Boundary conditions and the aeolian sediment state of the Olympia Undae Dune Field, Mars. W. Middlebrook[1], R.C. Ewing[1], F. Ayoub[2], N. T. Bridges[3], I. Smith[4], A. Spiga[5]. [1]Texas A&M University, 3115 TAMU, College Station, TX 77843 (rce@tamu.edu), [2] California Institute of Technology, Pasadena, CA 91125; [3]Johns Hopkins Applied Physics Laboratory, Laurel, MD 20723), [4]Southwest Research Institute, Boulder, CO, [5]Laboratoire de Meteorologie Dynamique, Paris, France.

Introduction: The dominant geomorphic process on Mars today is the transport of particles by wind, which exerts a primary control on planetary resurfacing rates. Detemining sediment fluxes is a primary means to constrain these rates. In the equatorial region of Mars, sediment fluxes comparable to those on Earth have been measured over barchan dunes [1]. However, as on Earth, sediment fluxes should vary with environmental boundary conditions, such as sediment supply, sediment availability and wind transport capacity [2, 3]. In the north polar region of Mars within the Olympia Undae Dune Field, for example, seasonally varying CO_2 frost covers the dune fields for part of the year. Are fluxes in the north polar region of Mars similar to those in the equatorial regions? What boundary conditions affect sand transport in the polar region of Mars? How do these boundary conditions vary spatially and temporally?

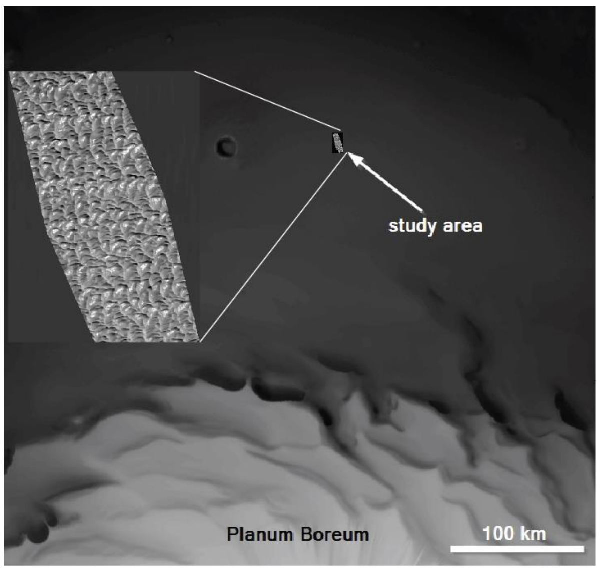

Figure 1. Study area in Olympia Undae

Here we evaluate the boundary conditions in Olympia Undae that affect sand flux. We document variations in seasonal CO_2 cover on dune field patterns, map two and three dimensional dune parameters from two locations proximal and distal to Planum Boreum and constrain sediment fluxes. We compare our results with a mesoscale atmospheric model in order show how topographic driven winds and seasonal variability in wind patterns influence dunes mobility. We develop a sediment state model for Olympia Undae for annual changes in sediment supply, sediment availability and wind transport capacity.

Methods: Repeated High Resolution Imaging Science Experiment (HiRISE) images and digital terrain models (DTMs) were used from two locations to study seasonal changes in the dune field patterns. Two and three dimensional dune parameters such as crest length, crest spacing, dune height and meter-scale slope were measured using the DTMs. Repeated imagery was processed using Co-registration of Optically Sensed Images and Correlation (COSI-Corr)[4], which uses sub-pixel image correlation to measure horizontal surface displacements. Ripple displacement is tracked by this method and provides a measure of sediment flux [1] (Fig. 2). Where dune migration could be measured, flux measurements were constrained by mapping crest line migration. Mesoscale atmospheric model simulations were run at resolutions of 18 km per grid point for three days every 5° or 10° of L_s with increased fre-

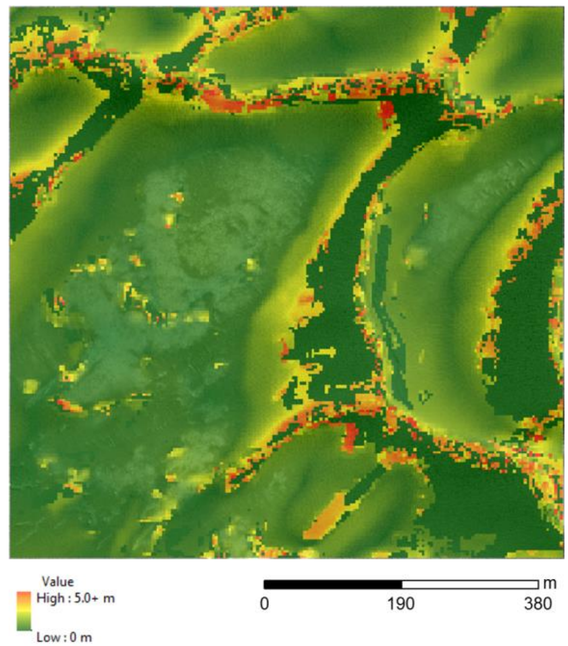

Figure 2. Ripple displacement magnitude map of study area 1 from My 30, Ls 135 to My 31, Ls 130 (677 Earth days). 95th percentile of ripple displacement on primary and secondary dunes is 1.23 m ± .25 mean interdunal displacement error per Earth year. The average ripple displacement is 0.6 meters per year. Colors indicate meters per Mars year.

quency near the summer solstice (See also Smith *et al.*, from this conference) [7,8].

Results: Multi-temporal HiRise images show no dune and ripple activity during the frost covered time of year. Transport during this period is limited to wind blown frost movement, slumping and cryoventing [5]. Dunes in both localities were fully defrosted by L_s 90. Dune and ripple movement occurred during the time period in which the dunes were defrosted.

Variations in dune morphology between localities are controlled by local dune field boundary conditions. Adjacent to the cavi escarpment, dune morphology is dominated by a line source area of sediment. Dunes emerge from a line-source area [6], develop into proto-dunes, increase in height and spacing downwind and decrease in defect density downwind. Dune migration rates near the escarpment range up to two meters per Mars year and are greatest at the most upwind margin where dunes are a few meters in height. Maximum downwind dune heights are 20 meters. Crest line orientations adjacent to the escarpment are transverse to the local orientation of the escarpment and nearly perpendicular to modeled winds (Fig. 3).

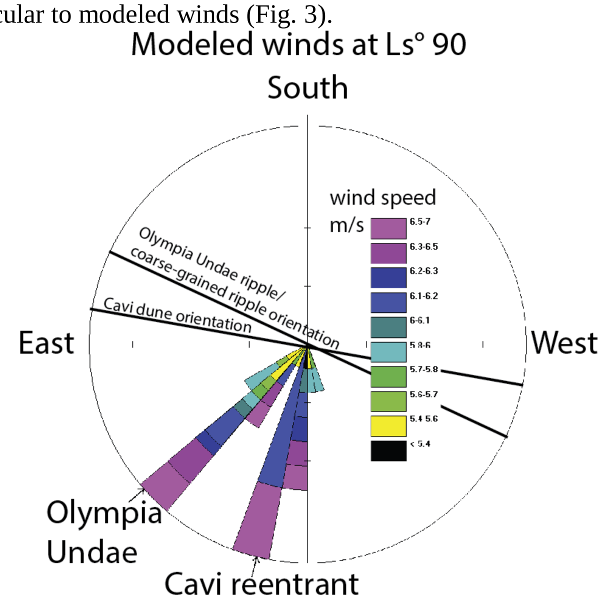

Figure 3. Rose diagram showing wind speed and direction for study locations near the cavi escarpment and in the core of Olympia Undae Dune Field.

In the core of the Olympia Undae Dune Field dunes are controlled by a multi-modal wind regime and a transition to availability limited conditions. Two trends of crestlines intersect non-orthogonally. Primary crestlines dominate the pattern and trend NNE-SSW. Secondary dunes lacking slipfaces trend WSW-ENE. Modeled winds are oblique to both crest lines. Dune heights range up to 40 meters from the interdune surface. Dune migration rates are not measureable at this location over the temporal scale of the imagery, but ripple migration on the dunes ranges up to 2.5 meters per Earth year and average around 0.6 m per year (Fig. 1). Ripple orientation is nearly orthogonal to the modeled winds, but dune orientations are oblique to the dominant modeled wind mode.

Discussion: In the polar region, seasonal differences in CO_2 ice cover act to limit sediment supply, sediment availability and wind transport capacity. Supply is limited because CO_2 covers surfaces subject to deflation by aeolian processes. Sediment availability is limited because the CO_2 ice covers and freezes the majority of ripples and dunes in place, preventing the transport of the sand grains by wind. Model results indicate that wind transport capacity varies seasonally with peak winds occurring during the retreat and onset of the CO_2 cap [7], in late spring leading up to L_s 90.

Non-orthogonal, intersecting crest lines within Olympia Undae are thought to be the result of the superposition of different generations of crestlines [8] generated by an influx of sediment from the cavi reentrant. This is supported by the break-up of the larger crests by smaller crests. An alternative hypothesis, is that the crest lines are forming simultaneiously under the influence of two winds, but affected by spatial changes in sediment availability. This could be support ed by the general trend from transport- to availablility-limited dunes from the east to west side of Olympia Undae denoted by east-to-west increase in the exposure of the interdune areas and a change from orthogonally intersecting crestlines to non-orthogonally intersecting crestlines. In this scenario, the dunes on the western side of the dune field could be transitioning to a fingering-mode of dune orientation [9], in which the crest line orients to the resultant sand flux direction rather than gross-bedform normal transport [10].

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