MARS DIGITAL DUNE DATABASE: MORE PRELIMINARY SCIENCE RESULTS. L. K. Fenton[1], R. K. Hayward[2], K. F. Mullins[2], T. N. Titus[2], T. Colaprete[3], [1]Carl Sagan Center, NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035, [2]U.S.G.S. 2255 N. Gemini Dr., Flagstaff, AZ 86001, [3]NASA Ames Research Center.

Introduction: The Mars Digital Dune Database (see Hayward et al., this meeting) provides a unique opportunity to study the global distribution and climatological environment of aeolian sand dunes on Mars. Because sand dunes are composed of grains eroded from bedrock or produced by primary volcanic processes, the study of sand dunes adds to the understanding of the sedimentary history of a region [e.g., 1-3]. Because the sand grains move under the influence of wind stress they also provide a record of strong, prevailing winds, potentially documenting climate-driven changes in wind directions and strengths [4]. For the first time, this catalog of martian dune fields provides the necessary detail for a global-scale comparison with terrestrial dune fields. Furthermore, the high resolution of the data used in compiling the database allows for an update of previous global dune studies on Mars [5] and preliminary comparison with modeled winds [6].

Dune field size distribution on Earth and Mars: The total areal extent of martian dunes in the database (i.e., those between 65º S and 65º N) is ~70,000 km^2. Including preliminary estimates of south polar dunes (i.e., those between 90º S and 65º N), the areal coverage is ~118,000 km^2. Adding in a previous estimate of areal coverage of the north polar ergs of 680,000 km^2 [7], the total coverage of martian dune fields comes to **~798,000 km^2**. The only terrestrial compilation of dune fields consists of ~800 dune fields [8] (with some recent updates [9,10]). The largest dune fields on Earth each cover more than 500,000 km^2, regions that are much greater in size than most dune fields on Mars. Thus, the first major result from this study is that martian dune fields, while apparently ubiquitous in many regions of that planet, pale in comparison to the vast deserts of Earth.

The size distribution of terrestrial dune fields shows that 85% of the terrain covered by sand occurs in dune fields larger than 32,000 km^2 in size, leading to the suggestion that there is a "natural" size into which dune fields grow [8]. Because of this break in distribution, the term "sand sea" has been used to define dune fields with areal extents larger than 30,000 km^2 [9]. The Mars Digital Dune Database shows that the 58 largest dune fields on Mars (between 65º S and 65º N) are each larger than 300 km^2 and account for 60% of the total areal coverage of dune sand. It is possible that once the database has been expanded to include the northern polar ergs, the size distribution will be skewed even farther towards large dune fields, allowing for a martian "sand sea" classification to be created.

Figure 1 shows the distribution of martian dune field sizes as a function of both number and area. This figure was created for direct comparison with a similar plot created for terrestrial dune fields (e.g., see Fig. 6 of [8]), although our abscissa consists of a much smaller size range than that for terrestrial dune fields.

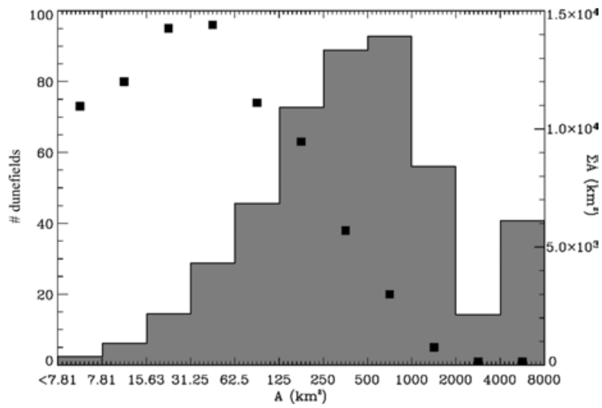

Figure 1. Dune field size distribution by number (▪) and by areal extent (shaded gray).

In Figure 1, the frequency of dune fields peaks at 30 km^2, dropping off for larger and smaller sizes and rounding out at ~2000 km^2. Terrestrial dune fields show peak frequency in the smallest size bin, 62.5 km^2, with a steady drop in number with increasing size that rounds out at ~8000 km^2. Earth has more large dune fields than Mars.

The areal frequency of martian dune fields is bimodal, peaking at 500 km^2 and 4000 km^2. The terrestrial areal distribution has a dramatic jump at 32,000 km^2 and much subtler peaks at 1000 km^2 and 4000 km^2. It is unclear whether these subtle peaks correspond to the similar peaks in the martian areal distribution, but it is clear that there is no peak corresponding to a "sand sea" classification.

Discussion. The difference in dune field size distributions between Earth and Mars may be caused by many factors. Terrestrial dune fields typically form in large, tectonically stable basins in regions with little rainfall and/or high evaporation rates. However, on Mars the dune fields seem to have accumulated in small topographic depressions on a scale of 300 km or less (e.g., craters). Only the large north polar ergs are located in a large low-lying plain like the largest deserts on Earth. It is possible that most of the sand supply on Mars is located in a different type of terrain than is typical of terrestrial deserts, preventing Mars from forming large sand seas.

Slipface orientations, crater centroid azimuths, and comparison with GCM wind predictions. In order to compare global dune field morphology with modeled winds, two sets of measurements were made using the dune database. Dune slipface measurements were compiled using MOC NA (Mars Orbiter Camera – Narrow Angle) and THEMIS VIS (Thermal Emission Imaging System – Visual) images. For each dune field, individual slipface orientations were averaged into a single vector. Some dune fields clearly indicate multiple slipface orientations indicating a multi-directional wind regime, and for these each characteristic set of directions were averaged into a vector, leading to multiple vectors for these dune fields.

A large percentage of dune fields on Mars are located in impact craters. It is likely that the orientation of the dune field itself relative to the center of the crater corresponds to prevailing winds, and so the vector between these dune field centroids and crater centroids (here called "cdaz") was also measured and added to the dune database.

These two sets of measurements may be compared to predicted prevailing winds from an atmospheric model. The Ames Mars Global Circulation Model (GCM) was run at a resolution of 5º of latitude by 6º of longitude for a full martian year [11]. Others have shown that winds stronger than a threshold stress value of 0.0225 N m^{-2} in the Ames Mars GCM produce a dust lifting pattern (in which dust is lifted by bombardment from saltating sand grains that only move when wind stresses are greater than the threshold value) qualitatively similar to that observed on Mars [e.g., 12]. For consistency with previous work, we assume that winds weaker than 0.0225 N m^{-2} are too weak to saltate sand, and that only winds above this value are responsible for influencing dune and dune field morphology.

There are regions on Mars where dune fields exist and yet no winds are predicted to rise above the saltation threshold. These regions are not used in the following analysis. It is likely that the GCM cannot account for all weather and turbulence (i.e., wind gusts) at localized areas, given the broad size of each horizontal grid point (i.e., each bin of 5º of latitude is ~300 km in length). Alternatively, dunes located in calmer regions may be dormant or indurated.

Of the 546 dune fields in the Equatorial Region (65º S – 65º N) of the Mars Digital Dune Database, 449 (82%) are near GCM grid points that rose above the saltation threshold. Of these 449 dune fields, 369 (68% of the total) have slipface and/or cdaz measurements. Positive correlations with GCM winds are defined as slipface or cdaz orientations that fall within 45 degrees of a GCM wind stress vector within the geographic span of that GCM grid point.

Table 2. Correlation of dune field measurements with Ames Mars GCM wind predictions.

	# of dune fields	Percent of total
Dune fields with no GCM grid point	100	18.3% of total 546
Dune fields with no sf or cdaz	84	15.4% of total 546
Dune fields with GCM and sf , cdaz, or both ("sf/cdaz")	**369**	**68% of total 546**
GCM shows **no positive correlation** to sf or cdaz	121	22.2% of total 546 **32.8%** of 369 sf/cdaz
GCM correlates to **sf only**	35	6.4% of total 546 **9.5%** of 369 sf/cdaz
GCM correlates to **cdaz only**	179	32.8% of total 546 **48.5%** of 369 sf/cdaz
GCM correlates to **sf and cdaz** overlap	34	6.2% of total 546 **9.2%** of 369 sf/cdaz
GCM correlates to **sf and sf/cdaz**	69 (=35+34)	12.6% of total 546 **48.6%** of 142 sf & sf/cdaz
GCM correlates to **cdaz and sf/cdaz**	213 (=179+34)	39.0% of total 546 **61.7%** of 345 cdaz & sf/cdaz

Discussion. Table 1 shows percentages of dune field slipface and cdaz orientations that correlate with GCM wind predictions. Of the 369 dune fields with comparable parameters, 142 have slipface orientations and 345 have cdaz orientations (there is considerable overlap). Nearly one third of the slipface and cdaz measurements show no clear correlation with GCM winds. This may indicate that the GCM sometimes does not capture local influences that may change wind directions (e.g., extreme topography). Of the measurements that do correlate with the GCM winds, two measurements stand out: 61.7% of the total cdaz orientations and 48.6% of the total slipface orientations correlate with GCM winds, indicating that half of the dune slipfaces and more than half of the dune field locations are determined by global- or regional-scale dynamics.

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