Lunar Reconnaissance Orbiter: Enabling CLPS Mission Success

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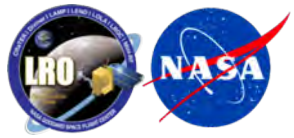
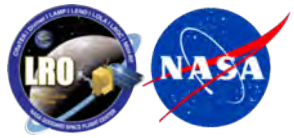
Outline



- Goals: What data already exist, what data can you ask for, and what to expect when you ask for new data

- Data: LRO Instruments, data, and examples
- Visualization tools: Quickmap and Jmoon
- Archives: The Planetary Data System
- Menu of help options

Lunar missions & datasets



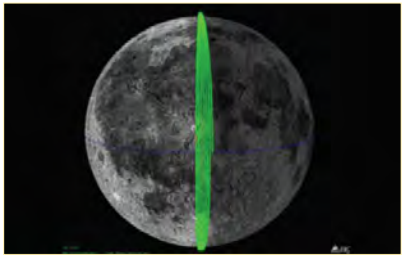
- Ranger, Surveyor, Lunar Orbiter, Apollo, Luna, Lunokhod (1970's)
- Galileo & Cassini (1990's) - flybys
- Clementine (1994) – orbiter, mapped most of the lunar surface in UV-VIS-NIR (TiO2, FeO, soil maturity maps)
- Lunar Prospector (1998-99) – orbiter. Gamma Ray Spectrometer (GRS) - global element maps (U, Th, K, Fe, Ti, O, Si, Al, Mg, Ca) at 150 km/px and variable precision, and Neutron Spectrometer (NS) – H abundance at 150 km/ px
- SMART-1, Kaguya, Chang'E, Chandrayaan-1 – international orbiters – see next slide
- Ch-1 Moon Mineralogy Mapper (M3) - Global mineral maps, surface water
- LRO (2009) – mapping orbiter – more to come
- LCROSS (2009) – polar impactor at south pole: 5-10 wt.% water, other volatile substances
- ARTEMIS (2010) - Lunar space environment, solar wind, magnetotail and lunar wake
- GRAIL (2011) - Highest-quality gravity field of the Moon
- LADEE (2012) - Characterize the lunar atmosphere, document the dust environment at 50 km
- EM-1 Cubesats (2020) - Lunar Flashlight, Lunar IceCube, LunaH-Map, LunIR, OMOTENASHI

Mission	Kaguya (Japan) 2007-09	Chang'e 1,2 (China) 2007-09	Chandrayaan (India) 2008-09	LRO/LCROSS (NASA) 2009-
Imaging:				
Camera (VIS monochrome)	x	x	x	x
Typical VIS image resolution (m)	10 (global)	120 (global?)	100 (global)	0.5 (regional)
UV imaging	x			x
IR imaging	x	x	x	x
Thermal (broadband) IR				x
Multi-band UV-VIS-IR imaging	x		x	x
Spectroscopy:				
Gamma Ray Spectrometer	x	x	x	
Neutron Spectrometer				x
Alpha Particle Spectrometer	x			
X-Ray Spectrometer	x	x	x	
Infrared Spectrometer	x		x	
Planetary shape and structure				
Radar	x	x	x	x
Laser Ranging/Altimeter	x	x	x	x
Gravity	x (far side)	x	x	x
Particles and fields:				
High-energy Detector	x	x		
Solar Wind Detector		x	x	
Solar X-Ray Monitor			x	
Lunar Radiation Environment				x
Plasma Analyzer	x			
Plasma Imager (terrestrial)	x			
Radio Science (lunar ionosphere)	x			
Radiometer		x		
Magnetometer	x			
Impactor experiments:			x	x

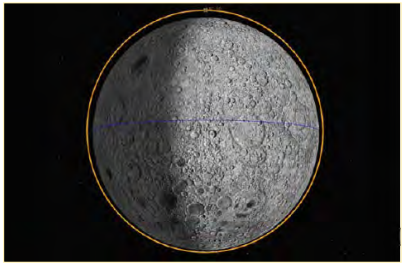
LRO Overview

- Safe Landing Sites
  - High resolution imagery
  - Global maps
    - Topography
    - Rock abundances
- Locate potential resources
  - Water at the lunar poles?
  - Continuous source of solar energy
  - Mineralogy
- Space Environment
  - Energetic particles
  - Neutrons
- New Technology
  - Advanced Radar

- Launched on an Atlas V into a direct insertion trajectory to the moon. Co-manifested with LCROSS lunar impacter mission.
- On-board propulsion system used to capture at the moon, insert into and maintain 50 km mean altitude circular polar orbit.
- 1 year exploration mission followed by handover to NASA Science Mission Directorate.
- Orbiter is 3-axis stabilized, nadir pointed, operates continuously during the primary mission.
- Data products delivered to Planetary Data Systems (PDS) within 6 months of completion of primary mission.

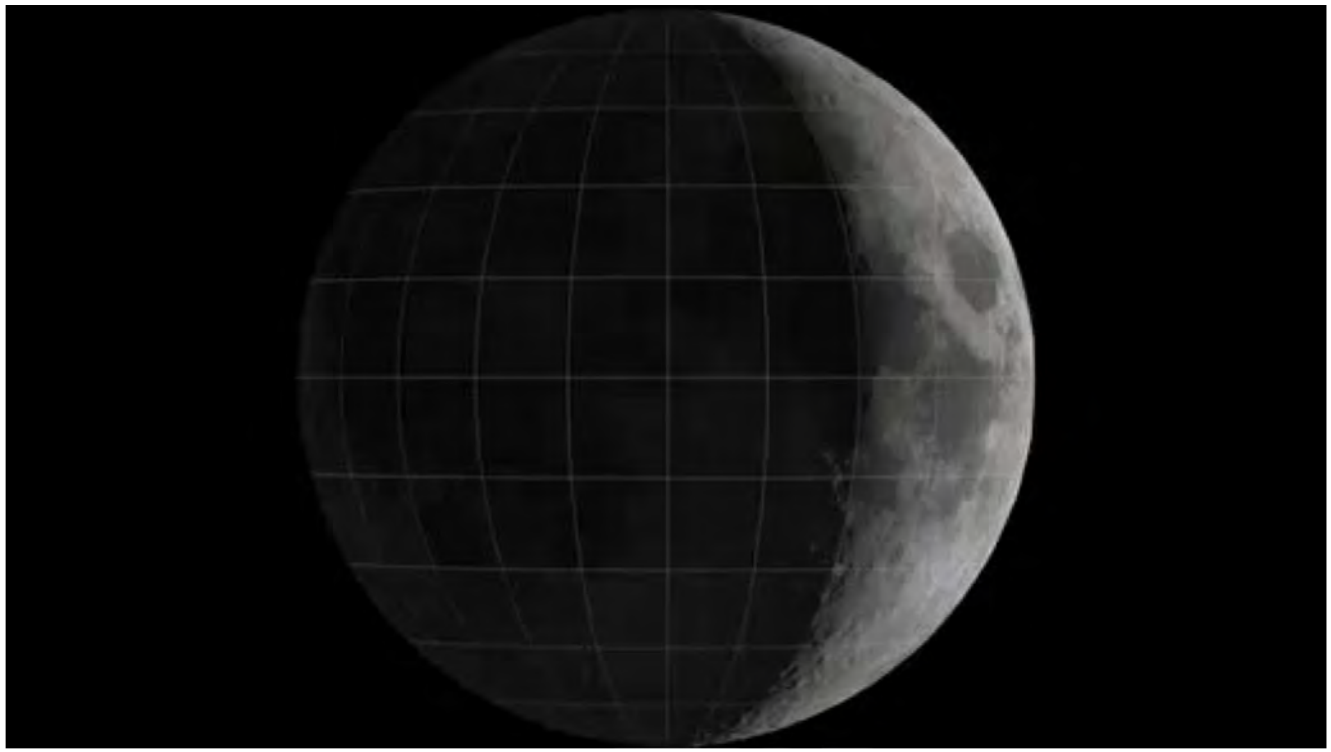


Polar Mapping Phase, 50 km Altitude Circular Orbit, At least 1 Year



Commissioning Phase, 30 x 216 km Altitude Quasi-Frozen Orbit, Up to 60 Days

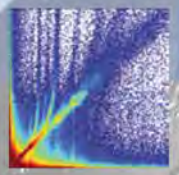
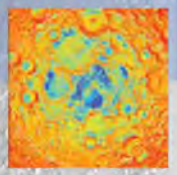
LRO maps in a fixed polar orbit

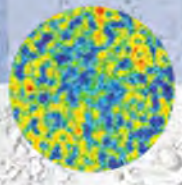


Current orbital altitude: 100 km; period:
https://www.lroc.asu.edu/about/whereislro
Can see an LRO-eye view in Quickmap (more following)

LRO Data and Data Products

Instrument	CRaTER	Diviner	LAMP	LEND	LOLA	LROC NAC	LROC WAC	Mini-RF
Instrument Classification	Primary and albedo cosmic ray sensor	Radiometer	UV Imaging Spectrograph	Neutron Detector	Laser Altimeter	High Resolution Camera	Multi-Spectral Camera	X-and S-band Synthetic Ap. Radar
Primary Data	Lunar and Deep Space Radiation environment	NIR Spectra of the lunar surface	UV Spectra of the lunar surface	Neutron abundances in the near surface	Surface Topography	~50 cm scale images	UV-VIS at 100m	Radar imaging
Key Data Products	• Proton Albedo of the Surface • Radiation exposure from GCR's and the Sun	•Temperature (Max/Min/ local time) •Rock Abundance •Regolith "density"	• Surface volatiles • UV Albedo	• Water equivalent Hydrogen	• Global 100 m Topography • Slope • Roughness • Albedo at 1024 nm • Degree of Permanent Shade • Earth Visibility	• Local 2m topography • Slope • Roughness • Hazard mapping • Roughness	• TiO2 abundance • Topography • Slope • Roughness	• Roughness • Ice at depth • Circular Polarization Ratio Maps

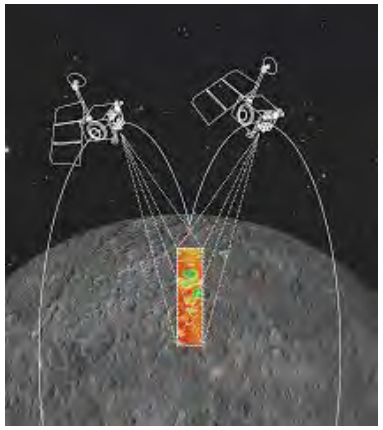





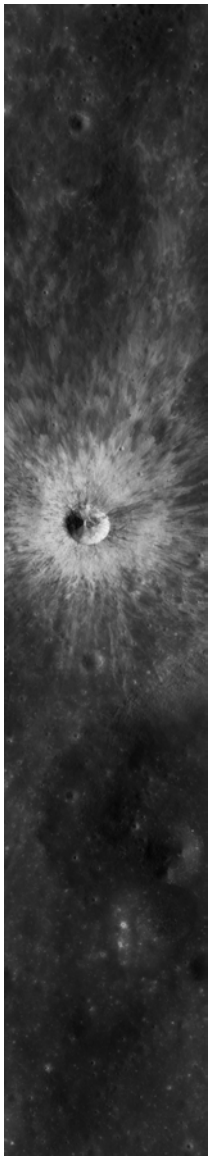

Lunar Reconnaissance Orbiter Instruments and Data products

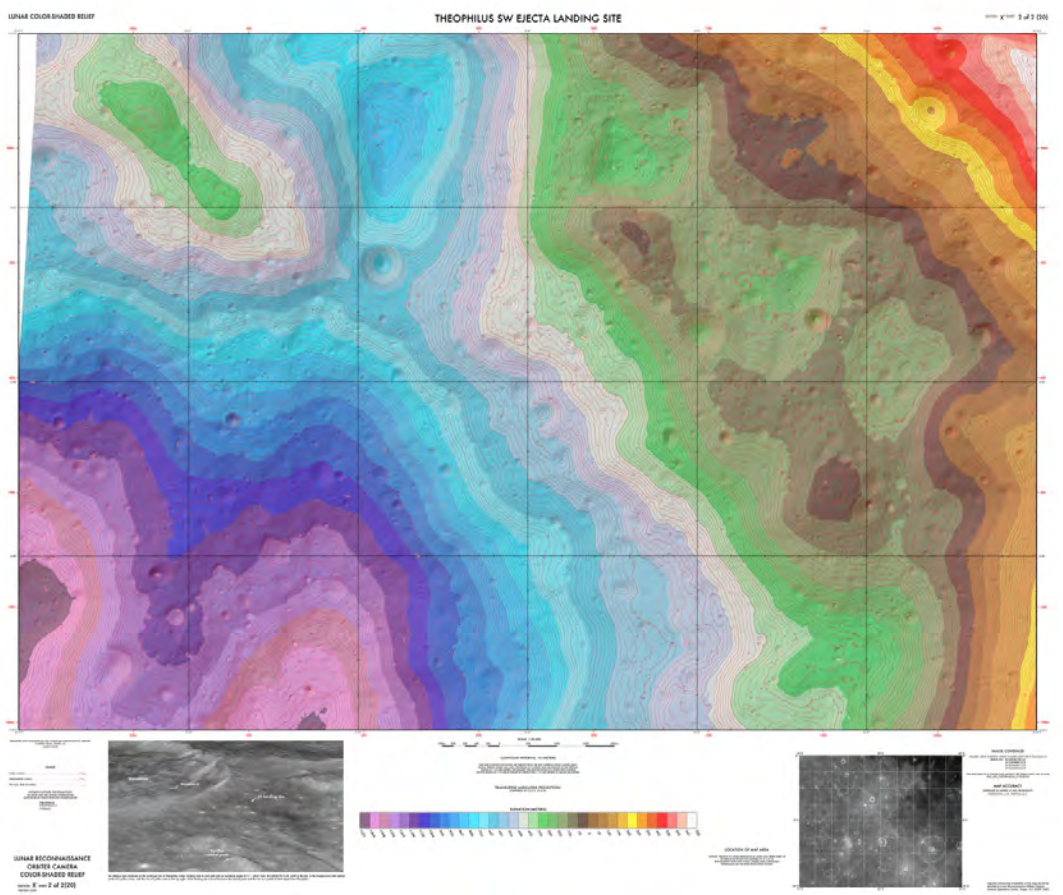
Images

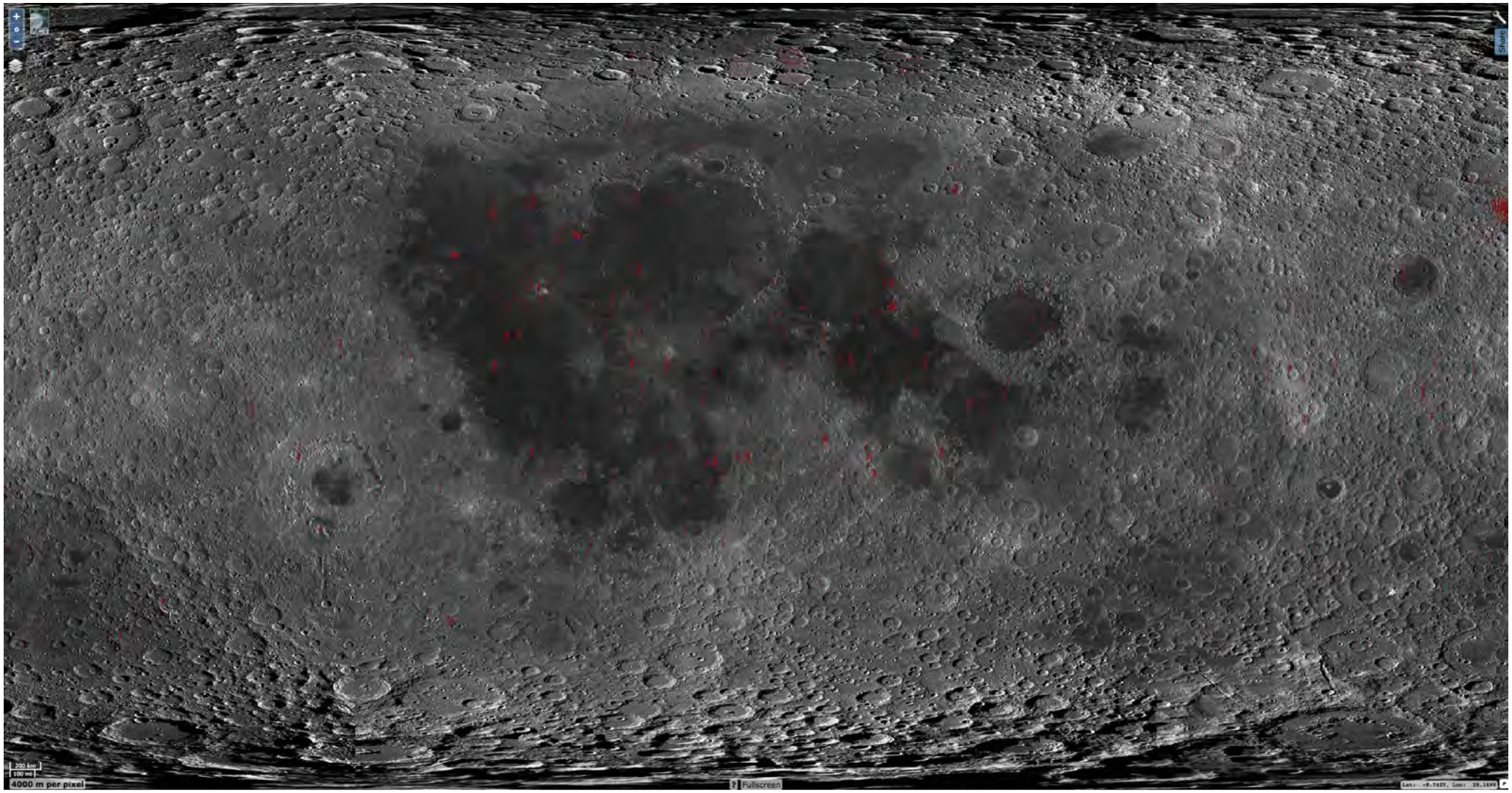
Data: High-resolution images (50 cm per pixel)
Products: NAC mosaics, high resolution Digital Terrain models (DTMs), slope and roughness maps



LROC NAC-derived DTMs require multiple observations of the same area at the same lighting conditions



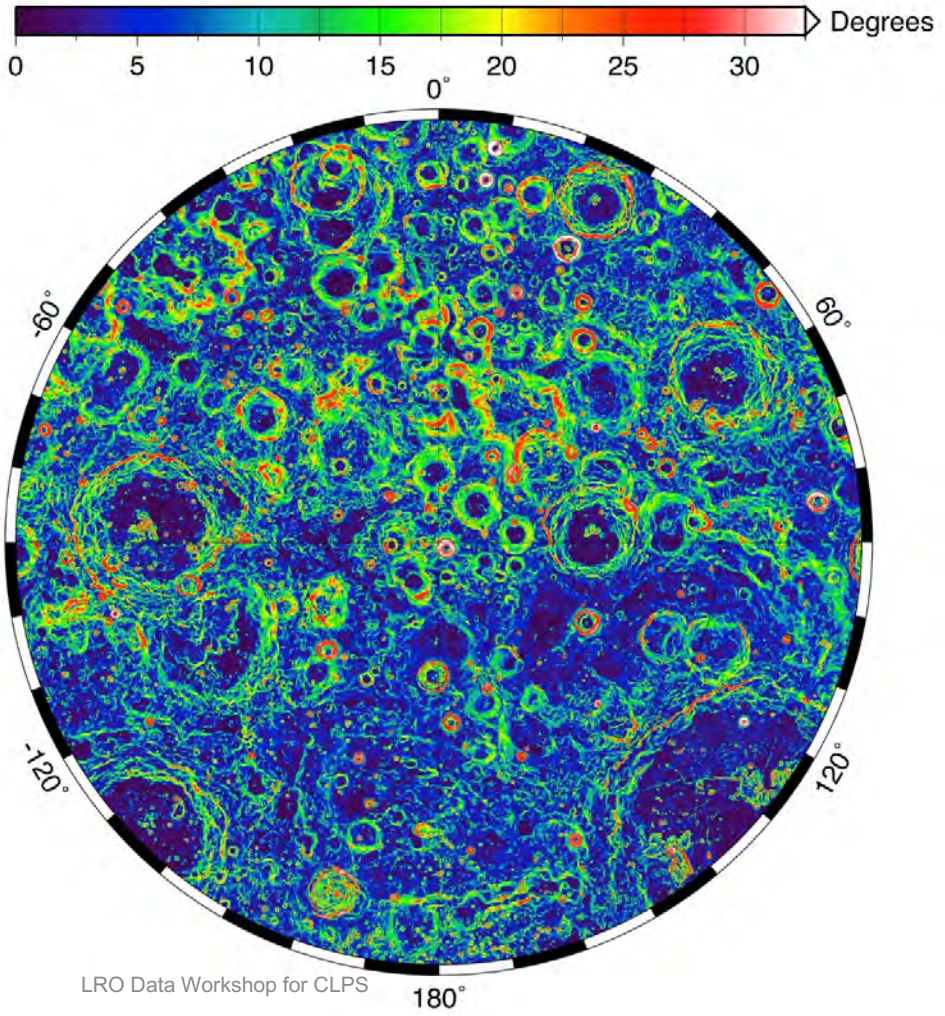




Available NAC DTM's

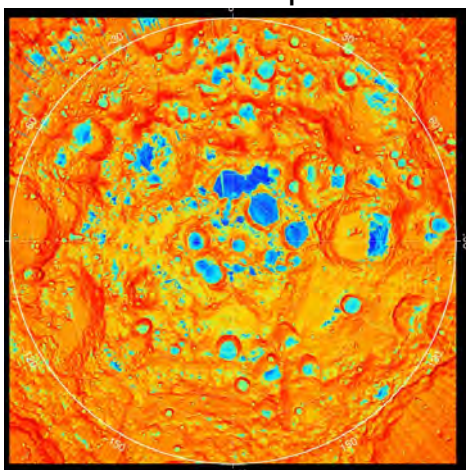
Topography

- Data from the LOLA instrument provides global topography
- Products: local and regional slope data
- Slope data can be used for identifying safe landing sites as well as traverse planning.

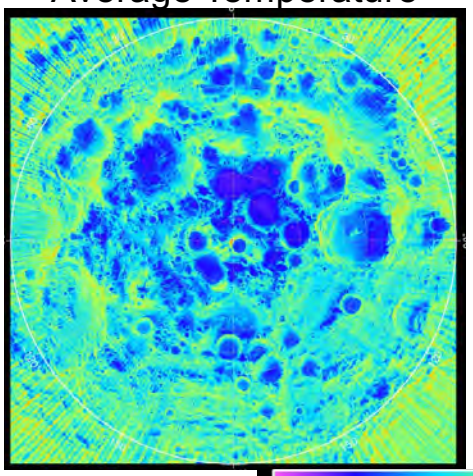


Temperature

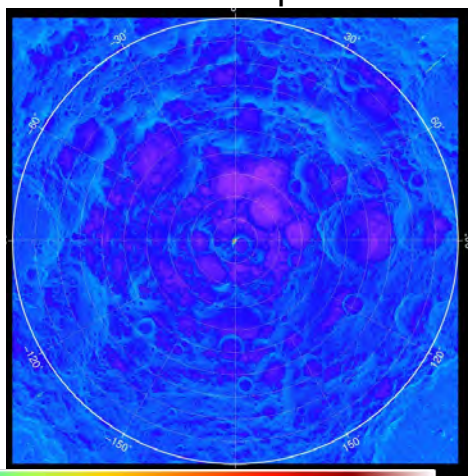
Maximum Temperature

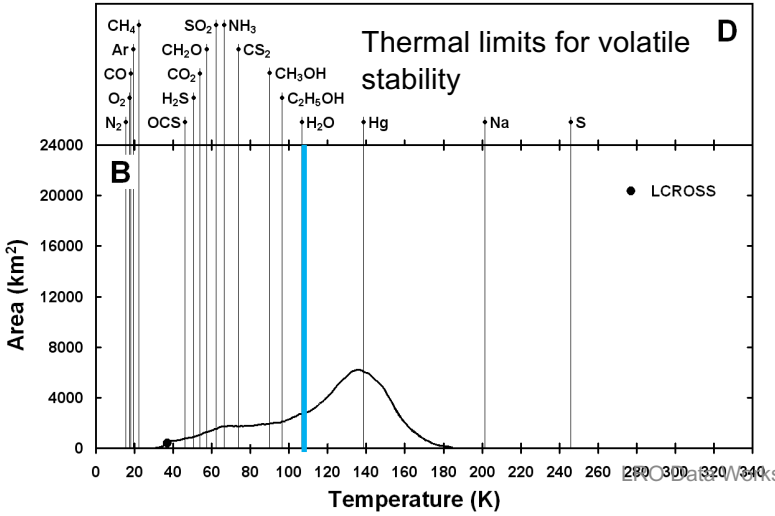


Average Temperature



Minimum Temperature

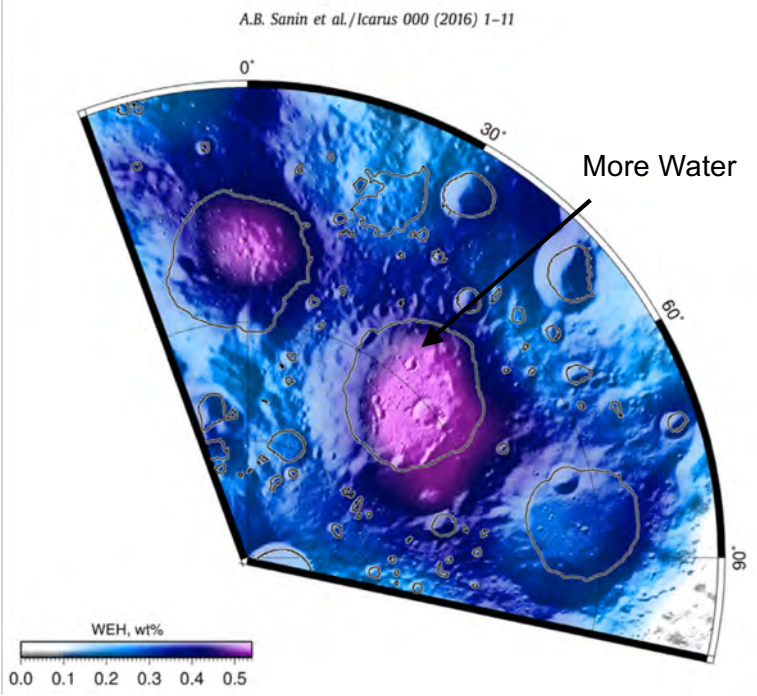


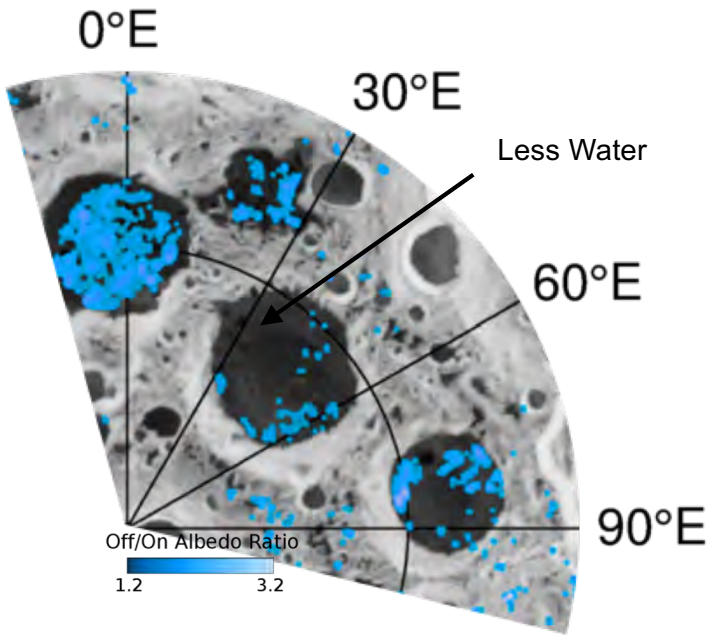


Diviner has observed the lunar poles over a wide range of local times and seasons
Diviner data constrains subsurface temperature

- Map 3-d Volatile Stability
- Guide Volatile Detection

Surface and subsurface ice



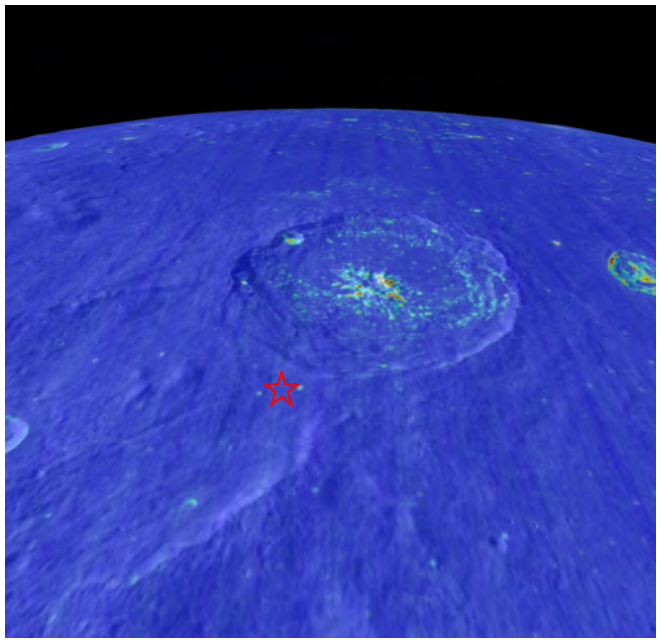


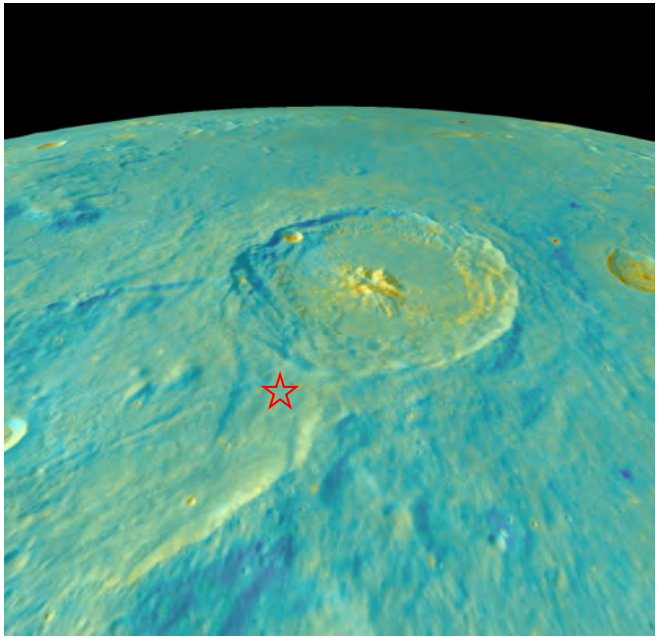
LEND - Water-equivalent hydrogen (WEH) **in the upper ~1 m** (Sanin et al., 2016). Some areas near the South Pole contain more than .34% hydrogen or 3% water equivalent (model dependent)

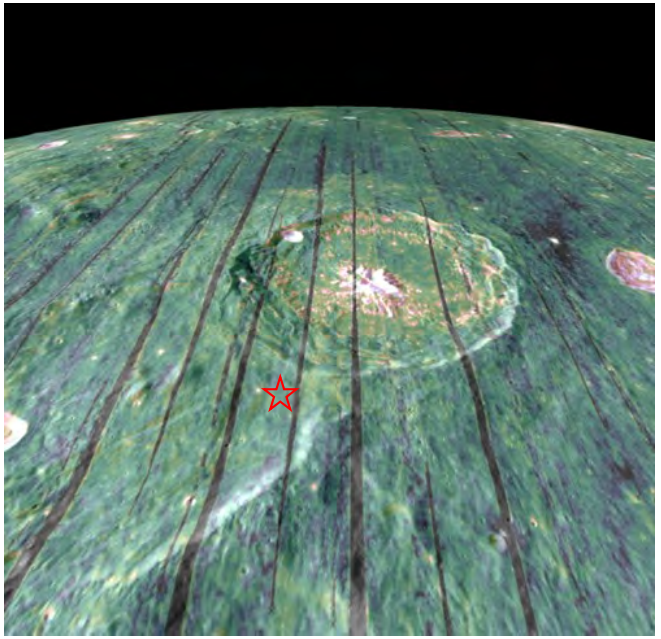
LAMP, LOLA, M3 - H_2O detection **at the surface** (Hayne et al., 2015) – concentrations unknown

Landing hazards and environment

Diviner level 3 summary products on LOLA DEM shaded with WAC global mosaic
Crater Theophilus ~100 km across







0 10 %

Rock abundance

-10 40 K

ΔT – night regolith T

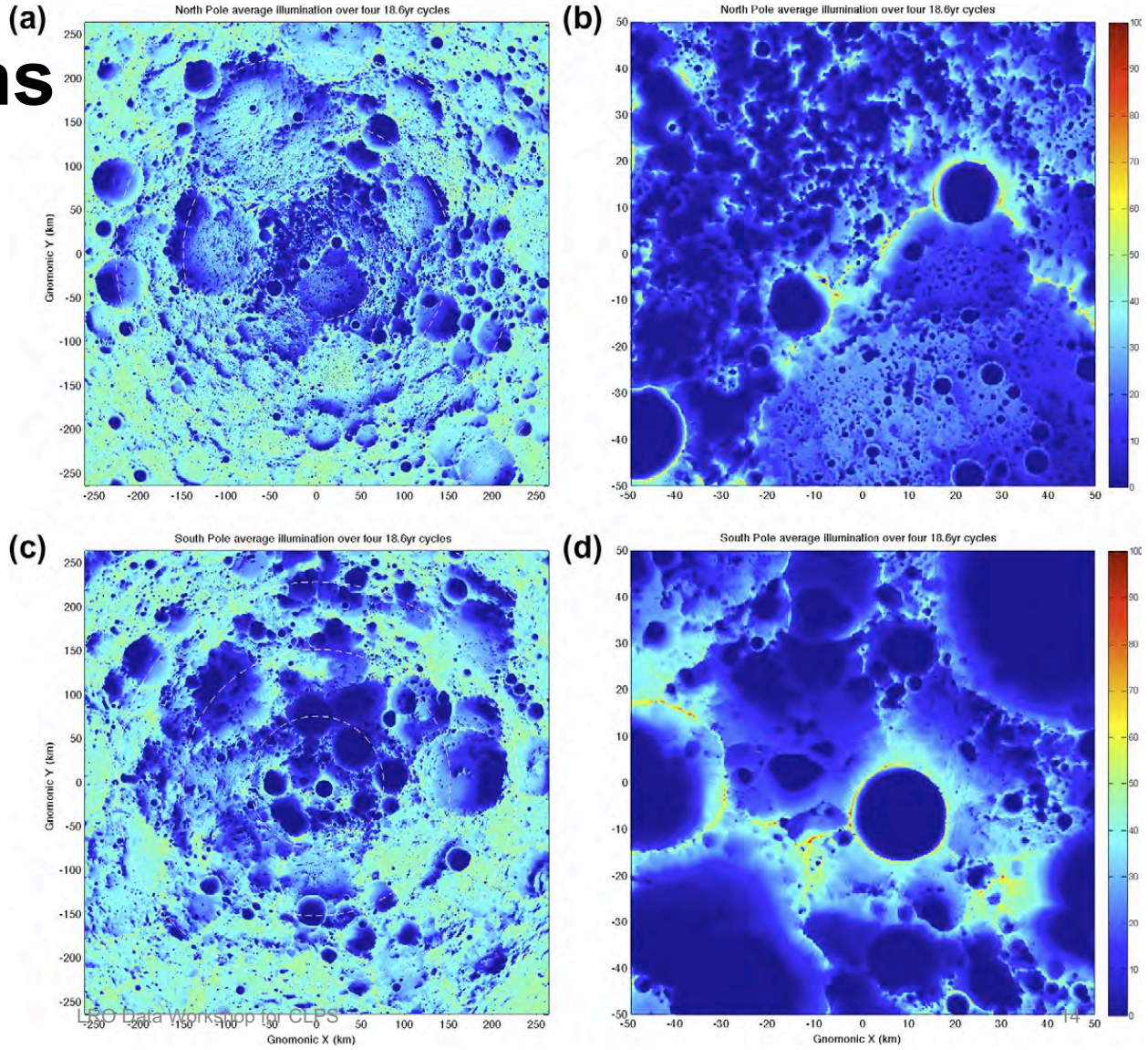
20 90 cm

H parameter

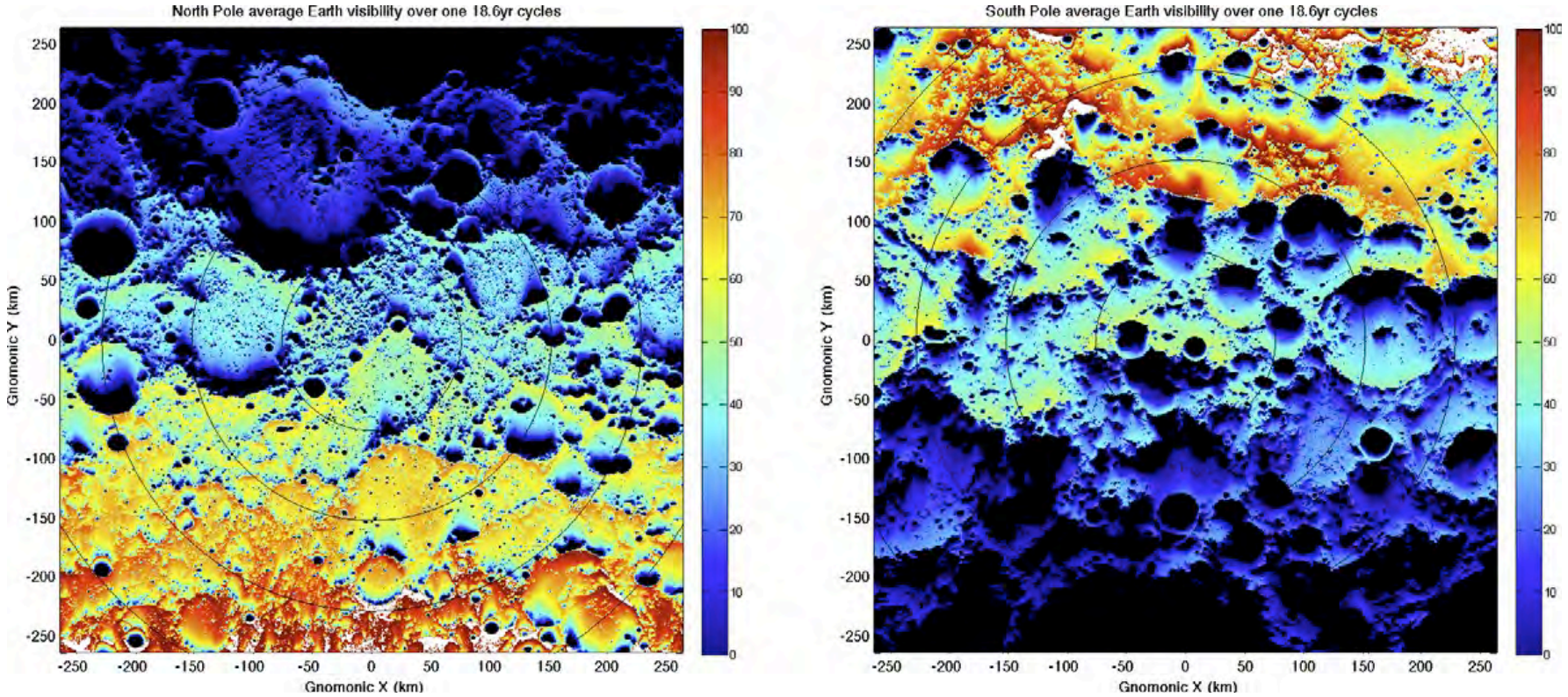
Lighting conditions

Calculated average illumination (in percent) for the north (top) and south (bottom) polar regions. Frames (a,c) extend to 80º; (b,d) extend to 88º. Model based on LOLA Topography

Areas of nearly continuous illumination can utilize photovoltaic power systems!



Earth Visibility Maps

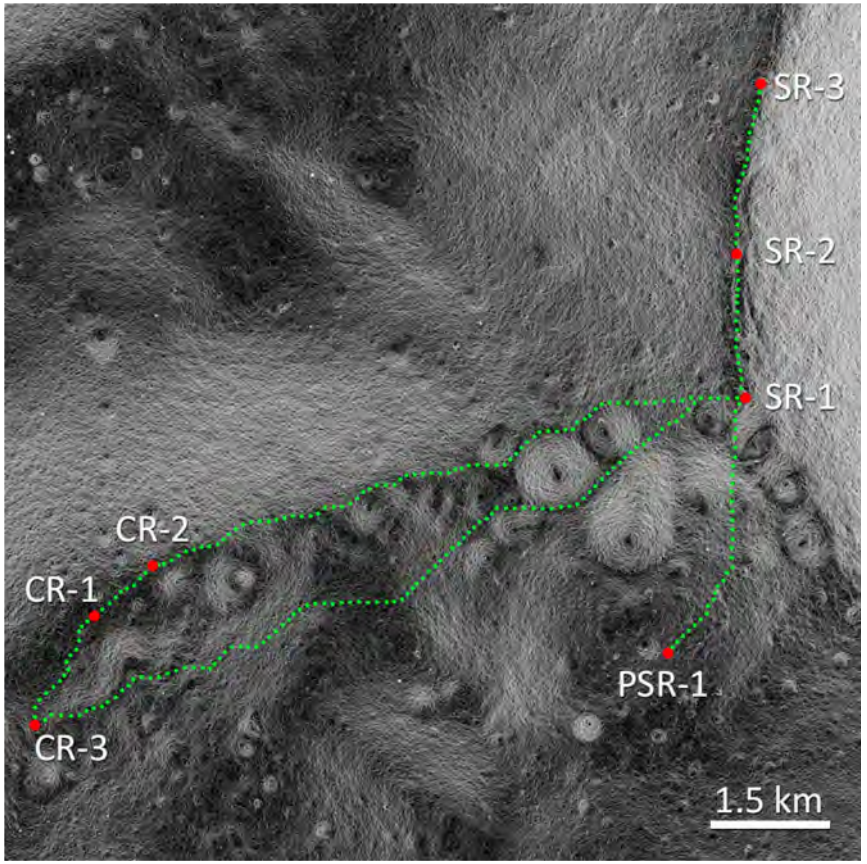


The average visibility of Earth (in percent of a full 18.6 year cycle) for the north (left) and south (right) polar regions.

Full visibility and total lack of visibility are indicated by white and black respectively.

Surface Navigation/Trafficability

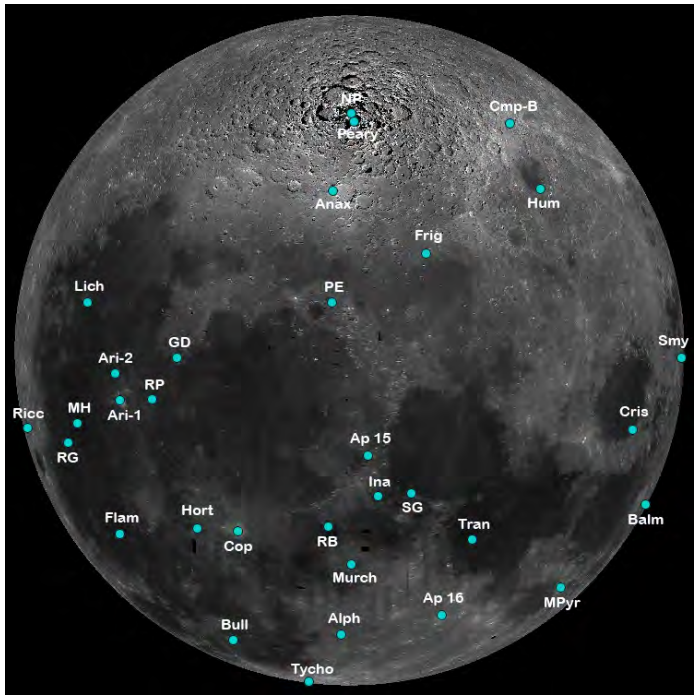
- LRO data, such as topography models from the Narrow Angle Camera and LOLA as well as temperature data derived from the Diviner, has enabled the development of a tool for use in surface traverse planning.
- Based on topography from NAC and LOLA and known surface properties, we can estimate the energy required to traverse between different targets using a terra-mechanics model.
- We also can calculate the illumination conditions along the traverse at any point in time.



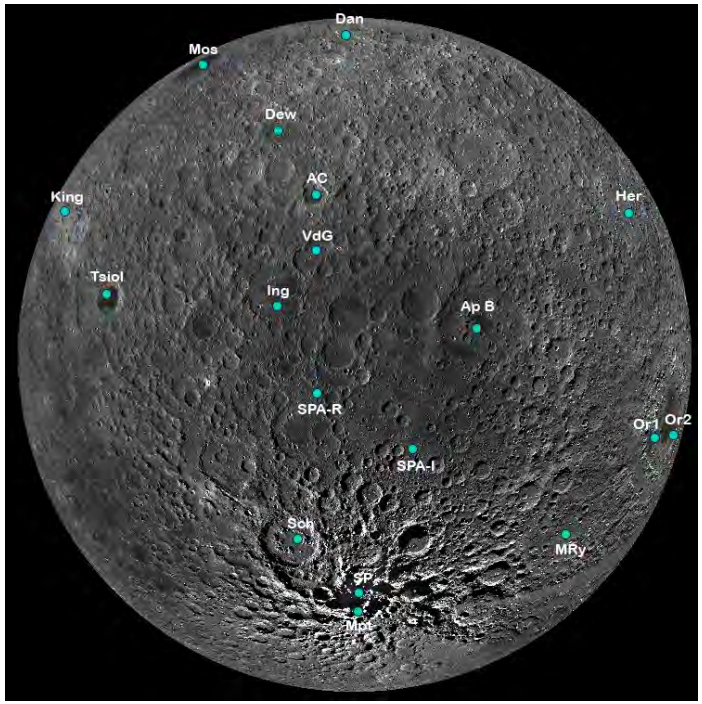
Example of an optimized traverse located along nearly persistently illuminated points on the rim of Shackleton crater (Speyerer et al., 2016).

Constellation Regions of Interest

- NASA's Constellation Program selected 50 sites for intense mapping*
- Represent broad range of terrain types and geologic features of interest for human and robotic exploration
- Cx targets included nested 10, 20, and 40 km square regions of interest (ROI).



Near Side and North Polar

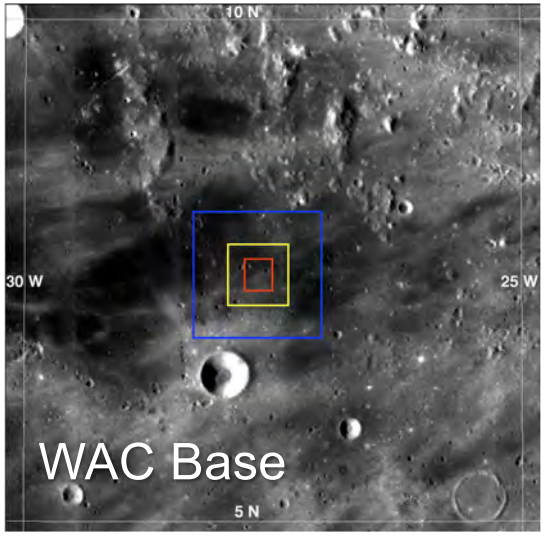


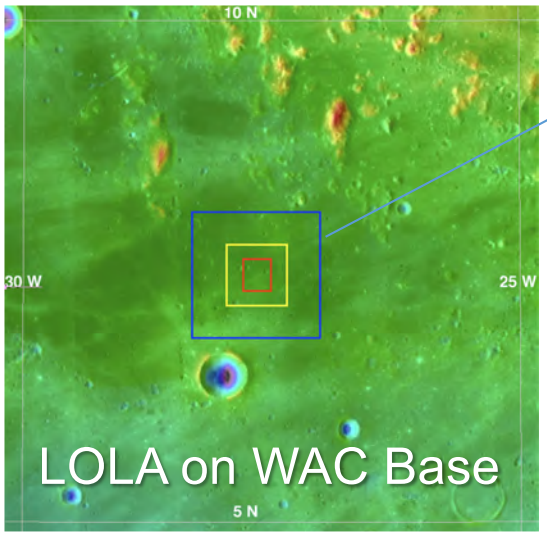
Far Side and South Polar

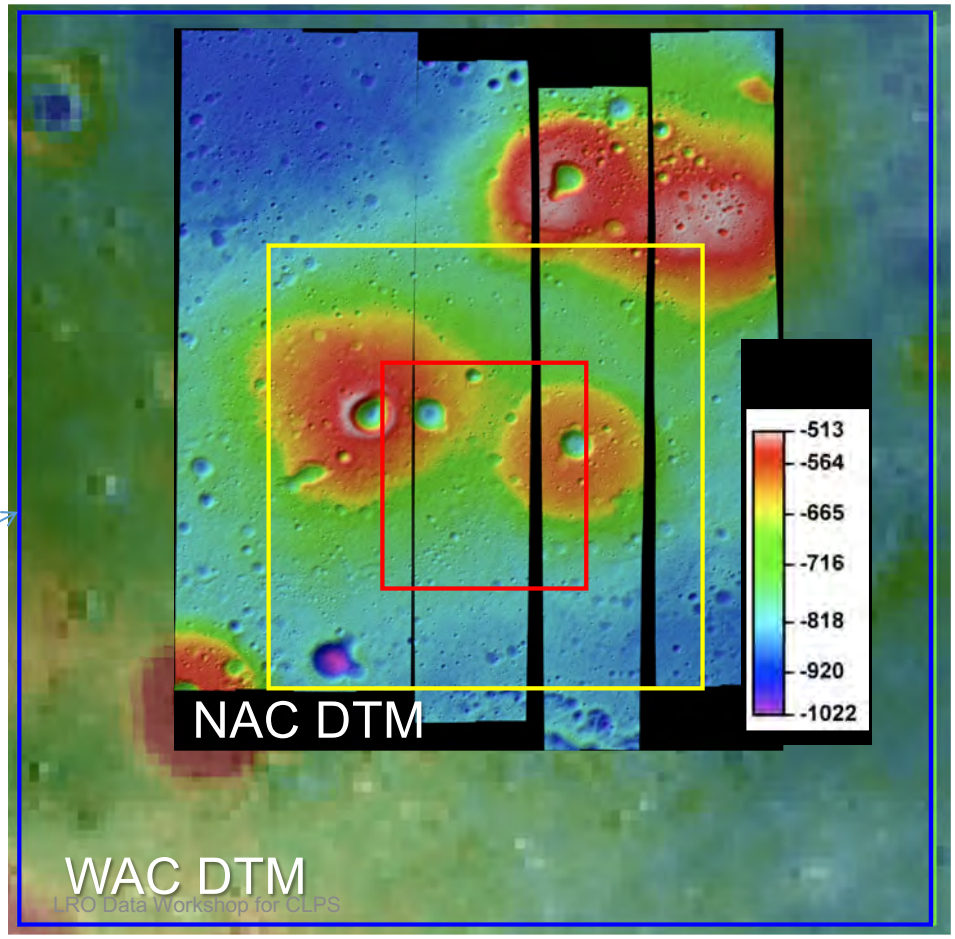
*Gruener, J. E. And B.K. Joosten, NASA Constellation Program Office Regions of Interest on the Moon: A Representative Basis for Scientific Exploration, Resource Potential, and Mission Operations, Lunar Reconnaissance Orbiter Science Targeting Meeting, Tempe, 2009.

Hortensius Domes

Low Shield Volcanoes in Mare Terrain

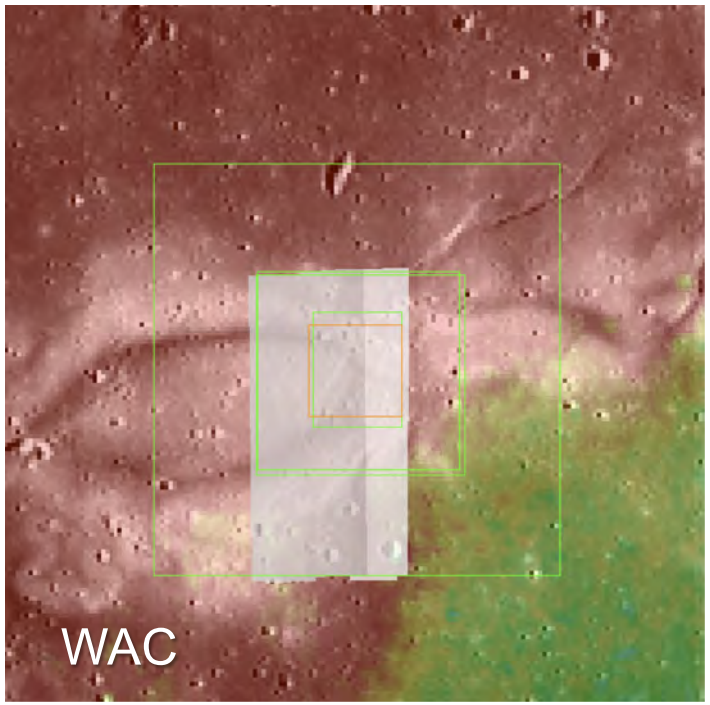


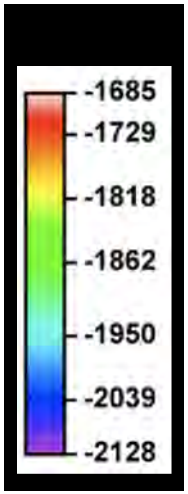


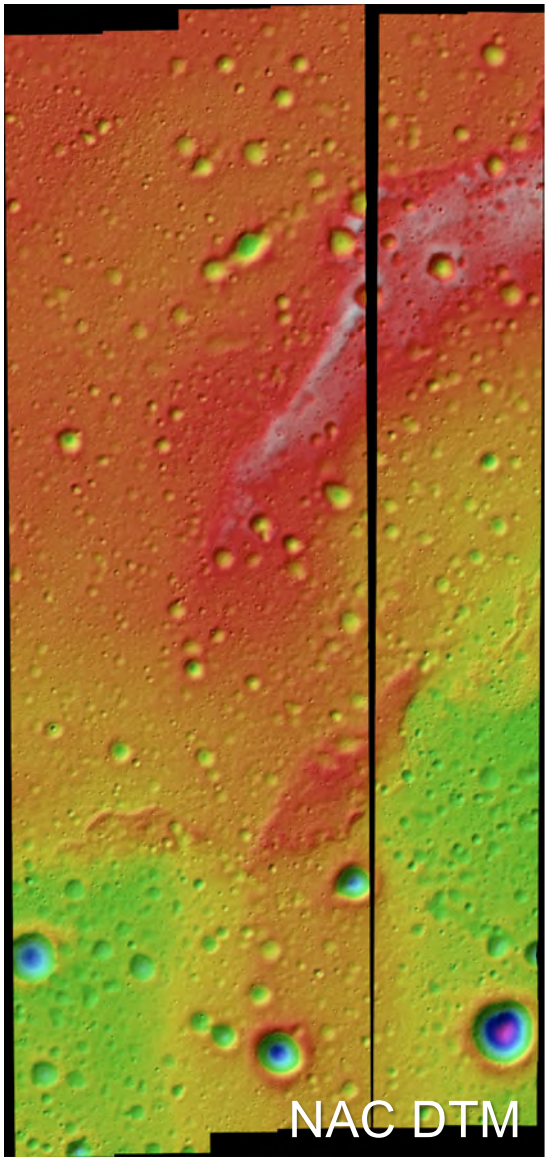


Reiner Gamma

magnetic swirl

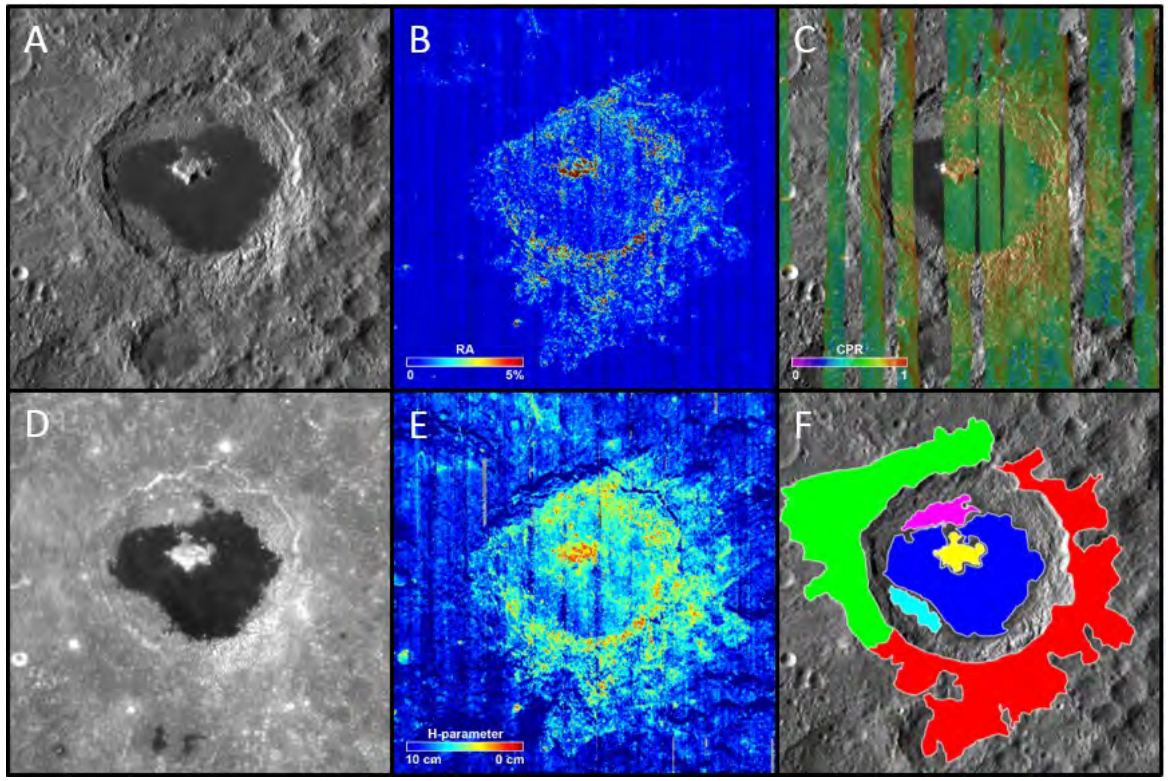






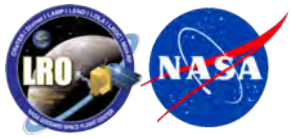
LRO Results – easy reference

- Icarus, Volume 273, Pages 1-356 (15 July 2016) and Volume 283, Pages 1-358 (February 2017)
- A collection of 50 articles featuring results from each of the seven instrument teams
- Many of the results include cross-instrument data analysis



Tsiolkovskiy crater as seen in various datasets from LRO (A) LROC WAC morphological mosaic, (B) Diviner rock abundance, (C) Mini-RF Circular Polarization Ratio, (D) LROC WAC 689 nm normalized albedo, (E) Diviner H-parameter, and (F) ROIs used in the rock abundance study.

Exploring LRO (and other lunar) data



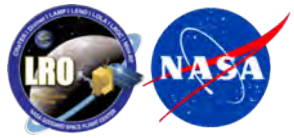
Visualization tools: ACT-REACT Quickmap and JMARS for Earth's Moon

- Free to use
- Online access using web browser – nothing to store locally
- Feature-rich
- Ability to export custom products
- Accessible for the life of the project

Planetary Data System

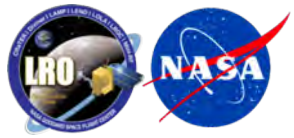
- All data ever collected in raw and processed forms
- Free and permanent
- Includes community-created content (like crater catalogs, mosaics, etc.)
- No limits to data download – but easier to use tools to look at data

How can the LRO team support you?



- POC: Barbara Cohen, Barbara.A.Cohen@nasa.gov, 301-614-6803
- Mission Planning
- Landing and Concurrent Observations
- Post-Landing Assessment

Mission Planning



Finding a landing site

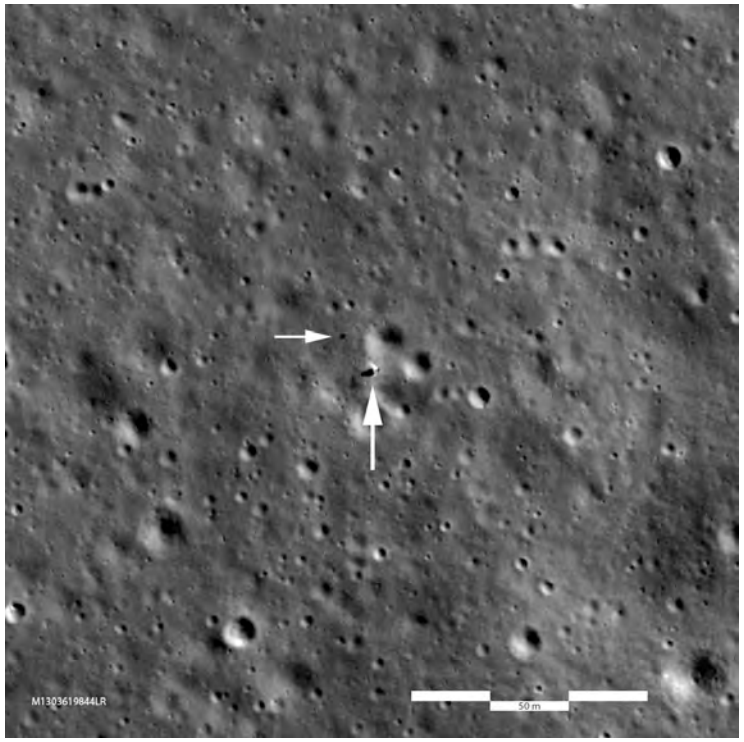
- The LRO science team are the world's experts in lunar science and data analysis – we can help you find a great site!
- Sites based on safety and/or mission objectives - water ice, pyroclastic deposits, lava pits, etc.
- Science community priority sites are in the Landing site workshop report from 2017: https://lunar-landing.arc.nasa.gov/downloads/LunarLandedScience_Publication.pdf
- NASA guidelines on historical sites: https://www.nasa.gov/pdf/617743main_NASA-USG_LUNAR_HISTORIC_SITES_RevA-508.pdf

Characterizing a landing site

- You can request new coverage of a previously-unexplored site, with any instrument (tool for LROC request in QuickMap)
- First – use the tools to check the coverage that exists!
- Remember that LRO is in a fixed orbital plane, so we can't improve imaging resolution (currently ~100 cm/px)
- Data are delivered to PDS and are publicly-accessible
- Data products (stereo, rock abundance, predictive maps, etc.) may be worked on a case-by-case basis - these take time (months) and coordination with the project and possibly HQ, depending on volume

Landing and Concurrent Observations

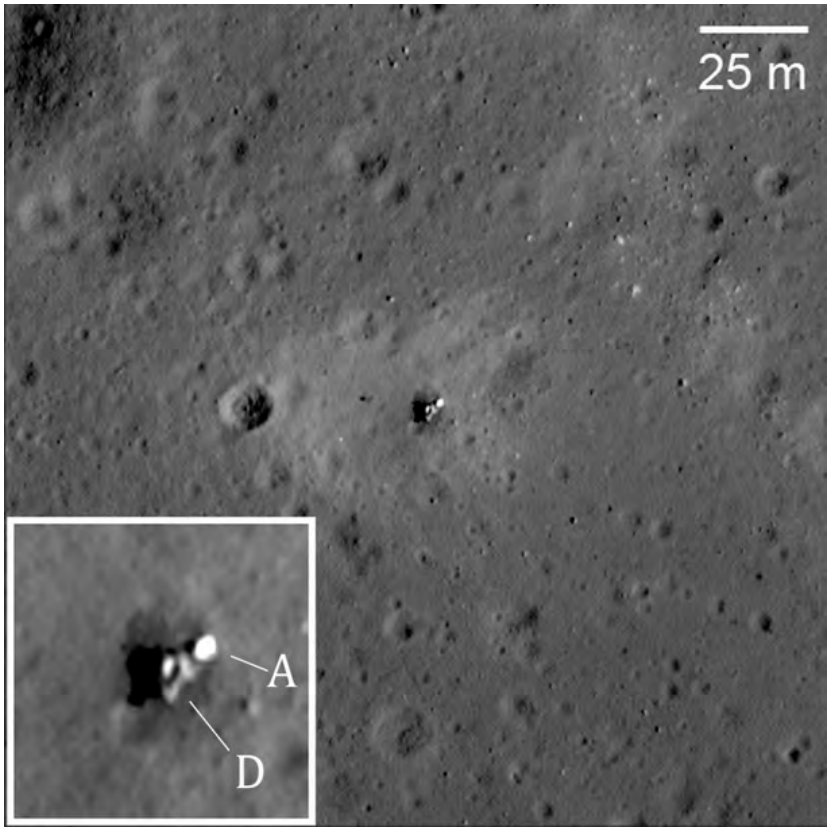
- LROC uses a pushbroom camera to build up images line by line – we can't snap a photo while you're landing like you see at Mars
- LRO's fixed orbit means that coverage of any given site is not continuous but changes day to day – it may be weeks before a site comes into view
- LRO can fairly easily observe a site before-and-after landing, but the timing depends on the site and how far in advance coordinates are provided
- LAMP and Diviner can attempt to observe the evolved gases from the landing plume and temperature changes if you pick an appropriate site and date
- Careful & constant coordination is needed – think *months* in advance, the sooner you can provide a date and landing coordinates the better!



Looking down on the Chang'e 4 landing site; lander is just beyond tip of large arrow, rover at tip of small arrow. Image is 468 meters (1535 feet) across, 2x enlargement, LROC M1303619844LR [NASA/GSFC/Arizona State University].

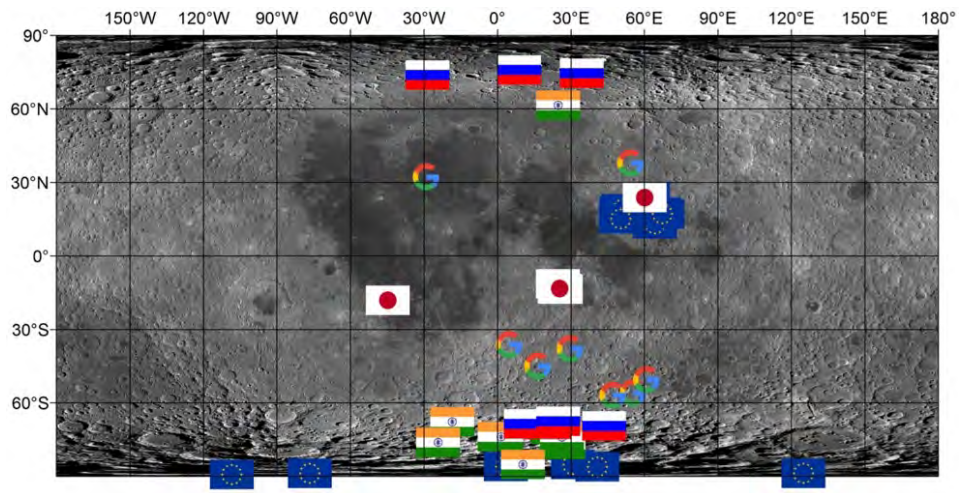
Post-Landing Assessment

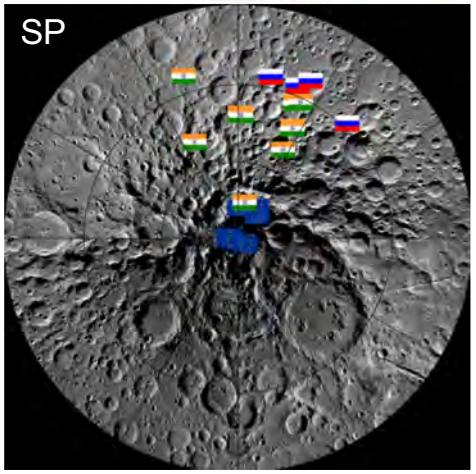
- LRO can image the landing site and precisely locate (at NAC resolution) the lander as well as track the motion of a rover
- LRO can attempt to range to the lander using the LRO laser altimeter (LOLA) assuming a NASA-provided corner cube is included on the payload
- Regolith disturbance by landing and any subsequent operations
- LRO can perform “accident investigation” if necessary (we hope not!)

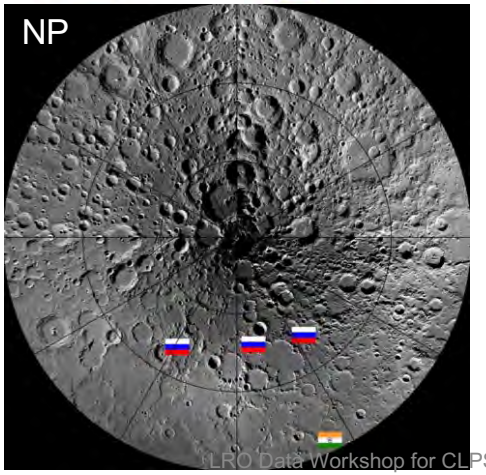


Luna 23 crash site

LRO wants to work with you!







ESA

13 sites, 194 total images
- 70 nadir
- 74 geo stereo
- 34 featured mosaic
- 2 oblique

ISRO

14 sites, 252 total images
- 150 nadir
- 52 geo stereo
- 36 featured mosaic
- 12 oblique

JAXA

5 sites, 110 total images
- 42 nadir
- 36 geo stereo
- 26 featured mosaic
- 4 oblique

ROSCOSMOS

7 sites, 114 total images
- 64 nadir
- 18 geo stereo
- 20 featured mosaic
- 10 oblique

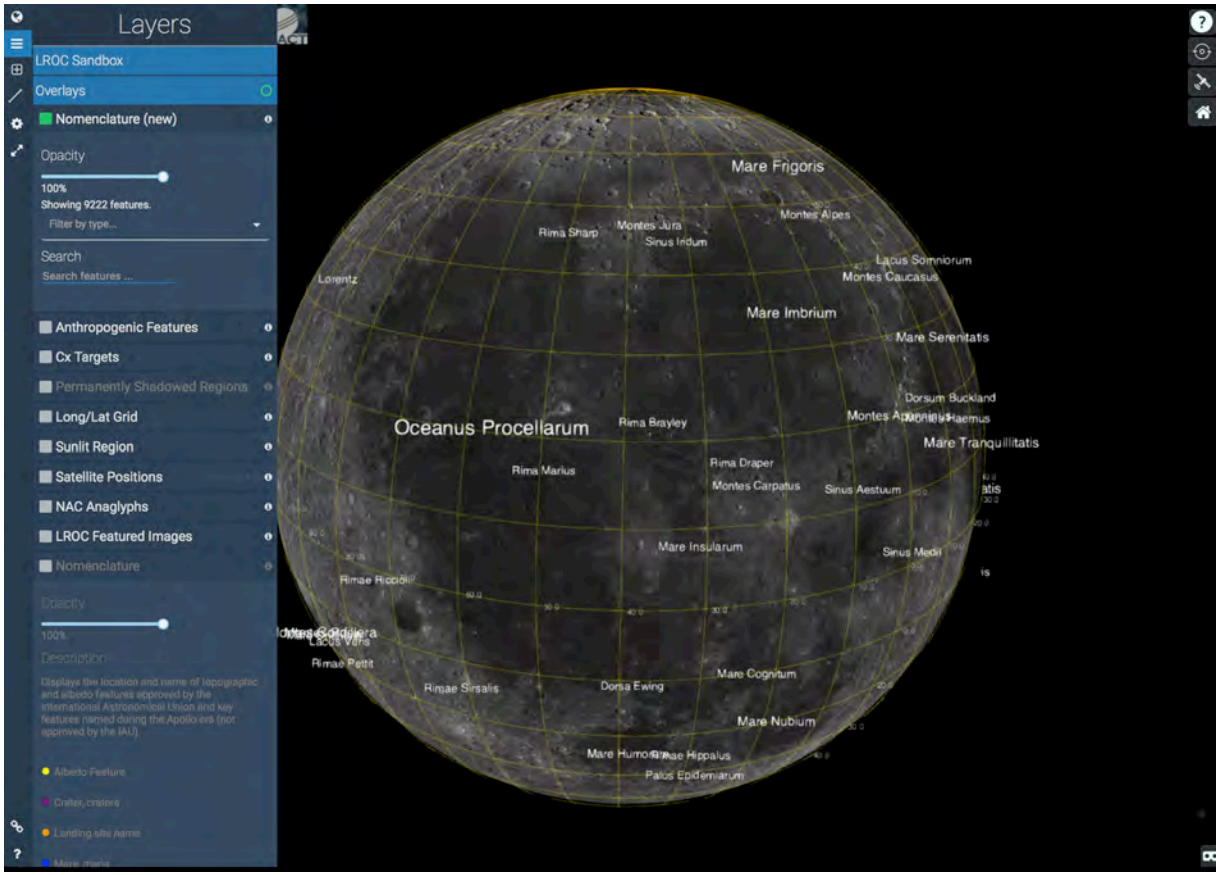
X-PRIZE

8 sites, 102 total images
- 22 nadir
- 60 geo stereo
- 20 featured mosaic

JMARS for the Earth's Moon Interactive tool

To download JMARS, go to this website: http://jmars.asu.edu/

Lunar QuickMap Demo



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www.actgate.com malaret@actgate.com

Lunar QuickMap : Overview

- QuickMap provides an easy-to-use yet powerful web interface for many Lunar products.
  - works on desktops and mobile devices
- It was designed with the end-user in mind.
- QuickMap offers rapid access to data without the tedium of handling file format details and data ingestion and archive structures.
- **Access from** ➔ ASU LROC webpage

Lunar QuickMap : Overview

- In general it provides easy access to:
  - **Global** and **regional** mosaics
  - Digital Elevation Models (**DEM**)
  - Instrument coverage views
  - Location overlays, e.g. latitude and longitude grid, recent feature images, sites of interest, ...
  - Special products, e.g. master target lists …
  - Satellite position (based on JPL/NAIF/SPICE kernels)
  - Ability to validate products and fuse data both within a mission and across servers.
  - Ability to generate products on the fly ➔ **Boolean Layers**
  - Ability to export cartographic views for other applications
  - Export **active views as short URL** ➔ good for collaboration

QuickMap Search Tools

QuickMap Search Tools can be configured to access/analyze many types of lunar data and products

Present list of search tools:

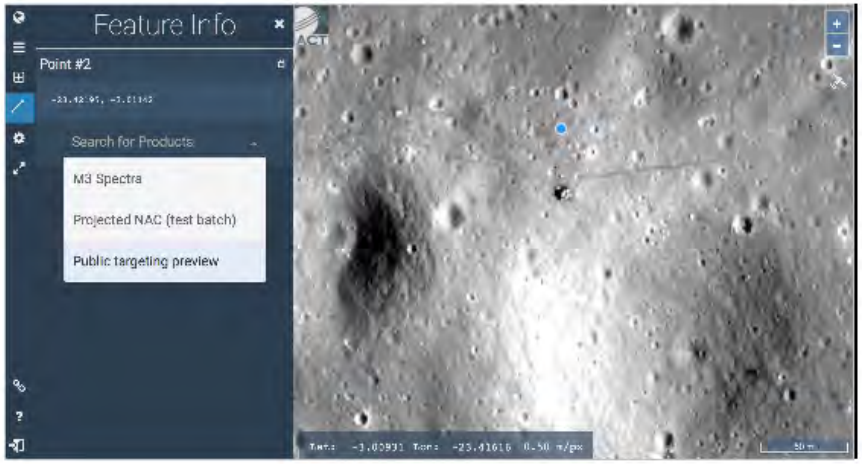
Summary of Actions for different Drawn Objects ⇒ 17 search/action types!		
Point items	***Line segment items***	***Close Polygon items***
1. *M3 Spectra (at PDS)* 2. *Projected NAC* 3. *LROC Public Targeting*	1. *DEM Profiling* 2. *M3 L2 Cal Steps*	1. *3D printing (of ROI)* 2. *ALL LROC products* 3. *Hiesinger Mare Age Units* 4. *M3 (list over ROI)* 5. *M3 observations (generate links to summary info)* 6. *NAC* 7. *NAC (unfiltered)* 8. *NAC DTMs* 9. *NAC Feature Mosaics* 10. *NAC Regional Mosaics* 11. *NAC Stereo* 12. *WAC*

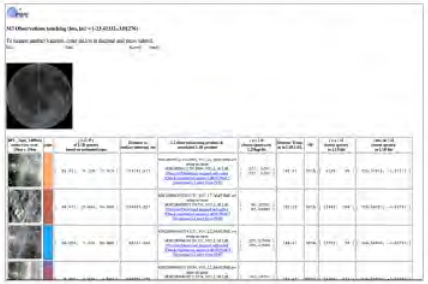
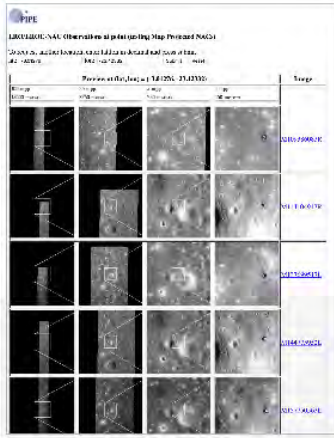
Note: More actions can be added based on community feedback.

Examples of QuickMap Search Tools

Point Based Search Tools

Points allow to search for products, using 3 different actions , as shown below:

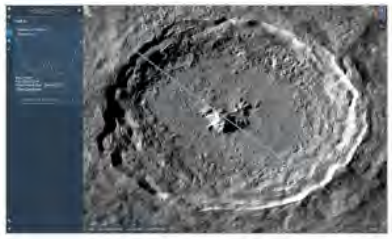


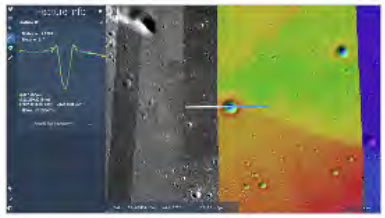
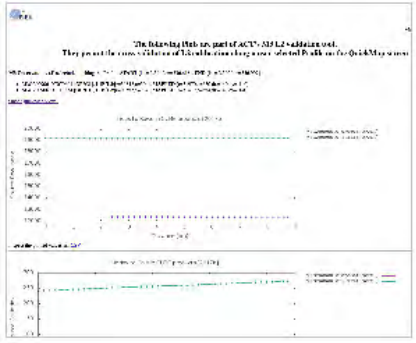
Point Query Option	Sample Output Screen
M3 Spectra *List of M3 images with regional previews radiance and apparent reflectance plots of chosen location.* *User can download a hyperspectral subcube* *(stand alone external resource)*	
Projected NAC (test batch) *Zoom-out to Zoom-in context views of available NAC images at the chosen location* *100m==> 25m==> 5m==> 1m* *(stand alone external resource)*	
Public targeting preview *LROC target submission interface for the general public* *(stand alone external resource)*	

Examples of QuickMap Search Tools

Line Based Search Tools

Line based search tools allow to inspect line profiles using 2 different actions, i.e. DEMs and also access M3 calibration plots

DEM Profiling 	example: This link shows profiles of the different DEMs now in QuickMap. To see it, go to the draw/seach tool, and select Feature#1. Also note that in the layers tree, the SLDEM2015 is displayed using the same palette as GLD100. Zoomed-in on NAC DTM

	 If there is high resolution NAC based DTM it will be used!
M3 L2 Calibration Steps *This tool provides detail information on all parameters used in the calibration of hyperspectral data for M3.*	

Examples of QuickMap Search Tools

Closed Polygon Based Search Tools

Closed Polygons *allow to do search/act over an area of interest (AOI). Presently it allows for* ***12 different actions****!*

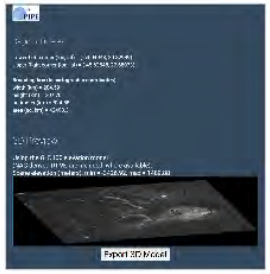
The different actions are :

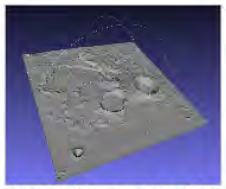
3D printing (of ROI)
ALL LROC products
Hiesinger Mare Age Units
M3 (list over ROI)
M3 observations (generate links to summary info)
NAC
NAC (unfiltered)
NAC DTMs
NAC Feature Mosaics
NAC Regional Mosaics
NAC Stereo
WAC

Examples of QuickMap Search Tools

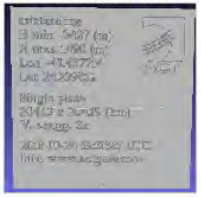
3D printing (of ROI)

Create a custom 3D model export (for 3D printing) and interactive visualization





Note: detail info on back of 3D model



ALL LROC products

List of NAC/WAC/Featured Images within ROI

*The listing is **limited to 50 records,** contains key metadata and link to detailed page from ASU*

LROC NAC images within ROI
(9 records):

```
image_id,orbit_no,start_time,i_angle,e_angle
[redacted], 569, 2009-08-10 19:08:43, 62.133, 1.707
[redacted], 569, 2009-08-10 19:08:43, 62.215, 1.140
[redacted], 3500, 2010-03-30 23:59:14, 44.234, 1.692
[redacted], 10278, 2011-09-14 06:29:13, 42.013, 1.691
[redacted], 10278, 2011-09-14 06:29:13, 42.032, 1.153
[redacted], 11820, 2012-01-14 23:19:45, 72.721, 1.148
[redacted], 18930, 2013-08-23 14:41:27, 43.797, 1.703
[redacted], 26046, 2015-04-01 08:14:08, 57.710, 1.707
[redacted], 36253, 2017-07-10 09:54:09, 42.374, 1.702
```

LROC WAC images within ROI
(limited to 50 records):

```
image_id,orbit_no,start_time,i_angle,e_angle
[redacted], 1935, 2009-11-28 01:20:30, 63.855, 1.141
[redacted], 2803, 2010-02-04 06:03:47, 65.125, 1.140
[redacted], 2804, 2010-02-04 07:57:02, 64.907, 1.142
[redacted], 2805, 2010-02-04 09:49:52, 65.312, 1.138
[redacted], 2807, 2010-02-04 13:36:24, 64.952, 5.333
[redacted], 2808, 2010-02-04 15:29:14, 65.719, 20.357
[redacted], 3151, 2010-03-03 14:02:08, 49.515, 1.140
[redacted], 3152, 2010-03-03 15:55:25, 49.088, 1.145
[redacted], 3153, 2010-03-03 17:48:14, 49.865, 1.146
[redacted], 3846, 2010-04-27 04:18:41, 50.245, 1.141
```

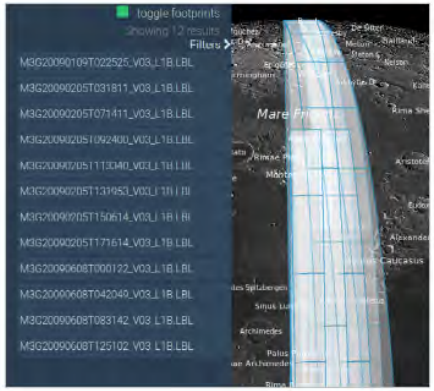
Hiesinger Mare Age Units

Mare Age (from crater counting)

M3 ⇒ *Moon Mineralogy Mapper Observations*

Interactive footprints and metadata for M3 observations within ROI

Note: each footprints is made out of multiple polygons .



M3 observations

Generates a list M3 observations within the AOI selected. The resulting list contains:

- *image ID*
- *OP*
- *links to metadata*

M3 Observations within ROI
(12 records):

filename	OP sub group
[redacted]	OP1A
[redacted]	OP1B
[redacted]	OP1B
[redacted]	OP1B
[redacted]	OP1B
[redacted]	OP1B
[redacted]	OP1B
[redacted]	OP1B
[redacted]	OP2C1
[redacted]	OP2C1
[redacted]	OP2C1
[redacted]	OP2C1

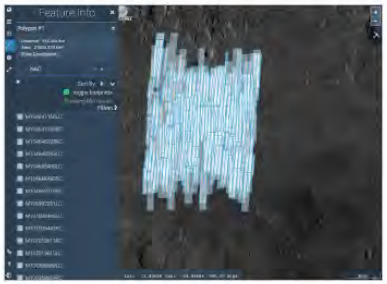
Examples of QuickMap Search Tools

NAC

Interactive *list of NAC images in ROI.*
Note: EXCLUDES dark or bad quality images.

Special Features:

- *for many images if there is data available it is possible to display the content of the NAC on-the-fly, not just the footprint, just by clicking on the image ID*
- *Another feature is that it is possible to change the stretching on-the-fly using the intensity slidebar*
- ***Allows interactive filtering***

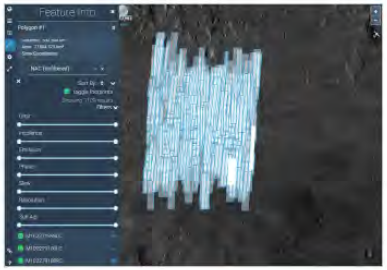


NAC (unfiltered)

Interactive *list of NAC images unfiltered*
Note: INCLUDES dark or bad quality images.

Same as above but shows ALL available footprints, ***without any prefiltering for dark or bad quality images***

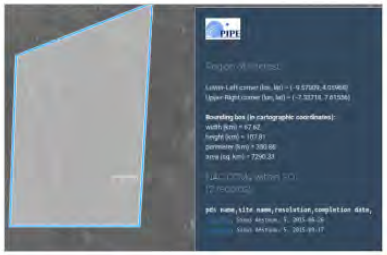
TBD: merge unfiltered and filtered into same source shapefile with a new attribute



NAC DTMs

List of NAC DTMs within ROI

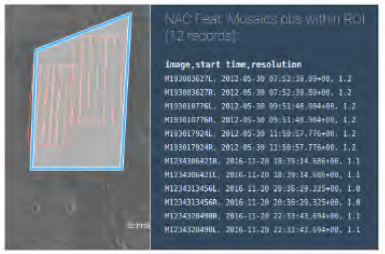
The listing is limited to 50 records, contains key metadata and link to detailed page from ASU



NAC Featured Mosaics

List of NAC images selected as part of a featured mosaic

The listing is limited to 50 records, contains key metadata

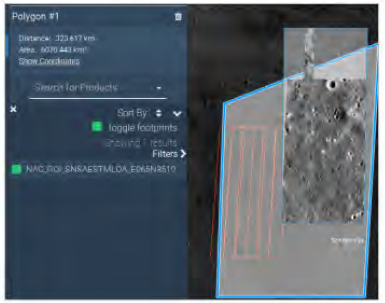


NAC Regional Mosaics

Interactive *list of NAC Regional Mosaics within ROI.*

NOTE: for many items if there is data available it is possible to display the content of the ***Mosaic on-the-fly,*** *not just the footprint, just by clicking on the mosaic ID*

Another feature is that it is possible to change the ***stretching on-the-fly*** *using the intensity slidebar*



NAC Stereo

List of NAC images selected as part of a stereo pair

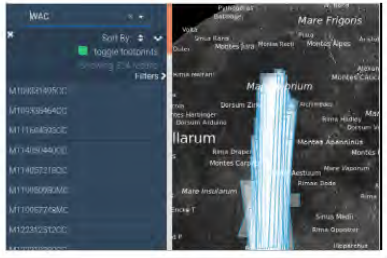
The listing is limited to 50 records, contains key metadata

WAC

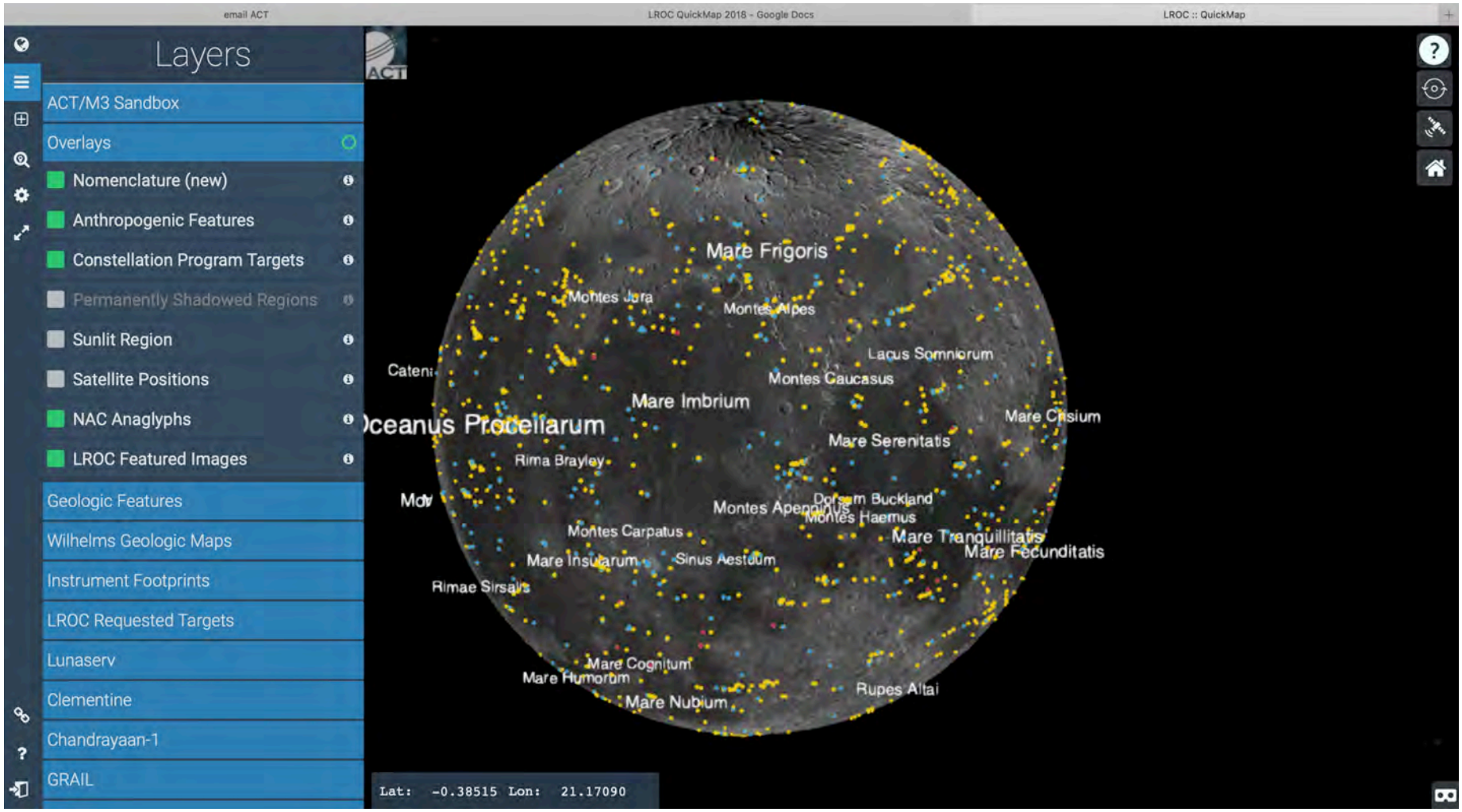
Interactive list of WAC images within ROI.

Special Features:

- *User can sort using different criteria.*



EXAMPLE SESSION… or live demo if possible ➔ http://bit.ly/2H56VGR



Concluding Remarks..

ACT is committed to continue expanding the capabilities of Lunar QuickMap with

- Additional relevant data sources
- Additional analytical resources
- New virtual layers

Your feedback is highly welcome.

➔ It can be provided directly from QuickMap.

NASA's Planetary Data System

Planetary Data System (PDS):

- Established by NASA in 1989
- A solution to concerns that the data being returned by scientific satellites was in danger of being lost

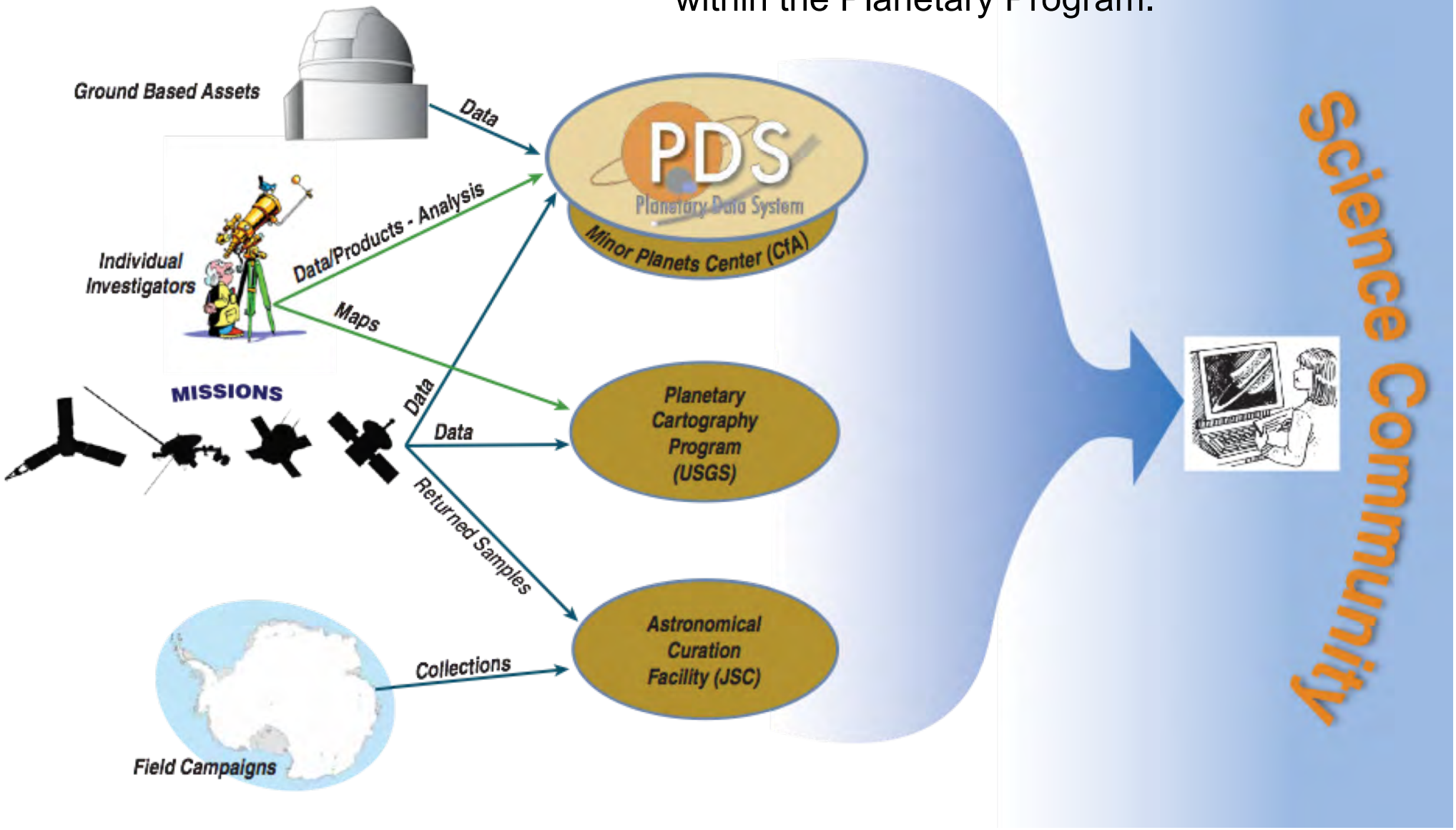
Purpose: Collect, archive and make accessible for *current and future* use the digital data and documentation produced from NASA's exploration of the solar system from the 1960s to the present.

- PDS works with every NASA planetary mission with the goal of obtaining a complete archive of data from that mission.
- All PDS-curated products are peer reviewed, well documented, and ***available online to scientists and to the public without charge***.
- Online search capabilities are provided.
- The PDS is an actively accumulating data archive.

The PDS is the archive for NASA's planetary missions, but it is only one of 16 formal NASA Archives, plus 22 Guest Observer Facilities and Science Centers, supporting all of the science missions within the Science Mission Directorate within NASA.

Overview - What is the Planetary Data Environment Like?

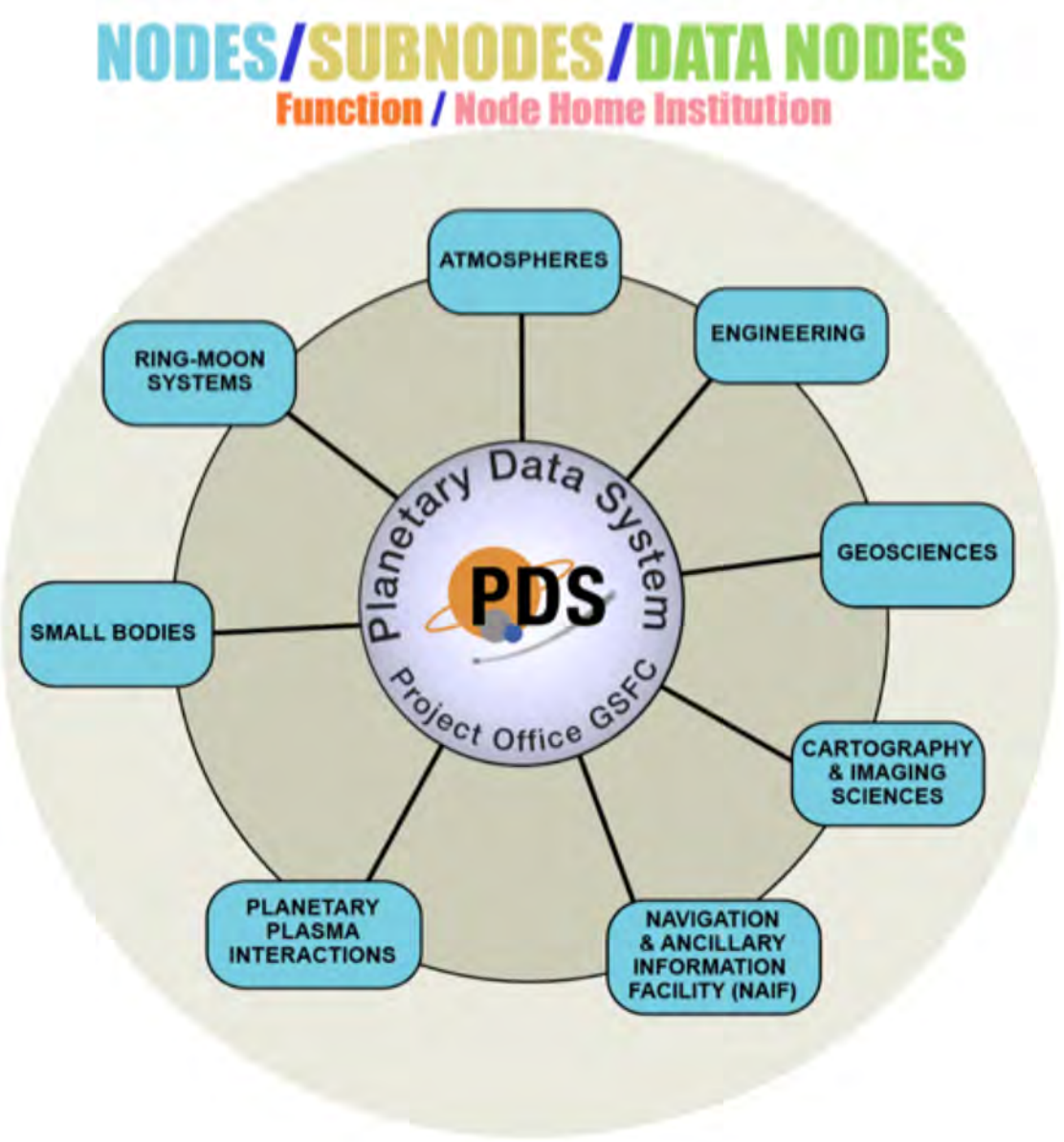
The PDS is one of three complementary archival elements within the Planetary Program.



Overview - PDS Structure Detailed

Following the National Academy's recommen-dations, the PDS uses:

I. **Discipline oriented nodes**,
II. **Two support nodes**
III. **Small project office at GSFC** to manage funds, and to coordinate activities



Overview - PDS Structure Detailed

Following the National Academy's recommen-dations, the PDS uses:

I. **Discipline oriented nodes**,
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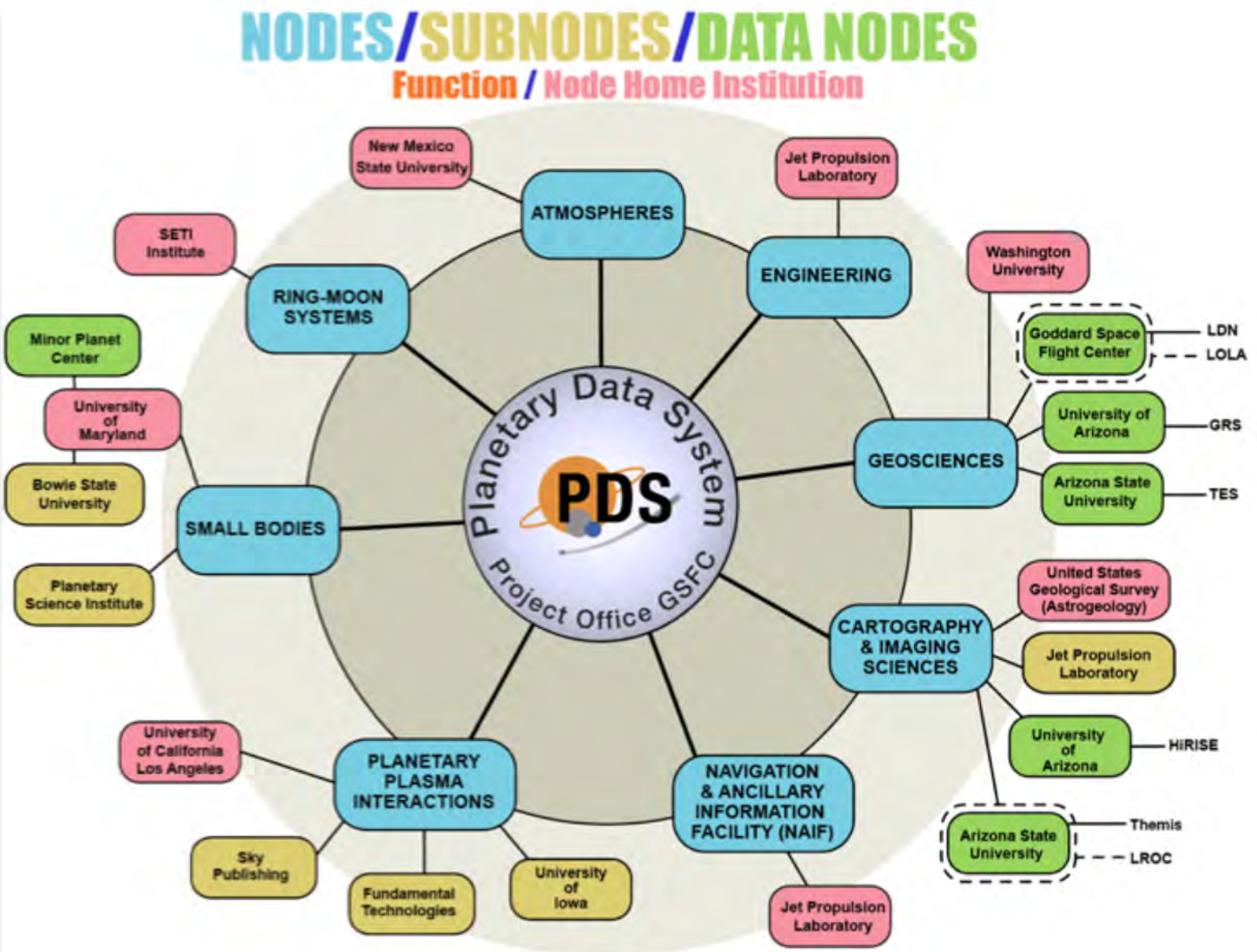
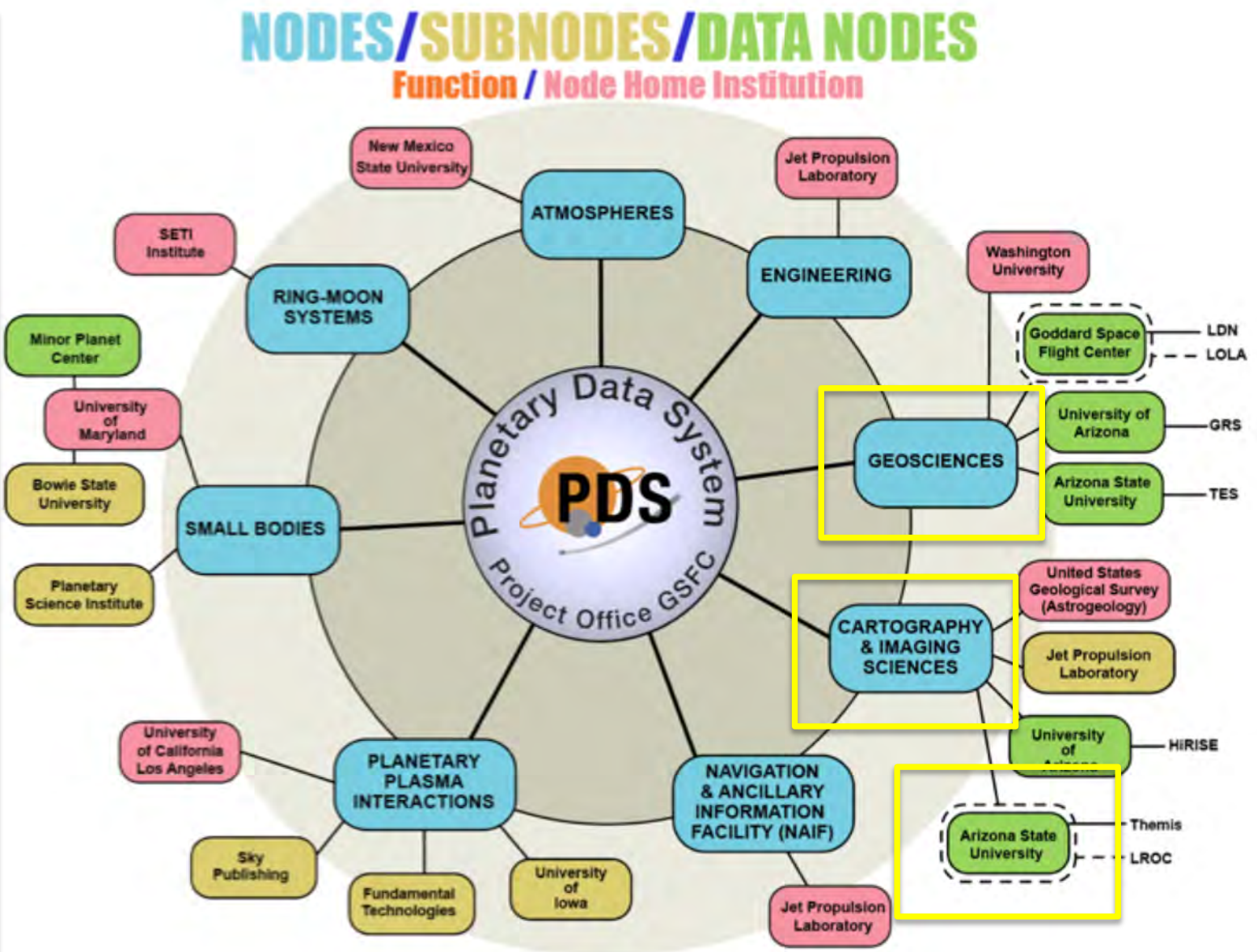


Overview - PDS Structure Detailed

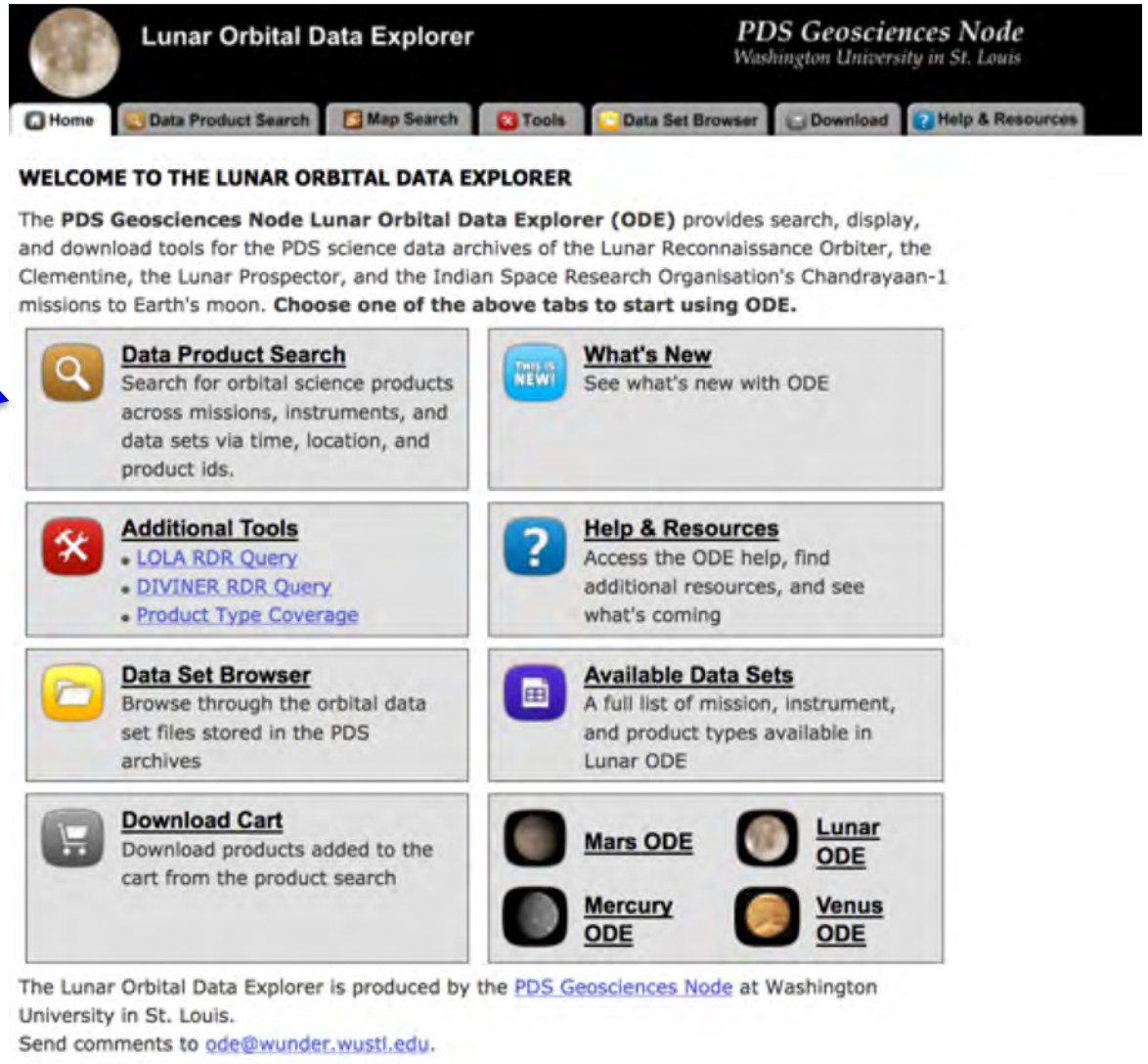
Following the National Academy's recommen-dations, the PDS uses:

I. **Discipline oriented nodes**,
II. **Two support nodes**
III. **Small project office at GSFC** to manage funds, and to coordinate activities



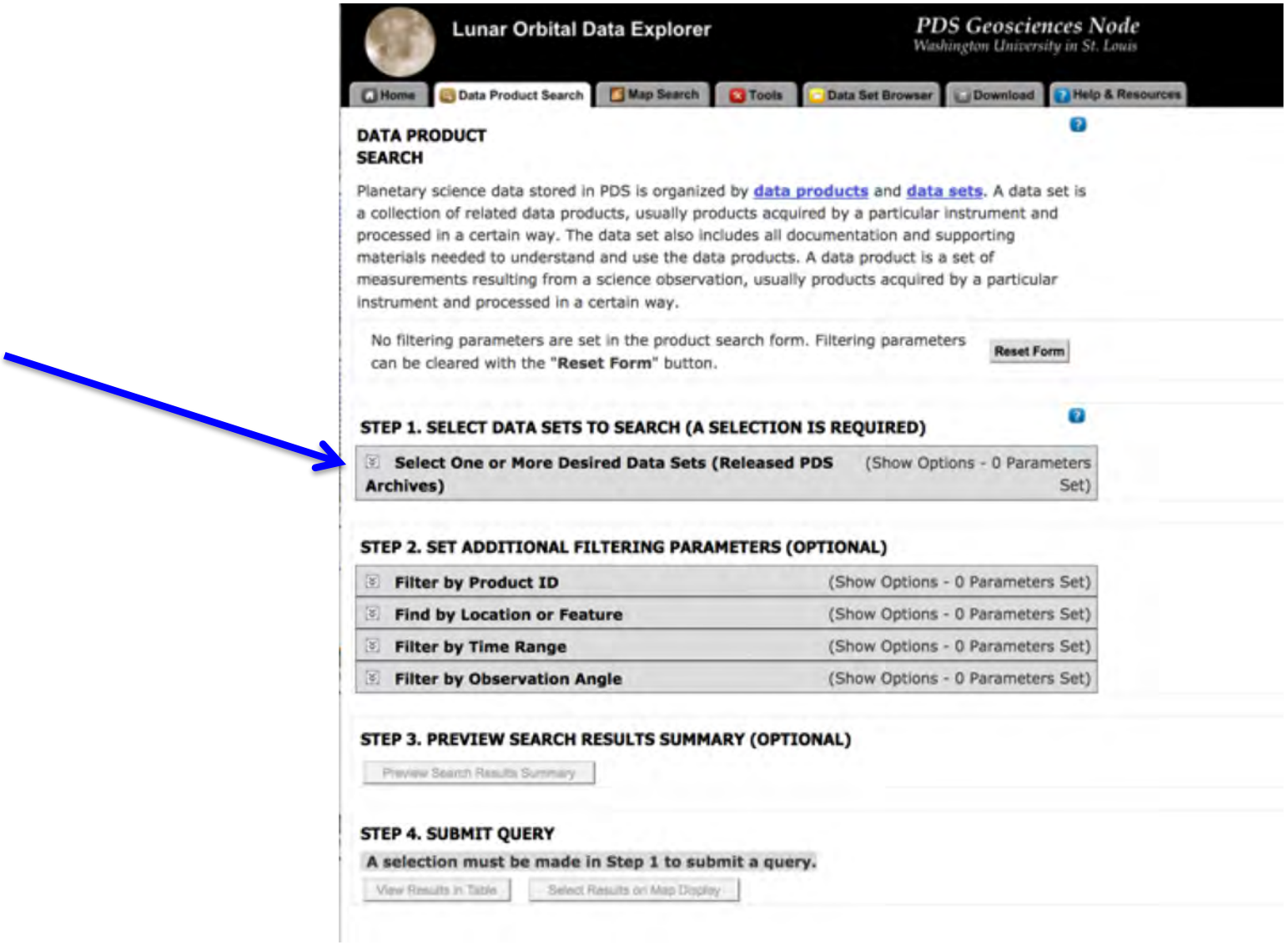
Geosciences node

https://ode.rsl.wustl.edu/moon/index.aspx

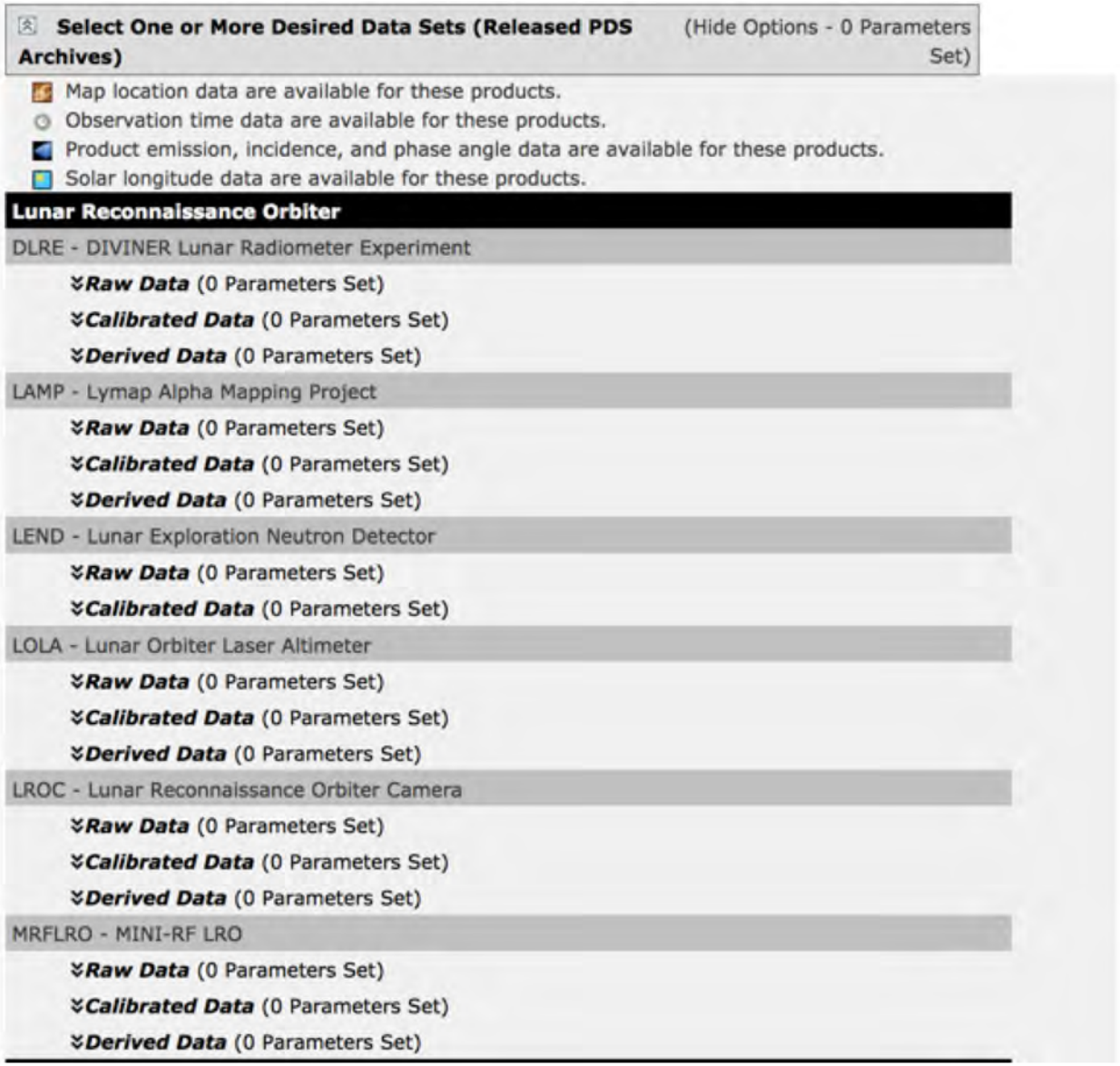


Geosciences node: Data Product Search

https://ode.rsl.wustl.edu/moon/indexproductsearch.aspx



Geosciences node: Data Product Search

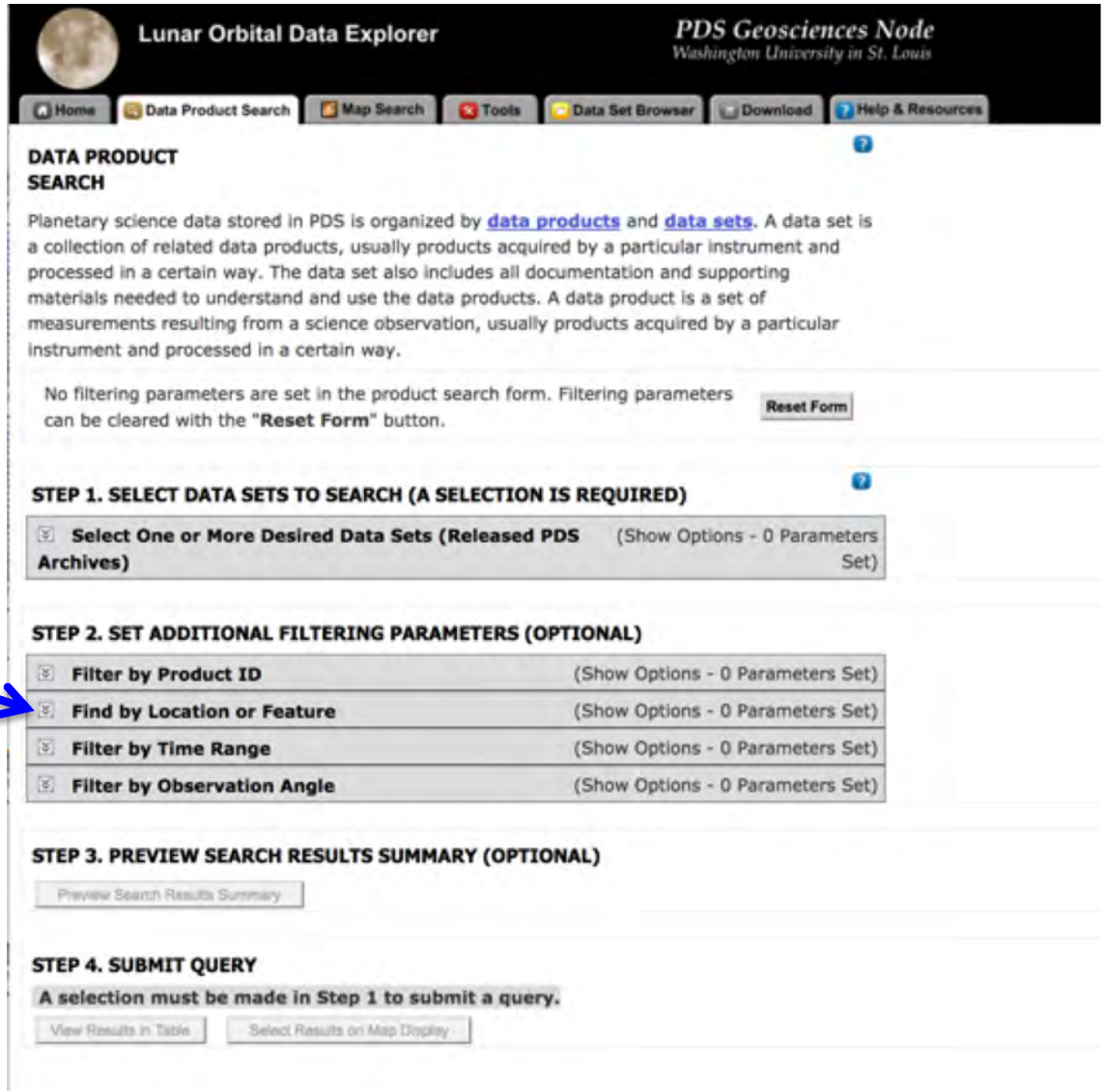


Also:

- ISRO's Chandrayaan-1
- GRAIL
- Clementine
- Lunar Prospector
- Lunar Orbiter
- Arecibo Observatory

Geosciences node: Data Product Search

https://ode.rsl.wustl.edu/moon/indexproductsearch.aspx



Geosciences node: Data Product Search

STEP 2. SET ADDITIONAL FILTERING PARAMETERS (OPTIONAL)

Filter by Product ID (Show Options - 0 Parameters Set)

Find by Location or Feature (Hide Options - 0 Parameters Set)

Select a Specific Feature

A selected feature's Latitude and Longtude bounding box will be used for search criteria.

Feature Type: -Select Feature Type- Feature Type Descriptions

Clear Feature Selection

Feature Name: -Select Feature Name- Full Feature Name List

or

Directly specify a Latitude and Longitude coverage area

Lunar ODE uses planetocentric coordinates that are based on the product's center latitude and longitude.

Max Latitude (-90 to 90)

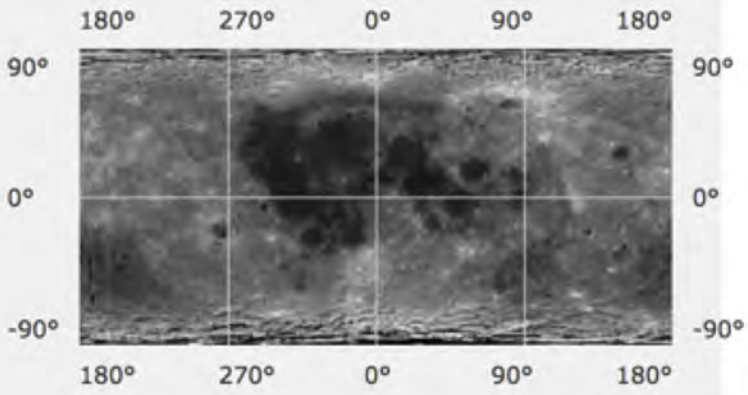
Western most Longitude (0 to 360)

Eastern most Longitude (0 to 360)

Min Latitude (-90 to 90)

Show Area On Map

Selected Search Area

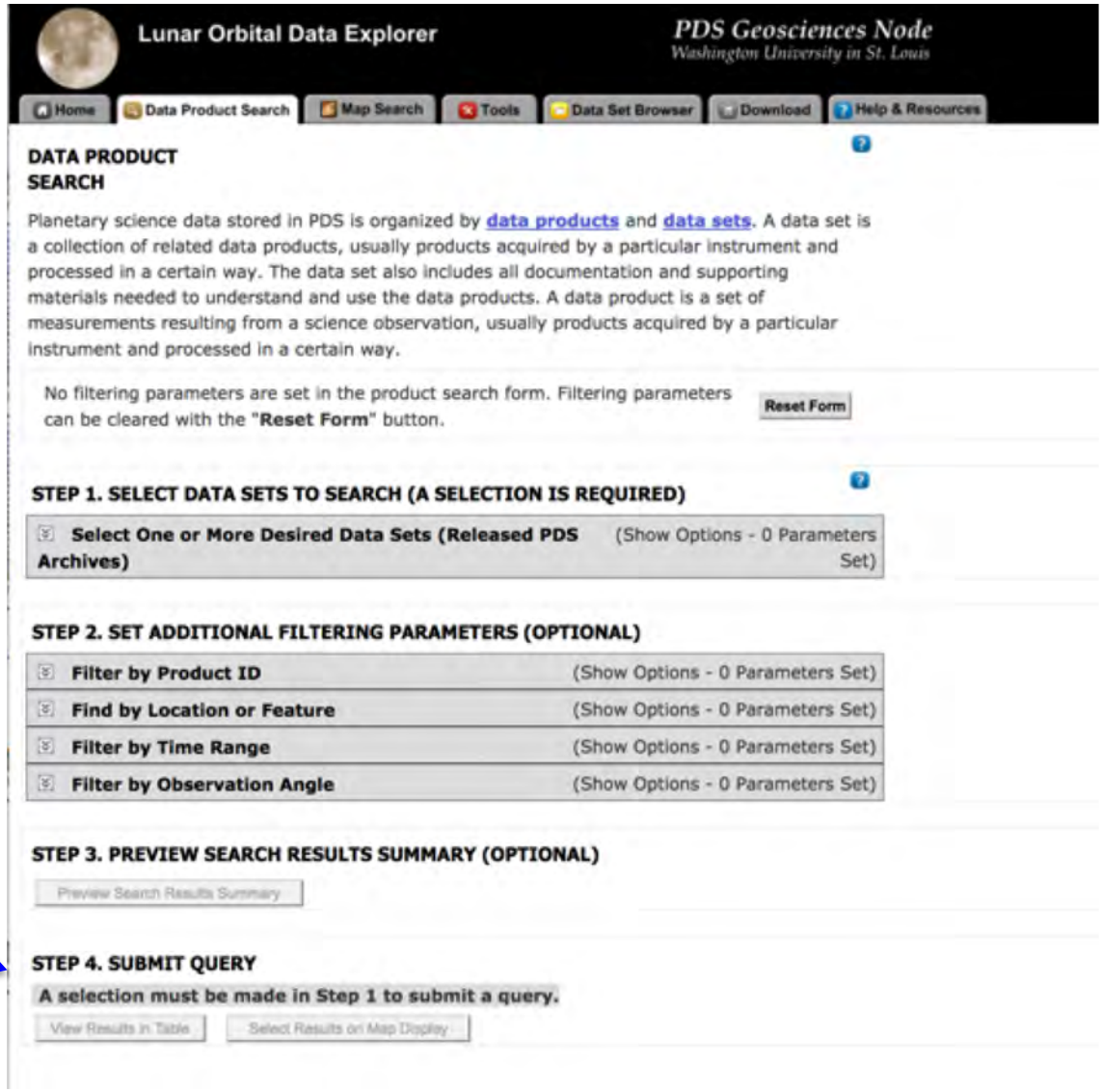


Filter by Time Range (Show Options - 0 Parameters Set)

Filter by Observation Angle (Show Options - 0 Parameters Set)

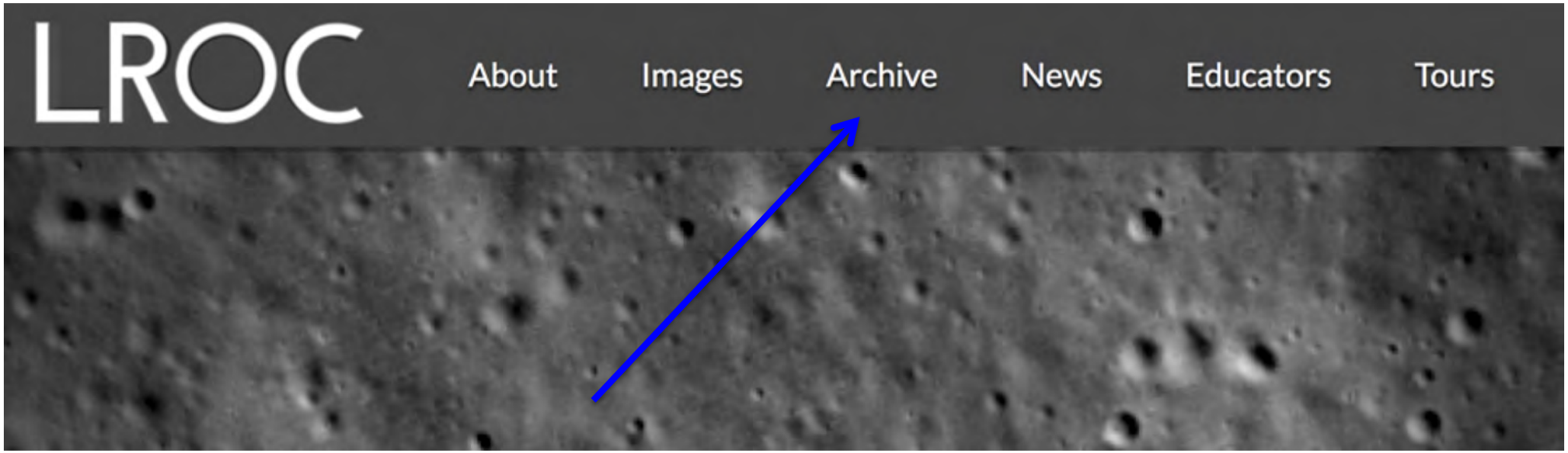
Geosciences node: Data Product Search

https://ode.rsl.wustl.edu/moon/indexproductsearch.aspx

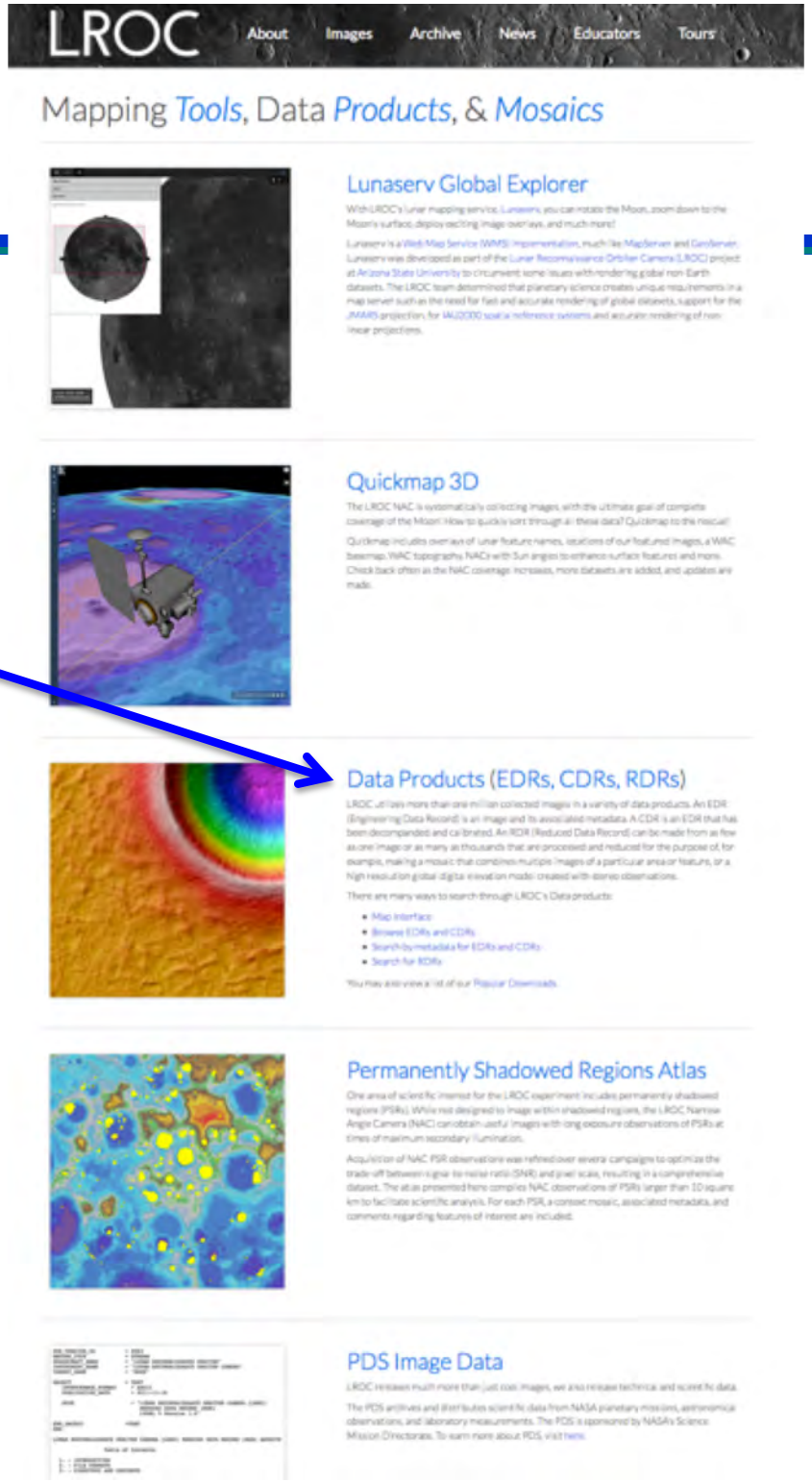


Arizona State University Data node: LROC data

https://www.lroc.asu.edu/



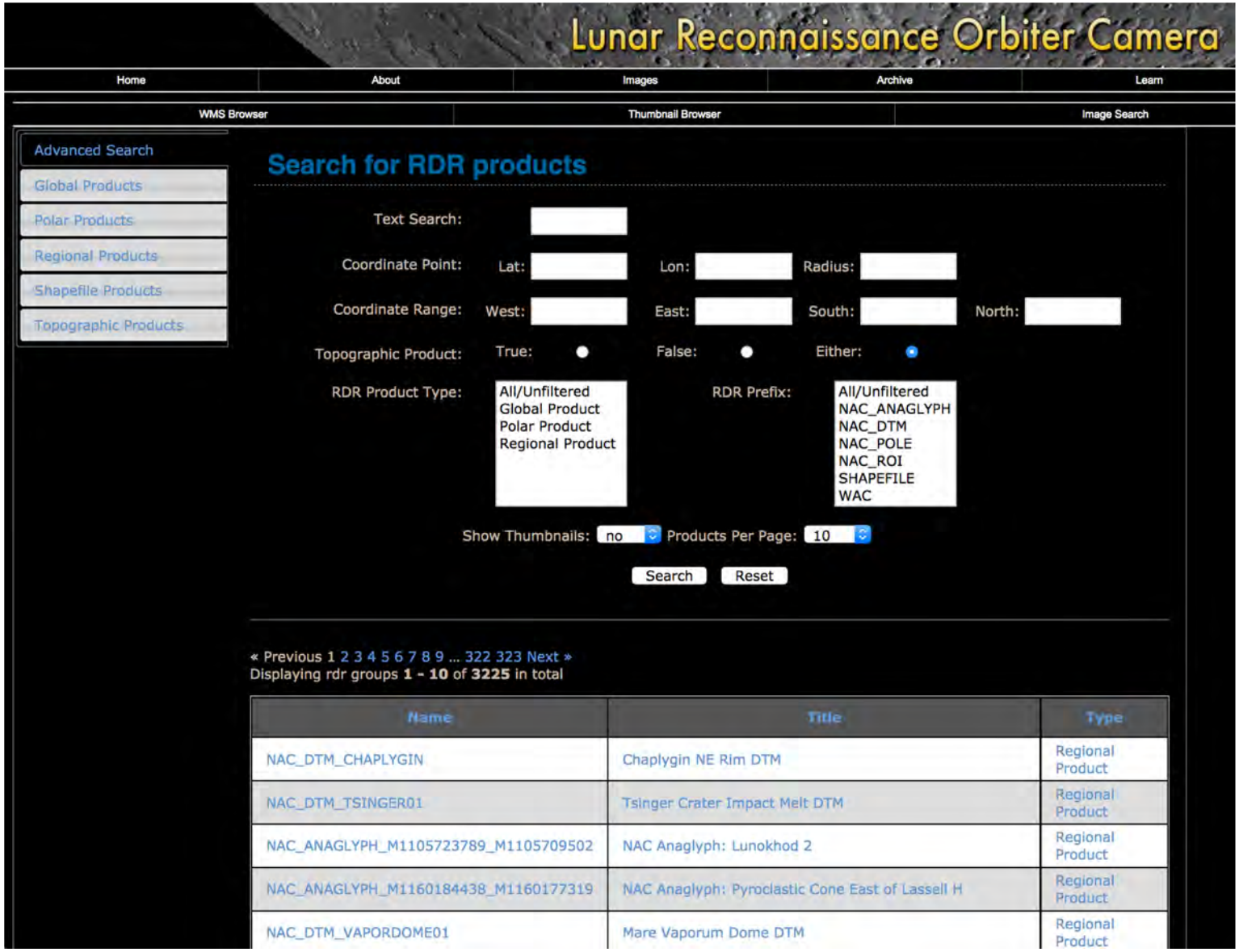
Arizona State University Data node: LROC data



https://www.lroc.asu.edu/archive

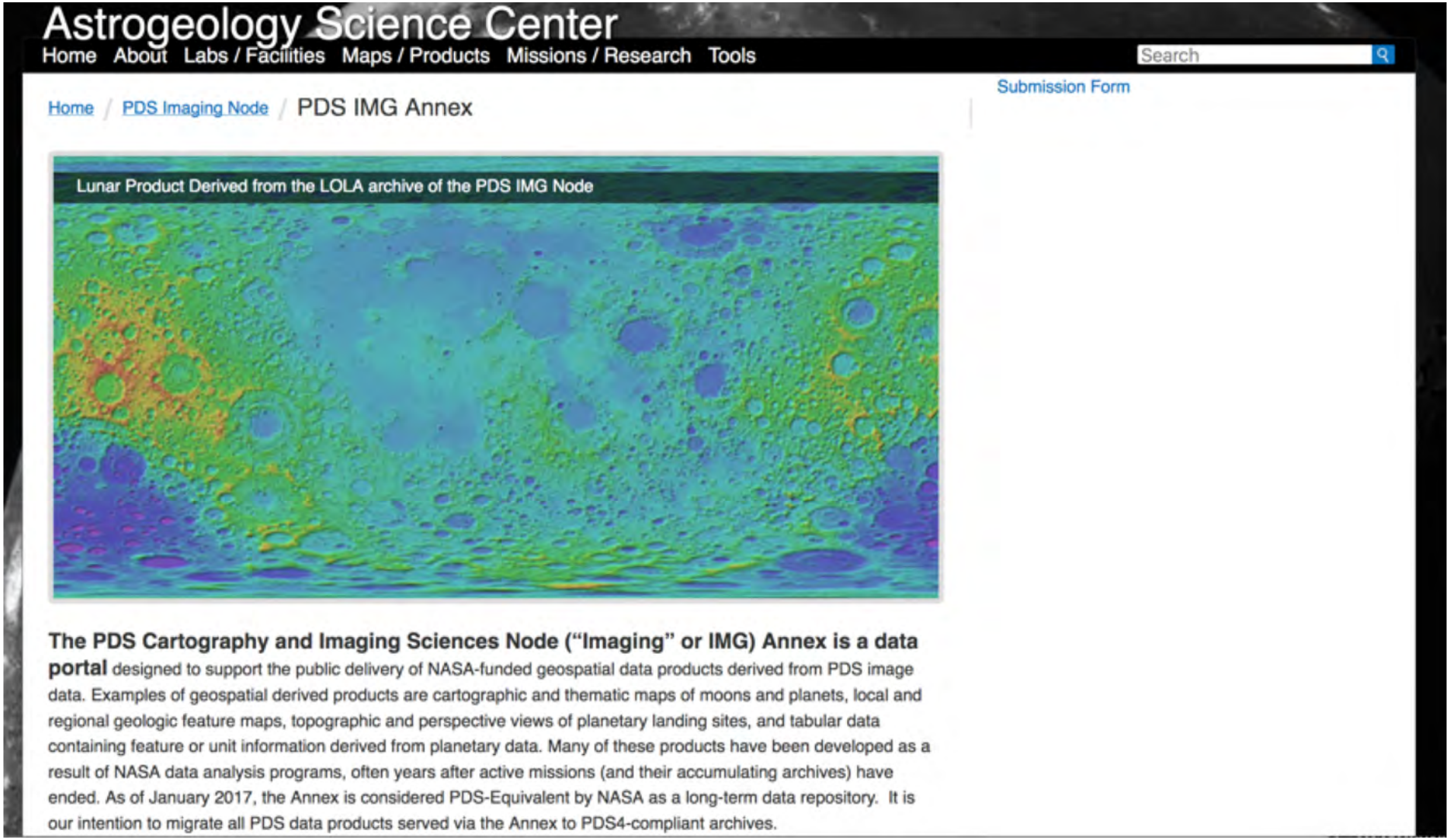
Arizona State University Data node: LROC data

http://wms.lroc.asu.edu/lroc/rdr_product_select



Imaging node: PDS Annex of Geospatial Products

https://astrogeology.usgs.gov/pds/annex



Imaging node: PDS Annex of Geospatial Products

https://astrogeology.usgs.gov/pds/annex