

Lunar Polar Illumination

What We Know & What We Don't

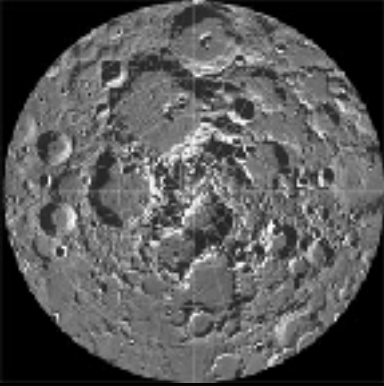


Ben Bussey

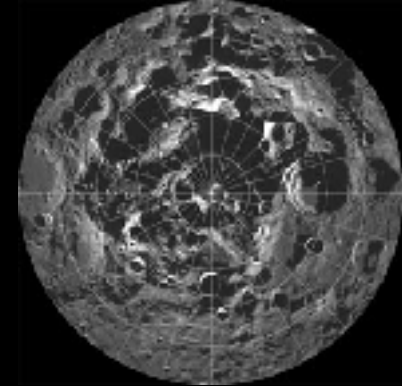
Paul Spudis

*Planetary Exploration
Group*

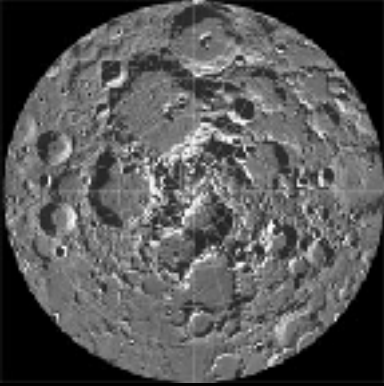
*The Johns Hopkins
University Applied
Physics Laboratory*



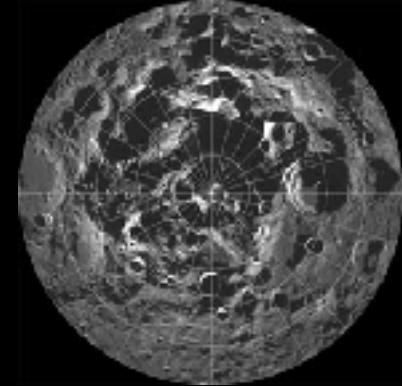
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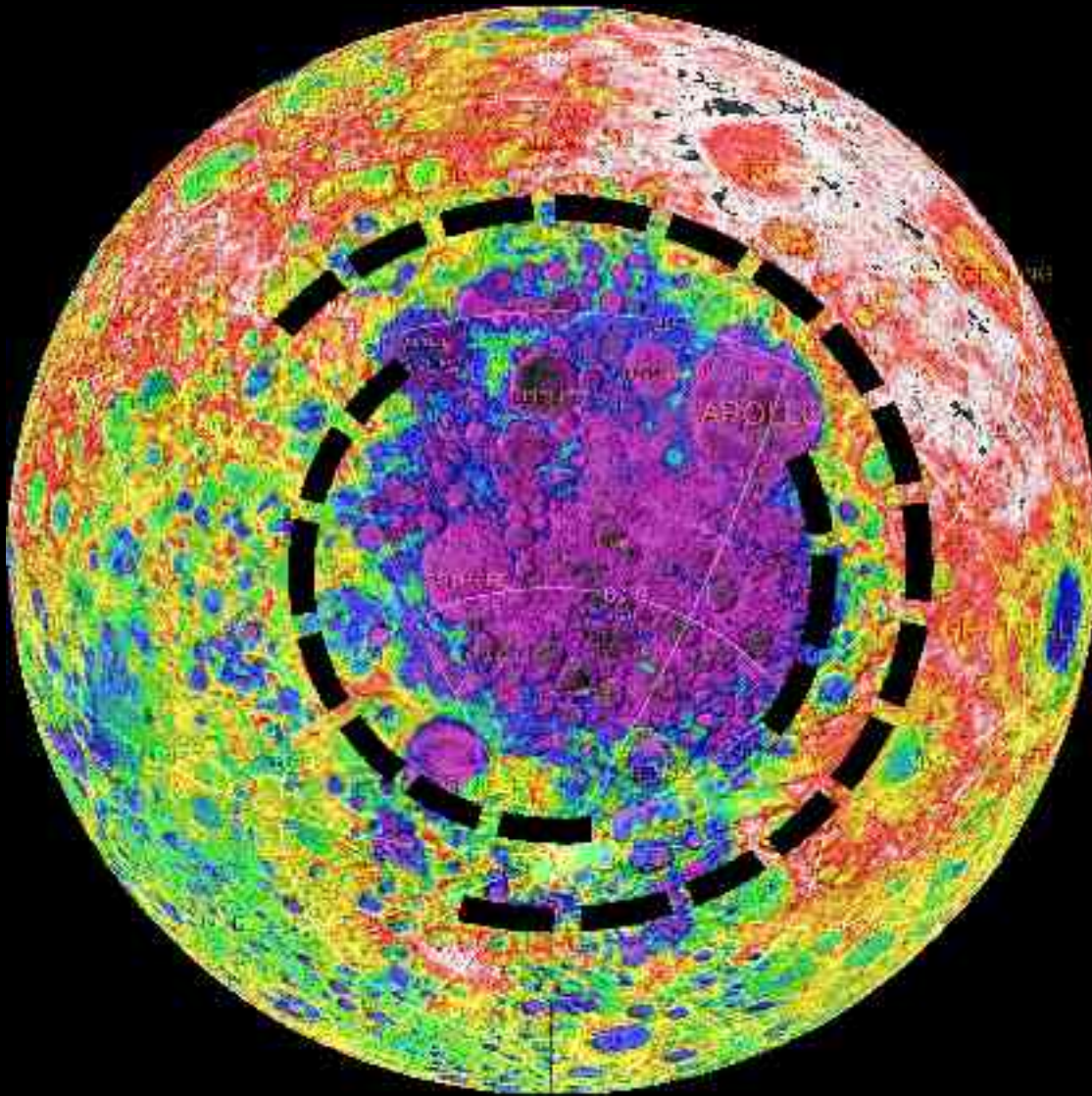


Lunar Poles

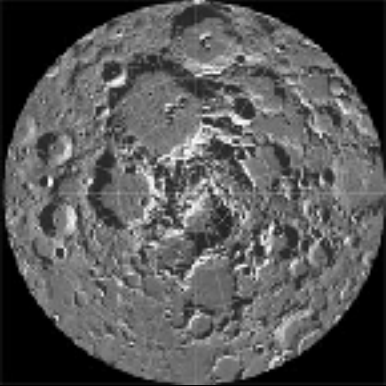


- Interesting for both operational and scientific reasons
- Spin axis 1.5° from the perpendicular to the ecliptic plane results in special illumination conditions
- Sun always close to the horizon during the 708 hour lunar day
- Permanently shadowed regions are cold traps ($< 100\text{K}$) and are possible locations of ice deposits
- Poles offer abundant solar power and relatively benign operational environment ($220 \pm 10\text{K}$)
- Light is a resource too!

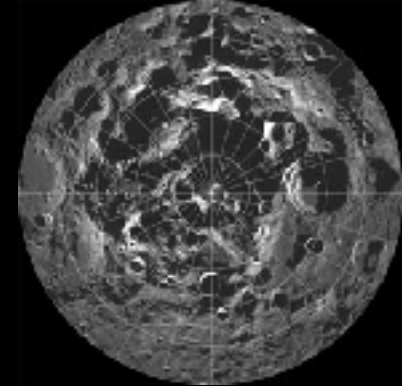
Location
Location
Location



- South pole inside SPA basin rim.
- 2800 km diameter
- Mantle deposits?
- Quiet farside



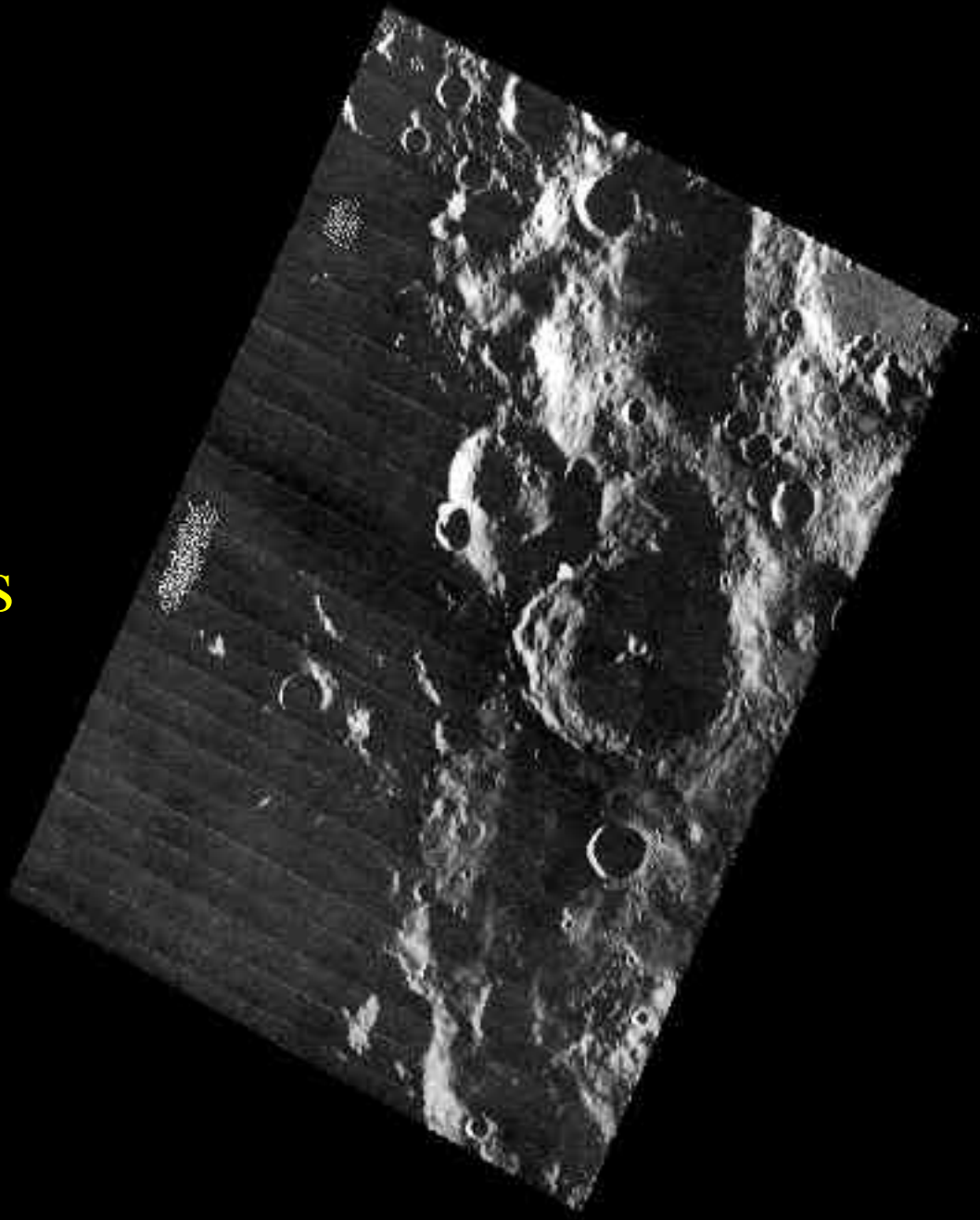
Available Data



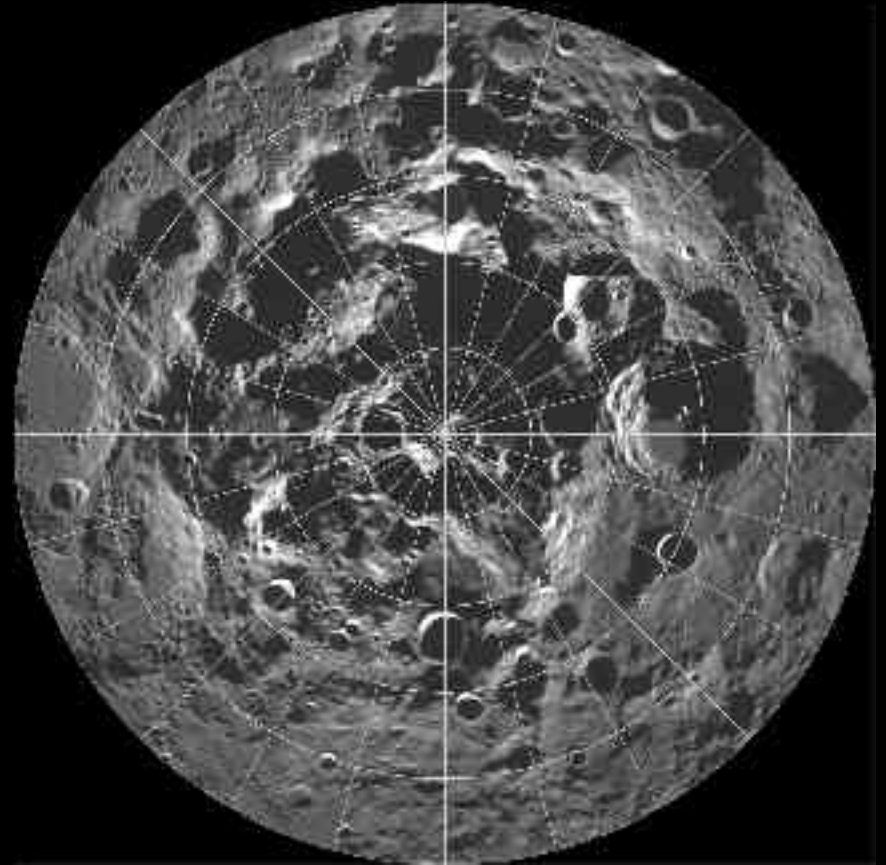
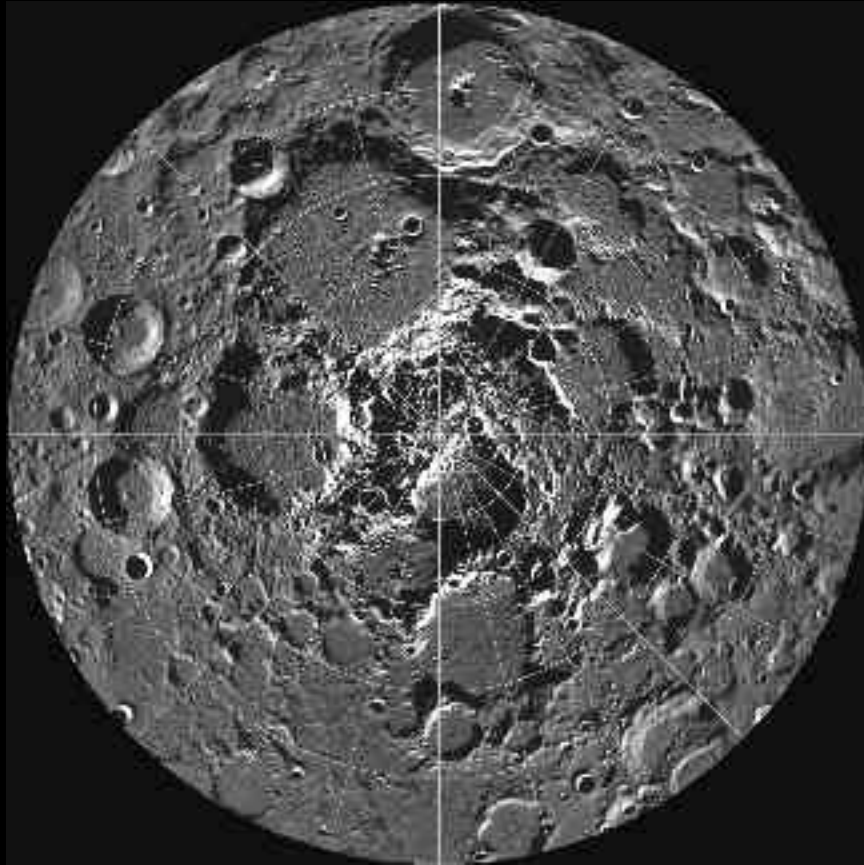
- Four missions imaged the poles
 - Lunar Orbiter
 - Mariner 10
 - Galileo
 - Clementine
- Absolute polar topography is unknown
- Clementine Stereo & Earth based radar provide our best view

Lunar Orbiter IV

- Relatively few images
- LO concentrated on equatorial regions because of Apollo
- CM imaging all equatorial



Clementine



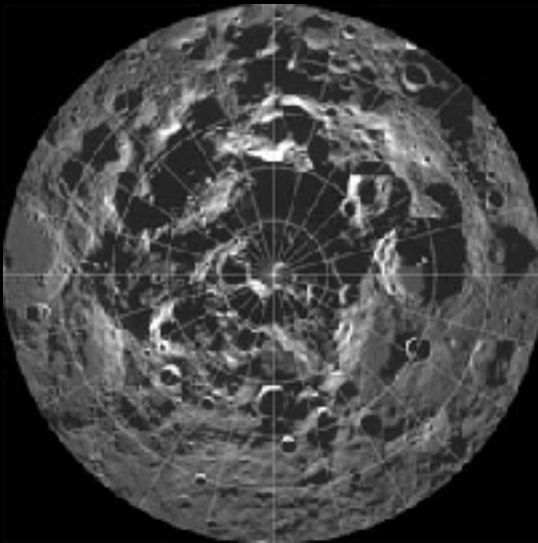
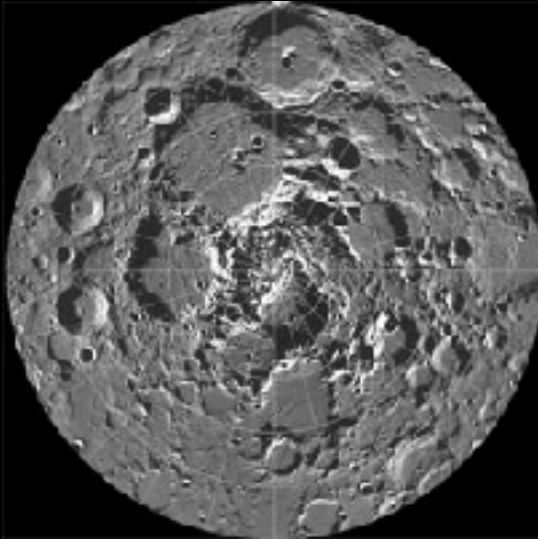


Ideal Data

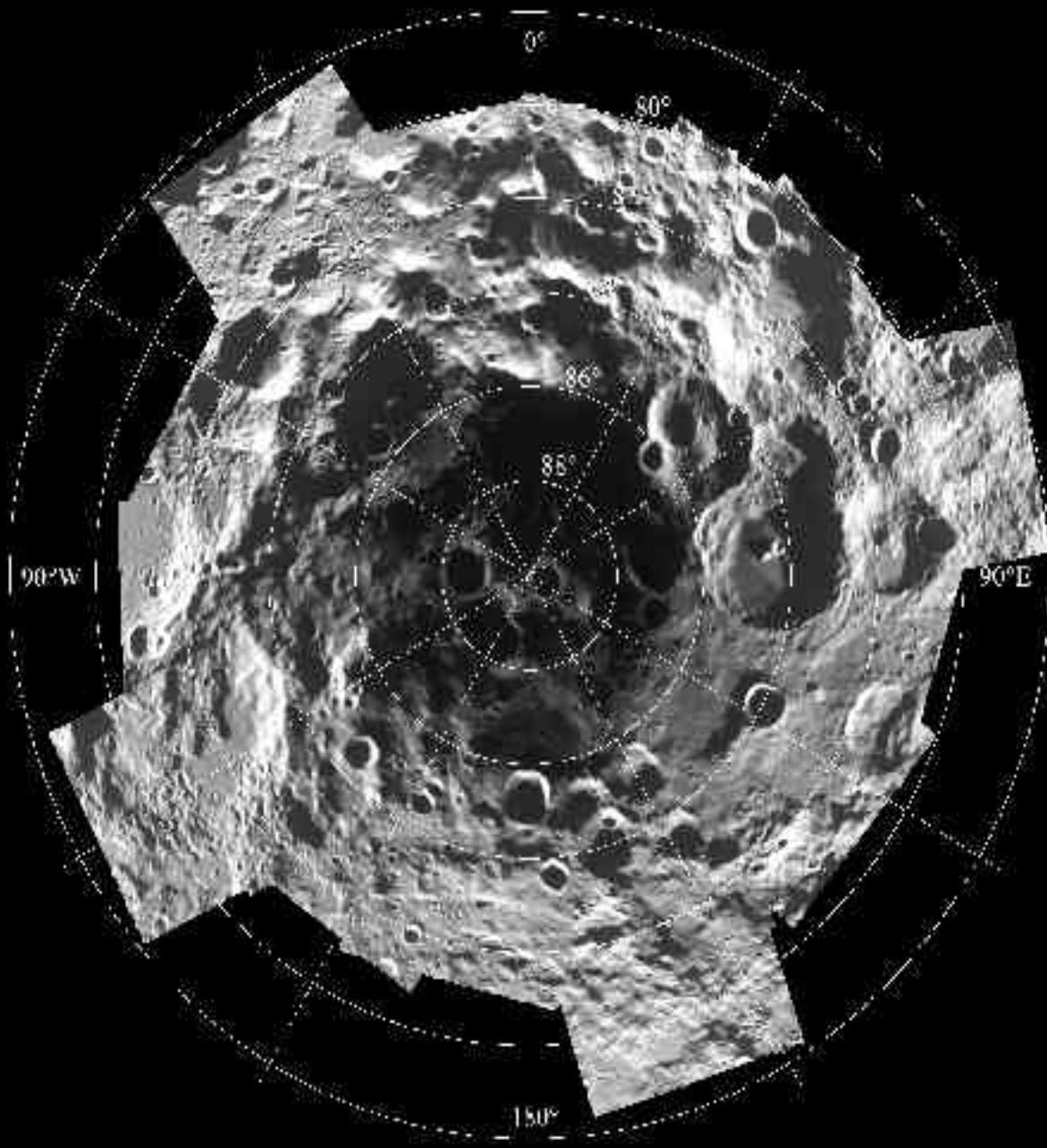
- Large FOV
- Frequent coverage
- All seasons
- High resolution topography

Where is it light?

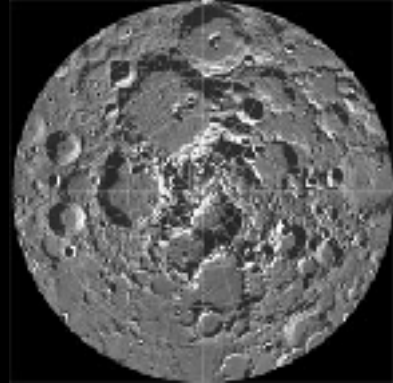
Clementine's View of the Poles



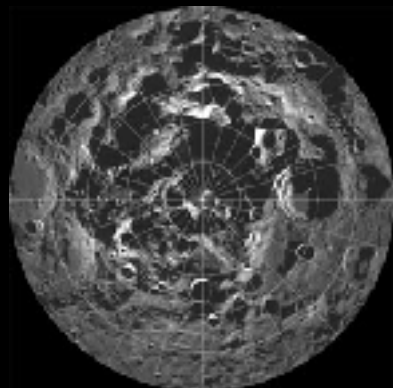
- Imaged each pole every 10 hours for 71 days
- Data collected during winter in the southern hemisphere
- Perilune change produces two resolutions, 250 & 500 m/pixel
- High resolution data collected at 15 m/pixel



South Pole 750 nm

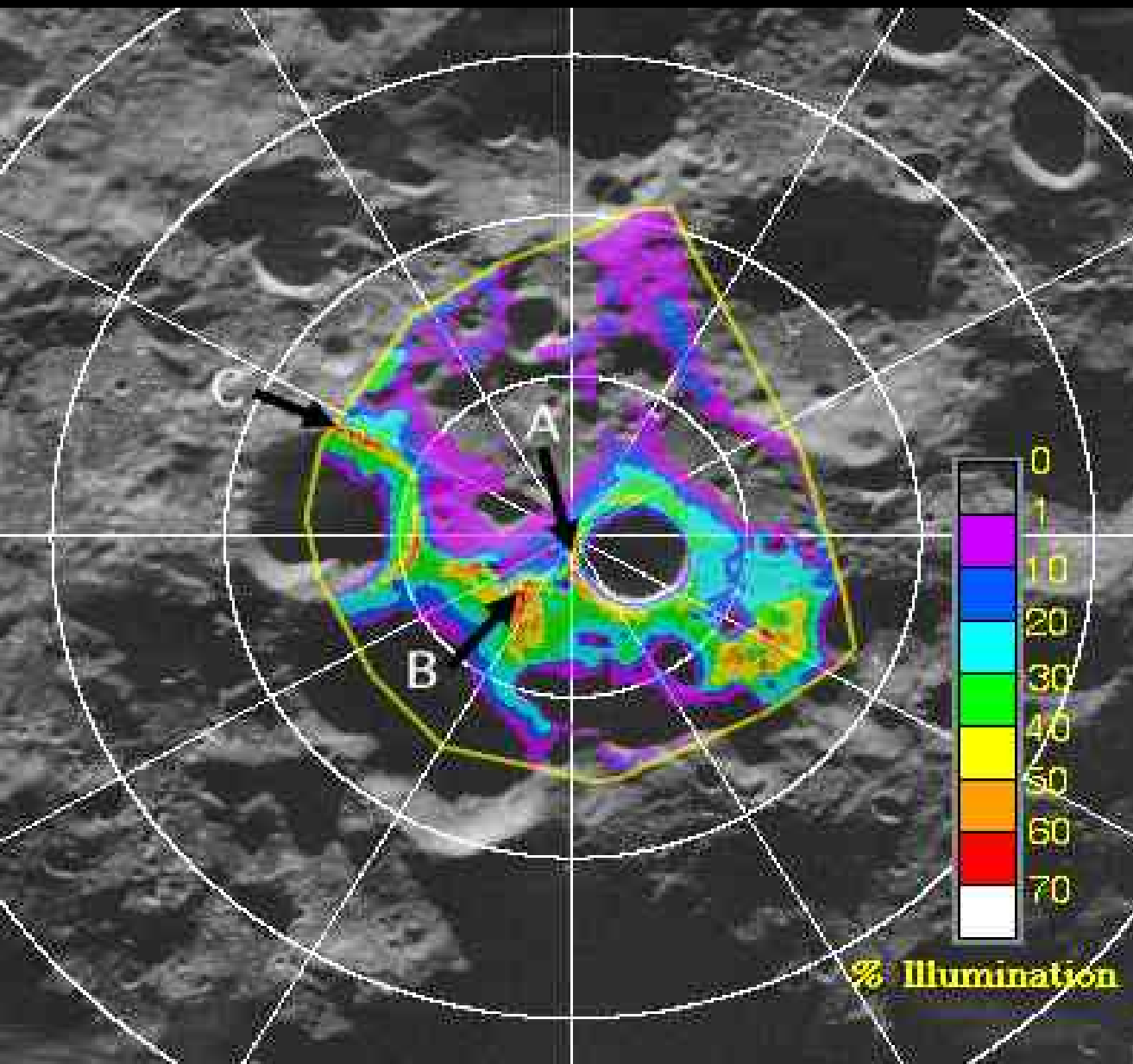


South Pole Movie

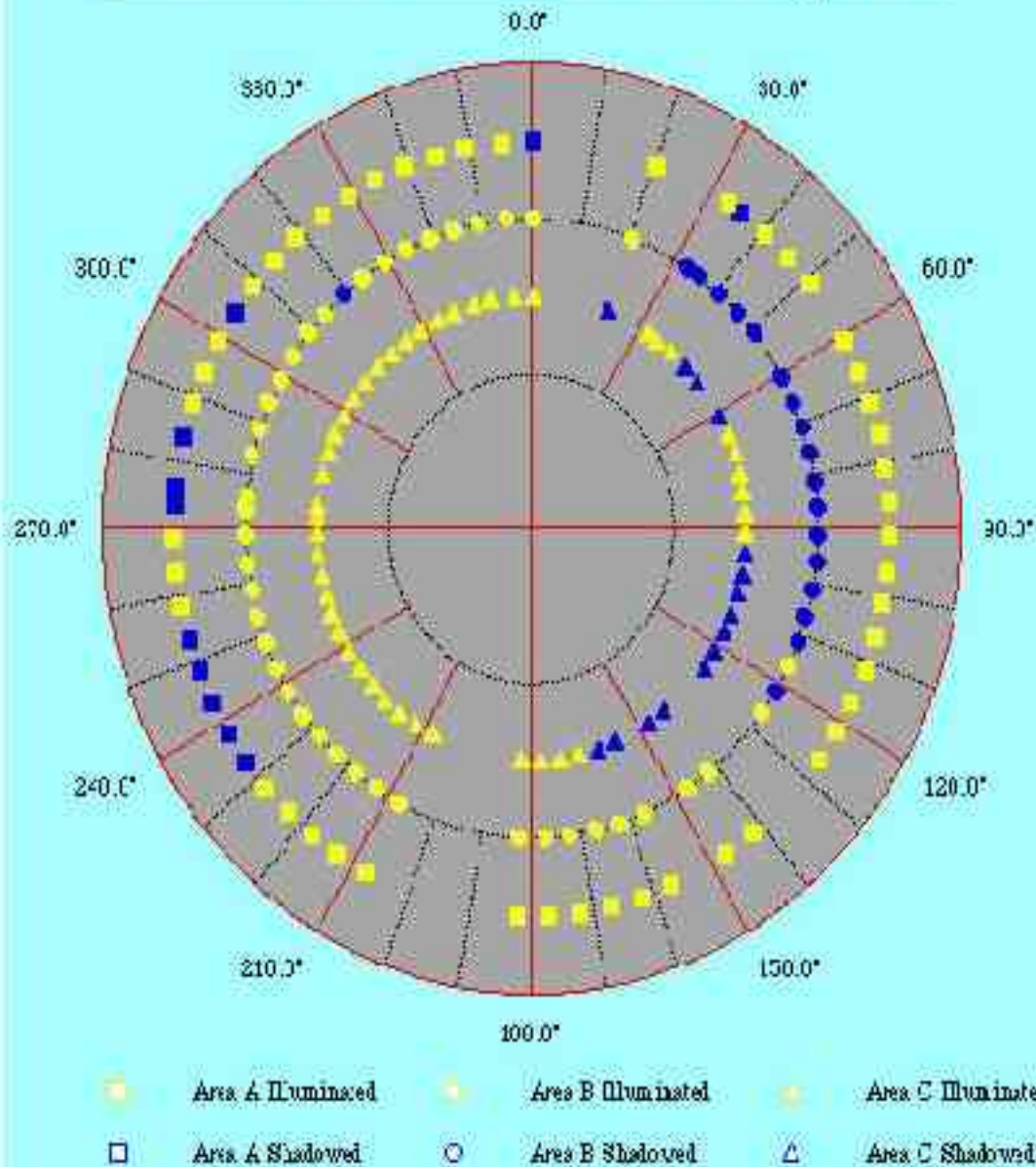


Quantitative Illumination Map

- No constant illumination
- A,B,C lit more than 70% of a winter day
- A&B collectively lit > 98%



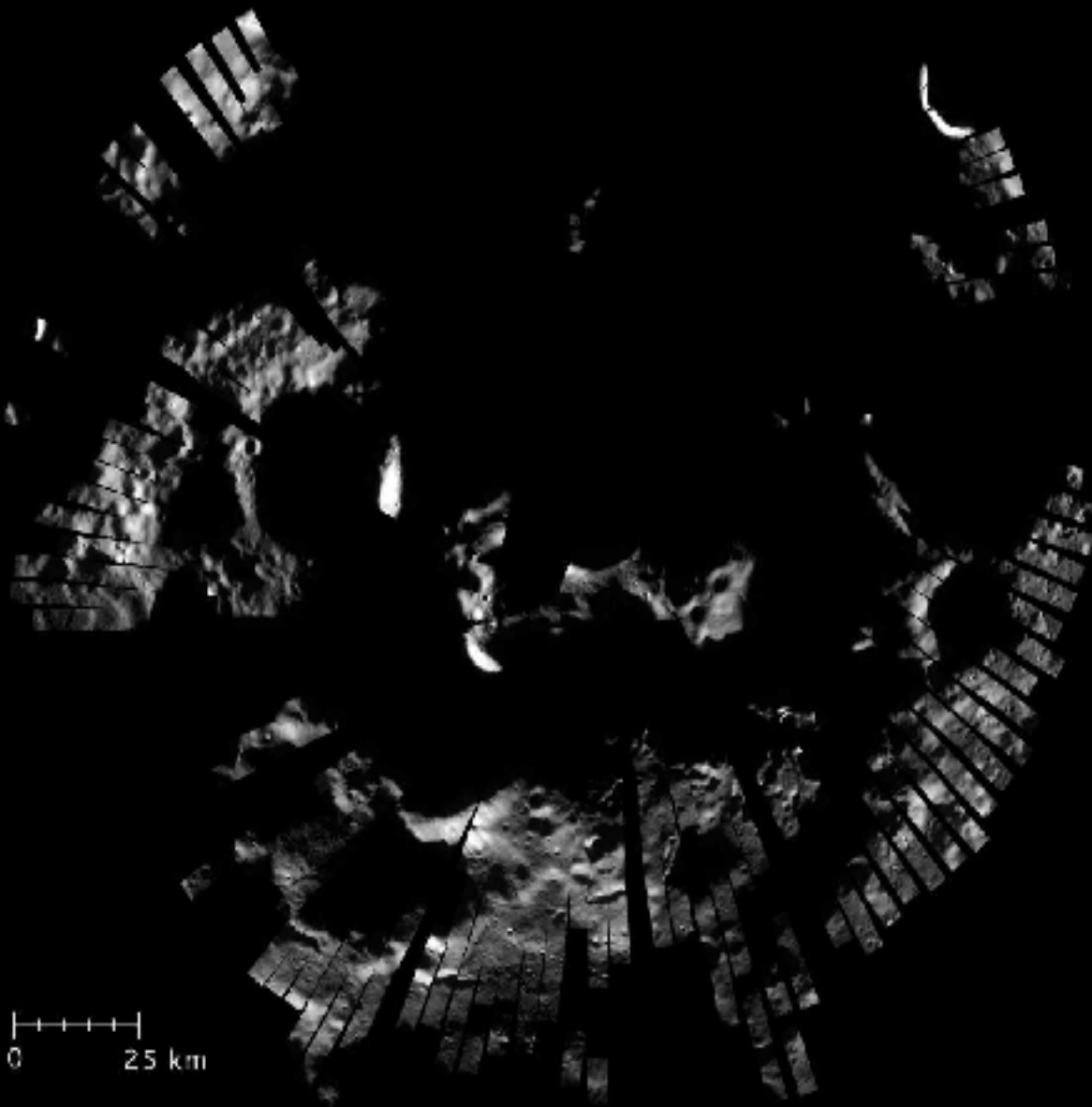
Illumination Conditions at Areas A, B & C



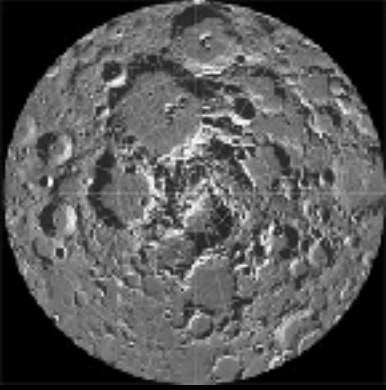
Illumination Profiles

- No constant illumination
- A,B,C lit more than 70% of a winter day
- A&B collectively lit > 98%

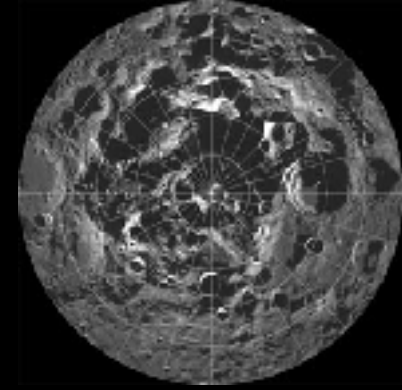
High
Resolution
South Polar
Mosaic
(20 m/pixel)



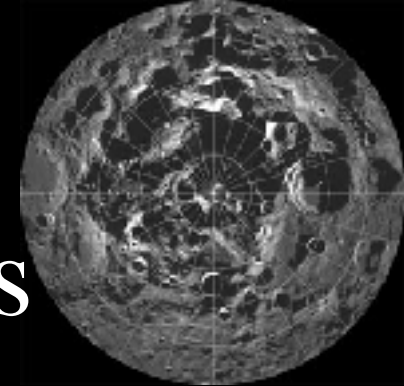
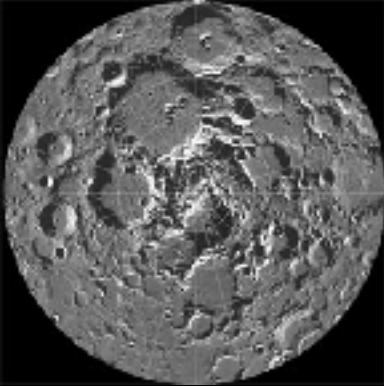
0 25 km



Conclusions



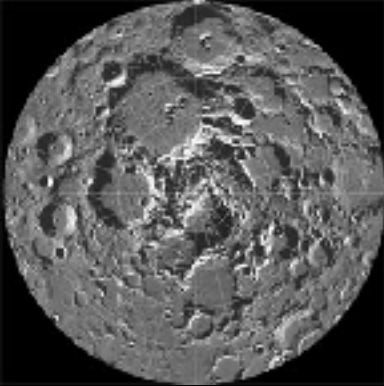
- No continuously illuminated areas at the south pole. Possibly at the north.
- Extensive dark regions at both poles, potential locations for ice deposits.
- Widely distributed highly illuminated areas.
- Potential for constant solar power



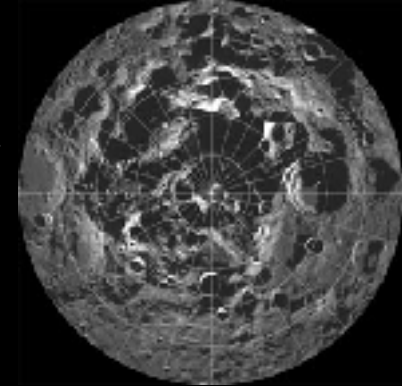
Where is it dark? Topography Simulations



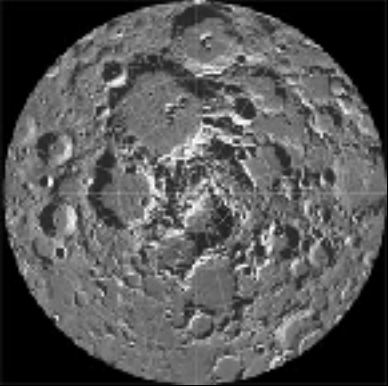
- Current illumination coverage is limited.
- Simulations permit investigations of all lighting conditions.
- Lunar topography data exist (Margot et al., 2000; Cook et al., 2000).
- Lunar crater profiles are known (Pike, 1977).



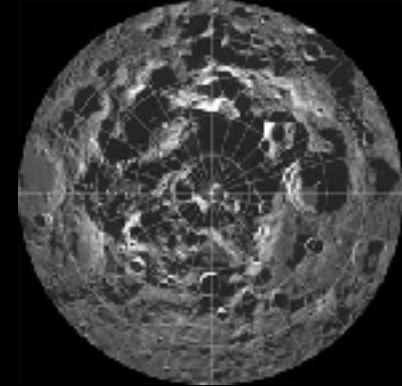
Topography Simulation Results



- Both topography datasets produce reasonably accurate results.
- Radar topography produces more accurate simulations but are constrained to nearside illumination direction due to the spatial coverage of DEM.
- Stereo topography permits equally accurate simulations for all illumination directions.



Simulated Simulations

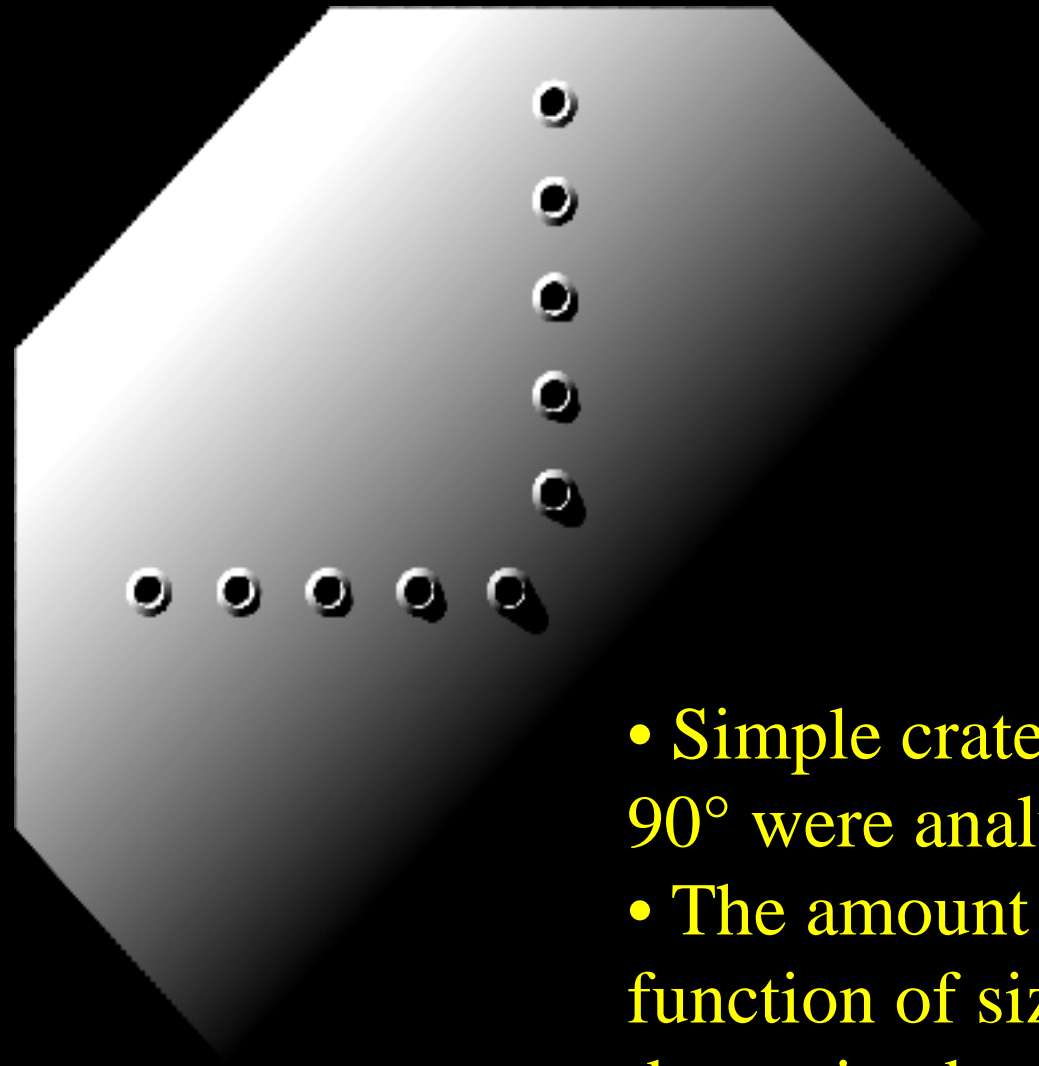


20 km Crater Profile

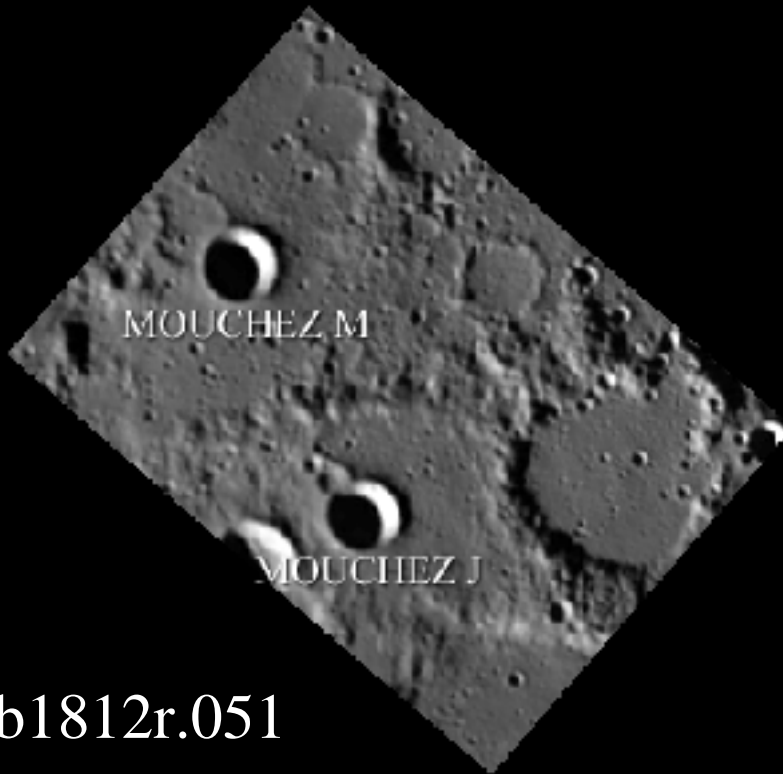


- Crater profiles for lunar craters are known (e.g. Pike, 1977).
- Investigate amount of permanent shadow in simple craters as a function of size, and location.

Topography simulations



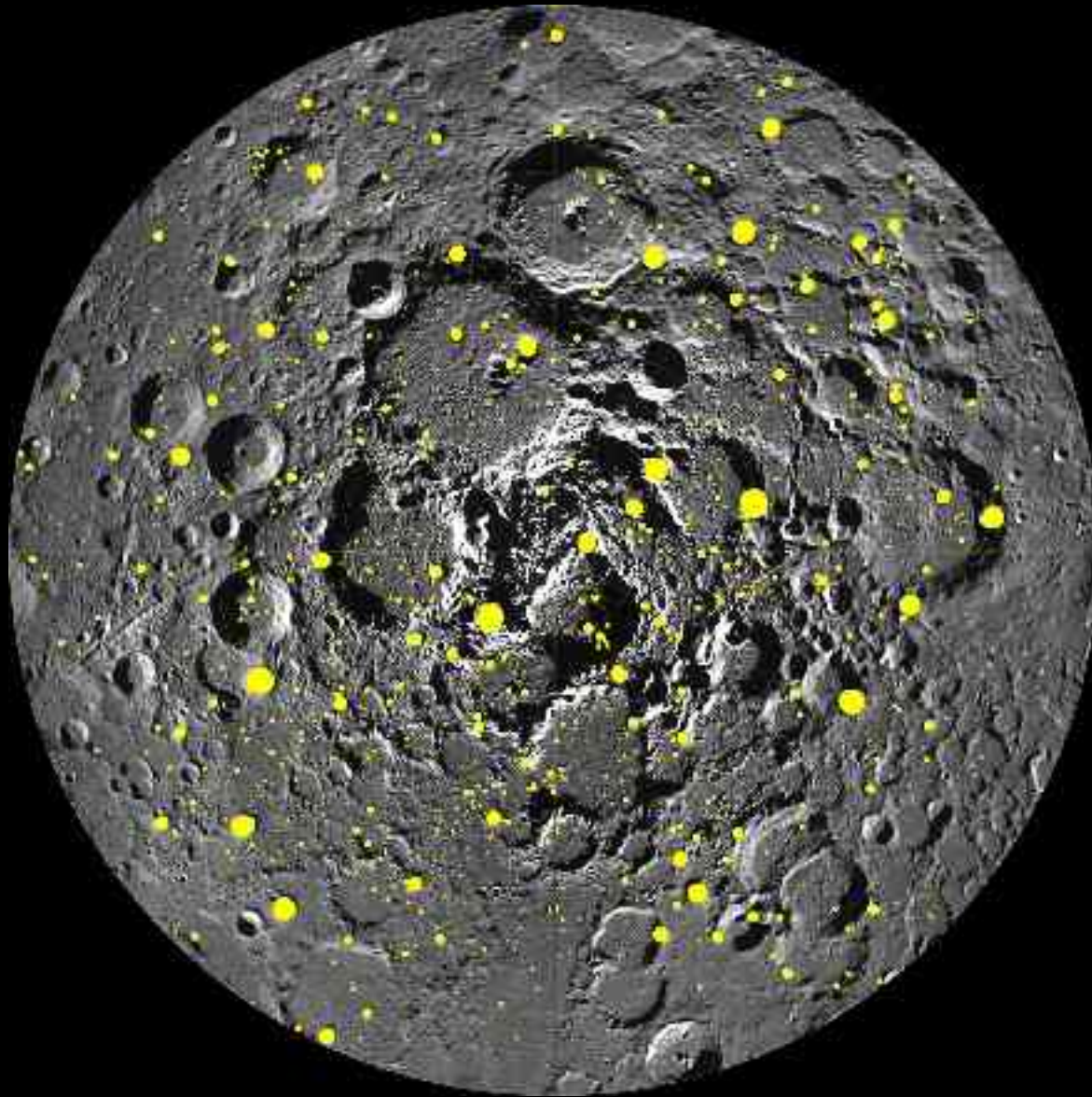
- Simple craters (< 20 km) from 70° to 90° were analyzed
- The amount of permanent shadow as a function of size and location was determined



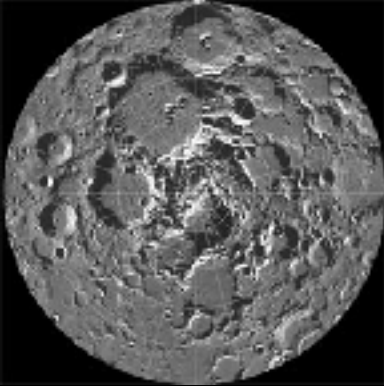
lub1812r.051

$$S = (0.9465 \times D) + (0.0202 \times \theta^2) - (0.009258 \times \theta \times D) - 78.06$$

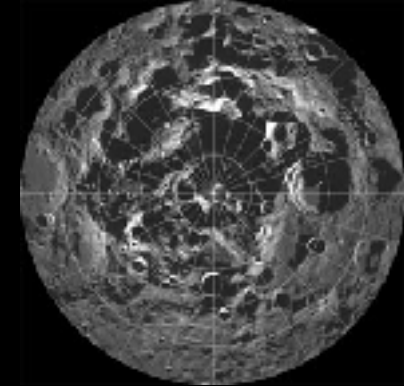
Permanent Shadow



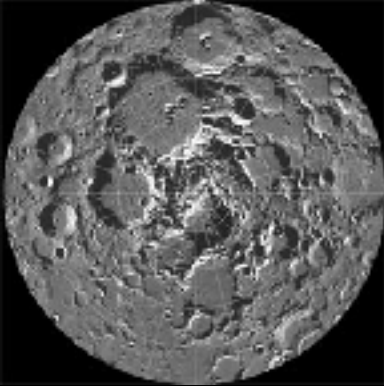
- 1000's km² of permanent shadow in simple craters at both poles
- Permanent shadow exists in simple craters at long distances from the pole
- Represent possible locations of volatile deposits



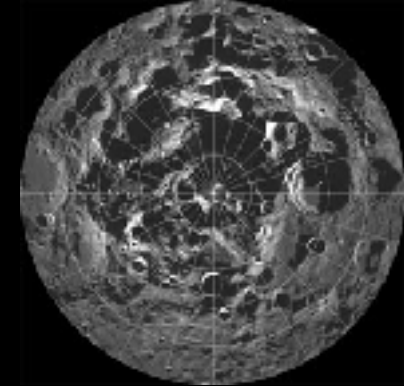
Lunar Reconnaissance Orbiter



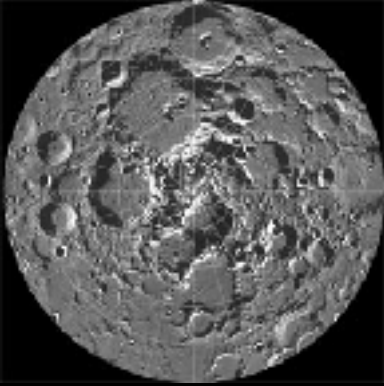
- Launch by the end of 2008.
- Two primary goals are global geodetic control and analysis of polar regions.
- 50 km polar orbit for 12 months
- Possible payload: lidar, radar, neutron spectrometer, radiometer, imager



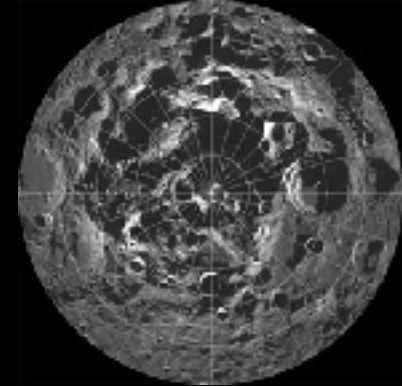
Objectives/Requirements Definition Team



- **Global topography with 10-m vertical accuracy at 3-km equatorial cross-track and 30 m along-track sampling**
- **Characterize surface morphology in regions of permanent shadow at ~50 m spatial resolution.**
- **Characterize abundance of hydrogen within the upper 1 m to 20% accuracy and ~5 km resolution, with 100 ppm detection limit.**
- **Characterize the temperature, from 35-200 K, of the polar cold traps to 1 km spatial resolution and 5 K precision.**
- **Identify putative deposits of appreciable near-surface water ice in polar cold traps at ~100 m spatial resolution.**
- **Measure illumination conditions, within 5 deg of the poles, to ~ 100 m spatial resolution and 5 hr temporal resolution.**



International Lunar Missions



- **ESA's SMART-1**
 - AMIE, 27 m/pixel
- **India: Chandrayaan-1**
 - 5 m spatial, 40 km swath
 - Laser altimeter with 10 m vertical accuracy
- **JAXA: SELENE**
 - 10 m/pix & 20 m/pix cameras
 - Laser altimeter, 1Hz 5 m height resolution
- **China: Chang'e-1**
 - Acquire 3-D lunar images