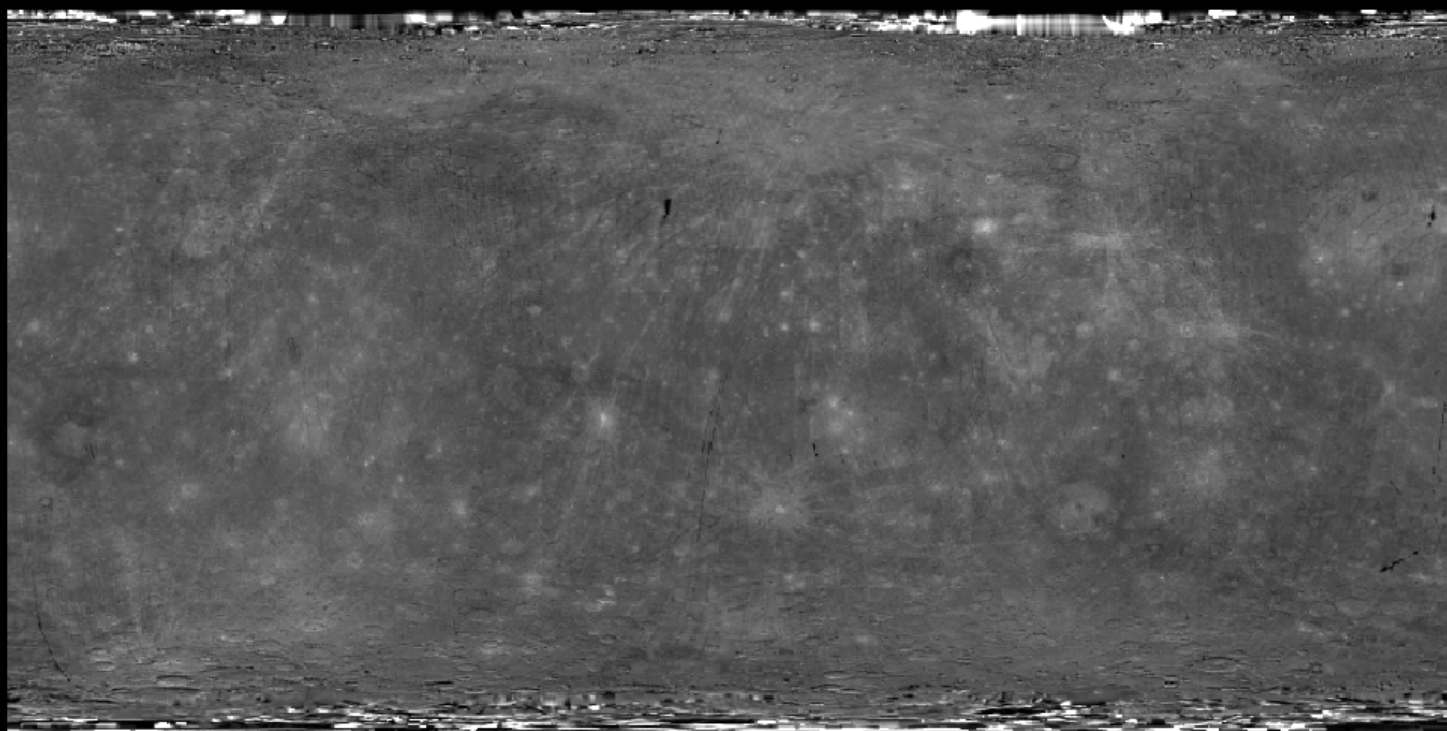
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Global Overview IV

Mercury Layers

- Models for 3D printing (NEW)
- Instrument Footprints
 - MDIS Color Coverage
 - MDIS Mono Coverage
 - MASCS/VIRS Coverage
 - XRS Coverage density
 - NS Coverage density
 - GRS Coverage density
 - MLA Tracks
- Location Overlays
 - Arecibo Radio Telescope
 - XRS composition maps
 - GRS Composition Maps
 - Special Products
 - Terrain Elevation
- MASCS/VIRS Global Mosaic
 - 750nm Mosaic
 - ☒ 750nm Interpolated
 - Color Mosaic
 - Color Mosaic Interpolated
- MDIS Regional Targeted Mosaics
- MDIS Global Mosaic Campaigns
 - 8-Color Global Map
 - 3-Color High-Resolution Northern



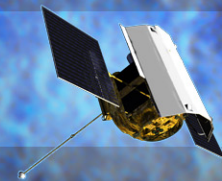
- VIRS 750nm Interpolated Mosaic



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Global Overview V

Mercury Layers

- Special Products
- Terrain Elevation
- MASCS/VIRS Global Mosaic
 - 750nm Mosaic
 - 750nm Interpolated
 - ☒ Color Mosaic

Info

Opacity: 100%

Description:
MASCS/VIRS Color Mosaic created combining Apparent Reflectance ratios:

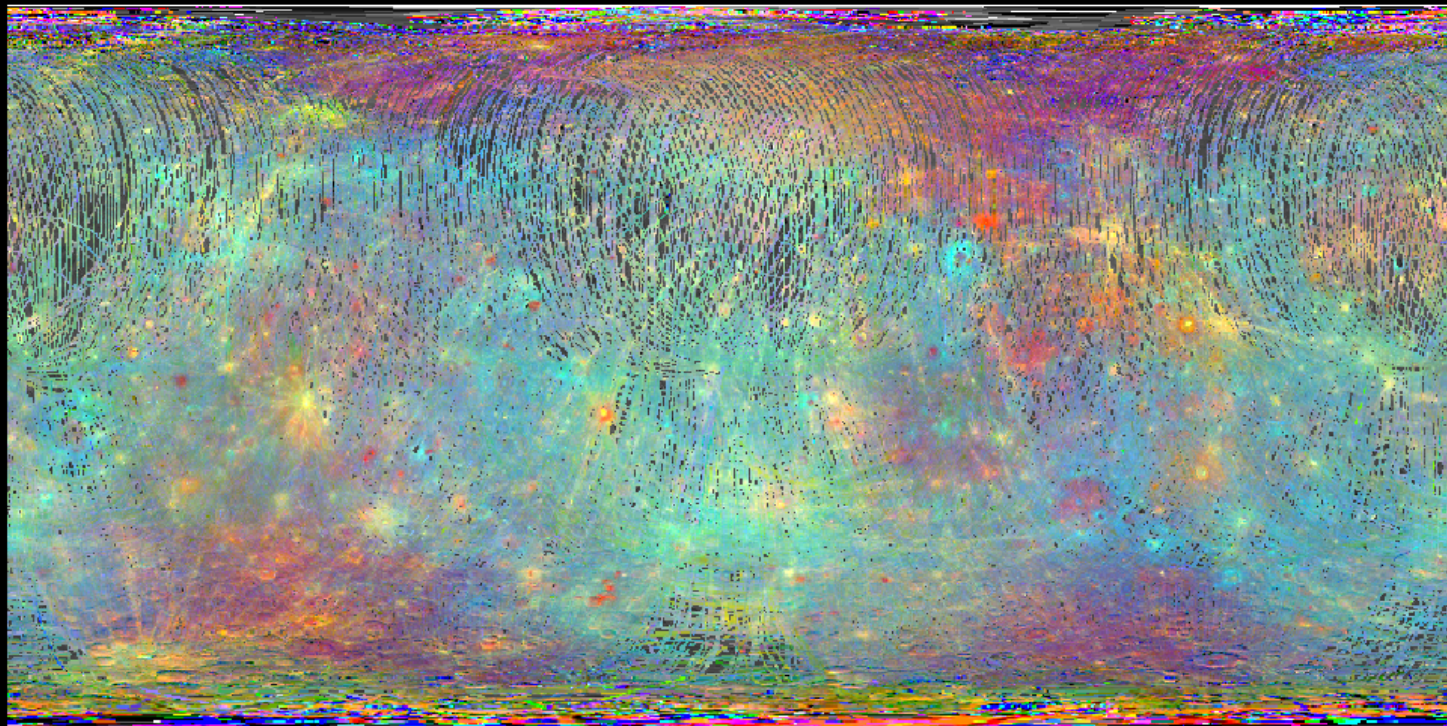
Red = 575 nm: stretch MIN = 0.03; MAX = 0.10
Green = 415 nm/750 nm: stretch MIN = 0.48; MAX = 0.65
Blue = 310 nm/390 nm: stretch MIN = 0.57; MAX = 0.71

MASCS/VIRS footprints collected after orbit insertion are used.
A metric defined as $M = \text{footprint_area} / (\cos(e) * \cos(i))$ is computed for each observation. Observations with the lowest metric value are stacked on top.
The observations accepted have $M > 0$, emission angle < 80 degrees and incidence angle < 70 degrees for footprints with latitude in [-65,65] or incidence angle < footprints latitude + 5 degrees for other footprints.

[N. R. Izenberg et al., 2014, Icarus 228, 364-374](#)

Data provided by MESSENGER team

- Color Mosaic Interpolated
- MDIS Regional Targeted Mosaic



• VIRS Color Mosaic

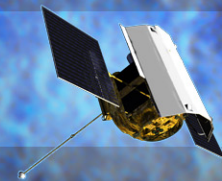
- Red = 575nm Reflectance
- Green = 415 nm / 750 nm
- Blue = 310 nm / 390 nm



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Global Overview VI

Mercury Layers

- Special Products
- Terrain Elevation
- MASCS/VIRS Global Mosaic
 - 750nm Mosaic
 - 750nm Interpolated
 - Color Mosaic
 - ☒ Color Mosaic Interpolated

Info

Opacity:
100%

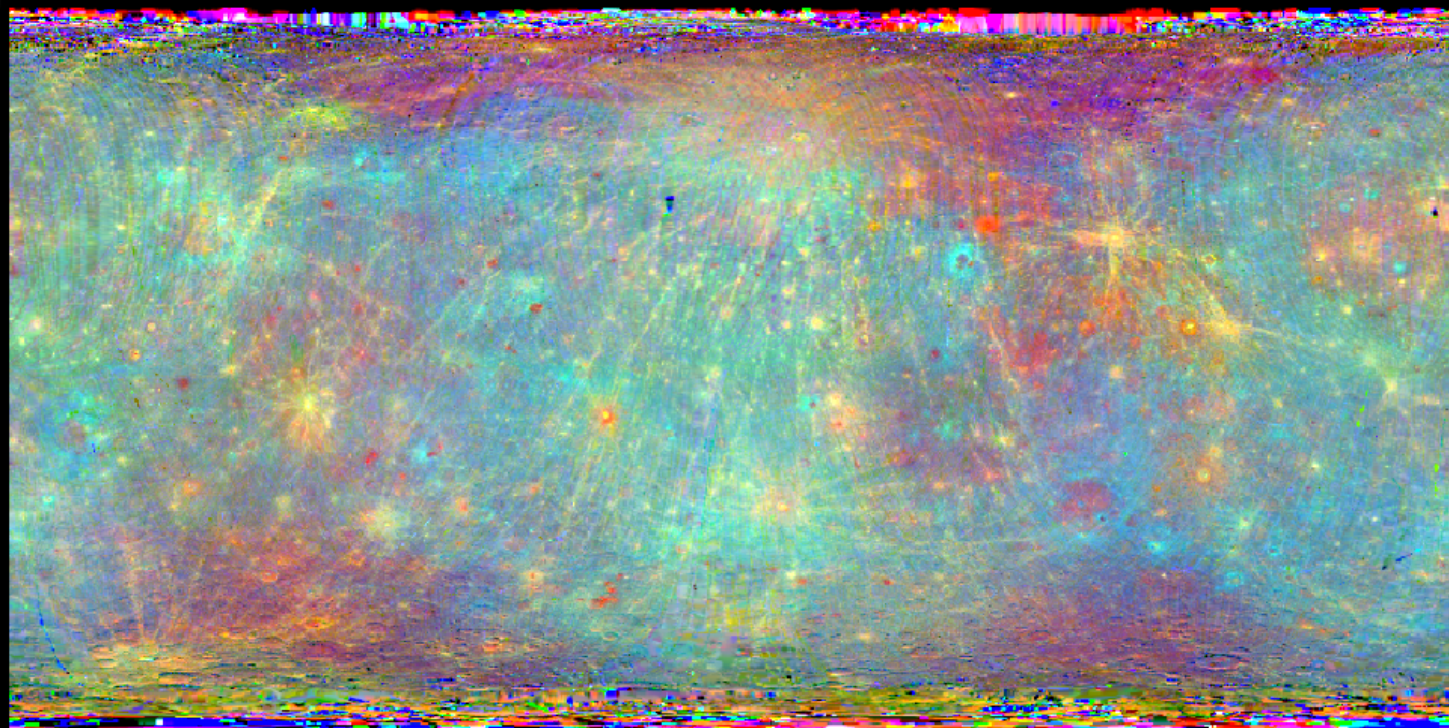
Description:
MASCS/VIRS Interpolated Color Mosaic created combining Apparent Reflectance ratios interpolated (inverse distance weighting)

Red = 575 nm: stretch MIN = 0.03; MAX = 0.10
Green = 415 nm/750 nm: stretch MIN = 0.48; MAX = 0.65
Blue = 310 nm/390 nm: stretch MIN = 0.57; MAX = 0.71

[N. R. Izenberg et al., 2014, Icarus 228. 364-374](#)

Data provided by MESSENGER team

- MDIS Regional Targeted Mosaics
- MDIS Global Mosaic Campaigns
 - 8-Color Global Map
 - 3-Color High-Resolution Northern Hemisphere Map
 - 5-Color High-Resolution North Polar



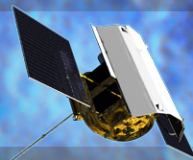
- VIRS Interpolated Color Mosaic



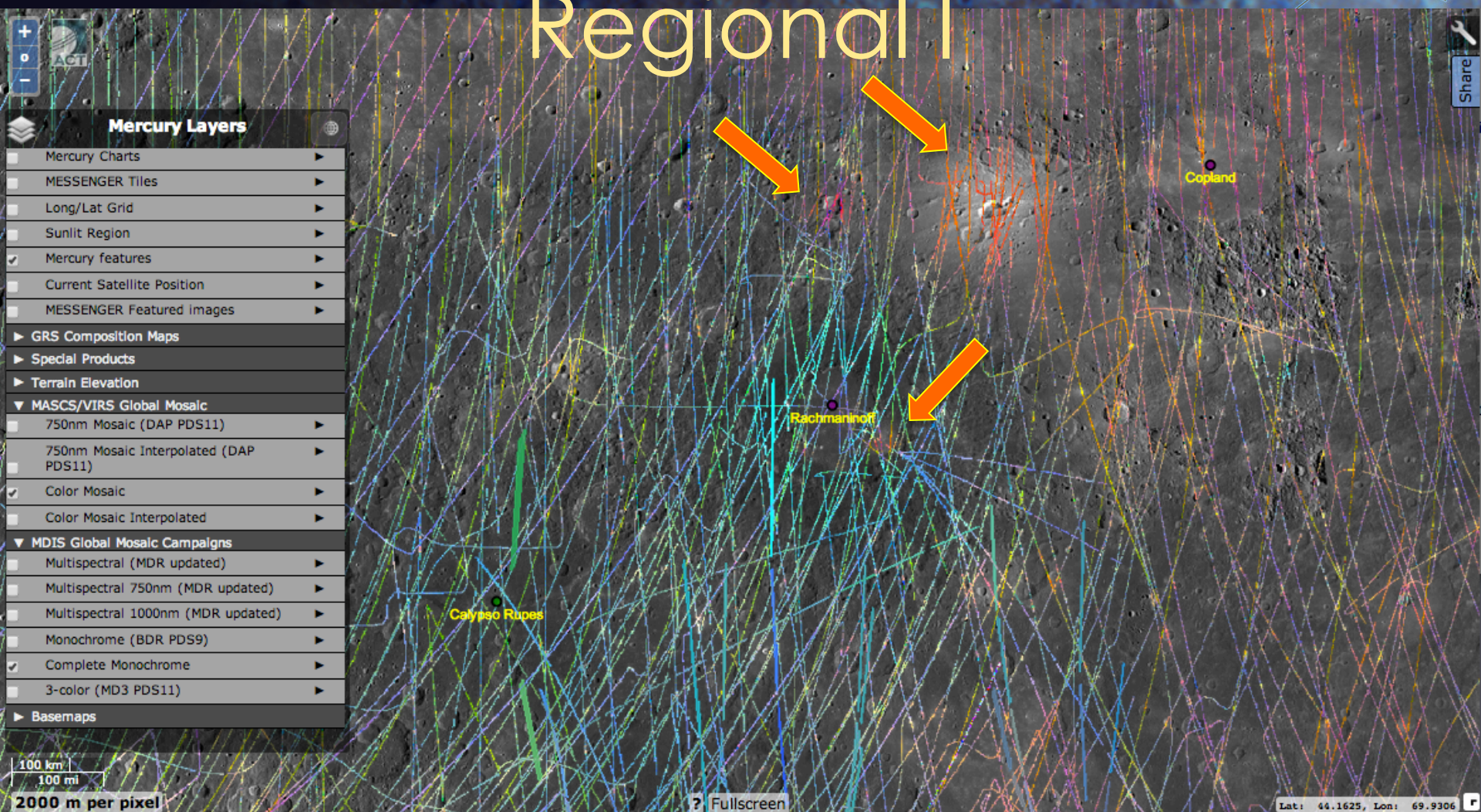
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Regional I



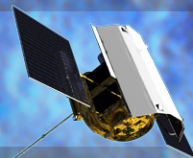
- Regional zoom with VIRS color mosaic on MDIS base map. Prominent named features are labelled. VIRS colors show areas of interest with different spectral properties.



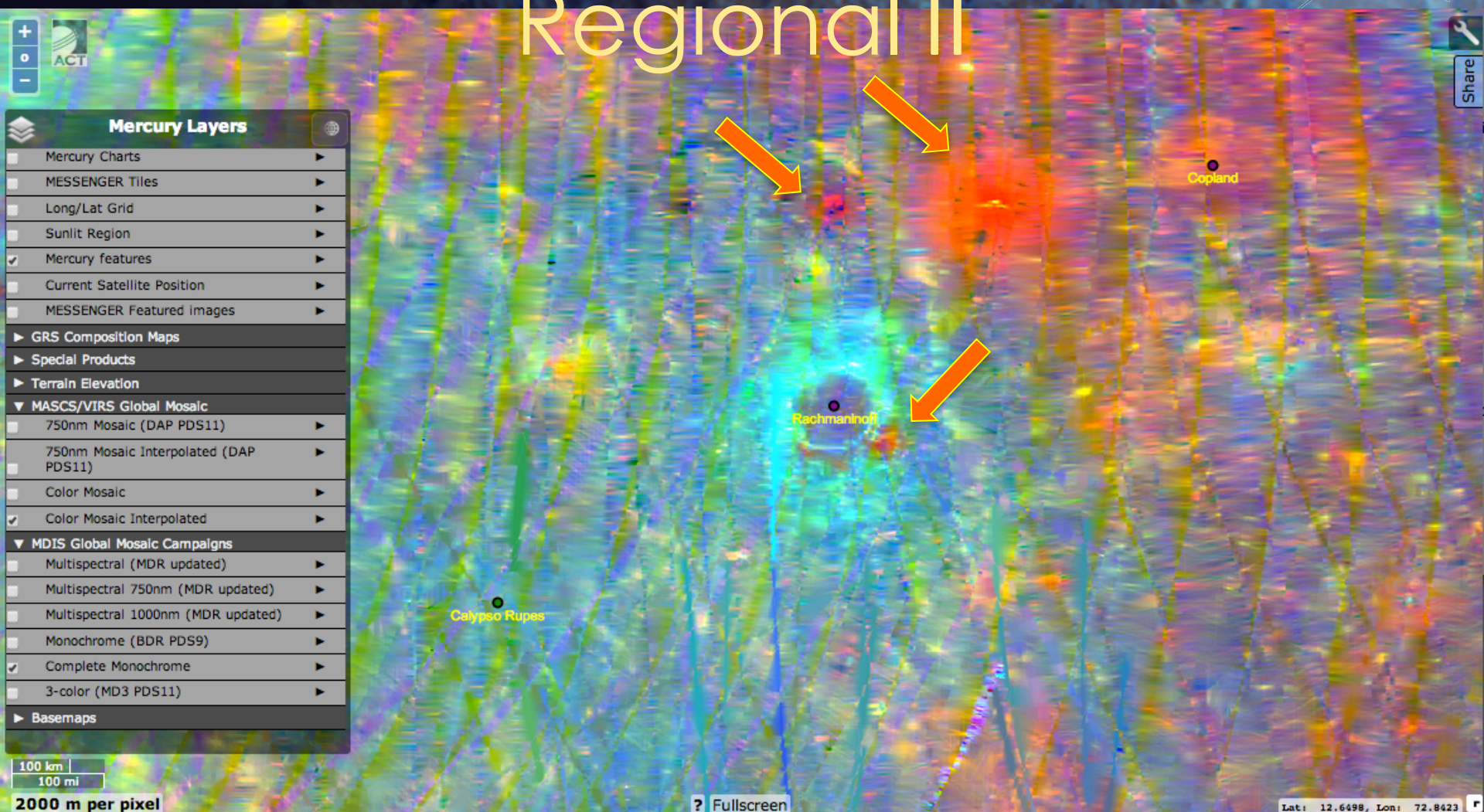
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Regional II



- VIRS Interpolated Color Mosaic can emphasize spectral differences.

Share

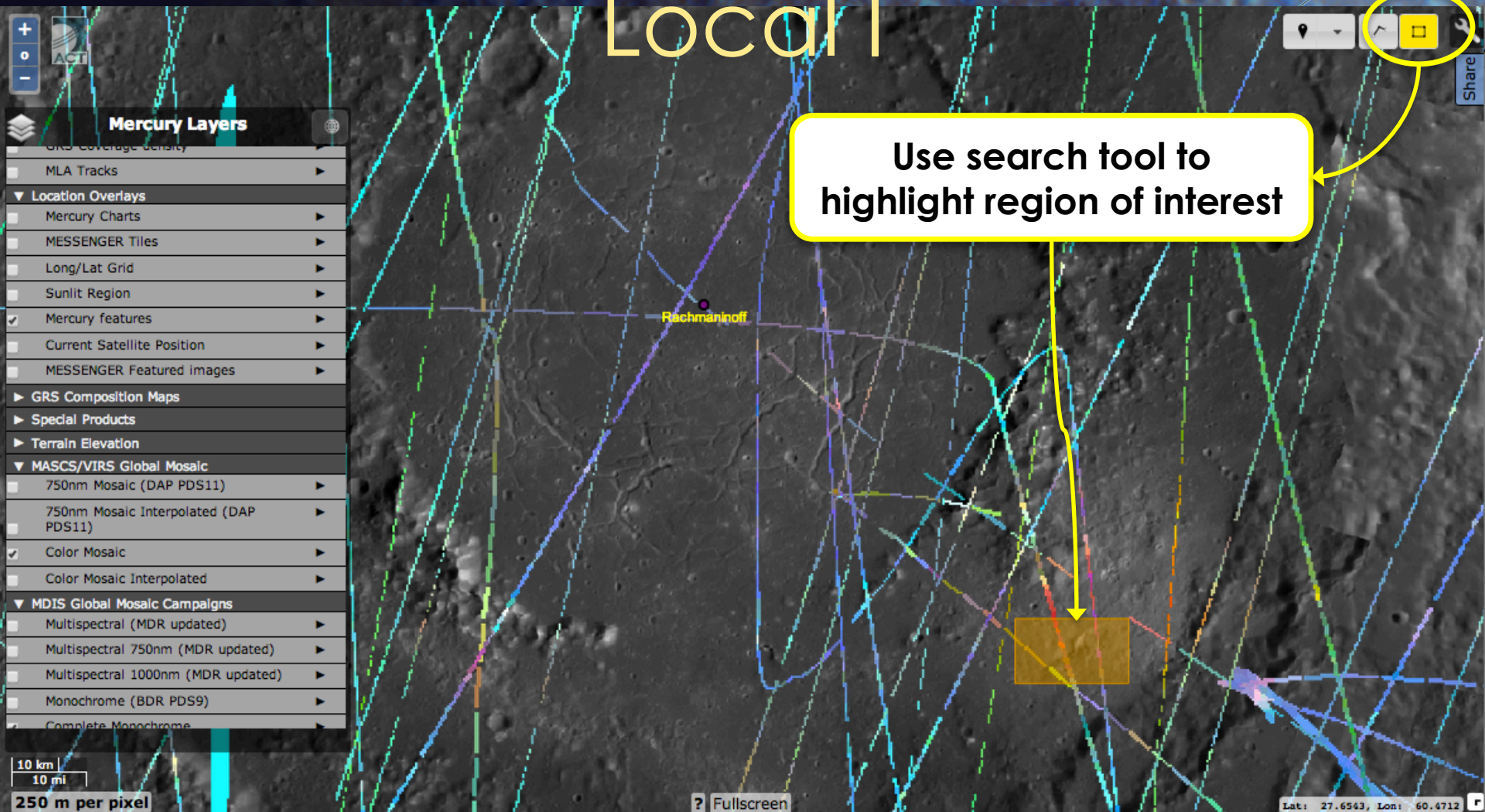
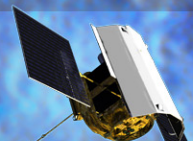




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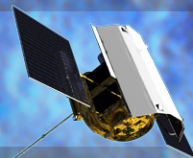
- Getting at individual spectra, Method A: Region of Interest (ROI)



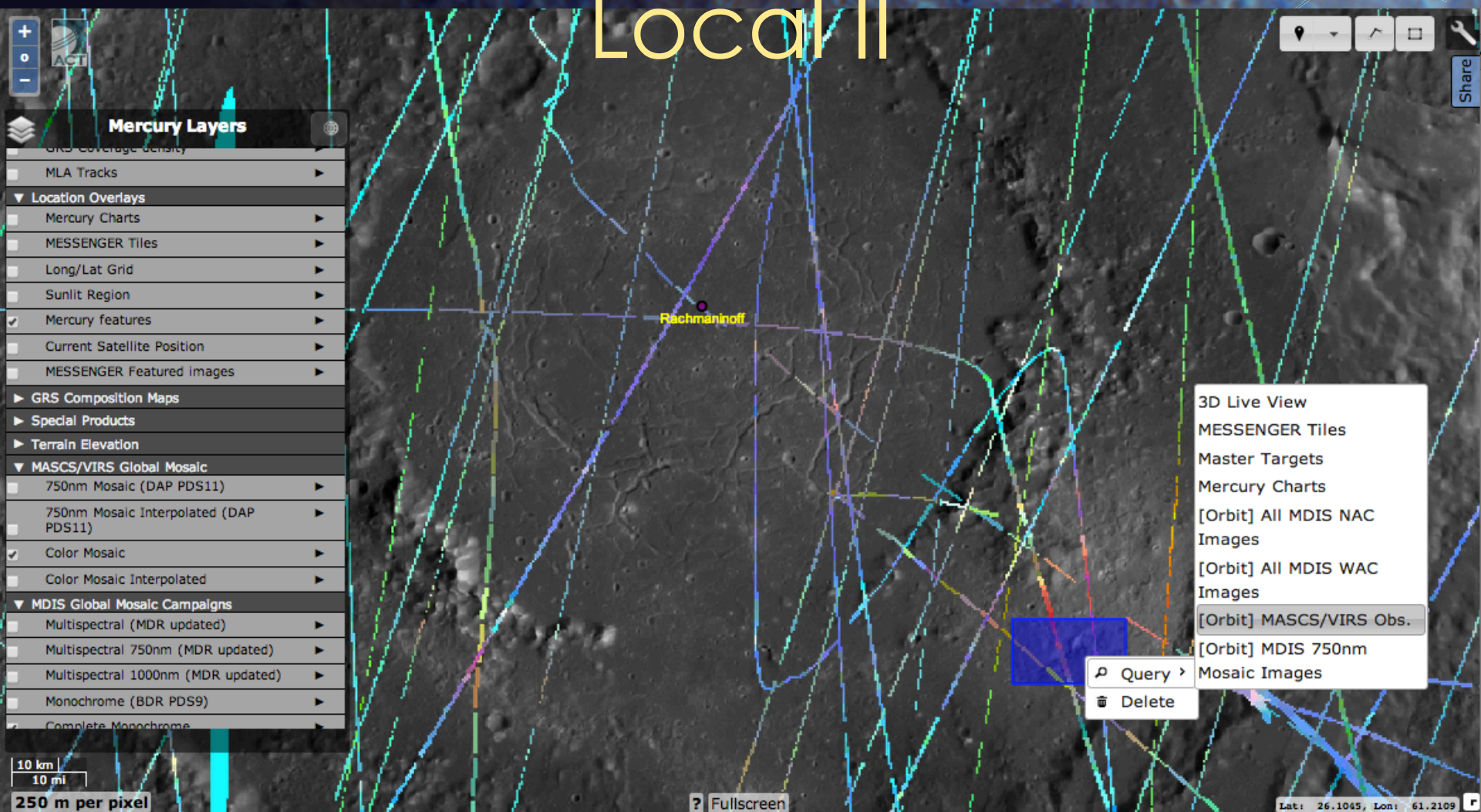
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Local II



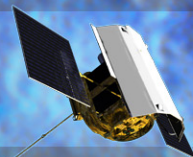
- Method A: Selecting VIRS spectra in ROI



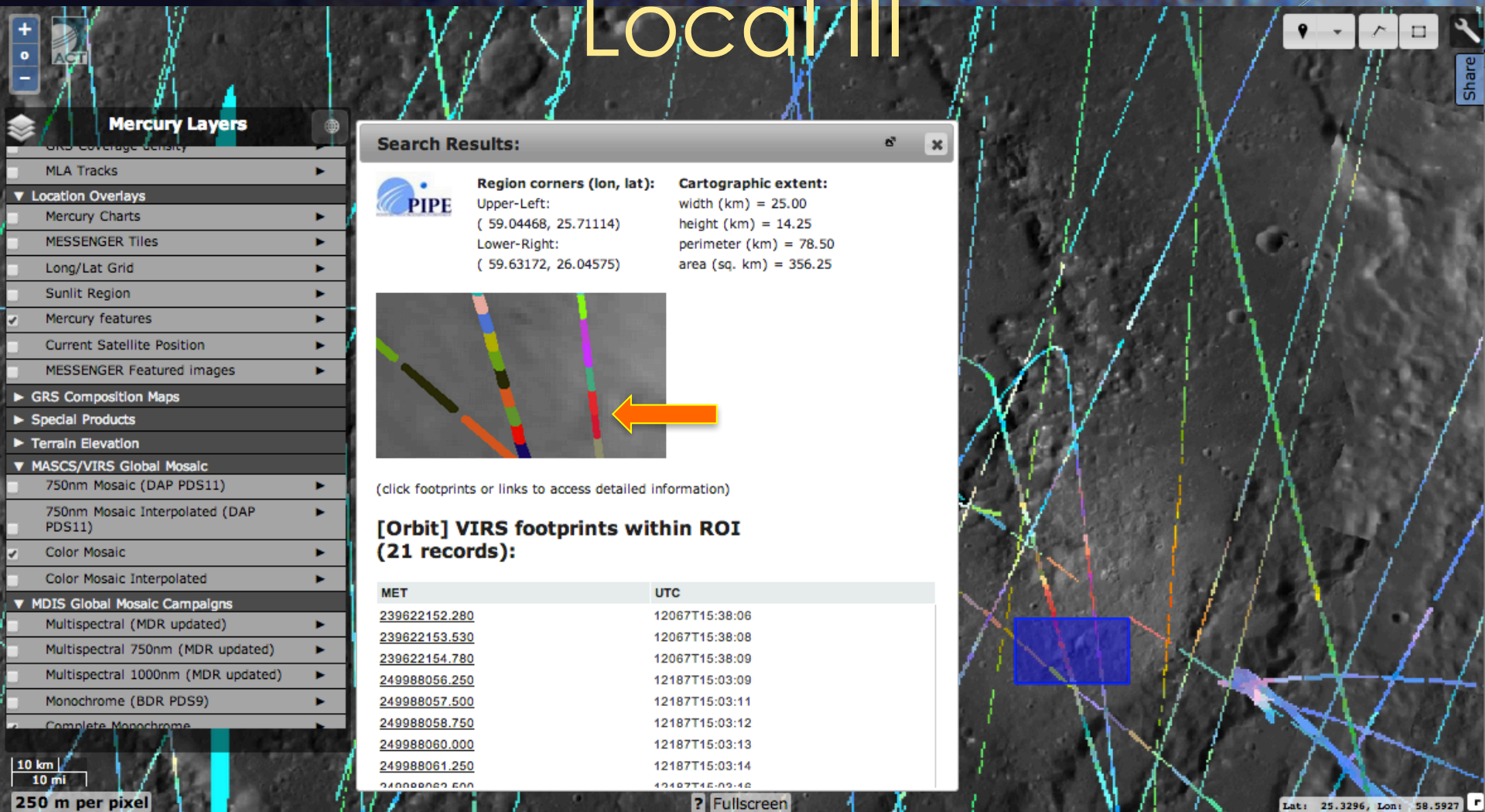
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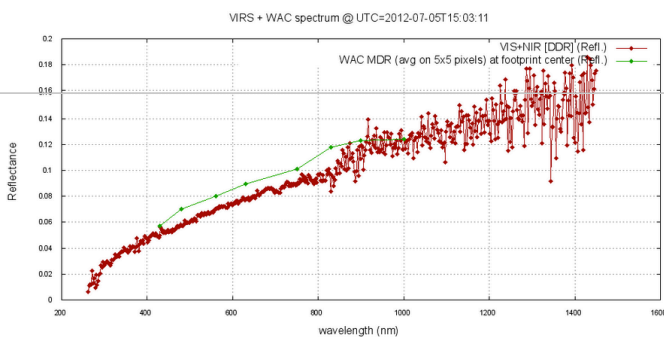
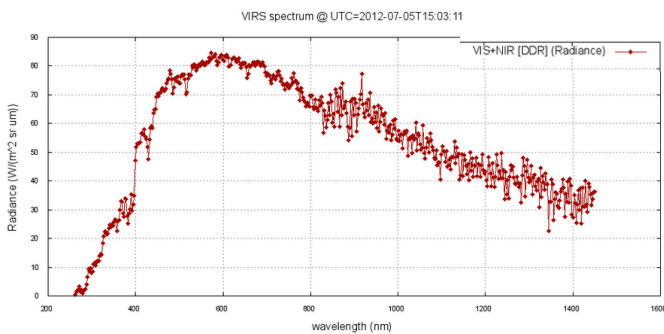
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Local III



- Method A: Individual Spectra are selectable from pop-up window. Clicking on one of the spectra will open new page (next slide)



inspect the plotted values as: CSV

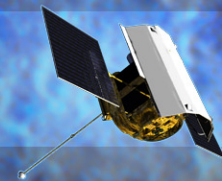
st	394772658.60967654000000
met	1/249988057:500000
time	1.0000000000000000
SC2TPerD	3854.90091433999990
SubSCLAT	27.78791953000000
SubSCLON	50.98660735000000
NADIR_ALI	1415.63477723999990
SubSolLAT	-0.01866909000000
SubSolON	112.20158542000000
FOV_0	0
BS_pLon0	59.48971428000001
BS_pLat0	25.77633301999999
BS_pEmi0	20.89589192000000
BS_pInc0	56.94959645000001
BS_pPha0	77.83860387000000
SUN2grm0	68922493.24486605800000
BS_twist0	-1.90312889000000
sc2BSdist0	1476.40671200000000
IJOVtrack	0.59263236000000
IJOVstrack	0.63431436000000
a-smear	1.64835958000000
x-smear	0.00093520000000
a-azimuth	-6.07395487000000
BLatStart	25.79558860999999
BLonStart	59.48742733000003
BLatEnd	25.75709939000000
BLonEnd	59.49197624000000
BS_pEmiAvg	20.895895486000001
BS_pIncAvg	56.949596201999995
BS_pPhaAvg	77.838603957999993
area	1.288463771772661
SPENUM	864

BS_pEmiAvg	20.895895486000001
BS_pIncAvg	56.949596201999995
BS_pPhaAvg	77.838603957999993
area	1.288463771772661
SPENUM	864
SPEMET	249988057.500000000000000
SPEUTC	12187T15:03:11
BIN	1
DARK	0
VIS310	11.262000100000000
VIS390	32.771000899999997
VIS415	56.489500000000000
VIS575	83.750499700000006
VIS750	72.794002500000005
NIR950	62.208999599999999
CDRFILE	VIRSV_C_OB2_12187_144509.DAT
VIS_TEMP	9.266000000000000
NIR_TEMP	11.641999999999999
VIS750_RFL	0.089721700000000
CDRDate	12187
CDRTIME	144509
mdr_metric	2.528843069000000

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Environment, GEOchemistry, and Ranging

Local IV



Method A: Individual Spectra view

- Radiance, reflectance plots
- CDR/DDR source
- CSV Downlink (wavelength, radiance, reflectance data)
- Viewing Geometry
- Spectrum, time
- Source file name
- Detector temps

et (s)
Ephemeris time at start of integration time

met
Mission elapsed time at start of integration time.
Format: <partition_number>/<met_seconds>:<met_microseconds>

tint(s)
Integration Time used as sensor observation duration.

SC2TPctrD(Km)
Space-craft to Target Planet center distance.

SubSCLAT
Derived subspacecraft latitude on planet surface.

SubSCLON
Derived subspacecraft longitude on planet surface.

NADIR_ALT(Km)
Derived spacecraft altitude above nadir point in meters.

SubSolLAT(deg)
Derived subsolar latitude on planet surface.

SubSolLOW(deg)
Derived subsolar longitude on planet surface.

FOV [i-th](int)
0. This number will match the ith vector in the bore-sight list.
Index 0 corresponds to the center of the field of view.

BS_pLon[i-th](deg)
Derived longitude and latitude of [i-th] boresight intercept point, on planet corresponding to observation.

BS_pLat[i-th](deg)
Derived longitude and latitude of [i-th] boresight intercept point, on planet corresponding to observation.

BS_pEmi[i-th](deg)
Derived emission angle of [i-th] boresight intercept point.

SUN2grnd[i-th](Km)
Derived subsolar distance to [i-th] boresight intercept point on planet

BS_twist[i-th](deg)
Twist angle.

sc2BSdist[i-th](Km)
Derived slant range from s/c to [i-th] boresight intercept point in Km (equal to s/c NADIR_ALTITUDE in nadir pointing case).

IFOVatrack(deg)
Field of view along track.

IFOVxtrack(deg)
Field of view across track.

a-smear(Km)
Derived length of VIRS footprint along track over the integration time, accounting for smear across surface.

x-smear(Km)
Derived instantaneous width of VIRS footprint across track at the integration midpoint, accounting for jitter across surface.

a-azimuth(deg)
Derived angle of footprint smear relative to a N-S line.
0 is North, plus/minus 180 is South, sign denotes east (clockwise) or west rotation of azimuth from North.

BLatStart(deg)
Derived latitude of boresight ground intercept point, at the start of integration time.

BLonStart(deg)
Derived longitude of boresight ground intercept point, at the start of integration time.

BLatEnd(deg)
Derived latitude of boresight ground intercept point, at the end of integration time.

BLOHRA(deg)
Derived longitude of boresight ground intercept point, at the start of integration time.

BS_pEmiAvg(deg)
Average emission angle of boresight intercept points.

BS_pIncAvg(deg)
Average incidence angle of boresight intercept points.

BS_pPhaAvg(deg)
Average phase angle of boresight intercept points.

area(Km^2)
Estimated observation area on the ground.

SPENUM(int)
Ordered number sequence for spectra in a given observation.
First spectrum is 0, second is 1, third is 2, and so on.

SPEMET(s)
Mission elapsed time at start of integration time represented as a double.

SPEUTC(date)
UTC time in YYDOYTHH:MM:SS.00 at start of integration time.

BIN(int)
Number of pixels that were binned together in the data.

DARK(bool)
Dark Observation.
0 = No
1 = Yes

VIS310(W/(m^2 steradian micron))
Radiance at 310 nm (binned).

VIS390(W/(m^2 steradian micron))
Radiance at 390 nm (binned).

VIS415(W/(m^2 steradian micron))
Radiance at 415 nm (binned).

VIS575(W/(m^2 steradian micron))
Radiance at 575 nm (binned).

VIS750(W/(m^2 steradian micron))
Radiance at 750 nm (binned).

NIR950(W/(m^2 steradian micron))
Radiance at 950 nm (binned).

CDRFILE
CDR file the observation belongs to.

VIS_TEMP (degrees Celsius)
VIS temperature.

NIR_TEMP (degrees Celsius)
NIR temperature.

VIS750_RFL
Photometrically corrected reflectance at 750 nm (binned).

CDRDate(date)
Observation CDR date in the form YYDOY.

CDRDate(date)
Observation CDR time in the form HHMMSS.

mdr_metric
Observation metric, computed as footprint_area/(cos(e)*cos(i)).
Smaller values indicate better spectra values.



Local V

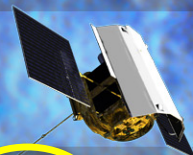
- Method A: Linked parameter descriptions from individual spectrum



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MErcury Surface, Space ENvironment, GEochemistry, and Ranging



Local VI

The screenshot displays the MESSENGER Local View interface. On the left is a sidebar menu titled 'Mercury Layers' with various options like 'MLA Tracks', 'Location Overlays', 'Mercury Charts', 'MESSENGER Tiles', 'Long/Lat Grid', 'Sunlit Region', 'Mercury features', 'Current Satellite Position', 'MESSENGER Featured Images', 'GRS Composition Maps', 'Special Products', 'Terrain Elevation', 'MASCS/VIRS Global Mosaic', and 'MDIS Global Mosaic Campaigns'. The main area shows a grayscale map of Mercury with colorful dashed lines representing spectral data. A yellow callout box with a white background and black text says: 'Use probe tool to target point of interest, then request Spectra Retriever for that point'. A yellow arrow points from this box to a red crosshair on the map. Another yellow arrow points from the crosshair to a 'Probes - Lat, Lon' window in the top right corner, which displays the coordinates '+26.12207, 58.28739'. Below this window is a 'Request' button. A third yellow arrow points from the 'Request' button to a 'MASCS/VIRS Spectra Retriever' window, which also contains the coordinates and a 'Request' button. The bottom left of the interface shows a scale bar for 10 km and 10 mi, and '250 m per pixel'. The bottom right shows the current latitude and longitude: 'Lat: 28.0476, Lon: 60.9702'. A 'Fullscreen' button is also visible at the bottom center.

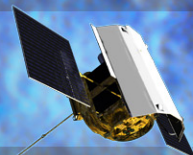
- Getting individual spectra Method B: MACS/VIRS Spectra Retriever



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Local VII

The screenshot displays the MESSENGER Local VII interface. On the left, a 'Mercury Layers' panel lists various data layers, including 'MLA Tracks', 'Location Overlays', 'Mercury Charts', 'MESSENGER Tiles', 'Long/Lat Grid', 'Sunlit Region', 'Mercury features', 'Current Satellite Position', 'MESSENGER Featured Images', 'GRS Composition Maps', 'Special Products', 'Terrain Elevation', 'MASCS/VIRS Global Mosaic', and 'MDIS Global Mosaic Campaigns'. A 'Query Results' pop-up window is centered, showing the 'PIPE' logo and a link to the 'MESSENGER MASCS/VIRS - QuickSpectra-Retriever'. The pop-up also displays a red crosshair at coordinates (58.28739, 26.12207) and a text box indicating 'Access VIRS spectra over [1x1] [3x3] [5x5] km^2 region'. A 'Request' button is visible next to the coordinates. The background is a grayscale map of Mercury with colorful dashed lines representing various data tracks. A scale bar at the bottom left indicates '10 km' and '10 mi', and a '250 m per pixel' resolution. A 'Fullscreen' button is at the bottom center, and a 'Share' button is at the bottom right.

Mercury Layers

- GRS Coverage density
- MLA Tracks
- Location Overlays
 - Mercury Charts
 - MESSENGER Tiles
 - Long/Lat Grid
 - Sunlit Region
 - Mercury features
 - Current Satellite Position
 - MESSENGER Featured Images
- GRS Composition Maps
- Special Products
- Terrain Elevation
- MASCS/VIRS Global Mosaic
 - 750nm Mosaic (DAP PDS11)
 - 750nm Mosaic Interpolated (DAP PDS11)
 - Color Mosaic
 - Color Mosaic Interpolated
- MDIS Global Mosaic Campaigns
 - Multispectral (MDR updated)
 - Multispectral 750nm (MDR updated)
 - Multispectral 1000nm (MDR updated)
 - Monochrome (BDR PDS9)
 - Complete Monochrome

Query Results

Links to MESSENGER MASCS/VIRS - QuickSpectra-Retriever

+ p1 at (58.28739, 26.12207):

Access VIRS spectra over [1x1] [3x3] [5x5] km² region

Request >

Probes - Lat,Lon

+ 26.12207, 58.28739

10 km
10 mi
250 m per pixel

Fullscreen

Lat: 26.7326, Lon: 60.8997

- In pop-up, select focus region. New page opens (next slide)

Specify the search region (depicted as yellow box below)

Current Projection: Equidistant Cylindrical

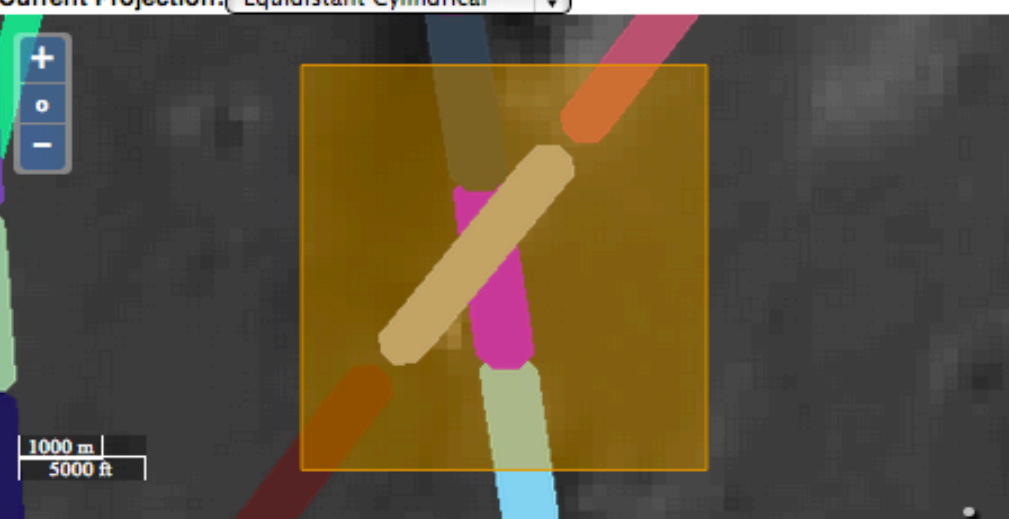
+

o

-

1000 m

5000 ft



Center

Latitude 26.12207 Longitude 58.28739

Size 5 sq. km

Match results:

☒ Any (any portion of the search region could be touched)

☐ All (the whole search region must be covered)

Reset

Submit

Note: For faster results limit search region to capture a small amount of obs

Local VIII

Zoom region at top of page, with postage-stamp views of every spectrum in the local area below.

FOUND 6 OBSERVATIONS with positive metric, ordered from best (lower value) to worst (higher value)

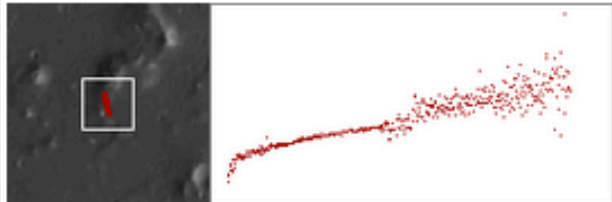
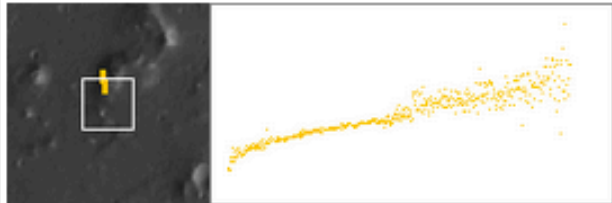
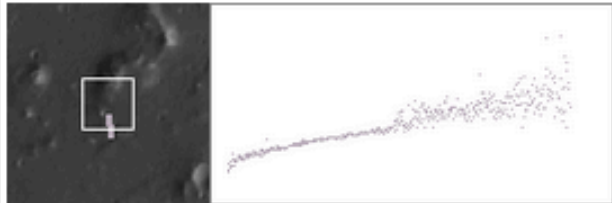
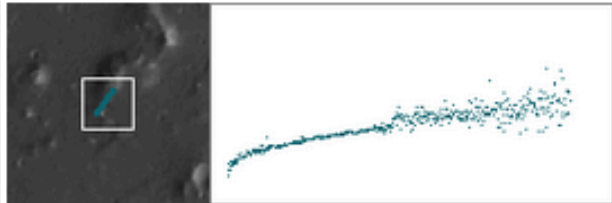
The following table can be sorted by clicking the header of the various columns

Clicking on each observation footprint allows to access additional metadata and VIRS/MDIS comparison plot

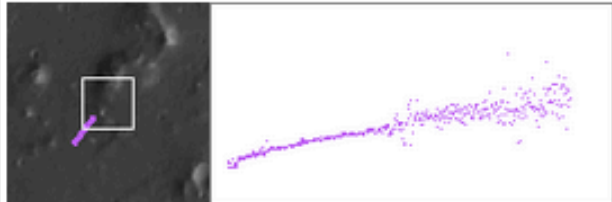
Individual spectra can be selected to not be included in the charts at the bottom and 'redraw plots' clicked to redraw with the given parameters

39

redraw plots

ortho. preview (20x20 sqkm)	source locator	Incidence angle (avg. on sphere)	Emission angle (avg. on sphere)	Phase angle (avg. on sphere)	VIS Temp.	NIR Temp.	area (sqkm)	metric
 ☐ exclude from the plots below	VIS: VIRSVC_ORB_12012_050451 [.DAT] [.LBL] NIR: VIRSNC_ORB_12012_050451 [.DAT] [.LBL] Spectrum no. 1256 MET: 1/234833729:530000 UTC: 2012-01-12 05:31:03 Inspect spectrum as CSV	56.556	22.859	77.826	14.238	16.980	1.584	3.118
 ☐ exclude from the plots below	VIS: VIRSVC_ORB_12012_050451 [.DAT] [.LBL] NIR: VIRSNC_ORB_12012_050451 [.DAT] [.LBL] Spectrum no. 1257 MET: 1/234833730:780000 UTC: 2012-01-12 05:31:04 Inspect spectrum as CSV	56.579	22.836	77.827	14.240	16.981	1.584	3.120
 ☐ exclude from the plots below	VIS: VIRSVC_ORB_12012_050451 [.DAT] [.LBL] NIR: VIRSNC_ORB_12012_050451 [.DAT] [.LBL] Spectrum no. 1255 MET: 1/234833728:280000 UTC: 2012-01-12 05:31:01 Inspect spectrum as CSV	56.533	22.882	77.826	14.236	16.979	1.585	3.120
 ☐ exclude from the plots below	VIS: VIRSVC_OB2_12187_144509 [.DAT] [.LBL] NIR: VIRSNC_OB2_12187_144509 [.DAT] [.LBL] Spectrum no. 917 MET: 1/249988123:750000 UTC: 2012-07-05 15:04:17 Inspect spectrum as CSV	58.090	20.645	77.805	9.489	11.765	1.858	3.756
 ☐ exclude from the plots below	VIS: VIRSVC_OB2_12187_144509 [.DAT] [.LBL] NIR: VIRSNC_OB2_12187_144509 [.DAT] [.LBL] Spectrum no. 916 MET: 1/249988122:530000 UTC: 2012-07-05 15:04:16 Inspect spectrum as CSV	58.065	20.571	77.806	9.477	11.751	2.004	4.047

Postage stamps with links to data

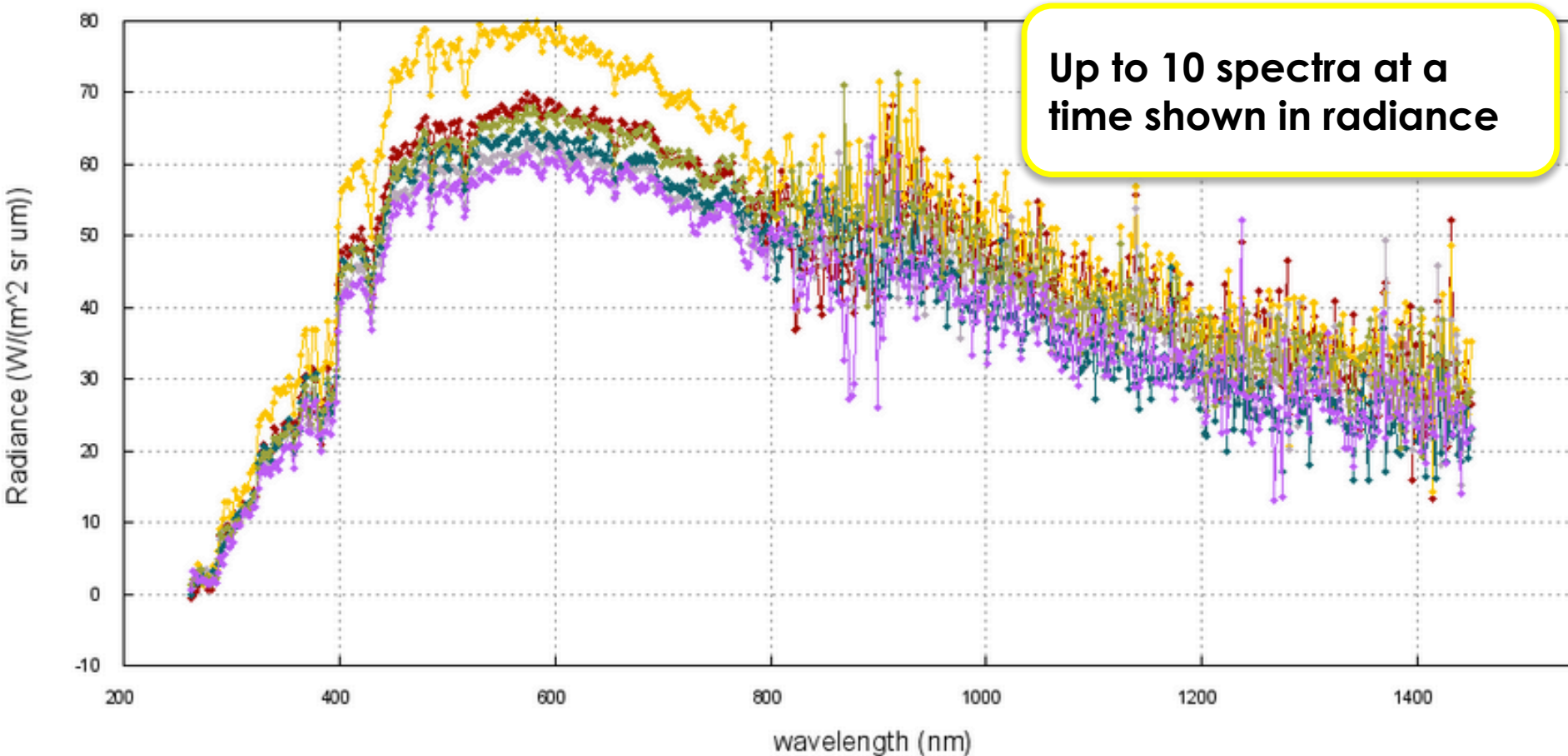


☐ exclude from the plots below

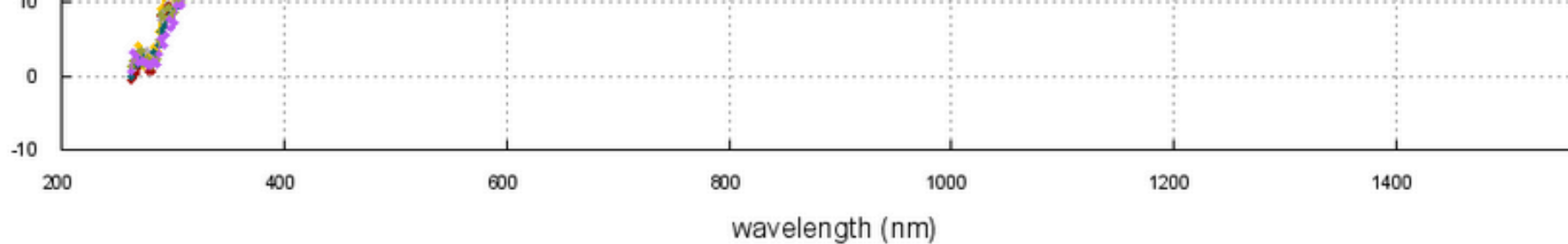
VIS: VIRSVC_OB2_12187_144509
[\[.DAT\]](#) [\[.LBL\]](#)
 NIR: VIRSNC_OB2_12187_144509
[\[.DAT\]](#) [\[.LBL\]](#)
 Spectrum no. 918
 MET: 1/249988125:0
 UTC: 2012-07-05 15:04:18
 Inspect spectrum as [CSV](#)

58.116	20.726	77.803	9.489	11.765	2.053	4.156
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VIRS spectra (Radiance) @ lon=58.287 lat=26.122 (5x5 sqkm)

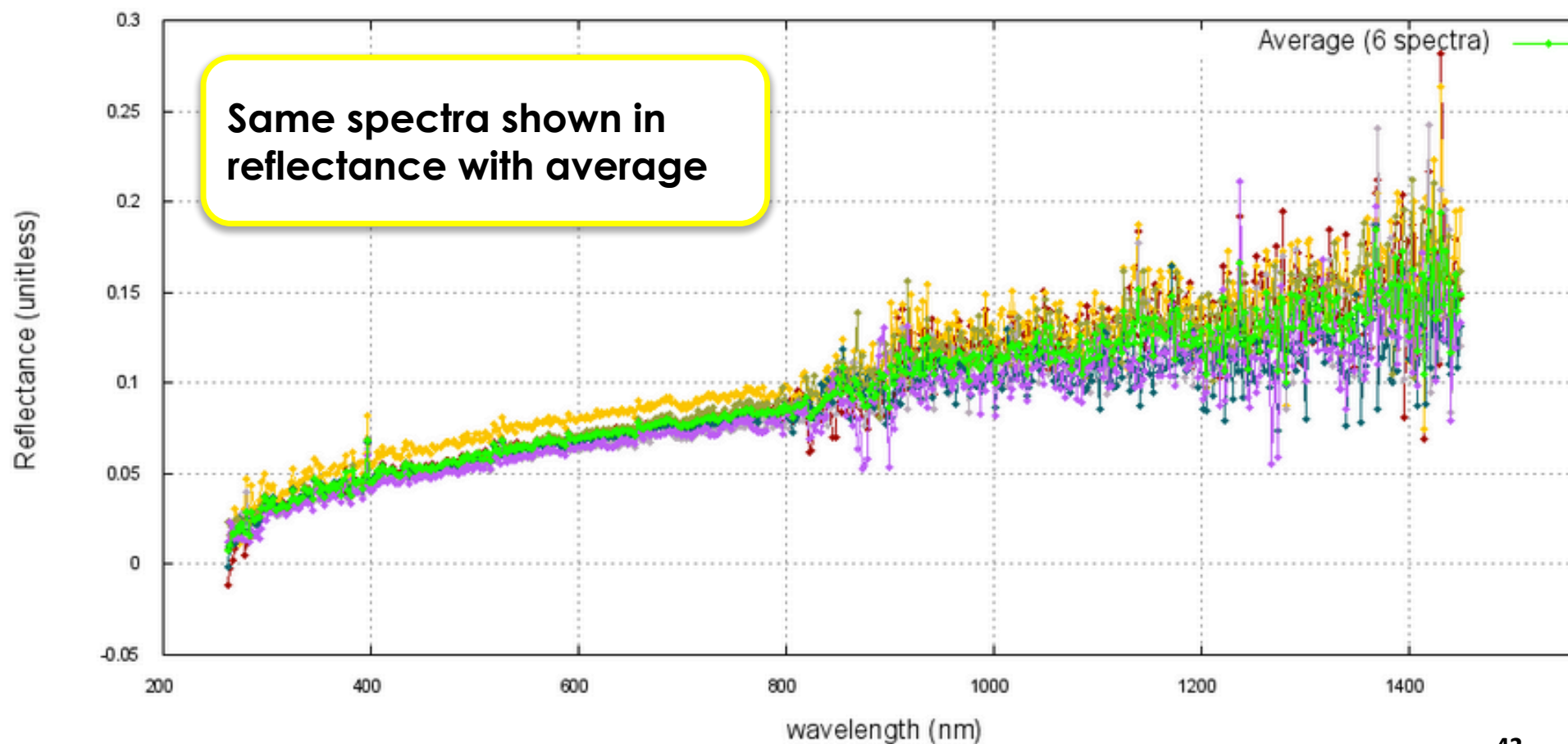


The following plot shows the spectra listed on the table above, as well as their average (in green).



The following plot shows the spectra listed on the table above, as well as their average (in green).

VIRS spectra (Reflectance) @ lon=58.287 lat=26.122 (5x5 sqkm)

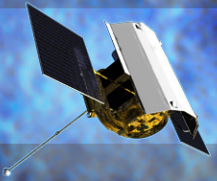




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MERCURY SURFACE, SPACE ENVIRONMENT, GEOCHEMISTRY, AND RANGING



Accessing MASCS/VIRS Data Directly: Downloading from PDS and Reading Structures into IDL

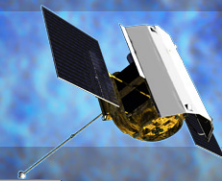
PDS Geosciences Node:
pds-geosciences.wustl.edu



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PDS Geosciences Node: pds-geosciences.wustl.edu

The screenshot shows the PDS Geosciences Node website. At the top is the NASA logo and the text "NATIONAL AERONAUTICS AND SPACE ADMINISTRATION". To the right are links: "+ NASA Homepage", "+ NASA en Español", and "+ Contact NASA". The main header features a Mars landscape image with the text "PDS Geosciences Node" and "Washington University in St. Louis". Below this is a navigation bar with links: HOME, DATA AND SERVICES, TOOLS, ABOUT US, CONTACT US, and SITE MAP.

On the left side, there is a "Services" menu with links: Analyst's Notebooks, Virtual Astronaut, Orbital Data Explorers, Spectral Library, FTP Access, and Workshops. Below this is the "Geosciences Node Data" section with a list of celestial bodies: Mars, Venus, Mercury, and Moon. The "Mercury" link is circled in red, and a red arrow points to it from a text box. Below this list are links for "Earth", "Asteroids", "Gravity Models", and "All Geosciences Data Holdings". At the bottom left is a "Help" section with a link to "Frequently Asked Questions".

The main content area has a "Welcome to the Geosciences Node" section. It contains text about the PDS archives and digital data. A red box highlights the text "Click Mercury to go to the MESSENGER page." with an arrow pointing to the "Mercury" link in the left menu.

On the right side, there is a "What's New" section. It contains two updates: "Odyssey RDR and NS-EDR data from Jan 1-Mar 30, 2013 have been posted." and "January 17, 2014. Products from sols 270 through 359 have been added to the [safed MSL SAM EDR](#) data set." Below this is another update: "Jan. 14, 2014. New Odyssey Radio Science data are posted."

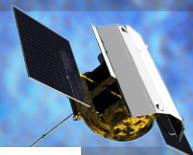
At the bottom right, there is a "Coming Soon" section with a bullet point: "March 3, 2014 - MRO Release 28".



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NATIONAL AERONAUTICS
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+ NASA en Español
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PDS Geosciences Node

Washington University in St. Louis

HOME

DATA AND SERVICES

TOOLS

ABOUT US

CONTACT US

SITE MAP

Services

[Analyst's Notebooks](#)
[Virtual Astronaut](#)
[Orbital Data Explorers](#)
[Spectral Library](#)
[FTP Access](#)
[Workshops](#)

Geosciences Node Data

[Mars](#)
[Venus](#)
[Mercury](#)

[MESSENGER](#)

[About
MESSENGER](#)

[GRS/NS](#)

[MASCs](#)

[MLA](#)

[Radio Science](#)

[XRS](#)

[Moon](#)

[Earth](#)

[Asteroids](#)

[Gravity Models](#)

[All Geosciences Data Holdings](#)

Help

[Frequently Asked Questions](#)
[Geosciences Node Forums](#)
[Help for Data Users](#)
[Help for Data Reviewers](#)
[Help for Proposers](#)

MESSENGER

The MESSENGER (Mercury Surface, Space Environment, Geochemistry and Ranging) mission was launched in August 2004 on a long journey to Mercury. The spacecraft completed one flyby of Earth, two of Venus, and three of Mercury before entering Mercury's orbit in March 2011. MESSENGER is now in its second extended mission, which runs through March 2015.

September 6, 2013. MESSENGER Release 10. MESSENGER Release 10 includes raw and calibrated data acquired from September 18, 2012, through March 17, 2013.

Instruments and Archives

Instrument	PDS Archives
EPPS (Energetic Particle and Plasma Spectrometer)	EPPS Archive (at the PPI Node)
GRS (Gamma Ray Spectrometer) and NS (Neutron Spectrometer)	GRS and NS Archive
MAG (Magnetometer)	MAG Archive (at the PPI Node)
MASCs (Mercury Atmospheric and Surface Composition Spectrometer) includes: UVVS (Ultraviolet/Visible Spectrometer)	MASCs Archive

Click **MASCs Archive**.

Sept. 6, 2013. MESSENGER Release 10 includes raw and calibrated data acquired from September 18, 2012, through March 17, 2013.

August 23, 2013. [MASCs CDR and DCR Reader](#) software is available.

March 8, 2013. Release 9 data are online. Raw and calibrated data go through September 17, 2012, and derived data for most instruments through March 25, 2012.

Sept. 7, 2012. Release 8 data are now online, covering the first 12 months of orbital operations (through March 25, 2012).

March 8, 2012. Release 7 data are now online, covering the first six months of orbital operations (through September 17, 2011).

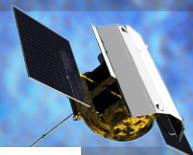
Sept. 8, 2011. Release 6 data are now online, covering the



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AND SPACE ADMINISTRATION

+ Contact NASA

PDS Geosciences Node

Washington University

HOME DATA AND SERVICES TOOLS

Services

- Analyst's Notebooks
- Virtual Astronaut
- Orbital Data Explorers
- Spectral Library
- FTP Access
- Workshops

Geosciences Node Data

- Mars
- Venus
- Mercury
 - MESSENGER
 - About
 - MESSENGER
 - GRS/NS
 - MASCS
 - MLA
 - Radio Science
 - XRS

- Moon
- Earth
- Asteroids
- Gravity Models
- All Geosciences Data Holdings

Help

- Frequently Asked Questions
- Geosciences Node Forums
- Help for Data Users
- Help for Data Reviewers
- Help for Proposers
- About Checksums
- Email Us

Scheduled Maintenance

This site may be down on **Thursdays** between 7:00 and 9:30 pm Central Time for maintenance.

MESSENGER: MASCS

September 6, 2013. MESSENGER acquired from September 14 to September 21, 2013.

August 23, 2013. MASCS CDR and DDR data files are available from the PDS Geosciences Node.

MASCS is the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) on the MESSENGER spacecraft. The data sets are processed by the University Applied Physics Laboratory, Laurel, Maryland.

MASCS has two subsystems, UVVS (Ultraviolet and Visible Spectrometer) and VIRS (Visible and Infrared Spectrograph). UVVS data are archived by the PDS Atmospheres Node, and VIRS data are archived by the PDS Geosciences Node. Both data sets are stored on the same archive volume, available from both nodes.

MASCS Data Sets

Raw Data Products

UVVS and VIRS EDRs - MASCS Ultraviolet/Visible Spectrometer and Visible/Infrared Spectrograph Experiment Data Records

Derived Data Products

UVVS and VIRS CDRs and DDRs - MASCS Ultraviolet/Visible Spectrometer and Visible/Infrared Spectrograph Calibrated Data Records and Derived Data Records

Tools

-  **Mercury Orbital Data Explorer** - Provides search, display, and download tools for this data set.
- Mercury Footprint Coverage Explorer** - Part of the Mercury ODE, this page links to product coverage maps in Google Earth and other formats.
- MESSENGER QuickMap** - This simple, interactive map interface used by the MESSENGER science team is now available to the public.
- MASCS CDR and DDR Readers** - The MASCS Team has provided IDL functions to read CDR and DDR data files into an IDL array of data.

Two ways to find MASCS data:

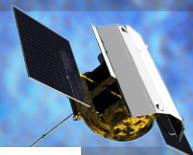
- Follow links directly to raw and derived archives online.
- Use the **Mercury Orbital Data Explorer** search tools to select data products.



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Method A: Direct links to data online

s-geosciences.wustl.edu - /messenger/mess-e_v_h-mascs-3-virs-
-caldata-v1/

Parent Directory]

/2013	2:53 PM	<dir>	messmas 2001
/2013	1:36 PM	28484832	messmas_2001_130930.md5

The MASCS derived data archive is in volume **messmas_2001**.

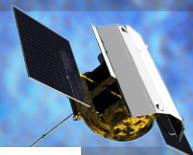
s-geosciences.wustl.edu - /messenger/mess-e_v_h-mascs-3-virs-
-caldata-v1/messmas_2001/

Parent Directory]

/2013	9:15 AM	30056	aareadme.txt
/2011	4:47 PM	<dir>	calib
/2013	1:06 PM	<dir>	catalog
/2013	9:19 AM	<dir>	data
/2013	10:35 AM	<dir>	document
/2013	2:53 PM	30407	errata.txt
/2013	3:56 PM	<dir>	extras
/2012	1:38 PM	<dir>	geometry
/2013	3:56 PM	<dir>	index
/2013	3:56 PM	<dir>	label
/2013	8:25 AM	3433	voldesc.cat

Data products are in the **data** directory. Click down the data directory tree to choose product type, mission phase, VIRS data, observation date, and sensor.

The **data** directory contains “**cdr**”, “**ddr**”, and “**dap**” subdirectories for direct access to all data.



Method A: Direct links to data online, continued

ds-geosciences.wustl.edu - /messenger/mess-e_v_h-mascs-
-virs-cdr-caldata-v1/messmas_2001/data/ddr/ob2/virs
mascs20120318/vis/

[Parent Directory\]](#)

15/2013	3:15 PM	711144	virsvd ob2 12078 011909.dat
15/2013	3:15 PM	2424	virsvd ob2 12078 011909.lbl
15/2013	3:15 PM	2593584	virsvd ob2 12078 014105.dat
15/2013	3:15 PM	2426	virsvd ob2 12078 014105.lbl
15/2013	3:15 PM	4643352	virsvd ob2 12078 070334.dat
15/2013	3:15 PM	2426	virsvd ob2 12078 070334.lbl
15/2013	3:15 PM	209160	virsvd ob2 12078 071824.dat
15/2013	3:15 PM	2424	virsvd ob2 12078 071824.lbl
15/2013	3:15 PM	209160	virsvd ob2 12078 071933.dat
15/2013	3:15 PM	2424	virsvd ob2 12078 071933.lbl
15/2013	3:15 PM	209160	virsvd ob2 12078 072020.dat
15/2013	3:15 PM	2424	virsvd ob2 12078 072020.lbl

Every data file (.dat) comes with a PDS label (.lbl) that describes it. You'll need both files. Right-click to download.

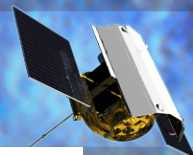
If you want more than just a few files, it will be easier to get them with FTP. You can use any FTP client. We recommend **Filezilla** (filezilla-project.org) because it allows easy drag-and-drop downloading. See next page for an example ...



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Method A: Direct links to data online, continued

ftp://pds-geosciences.wustl.edu - /messenger/mess-e_v_h-mascs-3-virs-cdr-caldata-v1/messmas_2001/data/ddr/ob2/virs/mascs20120318/vis/

To get the FTP address, put **ftp://** in front of the link in your browser window, and use that link in your FTP software.

This example uses Filezilla FTP software.

The screenshot shows the FileZilla FTP client interface. The top toolbar includes buttons for File, Edit, View, Transfer, Server, Bookmarks, and Help. The Host field is set to `pds-geosciences.wustl.edu`, the Username is `anonymous`, and the Password field is empty. The Remote site is set to `_h-mascs-3-virs-cdr-caldata-v1/messmas_2001/data/ddr/ob2/virs/mascs20120318/vis`. The local site is `C:\`. The remote directory listing shows the following files:

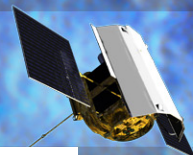
Filename	Filesize	Filetype	Last modified
..			
virsvd_ob2_12078_011909.dat	711,144	DAT File	1/15/2013 3:15...
virsvd_ob2_12078_011909.lbl	2,424	PDS Label	1/15/2013 3:15...
virsvd_ob2_12078_014105.dat	2,593,584	DAT File	1/15/2013 3:15...
virsvd_ob2_12078_014105.lbl	2,424	PDS Label	1/15/2013 3:15...



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Other files you might need

Look inside the PDS label. There may be a line like
^STRUCTURE = "VIRSVD.FMT".

Structure files describe the format of the data table.
You'll find them in the LABEL directory of the archive.

**pds-geosciences.wustl.edu - /messenger/mess-
e_v_h-mascs-3-virs-cdr-caldata-v1/messmas_2001
/label/**

[\[To Parent Directory\]](#)

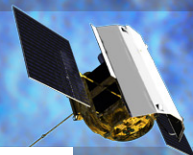
7/11/2013	9:22 AM	1382	labinfo.txt
9/7/2012	1:38 PM	9674	uvvshdrc.fmt
6/18/2013	1:50 PM	24349	uvvsscic.fmt
1/10/2013	8:27 AM	12376	uvvsscid.fmt
12/7/2012	1:12 PM	26470	virsnc.fmt
12/11/2012	10:37 PM	18161	virsnd.fmt
12/17/2012	7:53 AM	26462	virsvc.fmt
12/10/2012	12:42 PM	18248	virsvd.fmt



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Other files you might need

pds-geosciences.wustl.edu - /messenger/mess-
e_v_h-mascs-3-virs-cdr-caldata-v1/messmas_2001
/document/

[\[To Parent Directory\]](#)

6/13/2013	8:22 AM	5924	docinfo.txt
5/5/2011	7:43 AM	864	mascs cal rpt.lbl
5/5/2011	7:43 AM	1421580	mascs cal rpt.pdf
5/5/2011	7:43 AM	85654	mascs cal rpt.txt
1/24/2012	1:28 PM	1147	uvvs calibration changes pds7.lbl
1/27/2012	12:31 PM	67117	uvvs calibration changes pds7.pdf
1/27/2012	12:34 PM	2255	uvvs calibration changes pds7.txt
1/31/2013	12:41 PM	574	uvvs cdr2ddr.lbl
1/31/2013	12:45 PM	119262	uvvs cdr2ddr.txt
6/19/2013	10:53 AM	1722	uvvs cdr ddr sis.lbl
6/19/2013	11:35 AM	1286113	uvvs cdr ddr sis.pdf
6/19/2013	12:53 PM	203798	uvvs cdr ddr sis.txt
7/18/2013	10:07 AM	484	uvvs edr2cdr.lbl
7/18/2013	10:07 AM	254016	uvvs edr2cdr.txt
12/13/2012	9:03 AM	1287	virs calibration changes pds9.lbl
12/13/2012	9:01 AM	54442	virs calibration changes pds9.pdf
12/13/2012	8:56 AM	1904	virs calibration changes pds9.txt
1/14/2013	10:45 AM	574	virs cdr2ddr.lbl
1/14/2013	10:45 AM	39605	virs cdr2ddr.txt
6/17/2013	8:49 AM	1767	virs cdr ddr dap sis.lbl
6/17/2013	11:07 AM	1024599	virs cdr ddr dap sis.pdf
6/17/2013	11:05 AM	203678	virs cdr ddr dap sis.txt
1/24/2012	10:20 AM	1317	virs dark analysis report 1.lbl
1/24/2012	9:57 AM	3473422	virs dark analysis report 1.pdf

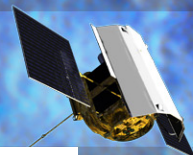
Documentation is found in the DOCUMENT directory. Each document comes in a PDF version and a plain text version, with a label that describes both. The SIS (Software Interface Specification) is the primary document.



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Now for Method B, using the Mercury Orbital Data Explorer.

PDS Geosciences Node
Washington University

HOME DATA AND SERVICES TOOLS

Services

- Analyst's Notebooks
- Virtual Astronaut
- Orbital Data Explorers
- Spectral Library
- FTP Access
- Workshops

Geosciences Node Data

- Mars
- Venus
- Mercury
 - MESSENGER
 - About
 - MESSENGER
 - GRS/NS
 - MASCS
 - MLA
 - Radio Science
 - XRS
- Moon
- Earth
- Asteroids
- Gravity Models
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Scheduled Maintenance

This site may be down on **Thursdays** between 7:00 and 9:30 pm Central Time for maintenance.

MESSENGER: MASCS

September 6, 2013. MESSENGER acquired from September 14 to September 15, 2013.

August 23, 2013. MASCS CDR and DDR data files are available from both nodes.

MASCS is the Mercury Atmospheric and Surface Composition Spectrometer (MASCS) on the MESSENGER spacecraft. The data sets are processed by the University Applied Physics Laboratory, Laurel, Maryland.

MASCS has two subsystems, UVVS (Ultraviolet and Visible Spectrometer) and VIRS (Visible and Infrared Spectrograph). UVVS data are archived by the PDS Atmospheres Node, and VIRS data are archived by the PDS Geosciences Node. Both data sets are stored on the same archive volume and are available from both nodes.

MASCS Data Sets

Raw Data Products

- [UVVS and VIRS EDRs](#) - MASCS Ultraviolet/Visible Spectrometer and Visible/Infrared Spectrograph Experiment Data Records

Derived Data Products

- [UVVS and VIRS CDRs and DDRs](#) - MASCS Ultraviolet/Visible Spectrometer and Visible/Infrared Spectrograph Calibrated Data Records and Derived Data Records

Tools

- [Mercury Orbital Data Explorer](#) - Provides search, display, and download tools for this data set.
- [Mercury Footprint Coverage Explorer](#) - Part of the Mercury ODE, this page links to product coverage maps in Google Earth and other formats.
- [MESSENGER QuickMap](#) - This simple, interactive map interface used by the MESSENGER science team is now available to the public.
- [MASCS CDR and DDR Readers](#) - The MASCS Team has provided IDL functions to read CDR and DDR data files into an IDL array of data.

Two ways to find MASCS data:

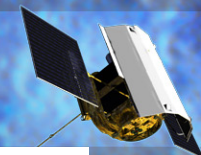
- Follow links directly to raw and derived archives online.
- Use the Mercury Orbital Data Explorer search tools to select data products.



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Method B: Using the Mercury Orbital Data Explorer

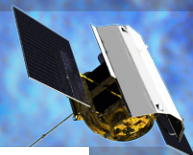
Choose Data Product Search.



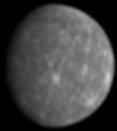
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Method B: Using the Mercury Orbital Data Explorer, continued



Mercury Orbital Data Explorer

PDS Geosciences Node
Washington University in St. Louis

[Home](#) [Data Product Search](#) [Map Search](#) [Tools](#) [Data Set Browser](#) [Download](#) [Help & Resources](#)

DATA PRODUCT SEARCH

Planetary science data stored in PDS is organized by [data products](#) and related data products, usually products acquired by a particular instrument. This page also includes all documentation and supporting materials needed to understand a product. A product is a set of measurements resulting from a science observation, processed by an instrument and processed in a certain way.

Open the **Select Data Sets** pulldown.

Click the checkboxes next to MASCS VIRS data sets.

STEP 1. SELECT DATA SETS TO SEARCH (A SELECTION IS REQUIRED)

 **Select One or More Desired Data Sets (Released PDS Archives)** (Hide Options - 2 Parameters Set)

-  Map location data is available for these products.
-  Observation time data is available for these products.
-  Product emission, incidence, and phase angle data is available for these products.
-  Solar longitude data is available for these products.

MESSENGER

GRS - Gamma Ray Spectrometer

Other Product Types 

- ☐ CDR - Calibrated Data Record 
- ☐ RDR - Reduced Data Record 

[Data Set Description](#)

[Data Set Description](#)

MASCS - MERCURY ATMOSPHERIC AND SURFACE COMPOSITION SPECTROMETER

Other Product Types 

- ☐ UVVCDR - UVVS Calibrated Data Record  
- ☒ VIRCDR - VIR Calibrated Data Record  
- ☐ UVVDDR - UVVS Derived Data Record  
- ☒ VIRDDR - VIR Derived Data Record  

[Data Set Description](#)

[Data Set Description](#)

[Data Set Description](#)

[Data Set Description](#)

MDIS-NAC - Mercury Dual Imaging System - Narrow Angle Camera

Other Product Types 

- ☐ CNR-NAC - Narrow Angle Camera Calibrated Data Record  

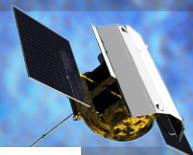
[Data Set Description](#)



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Method B: Using the Mercury Orbital Data Explorer, continued

STEP 2. SET ADDITIONAL FILTERING PARAMETERS (OPTIONAL)

☒ Select a Product ID or filter by a partial Product ID

☒ Find by Product Location

Select a Specific Feature

A selected feature's Latitude and Longitude bounding box will be used for search

Feature Type: [Feature Type De](#)

Feature Name: [Full Feature Name List](#)

OR

Directly specify a Latitude and Longitude coverage area

Mercury ODE uses [planetocentric coordinates](#) that are based on the product's center latitude and longitude.

Max Latitude
(-90 to 90)

73

Western
most
Longitude
(0 to 360)

124.5

125.5

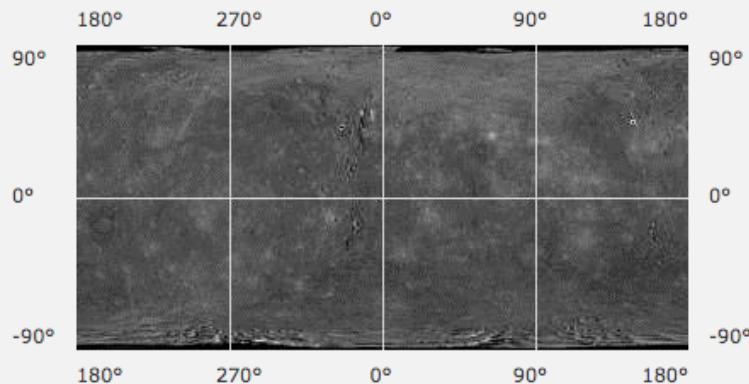
Eastern
most
Longitude
(0 to 360)

72

Min Latitude
(-90 to 90)

Show Area
On Map

Selected Search Area



Further down the page, enter your desired search criteria.

For example, to search a specific area, first open **Find by Product Location**, and then enter latitude-longitude limits.

STEP 4. SUBMIT QUERY

☒ View Results in Table

☐ Select Results on Map Display

☒ Display Product Thumbnails on search results page

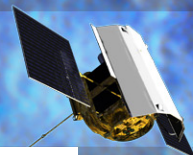
When ready, choose
View Results in Table.



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Method B: Using the Mercury Orbital Data Explorer, continued

Click a Product ID to see more information on the right side of the screen

Check the products to be downloaded

Click **Update Cart** to add checked products to your shopping cart

When ready, click **Download**.

Mercury Orbital Data Explorer

PDS Geosciences Node
Washington University in St. Louis

Home Data Product Search Map Search Tools Data Set Browser Download Help & Resources

SEARCH RESULTS

Output Results View on Map Back To Search ?

Products Found: 36

☒ Display Product Thumbnails

Update Cart

Instrument	Type	Product ID	Obs. Time	
MESSENGER MASCS	VIRCDR	VIRSNC_OB2_12086_010330_DAT	2012-03-26T01:03:51.500	☒
MESSENGER MASCS	VIRCDR	VIRSNC_OB2_12177_070123_DAT	2012-06-25T07:11:10.500	☒
MESSENGER MASCS	VIRCDR	VIRSNC_OB2_12177_230048_DAT	2012-06-25T23:11:02.000	☒
MESSENGER MASCS	VIRCDR	VIRSNC_OB2_12259_154023_DAT	2012-09-15T15:40:44.500	☒
MESSENGER MASCS	VIRCDR	VIRSNC_OB2_12354_073512_DAT	2012-12-19T07:46:22.000	☒
MESSENGER MASCS	VIRCDR	VIRSNC_OB2_13069_082140_DAT	2013-03-10T08:22:01.500	☐
MESSENGER MASCS	VIRCDR	VIRSNC_ORB_11097_033945_DAT	2011-04-07T03:40:07.500	☐
MESSENGER MASCS	VIRCDR	VIRSNC_ORB_11133_204806_DAT	2011-05-13T21:06:59.500	☐
MESSENGER MASCS	VIRCDR	VIRSNC_ORB_11192_145126_DAT	2011-07-11T15:02:01.000	☐
MESSENGER MASCS	VIRCDR	VIRSNC_ORB_11214_081907_DAT	2011-08-02T09:06:42.000	☐
MESSENGER MASCS	VIRCDR	VIRSNC_ORB_11309_100323_DAT	2011-11-05T10:03:45.500	☐
MESSENGER MASCS	VIRCDR	VIRSNC_ORB_11364_225228_DAT	2011-12-30T23:00:55.500	☐
MESSENGER MASCS	VIRDDR	VIRSND_ORB_11097_033945_DAT	2011-04-07T03:40:07.500	☐
MESSENGER MASCS	VIRDDR	VIRSND_ORB_11133_204806_DAT	2011-05-13T21:06:59.500	☐

VIRSNC_OB2_12177_230048_DAT

MESSENGER MASCS VIRCDR - VIR Calibrated Data Record

[Product Description and Data Set Documents \(click to show\)](#)

Browse Meta Data Label Map Context

No product browse version is available.

Add Product to Cart Remove Product from Cart [Cart & Download Help](#)

PDS Product Files Derived Files

Product Files & Labels KB

virsnc_ob2_12177_230048.dat	4,865
Product Data File	
virsnc_ob2_12177_230048.lbl	3
Product Label File	

Referenced Files KB

virsnc.fmt	27
Label Format File	

Product Summary

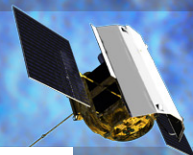
Instrument Host ID	MESSENGER
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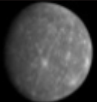
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Method B: Using the Mercury Orbital Data Explorer, continued



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SELECTED ITEMS FOR DOWNLOAD

PDS Data products are **freely available to the public**. The ODE download cart allows a user to select multiple products and individual files for convenient download. For most requests, the ODE system will acquire, compress, and place the requested files on an FTP server. The user will receive an email when the files are ready for download.
[More Product Download Information](#)

Confirm the products you have selected for download. After removing any unwanted products, click the **Continue** button.

STEP 1. REVIEW PRODUCTS SELECTED FOR DOWNLOAD

Products Selected for Download: 5
Size of current cart selections: **15 MB**

☒ **Review Products Selected for Download** (Show Selection List - 5 Products)

STEP 2. DO YOU WISH TO ADD ADDITIONAL DATA SET FILES TO THE CART? - CREATE MINI-ARCHIVE

The Mini-Archive option will add all related files from the PDS Archive including: documentation, software, errata, extras, catalogs, indexes, and the browse images of any products selected for download.

Download Options:	
☒ Selected Products (label, data product, and browse images)	Products Selected for Download: 5 Files from Product selections: 11 Size of current cart selections: 15 MB
☐ Selected Products' Derived Files (map projected, etc.)	Derived files: 10 Size of derived files: 0 MB
☐ Mini-Archive Files (related files from the PDS Archive including: documentation, software, errata, extras, catalogs, and indexes)	Files from Mini-Archive selections: 36 Size of Mini-Archive files: 1 MB
Selection Total	Products Selected for Download: 5 Files from Product selections: 11 Size of current cart selections: 15 MB

Open **View Products Selected for Download** to see what's in the shopping cart.

Check one of the Download Options to include additional files in the cart.

When ready, click

Continue >

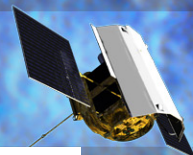
at the bottom of the page.



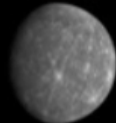
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Method B: Using the Mercury Orbital Data Explorer, continued



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DOWNLOAD SETUP [< Back](#) [?](#)

Details for acquiring the selected data files:

1. The Geosciences Node will retrieve the files you have requested and place them in a user specific FTP folder for your download. After the completion and submission of this form, an automated system will prepare the files for you to download the selected files from. You will receive an email when the files are ready for download. The email will include the FTP address and username.

Select format: ☒ Zip ☐ Tar ☐ Tar.Gz ☐ No Compression

Terms and Conditions
PDS data products and data set files are freely available to the public.

Policy for Citations of PDS Data [click here for a new window](#)

Your email:

(You will be notified at this email address when the files are ready for download.)

Please only click this button once. Multiple clicks may result in problems with your request.

Enter your email address to be notified when your order is ready to download.

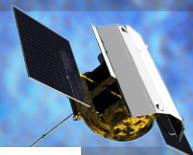
Then click **Submit Request.**



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Other Useful Tools

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Scheduled Maintenance
This site may be down on **Thursdays** between 7:00 and 9:30 pm Central Time for maintenance.

MESSENGER: MASCS

September 6, 2013. MESSENGER Release 10 includes MASCS EDR and CDR data acquired from September 18, 2012, through March 17, 2013.

August 23, 2013. [MASCS CDR and DDR Reader](#) software is available.

MASCS is the Mercury Atmospheric and Surface Composition Spectrometer instrument on MESSENGER. The data sets are produced by the MASCS Science Team at Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland.

MASCS has two subsystems, UVVS (Ultraviolet and Visible Spectrometer) and VIRS (Visible and Infrared Spectrograph). UVVS data are archived by the PDS Atmospheres Node, and VIRS data are archived by the PDS Geosciences Node. Both data sets are stored on the same archive volume, available from both nodes.

MASCS Data Sets

Raw Data Products
[UVVS and VIRS EDRs](#) - MASCS Ultraviolet/Visible Spectrometer and Visible/Infrared Spectrograph Experiment Data Records

Derived Data Products
[UVVS and VIRS CDRs and DDRs](#) - MASCS Ultraviolet/Visible Spectrometer and Visible/Infrared Spectrograph Calibrated Data Records and Derived Data Records

Tools

 [Mercury Orbital Data Explorer](#) - Provides search, display, and download tools for this data set.

[Mercury Footprint Coverage Explorer](#) - Part of the Mercury ODE, this page links to product coverage maps in Google Earth and other formats.

[MESSENGER QuickMap](#) - This simple, interactive map interface used by the MESSENGER science team is now available to the public.

[MASCS CDR and DDR Readers](#) - The MASCS Team has provided IDL functions to read CDR and DDR data files into an IDL array of data structures.

Mercury Footprint Coverage Explorer shows product coverage maps in various formats.

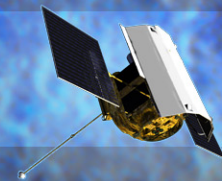
MESSENGER Quickmap allows map-based searches and downloads.

MASCS CDR and DDR Readers help read data into IDL.



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More Information from PDS

Geosciences Node Forums for data
users and data providers, at
<http://geoweb.rsl.wustl.edu/community/>

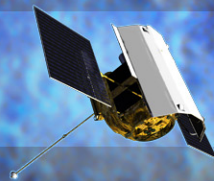
If you can't find the answer on the
forums, send an email to
geosci@wunder.wustl.edu



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IDL Reader Files (CDR and DDR)

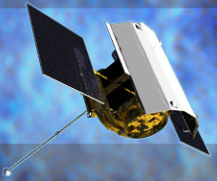
- Available at http://pds-geosciences.wustl.edu/missions/messenger/mascs_software.htm
- Not officially part of PDS delivery (not reviewed and support not guaranteed – but they work as of March 2017 in IDL 8.X)
- Reads MASCS data (CDRs, DDRs) into an IDL structure that can be used in programs or to plot data
- Use `show_dqi.pro` to read data quality index into proper format



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IDL Readers – Required Files

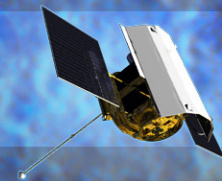
- CDR Readers
 - init_mascs_cdr_templates_6.pro
 - **read_mascs_cdr_6.pro**
 - read_uvvs_cdr_hdr_6.pro
 - read_uvvs_cdr_sci_6.pro
 - read_virs_nir_cdr_6.pro
 - read_virs_vis_cdr_6.pro



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MERCURY SURFACE, SPACE ENVIRONMENT, GEOCHEMISTRY, AND RANGING



IDL Readers – Required Files

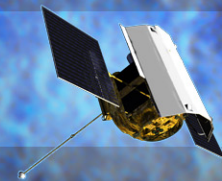
- DDR Readers
 - init_mascs_ddr_templates.pro
 - **read_mascs_ddr.pro**
 - read_uvvs_ddr.pro
 - read_uvvs_surf_ddr.pro
 - read_uvvs_surf_hdr.pro
 - read_virs_nir_ddr.pro
 - read_virs_vis_ddr.pro



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