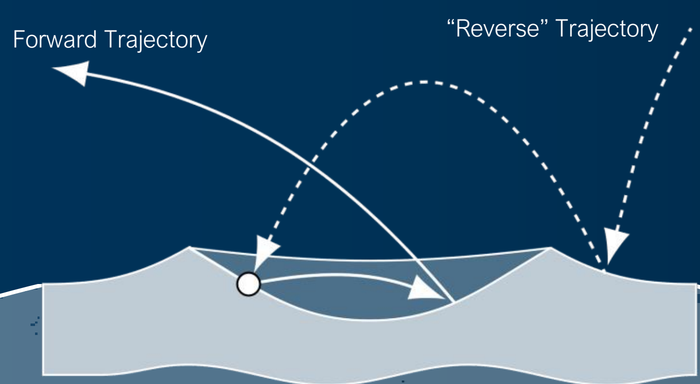
TUM

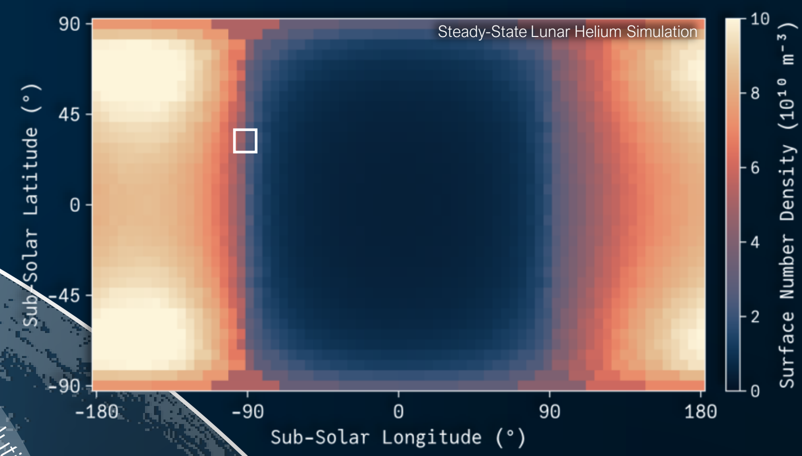
A Reverse Monte Carlo Method to Investigate the Topography Interaction with the Lunar Exosphere

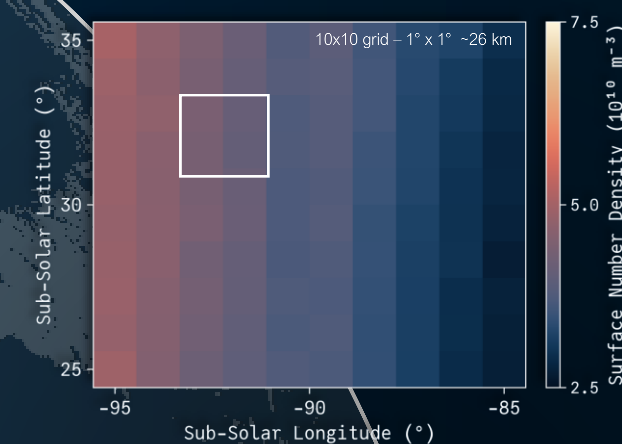
Alexander Smolka[1] (a.smolka@tum.de), Carlos Saenz Reguero[1], Philipp Reiss[1], [1]Technical University of Munich, Germany

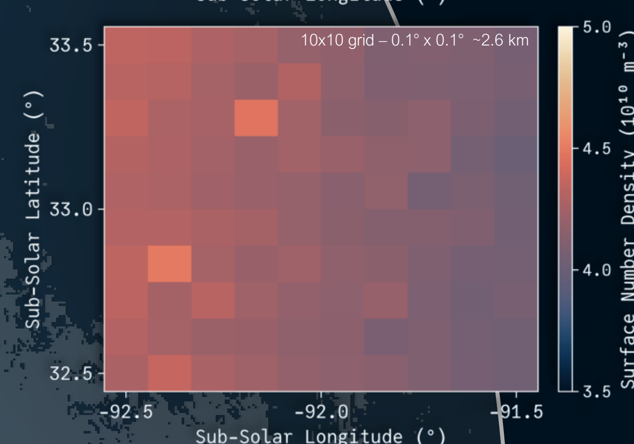


From the initial position, the particle is tracked both backwards using "reverse" Monte Carlo, as well as forward using a regular "forward" Monte Carlo method. The numerical weight of each trajectory is evaluated based on the Bayesian law which relates the probabilities for the reverse trajectory and the identical forward trajectory.

The method is used to zoom into a specific region of interest. By always using the same number of points, the resolution can be improved *without increasing the computational effort*.

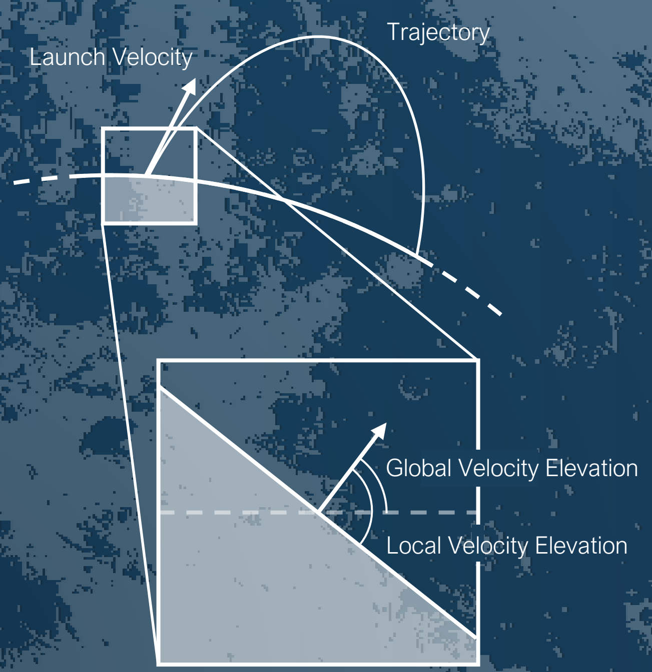






method allows higher resolution

higher resolution allows topography



Topography influences exosphere simulations through a tilted surface geometry leading to particles being ejected in different angles. Through a surface slope, both the landing and launching velocity distributions are rotated around the surface slope.

Reverse Trajectories Allow Computationally Efficient Topography Investigations

Having been around for several decades (Hodges et al., 1973 – Farrell et al., 2023; Smolka et al., 2023), most exosphere models are based on the Monte Carlo model assuming a perfectly spherical planetary body to solve for the trajectories of each particle, tracking them from their source to their eventual loss. Including topography poses a problem due to the difference in scale (Milillo et al., 2023): while a planetary diameter is typically in the order to thousands of kilometers, topographic scales can vary from meters to several kilometers, while surface roughness acts on a millimeter scale (Prem et al., 2018). We present a reverse Monte Carlo method (RMC), which uses reverse trajectories for the density calculation. This approach removes the need for a global discretization and allows to investigate any position at a constant computational effort.

Our next steps will focus on a thorough slope investigation to answer our main research question: How does a crater affect the exosphere composition and density above?

EUROPLANET SCIENCE CONGRESS

Hodges et al., 1973. *Composition and dynamics of lunar atmosphere*. Proceedings of the Fourth Lunar Science Conference, 3, 2855–2864.
Prem et al., 2018. *The influence of surface roughness on volatile transport on the Moon.* Icarus, 299, 31–45. 10.1016/j.icarus.2017.07.010
Farrell et al., 2023. *The Dust, Atmosphere, and Plasma at the Moon.* Reviews in Mineralogy and Geochemistry, 89(1), 563–609. 10.2138/rmg.2023.89.13
Milillo et al., 2023. *Future Directions for the Investigation of Surface-Bounded Exospheres in the Inner Solar System*. Space Science Reviews, 219. 10.1007/s11214-023-00994-8
Smolka et al., 2023. *Coupled H, H_2, OH, and H_2O lunar exosphere simulation framework and impacts of conversion reactions.* Icarus, 397, 115508. 10.1016/j.icarus.2023.115508

github.com/Smolkaa/ExESS.jl