NUMERICAL EXOSPHERIC SIMULATION OF WATER DELIVERY TO THE LUNAR POLAR REGIONS Jasmeer Sangha[1], Norbert Schorghofer[2] and John E. Moores[1]. [1]Center for Research in Earth and Space Science, York University, 4700 Keele Street, Toronto, ON M3J 1P3 Canada. jsangha3@yorku.ca, [2]University of Hawaii, Honolulu, HI 96822, USA.

Introduction: Cabeus crater, and other low lying areas near the southern pole of the Moon are known to be permanently shadowed regions (PSRs) [1,2] where water ice can be trapped. These PSRs receive no direct solar radiation and thus fall over 60 K below water's volatility threshold [3]. Signals of water ice near the lunar poles have been observed through neutron spectroscopy [4,5,6]. Reflectivity of Lyman-alpha [7] and ultraviolet albedo spectra [8] have also been observed by the Lunar Reconaissance Orbiter (LRO) and the Crater Observation and Sensing Satellite (LCROSS) found evidence of sub-surface ice in Cabeus crater in its analysis of the ejected plume of material [9].

Recently, it has been proposed that the offset between the observed neutron enhancements from the north and south poles of the moon are due to True Polar Wander (TPW) [10]. This would imply that the subsurface ices of Cabeus crater are several Ga old and that new delivery of ice to polar PSRs is relatively insignificant. However, the offset can be replicated without the need to invoke ancient ices. For instance, [11] showed that the cold temperatures of the poles create potential energy barriers for incoming particles which in turn allow lower latitude craters to have higher concentrations than their poleward neighbours: a process comparable to rain shadows [11] observed for terrestrial precipitation.

Results: This effect was further explored using a combination of numerical models of ballistic transport of water vapour on the present-day lunar surface including both a validated Monte Carlo model [11] and a full lunar exospheric model [12] which had not previously been explored pole-ward of 85ºS.

As shown in Figure 1, for the full exospheric model, all PSRs accumulated fractional concentrations of water ice compared to Cabeus similar to those reported in [11].

Discussion: All but Shoemaker and Haworth craters have both sets of data falling within the 95% confidence interval. The confidence intervals reported for this work are larger compared to that from [11] due to the differences in simulation method. As opposed to [11] method, the full exospheric model simulates all particles simultaneously stepping the entire exosphere forward in time evenly. With additional simulation time these intervals will shrink and are expected to be comparable to [11] at the time of presentation.

Future Considerations: This work supports the hypothesis that diffusive water migration in an exosphere is a viable process for water collection in the Moon's southern PSRs and can generate an offset water distribution in the modern era. However, it is necessary to investigate how water is distributed in the North polar PSRs to answer the question of whether the enhanced neutron signals in the North can be explained by modern era deposition of ice. Compared to its southern counterpart, the northern lunar pole has less trapping area due to its higher average topographical height. Unlike in the South, the neutron enhancement is not associated with a large low-latitude PSR as the signal in the south is associated with Cabeus crater. The differences in trapping area may yield interesting results.

References: [1] Watson, K., B. C. Murray, and H. Brown, 1961a, J. Geophys. Res., 66(5), 1598–1600. [2] Watson, K., B. C. Murray, and H. Brown, 1961b, J. Geophys. Res., 66(9), 3033–3045. [3] Paige, D. A., et al., 2010, Science, 330, 479–482. [4] Feldman, W. C., et al., 1998, Science, 281(5382), 1496–1500. [5] Mitrofanov, I., et al., 2010, Science, 330(6003), 483–486. [6] Mitrofanov, I., et al., 2012, J.

Geophys. Res., 117, E00H27. [7] Gladstone, G. R., et al., 2012, J. Geophys. Res., 117 E00H04. [8] Hayne, P. O., et al., 2015, Icarus, 255, 58 - 69. [9] Colaprete, A., et al., 2010, Science, 330, 463–468. [10] Siegler, M. A., et al., 2016, Nature, 531, 480 -484. [11] Moores, J. E., 2016, J. Geophys. Res. Planets, 121, 46–60. [12] Schorghofer, N., et al., 2016, Geophys. Res. Lett., 43, 6783–6789.

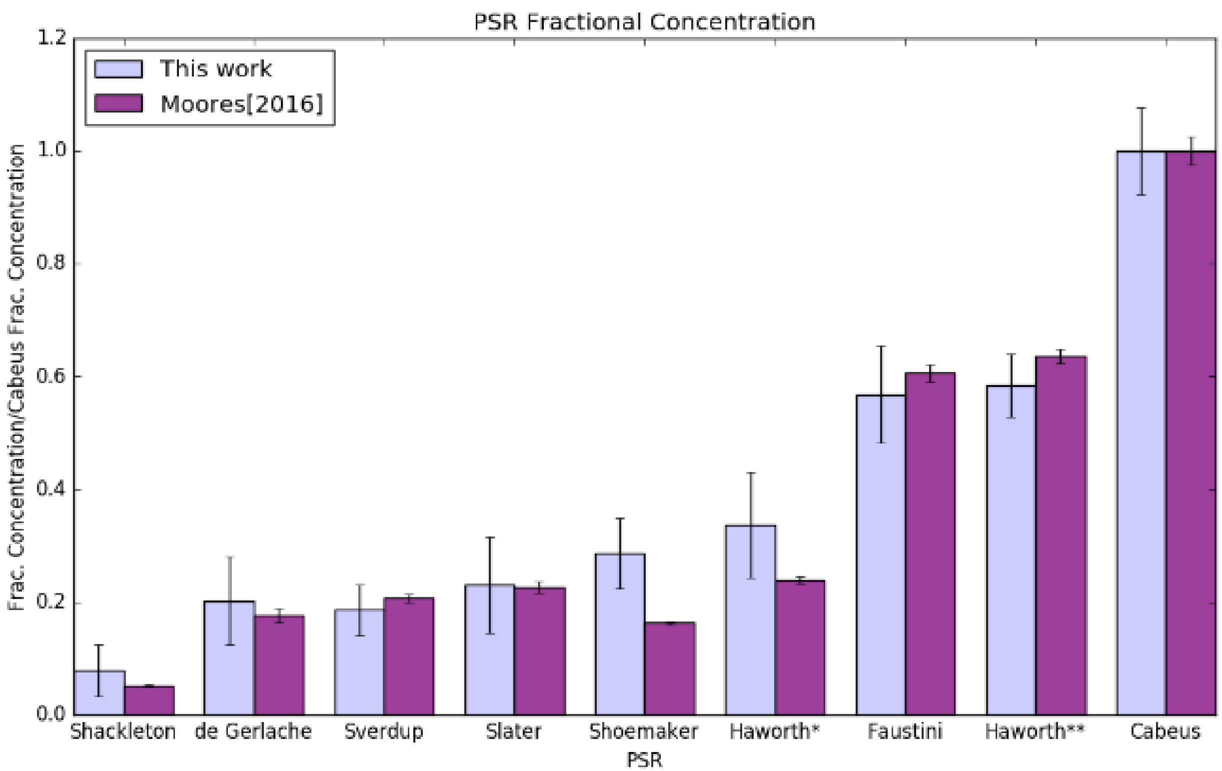

Figure 1. *Model-predicted thickness of water ice deposits relative to Cabeus crater. Traps are organized by distance from the South pole: Shackleton residing at 0.4° from pole and Cabeus being 5.5° away. Each PSR's fractional concentration is found by taking the number of particles trapped and dividing by the area of the respective trap. The concentrations are then scaled about Cabeus by being divided by its concentration. Cabeus shows the highest fractional concentration at 1, as craters farther poleward have smaller fractional concentrations. This work is compared to the results from [11]. * Crater, ** Lowlands*