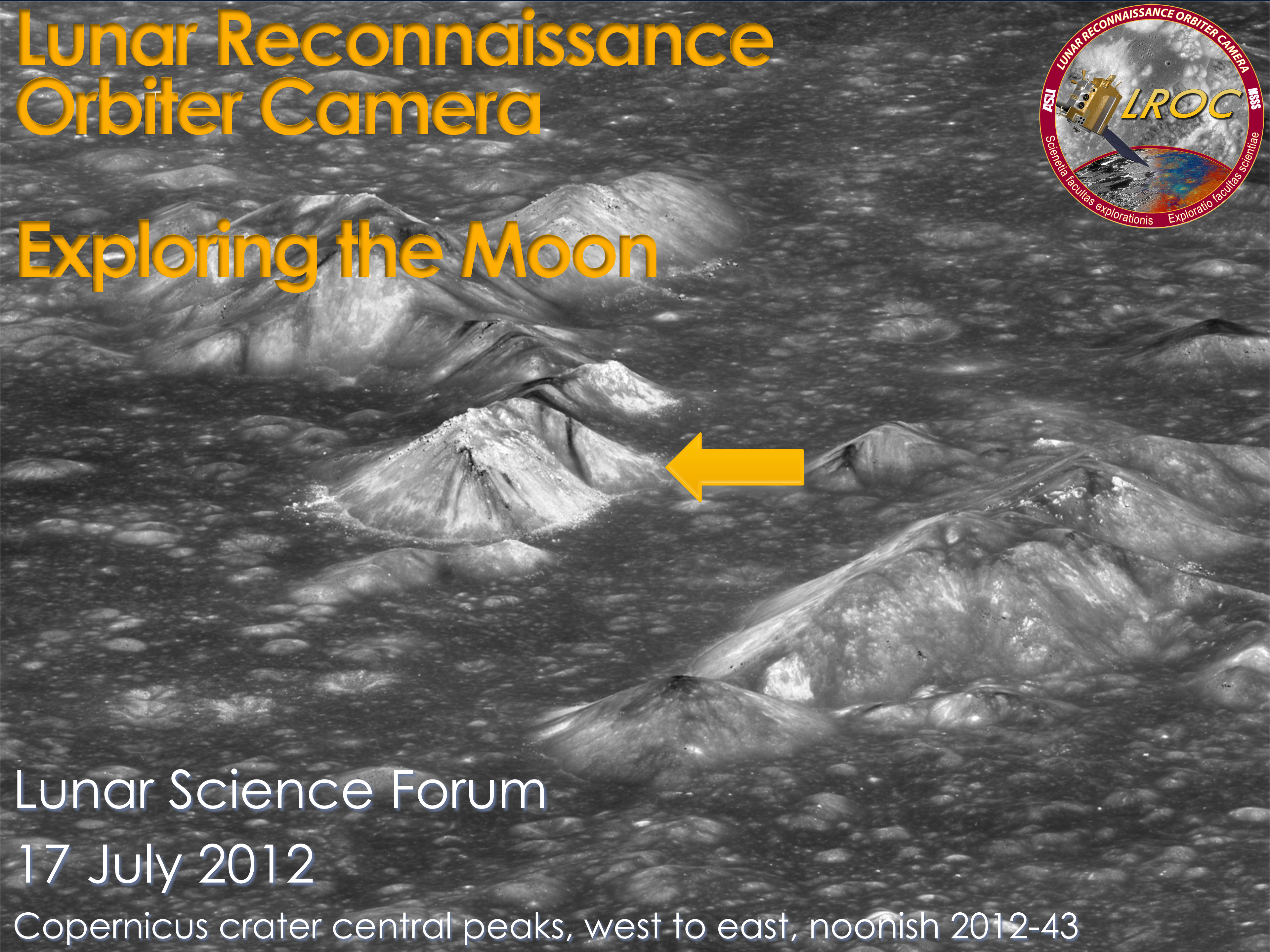
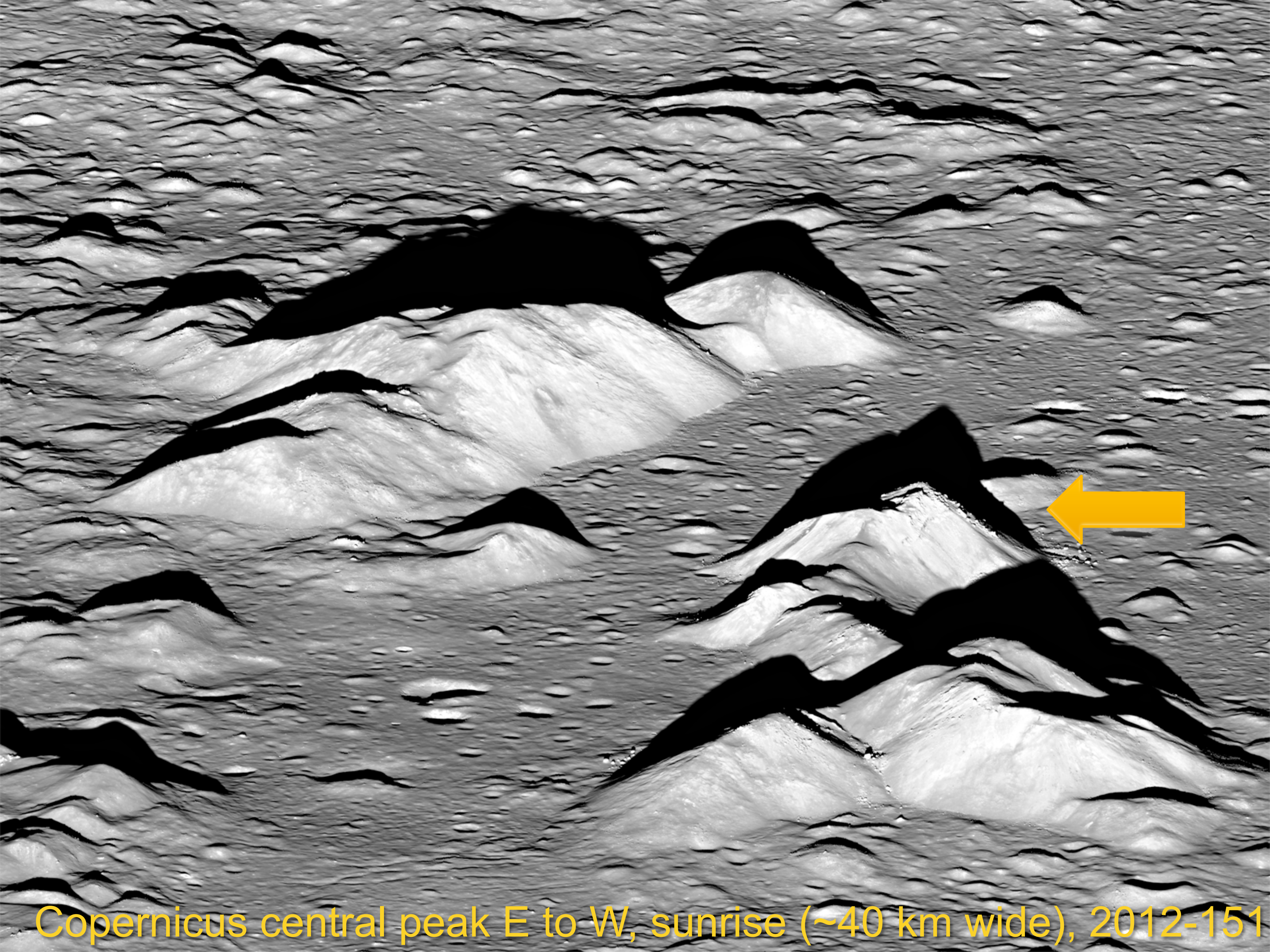
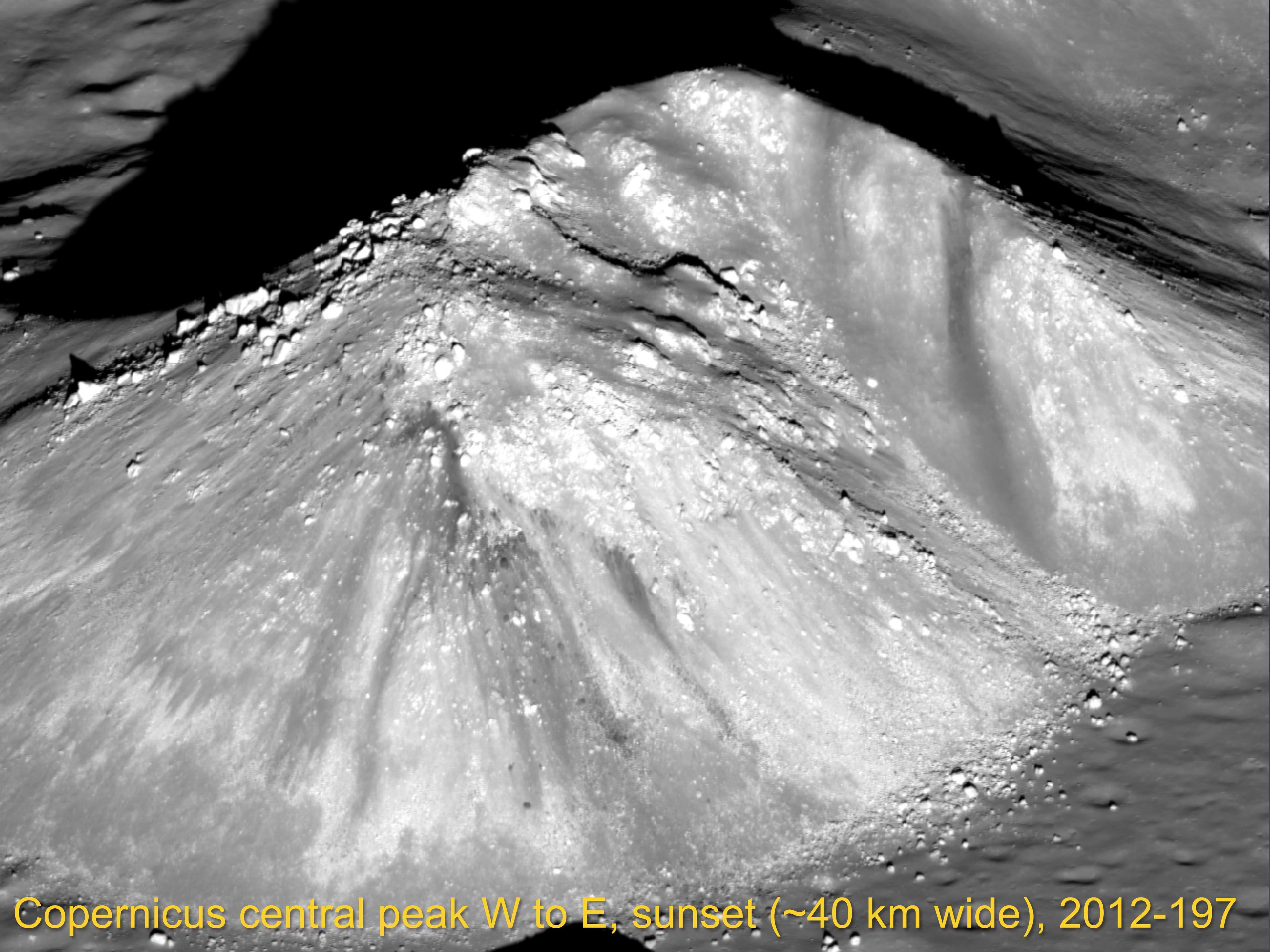
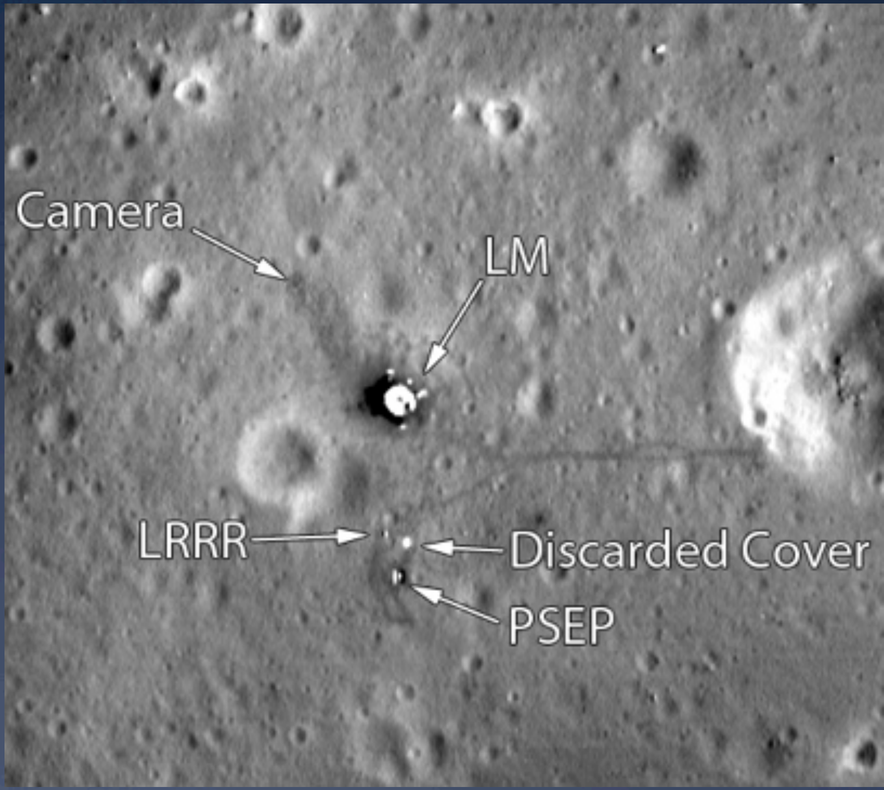

Lunar Reconnaissance Orbiter Camera
Exploring the Moon
LUNAR RECONNAISSANCE ORBITER CAMERA
LROC
ASU
MSSS
Scienetia facultas explorationis
Exploratio facultas scientiae
Lunar Science Forum
17 July 2012
Copernicus crater central peaks, west to east, noonish 2012-43


Copernicus central peak E to W, sunrise (~40 km wide), 2012-151


Copernicus central peak W to E, sunset (~40 km wide), 2012-197

LROC Status – Nominal
1 July 2012

- >400 Gbits image data per day!
- NAC
  - 514,860 <91° incidence angle
  - *1.4E14 reflectance measures*
  - *Over time NACs could map whole Moon at 0.5 to 2 m/p*
- WAC
  - 145,260 images <91° incidence post 20 Sept 2009
  - Thirty three complete global datasets
- 50 km orbit for 2.17 years, fantastic dataset!!! Two months of 25 km peripase…
- New Orbit… new opportunities



Enlargement of Apollo 11 landing site, from 25 km periapse. All Apollo sites imaged and Luna sites imaged from low orbits. As well as *thousands* of key science targets.

NAC Dayside Coverage

Very common question! How much NAC coverage do you have? Actually not a simple question!

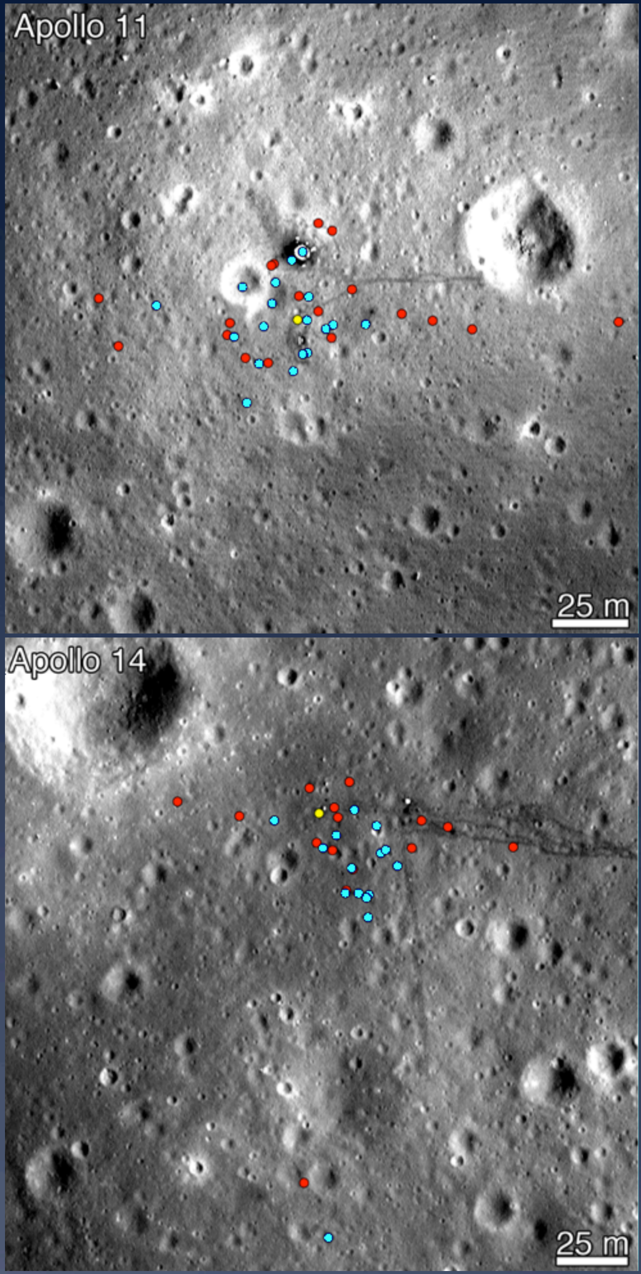
	Beta 0-45 noonish	Beta 45-80 sunset-rise	Beta 0-80
LAT Range (-45 to 45)	30 %	37 %	55 %
LAT Range (-75 to 75)	43 %	51 %	71 %

Notes:
Emission Angle <30°
Until July 1, 2012

Think of beta angle as incidence angle at the equator

Absolute NAC Pointing

- Calculated using Apollo and Lunokhod retroreflectors and improved ephemeris from ***LOLA team***.
- Cross-track error correlated with East/West slew and SCS temperature and a time offset was correlated to down track offsets.
- Cross-track accuracy improved from ±70 m to ±25 m.
- Down-track accuracy improved from ±25 m to ±15 m.

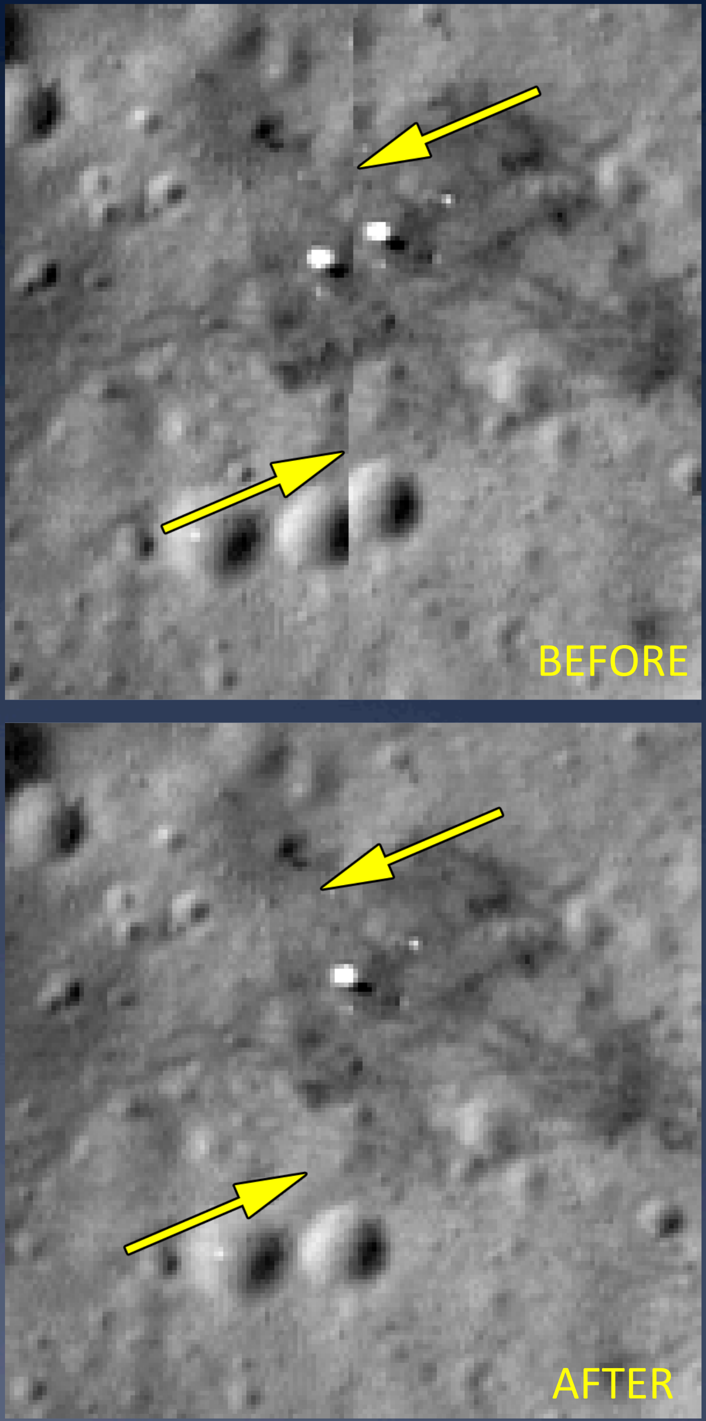


Calculated locations before (red) and after (blue) the correction compared to the actual location (yellow).

The correction is better than shown at right… plots were made without the light time correction

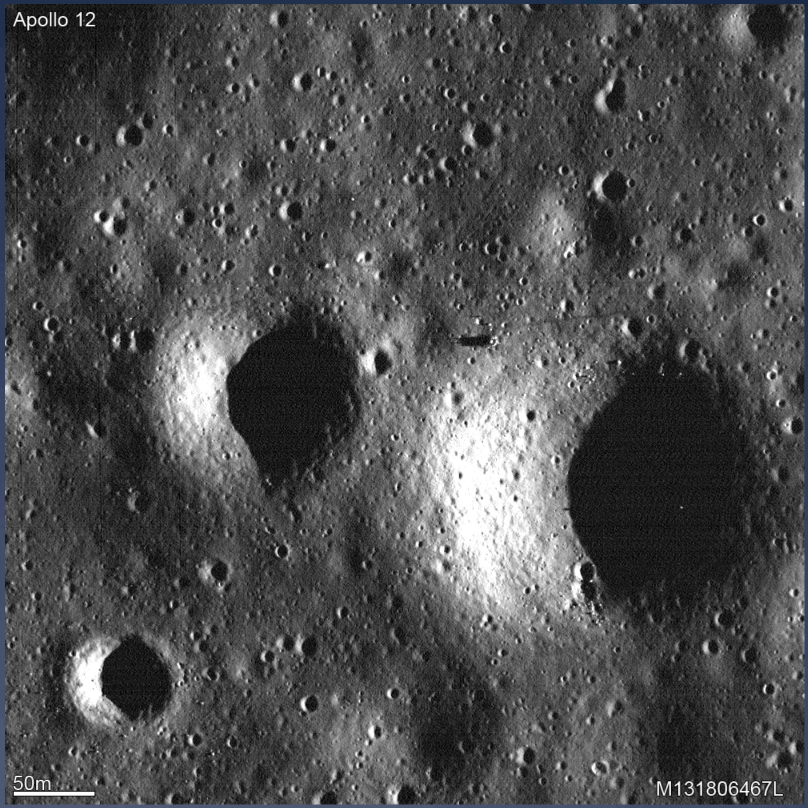
NAC Left to NAC Right Offset

- Previously, there were offsets between map projected NAC left/right pairs
- Compared >10,000 pairs under all lighting conditions and temperatures
- The offset is not constant, varies with spacecraft temperature!
- Absolute and relative pointing correction will be improved with the release of new LROC temperature dependent CKs



Repeat Coverage

- Photometry (NAC and WAC)
- Geomorphology (NAC and WAC)
- Cartography (mosty NAC), ties to absolute points, think of LRRRs as benchmarks



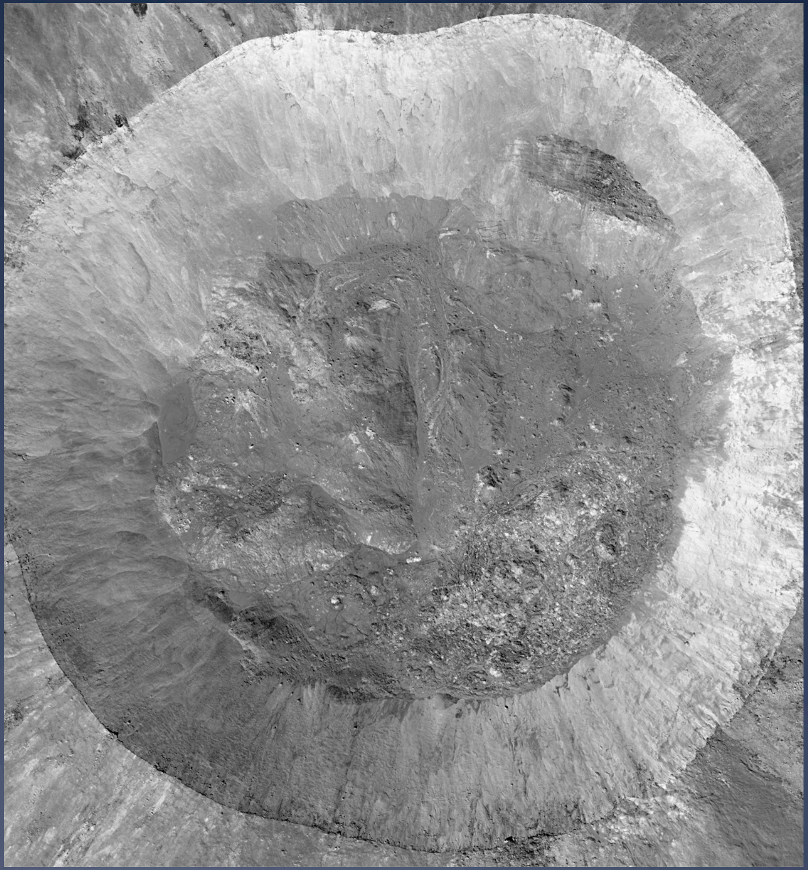
Highlights of Apollo Imaging Webpage Being Added Soon

Fixed Orbit*
11 December 2011

- 35 km at south pole
- 60 km at 45°S
- 110 km at equator
- 165 km at 45°N
- 190 km north pole

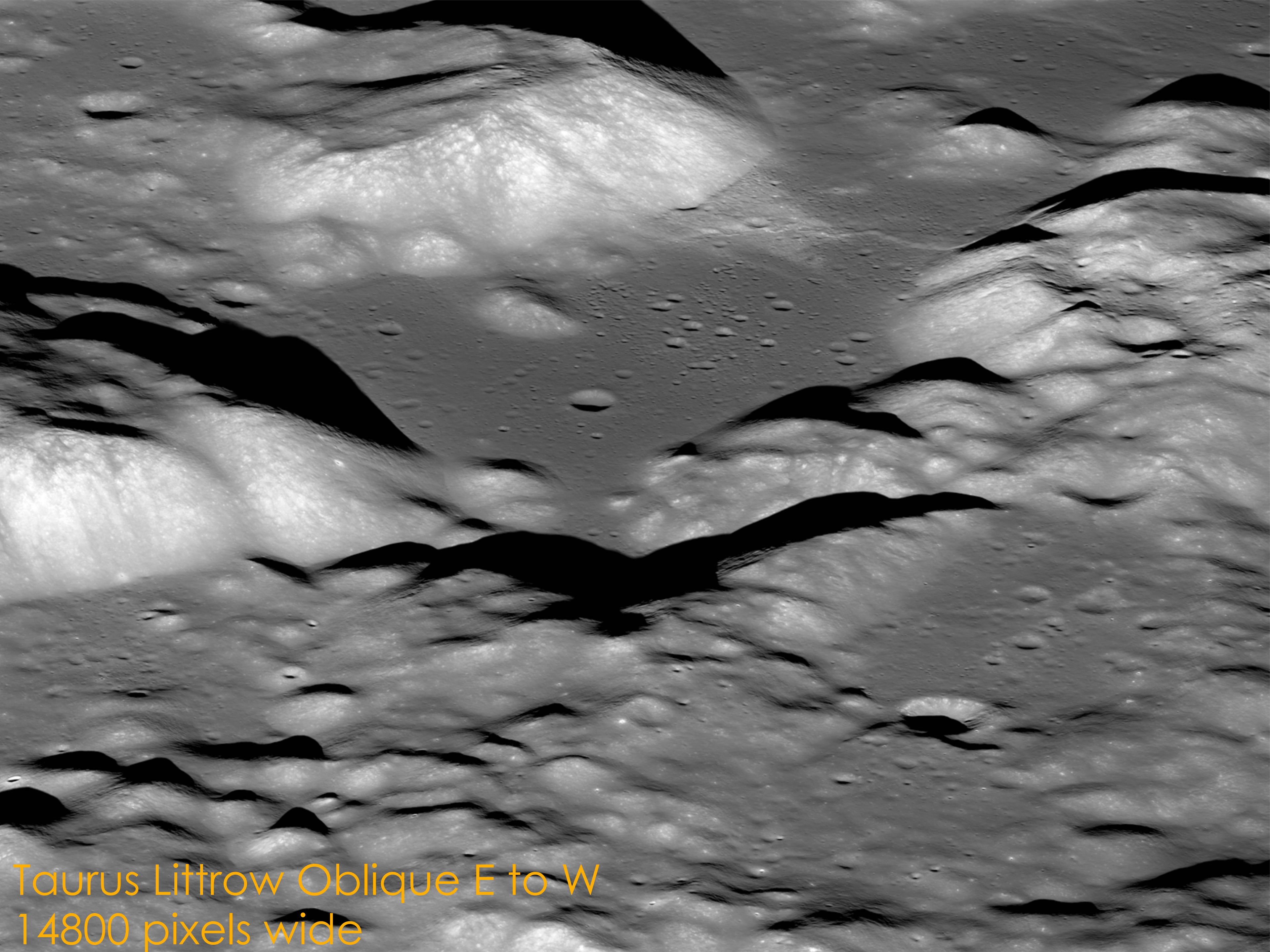
- Divide by 100 and switch km to m for NAC pixel scale

- Multi-NAC pair mosaics in n. hemisphere →
- Obliques



Eight image mosaic GB

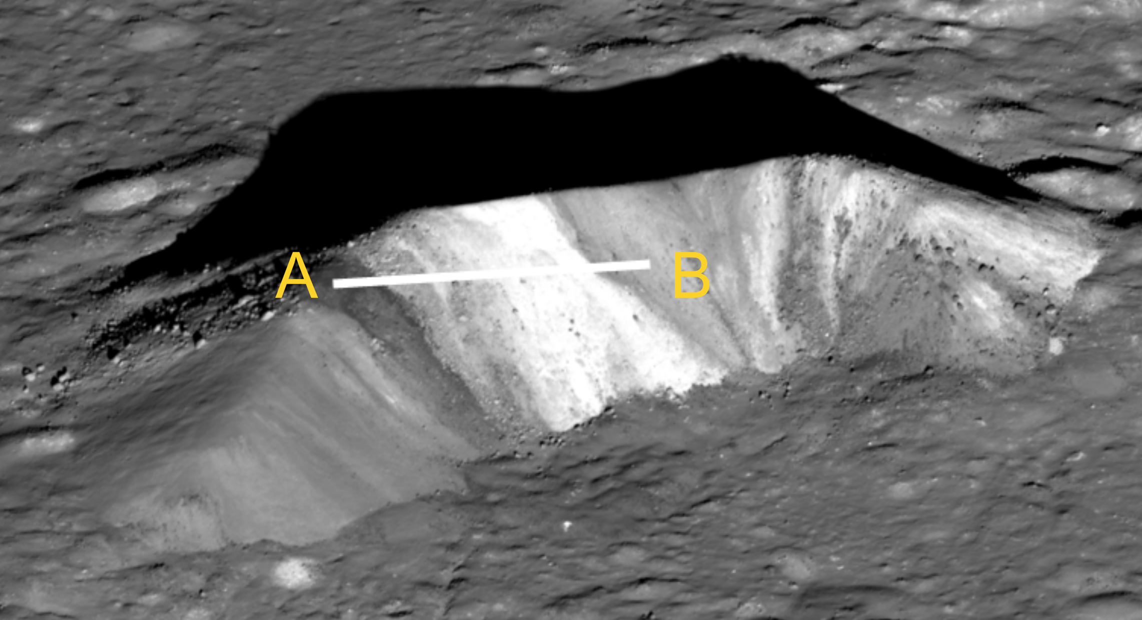
*Not really fixed, varies a lot! Low maintenance


Taurus Littrow Oblique E to W
14800 pixels wide

LM view of CM from 26 km altitude
AS17-147-22467


Lee Lincoln scarp
Shorty crater
LROC NAC detail

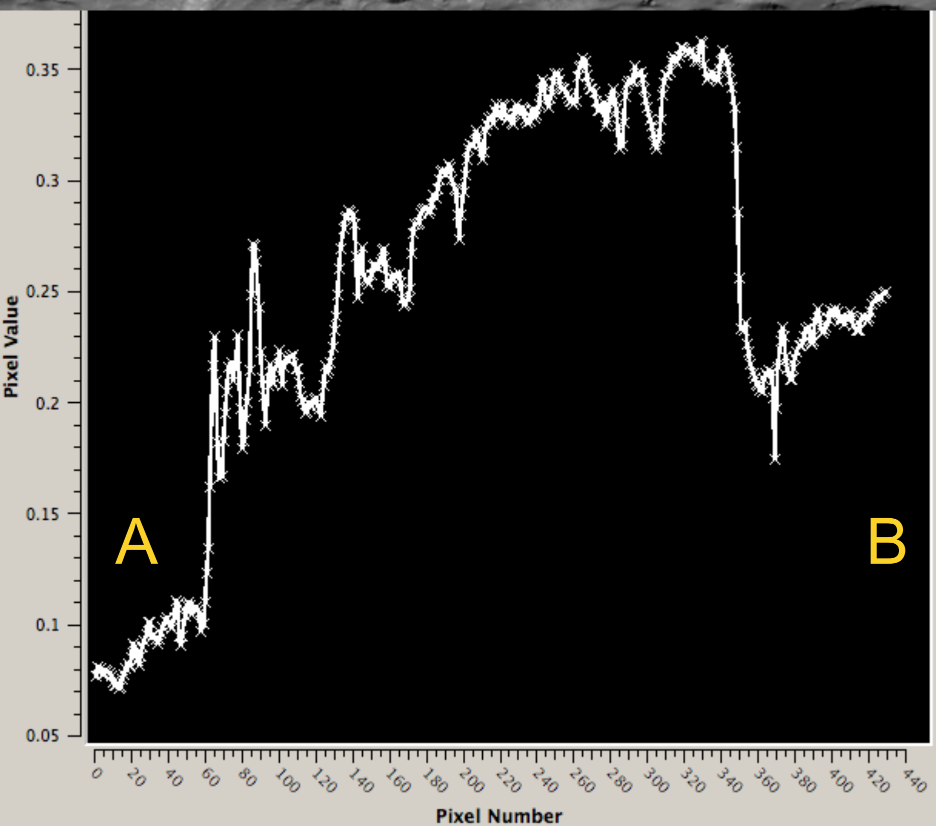
Aristarchus Crater South Rim

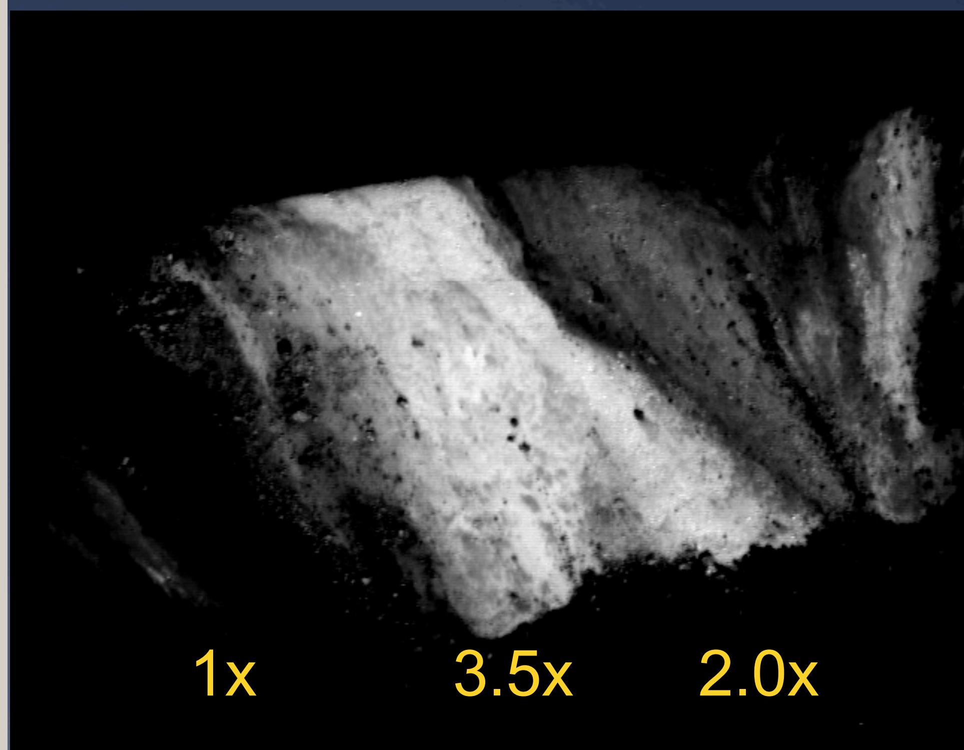


Aristarchus Central Peak Complex

NAC has broad dynamic range, Aristarchus is no problem!

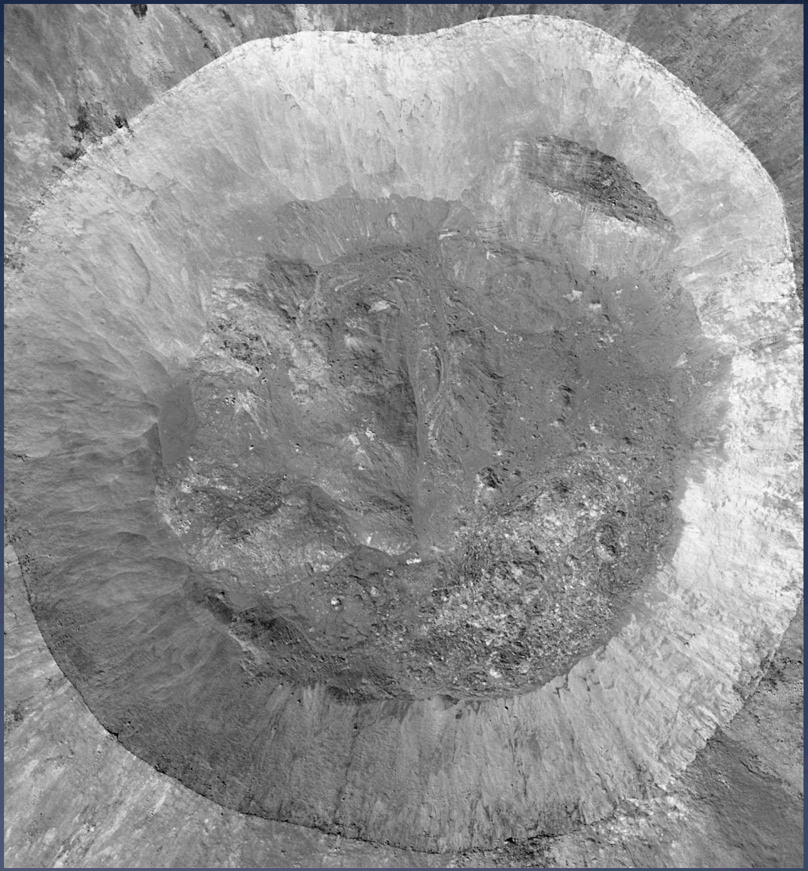
MSSS builds great Cameras!





Feature Mosaic: G Bruno

- From higher altitudes contiguous coverage can be obtained from 4 or 5 orbits with modest slews (<15°).
- Derived mosaics are a fantastic tool for mapping.
- Combined with NAC DTMs… wow!

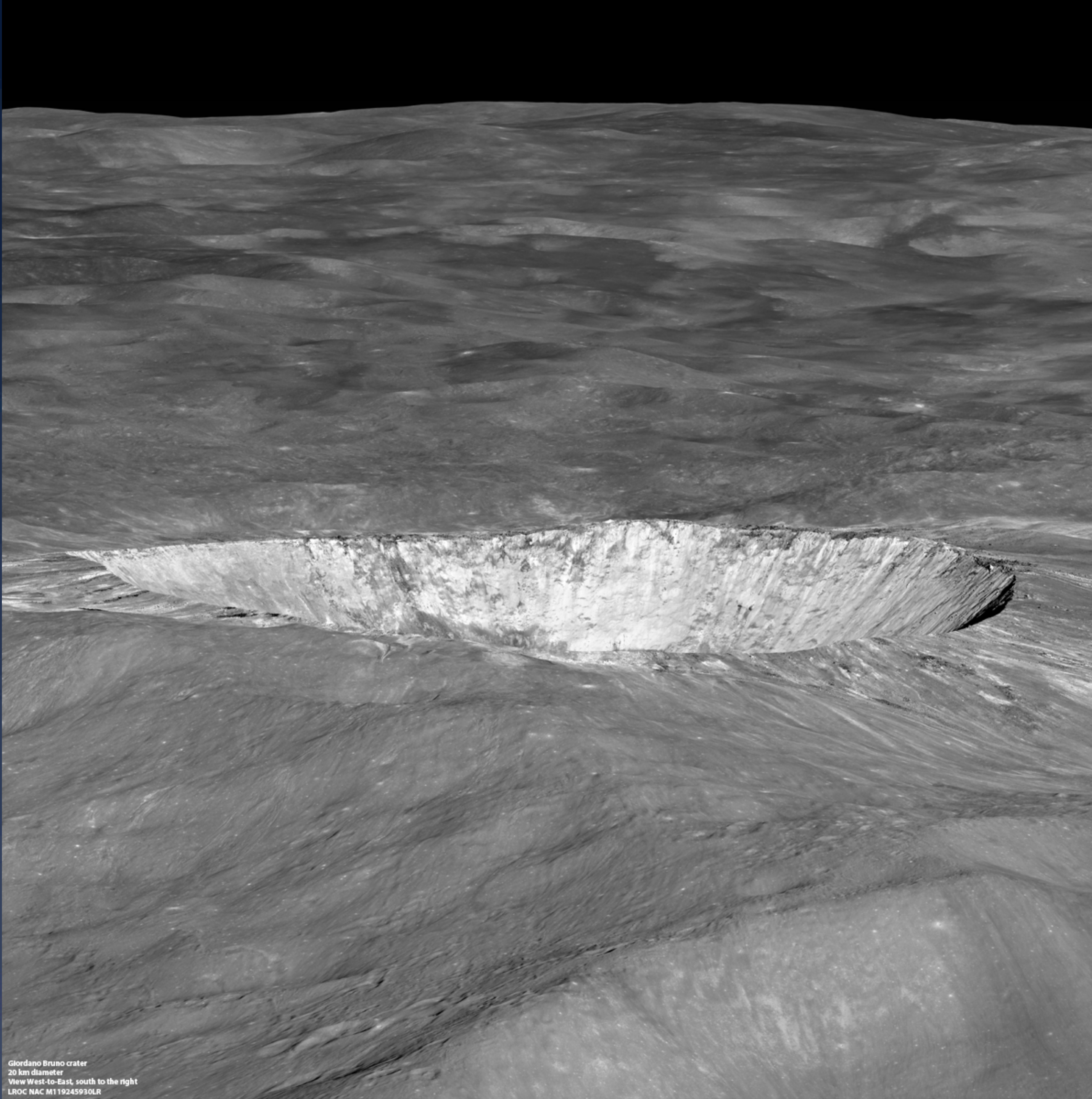


Mosaic of eight LROC NAC images provides this spectacular view of the interior of Giordano Bruno crater (21 km diameter).

Movie next slide

NAC Feature Mosaic plus 50-km Orbit Stereo DEM

Giordano Bruno Extreme Oblique (79°)



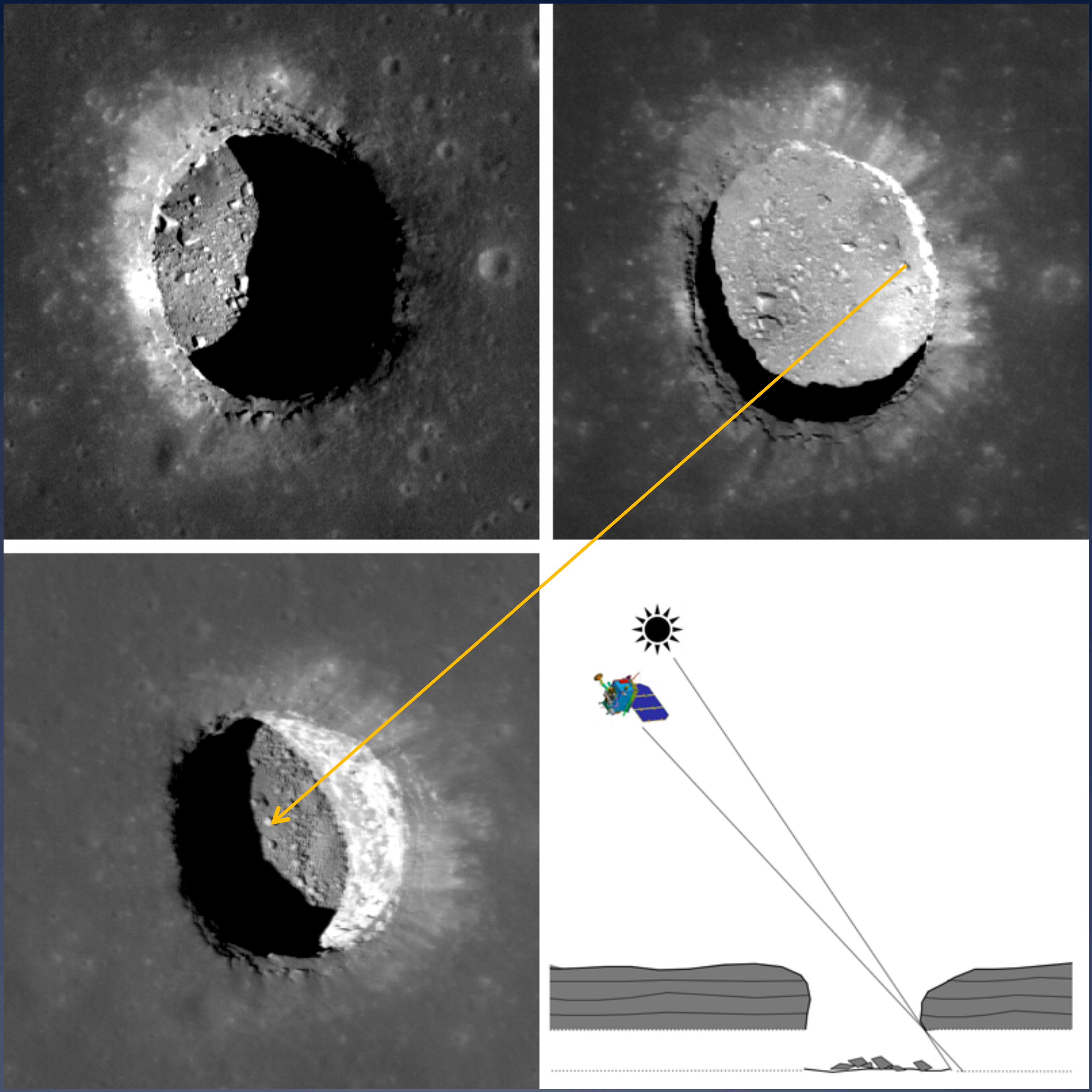
Mare PITS

- Multiple coverage scores again!
- Mare Tranquillitatis pit
- Pit diameter 100 m
- Pit depth 107 m

- Are there extant sublunarean tubes?

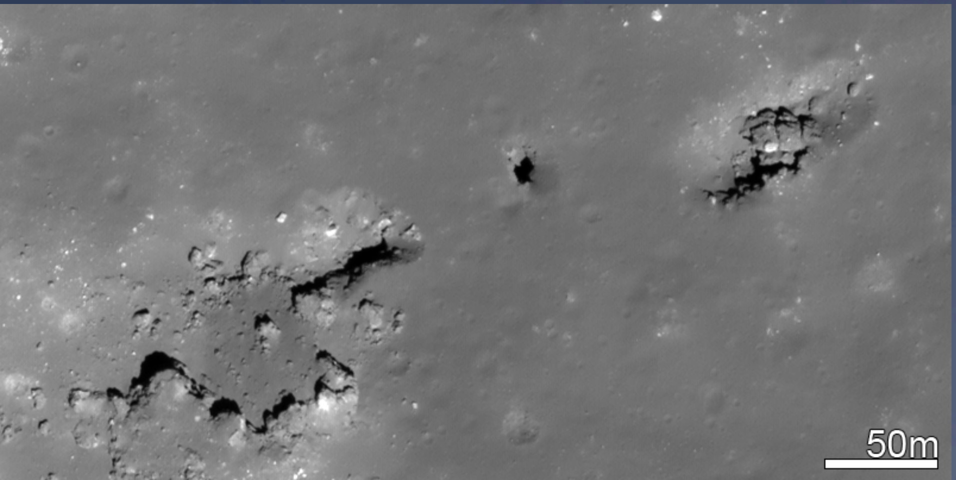
- Oblique imaging!

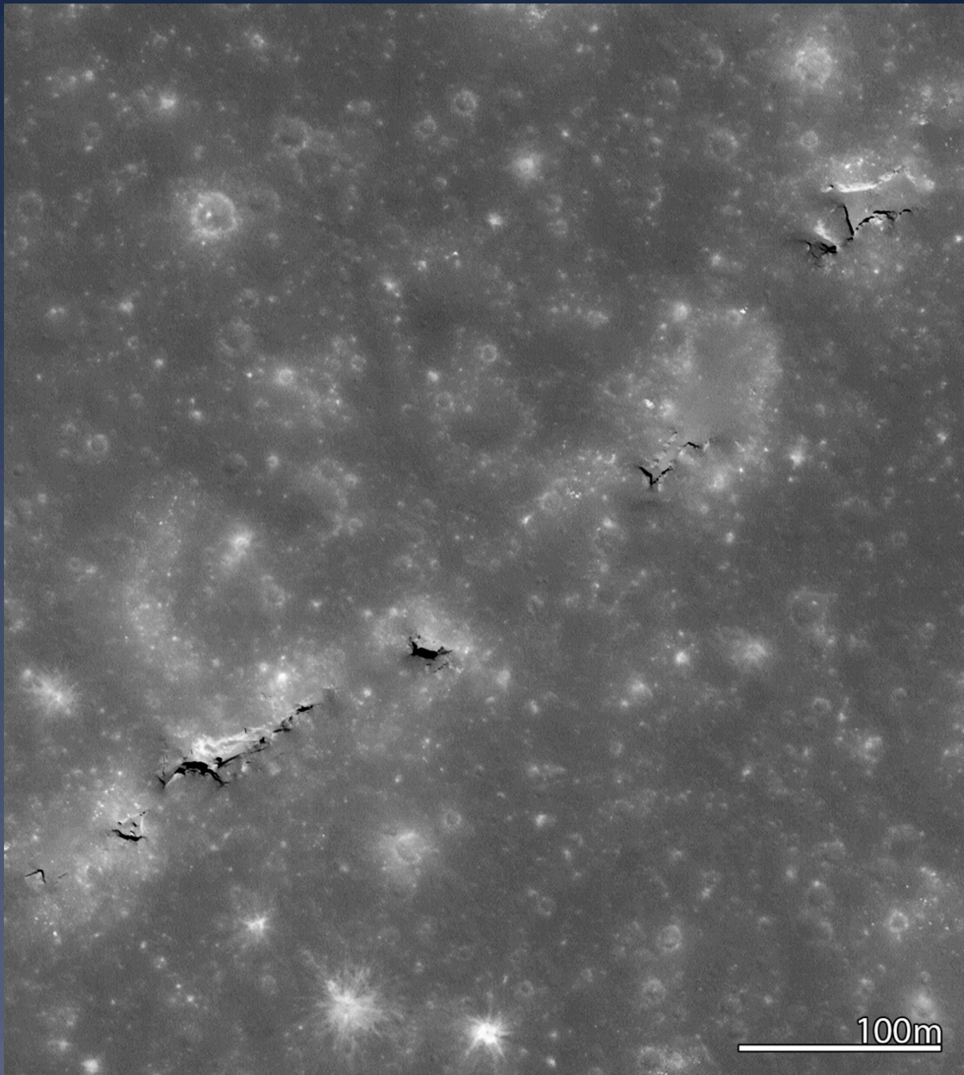
- Answer is yes – but how far?



Impact Melt Pits

- 160 pits in 25 craters (so far)
- Melt often flows after crust forms, leaving void spaces
- Melt pools had complex plumbing systems!
- *Wagner et al, Wed @ 10:30, main room*



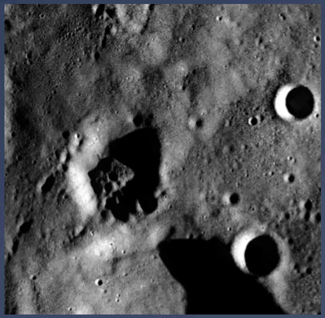


NAC Polar Mosaicking Techniques: Strategies to Optimize Uniform Illumination and Coverage

Samples of South Pole Summer Mosaics Centered at 85.9°S, 145.0°E

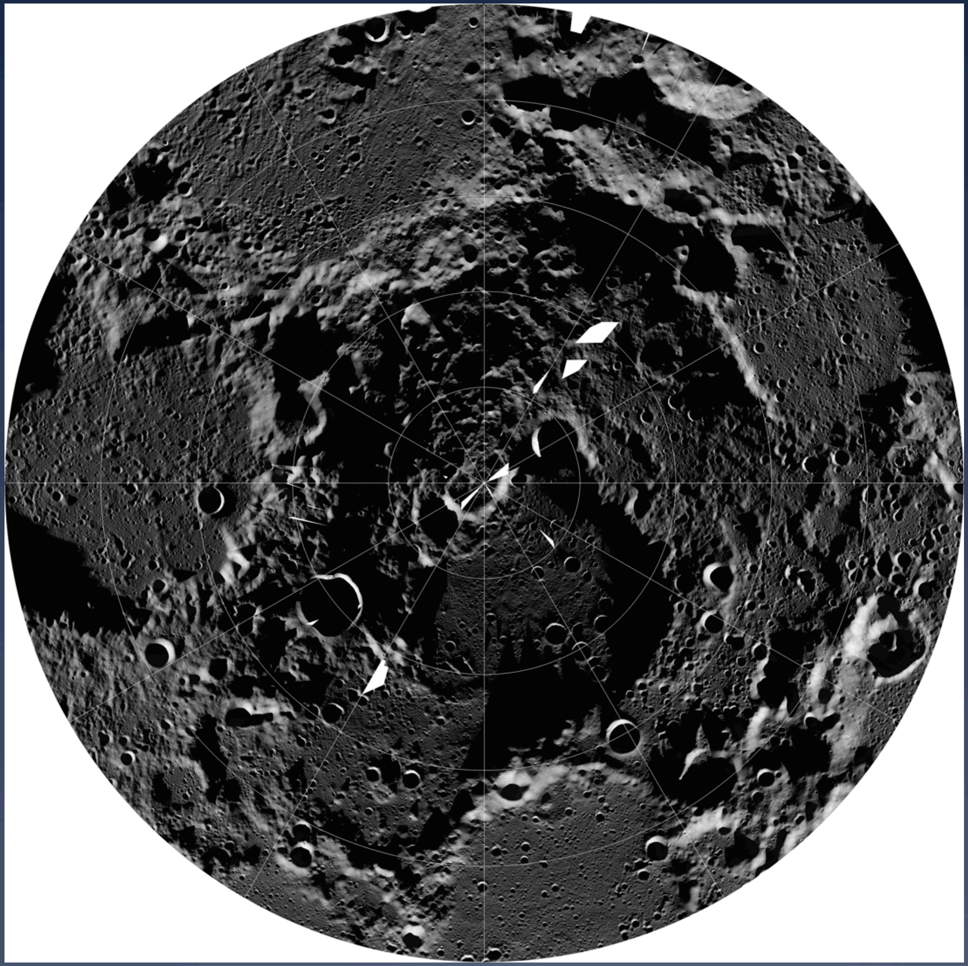
Morning (9 am)

Noon



Afternoon (3pm)

North Pole Summer Noon Uncontrolled Mosaic reduced to 25 m/pix



latitude in 1° increments
longitude in 30° increments

Images for each pole are sorted into bins of 10° of sub-solar longitude.

Four mosaics were created for each pole: using 40°, 30°, 20° and 10° of longitude centered on each of the sub-solar longitude bins.

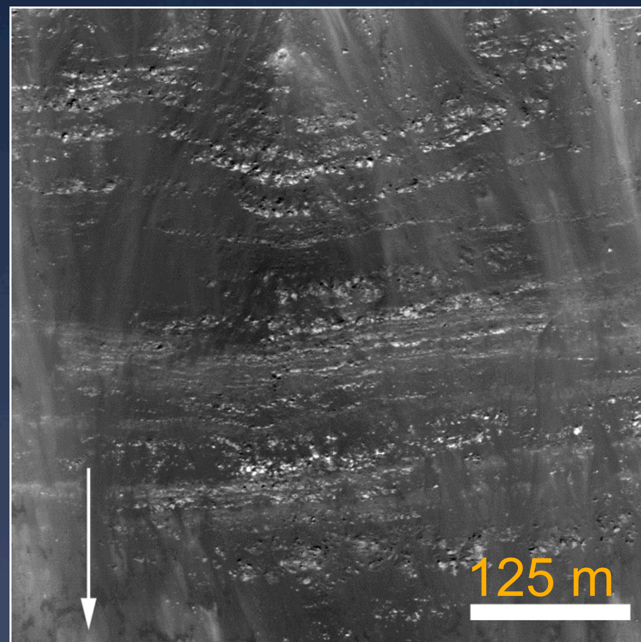
These were sequentially stacked to create noon mosaics for each pole that optimized illumination and coverage.

North and South pole morning (9am) and afternoon (3pm) mosaics were also constructed using this technique.

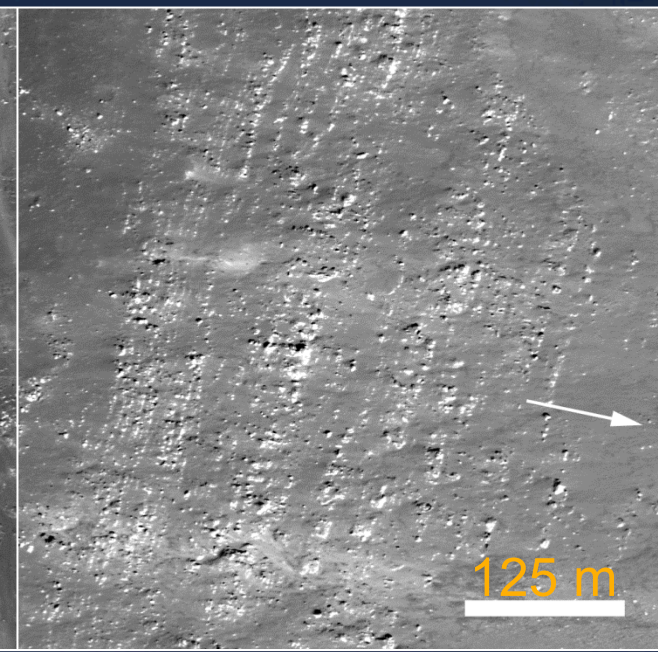
Henriksen et al Poster

Layered Mare Craters

- 1466 potential craters identified
- 272 craters with exposed layering
- 48 layered craters measured for layer thickness
  - Flows are 14 +/- 5 m
  - Outcrops are vertically extensive



Euler crater, LROC NAC M124763045LE
Layers ~ 19 m thick

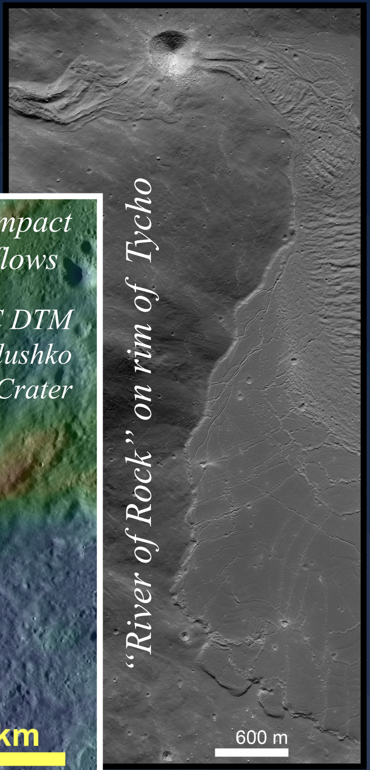


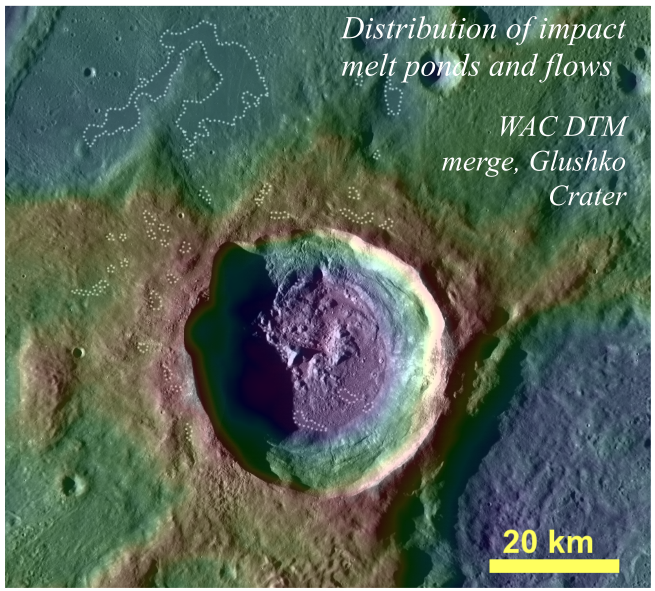
Carlini crater, LROC NAC M111754983RE
Layers ~7 m thick

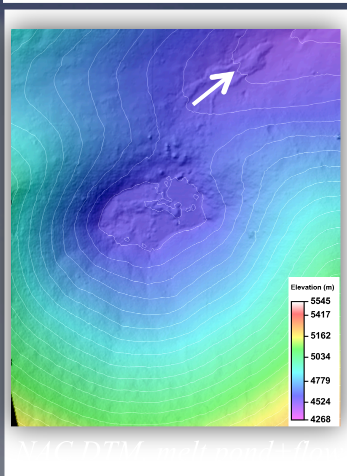
Enns and Robinson poster

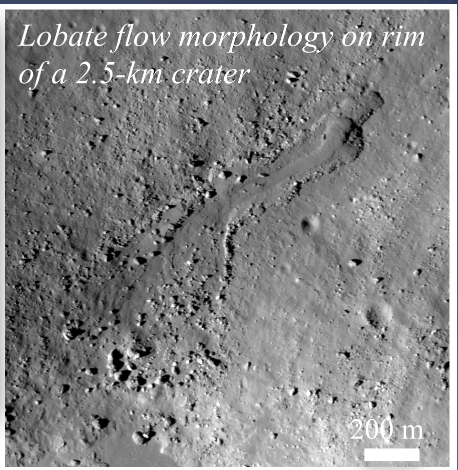
Impact Melt Production and Emplacement Mechanisms

- LROC NAC and WAC images reveal global distribution of impact melt-rich lithologies at crater scales from tens of meters to basin size
  - Evaluate the potential effects of impact angle and direction, pre-existing topography, wall slumping, crater and peak uplift that influence the asymmetric ejection of low velocity impact melts from the crater cavity
  - Assess occurrence melt as a function of crater size, target properties, and impact angle
- NAC and WAC-derived topography
  - Determination of rheology and temperature of melt from melt deposit dimensions and morphology (e.g., Denevi et al. 2012, Icarus)
  - Calculate volumes of melt production, retention and ejection to better calibrate current models largely based on terrestrial impact crater volumes, which can be significantly eroded, and laboratory-scale experiments
  - Calculate angles and velocity of melt emplacement assuming ballistic trajectory and using melt morphology and local topography to determine the horizontal velocity component as a function of distance from the crater rim









Stopar et al. (WED AM), see also Koeber et al poster

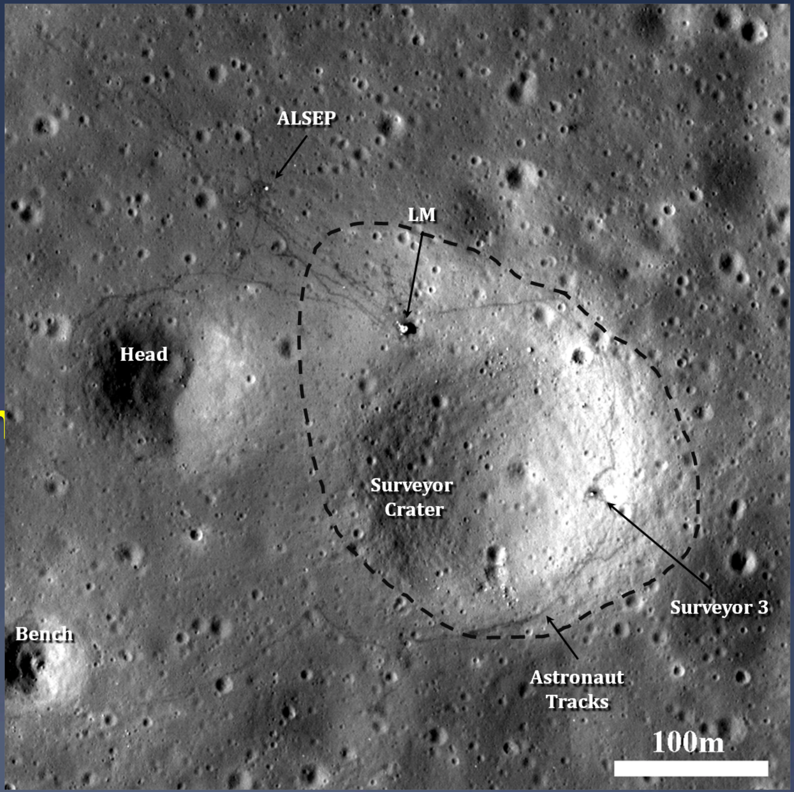
Landing Site Photometry

- Effects of the Apollo (and Surveyor and Luna) descent engine plumes are visible as photometric anomalies at the landing sites in NAC images.

-Phase-ratio images indicate that blast zones are more forward scattering (less backscattering) than undisturbed background regions.

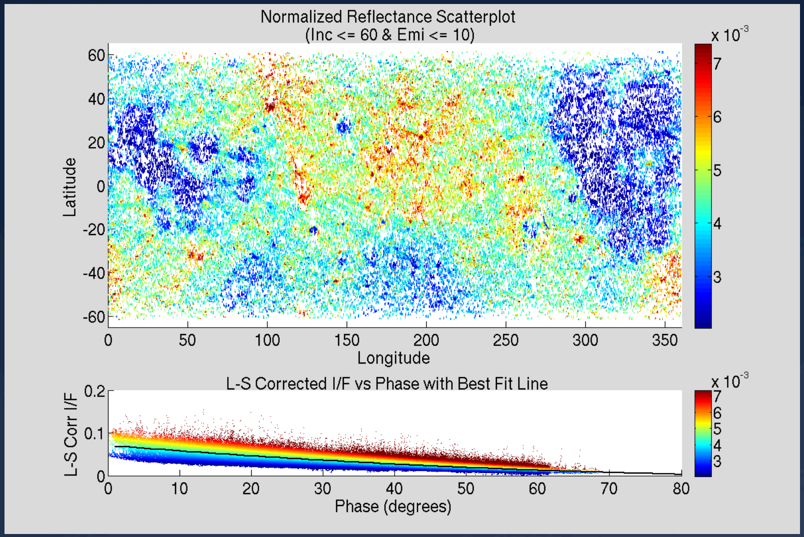
-Destruction of fairy-castle structure and/or smoothing of small-scale topography may explain this reduction of backscattering characteristics.

Talk: Clegg et al., Wednesday, 10:30 am.



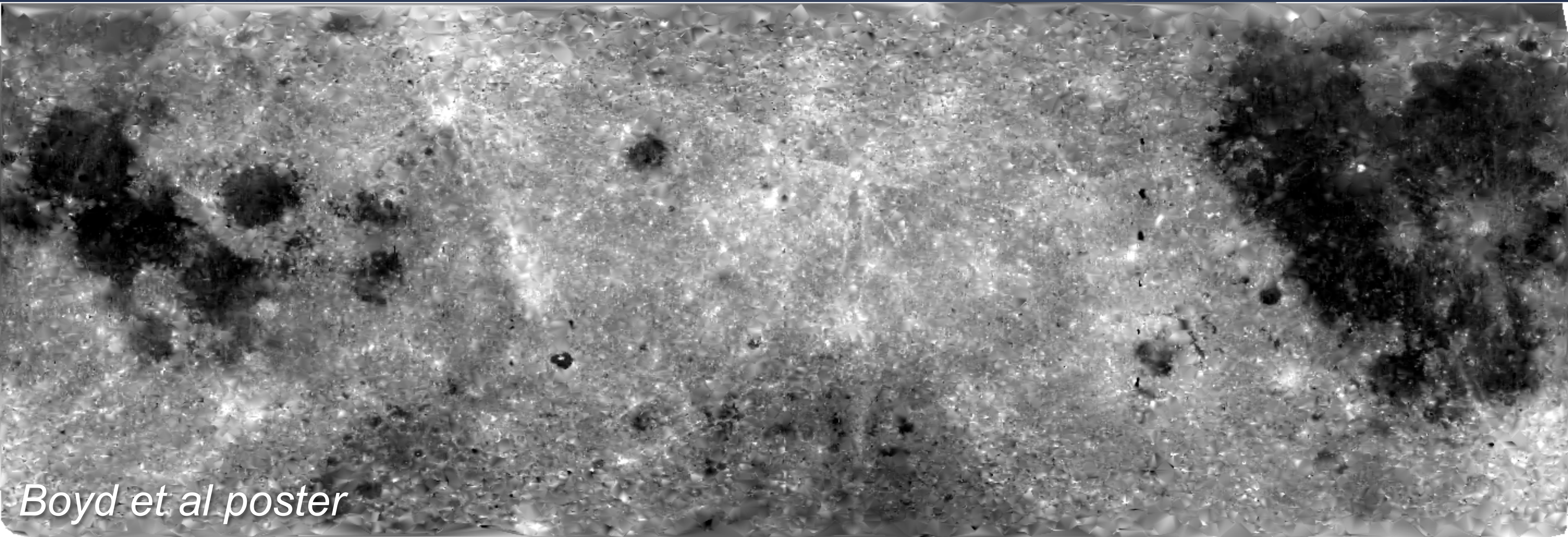
Apollo 12 and Surveyor 3, image M120005333L

NAC Photometry



- 212,413 NAC images were processed
- NAC images were filtered by incidence angle ≤ 60° and emission angle ≤ 10° leaving 95,928 Images
- 2500 m x 2500 m (5000x5000 native NAC pixels) tiles were created from the images for improved resolution
- Lommel-Seeliger Bidirectional Reflectance Distribution Function was used as the initial correction followed by a quadratic fit of the L-S Corrected I/F to phase angle

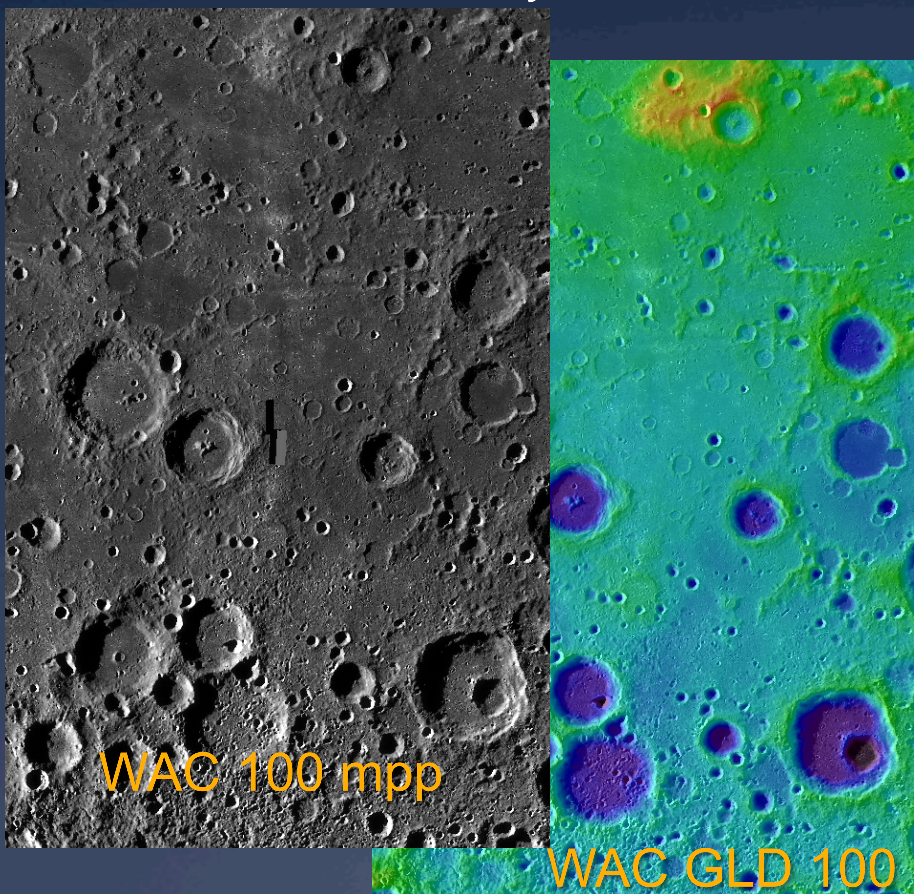
NAC Normalized I/F (4 pix/deg)

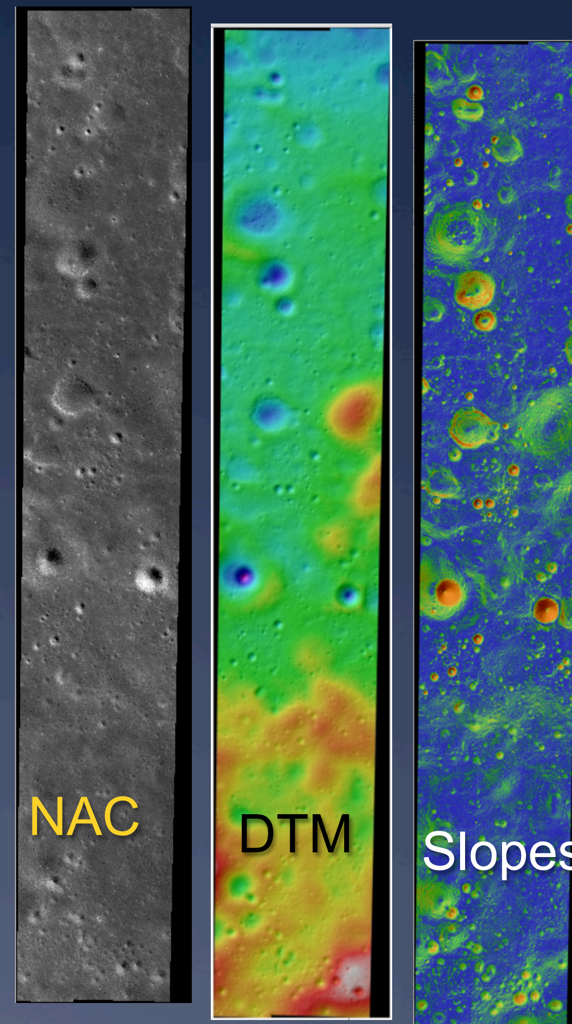


LRO Targeting of the South Pole-Aitken Basin for the Extended Science Mission

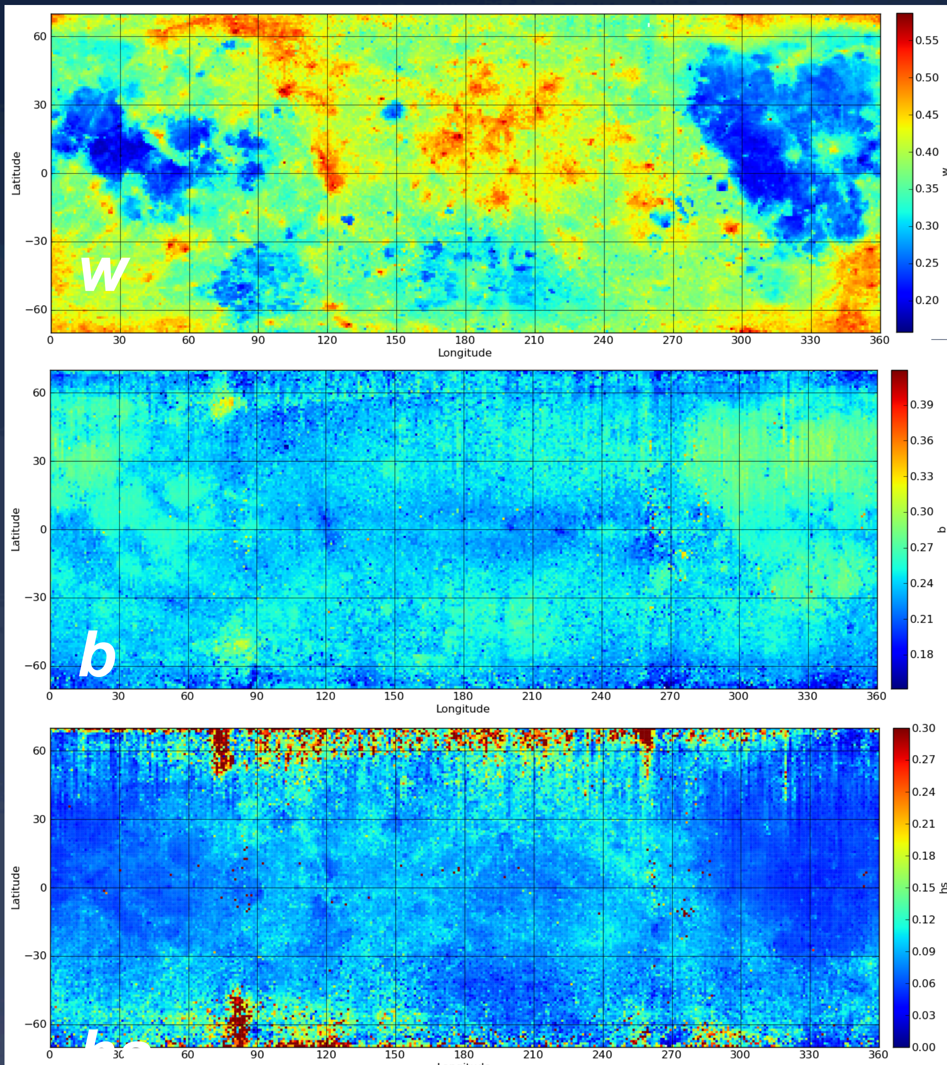
Targeting within SPA for science analysis and landing-site assessments (including geometric stereo) is a priority for LROC in the extended science mission.

Jolliff et al., Thursday, 9:15 am

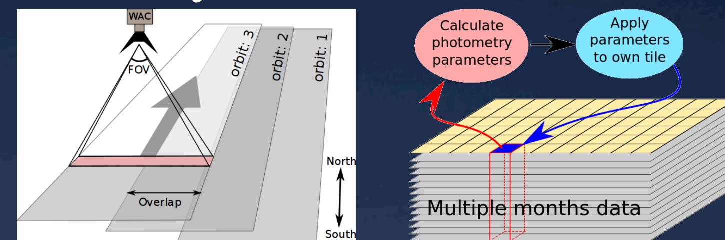




WAC photometric parameter maps



Tile-by-tile method



Spatially resolved photometric parameters of Hapke bidirectional reflectance model for the Moon from 23 months of WAC data sets, employing “tile-by-tile” method.

w: Single scatteing albedo

b: H-G phase function parameter, related to the surface roughness, opacity of the regolith grains

hs: Angular widths of shadow hiding opposition surge effect, related to the filling factor of the regolith

Sato et al poster

643 nm band

WAC Global Topography