Focusing on the water ice crystallization from surface thermal flux in Lunar permanently shadowed craters using LRO Diviner. C. J. Ahrens[1], N. Petro[2], M. A. Siegler[3], [1]Arkansas Center for Space and Planetary Science, Fayetteville, AR 72701 (ca006@email.uark.edu), [2]NASA Goddard Space Flight Center, Solar System Exploration Division, Greenbelt, MD, [3]Planetary Science Institute

Introduction: Volatiles are observed at several lunar polar craters, particularly the permanently shadowed regions (PSRs) using measurements from Lunar Reconnaissance Orbiter's Lunar Orbiter Laser Altimeter (LRO-LOLA), Diviner Lunar Radiometer Experiment (Diviner), and Moon Mineralogy Mapper (M^3).

Hayne et al. [1] found that many PSR's near the lunar south pole have maximum surface temperatures < 100 K, consistent with the presence of stable water ice [2].

There is a current lack of understanding regarding the thermal stability and surface thermal flux of these PSRs, and the crystallization of the water ice. In this work, we measure the day and night-time bolometric temperatures from Diviner. From these changes in day-night temperatures, we can calculate the surface thermal flux within a crater to either verify or redefine the PSR volatile ice stability.

These temperatures were then compared to water ice crystallization regimes, which are amorphous (< 140 K; though a density change within the ice matrix can occur at 77 K) and crystalline (> 140 K). These differences in crystallization (and densities) could have a profound effect in the thermal inertia and other regolith properties [3].

We use Rozhdestvenskiy U crater as an example in this abstract.

Methodology: LROC Wide Angle Camera (WAC) and Diviner data were used, all publicly available on the Planetary Data System (PDS) Geosciences Node, together with the Java Mission-planning and Analysis for Remote Sensing (JMARS) software. The day-night bolometric temperatures were plotted across the crater diameter (in 10 traverse sections) over a period of time (years 2009-2016).

Once the Diviner bolometric temperature are recorded across an impact crater, the average difference in day and night-time temperatures (ΔT) within a whole year are used to determine the heat transfer Q (in units of W):

$$Q = \frac{kA(\Delta T)}{d}$$

Where k is the thermal conductivity (used as 0.0093 ($W\ m^{-1}\ K^{-1}$) from [4], A is the area of the crater, and d is a uniform thickness (in this study, we used 0.02 m). Q is then be used to determine the surface thermal flux as:

$$Q_{IR} = \frac{Q}{A}$$

Results: *Rozhdestvenskiy U (84.8°N, 152.4°E):* After plotting the bolometric temperatures from Diviner, the PSR regions in this crater are mostly within the < 77 K region (low-density amorphous), with more stability in Traverses 6-7. After applying the bolometric day-night temperature differences to the above thermal flux equations, the lowest thermal flux values were found in Traverses 6-7 (Fig. 1), verifying the stability of the previously observed PSR locations within this crater [5].

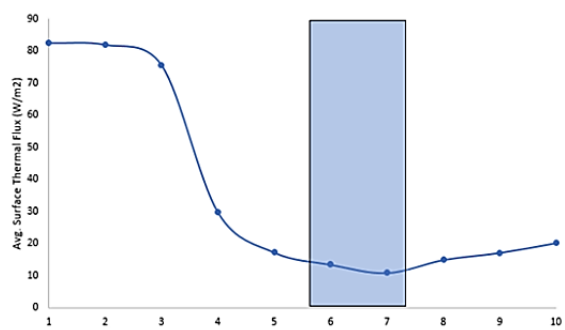

Figure 1: *Example of surface thermal flux model from Rozhdestvenskiy U Traverses. Shaded box indicates the lowest thermal flux (most stable) Traverses.*

Conclusions: The thermal flux measurements further our understanding of thermal stability, volatile crystallization processes, and cold trapping. Knowing the different water ice crystallization regimes gives us insight to the regolith properties and how the thermal stability of the PSRs region would influence the overall structure of the crater (i.e., morphology, ejecta volume, mass wasting, etc.). Thus, the thermal modeling used from this work could help define the amorphous or crystalline state of water ice at PSRs. These PSR water ice locations have the potential to address key lunar exploration questions, especially the perspective on volatile distribution and regolith properties outlined in the Planetary Science Decadal Survey, Visions and Voyages [6].

References: [1] Hayne, P., et al. (2015) *Icarus*, 255, 58-69. [2] Gladstone, G.R., et al. (2010) *Space Sci. Rev.*150(1-4), 161–181. [3] Andersson, O., Inaba, A. (2005) *Phys.Chem.*, 7, 1441-1449. [4] Siegler, M., et al. (2015) *Icarus*, 255, 78-87. [5] Li, S., et al., (2018) *PNAS*, 115 (36), 8907-8912. [6] NRC (2011).