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Effects of Realistic Surface Temperature Variations and Orography on the Structure of the Lunar Exosphere

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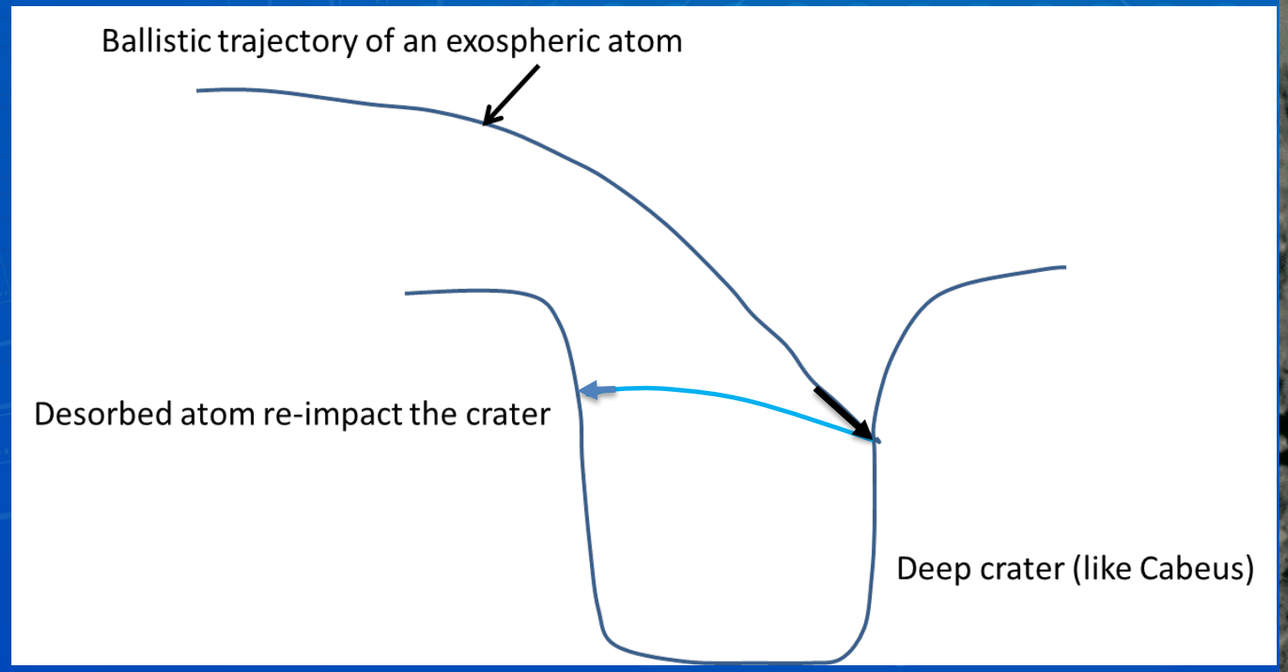
Motivation

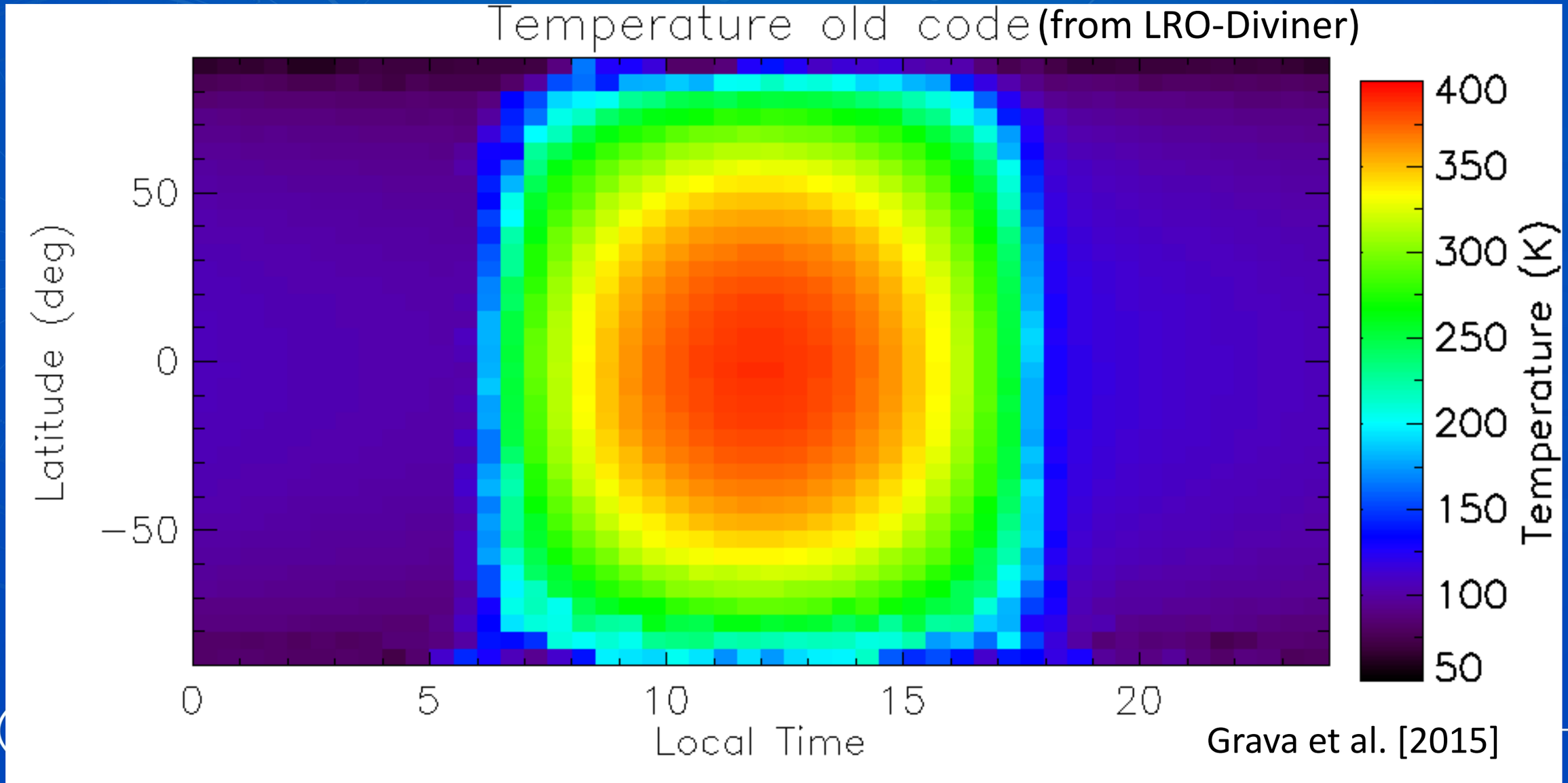
"Sunrise at the site is delayed 8 hours by shadowing from the mountains to the east which preclude significant local heating before this time [dawn]"

Hoffman et al., 1973, 4th LPSC Proceedings

Micro-topography plays a role in the distribution of volatiles in the exosphere and at the surface [Prem+ 2018, Hayne+ 2020]

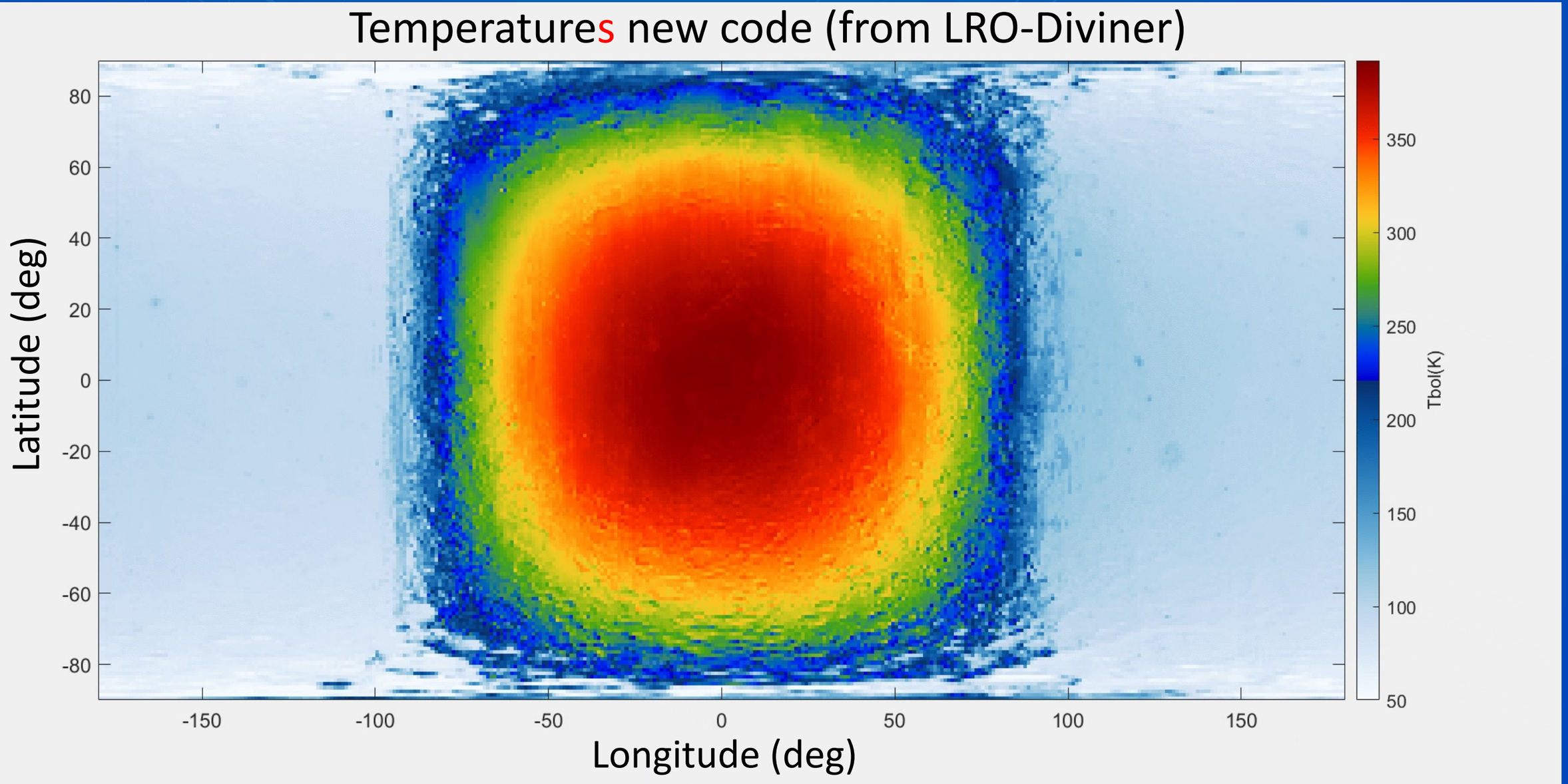


How do real surface temperature variations affect exospheric transport of volatiles and surface deposition?

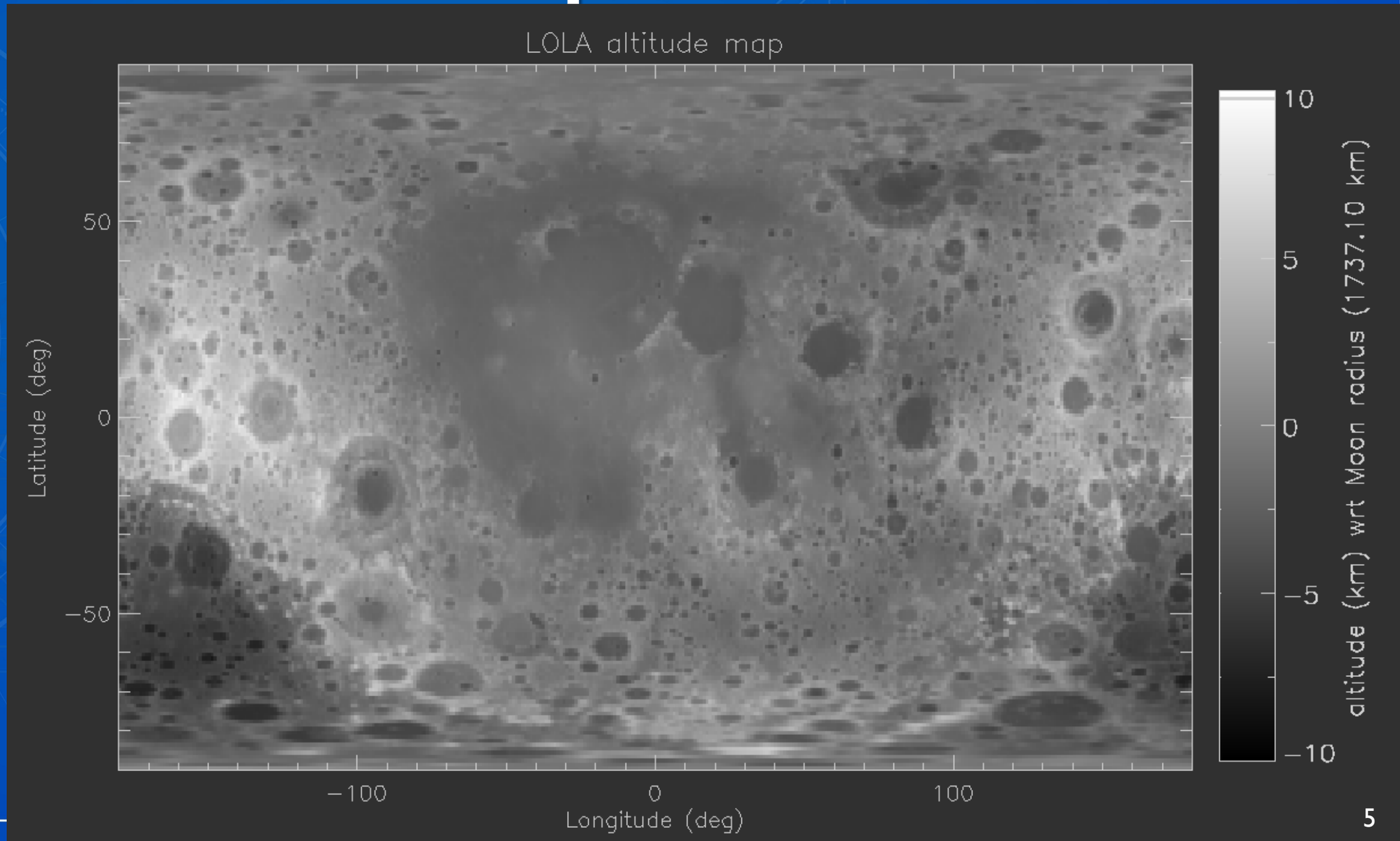


Grava et al. [2015]

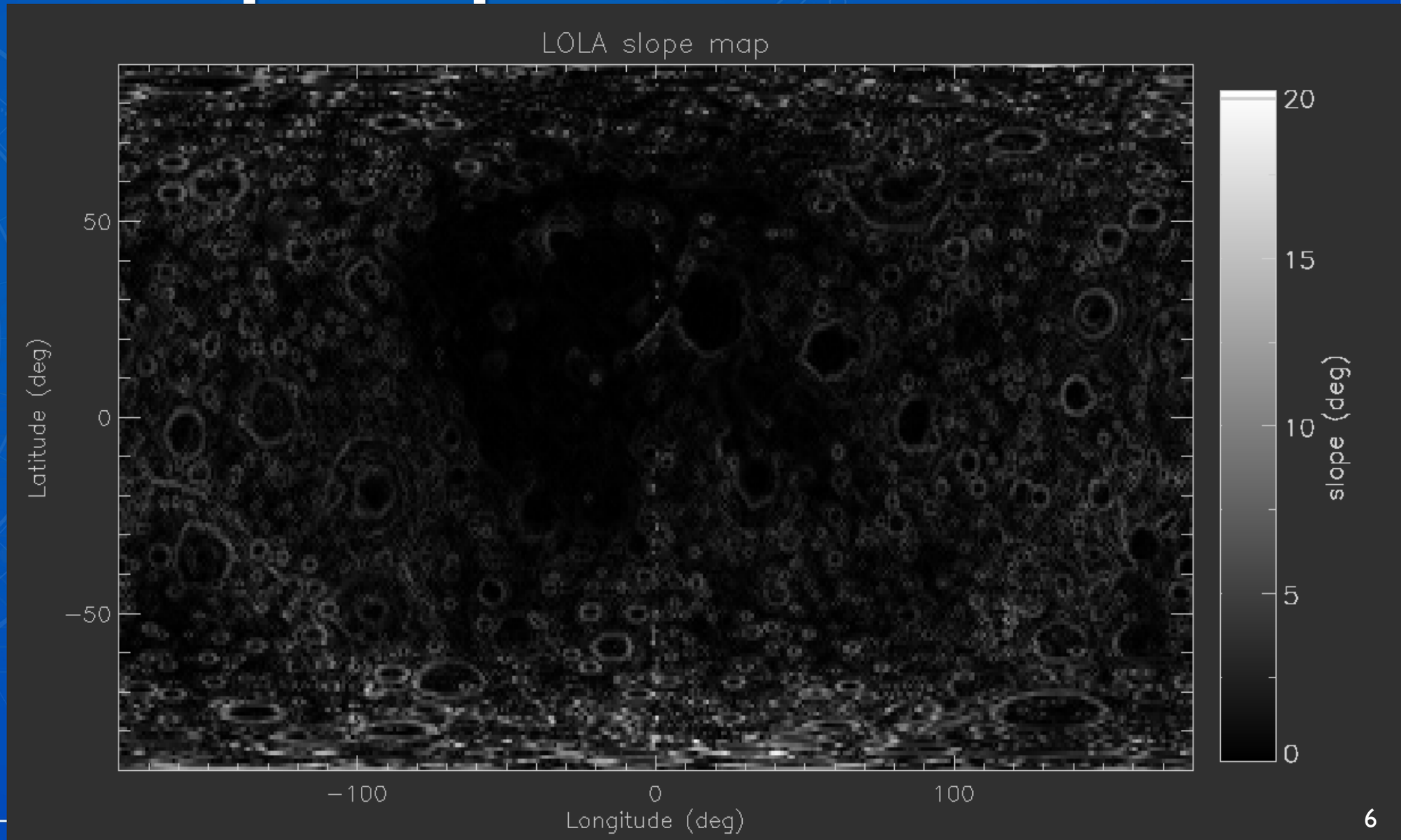
How do real surface temperature variations affect exospheric transport of volatiles and surface deposition?



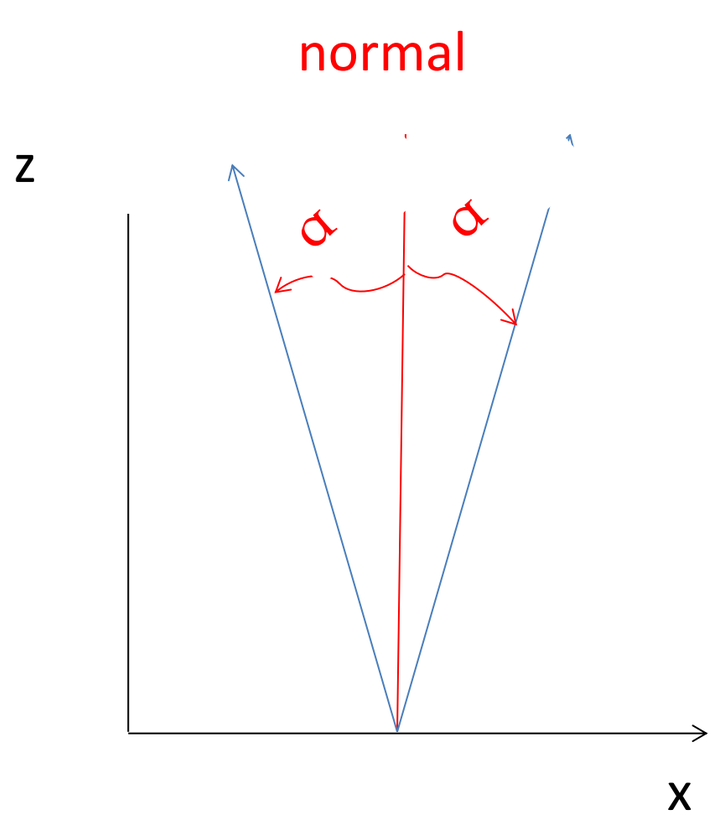
LRO-LOLA altitude map

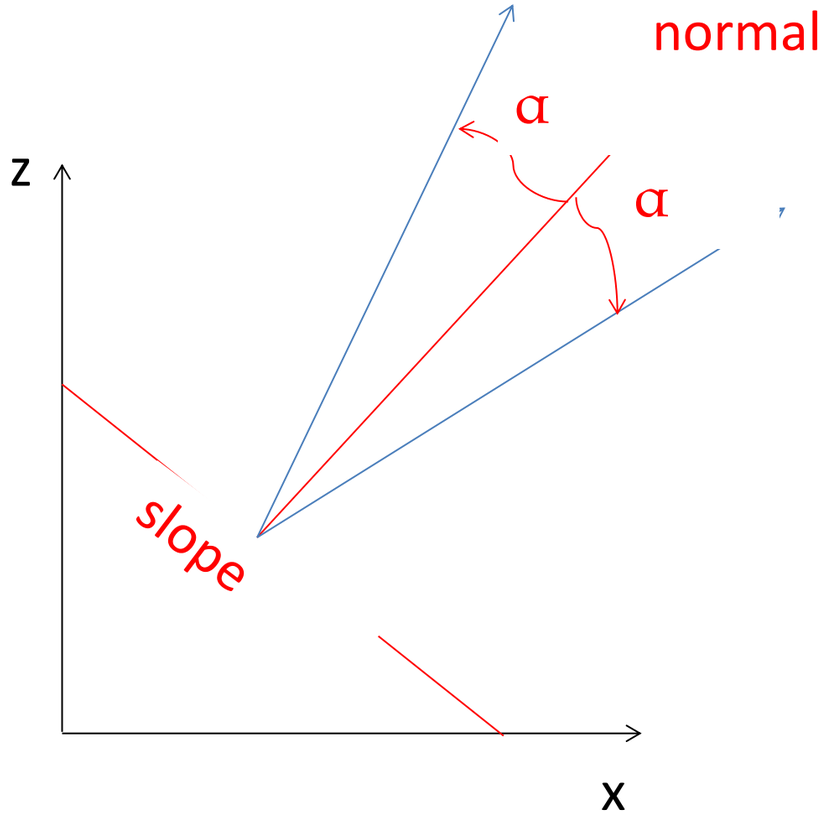


LRO-LOLA slope map



How slope affect direction of ejection



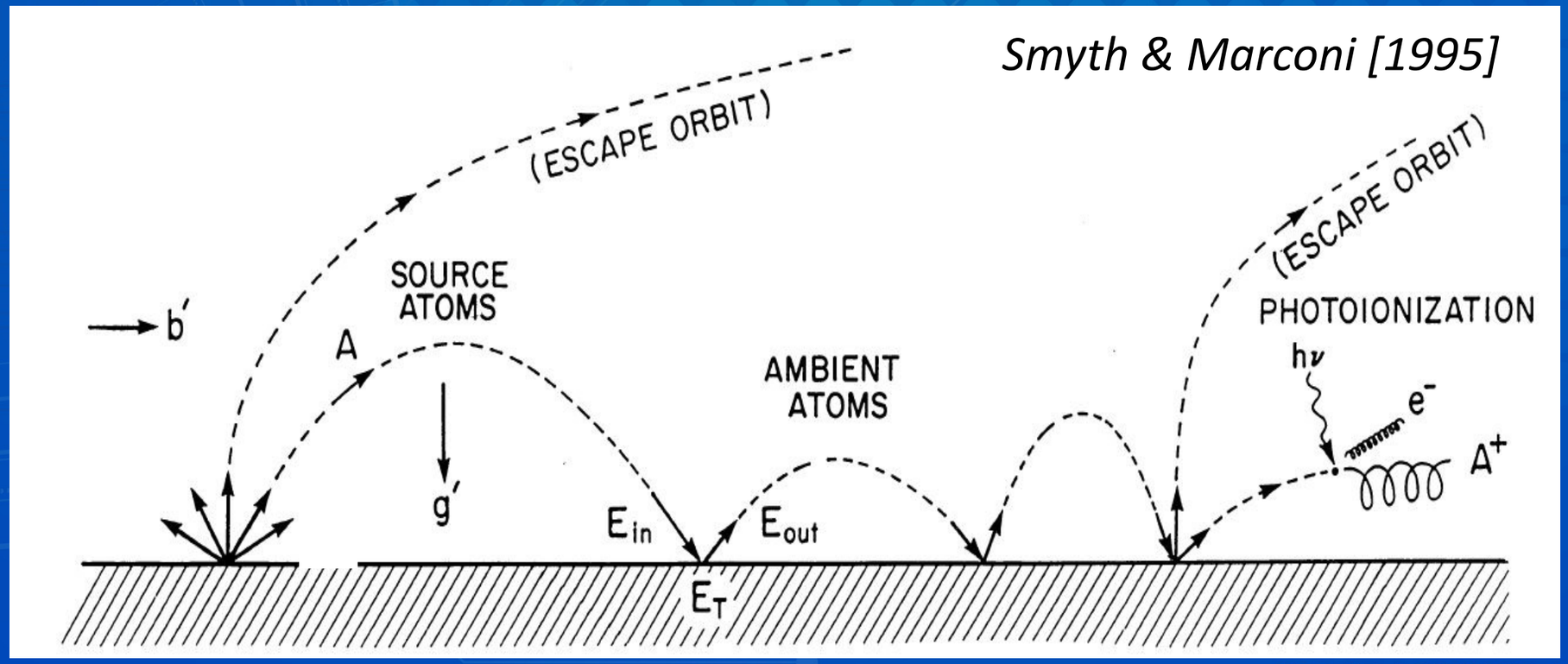


Exospheric modeling

Particles are traced along their hops until they are ionized or escape the Moon.

Adsorbable particles that impact upon the surface can be permanently cold-trapped depending on the surface temperature.

We assume full thermalization of atoms with surface ($E_K = E_T$)



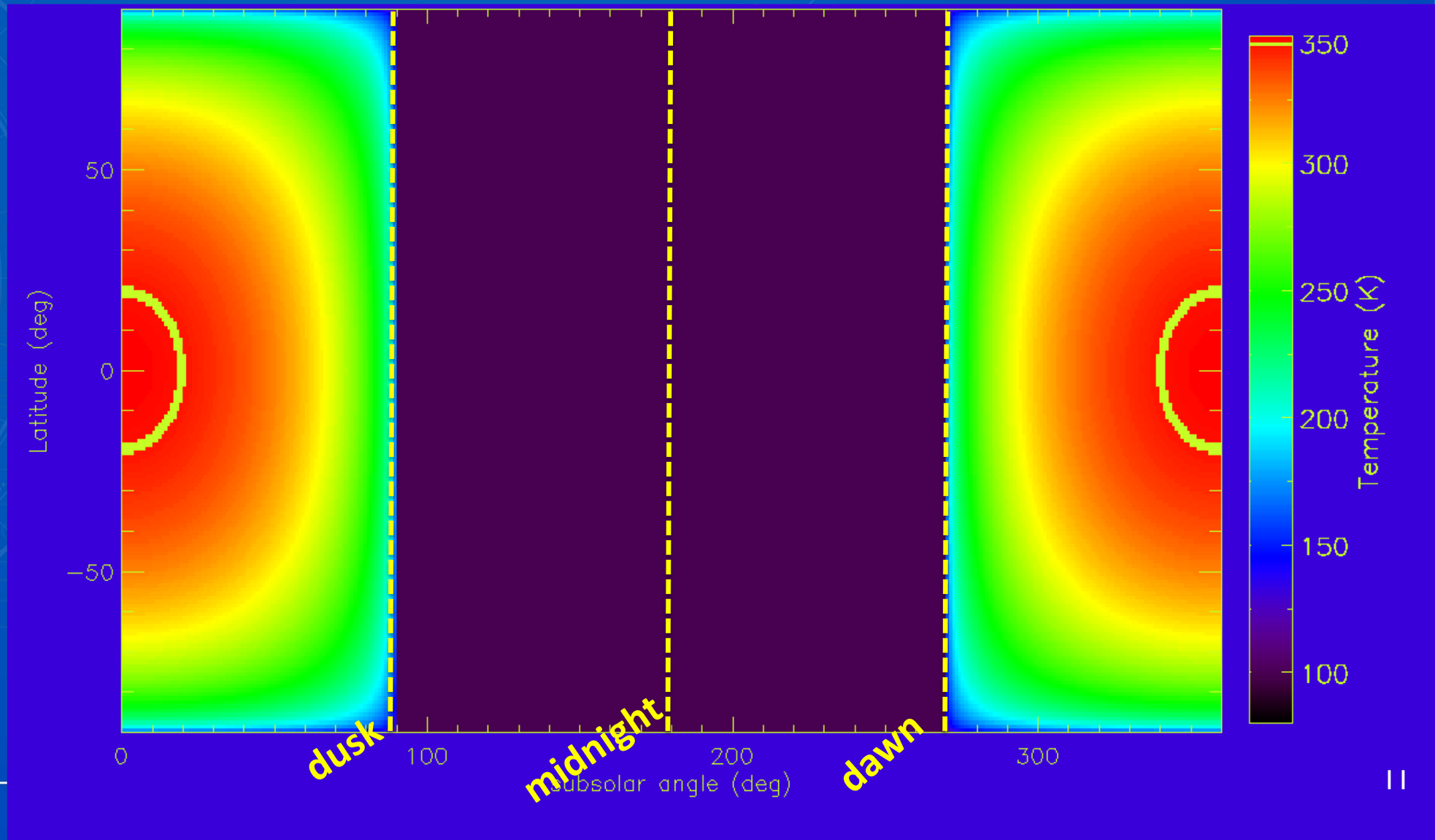
Simulations

1. Analytical formula for surface T, smooth Moon:
   $T = 250\ K * \cos^{1/4}(sza) + 100\ K$, where sza = solar zenith angle [Killen+ 2019]
2. One diviner map, smooth Moon
3. Multiple Diviner maps, smooth Moon
4. Multiple Diviner maps, rough Moon (topography)

Neon: non-condensable

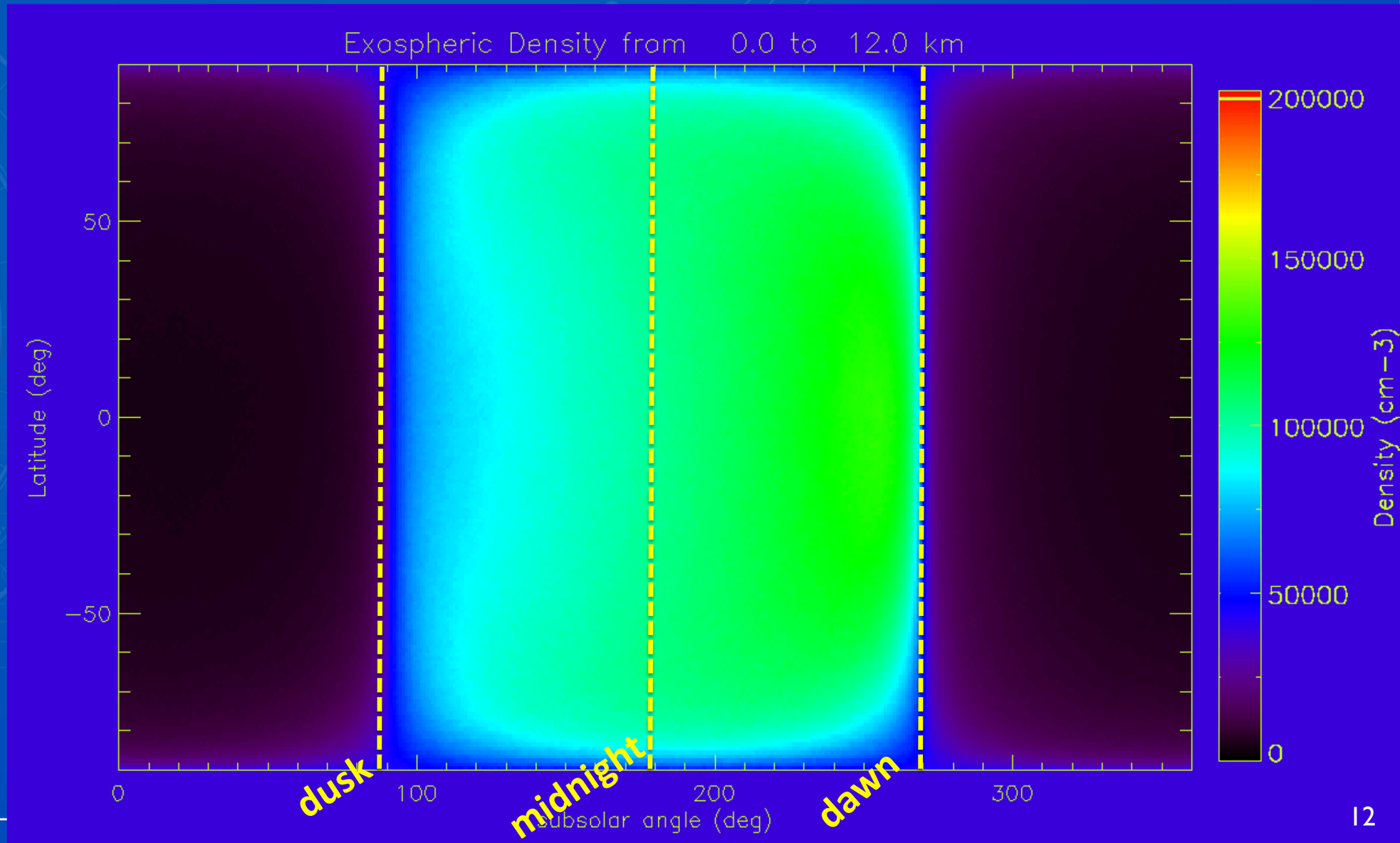
Surface Temperature

analytical function of T



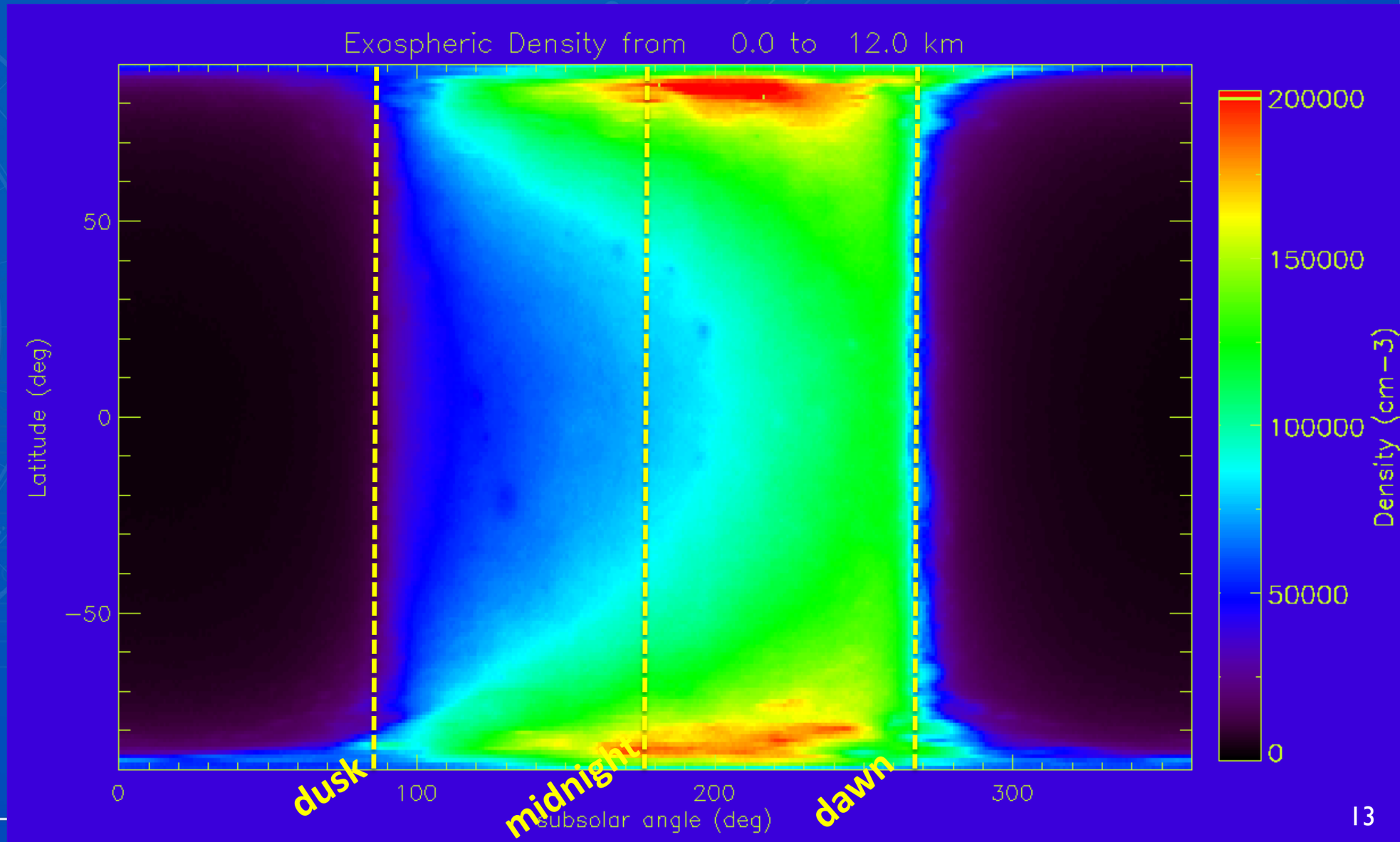
2D exospheric density close to the surface

Smooth Moon, analytical function of T



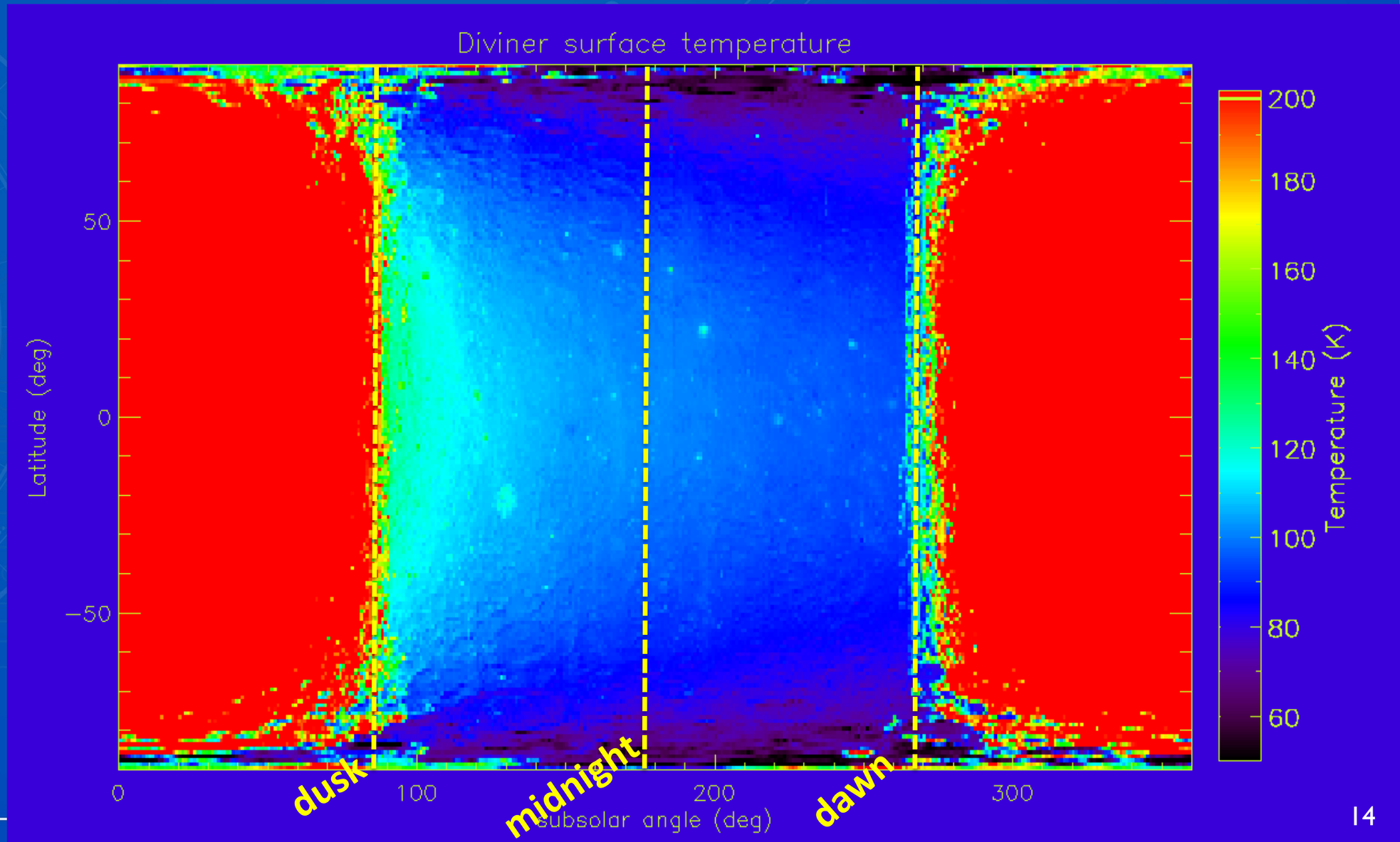
2D exospheric density close to the surface

Smooth Moon, single Diviner T map



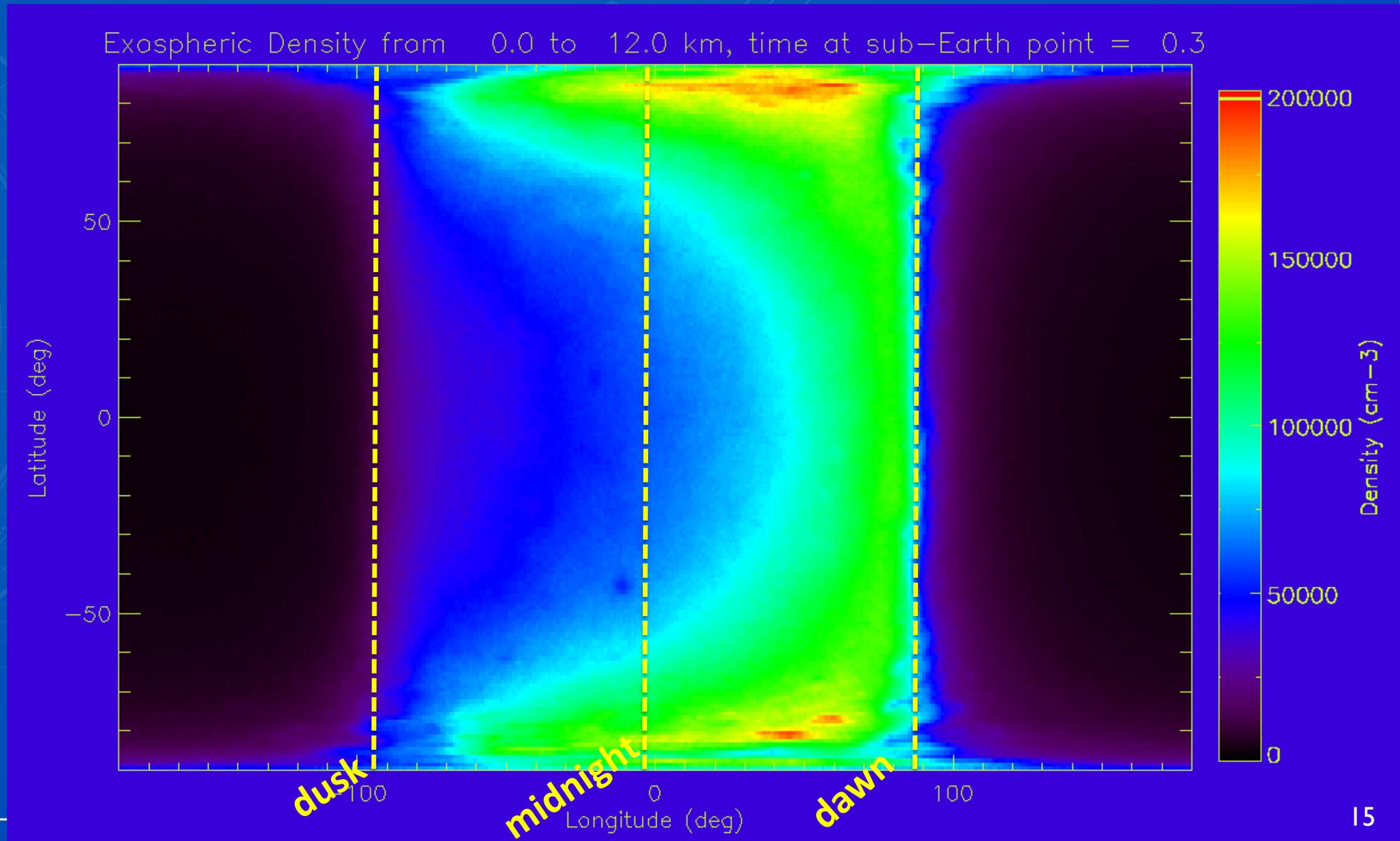
Surface Temperature

Smooth Moon,
single Diviner map



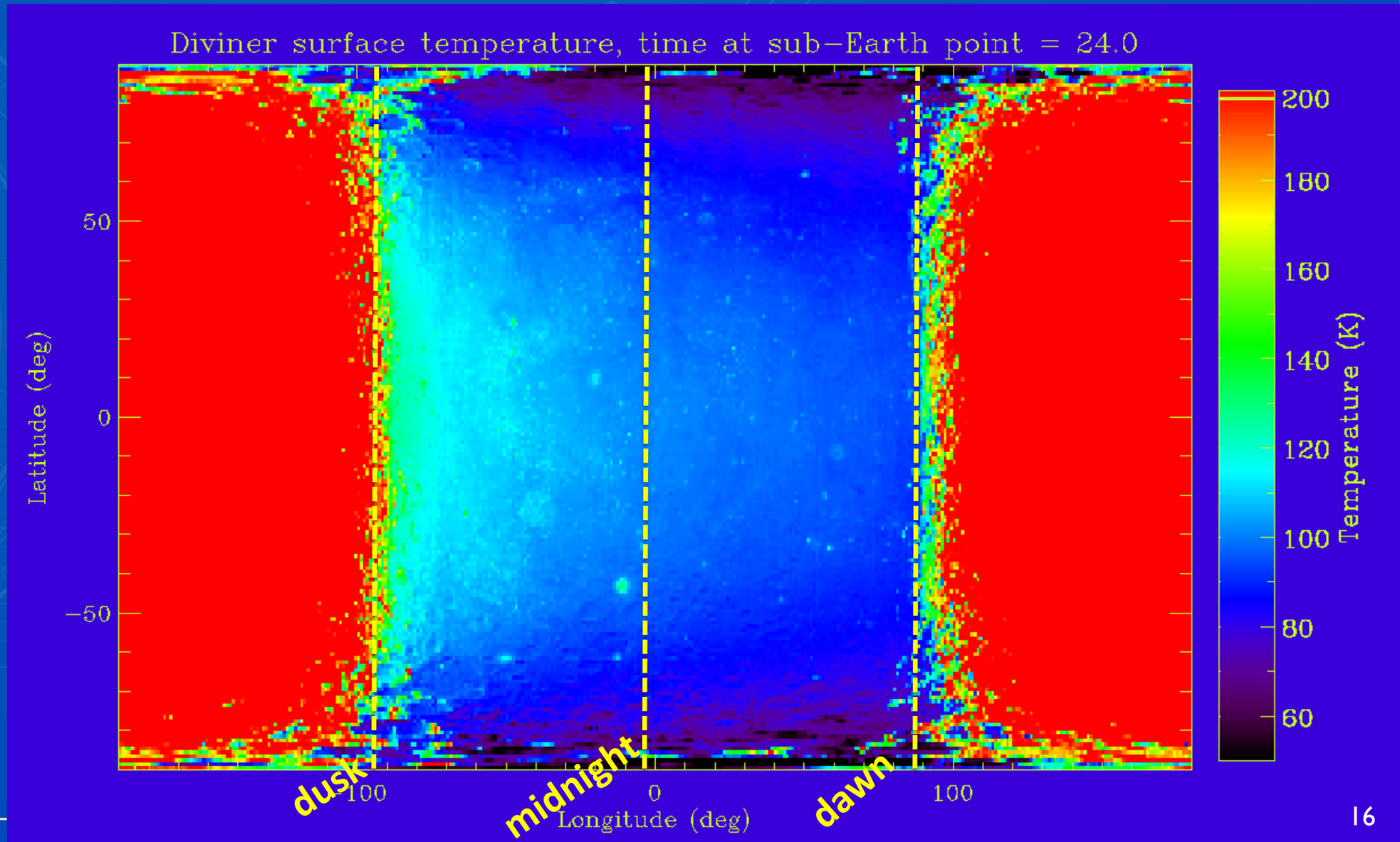
2D exospheric density close to the surface

Smooth Moon, multiple Diviner T maps



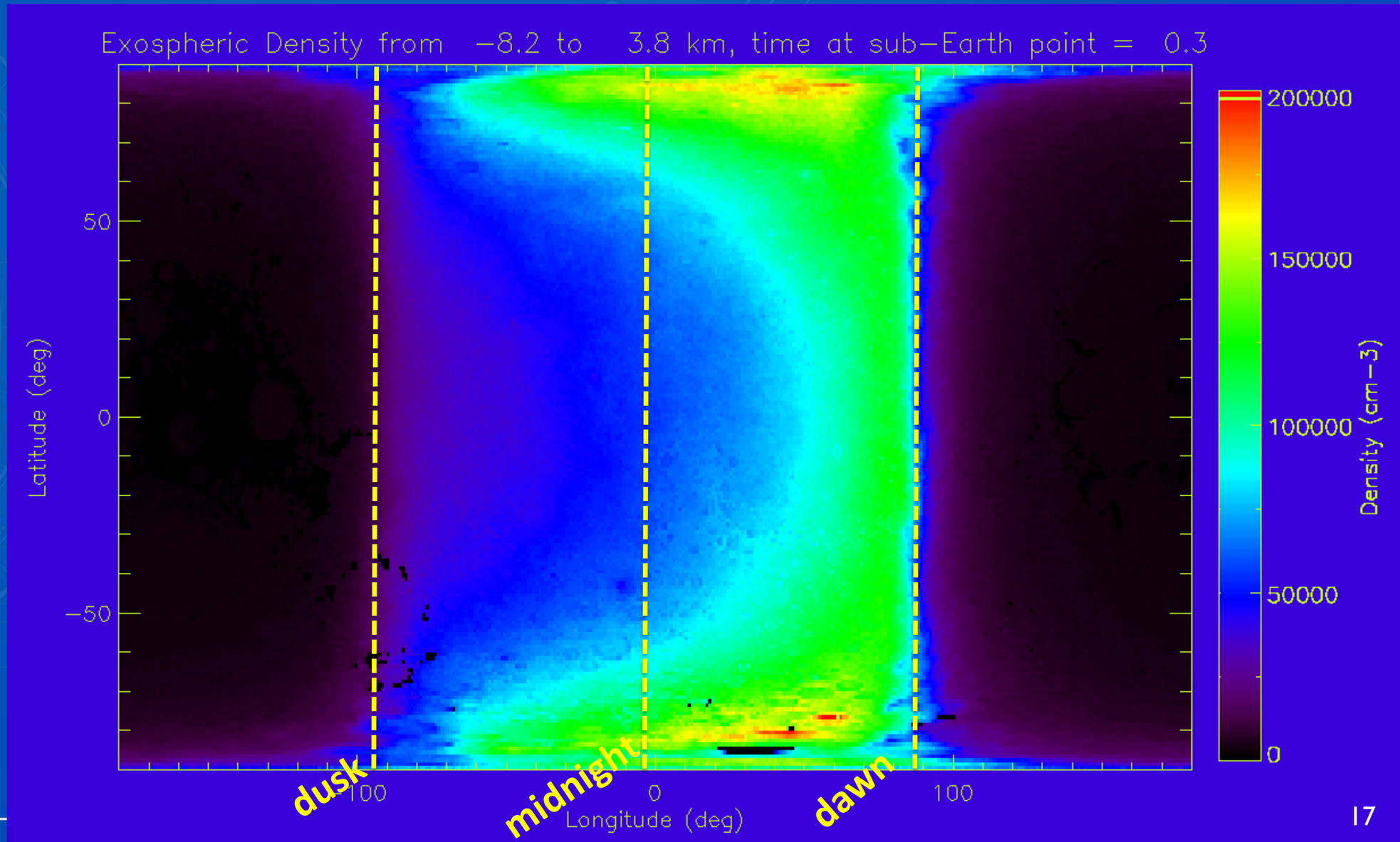
Surface Temperature

Smooth Moon, multiple Diviner T maps

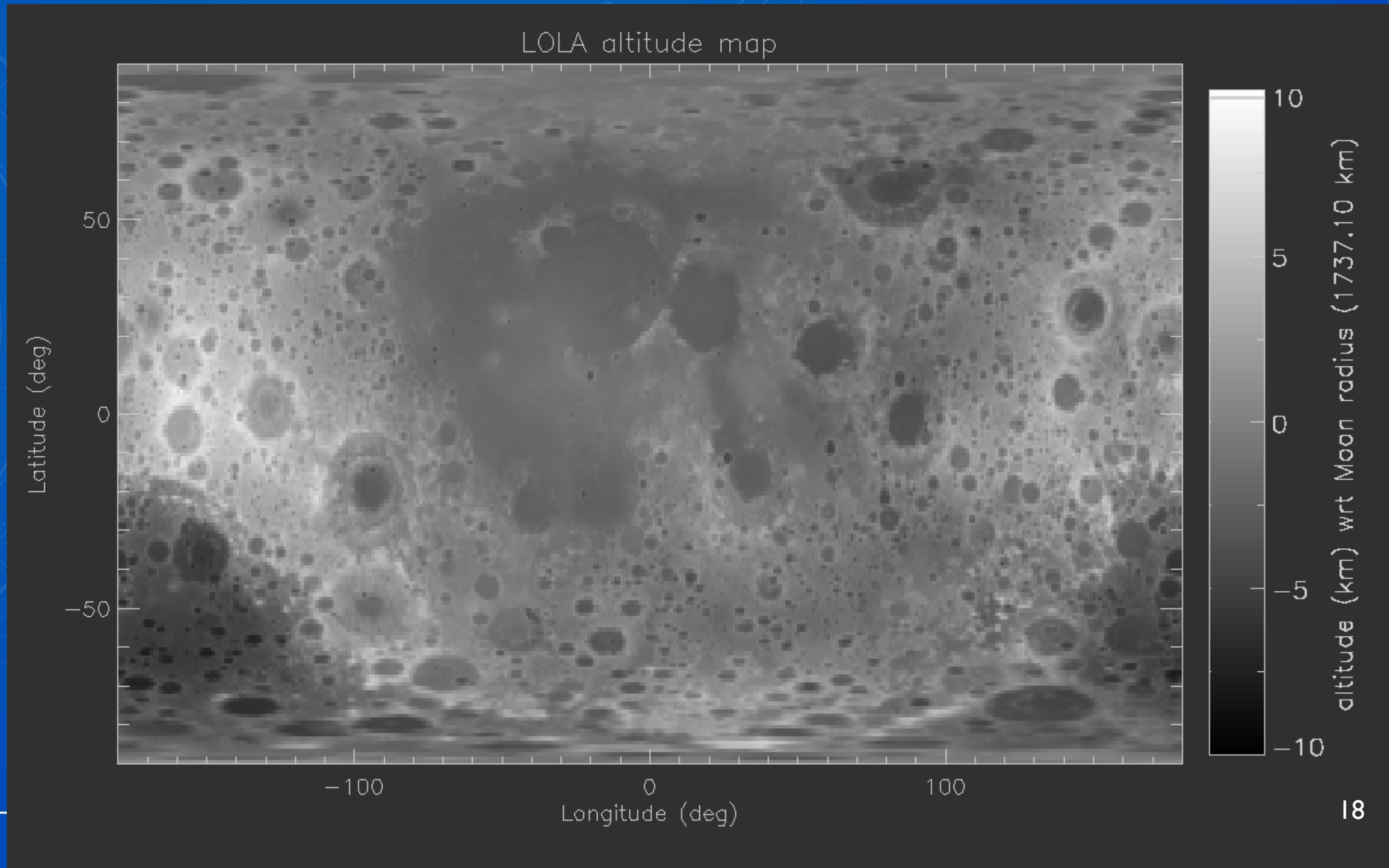


2D exospheric density close to the surface

Rough Moon,
single Diviner map

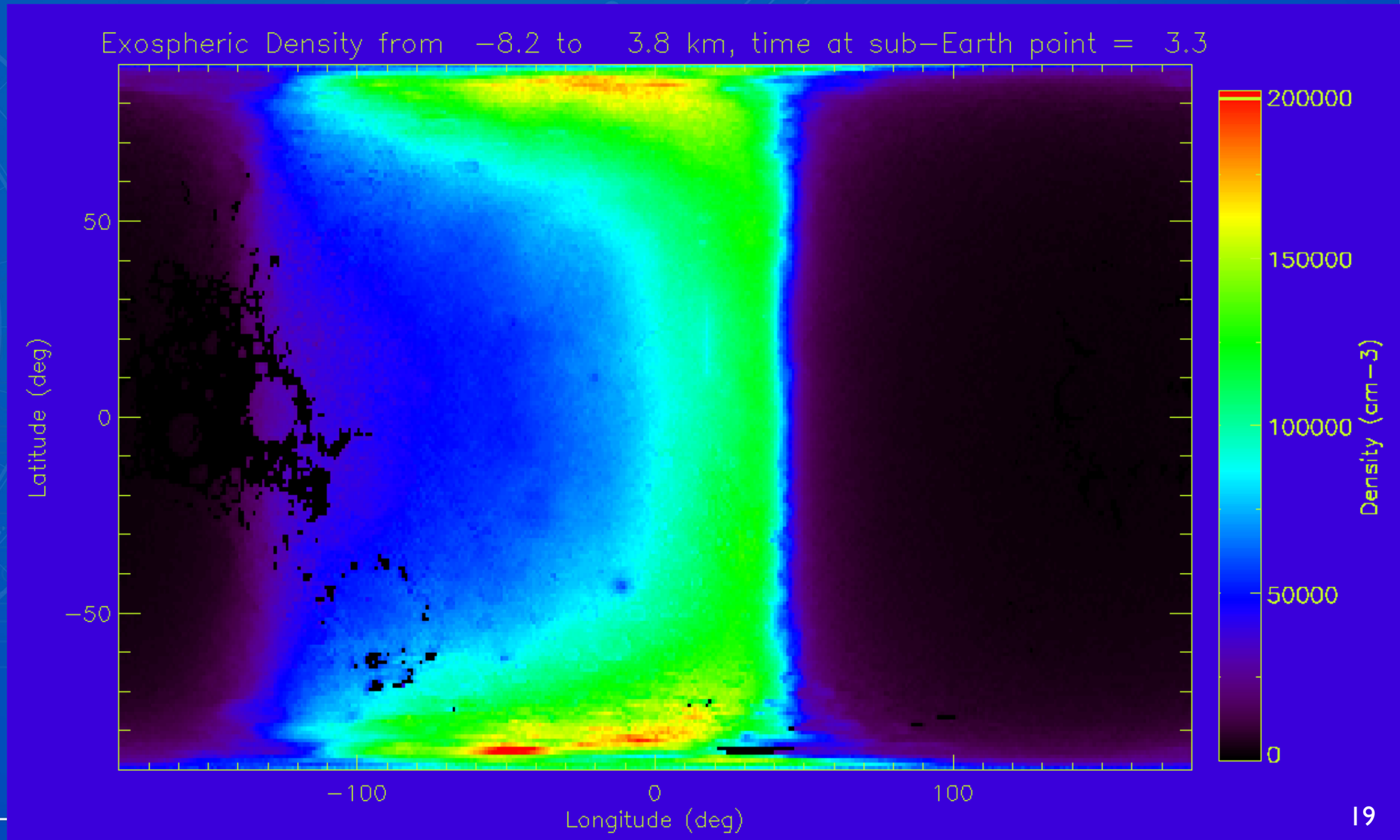


Altitude from LOLA



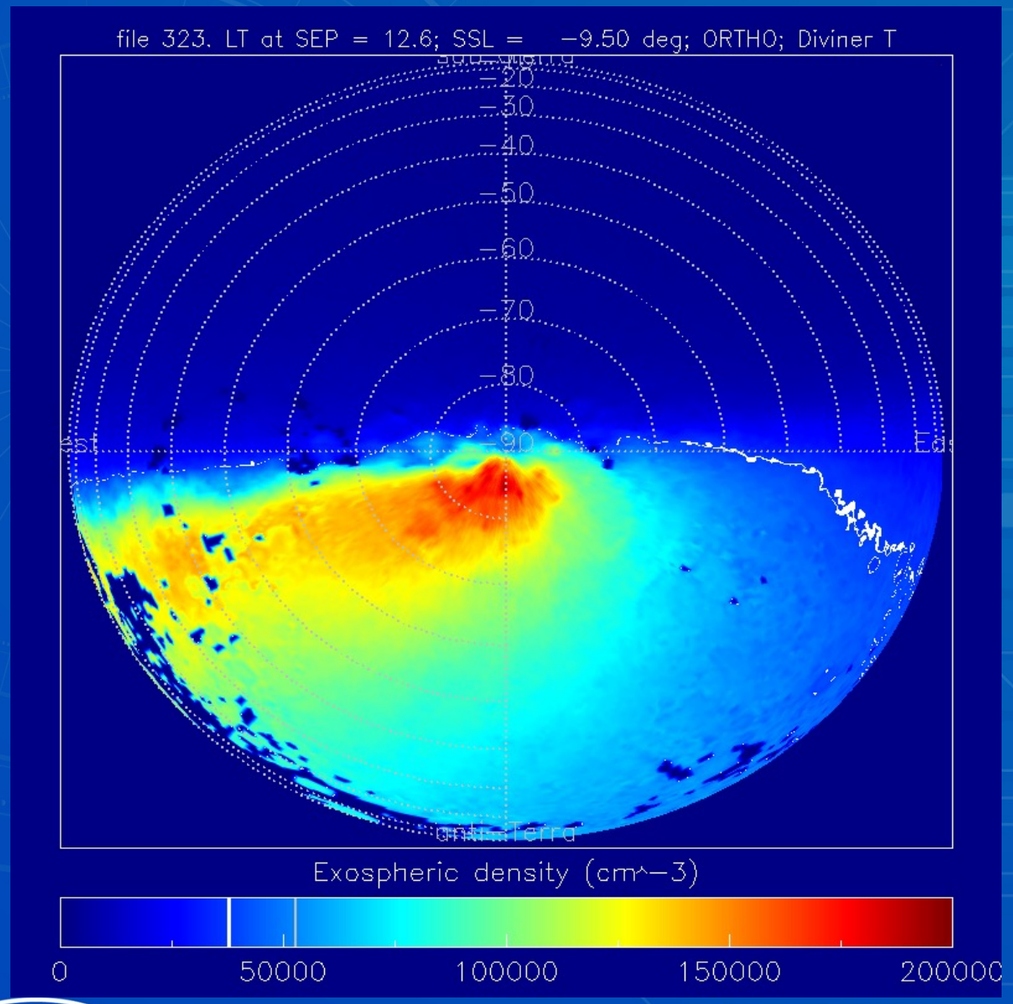
Neon: Movie

Rough Moon,
single Diviner map

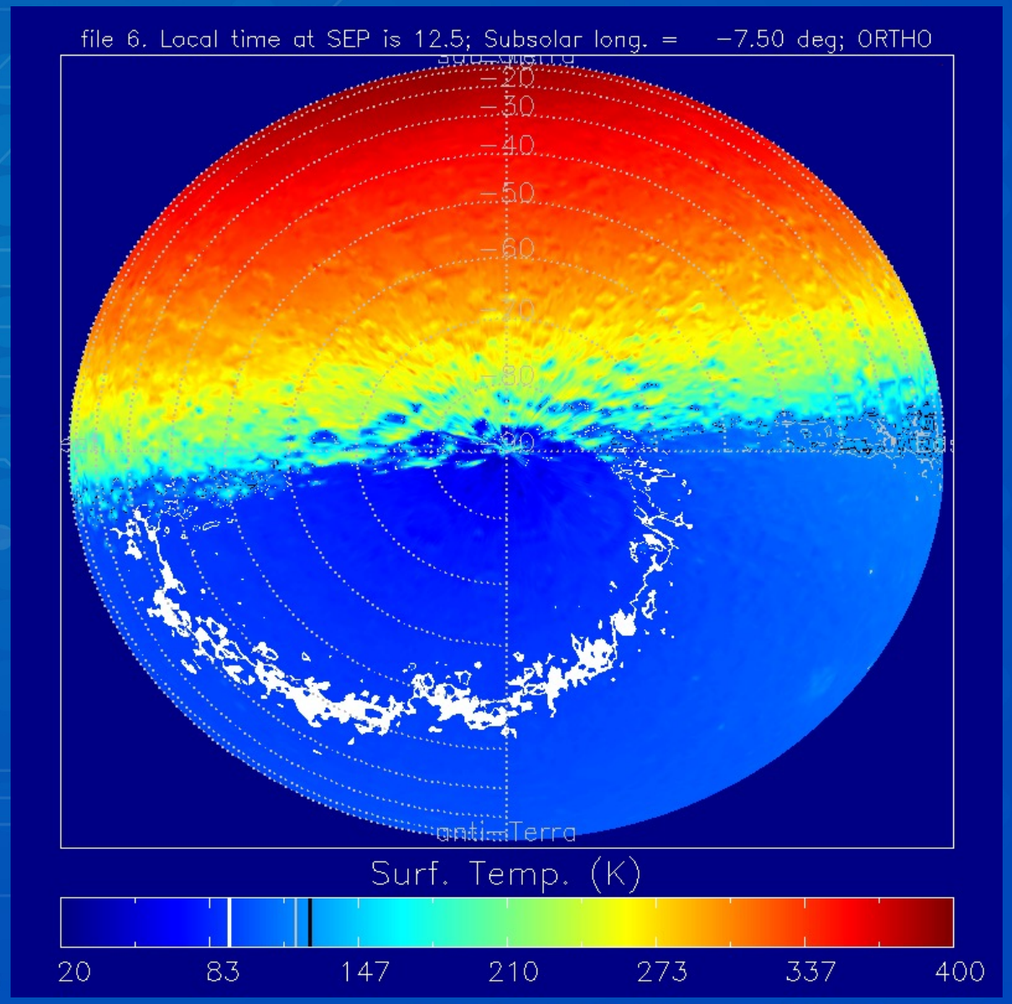


Neon.  View from S pole.  Earth is up.

Exospheric density (movie)



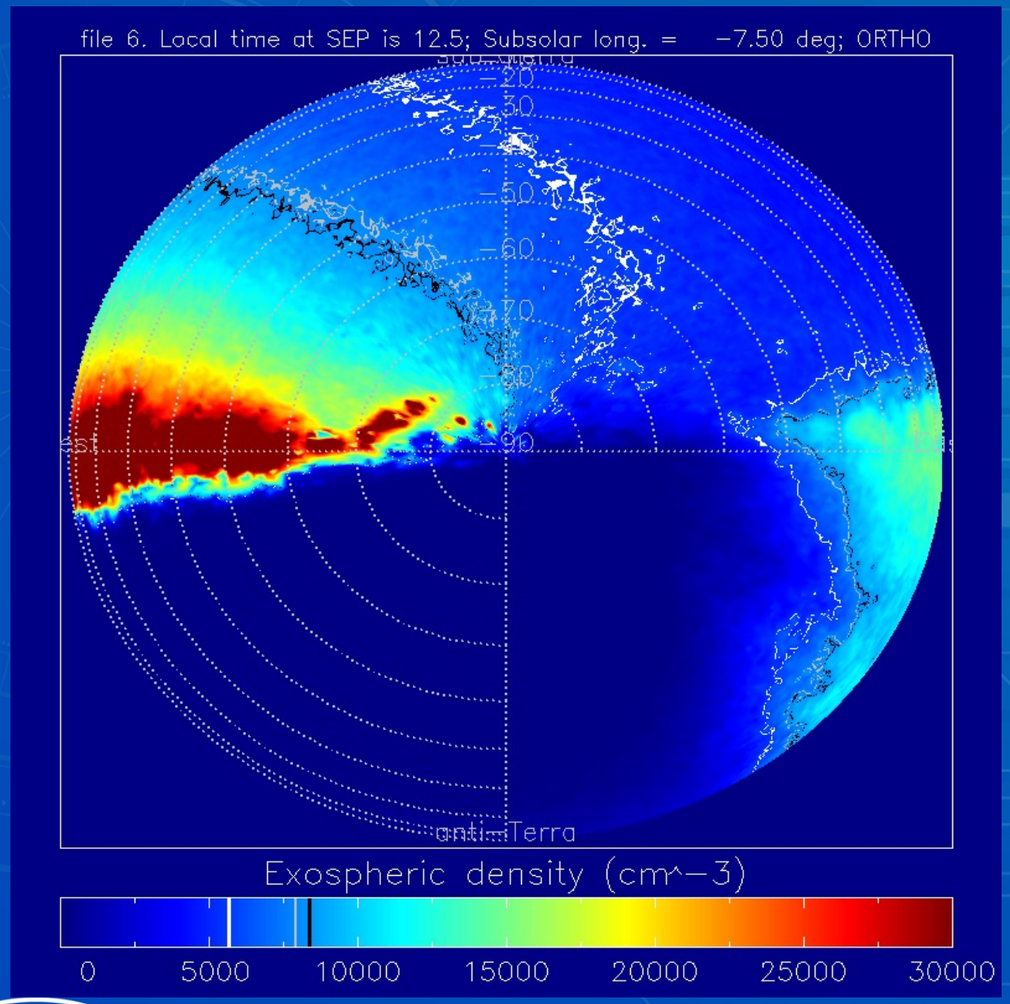
Surface Temperature (movie)



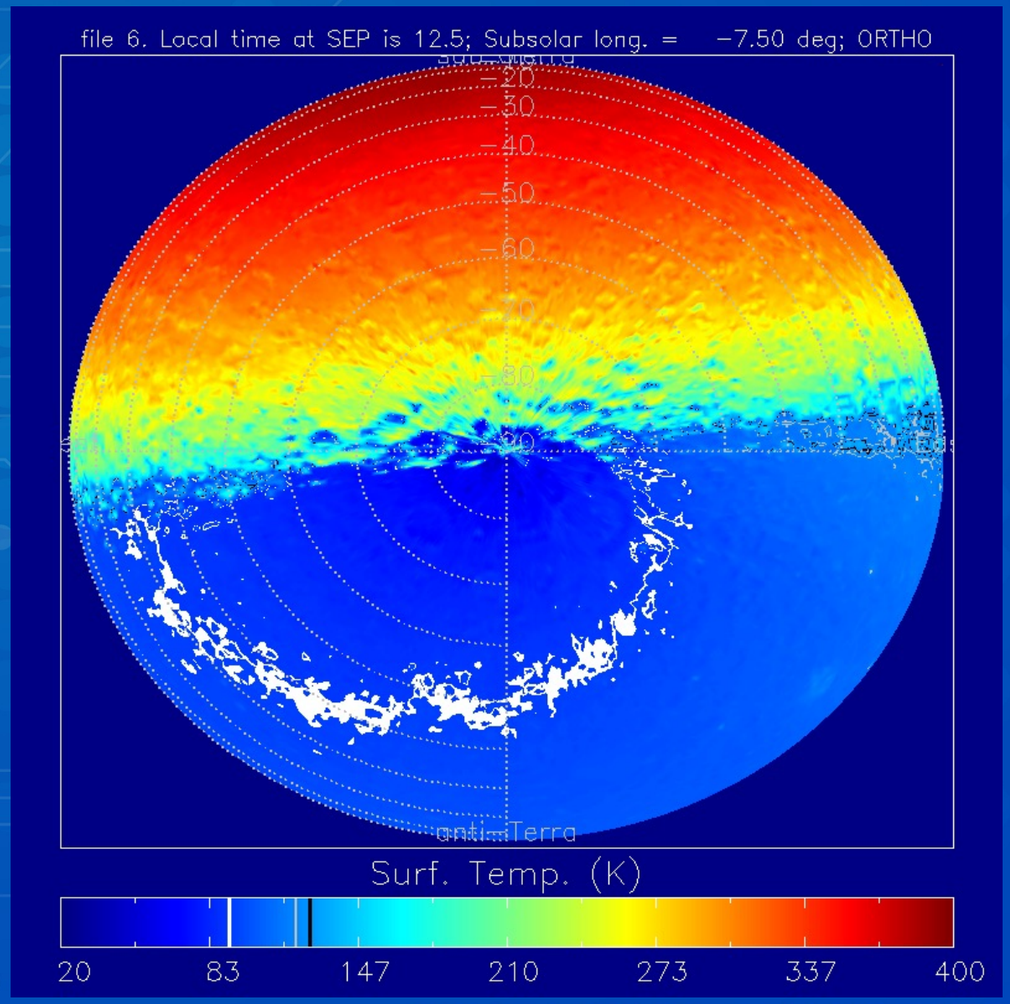
Argon: condensable

Argon.  View from S pole.  Earth is up.

Exospheric density (movie)

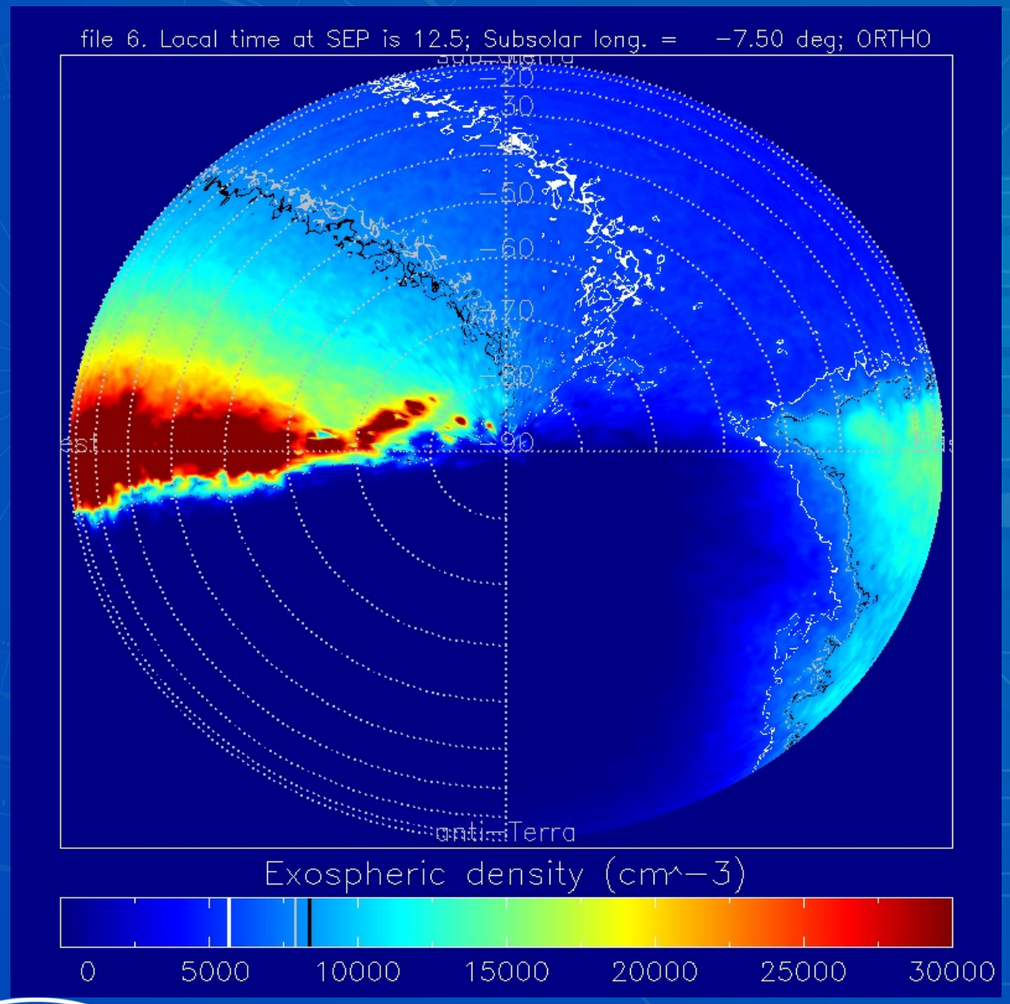


Surface Temperature (movie)

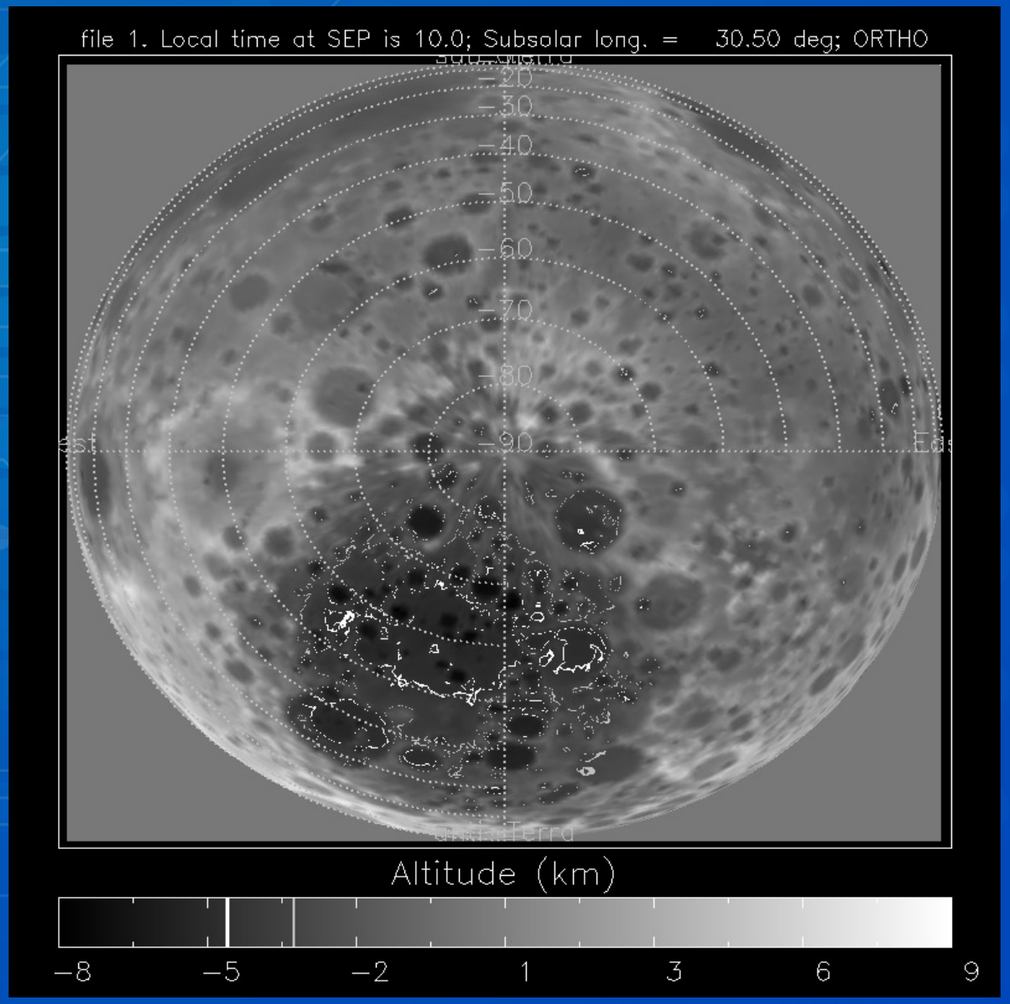


Argon.  View from S pole.  Earth is up.

Exospheric Density

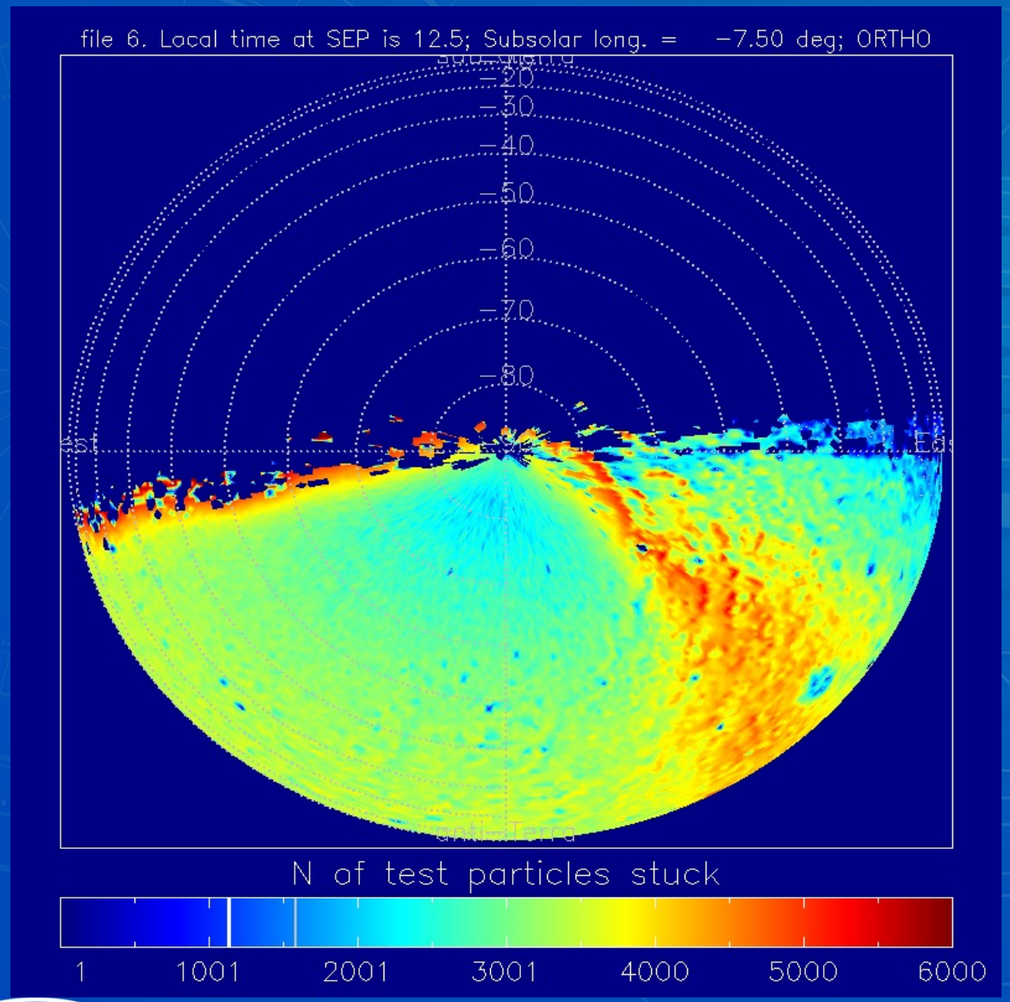


Altitude

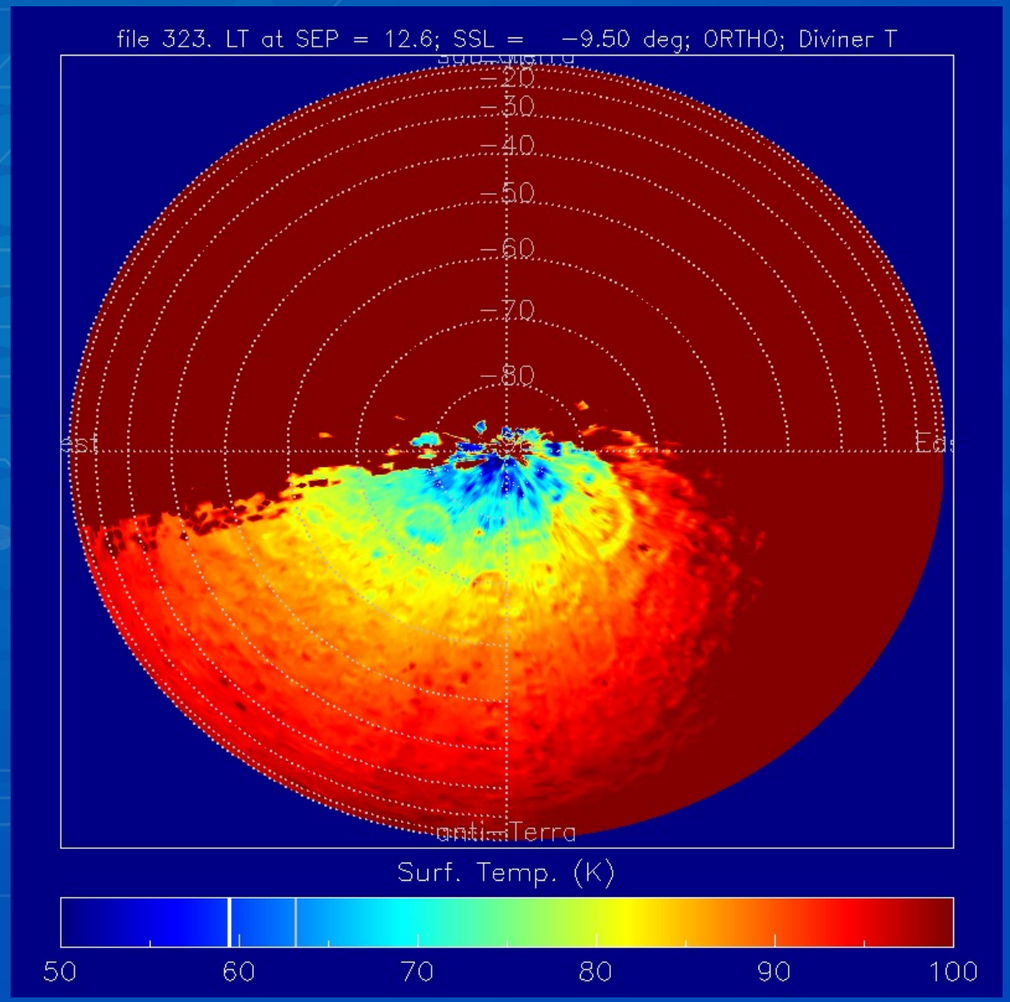


Argon.  View from S pole.  Earth is up.

Number of adsorbed test particles (movie)



Surface Temperature (movie)



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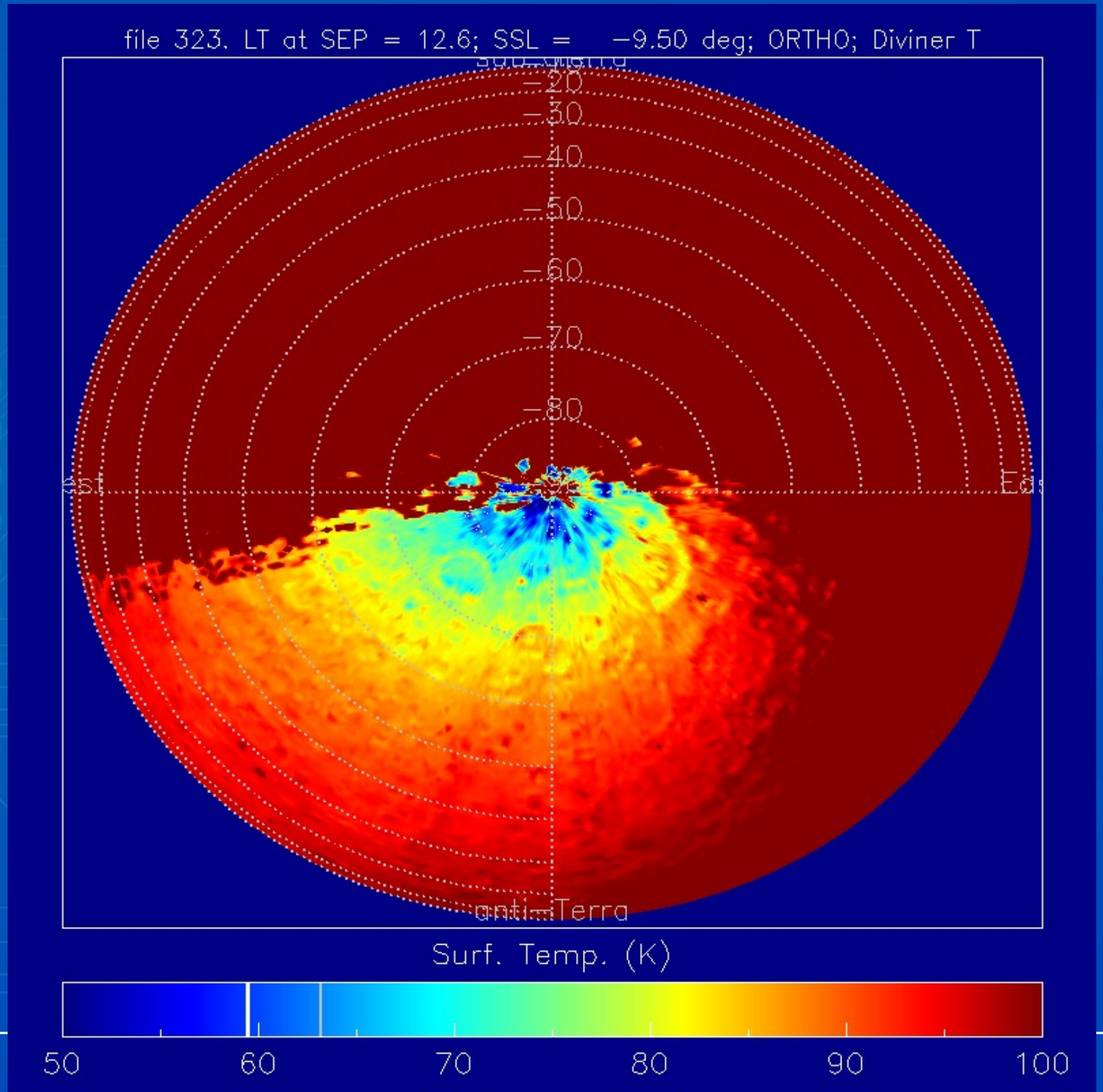
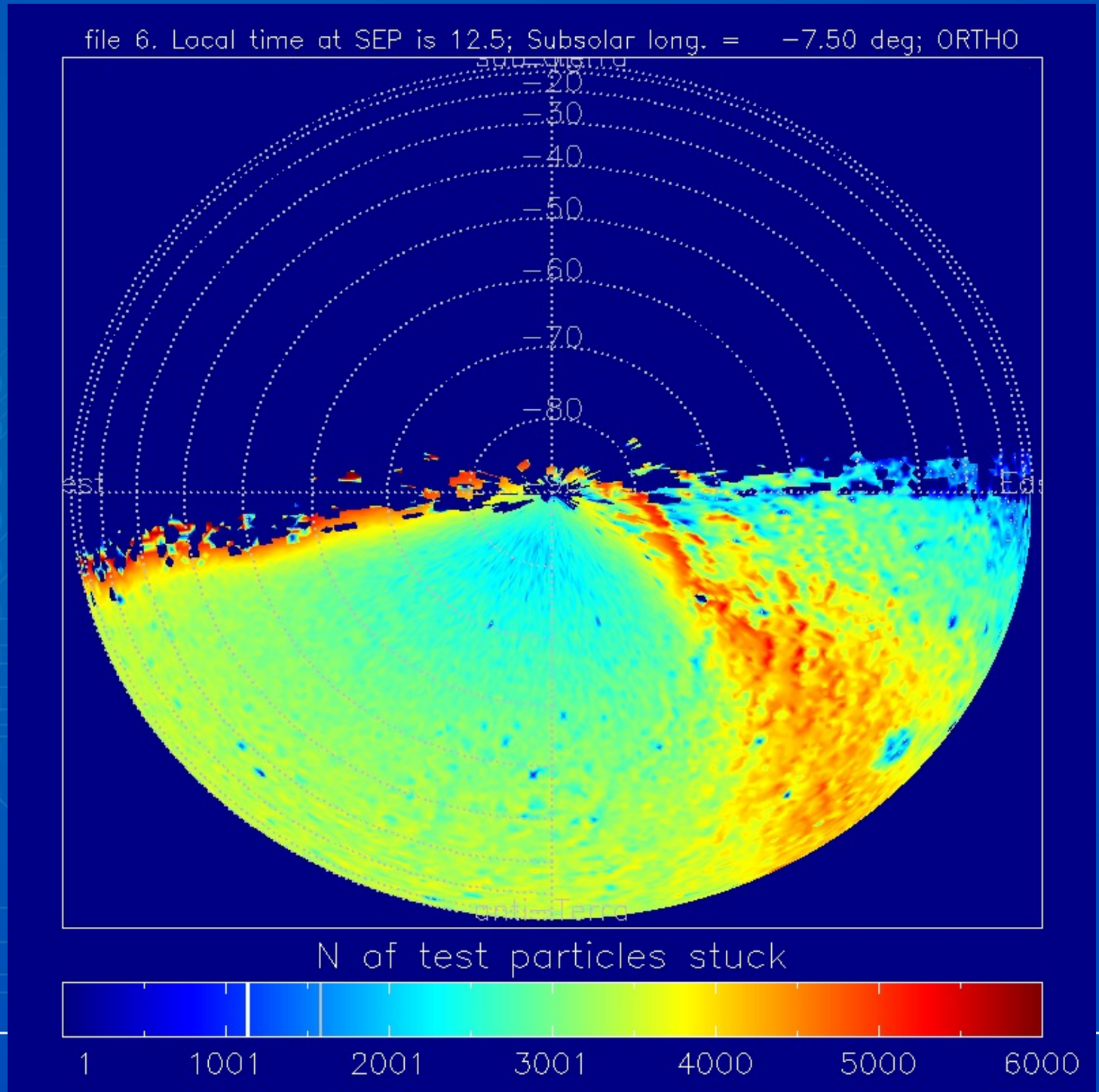
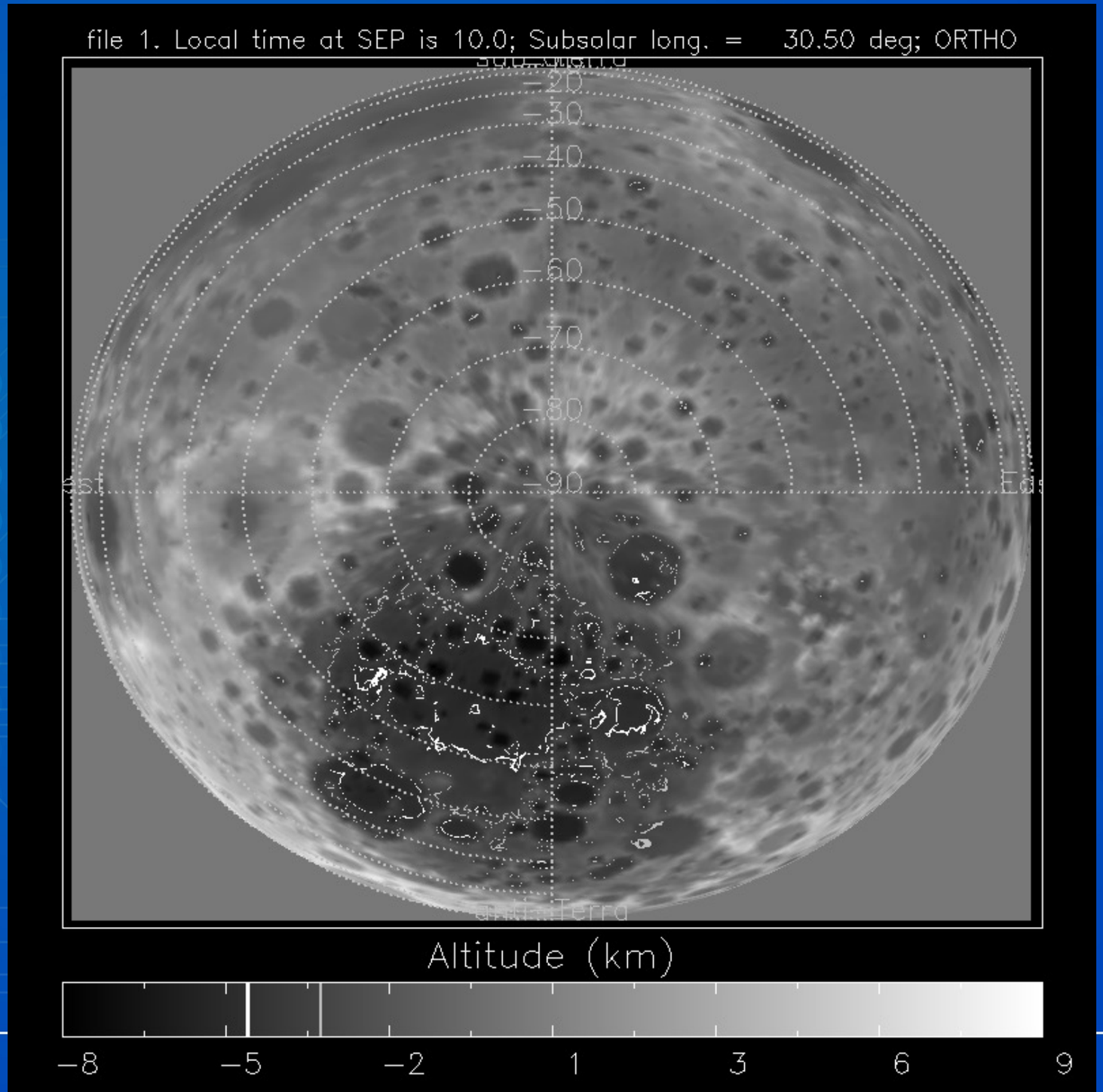
Surface temperature



Argon: number of adsorbed test particles



Altitude


file 1. Local time at SEP is 10.0; Subsolar long. = 30.50 deg; ORTHO
Altitude (km)
−8
−5
−2
1
3
6
9

Conclusions

- Topography and Surface temperature variations affect the distribution of volatiles in the exosphere and on the surface
- For the exosphere, surface temperature variations are more important than topography
- For adsorbed/cold-trapped molecules, topography is as important as surface temperature variations
- They should be included in any model of a surface-bound exosphere
- Variations in exospheric density due to topography and surface temperature should be detectable by an adequately sensitive mass spectrometer

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