MARS GLOBAL DIGITAL DUNE DATABASE: GLOBAL WIND DIRECTION OBSERVATIONS R. K. Hayward[1], L. K. Fenton[2], and T. N. Titus[1] [1]U.S.G.S. 2255 N. Gemini Dr., Flagstaff, AZ 86001, rhayward@usgs.gov. [2]Carl Sagan Center/Ames Research Center, Moffett Field, CA.

Introduction: The Mars Global Digital Dune Database (MGD[3]) has been completed. It is available in three USGS Open-File Reports: the equatorial (EQ) region [1], the north pole (NP) region [2], and the south pole (SP) region [3]. Together they map ~975,000 km^2 of medium to large-size dark dune fields. Here we summarize global observations of dune field distribution and ground-based wind directions, as derived from dune centroid azimuth (DCA) and slipface (SF) orientations.

Dune Field Distribution: The NP ergs hold the vast majority of dune fields on Mars. Approximately 75% of the mapped dune fields lie between 70° N and 85° N latitude. Another 15% of the dune fields lie in the SP region, between 60° S and 80° S latitude. About 6% lie between 40° S and 60° S latitude, leaving only about 4% for the vast area between 40° S and 70° N latitude. The abundance of dune fields in the NP region may result from the ready availability of source material from north polar layered deposits [e.g. 4, 5]. Outside the NP, ~70% of dune fields are found in craters. It has been suggested that sand lenses, exposed in the walls or bottoms of impact craters, may be the source of sand for dune fields in craters [6]. Therefore the abundance of dune fields in the SP region may be due to both south polar layered deposits (SPLD) and cratering processes [5, 6]. If sand lenses exposed by cratering processes are an important sediment source in non-polar regions, it may explain in part why the resurfaced northern plains are sparsely populated with dune fields and why some of the craters in the southern highlands contain dune fields while adjacent craters are without dunes. It should be noted that the ~975,000 km^2 of mapped dune fields include both thick, continuous dune fields, and areas that are only sparsely covered with dunes. If we remove the barren portions of mapped dune fields from the total, our global estimate of area covered by dunes would be reduced to ~500,000 km^2.

Wind Direction Evidence: *Slipface Orientation.* SF orientation probably indicates the direction of prevailing wind during the latest period of major dune modification, thus preserving a relatively short-term, local record [7]. Slipface measurements were made based on either high-resolution images where slipfaces are clearly visible, or the gross morphology of dunes formed by unidirectional winds (i.e. barchan, barchanoid and transverse dunes). Assignment of a SF direction does not imply that dunes are currently active. We used THEMIS visible-wavelength (VIS, 18 m/pixel resolution), Mars Reconnaissance Orbiter Context Camera (MRO CTX, 6 m/pixel resolution), Mars Orbital Camera Narrow Angle (MOC NA, ~1.5 m/pixel resolution), and MRO High Resolution Imaging Science Experiment (HiRISE, 0.25/0.5 m/pixel resolution) images to measure ~15,000 SFs globally. For ease of plotting and comparison, we averaged the individual (raw) SFs of similar azimuth (< 45º difference) within each dune field, resulting in ~750 average SFs globally.

Dune Centroid Azimuth. DCA, a measure of a dune field's relative location within a crater, may indicate the prevailing wind direction during the period of dune field migration across a crater floor, thus preserving a relatively broad, regional record of wind regime. We used ESRI ArcMap tools to locate the centroid (geographic center) of the crater, the centroid of the dune, and to calculate the azimuth of the line connecting the centroids. Dune fields with nearly central locations, dune fields located in topographically complex craters, and dune fields in craters with multiple widely scattered dune fields were not assigned a DCA because they would likely not yield meaningful azimuths [7]. We have calculated more than 750 DCAs globally.

Discussion: In the following figures and discussion, wind directions are plotted and discussed in terms of the direction of sediment movement, with standard meteorological designation in parentheses. In the past, we have compared ground-based wind direction evidence to GCM output. In the EQ region, DCA and GCM correlate fairly well, suggesting that DCA may preserve the broad-scale winds that are modeled by the GCM. SF and GCM did not correlate as well, suggesting that SF may be influenced by local winds that are not modeled at GCM scale. We do not compare ground-based observations with GCM winds in the polar regions because GCM winds above the saltation threshold are sparse, and because modeled wind directions are less accurate at very high latitudes. We will limit our global discussion to wind direction derived from SF and DCA.

SF-derived Winds. In Figure 1, SF-derived wind directions are plotted by latitude. Globally, the majority of SF-derived wind directions suggest sediment transport to the west (easterly winds). Between 40° S and 80° S latitude, ~52% of measured wind directions are toward the west (easterly). The trend is similar for SF both inside and outside of craters. Between latitude 40° S and 70° N, no single wind direction was consistently preserved by SF. Between 70° and 78° N, transport was toward the east (westerly winds) and

north of 78° N, transport was toward the west (easterly winds). These NP dune-derived patterns were recognized in Viking images and continue to be studied [e.g. 8, 9]. It has been suggested by researchers [e.g. 10, 11] that SF directions are influenced by local topographically controlled winds and winds that are modified by the dune fields themselves. Although SF direction appears to be greatly affected by local topography, a signal from prevailing winds (e.g. polar easterlies) may be present in the SP and NP polar regions.

DCA-derived Winds. In Figure 2, DCA-derived wind direction is plotted by latitude. Globally, the majority of DCA-derived wind directions suggest sediment transport to the north (southerly wind). Between 40° S and 80° S latitude, ~60% of DCA-derived wind directions are toward the north (southerly). Note that ~85% of DCA measurements are between latitude 40° S and 80° S because that is where the majority of intracrater dune fields are located. North of latitude 40° S, no single DCA-derived wind direction predominates, although sediment transport is more commonly toward the south and west, suggesting a somewhat stronger influence of northeasterly winds.

Summary/Conclusions: Globally, dunes on Mars are concentrated in ergs north of 70° N and in craters south of 40° S, probably due to the availability of sediments in layered deposits and through cratering processes. Many factors affect the preservation of wind direction in SF and DCA, and in some regions no dominant wind direction is preserved. However, between 40° S and 80° S both SF and DCA measurements preserve dominant (though different) wind directions.

References: [1] Hayward R.K., et al. (2007) U.S.G.S. Open File Rep., 2007–1158. (http://pubs.usgs.gov/of/2007/1158) [2] Hayward R.K., et al. (2010) U.S.G.S. Open File Rep., 2010–1170. (http://pubs.usgs.gov/of/2010/1170) [3] Hayward R.K. et al. (2012) U.S.G.S. Open File Rep., 2012–1259 (in press). (http://pubs.usgs.gov/of/2012/1259) [4] Byrne S. and Murray, B. (2002) JGR 107 doi 10.1029/2001JE001615. [5] Thomas, P.C. and Weitz, C. (1989) Icarus 81, 185-215. [6] Tirsch, D., et al. (2011) JGR 116, E03002, doi:10.1029/2009JE003562. [7] Hayward R.K., et al. (2007) JGR, 112, E11007, doi 10.1029/2007JE002943. [8] Tsoar et al. (1979) JGR 84, 8167–8180. [9] Ewing et al. (2010) JGR 115 E08005, doi:1029/2009JE003526. [10] Cardinale et al. (2012) ESP&L 37, doi: 10.1002/esp.3289. [11] Silvestro et al. (2012) ESP&L 37, doi: 10.1002/esp.3286.

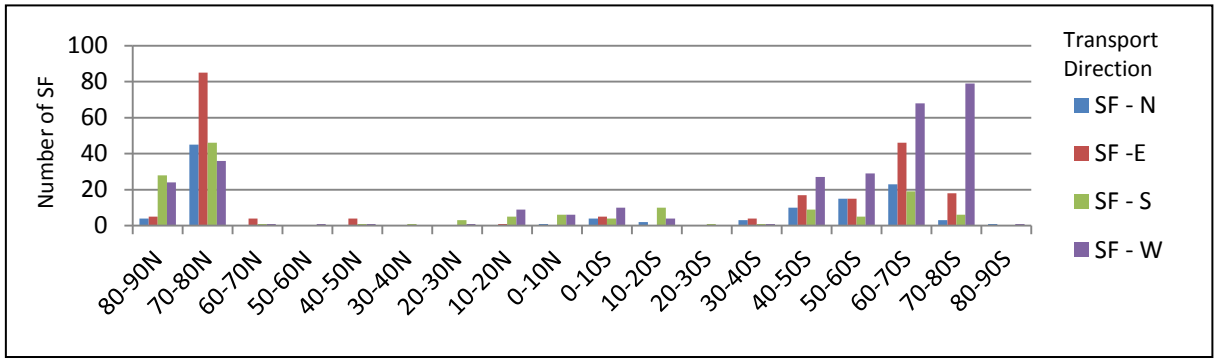

Figure 1. Slipface-derived wind direction in 10-degree latitudinal bins. Direction is given as the direction sediment moves, e.g., N = sediment transported north (southerly wind). Strongest consistent direction is toward west (easterly wind) between 40° S - 80° S.

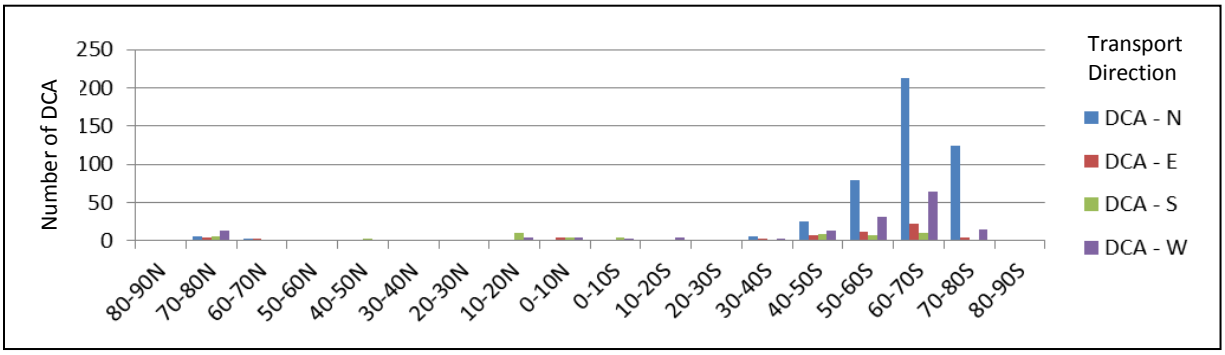

Figure 2. DCA-derived wind direction in 10-degree latitudinal bins. Direction is given as the direction sediment moves, e.g., N = sediment transported north (southerly wind). Strongest consistent direction is toward north (southerly wind) between 40° S - 80° S.