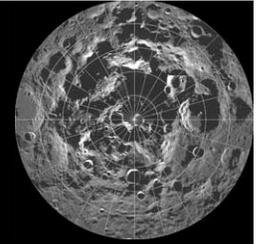


Lighting Conditions for the Moon's Poles



Josh Cahill, Ben Bussey, Daven
Quinn, Andy McGovern
JHU/APL

Paul Spudis
LPI

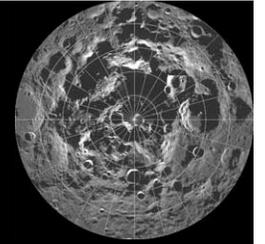
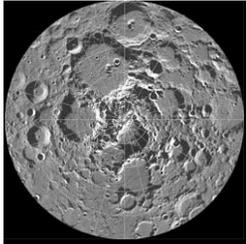
Soren Sorensen
UCL

Hiroto Noda, Hiroshi Araki,
Yoshiaki Ishihara
JAXA



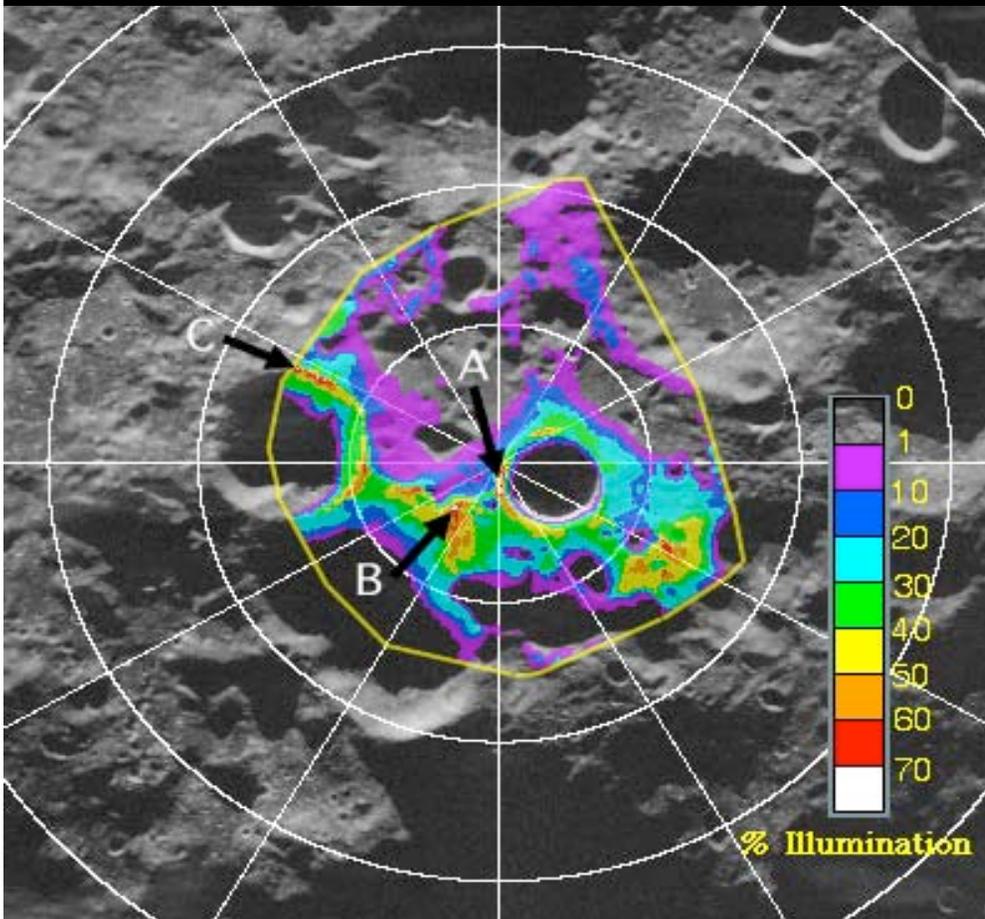
Clementine + Kaguya + LRO





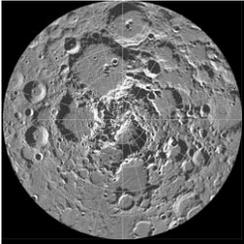
Clementine

Optical

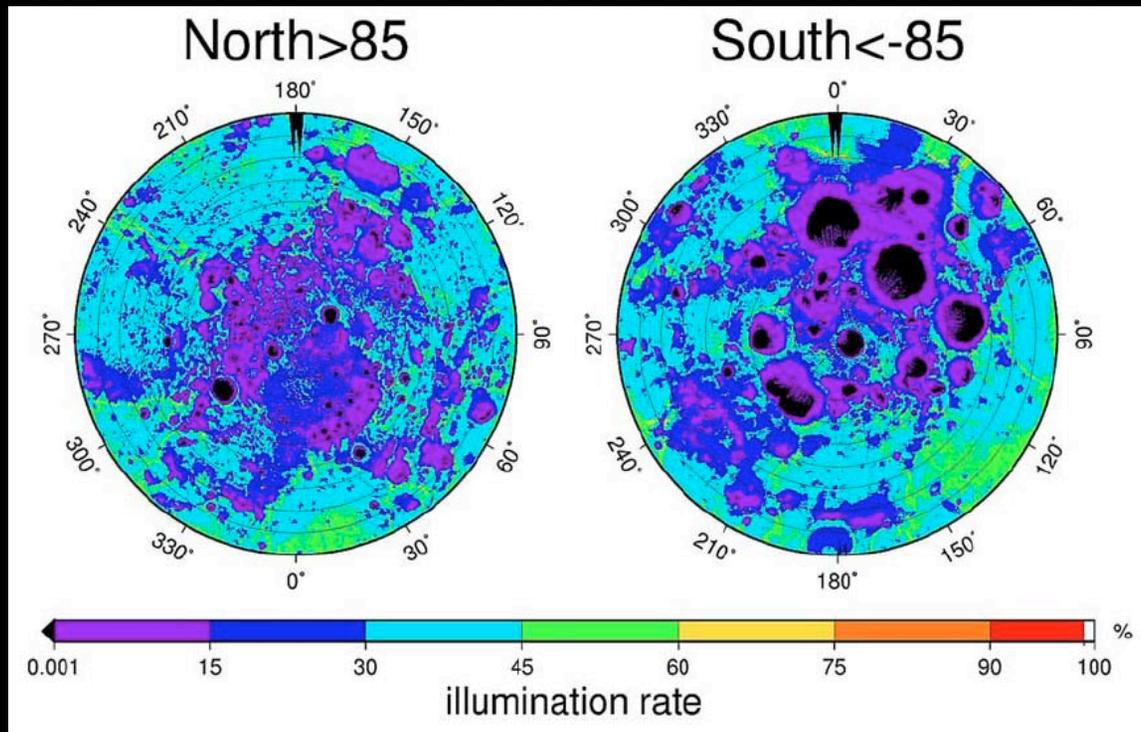
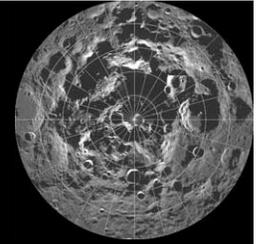


- Used 1994 Clementine optical data
- Identified four locations of high interest due their near continuous illumination

Bussey et al., GRL 1999



Kaguya Topography

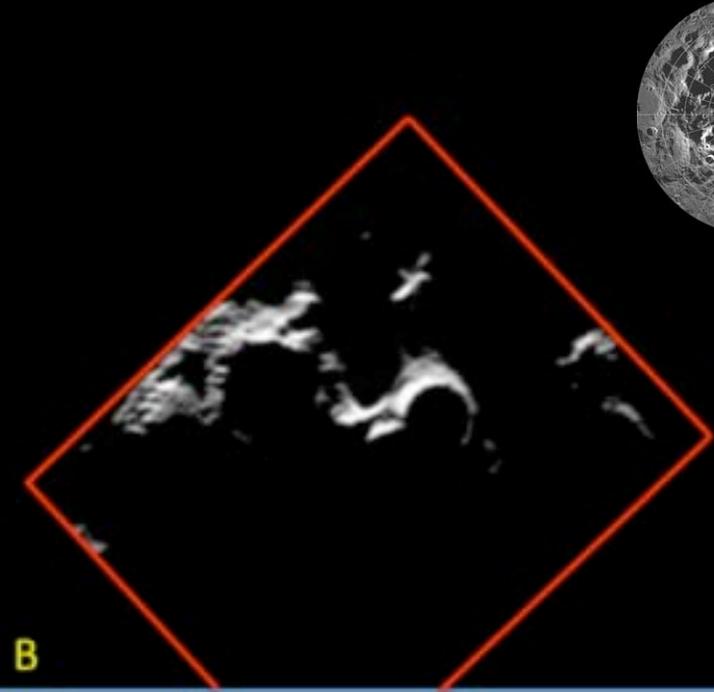
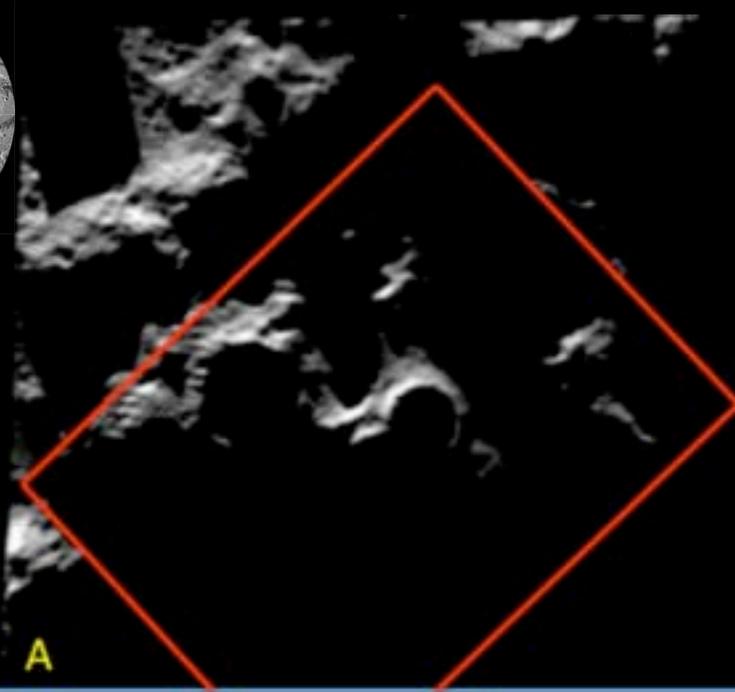
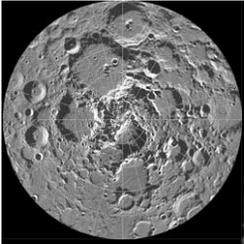


- 1 Hz 1064 nm laser
- 40 m spot size
- 5 m vertical accuracy
- 500 m/pixel spatial

Findings

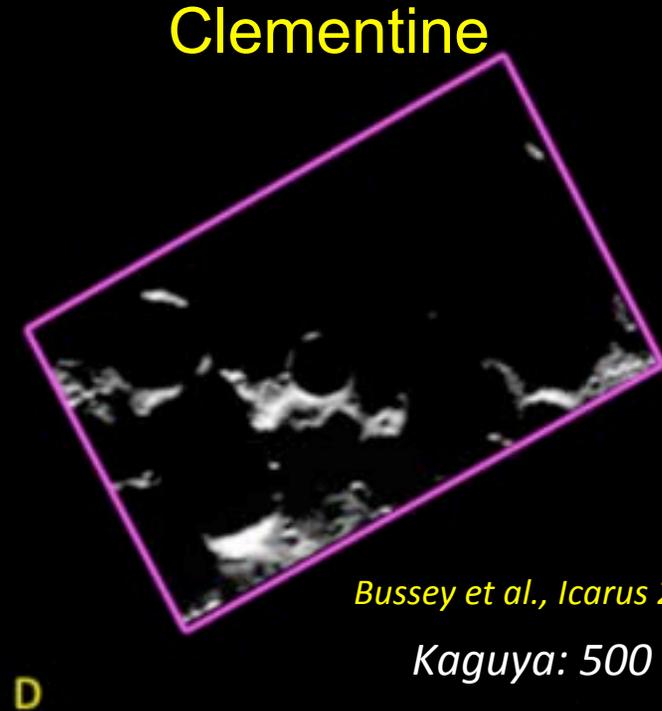
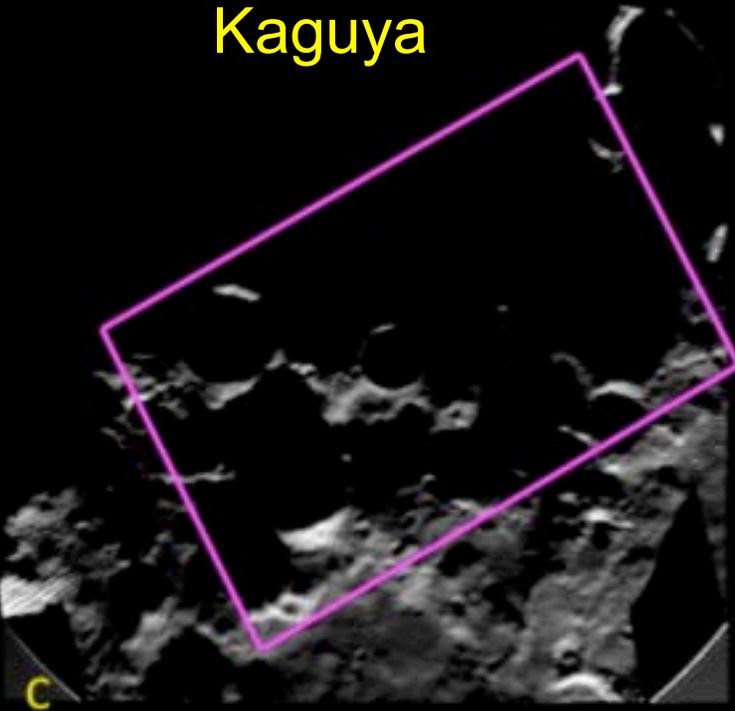
- No 100% areas
- Regions >80% exist at both poles

Noda et al., *GRL* 2008



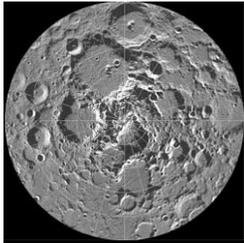
Kaguya

Clementine

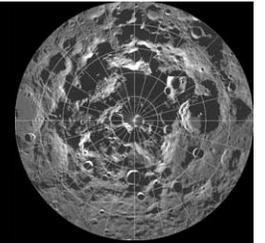


Bussey et al., Icarus 2010

Kaguya: 500 m/pixel

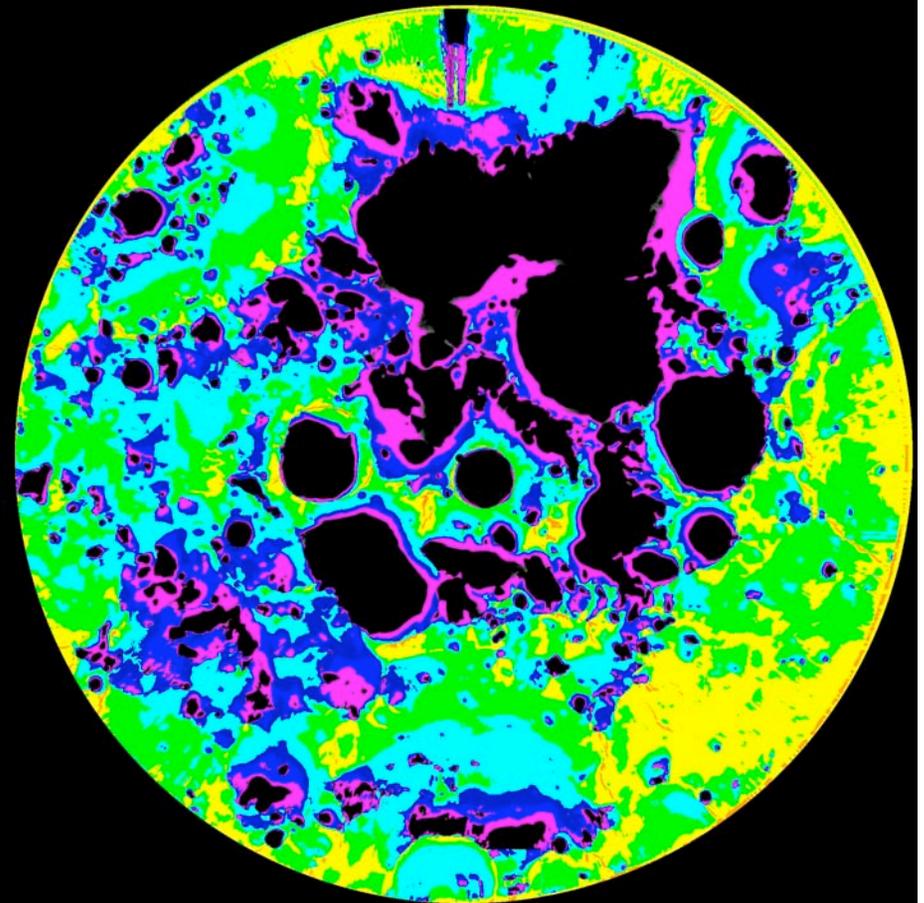
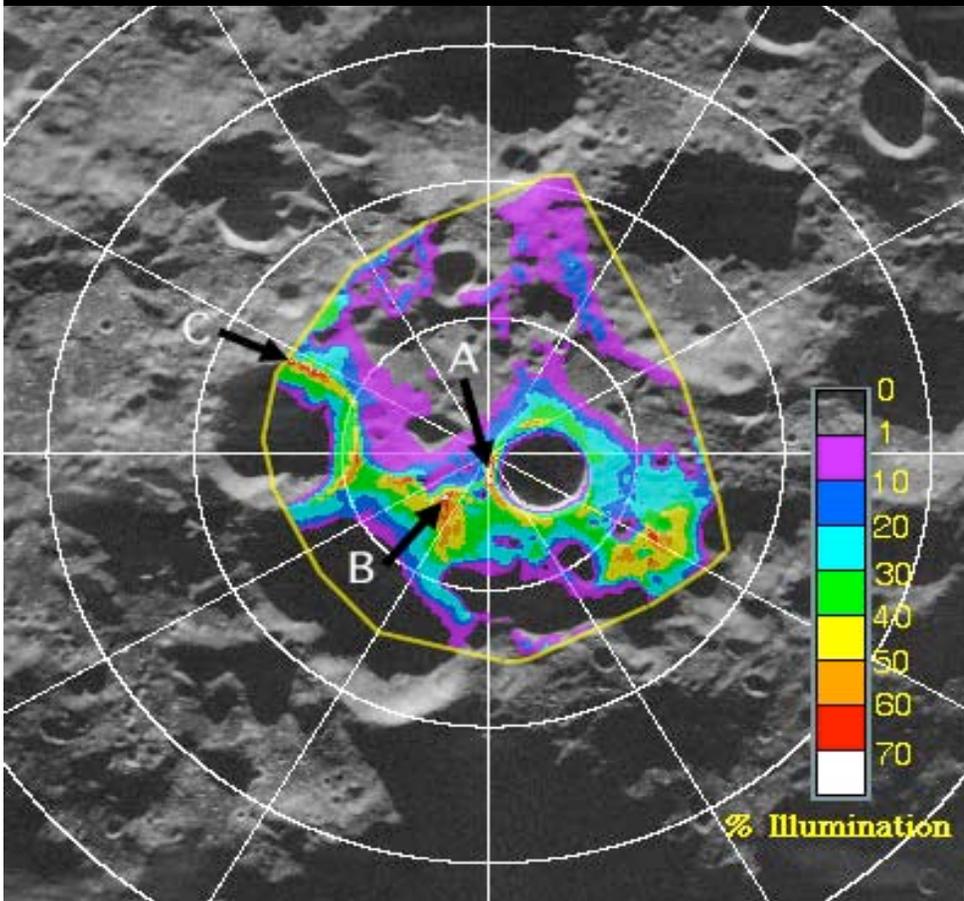


South Pole Clementine vs. Kaguya



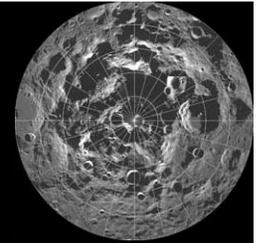
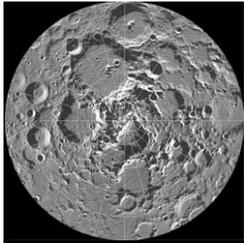
Optical vs. Laser Altimetry

Highest Mean Illumination ~87%



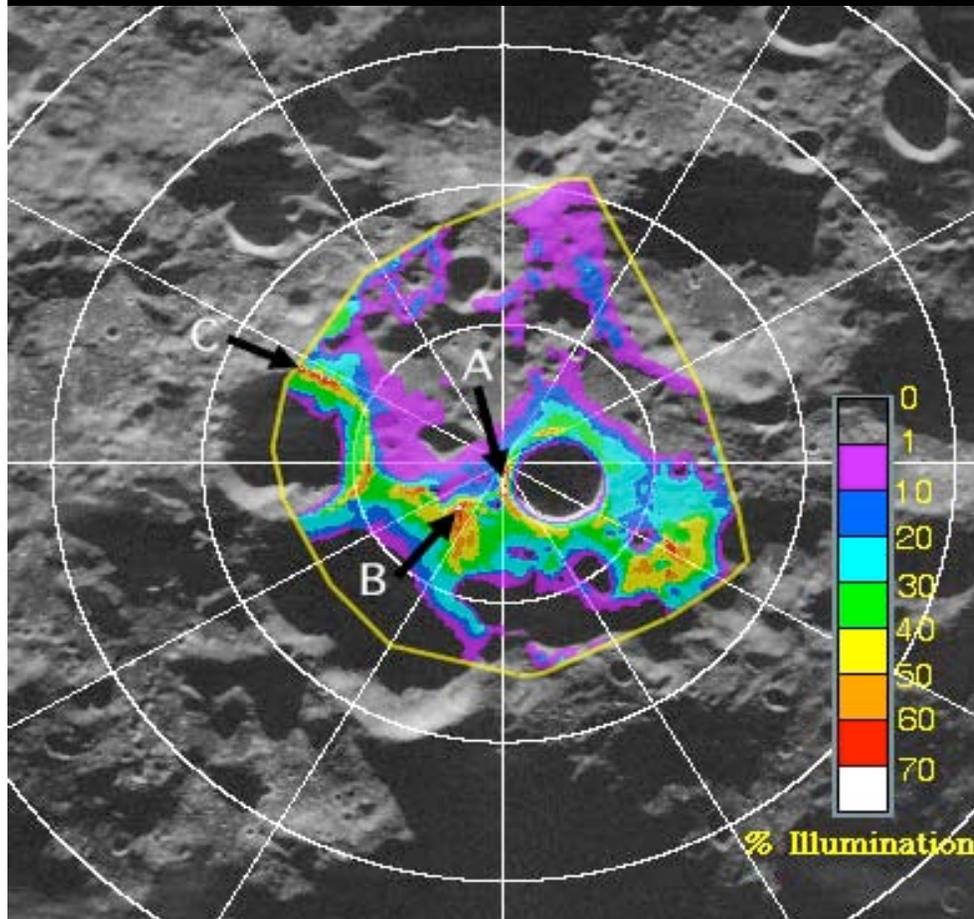
Bussey et al., GRL 1999

Bussey et al., Icarus 2010

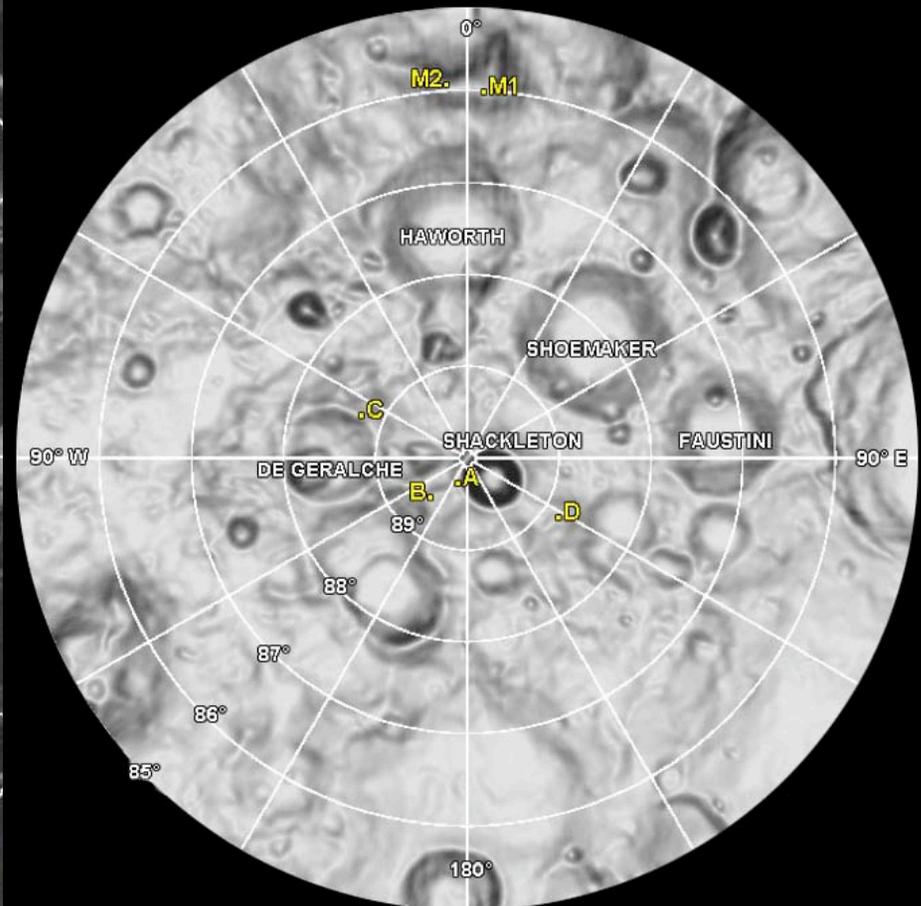


South Pole Clementine vs Kaguya

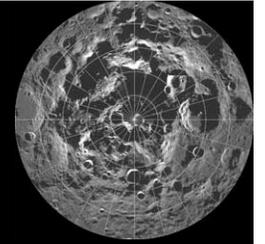
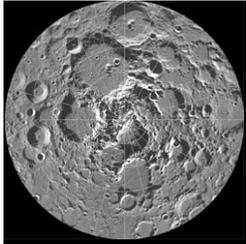
*Optical vs Laser Altimetry
Same four locations!*



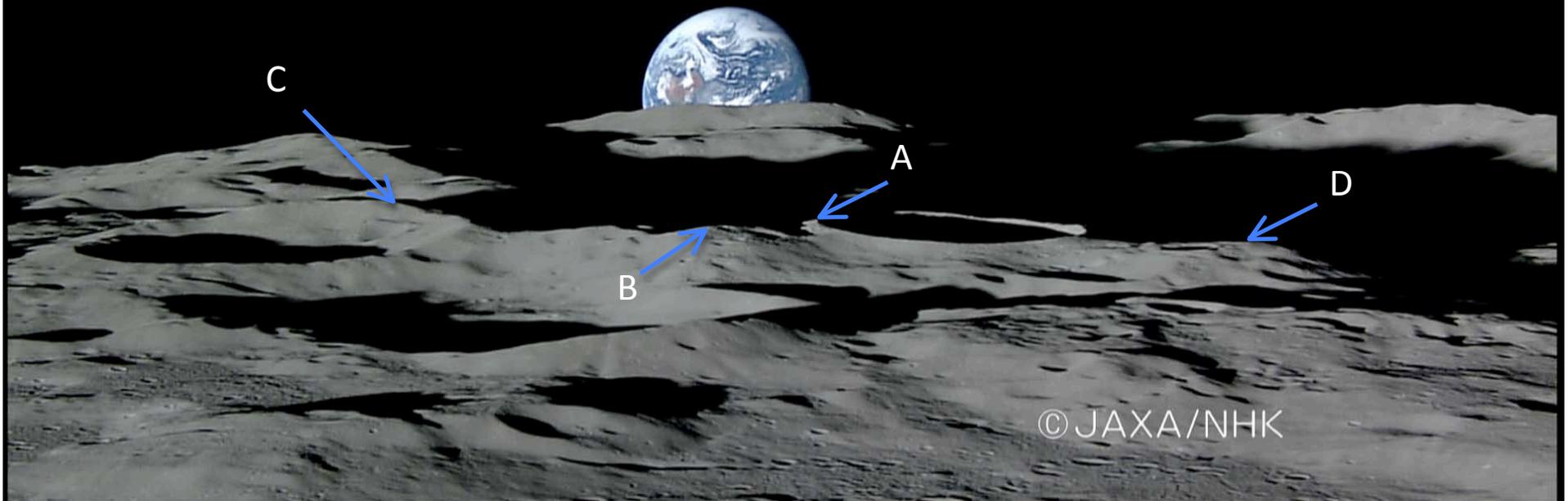
Bussey et al., GRL 1999



Bussey et al., Icarus 2010

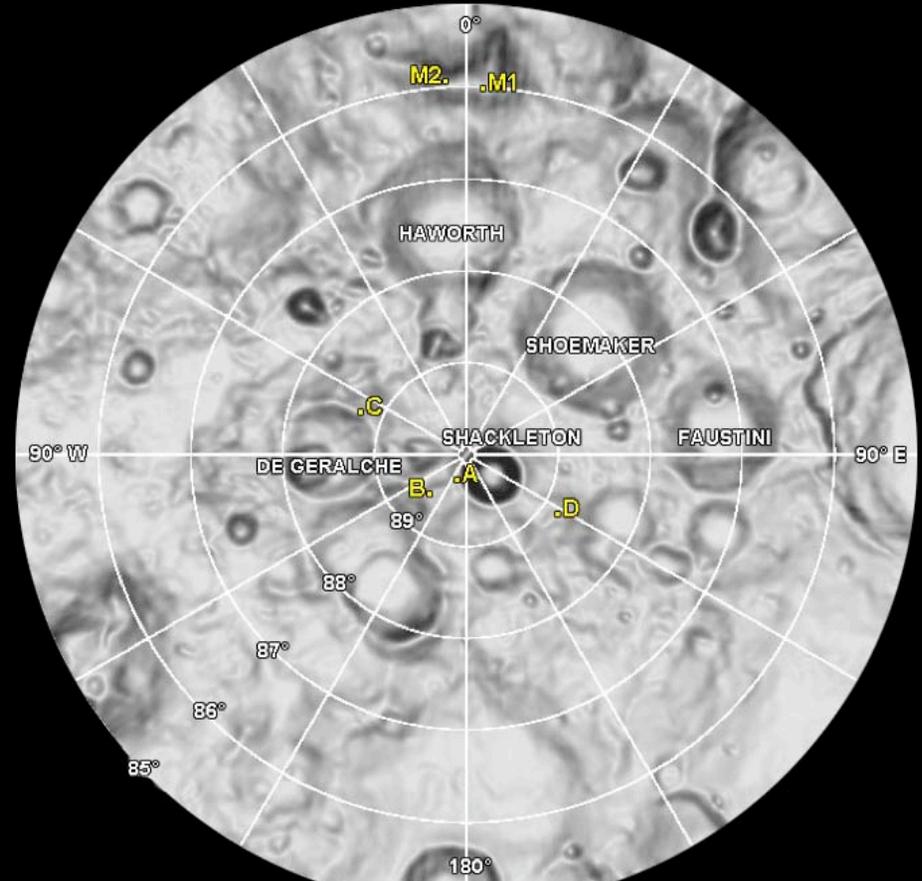
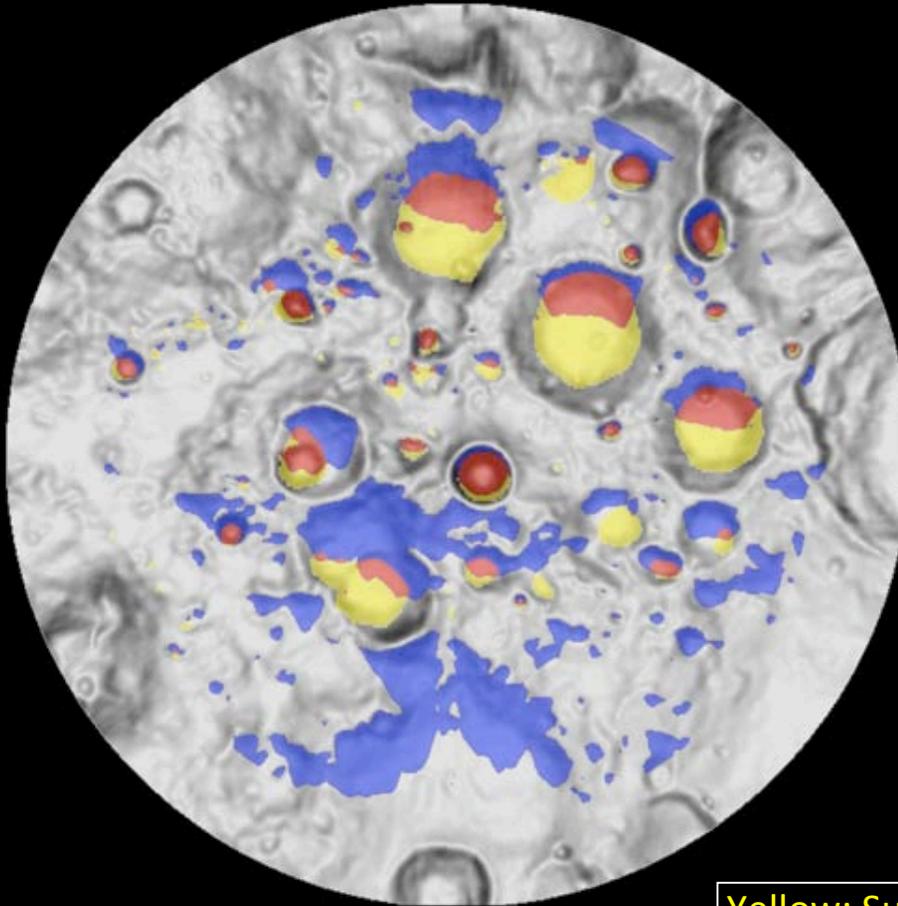
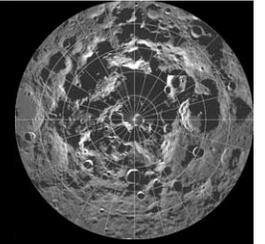
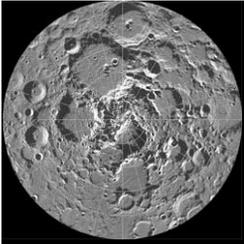


Kaguya/Selene



© JAXA/NHK

Permanent Shadow

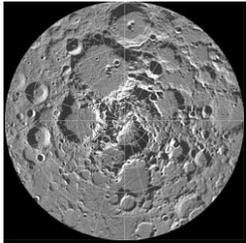


Bussey et al., Icarus 2010

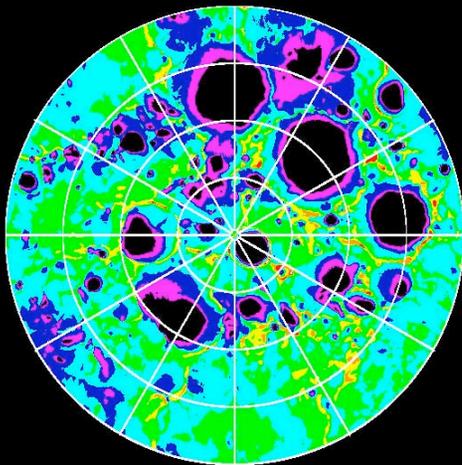
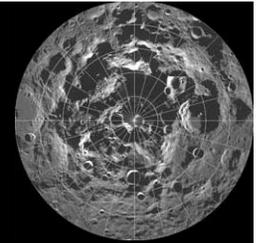
Yellow: Sun Shadowed - 5058 Km²

Red: Sun & Earth Shadowed - 2653 Km²

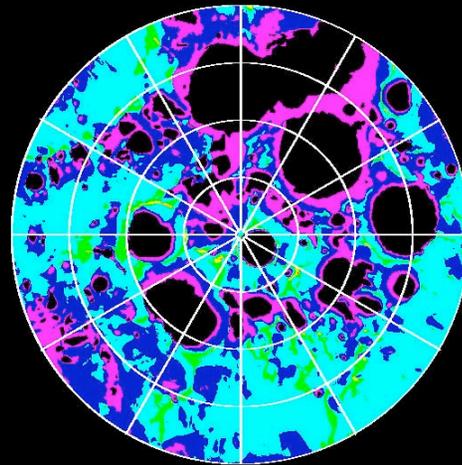
Blue: Earth Shadowed - 10,520 Km²



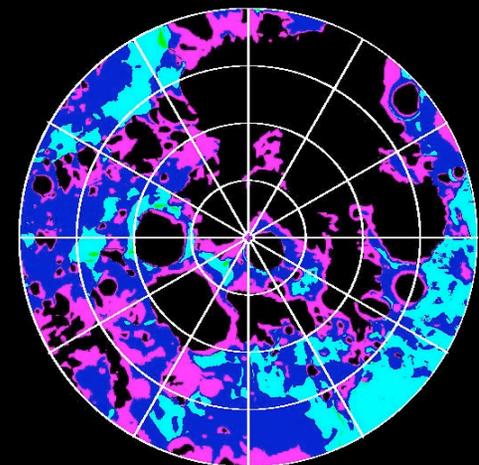
South Pole 2020 Seasonal Variations



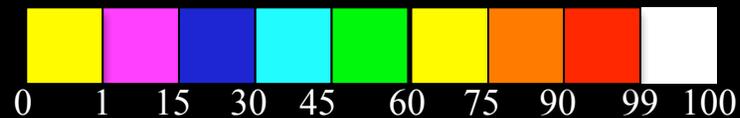
Summer



Autumn



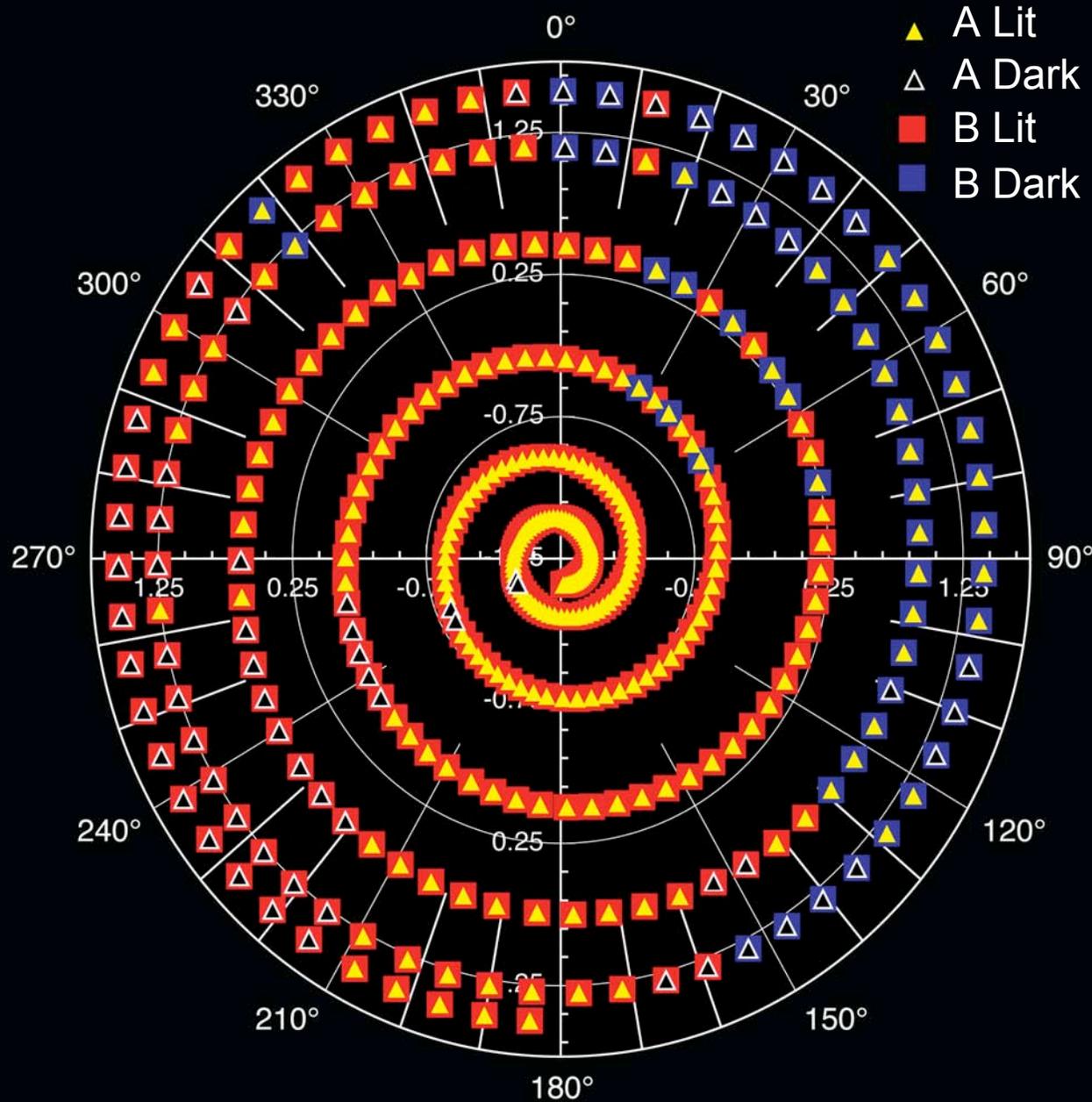
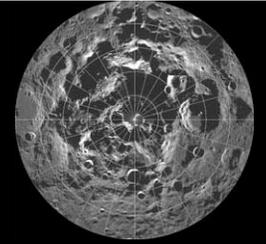
Winter



% Illumination



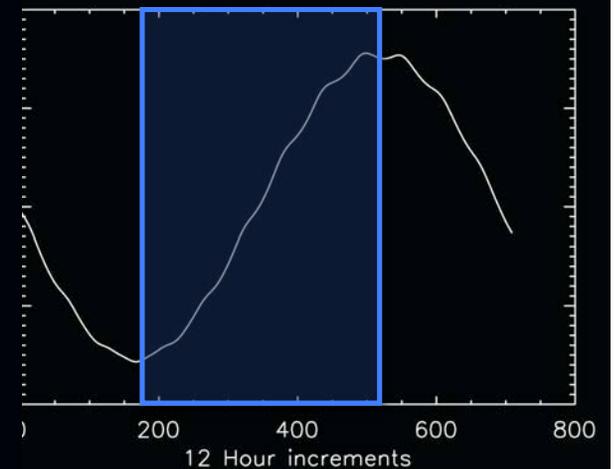
Point A & B



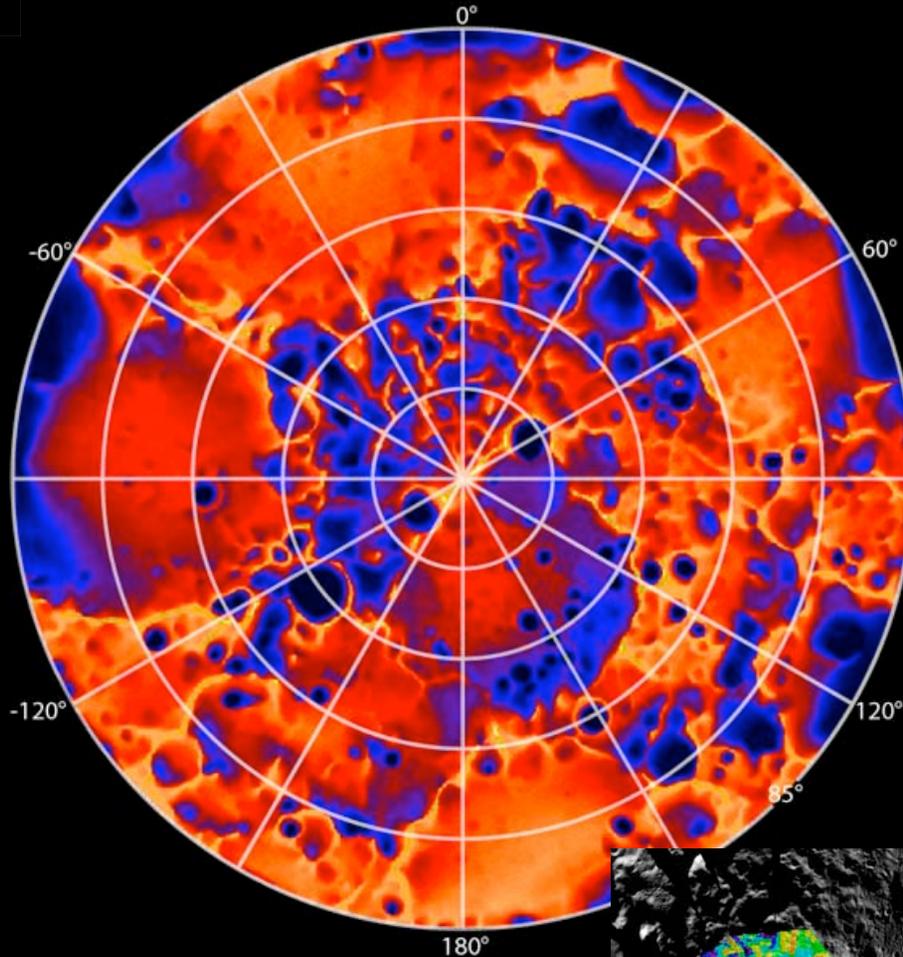
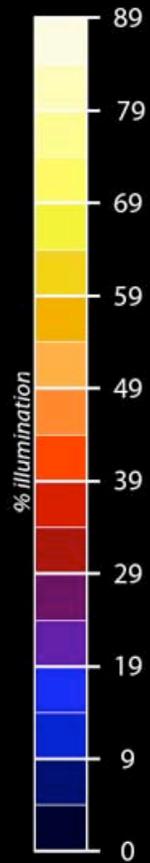
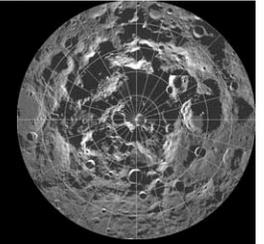
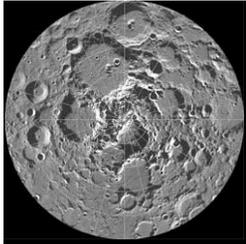
Shows ~6 months
(summer through
winter)

94% Collective
Illumination

8 months collective
summer illumination

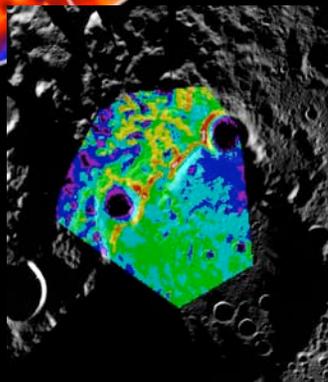


NP Mean Illumination



Mean North Pole Illumination

Bussey et al., Nature 2005

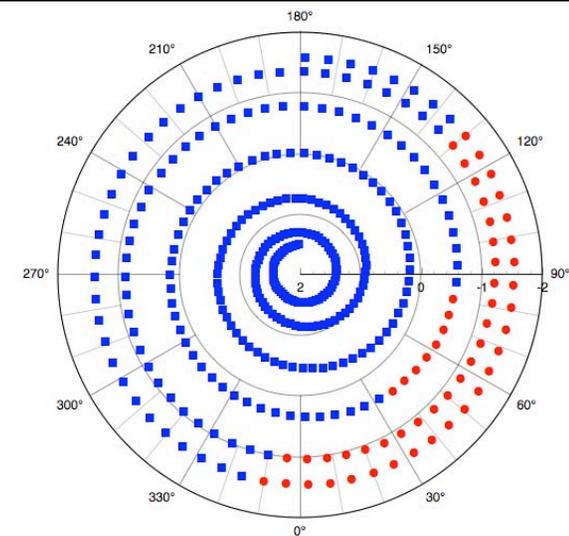


Aepinus

- Illuminated >80%
- 7 months constant summer illumination
- Most constant illumination of either pole

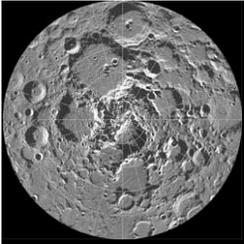
Whipple

- Two locations on crater rim
- Most Illumination >80%

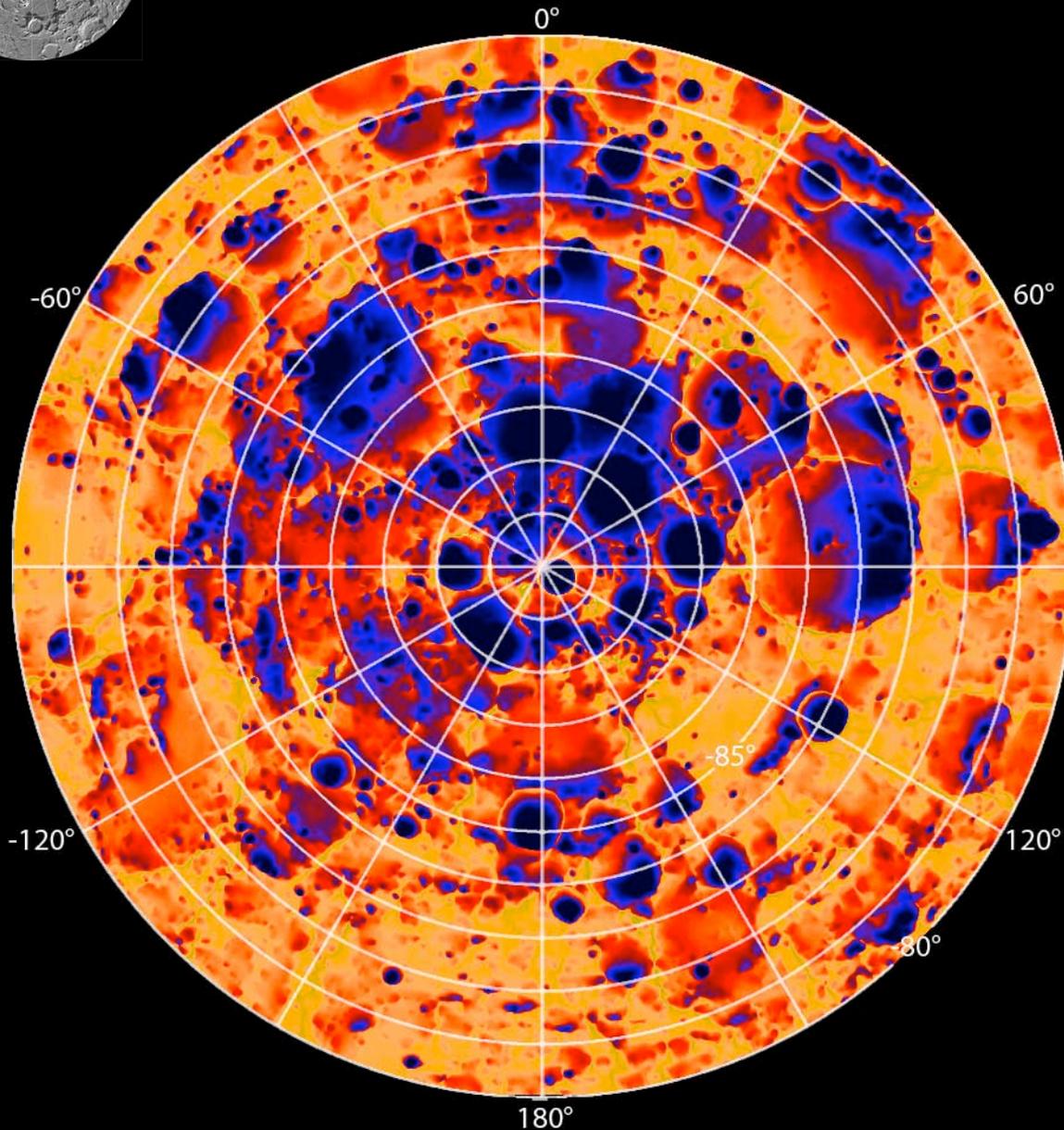
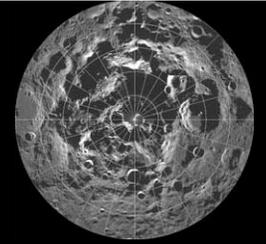


■ Aepinus Lit

● Aepinus Dark



Polar Illumination



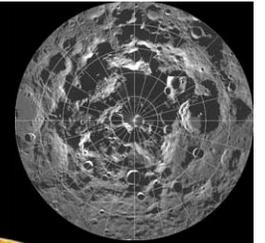
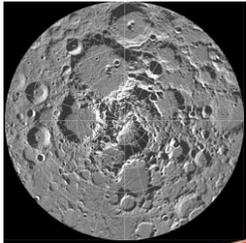
On going work

- Hires Kaguya data
~236 m/pixel spatial
- $\pm 80^\circ$ to $\pm 90^\circ$ latitude

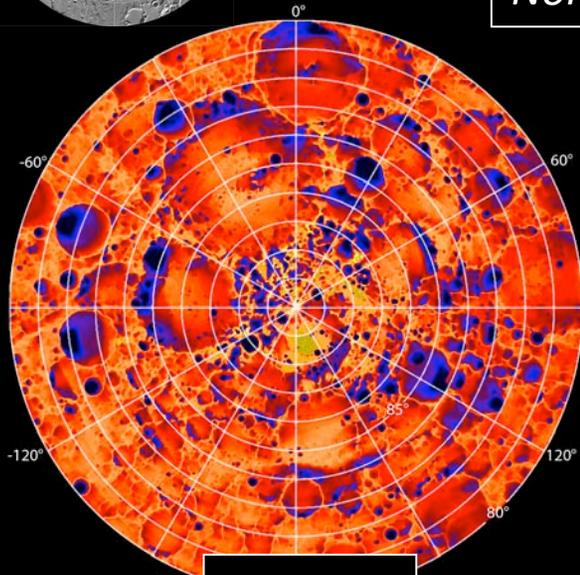
Preliminary Findings

- No regions 100% illuminated

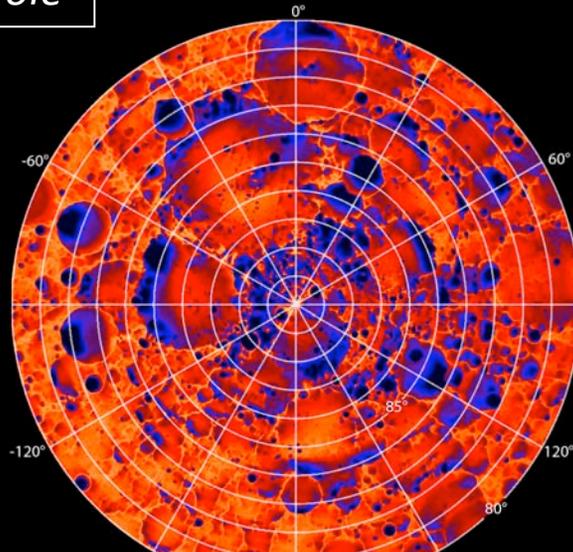
2020 Seasonal Variations



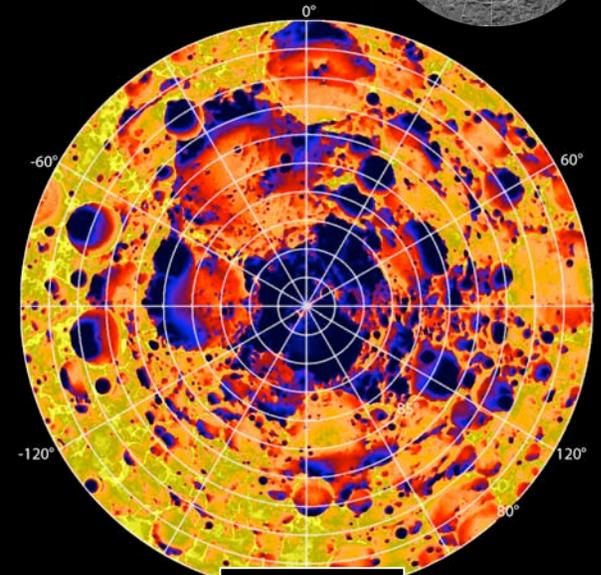
North Pole



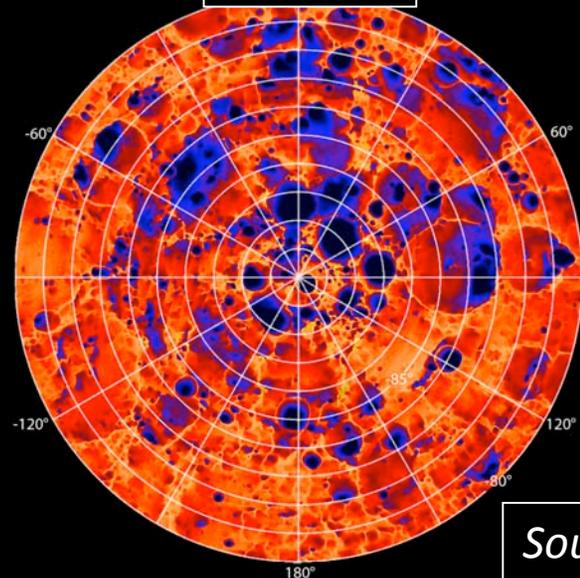
Summer



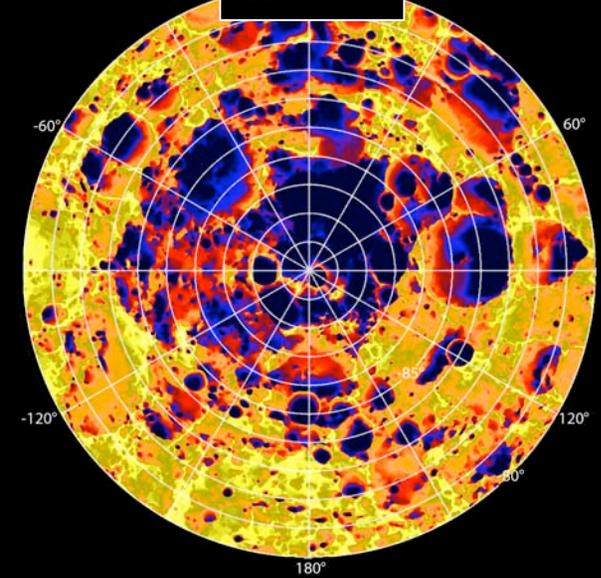
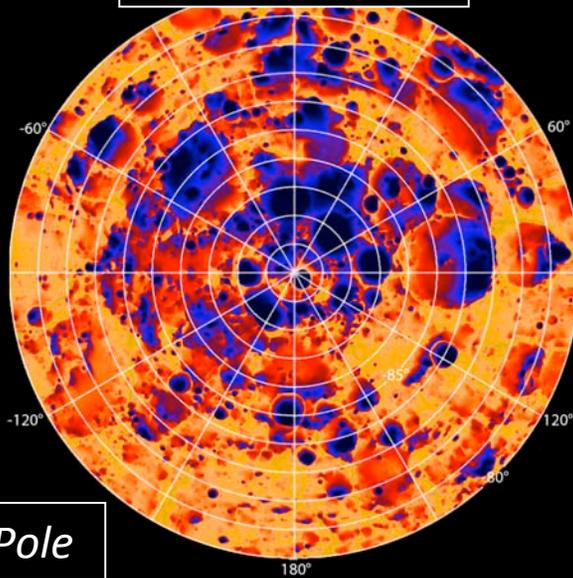
Autumn/Spring



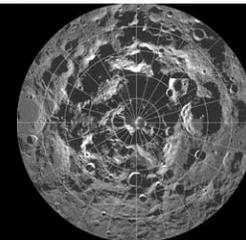
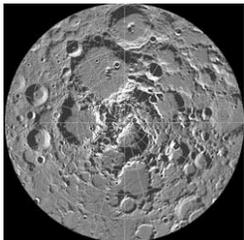
Winter



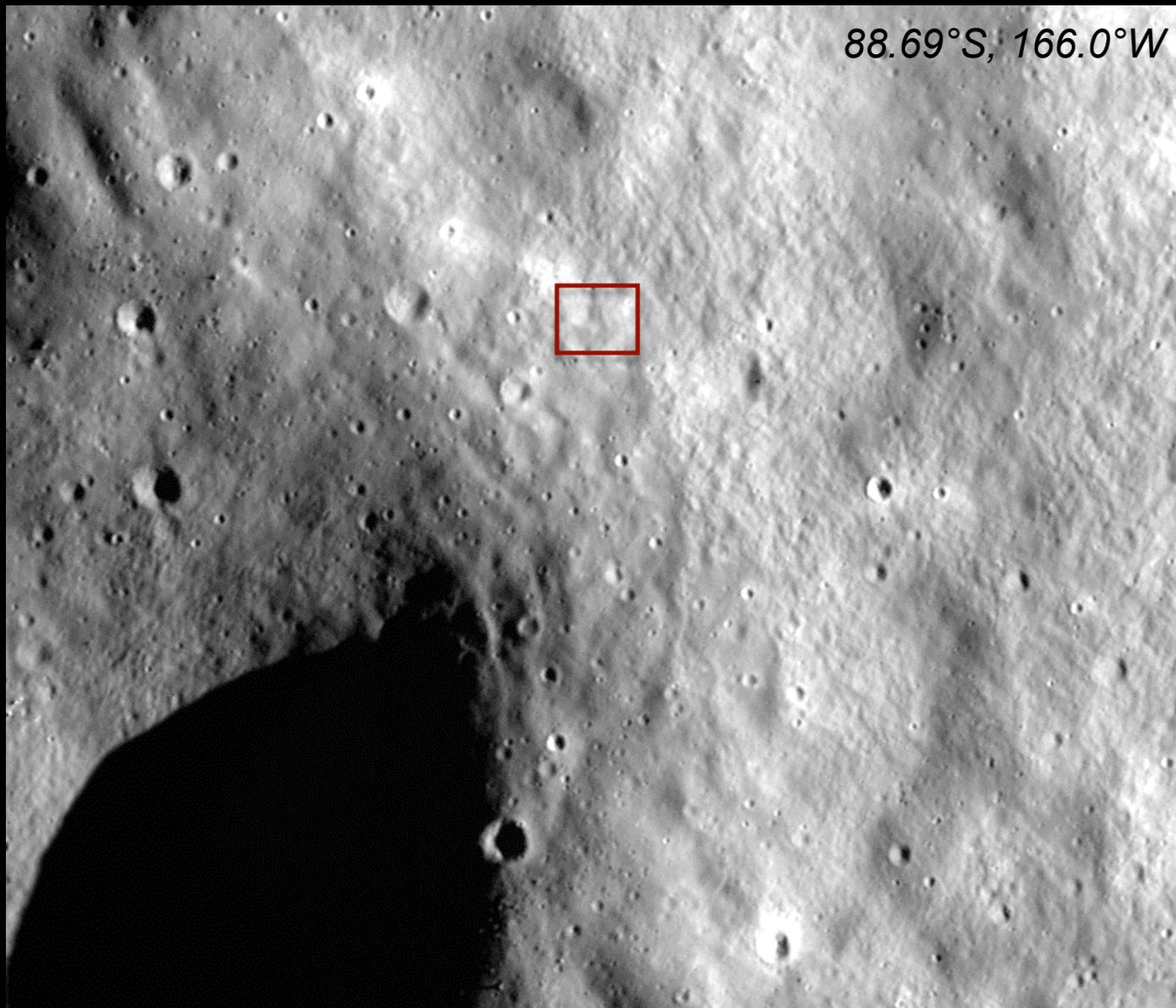
South Pole



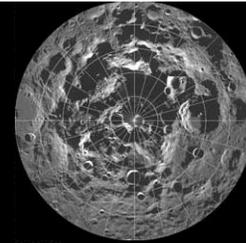
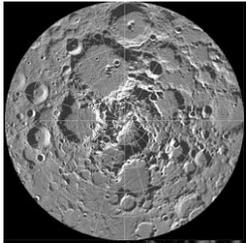
Point A



88.69°S, 166.0°W



Point B

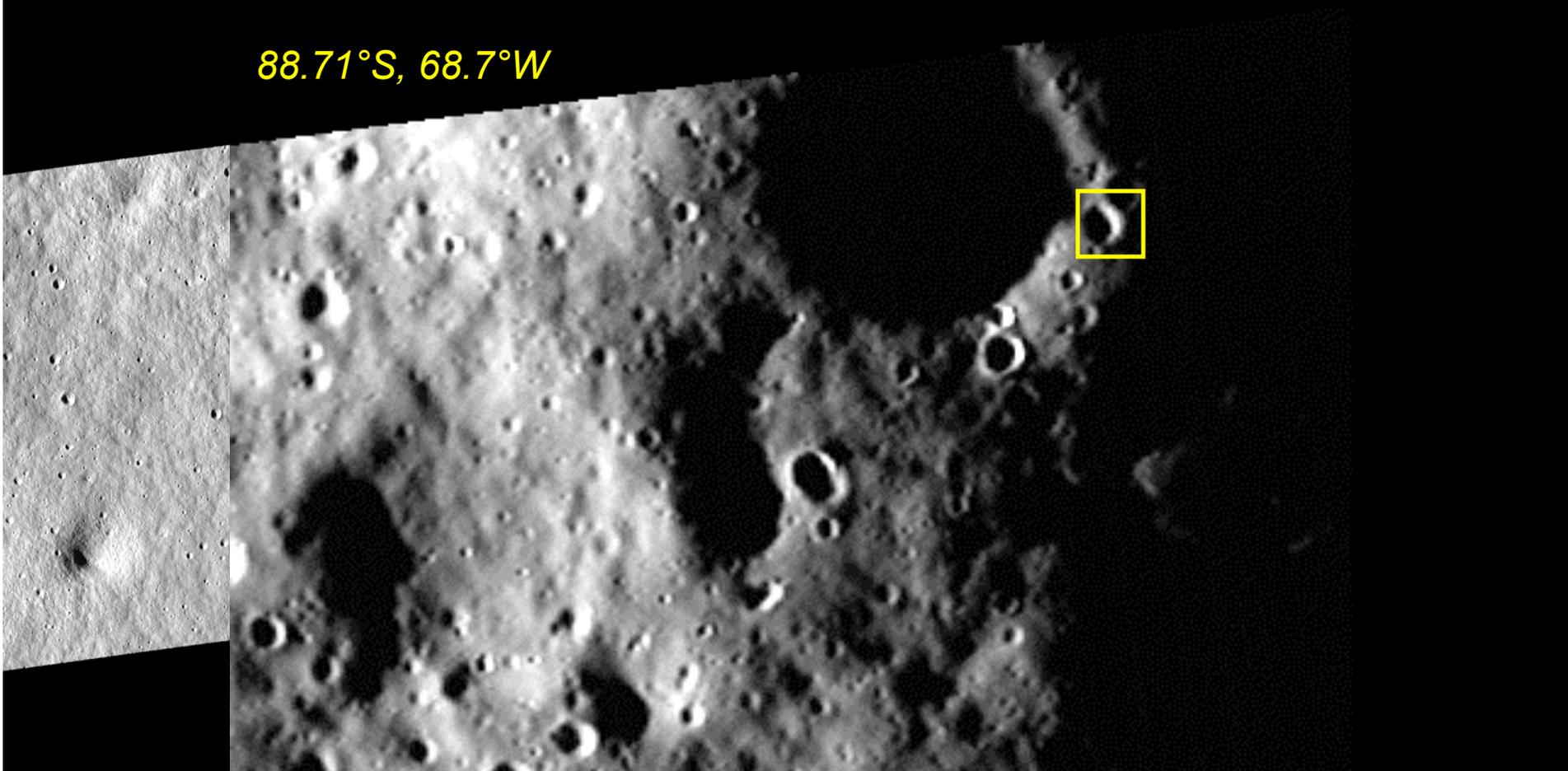
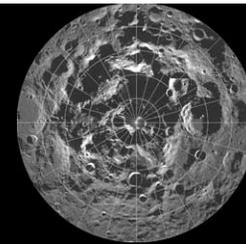
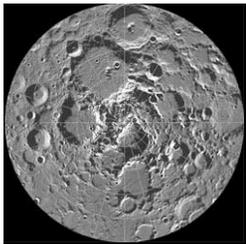


89.44°S, 141.8°W

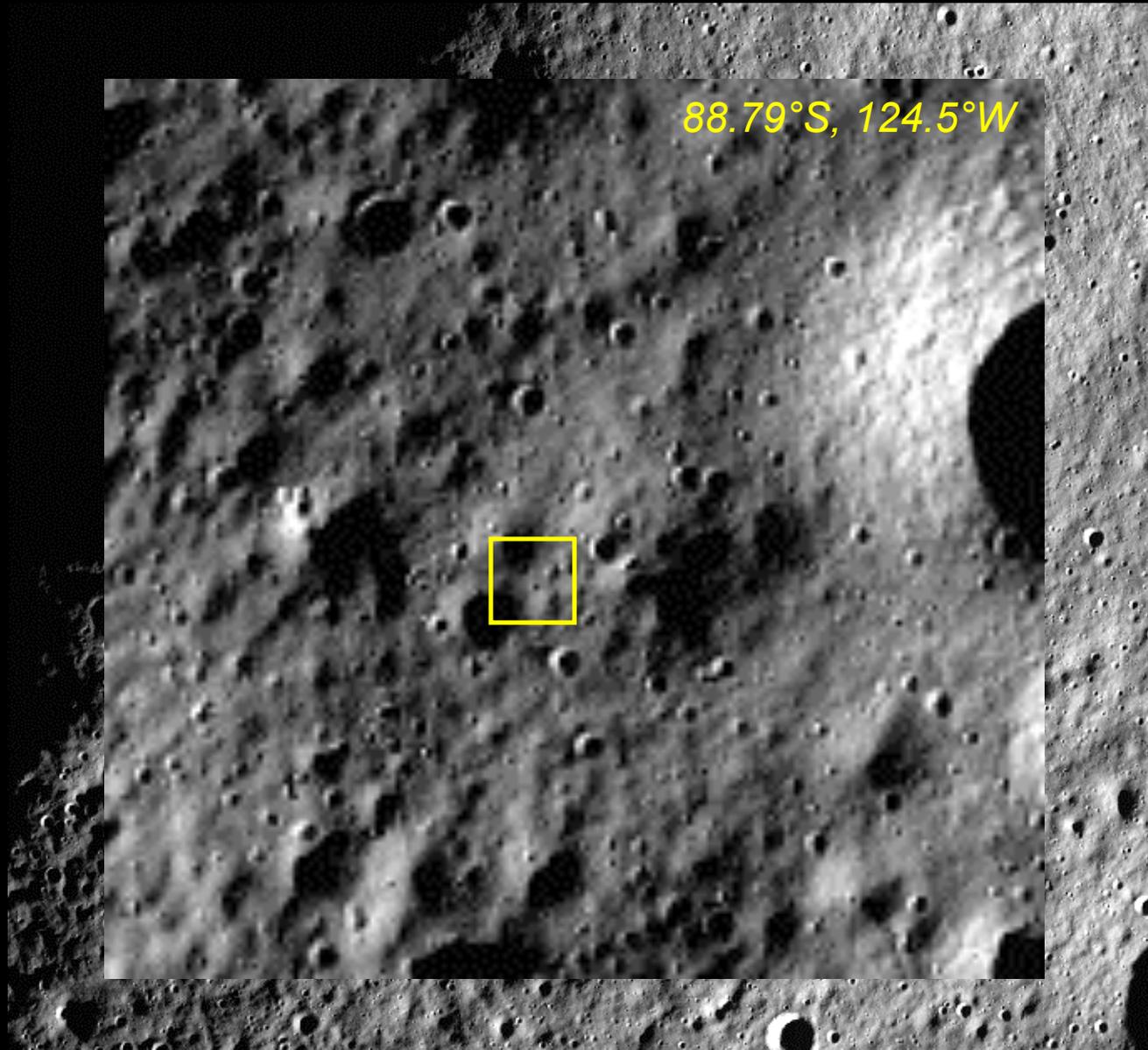
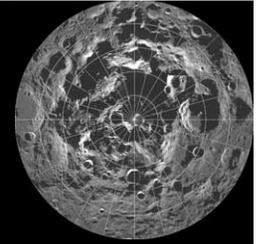
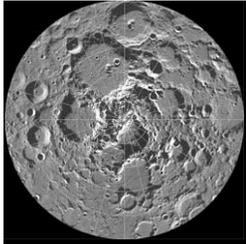


Point C

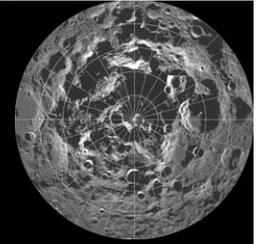
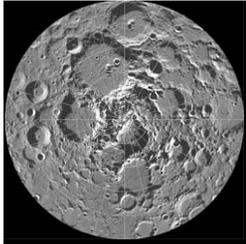
88.71°S, 68.7°W



Point D



88.79°S, 124.5°W

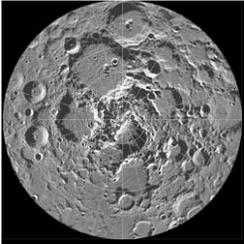


Conclusions

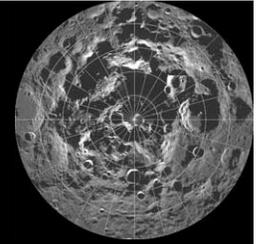
Low Res. Kaguya Illum. Models

- Reconfirmed 4 locations of high interest for near continuous illumination
- Seasonal Illumination Profiles suggest Point A and B near Shackleton collectively lit ~ 94% of the time and for 8 months in summer
- Places exist whose single longest eclipse is ~ 6 days
- North Pole: Whipple (2 locations) and Aepinus >80% illumination





Ongoing Research



High Res. Kaguya Illum. Models

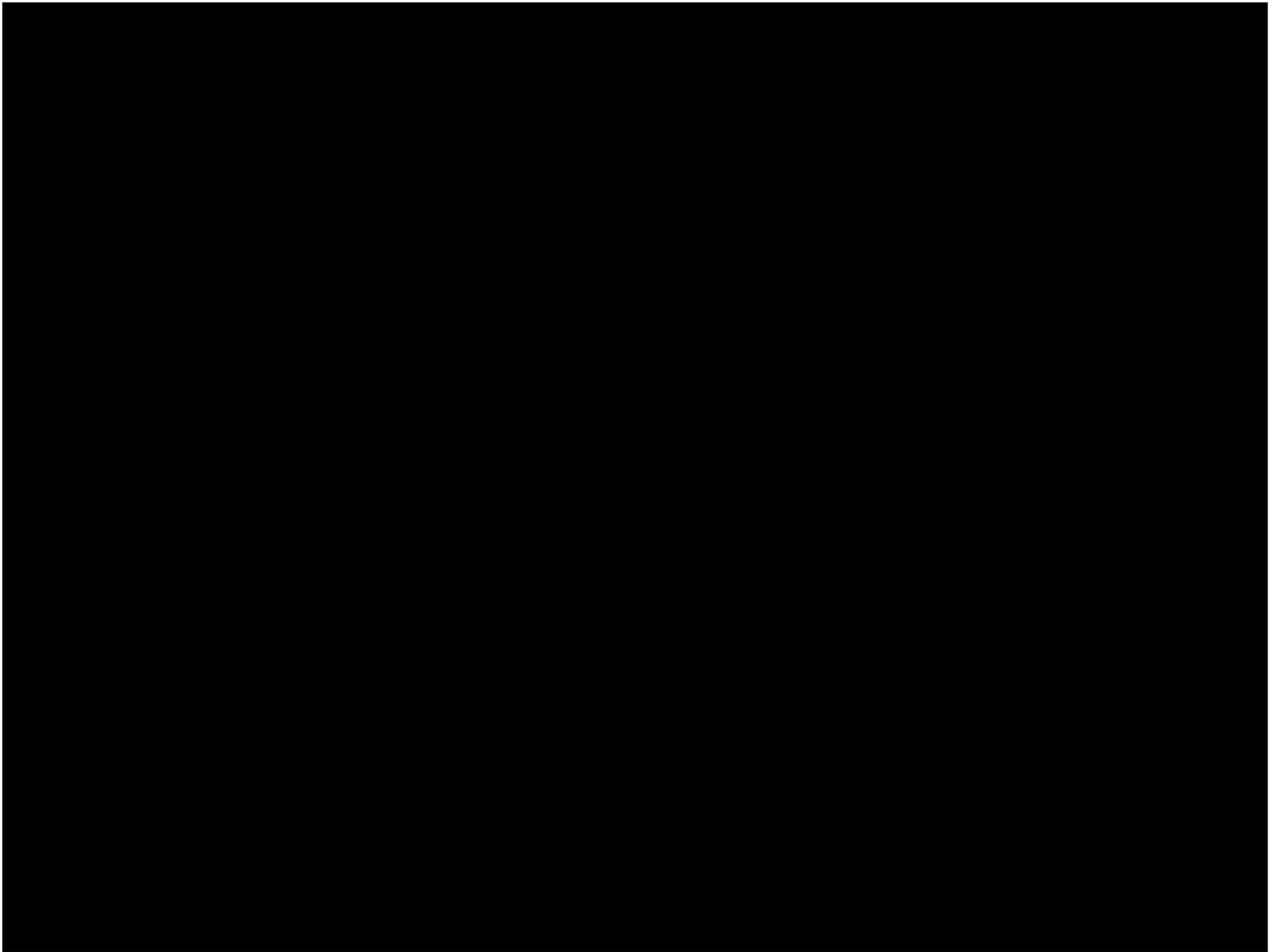
- Initial results qualitatively consistent with same points of interest with near continuous illumination



LROC Narrow Angle Camera

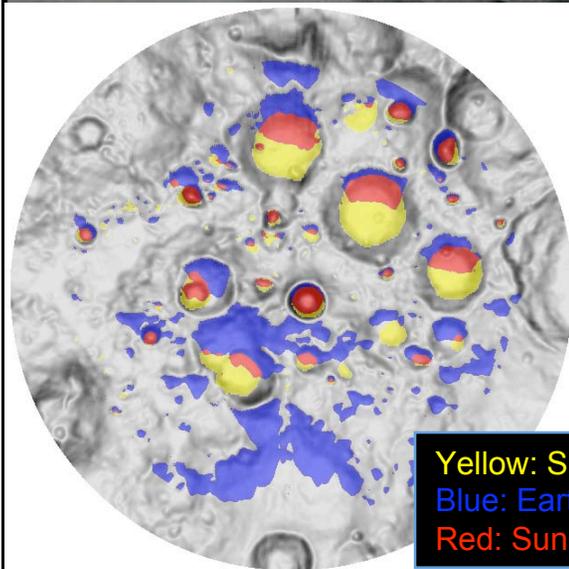
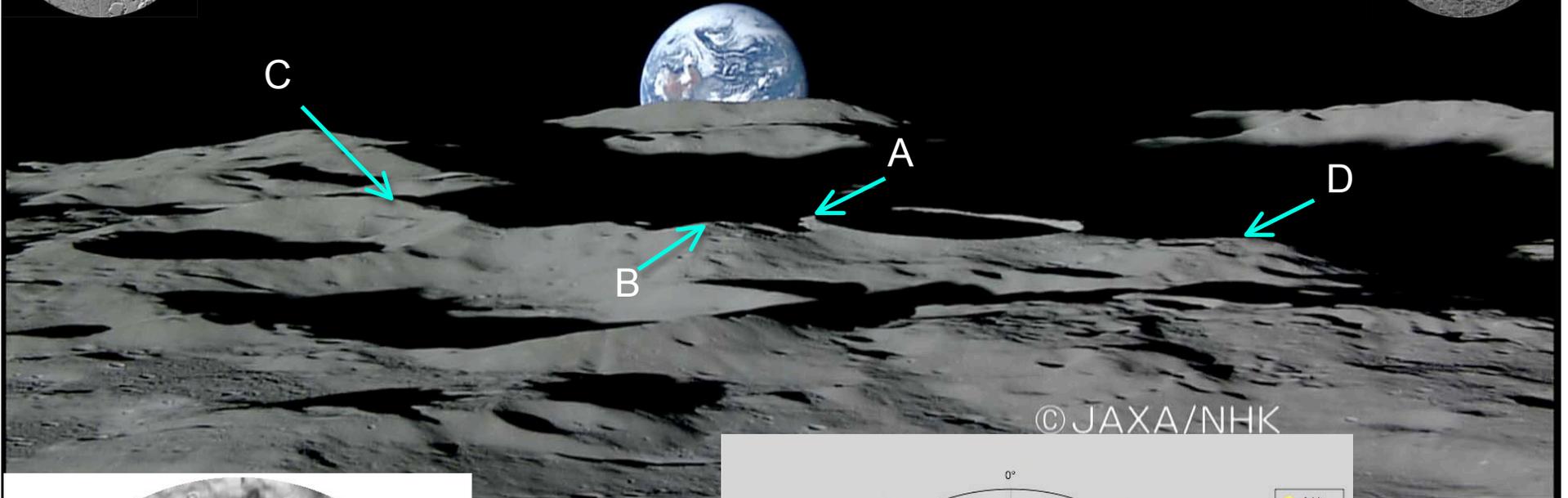
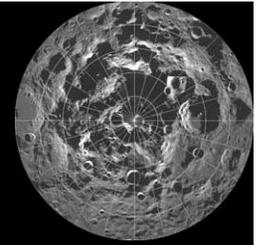
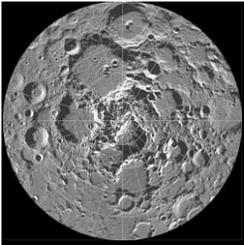
- Beginning to take a closer look at the locations of near continuous illumination



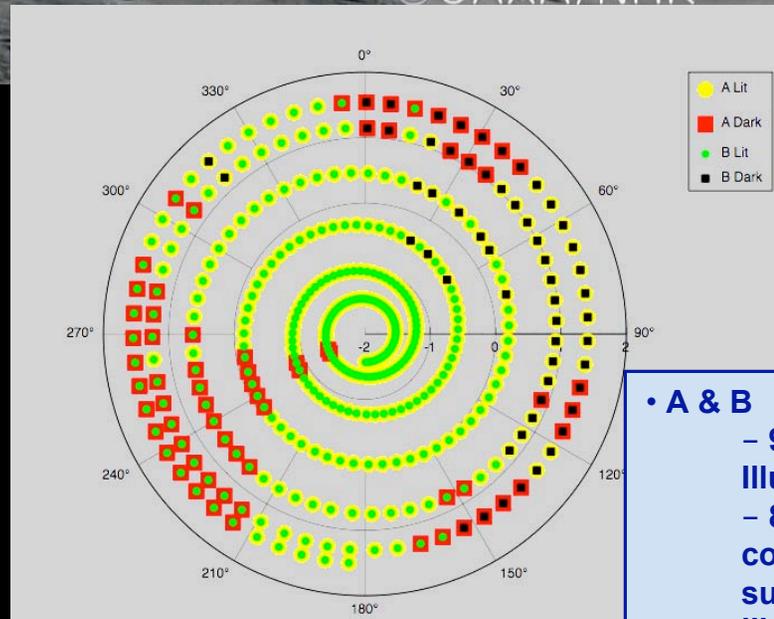




Illumination Studies

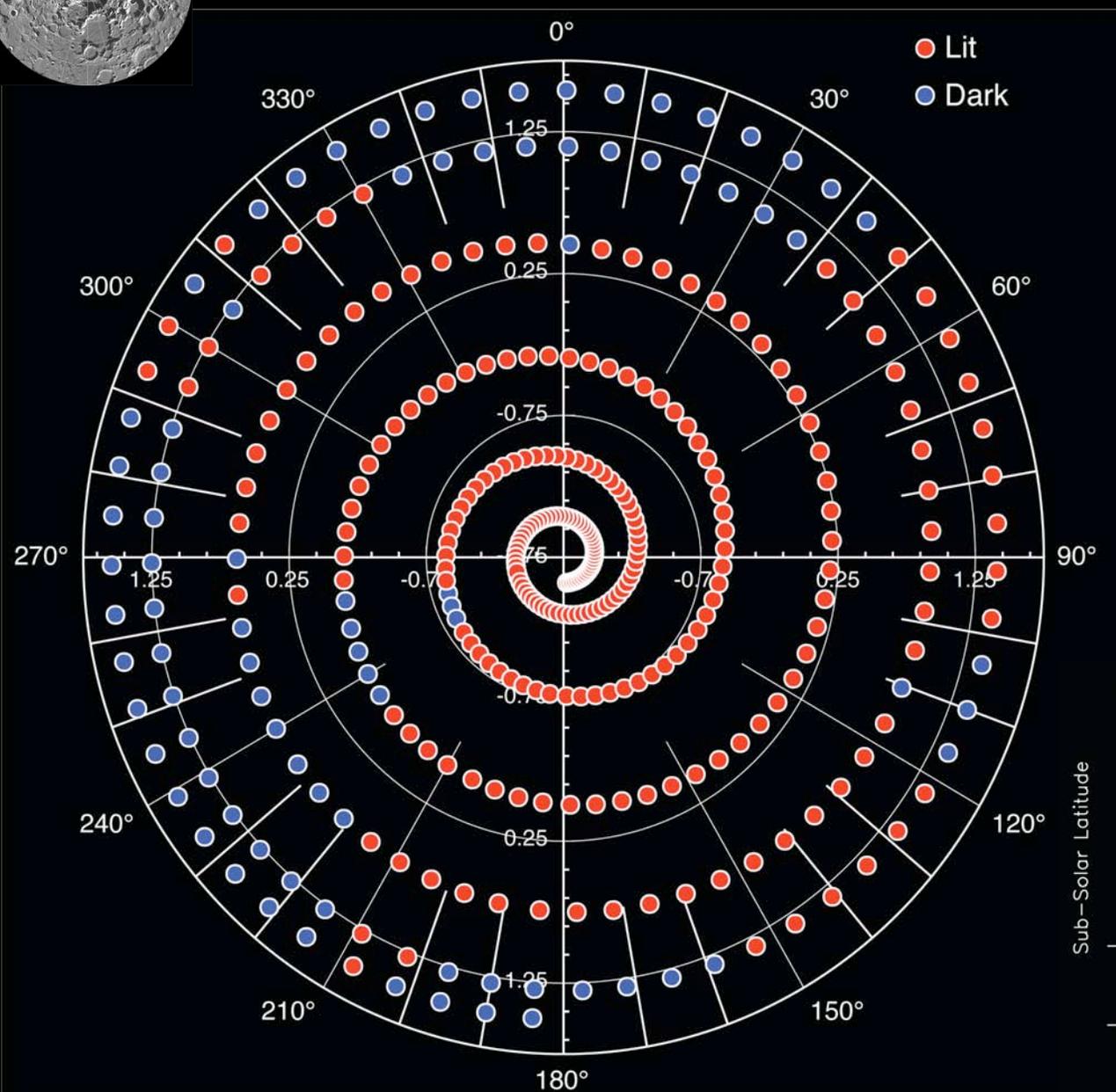
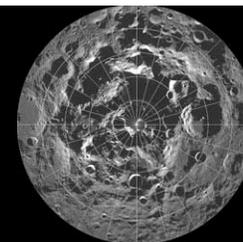
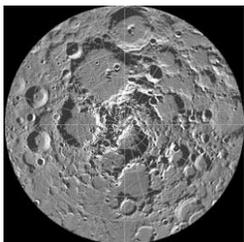


Yellow: Sun Shadowed
 Blue: Earth Shadowed
 Red: Sun & Earth Shadowed

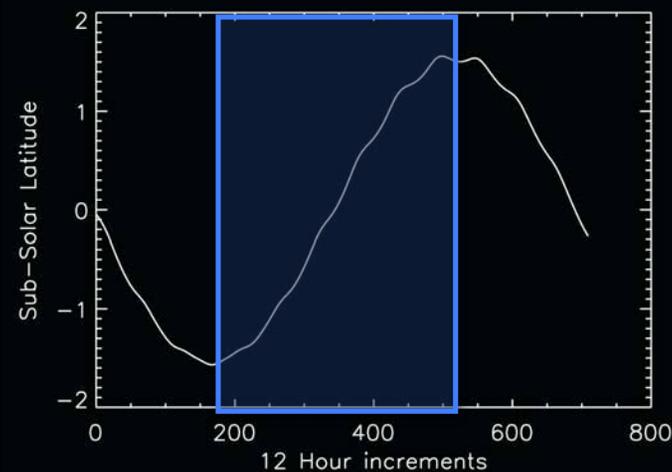


• A & B
 - 94% Collective Illumination
 - 8 months collective summer illumination

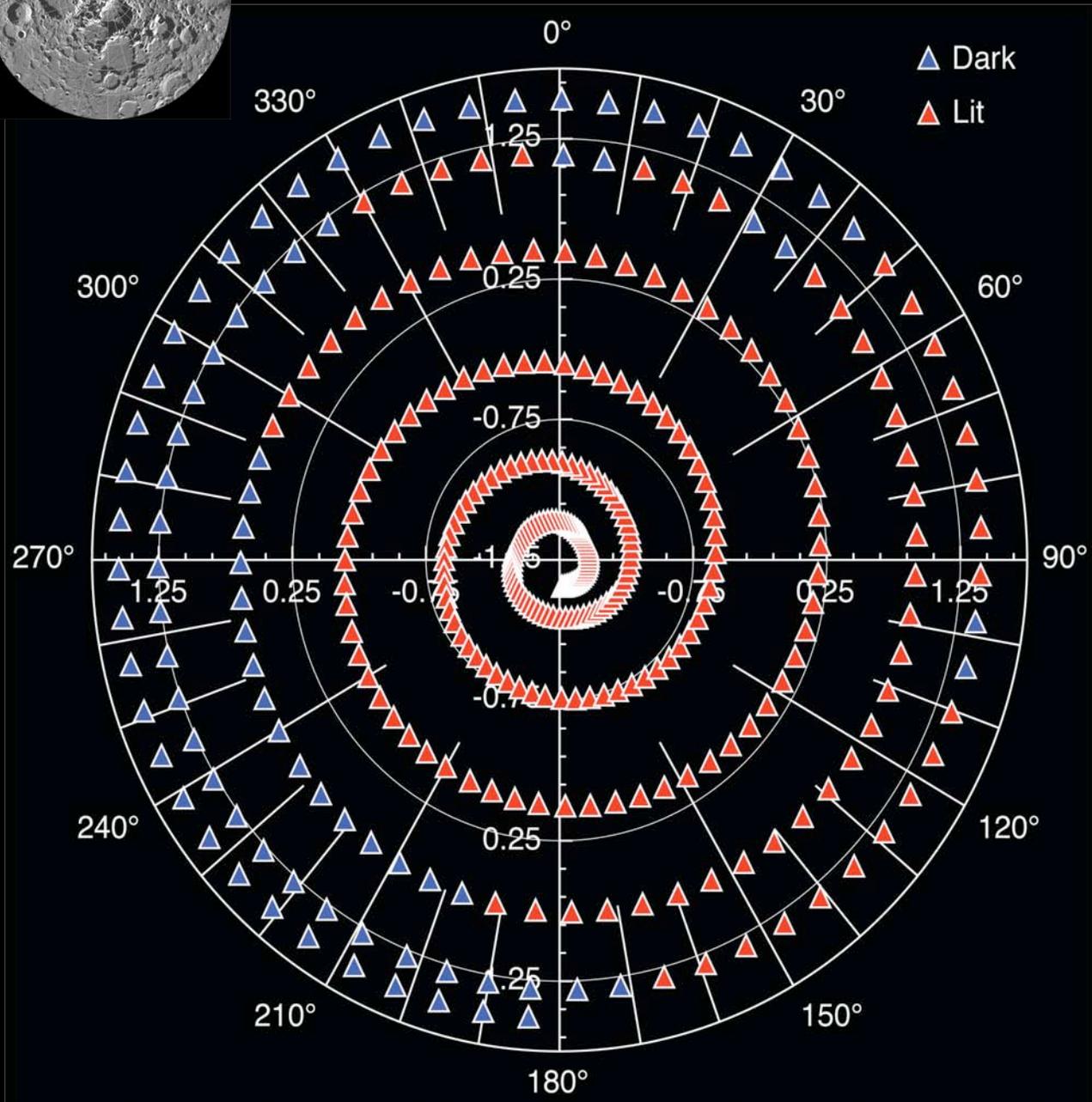
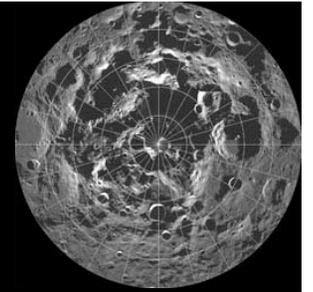
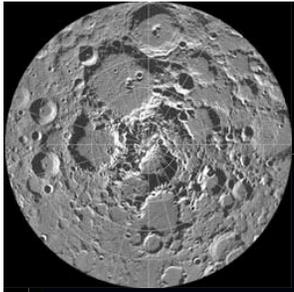
Point A



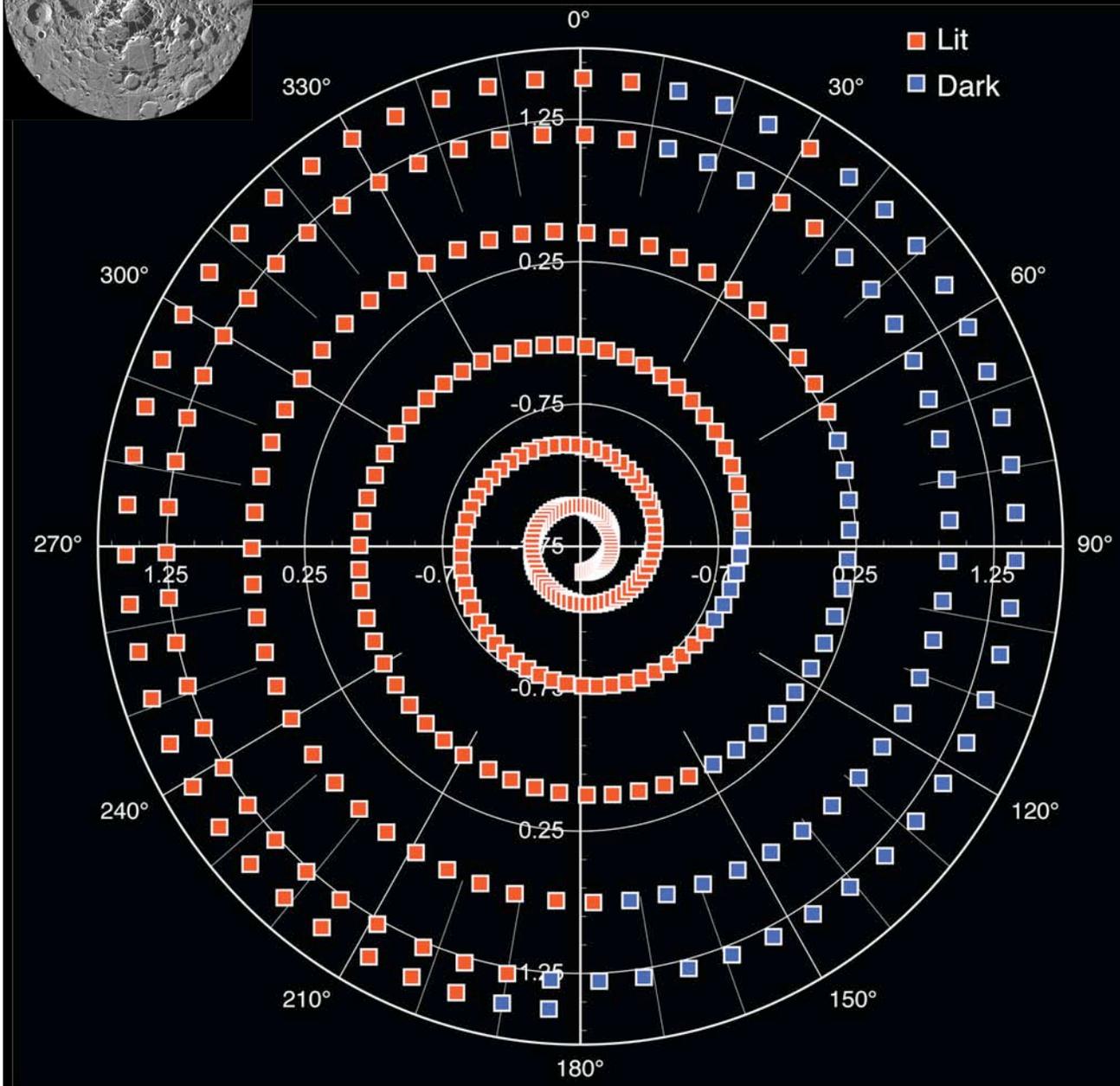
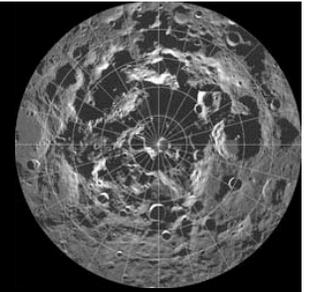
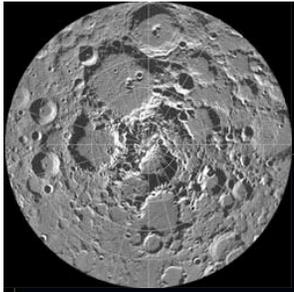
- Shows ~6 months (winter through summer)



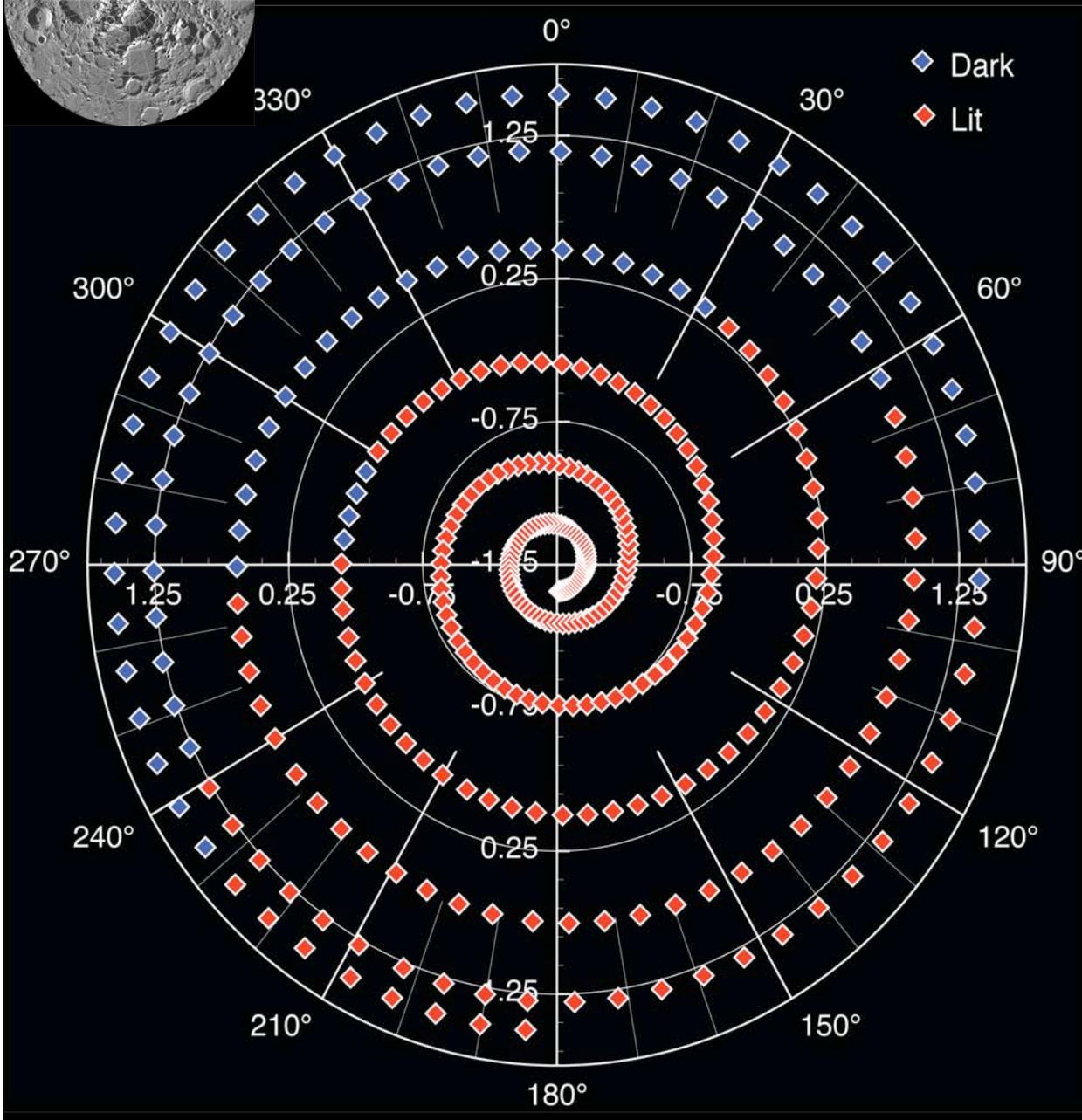
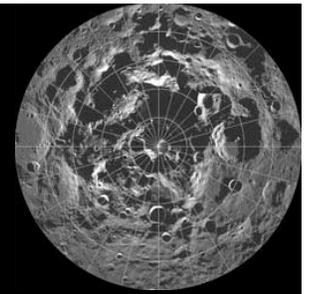
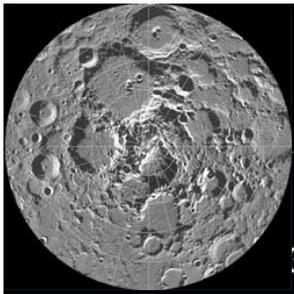
Point B



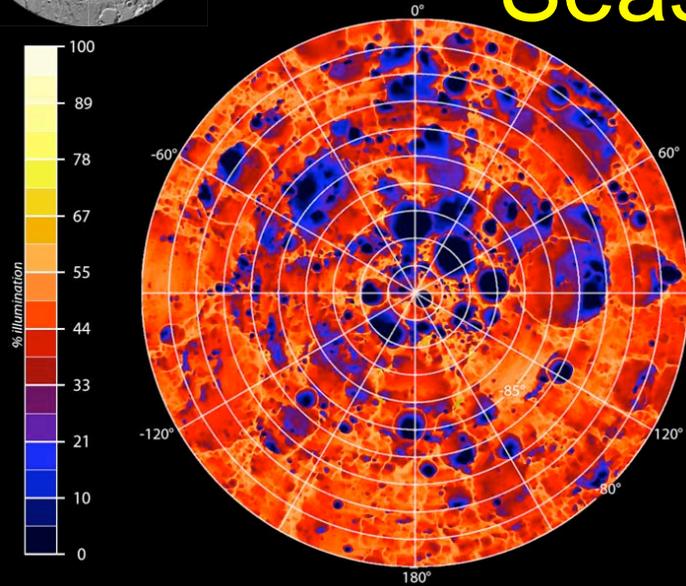
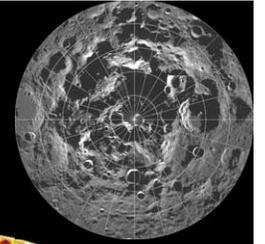
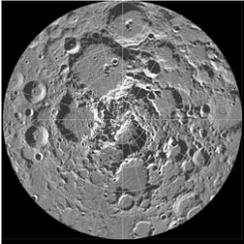
Point C



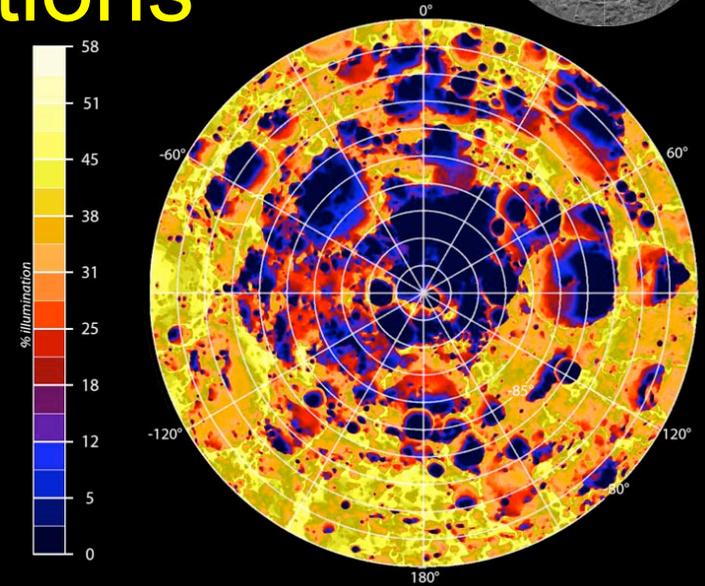
Point D



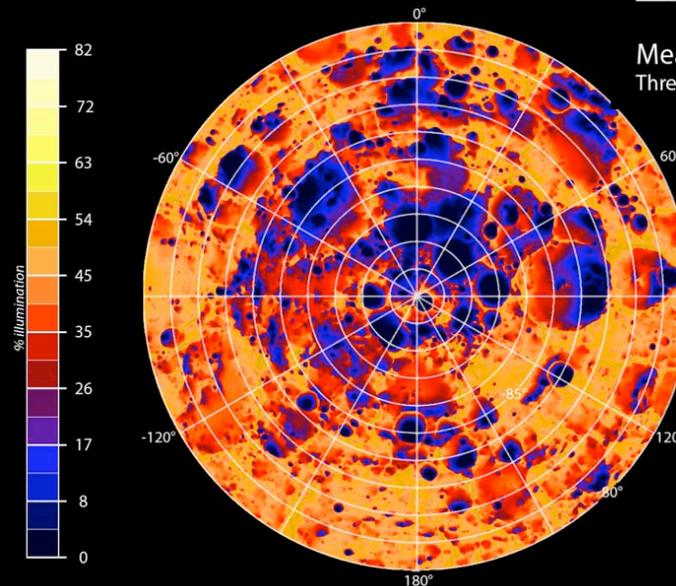
South Pole Seasonal Variations



Mean South Pole Illumination: Summer
Three Months: Days 45-136

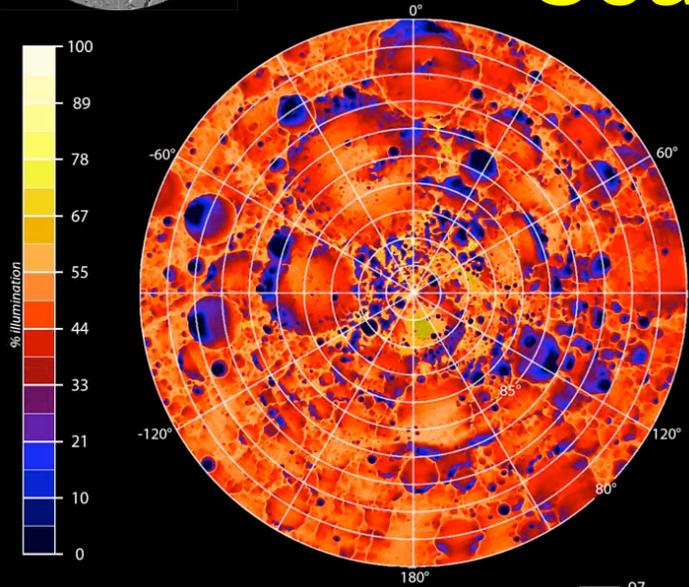
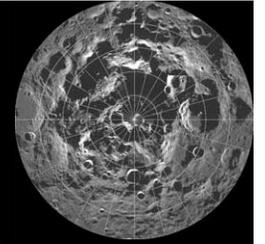
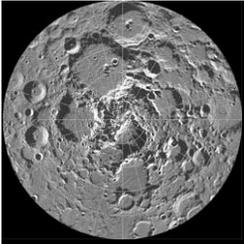


Mean South Pole Illumination: Winter
Three Months: Days 227-318

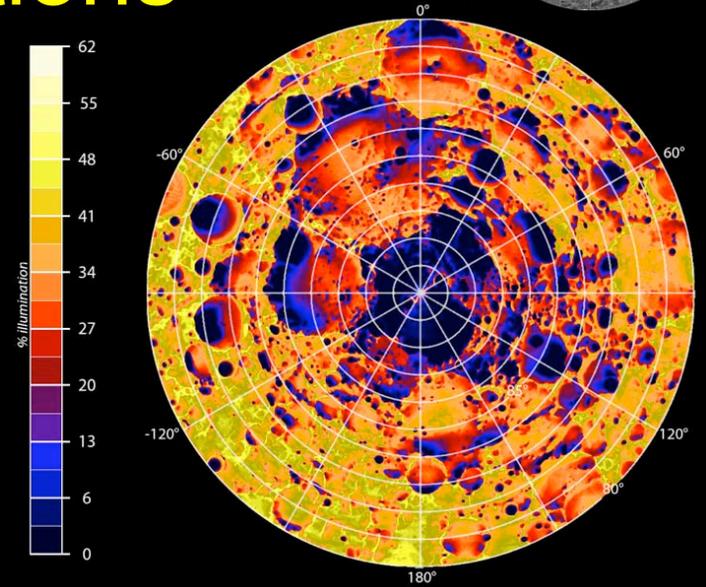


Mean South Pole Illumination: Autumn
Three Months: Days 136-227

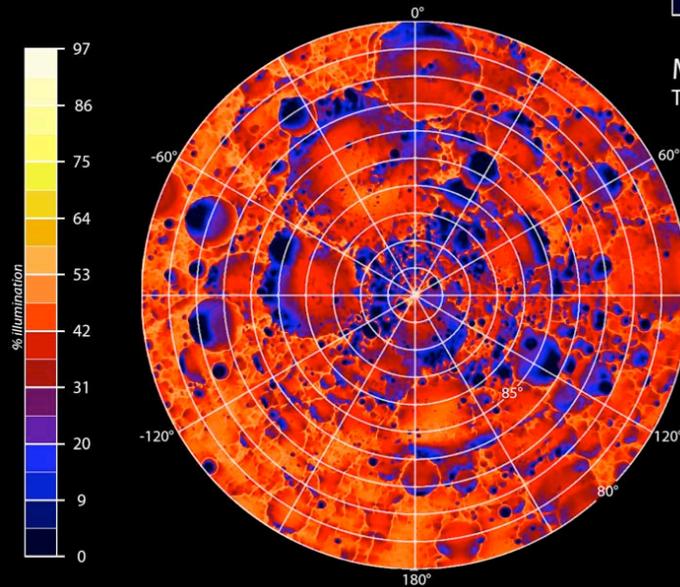
North Pole Seasonal Variations



Mean North Pole Illumination: Summer
Three Months: Days 227-318

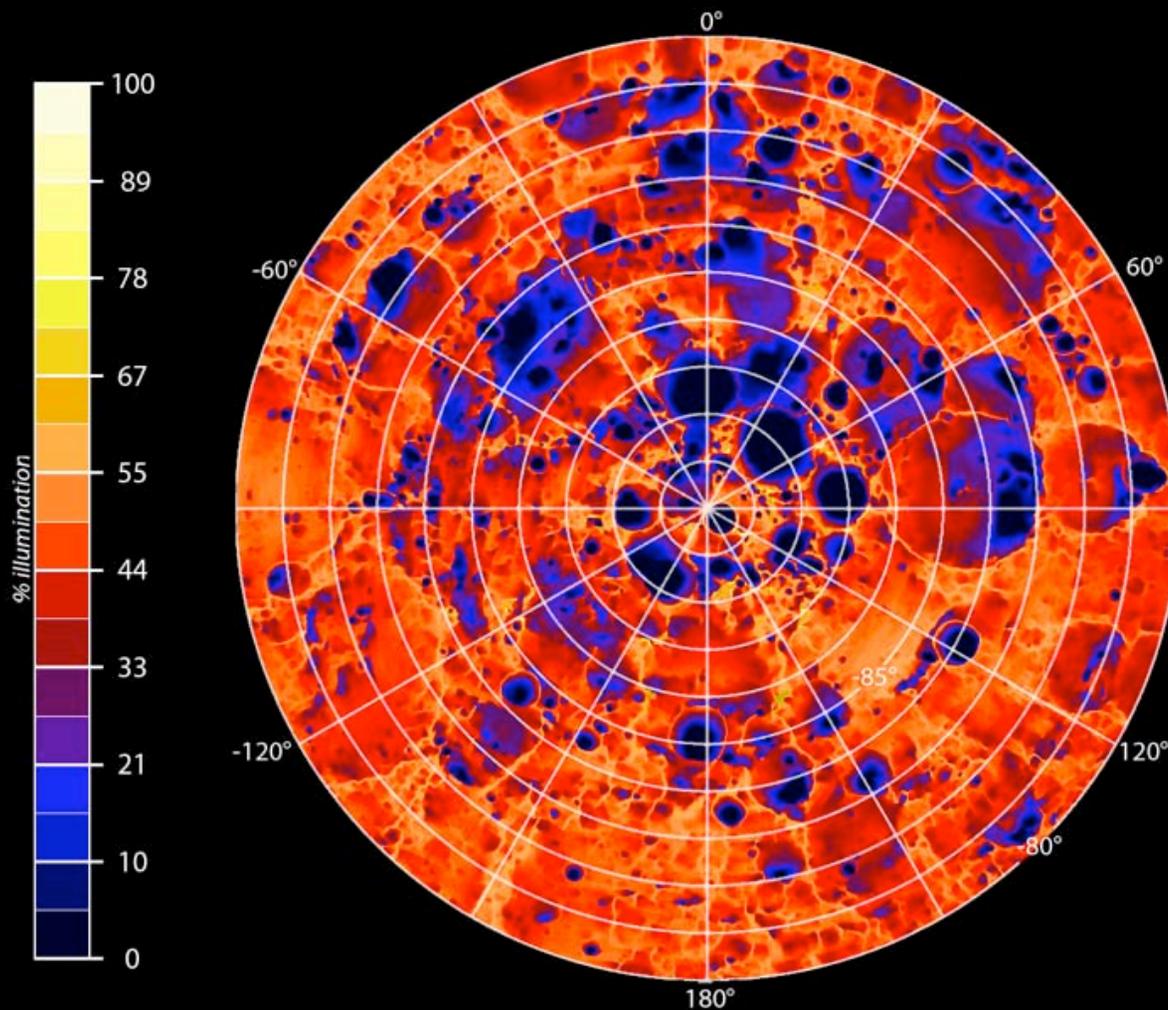
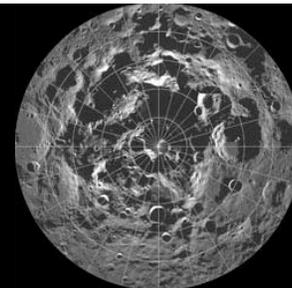
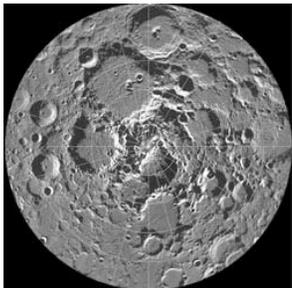


Mean North Pole Illumination: Winter
Three Months: Days 45-136



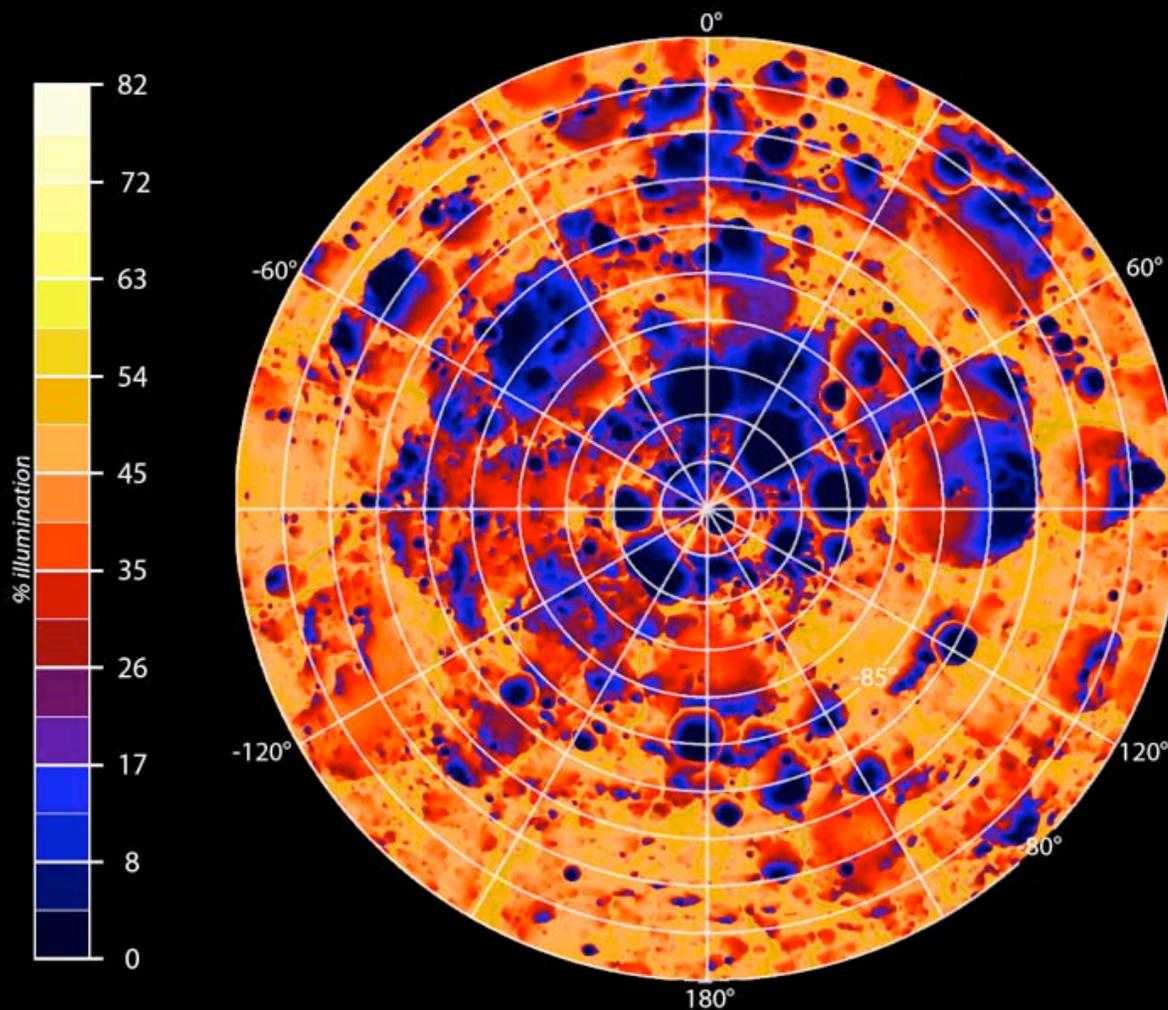
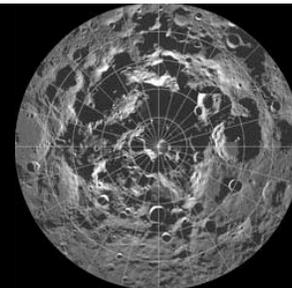
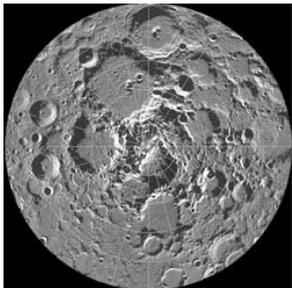
Mean North Pole Illumination: Spring
Three Months: Days 136-227

South Pole Seasonal Variations



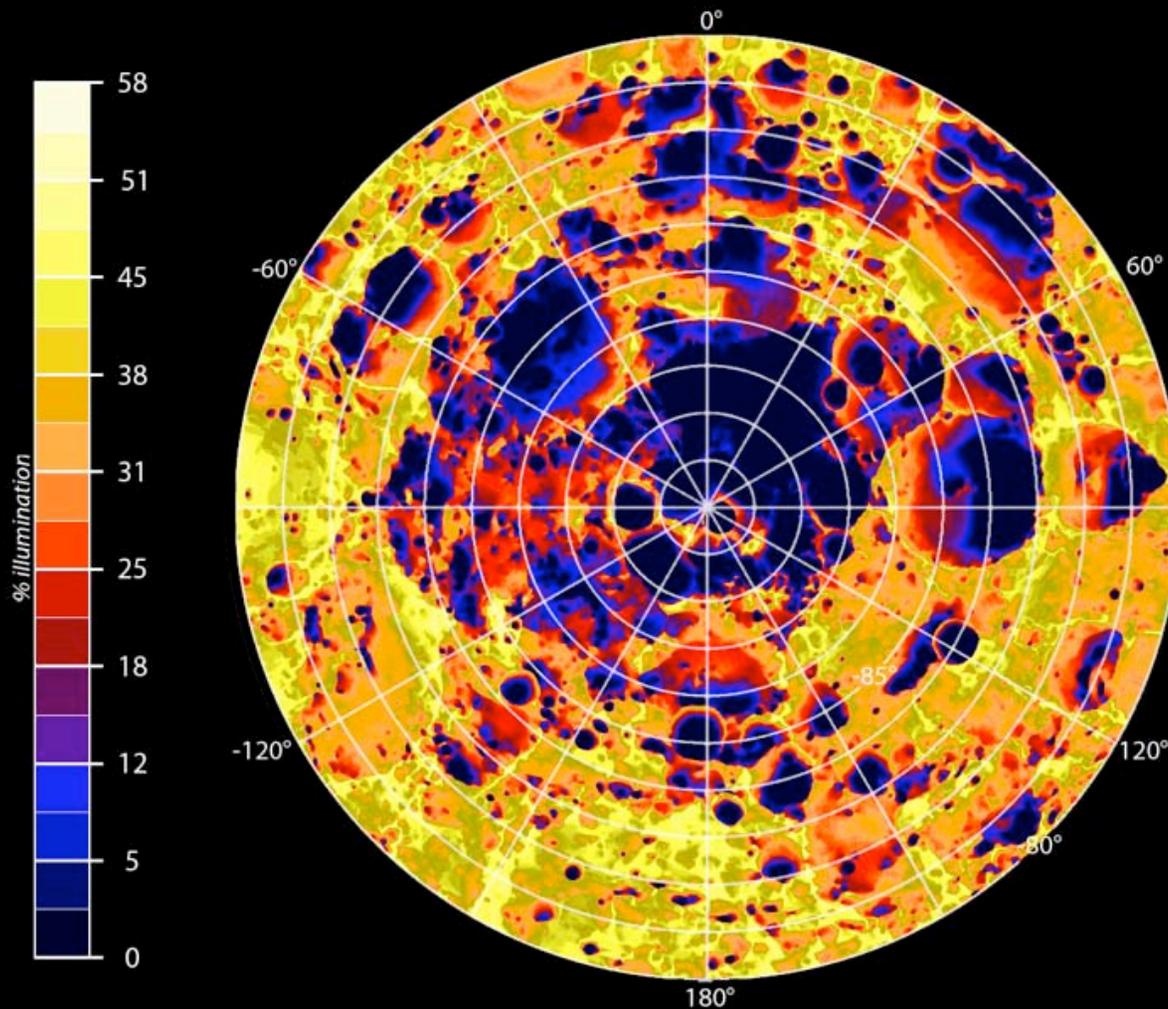
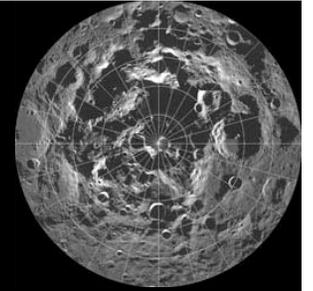
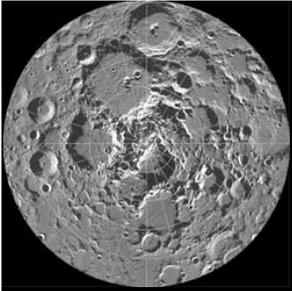
Mean South Pole Illumination: Summer
Three Months: Days 45-136

South Pole Seasonal Variations

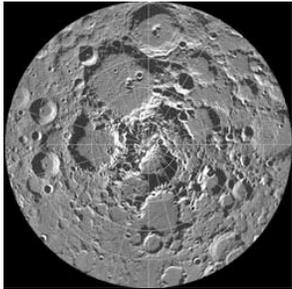


Mean South Pole Illumination: Autumn
Three Months: Days 136-227

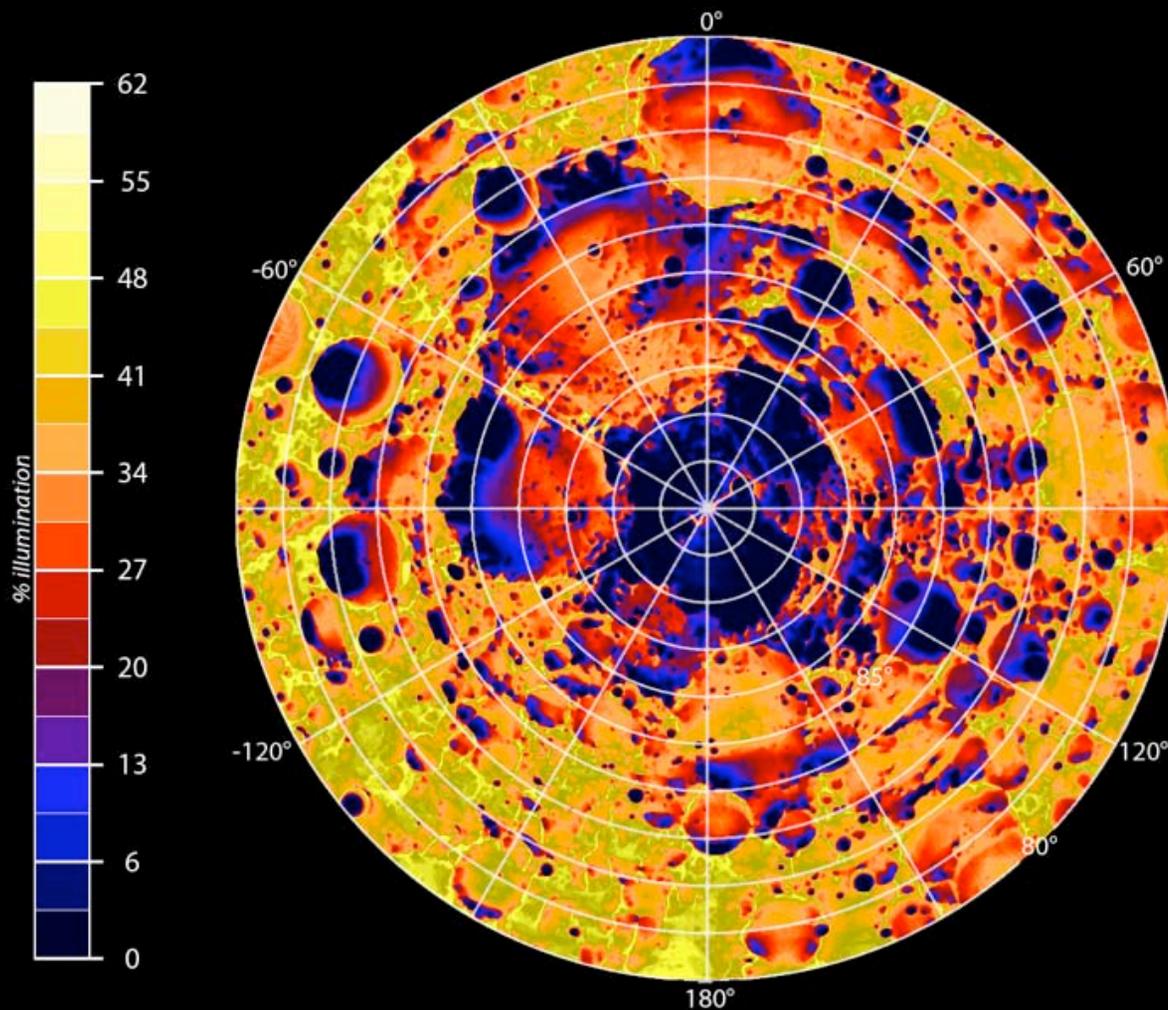
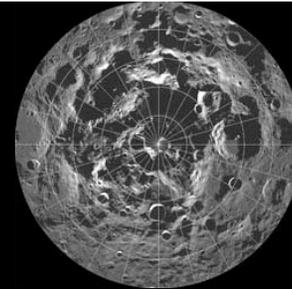
South Pole Seasonal Variations



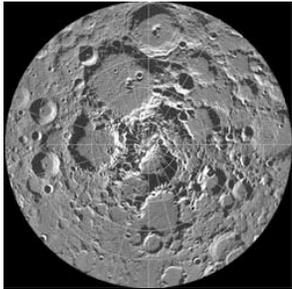
Mean South Pole Illumination: Winter
Three Months: Days 227-318



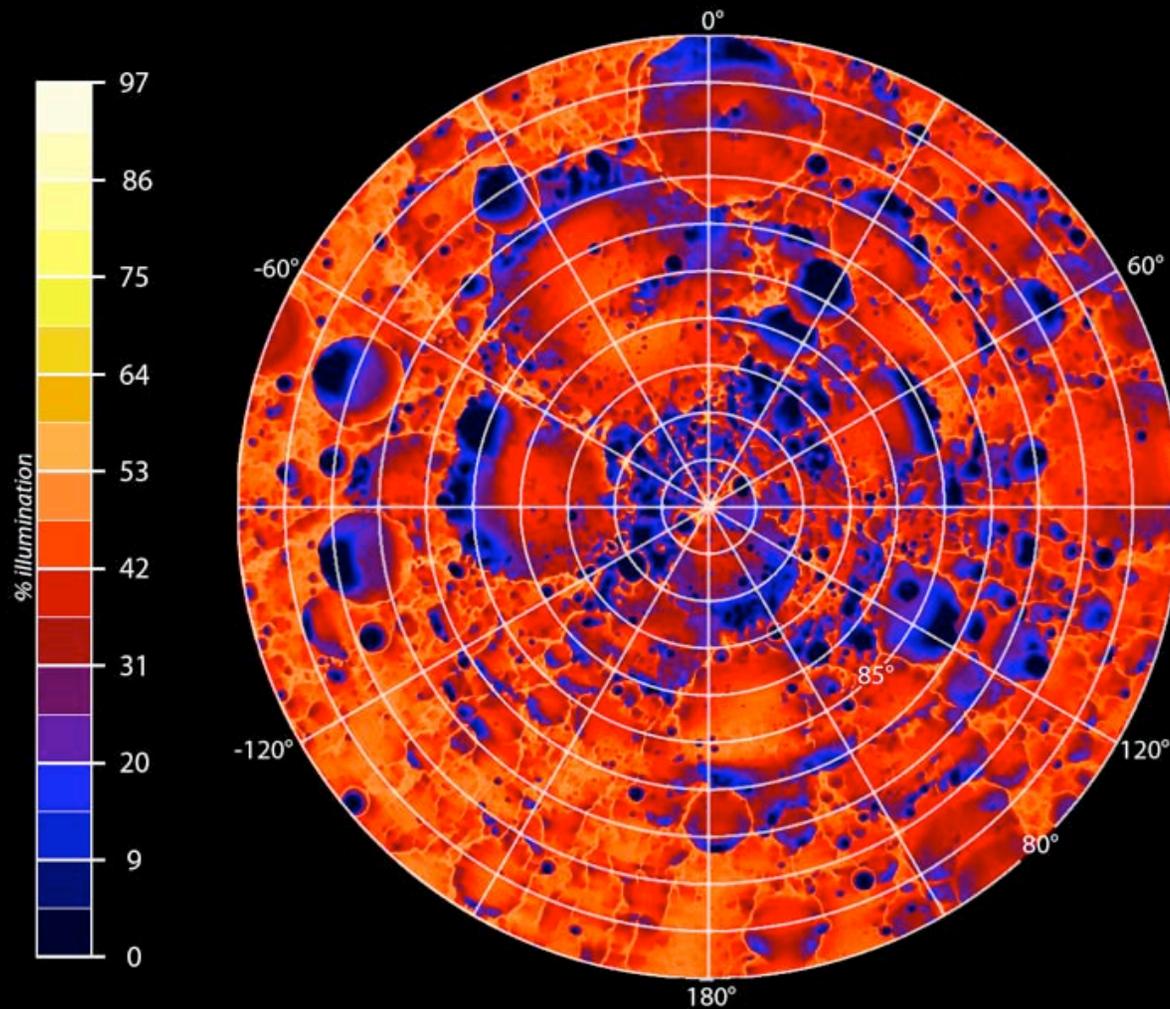
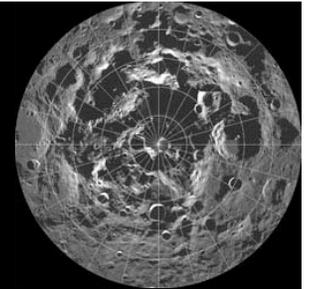
North Pole Seasonal Variations



Mean North Pole Illumination: Winter
Three Months: Days 45-136

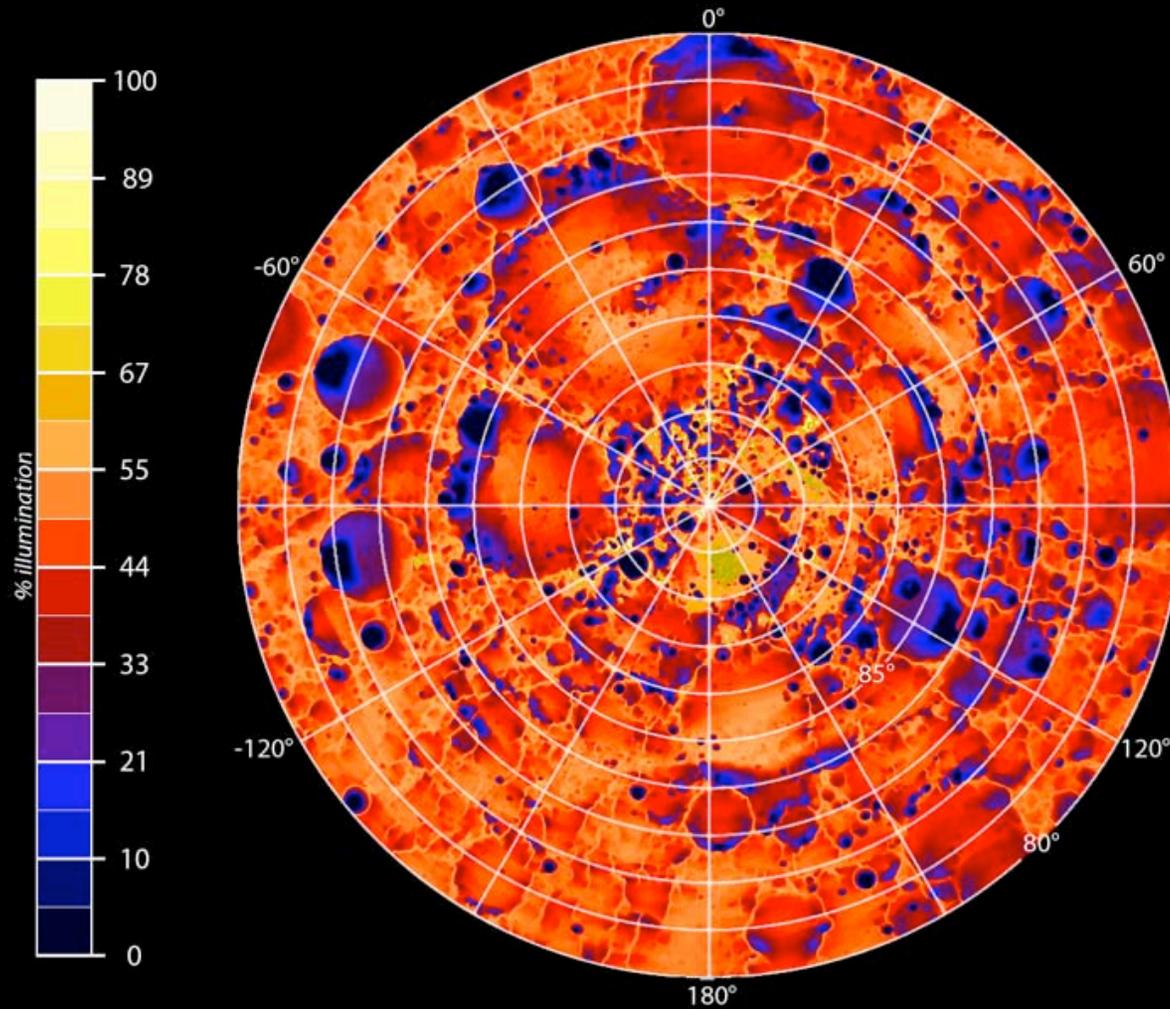
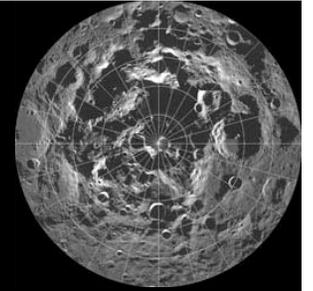
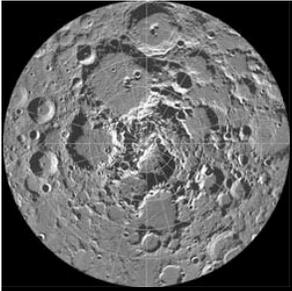


North Pole Seasonal Variations

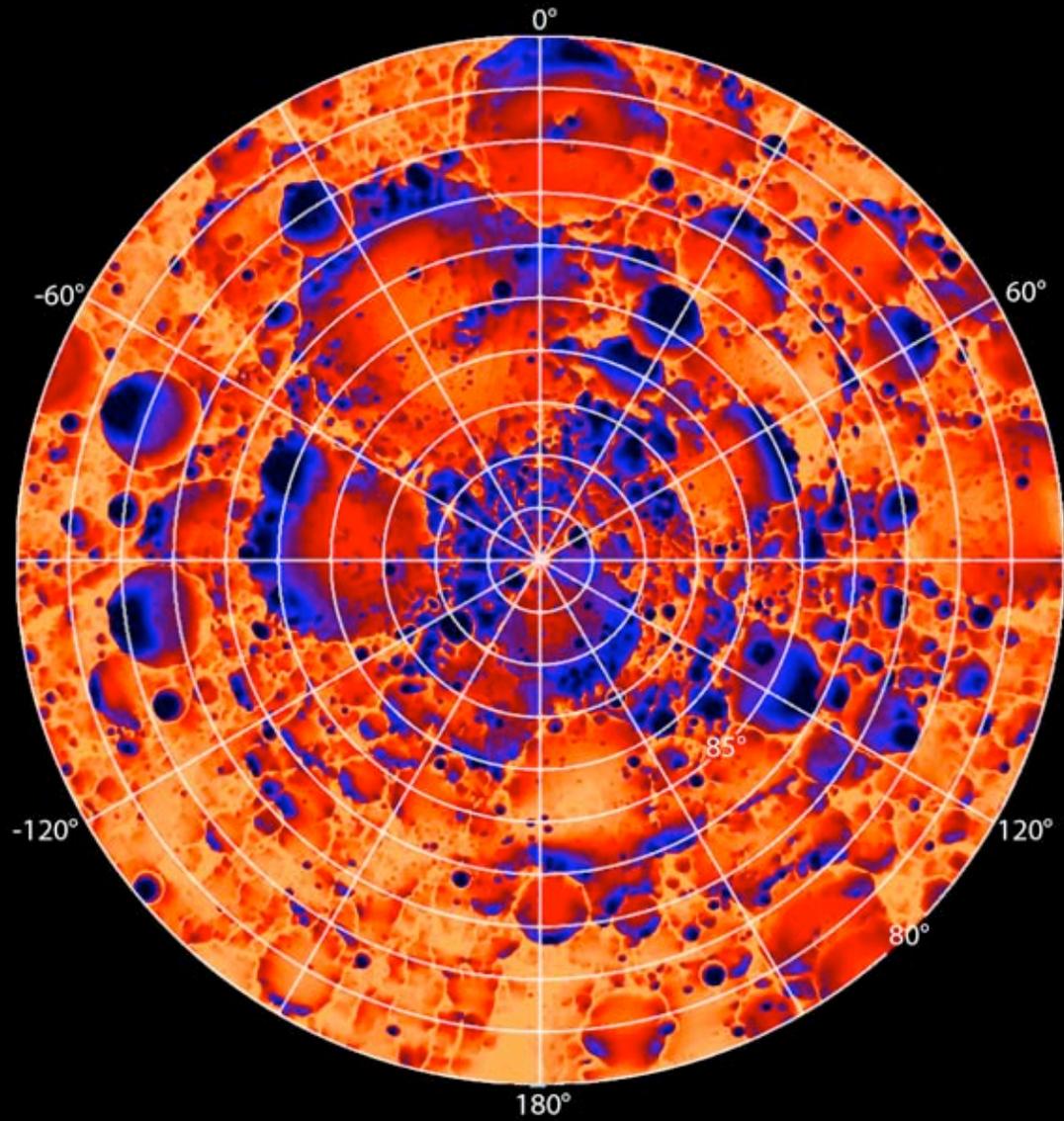
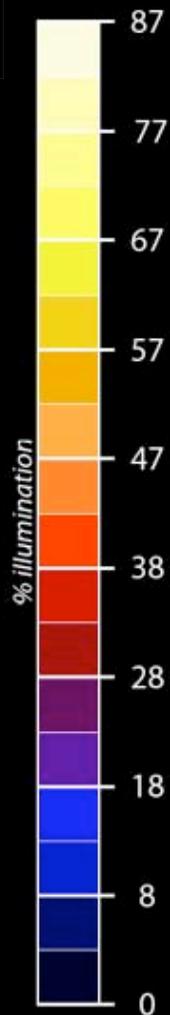
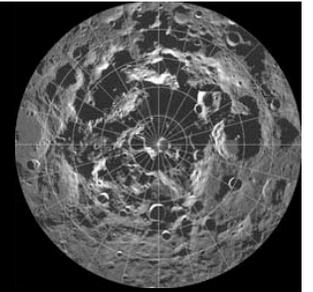
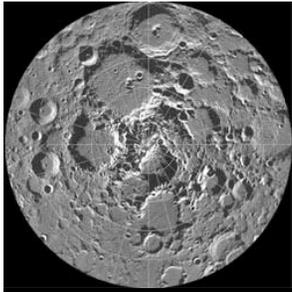


Mean North Pole Illumination: Spring
Three Months: Days 136-227

North Pole Seasonal Variations

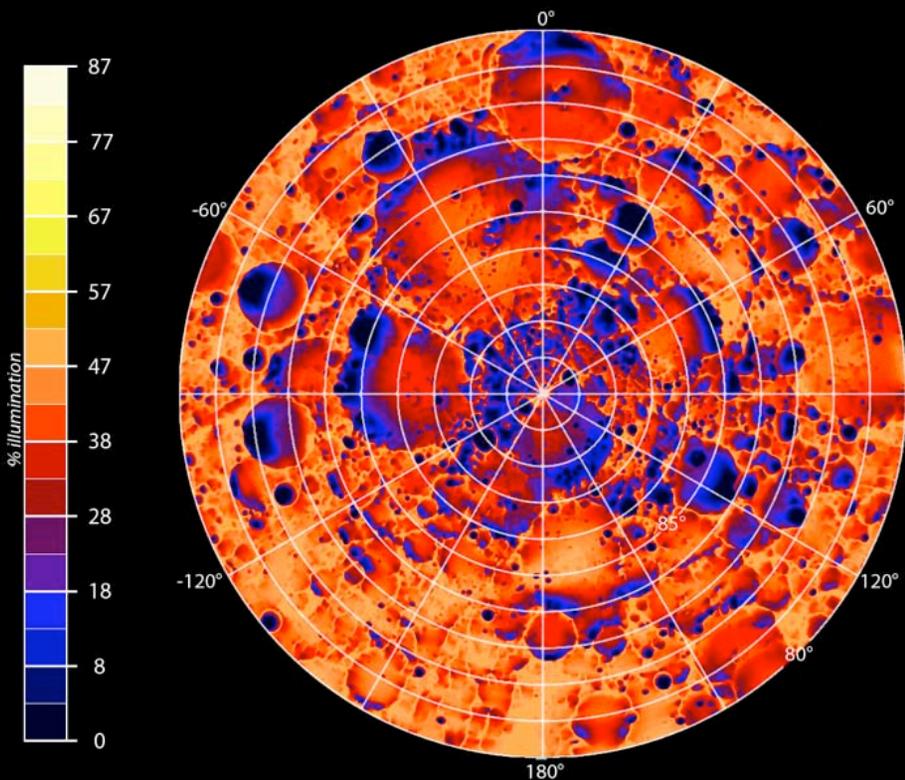
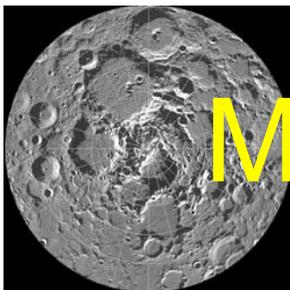


Mean North Pole Illumination: Summer
Three Months: Days 227-318

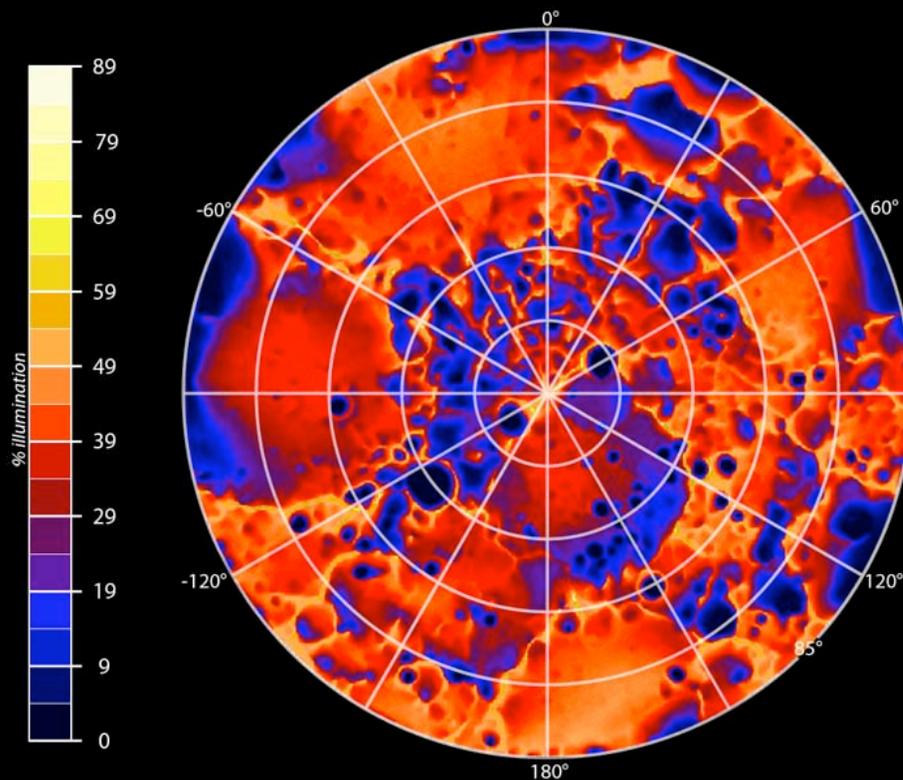


Mean North Pole Illumination
One Year: Days 1-355

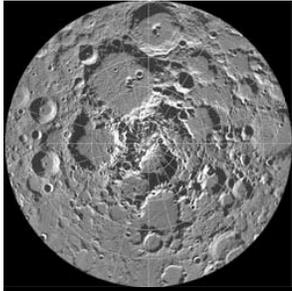
Mean North Pole Illumination



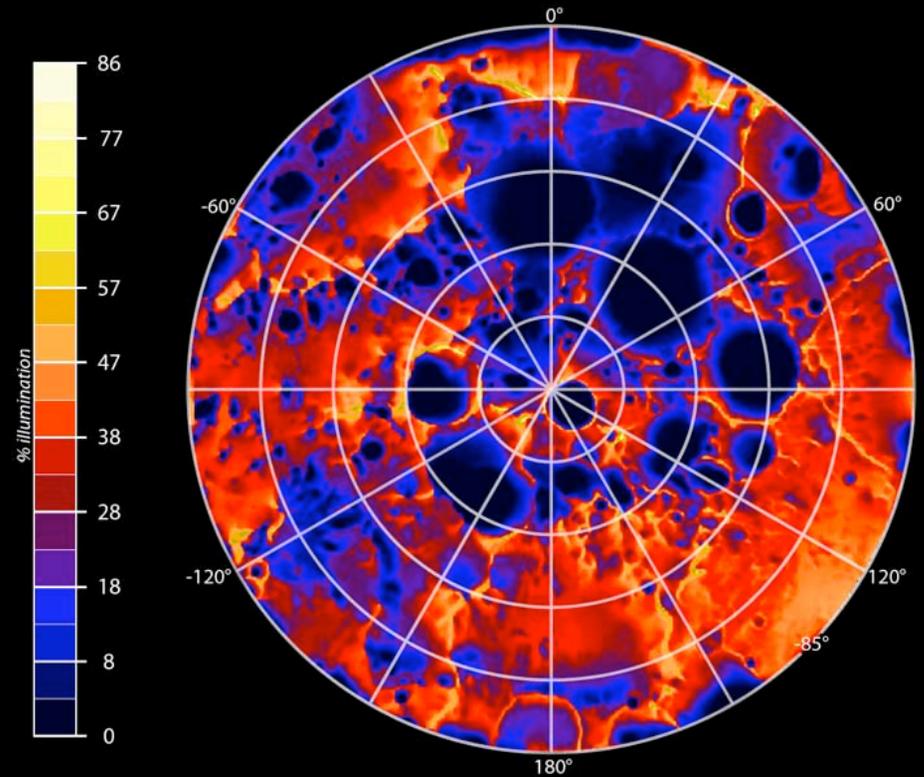
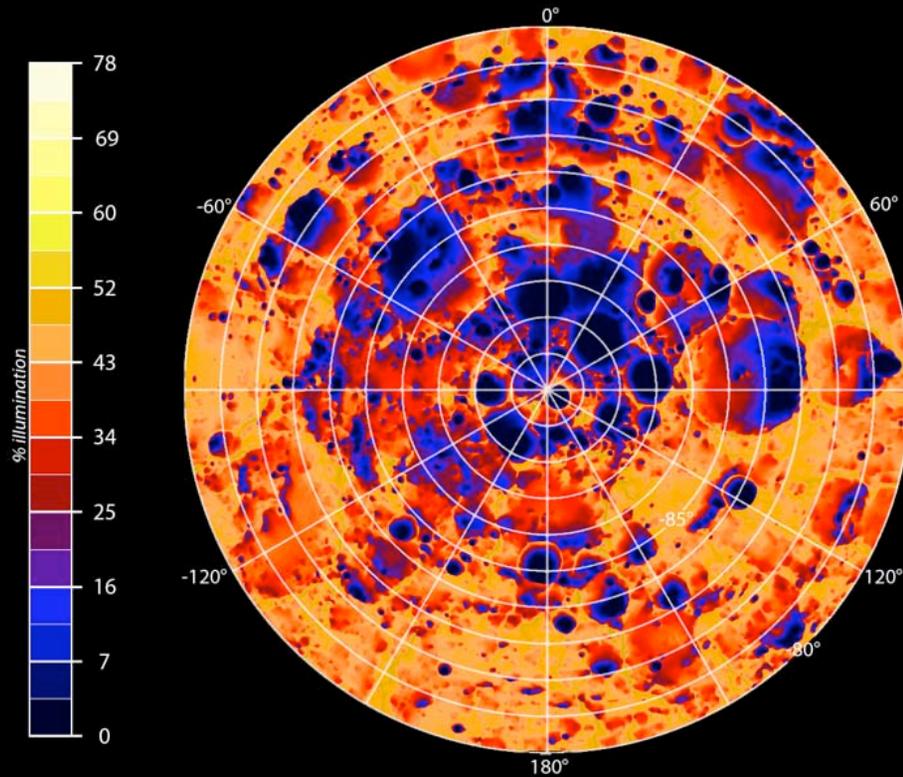
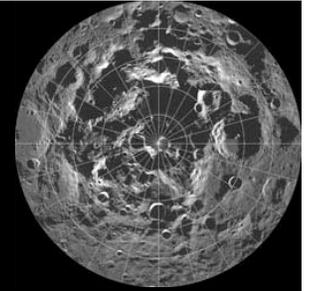
Mean North Pole Illumination
One Year: Days 1-355

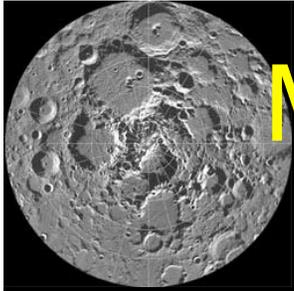


Mean North Pole Illumination
One Year: Days 1-355 (Low Resolution)

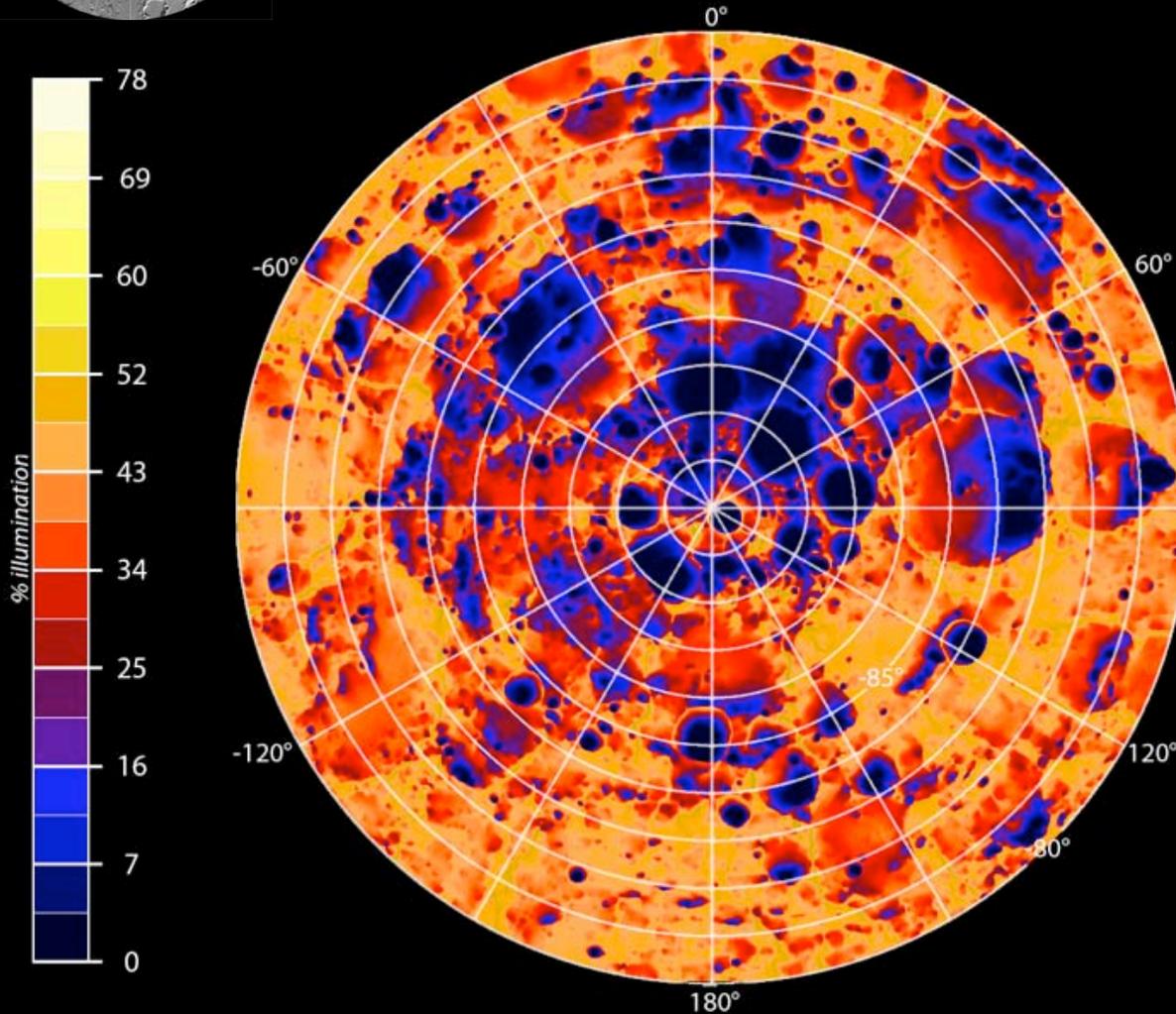
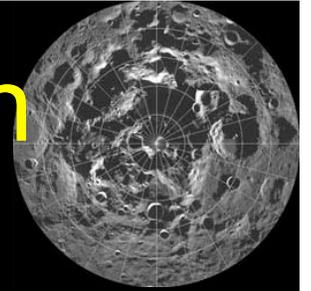


South Pole





Mean South Pole Illumination



- -80° to -90° latitude range
- 236 m/pixel spatial

Preliminary Findings

- No 100% areas
- No regions $>80\%$ exist at south pole

Mean South Pole Illumination
One Year: Days 1-355