COMBINING MESOSCALE WIND MODELING WITH DUNE FIELD ANALYSIS TO CONSTRAIN MODERN WIND REGIME, HYPERBOREAE UNDAE, MARS. S. Christian[1] and G. Kocurek[1]; [1]Jackson School of Geosciences, University of Texas, Austin, TX 78512 (schristian@utexas.edu).

Introduction: Using dune fields to interpret wind regimes [1] and regional climatic events [2] on planetary surfaces is not straightforward [1], particularly when the field demonstrates apparently inconsistent dune morphologies [2]. Hyperboreae Undae (HU), one of several dune fields surrounding the north polar plateau of Mars, Planum Boreum [3] (Fig. 1), has well-known examples of coexisting barchanoid and linear-type dunes and yardangs [2, 3] (Fig. 2).

The seemingly incompatible configuration of barchanoid and linear dune forms in HU and elsewhere on Mars has been explained by spatial change from bimodal to unimodal wind regime due to topographic funneling [4] or temporal change coupled with dune induration [2]. While the first hypothesis cannot explain the co-existence of the two morphologies (Fig. 2), the second is not easily tested when reconstructing the dune field history.

An alternative approach to explaining the HU dune field utilizes results from wind modeling of Planum Boreum [5]. Through the gross bedform-normal calculation, dune trends are predicted using modeled wind vectors; predicted trends are then compared to measured trends.

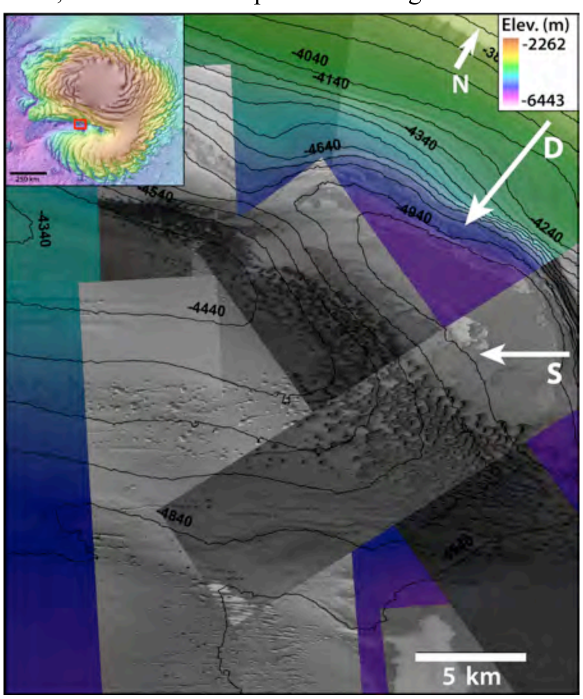

Figure 1. Topography largely controls dune field distribution. Dominant (D) and subordinant (S) wind vectors are from [Spiga]. Dune distribution is shown in HiRISE imagery coregistered with MOLA topography. Inset shows the study site delineated by the red box.

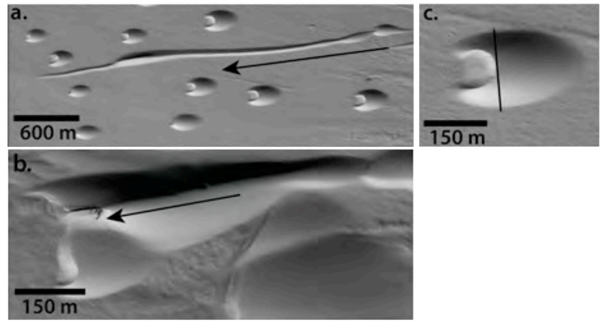

Figure 2. (a) Coexisitng barchanoid and linear dunes and (b) yardang creslines demonstrate local transport direction (black arrows) in Hyperboreae Undae. (c) Bedform trend measured parallel to barchan crest.

Results from this study demonstrate that the orientations of dunes in HU are consistent with the modern, rather than a previous, wind regime of Planum Boreum. Furthermore, agreement between predicted and measured dune trends allows adjustment of wind model results based on the higher resolution data provided by dune field analysis.

Methods: The preliminary study site in HU is at the edge of Boreum Cavus (Fig. 1). High Resolution Imaging Science Experiment (HiRISE) images PSP_010169_2650, PSP_007242_2650, PSP_009914_2750, PSP_010682_2650, and ESP_016261_2650 were co-registered with Mars Orbiter Laser Altimeter (MOLA) data that were contoured at 100 m intervals (Fig. 1). Co-registration and contouring were done in ESRI's ArcGIS.

It is generally accepted that dune crestlines orient to be as perpendicular as possible to all constructive winds [e.g. 6,7]. This principle of gross bedform-normal transport allows prediction of bedform trends when wind directions are known, or, conversely, the prediction of a set of potential wind regimes when crestline orientations are known.

Vectors produced by wind modeling of Planum Boreum [5] (Fig. 1) provide direction and magnitude estimates of the modern winds entering Chasma Boreale at Boreum Cavus. The length ratio, R, of the dominant to subordinate wind and the angle γ between the two winds is related to the bedform trend by

$$\tan \alpha = \pm \frac{R + |\cos \gamma|}{|\sin \gamma|} \qquad (1)$$

[6], where α is the angle between the dominant wind and the bedform trend. Bedform trend was predicted

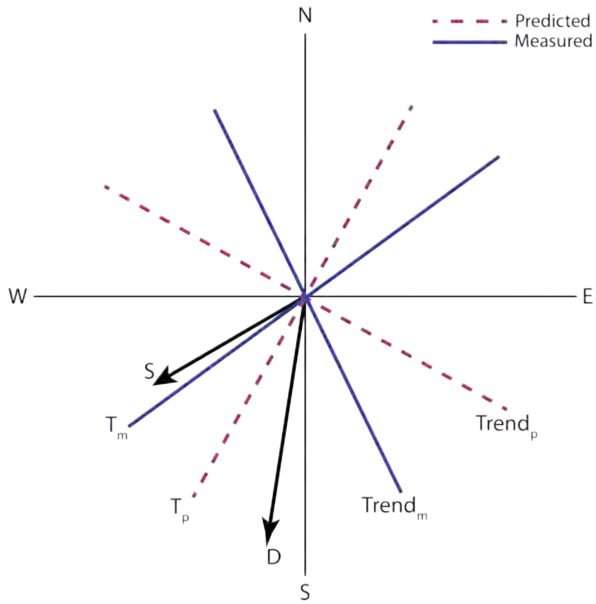

Figure 3. Predicted bedform trend (Trend$_p$) and predicted transport direction (T$_p$) resulting from a gross bedform-normal calculation using dominant (D) and subordinant (S) winds after [5]. The angle between D and S, γ, is 51°. Measured transport direction (T$_m$) and bedform trend (Trend$_m$) for a part of the dune field are also shown.

for the study site region by measuring wind vector lengths and γ values, and calculating α.

Empirical bedform trend was measured parallel to the crestline of 28 barchans in the study site (Fig. 2), and the values were averaged for comparison to predicted trends. Additionally, 10 total linear crestlines and axes of linear yardangs were measured to attain average transport direction (Fig. 2).

Results: The distribution of dunes at the study site closely follows elevation contours and appears to be largely controlled by topographic features. Noticeably, the low and high points in the study site are mostly devoid of dunes (Fig. 1), which indicates low sediment supply, low sediment availability, and/or a wind transport capacity that is below or above that in which dunes develop [8].

Assuming that net transport direction is parallel to the measured linear crestlines and the axes of linear yardangs, transport direction is towards 234° while average bedform trend is 334° (Fig. 3). Although [Spiga 2011] shows a complicated pattern for winds entering Chasma Boreale at Boreum Cavus, vectors from the north and north-east (Fig. 1) appear to be the most influential winds based on southwest-trending yardangs in the same region [3].

The dominant northerly winds (D, towards 189°) are in a ratio, R, of 1.46 to the subordinate north-easterlies (S, towards 240°). This results in a γ value of 51° (Fig. 3). By (1), α is 70°, which yields a predicted average bedform trend of 299° (Fig. 3). The predicted bedform trend varies from the measured trend by 35°. The disparity between measured and predicted trends can be accounted for by the lower resolution of the model input (10 km horizontal resolution vs. 25 cm/pixel), the comparatively small sample size, and the presence of winds entering Boreum Cavus from more than 2 directions.

General agreement between the modeled and measured results strongly suggests that HU formed in the modern wind regime. Following this conclusion, the wind model could be tweaked based on orientations measured for the dune field; for instance, if the north-easterly wind is made dominant to the northerly wind in a ratio of 5:1, a bedform trend of 335° is predicted, which aligns modeled and empirical results.

Conclusions: The principle of gross bedform-normal transport demonstrates that no unusual circumstances are required to form Hyperboreae Undae, and that measurements of dune trend can be used to predict possible formative wind regimes. Comparisons between measured bedform trends and trends predicted by wind modeling provide relative timing constraints on the formation of HU by suggesting consistency with the modern wind regime. Adjustments made to the model based on dune field measurements will improve model results, leading to better predictions of modern wind conditions on Planum Boreum.

Future Work: Calculations presented here are for a small area of HU; to verify the results and use them to inform modeling, the full dune field will be studied. Morphological studies will be conducted to explain the formation of barchan and linear dunes in the same field. Comparison of HU's bedform trends with those calculated from the Planum Boreum cavi unit [3, 9] outcrops can provide insight into the evolution of wind regimes and sedimentary environments throughout the construction of the Chasma Boreale region [10].

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References: [1] Ewing, R.C. et al. (2010) *JGR,* doi:10.1029/2009JE003526. [2] Schatz, V. et al. (2006) *JGR*, doi:10.1029/2005JE002514. [3] Tanaka, K.L. et al. (2008) *Icarus*, *196*, 318-358. [4] Edgett, K.S., and Blumberg, D.G. (1994) *Icarus, 112*, 448-464. [5] Spiga, A., et al. (2011) *Icarus, 212*, 504-519. [6] Rubin, D.M., and Hunter, R.E. (1987) *Science, 237*, 276-278. [7] Rubin, D.M., and Ikeda, H. (1990) *Sedimentology, 37*, 673-684. [8] Eastwood, E., et al. (2011) *Sedimentology, 58*, 1391-1406. [9] Kocurek, G., et al. (2011) *MPSE 5*, Abstract #6020. [10] Holt, J.W. et al. (2010) *Nature, 465*, 446-449.