Review of Lunar Polar Illumination

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and

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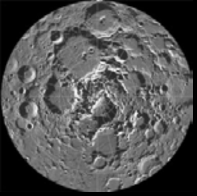
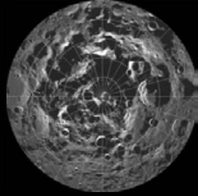
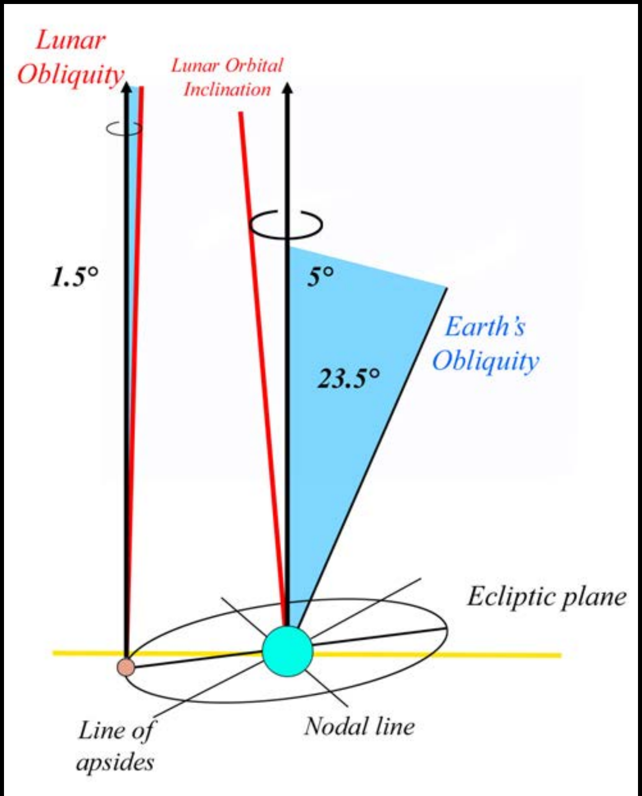


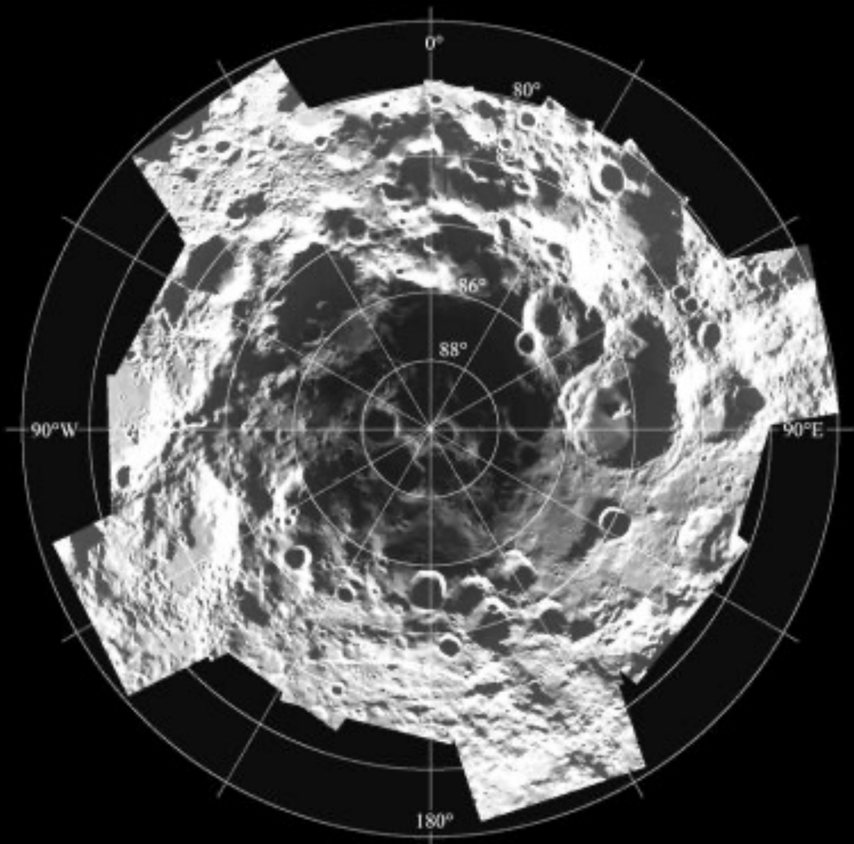
Lunar Poles



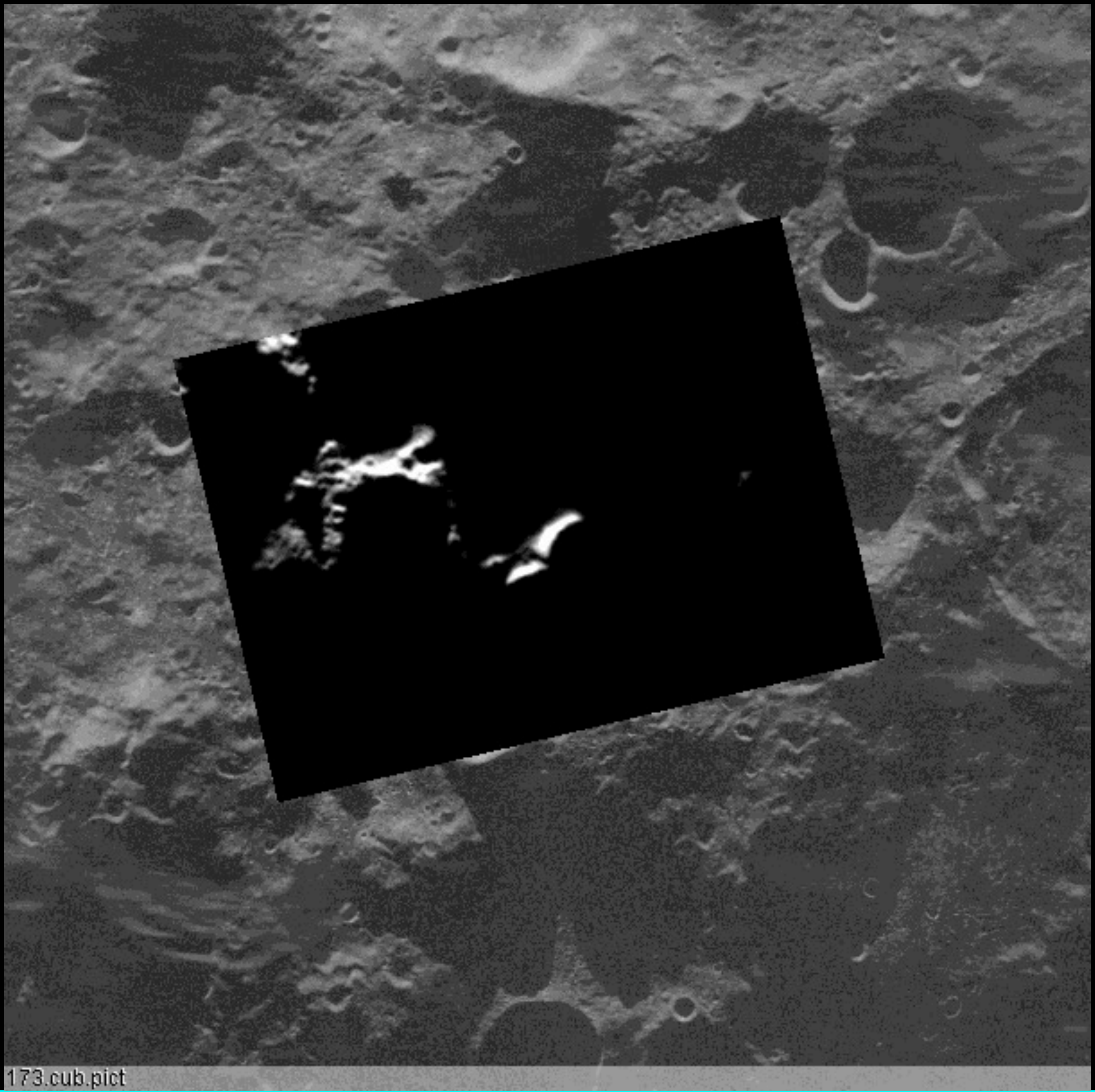


- Spin axis 1.5° from the perpendicular to the ecliptic plane results in special illumination conditions
- Permanently shadowed regions are cold traps (< 100K) and are possible locations of ice deposits
- First mention that permanent shadowed regions could exist was by Urey in his 1952 book The Planets

Clementine's View of the Poles



- Imaged each pole every 10 hours for 71 days
- Data collected during winter in the southern hemisphere
- High resolution data collected at 15 m/pixel
- Shoemaker 1994 Science paper estimated at least 30,000 km^2 of shadow in the south polar region



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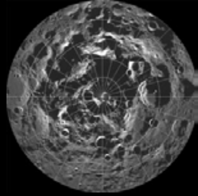
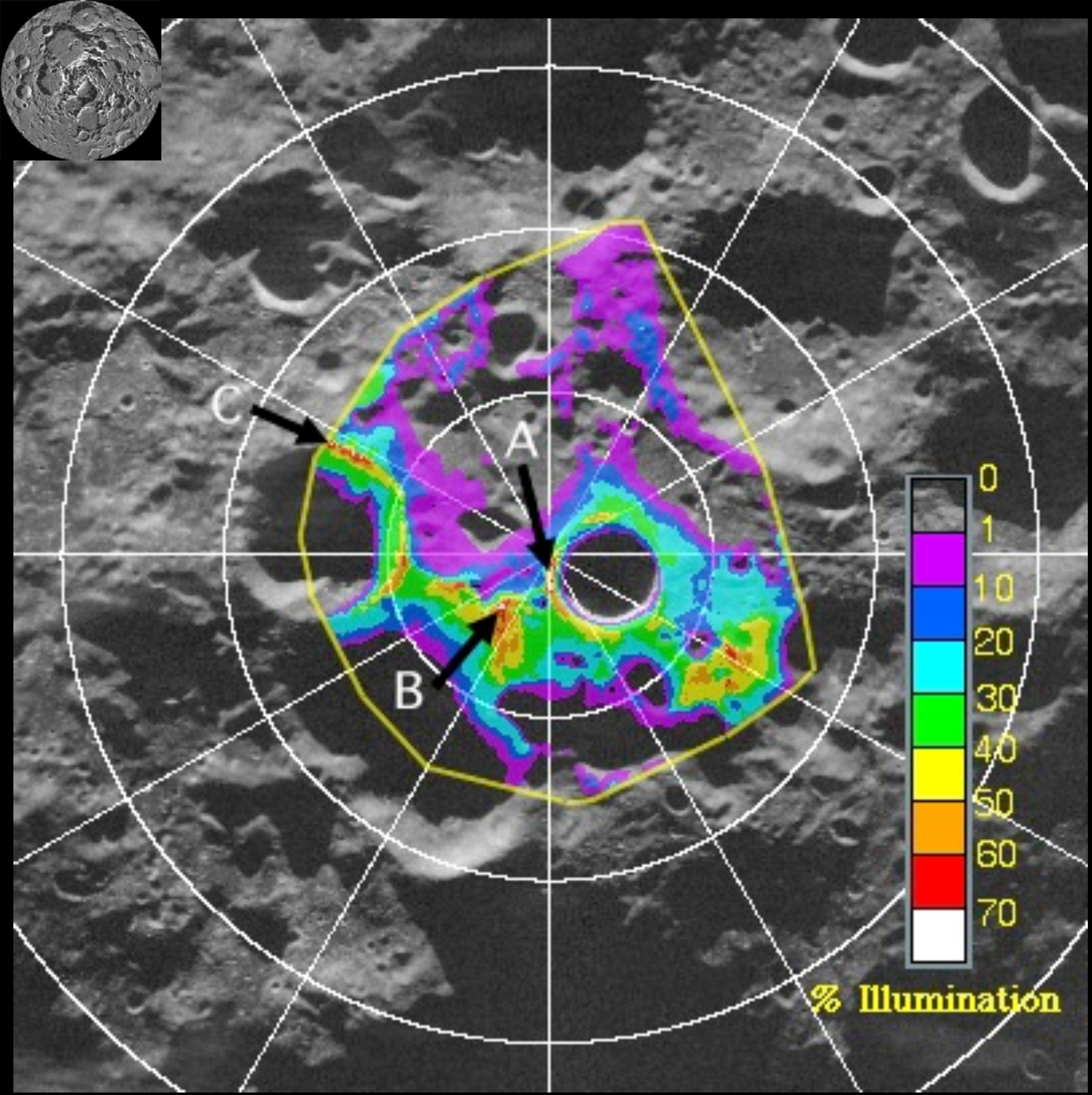
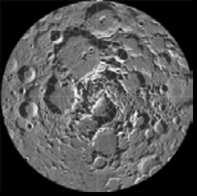




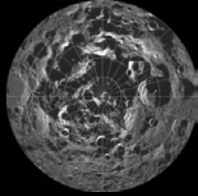
Quantitative Illumination Map

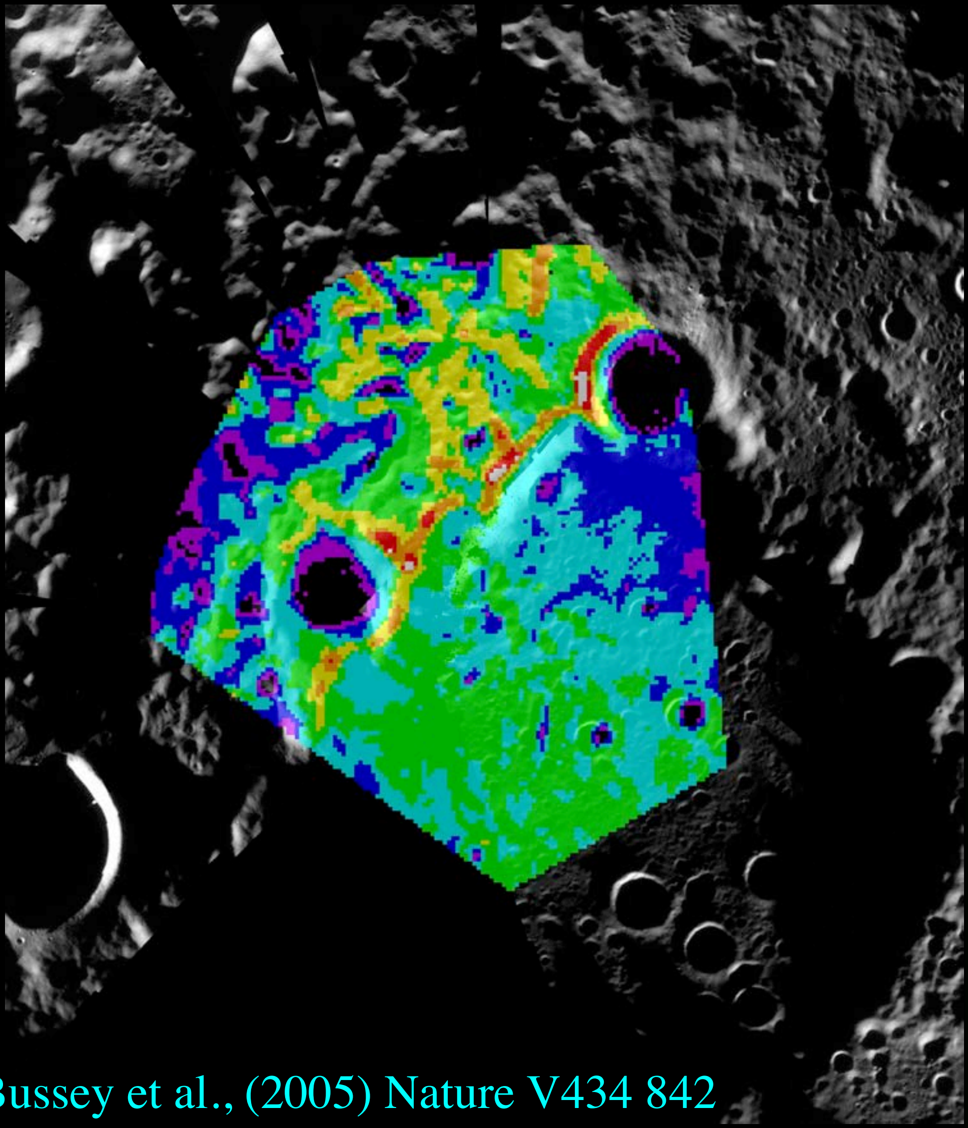
- No constant illumination
- A,B,C lit more than 70% of a winter day
- A&B collectively lit > 98%

Bussey et al., (1999) GRL V26 No. 9, 1187-1190

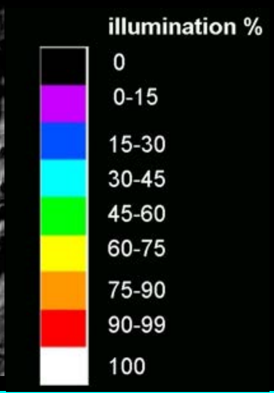


North-Pole Illumination Map





- Four places on the rim of Peary crater were constantly illuminated during a lunar summer day
- All are in close proximity with permanently shadowed regions.



Bussey et al., (2005) Nature V434 842

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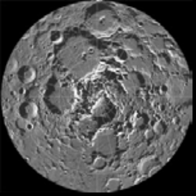
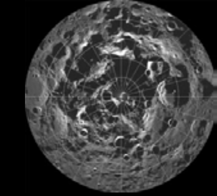
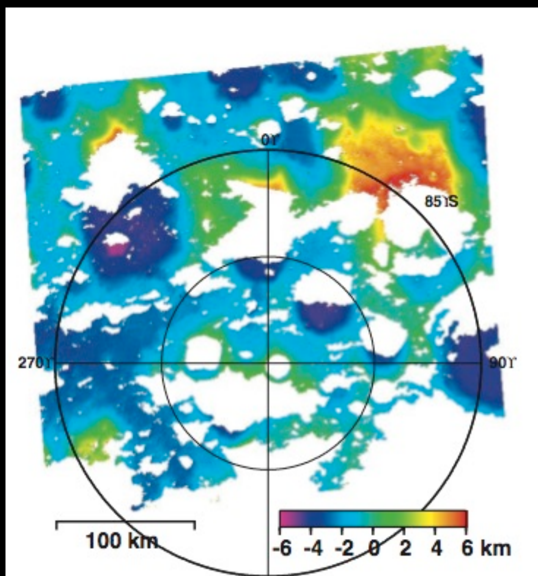
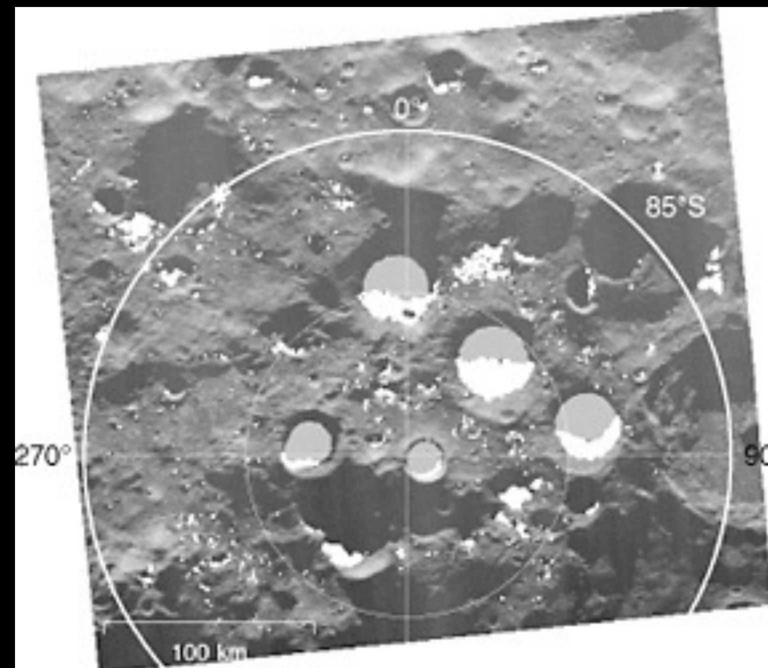


Earth-Based Radar



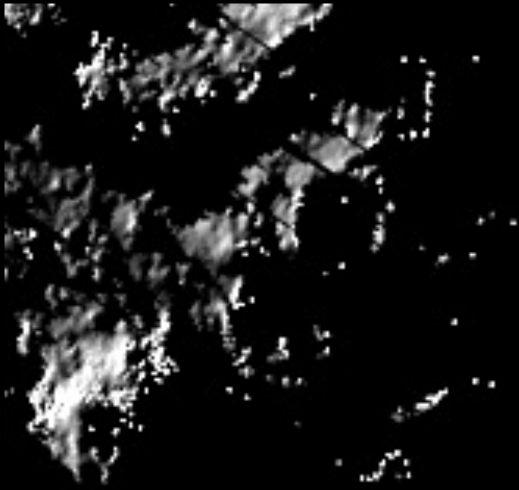




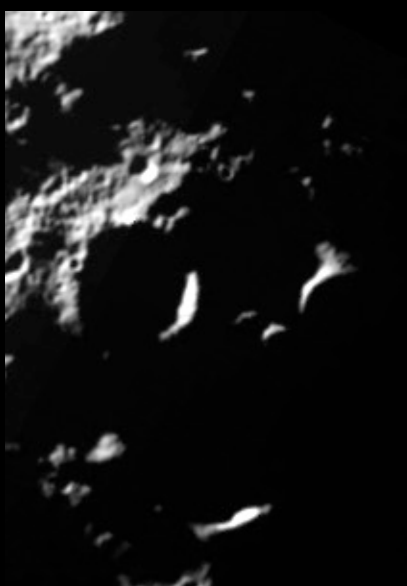
- Made from Goldstone data
- 150 m Spatial, 50 m vertical DEM
- Mapped locations of permanent shadow

Details in Margot et al (1999) Science V 284 1658-1660

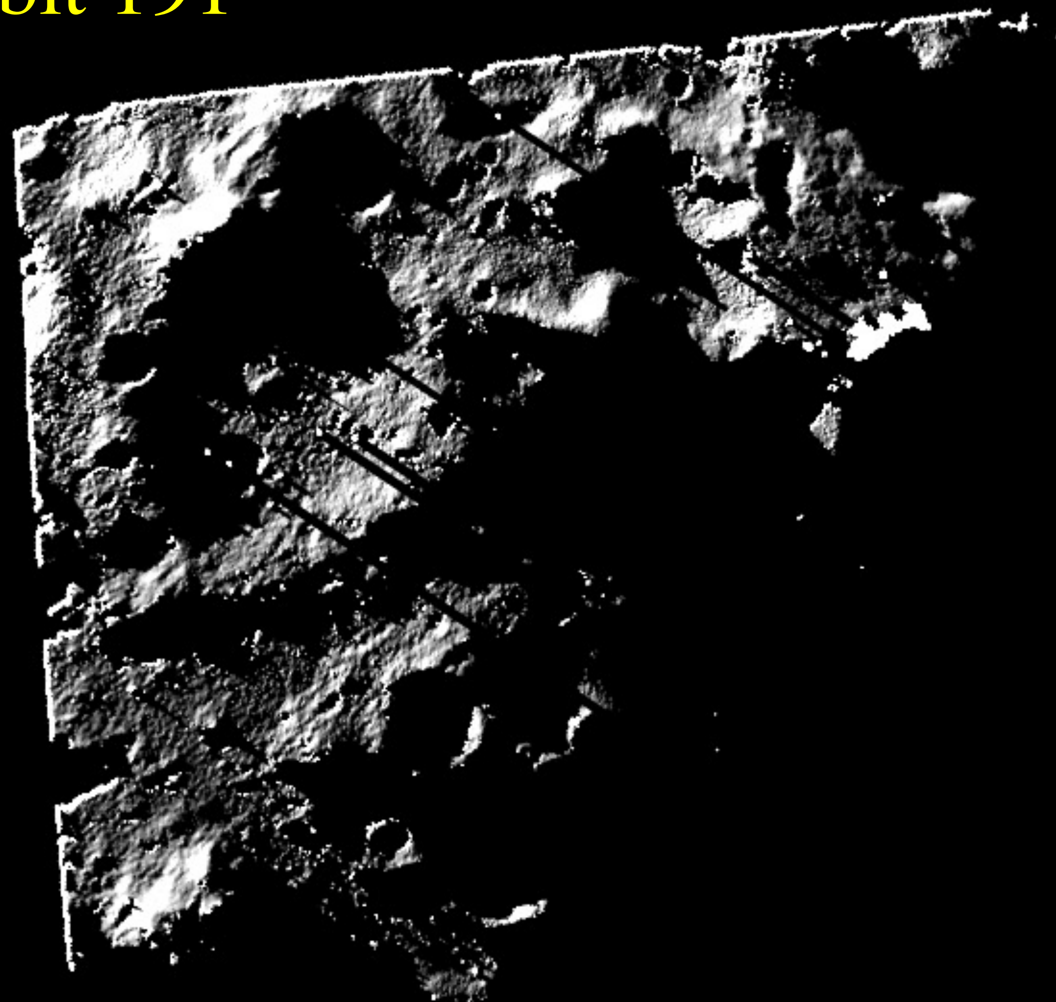
Orbit 191



Clementine stereo



Clementine UVVIS



Radar topography

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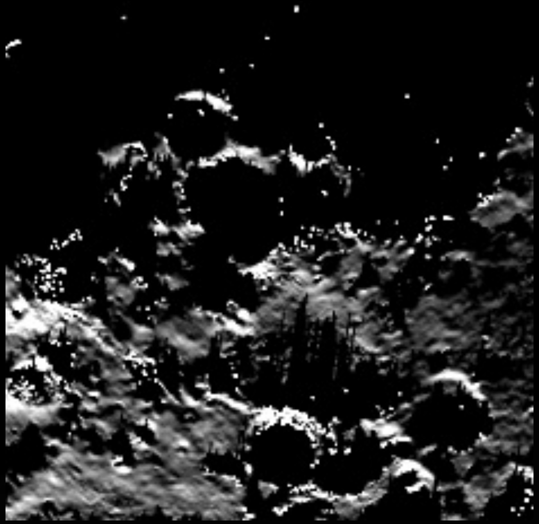
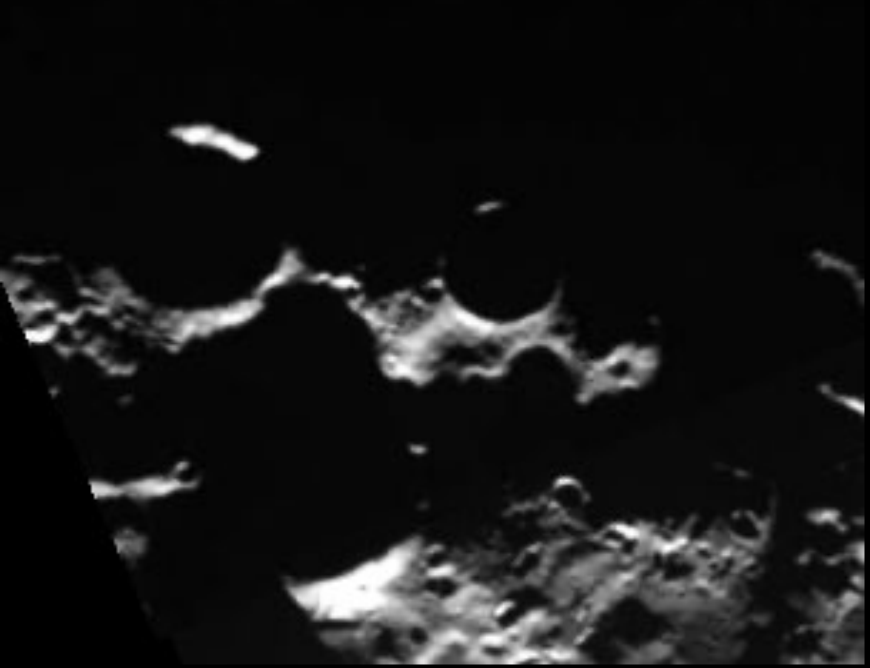
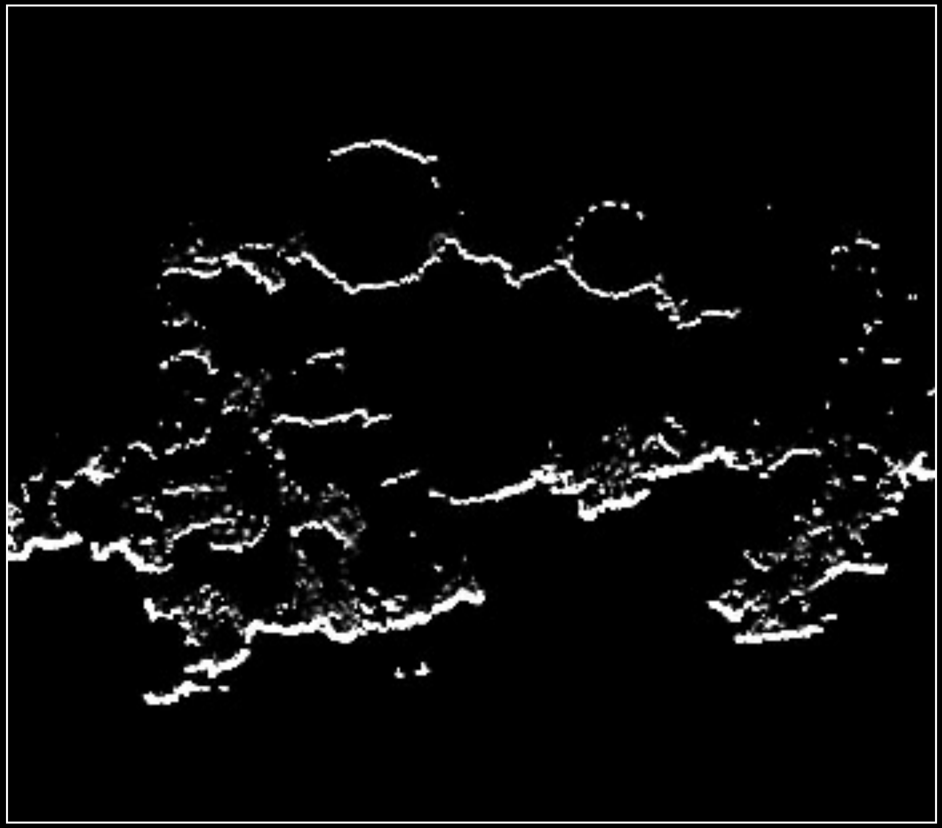
Orbit 243



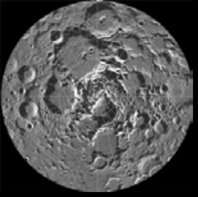
Clementine stereo



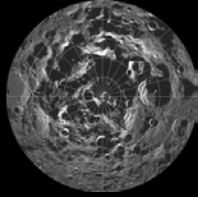
Clementine UVVIS

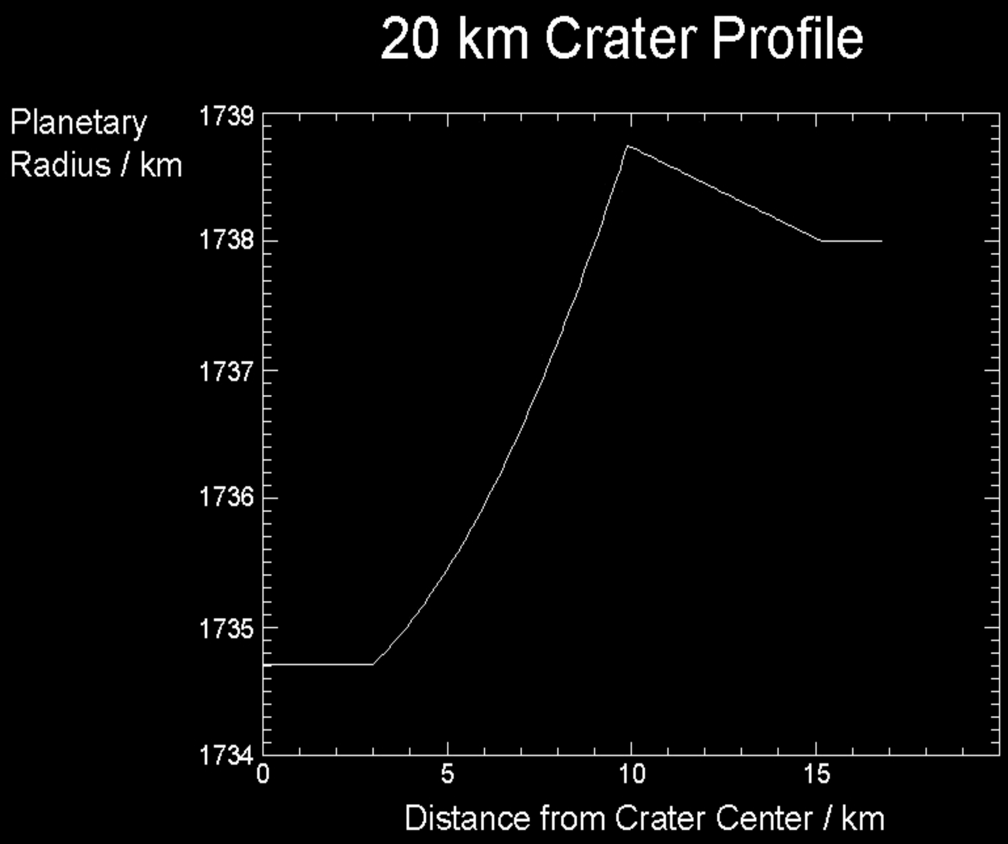


Radar topography

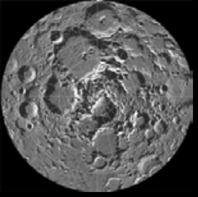


Simulated Simulations

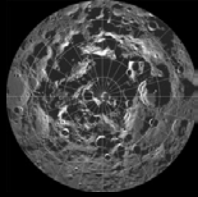


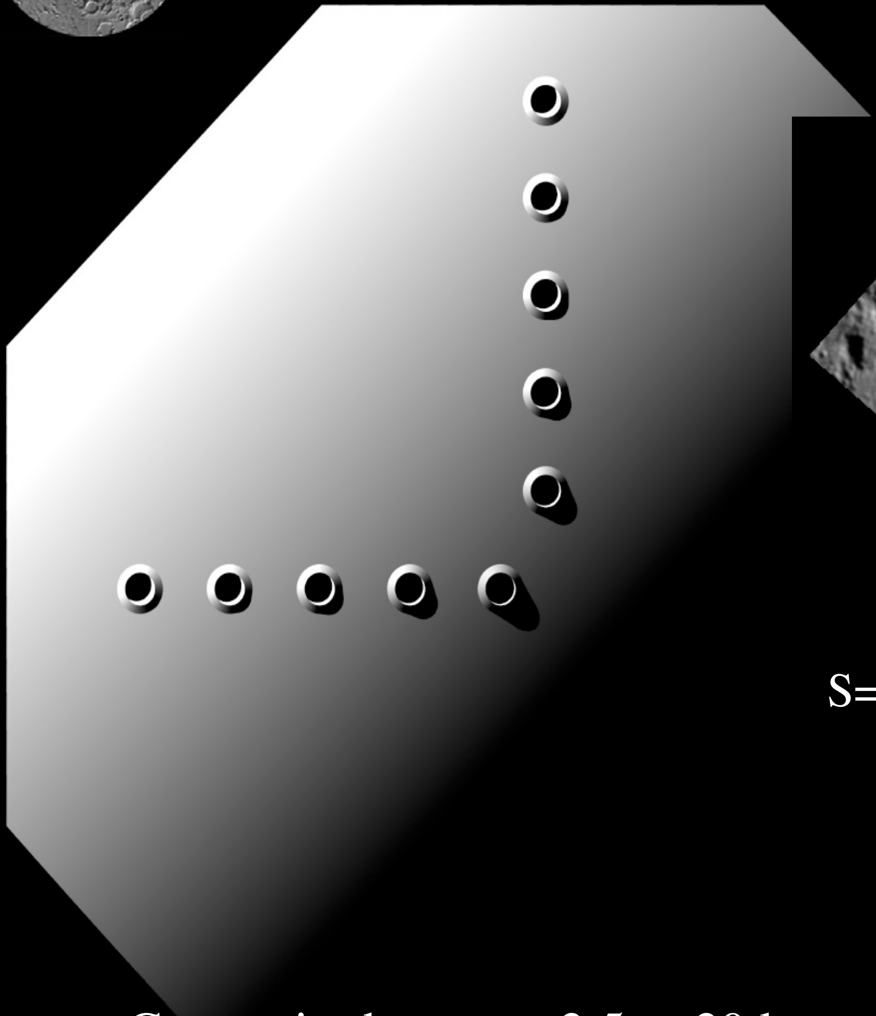


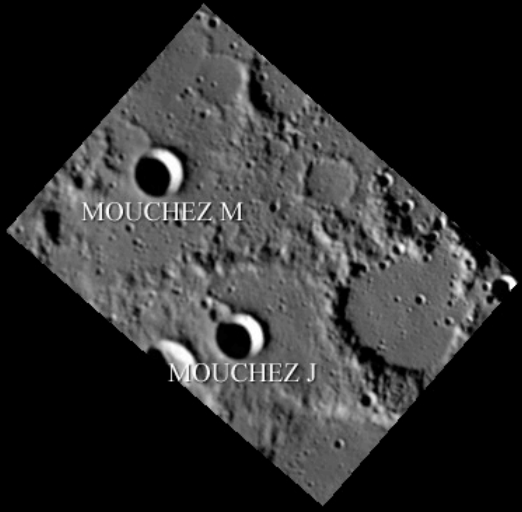
- Crater profiles for lunar craters are known (e.g. Pike, 1977).
- Investigate amount of permanent shadow as a function of size, latitude and season.

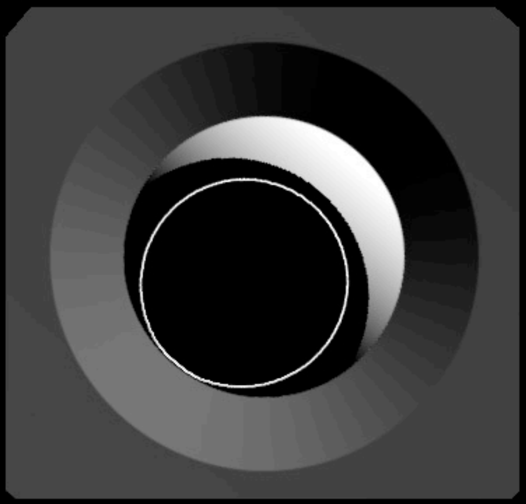


Topography simulations









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

- Craters in the range 2.5 to 20 km were studied
- Craters placed every 1° latitude from 70° to 90°
- A series of runs are conducted to calculate the extent of permanent shadow

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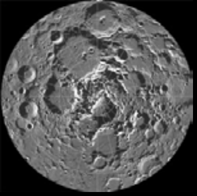
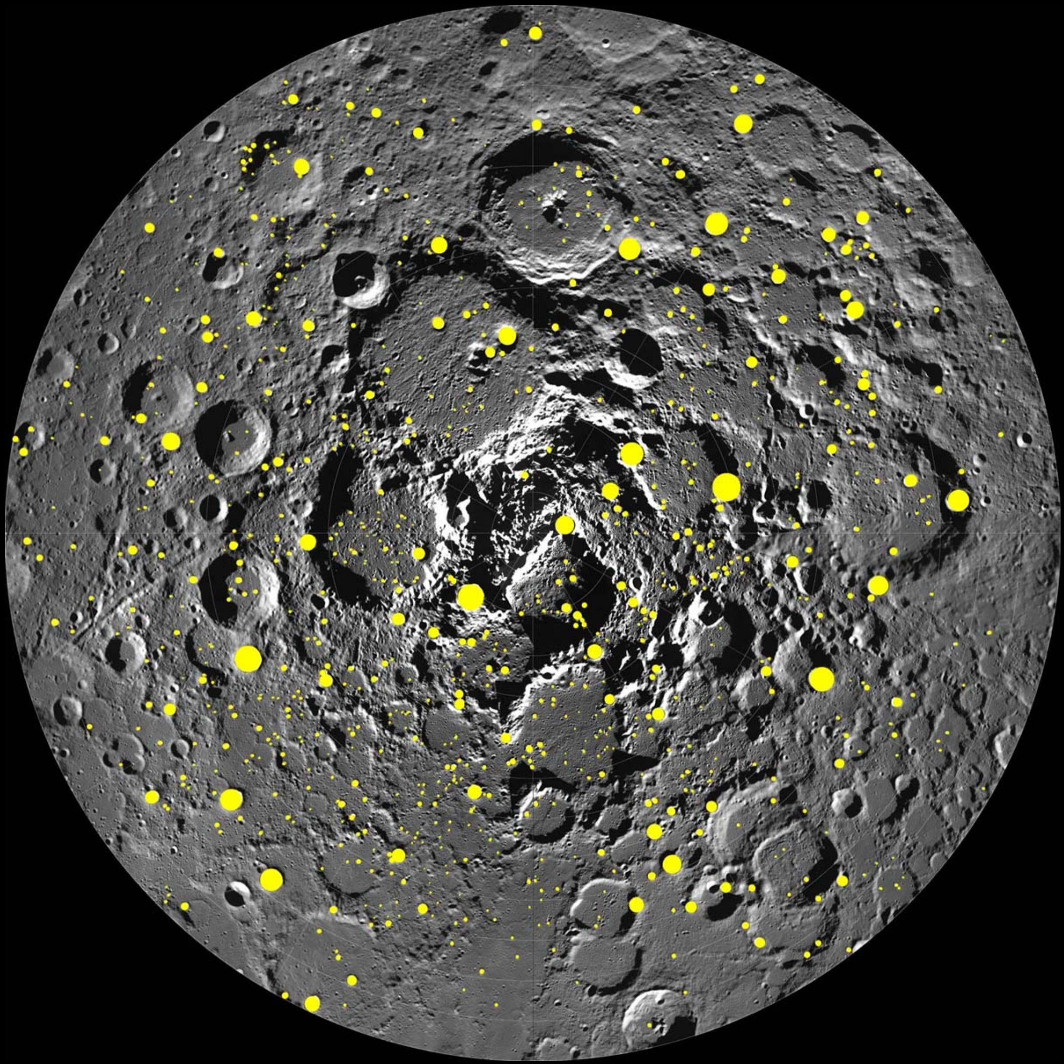
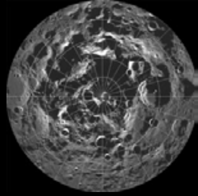


Permanent Shadow

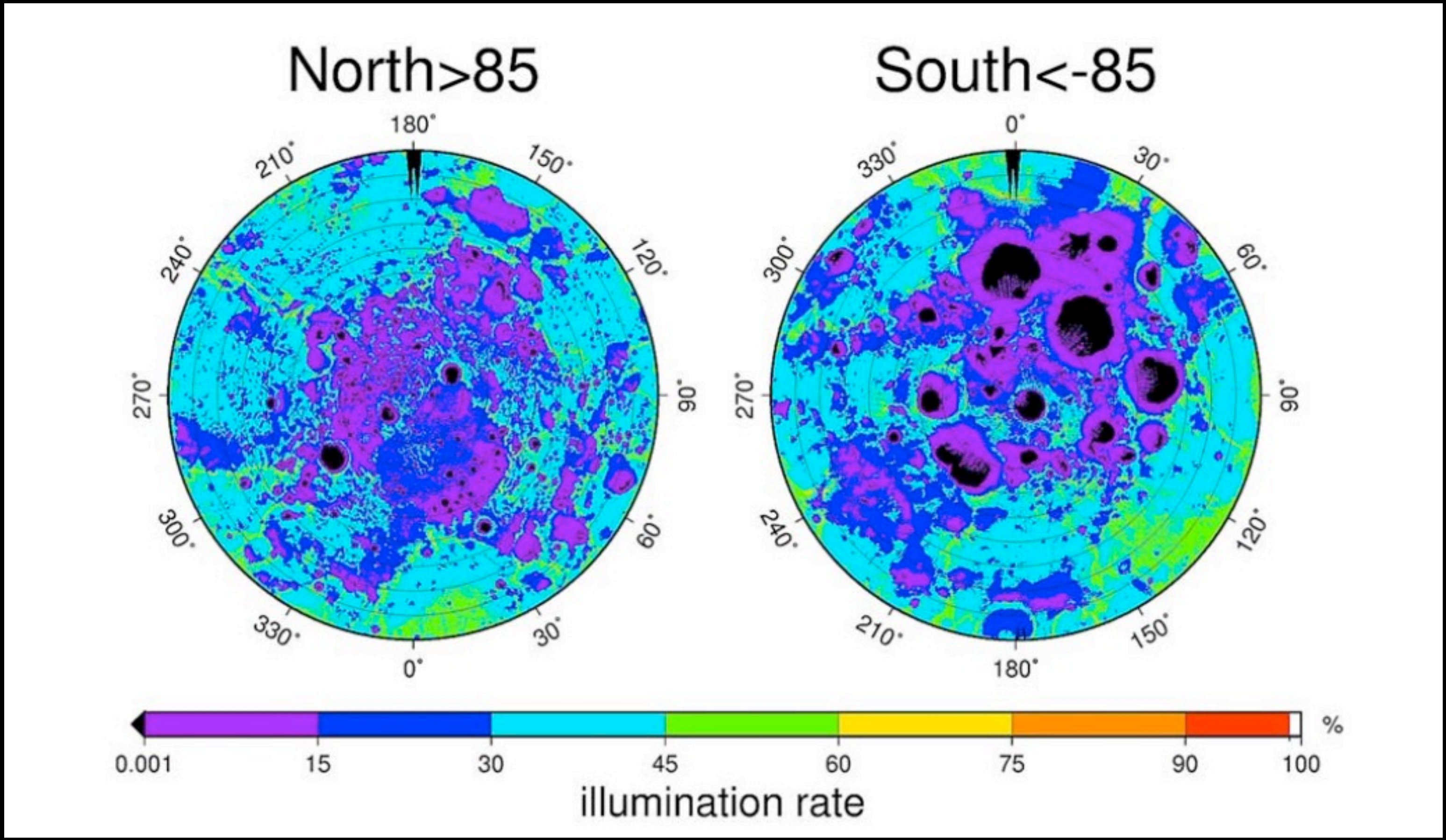




- 1000’s km^2 of permanent shadow in simple craters at both poles
- Permanent shadow exists in simple craters at long distances from the pole
- Represent possible locations of volatile deposits

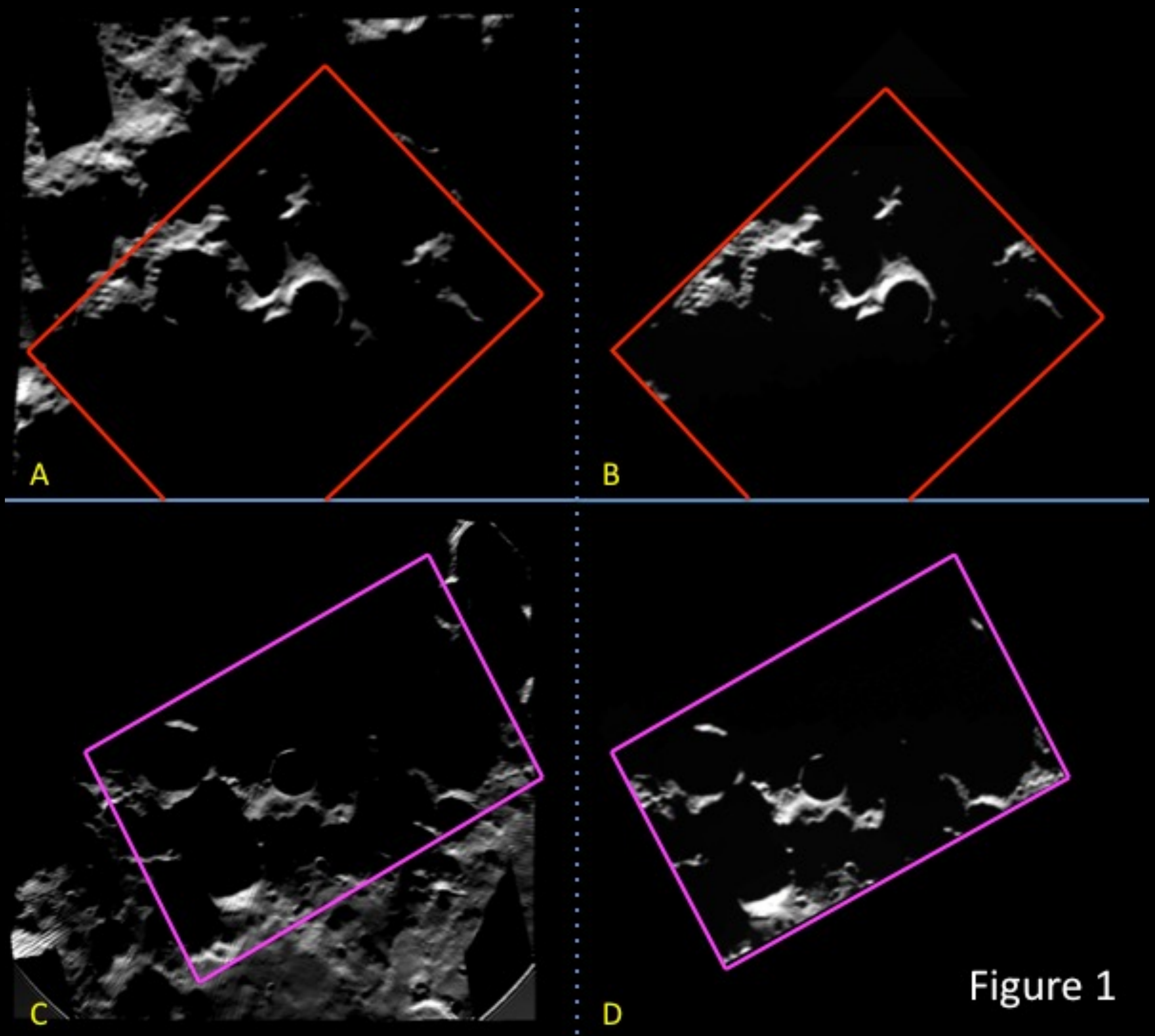
Bussey et al., (2003) GRL V30 No. 6, 1278-1281

Kaguya



- No 100% illuminated areas
- Both poles have locations that receive illumination > 80% of the time
- See Noda et al., (2008) GRL V35 L24203

Kaguya-Clementine Comparison



From Bussey et al., Icarus, 2010

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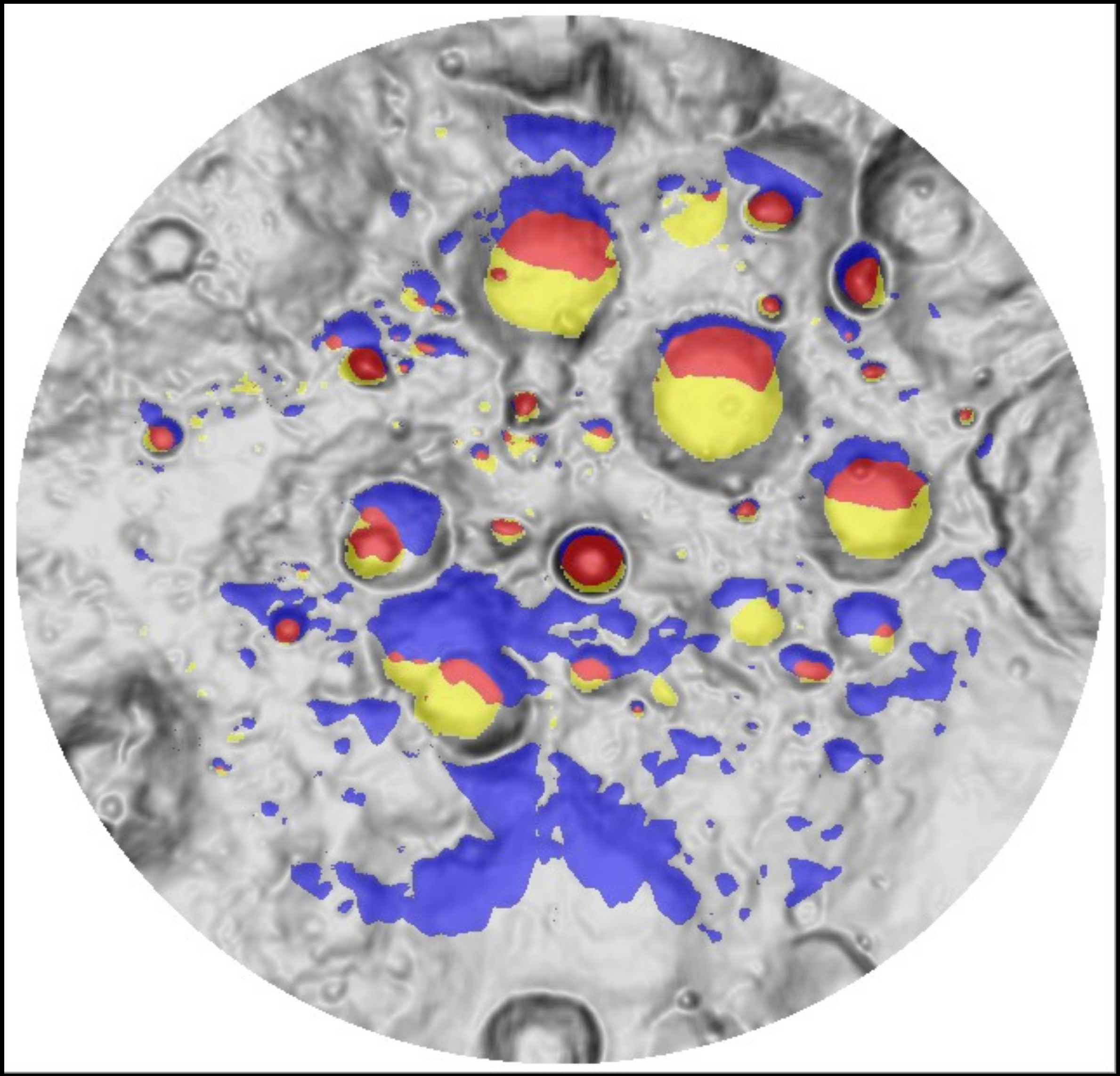
Earth & Sun Shadows



- Earth Shadowed
  - Blue & Red
- Sun Shadowed
  - Yellow & Red

From Bussey et al., Icarus, 2010

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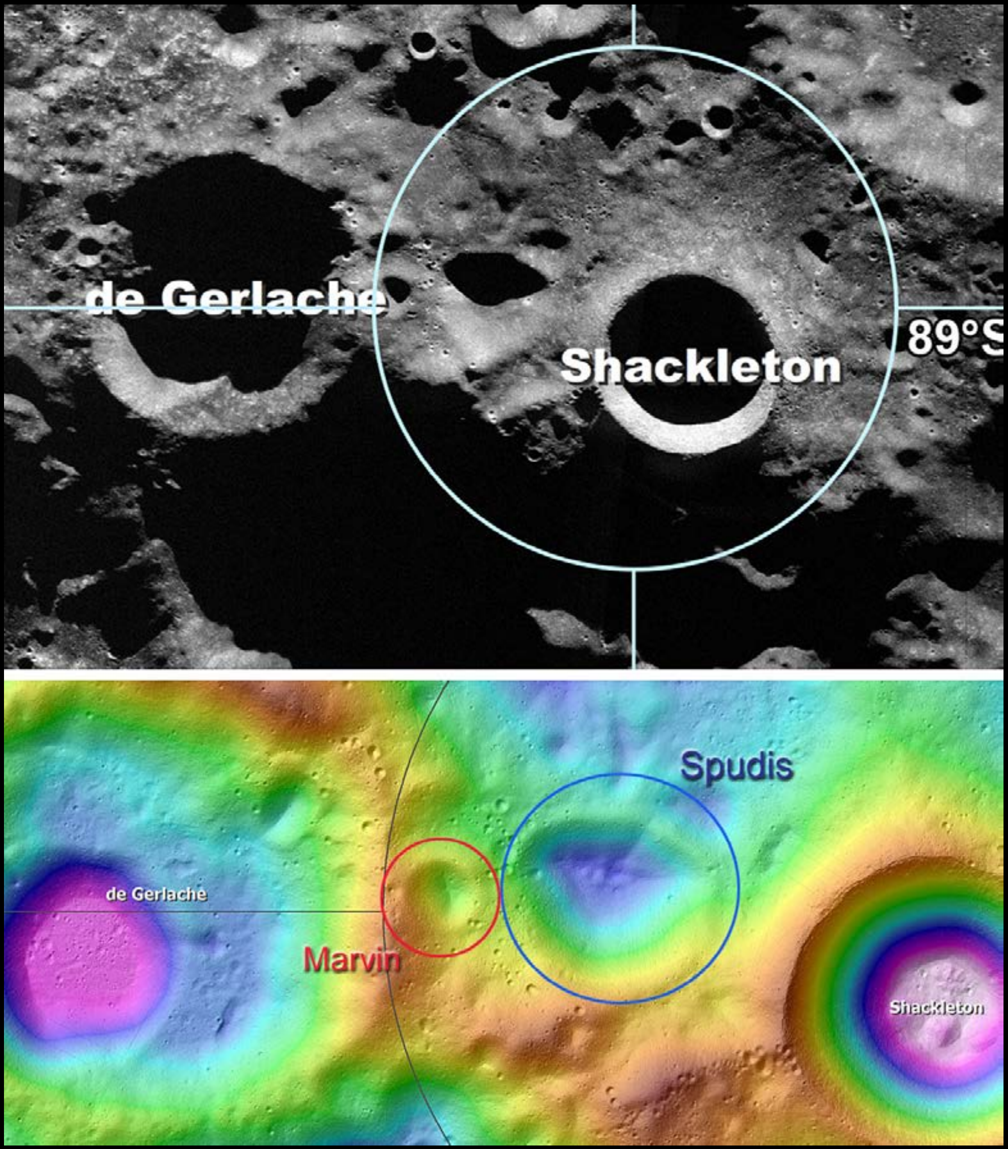
LRO



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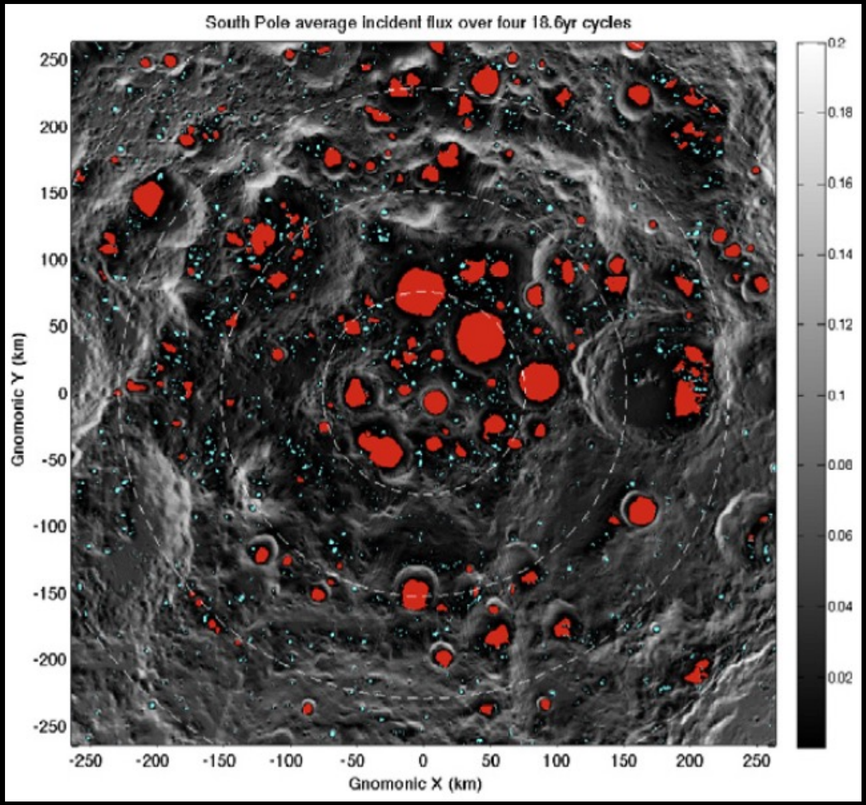
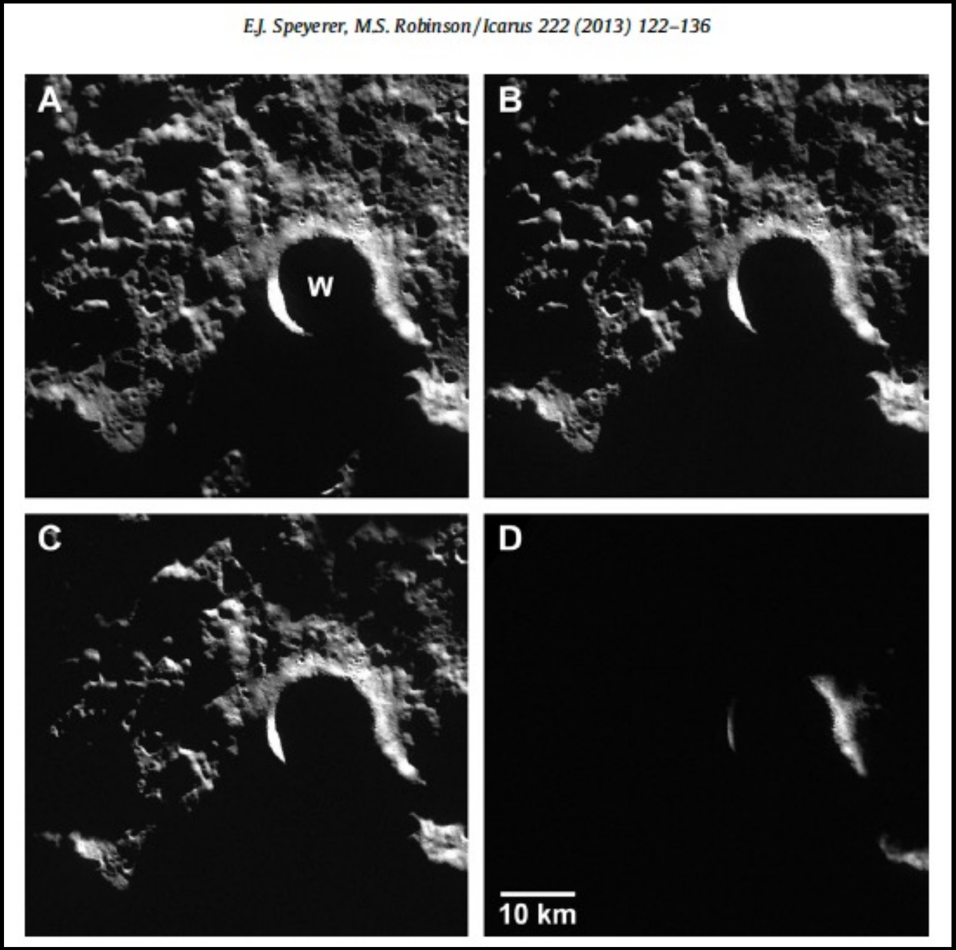
LOLA

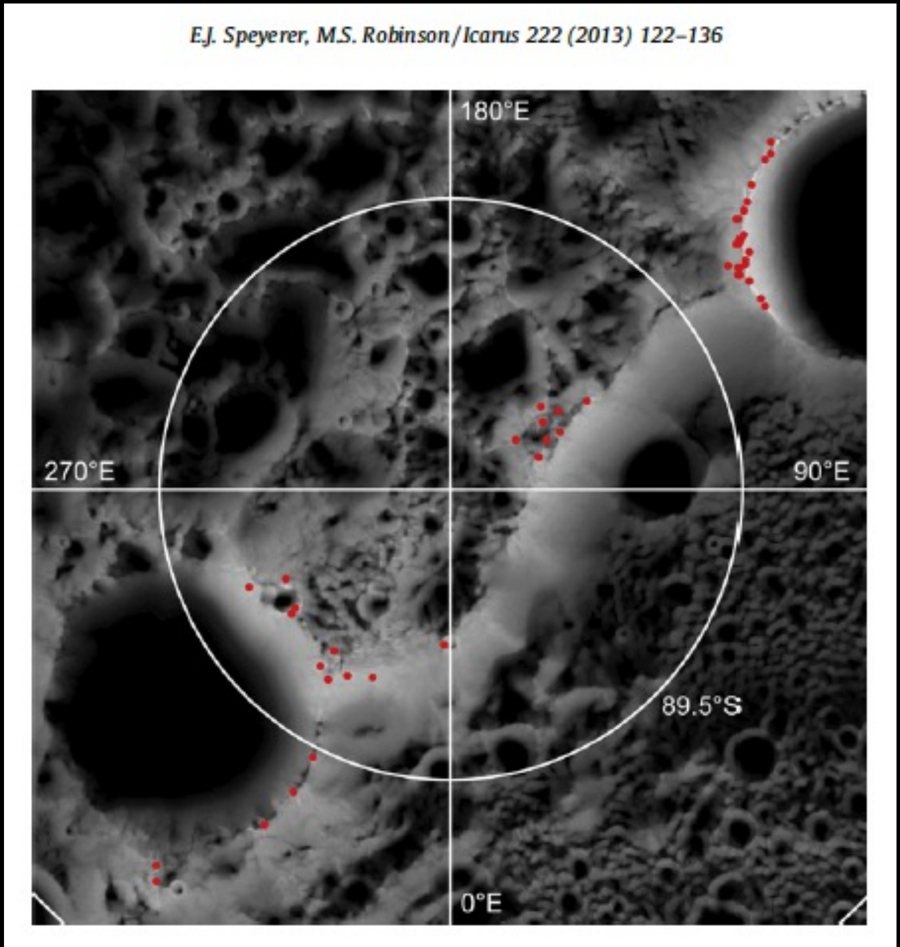


Region	North	South
~80°	12866	16055
>82.5°	8881	12202
>85°	4764	7024
>87.5°	1769	3660
>87.5° > 1 km^2	1665	3632
>87.5° > 2 km^2	1496	3588
>87.5° > 5 km^2	1236	3516
>87.5° > 10 km^2	983	3397
>87.5° > 20 km^2	575	3306
>87.5° > 50 km^2	523	3187

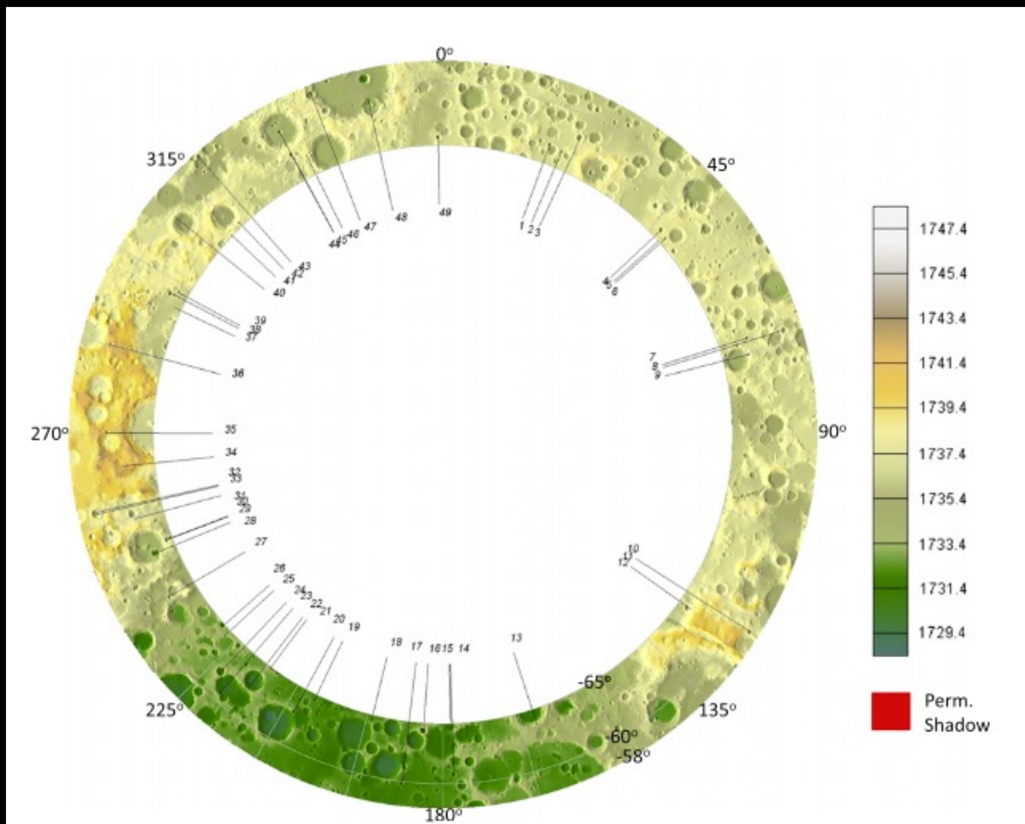
From Mazarico et al., Icarus, 2011

LROC

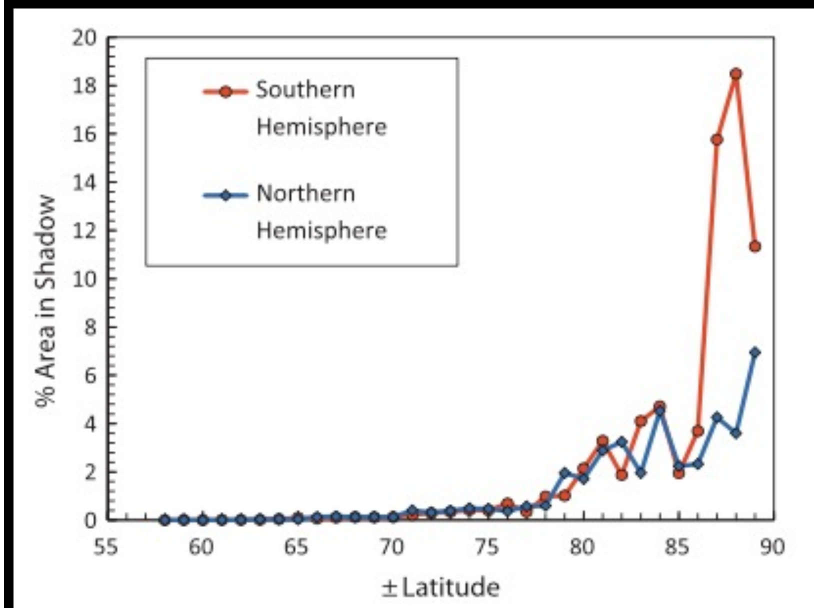

E.J. Speyerer, M.S. Robinson / Icarus 222 (2013) 122–136
A
B
C
D
W
10 km


E.J. Speyerer, M.S. Robinson / Icarus 222 (2013) 122–136
180°E
270°E
90°E
89.5°S
0°E

LOLA & LROC

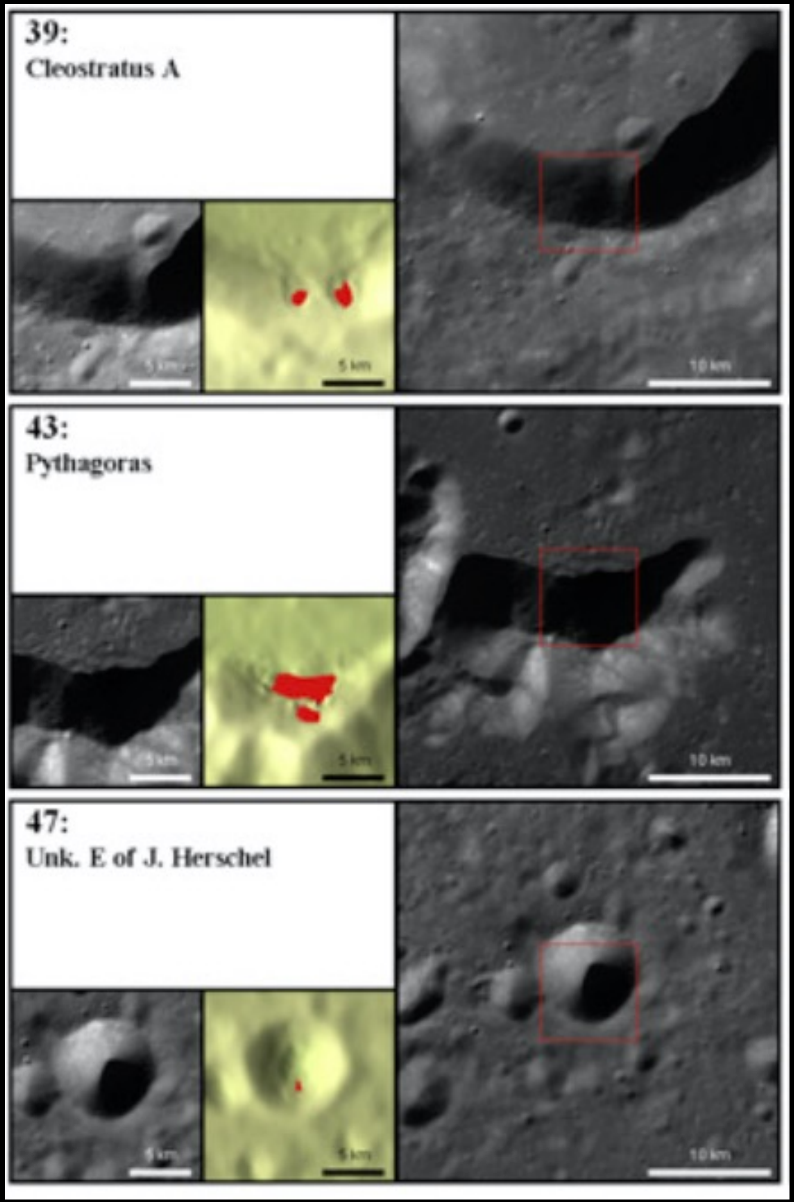


58 - 65° S



From McGovern et al., Icarus, 2013

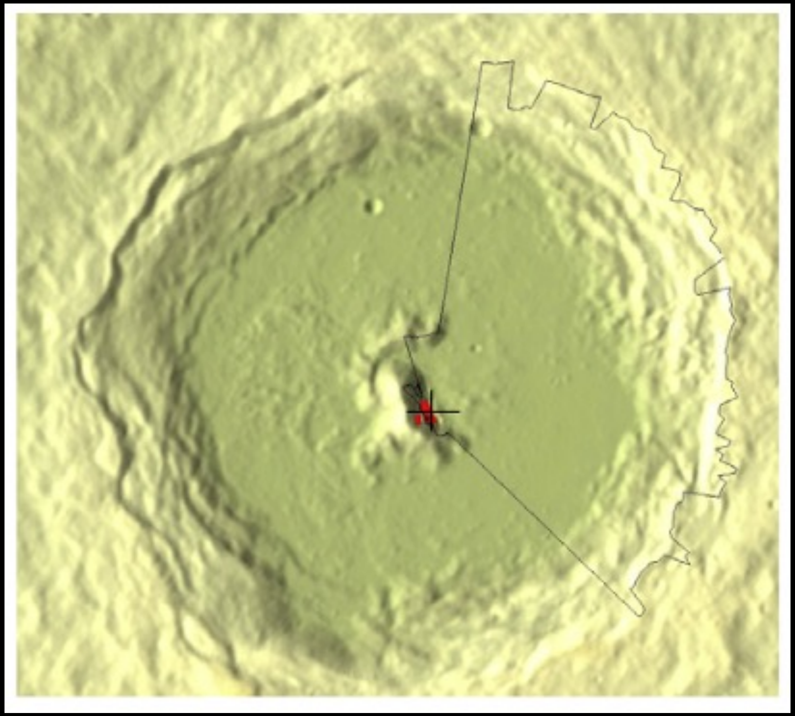
LOLA & LROC



62.2° N

63.5° N

64.9° N



From McGovern et al., Icarus, 2013

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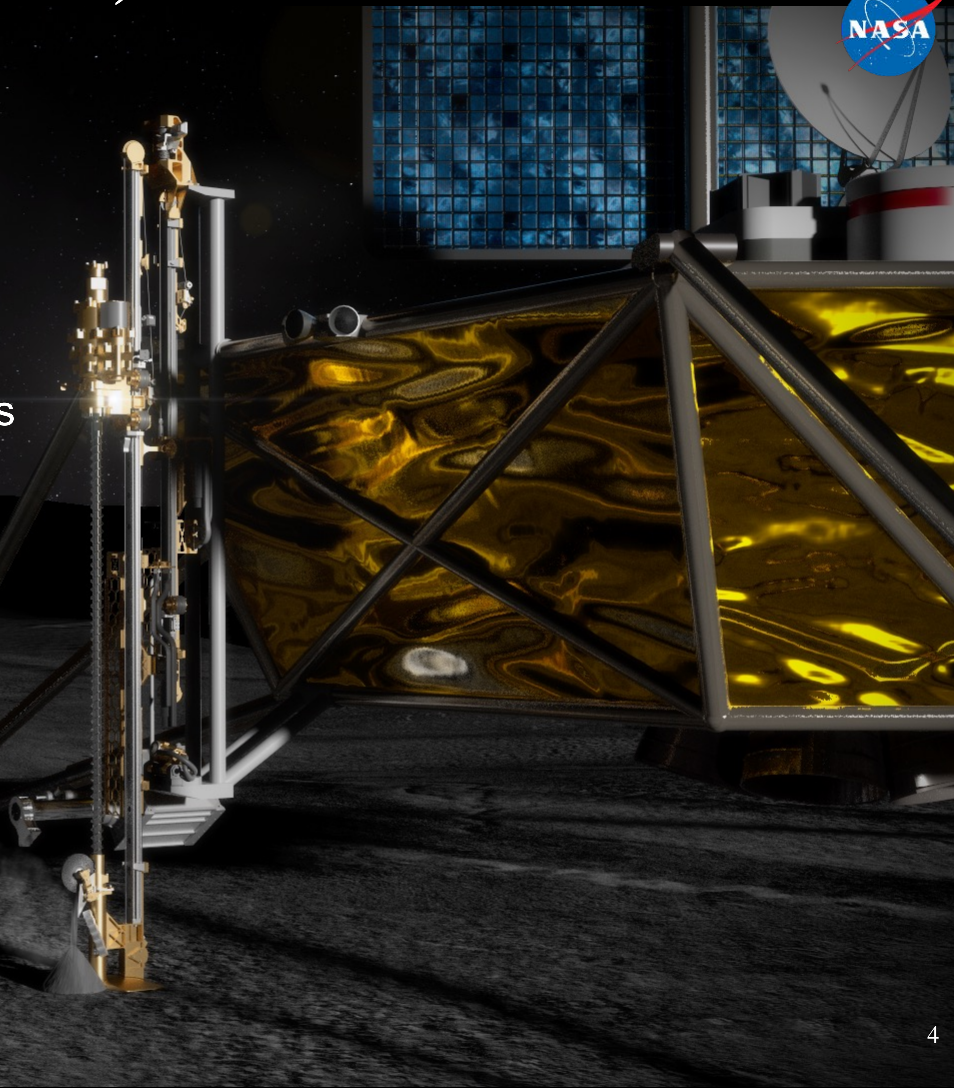
Polar Resources Ice Mining Experiment-1 (PRIME-1)

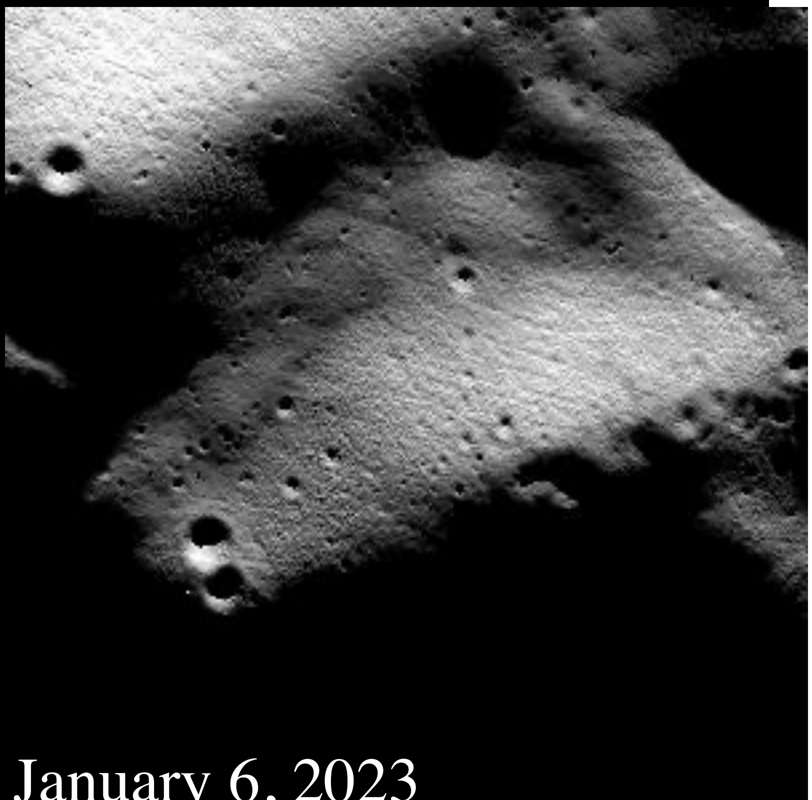
Space Technology is developing technologies for the collection, processing, storing and use of material found or manufactured on other astronomical objects.



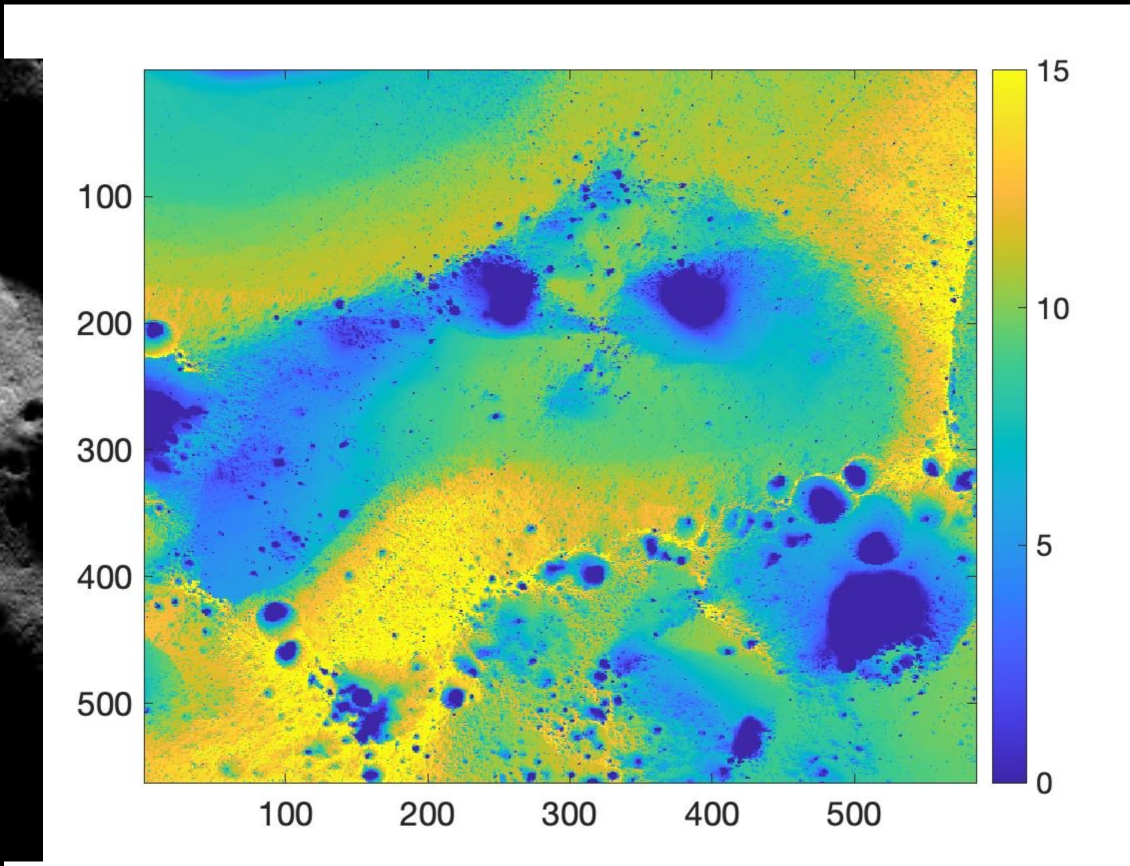
- Consists of two high-TRL instruments – a Mass Spectrometer observing lunar operations (MSolo) and The Regolith and Ice Drill for Exploring New Terrain (TRIDENT)
  - Will fly to the south pole in late 2022 on an Intuitive Machines CLPS delivery

NASA is utilizing APL's expertise in precision illumination and thermal simulations to help select the best landing site for mission success

Longest period of continuous sunlight, starting January 2, 2023



January 6, 2023



LOLA 25m DEM to 80S

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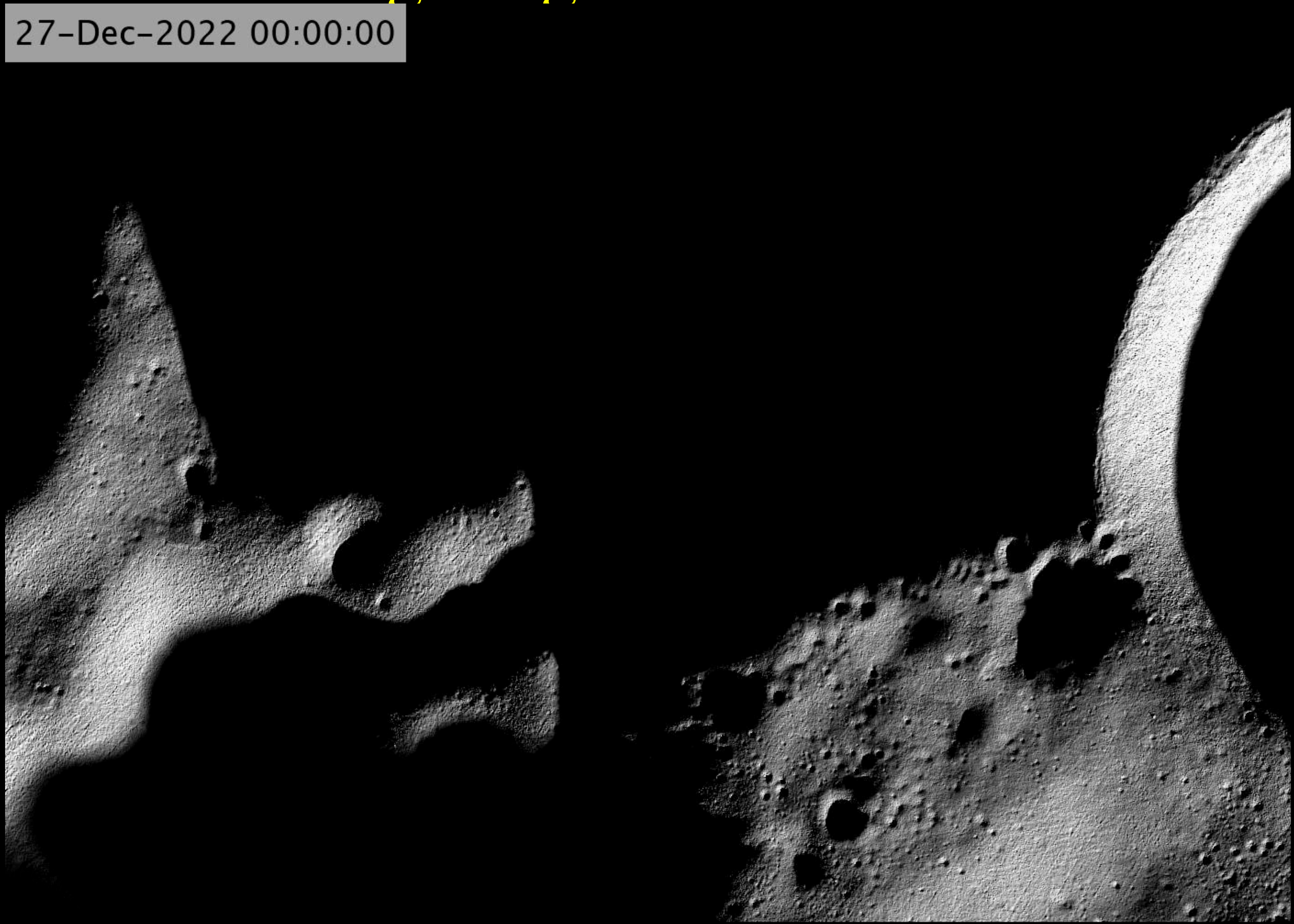
Simulated Lighting Conditions – 25 m DEM



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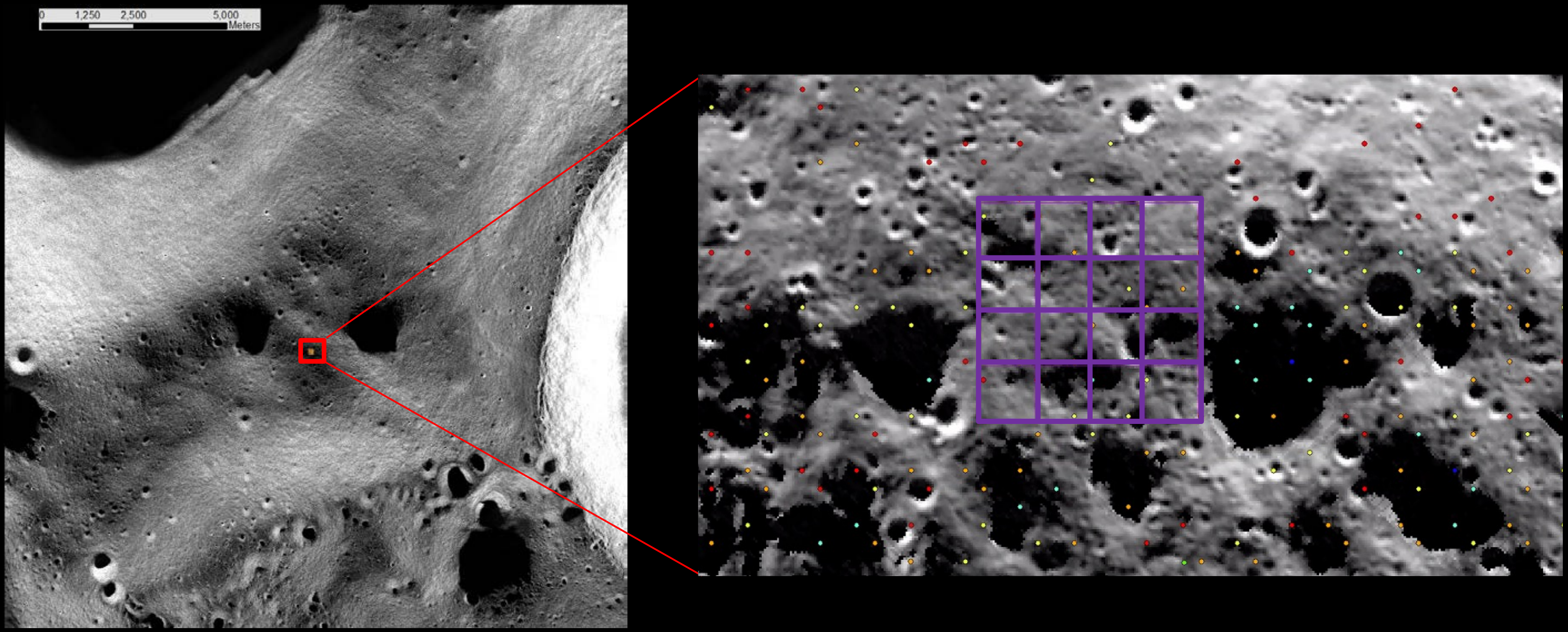
Valley Ridge Region



LOLA 25m DEM to 80S

Ice Stability

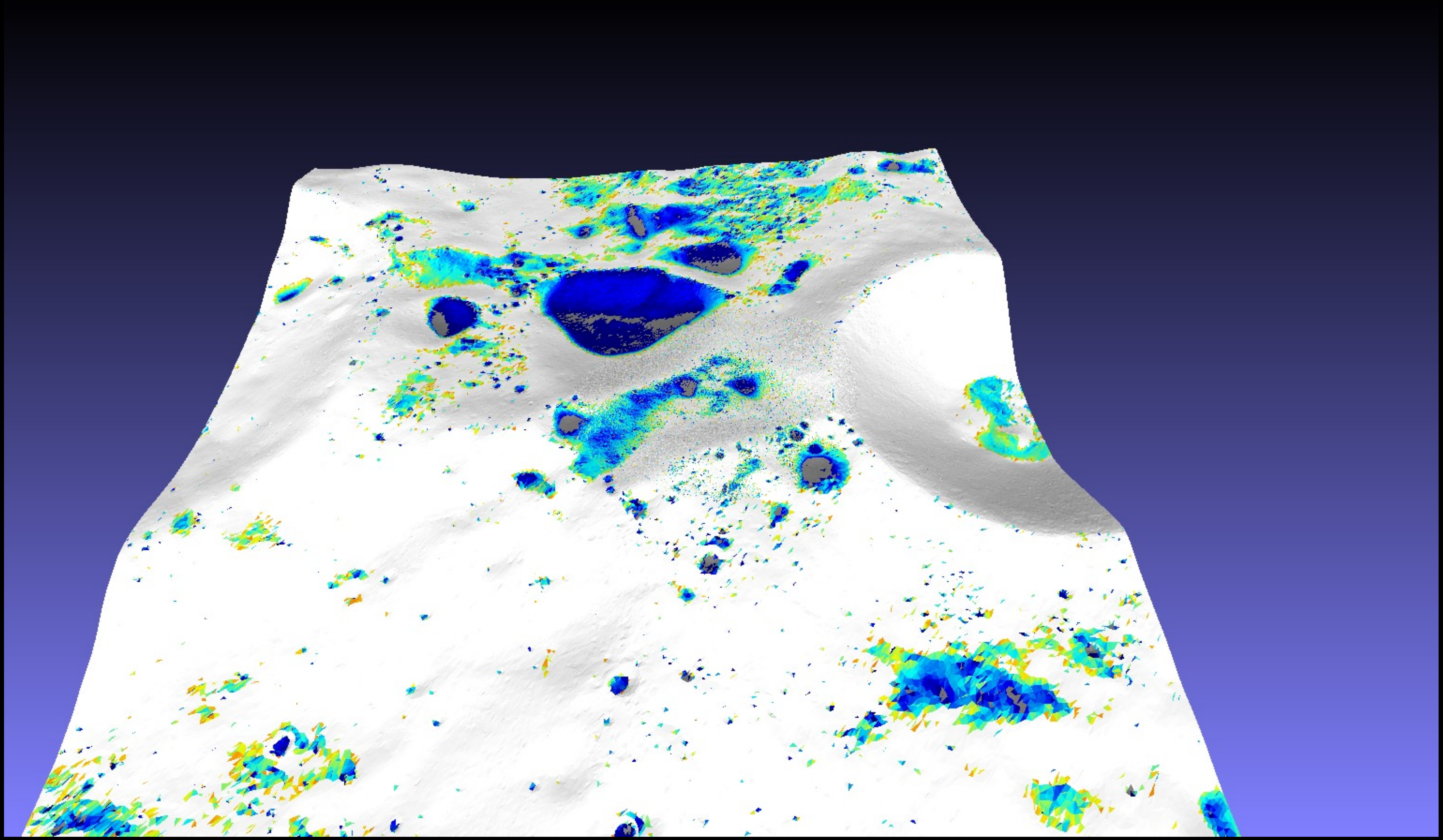


Image courtesy of Matt Siegler, SMU

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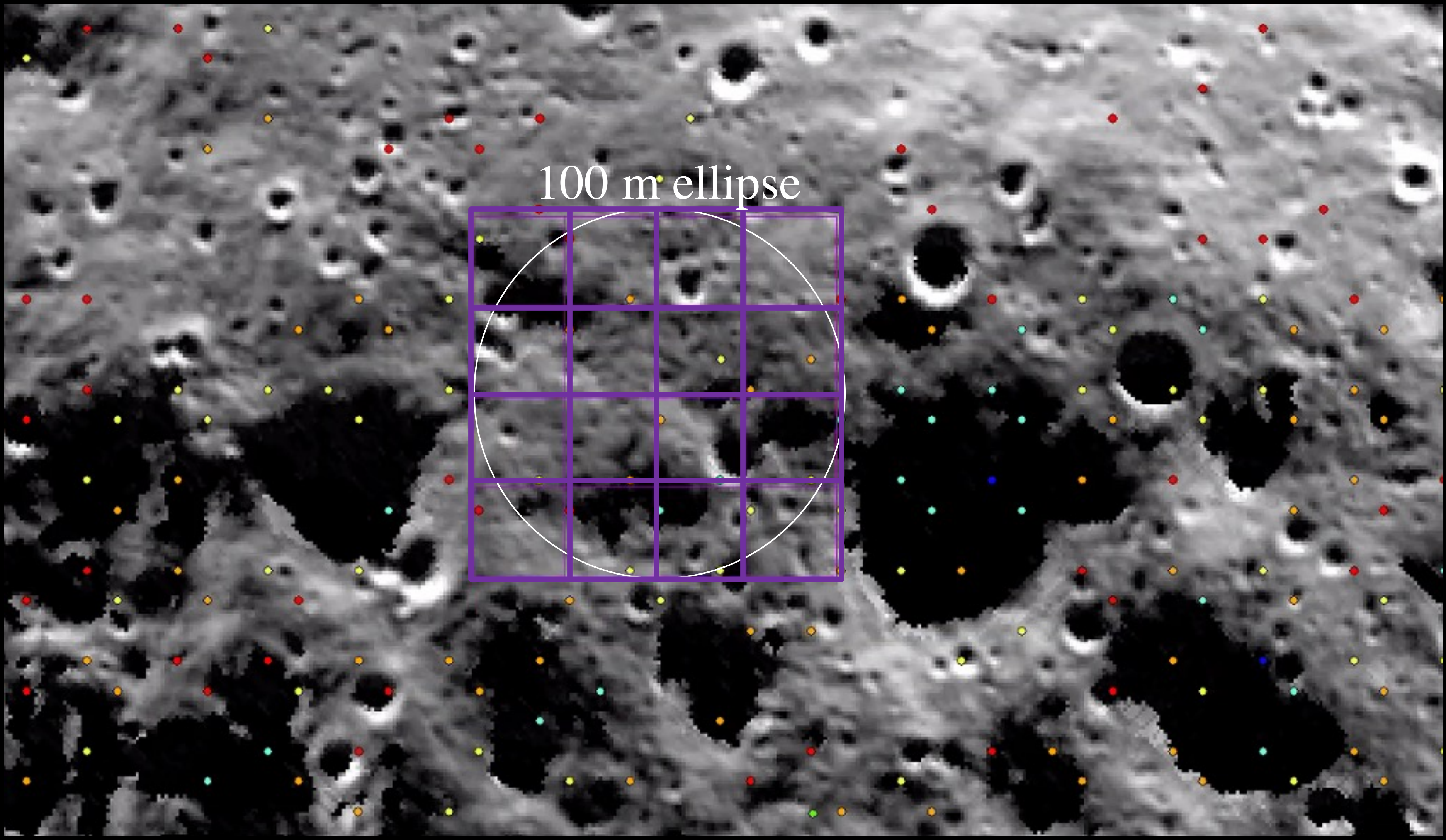
Valley Ridge Region,-89.6°, -125.4°



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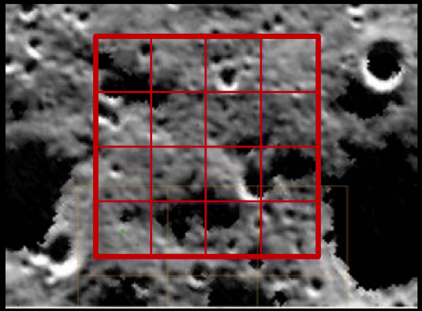
Valley Ridge Region

-89.6°, -125.4°



LOLA 25m DEM to 80S

1	5	9	13
2	6	10	14
3	7	11	15
4	8	12	16

Max total consecutive days sunlight

10	10	10	5
5	10	10	10
10	10	10	7
10	4	10	10

Jan

10	10	10	5
5	10	10	10
10	10	10	7
10	4	10	10

Feb

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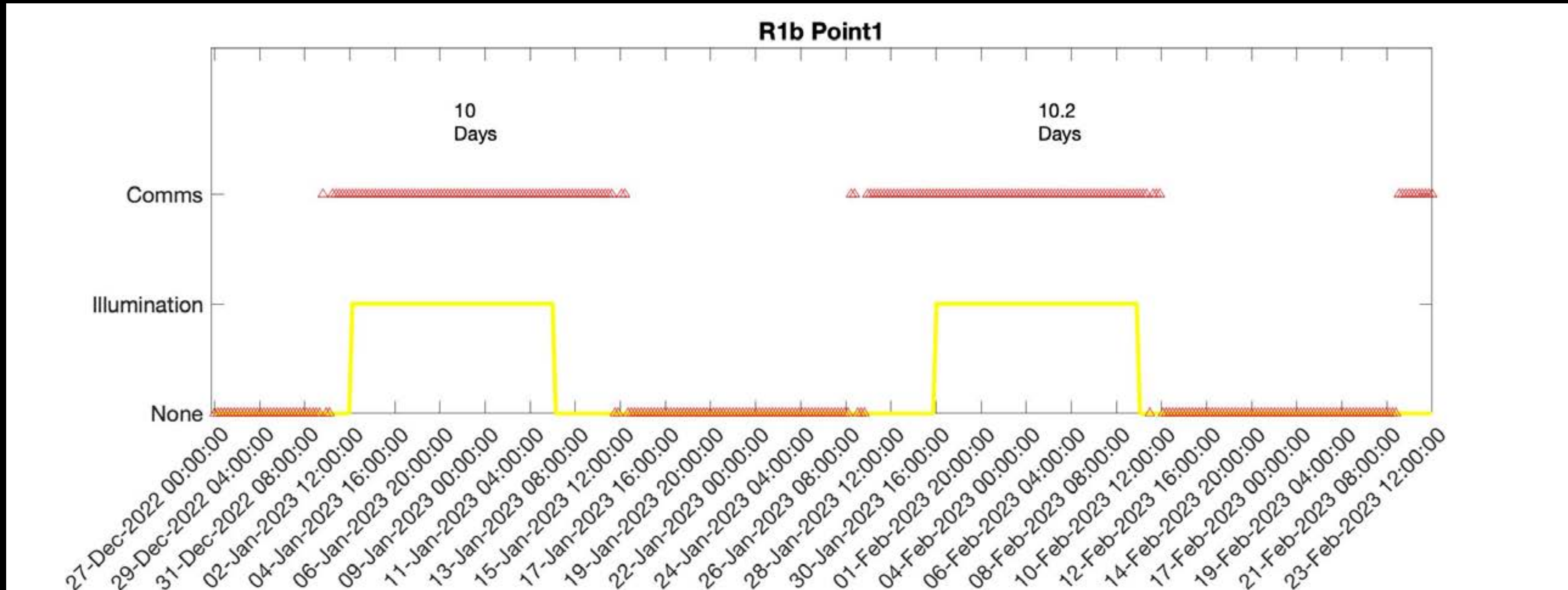
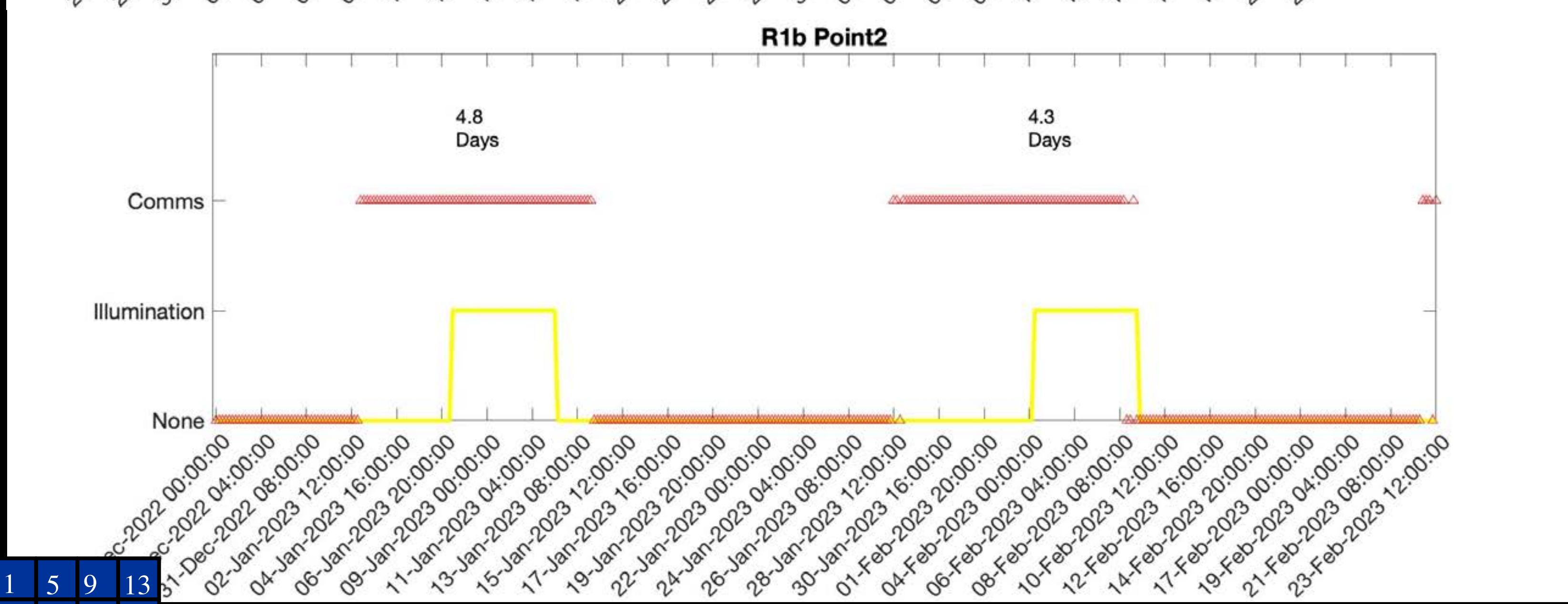
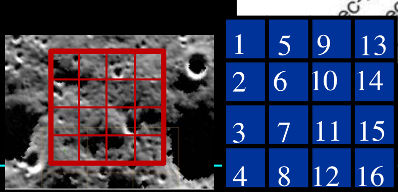
Point 1



Point 2





LOLA 25m DEM to 80S

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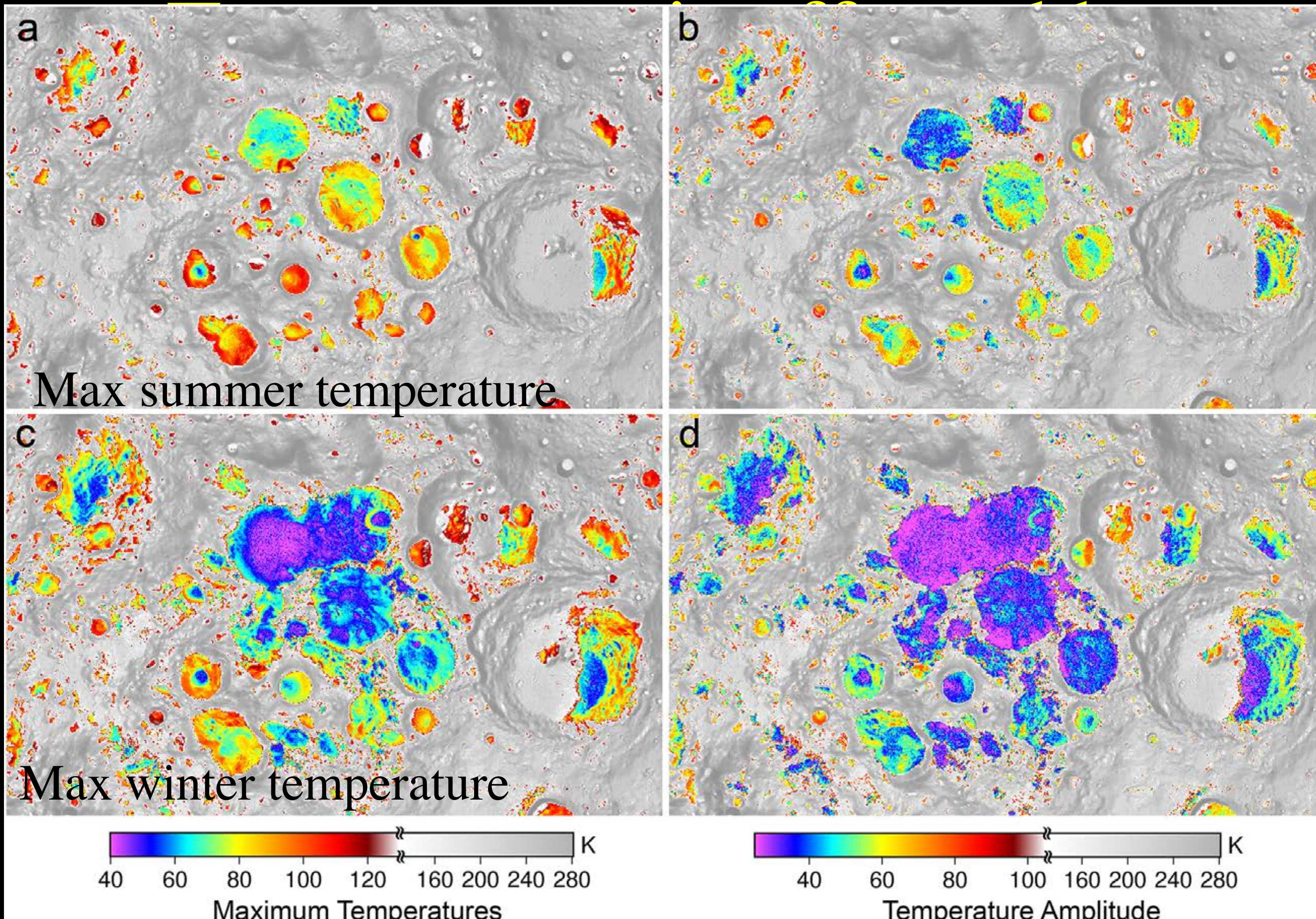

Seasonal temperatures from the Diviner instrument

JGR Planets, Volume: 124, Issue: 10, Pages: 2505-2521, First published: 14 August 2019, DOI: (10.1029/2019JE006028)

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