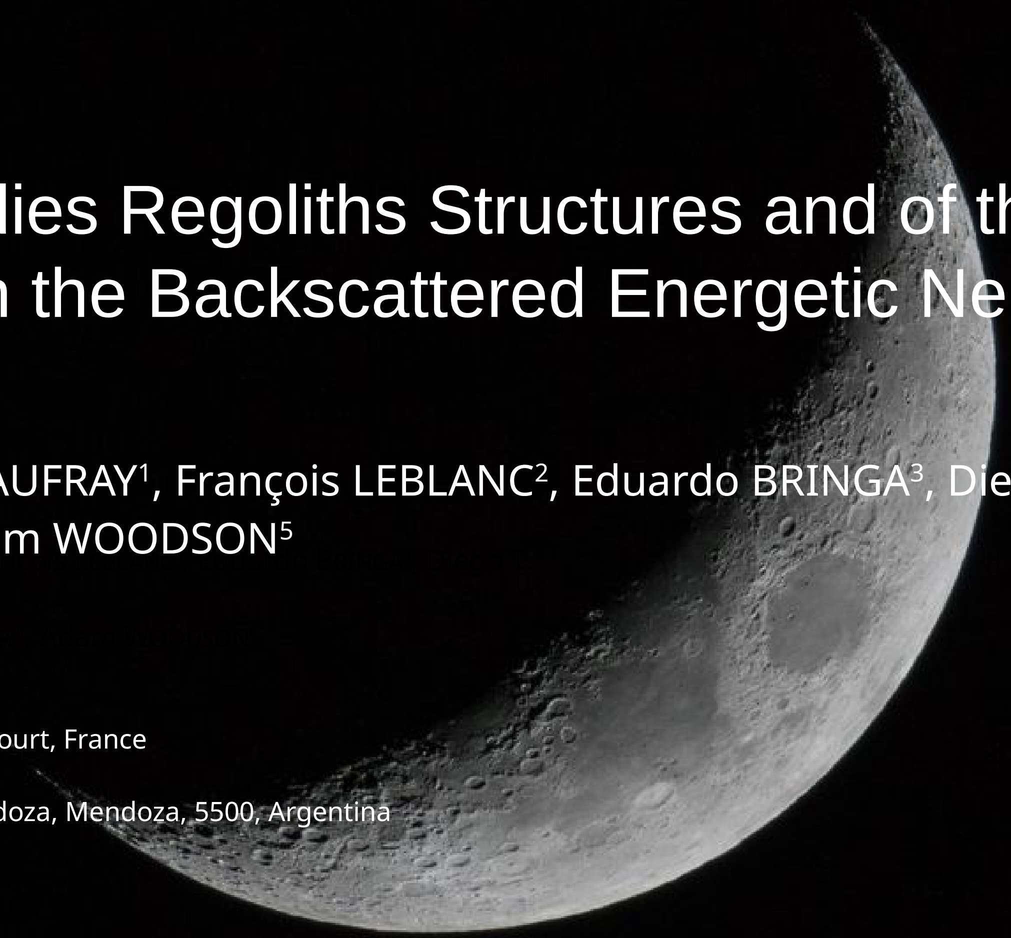
Axe Astrophysique



Effects of the Airless Bodies Regoliths Structures and of the Solar Wind Properties on the Backscattered Energetic Neutral Atoms Flux

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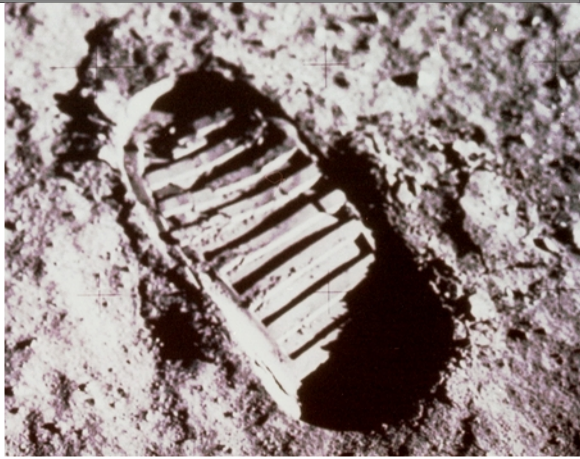
19/10/2023



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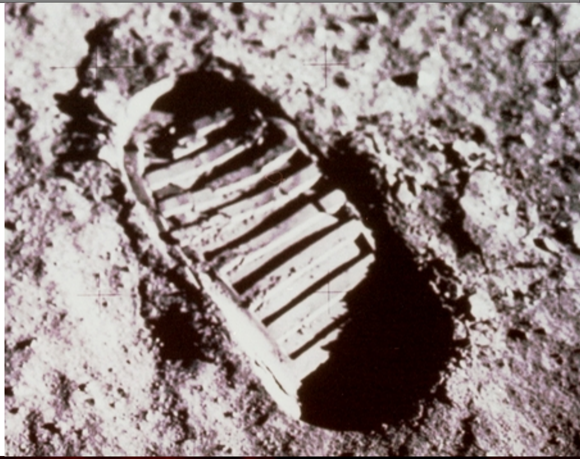

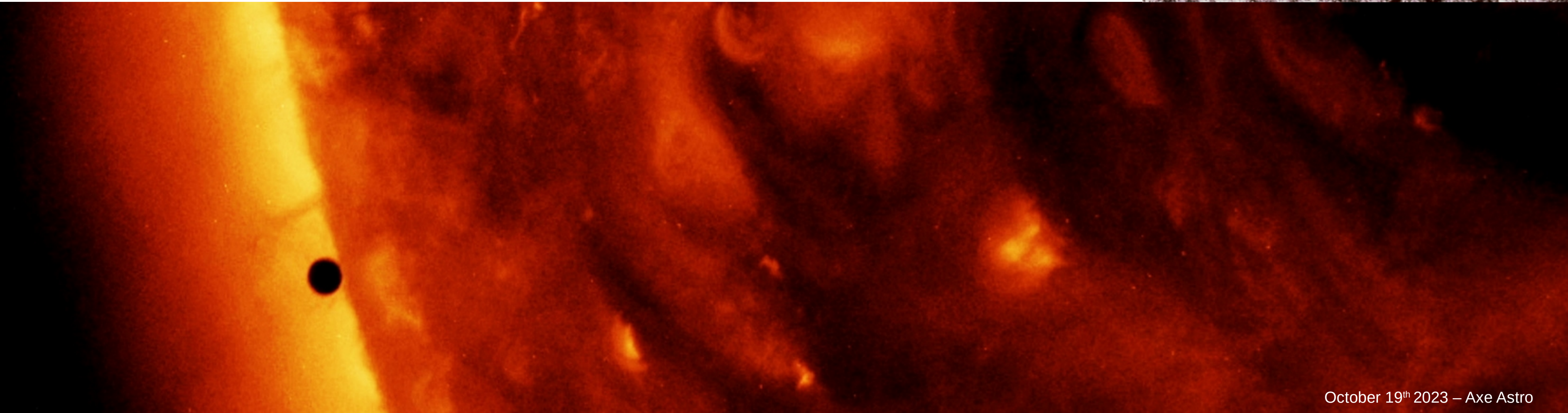

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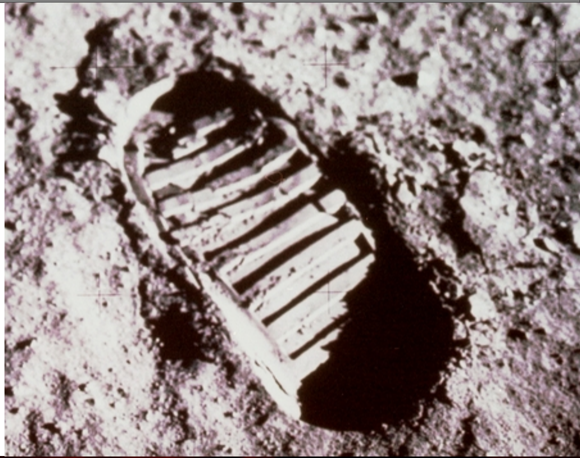
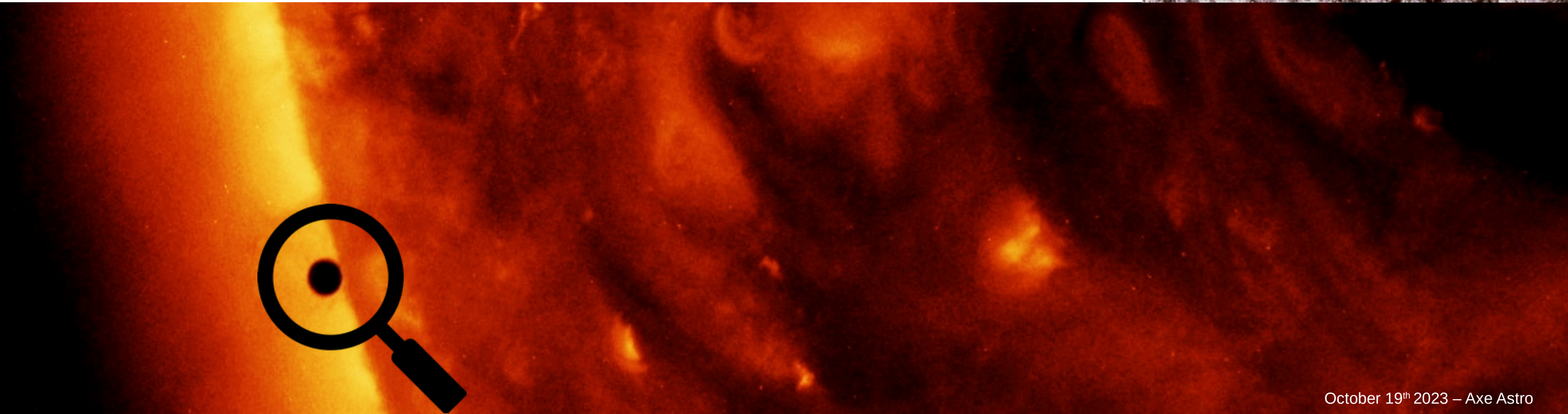
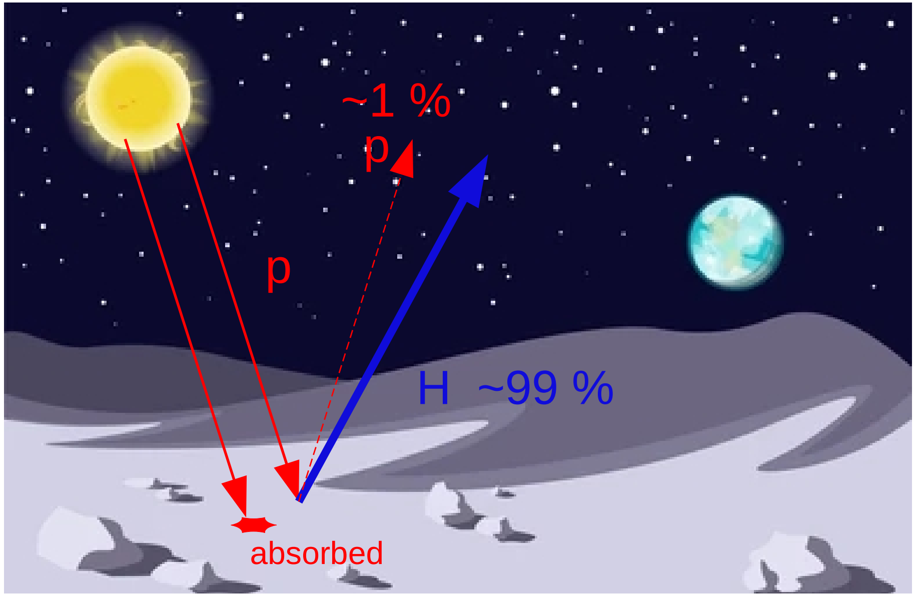




Regolith : Microstructure with huge importance ?

- Solar protons impacting the lunar surface are either absorbed or backscattered as Energetic Neutral Atoms (ENA)



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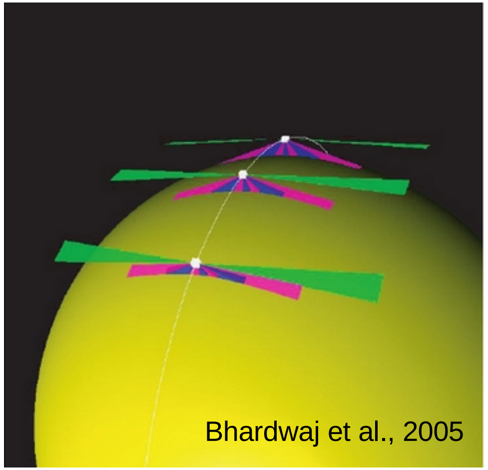
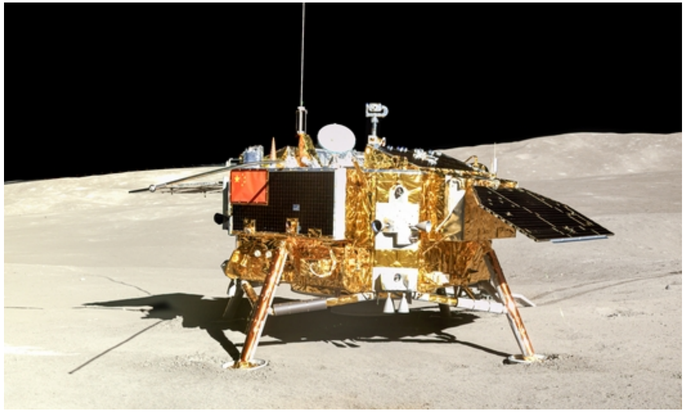
- Many missions with different observations :
  - IBEX : 9 % +- 5 % (Saul et al. 2011)
  - Chandrayaan-1 : 10 to 20 % (Futaana et al. 2012)
  - Chang'E 4 : 32 % (Zhang et al. 2020)



Bhardwaj et al., 2005



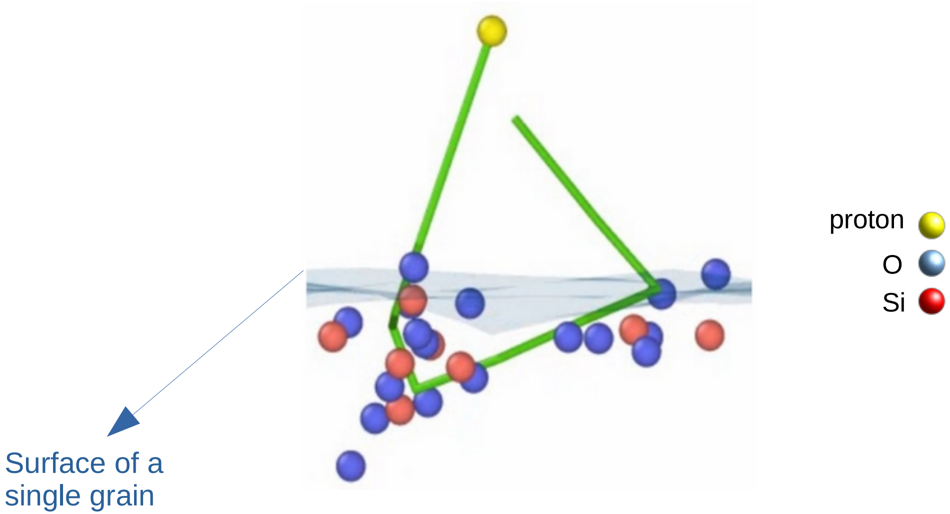
CSNA/Siyu Zhang

Regolith : Microstructure with huge importance ?

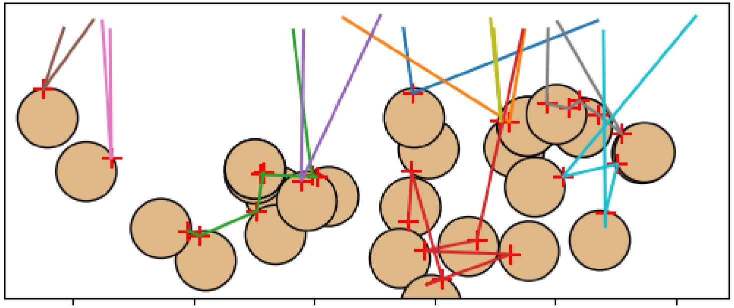
- Different ENA reflection fraction observed
- Multiple factors : geometry of observation, solar wind conditions, local surface (micro)structure
- Could we deduce the regolith structure from ENA signature ?

Models :

- One describing the interaction of a proton with a grain (MD)



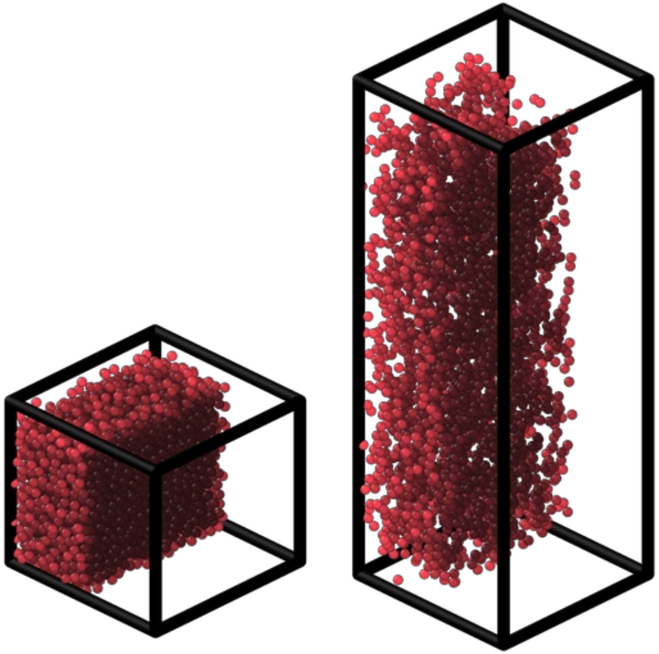
- Another describing the protons journey through the lunar regolith (Monte Carlo)

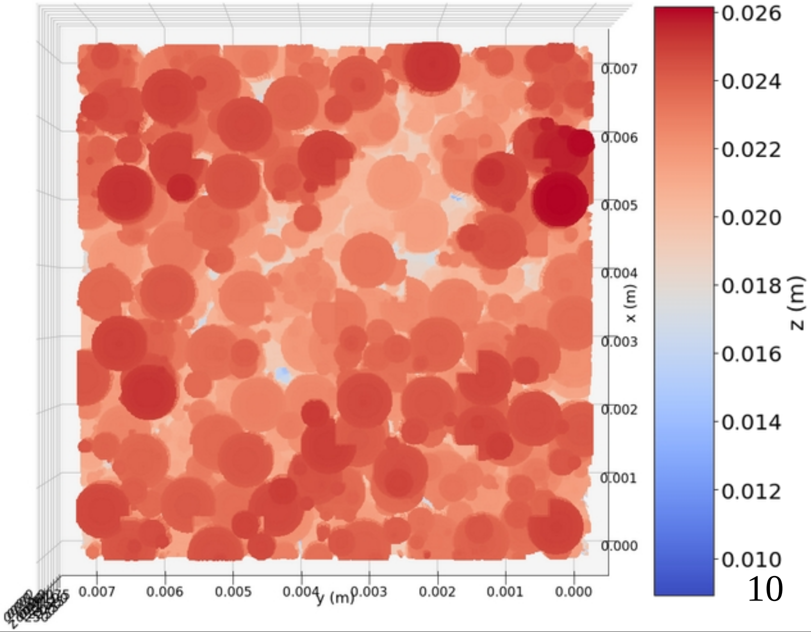


Results :

- Characterizing regoliths by their roughness : using ray tracing

$$R = Area_{Textured} / Area_{Projected}$$

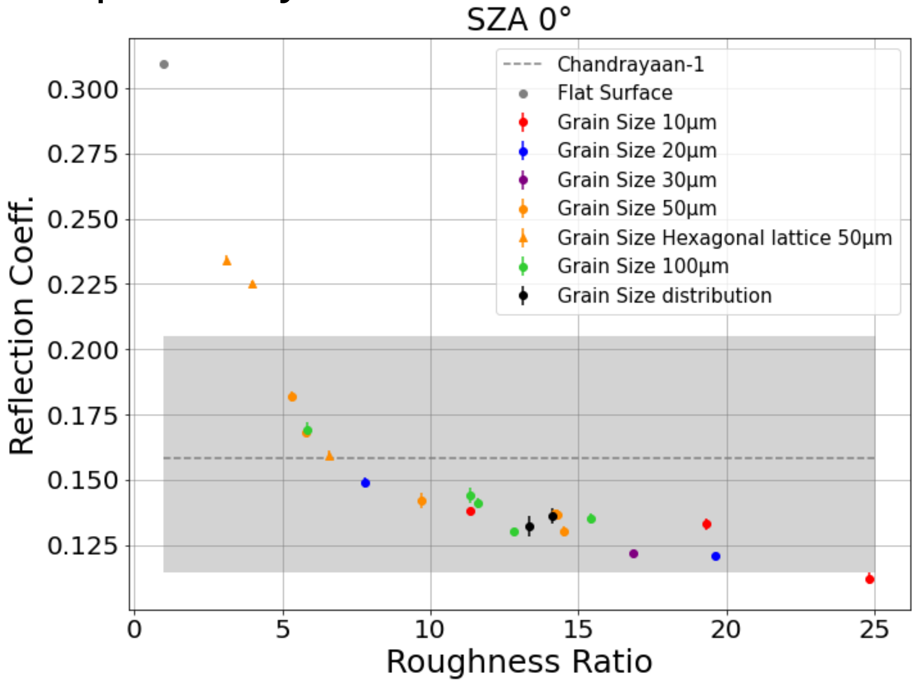




Results :

- Characterizing regoliths by their roughness : shows a dependency between reflection of ENA and roughness

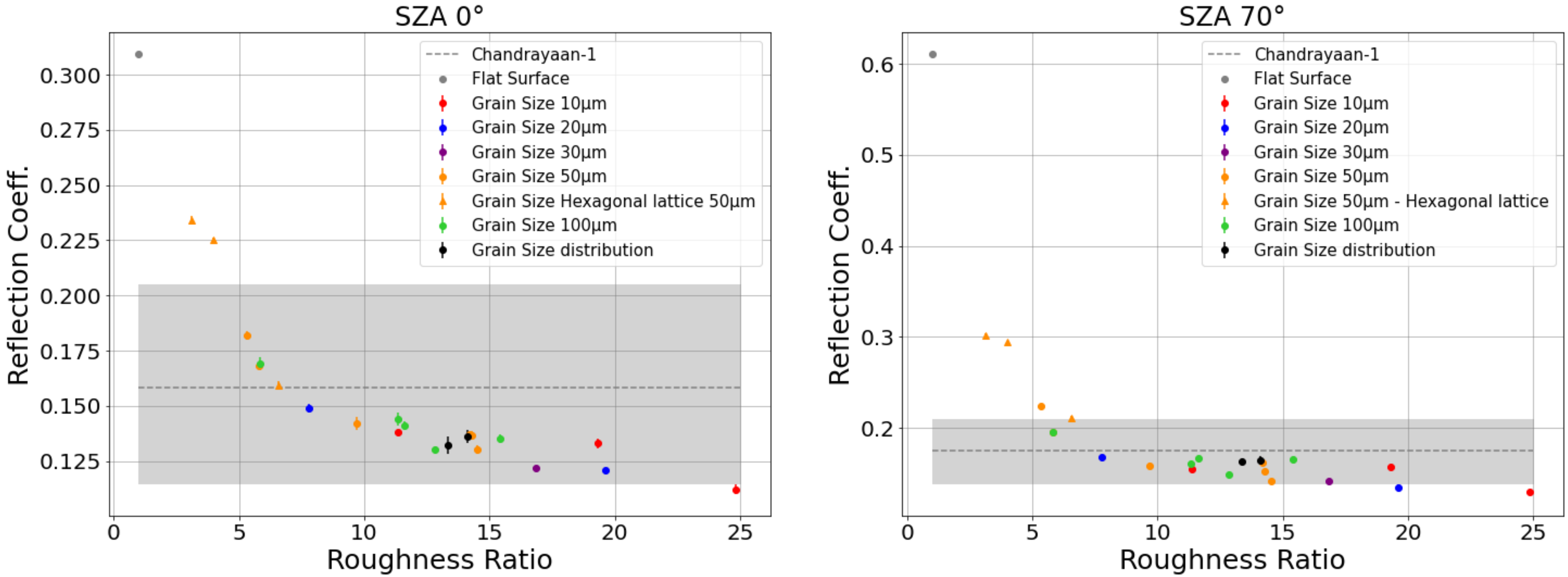
$$R = Area_{Textured} / Area_{Projected}$$



Results :

- With increasing SZA, increasing reflection ENA fraction

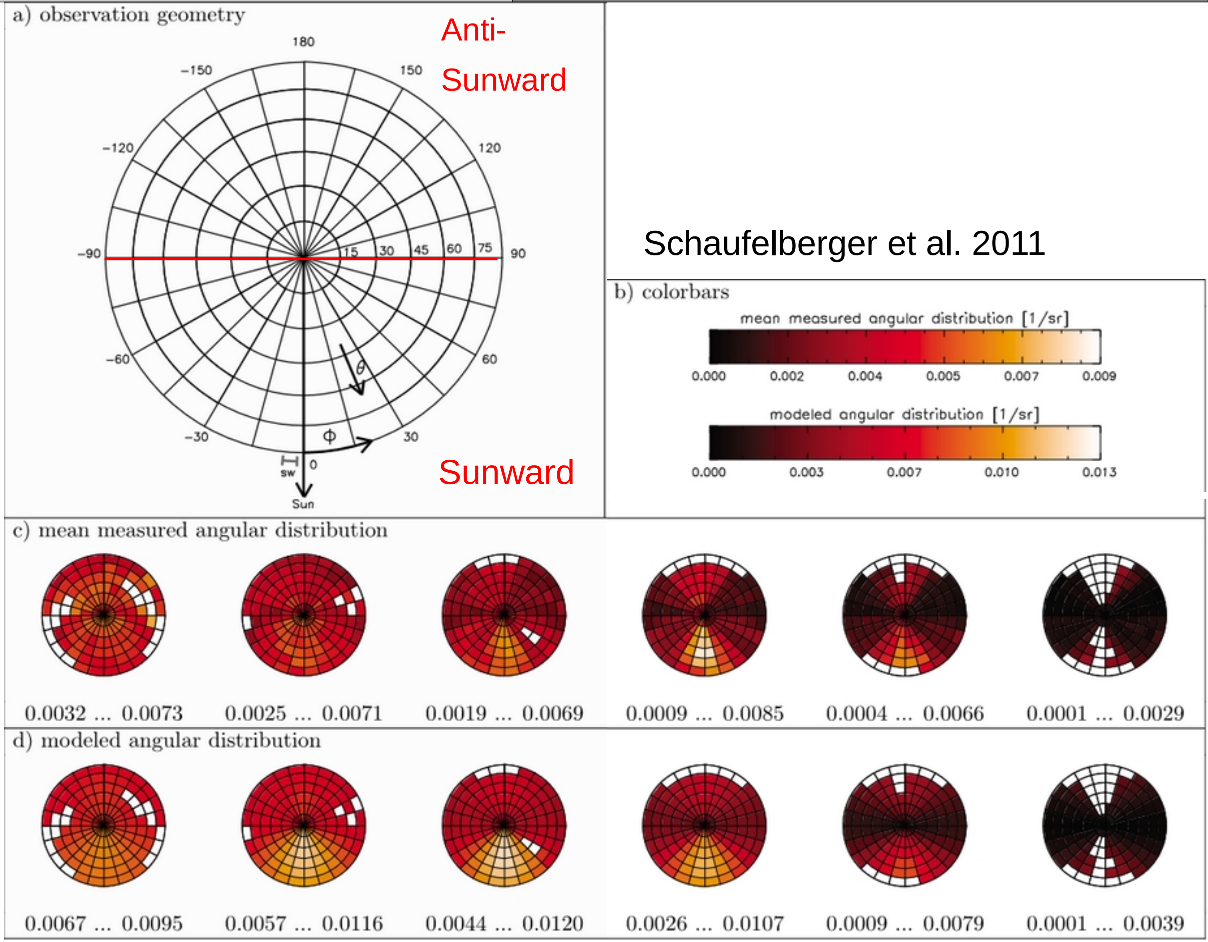
$$R = Area_{Textured} / Area_{Projected}$$



Results :

- Impact on the angular distribution of ENA ?
- Observations show that with increasing SZA :

1. Bigger ratio of sunward versus anti-sunward flux
2. Less azimuthal uniformity
3. Shallower scattering
4. Amplitude decrease



Schaufelberger et al. 2011

SZA (°) : 0-15 15-30 30-45 45-60 60-75 75-90

Results :

$$S_a(SZA) = \iint_A |Z(x,y)|\,dxdy\,,\quad \text{with}\quad Z(x,y) = z(x,y) - \bar{z}$$

where x and y are the plane coordinates, z(x,y) is the height of the surface at (x,y) with respect to the bottom of the simulation box and $\bar{z}$ is the mean height of the surface

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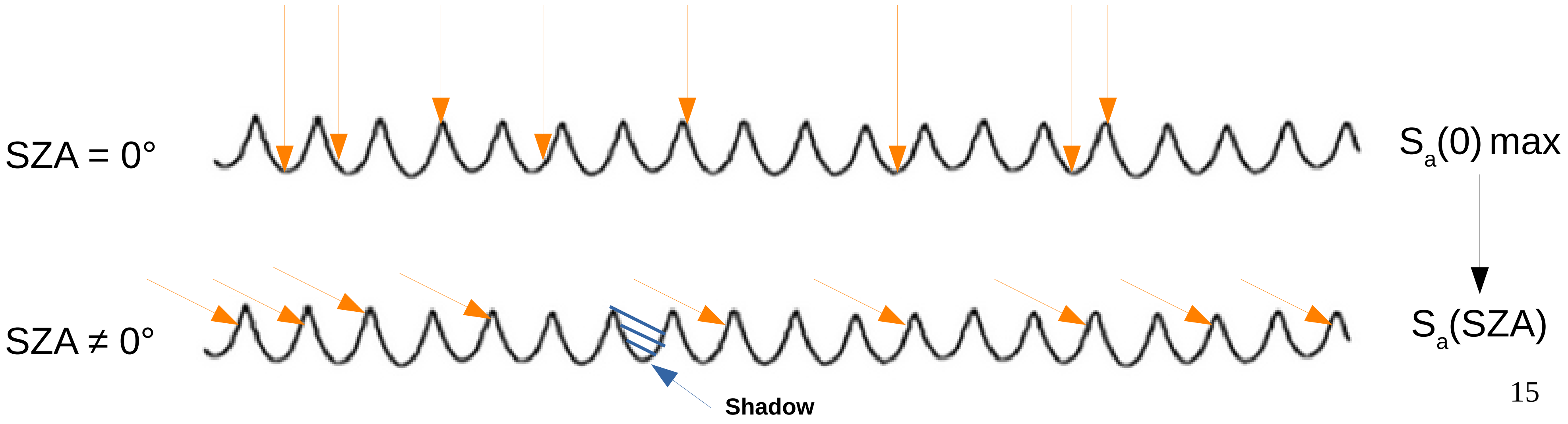
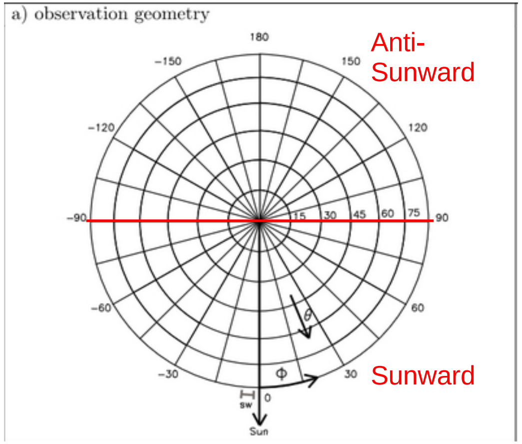
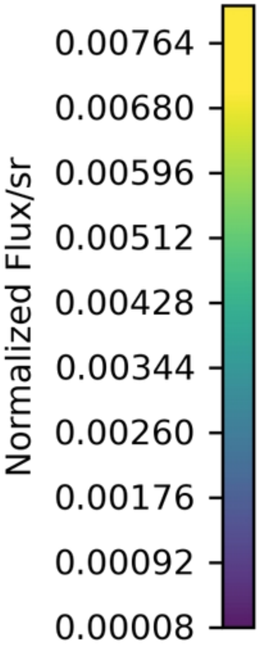


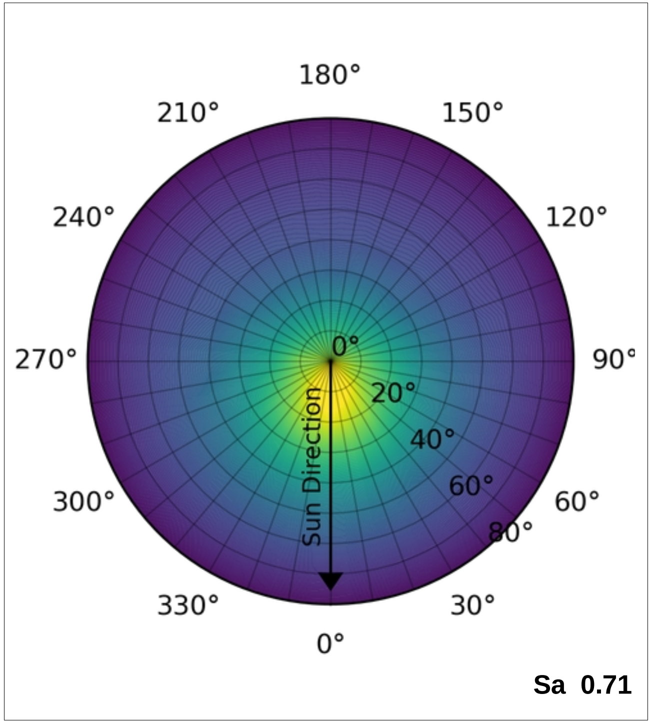
Results :

SZA = 20°

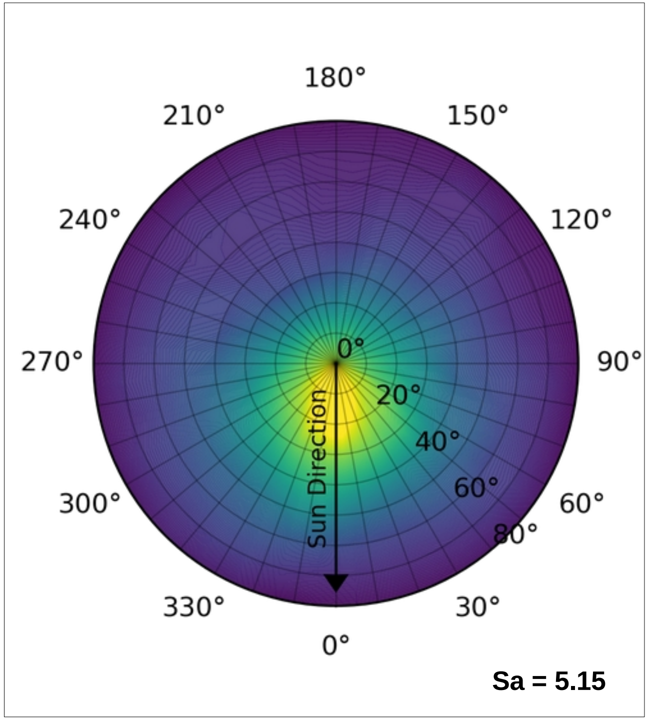




Low Roughness

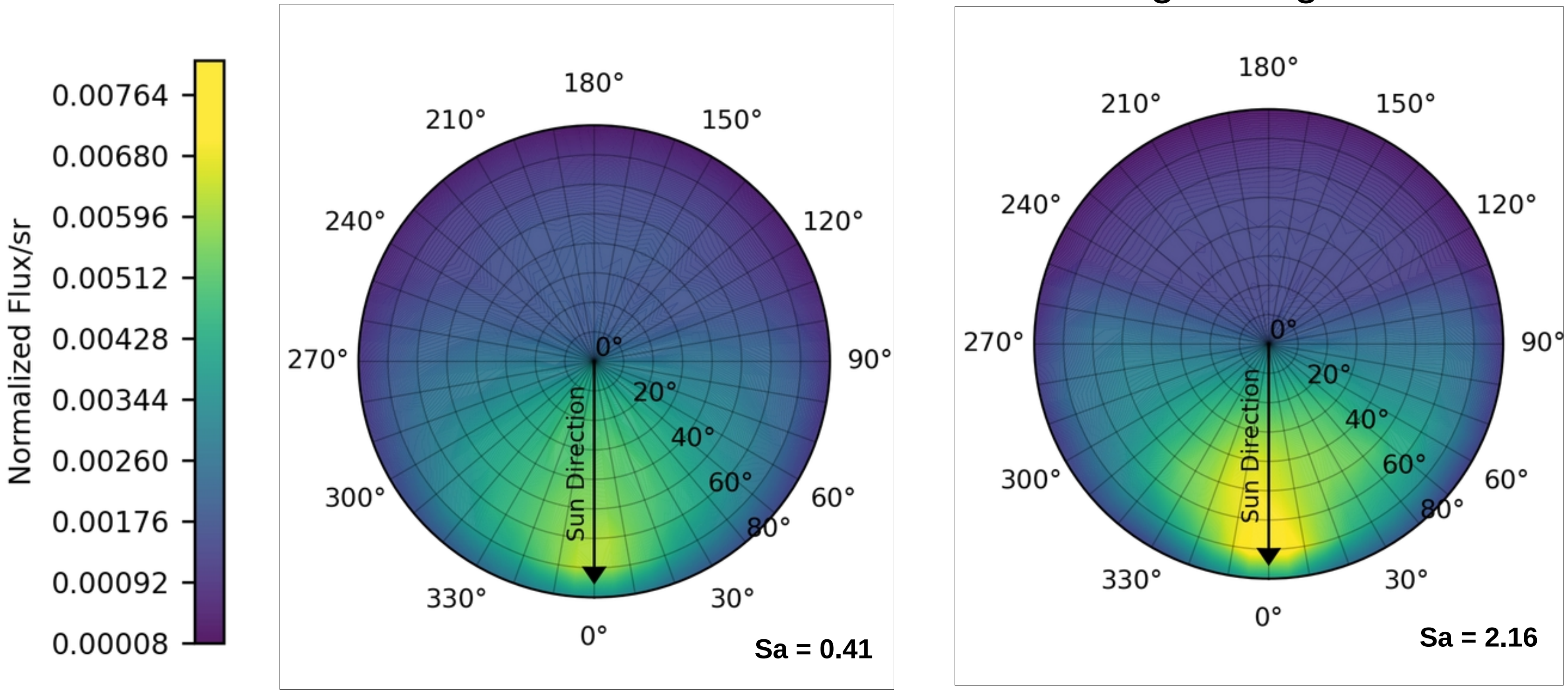


Large Roughness

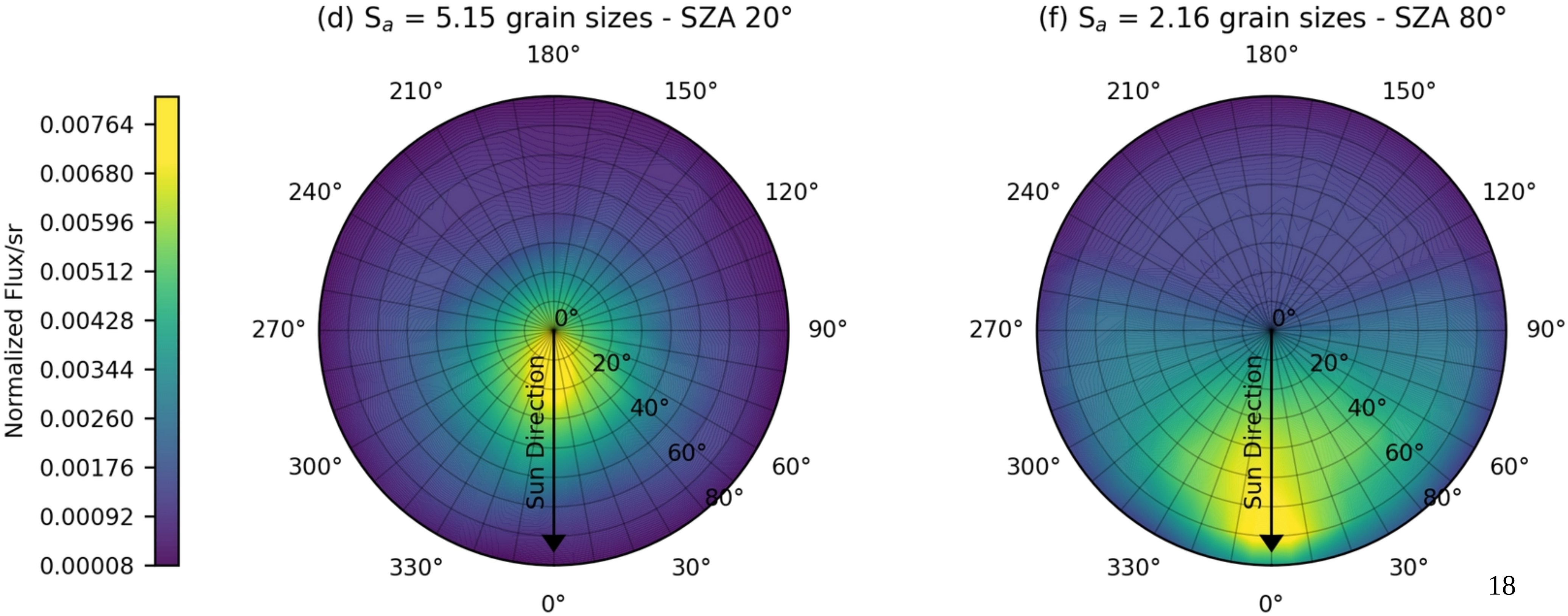


Results :

SZA = 80°   Low Roughness   Large Roughness

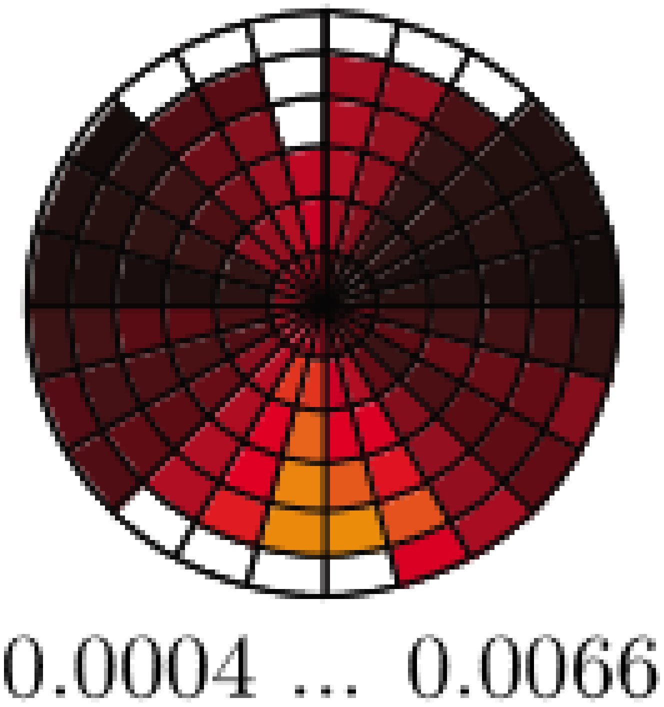


Results :

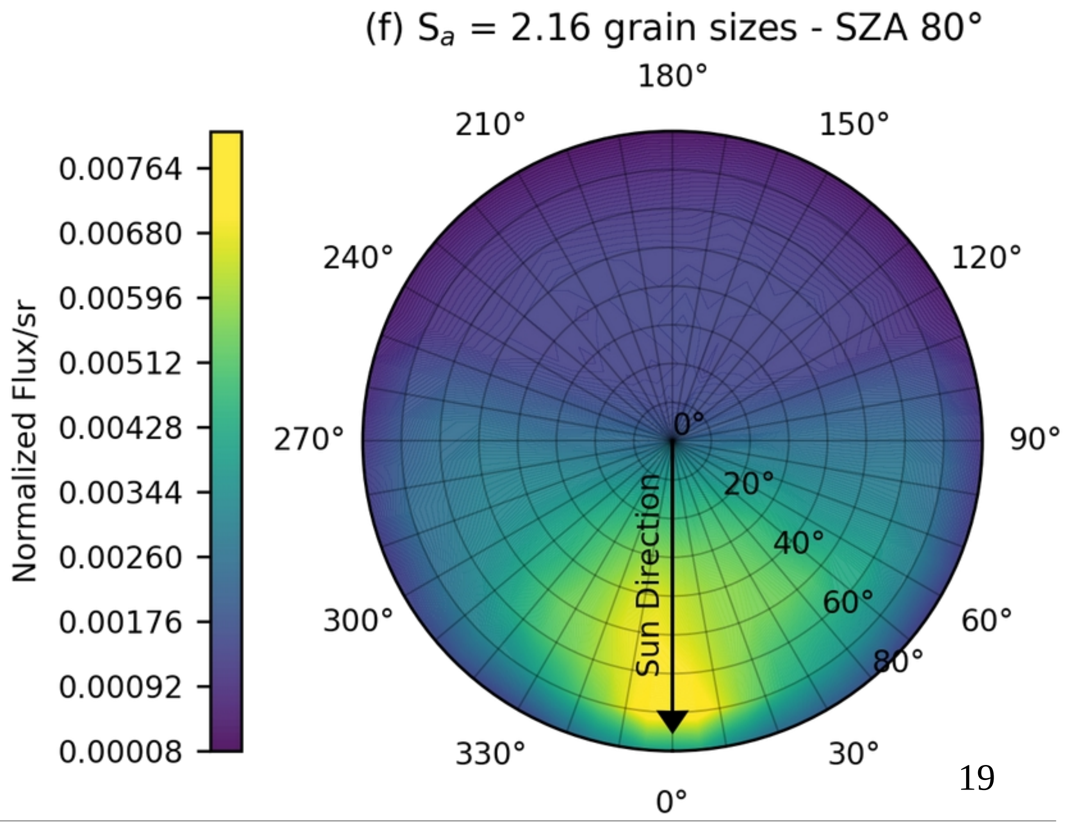

(d) S_a = 5.15 grain sizes - SZA 20°
(f) S_a = 2.16 grain sizes - SZA 80°
Normalized Flux/sr
0.00764
0.00680
0.00596
0.00512
0.00428
0.00344
0.00260
0.00176
0.00092
0.00008
180°
210°
150°
240°
120°
270°
90°
300°
60°
330°
30°
0°
20°
40°
60°
80°
Sun Direction

Results :

SZA 60-75°



Schaufelberger et al. 2011

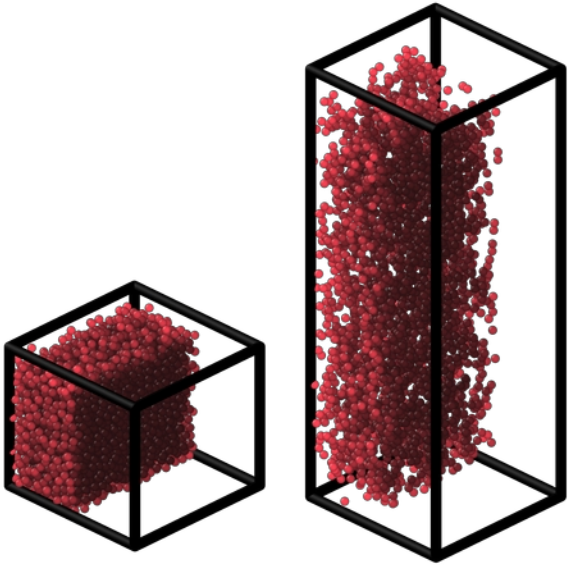


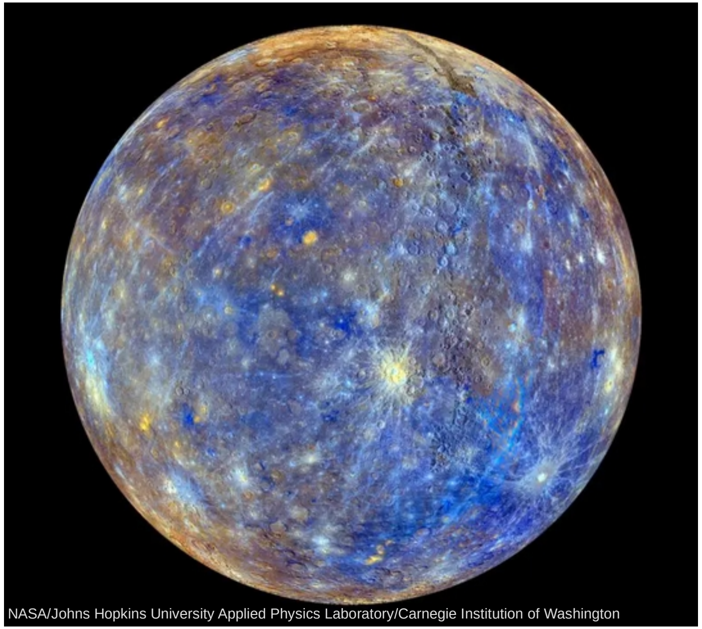
Conclusion :

- Our model's results are **coherent with previous models**
- Global behavior of the modeled angular distribution with SZA is influenced by the average roughness and **coherent with the observations** from Chandrayaan-1
- Larger roughness ratio exhibits smaller ENA backscattered fraction of the lunar regolith
- Roughness ratio identified as a **key structural parameter** influencing the global ENA backscattering coefficient
- This work underlines the **important role of the top-most lunar regolith layer** an its roughness in the ENA backscattering
- **More details in the paper : Planetary Science Journal, Verkercke et al. 2023**
- Similar conclusion reached by Szabo et al. 2023 recently using a different approach

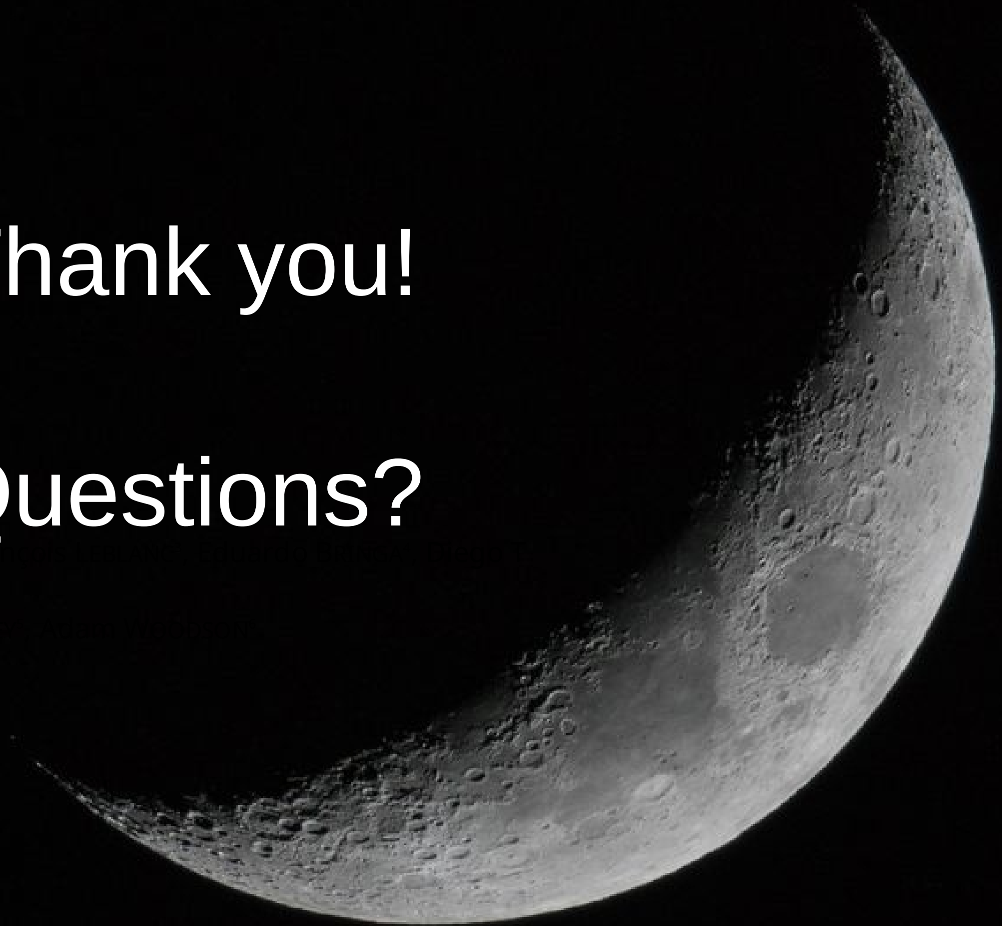
Perspective :

- Effects of microstructure on the exosphere (BepiColombo mission ESA - JAXA)





Axe Astrophysique



Thank you!

Questions?