UNDERSTANDING STRATIGRAPY IN LUNAR POLAR COLD TRAPS. D. H. Crider[1] and R. R. Vondrak[2], [1]Catholic University of America, 106 Driftwood Dr., Gibsonville, NC 27249, crider@cua.edu, [2]NASA Goddard Space Flight Center, Code 690, Greenbelt, MD 20771, Richard.Vondrak@nasa.gov.

Introduction: In regions near the lunar poles, where topography combined with the low obliquity of the Moon produce locations on the lunar surface that never receive solar illumination, water ice may exist [1]. These Permanently Shadowed Regions (PSRs) never exceed temperatures of ~90K [2] and are, thus, stable against sublimation of ice over billions of years. There has been no *conclusive* evidence of the presence of water ice in PSRs. Similarly, no data have outright precluded the existence of water ice well mixed with the surrounding regolith. The combined neutron and radar measurements suggest that water ice might be present in concentrations of <10% [3,4].

Water ice might be stable against sublimation in PSRs; however, there are other competing source and loss mechanisms at work. Possible sources of water ice include comet impacts and migrating water vapor released from the soil by micrometeoroid impacts (which ultimately came from implanted solar wind hydrogen) [1,5]. Any water ice exposed to the extreme surface has the potential to be lost from interstellar Lyman-alpha radiation, EUV scattered from the Earth's corona, ion sputtering, and diffusion [5,6]. Water ice below the surface can be affected by the prevalent regolith process of "impact gardening." Impact gardening is the process that has produced the lunar regolith through the constant pummeling of the Moon by impactors of all scale-sizes. Impacts have the following effects: breaking up rocks, fusing glasses, exposing buried material, and emplacing ejecta layers over the surface. Impact gardening and any other result occurring from the exposure of the surface of the Moon to space are grouped as processes under the term "space weathering."

In the top layers of regolith, impact gardening rearranges and disrupts strata. So if ice were deposited by a comet in a PSR, the durability of the layer of ice is determined by impact gardening which rearranges material with depth and loss processes which affect exposed material. Therefore, it is important to understand the expected depth and lateral coherence of putative ice deposits in the lunar cold traps to interpret existing and future observations in terms of bounding the origin of any materials that might be present. Additionally, understanding the effects of space weathering on the distribution of water ice in PSRs is advantageous to facilitate planning of future observations of lunar cold traps and to evaluate cold trap contents as resources for human exploration. This work offers that context.

Model: We simulate the evolution of the depth distribution of water ice in the lunar cold traps over time due to space weathering effects using a Monte Carlo model [7]. Our 1-D Monte Carlo model starts with an initial depth distribution of water in the top 5 m of lunar regolith using bins with a single column of bins with thickness of 1 mm and a very small area. Using the impact production function, the model generates a unique impact history for every random seed used in the runs. Due to the numerous quantity but small effect of small meteoroids, the model only considers discrete impactors down to a lower mass limit, similar as was done in [8].

The time until the next discrete impact is generated by a random number generator and the crater production function [9]. For the time in between discrete impacts, all effects from exposure and small meteoroids are handled in a cumulative, continuous manner. The model simulates the churning of the regolith by a depth and time dependent churning algorithm that rearranges cells with depth and assigns exposure time to the cells. The change in the water content of exposed cells is a function of the exposure time. Rearranging of cells at depth without exposure does not alter the water content of a cell.

Discrete impacts are handled by using random numbers to determine the impactor size and the location of the column within the entire crater structure. Then, using an assumed crater shape, an amount of material is added to the top of the column (for columns in the ejecta blanket) or taken off of the top (for columns in the excavated part of the crater.) The model only tracks 5 m in depth at a time, so material is added or removed from bottom of the column in the simulation to make up for what is removed or added to the top of the column from the impact, respectively. The water concentration in the material added to the bottom is low. The water concentration in ejecta layers depends on the time and size of the impactor. In some simulations that we do, a fraction of the ejecta blankets can be water-rich to simulate nearby cometary impacts.

A new aspect of our model is that we have extended our 1-D model to include multiple columns at various lateral spacings. The impact history is generated for each individual column; however, each impact is checked to see if it affects the other columns. When an impact affects multiple columns, the countdown timers are adjusted. We use the simultaneous calculation of columns to correlate strata properties over various lateral distances.

Stratigraphic Predictions: We perform a parametric analysis of durability of ice deposits using our model and various initial conditions and assumptions. We examine the following quantities: erosion rate, retention efficiency, peak concentration, correlation time, and correlation length. All of these quantities vary depending on the source, size, and timing of the water ice in the cold traps. We have fleshed out our previous studies [7,10,11] and incorporated the lateral aspect. Further, we apply this work in planning for upcoming lunar missions that seek to determine in situ the form, distribution, and total contents of water ice available as a resource to human exploration of the Moon.

Remote Sensing Interpretations: We average results over many columns to compare our simulations with remote sensing data, which have some footpoint on the Moon. We find the limits of initial ice layers that are consistent with the neutron data and the radar data.

References: [1] Watson K. et al. (1961) *JGR* 66, 3033. [2] Vasavada A. et al. (1999) *Icarus., 141,* 197. [3] Lawrence D. et al. (2006) *JGR 111*, E08001. [4] Campbell D. et al. (2006) *Nature 443*, 835. [5] Arnold J. (1979) *JGR 84*, 5659. [6] Morgan T. and Shemansky D. (1991) *JGR 96*, 1351. [7] Crider D. and Vondrak R. (2003) *JGR 108*, 5079. [8] Arnold J. (1975) *LPSC VI,* 2375 [9] Neukum G and Dietzel H. (1971) *PSL 12*, 59. [10] Crider D. and Vondrak R. (2003) *ASR 31*, 2293. [11] Crider D. et al. (2006) *Adv. in Geosci. 3*, 93.