

WP

eur PLANET 2024

Research Infrastructure





Geology & Planetary Mapping
Winter School

Planetary Data for Mapping

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 @pozzoq



UNIVERSITÀ
DEGLI STUDI
DI PADOVA



DIPARTIMENTO
DI GEOSCIENZE

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Research Infrastructure

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871149.



Moon Data



Missions providing useful data for geological mapping

- Lunar Reconnaissance Orbiter (LRO)
 - LOLA
 - LROC (Lunar Reconnaissance Orbiter Camera)
 - WAC (Wide Angle Camera)
 - NAC (Narrow Angle Camera)
- SELENE - Kaguya
 - TC (Terrain Camera)
 - MI (Multispectral Imager)

Main Moon data repositories

...or access points/mirrors

Google Moon

ODE – Orbital Data Explorer

PILOT – Planetary Imager Locator Tool

LROC Quickmap

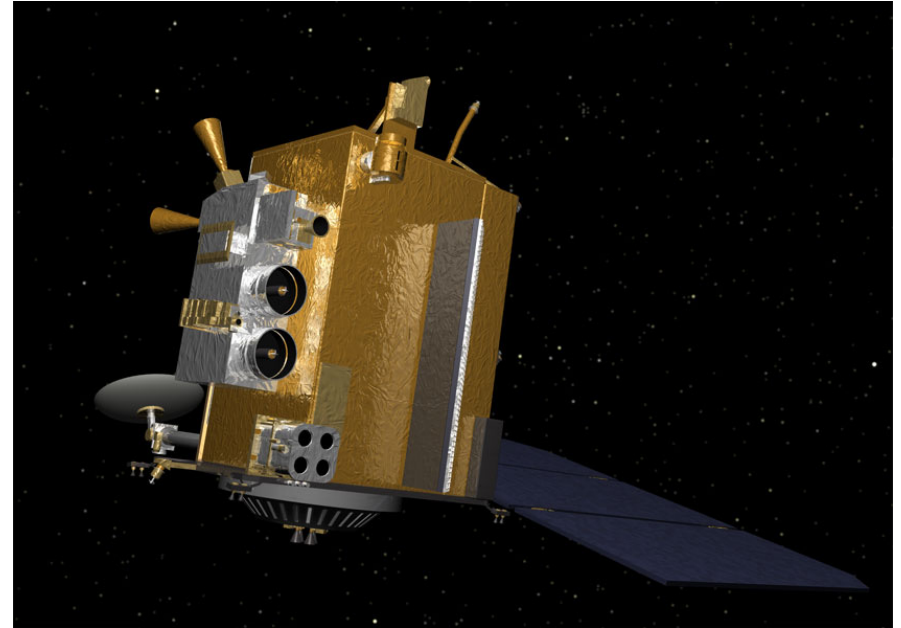
USGS Astrogeology

Jmars



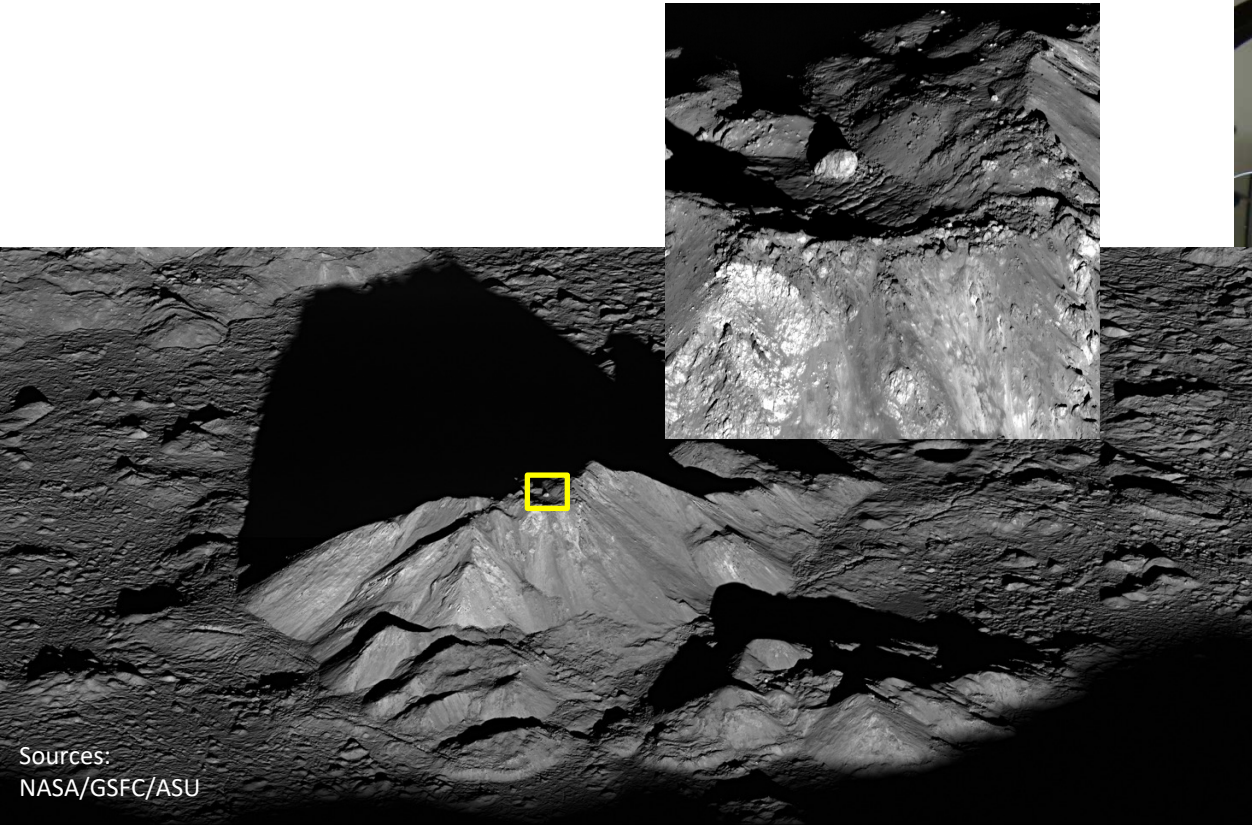
LRO - Lunar Reconnaissance Orbiter

- NASA mission
- Launched from Cape Canaveral in June 2009
- Data provided (*this list is limited to those useful to geologic mapping*):
- Global image coverage (LROC WAC, 100 m/pixel)
- High resolution imaging (LROC NAC, 0.5 m/pixel)
- Lidar-based topography (LOLA, 118 m/pixel)
- Stereo Topography (LROC, 1 m/pixel)
- Thermal maps for cold traps (DIVINER)



Source: Arizona University

NAC – Narrow Angle Camera (Robinson et al., 2010)

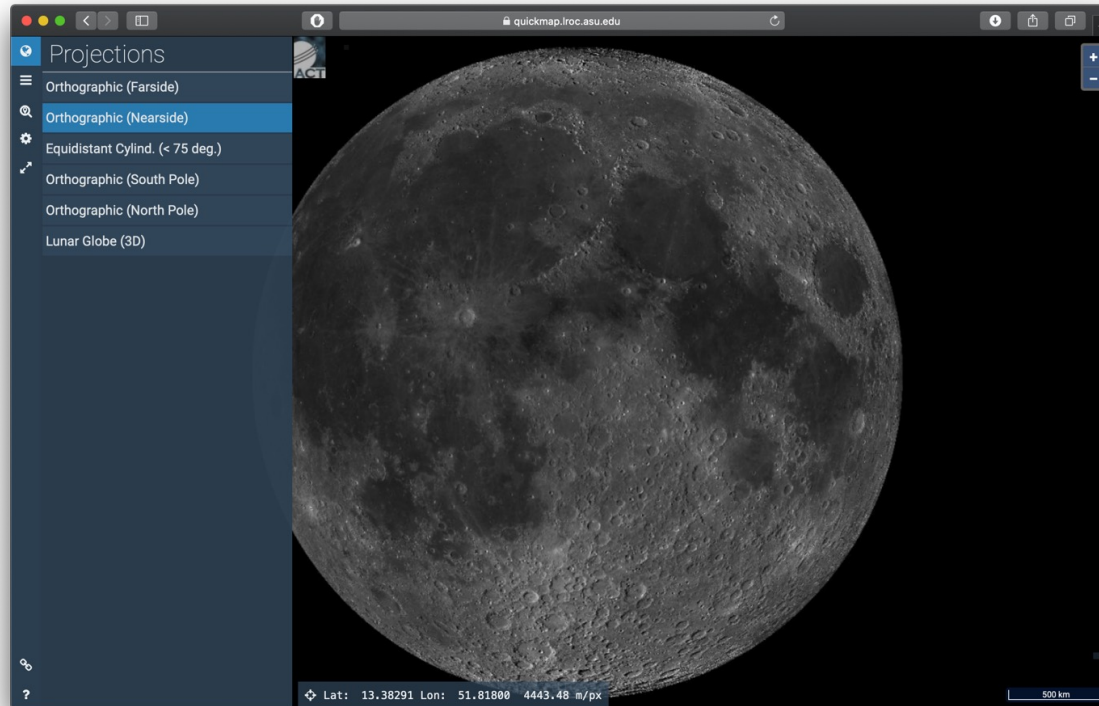


Sources: NASA/GSFC/ASU

Sources:
NASA/GSFC/ASU

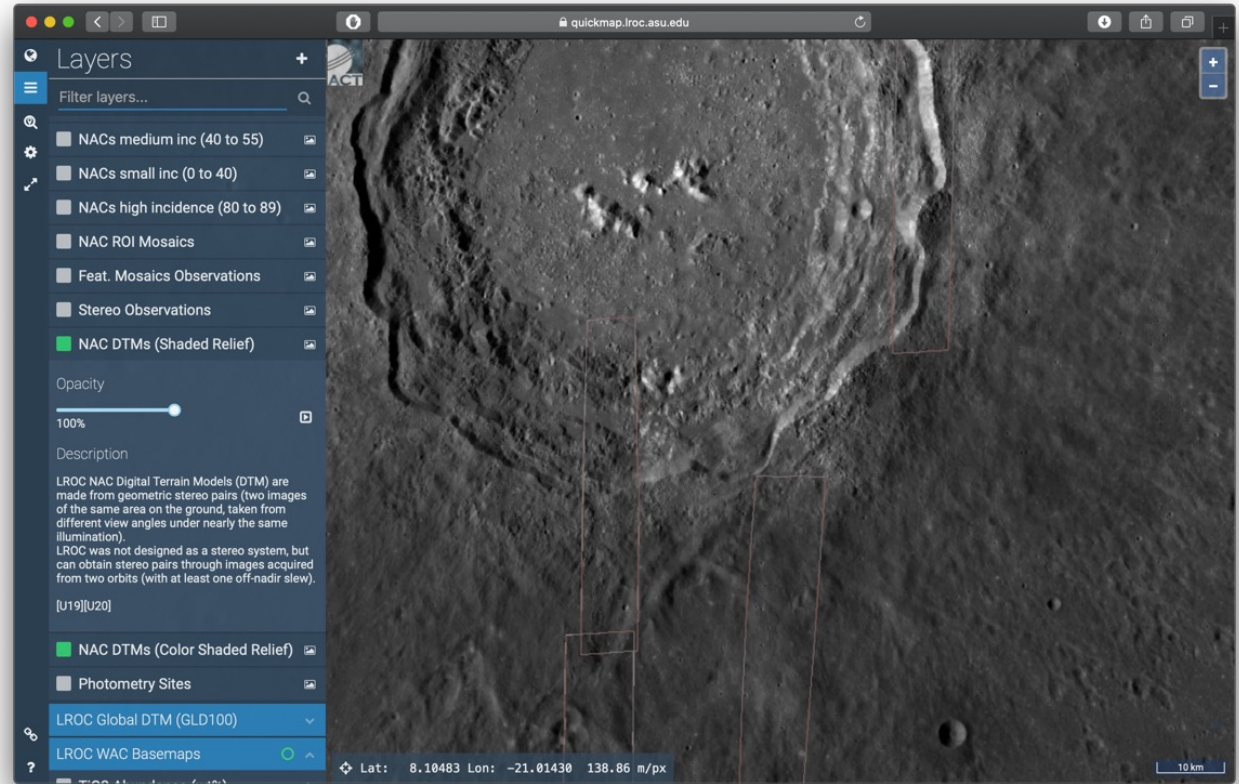
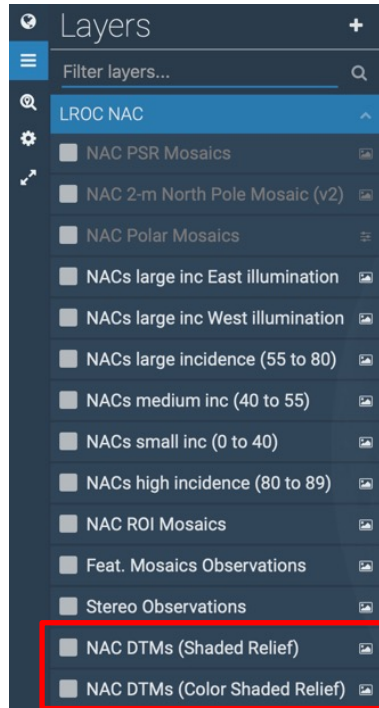
ASU LROC Quickmap

<https://quickmap.lroc.asu.edu>



Source: NASA/GSFC/ASU

LROC Quickmap: image consultation



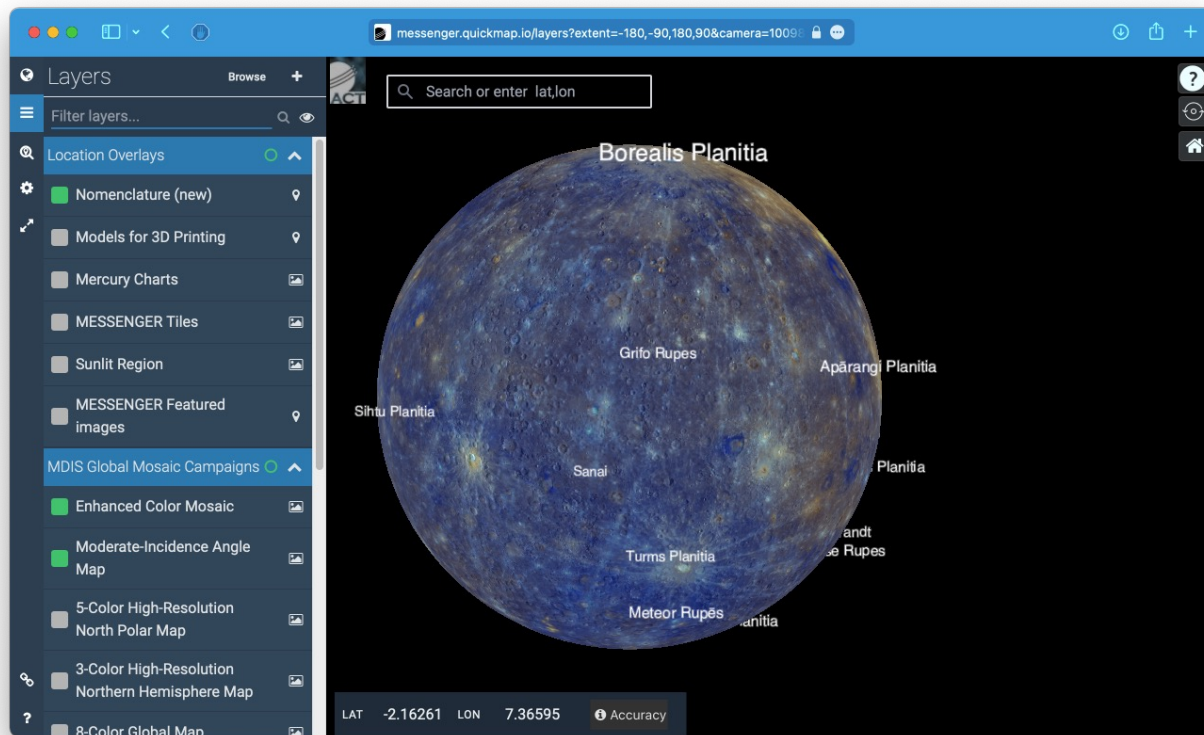
LROC Quickmap: products download

Extra Downloads	Downloads
README - (5.69 KB) Slope Legend	Color Slope Map Confidence Map Digital Terrain Model (32-bit GeoTIFF) Digital Terrain Model (PDS IMG) Orthophoto (1.10 m/px): M1121358630 Orthophoto (1.10 m/px): M1121372830 Orthophoto (5.00 m/px): M1121358630 Orthophoto (5.00 m/px): M1121372830 Shaded Relief Map

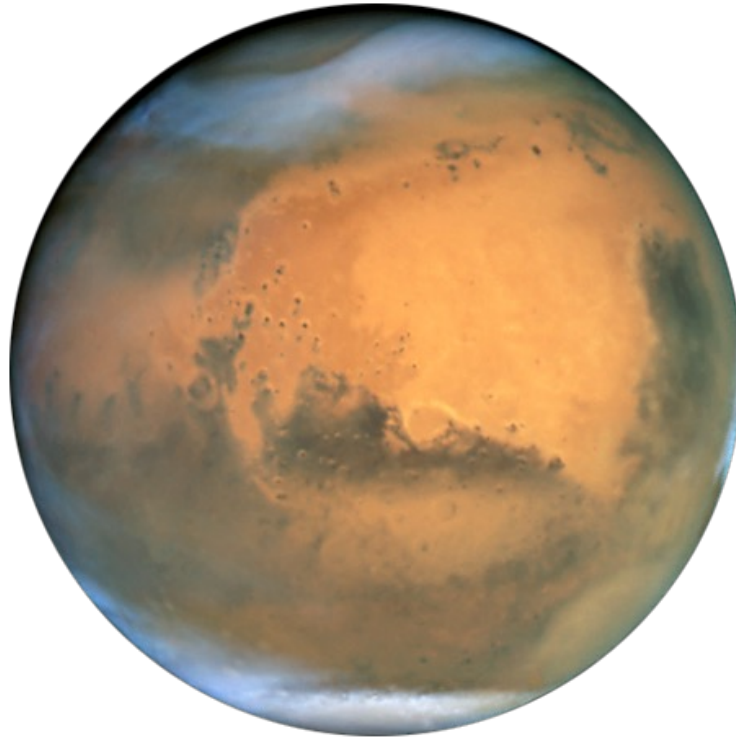
The screenshot shows the LROC QuickMap web interface. The browser address bar indicates the URL is wms.lroc.asu.edu. The page title is "Lunar Reconnaissance Orbiter Camera". The main content area displays the "Copernicus Graben DTM" with a "Colorshade (click for more information)" label. A "Color Shade Legend" on the right shows an elevation scale in meters, ranging from 380 to -1072. The legend values are 380, 234, -56, -201, -491, -781, and -1072. At the bottom of the interface, there are two buttons: "Extra Downloads" and "Downloads".

Mercury – MESSENGER Quickmap

<https://messenger.quickmap.io>



Mars data



Source: NASA/GSFC

Missions providing useful data for topography/photogrammetry (but not only)

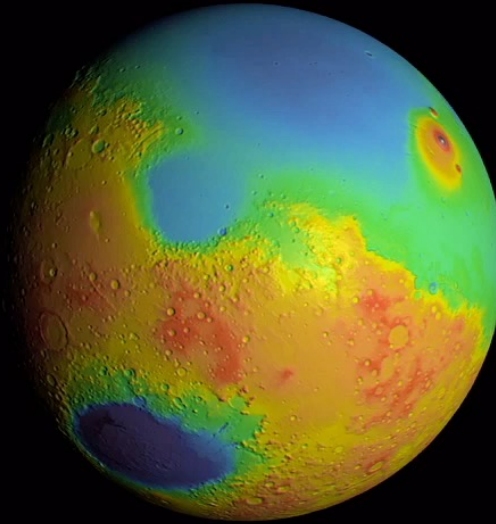
- Mars Global Surveyor (MGS, 1999-2006)
 - MOLA (Lidar ~460 m/pixel)
 - MOC (Camera, 1.5 – 12 m/pixel)
- Mars Odissey (2001-ongoing)
 - THEMIS (Thermal camera ~100 m/pixel)
- Mars Express (MEX, 2003-ongoing)
 - HRSC (Camera, 12.5 m/pixel)
 - OMEGA (Spectrometer, 0.3-5 km/pixel)
- Mars Reconnaissance Orbiter (MRO, 2007 - ongoing)
 - CTX (Camera ~6 m/pixel)
 - CRISM (Spectrometer, 15-19 m/pixel)
 - HiRISE (Camera 0.25 m/pixel)
- ExoMars Trace Gas Orbiter (TGO, 2007 - ongoing)
 - CaSSIS (Camera 4.5 m/pixel)

Main Mars data repositories

...or access points/mirrors

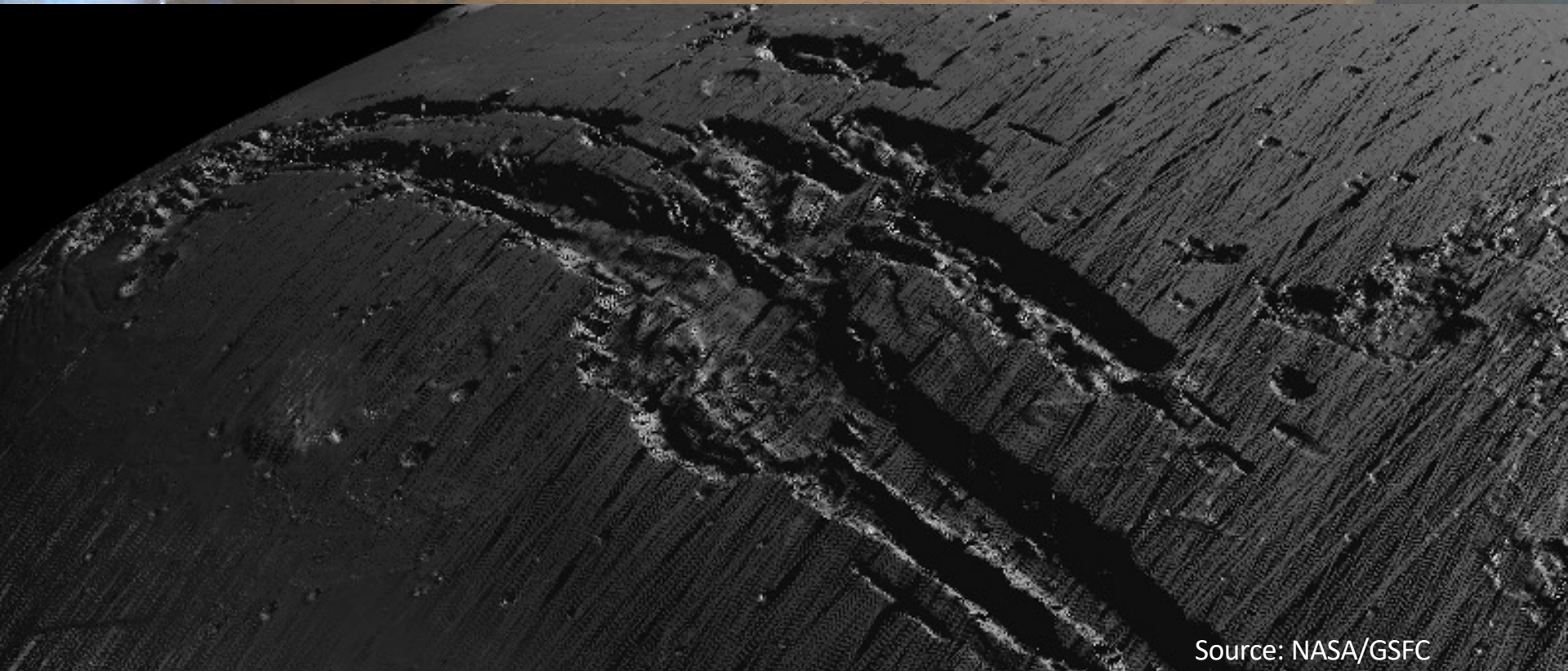
Google Mars
ODE – Orbital Data Explorer
PILOT – Planetary Imager Locator Tool
HiRISE webpage
ASU CTX webpage
ESA PSA – Planetary Science Archive
Jmars
Murray Lab
HRSC FU Berlin portal

MOLA – Mars Orbiter Laser Altimeter



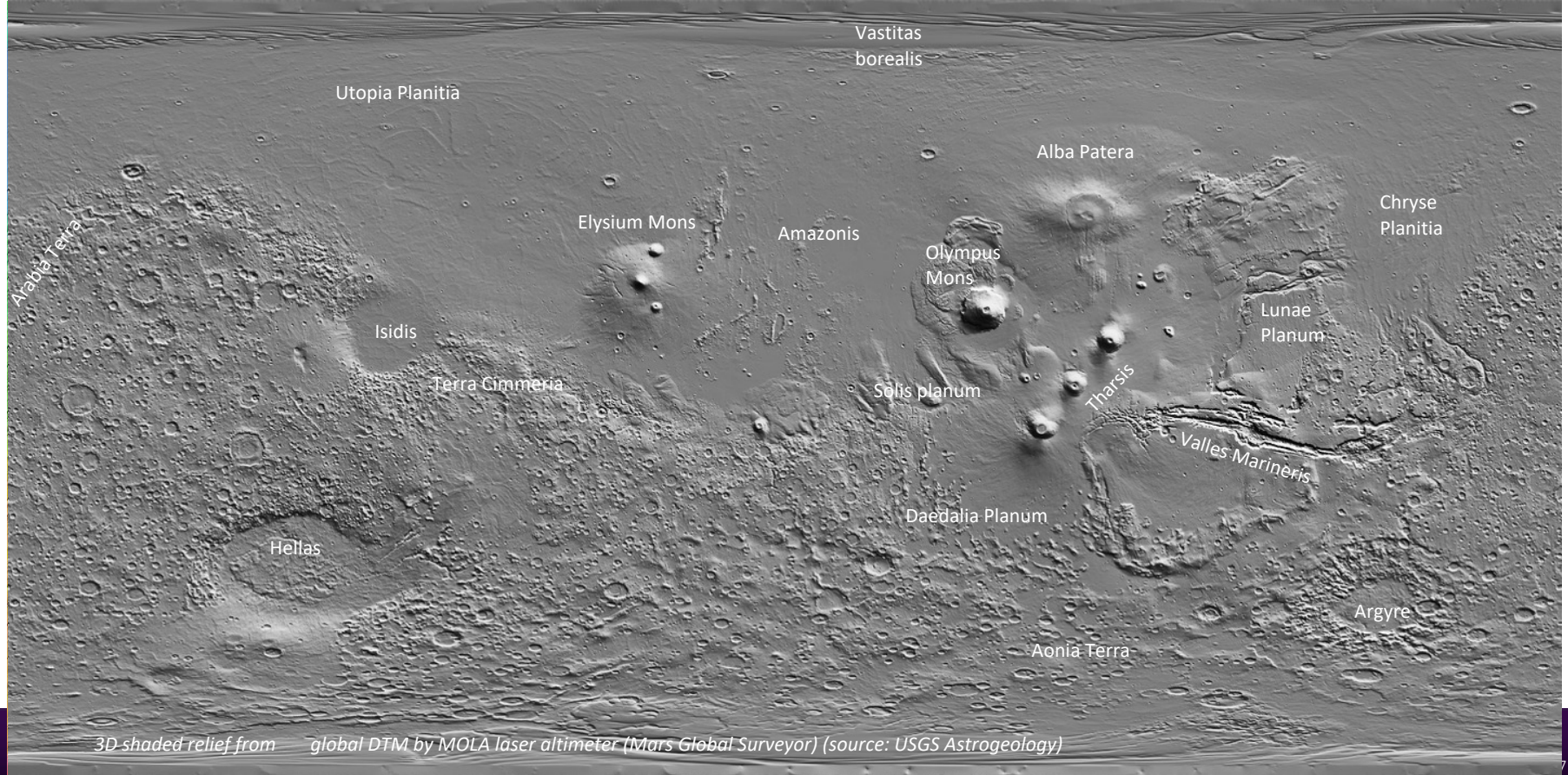
Source: NASA/GSFC

MOLA – Mars Orbiter Laser Altimeter



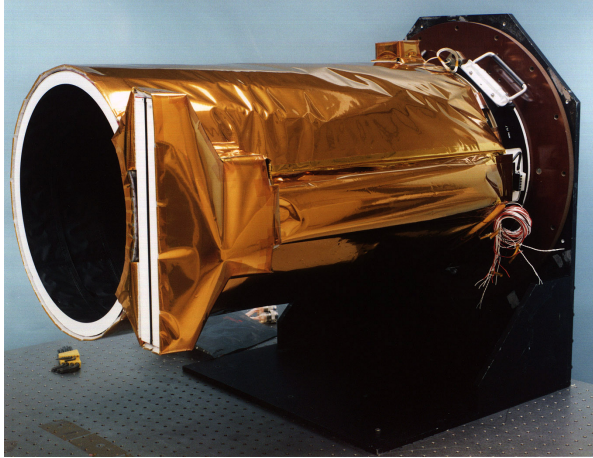
Source: NASA/GSFC

MOLA – Mars Orbiter Laser Altimeter

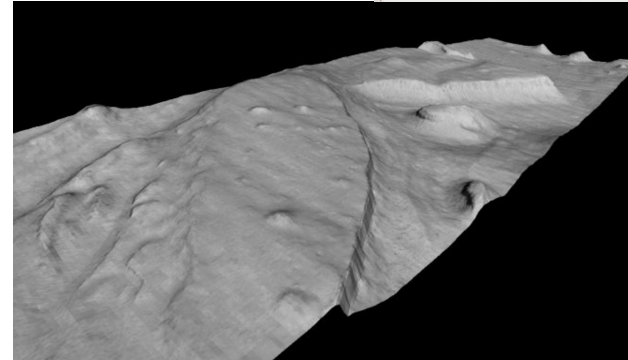
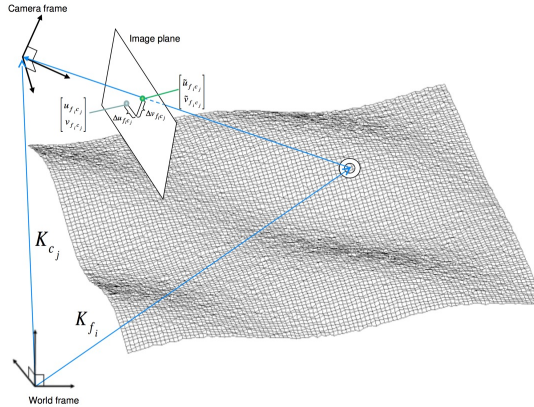


3D shaded relief from global DTM by MOLA laser altimeter (Mars Global Surveyor) (source: USGS Astrogeology)

MOC – Mars Orbiter Camera

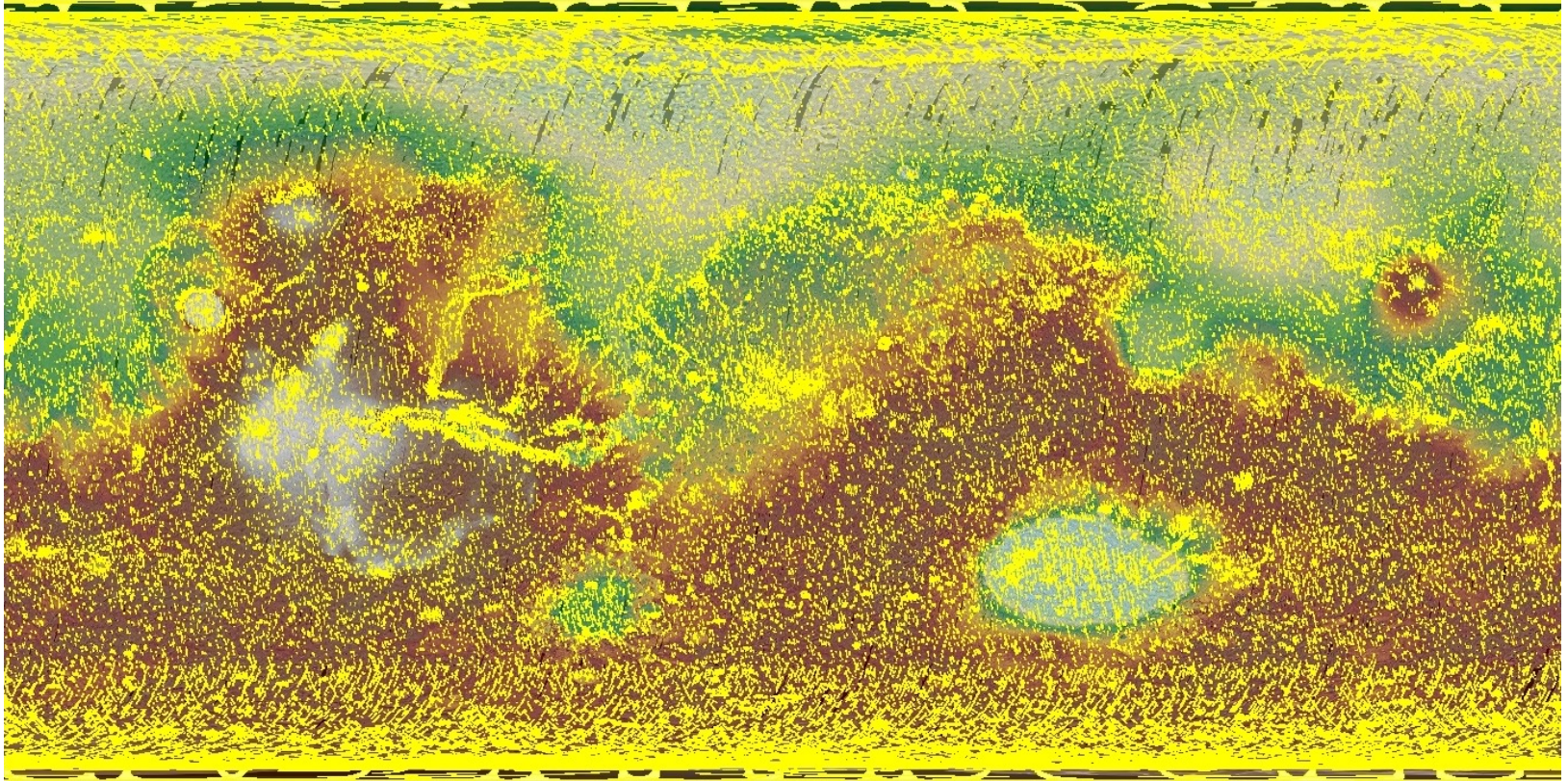


Source: NASA/MSSS



- Panchromatic camera with targeted observations
- Resolution between 1.5 and 12 m/pixel
- Stereo capabilities for DTM reconstruction

MOC - Coverage

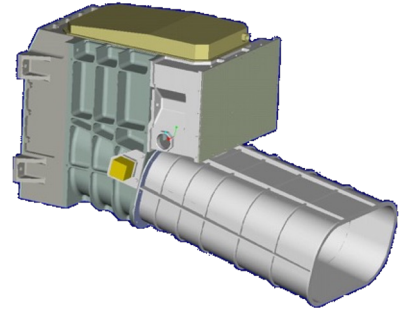


Source:
modified
from PDS-
ODE

THEMIS – Thermal EMISsion camera

THEMIS is a system that acquires thermal images

- It consists into two multi spectral subsystems:
 - IR (Thermal Infrared Imager) in 10 bands -> 6.78-10.21 microns
 - VIS (visible) in 5 bands -> 0.425-0.860 microns



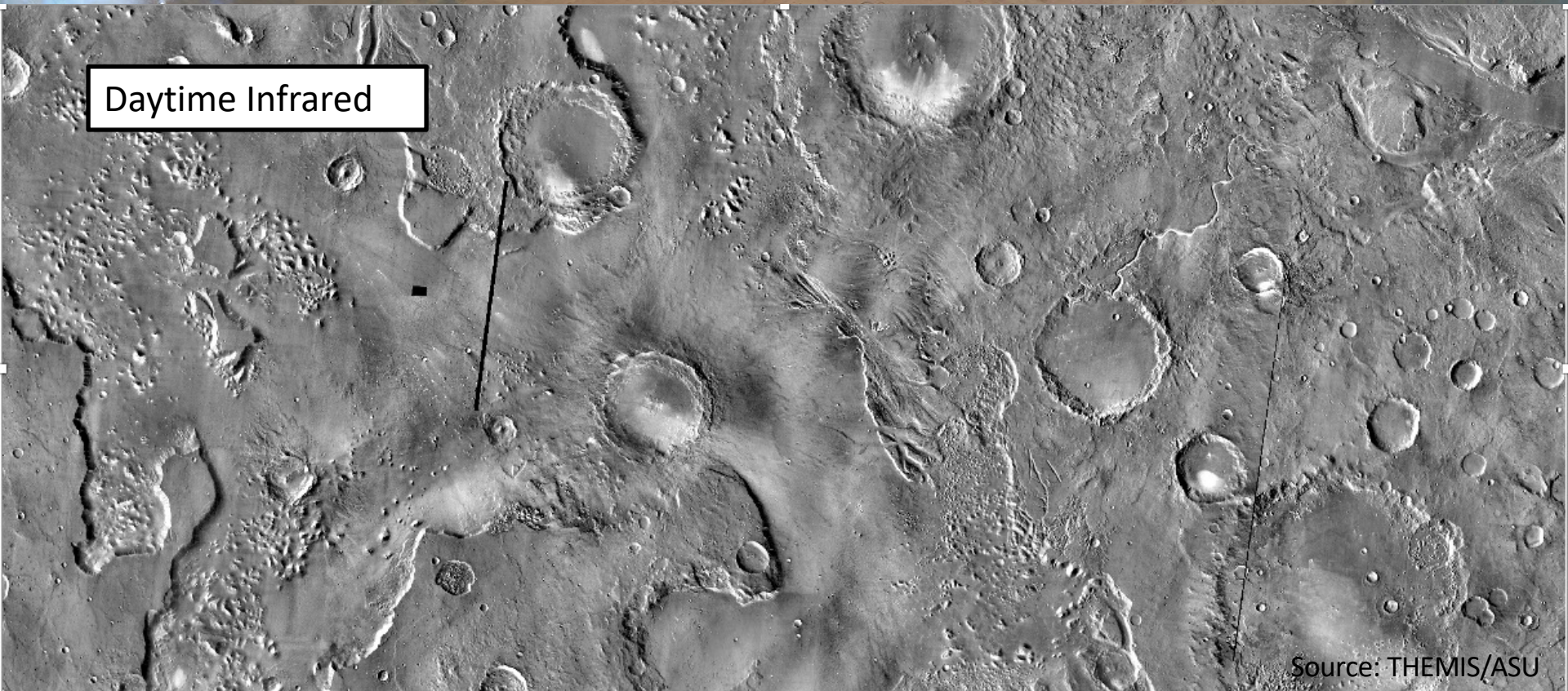
Source: Christensen et al., 1998, 2001 and THEMIS website

- IR: global mosaic at 100 m/pixel both in daytime and nighttime
Very useful for detecting geologic contacts
- VIS: 10 m/pixel

This resolution helps fill in the gap between large-scale geological images from the Viking orbiters in the 1970s and the very high-resolution images from the currently orbiting Mars Global Surveyor.

THEMIS – Thermal EMISsion camera

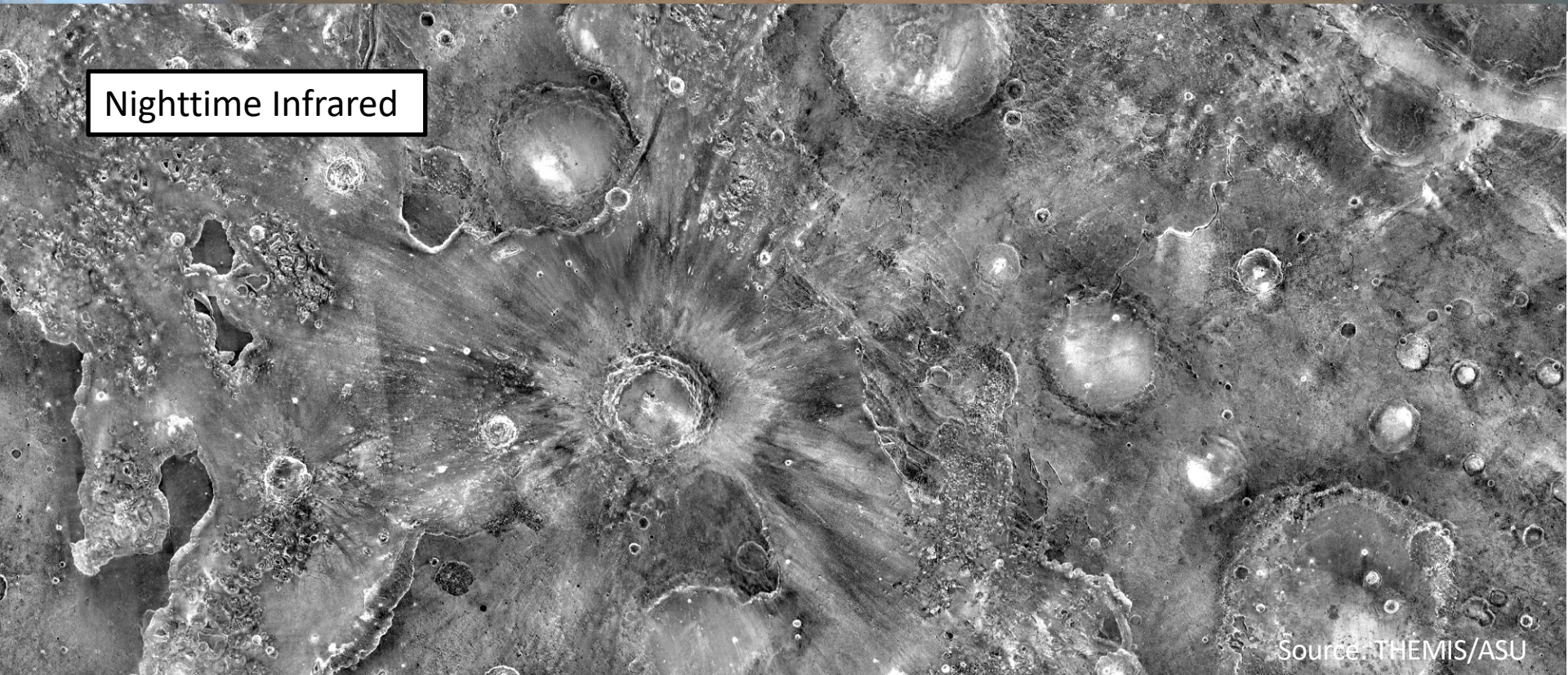
Daytime Infrared



Source: THEMIS/ASU

THEMIS – Thermal EMISsion camera

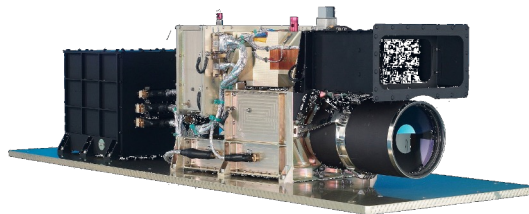
Nighttime Infrared



Source: THEMIS/ASU

MEX HRSC – High Resolution Stereo Camera

- 1 nadir channel
- Color filters in nadir (BL, GR, IR)
- 2 stereo channels (Left + Right)
- Stereo DTMs can be generated in-house or available by the instrument team at 100 m of grid spacing
- 1 super resolution channel



Credits: ESA/DLR/FU Berlin (G. Neukum)

Swath width: 52 km

Swath length: 300 km (minimum)

Archive FTP url:

<ftp://psa.esac.esa.int/pub/mirror/MARS-EXPRESS/HRSC/>

[H2086_0000_BL4.IMG](#)

[H2086_0000_DA4.IMG](#)

[H2086_0000_DT4.IMG](#)

[H2086_0000_GR4.IMG](#)

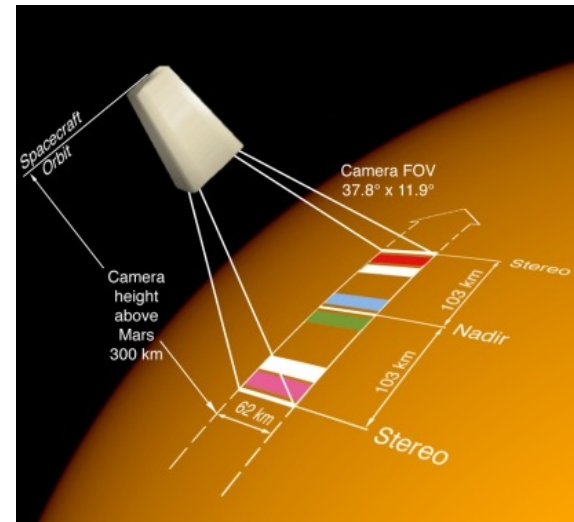
[H2086_0000_IR4.IMG](#)

[H2086_0000_ND4.IMG](#)

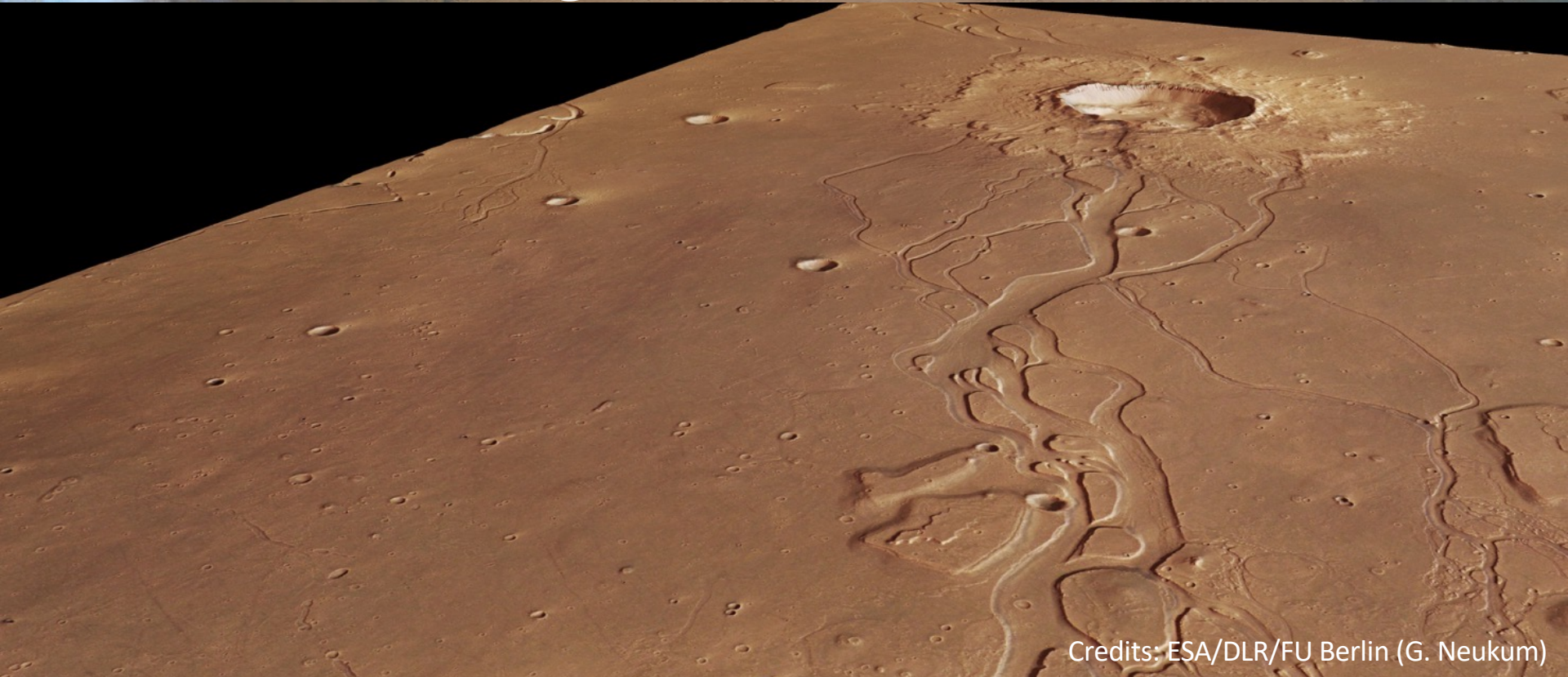
[H2086_0000_RE4.IMG](#)

DTM registered on MOLA

Nadir channel

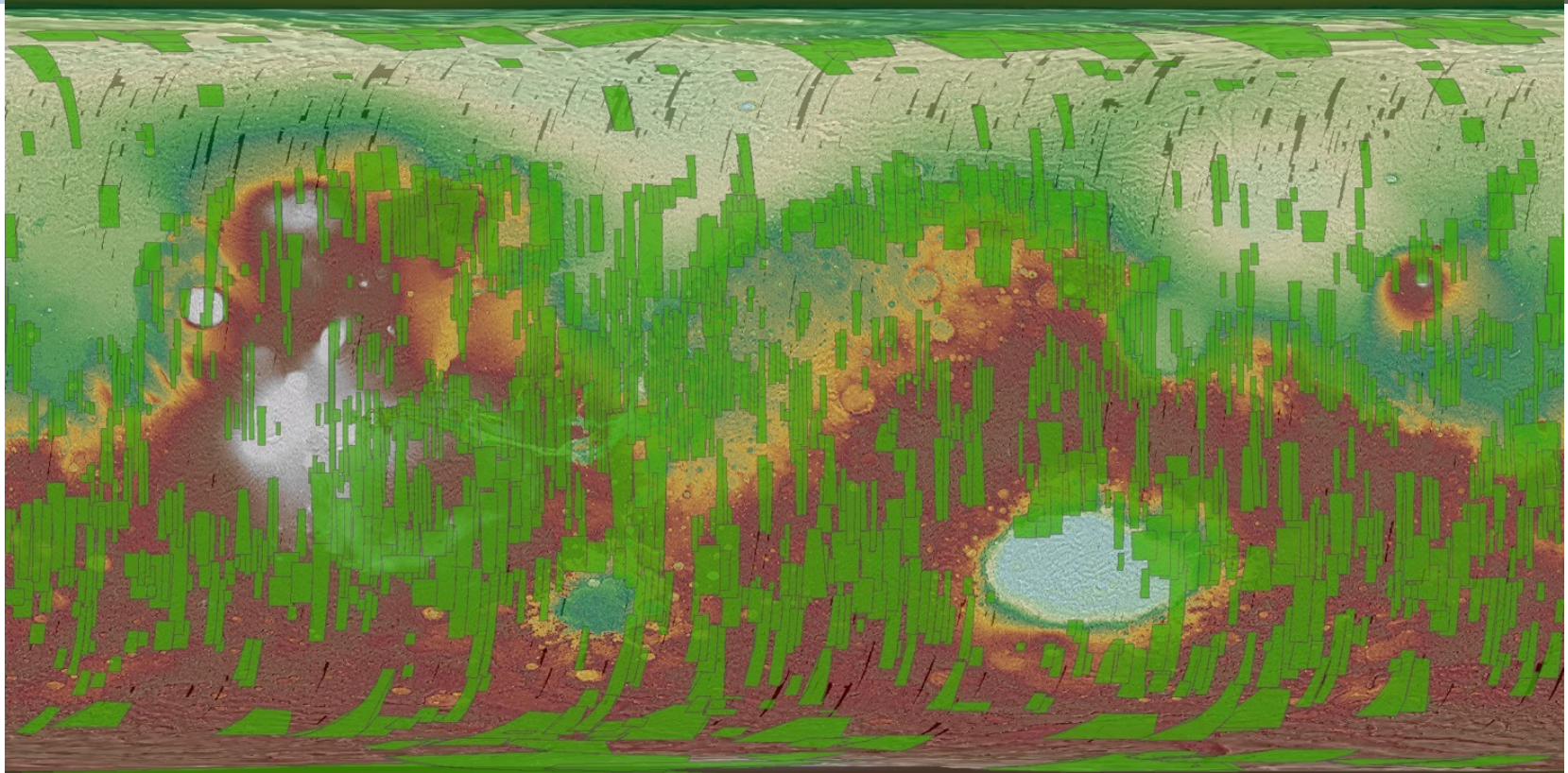


MEX HRSC – High Resolution Stereo Camera



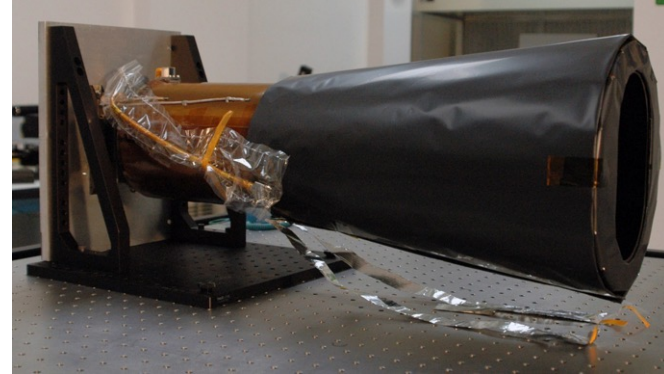
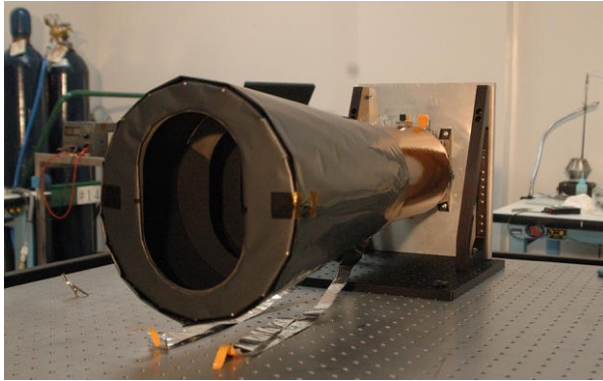
Credits: ESA/DLR/FU Berlin (G. Neukum)

MEX HRSC – DTM + Nadir+color coverage



Source:
modified
from PDS-
ODE

MRO CTX – ConteXT Camera



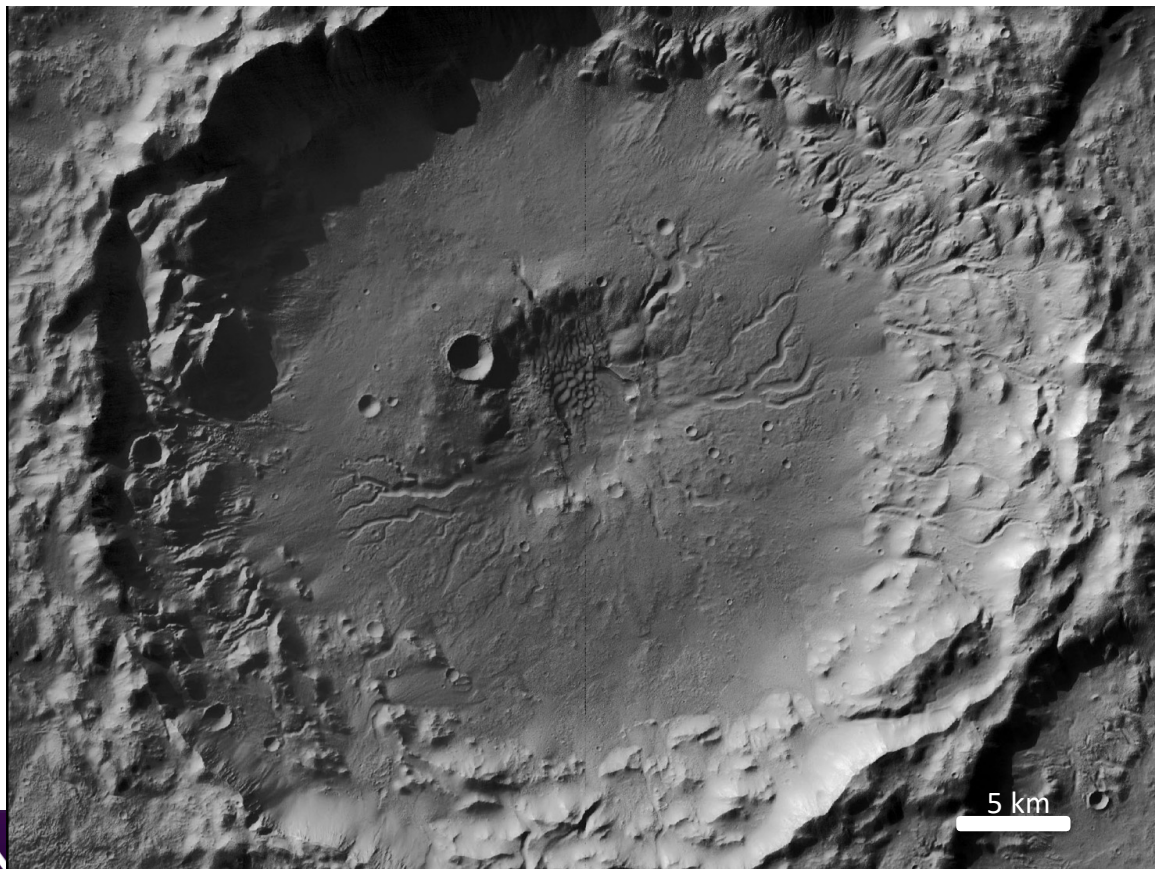
Source: NASA/MSSS – Malin Space Science Systems, (Malin et al., 2006)

- Used to give context to HiRISE images
- Average resolution 6 m/pixel (but can go up to 4-5 meters)
- Only one panchromatic channel

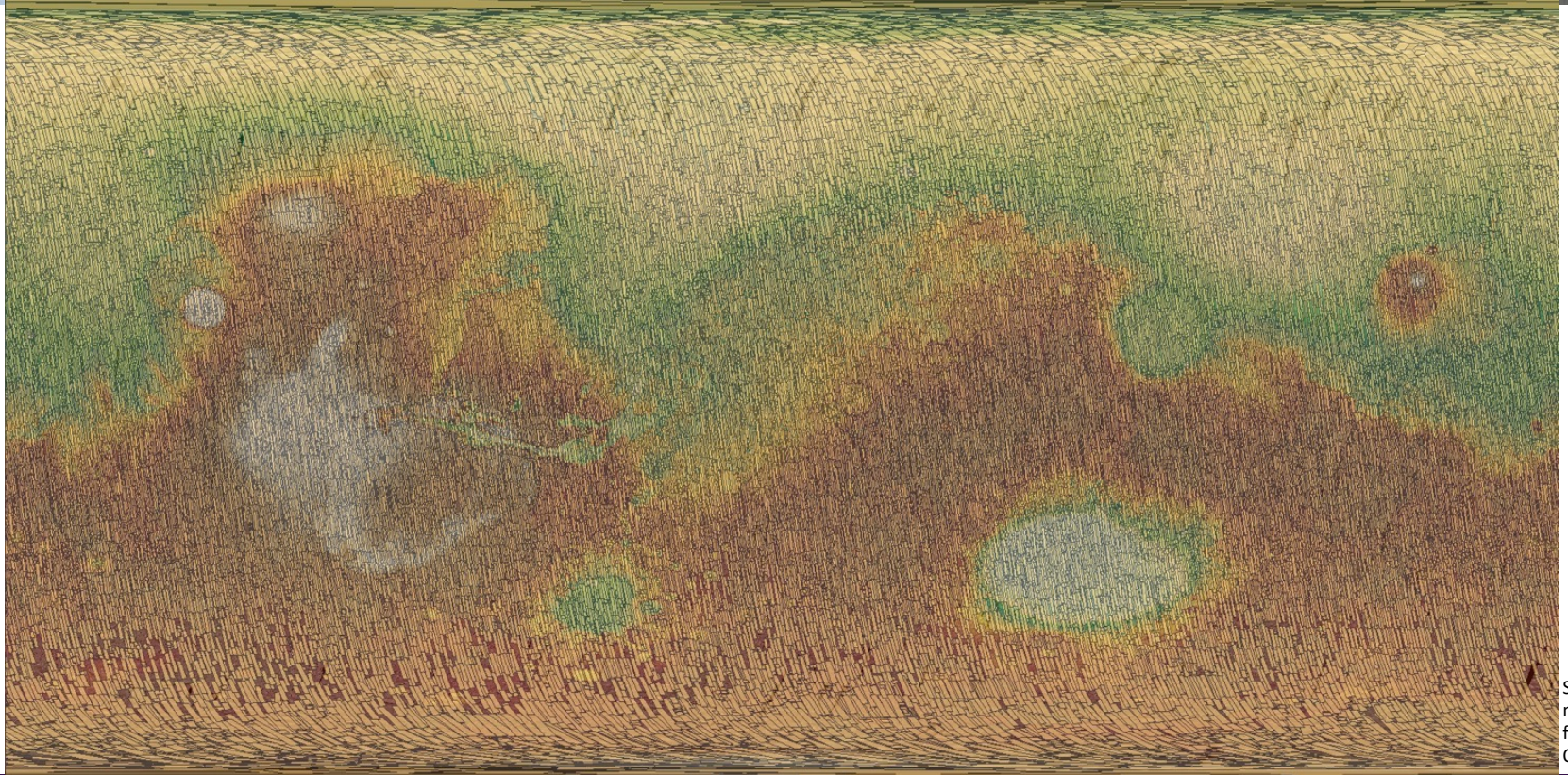
Swath width: 30 km

Swath length: variable between 50 km and 300 km

MRO CTX – ConteXT Camera mosaics



MRO CTX – Coverage



Source:
modified
from PDS-
ODE

MRO • HiRISE – High Resolution Imaging Science Experiment

HiRISE (McEwen et al., 2006) offers unprecedented resolution with three types of data:

- Experiment Data Record (EDR) data set
- Reduced Data Record (RDR) data set
- Digital Terrain Model (DTM) data set

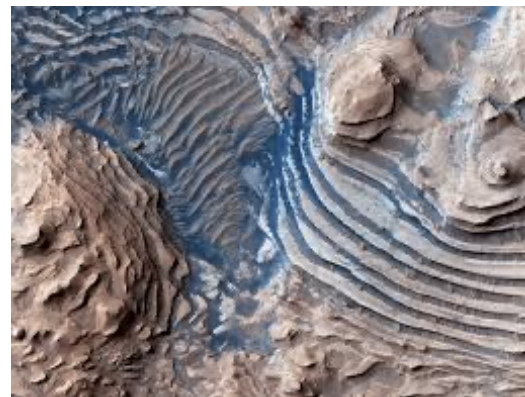
- Ground resolution of 0.25 m/pixel!
- Designed for stereoscopy -> DTM with 1 meter resolution
- Has three filters (RED, Blue/Green, NIR)

Data are delivered already calibrated and projected ready to use

<http://hirise.lpl.arizona.edu>

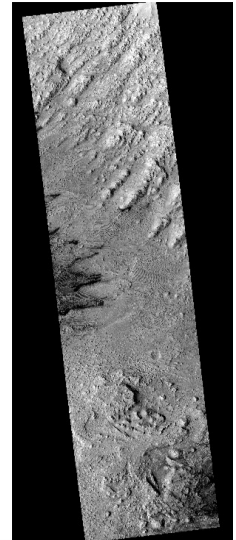
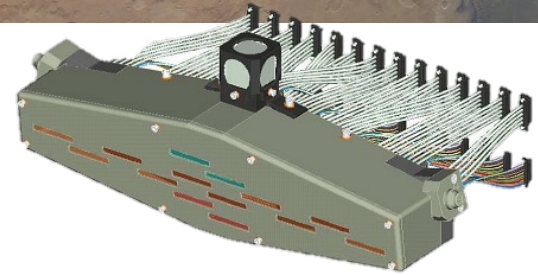
DTMs can be generated "in house" or use those provided by the HiRISE science team at <https://www.uahirise.org/dtm/>

Targeted HiRISE observations can also be requested with HiWISH tool
<https://www.uahirise.org/hiwish/>



Sensor and images

- EDR (Experiment Data Record): contains all data collected all of the 14 CCD available that present two output channels (14x2)
 - 14 CCD with 2 outputs
 - 10 red
 - 2 infrared
 - 2 blue/green
- When the electronics reads the data collected by the CCD it divides it into two parts per channel (left + right)
- Each HiRISE observation sends 28 image files to Earth (14 CCD x 2)
- RDR: Reduced Data Record: EDR mosaic and radiometrically corrected, geometrically corrected and projected.
- Swath size typically
 - 12x6 km in RED channel
 - 12x 1.2 km in the RED+IR+B/G channels

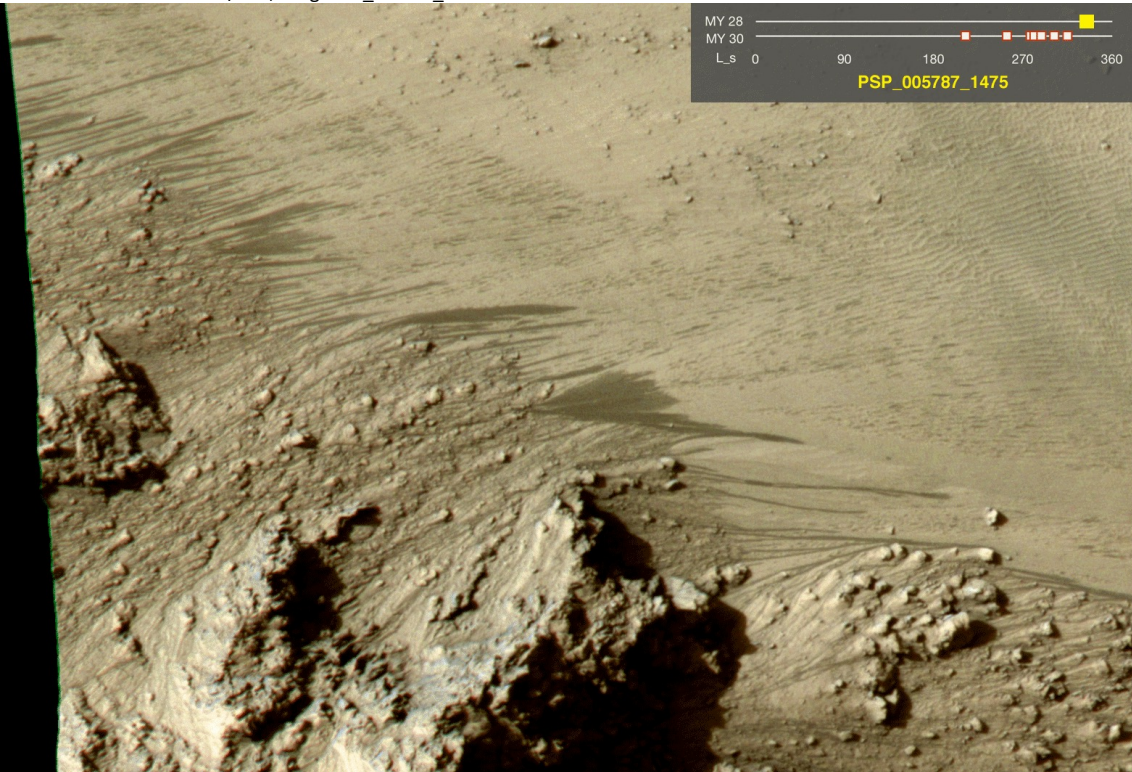


Source: Mars Reconnaissance Orbiter JPL Document Number D-32005, NASA-JPL/ASU

MRO HiRISE – High Resolution Imaging Science Experiment

Some image examples: RSL and MSL-Curiosity rover

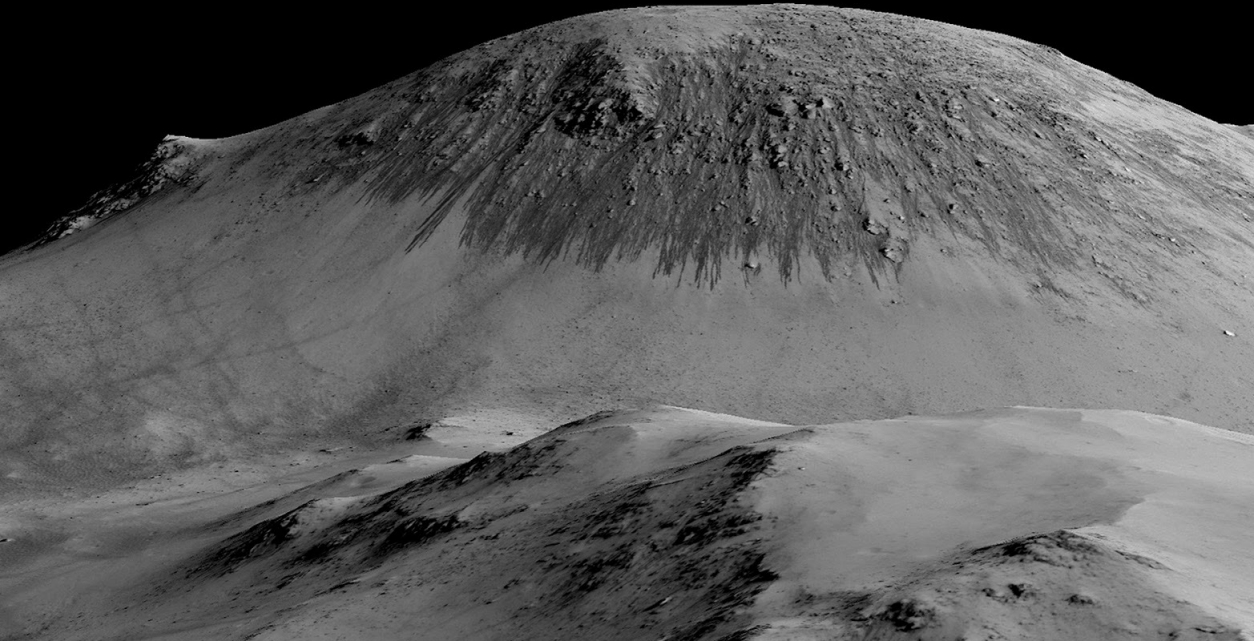
Source: NASA-JPL-Caltech/ASU, image ESP_036128_1755



MRO HiRISE – High Resolution Imaging Science Experiment

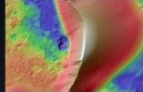
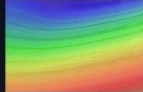

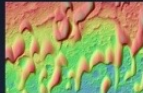
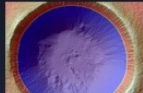



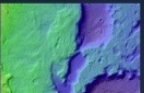
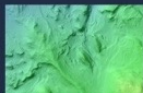

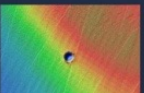
Some DTM+ image examples and ASU repository

Source: NASA-JPL-Caltech/Arizona State University



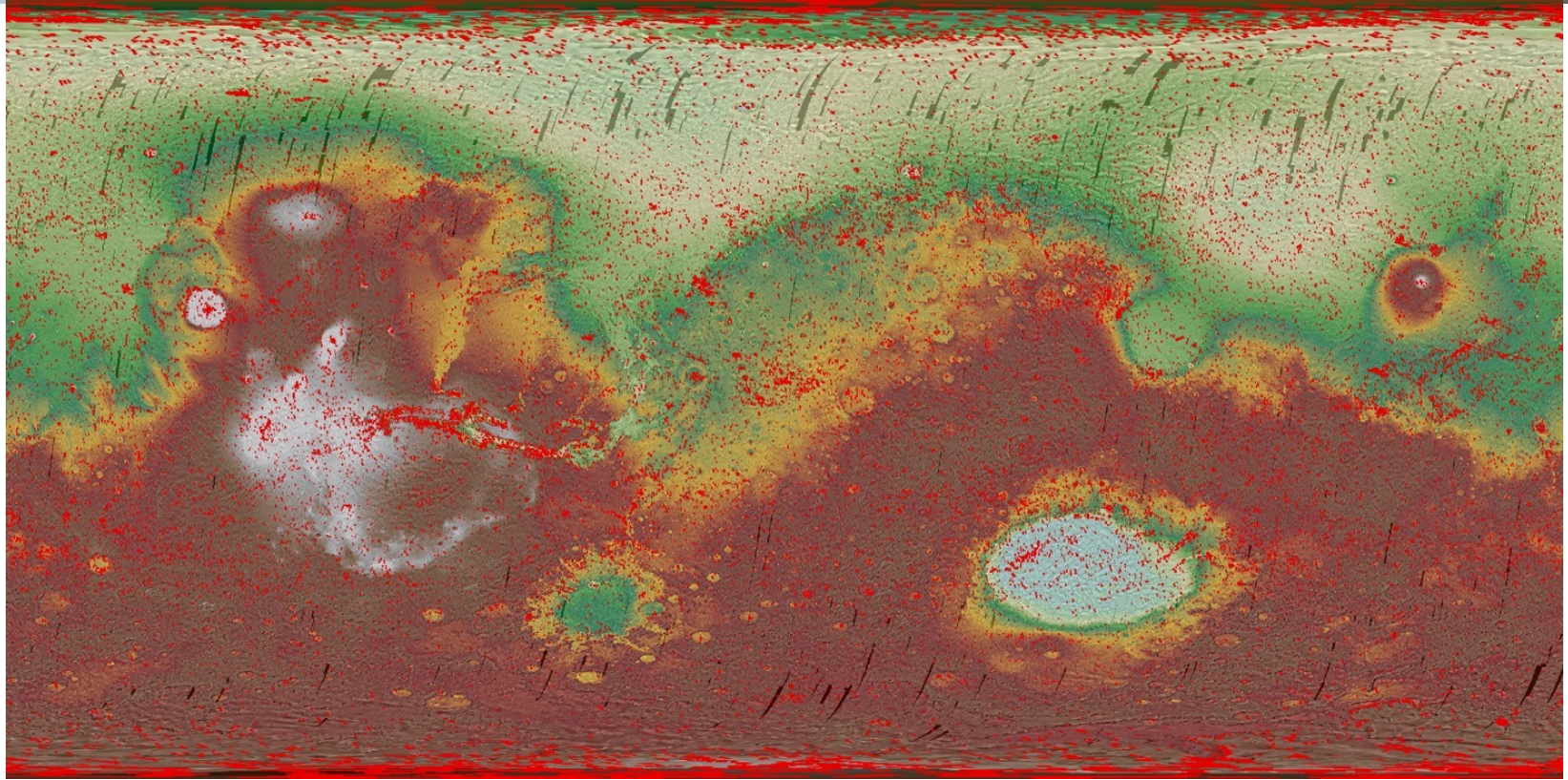
DIGITAL TERRAIN MODELS

High resolution digital terrain models (DTM) of Mars are created from HiRISE stereo pairs. For more detailed information about DTMs, please view our [overview page](#)

 <p>Avalanche Features of Dune Slip Face Seen in MOC Image R06-00380 4 Nov 2010</p>	 <p>Layering in North Polar Layered Deposits 1 Nov 2010</p>	 <p>Northern Residual Cap Crater 4 Oct 2010</p>
 <p>Dark Dunes in Herschel Crater 4 Oct 2010</p>	 <p>Zumba Crater: Fresh Crater with Impressive Ejecta/Ray Pattern 2 Aug 2010</p>	 <p>Fresh Crater in North Polar Layered Deposit 2 Aug 2010</p>
 <p>Possible MSL Landing Site in Mawrth Vallis 2 Aug 2010</p>	 <p>Fan Surfaces in West Holden Crater 2 Aug 2010</p>	 <p>Possible MSL Landing Site in Holden Crater 2 Aug 2010</p>
 <p>Inverted Riverbed in Gale Crater 2 Aug 2010</p>	 <p>Potential MSL Landing Site in Eberswalde Crater 2 Aug 2010</p>	 <p>North Polar Crater 28 Jun 2010</p>

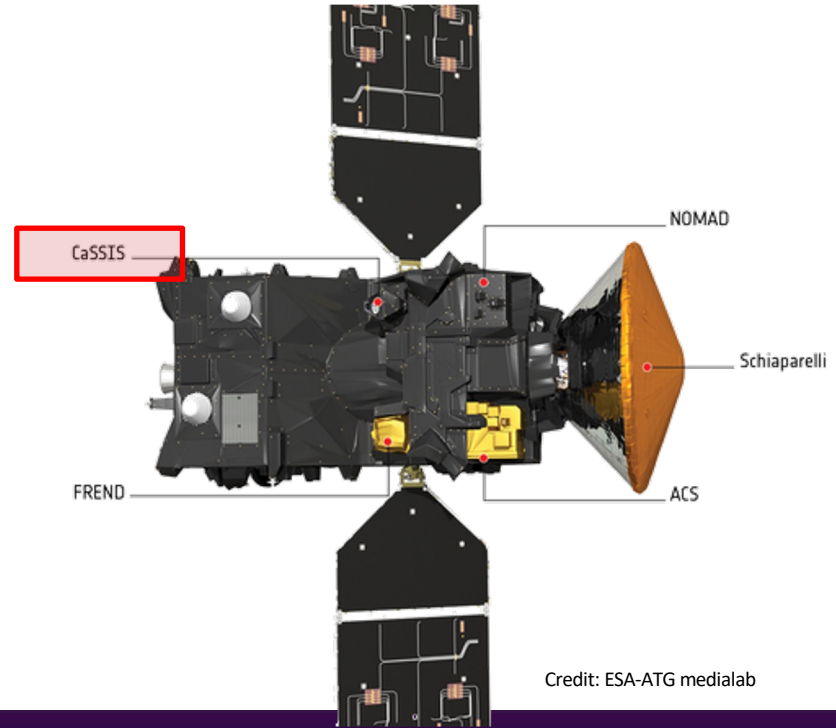
Page 1 of 5 pages (55 images) [Next](#) [Last Page](#)

MRO HiRISE – Coverage



Source:
modified
from PDS-
ODE

ExoMars trace Gas Orbiter - TGO

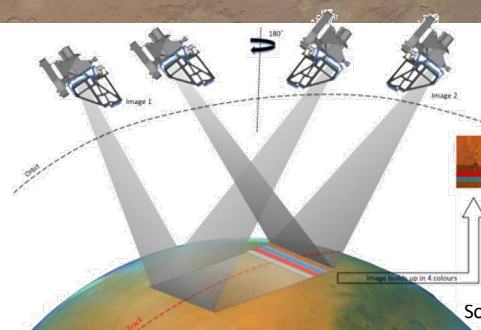


Credit: ESA-ATG medialab

ExoMars TGO – CaSSIS – Colour and Stereo Surface Imaging System

Colour stereo coverage at ~4.5 m/pixel /targeted)

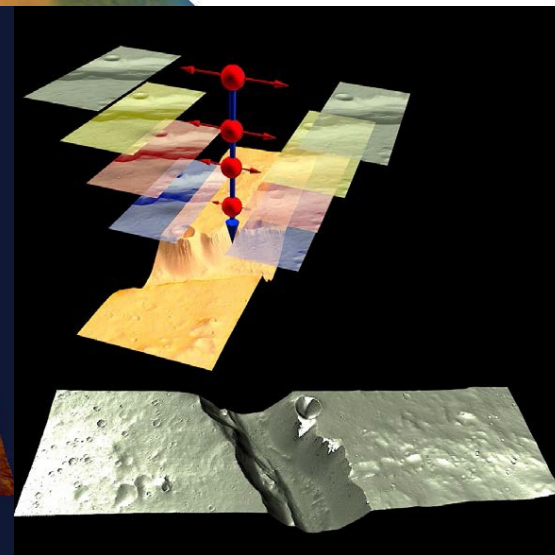
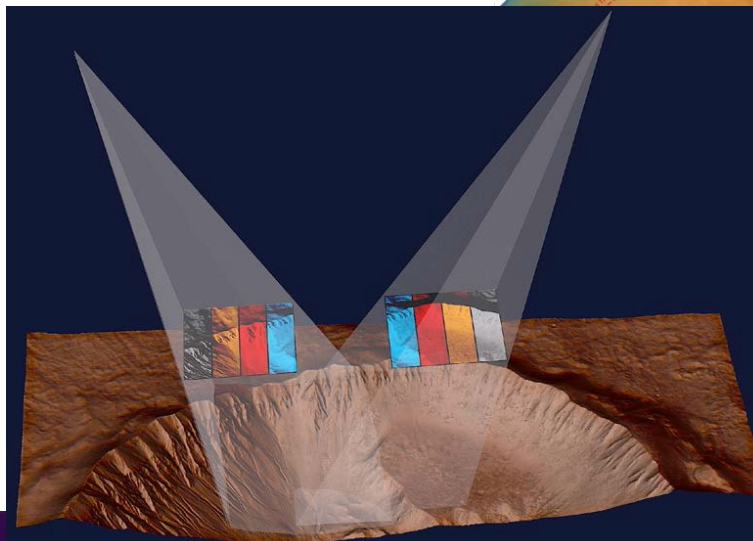
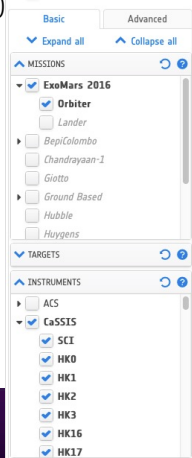
- Panchromatic at 650 nm
- IR at 950 nm
- NIR at 850 nm
- Blue/Green at 150 nm



Sources: Thomas et al., 2017, University of Bern

- Swath width: 7-9 km
- Swath length: 40 km

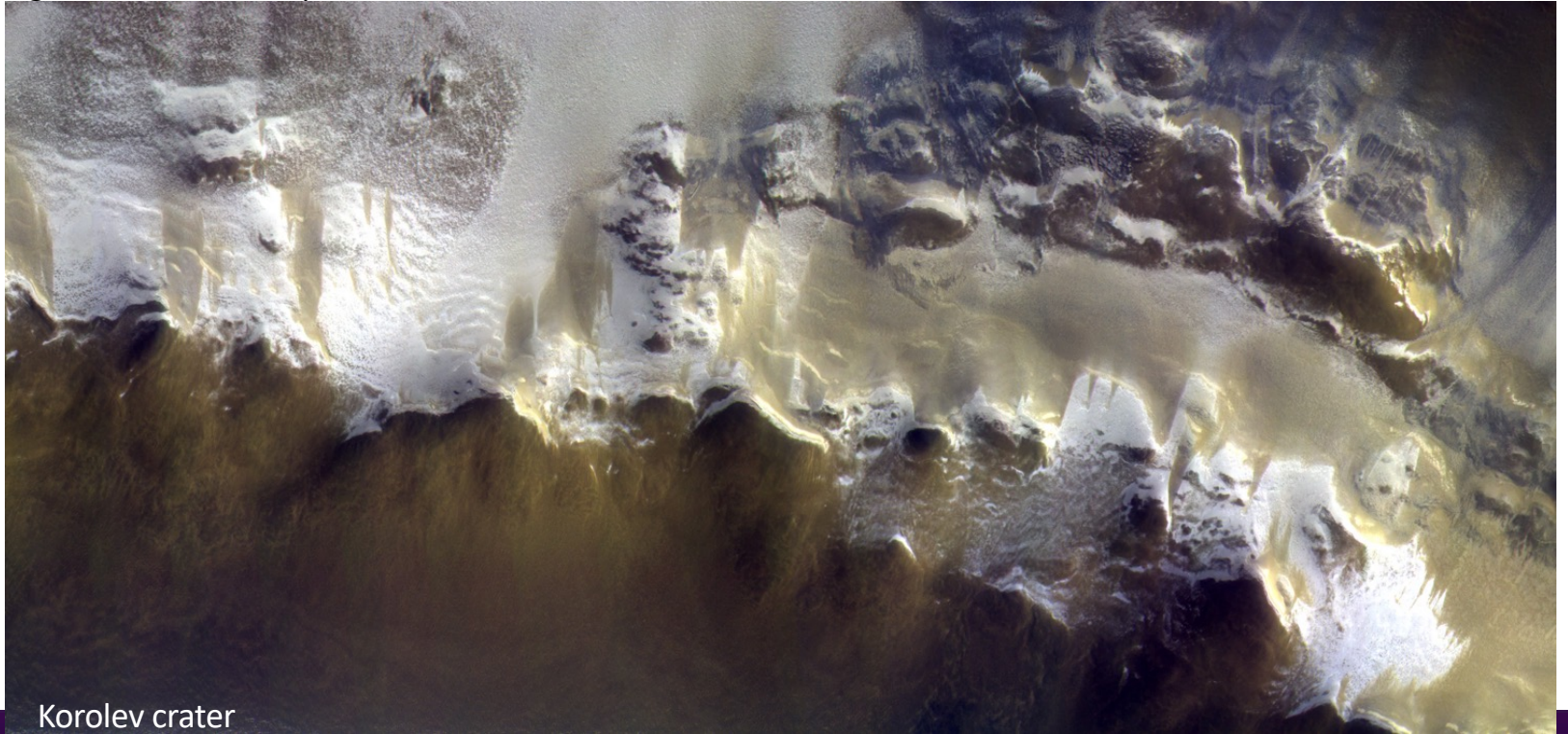
Data available at
ESA PSA



ExoMars TGO – CaSSIS – Colour and Stereo Surface Imaging System

More images and news at <https://www.cassis.unibe.ch>

Source: ESA/Roscosmos/Ube/CaSSIS



Korolev crater

ExoMars TGO – CaSSIS coverage at early 2021

Public CaSSIS data are accessible at ESA PSA (sorry no map search...yet)

<https://archives.esac.esa.int/psa>

DTMs are generated and provided by INAF-OAPD to registered users

Home | Log In | Register | Help

Welcome to Cassis DTM Repository

The OAPD DTM Management Framework

Log In Sign Up

Log In or Create an account to manage your DTM

You need an account to save or retrieve your DTMs.

Search free DTM library

You don't need an account to search through the free repository. [Search DTMs](#)

Source: INAF-OAPD

planetary science archive
PSA 6.0

TABLE VIEW

Filter by string in the current page

Number of selected items: 0

Postcard	Product Identifier	Start Time	Stop Time	Target	Missions
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	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094407640-red-3-8	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094406040-mul-2-6	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094408040-ex1-0-10	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094407240-pan-1-7	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094406040-pan-1-5	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094405240-ex1-0-2	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094404040-ex1-0-0	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094406040-pan-1-6	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094406040-red-3-5	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094406040-ex1-0-1	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...
	cas_raw_sc_20160407081500-20160407125030-0-1-1-20160407094408040-red-3-10	2016-04-07 08:15:00.0...	2016-04-07 12:50:30.0...	Non Scien...	ExoM...

Page: 1 917 >>>

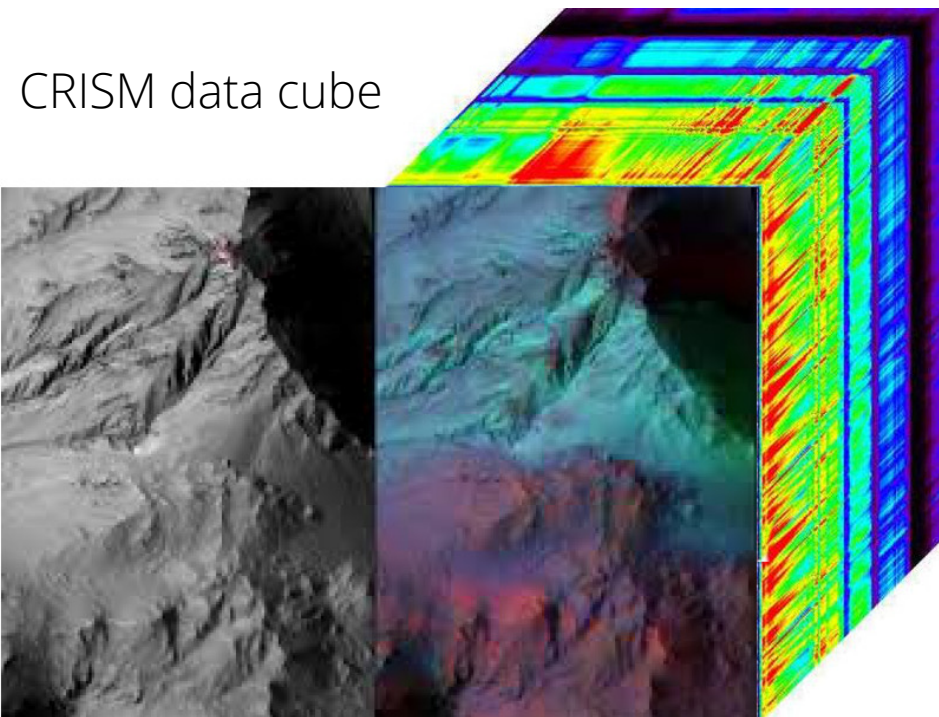
Items/page: 3000 | Displaying 1 - 3000 of 2749693

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Source: ESA/Roscosmos/CaSSIS

Spectral imaging

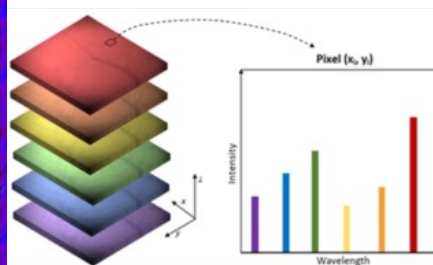
CRISM data cube



Source: adapted from CRISM website, JHU/APL and Cristophe et al. 2009

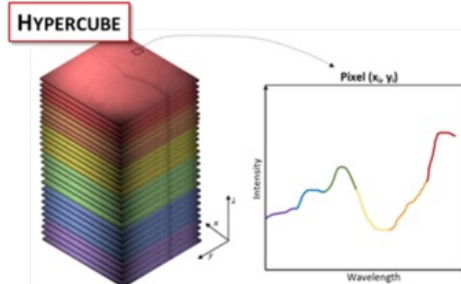
MULTISPECTRAL IMAGING

- N separated bands

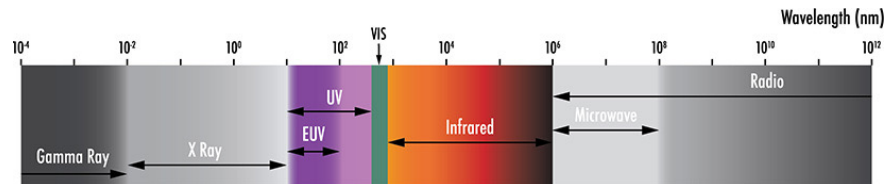


HYPERSPPECTRAL IMAGING

- Continuous spectrum



Source: Nireos, Adapted from Giannoni et al 2018 J. Opt. 20 044009



Spectral imaging: CRISM

60 cm

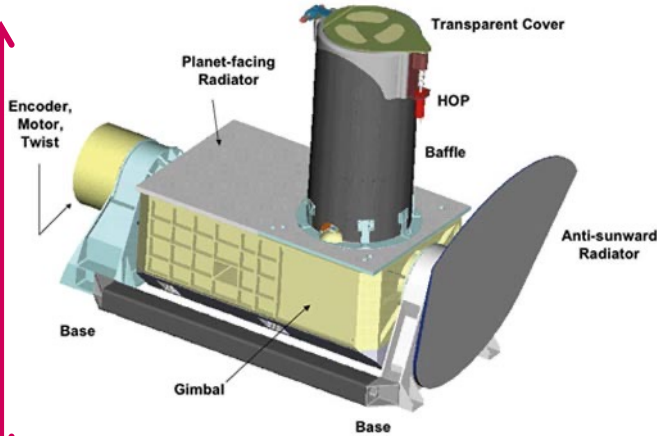
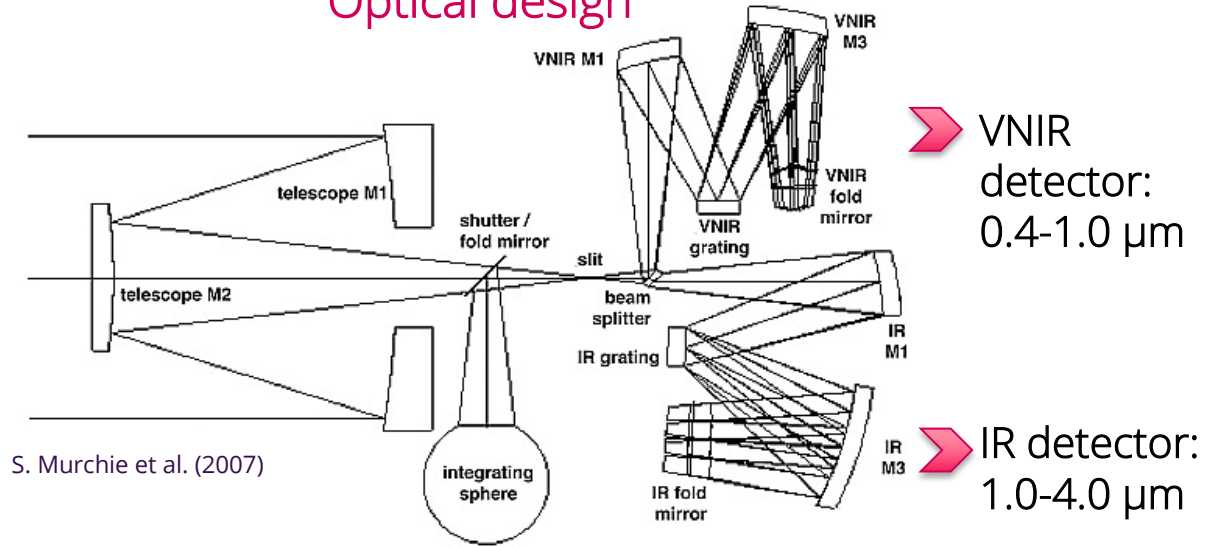


Image credits: NASA

Optical design

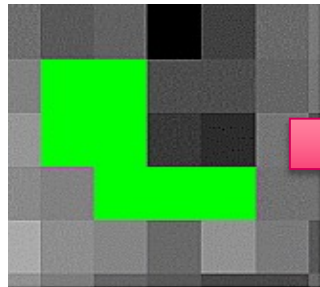


Spectral imaging:CRISM

- 0.4 - 4.0 μm spectral range
- High-resolution, hyperspectral targeted images (18-36 m/pixel @ 300 km, 544 spectral channels)

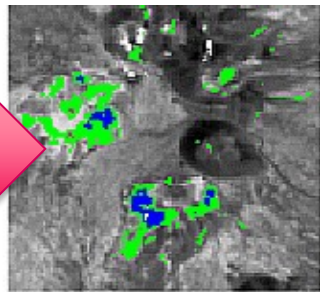
OMEGA spectrometer (MEX)

CRISM targeted observation



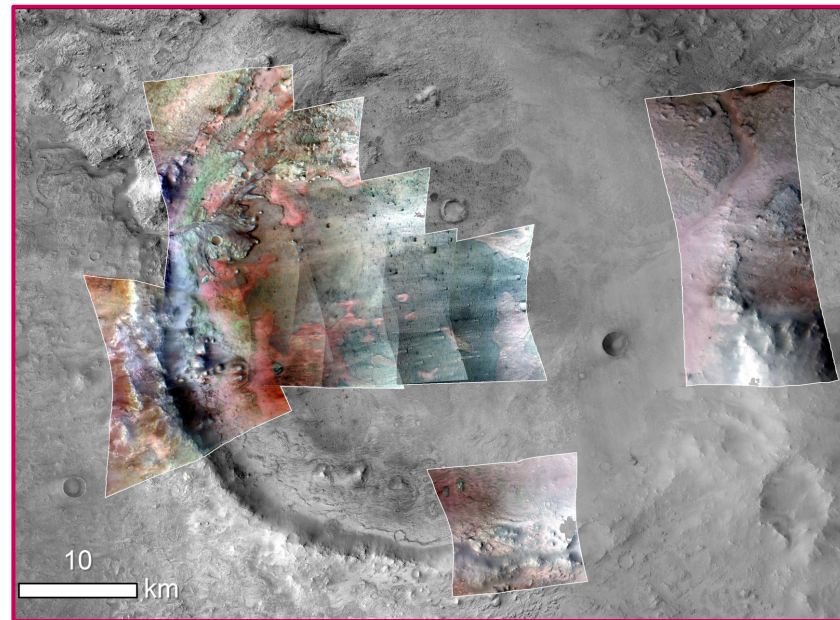
OMEGA (300-1000 m/pixel, 13 nm/ch.): discovers large deposits

Modified from S. Murchie et al. (2007)



CRISM targeted hyperspectral (15-38 m/pixel, 6.55 nm/ch): characterizes deposits

Targeted images have typical hourglass shape



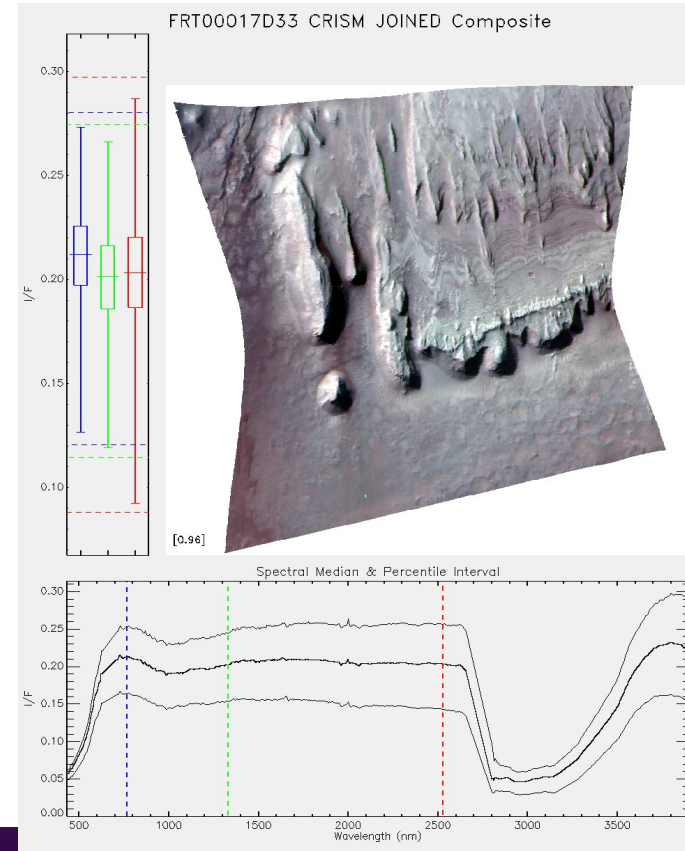
Credits: NASA/JPL-Caltech/MSSS/JHU-APL/Purdue/USGS

Spectral imaging: CRISM

CRISM Map-projected Targeted Reduced Data Records (MTRDRs)

- Full spectral range joining VNIR and IR;
- The IR is already corrected for geometric, photometric, atmospheric, and instrumental effects;
- Removal of spectral channels with suspect radiometry (“bad bands”).

MTRDRs are currently best available data



Spectral imaging:CRISM

CRISM Map-projected Targeted Reduced Data Records (MTRDRs)

Browse Files		KB
crism_ter_mtrdr_review_info.xls	Information generated by the release review process	6,360
ftr000047a3_07_brcarj_mtr3.hdr	Carbonates Browse ENVI Header	
ftr000047a3_07_brcarj_mtr3.img	Carbonates Browse PDS Image	
ftr000047a3_07_brcarj_mtr3.lbl	Carbonates Browse Label	
	ftr000047a3_07_brcarj_mtr3.png Carbonates Browse Quicklook	
ftr000047a3_07_brchljl_mtr3.hdr	Inferred Chloride Deposits Browse ENVI Header	2
ftr000047a3_07_brchljl_mtr3.img	Inferred Chloride Deposits Browse PDS Image	2,054
ftr000047a3_07_brchljl_mtr3.lbl	Inferred Chloride Deposits Browse Label	8

.img browse products that can be directly put in GIS project

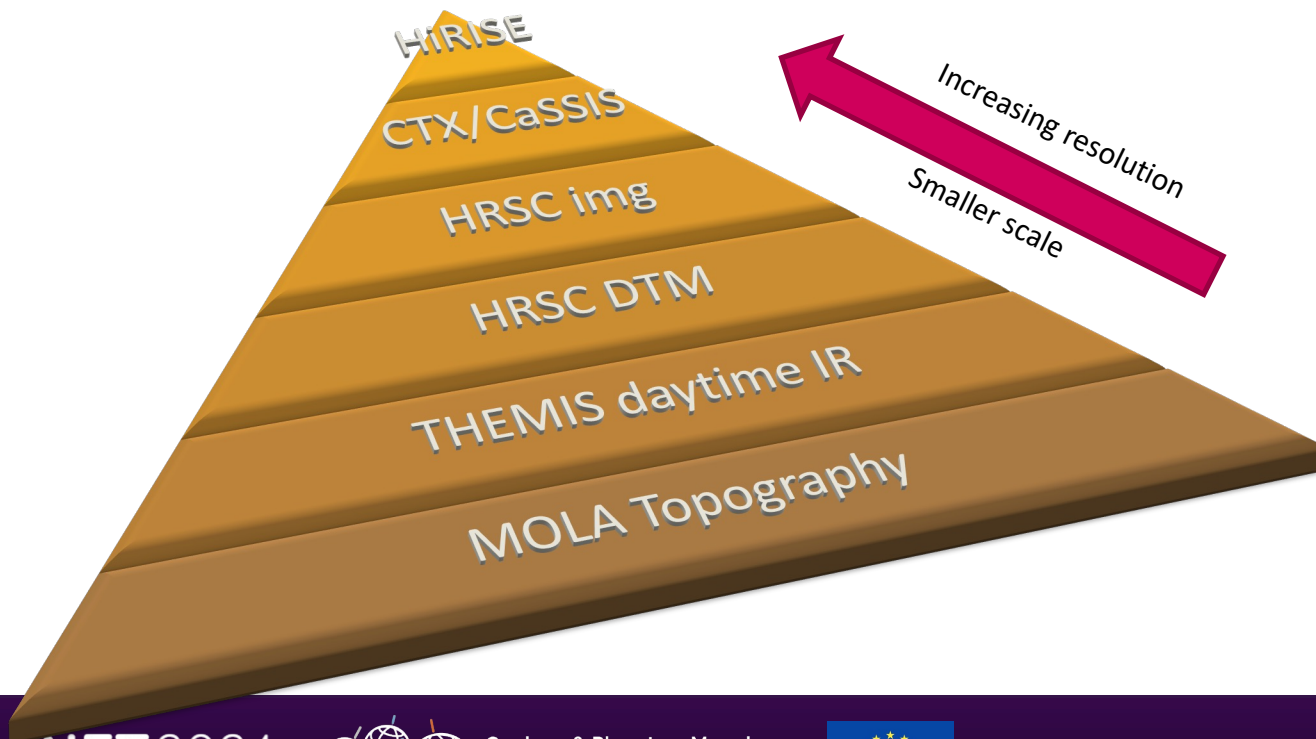
Browse products

With browse products you can quickly assess the mineralogy of a CRISM scene

☞ Refer to *Viviano-Beck et al. (2014)* for common browse products and their interpretation.

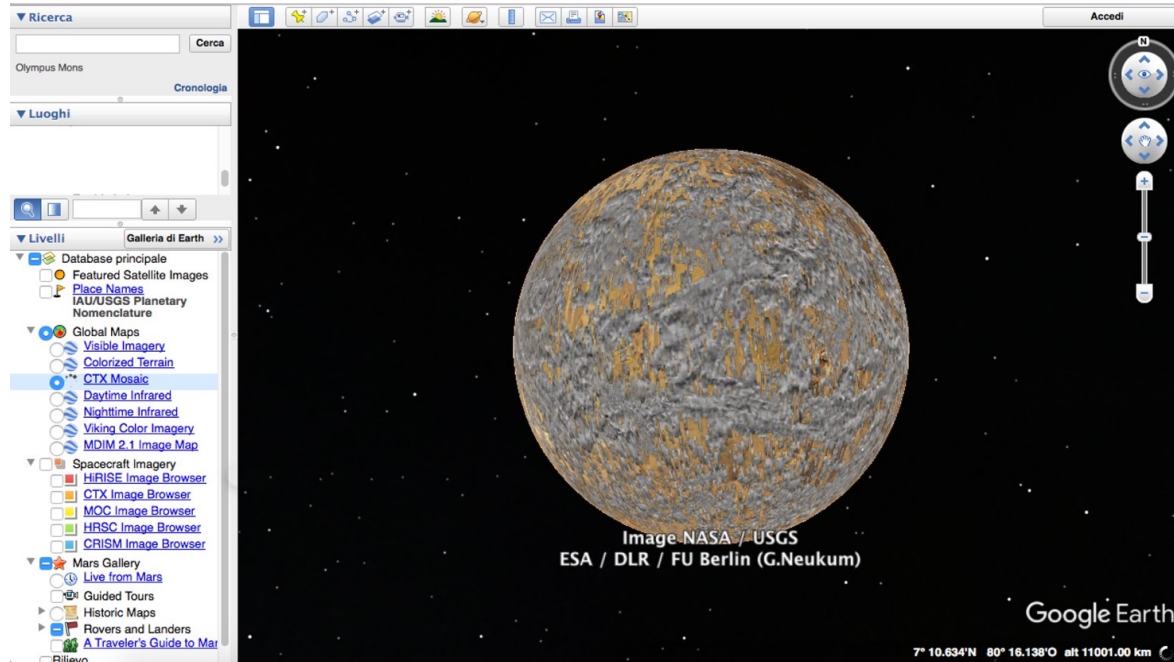
☞ Check out presentation from last year ([Spectral data in the sedimentary deposits of Mars](#))

Tips for organizing a MARS GIS project

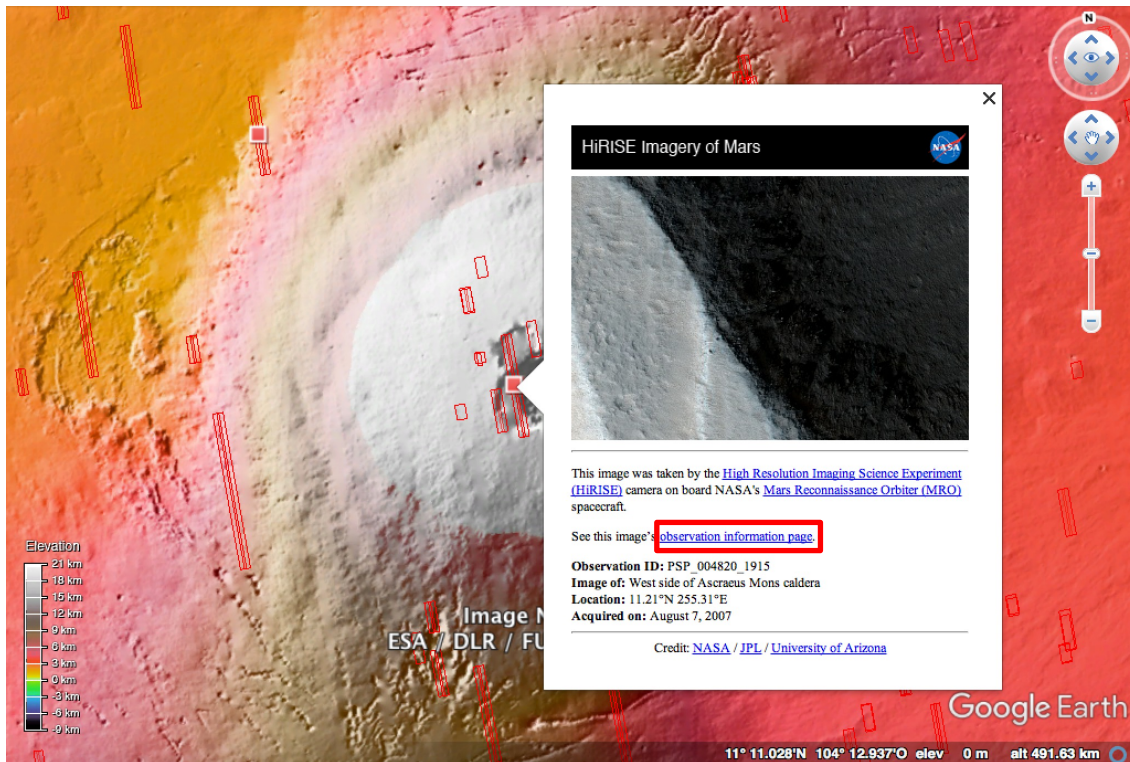


How to visualize on the fly planetary data

- Google Earth (limited to Moon and Mars)



Google Earth – HiRISE scouting and download



Acquisition date 07 August 2007	JPEG Black and white map projected non-map	ADDITIONAL INFORMATION B&W label Color label Merged IRB label Merged RGB label EDR products HiView
Local Mars time: 14:27	IRB color map projected non-map	NB IRB: Infrared-red-blue RGB: red-green-blue About color products (PDF)
Latitude (centered) 11.209°	Merged IRB map projected	Black & white is 5 km across; enhanced color about 1 km For scale, use JPEG/J2 black & white map-projected images
Longitude (East) 255.311°	Merged RGB map projected	USAGE POLICY All of the images produced by HiRISE and accessible on this site are within the public domain; there are no restrictions on their usage by anyone in the public, including
Range to target site 255.4 km (159.6 miles)	RGB color non-map projected	
Original image scale range 51.1 cm/pixel (with 2 x 2 binning) so objects ~153 cm across are resolved	JP2 Black and white map-projected (776MB)	
Map projected scale 50 cm/pixel and North is up	IRB color map-projected (364MB)	
Map projection	JP2 EXTRAS	

Google Earth – CTX scouting and download

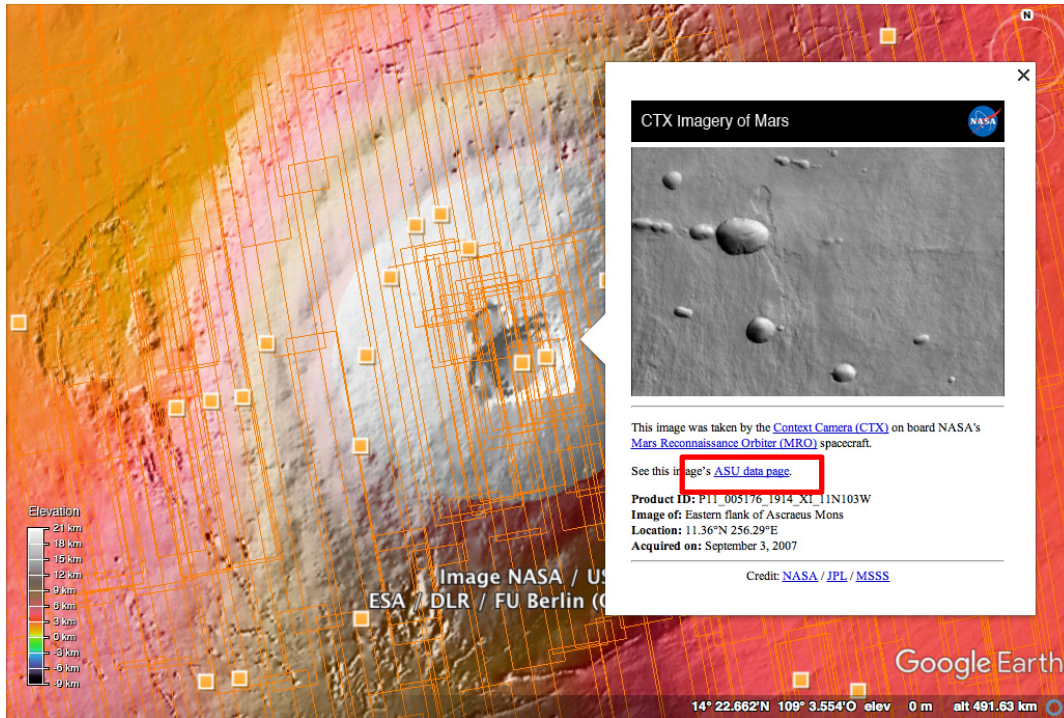


Image Explorer

MARS ASI

THEMIS MRO Context Camera HiRISE HiRISE Analytics CRISM Mars Express HiSC/BSIC Mars Orbiter Camera OMEGA Viking SHARAD

FAQ Glossary Themis Documentation Contact Us Log In/Register

MRO Context Camera

Search CTX Results P11_005321_1913_XN_11N102W

CTX: P11_005321_1913_XN_11N102W

Context

Click on the field name to see the glossary definition for that field.

Name	Value
Image ID	P11_005321_1913_XN_11N102W
Center Lat.	11.26°
Center Lon	257.14°
Local Time	14.21
Solar Longitude	314.04°
Scaled Pixel Width	5.49 m
Incidence Angle	43.87°
Emission Angle	0.1°
Orbit	9321
Image Time	2007-09-15T01:40:48.647
Description	East flank of Ascræus Mons
Volume ID	mrnx_3202
Instrument Mode ID	NPL
Image Swath Angle	90.1°
Slant Distance	274.36 km
Phase Angle	43.92°
Solar Distance	216759912 km
Subsolar Azimuth	145.78°
Subsolar Latitude	-18.02°
Subsolar Longitude	136.12°
Subspacecraft Latitude	11.27°
Subspacecraft Longitude	102.86°
Spacecraft Altitude	274.36 km
North Azimuth	277.1°
Focal Plane Temperature	295.4K
Offset Mode Id	196/205/201
Target Name	MARS
Usage Note	N
Data Quality	OK
Scaled Image Height	314.83 km
Spacecraft Clock Start Count	0874287668-012
Mission Phase	PSP
Mars Year	28

Image Formats: PNG GIF JPEG TIFF PDE

Full Image Formats: JPEG2000 ISIS.Header PDS.Source.EDR Download.HiView.Image.Data.Explorer*

Main Planetary Data Repositories for visualization and download of data useful for mapping

- PDS (NASA)
- PSA (ESA)
- ODE (NASA)
- PILOT (USGS)
- Astropedia (USGS)
- JMARS (Arizona State University)

PDS – Planetary Data System

- <https://pds.nasa.gov>

The screenshot shows the PDS Planetary Data System homepage. At the top, there is a navigation bar with 'HOME', 'DATA SEARCH', 'TOOLS', and 'DATA STANDARDS'. Below this is a 'Data Search' section with a 'Keyword Search' button and links for 'Data Set Status' and 'Data Releases'. On the left, there is a 'PDS Nodes' sidebar listing various planetary science disciplines. The main content area features a 'Data Search' heading and a paragraph explaining that advanced search tools are available from several PDS discipline nodes. Below the text are two search input fields: 'Search based on Target:' and 'or Mission:'. The NASA logo is visible in the top left corner.

The screenshot displays the PDS Image Atlas interface. At the top, it shows the NASA Jet Propulsion Laboratory logo and the title 'PDS Image Atlas'. A search bar is present with a search button. Below the search bar, there is a 'Show results for' section with a 'Share' button and a list of filters: 'remove all', 'TARGET_NAME:mercury', and 'ATLAS_MISSION_NAME:messenger'. A sidebar on the left lists various mission and data categories. The main area shows a grid of image thumbnails. Some thumbnails are labeled 'Browse Not Available', while others show planetary surfaces with IDs like 'CN1072716046M_IF_5' and 'CN1072716046M_RA_5'. There are also buttons for 'Click on image to display higher resolution.' and 'Bulk File Download'.

ESA PSA - Planetary Science Archive

- <https://archives.esac.esa.int/psa/>

The screenshot shows the ESA Planetary Science Archive (PSA) website. At the top, there are navigation links for 'EUROPEAN SPACE AGENCY', 'SCIENCE & TECHNOLOGY', and 'COSMOS', along with a 'SIGN IN' link. A yellow banner indicates a system maintenance period: 'The system will be under maintenance and temporarily unavailable on February 1st from 12h to 13h CET for the upgrade to version 6.0.1'. The main header features the 'planetary science archive' logo and the ESA logo. Below the header is a navigation bar with icons for home, list, image, map, search, and help. The main content area is titled 'HOME VIEW' and features a central search section with a globe icon and the text 'START SEARCHING YOUR DATASET!'. Below this is a search input field with a search button and a help icon. A paragraph of text describes the PSA as the central repository for scientific and engineering data from ESA's Solar System missions, including Giotto, Huygens, Mars Express, Rosetta, SMART-1, ExoMars 2016, Chandrayaan-1, BepiColombo, and Venus Express. Below the search section are three columns of links: 'DATA ACCESS' (Table View, Image View, Map View, Downloads, FTP Access), 'PRODUCT INFO & TOOLS' (Ancillary Data, Tools, Documentation, ESA Missions), and 'USEFUL INFORMATION' (Workshop, User Group, Help & FAQ, Contact). On the right side, there is a 'Tweets by @esapsanews' section with two tweets. The bottom of the page has a copyright notice: 'COPYRIGHT 2004 - 2021 © EUROPEAN SPACE AGENCY. ALL RIGHTS RESERVED.'

ODE – Orbital Data Explorer

Part of the PDS Geosciences Node
<https://ode.rsl.wustl.edu>



Welcome to the Orbital Data Explorer

The PDS Geosciences Node Orbital Data Explorer (ODE) website is a cross-mission and instrument query, search, display, and download tool for locating and retrieving PDS orbital science data archives of Mars, Mercury, Venus, and Earth's moon.

Orbital Data Explorer Targets:

Mars Orbital Data Explorer
The Mars Orbital Data Explorer (ODE) provides search, display, and download tools for selected PDS science data archives of the Mars Reconnaissance Orbiter (MRO), the 2001 Mars Odyssey, the Mars Global Surveyor (MGS), the Viking Orbiter 1 and 2, and the European Space Agency's Mars Express missions.

Mars Orbital Data Explorer

Supported Missions and Instruments:
Mars Reconnaissance Orbiter (MRO): CRISM, CTX, Gravity/Radio Science, HiRISE, MCS, SHARAD
ESA's Mars Express: HRSC, MARSIS, OMEGA, PFS
2001 Mars Odyssey: GRS, THEMIS
Mars Global Surveyor: MOC, MOLA, TES
Viking Orbiter 1 and 2: VISAB

Lunar Orbital Data Explorer

The Lunar Orbital Data Explorer (ODE) provides search, display, and download tools for the PDS science data archives of the Lunar Reconnaissance Orbiter (LRO), the Gravity Recovery and Interior Laboratory (GRAIL), the Clementine, the Lunar Prospector, the Lunar Orbiter, and the Indian Space Research Organisation's Chandrayaan-1 missions.

Lunar Orbital Data Explorer

Supported Missions and Instruments:
Lunar Reconnaissance Orbiter (LRO): DLRE, LAMP, LEND, LOLA, LROC, MRFRO
ISRO's Chandrayaan-1: M3, Mini-RF
Gravity Recovery and Interior Laboratory (GRAIL): LGRS
Clementine: HIRIS, LIDAR, LWIR, NIR, RSS, UVVIS
Lunar Prospector: ER, GRS, MAG, NS, RSS
Lunar Orbiter: 24 Inch Focal Length Camera, 80mm Focal Length Camera

Mercury Orbital Data Explorer

The Mercury Orbital Data Explorer (ODE) provides search, display, and download tools for the PDS science data archives of the MESSENGER (Mercury Surface, Space Environment, Geochemistry, and Ranging) mission.

Mercury Orbital Data Explorer

Supported Missions and Instruments:
MESSENGER: GRS, MASCS, MDIS-NAC, MDIS-WAC, MLA, NS, RSS, and XRS

Venus Orbital Data Explorer

The Venus Orbital Data Explorer (ODE) provides search, display, and download tools for the PDS science data archives of the Magellan mission and the MESSENGER mission's Venus data.

Venus Orbital Data Explorer

Supported Missions and Instruments:
Magellan: RDRS, RSS
MESSENGER (Venus Data): GRS, MASCS, MDIS-NAC, MDIS-WAC, MLA, NS, RSS, and XRS

PDS Nodes: PDS Atmospheres Geosciences Imaging NAIF PPI Rings Small Bodies

Mars ODE Map Interface - Cylindrical Center 0

Zoom In Zoom Out Full Extent Prev Extent Next Extent Pan Select Products By Area Remove Area Selection Select Projection Map Help

Map Display Controls

Select Layers Set Filters (Optional) View Sele

- MGS - MOC NADSDP [show details](#)
- MGS - MOC WASDP [show details](#)
- MGS - MOC WADSDP [show details](#)
- MGS - MOLA MEGDR [hide details](#)

MOLA MEGDR - Mission Experiment Gridded Data Recc
(footprint layer)
[More about this Data Set](#)
Set Layer Transparency

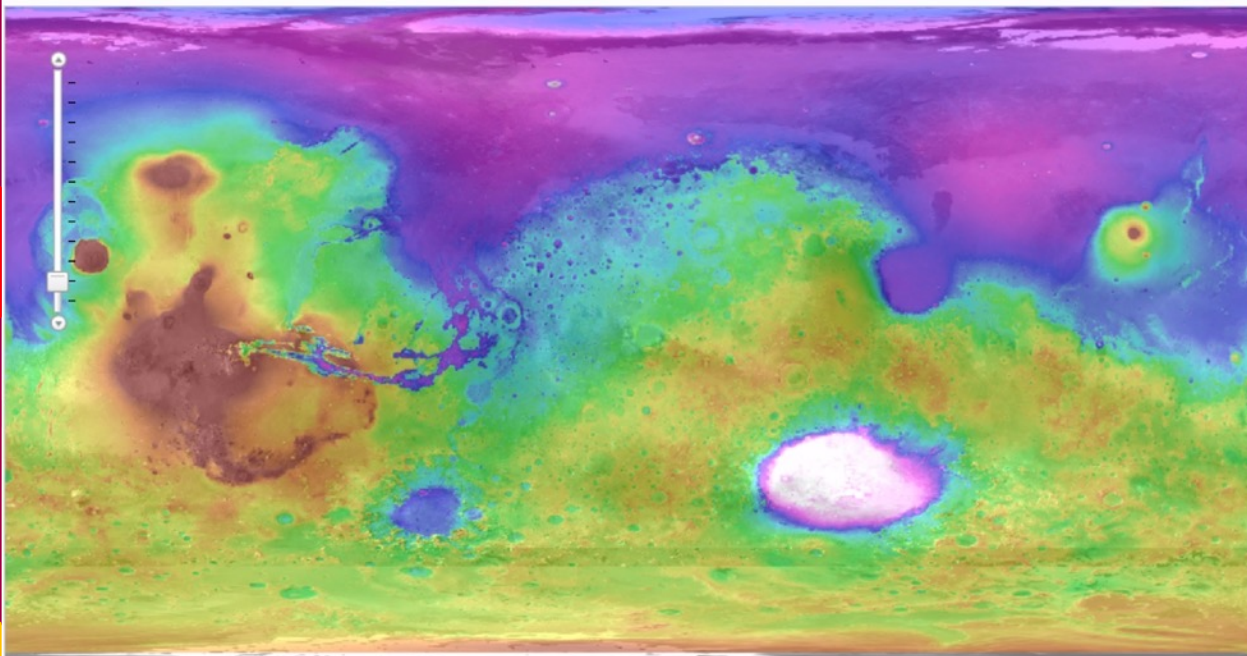
invisible transparent opaque

- ODY - THEMIS IRGEO1 [show details](#)
- ODY - THEMIS IRGEO2 [show details](#)
- ODY - THEMIS IREDR [show details](#)
- ODY - THEMIS IRRDR [show details](#)
- ODY - THEMIS IRBTR [show details](#)
- ODY - THEMIS IRPBT1 [show details](#)
- ODY - THEMIS IRPBT2 [show details](#)
- ODY - THEMIS VGEO1 [show details](#)
- ODY - THEMIS VGEO2 [show details](#)
- ODY - THEMIS VISED [show details](#)
- ODY - THEMIS VISRDR [show details](#)

- ODY - THEMIS VISABR [show details](#)
- ODY - THEMIS VISALB [show details](#)
- VO - VISAB DTM [show details](#)
- VO - VISAB MDIM [show details](#)
- VO - VISAB EDR [show details](#)

Available Base Maps

- Odyssev THEMIS Nicht IR Global Mosaic [show details](#)



1715 km
-114.79, 76.14





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

Mars ODE Map Interface - Cylindrical Center 0

- Zoom In
- Zoom Out
- Full Extent
- Prev Extent
- Next Extent
- Pan
- Select Products By Area
- Remove Area Selection
- Select Projection
- Map Help

Map Display Controls

- Select Layers
- Set Filters (Optional)
- View Selection Results

Coverage Display Options

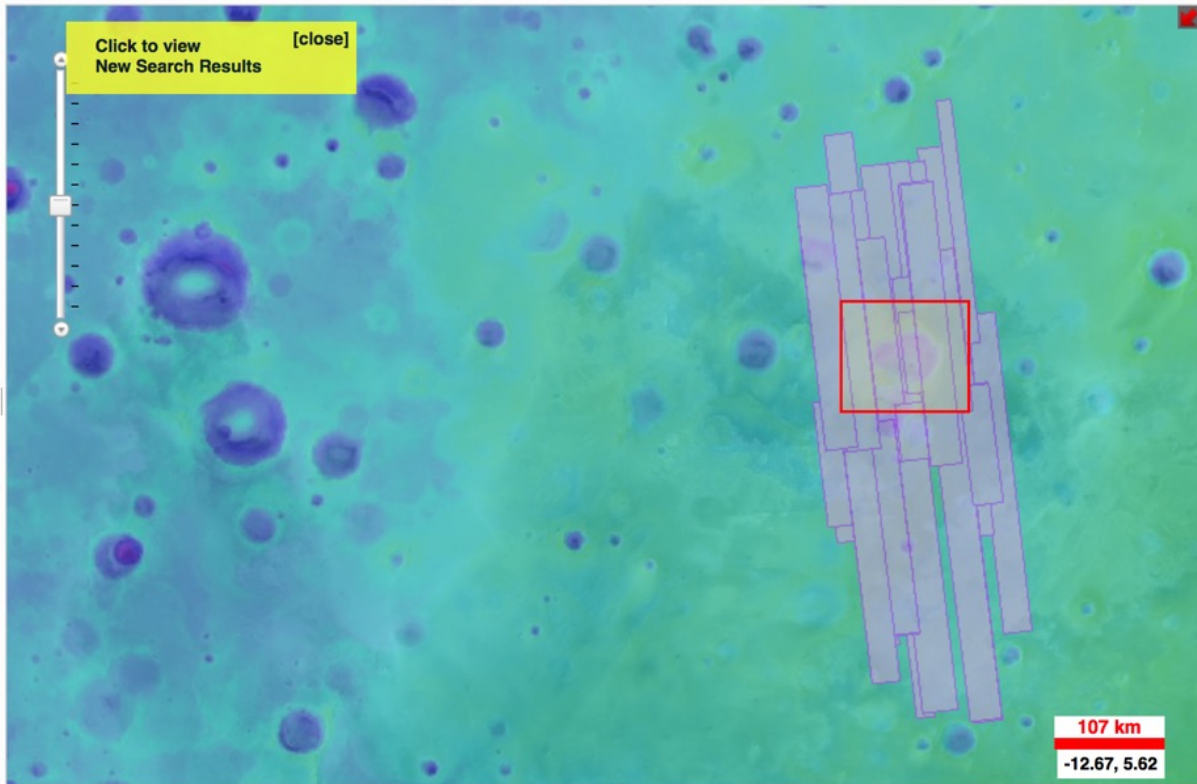
- Display All Products' Coverage (with any filters applied)
- or
- Display Only Products Selected By Area (with any filters applied)

[Help](#)

Available Map Layers with footprints

[Help](#)

- Mars Feature Layer (Landers and Nonmenclature) [show details](#)
- MRO - CRISM TRDR [show details](#)
- MRO - CRISM Center (FRT,HRL,HRS, FRS, ATO,ATU) TRDRs [show details](#)
- MRO - CRISM (FRT,HRL,HRS, FRS, ATO,ATU) TRDRs [show details](#)
- MRO - CRISM (MSP MSW,HSV,HSP,MSV) TRDRs [show details](#)
- MRO - CRISM (EPF,TOD) TRDRs [show details](#)
- MRO - CRISM (LMB) TRDRs & LDRs [show details](#)
- MRO - CRISM (FFC) TRDRs [show details](#)
- MRO - CRISM MRDR [show details](#)
- MRO - CRISM MTRDR [show details](#)
- MRO - CRISM TER [show details](#)
- MRO - CRISM LDR [show details](#)
- MRO - CTX EDR/RDR [show details](#)
- MRO - HIRISE RDRV11 [show details](#)
- MRO - HIRISE DTM [show details](#)
- MRO - HIRISE ANAGLY [show details](#)
- MRO - RSS RSDMAP [show details](#)
- MRO - SHARAD USRDR [show details](#)
- MRO - SHARAD USGEOM [show details](#)



ODE – Mars data download

SEARCH RESULTS

Output Results [Back To Search](#)

Products Found: 70

Display Product Thumbnails

[Add All Results to Cart](#)

[Update Cart](#)

Instrument	Type	Product ID	Obs Time		
MRO CTX	EDR/RDR	B01_010011_1846_XI_04N358W	2008-09-14T13:32:11	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	B05_011501_1820_XI_02N359W	2009-01-08T16:04:26	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	B05_011633_1819_XI_01N000W	2009-01-18T22:55:32	<input type="checkbox"/>	
MRO CTX	EDR/RDR	B05_011712_1819_XI_01N000W	2009-01-25T02:39:56	<input type="checkbox"/>	
MRO CTX	EDR/RDR	B07_012345_1818_XI_01N359W	2009-03-15T10:25:09	<input type="checkbox"/>	
MRO CTX	EDR/RDR	B07_012490_1826_XI_02N358W	2009-03-26T17:35:44	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	B09_013057_1826_XN_02N358W	2009-05-09T21:56:29	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	B11_013769_1827_XN_02N358W	2009-07-04T09:28:32	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	B11_013980_1858_XI_05N358W	2009-07-20T20:05:43	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	B16_015958_1831_XI_03N358W	2009-12-21T22:59:43	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	B17_016235_1830_XI_03N358W	2010-01-12T13:00:38	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	D05_028973_1853_XN_05N359W	2012-10-01T02:10:56	<input checked="" type="checkbox"/>	In Cart
MRO CTX	EDR/RDR	D07_029896_1817_XI_01N358W	2012-12-12T00:19:04	<input checked="" type="checkbox"/>	In Cart

Select the desired products and update the cart

In the cart select the data products and the preferred format

MRO CTX Products (54) are in the cart

Select the types of files you would like for these products

Selected Files: **54**

Estimated size of ASU processed files: **24.98 MB**

Include PDS Source EDR & Source Browse

Non-PDS processed versions from [ASU Mars Space Flight Facility's Mars Image Explorer](#)

JPEG2000 ISIS Header **PNG** JPEG TIFF PDF

PILOT – Planetary Image Locator Tool

USGS metadata-based browser for image data
Processing via server with POW (Processing on the Web)

<https://pilot.wr.usgs.gov>

USGS science for a changing world

PILOT

PDS Planetary Data System

NASA

Planetary Image Locator Tool explore NASA's largest raw spacecraft imagery archive

Mercury 287,132 images	Saturn 391,253 images	Small Bodies
Venus 7,254 images	Atlas 1,401 images	Ceres 35,866 images
Earth 17,674 images	Calypso 1,090 images	Vesta 24,895 images
Moon 3,224,044 images	Daphnis 650 images	Uranus 5,024 images
Mars 2,487,489 images	Dione 9,807 images	Ariel 101 images
Deimos 246 images	Enceladus 18,606 images	Miranda 90 images
Phobos 444 images	Epimetheus 1,853 images	Oberon 74 images
Jupiter 85,491 images	Helene 2,062 images	Titania 102 images
Adrastea 23 images	Hyperion 4,956 images	Umbriel 100 images
Amalthea 227 images	Iapetus 9,754 images	Neptune 5,590 images
Callisto 1,933 images	Janus 2,640 images	Nereid 188 images
Europa 2,192 images	Methone 1,003 images	Triton 613 images
Ganymede 2,247 images	Mimas 6,031 images	Untargeted Images
Himalia 393 images	Pallene 1,052 images	
Io 3,063 images	Pan 1,394 images	
Metis 27 images	Pandora 1,554 images	
Thebe 46 images	Phoebe 2,682 images	
	Polydeuces 738 images	
	Prometheus 3,855 images	
	Rhea 14,600 images	
	Teleso 1,093 images	
	Tethys 9,445 images	
	Titan 99,425 images	
	Ymir 66 images	

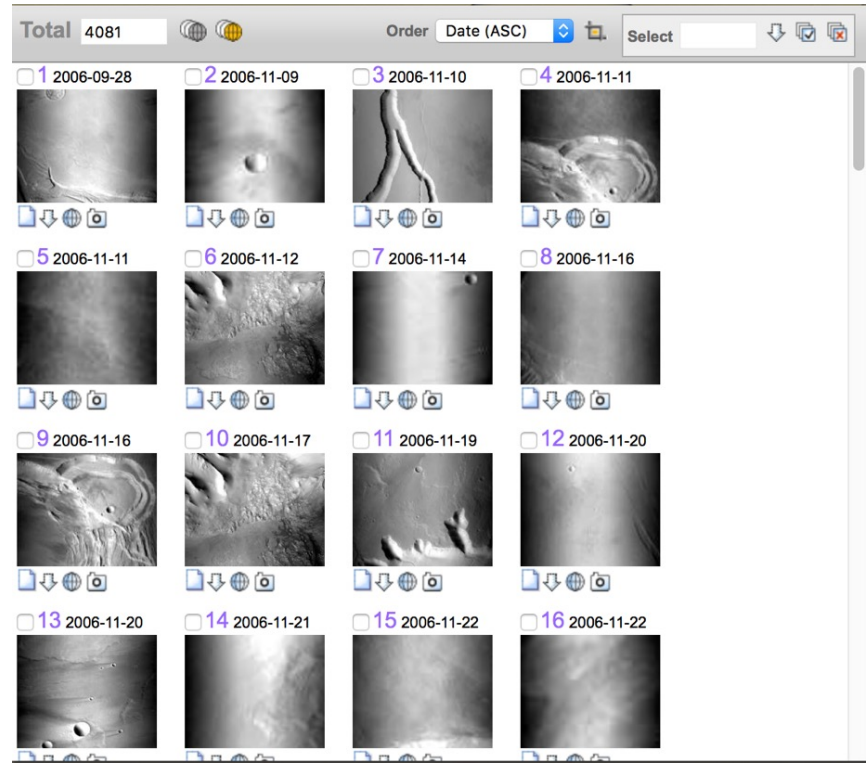
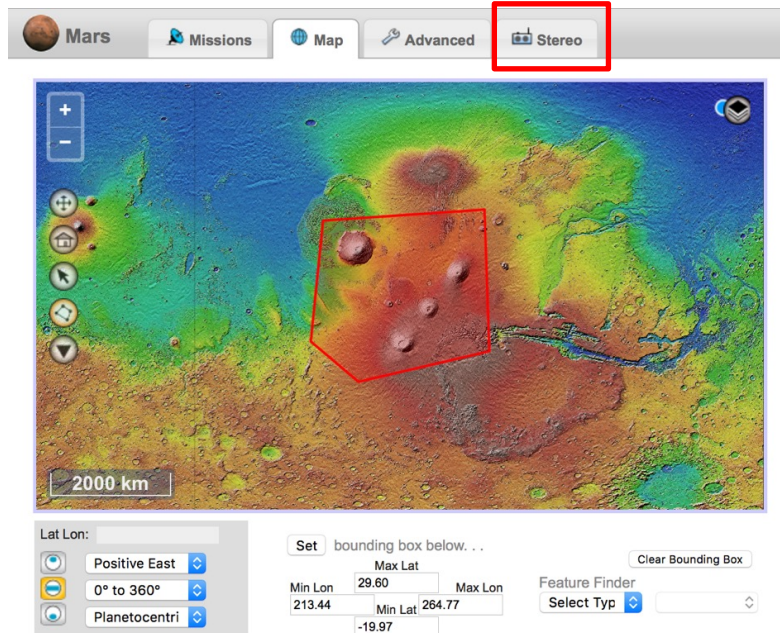
Resources

- [Tutorial for New Users](#)
- [Contact](#)
- [FAQ](#)
- [Source Code on GitHub](#)

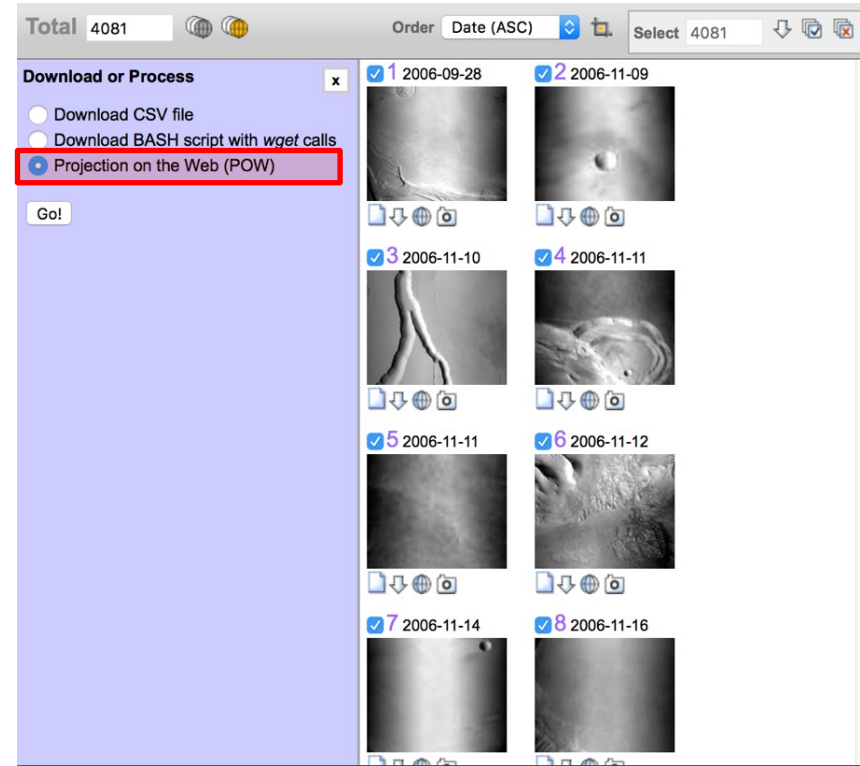
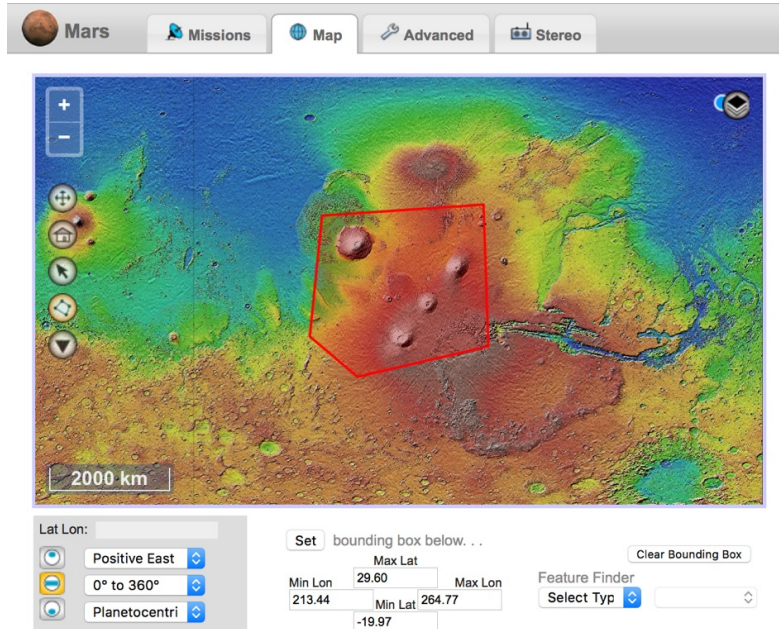
News

The UPC database on which PILOT is based is currently being updated. During this time, product searches using PILOT may produce different results from other PDS search tools. Please refer back to this page for updates. In the meantime, consider searching for PDS products on the [Image Atlas](#) or the [Orbital Data Explorers](#).

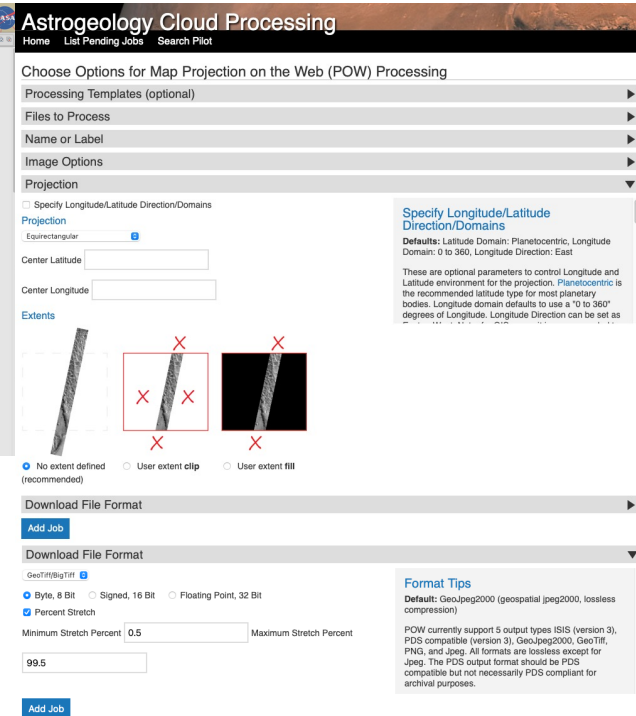
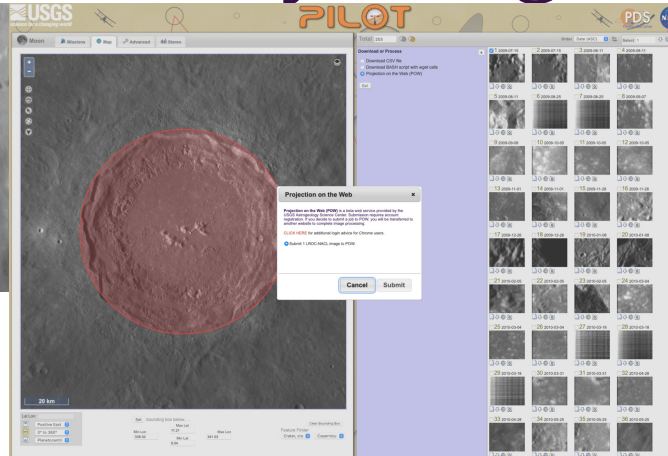
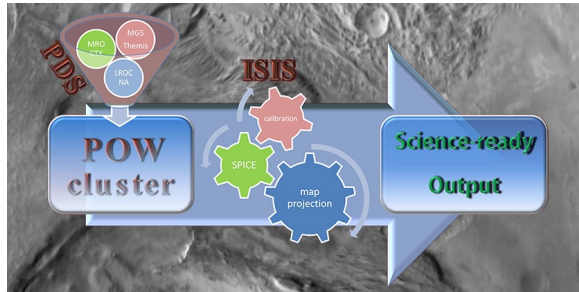
PILOT – Planetary Image Locator Tool



PILOT – Planetary Image Locator Tool



PILOT – Planetary Image Locator Tool



You can click on the map, choose your specific location by drawing polygons or use pre-defined categories

When you select the images you want to download you can choose projection and file format.

By clicking “add job” and inserting the email address you will receive a link to download GIS-ready data when they are ready

Astropedia (USGS Astrogeology)

USGS mapping and processed data products repository (mosaics, USGS geologic maps, shapefiles, databases and useful tools)

<https://astrogeology.usgs.gov/>

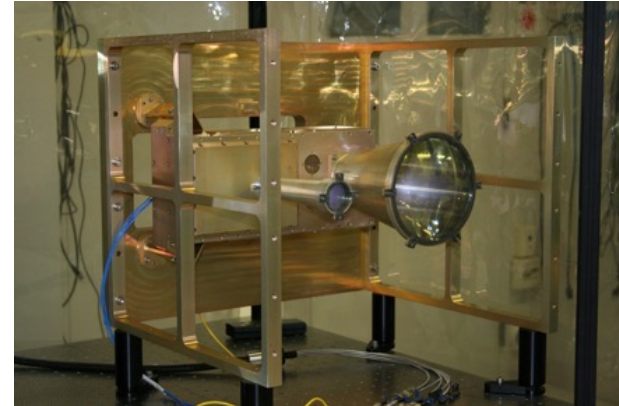
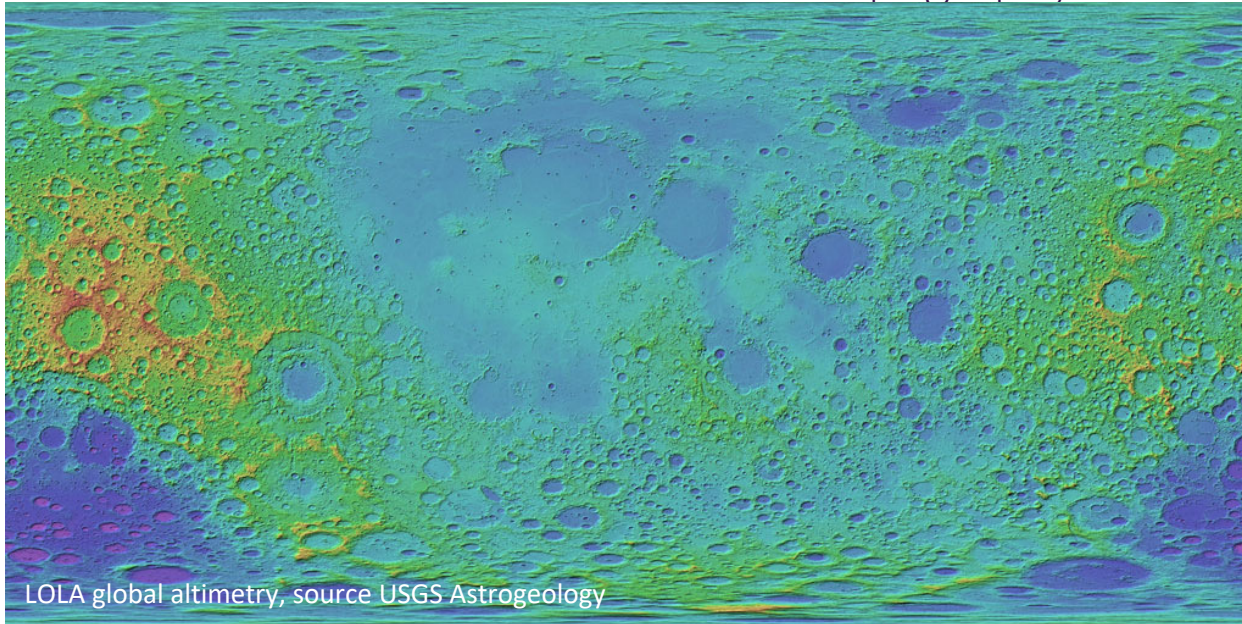
The screenshot displays the ASTROPEDIA website interface. At the top, there are search filters for Product Type (Topographic Map), Spaceraft (MOLA), Instrument (MOLA), Region (Select...), and Feature Finder (Select...). Below the filters, a list of products is shown, including:

- Mars MGS MOLA - MEX HRSC Blended DEM Global 200m v2** (application/octet-stream 1 KB, Jan 31 2018). Product Information: This data product, now at version 2, is a blend of digital elevation model (DEM) data derived from the Mars Orbiter Laser Altimeter (MOLA), an instrument aboard NASA's Mars...
- Mars MGS MOLA Global Color Shaded Relief 463m v1** (application/isis 3 GB). Product Information: This map is based on data from the Mars Orbiter Laser Altimeter (MOLA) (Smith, et al., 2001), an instrument on NASA's Mars Global Surveyor (MGS) spacecraft (Albee, et al....
- Mars Global Surveyor MOLA Topographic Map** (application/pdf 2 MB). This map is based on data from the Mars Orbiter Laser Altimeter (MOLA) (Smith and others, 2001), an instrument on NASA's Mars Global Surveyor (MGS) spacecraft (Albee and others, 2001). The image used...
- Mars Global Surveyor MOLA Globe** (application/pdf 9 MB). The color shaded relief image used as the base for this globe has a resolution of 32 pixels per degree (approximately 1850 m/pixel), and was produced and supplied by the MOLA Science Team. The image...
- Mars MGS MOLA Global Shaded Relief 463m v1** (application/isis 990 MB). Product Information: This map is based on data from the Mars Orbiter Laser Altimeter (MOLA) (Smith, et al., 2001), an instrument on NASA's Mars Global Surveyor (MGS) spacecraft (Albee, et al....

On the left side of the interface, there is a navigation menu for various celestial bodies (MERCURY, VENUS, EARTH, MOON, MARS, SMALL BODIES, JUPITER, SATURN, URANUS, NEPTUN, PLUTO) and a section for Mars sub-targets (Phobos, Deimos). Below this, there are statistics for Mars (Equatorial Radius, Polar Radius, Max Elevation, Max Depression, Right Ascension, Declination, Length of Day) and links to nomenclature and raw spacecraft imagery.

LOLA - Lunar Orbiter Laser Altimeter

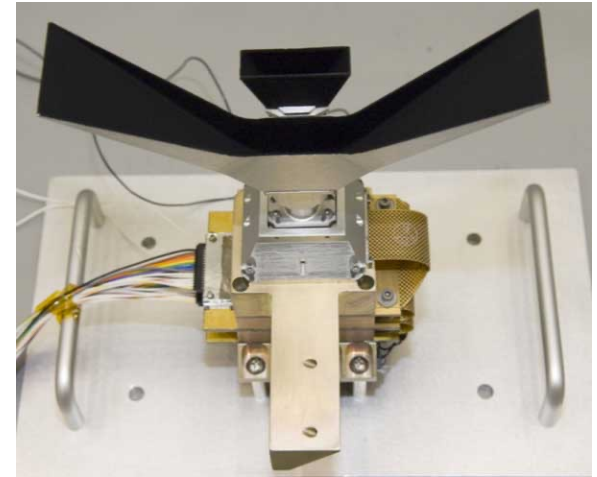
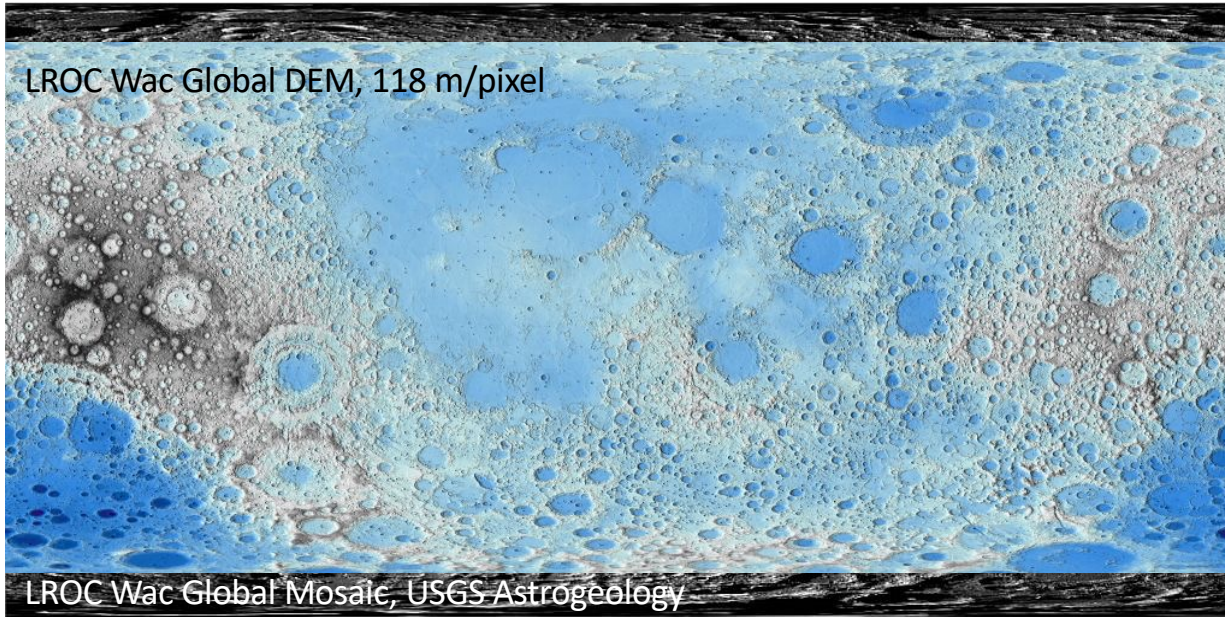
Global DEM topography at ~118 m/pixel



Sources: NASA/GSFC/ASU

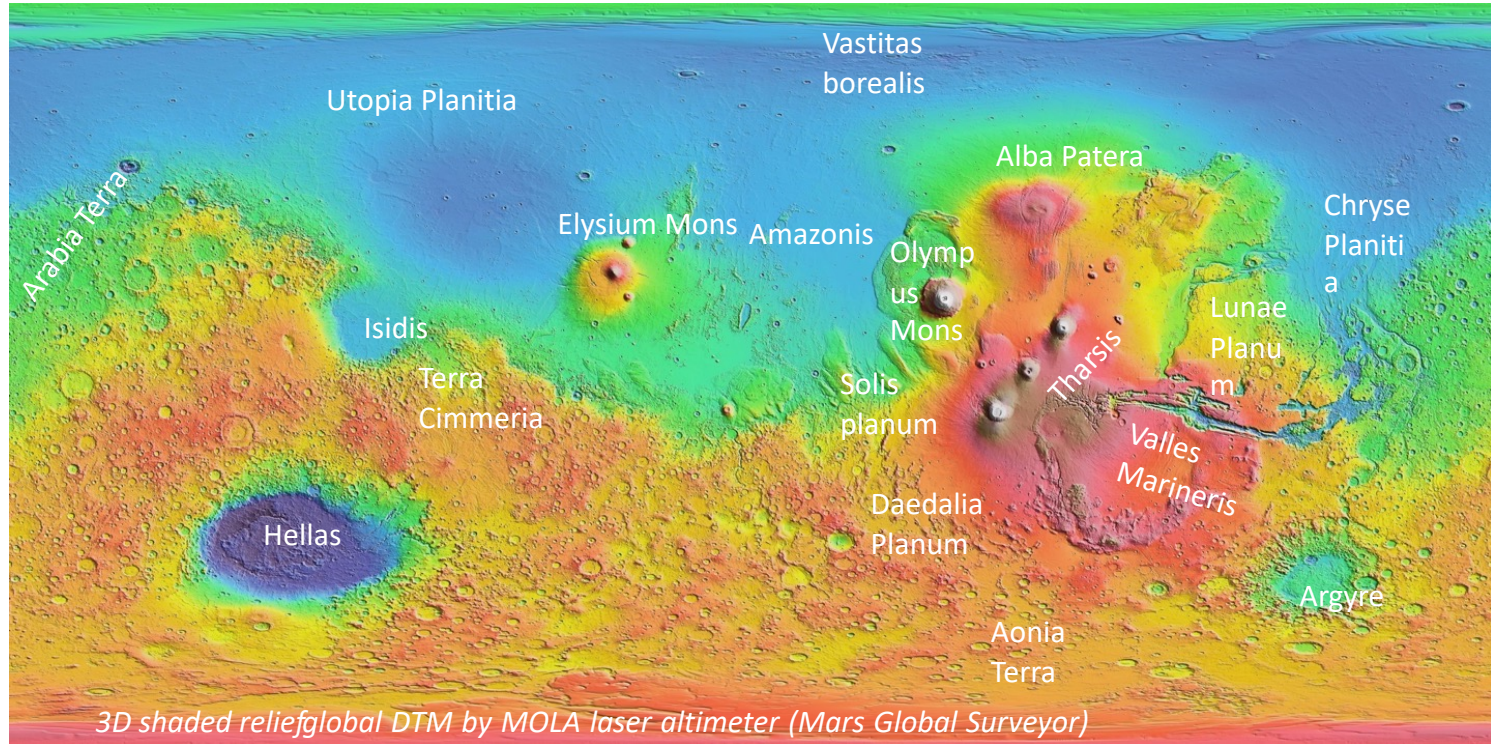
WAC – Wide Angle Camera (Robinson et al., 2010)

- Lunar global mosaic by stitching together 15.000 images acquired between 2009 and 2011



Sources: NASA/GSFC/ASU

MOLA – Mars Orbiter Laser Altimeter



Astropedia (USGS Astrogeology) – quick example

Annex NASA PDS and Derived Products

ASTROPEDIA
Lunar and Planetary Cartographic Catalog

Download

Sample (jpg) 1024px wide

Original (tif*) (11 GB)

Click to download original data

OPEN

Mars MGS MOLA - MEX HRSC Blended DEM Global 200m v2

Product Information:

This data product, now at version 2, is a blend of digital elevation model (DEM) data derived from the Mars Orbiter Laser Altimeter (MOLA), an instrument aboard NASA's Mars Global Surveyor spacecraft (MGS), and the High-Resolution Stereo Camera (HRSC), an instrument aboard the European Space Agency's Mars Express (MEX) spacecraft. This was created in support of thermal modelling studies and product creation for Mars (Ferguson et al., 2017; Laura & Ferguson, 2016). Resolution is 200 meters per pixel (m).

MOLA fired infrared laser pulses downward 10 times per second, and measured the time it took for the reflected pulses to return from the surface. The image used for the MOLA base of this map represents more than 600 million measurements gathered between 1999 and 2001. The average accuracy of each point is originally ~100 meters in horizontal position and the total elevation uncertainty is at least ± 3 m. MOLA produced global topographic coverage with a spatial resolution of about 300 x 1000 m at the equator, and better near the poles.

HRSC, the only dedicated stereo camera orbiting Mars, is a multi-sensor push broom instrument comprising 9 CCD line sensors mounted in parallel for simultaneous high-resolution stereo, multicolor and multi-phase imaging by delivering 9 superimposed image swaths. The HRSC design permits stereo imaging with triple to quintuple panchromatic along-track stereo including a



Project, clip, convert format (e.g. PDS, GeoTIFF, Jpeg) and download this product with Map a Planet (requires [account](#))

[CLICK HERE](#) for login advice for Chrome users.

Process

PDS Status: [PDS 3 Like](#)

FGDC: [xml metadata](#)

Ancillary Products

[ISIS3 Label \(lbl\)](#) 1 kB

[PDS3 Label \(lbl\)](#) 2 kB

[HRSC Coverage Mapv2 \(pdf\)](#) (pdf) 7 MB



Astropedia WMS (USGS Astrogeology)

- WMS: Web Map Service
- Has several advantages:
- You can work on huge image mosaics
- You don't have to download any data (you can save disk space)
- You can work on old computers

- But also disadvantages:
- Not possible to extract topographic information
- You depend on the quality of your internet network

All WMS USGS Astrogeology can be found here

<https://astrowebmaps.wr.usgs.gov/webmapatlas/Layers/maps.html>

Astropedia (USGS Astrogeology) - WMS

Target	system	Targets NAIF ID	A Axis Radius	B Axis Radius	C Axis Radius	Layer Name	Get Capabilities	Projection	Control Network	Layer Type	URL	Map	Layer	Units
ADRASTEA	JUPITER	515	8.2	8.2	8.2	LatLon Grid Lines	Get Capabilities	cylindrical	UNKNOWN	WMS	https://planetarymaps.usgs.gov/cgi-bin/mapserv	/maps/generic/generic_simp_cyl.map	GENERIC	dd
ADRASTEA	JUPITER	515	8.2	8.2	8.2	Show Feature Names	Get Capabilities	cylindrical	UNKNOWN	WMS	https://wms.wr.usgs.gov/cgi-bin/mapserv	/maps/jupiter/adrasrea_nomen_wms.map	NOMENCLATURE	dd
ADRASTEA	JUPITER	515	8.2	8.2	8.2	Show Feature Names	Get Capabilities	cylindrical	UNKNOWN	WFS	https://wms.wr.usgs.gov/cgi-bin/mapserv	/maps/jupiter/adrasrea_nomen_wfs.map	NOMENCLATURE	dd
AITNE	JUPITER	531				LatLon Grid Lines	Get Capabilities	cylindrical	UNKNOWN	WMS	https://planetarymaps.usgs.gov/cgi-bin/mapserv	/maps/generic/generic_simp_cyl.map	GENERIC	dd

Gestore delle Sorgenti Dati

Crea Vettore

- Aggiungi Layer
- Includi Layer e Gruppi...
- Aggiungi da un File di Definizione del Layer...
- Copia Stile
- Incolla Stile
- Copia Layer
- Incolla Layer/Gruppo
- Apri Tabella Attributi
- Attiva Modifiche
- Salva Modifiche Vettore
- Modifiche in uso
- Salva con nome...
- Salva come File di Definizione del Layer...
- Rimuovi Layer/Gruppo
- Duplica Layer
- Imposta la visibilità in base alla scala del/dei layer
- Imposta SR del/i layer
- Imposta SR del progetto dal layer
- Proprietà del Layer...
- Filtro...
- Etichettatura
- Mostra nella Panoramica
- Mostra Tutto nella Panoramica
- Nascondi Tutto dalla Panoramica

Gestore delle sorgenti dati | WMS/WMTS

Layer Online layer Gruppi di mattonella Cerca Server

Connetti **Nuovo** Modifica Rimuovi Carica Salva gi Server Pre

ID	Nome	Titolo	Riassunto

Codifica Immagine

Opzioni

Dimensione mattonella

Richiedi dimensione passo

Limite di elementi per GetFeatureInfo

EPSG-4326 - WGS 84

Usa la legenda WMS contestuale

Nome layer

Pronto

Crea una Nuova WMS/WMTS Connessione

Dettagli Connessione

Nome Moon LROC WAC

URL https://planetarymaps.usgs.gov/cgi-bin/mapserv?map=fi

Autenticazione

Configurazioni Base

Scegli o crea una nuova configurazione di autenticazione

Nessuna autenticazione

Le configurazioni memorizzano le credenziali criptate nel database di autenticazione di QGIS.

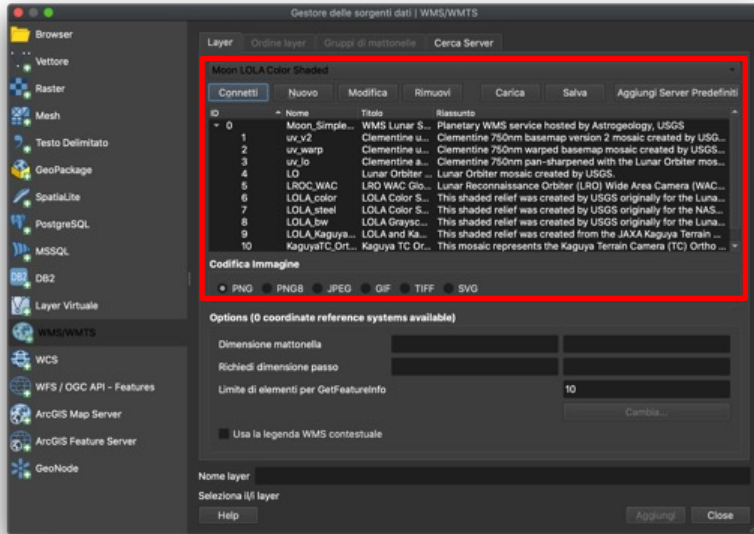
WMS/WMTS Options

Referer

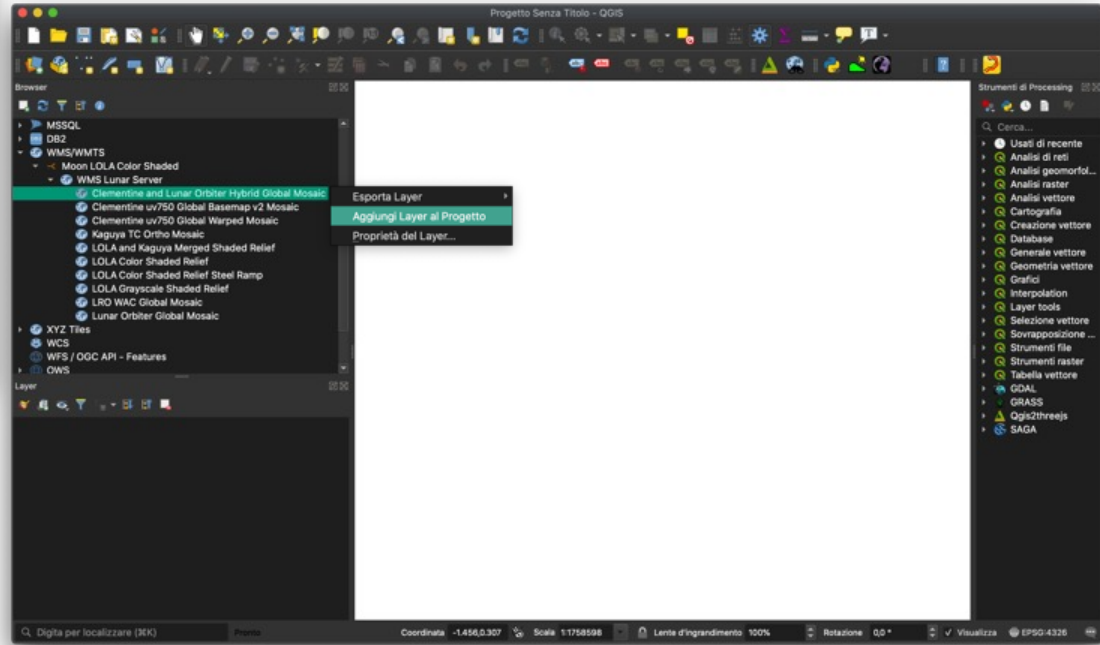
DPI-Mode tutto

- Ignora la URI GetMap/GetTitle riportata nelle capabilities
- Ignora la URI GetFeatureInfo riportata nelle capabilities
- Ignora orientamento assi (WMS 1.3/WMTS)
- Ignore reported layer extents
- Inverti l'orientazione degli assi
- Trasformazione con allisciamento

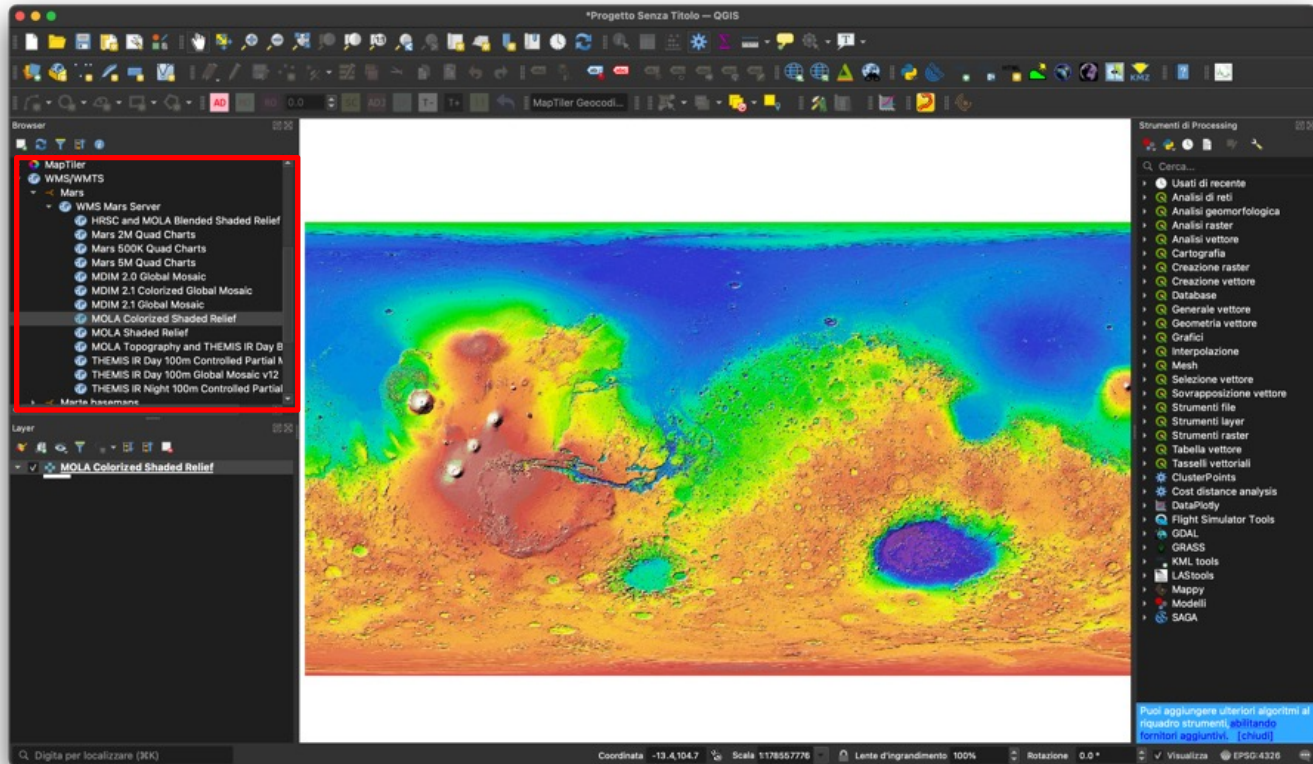
Astropedia (USGS Astrogeology) - WMS



When you click "connect" a list of available basemap layers will appear

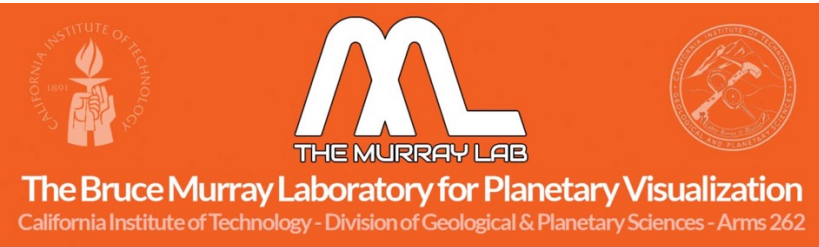


Astropedia WMS (USGS Astrogeology)



Murray Lab for Mars data visualization (and download)

<http://murray-lab.caltech.edu>



Mars 2020 Rover	Global CTX Mosaic of Mars	Time-lapse Imaging
Planetary GIS	GCM/GIS Integration	3D Drone Mapping
High-Resolution Gravity	4K 3D Visualization	Research Highlights

- QGIS CTX global mosaic streaming
- CTX tiles download
- HiRISE download

Mars data: HiRISE

Daven Quinn, 2014-2016

Selected area [FR](#) >

Longitude -7.657 -2.252°
Latitude -5.791 -0.264°

Shift-click/drag the map to modify the bounding box.

Footprints

199 of 116,779 displayed

ESP_012688_1765	>
ESP_012754_1780	>
ESP_012820_1780	>
ESP_013044_1775	>
ESP_013255_1765	>
ESP_014178_1765	>
ESP_011620_1750	>
ESP_011765_1780	>
ESP_011976_1745	>
ESP_012253_1780	>
ESP_012398_1775	>
ESP_012477_1775	>
ESP_012985_1770	>

0 selected

Select some footprints in order to download data! You can do this by clicking footprints either in the list above or on the map.



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

[See this product at the HiRISE PDS Data Node](#)

[HiVIEW JPSP Link \(See the HiRISE Site for a copy of HiVIEW\)](#)

► Indicates a download link from another PDS data node.

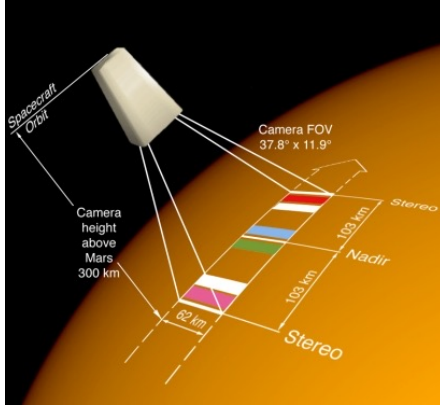
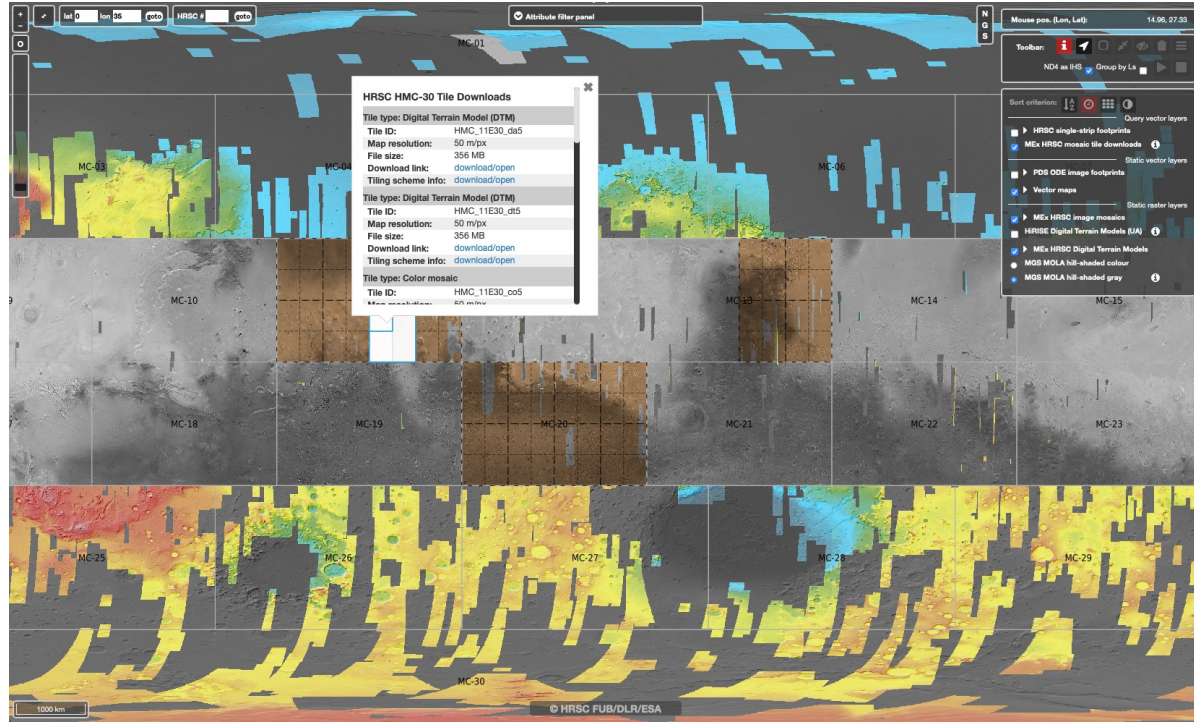
PDS Product Files **Derived Files**

Product Files & Labels	KB
esp_012477_1775_red.jp2 ►	1,484,966
esp_012477_1775_red.lbl ►	9
Product Label File	

Mars Express HRSC (High Resolution Stereo Camera) portal

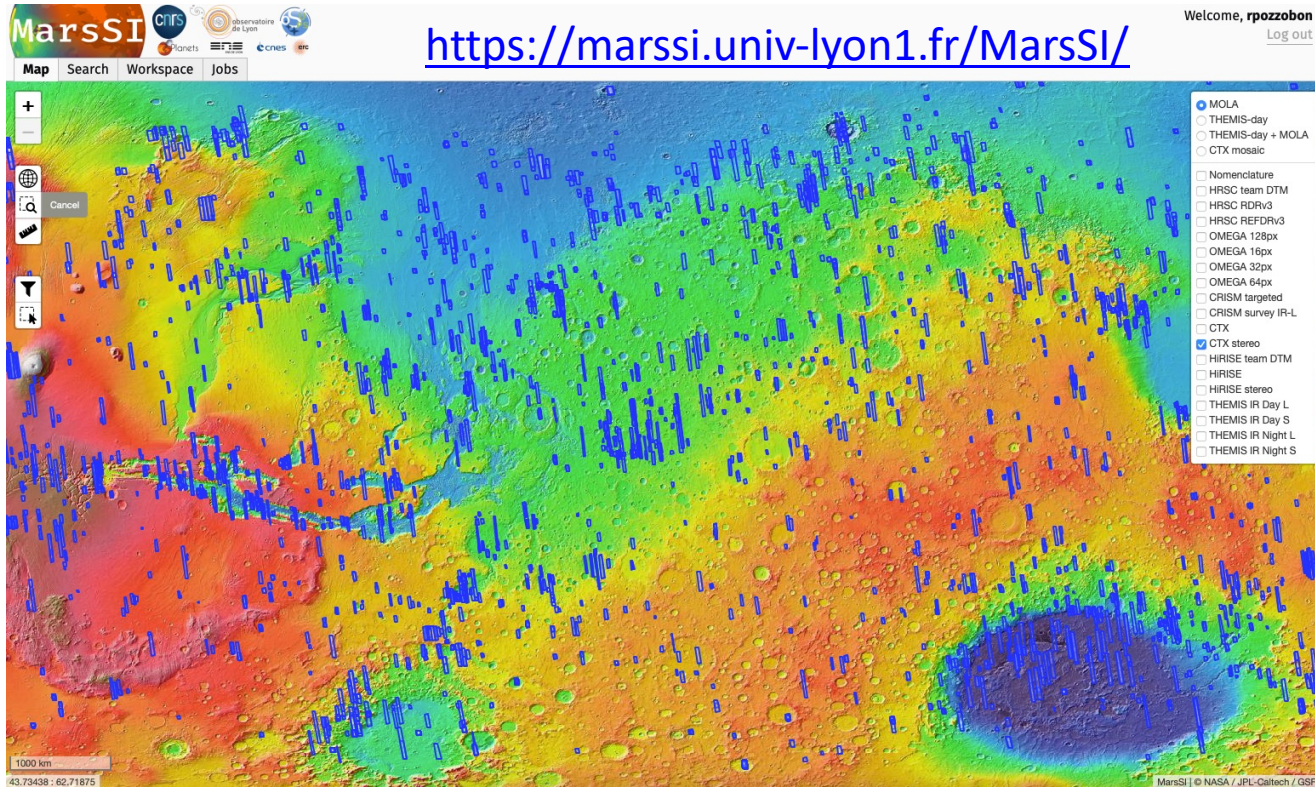
<https://maps.planet.fu-berlin.de/>

- Multi-orbit DEMs
- CTX Pan-Sharpened Color HRSC
- Equalized multi-orbit mosaics



The MarsSI service

<https://marssi.univ-lyon1.fr/MarsSI/>

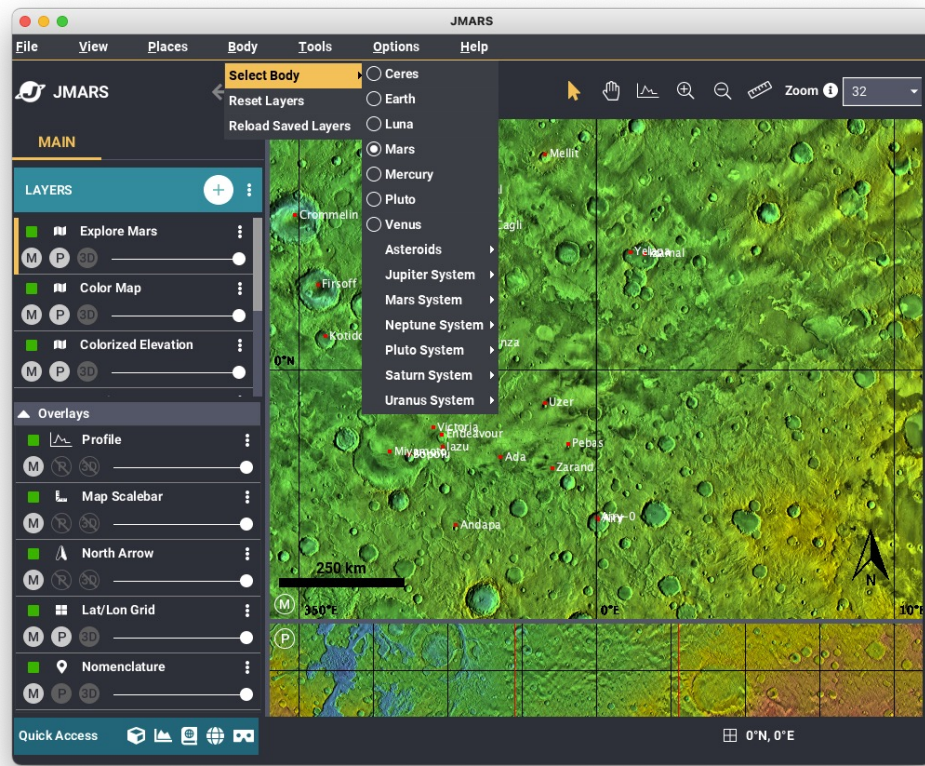


JMARS – Java Mission Planning and Analysis for Remote Sensing

<https://jmars.mars.asu.edu>



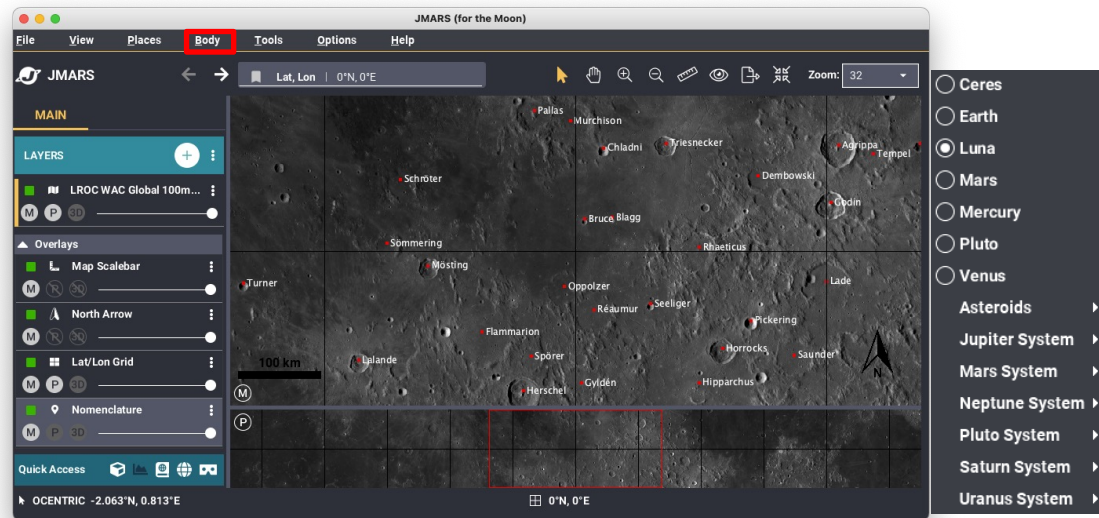
- data analysis
- mission planning
- visualization
- Mapping capabilities
- Crater counting capabilities
- Map streaming
- Import custom raster/vectors



JMARS – Java Mission Planning and Analysis for Remote Sensing

<https://jmars.mars.asu.edu>

It is a geospatial information system (GIS) developed by ASU's Mars Space Flight Facility to provide mission planning and data-analysis tools to NASA scientists, instrument team members, students of all ages and the general public. JMARS has been available to the public since 2003. It is used in over 65 countries and has over 6,000 active users.

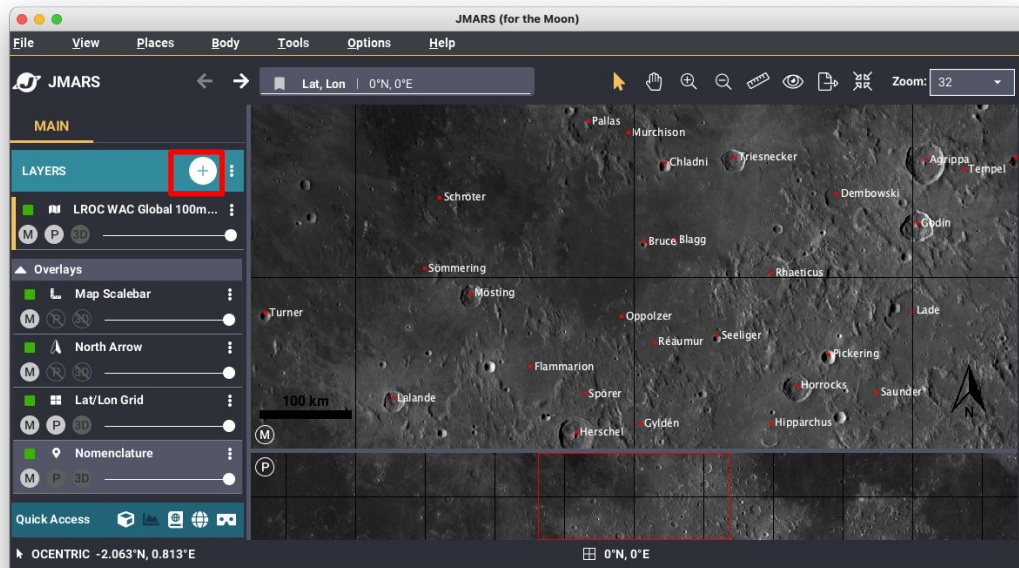


Source: Jmars-Arizona University

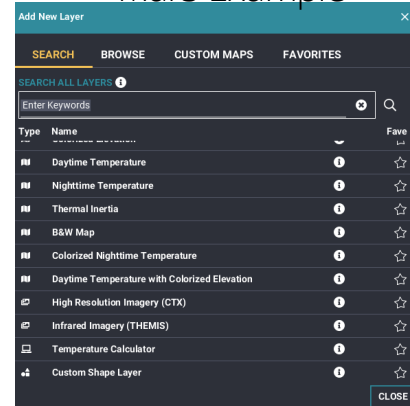
JMARS – Java Mission Planning and Analysis for Remote Sensing

<https://jmars.mars.asu.edu>

- Tables and shapefiles can be imported as well as created and exported
- All data are streamed via the application, with custom maps, databases and thematic basemaps
- Used for several purposes among which observation strategy planning (e.g. HiRISE, CaSSIS)
- Can stream shape models of asteroids in a 3D viewer



Mars Example



Moon Example

