FIELD OBSERVATIONS OF THERMOCLINOMETRIC EFFECTS IN DUMONT DUNES, CALIFORNIA S. C. Whisner, J. E. Moersch, and C. J. Hardgrove, Dept. of Earth and Planetary Sciences, The University of Tennessee, Knoxville, TN 37996-1410, geowhis@utk.edu

Introduction: Many fluvial and aeolian systems sort their clastic sediment loads by particle size into characteristic facies that have recognizable spatial patterns. These patterns are observable in close-up visible images capable of resolving the component clasts, but may also be distinguished from much greater range using thermal infrared images. Diurnal thermal curves of geologic surfaces are affected by properties of the material making up the feature as well as external environmental variables. The overarching goal of our project is to characterize the spatial-thermophysical signatures of various types of sedimentary landforms, such as alluvial fans, dry deltas, and evaporite deposits on Earth as analogs for Mars. However, we must first understand the effects of non-material properties, such as slope and orientation on diurnal thermal curves. To do this we try to control as many of the variables as possible, e.g., grain size, albedo, composition, water content, and degree of induration. Active dunes are composed of grains that are well sorted into a narrow, unimodal size distribution. Dunes are also relatively uniform in albedo and composition at a scale that is relevant in controlling surface temperature. As such, dunes make ideal control subjects in thermophysical remote sensing for understanding the influence of non-material properties on diurnal temperature curves. The Dumont Dunes (Figs. 1,2) of southern California, classified as star dunes [1], are a suitable research site due to multiple facet orientations visible from a single vantage point, and hills immediately adjacent from which ground-based remote observations can be made.

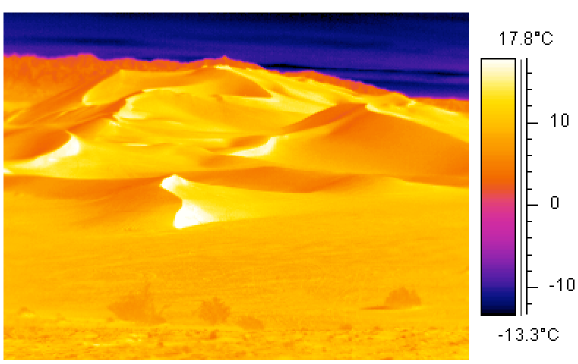

Fig. 1: Thermal infrared image of Dumont Dunes looking east.


Fig. 2: Visible image of Dumont Dunes looking east.

Background: Visible wavelength comparisons between terrestrial and Martian sedimentary landforms are numerous in the literature [2][3][4]. However, little previous work exists in the characterization of sedimentary features on Earth using thermal images. This type of study may add an extra dimension to the identification and understanding of how these landforms form due to the relationship between thermophysical properties and grain size. Thermal infrared images from the Mars Odyssey Thermal Emission Imaging System (THEMIS)[5] and ASTER imagery of Earth allow comparison of features at similar spatial resolutions (100 m). At the spatial resolution of these instruments, differences in diurnal thermal signatures of surfaces of individual landforms become apparent. However, thermoclinometric effects complicate the diurnal thermal behavior of these landforms. In order to use diurnal thermal remote sensing to study the material properties of sedimentary landforms, thermoclinometric effects must be accounted for.

Methods: Several dunes fields in Southern California and Nevada were evaluated as potential test sites in mid-late December 2006. Sites were eliminated from consideration for lack of vantage points, high moisture content, excess vegetation, and/or excessive human disturbance of sedimentary features. Dumont Dunes, 30 miles north of Baker, California, best met our criteria. Diurnal temperature cycles were collected at Dumont Dunes using a FLIR Systems S45 thermal infrared camera. Orientation measurements on the dunes were collected at various locations visible from the thermal camera's vantage point. Visible digital photography was used to record slope shading due to sun angle and shadowing by the dunes. We then compared diurnal temperature curves from many different parts of the dune to understand the change in temperature response with slope orientation. Diurnal temperature curves from faces of known orientation were selected, and the change diurnal thermal behavior was plotted in comparison to the dune face orientation.

Thermal imagery from this study has also been compared to ASTER apparent thermal inertia (ATI)[6] measurements to see how the slope and orientation effects change the reported ATI. Principal component analysis was also performed to determine if specific minimum noise fraction bands show a clear correlation to different thermophysical properties of the dunes.

Results: Given that most other factors are uniform across the dune (grain size, albedo, composition), the temperature curves are shifted and their amplitudes magnified exclusively by orientation to the sun. This allows us to directly correlate slope orientation to the difference between maximum and minimum temperatures at any point on the dune (Fig. 3). Shifts in maximum temperature achieved by each face as well as differences in time of onset of heating were observed on different orientations. For example, north-facing slopes, which receive the least sunlight, reach a lower maximum temperature and also start climbing toward that temperature later than faces which are purely south-facing (Fig. 4). This is all intuitive; however, quantifying the effect of slope and orientation will allow us develop accurate reporting of ATI, which is currently modeled for rather flat surfaces. Temperature depressions on the night portion of the curves are probably due to wind or high level clouds restricting radiative cooling. During the second heating cycle, passing clouds seem to depress the temperature of the dune only briefly and then it returns to the same curve as seen in day 1.

Preliminary principal component analysis show correspondence to specific bands by range to target, slope, azimuth orientation, elevation and other properties of the dunes. The direct correlation between Minimum noise fraction (MNF) bands and their related properties is currently being explored and we will have more of this data available in Houston.

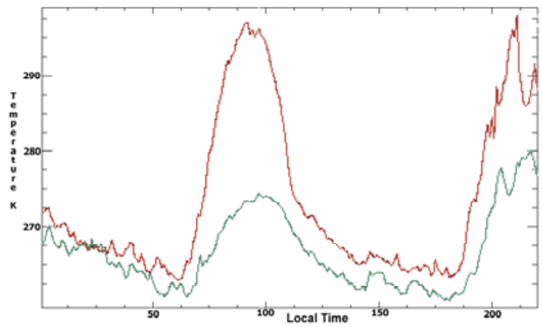

Fig. 3: Representative diurnal thermal curves from a south-facing slope (red) and a north-facing slope (green). The timing difference of the onset of heating each day between the two curves is 50 minutes. Temperature scale is 260-300 °K.

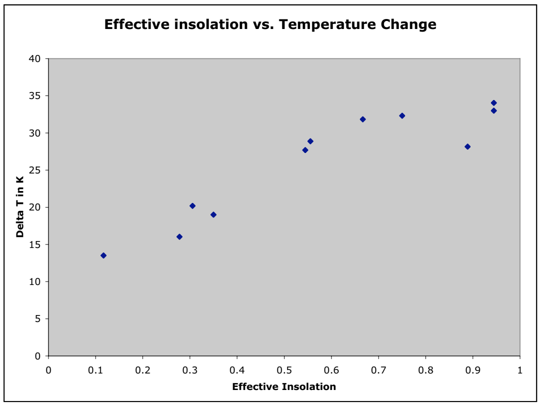

Fig. 4: Effective Insolation vs. Diurnal temperature variation. Zero is due north-facing slope, one is due south.

References: [1] Nielson and Kocure (1987) *GSA Bull., 99,* 177-186. [2] Carr (1995) *Water on Mars.* [3] Malin M.C. and Edgett K.S. (2003) *Science, 302,* 1931-1934. [4] Moore J.M. and Howard A.D. (2005) *JGR, 110.* [5] Christensen, P. et al. (2004) *Space Sci Rev., 110,* 85-130. [6] Gupta, R. P. (2003) *Rem. Sens.Geol.*.