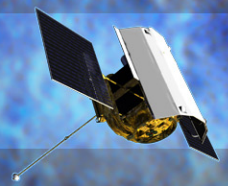
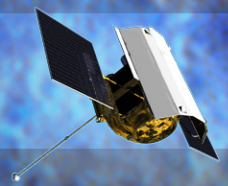
MESSENGER
MErcury Surface, Space ENvironment, GEochemistry, and Ranging



MASCS Instrument & VIRS Calibration

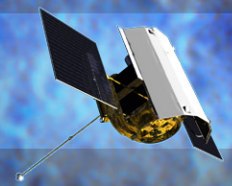
Rachel Klima (on behalf of the MASCS team)
JHU/APL

MASCS/VIRS Data Users' Workshop
LPSC 2014, The Woodlands, TX
March 17,2014



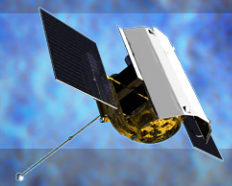
Mercury Atmospheric and Surface Composition Spectrometer (MASCS)

- 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)

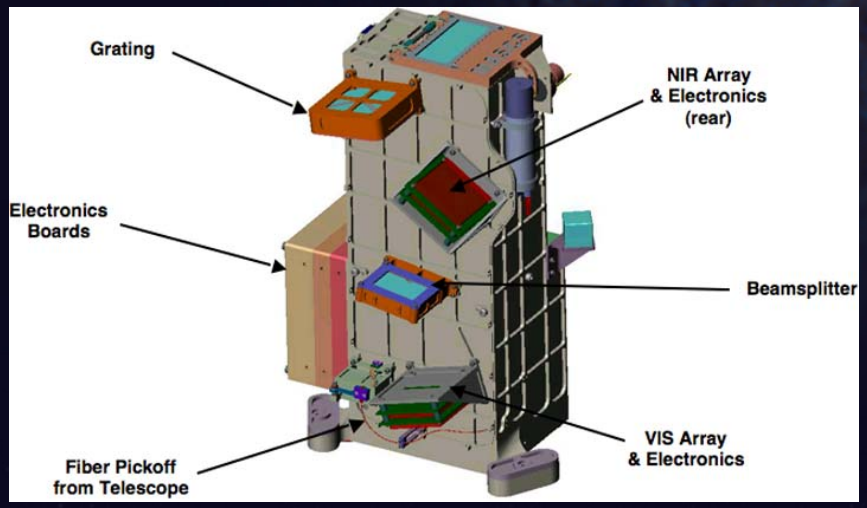


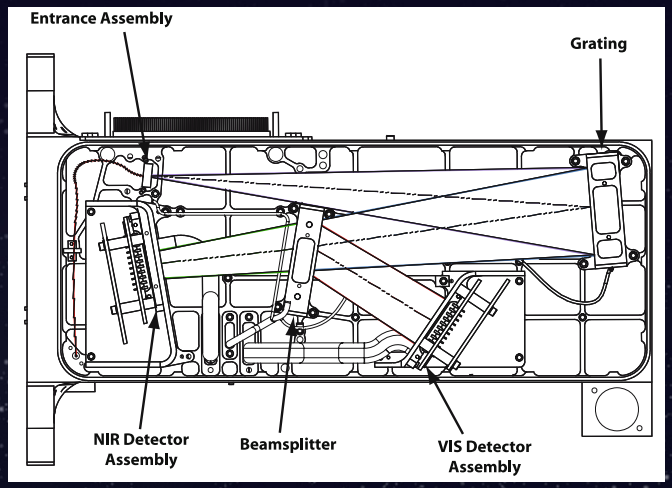
VIRS Observations

- Since entering orbit in March 2011, >10 million spectra have been collected (~95% surface coverage at 20 km spacing between footprints)
- Observation geometry is heavily restricted by spacecraft operational requirements. Global data at latitudes below 70°N and S are limited to incidence <70°, emission <85°, Phase ranges from 78-102°



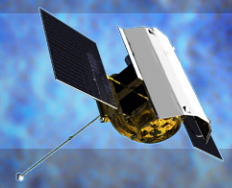
VIRS Instrument Design





- 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

Figures from McClintock and Lankton, 2007, SSR

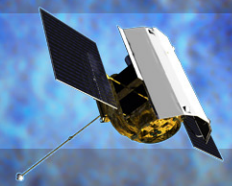


Nominal VIRS Calibration (to CDR)

- Raw 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)

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

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 DN s^{-1}(W m^{-2} sr^{-1} $\mu m^{-1})^{-1}$



Nominal VIRS Data Calibration (to DDR)

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

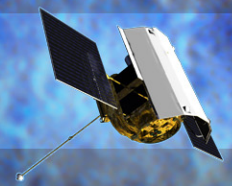
$$f(i, e, \alpha) = \frac{\cos i}{\cos i + \cos e} p(\alpha)$$

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

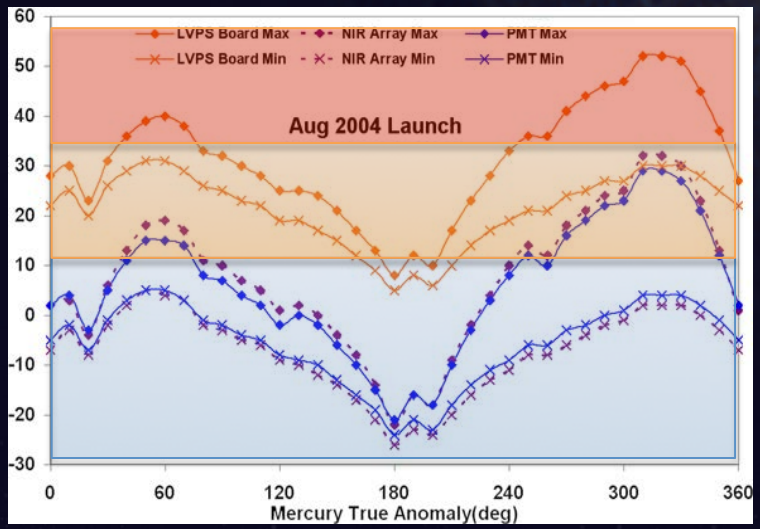
$$r'(45, 45, 90) = r(i, e, \alpha) \frac{f(45, 45, 90)}{f(i, e, \alpha)}$$

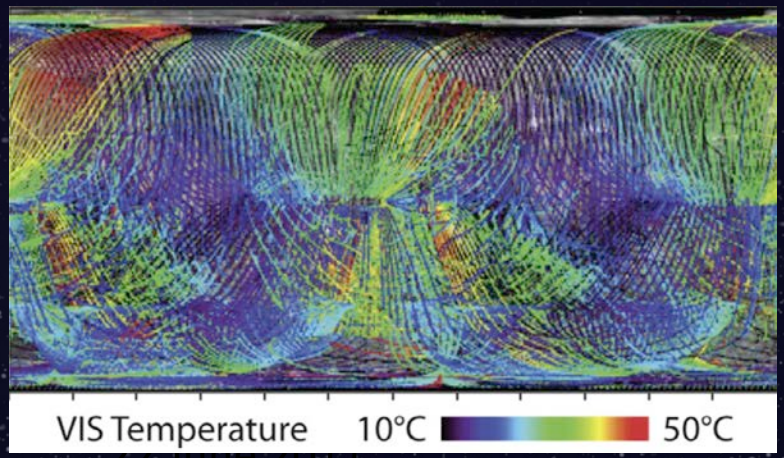
L = radiance at the sensor (W m^{-2} sr^{-1} μm^{-1})
E_{Sun} = Solar spectrum irradiance (W m^{-2} μm^{-1})
f = dependence of reflectance on viewing geometry
i = incidence angle
e = emission angle
α = phase angle
$p(\alpha)$ = phase function
a_0 = 0.0576
a_1 = -3.52 x 10^{-4}
r' = normalized reflectance

- Radiance divided by solar spectrum to get radiance factor
- Corrected for viewing geometry and phase dependence
- Noise spectrum converted to reflectance units

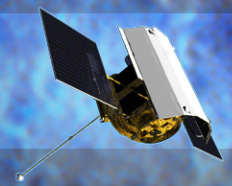


High Temperature Issues

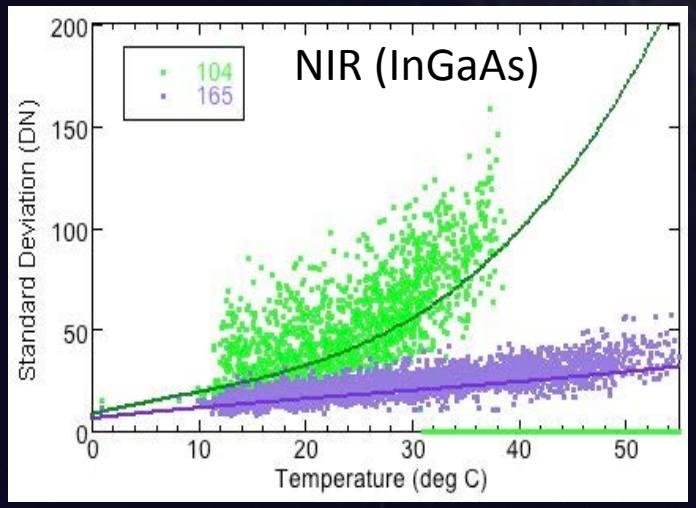


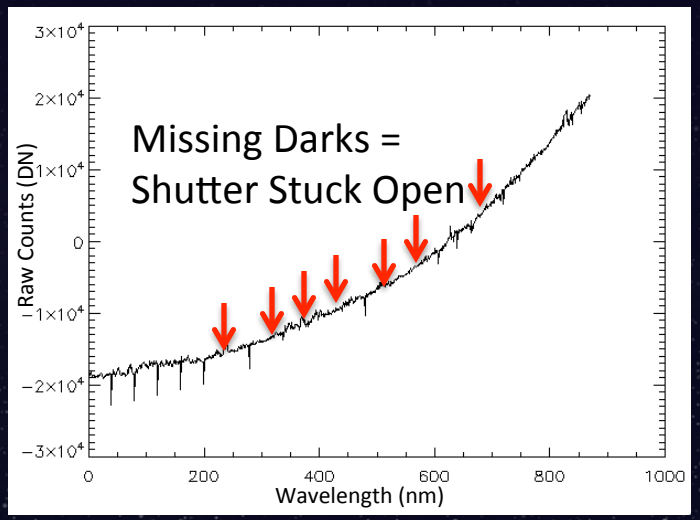


- Temperatures were predicted to remain under ~30°C. Data calibration was anticipated to be more challenging at >10°C
- Actual temperatures have exceeded 10°C for most of the orbital data. The bulk of data have been obtained at 10-35°C, but some reach >50°C



High Temperature Issues





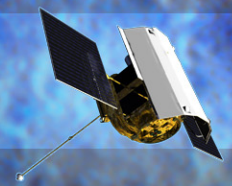
1. Saturation and increased noise in NIR

   Some pixels more sensitive to thermal noise than others

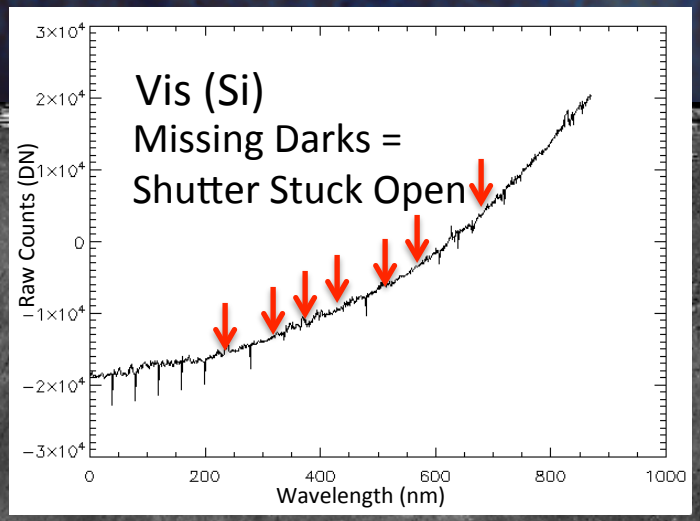
2. 'Sticking' of the shutter mechanism (affects both VIS and NIR)

   'Dark' observations used to perform background subtraction are actually light, resulting in the radiance being excessively low or total dark subtraction failure

(for more info, see Klima et al., LPSC 2014, #1978, Thursday Posters)



High Temperature Issues



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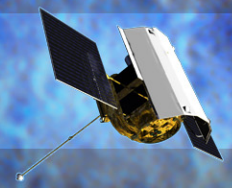
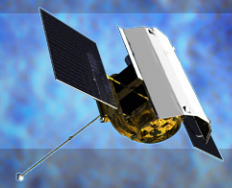


MASCS/VIRS Data Record Structure What are EDRs, CDRs, and DDRs?

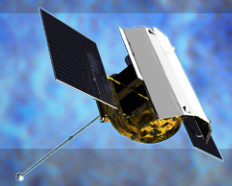
Rachel Klima (on behalf of the MASCS team)
JHU/APL

MASCS/VIRS Data Users' Workshop
LPSC 2014, The Woodlands, TX
March 17,2014



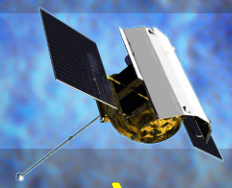
Experiment Data Records (EDRs)

- Experiment 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 CDR/DDR SIS available here: http://pds-geosciences.wustl.edu/messenger/mess-e_v_h-mascs-3-virs-cdr-caldata-v1/messmas_2001/document/virs_cdr_ddr_sis.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.



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 (W m^{-2} sr^{-1} μm^{-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)



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 deg C threshold
1 = Temperature exceeds 15 deg C threshold but less than 25 deg C threshold.
2 = Temperature exceeds 25 deg C threshold but less than 40 deg C threshold
3 = Temperature exceeds 40 deg 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)

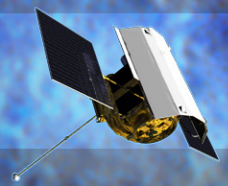
K: UVVS Operating Flag: 0 = UVVS is not scanning during readout; 1 = UVVS is scanning during readout.

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.

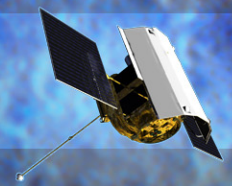
0 = No SPICE
1 = Predict
2 = Actual

N-P: Spares



Derived Data Records (DDRs)

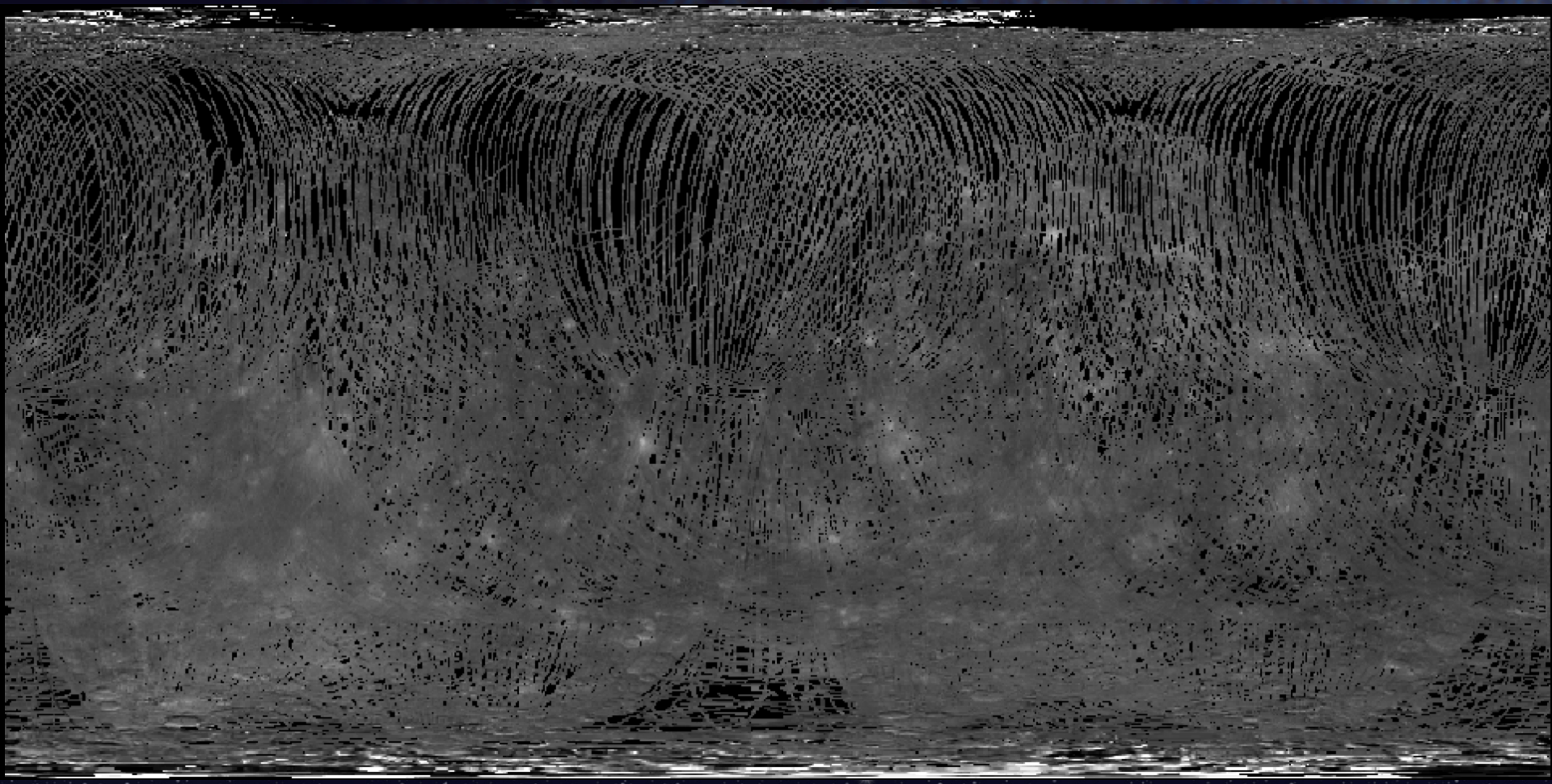
- Temperatures, dark frequency, integration time, spacecraft time from EDR; UTC, Data Quality Index, Spice derived geometry from CDR
- Spectra included (one row per spectrum):
  - IoF Spectrum – reflectance at sensor (no correction for viewing geometry)
  - Photom IoF Spectrum – reflectance at sensor corrected to a viewing geometry of 45,45, 90 (see slide 6 and Izenberg et al., 2014)
  - 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



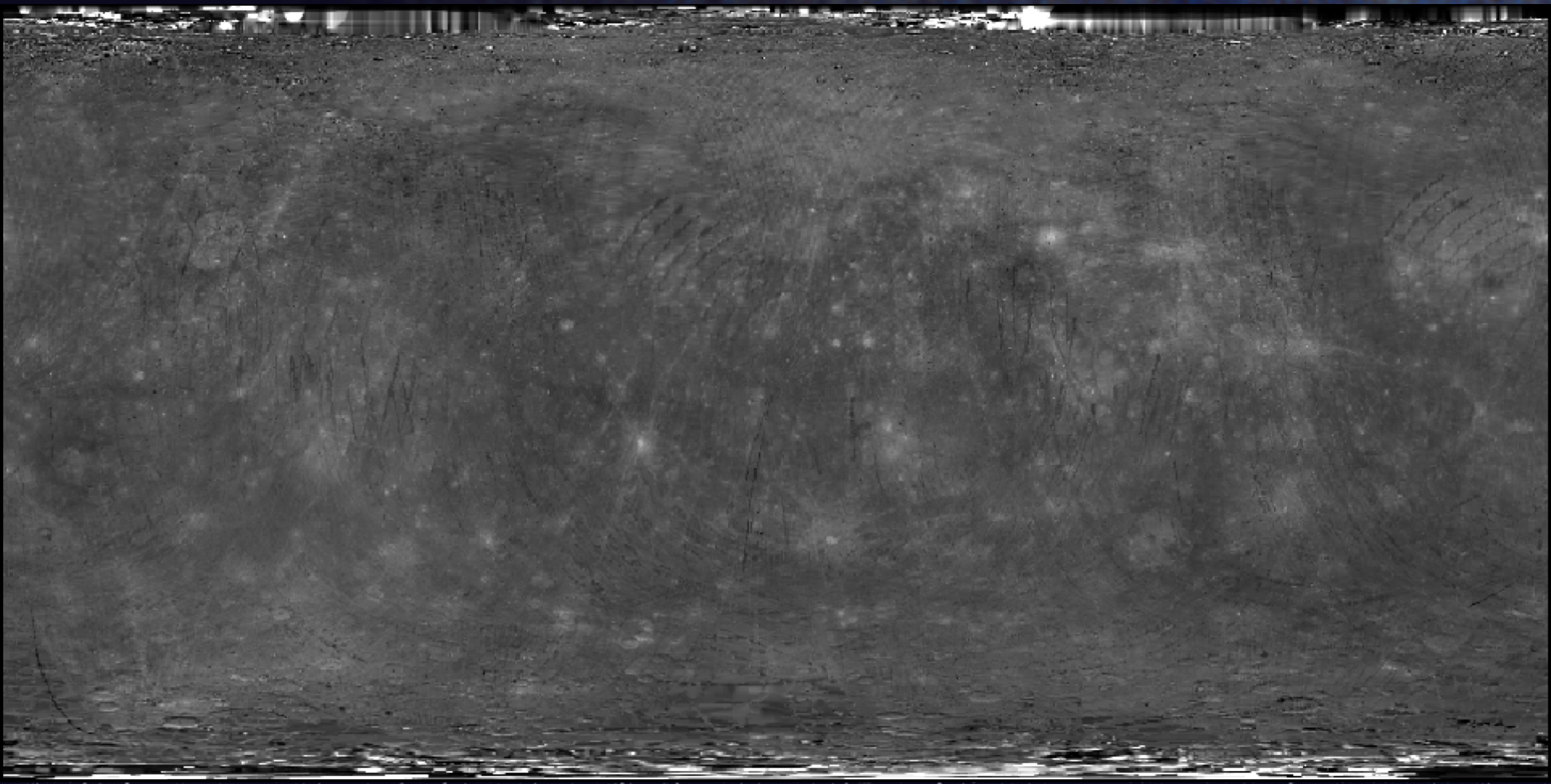
Derived Analysis Products (DAPs)

1. An image file containing the mosaic of MASCS/VIRS reflectance @750nm,
2. An image file containing the interpolated mosaic of MASCS/VIRS reflectance @750nm,
3. An image file containing the incidence angle of MASCS/VIRS observations used in mosaic,
4. An image file containing the emission angle of MASCS/VIRS observations used in mosaic,
5. An image file containing the phase angle of MASCS/VIRS observations used in mosaic,
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.

750 nm Reflectance Map



Interpolated 750 nm Reflectance Map



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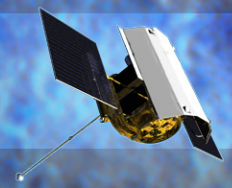


Accessing MASCS/VIRS Data Directly: Downloading from PDS and Reading Structures into IDL

Rachel Klima (on behalf of the MASCS team)
JHU/APL

MASCS/VIRS Data Users' Workshop
LPSC 2014, The Woodlands, TX
March 17,2014

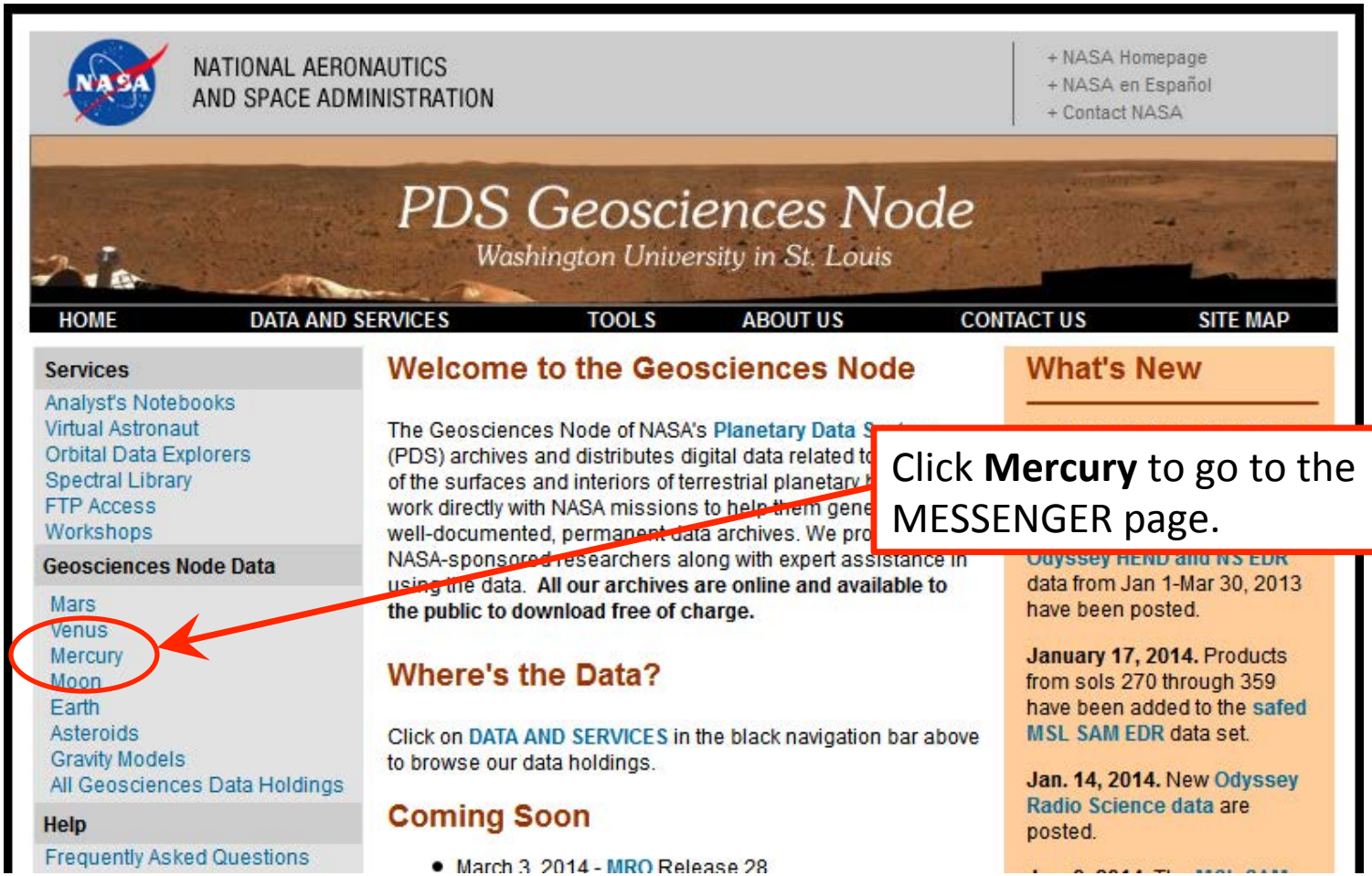
How To Get MESSENGER MASCS VIRS Data from the Planetary Data System

PDS Geosciences Node

For the MASCS VIRS Workshop

Lunar and Planetary Science Conference, March 2014

PDS Geosciences Node: pds-geosciences.wustl.edu



NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

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PDS Geosciences Node

Washington University in St. Louis

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MESSENGER

Click **MASCS Archive.**

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 Archives
MAG (Magnetometer)	MAG Archive *(at the PPI Node)*
MASCS (Mercury Atmospheric and Surface Composition Spectrometer) includes: **UVVS** (Ultraviolet/Visible Spectrometer) **VIRS** (Visible/Infrared Spectrograph)	MASCS Archive

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

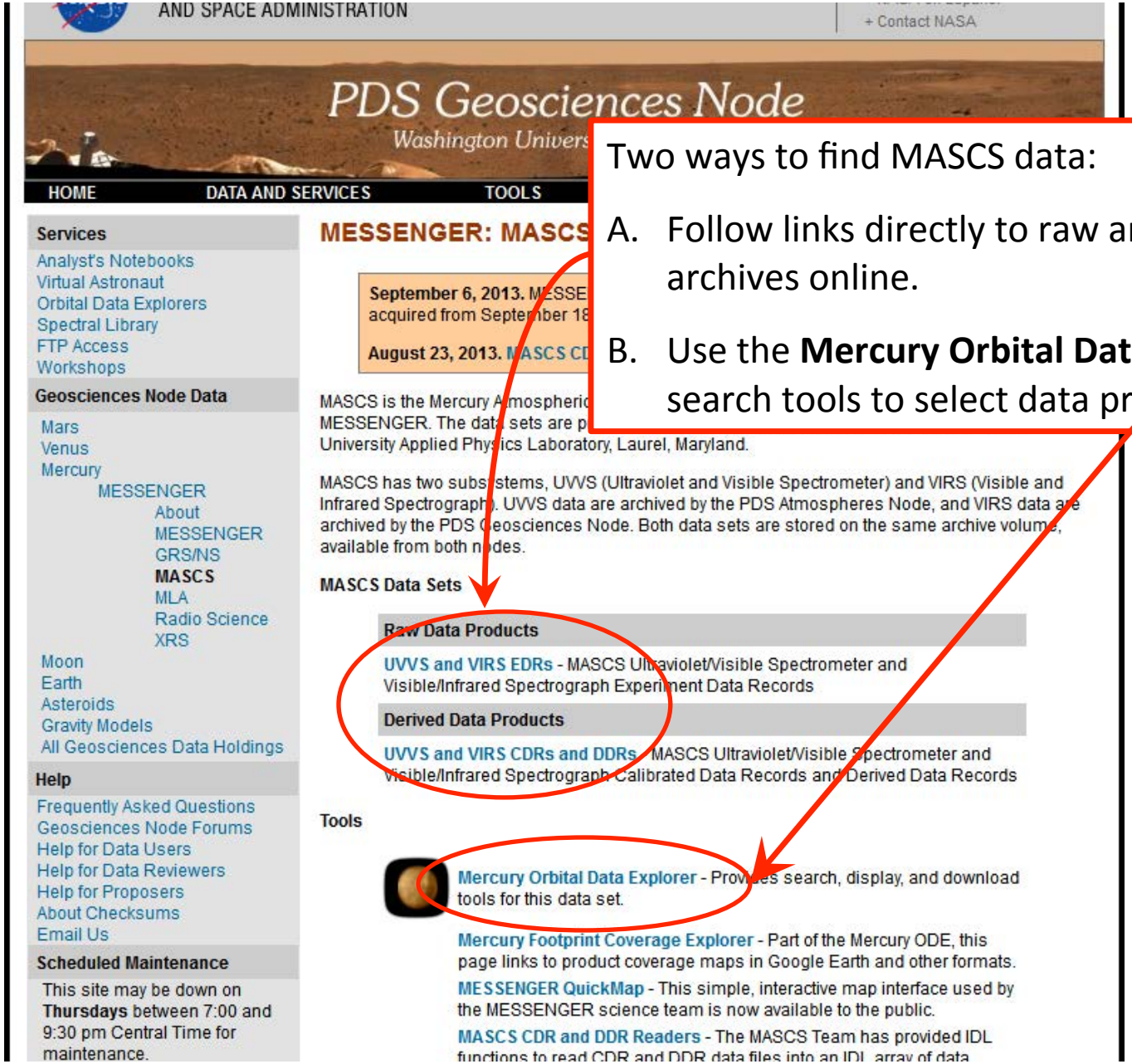
August 23, 2013. MASCS CDR and DDR Reader software is available.

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 period after the third flyby through the first two months of



Two ways to find MASCS data:

A. Follow links directly to raw and derived archives online.

B. Use the **Mercury Orbital Data Explorer** search tools to select data products.

Method A: Direct links to data online

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

[To Parent Directory]

9/23/2013	2:53 PM	<dir>	messmas_2001
9/30/2013	1:36 PM	28484832	messmas_2001_130930.md5

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

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

[To Parent Directory]

7/11/2013	9:15 AM	30056	aareadme.txt
7/22/2011	4:47 PM	<dir>	calib
9/6/2013	1:06 PM	<dir>	catalog
3/7/2013	9:19 AM	<dir>	data
9/10/2013	10:35 AM	<dir>	document
9/23/2013	2:53 PM	30407	errata.txt
9/5/2013	3:56 PM	<dir>	extras
9/7/2012	1:38 PM	<dir>	geometry
9/5/2013	3:56 PM	<dir>	index
9/5/2013	3:56 PM	<dir>	label
7/10/2013	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.

Method A: Direct links to data online, continued

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

[To Parent Directory]

1/15/2013	3:15 PM	711144	virsvd_ob2_12078_011909.dat
1/15/2013	3:15 PM	2424	virsvd_ob2_12078_011909.lbl
1/15/2013	3:15 PM	2593584	virsvd_ob2_12078_014105.dat
1/15/2013	3:15 PM	2426	virsvd_ob2_12078_014105.lbl
1/15/2013	3:15 PM	4643352	virsvd_ob2_12078_070334.dat
1/15/2013	3:15 PM	2426	virsvd_ob2_12078_070334.lbl
1/15/2013	3:15 PM	209160	virsvd_ob2_12078_071824.dat
1/15/2013	3:15 PM	2424	virsvd_ob2_12078_071824.lbl
1/15/2013	3:15 PM	209160	virsvd_ob2_12078_071933.dat
1/15/2013	3:15 PM	2424	virsvd_ob2_12078_071933.lbl
1/15/2013	3:15 PM	209160	virsvd_ob2_12078_072020.dat
1/15/2013	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 …

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 Parent Directory]

1/15/2013 3:15 PM 711144 virsvd_ob2_12078_011909.dat

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.

pds-geosciences.wustl.edu - FileZilla

File Edit View Transfer Server Bookmarks Help

Host: pds-geosciences.wus Username: anonymous Password:

Response: 125 Data connection already open; Transfer starting.
Response: 226 Transfer complete.
Status: Calculating timezone offset of server...
Command: MDTM virsvd_ob2_12078_215826.dat
Response: 213 20130115211552
Status: Timezone offsets: Server: -21600 seconds. Local: -21600 seconds. Difference: 0 seconds.
Status: Directory listing successful

Local site: C:\

Desktop
My Documents
Computer
C: (OS)

Remote site: _h-mascs-3-virs-cdr-caldata-v1/messmas_2001/data/ddr/ob2/virs/mascs20120318/vis

ddr
ob2
virs
mascs20120318
vis

Filename	Filesize	Filetype	Last modified
Config.Msi			
System Volume Information			
Program Files (x86)			
temp			

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...

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

Other files you might need

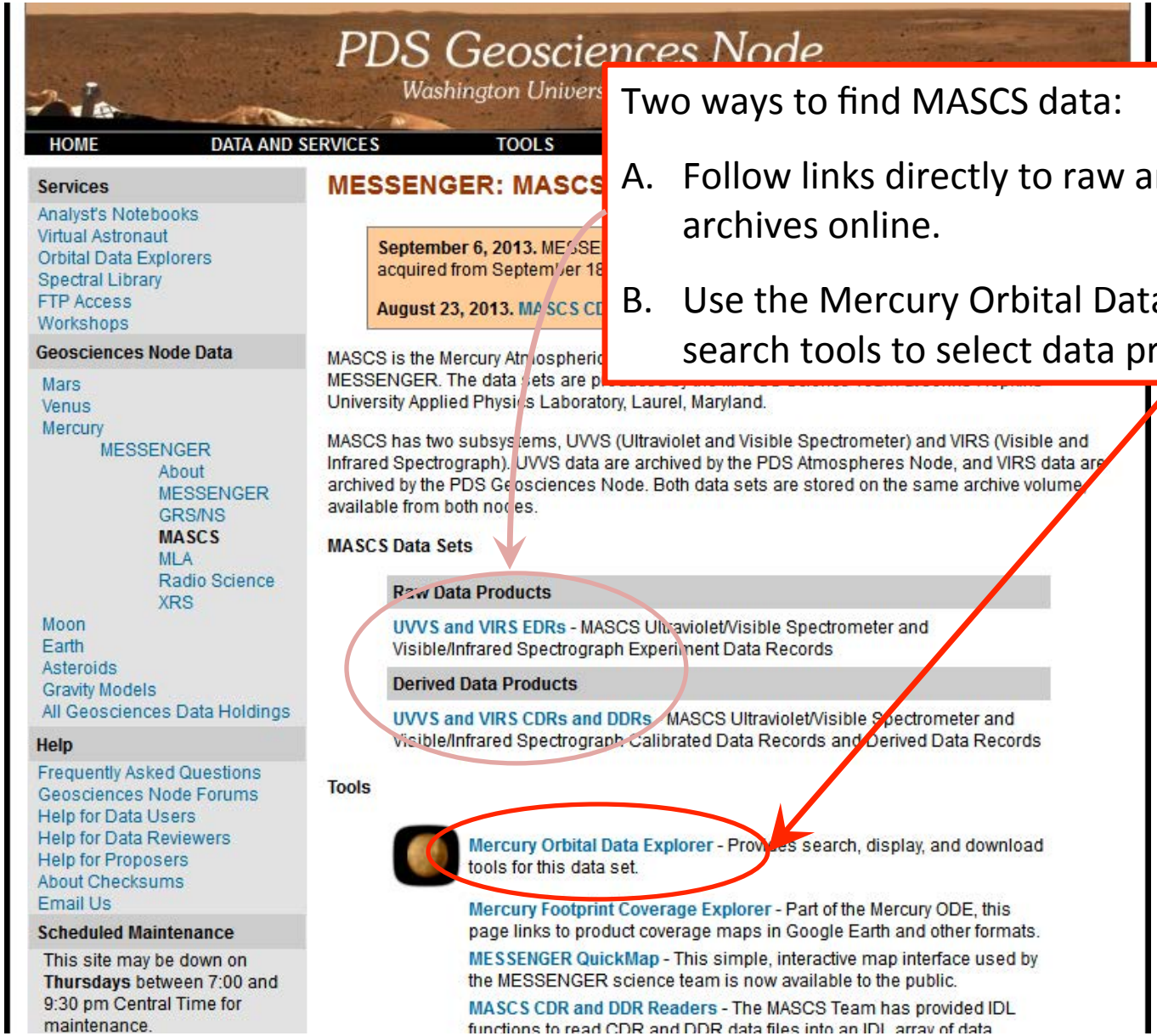
pds-geosciences.wustl.edu - /messenger/mess-e_v_h-mascs-3-virs-cdr-caldata-v1/messmas_2001/document/

[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	203676	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.

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

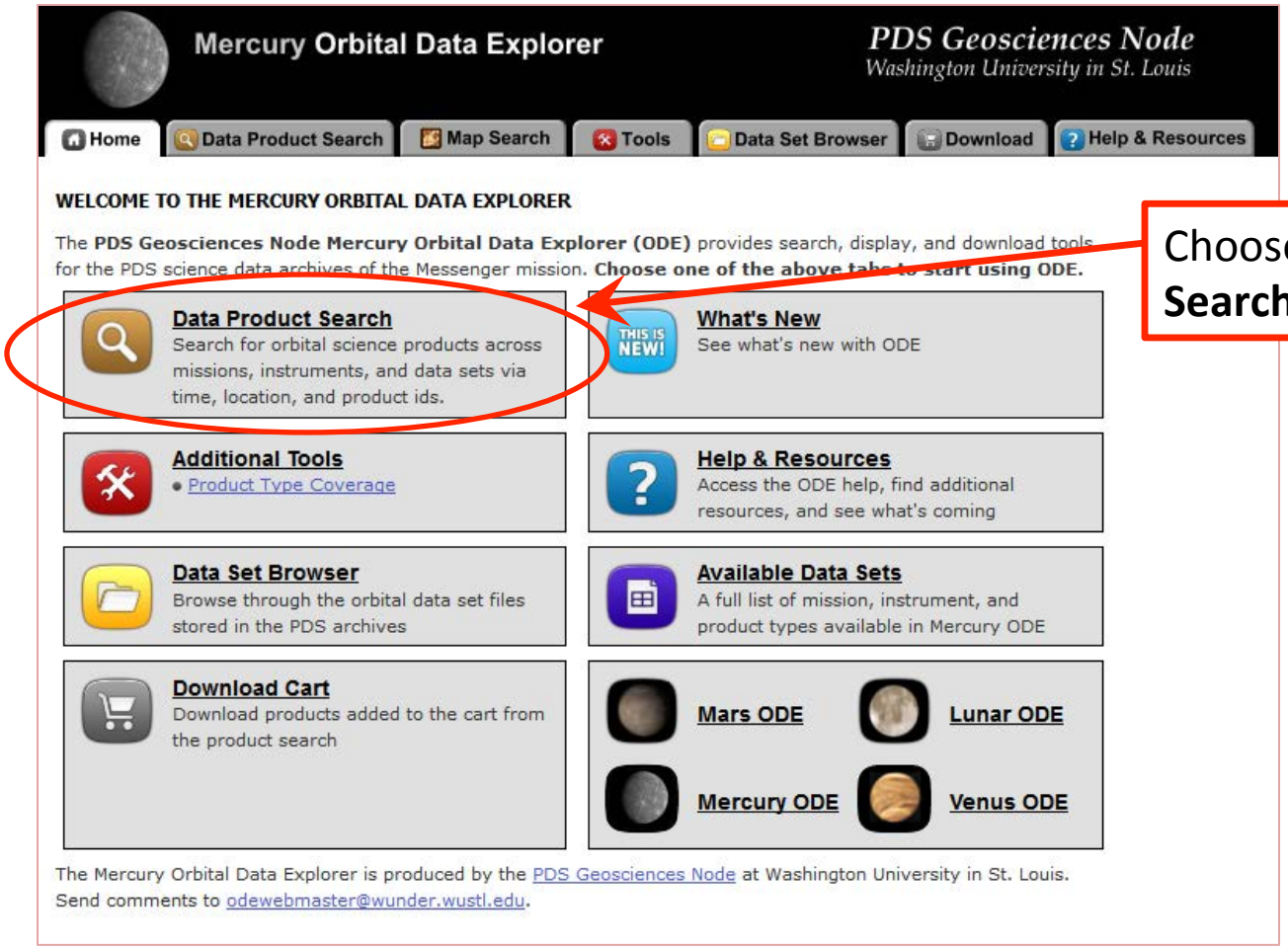


Two ways to find MASCS data:

A. Follow links directly to raw and derived archives online.

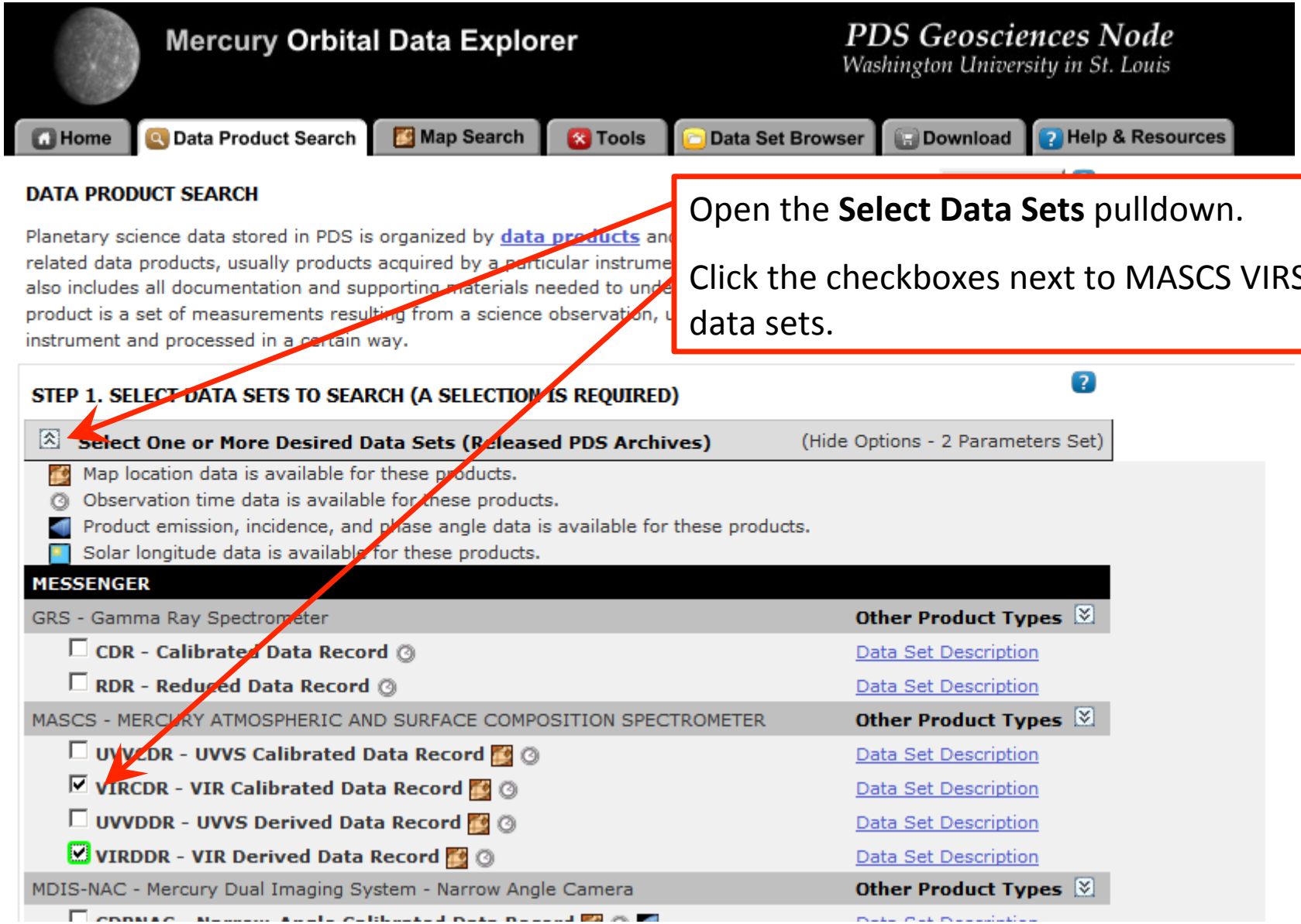
B. Use the Mercury Orbital Data Explorer search tools to select data products.

Method B: Using the Mercury Orbital Data Explorer



Choose **Data Product Search**.

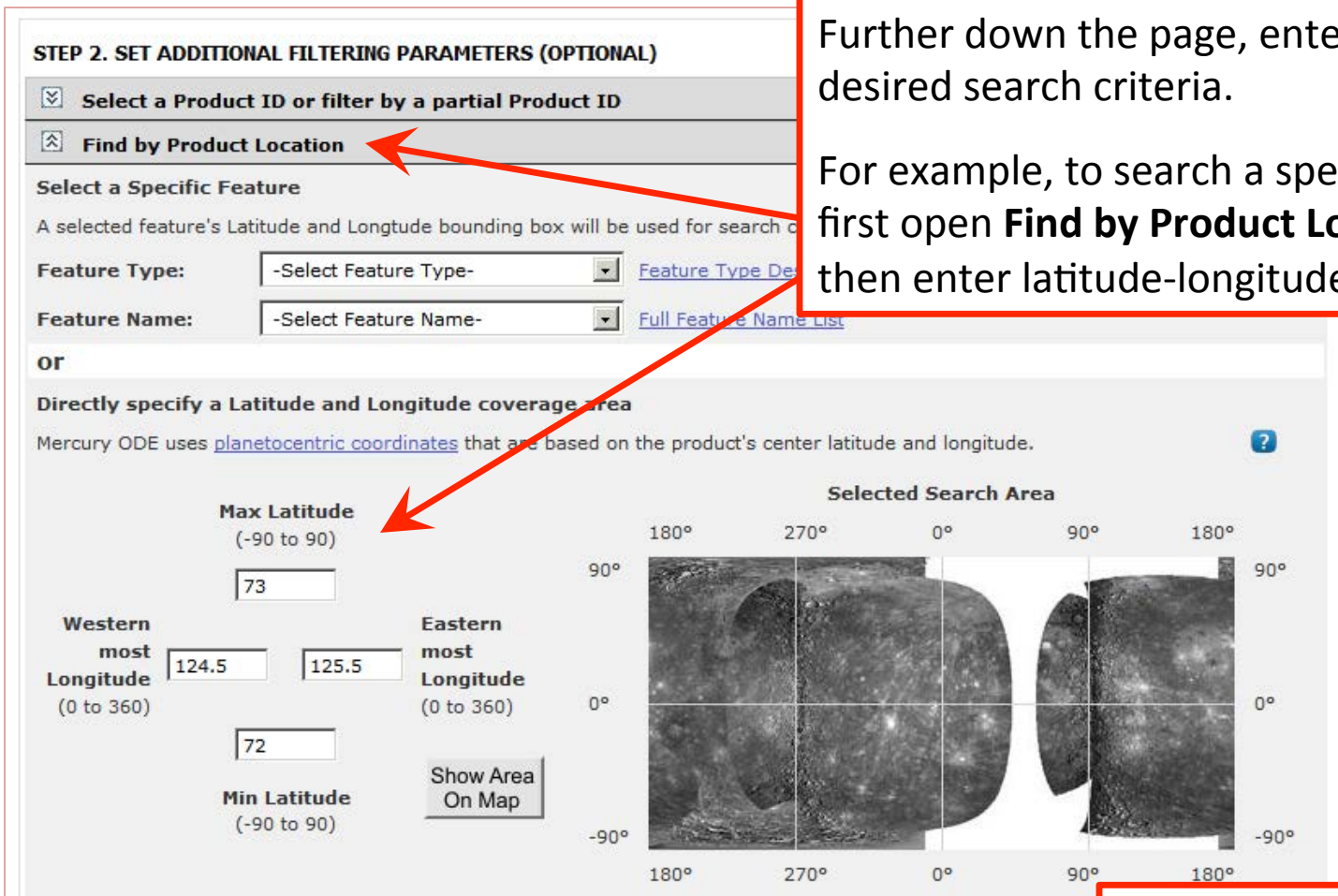
Method B: Using the Mercury Orbital Data Explorer, continued



Open the **Select Data Sets** pulldown.

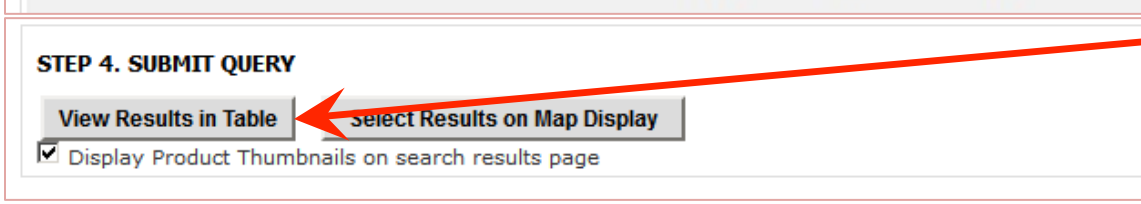
Click the checkboxes next to MASCS VIRS data sets.

Method B: Using the Mercury Orbital Data Explorer, continued



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.



When ready, choose **View Results in Table**.

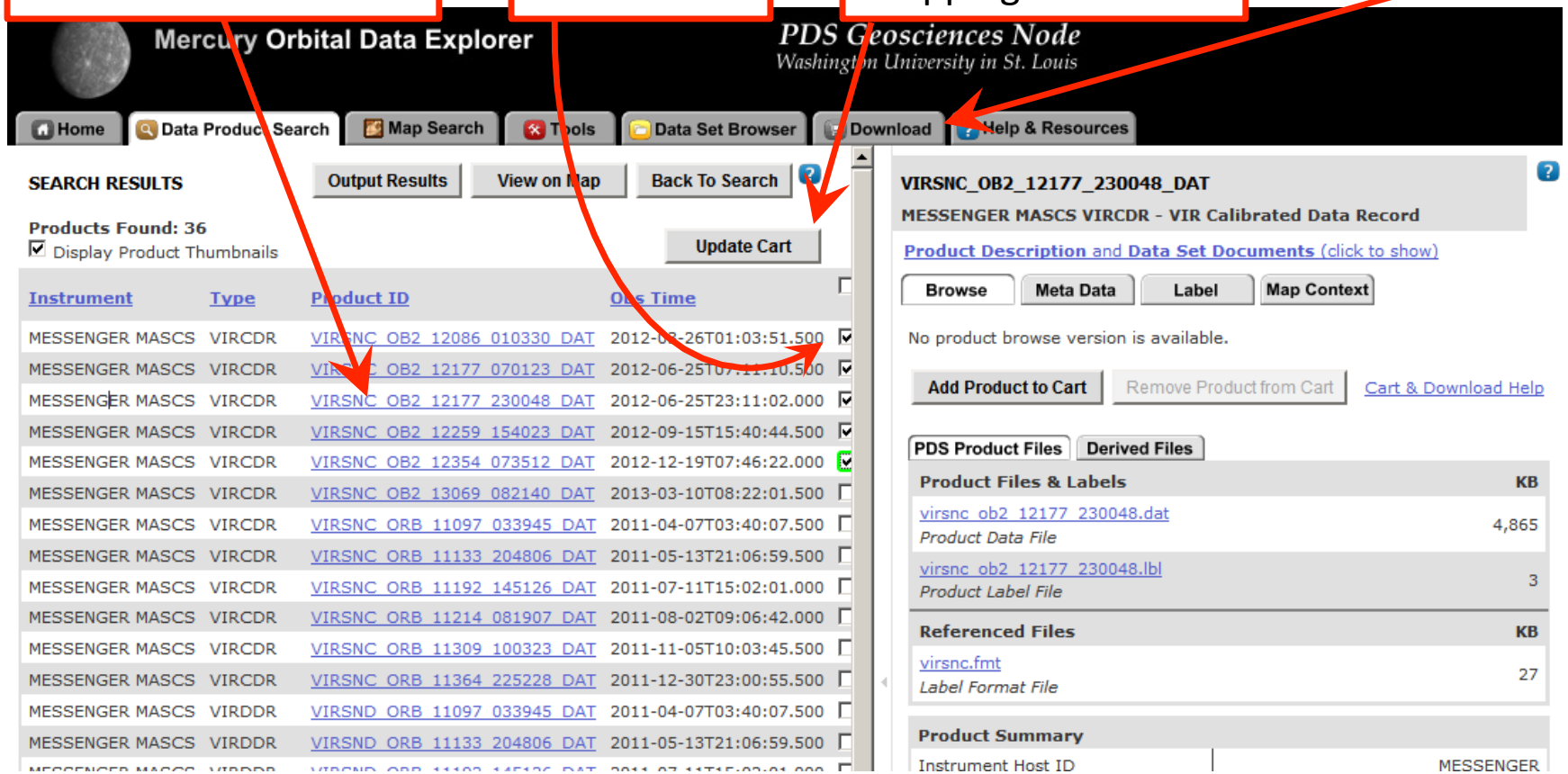
Method B: Using the Mercury Orbital Data Explorer, continued

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

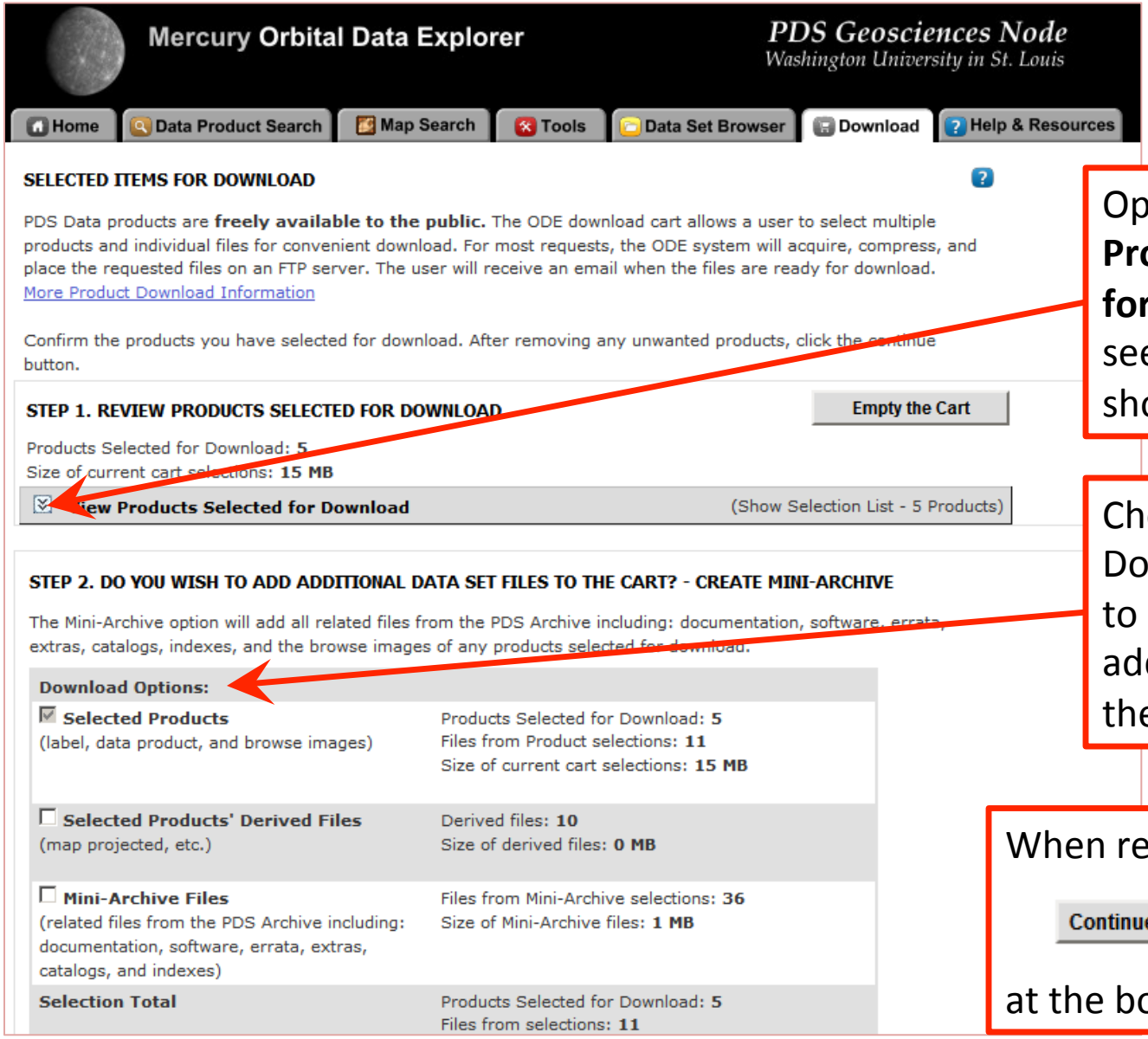
Check the products to be downloaded

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

When ready, click **Download**.



Method B: Using the Mercury Orbital Data Explorer, continued



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

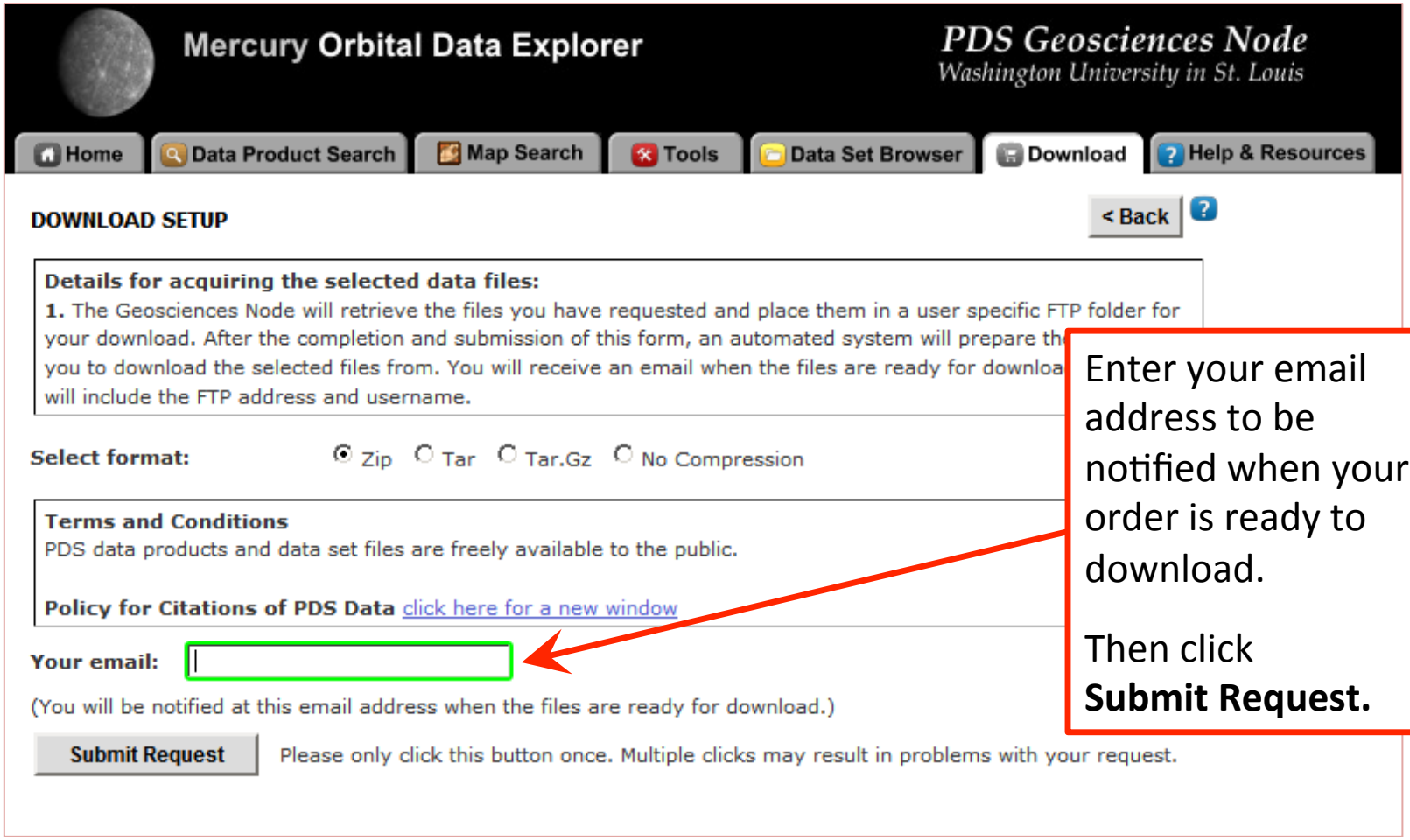
Check one of the Download Options to include additional files in the cart.

When ready, click

Continue >

at the bottom of the page.

Method B: Using the Mercury Orbital Data Explorer, continued



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

Then click **Submit Request.**

Other Useful Tools

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
- 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 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.

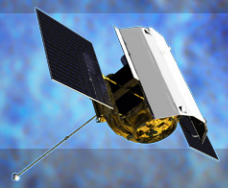
MASCS CDR and DDR Readers help read data into IDL.

For More Information

Visit the PDS Geosciences Node booth at LPSC to talk with PDS representatives and get a hands-on demonstration.

Questions after LPSC? Try the 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.



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)
- Reads MASCS data 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

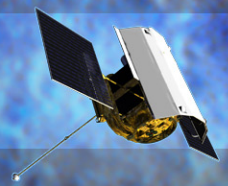
IDL Readers – Required Files

- 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

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

MESSENGER
MErcury Surface, Space ENvironment, GEochemistry, and Ranging



MASCS/VIRS Data Access Using Quickmap

Noam Izenberg (on behalf of the MASCS team)
JHU/APL

MASCS/VIRS Data Users' Workshop
LPSC 2014, The Woodlands, TX
March 17,2014

MASCS VIRS Data Access Using Quickmap

Noam Izenberg for the MASCS team
JHU/APL
noam.izenberg@jhuapl.edu

MESSENGER

MErcury Surface, Space ENvironment, GEochemistry, and Ranging

A NASA Discovery mission to conduct the first orbital study of the innermost planet

NASA | Carnegie Institution for Science | APL

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- The Mission
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Download iPhone/iPad App!

Explore Orbital Data with QuickMap

MESSENGER Q&A

Information about Mercury Orbital Operations

Where is MESSENGER?

Where is Mercury Now?

Subscribe to MESSENGER e-News

High-resolution Targeted Mosaics, Available in QuickMap

Mission Elapsed Time
August 3, 2004

DAYS	HRS	MINS	SECS
3509	11	55	21

Mercury Orbit Insertion
March 18, 2011
00:45 UTC

DAYS	HRS	MINS	SECS
1091	17	26	02

Time since Insertion Burn

Orbits Around Mercury

Orbits completed: 2885

Time until start of next orbit (hh:mm:ss): 04:01:04

Orbit start is at maximum altitude.

Mission News

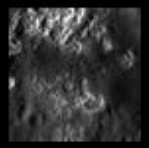
March 7, 2014

Eleventh MESSENGER Planetary Data System Release Is the Largest Yet

The Planetary Data System (PDS), which archives and distributes data from all of NASA's planetary missions, today released its eleventh batch of data collected by the MESSENGER mission. With this release, images and measurements are now available to the public for the fifth full Mercury solar day of MESSENGER orbital operations. [more]

VIRS Data Users' Workshop

Featured Images



March 12, 2014
High-resolution Hollows

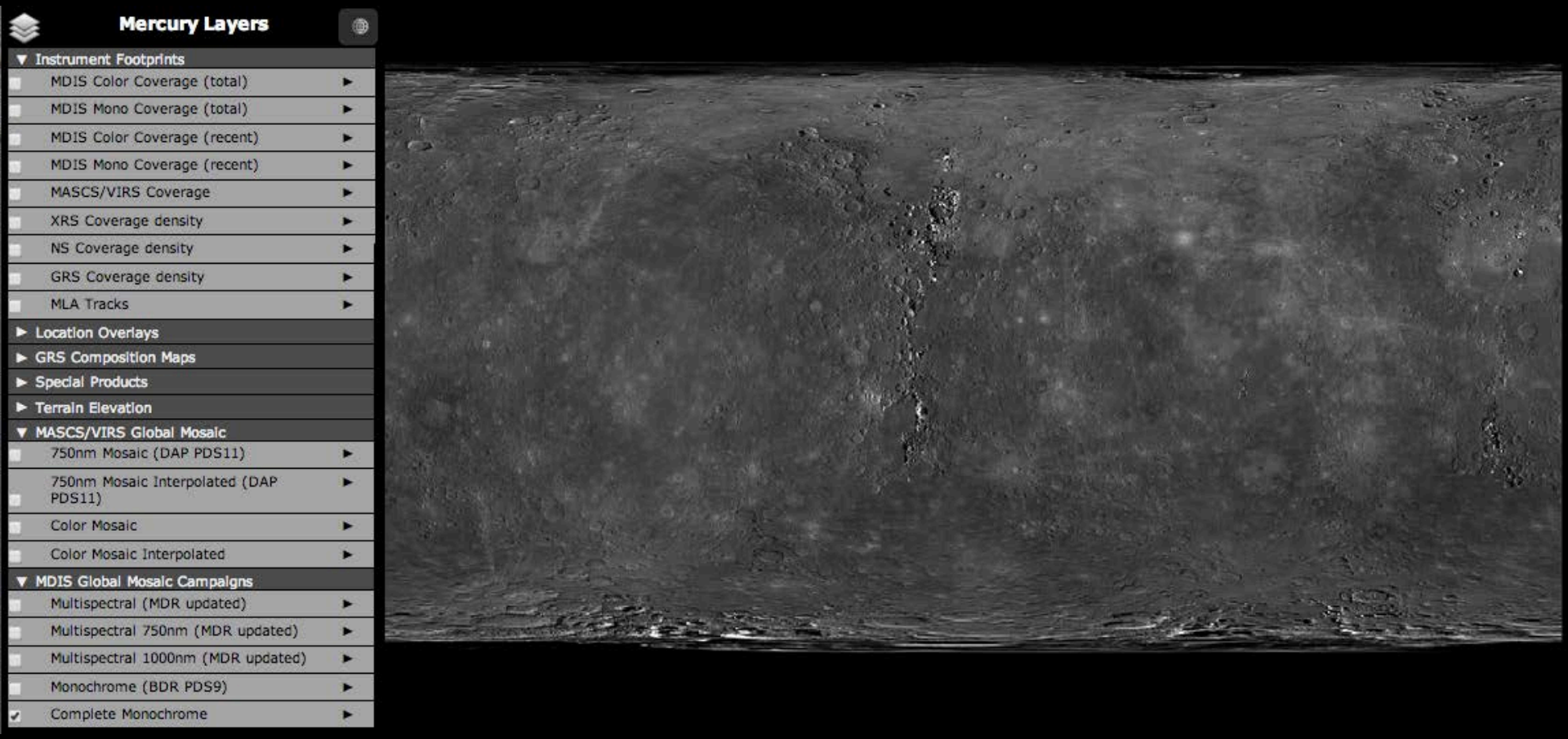
[more]

March 10, 2014
The New Three-Color Mosaic

[more]

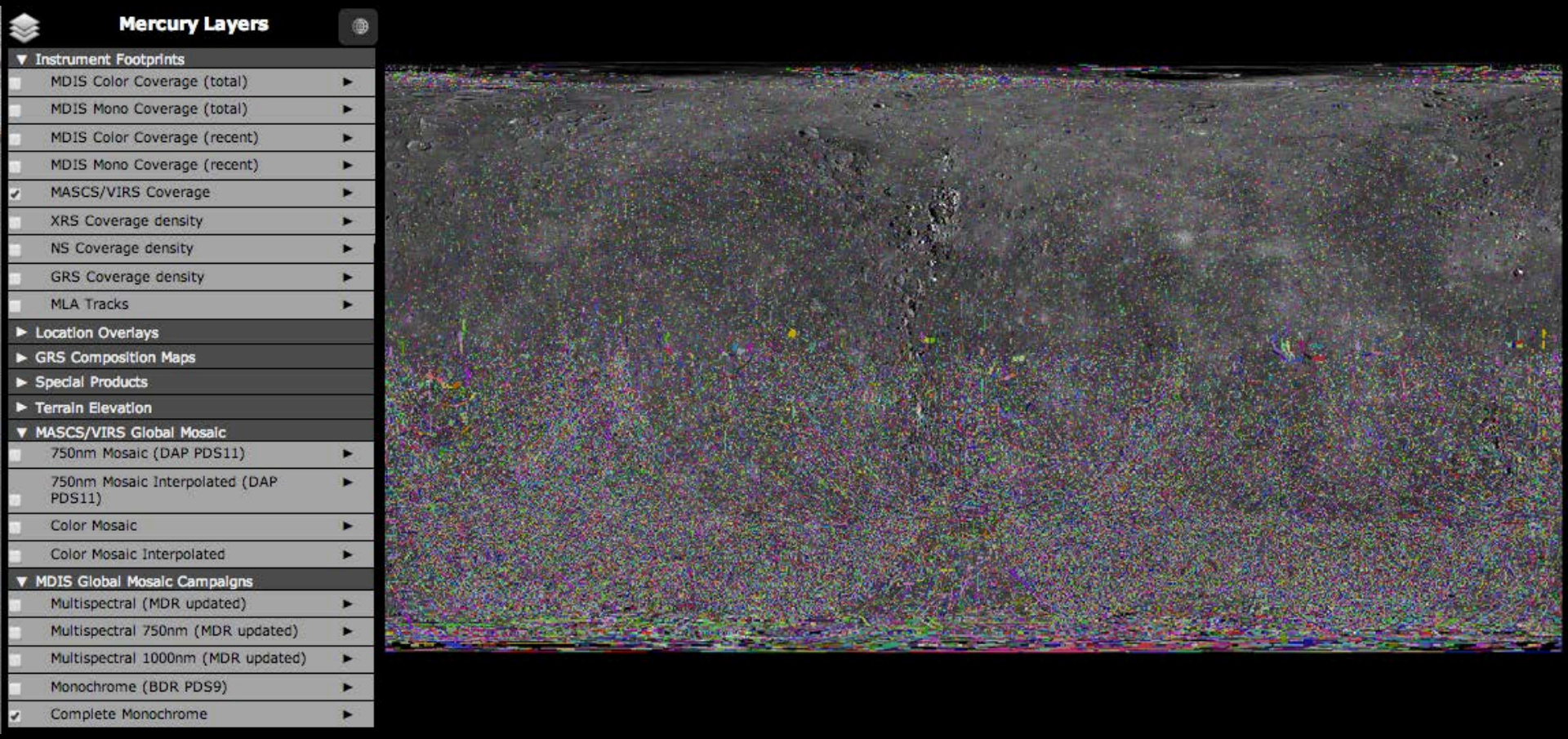
March 7, 2014
Odin Planitia

Global Overview I



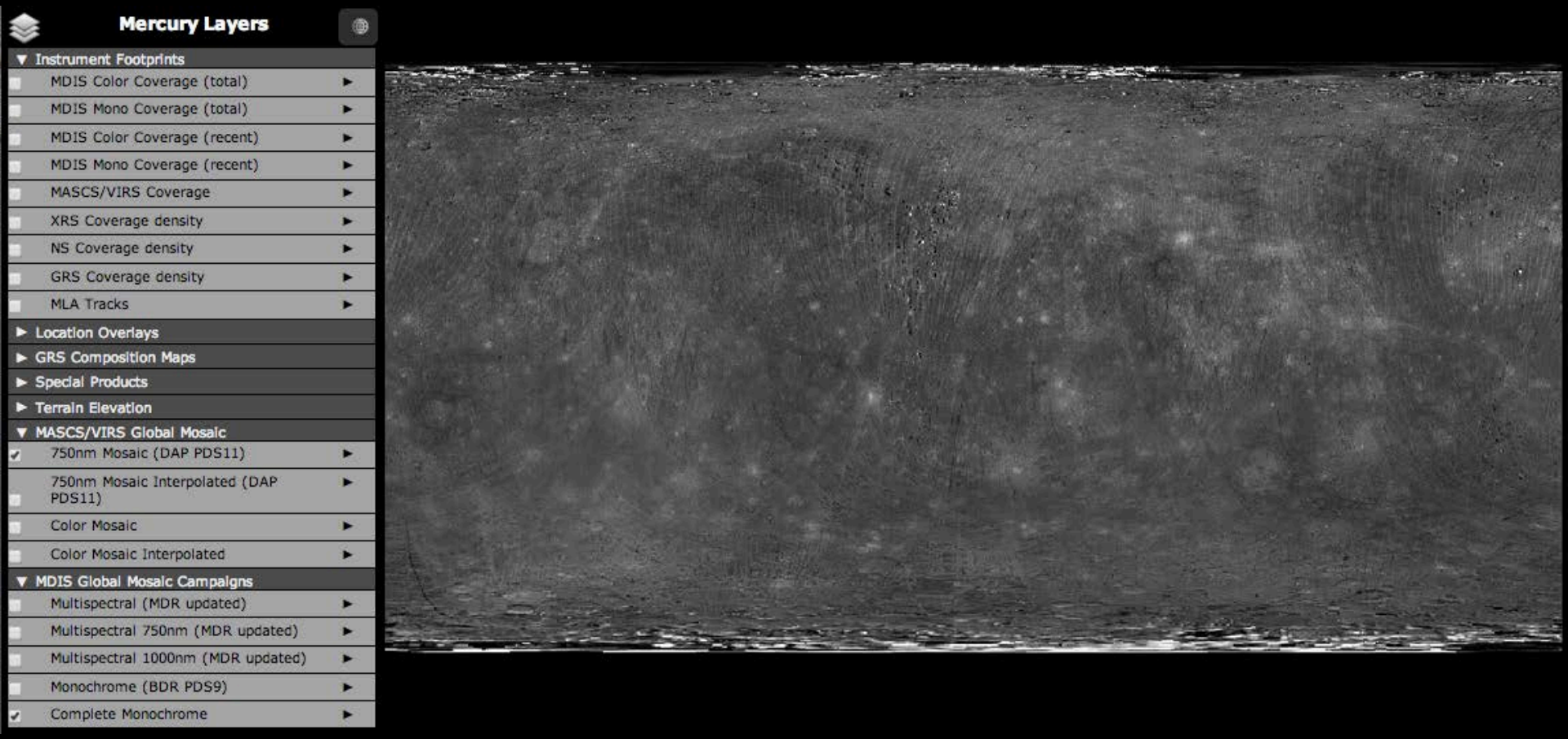
- MDIS basemap

Global Overview II



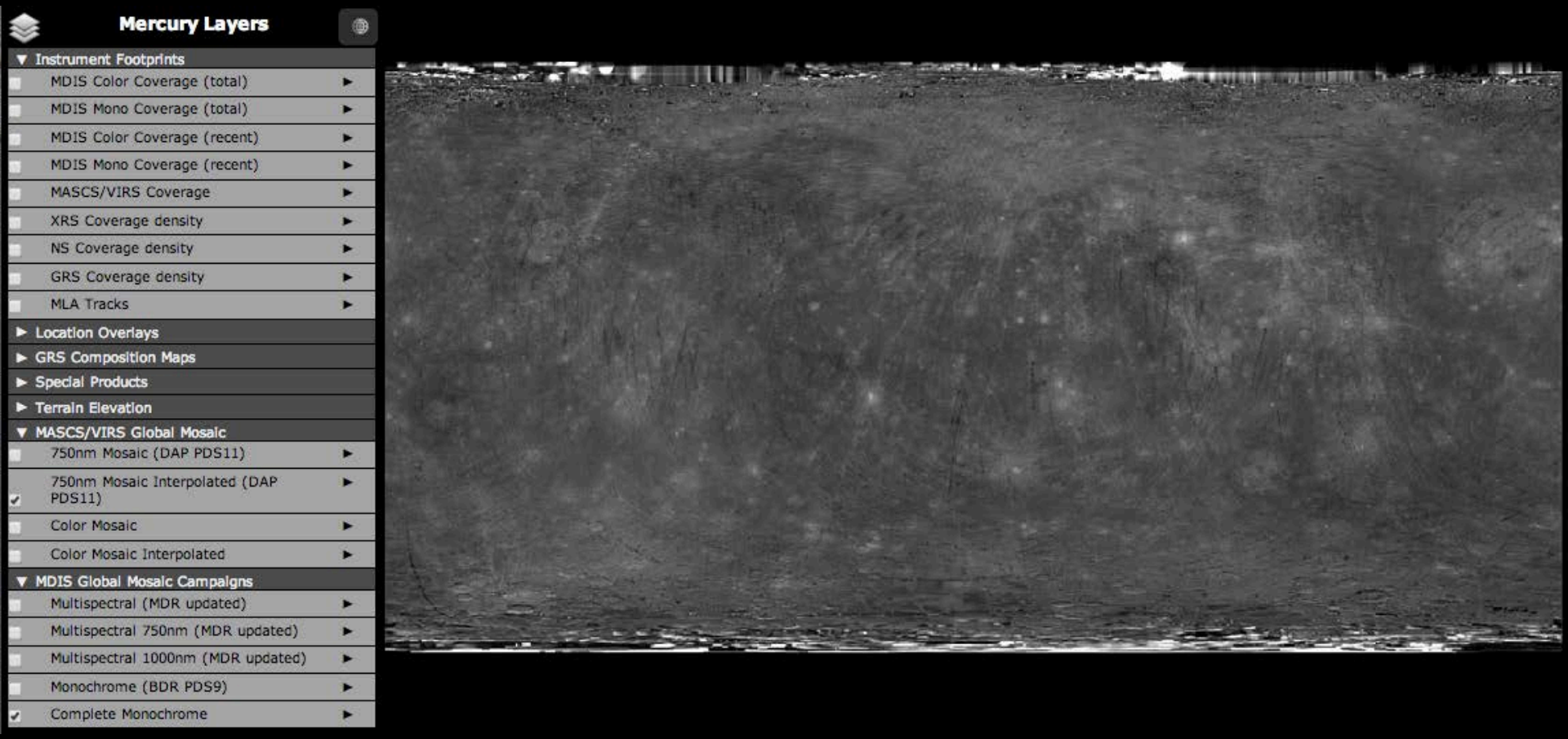
- VIRS Footprint map

Global Overview III



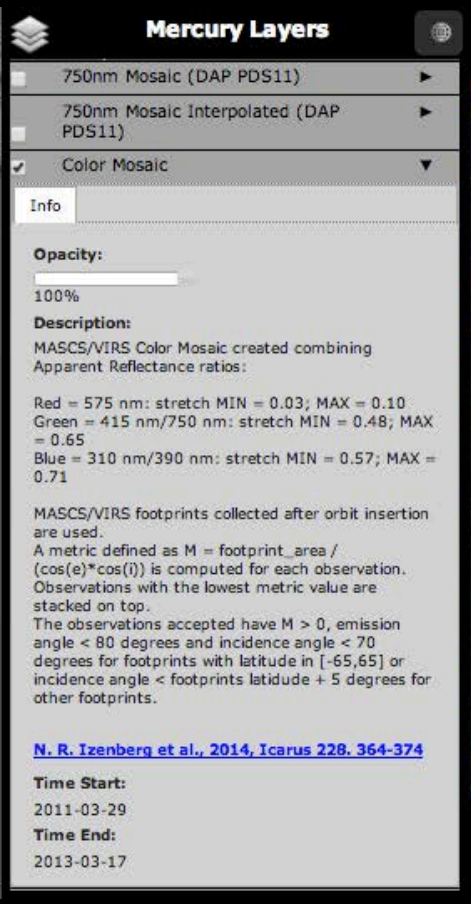
- VIRS 750nm Mosaic (DAP PDS11)

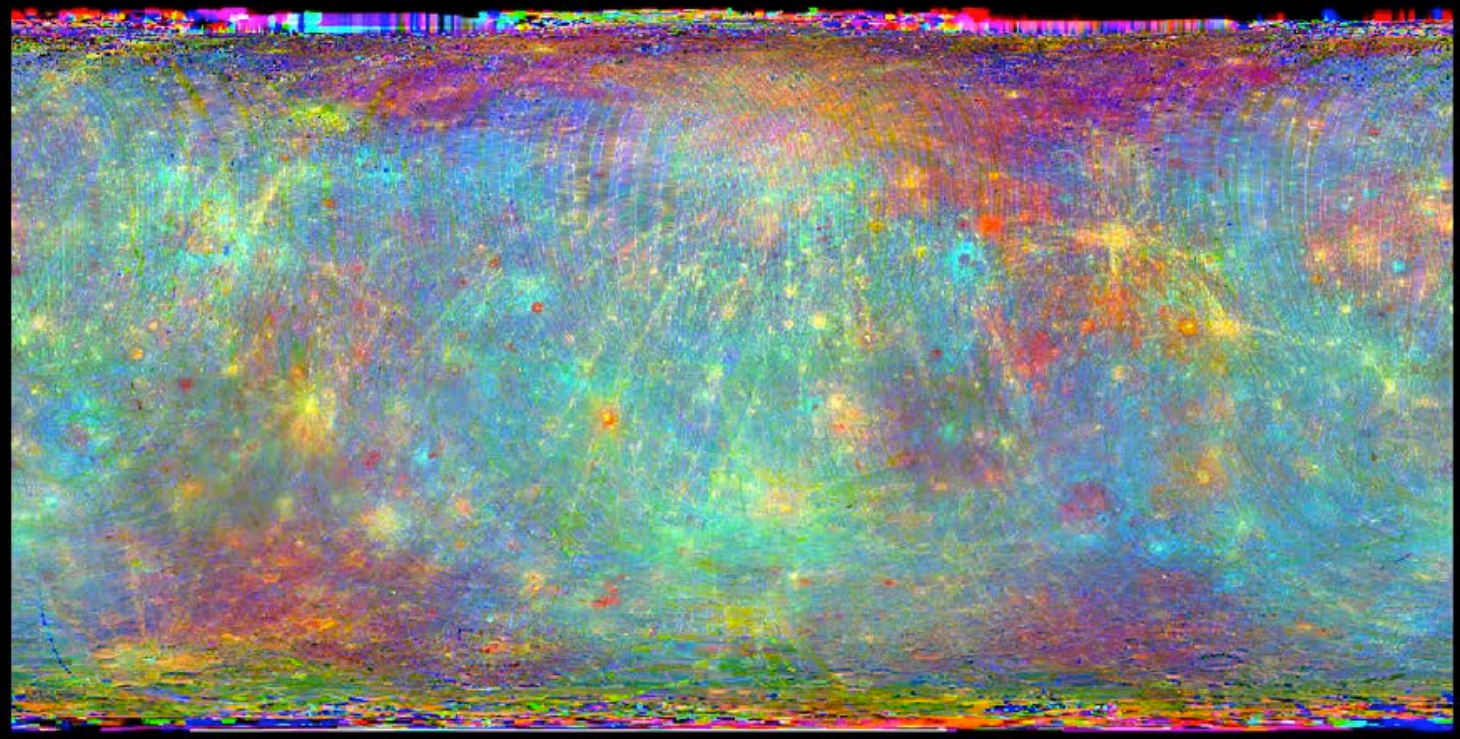
Global Overview IV



- VIRS 750nm Interpolated Mosaic (DAP PDS11)

Global Overview V

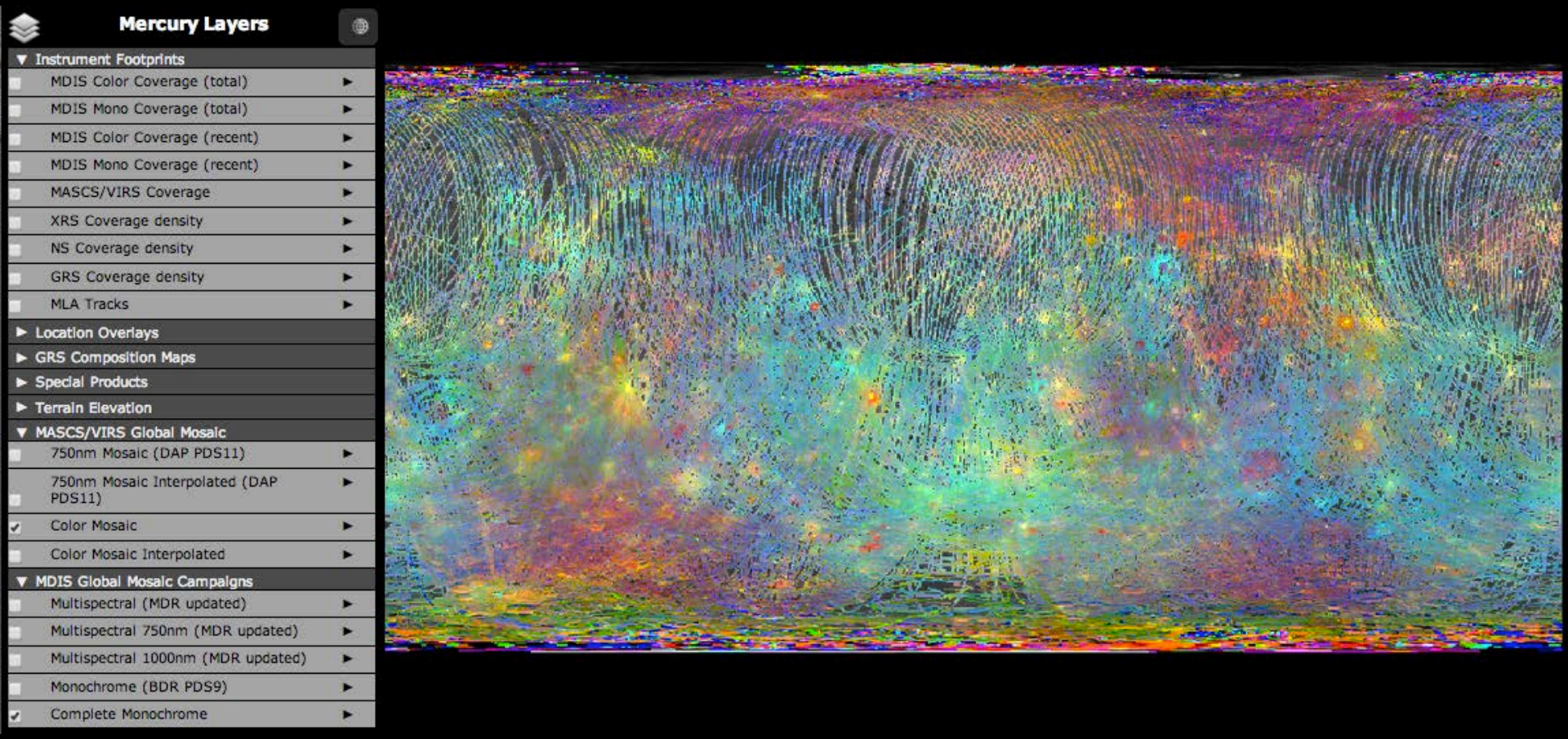




- VIRS Color Mosaic

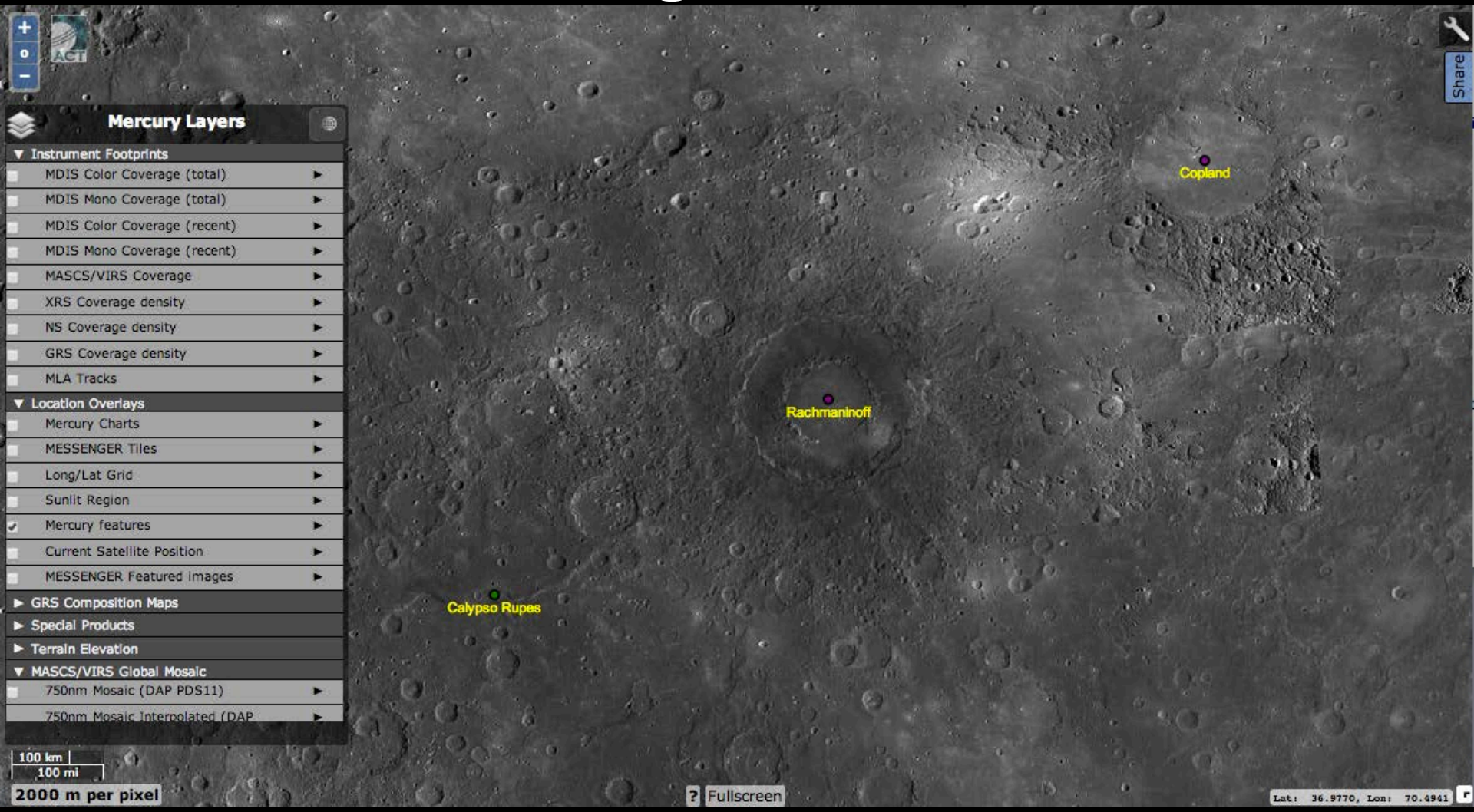
- Red = 575nm Reflectance
- Green = 415 nm / 750 nm
- Blue = 310 nm / 390 nm

Global Overview VI



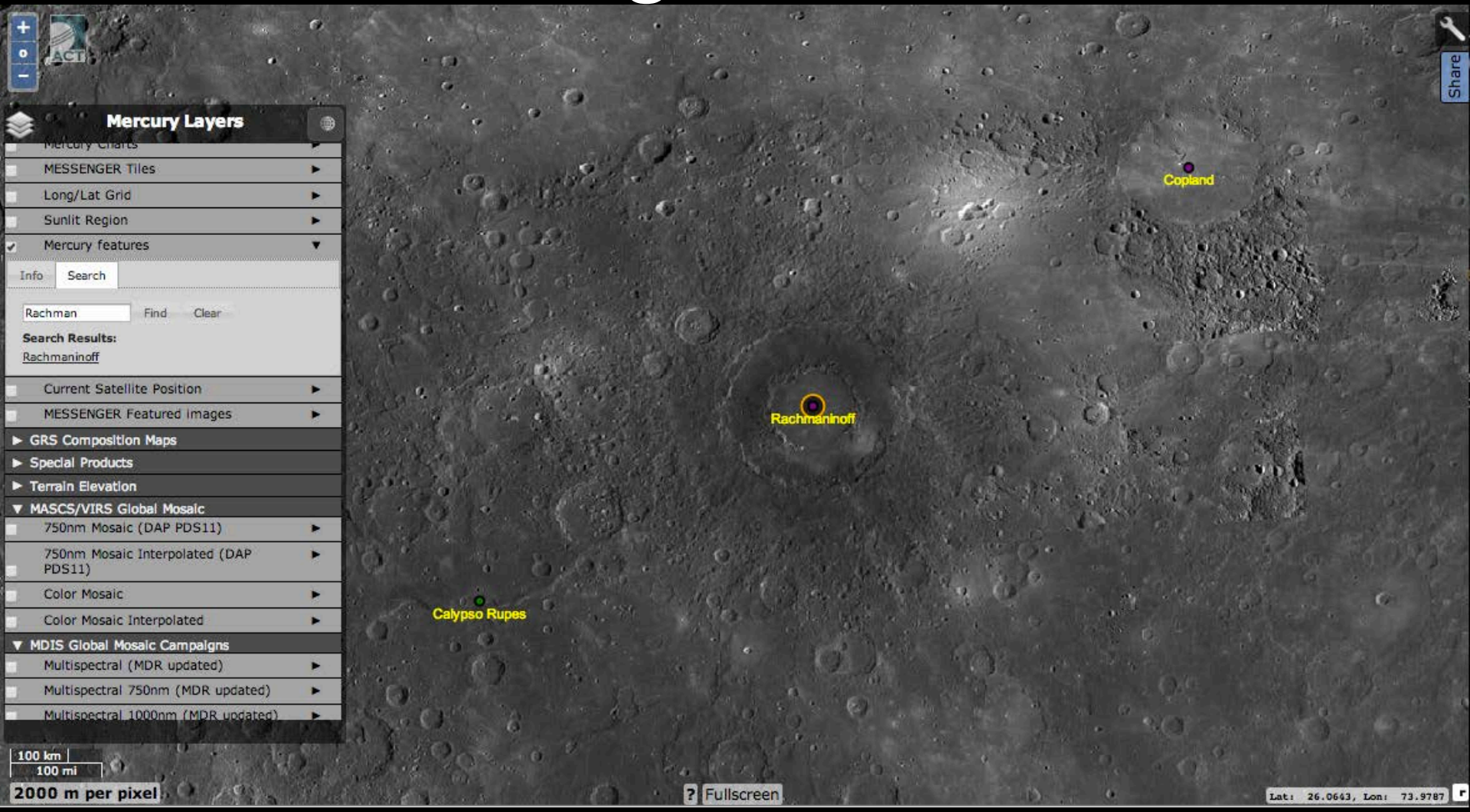
- VIRS Interpolated Color Mosaic

Regional I



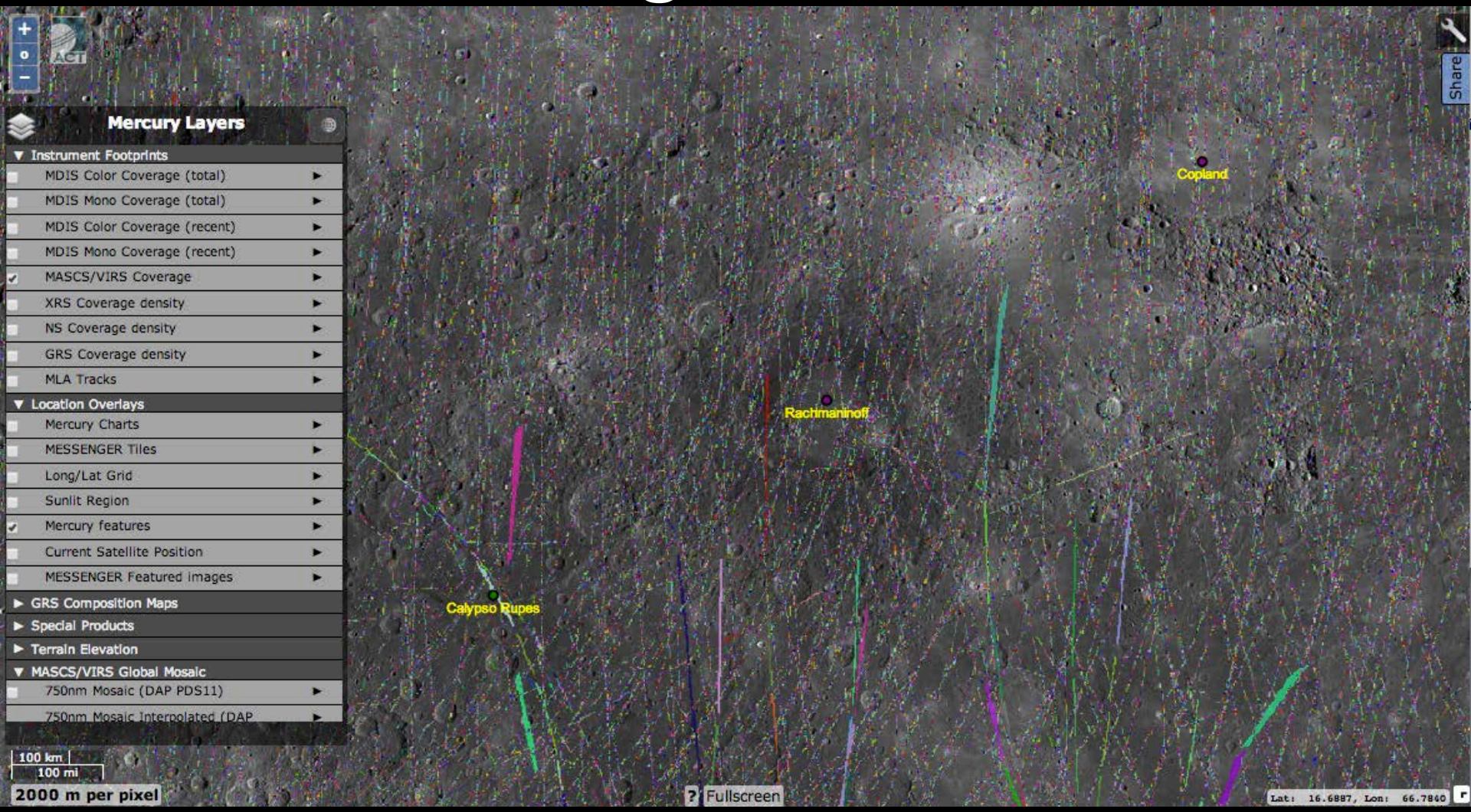
- MDIS basemap

Regional Ib



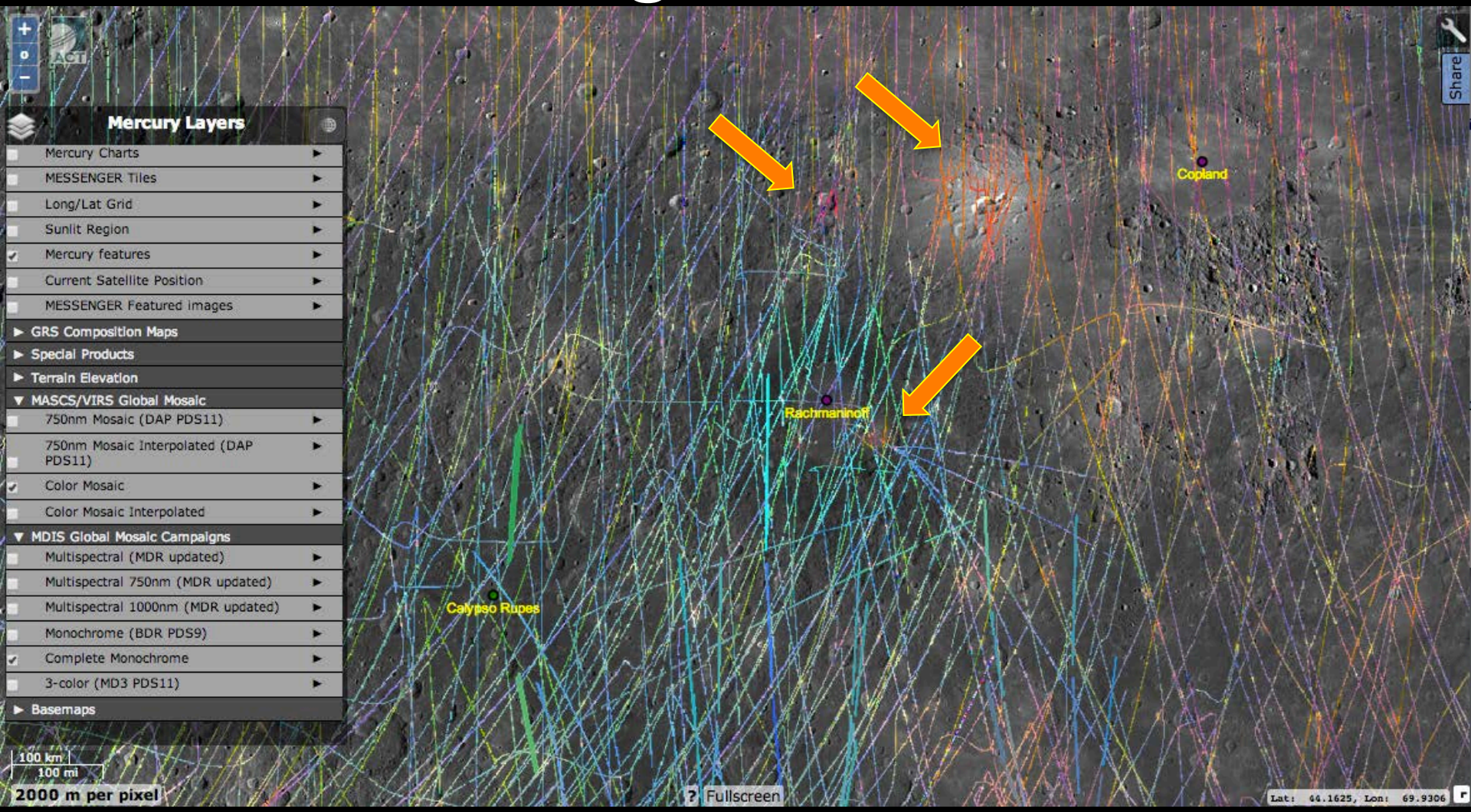
- Search by feature name

Regional II



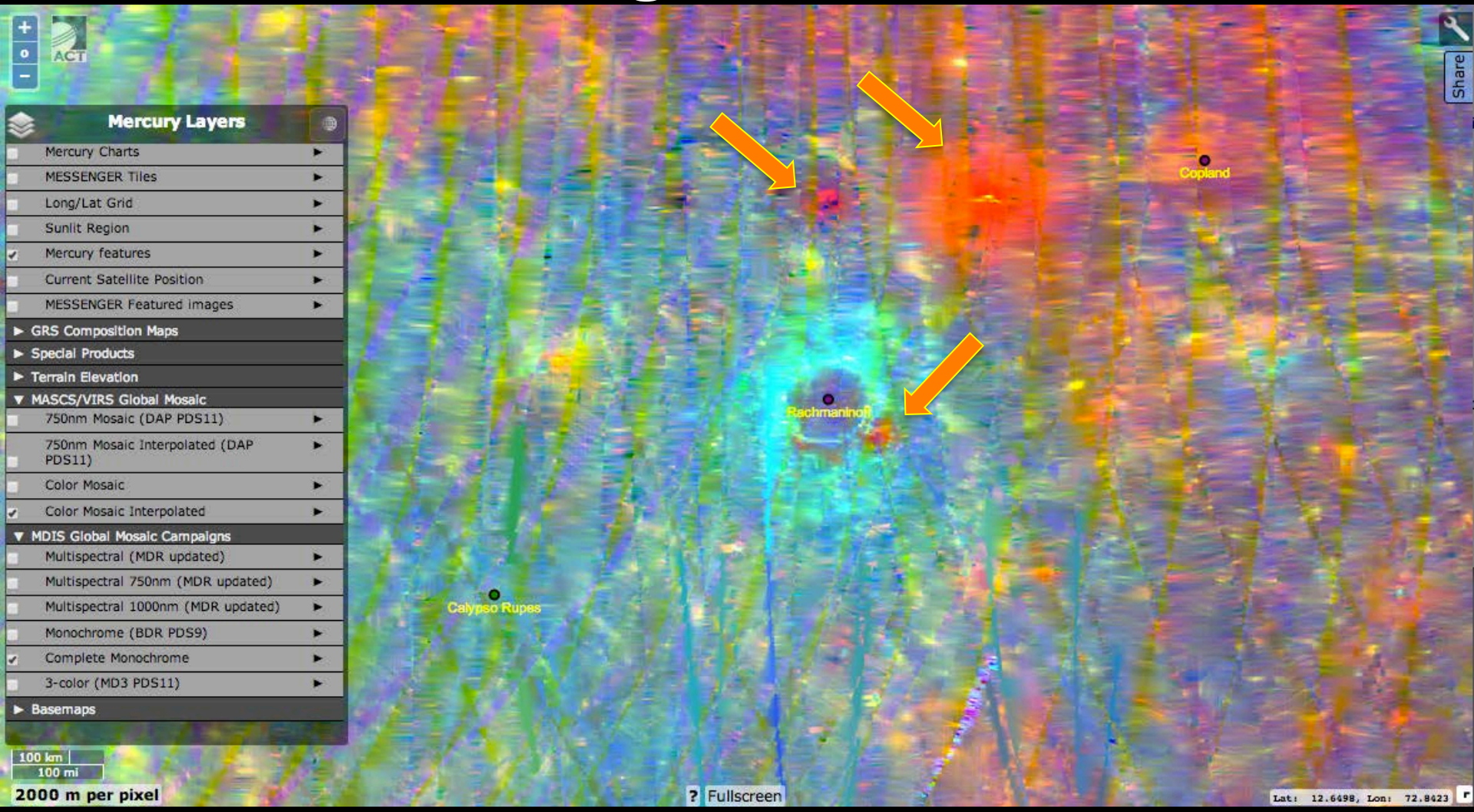
- VIRS Footprint map

Regional III



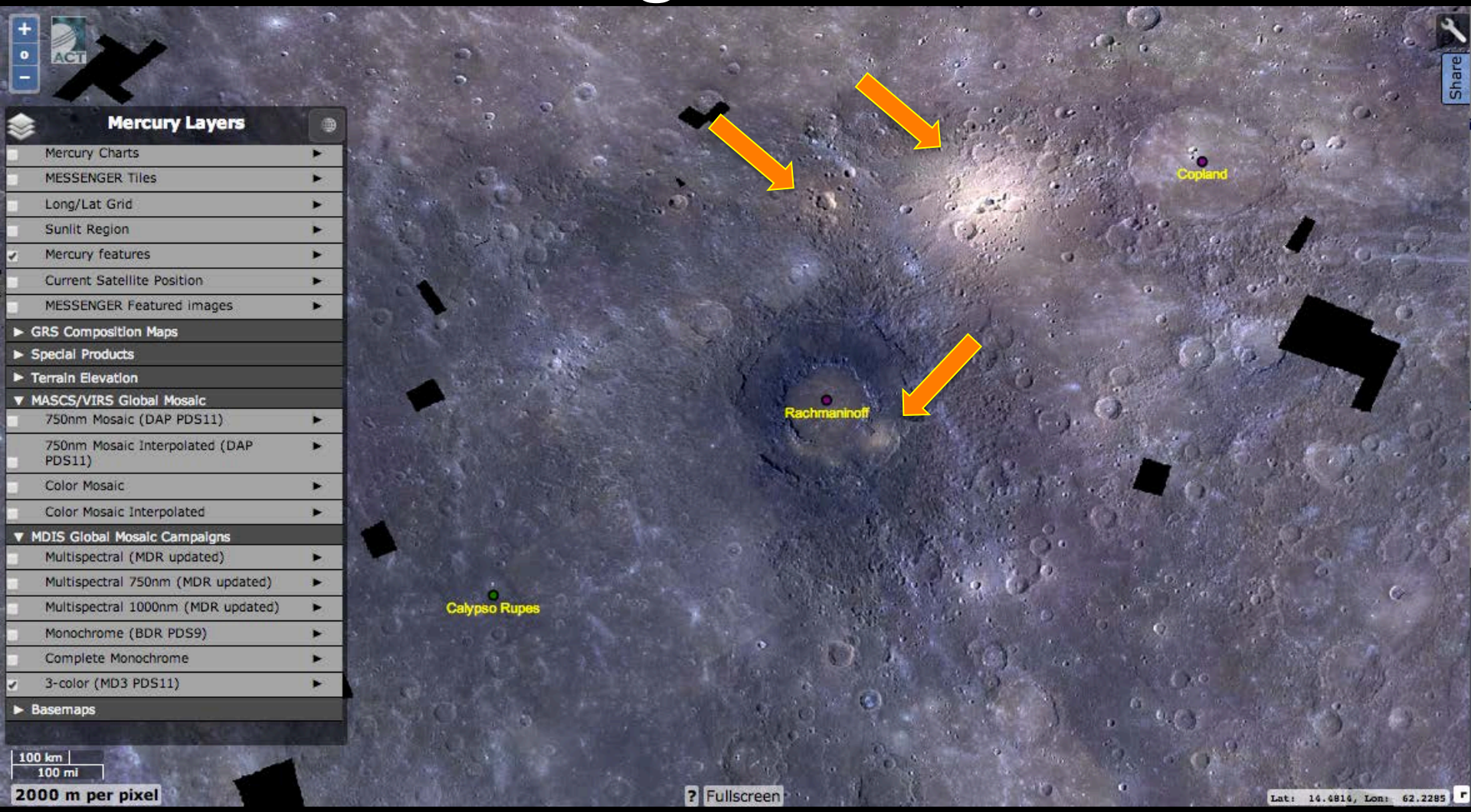
- VIRS Color Mosaic

Regional IV



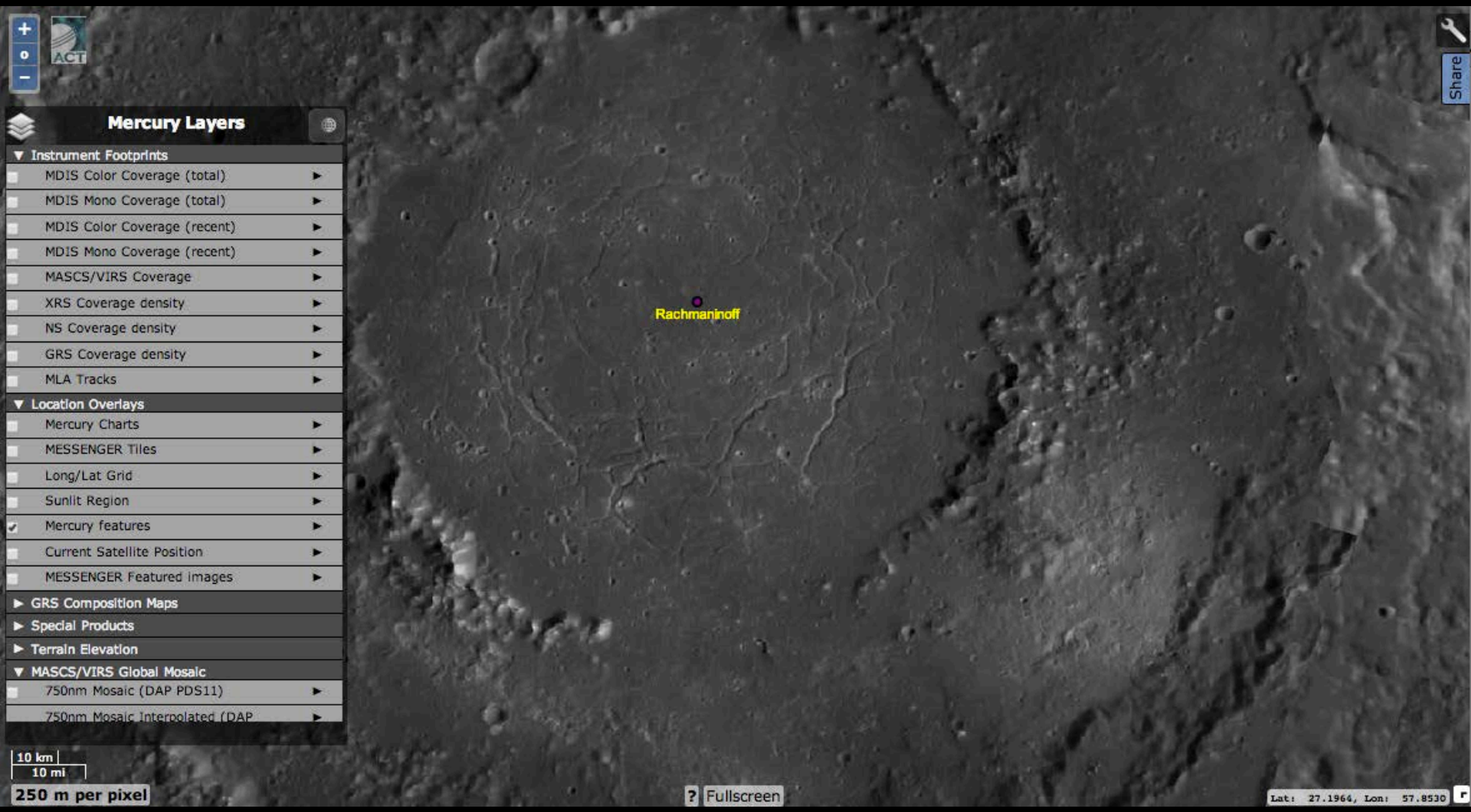
- VIRS Interpolated Color Mosaic

Regional V



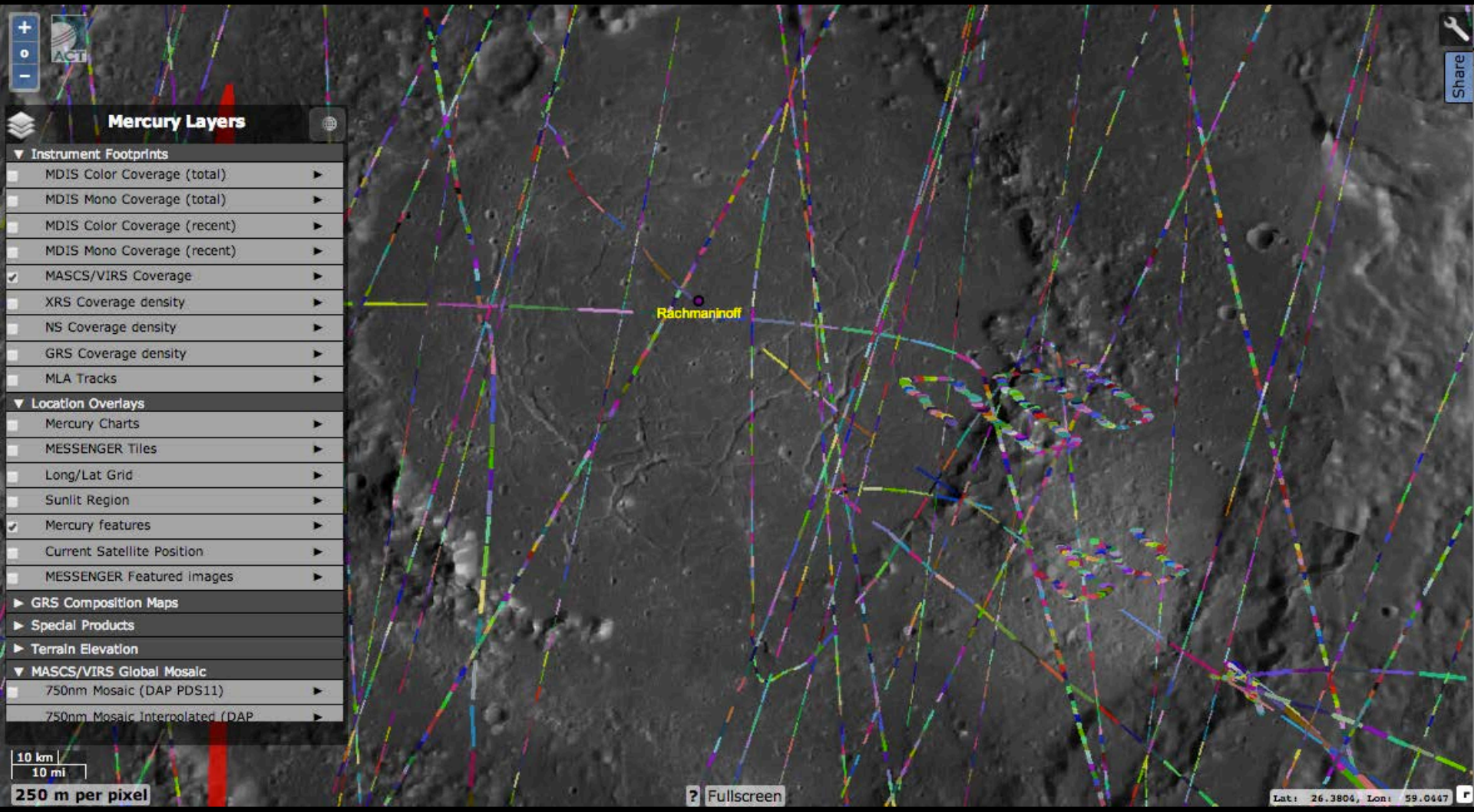
- MDIS Color Mosaic

Local I



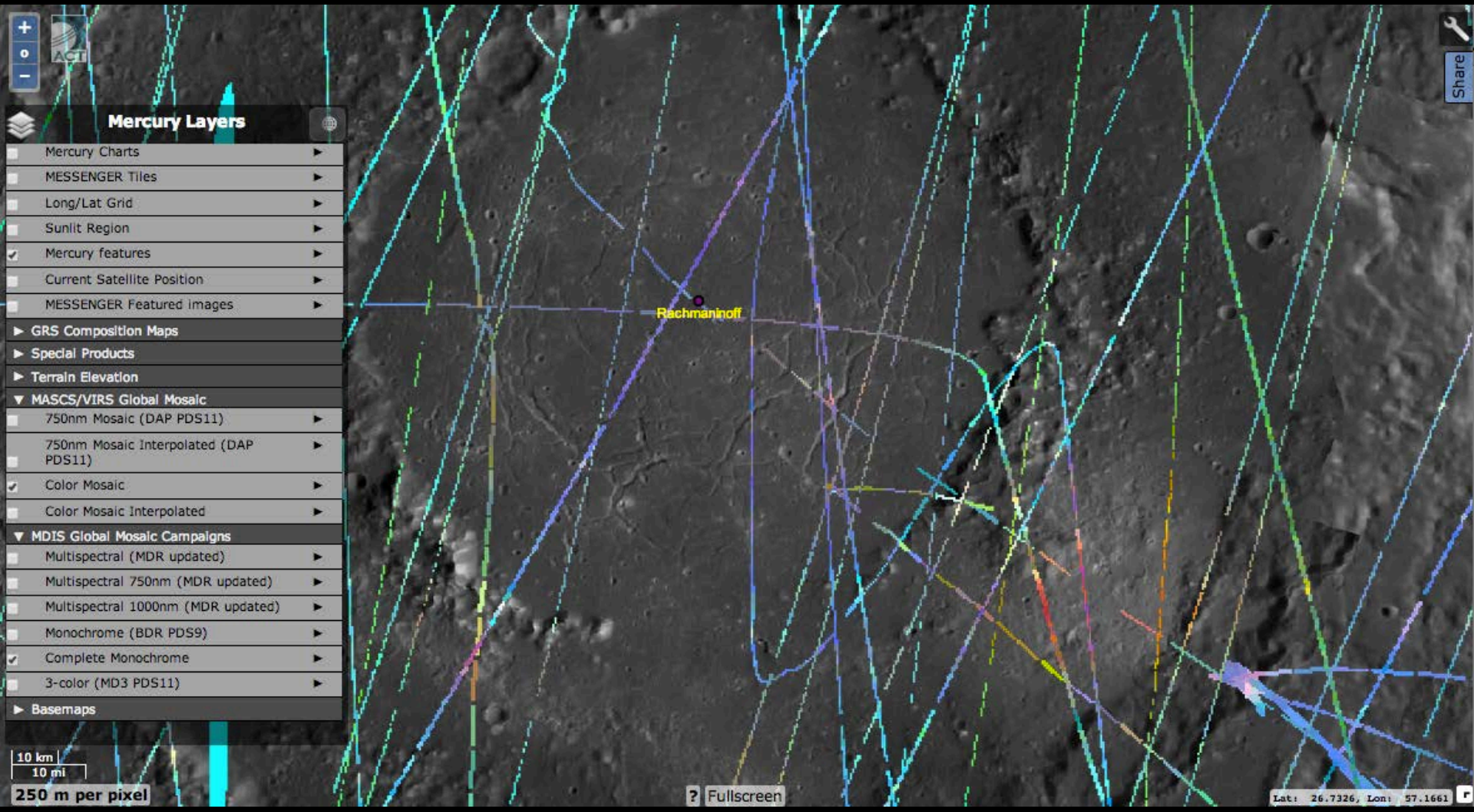
- MDIS basemap

Local II



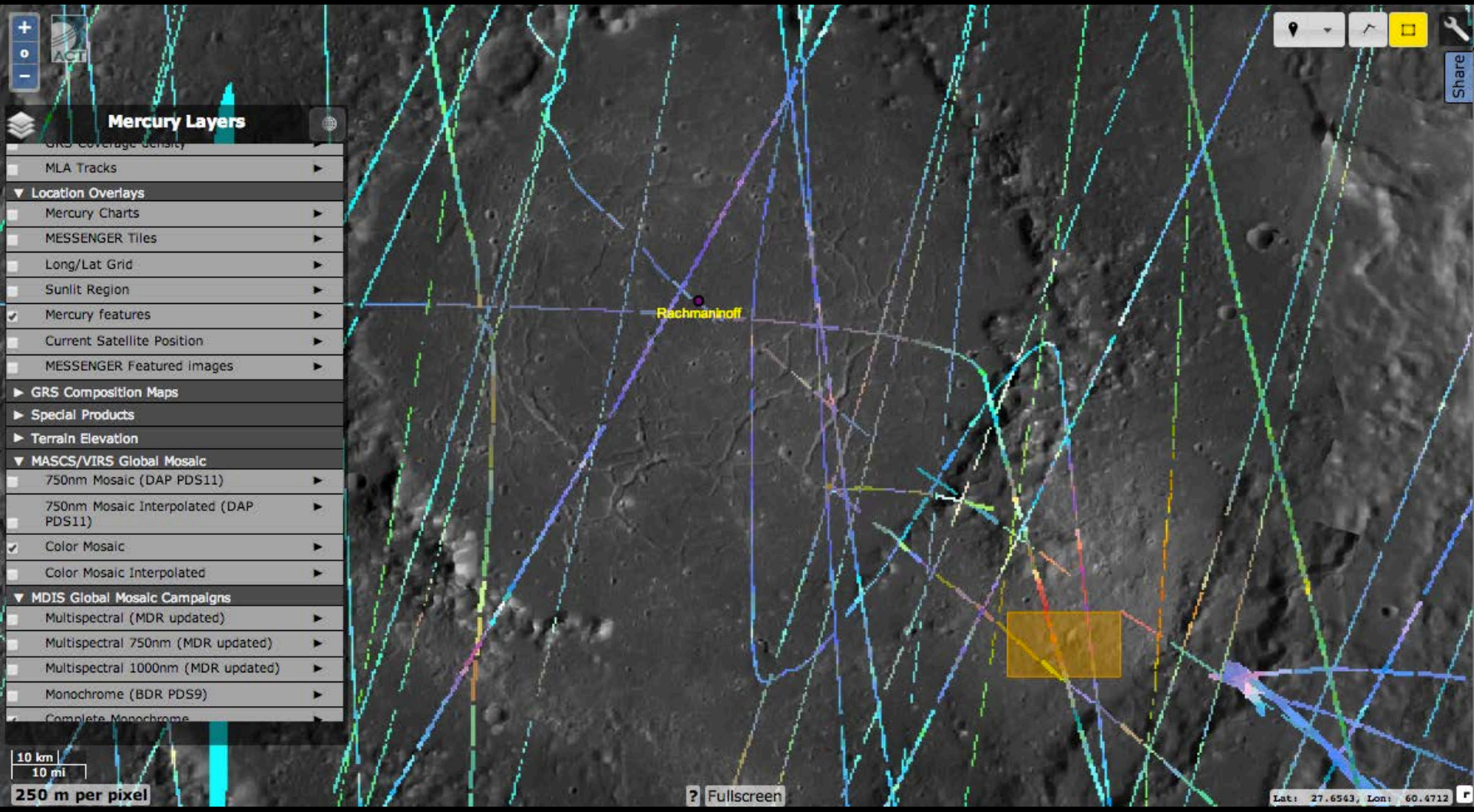
- VIRS Footprint map

Local III



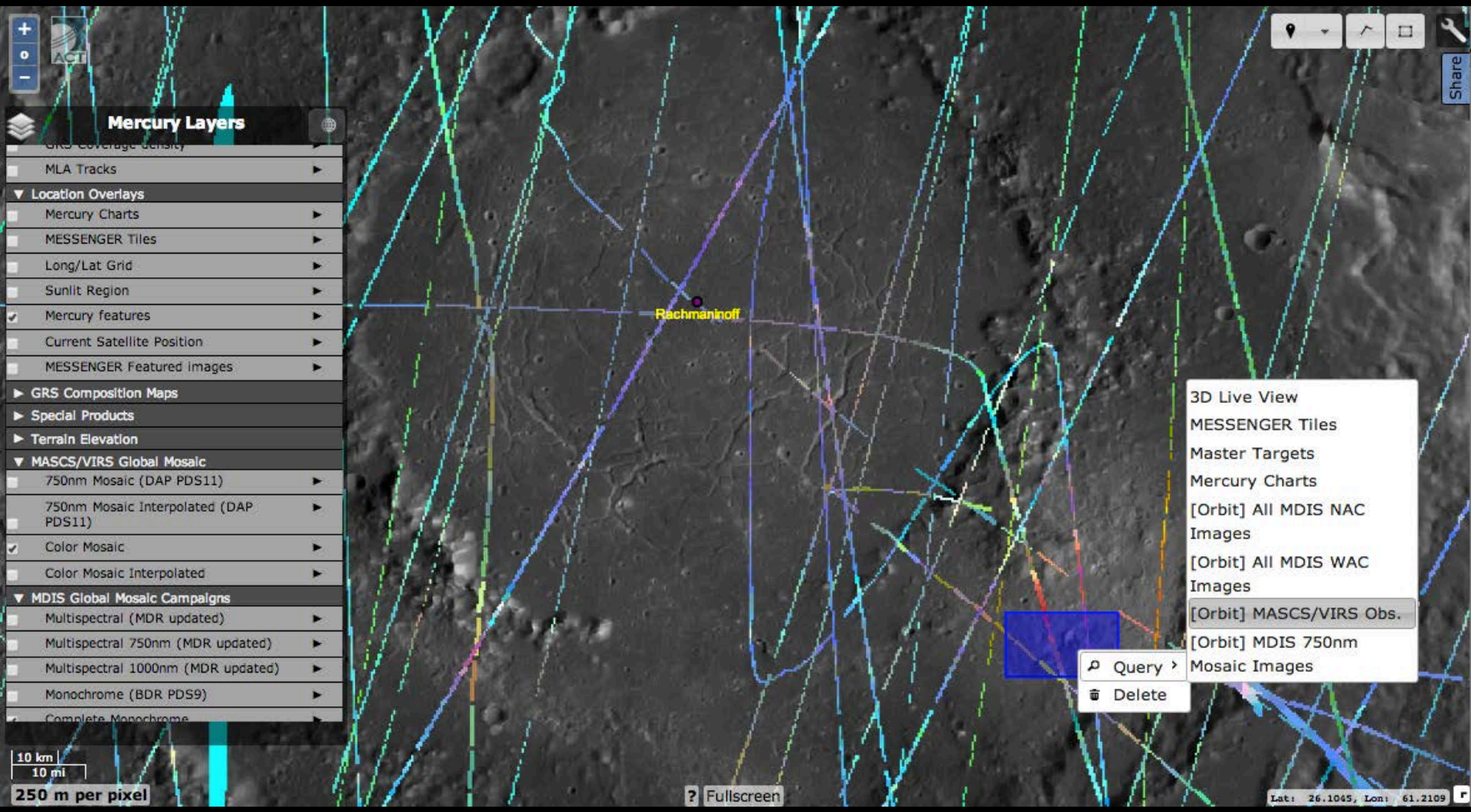
- VIRS Color Mosaic

Local IV



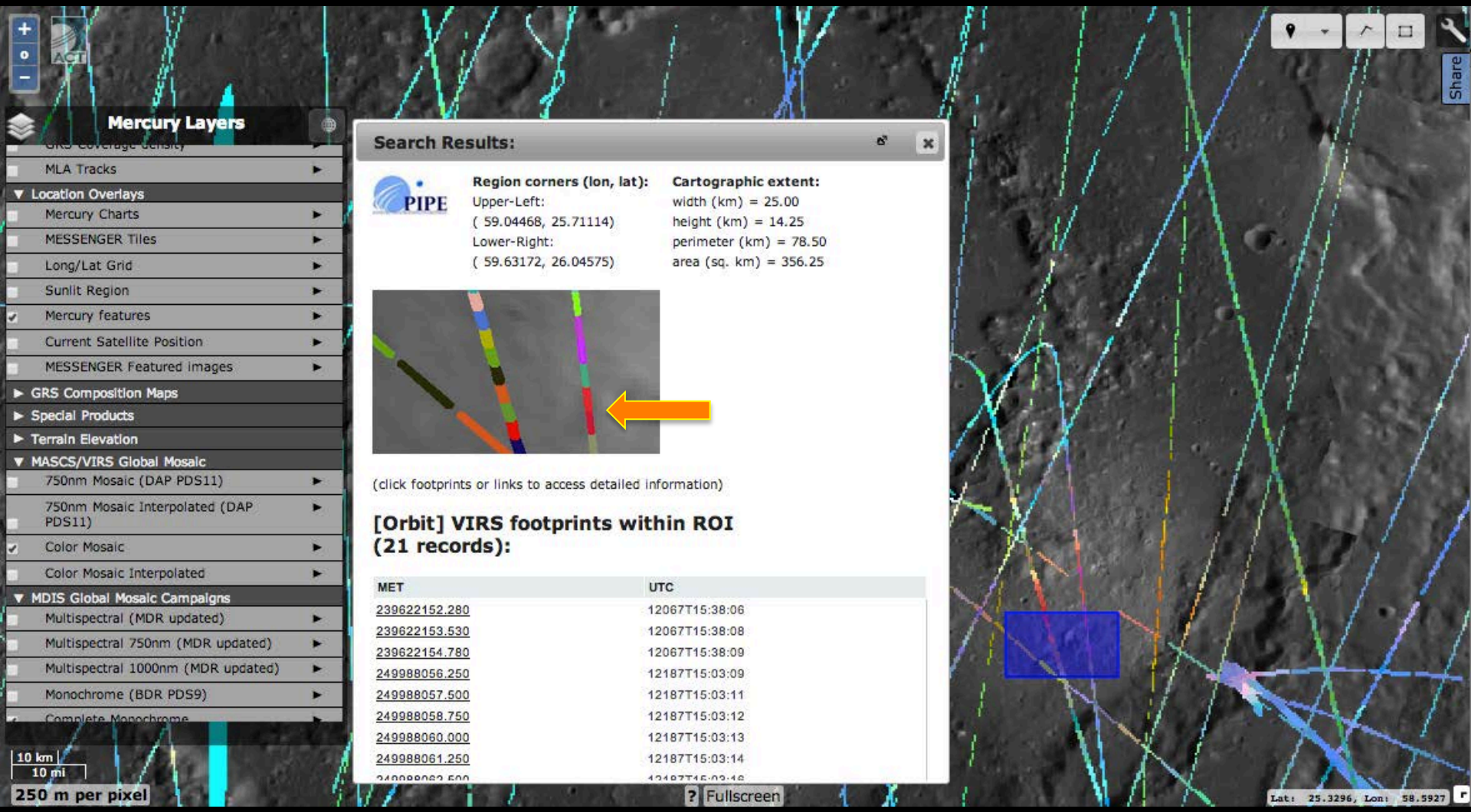
- Region of Interest

Local V



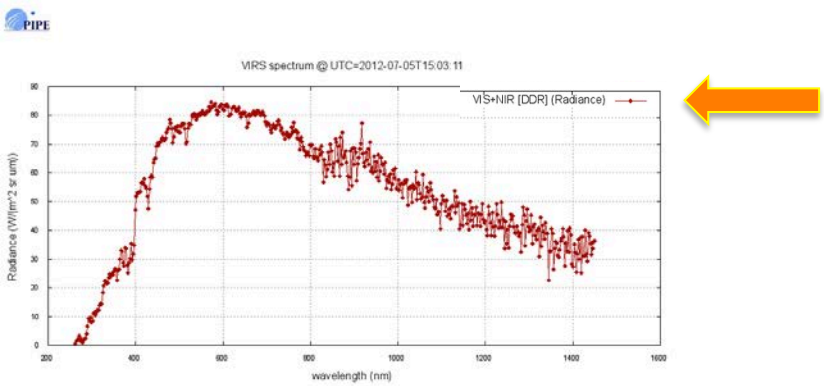
- Region of Interest

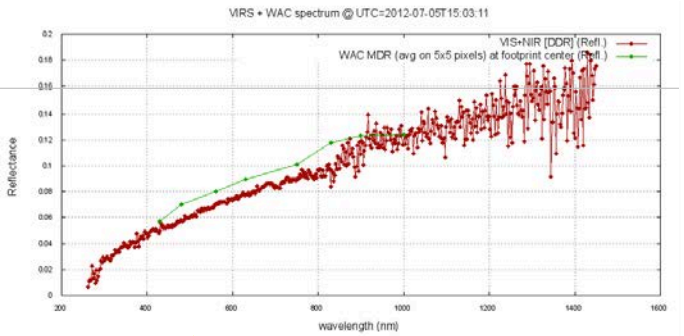
Local VI



- Individual Spectra

Local VII





inspect the plotted values as: CSV

et	394772658.60967654000000
met	1/249988057:500000
tint	1.0000000000000000
SC2TPetrD	3854.900914339999900
SubSCLAT	27.787919530000000
SubSCLON	50.986607350000000
NADIR_ALT	1415.634777239999900
SubSolLAT	-0.018669090000000
SubSolLON	112.201585420000000
FOV_0	0
BS_pLon0	59.489714280000001
BS_pLat0	25.776333019999999
BS_pEmi0	20.895891920000000
BS_pInc0	56.949596450000001
BS_pPha0	77.838603870000000
SUN2grnd0	68922493.24486605800000
BS_twist0	-1.903128890000000
sc2BSdist0	1476.406712000000000
IFOVatrack	0.592632360000000
IFOVxtrack	0.634314360000000
a-smear	1.648359580000000
x-smear	0.000935200000000
a-azimuth	-6.073954870000000
BLatStart	25.795588609999999
BLonStart	59.487427330000003
BLatEnd	25.757099390000000
BLonEnd	59.491976240000000
BS_pEmiAvg	20.895895486000001
BS_pIncAvg	56.949596201999995
BS_pPhaAvg	77.838603957999993
area	1.288463771772661
SPENUM	864

BLonEnd	59.491976240000000
BS_pEmiAvg	20.895895486000001
BS_pIncAvg	56.949596201999995
BS_pPhaAvg	77.838603957999993
area	1.288463771772661
SPENUM	864
SPEMET	249988057.50000000000000
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	VIRSVC_OB2_12187_144509.DAT
VIS_TEMP	9.266000000000000
NIR_TEMP	11.641999999999999
VIS750_RFL	0.089721700000000
CDRDate	12187
CDRTime	144509
mdr_metric	2.528843069000000

Individual Spectra view

- Radiance, reflectance plots
- DDR/CDR source
- CSV Downlink
- Viewing Geometry
- Spectrum, time
- CDR source name
- Detector temps

Local VIII

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.

SubSolLON(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.

BLonEnd(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 doubl

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).

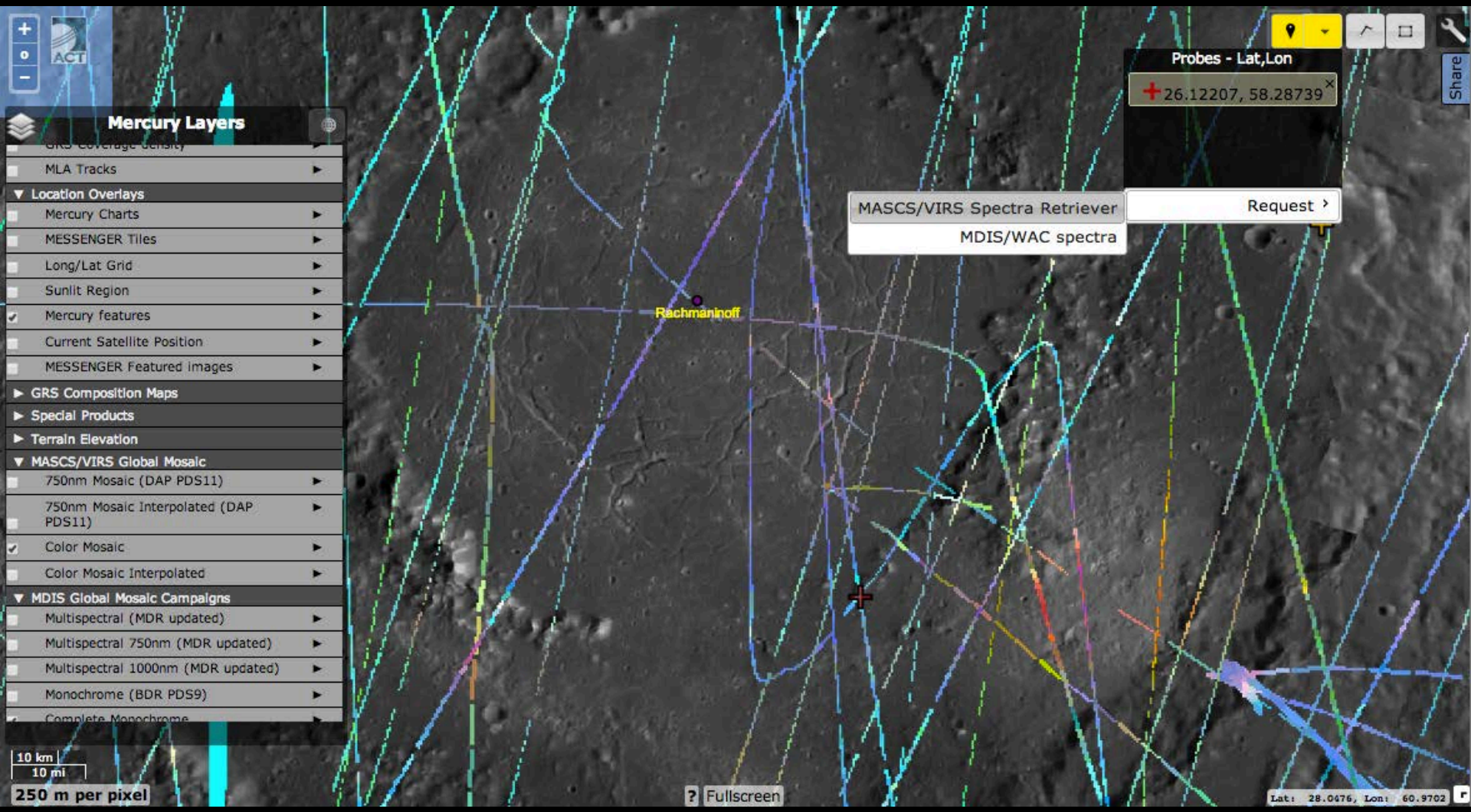
CDRDate(date)
Obervation CDR date in the form YYDOY.

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

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

- Linked parameter descriptions

Local IX



- QuickSpectra-Retriever

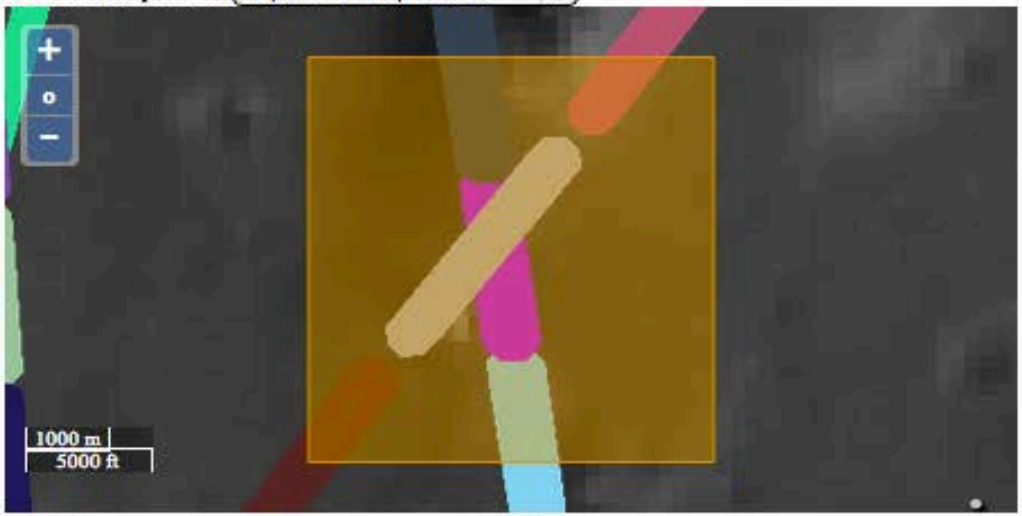
Local X

- QuickSpectra-Retriever

MESSENGER MASCS/VIRS - QuickSpectra-Retriever

Specify the search region (depicted as yellow box below)

Current Projection: Equidistant Cylindrical



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

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

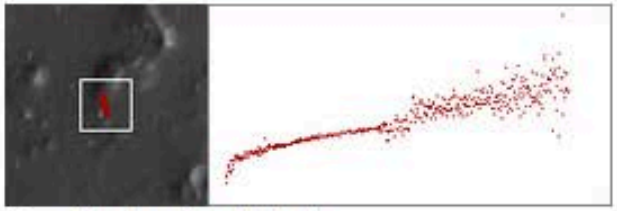
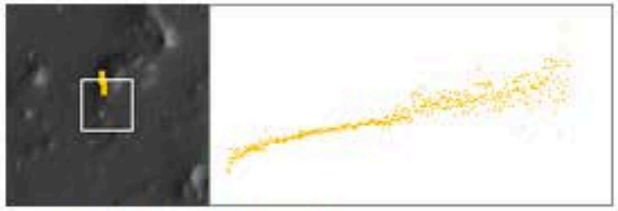
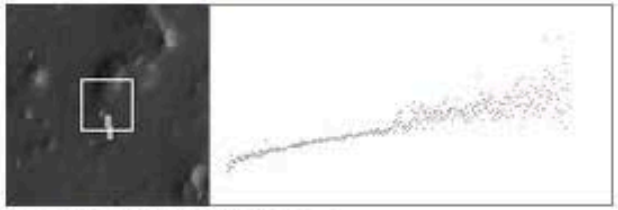
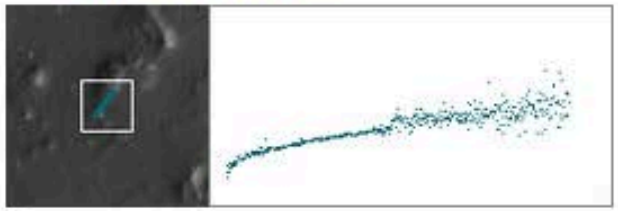
The following table can be sorted by clicking the header of the various columns

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

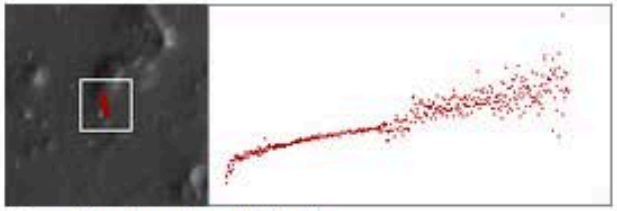
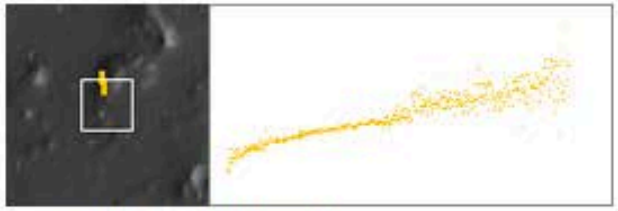
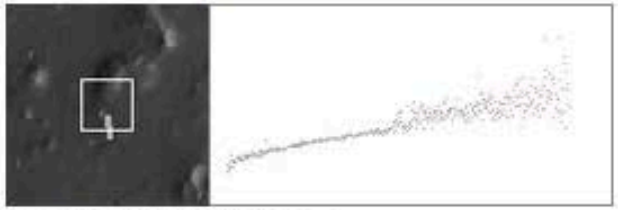
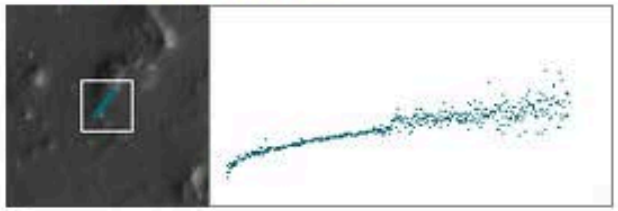
Observations at (lon, lat) = (58.28739,26.12207)

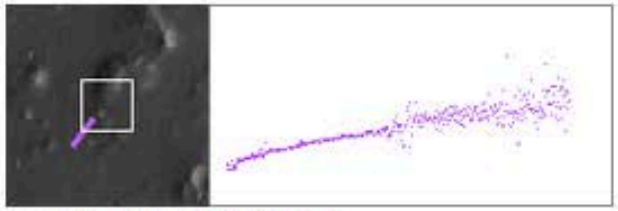
redraw plots

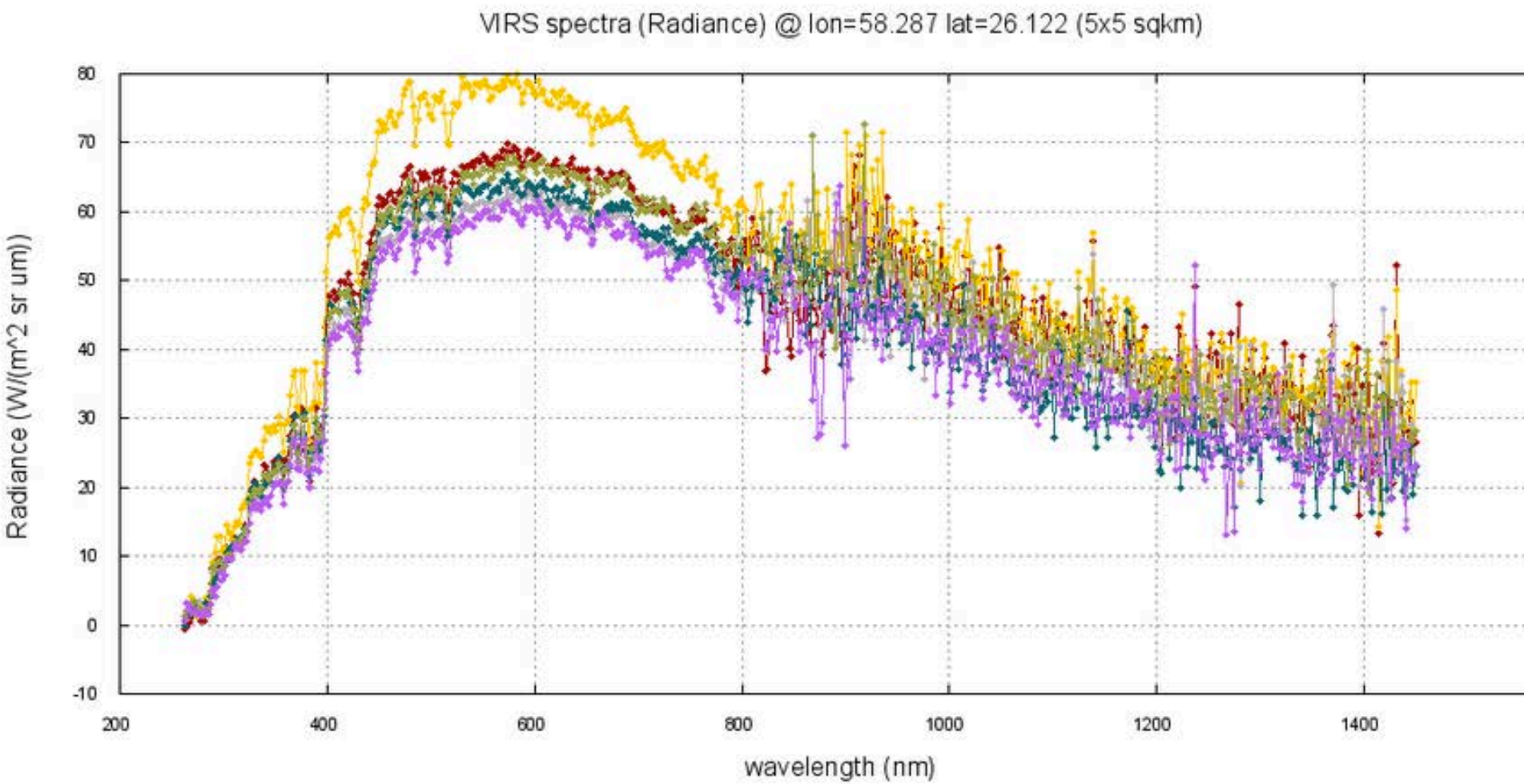
ortho. preview (20x20 sqkm)	source locator	Incidence angle (avg. on sphere)	Emission angle (avg. on sphere)	Phase angle (avg. on sphere)	VIS Temp.	NIR Temp.	area (sqkm)	metric
 exclude from the plots below	VIS: VIRSVC_ORB_12012_050451 [.DAT] [.LBL] NIR: VIRSNC_ORB_12012_050451 [.DAT] [.LBL] Spectrum 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
	VIS: VIRSVC_OB2_12187_144509 [.DAT] [.LBL] NIR: VIRSNC_OB2_12187_144509 [.DAT] [.LBL] Spectrum no. 916	58.065	20.571	77.806	9.477	11.751	2.004	4.047

Observations at (lon, lat) = (58.28739,26.12207)

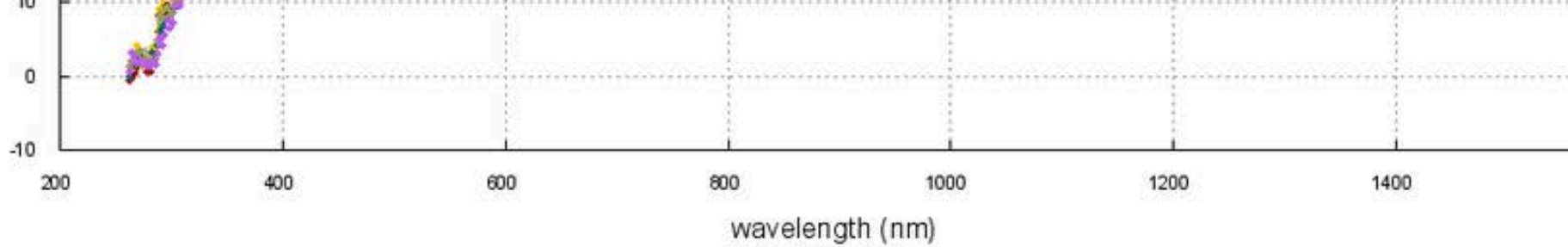
redraw plots

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
	VIS: VIRSVC_OB2_12187_144509 [.DAT] [.LBL] NIR: VIRSNC_OB2_12187_144509 [.DAT] [.LBL] Spectrum no. 916	58.065	20.571	77.806	9.477	11.751	2.004	4.047

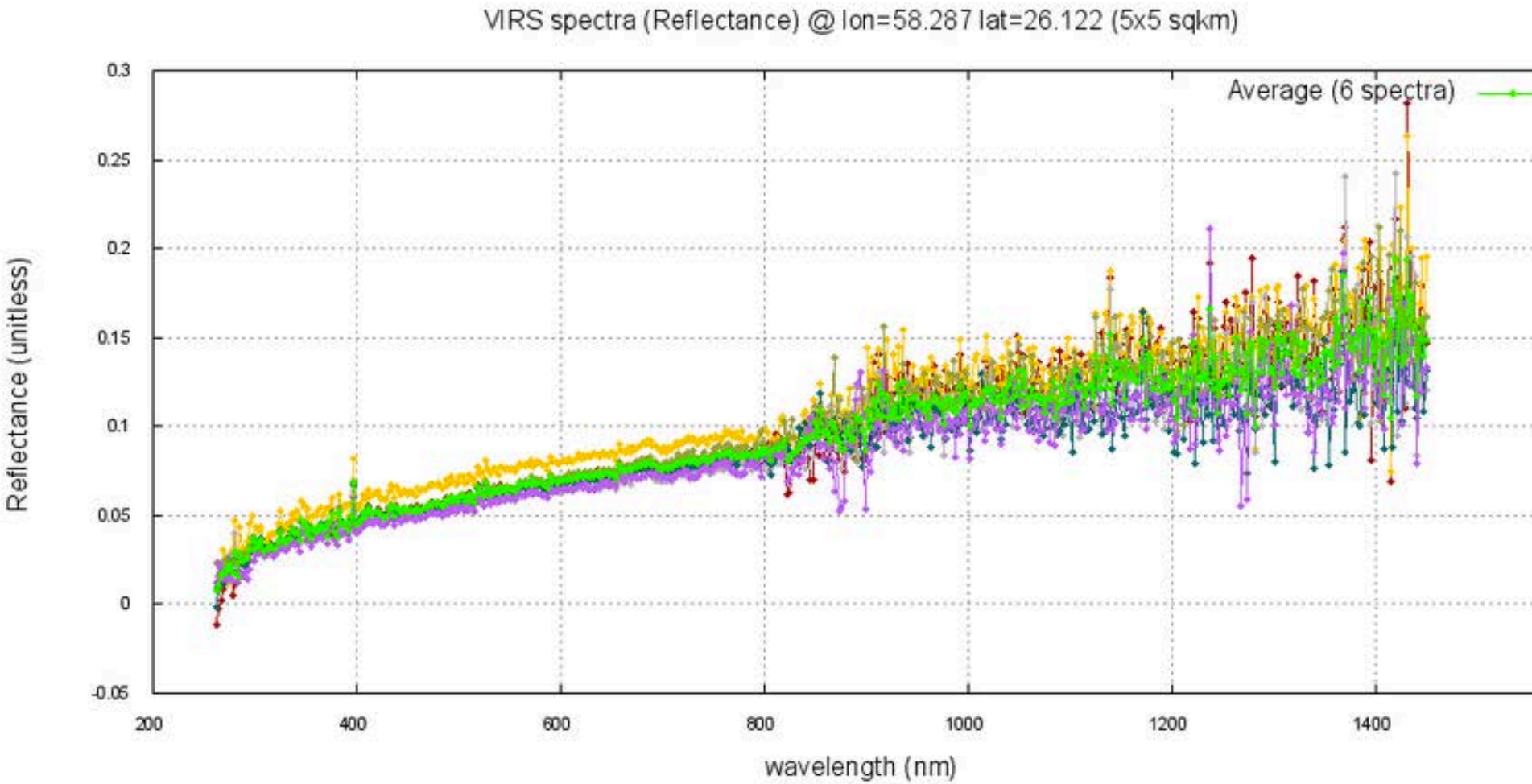
 exclude from the plots below	VIS: VIRSVC_OB2_12187_144509 [.DAT] [.LBL] NIR: VIRSNC_OB2_12187_144509 [.DAT] [.LBL] Spectrum no. 918 MET: 1/249988125:0 UTC: 2012-07-05 15:04:18 Inspect spectrum as CSV	58.116	20.726	77.803	9.489	11.765	2.053	4.156



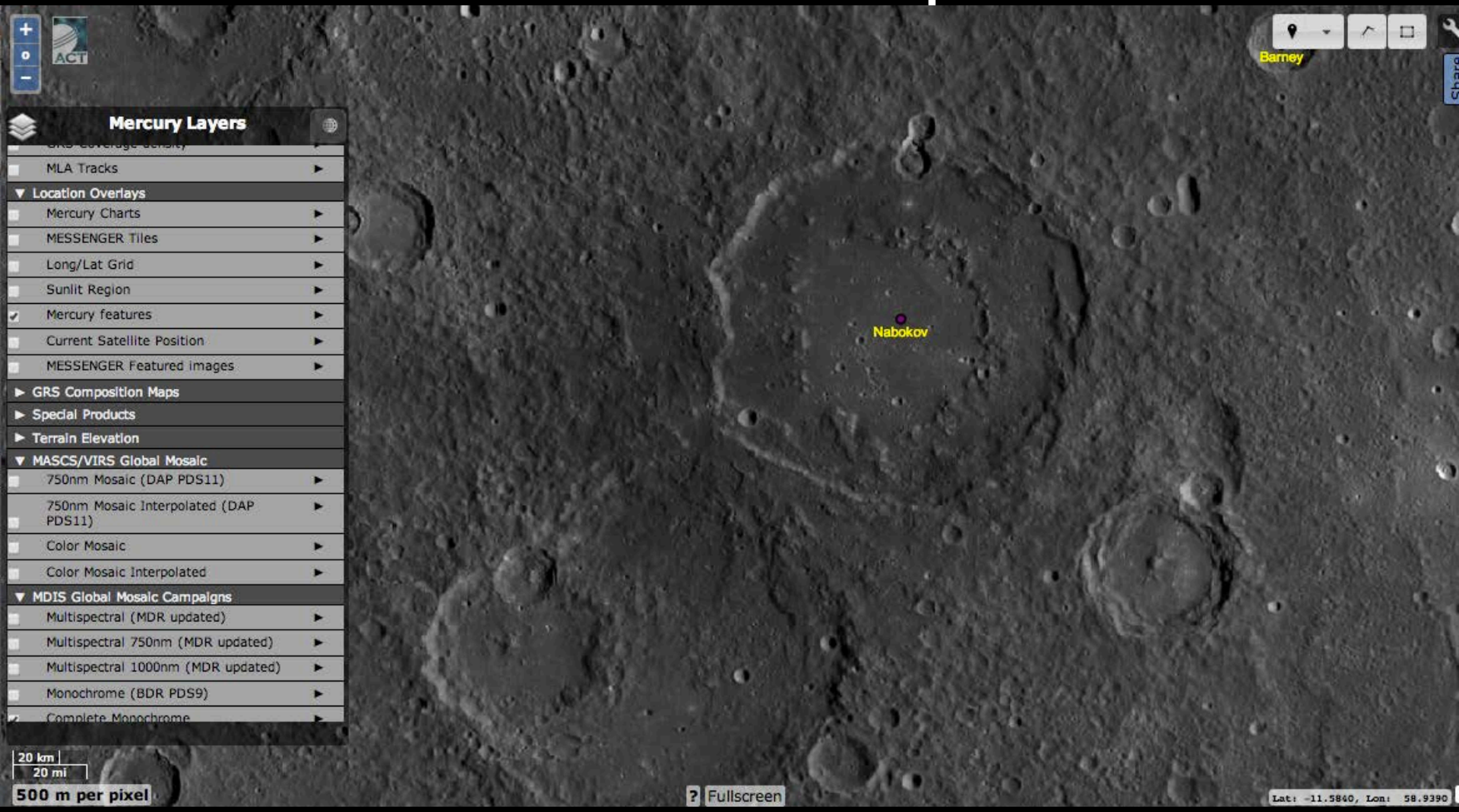
The following plot shows the spectra listed on the table above, as well as their average (in green).



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

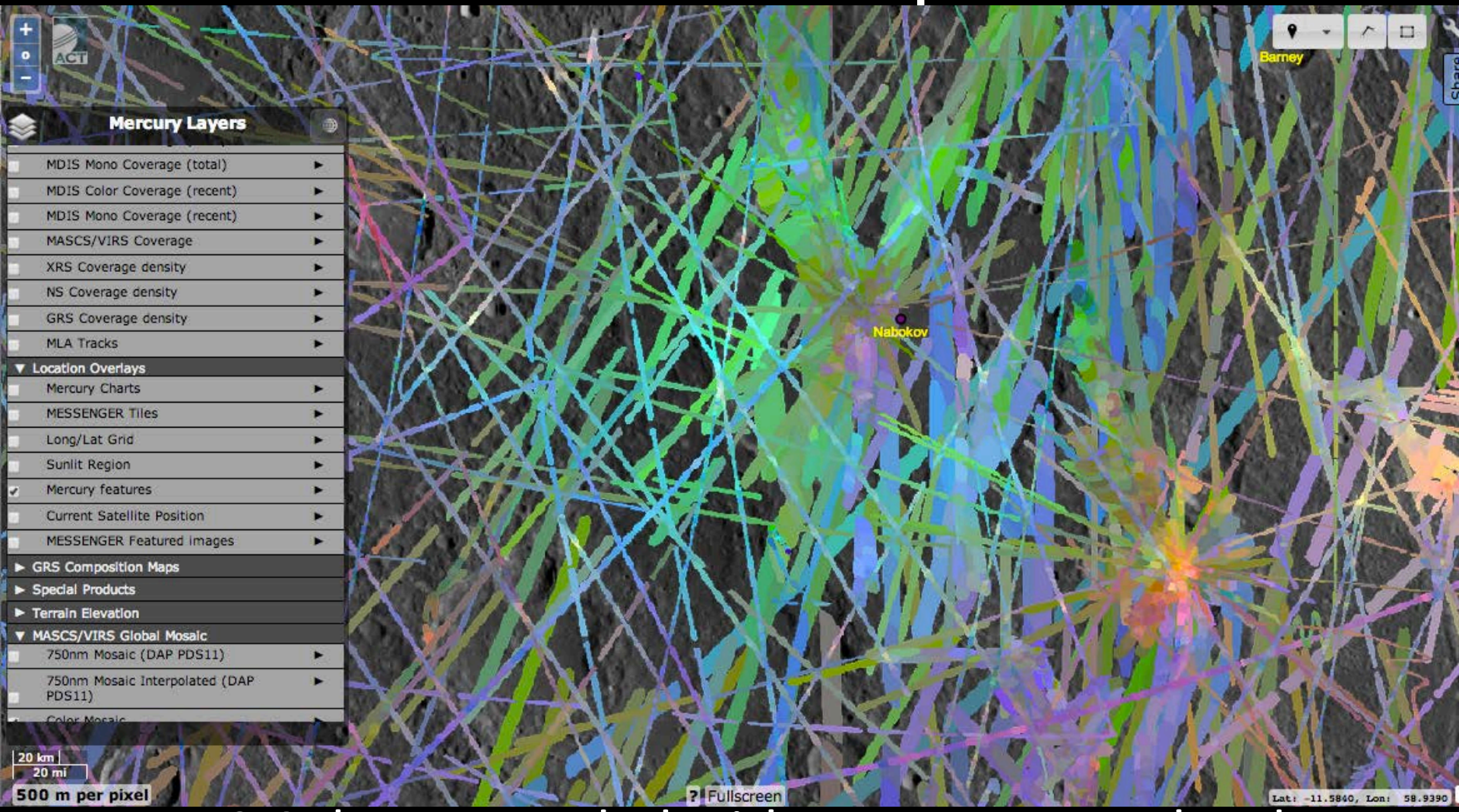


Nabokov Example I



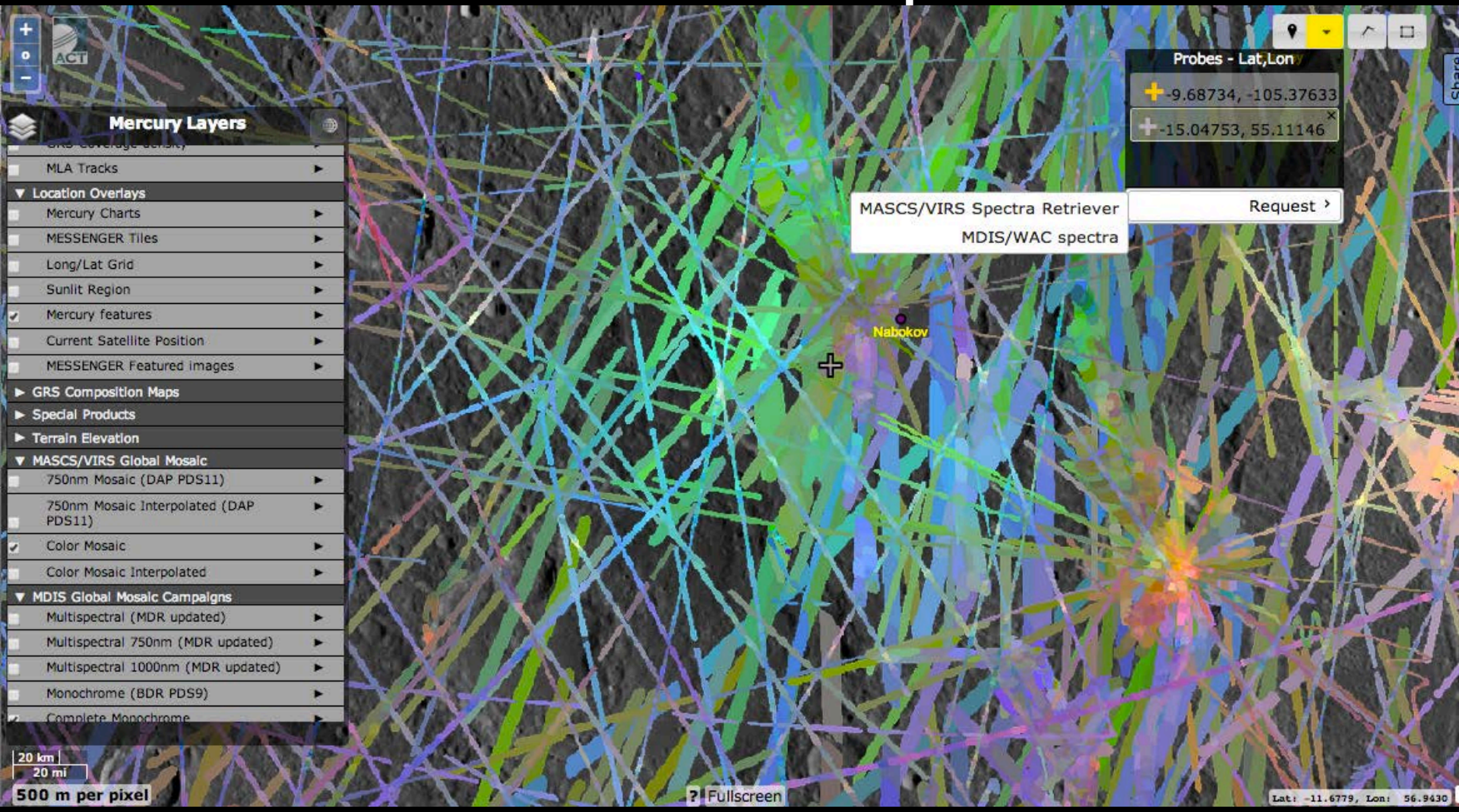
- MDIS basemap

Nabokov Example II



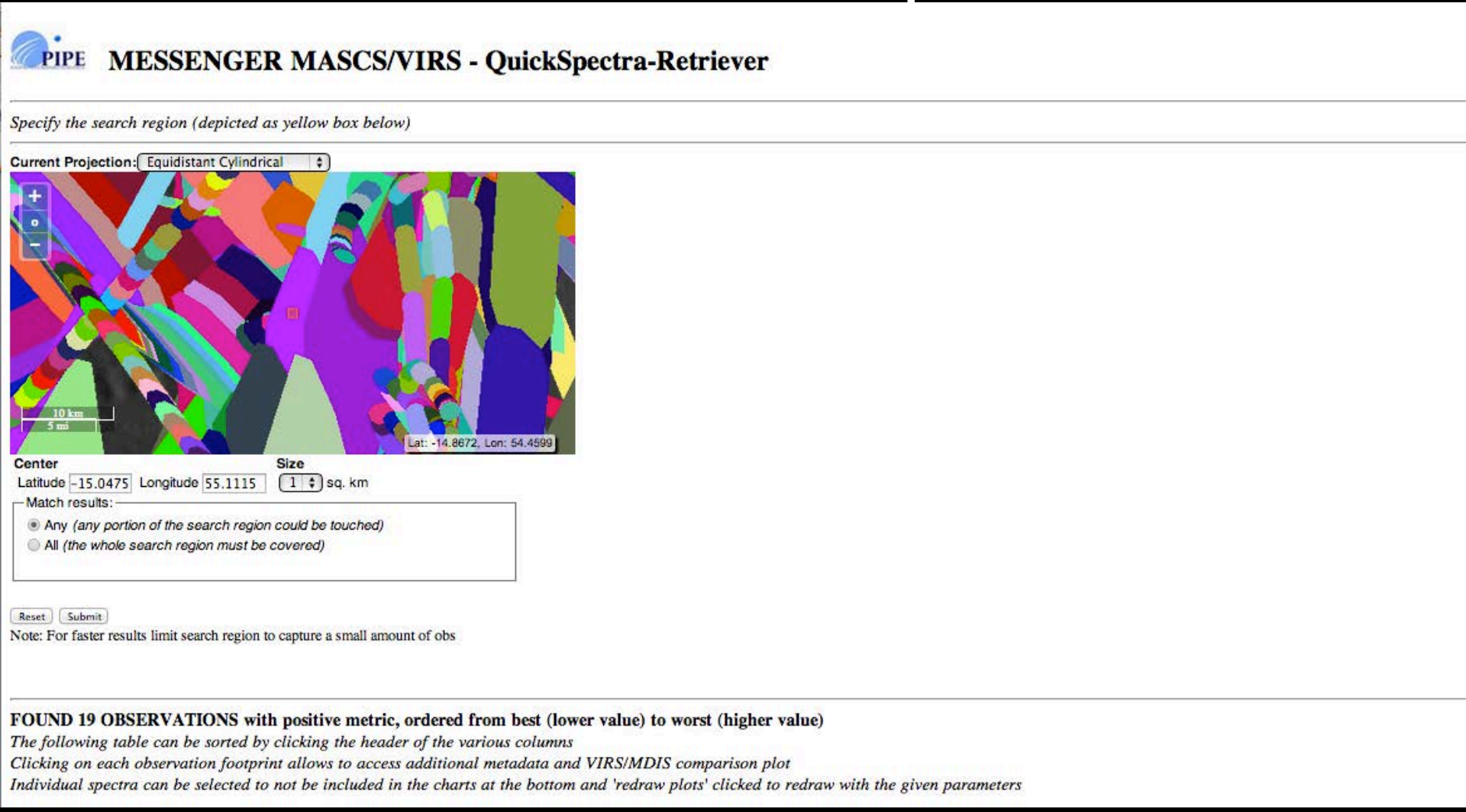
- VIRS Color – crowded with many spectra, hard to select one with accuracy. Use QuickSpectra

Nabokov Example III



- Probe spot and select small area (1x1 km)

Nabokov Example IV



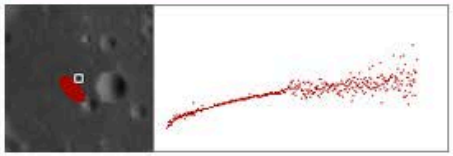
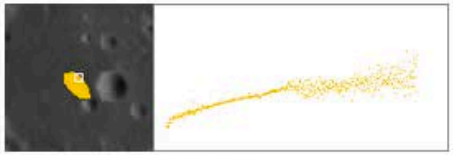
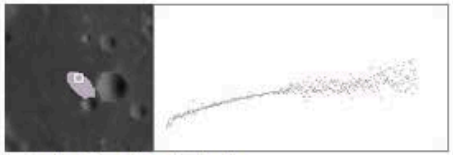
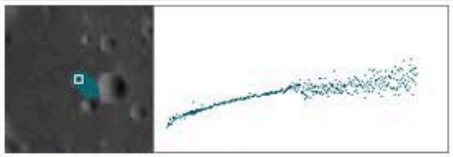
- Area filled with footprints, not all of high value

Nabokov Example V

Page: **[1]** [2]
(10 observations per page)

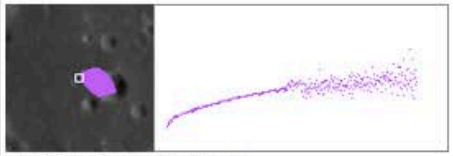
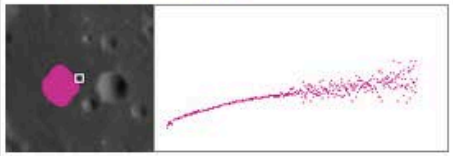
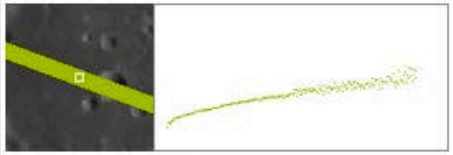
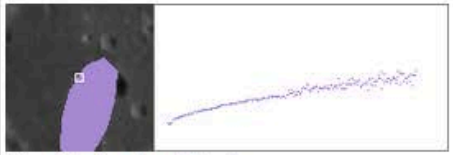
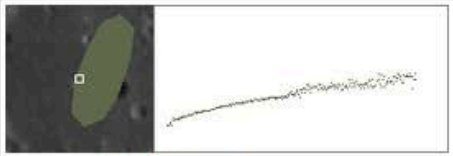
Observations at (lon, lat) = (55.11146,-15.04753)

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_11223_215320 [.DAT] [.LBL] NIR: VIRSNC_ORB_11223_215320 [.DAT] [.LBL] Spectrum no. 30 MET: 1/221587105:729000 UTC: 2011-08-11 21:53:58 Inspect spectrum as CSV	23.610	64.967	88.242	28.499	29.506	12.119	31.258
 exclude from the plots below	VIS: VIRSVC_ORB_11223_215320 [.DAT] [.LBL] NIR: VIRSNC_ORB_11223_215320 [.DAT] [.LBL] Spectrum no. 28 MET: 1/221587103:229000 UTC: 2011-08-11 21:53:55 Inspect spectrum as CSV	23.617	64.951	88.231	28.498	29.480	12.645	32.595
 exclude from the plots below	VIS: VIRSVC_ORB_11223_215320 [.DAT] [.LBL] NIR: VIRSNC_ORB_11223_215320 [.DAT] [.LBL] Spectrum no. 27 MET: 1/221587101:979000 UTC: 2011-08-11 21:53:54 Inspect spectrum as CSV	23.626	64.937	88.225	28.462	29.474	13.210	34.038
 exclude from the plots below	VIS: VIRSVC_ORB_11223_215320 [.DAT] [.LBL] NIR: VIRSNC_ORB_11223_215320 [.DAT] [.LBL] Spectrum no. 26 MET: 1/221587100:729000 UTC: 2011-08-11 21:53:53 Inspect spectrum as CSV	23.635	64.923	88.219	28.504	29.453	13.399	34.509

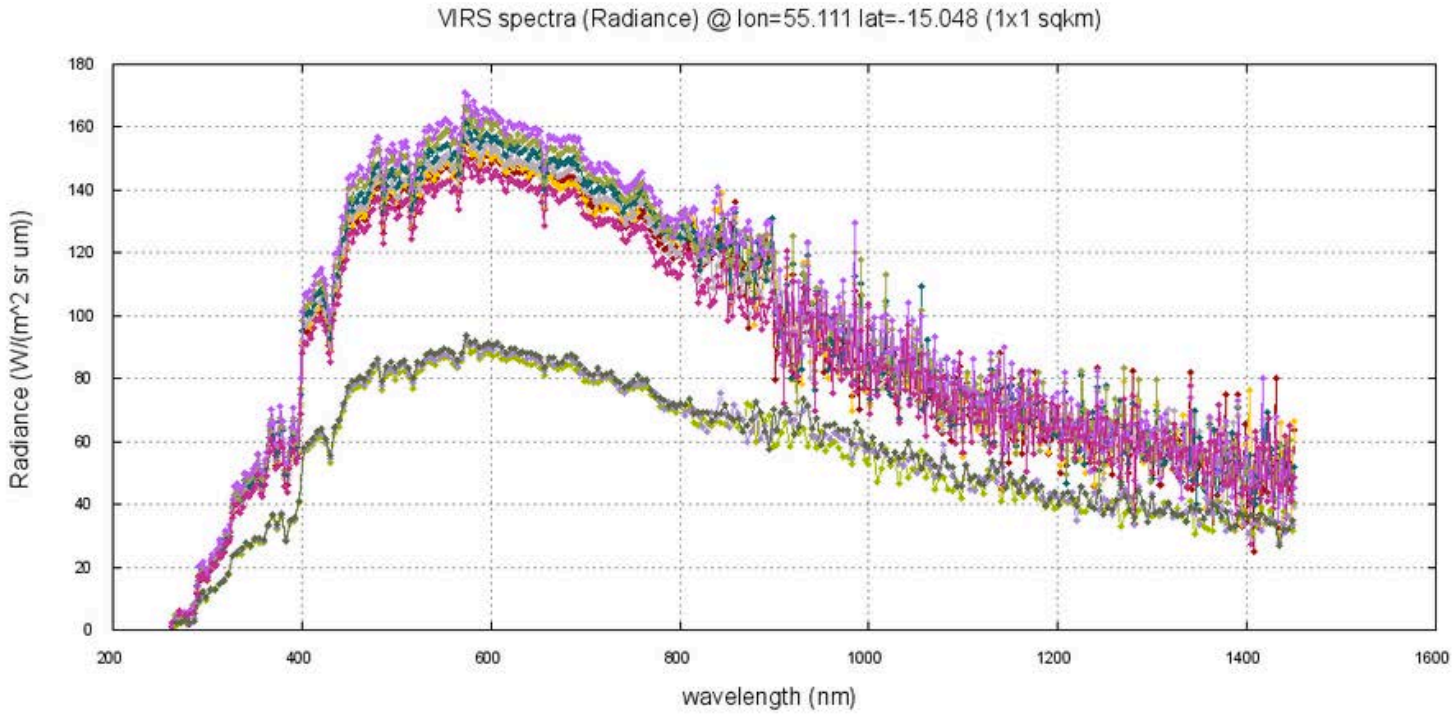
- Individual spectra that touch target area

Nabokov Example VI

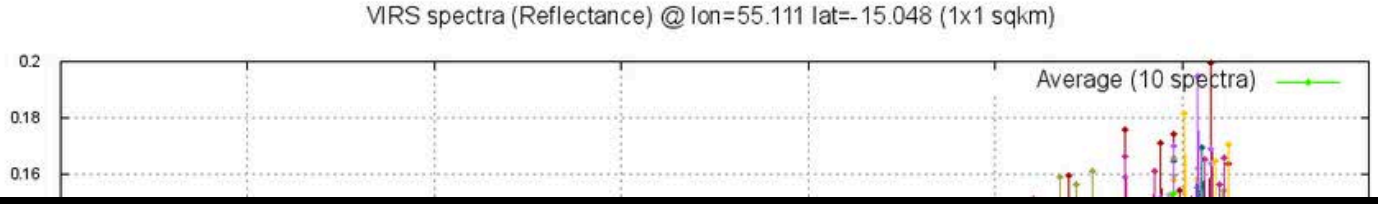
exclude from the plots below	UTC: 2011-08-11 21:53:51 Inspect spectrum as CSV							
 exclude from the plots below	VIS: VIRSVC_ORB_11223_215320 [.DAT] [.LBL] NIR: VIRSNC_ORB_11223_215320 [.DAT] [.LBL] Spectrum no. 20 MET: 1/221587093:229000 UTC: 2011-08-11 21:53:45 Inspect spectrum as CSV	23.664	64.861	88.187	28.444	29.458	17.160	44.101
 exclude from the plots below	VIS: VIRSVC_ORB_11223_215320 [.DAT] [.LBL] NIR: VIRSNC_ORB_11223_215320 [.DAT] [.LBL] Spectrum no. 15 MET: 1/221587086:979000 UTC: 2011-08-11 21:53:39 Inspect spectrum as CSV	23.574	64.921	88.184	28.474	29.378	22.491	57.894
 exclude from the plots below	VIS: VIRSVC_ORB_11205_090602 [.DAT] [.LBL] NIR: VIRSNC_ORB_11205_090602 [.DAT] [.LBL] Spectrum no. 1 MET: 1/219985832:474000 UTC: 2011-07-24 09:06:05 Inspect spectrum as CSV	43.661	47.872	87.469	10.295	13.944	126.711	261.115
 exclude from the plots below	VIS: VIRSVC_ORB_11203_054700 [.DAT] [.LBL] NIR: VIRSNC_ORB_11203_054700 [.DAT] [.LBL] Spectrum no. 1 MET: 1/219801089:474000 UTC: 2011-07-22 05:47:01 Inspect spectrum as CSV	50.487	55.799	89.547	9.661	13.706	93.948	262.687
 exclude from the plots below	VIS: VIRSVC_ORB_11203_054700 [.DAT] [.LBL] NIR: VIRSNC_ORB_11203_054700 [.DAT] [.LBL] Spectrum no. 2 MET: 1/219801090:724000 UTC: 2011-07-22 05:47:03 Inspect spectrum as CSV	50.393	55.969	89.557	9.661	13.717	100.645	282.095

- Excluding footprints you don’t want from average

Nabokov Example VII

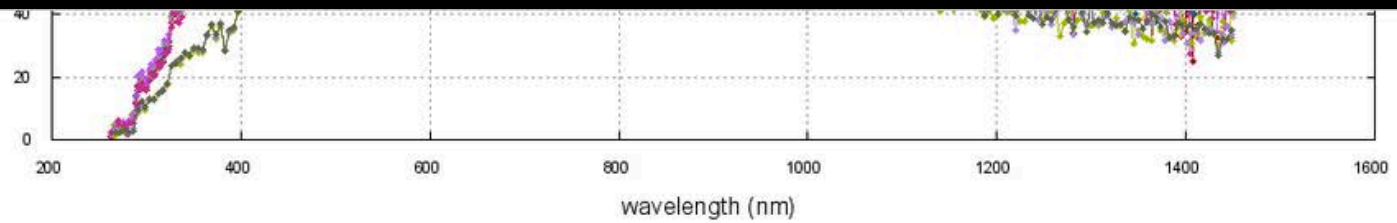


The following plot shows the spectra listed on the table above, as well as their average (in green).

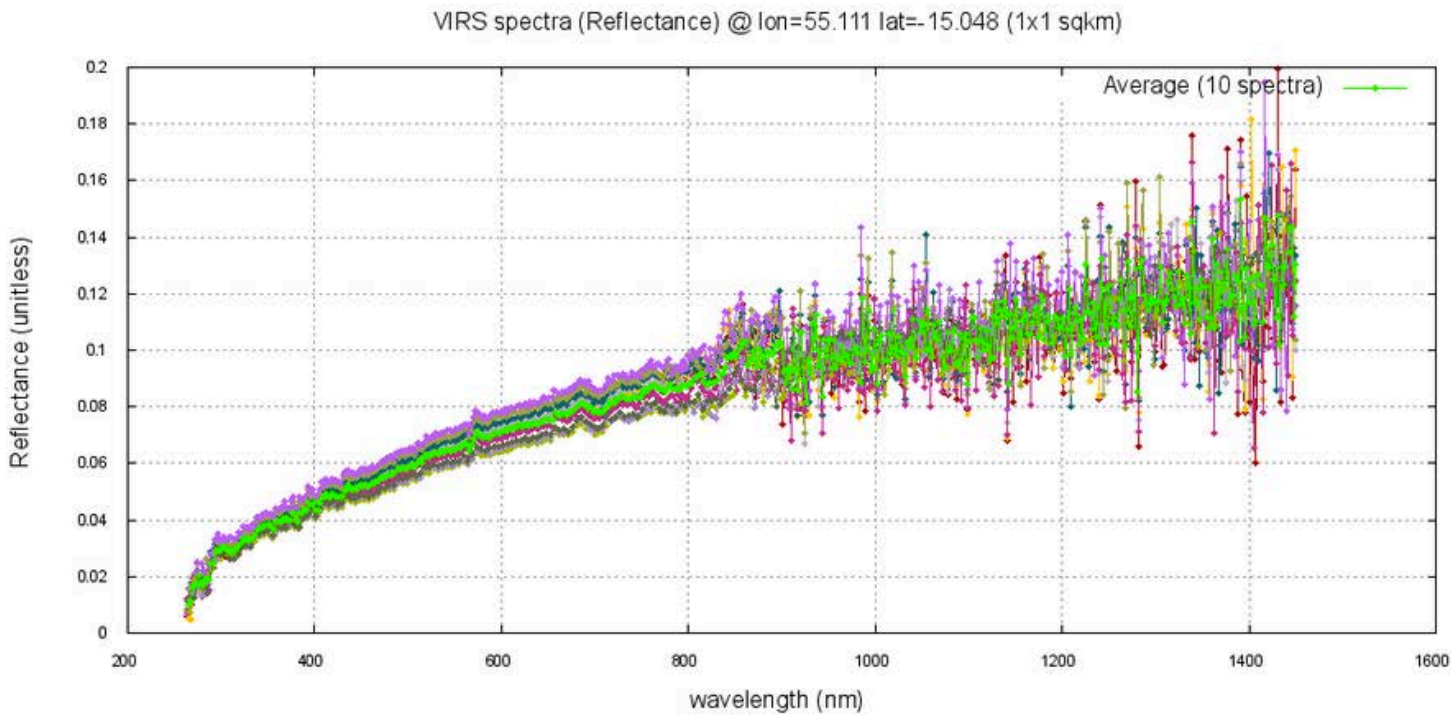


- Radiance

Nabokov Example VIII



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



- Shows only selected spectra and their average.

Do Science With VIRS!

- Planned, not yet implemented:
  - ROI multiple spectrum downloading (currently all bulk data access is via PDS)
- Questions, feedback
- Contact
  - noam.izenberg@jhuapl.edu
  - rachel.klima@jhuapl.edu

Key References:

- **McClintock and Lankton** (2007) *Space Science Reviews* 131, 481-521
- **McClintock et al.** (2008) *Science* 321, 62-65
- **Holsclaw et al.** (2010) *Icarus* 209, 179-194
- **Izenberg et al.** (2014) *Icarus* 228, 364-374
- **Klima et al.** (2014) *LPSC 45* #1978 on Thursday, March 20