MODELING SURFACE TEXTURE FORMATION OF THE MARTIAN NORTH POLAR RESIDUAL CAP. A. X. Wilcoski and P. O. Hayne, Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder CO 80309 (andrew.wilcoski@lasp.colorado.edu).

Introduction: The North Polar Residual Cap (NPRC) and North Polar Layered Deposits (NPLD) together represent one of the largest water-ice reservoirs on Mars. The NPLD consists of layers of ice of varying thickness and dust content, and has the potential to be used as a record of climate oscillations on Mars over the last 4-5 Myr [1]. The NPRC has been postulated to be the top most layer of the NPLD, as opposed to a disparate deposit [2]. If this is the case, an understanding of the mechanisms that control the formation of the NPRC will be valuable in the interpretation of the record preserved in the NPLD.

The NPRC surface is characterized by mounds and depressions that frequently form linear chains of ridges and troughs (Fig. 1). These mounds typically have heights of ~1 m and widths of ~10 m. The dominant wavelengths of these features have some dependence on elevation and latitude, suggesting that insolation-driven processes may control their formation [3,4]. However, wind-driven erosion/deposition and reorientation due to ice flow have also been suggested as mechanisms [4,5]. It is likely that the surface texture is shaped by some combination of processes, though it is not clear which processes dominate and over what timescales these features form.

We aim to constrain the effects of one of these processes by modeling the evolution of the NPRC surface texture in the regime where ice accumulation/ablation is driven only by insolation. We model the change in roughness of a perennial ice surface over time and note the emergence of dominant wavelengths in surface roughness. In addition, we investigate the timescales over which these features form. This work investigates the plausibility of insolation as the dominant mechanism controlling the NPRC surface texture, and may be useful in determining the age of this surface.

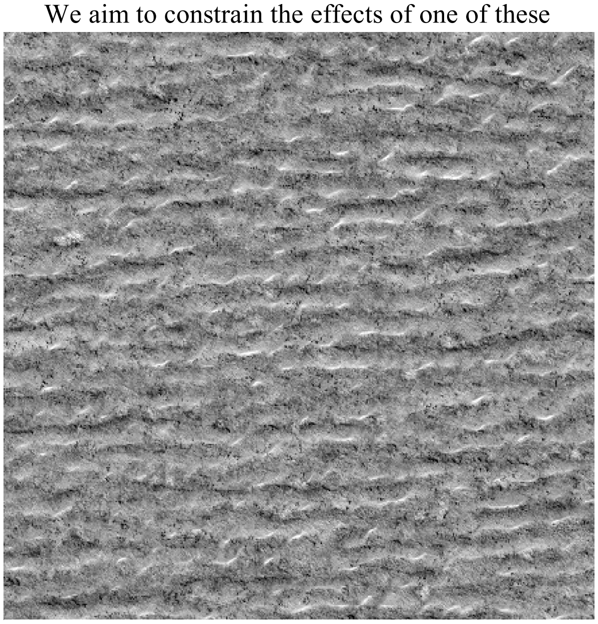

Figure 1. *Example of North Polar Residual Cap surface texture. Image shows a ~0.5 km by 0.5 km area at ~86° N latitude. HiRISE image ESP_036777_2660 (NASA/JPL/University of Arizona).*

Methods: We use a coupled thermal and atmospheric mixing model to explore the evolution of a 2D surface (height and length) of perennial ice caused by insolation-driven accumulation/sublimation. The thermal model calculates surface temperatures by balancing energy flux due to solar radiation modified by atmospheric effects, reradiated and reemitted visible and infrared radiation from nearby surfaces, and 1D vertical heat conduction. The model tracks accumulation/ablation of CO_2 frost, and surface temperatures are held at the frost point when CO_2 frost is present. Surface temperatures are validated using data from the Mars Climate Sounder (MCS) onboard the Mars Reconnaissance Orbiter [6]. The atmospheric mixing model calculates water vapor densities above the surface, similar to [7] using an upper boundary set by vapor mixing ratio estimates from the Mars Climate Database [8]. Surface temperatures and vapor densities are used to calculate accumulation/sublimation rates at each point on the 2D surface, which vary due to local slope, radiation from nearby surfaces, and shadowing effects.

The model is initialized with a relatively flat surface with small-scale roughness and a uniform power distribution across all wavelengths. The 2D surface is oriented North-South, and was chosen over a 3D surface for the sake of computational efficiency. The model is run for a period of 1 Mars-year over which the cumulative ice mass flux at each point on the surface is calculated. This ice mass flux is used to update the position of each point on the surface. In order to improve computation speed, it is assumed that this flux remains constant on timescales of ~10-100 Mars-years, and the model is advanced in 10-100 Mars-year increments. After the surface elevations have been updated, the process is repeated.

Results: The ice mass flux at any point on the model surface depends strongly on the modeled water vapor pressure above the surface. The surface tends towards accumulation when the vapor pressure is

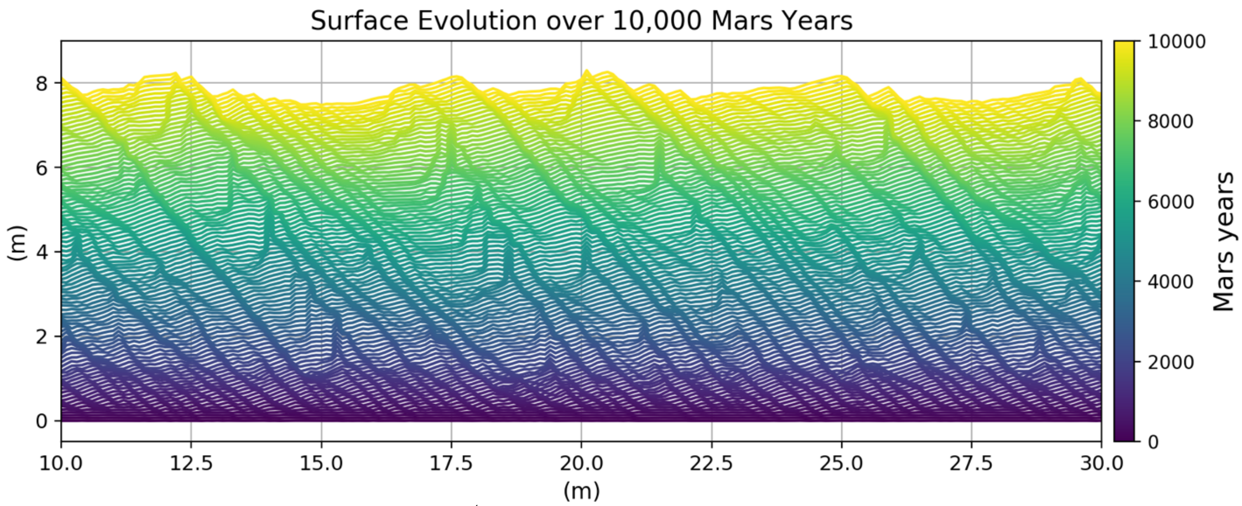

Figure 2. *Evolution of a surface over a 10^4 Mars-year model run in the accumulation regime. A 20 m section of a 60 m long surface at 85° N latitude is shown. The surface is oriented such that south is in the positive x-direction. The color gradient represents the time evolution of the surface, with the dark blue being the original surface and yellow being the final surface.*

high, and ablation when it is low. However, in both the accumulation and ablation regimes the model predicts an increase in surface roughness with time. This is due to the fact that regardless of the regime, the mass flux across all points on the surface is not uniform and still depends on local slopes and energy fluxes. In both regimes, dominant wavelengths emerge from initially uniform power distributions.

Figure 2 shows the evolution of a surface in the accumulation regime over time. While the initial surface is relatively flat, the final surface shows clear increases in roughness at longer wavelengths. There is a general migration of slopes northward, and numerous cases where slopes merge together as time progresses. Figure 3 shows the change in power spectral

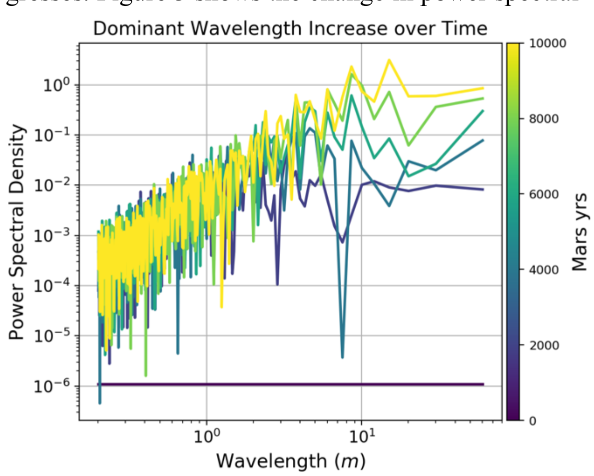

Figure 3. *Power spectral densities of the surface in Fig. 2 over time. PSDs are shown at 2000 Mars-year increments. The initial PSD is uniform by design. As the model progresses, the power peaks at longer wavelengths.*

density (PSD) of the same surface over the model run. The initial PSD of the surface is uniform by design. Power increases at all wavelengths relative to the initial PSD. The final surface has a dominant wavelength on the order of 10 m. The dominant wavelength tends to increase as the model progresses. If this trend continues indefinitely, then it is possible that the current dominant wavelengths on the NPRC are indicative of the ages of those surfaces.

Future Work: We will continue to explore surface evolution on longer timescales to determine whether dominant wavelength increases indefinitely or comes to some equilibrium wavelength with time. This may allow us to estimate the timescales required to form such terrain. We will also investigate the parameters that may control the wavelengths of these features, such as latitude and atmospheric water vapor content. We plan to utilize additional MCS data to constrain the thermal and atmospheric models using atmospheric profiles of temperature and aerosol opacity. Eventually, this model will be extended to 3D in order to more realistically reproduce NPRC surface textures.

References: [1] Levrard B. et al. (2007) JGR, 112, E06012. [2] Tanaka K. L. (2005) Nature, 437(7061), 991-994. [3] Parra S. A. et al. (2018) LPSC 49, #2272. [4] Milkovich S. M. et al. (2012) LPSC 43, #2226. [5] Fisher D. A. et al. (2002) Icarus, 159, 39-52. [6] McCleese D. J. et al. (2007), *JGR*, *112*(E5). [7] Bapst J. et al. (2018) Icarus, 308, 15-26. [8] Navarro T. et al. (2014) JGR, 119(7), 1479-1495.