A HIGHER RESOLUTION UPDATE TO VIKING-BASED MARTIAN NORTH POLAR DUNE SLIPFACE ANALYSES.

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Introduction: Given the current objective of landing humans on Mars within the next half century, a comprehensive understanding of the Martian climate is vital. A key element of understanding weather on any planet is understanding winds, and with them, atmospheric circulation patterns. Because of the limited availability of ground truth data for Mars, images of dunes - specifically their slipfaces - are the best resource available for the study of Martian winds and atmospheric circulation patterns.

Researchers have been cataloging and analyzing Martian dune slipfaces since the first Viking images were released in the late 1970s. By far, the most studied dune fields in this respect have been those that make up the north polar erg.

The existence of the north polar erg was first recognized in 1976 [1], and two models for polar wind patterns were published in 1979 [2, 3]. These initial models were based on Viking Orbiter 2 (VO2) images, which were still fairly low resolution (48-60 m/pixel for summer images, 23-38 m/pixel for limited spring images) [2], though much better than the initial Mariner 9 images. Tsoar et al. [2] used dune slipfaces and barchan shapes to determine wind directions, while Haberle et al. [3] created a purely numerical model that parameterized temperature variations along the edge of the polar ice cap, mass exchange processes between the ice cap and the atmosphere, influence of large-scale topography, and the size of the polar ice cap.

This study seeks to improve upon earlier efforts by using the much higher resolution Thermal Emission Imaging System–Visible (THEMIS-VIS) (19m/pixel) imagery now available for the north polar region.

Methods: We analyzed the north polar region as found in the Mars Global Digital Dune Database (MGD[3]) [4] in ArcGIS. Dune fields between 75°N and 90°N were first examined and divided into areas of unidirectional winds, multidirectional winds, and unknown wind directions (Fig. 1). Dunes were then examined in detail to determine the precise wind directions through the use of slipfaces (arrows were used to indicate wind directions, Fig. 1).

Results: There is a clearly defined double ring of average circulation patterns surrounding the Martian North Pole (Fig.1), with the inner ring rotating clockwise and the outer ring rotating counterclockwise. This pattern seems to be influenced by the shape of the polar ice cap; south of the Chasma Boreale, the divide between the two rings is around 75°N, and within Olympia Undae, the divide is near 80°N. This opposite rotation pattern is noted by Tsoar et al. [2] and by Ward and Doyle [5].

We observed several different wind directions in the north polar region (Table 1).

Table 1: Locations of various wind directions in the north polar region

Wind Directions	Locations
On-pole westerlies	120°E to 240°E, secondary ridges from 120°E to 240°E
Off-pole westerlies	240°E to 300°E, 0°E to 60°E
Off-pole easterlies	120°E to 240°E

Discussion: Haberle et al. [3] proposed strong off-pole easterly winds in the spring, mild easterlies during the summer, strong on-pole westerlies in the fall, and strong westerlies in the winter. As seen in Table 1, there is clear evidence for Haberle et al.'s models for spring and summer. However, their models for fall and winter have only weak support. While slipfaces showing evidence for on-pole westerlies and westerlies in general are observed, we also observe that slipfaces showing easterly winds appear to be dominant when present, and without any evidence for easterly winds associated with the slipfaces showing on-pole westerly winds, it is not possible at this time to gauge the relative strength of these winds.

Tsoar et al. [2] proposed on-pole westerlies for the spring, mild easterlies in the summer, and on-pole westerlies in the winter. No wind directions were given for fall. All of the wind directions proposed by Tsoar et al. [2] are represented in Table 1, though they make no mention of the apparent powerful easterlies evidenced by the extensive transverse ridges in the erg.

However, it is now recognized that the dunes of the north polar erg do not move appreciably between seasons [6], as once proposed by Tsoar et al. [2]. Isolated cases of dune motion have been observed [7], but these have been cases of single dunes disappearing rather than motion of the entire erg. Therefore, while the slipface evidence does indicate winds similar to those proposed by Tsoar et al., we cannot determine at this time which seasons or events those indicated wind directions are associated with.

Conclusions: Overall, there is strong agreement between the results of the early VO2-based studies and this updated, higher-resolution study. Some of the older models are not supported by our slipface evidence. For example, Haberle et al.'s [3] models for fall and winter are only loosely supported at best.

Future Work: A logical progression of this research is to compare wind directions inferred from slipfaces to those derived from a mesoscale model. A particularly interesting area for such a comparison would be between 150°E and 180°E, where slipfaces suggest that winds bend towards the pole.

References: [1] Cutts, J.A. et al. (1976) *Science, 194*, 1329–1337. [2] Tsoar, H. et al. (1979) *JGR., 84*, 8167-8180. [3] Haberle, R.M. et al. (1979) *Icarus, 39*, 151-183. [4] Hayward, R.K. et al. (2010) *LPS IXL*, Abstract #1109. [5] Ward, A.W. and Doyle, K.B. (1983) *Icarus, 55*, 420-431. [6] Schatz, V. et al. (2006) *JGR (Planets), 111*, doi:10.1029/2005JE002514. [7] Bourke, M.C. et al. (2008) *Geomorph., 94*, 247-255.

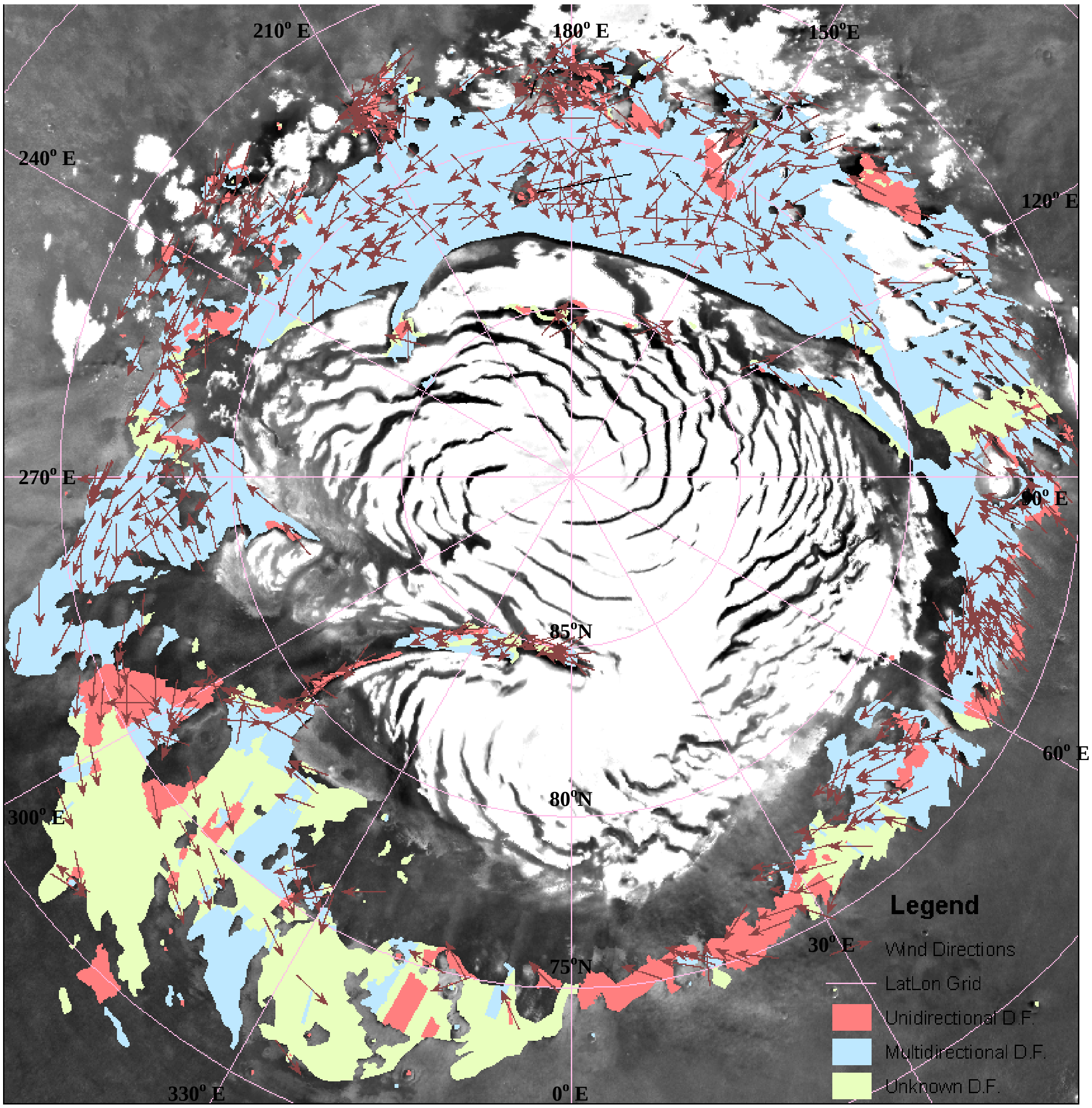

Figure 1: Map of wind directions recorded by dune slipfaces in the north polar region of Mars. Also includes a breakdown of dune fields into unidirectional, multidirectional, and unknown wind directions. Note the concentric circles with winds of opposite rotations. The inner ring rotates clockwise, while the outer ring rotates counterclockwise.