A RIM-SIDE VIEW OF COLD-TRAPPED VOLATILES RELEASED BY MICROMETEOROID IMPACTS.

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Introduction: Understanding the character and origin of lunar polar volatiles is a key science objective for lunar surface exploration [1]. Measurements near polar permanently shadowed regions (PSRs), e.g., at crater rims, offer a means of studying the composition of cold-trapped volatiles and the processes that affect their distribution, without exposure to the environmental extremes of the PSR itself [2]. Building on previous modeling work [2], we aim here to investigate more closely the question of how to relate measurements at the rim of a permanently shadowed lunar polar crater to its volatile content. Specific questions of interest include: How does micrometeoroid bombardment redistribute volatiles from an ice-bearing crater? How close to the crater would one need to be to acquire meaningful measurements? Can the signature from a volatile-rich PSR be distinguished from the background?

Method: We investigate the questions outlined above through Monte Carlo simulations that track the local transport of a large number of representative water molecules released from a Shackleton-like PSR (~9 km radius) and surrounding terrain. The simulations assume a continuous release of water molecules from a region 75 km radius region centered on the modeled PSR. The outward flux from non-PSR terrain is estimated to be 2×10^{-16} kg/m^2/s (based on LADEE observations [3]), and that from the PSR is estimated to be 1000 times greater, assuming that ice is exposed at the surface at a concentration of ~1 wt. %. As in [2], the initial velocity of molecules is drawn from a Maxwellian distribution at 4000 K, and subsequent ballistic trajectories are computed. The simulation is run for 40,000 s to allow for a quasi-steady state to be established.

Results and Discussion: Due to the high temperature associated with micrometeoroid impact vaporization, much of the water released escapes. Nonetheless, molecules with lower initial velocities return to the lunar surface, and may even reach neighboring PSRs. (Figure 1(a)). It can be seen from Figure 1(b) that even beyond the crater rim, ~90% of the water molecules falling to the surface originate from the modeled PSR.

Ongoing and future work includes accounting for the effects of crater geometry on molecule trajectory, examining the sensitivity of these results to model parameters such as the initial velocity distribution, and investigating the consequences of episodic events above the background bombardment level.

References: [1] Artemis 3 SDT Report (2020). [2] Farrell et al. (2015), *GRL* 42, 9, p.3160–3165. [3] Benna et al. (2019), *Nat. Geosci*. 12, p.333–338.

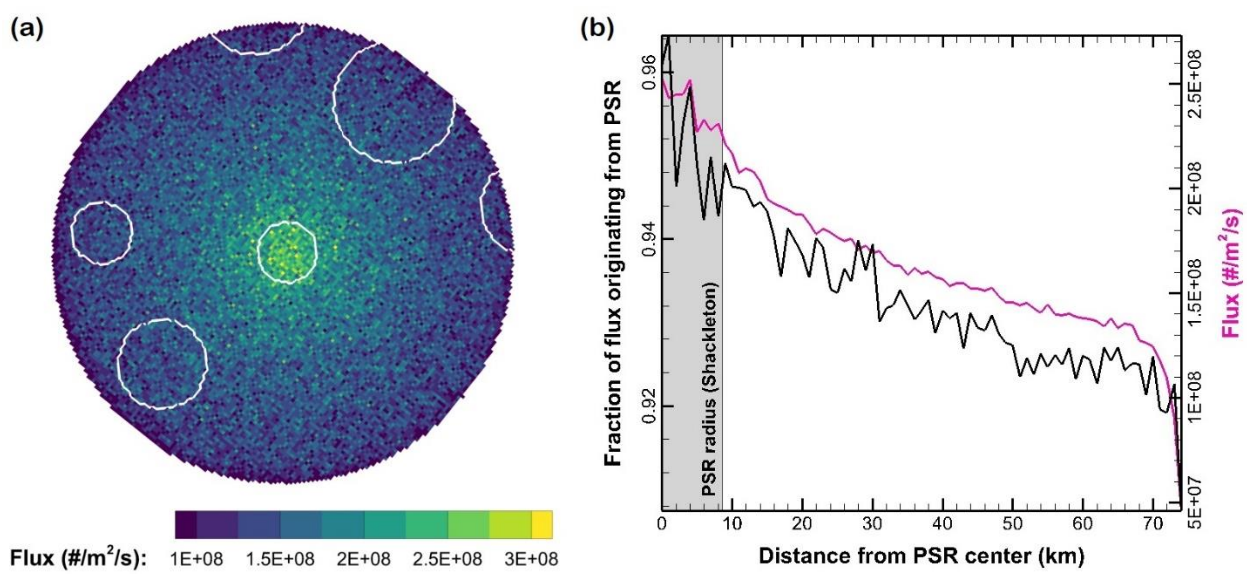

Figure 1. (a) Modeled flux to the surface of water molecules released from a Shackleton-like central PSR (Permanently Shadowed Region) and surrounding terrain. The approximate locations of other prominent lunar south polar PSRs are outlined in white. (b) Radially averaged flux (right vertical axis) as a function of distance from the PSR center, and the fraction of that flux (left vertical axis) originating from the PSR relative to the drier surroundings.