AEOLIAN DUNE SEDIMENT FLUX HETEROGENEITY IN MERIDIANI PLANUM, MARS. M. Chojnacki[1], A. C. Urso[1], T. I. Michaels[2], and L. K. Fenton[2]. [1]Lunar and Planetary Lab, University of Arizona, Tucson, AZ, 85721(chojan1@pirl.lpl.arizona.edu); [2]Carl Sagan Center at the SETI Institute, Mountain View, CA, 94043.

Introduction and Motivation: It is now known unambiguously that wind-driven bedform activity is occurring at scattered sites across Mars today [for a review see 1]. However, many of these reports are only based on one or a few sets of observations of relatively isolated bedforms, yielding preliminary but incomplete information. Moreover, volumetric sand fluxes, which are independent of dune size, have only been documented for a few sites.

The Meridiani Planum region is host to abundant intracrater low-albedo dark streaks, sand patches, and dune fields [for a review see 2]. All of these landforms are present in the vicinity of the Opportunity rover, now located on the edge of Endeavour crater. Bedforms within Endeavour crater have produced ample evidence for intra-crater aeolian change [3, 4], but may not be representative for the region.

Here, we investigate and quantify dune activity in the area surrounding the Opportunity rover (12°×12°). Related questions include: What are the regional variations of aeolian bedform transport rates, migration directions, and volumetric sediment fluxes? Do sediment flux estimates vary annually and/or seasonally?

Data Sets and Methods: To assess aeolian activity, dunes were examined using repeat fine-scale (25 cm/pix) images from the High Resolution Imaging Science Experiment (HiRISE) [5]. Dune heights (for sediment flux estimates) were extracted from HiRISE Digital Terrain Models (DTMs) (at 1 m post spacing) which were constructed from stereo pairs [6]. The remaining monitoring images for a given site were then orthorectified to the DTM to facilitate change detection and any bedform displacement measurements.

For sites without stereo data a slip face length height technique [7] was used, with the assumed angle of repose of 33° [8] (see [9] for details). In general, this technique results in an underestimation of the maximum dune height as the dune crest is often stossward of the slip face, and thus slightly underestimates the sediment flux. Manual registration of map-projected sub-regions to common immobile tie points was used for change detection at these sites. Volumetric sand fluxes of the dunes (over the intervening time between images; $m^3 m^{-1} yr^{-1}$) can be obtained using the product of the estimated height and the bedform displacement both over the intervening time [10].

Results: Twelve dune field sites were examined with repeat HiRISE observations separated by one-half to four Mars-years. Sites were classified into three categories: confirmed bedform migration (7), bedform change (4), and no detection (1) (**Fig. 1**). Meridiani barchan, barchanoid, and dome dunes were detected migrating at rates of 0.1–6 m/Earth-year (0.2–14 m/Mars-year) (**Fig. 2**; time periods are in Earth-years unless explicitly stated). The observed sediment transport direction was dominantly to the south-to-southeast, consistent with a regional northwesterly wind regime. Dune crest relief ranged from one to 40 meters in height. Locations where clear changes had occurred, but bulk dune migration was ambiguous showed evidence for ripple movement, bedform deflation, or dune border modification (e.g., Xainza crater).

Volumetric sand fluxes are a useful metric for comparison to other planetary dune fields as well as their relation to erosion rates [11]. Meridiani dune values ranged from 1 to 20 $m^3 m^{-1} yr^{-1}$ (**Fig. 2**). The largest crest fluxes correspond with tall, slowly-advancing barchan dunes – alternatively, large fluxes were also observed for small, extremely fast-translating dome dunes (e.g., **Fig. 3**) [4]. Additionally, dune construction times (or turnover times) range from 10–1500 Earth-years (5–800 Mars-years) [9].

Several sites possess images over multiple time

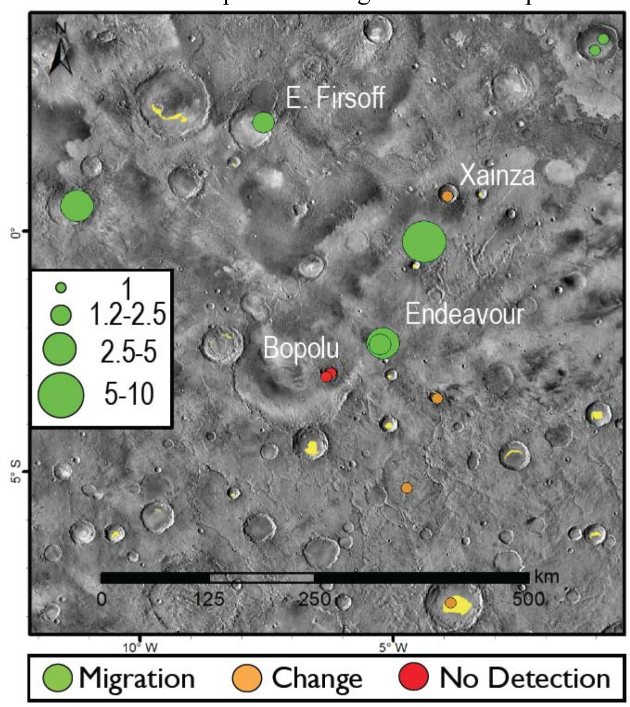

Figure 1. Meridiani dune activity classifications shown on a THEMIS day infrared mosaic. Average dune sand flux estimates of HiRISE-monitored sites are provided (green circles in units of $m^3 m^{-1} yr^{-1}$). Dune fields are mapped in yellow [2].

steps allowing annual or seasonal measurements to be made. A large degree of sediment flux heterogeneity is observed with respect to time, as some sites possessed greater fluxes during Mars Year (MY) 28/29-31 (i.e., t0-t1), while others had greater values in MY31-33 (i.e., t1-t2; **Fig. 2**). One example showed a particularly active time step in MY31 (L_s174°) - MY32 (L_s 49°), with fluxes for these two seasons alone being greater than the entire proceeding Mars year (**Fig. 3**). This active time period at this site included MY31 perihelion.

Discussion and Summary: The majority of dune sites in the study area with sufficient HiRISE data clearly showed aeolian activity (92%), if not bulk bedform migration (58%). The one site with no detection of activity (Bopolu crater) possessed only lower resolution (50 cm/pix) images with a small temporal separation, making analysis difficult – it may yet possess active dunes. Migration rates of most Meridiani dunes are near the averages from global studies (~1 m yr^{-1}) [1, 12], but several outliers exist which showed evidence for rapid sediment transport in short periods of time. Dune crest fluxes also showed substantial variation across the study area and per site – in some cases, values can span an order of magnitude for a given site or time step (**Fig. 2, 3**). Some of these detections are likely due to spatially-heterogeneous short-term diurnal and seasonal winds, including those during perihelion [13]. Mesoscale atmospheric modeling can provide more detailed insight into such wind patterns [14].

Dune sand fluxes described herein and at other locations on Mars (e.g., Nili Patera, Ganges Chasma [11,

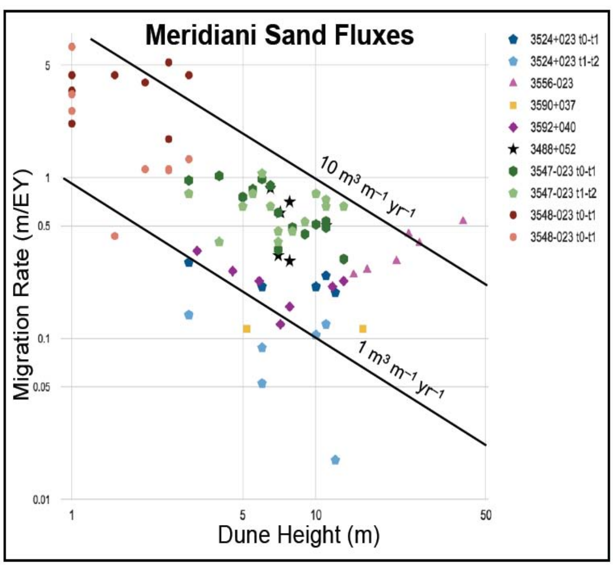

Figure 2. Log-log plot of dune migration rates vs. heights for active dunes in central Meridiani (Fig. 1). Diagonal lines are isopleths of sand flux. Sites with two sets of observations are noted (e.g., t0-t1) and possess a similar color scheme. See [16] for naming convention.

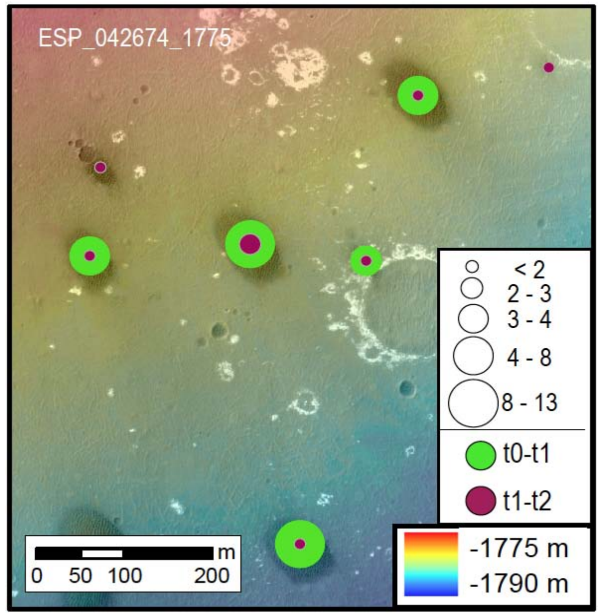

Figure 3. Seasonal and annual sediment fluxes in Endeavour crater. HiRISE with DTM elevation overlaid. t0-t1: MY31, L_s174° – MY32, L_s49°, t1-t2: MY32, L_s49° – MY33, L_s37°. Dunes without t1-t2 measurements deflated rather than migrated. Site 3548-023.

13, 15]) demonstrate the potential for high rates of aeolian sediment transport and the likely prolonged landscape modification on Mars [17]. Dune transport winds in Meridiani are dominantly driven by a regional northwesterly wind regime, consistent with Endeavor crater [3, 4]. Turnover times for Meridiani dunes are much less than modeled obliquity cycles, making it unnecessary to invoke paleo-climate wind regimes to explain their presence. Finally, Endeavour crater dune activity is rather typical for Meridiani dunes (i.e., not unique).

Acknowledgments: This research was supported in part by NASA MDAP Grants NNH14ZDA001N and NNX13AK68G and the HiRISE/MRO mission.

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