

GIS RESOURCES

Planetary Data Workshop
14 June 2017, Flagstaff, AZ

TRENT HARE

OUTLINE

- ▶ Community Examples (state of the art).
- ▶ Online GIS Data Resources
- ▶ GIS Applications update
 - ▶ ArcMap, QGIS, GDAL
- ▶ Highlight Foundation Data Examples
- ▶ Community Sensor Model (what is it).

MRCTR GIS Lab – What is it

Astrogeology Science Center

Home About Labs & Facilities Maps & Products News Tools Science Missions Outreach

Home > Labs & Facilities > GIS lab

The MRCTR “Mercator” GIS Laboratory

Mapping

Remote-sensing

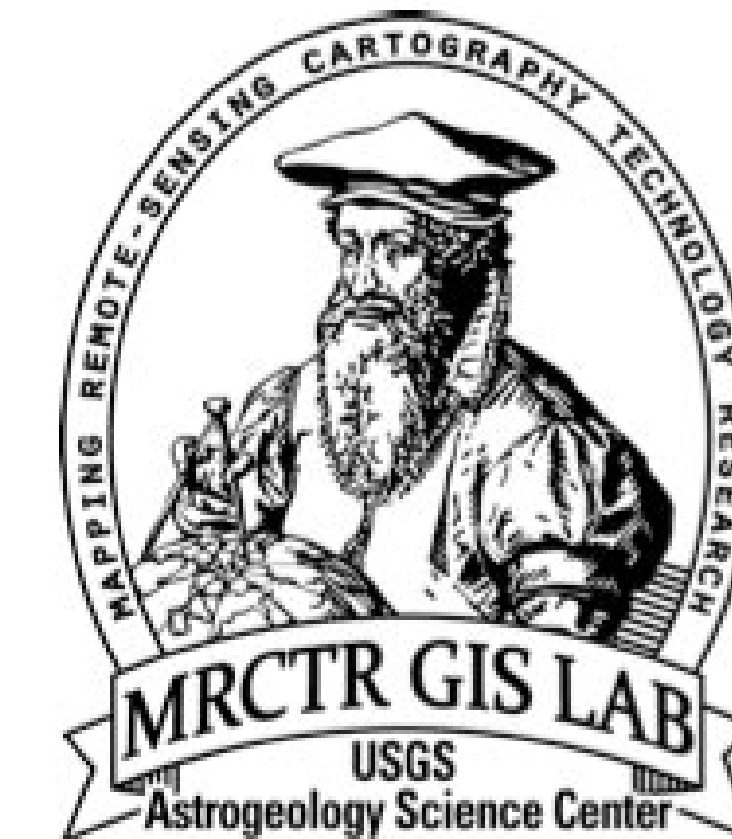
Cartography

Technology

Research

Expertise and community support for planetary mapping and GIS technologies including:

- GIS Tutorials
- Tool development
- GIS training workshops
- On-site training available
- Remote-sensing data processing and conversion
- Data integration
- 3D Visualization
- Research support
- Mission Support
 - Targeting tools
 - Landing site tools
- Standards
 - Formats
 - On-line web mapping (OGC)
 - Cartography (publication and symbology)
 - Federal Geospatial Data Consortium (FGDC) Metadata



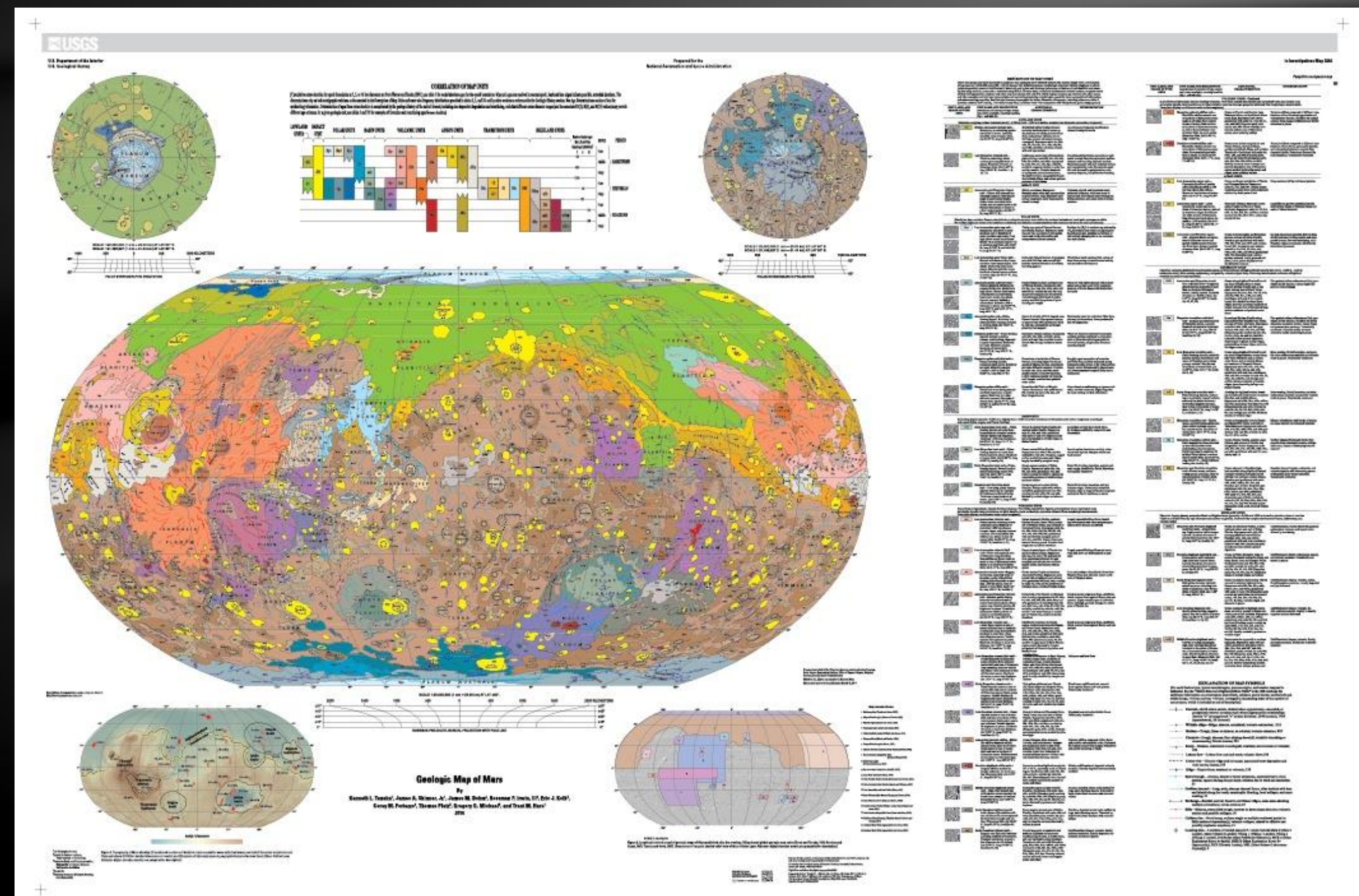
Funded by: NASA’s “PDSI” Program

For more information about the MRCTR GIS Lab and to find out about GIS training, contact Trent Hare at thare@usgs.gov

Updated on: Thursday, February 10, 2011

Our History of GIS

- GIS Data conversion ~1994
- **GIS Geologic map production ~1996**
- Mars Pathfinder 1997
- Online mapping 1999
- Data overlay
- Analysis



Geologic Map of Mars (Tanaka et al., 2003)

Planetary GIS Domain

Needs of the planetary community

Same as most any Earth-based mapping community

Need for common projections

Accurate data (to support robotic and human missions)

Support for huge data sets (eg 1TB, 16bt Kaguya mosaic)

- Data portals / Metadata
- Formats

On-line mapping services

Usability / Interoperability

True 3D surfaces (asteroids, in-situ)

PSDI TENET:

Spatial data should just work

1 Label

2 List

3 neural

WHERE ARE WE?



Planetary Web GIS online Resources

State of the Art Summary

- Community has realized several custom WMS/WCS/WCPS implementations
- **Examples:**
 - PlanetServer, Rasdaman hyperspectral WCS/WCPS server - Jacobs University
 - Lunarserv - Custom WMS/WCS and processing server - Arizona State University
 - MarsTrek, MoonTrek, VestaTrek – WMTS Server (and 3D interface) by JPL
 - JMars (mission planning, data viewer) - Arizona State University

State of the Art Summary

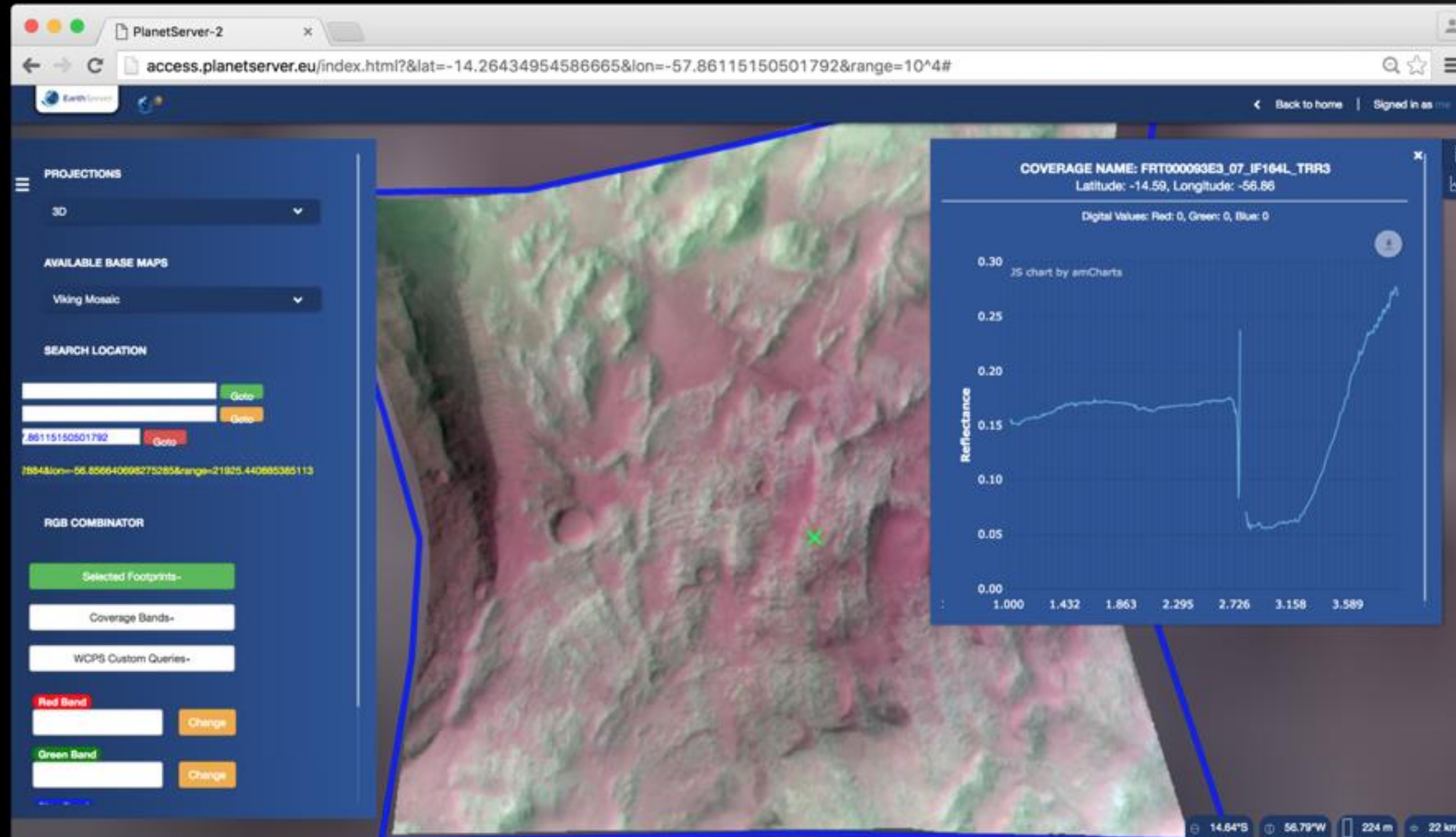
- Community has realized several custom WMS/WCS/WCPS implementations
- Examples:
 - Mars, Moon - Esri (S3) WMTS support – currently under beta
 - Supports optimized WMS and tile server code in GDAL
 - Best-of image bases (as WMS), WFS Nomenclature, ArcGIS Server – USGS
 - German Aerospace Center (Freie University/DLR)
 - Japan Aerospace eXploration Agency (JAXA)
- More...

COMMUNITY EXAMPLES

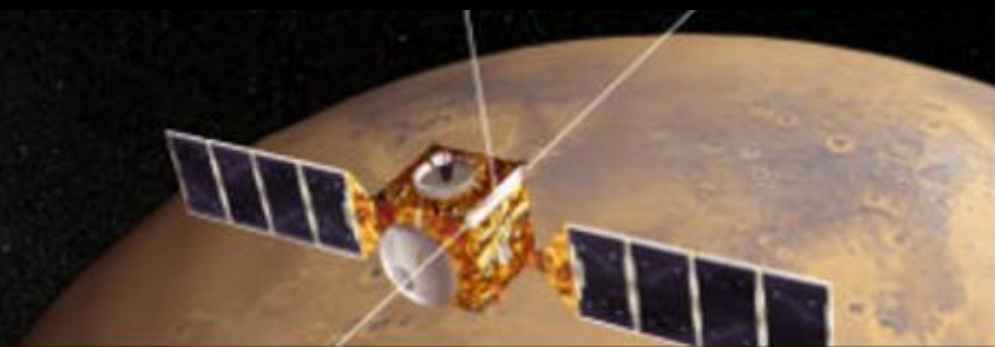
Community Example:

WC(P)S server supported by Jacobs University: access to 10^4 hyperspectral coverages

ESA
(NASA/ESA
data)



Community Example:



i-Mars

Web-GIS

The screenshot displays the i-Mars Web-GIS interface. At the top left, there are zoom controls (+/-) and a 'goto' button with input fields for 'lat 15' and 'lon -11.25'. A 'Time panel' is visible at the top center. On the right side, there is a 'Workflow' section with navigation icons and a 'Sort criterion' section with options for 'A-Z', 'Time', and a grid icon. Below these are sections for 'Query vector layers', 'Static vector layers', and 'Static raster layers'. The 'Static raster layers' section includes 'High-Res Repeat Coverage', 'MRO CTX ACRO mosaic', 'CTX/HiRISE OrthoRectified Images', 'MEx HRSC image mosaics', 'CTX/HiRISE Digital Terrain Models', and 'HRSC Digital Terrain Models' (which is checked). A topographic color scale legend is located at the bottom left, ranging from -8 to 20 km above GMM3 aeroid. A 1000 km scale bar is at the bottom left. A copyright notice at the bottom center reads '© 2016 i-Mars UCL/DLR/FUB/EPFL/UNOTT/UoS'.

ESA

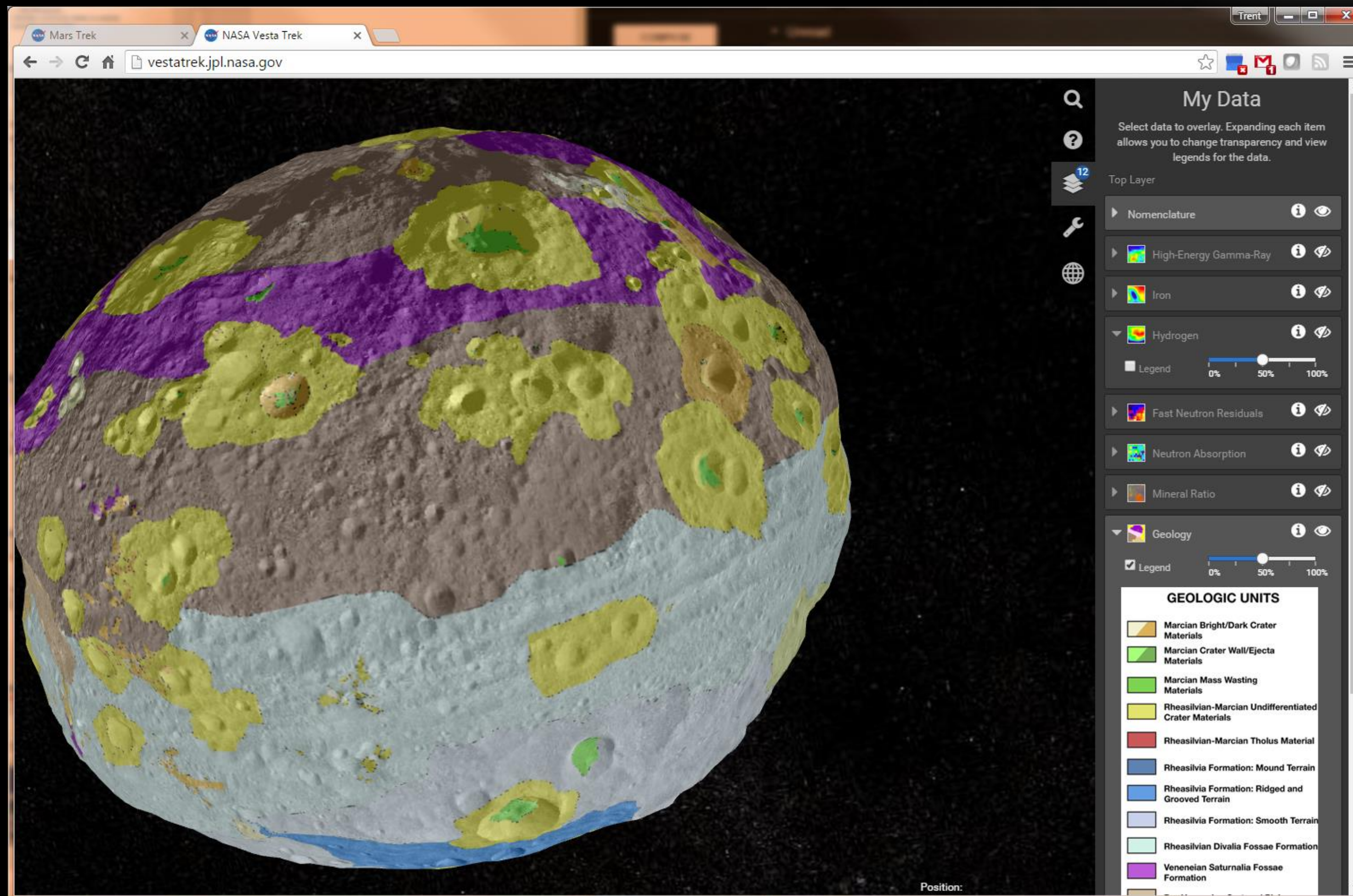
(NASA/ESA data)

Partners



Community Example: VestaTrek (MarsTrek, LunarTrek)

NASA Jet
Propulsion
Laboratory
and
AMES



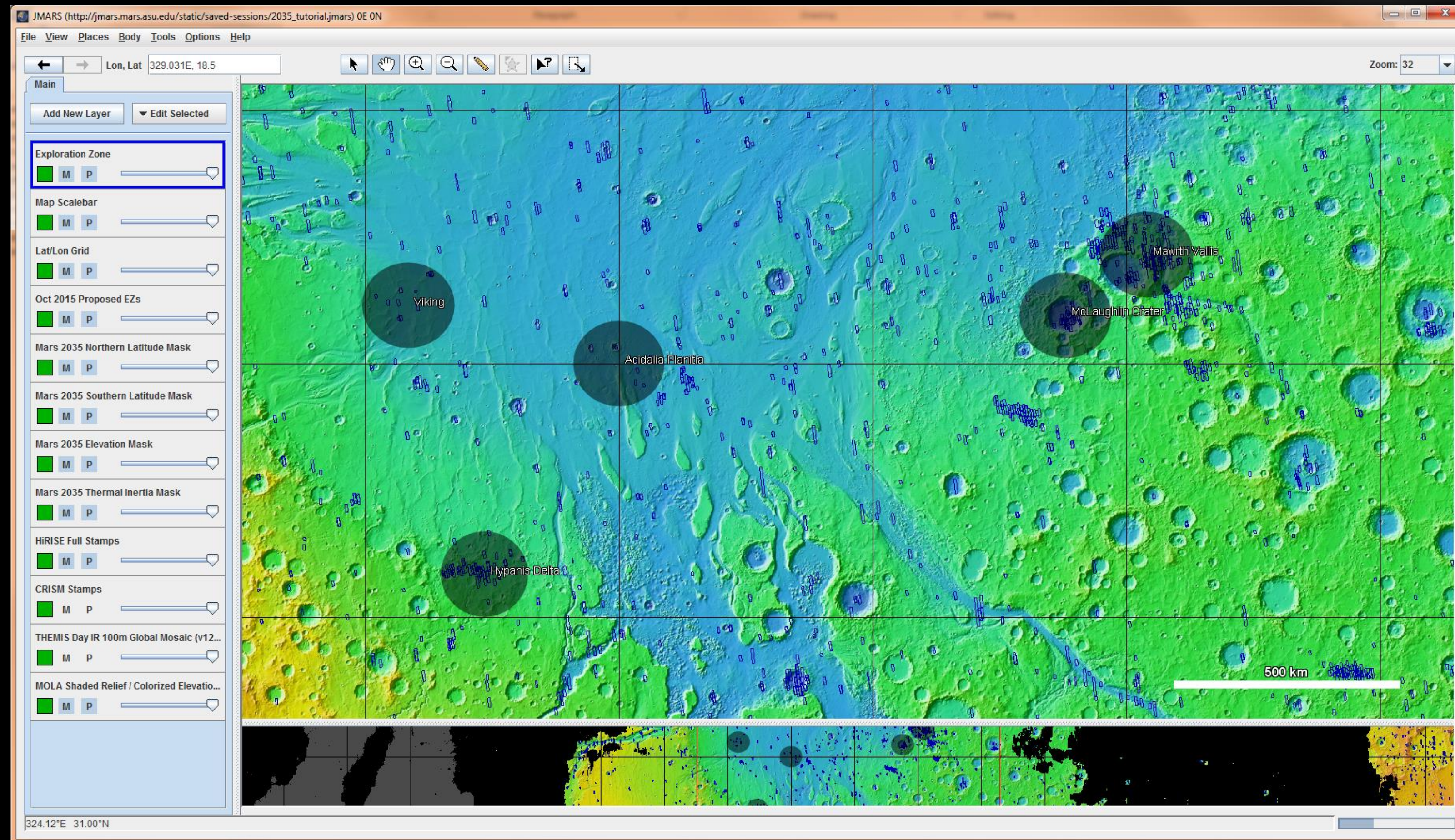
Community Example:

JMARS Mission Planning and GIS Application

Arizona
State
University

Advanced data
streaming techniques

Thick client app.



Community Example:

WMS services containing 30+ different planetary bodies with 100+ image layers

Astrogeology
USGS

direct access
from ArcMap,
QGIS or GDAL
(bit.ly/PlantaryGIS)

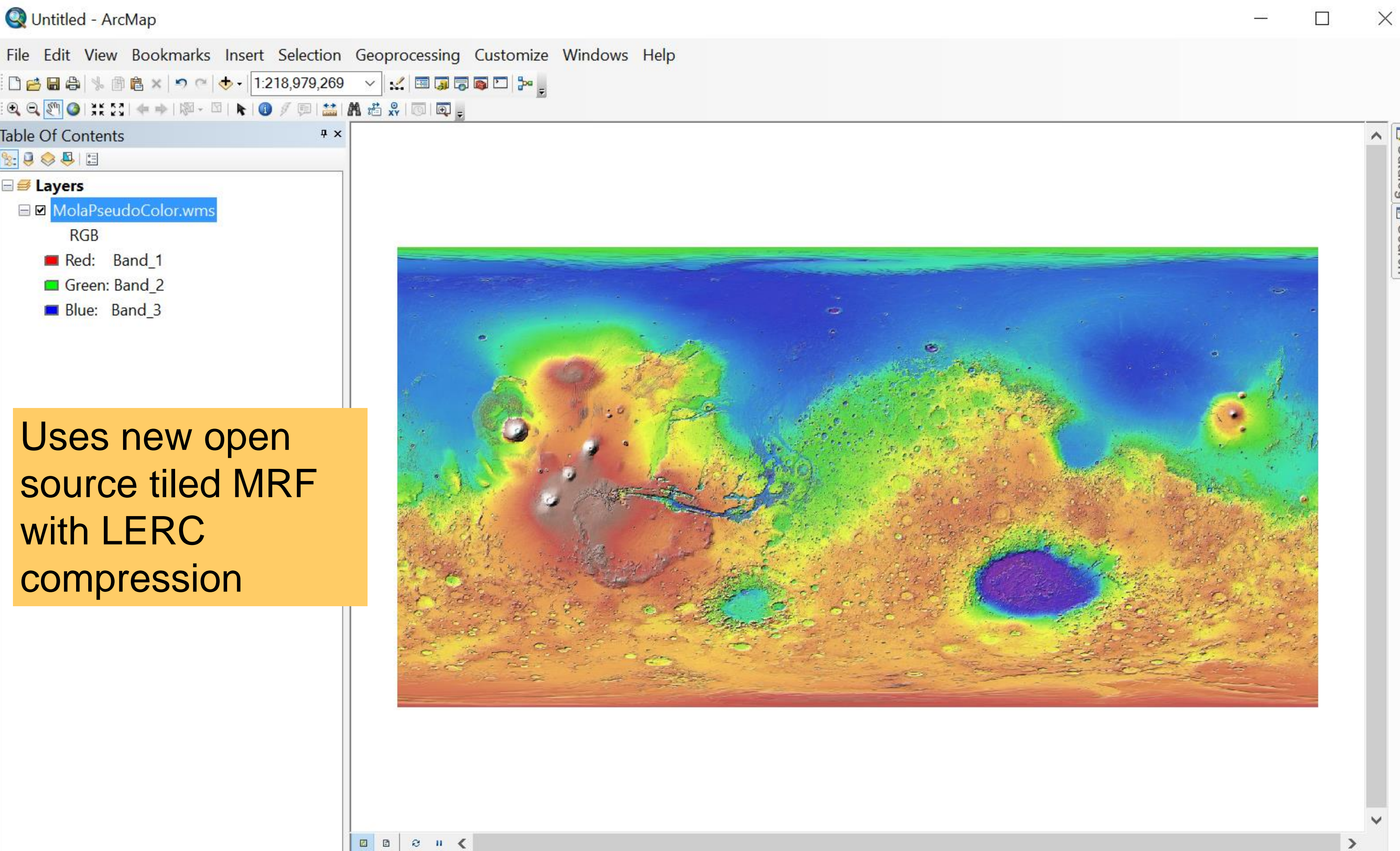
The screenshot shows the ArcGIS Planetary GIS group page. The browser address bar displays the URL: https://www.arcgis.com/home/group.html?owner=thare_USGS&title=Planetary%20GIS&focus=layers. The page features a navigation menu with options like Features, Plans, Gallery, Map, Scene, and Help. A search bar and a 'Sign In' button are also present. The main content area is titled 'Planetary GIS' and includes a 'JOIN THIS GROUP' button and a 'SHARE' button. Below this, a description states: 'Planetary ArcGIS Server and WMS services hosted by Astrogeology, USGS and other planetary facilities'. A 'Group Content' section lists several WMS services, each with a thumbnail image, title, description, and metadata. The services listed are:

- ArcGIS Server - Lunar Elevation Basemap**: Colorized shaded relief of the Lunar LOLA topographic gridded data set. Map Image Layer by thare_USGS. Last Modified: January 3, 2014. (0 ratings, 0 comments, 932 views)
- ArcGIS Server - Mars MDIM2.1 Basemap**: Mars Global GIS. Various layers from planetary community. Map Image Layer by thare_USGS. Last Modified: April 26, 2015. (0 ratings, 0 comments, 2,050 views)
- Titan SAR and VIMS Basemap**: Various Cassini Team layers. SAR processed by JPL and USGS. Map Image Layer by thare_USGS. Last Modified: January 3, 2014. (0 ratings, 0 comments, 152 views)
- WMS Callisto Server, Astrogeology**: Callisto WMS service hosted by Astrogeology, USGS. WMS by thare_USGS. Last Modified: December 8, 2013. (0 ratings, 0 comments, 9 views)
- WMS Ceres Server, Astrogeology**: Ceres Framing Camera mosaic by DLR.

On the right side of the page, there are social media links for Facebook and Twitter, and a 'Group Details' section. The group details include: Owner: thare_USGS, Status: Public, Contributors: Members, Tags: USGS, NASA, planetary, moon, Mercury, Venus, Mars, Saturn, Jupiter, Titan, Europa, and 5 Members: thare_USGS, bennett_wustl, joeguzi, trent_trial, usgsegis.

Community Example:

Tiled WMS – in Esri's (Amazon) Cloud



The screenshot shows the ArcMap interface with a tiled WMS map of Mars. The map uses a color scale where red and orange indicate higher elevations, green and yellow indicate mid-level elevations, and blue and purple indicate lower elevations. The legend in the 'Layers' panel shows the following configuration:

- MolaPseudoColor.wms
 - RGB
 - Red: Band_1
 - Green: Band_2
 - Blue: Band_3

The status bar at the bottom right displays the coordinates: 67.737 -135.474 Decimal Degrees.

Uses new open source tiled MRF with LERC compression

Community Example:

Paris Sud University, Orsay (live WMS layers in Cesium)

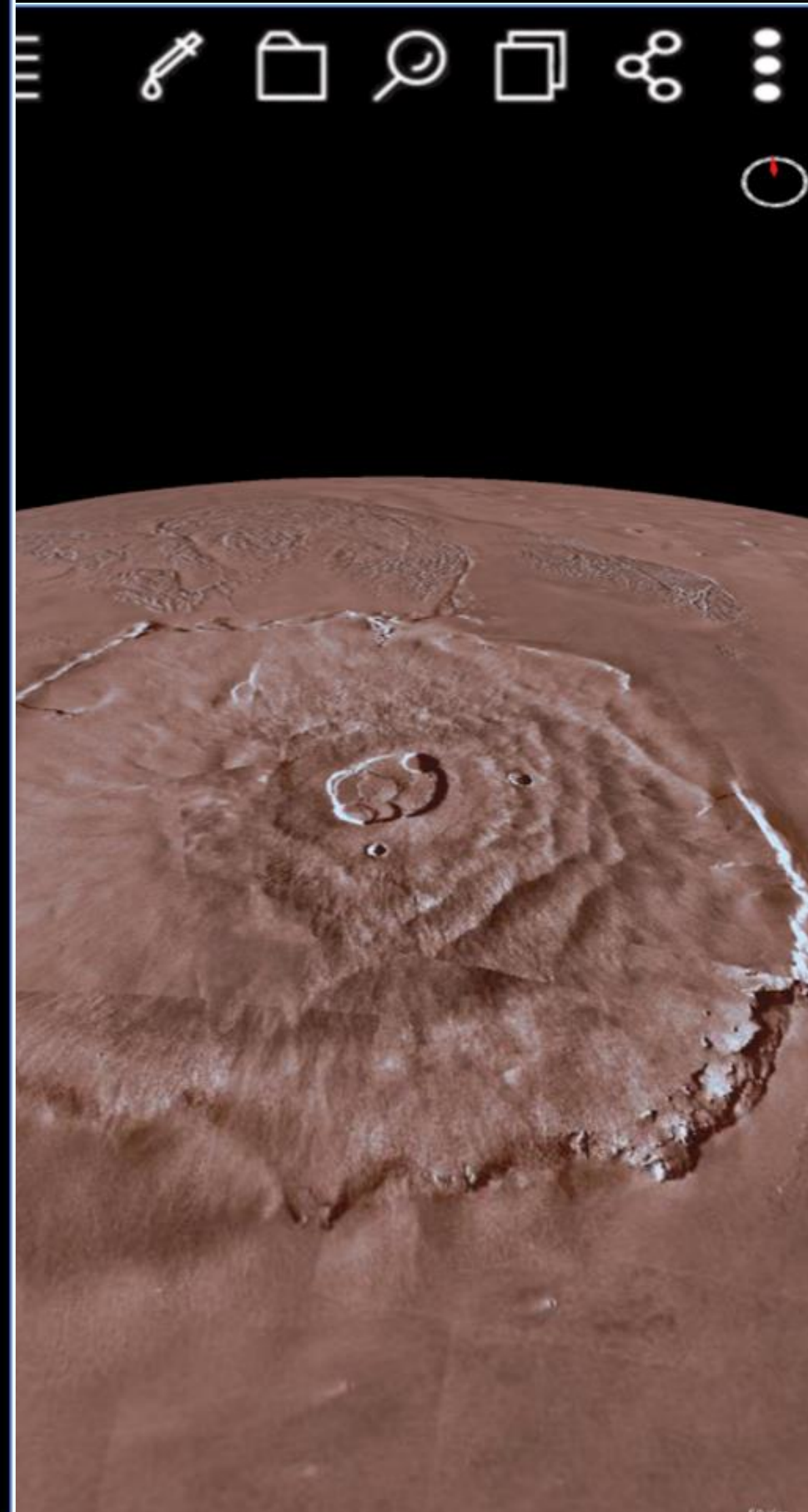
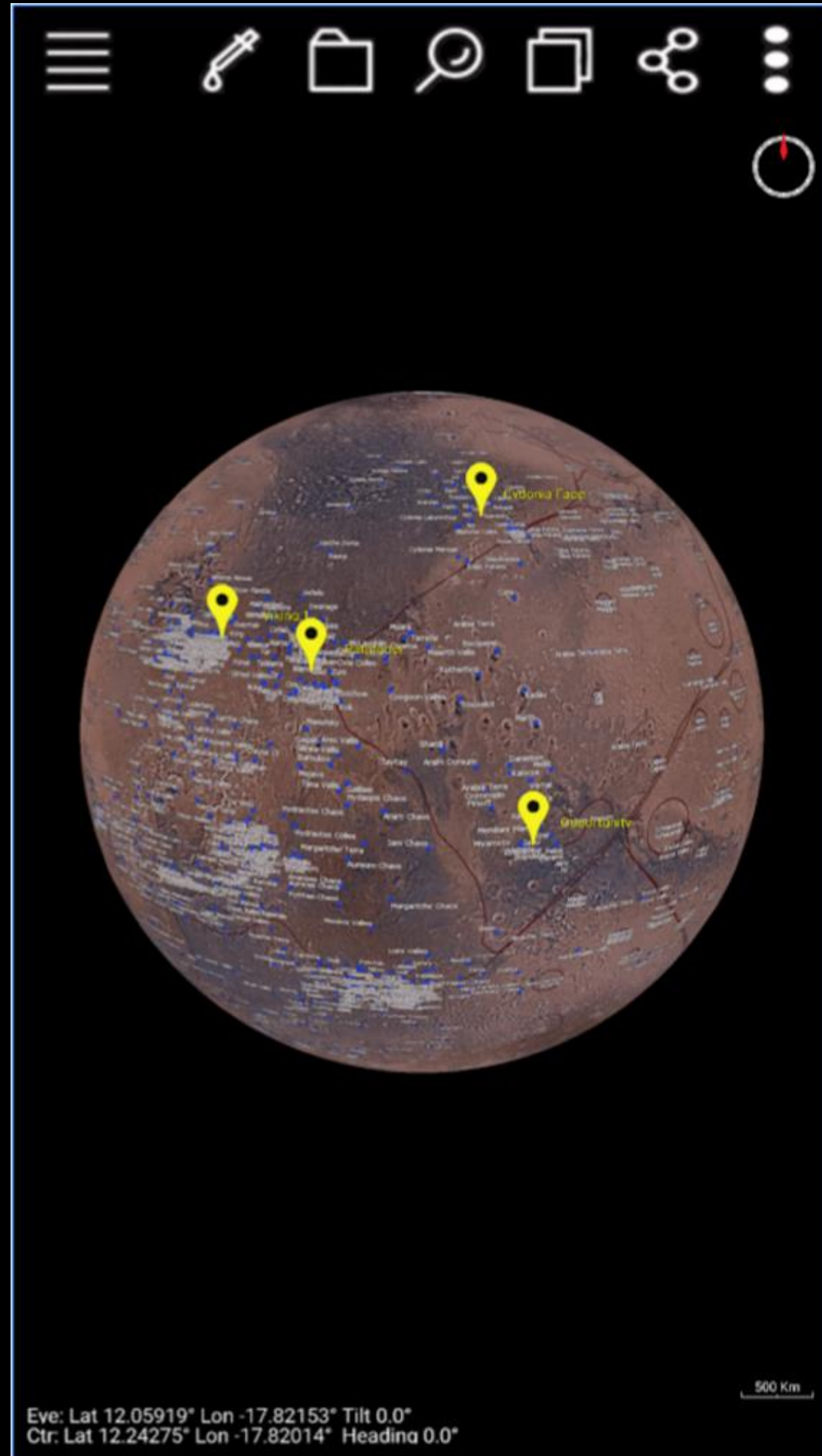
The screenshot shows a web browser window displaying a CesiumJS application. The address bar shows the URL: `134.158.75.177/viewer/Apps/PlanetaryCesiumViewer/index.html`. The application interface includes a top navigation bar with buttons for planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. A toolbar on the right contains icons for home, globe, help, and various map controls. A control panel on the left is titled "Mars :" and lists several WMS layers with checkboxes and sliders:

- Mola themis blend
- Themis
- Themis controlled
- Themis night
- Mdim21
- Mdim20
- Mdim21 color
- Mola color
- Mola bw
- Mars5m quads
- Mars2m quads
- Mars500k quads
- Nomenclature 180

At the bottom of the control panel are buttons for "Hide" and "Hide vectorial data". The main view shows a 3D topographic map of Mars with a color gradient from green (low elevation) to red (high elevation). A text box in the bottom right corner contains the text: "Planetary tweaks to Cesium hosted on [github](https://github.com)". The bottom of the browser window features logos for Cesium, USGS, GEOPS, Université Paris Sud, and CNRS.

Community Example:

WMS live layers in Android Phone App



Web Streaming Challenges

- WMS projection codes are Earth-based:
 - There exist planetary codes (IAU2000)
 - Supported by LunaServ WMS (open source)
 - Supported by JPL server (onMars/onMoon)
 - Support for projection registries (spatialreference.org)

Tiled WMS – still a little fragmented

Bandwidth limited

- WFS (vector streaming) – tiled vector maps
- WCS (data streaming) – compression techniques

ASTROGEOLOGY -- ONLINE "GIS" RESOURCES

Online GIS Resources



IAU Planetary Gazetteer

<http://planetarynames.wr.usgs.gov/>

Download GIS-ready Shapefiles (point file for each body, approx. bounds)

The screenshot shows the 'Gazetteer of Planetary Nomenclature' website. The main content area features a large image of Mars with a data box overlay. The data box contains the following information:

- Target: Mars
- Features: 1690
- Sub-targets: Phobos, Deimos
- Feature Types: Albedo, Catena, Cavus, Chaos, Chasma, Collis, Crater, Dorsum, Fluctus, Fossa, Labes, Labyrinthus, Mensa, Mons, Palus, Patera, Planitia, Planum, Rupes, Scopulus, Sulcus, Terra, Tholus, Unda, Vallis, Vastitas, Lingula

The news section on the right lists several recent updates, including 'Ten New Names Approved for Enceladus Features', 'Martian Crater Named Kibuye', 'Mercury Maps Showing Named Features', 'New Labyrinth Name on Titan', 'Changes to Venus Nomenclature', 'New Name for a Corona on Venus', 'Martian Crater Named Matara', and 'Six Names Approved for Martian Craters'.

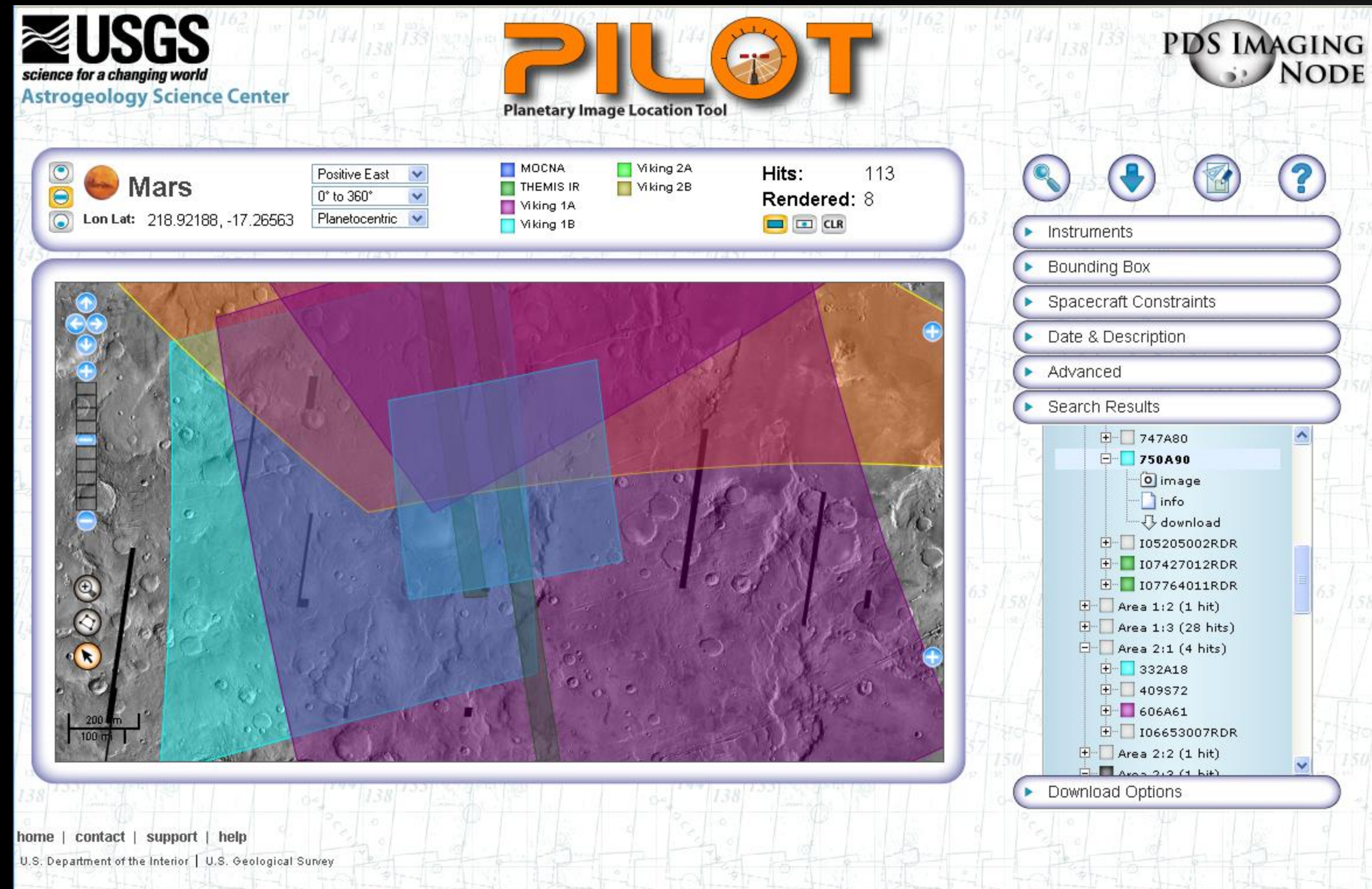
USGS, NASA, and IAU work collaboratively to uniquely identify planetary nomenclature for features on terrestrial bodies.

Online GIS Resources

UPC / PILOT – Planetary Image Location Tool

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

Find images and now stereo coverage,
download GIS shapefiles for each supported instrument



Geospatially search a subset of the PDS Imaging Node EDR archives

Data sets include

- Cassini, MGS, MRO
- Odyssey, Viking,
- Messenger,
- Clementine, ...

ability to process images in POW (ISIS cluster), returns GIS-ready images

Online GIS Resources

POW – Map Projection on the Web



astrocloud.wr.usgs.gov

USGS
science for a changing world

Astrogeology Cloud Processing

Home List Pending Jobs Search Pilot

Welcome thare@usgs.gov Administrator

Map Projection on the Web Map a Planet 2

PDS archives are typically stored in their "raw" or Engineering Data Record (EDR) format. Before they are truly useful for analysis, these images, at a minimum, should be radiometrically calibrated and map projected.

While some instrument teams provide science-ready versions of their data, many other archives must first be processed by the individual researcher. POW provides users with calibrated cartographic images that can be used for geologic mapping, analysis in a Geographic Image System (GIS), change detection, merging of dissimilar instrument images, and use in a host of other scientific applications (e.g., ArcMAP, ENVI, Matlab, JMARS, etc.). Output formats currently supported include ISIS, PDS, GeoTiff, GeoJpeg2000, Jpeg, and PNG.

Currently Supported Instruments in POW - Click for Instrument Notes

- Cassini ISSNA
- Cassini ISSWA
- Clementine HIRES
- Clementine NIR
- Clementine UV/VIS

ability to send order to POW, returns GIS-ready images

Online GIS Resources

PDS MAP-A-PLANET "v2"

Download full-res mosaics

Or

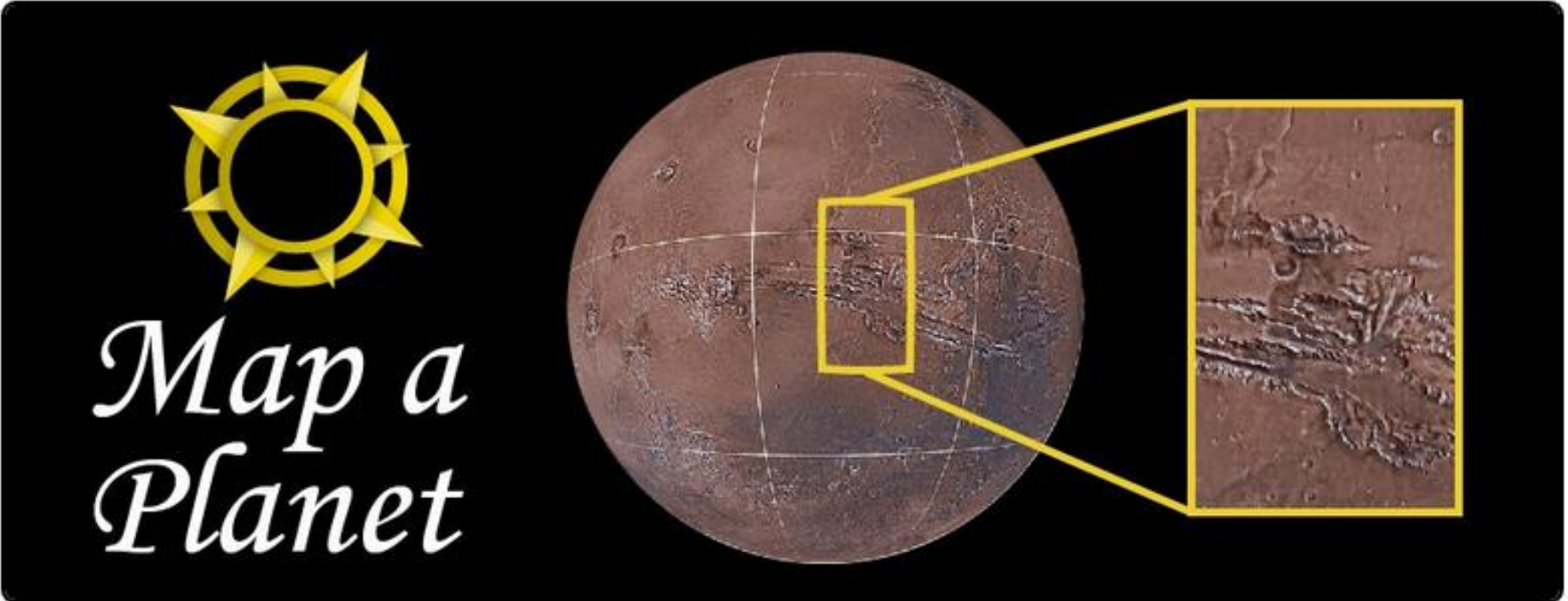
Extract and order areas of interest from existing community created mosaics

Targets include

- Mars, Mercury, Moon, Venus
- Galilean and Saturnian satellites, Vesta

GIS-ready formats (GeoTiff, GeoJp2),
"soft" image size limit~20GB,
ISIS/PDS images, graphical formats

<http://astrogeology.usgs.gov/tools/map>



Welcome to the new Map-A-Planet 2 (beta)
MAP2 allows users to select global image mosaics, which can then be map projected, clipped to extents, have algebra functions applied, and then converted to the user's desired file format.

Quick step-by-step directions

1. [Request](#) or [login](#) into a Astrocloud account
2. Select a target body from the list below and then select an individual product.
3. On the product page, click the "Process" button.
4. Select the MAP2 processing parameters (e.g., map projection, resolution and output format) and submit.
5. You will receive an email when your processed image is ready to be downloaded.

Bodies with eligible MAP2 cartographic products:

- [Mercury](#)
- [Venus](#)
- Earth
 - [Moon](#)
- [Mars](#)
- [Jupiter](#)

Online GIS Resources



Open Layers (w/ Planetary Extensions)

All code available

e.g. Geologic Mapping Tracking Site

Projects for Venus

VENUS
 Lat Lon: 44.65, 163.65

Positive East
 0° to 360°
 Planetocentric

Mapping Project Production
 Mapping, Submission, and Technical Review
 USGS Review and Publication Production

Project Name	Map	Current Mapping Phase	Mapper(s)
Sneurochka Planitia	V-1	Reviewer Sign Off	
Tellus Tessera	V-10	Data Hard Copy Complete	David Senske
Shimti Tessera	V-11	Data Map Posted On-Line	Jayne Aubele
Sedna Planitia	V-19	Nomenclature Review Complete	John Guest
Sappho Patera	V-20	Meta Data Creation Complete	George McGill
Sif Mons	V-31	Reviews Submitted to Mapping Coordinator	Duncan Copp
Scarpellini	V-33	Nomenclature Review Complete	John Guest
Stanton	V-38	Data Hard Copy Complete	Robert Brakenridge
Taussig	V-39	Data Map Posted On-Line	Ellen Stefan
Hurston	V-62	Meta Data Creation Complete	
Agnesi	V-45	Reviews Submitted to Mapping Coordinator	Vicki Hansen
Aino Planitia	V-48	Map Coordinator Review Complete	Ellen Stefan

Online GIS Resources

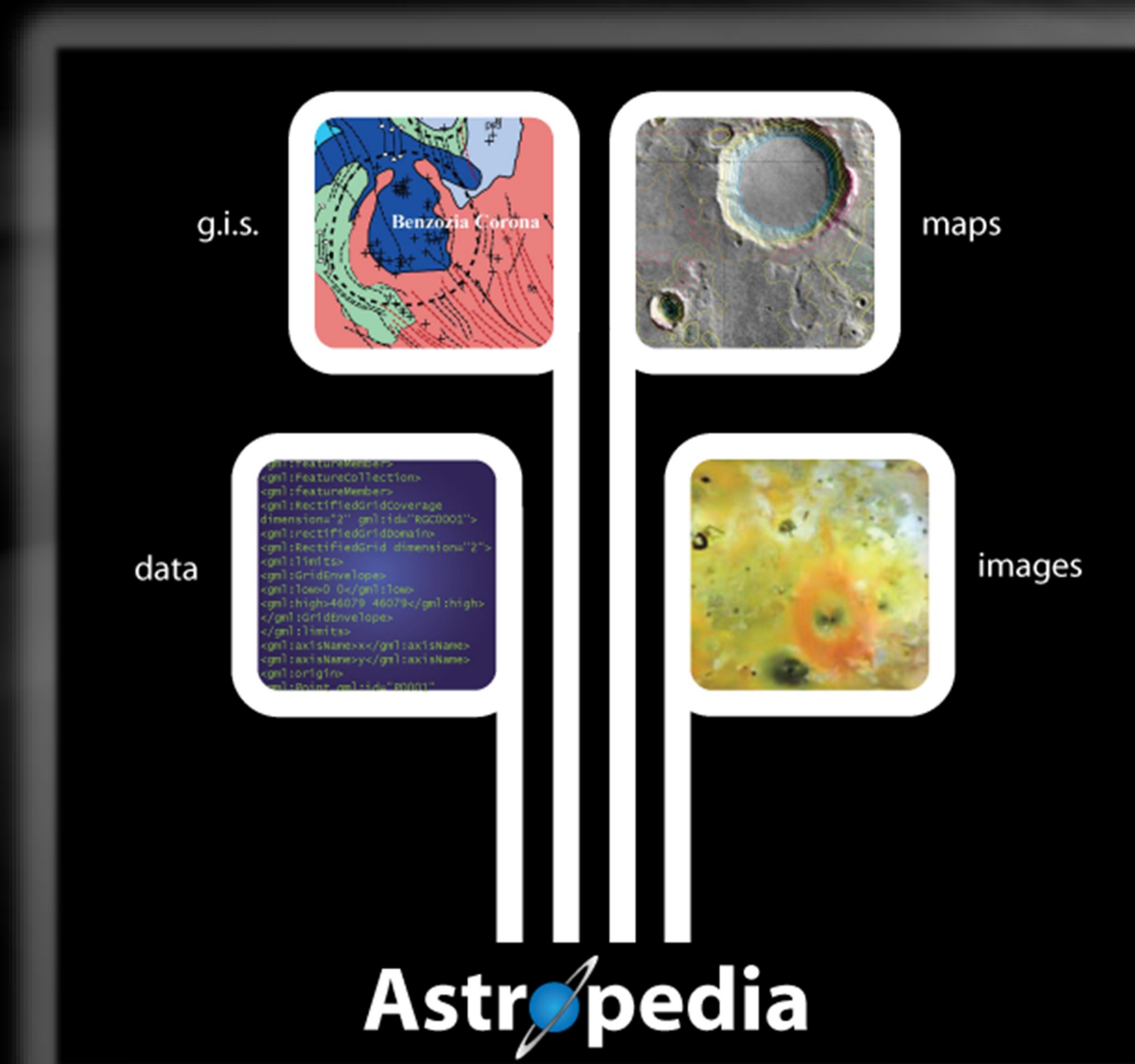
PDS Annex Data Portal



PDS Annex is a project at the Astrogeology Science Center to provide a **PDS-equivalent** archive for GIS layers, geologic maps, and other finished products which might not be accepted as a PDS product.

**Needs standardized OGC API
called Catalog Service**

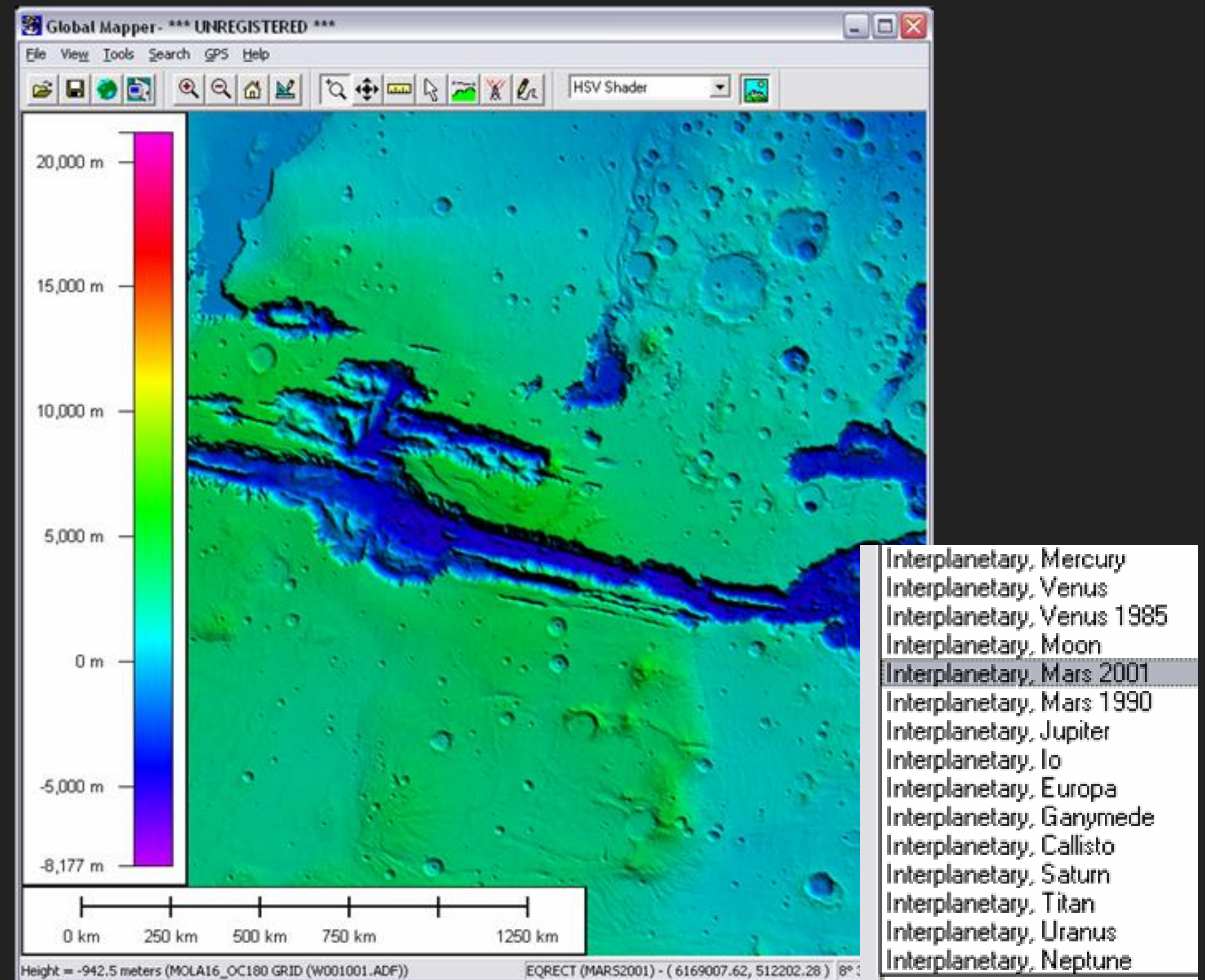
<http://astrogeology.usgs.gov/pds/annex>



GIS APPLICATION UPDATES

GIS DESKTOP SUPPORT FOR PLANETARY

- Commercial
 - ▶ Esri's ArcMap GIS / ArcGIS Pro
 - ▶ Global Mapper
 - ▶ ENVI (latest version – Esri's proj. engine)
- Open Source
 - ▶ **QGIS**
 - ▶ UDIG GIS
 - ▶ SAGA GIS
 - ▶ Generic Mapping Tools
 - ▶ GRASS

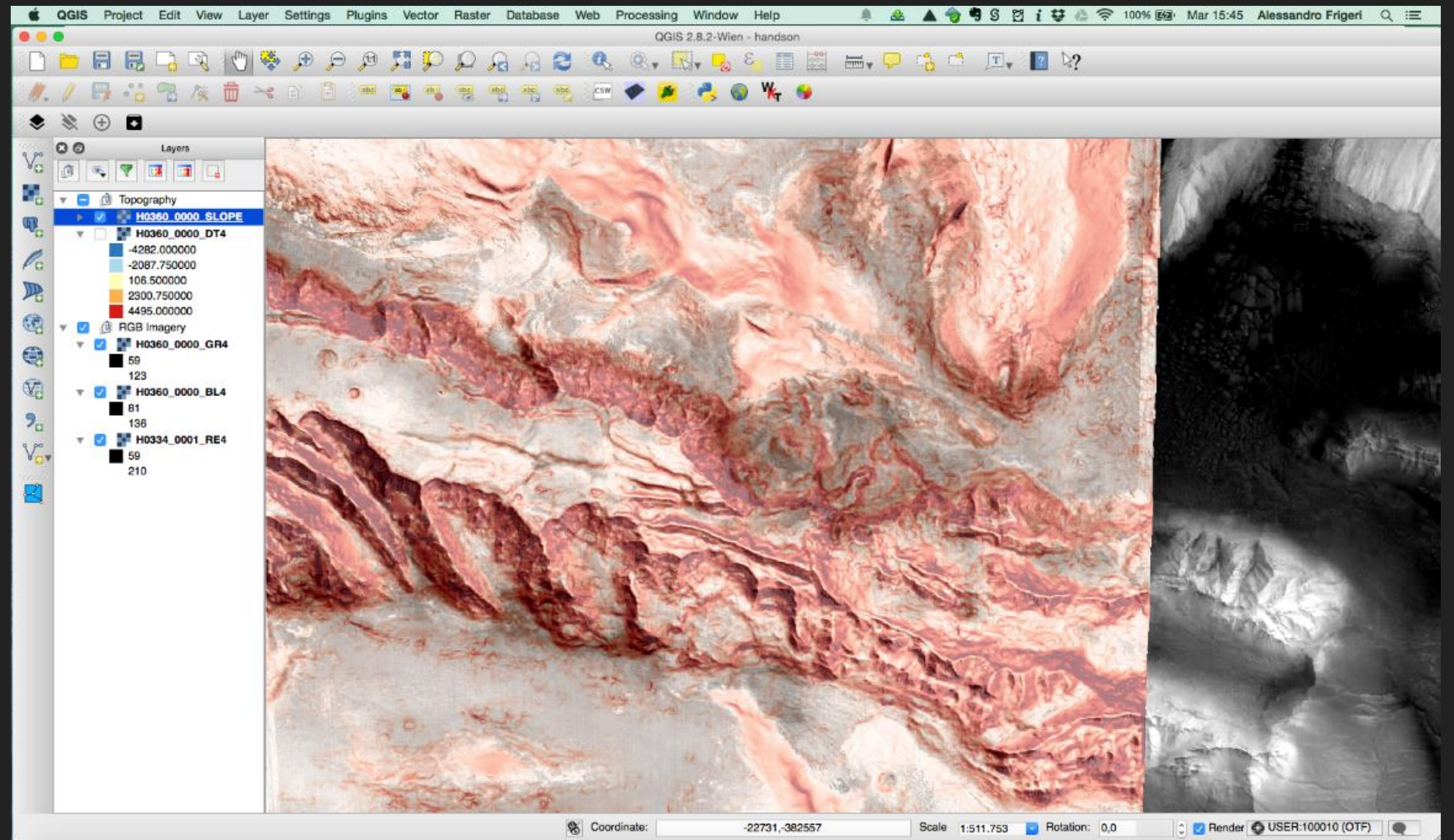


GIS DESKTOP SUPPORT FOR PLANETARY

- QGIS
 - SAGA GIS (add-in)
 - GRASS (add-in)

Today (David Mayer):

QGIS Demo 11:30 Agassiz



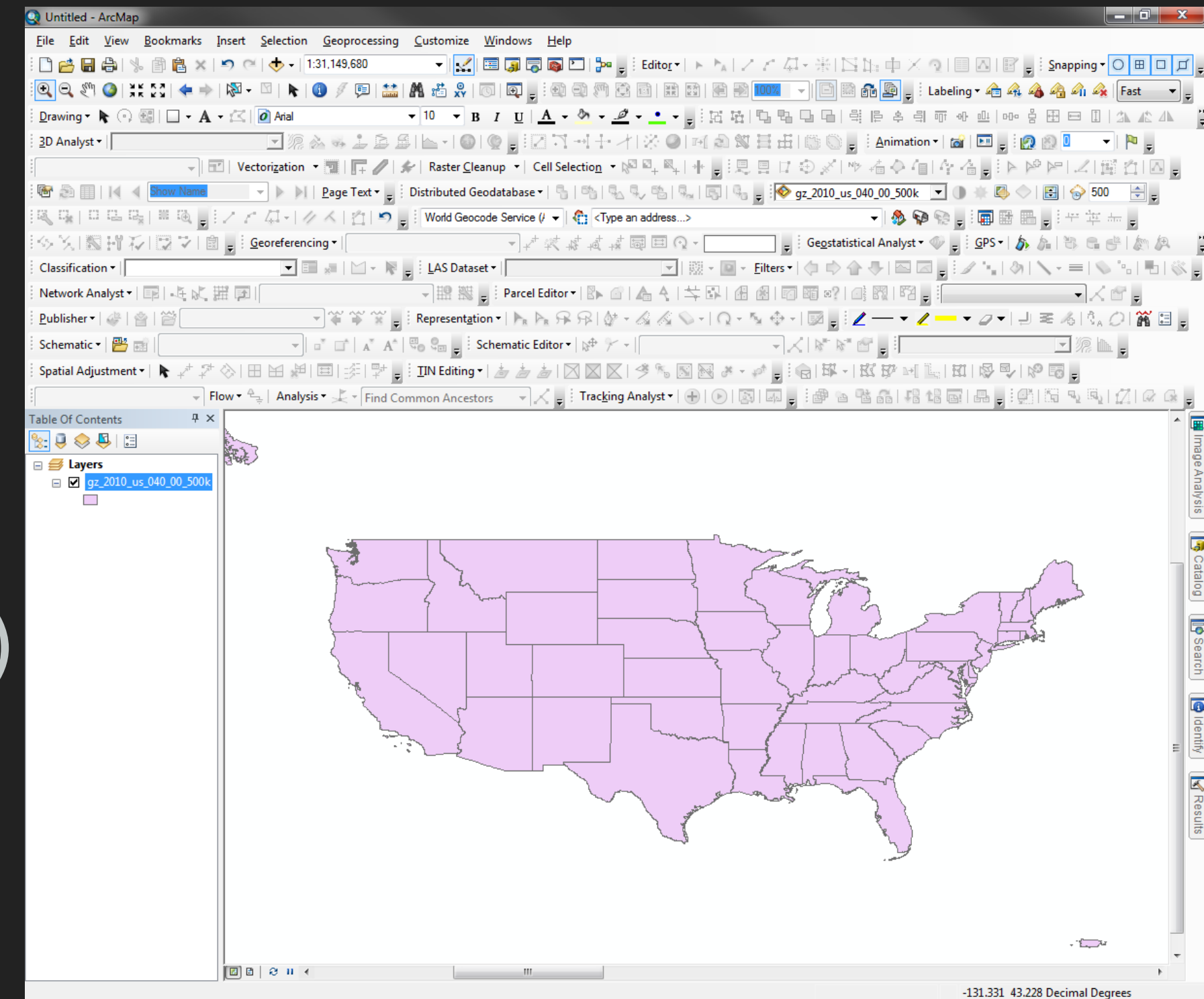
QGIS DESKTOP SUPPORT FOR PLANETARY

- ▶ Current Version: 2.18.6 'Las Palmas' (April 7th 2017)
- ▶ Tons of continued improvements
- ▶ Long Term Release (LTR): 2.14.x

- ▶ Upcoming releases: QGIS 3.0
- **QT5 and Python 3**
 - ▶ June 2017: retire 2.14, then 2.18 becomes LTR from June 2017 to 2018
 - ▶ July 2017: 3.0 feature freeze
 - ▶ Sept 2017: release 3.0 and release 3.2 as next LTR in release 3.0 + 4 Months (eta June 2018)

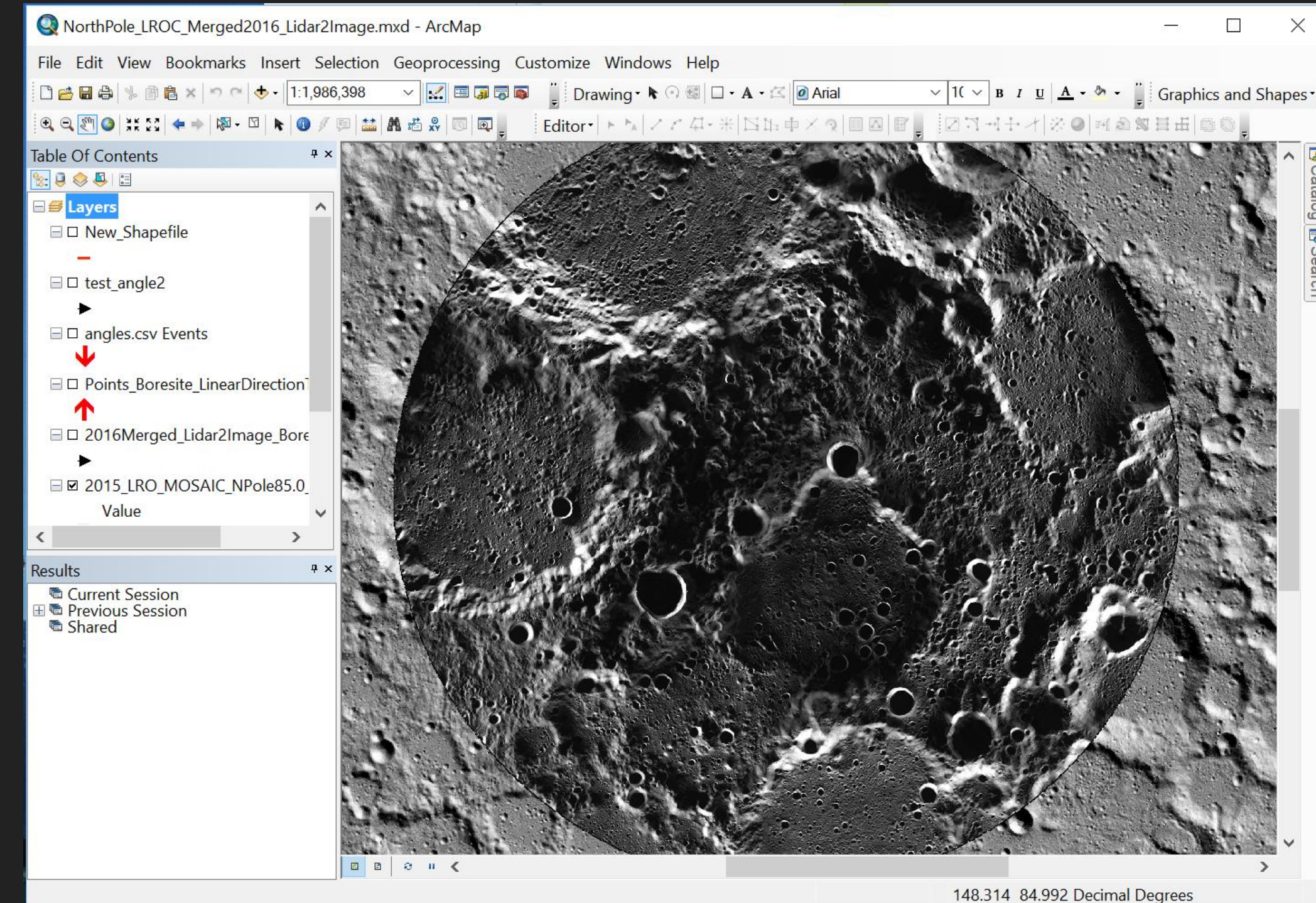
ARCMAP

- ▶ Esri added more bodies for 10.5.1?
 - ▶ E.g. Mars Sphere (3396190.0), Vesta, Ceres
- ▶ Esri supporting server for Mars and Moon.L. Plesea)
 - ▶ not yet public (tile cache)
- ▶ Esri just added planetary support for ArcGIS Online
- ▶ USGS upgrading ArcGIS (tile cache) Server to 10.5
- ▶ Willing to support PDS4...



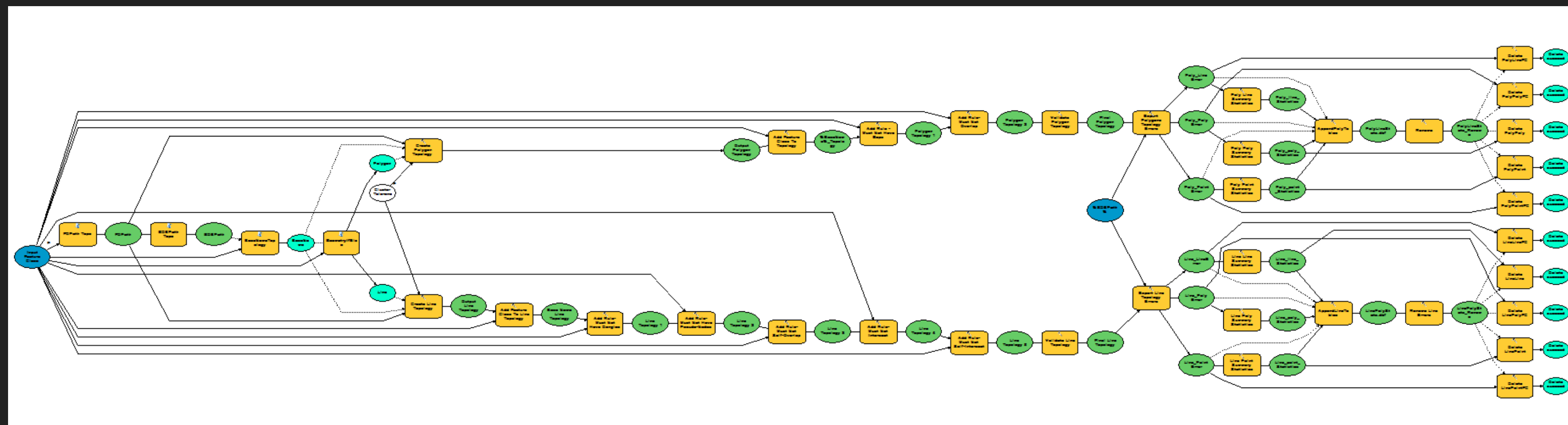
ARCMAP

- Topology Check tool
- Build Polygons tool
- Simple WKT geometry writer
- Zonal Stats cumulative slopes graph (rover)



Demo

1:30 Agassiz



ARCMAP -- TOOLS YOU MIGHT NOT KNEW EXISTED BUT SHOULD

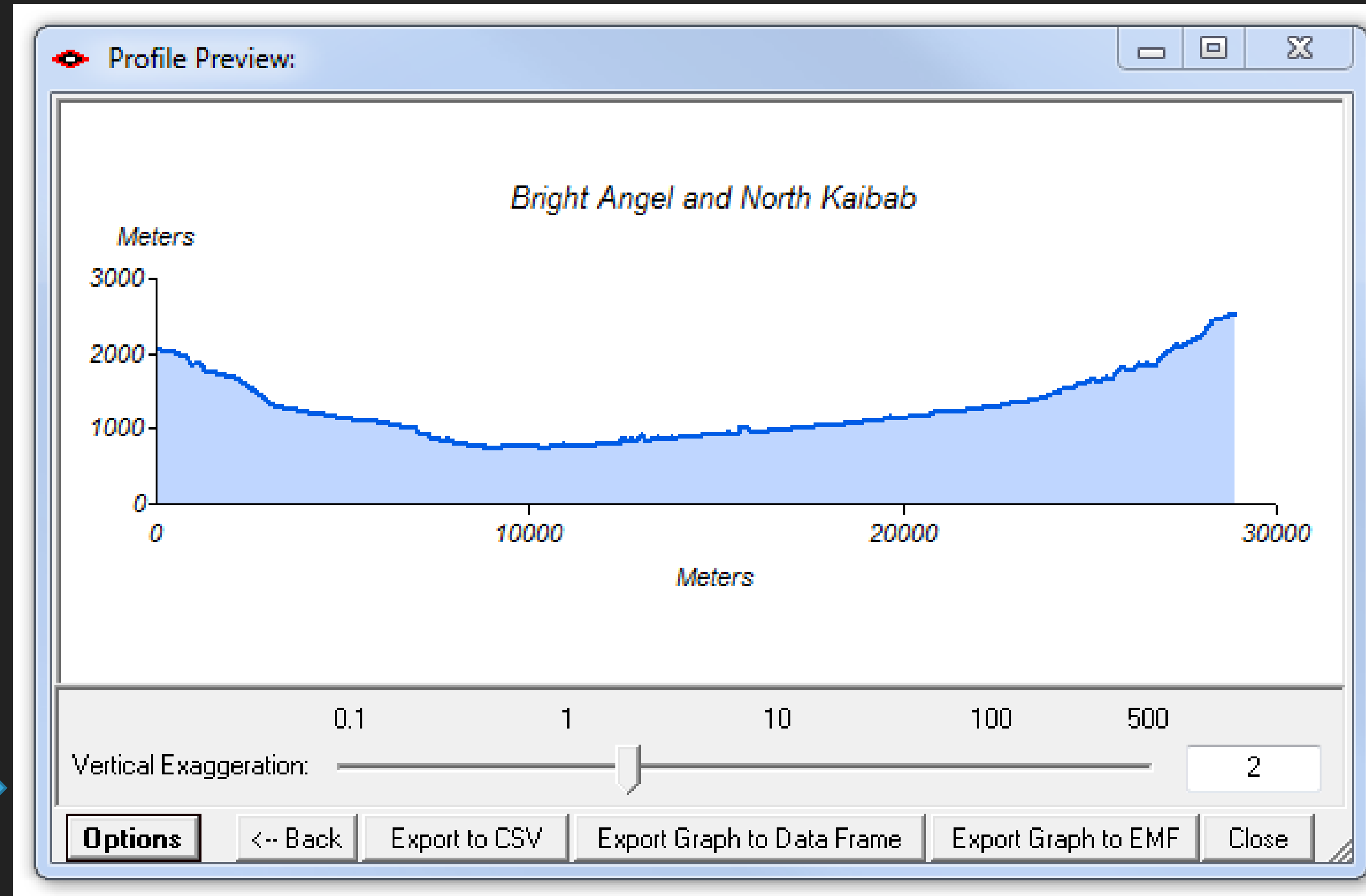
- **Tools for Graphics and Shapes** – Calculates geodesic areas, lengths and angles
 - By Jeff Jenness (partial USGS contract), <http://www.jennessent.com/>
- **Geodesic Profiler** – Calculates accurate profiles over large area
 - Still in beta testing (under USGS contract) – Newly available at Astro's MRCTR GIS
- **LayerTools** - Strike/Dip tool from high-resolution DEMs
 - By Thomas Kneissl (Freie Universität, Berlin), abstract. <http://www.lpi.usra.edu/meetings/lpsc2010/pdf/1640.pdf>
 - Slope & Aspect Test tool GUI (by USGS)
- **CraterTools** – crater collection and plotting tool also by Thomas Kneissl (Freie Universität, Berlin)
- **Block Adjustment Tool** - built-in since ArcMap 10.4

GEODESIC PROFILER



Elevation Profile of Polyline

Finally Exaggeration!!!



ARCMAP

- Block Adjustment Tool
- Use case:
 - CTX Human Landing Sites

Block Adjustment

toronto_old Block Adjustment Tools

Select By: Images Control Points Display: Control Points GCP IDs Residuals Images: 11,22,35,39

Viewer: 100% Center to Selected Tiepoint

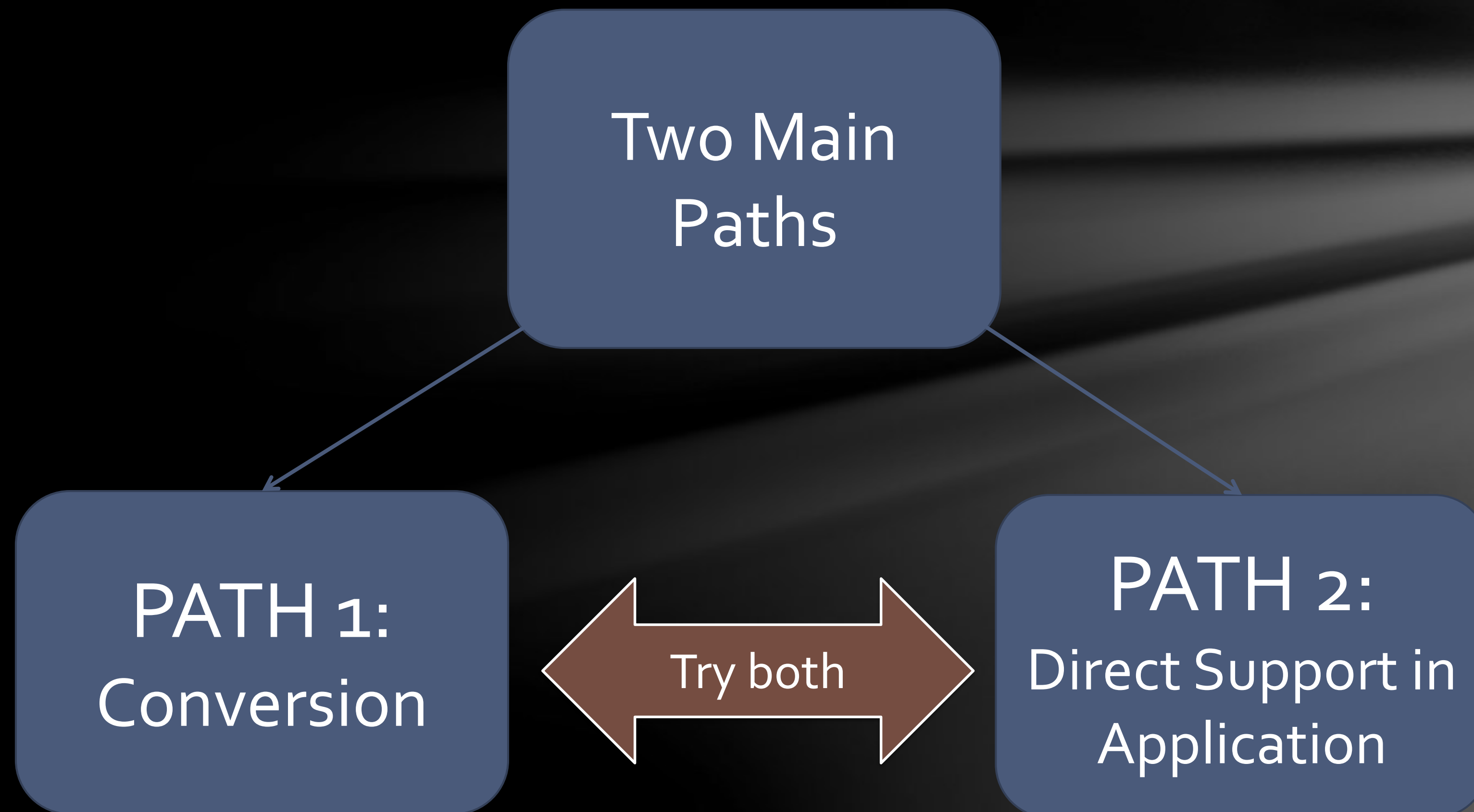
Images				Overlaps			Control Points				
ImageID	Coverage	#Points	RMS	ImageID	Images	#Points	ImageID	PointID	Type	Status	Residual
18	0.017	12	0.283218	11	20,22,39	0	22	5532	TIE	1	0.229521
12	0.019	16	0.664841	11	20,39	0	35	5532	TIE	1	0.476346
15	0.048	22	0.845986	11	20,22	0	22	5534	TIE	1	1.664693
21	0.149	22	1.082216	11	20	0	35	5534	TIE	1	0.795993
32	0.020	22	1.046967	11	22,35,39	7	22	5537	TIE	1	0.863748
36	0.027	22	1.155716	11	35,39	7	35	5537	TIE	1	0.676518
41	0.202	23	0.852165	11	22,35	7	11	5523	TIE	1	0.938118
11	0.025	25	0.713202	11	35	7	11	5526	TIE	1	1.017063
6	0.168	26	0.606495	11	22,39	25	11	5527	TIE	1	0.976867
24	0.142	27	1.063276	11	39	25	11	5529	TIE	1	0.829110
25	0.034	27	0.505436	11	22	25	11	5532	TIE	1	0.195608
35	0.006	28	0.867717				11	5534	TIE	1	0.948061



Format Resources

Need:

Support of planetary data in GIS / Mapping Apps



Path 1: Format Conversion

2006 - added PDS3 / ISIS2 read support to GDAL

2007 – ISIS3 read support added

2014 – VICAR read support added

2017 – "Geo" FITS to be added ([github](#) also fits2vrt script)

2017 – ISIS3 writer,

2107 – plans for PDS4 reader/writers

Goals:

- Convert to GIS/RS formats like GeoTiff, GeoJp2

Specifically to support:

- Derived data (not raw PDS)
- Planetary datums and map projections
- Large files
- Ability to use processing / Python tools

What is GDAL?

Geospatial Data Abstraction Library

- GDAL is a “**translator library** for raster geospatial data formats”
- Open source
- Used in many applications
- Can handle many image formats for read and slightly less for writing: PDS₃, ISIS, VICAR, **FITS (CFITSIO)**, GeoTiff, JPEG, PNG, NetCDF – plans for PDS₄

Path 2: Direct Application Support

Wrap planetary data in supported headers

- To support: Esri, ERDAS, PCI Geomatic, ENVI (raw headers) or use graphical formats with Worldfiles

But as GDAL grew in use so did **direct** planetary support

- QGIS/UDIG/Mirone
- Esri's ArcMap
- MapServer (WMS server)
- **AMES Stereo-pipeline**
- ...
- More recent
 - Generic Mapping Tools
 - GRASS
 - TuiView

Format Challenges

community improvements to GDAL
critical

For example:

- fix / report bugs
- add more writers?
- new formats (e.g. PDS₄)
- ...

Community Efforts:

eur PLANET

WORKSHOP

PLANETARY MAPPING AND
VIRTUAL OBSERVATORY

ROSCOFF, FRANCE, 19 – 21 April 2017

Community Efforts:

<http://openplanetary.co/>

OpenPlanetary

Share, discuss and improve your data, tools, workflow and overall knowledge of our Solar System

USE OUR FRAMEWORK



Blog



Slack



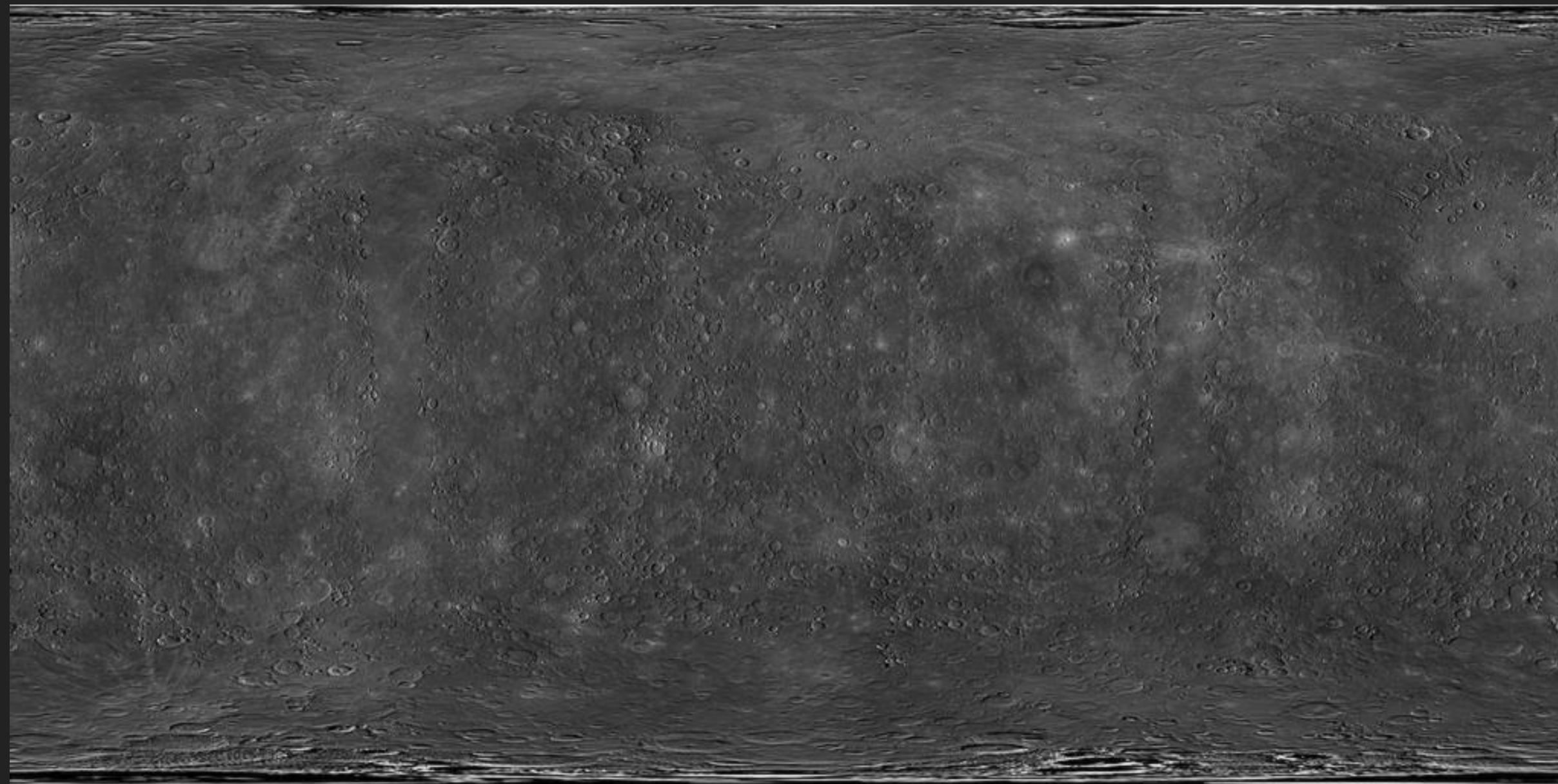
GitHub

-
- ▶ Foundational Data Products

HIGHLIGHT FOUNDATIONAL EXAMPLES

MESSENGER MOSAICS / DEM

- ▶ Messenger Team



166 m/p



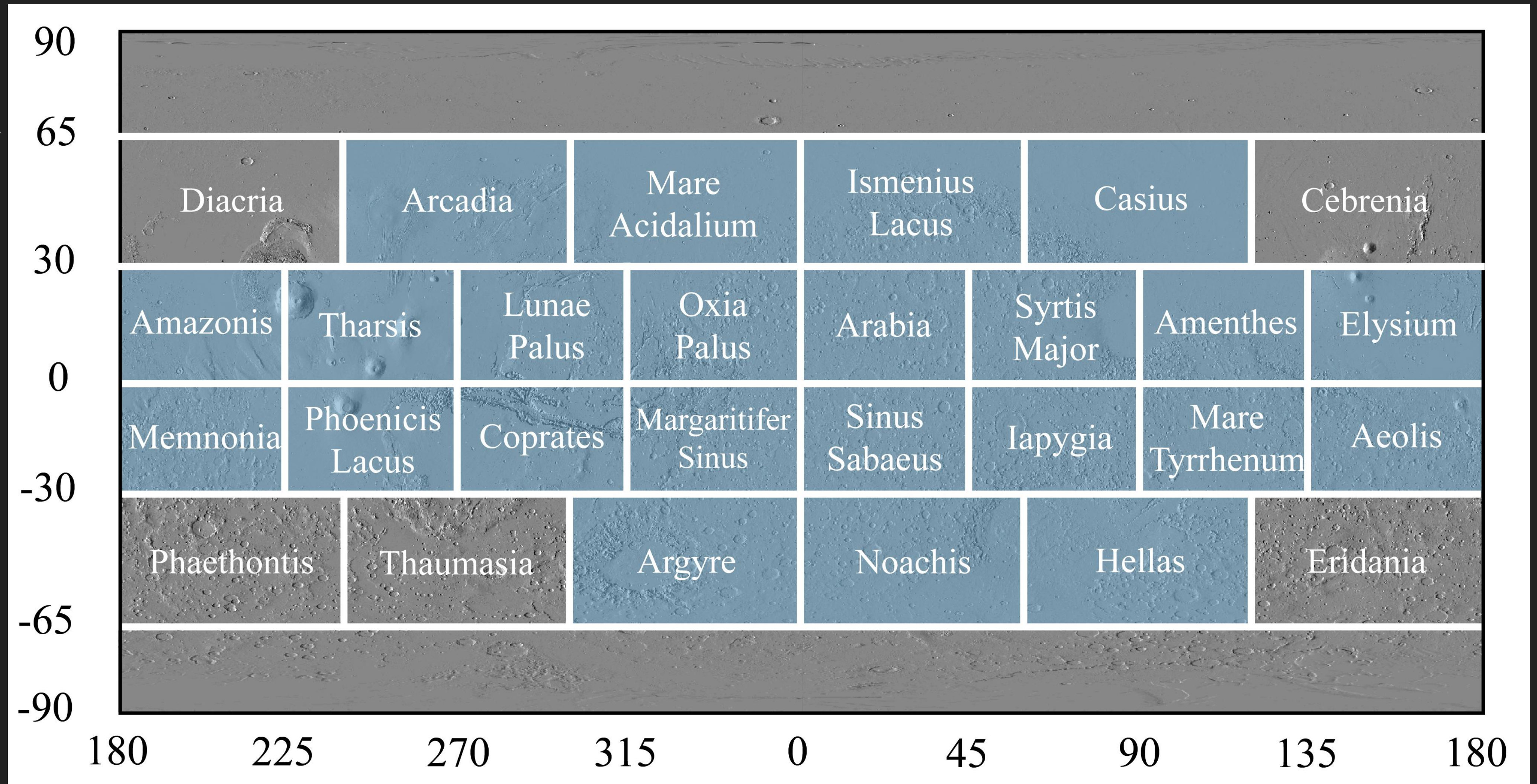
665 m/p

THEMIS IR CONTROLLED MOSAICS

▶ USGS

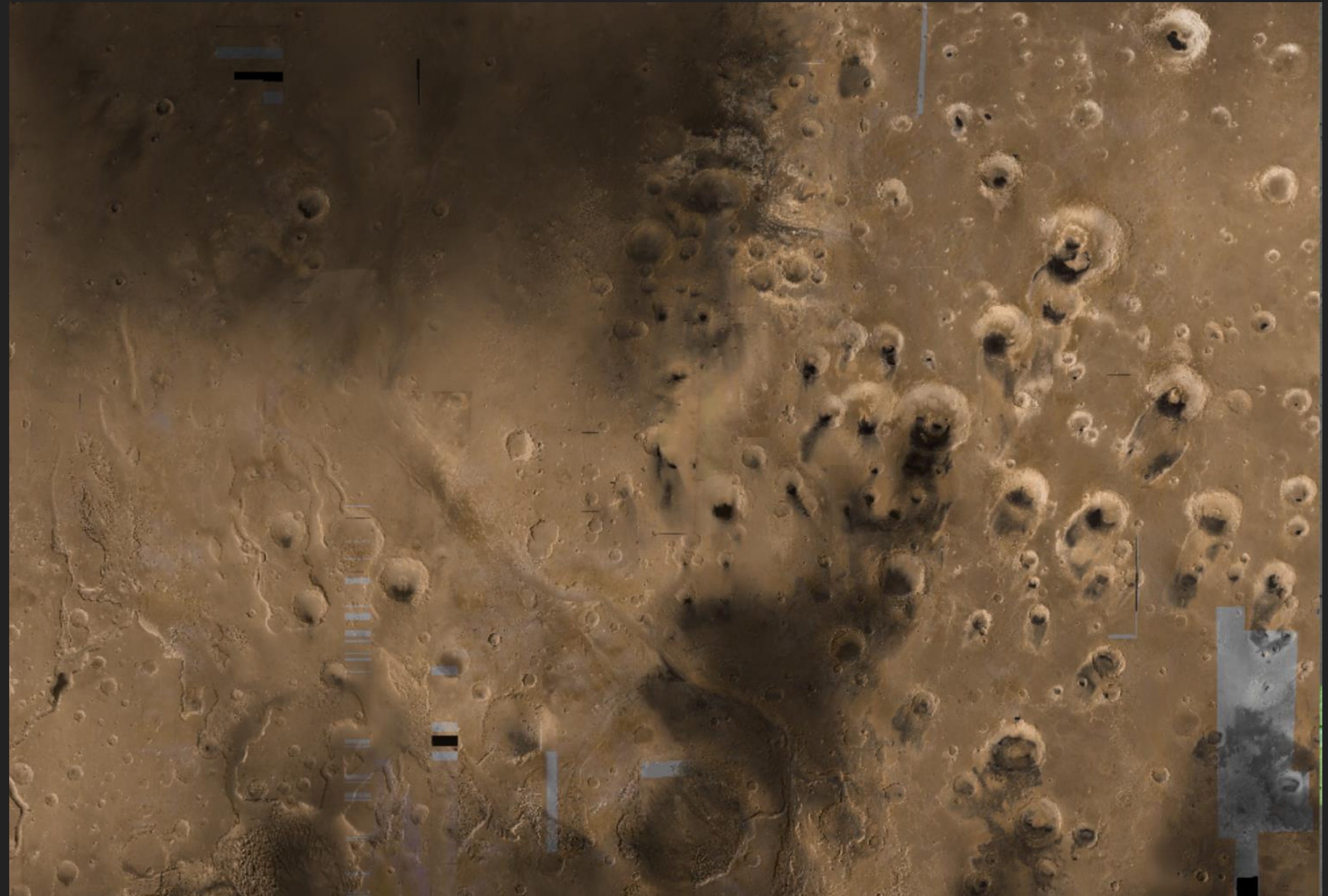
ASU / NASA

100 m/p



HRSC MOSAICS AND DEMS

- ▶ HRSC Team
 - ▶ See iMars talk



LOLA / KAGUYA TC STEREO MERGE

- ▶ Goddard / JAXA



59 m/p, only 60N to 60S

PLUTO / CHARON

- ▶ New Horizon Team
 - ▶ Pluto image mosaic (315 m/pixel)
 - ▶ Charon image mosaic (400 m/pixel)
 - ▶ Pluto DTM (315 m/pixel)
 - ▶ Charon DTM (400 m/pixel)
- ▶ coming out soon...

COMMUNITY INPUT

- ▶ Anything else being produced?
 - ▶ Forthcoming
 - ▶ Clementine UVVIS re-controlled
 - ▶ Europa basemap re-do
 - ▶ CTX equatorial mosaic...?
 - ▶ Phobos...?

CSM Standard for Planetary

Community Sensor Model

Trent Hare and Randy Kirk

Camera Sensor Model Definition

place data as taken by sensors onto the surface

Planetary Workflow:

SPIICE → CAMERA → SHAPE

Why?

PSDI tenet:

support infrastructural **standards**

What standard?

The **Community Sensor Model (CSM)** Working Group was established by the U.S. defense and intelligence community with the goal of **standardizing camera models** for various remote sensor types. The CSM standard, now at version 3.0.2, provides a well-defined application program interface (API) for multiple types of sensors and has been widely adopted by Earth remote sensing software systems.

CSM GOAL

1. Share camera software across photogrammetric systems

- ISIS₃
- VICAR
- AMES Stereo-pipeline
- Commercial
 - SOCET GXP
 - ArcMap
 - Harris (ENVI)

CSM GOAL

2. Serve as example for future mission instruments

- CSM doesn't make writing the software any easier but the standard provides a thoughtful design for how it can be used.
- Help to make camera model software understandable (not magic).

More Resources

OpenPlanetary Community: <http://openplanetary.co>

GRASS tutorial: https://grasswiki.osgeo.org/wiki/Planetary_mapping

QGIS Tutorial: <https://issues.cosmos.esa.int/psawiki/display/GISWS/Session+2+-+Hands-on>

Astrogeology MRCTR GIS Lab

<http://astrogeology.usgs.gov/facilities/mrctr-gis-lab>

Astrogeology Github:

<https://github.com/USGS-Astrogeology>

Planetary Data Workshop:

<http://astrogeology.usgs.gov/groups/planetary-data-workshop>

