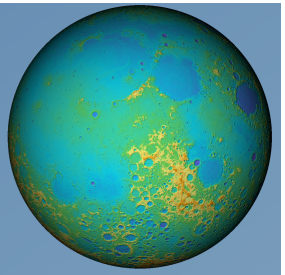
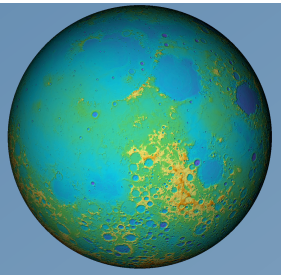


Lunar Reconnaissance Orbiter Data Workshop - LROC

45th LPSC

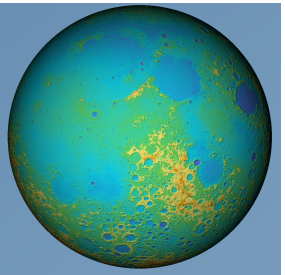
March 16, 2014

Overview

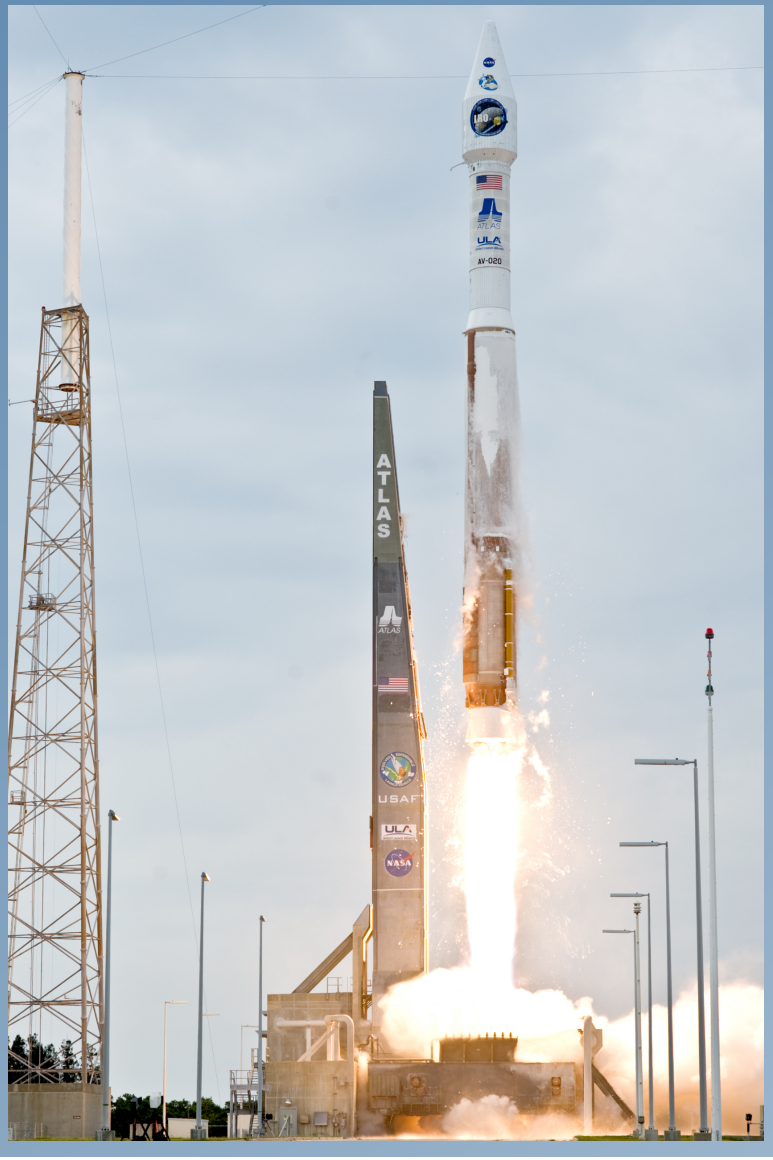


- Mission Review
- Instrument Review
  - NAC / WAC
- Product naming, what is available, data quality
  - EDR / CDR / RDR
- Searching & Downloading Products
- Basic Data Processing - radiometric calibration, basic map projection
- Advanced Data Processing - photometric calibration, controlled mosaics

LRO Mission



- Launched June 18, 2009 17:32 EDT (1731 days … and counting)
- 7 Instruments: CRaTER, DLRE, LAMP, LEND, LOLA, LROC, Mini-RF
- Polar Orbit
  - Mapping 50 km w/ two month low orbit
  - Stable (30 km x 190 km)
- Mission Phases: Commissioning, Mapping (ESMD), Science (SMD), Extended (ESM)
- Data downlink allocation: 430 Gbits/day

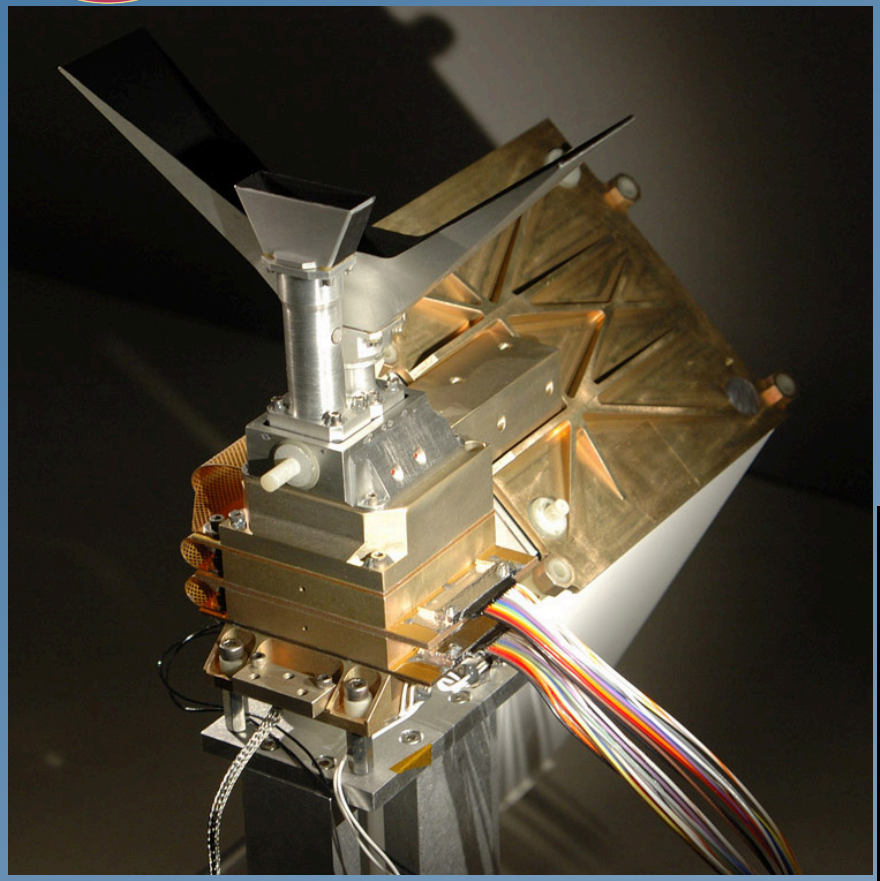


LROC NAC

- NACR – NACL (not stereo)
- 1x5064 Kodak KLI-5001G CCD
- 2.85° per NAC

Image Format: 5064 x 50k lines (max)
Imaging Mode: native, xtrack summing

LROC WAC



- Kodak KAI-1001 1024x1024 CCD
- 2 UV (321 / 360) - 5 VIS (415 / 566 / 604 / 643 / 689)
- FOV: 91.7° (vis) / 61.4° (color) / 60° (UV)

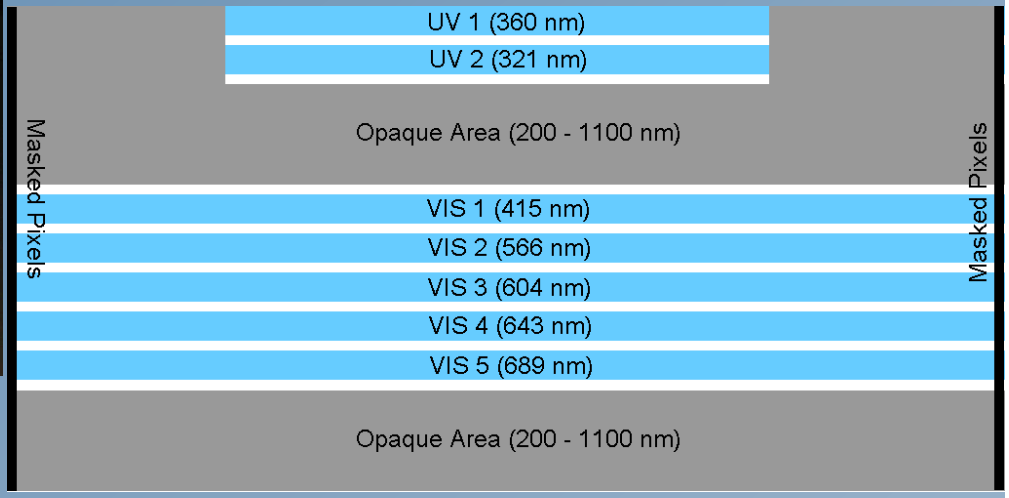
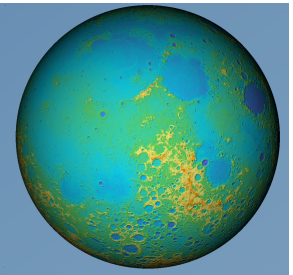


Image format:

- 1024 x 14 pixels monochrome (push frame)
- 704 x 14 pixels 5-filter (vis) (push frame)
- 128 x 4 2-filter UV color

WAC Detector Layout

What's in a Name?
PDS Naming Schemes



- EDR & CDR
  - [Target][MET][Instrument][Product]
    - Moon / Earth / Calibration / Star
    - 10 digits (1 digit for clock partition)
    - Right / Left / Monochrome / Color / VIS / UV
    - EDR / CDR

M1141772961ME
E103093560RC
C1109049397CC
S1124325043LE

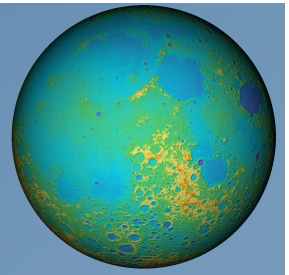
- RDR
  - Constructed using product name, map projection and coordinate of the center of the map mosaic. NAC DTM and ROI products also include site designator in the name

NAC_DTM_ARISTARCHU5_E250N3110.IMG NAC_POLE_P862S0750.IMG

http://lroc.sese.asu.edu/data/LRO-L-LROC-2-EDR-V1.0/LROLRC_0001/DOCUMENT/LROCSIS.PDF

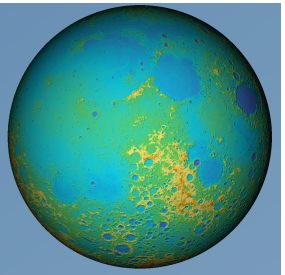
http://lroc.sese.asu.edu/data/LRO-L-LROC-5-RDR-V1.0/LROLRC_2001/DOCUMENT/RDRSIS.PDF

DATA_QUALITY_ID



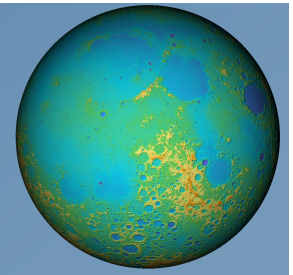
- PDS keyword (EDR/CDR), 8 bit value
  - Bit 1: No temperature telemetry or FPA temperature no in the range -50° C to 50° C
  - Bit 2: Count of DNs >= 250 exceeds 0.1%
  - Bit 3: WAC DN count <= 5 exceeds 0.1%; NAC DN count = 0 exceeds 0.1%
  - Bit 4: Observation is missing data packets due to downlink transmission error
  - Bit 5: SPICE SPK or CK information is missing or incorrect
  - Bit 6: Observation header, data bits or instrument housekeeping information is incorrect or missing
  - Bit 7 & 8: Reserved for Future Use
- Some images cannot be calibrated and/or map projected

Available Products?



- EDR v1.7 (Engineering Data Records)
  - Companded, 8 bit
- CDR v1.8 (Calibrated Data Records)
  - Decompanded, 16 or 32 bit, calibrated
- RDR (Reduced Data Records)
  - 16 bit, map projected products
  - Complies with LRO whitepaper "*A Standardized Lunar Coordinate System for the Lunar Reconnaissance Orbiter and Lunar Datasets*"

Where do I find LROC products?



LROC PDS Data Node

- *http://wms.lroc.asu.edu/lroc*

LROC WMS Service

- *https://webmap.lroc.asu.edu*

NASA PDS Imaging Node

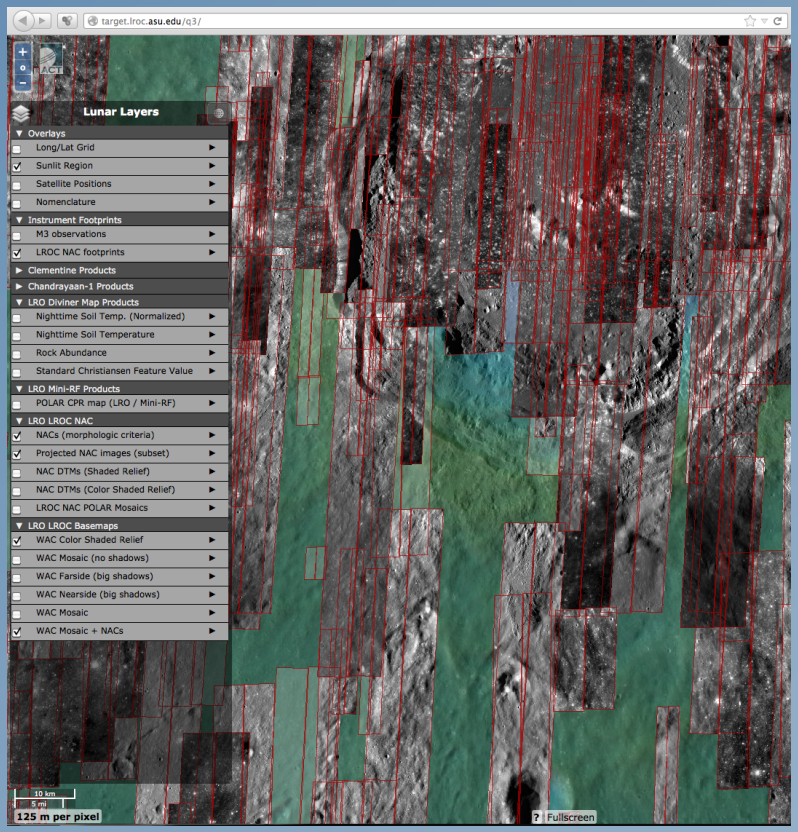
- *http://pds-imaging.jpl.nasa.gov/*

PDS Lunar ODE

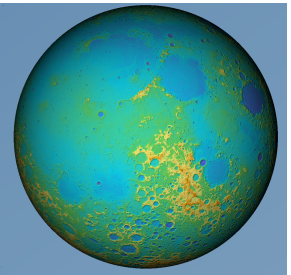
- http://ode.rsl.wustl.edu/moon/

Others

- LROC QuickMap *http://target.lroc.asu.edu/q3/*

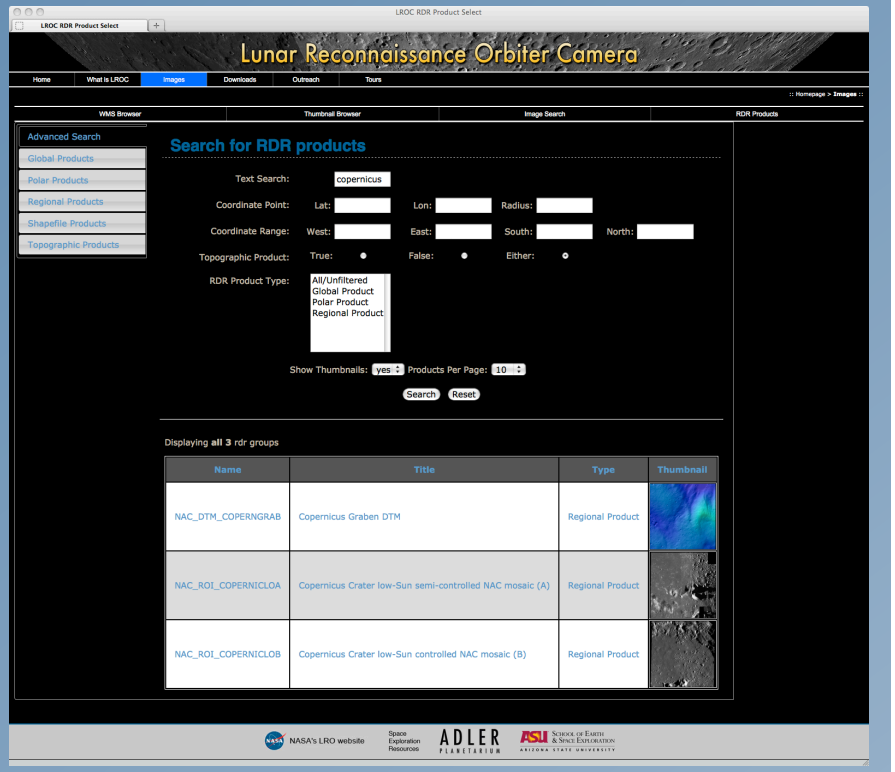


LROC PDS Data Node



4 interfaces for exploring LROC data

- WMS Browser
- EDR / CDR Thumbnail Browser
- EDR / CDR Search
- RDR Search



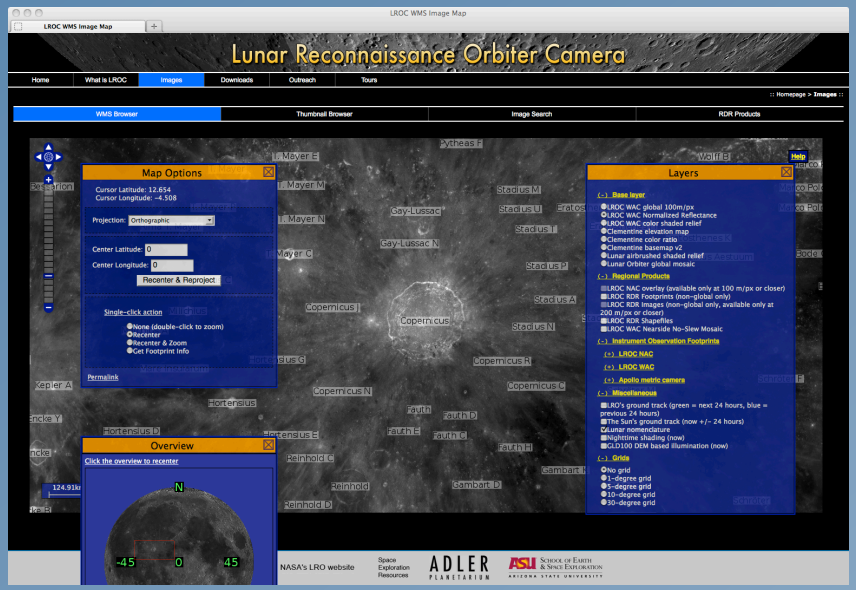
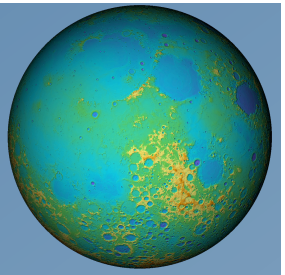


Image Search Interface



Lunar Reconnaissance Orbiter Ca

Home | What is LROC | Images | Downloads | Outreach | Tours

WMS Browser | Thumbnail Browser | Image Search

LROC Image Search

Product ID: (eg. M104612916L)

Coordinate Range: West: East: South: North:

Incidence Angle: Min: Max: (Enter only the min for a single value +/- 5 degrees)

Emission Angle: Min: Max: (Enter only the min for a single value +/- 5 degrees)

Resolution (m/pixel): Min: Max: (Enter only the min for a single value +/- .25 m)

Exposure (ms): Min: Max: (Enter only the min for a single value)

Sub-Solar Azimuth: Min: Max: (Enter only the min for a single value +/- 5 degrees)

Sub-Solar Latitude: Min: Max: (Enter only the min for a single value +/- 5 degrees)

Orbit: Min: Max: (Enter only the min for a single value)

Observation Date: Min: Max: (Enter only the min for a single value, times are in UTC)

Product Type: All/Unfiltered, CDR, EDR

Observation Type: All/Unfiltered, NACL, NACR, WAC_COLOR, WAC_MONO, WAC_UV, WAC_VIS

Show Thumbnails: no Products Per Page: 10

Search

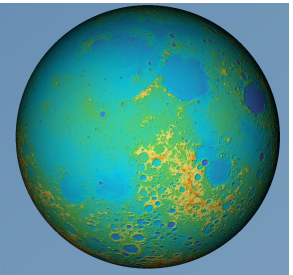
Reset

This search returned 2362529 items, please refine your search and try again.

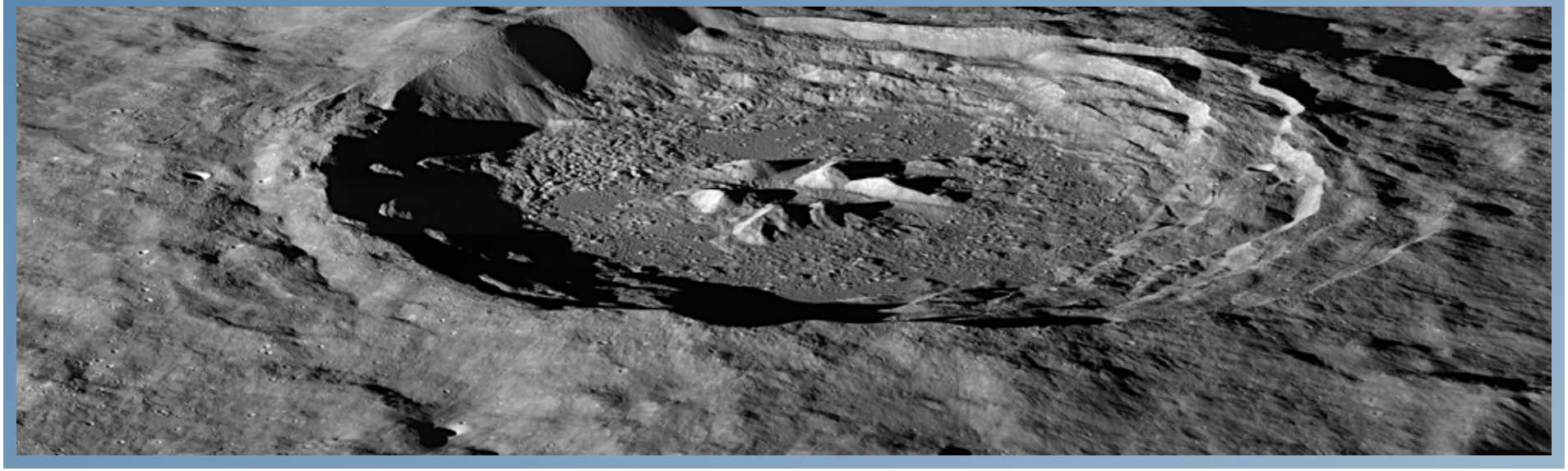
- 12 search fields
- Thumbnails
- Download list

Demo!

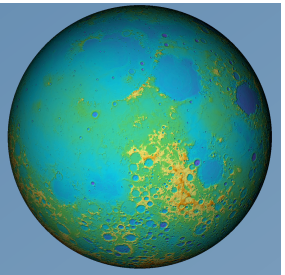
ISIS v3.4.5



- Need software (~1.2 GB), base data (~4.9 GB) and LRO data (~141 GB)
- Installation via rsync (need high speed network link, very slow otherwise)
- SPICE kernels need to be updated every 3 months
- Lots of scratch disk space for data processing (~4x NAC)

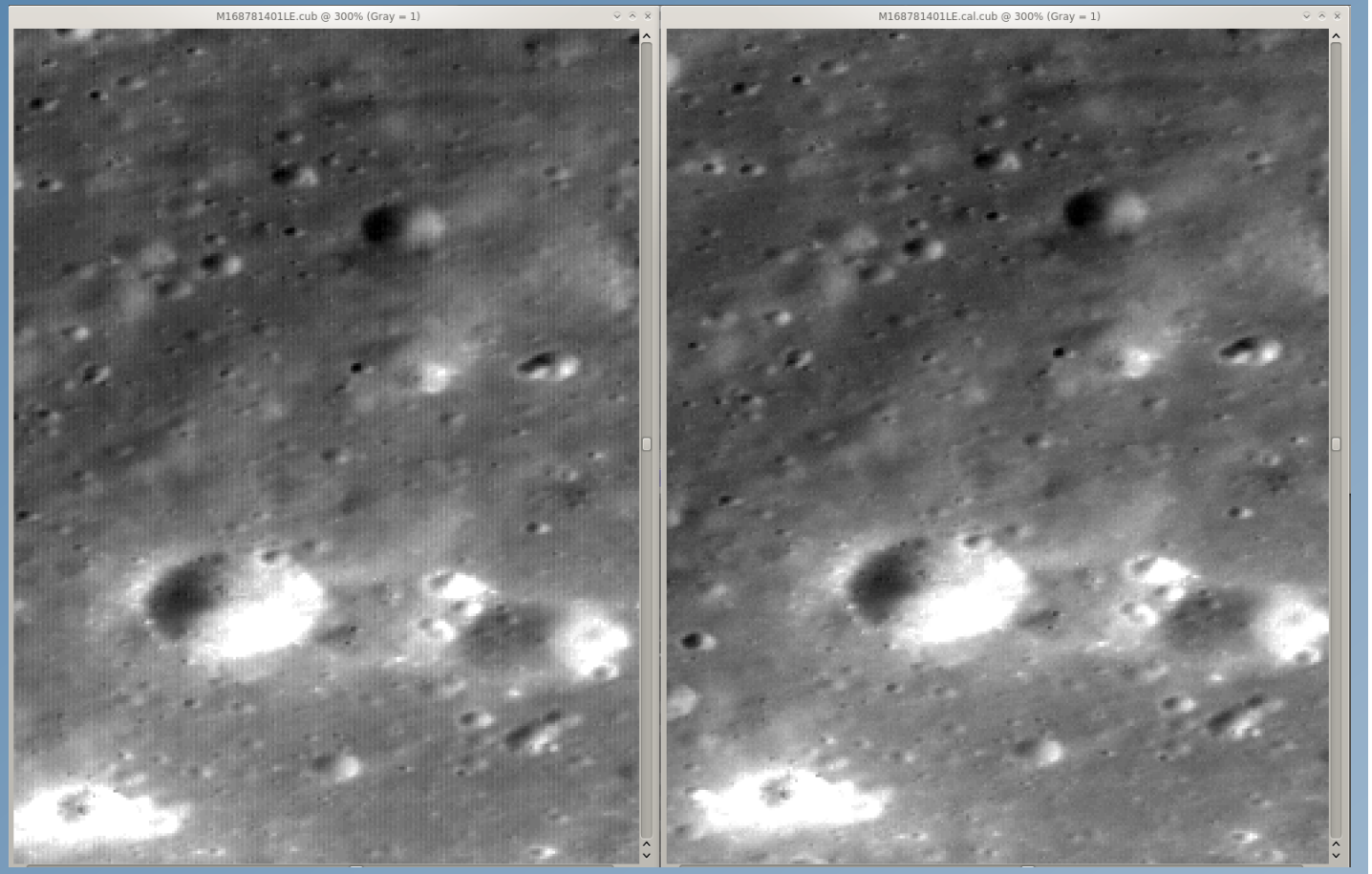


NAC Level 1 Processing



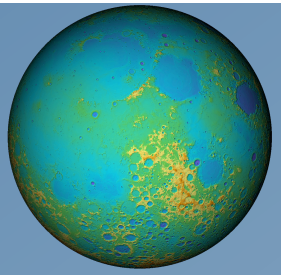
Calibration: masked pixels, dark current, nonlinearity, flat field and radiometric

1. lronac2isis
2. spiceinit*
3. lronaccal
4. lronacecho



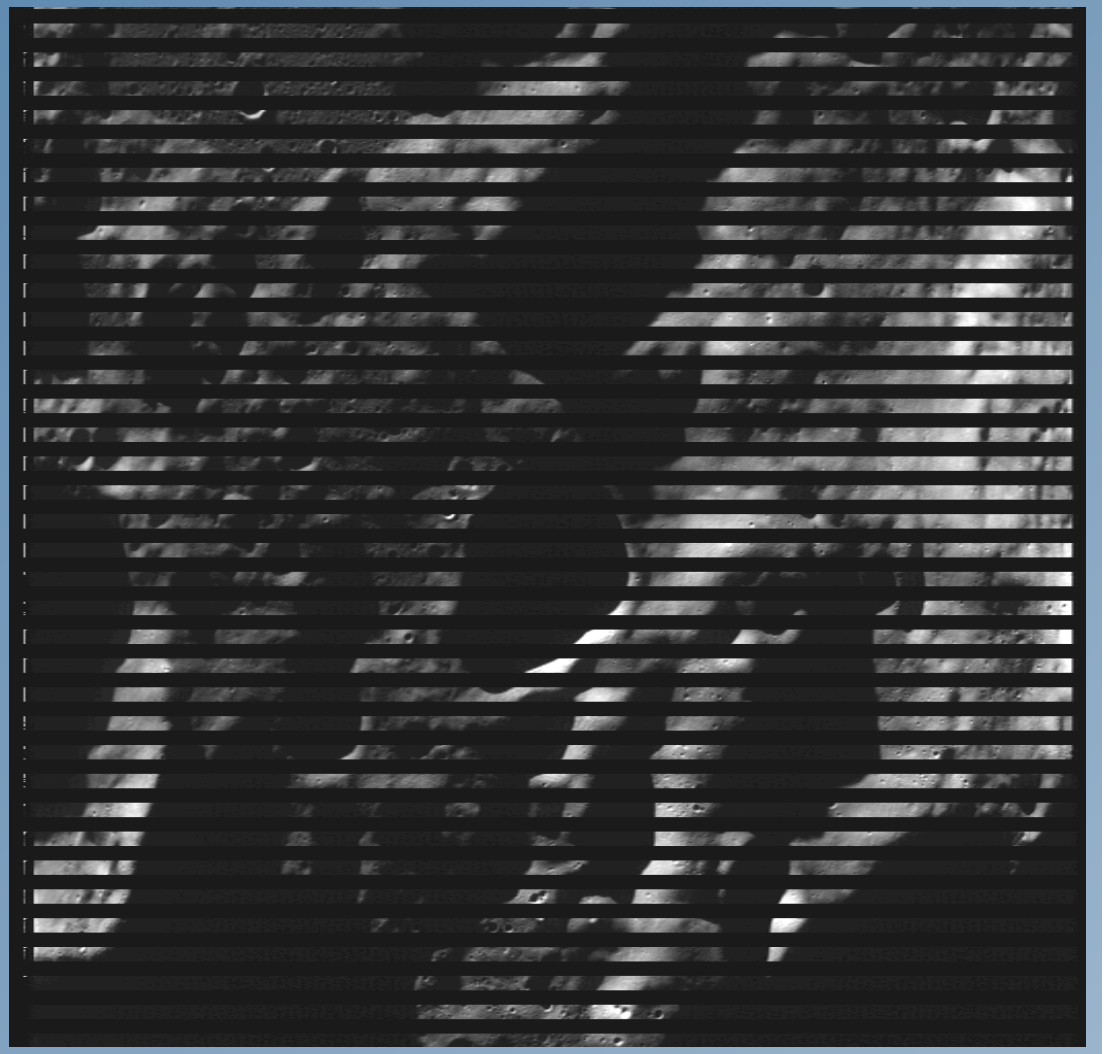
* Use LROC temperature corrected CK

WAC Level 1 Processing

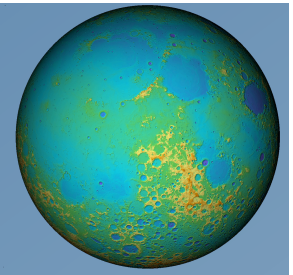


1. lrowac2isis
   - splits WAC image into 2 (VIS/UV/BW) or 4 files (COLOR)
2. spiceinit
   - on every file created in step 1
3. lrowaccal
   - on every file created in step 1

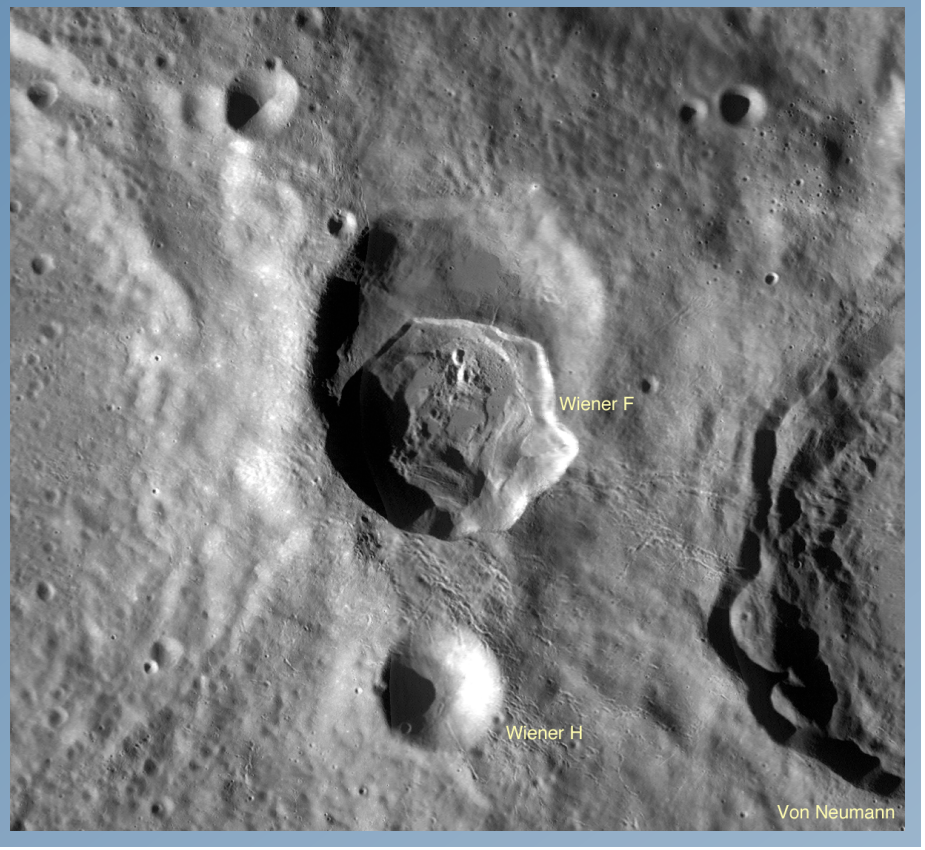
Calibration: dark current, flat field, radiometric, temperature



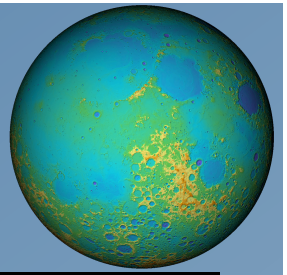
Basic Map Projection



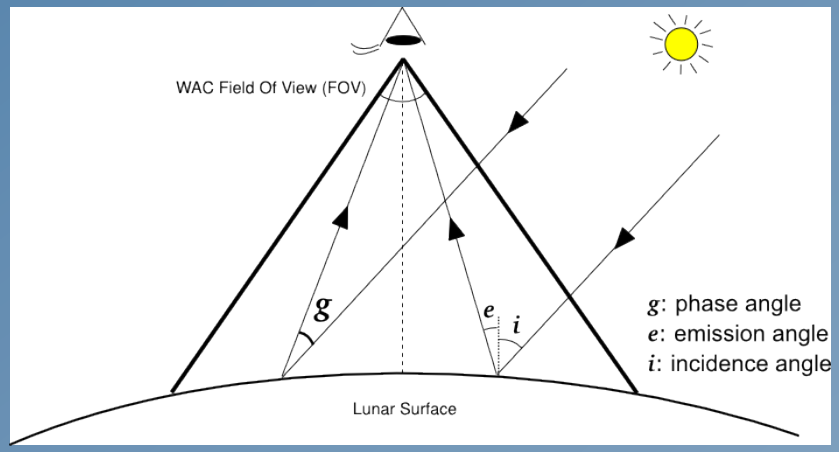
- NAC pair into single image
- WAC single band image
- WAC multi-band image
  - registration of bands
- ISIS Commands:
  - cam2map
  - mapmos or automos

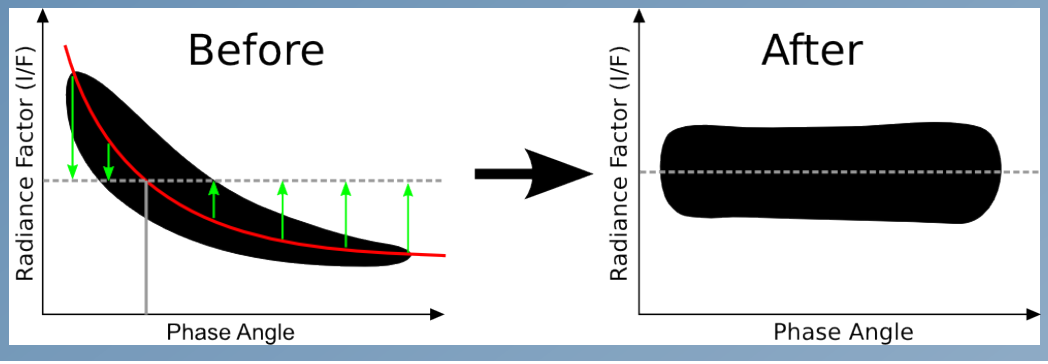


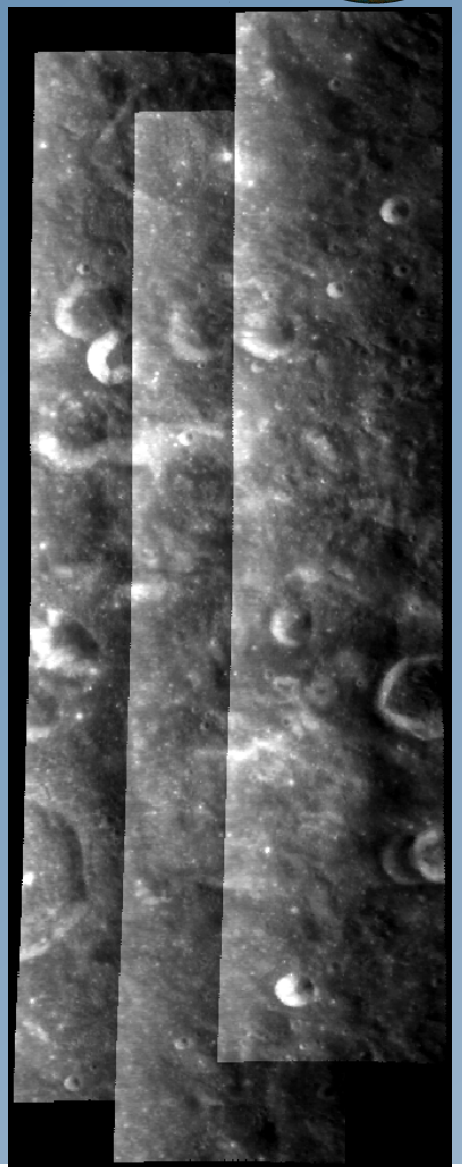
Photometric Correction



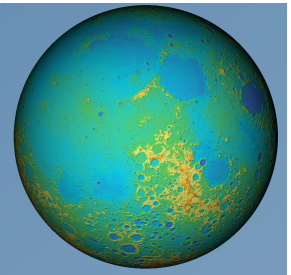
- NAC - photomet, lronacpho
- WAC – photomet, lrowacpho



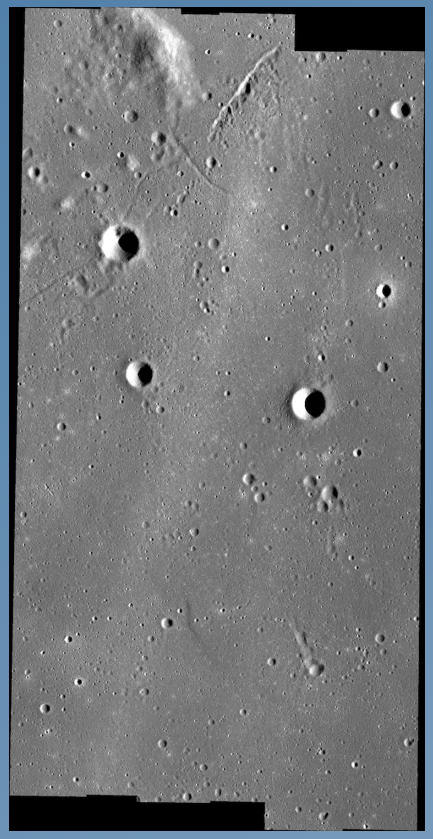


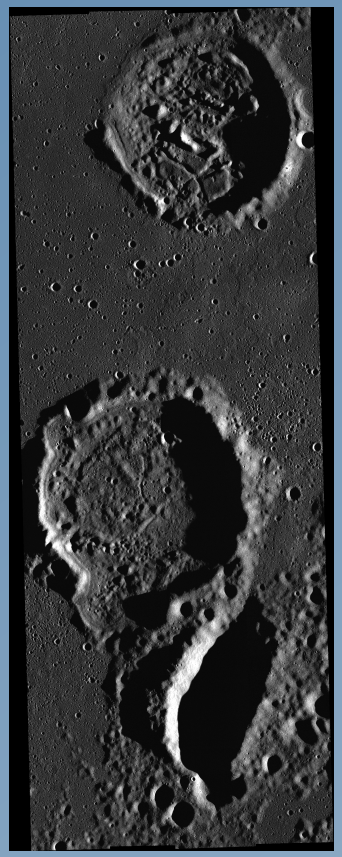


Multi-Image Mosaics



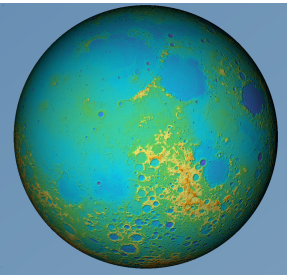
- Featured Image Mosaics



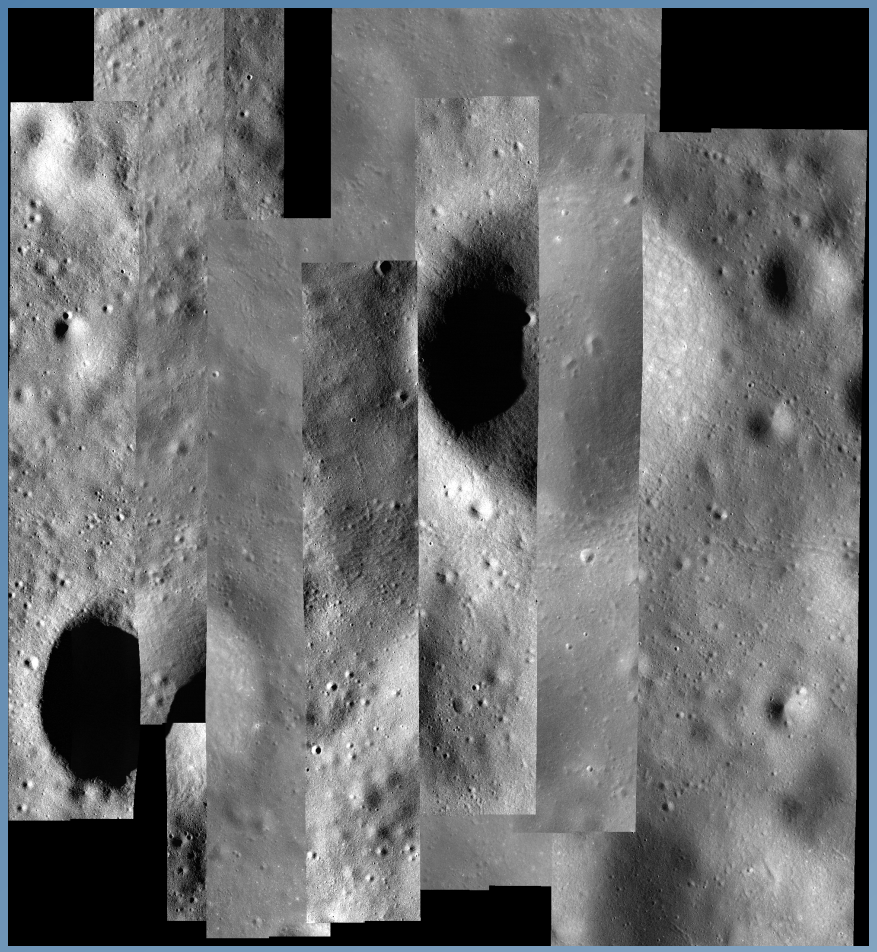


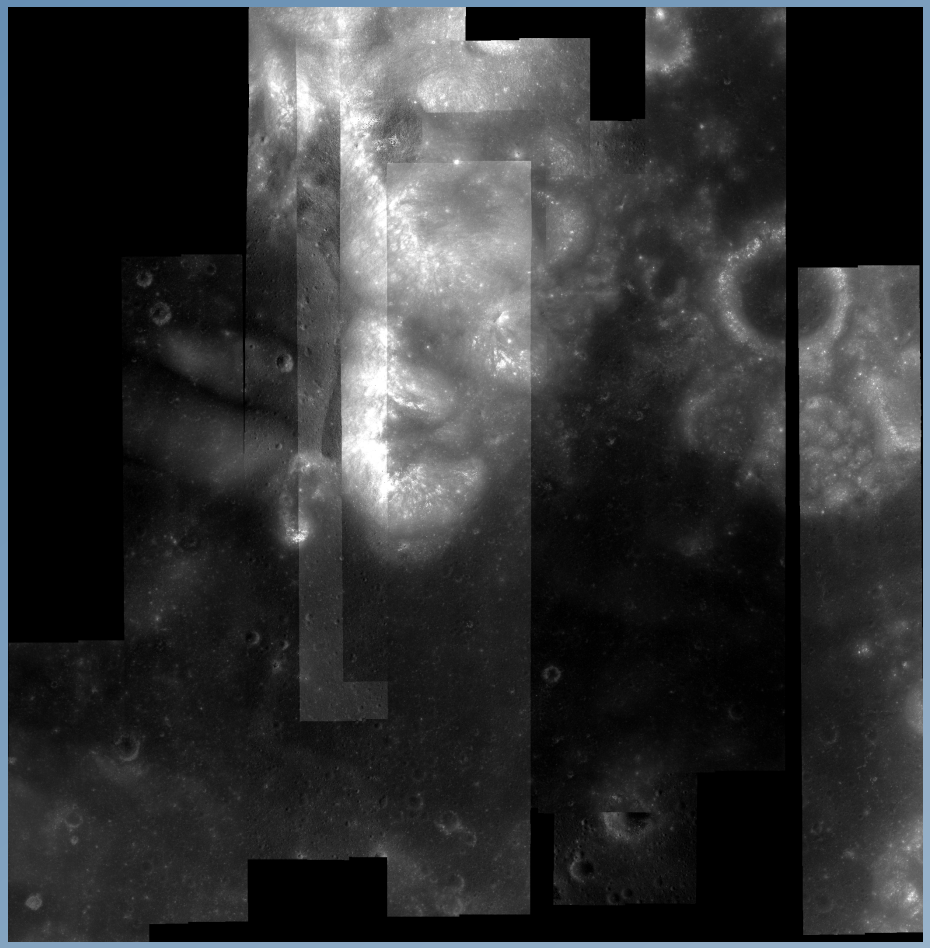
See Poster on Thu #521 - *Controlled LROC Narrow Angle Camera High Resolution Mosaics*

Multi-Image Mosaics (cont.)

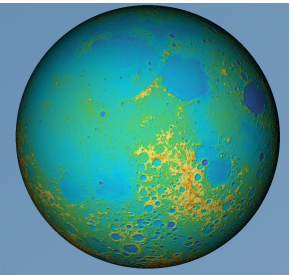


- Non-Featured





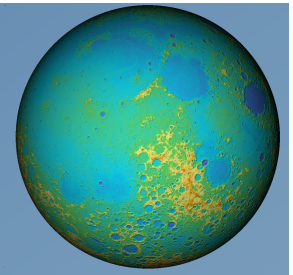
Multi-Image Mosaics (cont.)



WAC Morphology

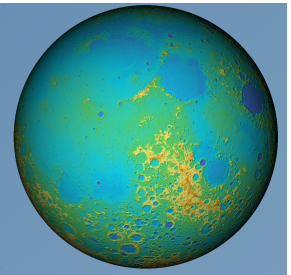
WAC Normalized Reflectance

Resources



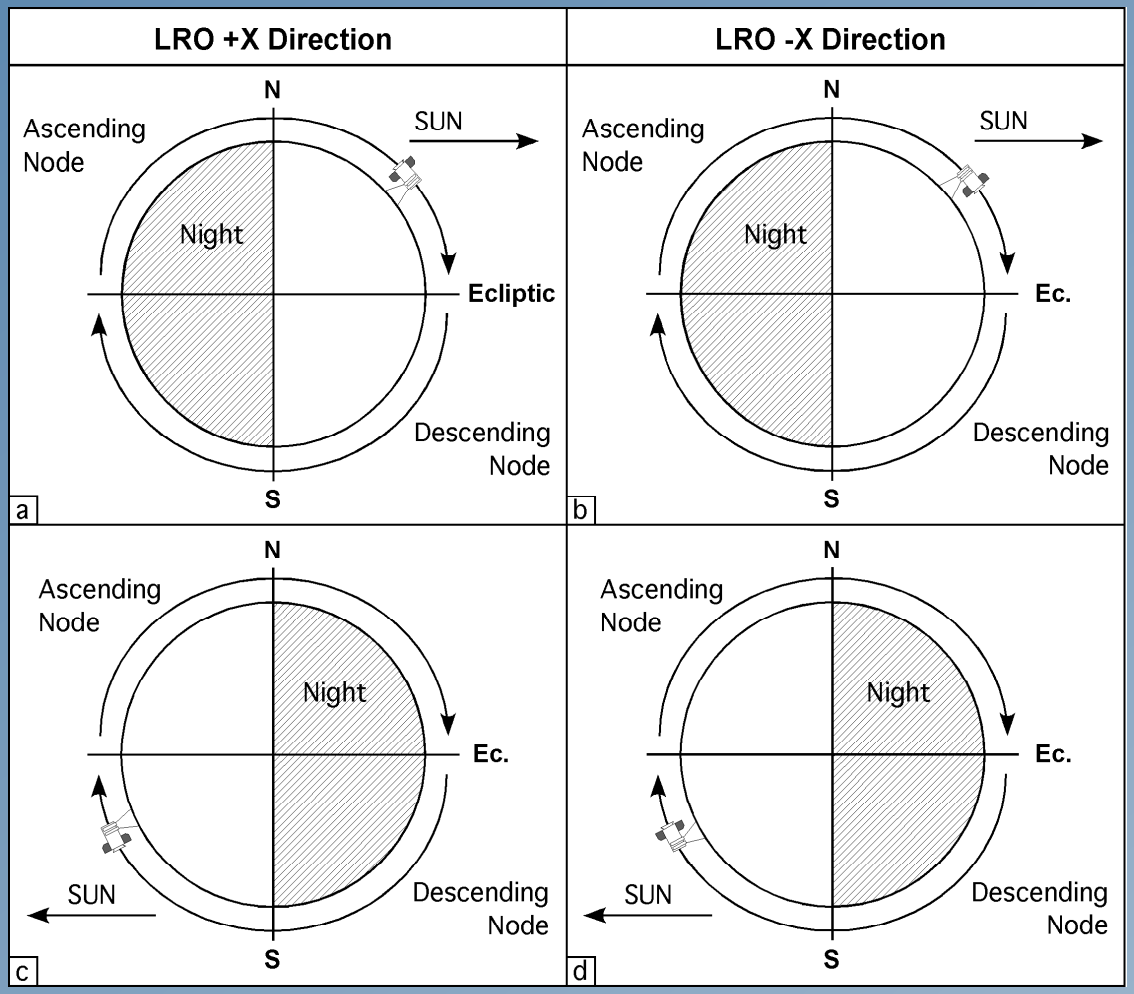
1. LROC EDR/CDR Product SIS - *http://lroc.sese.asu.edu/data/LRO-L-LROC-2-EDR-V1.0/LROLRC_0001/DOCUMENT/LROCSIS.PDF*
2. LROC RDR Product SIS - *http://lroc.sese.asu.edu/data/LRO-L-LROC-5-RDR-V1.0/LROLRC_2001/DOCUMENT/RDRSIS.PDF*
3. Robinson et. al., *Lunar Reconnaissance Orbiter Camera (LROC) Instrument Overview*, Space Science Reviews, Vol 150, pg81-124
4. Humm et. al. , *Flight calibration of the LROC Narrow Angle Camera,* submitted Space Science Reviews
5. Speyerer et. al., "*Pre-Flight and On-Orbit Geometric Calibration of the Lunar Reconnaissance Orbiter Camera*", submitted Space Science Reviews
6. Speyerer et. al., "*New Spice to Improve the Geodetic Accuracy of LROC NAC and WAC Images"*, 45th LPSC abstr #2421
7. Boyd et. al., *"LROC NAC Photometric Analysis: A Global Solution and Local Applications"*, 45th LPSC, abstr #2826
8. Sato et. al., "*Photometric Experiments Using LROC WAC Oblique Observations*", 45th LPSC abstr #2281
9. Klem et. al., *"Controlled LROC Narrow Angle Camera High Resolution Mosaics"*, 45th LPSC, abstr #2885
10. Estes et. al., *" Lunaserv 3 Development and Usage Over the Past Year"*, 45th LPSC, abstr #2180 (or visit our booth)

Backup Slides



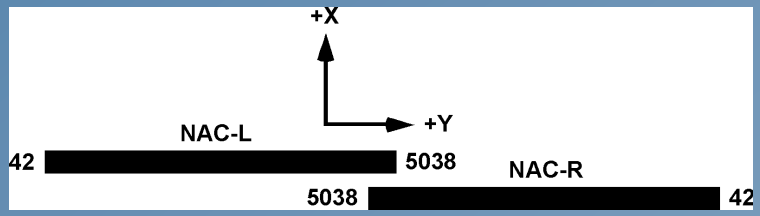
Spacecraft Orientation

The four possible cases of LRO orientation based on LRO direction of travel (+X or –X axis forward) and lighting conditions at a given node crossing



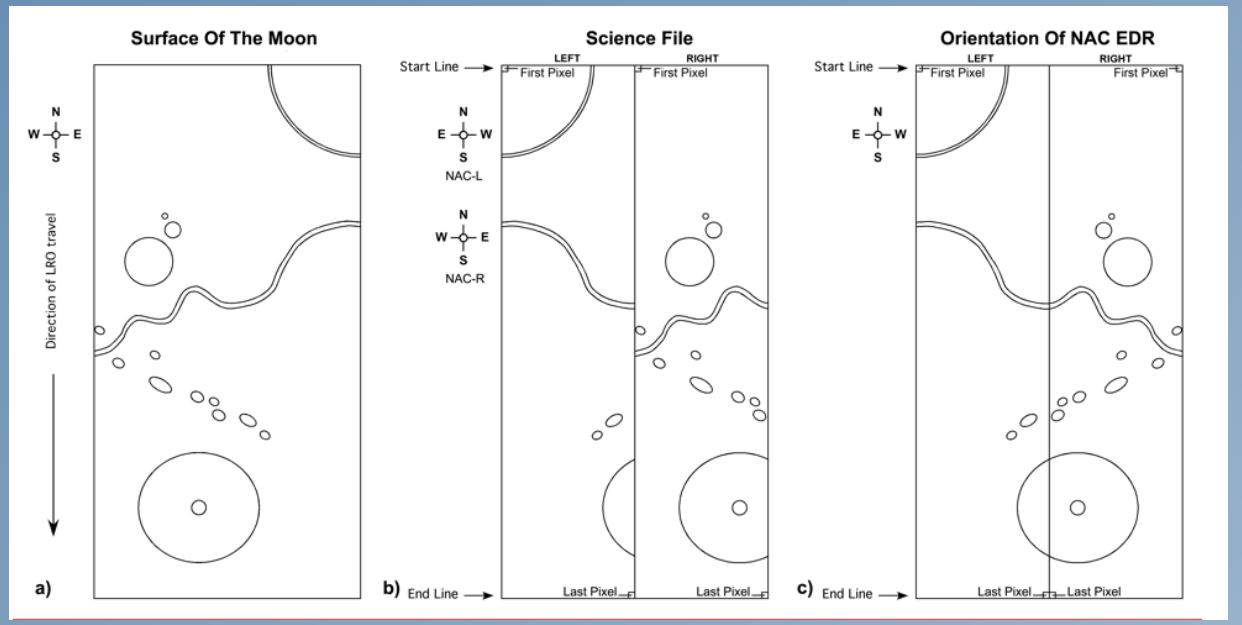
Detector Orientation

- NAC-R CCD oriented 180° relative to NAC-L CCD

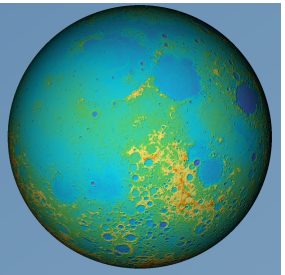


- NAC-R flipped to match NAC-L orientation

User never sees the before flip NAC-R image (only in telemetry file)



ISIS Script



1. ls *IMG | sed –e ‘s/.IMG//g’ >list
2. lronac2isis -batchlist=list from=\$1.IMG to=\$1.cub
   spiceinit -batchlist=list from=\$1.cub
3. lronaccal -batchlist=list from=\$1.cub to=\$1.cal.cub
4. trim -batchlist=list from=\$1.cal.cub to=\$1.tr.cub
   left=40 right=40
5. cam2map -batchlist=list from=\$1.tr.cub to=\
   $1.map.cub map=equi.map pixres=map