POSSIBLE SEASONAL INDURATION OF SOUTHERN MID-LATITUDE DUNE FIELDS ON MARS.
Carin Cornwall[1] and Stephen Wood[1], Molly Johnson, [1]Department of Earth and Space Sciences, University of Washington, Seattle, Washington, USA (carinc@uw.edu, sewood@uw.edu).

Introduction: Dune fields are highly sensitive to both circulation patterns and wind strengths and therfore preserve a unique record of the wind regime in which they formed. Due to their abundance and distribution over a wide range of latitudes, dune fields are valuable in studying global circulation patterns and help constrain Global Circulation Models (GCMs) [1]. Dune fields are also sensitive to climate change. Previous wind regimes may be preserved if the dunes are indurated due to a geochemical cement or ice [2, 3, 4, 5]. And the nature of the induration itself can provide insight into past and present climate processes.

There are many dune geometries on Mars that appear to be misaligned under the current wind regime [6]. These dune fields may be indurated and indicate past atmospheric circulation patterns [2, 4, 6, 7]. Many dune fields on Mars may contain layers of interbedded sand, snow, and ice [3]. The seasonal cap extends down to latitudes as low as -50° in the southern hemisphere during the autumn and winter seasons [8]. A number of dune fields are confined to craters in the southern highlands and may incorporate seasonal snow and ice deposits by processes such as diffusion of water vapor into pore spaces [9], burial, or simultaneous transportation and deposition of snow and ice [3].

We propose that some southern mid to high-latitude dune fields (~40°S to 60°S) may be niveo-aeolian deposits, composed of layers of snow, ice and sand. We expect many dunes to be wholly or partially indurated during the autumn, winter and early spring seasons. Thermal inertia values may indicate the presence of snow and ice in the near surface during the autumn, winter and early spring seasons and support the idea of niveo-aeolian deposits.

Data: This study uses a combination of data from the Thermal Emission Imaging System (THEMIS), Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), high-resolution Mars Orbiter Camera (MOC) and Mars Reconnaissance Orbiter Context Camera (CTX) images to investigate the presence of snow and ice within dune fields in the southern mid-latitudes.

Analysis: We use a series of THEMIS early morning images, ranging from 3 AM to 5 AM to derive thermal inertia values for dune fields throughout the Martian year to examine variations in thermal inertia. THEMIS observations are restricted to those having a low dust and ice opacity in order to ensure accurate estimates in thermal inertia throughout the Martian year. CRISM images are used to confirm the presence or absence of ice on the dune field as well as the surrounding area. MOC and CTX images are used to monitor the presence of frost on dune fields in autumn and winter and provide any visible indications of thawing in the spring (dark spots, flow features etc. [e.g. 10]).

We utilize a 1-D thermal model, similar to the Kieffer/Viking Thermal Model, to derive apparent thermal inertia values from THEMIS temperatures that takes into account slope and azimuth of dune surfaces as well as seasonal deposition of CO_2 frost. A second model, the MaxRTCM (Maxwellian Regolith Thermal Conductivity Model) [11], was used to calculate the thermal conductivity of particles as a function of grain size, also taking into account seasonal variations of temperature and atmospheric pressure, non-spherical particle shape, thermal conductivity of basalt, and porosity. These thermal conductivity values were then converted into thermal inertia values to compare with THEMIS-derived values.

Results. We show the preliminary results of thermal inertia values derived for the Kaiser crater dune field. A previous study of Kaiser crater dune morphology suggested that the dune field might be a niveo-aeolian deposit [3]. If this is the case, we expect thermal inertia values to vary seasonally, increasing in the autumn and winter seasons with the addition of new snow and ice, then decreasing in the spring as the seasonal cap recedes. If ice remains in the pore space after the seasonal cap recedes, we expect thermal inertia values to remain elevated and reflect induration. Figure 1 shows the temperature variation of a portion of the Kaiser crater dune field for Ls 41, 211, and 314. Figure 2 shows the seasonal thermal inertia variation of the dune field based on temperature data from seven THEMIS observations, including the three from Figure 1. Figure 2 also shows thermal inertia values derived from MaxRTCM-calculated thermal conductivity for 500 μm diameter basalt particles at temperatures and pressures corresponding to each THEMIS image. Our results show an interesting seasonal variation in thermal inertia values that indicates a strong dependence upon temperature, as suggested by Piqueux and Christensen [12]. More work needs to be done to account for the effects of near-surface ground ice on THEMIS-derived thermal inertia values to determine if these variations may be due in part to the presence of niveo-aeolian deposits.

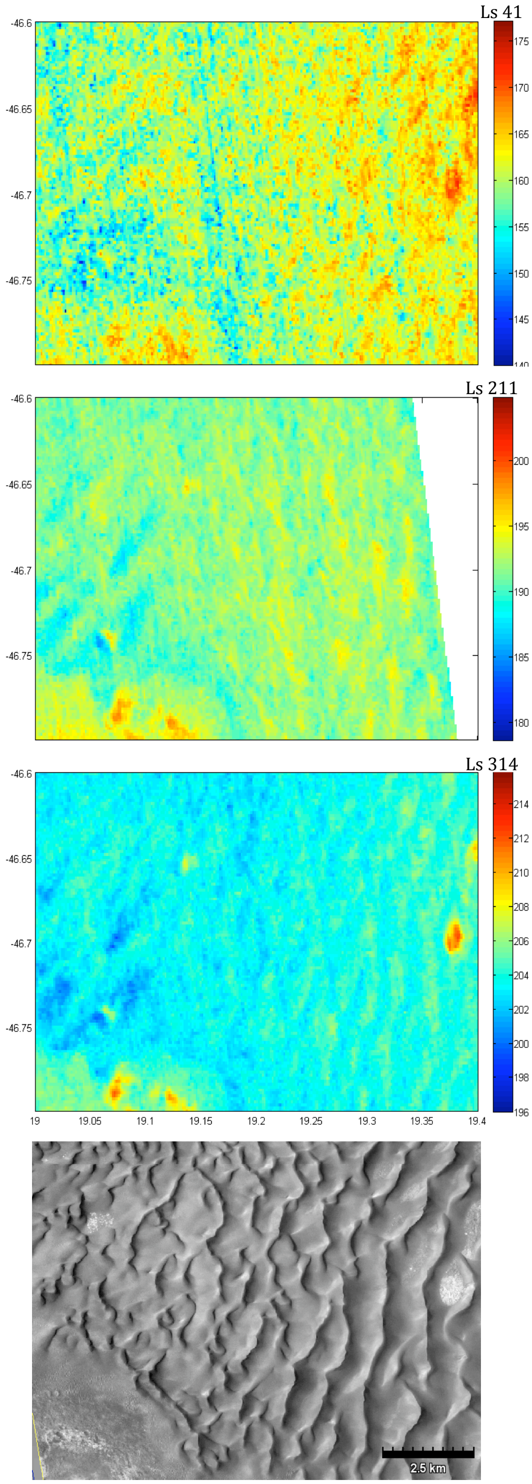

Figure 1. Temperature variations in Kelvin for a portion of the Kaiser crater dune field and a high resolution CTX image (B05_011527_1329_XN_47S340W) of the featured area. Top image corresponds to Ls 41 (late autumn), middle image; Ls 211 (spring), and bottom image; Ls 314 (summer).

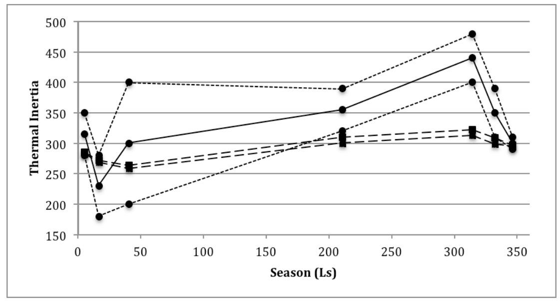

Figure 2. Graph of thermal inertia values derived from temperatures from 7 THEMIS observations. The solid line corresponds to average apparent thermal inertia values, where the dotted lines are the maximum and minimum values. The dashed lines correspond to minimum and maximum values of thermal inertia derived from thermal conductivity values calculated using MaxRTCM [11], assuming a porosity of 40%, sphericity of 0.85 and roundness of 0.60.

Conclusions. Preliminary results show an interesting seasonal variation in thermal inertia values for the Kaiser crater dune field. Results suggest a strong temperature dependence, where some of the variation may be accounted for by changes in CO_2 gas conductivity in the pore space [11, 12]. Further modeling will be made to determine if some component of these variations are due to seasonal induration of the sand or if these variations can be explained by contributions from ground ice heat storage and/or temperature-dependent conductivity of regolith particles and pore gas. If thermal inertia variations persist, these southern mid-latitude dune fields may be seasonally indurated and can potentially be classified as niveo-aeolian deposits, providing a unique record of a past wind regime on Mars, or insight into current climate processes.

References: [1] Hayward R. K. et al. (2009) JGR, 114, E11012. [2] Bourke M. C. (2004) Eos, Transactions, Fall Meeting Suppl., 85, abs #P21B-01. [3] Bourke M. C. (2005) LPSC XXXVI, abs. #2373. [4] Schatz V. et al. (2006) JGR, 111, doi:10.1029/2005JE002514. [5] Gardin E. et al. (2011) Icarus, 212, 590-596. [6] Fenton L. K. and Hayward R. K. (2010) Geomorph, 121, 98-121. [7] Malin M. C. and Edgett K. S. (2001) JGR, 106, 23,429-23,570. [8] James et al. (1979) J. Geophys. Res., 84, 2889-2922. [9] Mellon M. T. and B. M. Jakosky (1995) J. Geophys. Res, 100, 11,781-11799. [10] Gardin E. et al. (2010) JGR, 115, doi:10.1029/2009JE003515. [11] Wood S. (2011) LPSC XXXXII, abs. #2795. [12] Piqueux, S. and P. R. Christensen (2011) J. Geophys. Res., 116, doi:10.1029/2011JE003805.