ANNUAL VARIABILITY OF DUNE FIELD FLUXES ON MARS. M. Chojnacki[1], D. A. Vaz[2], S. Silvestro[3,4], & D. C. A. Silva[2]. [1]Planetary Science Institute, Lakewood, CO (mchojnacki@psi.edu); [2]Centre for Earth and Space Research of the University of Coimbra, Coimbra, Portugal; [3]INAF Osservatorio Astronomico di Capodimonte, Napoli, Italy; [4]SETI Institute, Mountain View, CA.

Introduction and motivation: Driven by insolation and volatile cycles, atmospheric winds frequently transport sediments across the surface of Mars today, as evidenced by the mobility of aeolian bedforms (*1–4*). This widespread, geographically- and temporally-variable bedform activity has been afforded by repeat high resolution orbital images and topography from High Resolution Imaging Science Experiment (HiRISE) camera (0.25–1 m/pix) (*5*). Although there are important implications regarding the degree and frequency of sand mobility (e.g., climate, dust cycles, etc.) little is known about the year-to-year variability.

Prior HiRISE surveys of bedforms have shown variable activity across Mars, but the majority of studies have focused on repeat observations with sufficient duration to detect changes (2-4 Mars years) (*6*). While these approaches demonstrate general trends in regional aeolian changes, these results fail to capture any annual or seasonal variability in the winds. For example, there have been two planet-encircling dust events (PEDE; 2007 and 2018) and numerous smaller storms (*7*) in the ~8 Mars years that MRO/HiRISE has been operating in orbit (2006-present; Mars Year (MY) 28-36).

The goal of this project is to characterize and explain how Martian aeolian bedform systems evolve spatially and temporally under the present-day climate. Driving questions include: *What are the annual variations in bedform migration and sand fluxes and how do those compare with long-baseline measurements? Are their examples of steady state or episodic migration, and if the latter what are the driving factors?*

Background and prior work: The annual variability of wind strength is driven by regional or global factors. Peak insolation (and thus surface heating) in near-equatorial regions generally occurs from L_s ~240° (perihelion at L_s ~251°) to northern winter (L_s ~340°), with areas north of the equator lagging those to the south. The current orbit of Mars has perihelion in the northern autumn that results in regional storms with net dust deposition northward via the cross-equatorial Hadley cell (*8*). In contrast repeatable storm track sequences (e.g., Acidalia, Utopia) travel from north to south (*9*). The finding that "*Locations with textured dust storms have a 23% higher average surface wind stress*" (*10*) may suggest that greater storm frequency equates to increased bedform transport rates.

Only a few studies have attempted to constrain seasonal/annual changes of bedforms. Sand fluxes were estimated for five Meridiani dune fields using two to three annual time steps of HiRISE data, ultimately showing variable results (*11*). Whereas year-to-year measurements at some sites were nearly identical consistent with steady-state migration, dunes in Endeavour crater responded significantly greater to winds during MY31 (fluxes varied 5×)(*11*). In contrast, Roback (*12*) used detailed measurements at Nili and Meroe Patera to show relatively consistent dune migration rates during MY 30-33, whereas ripple fluxes varied with prominent seasonal peaks following perihelion (~Ls 240-360).

Data sets and methods: To assess annual migration patterns, we utilized HiRISE orthoimages and digital terrain models of select aeolian sites. These locations host relatively swift dunes from prior surveys (*4*) and have 7-8 time steps of images that were typically acquired at similar season ($\Delta L_s \approx 20°$), but on different Mars years (**Fig. 1**). Displacement measurements were recorded by manually mapping polylines along the base of each leeface base or crest in *GIS* (*13*, *14*). Volumetric sand fluxes were computed across the full extent of the slip faces by multiplying the estimated heights and displacements over the intervening time (typically 1 Mars years) – see the method of (*15*). As dune heights are not likely to vary significantly over these time periods, slip face heights are measured in one of the time steps and used for a given time series. Annual ripple migration trends were also computed with COSI-Corr where possible and will be presented at the conference.

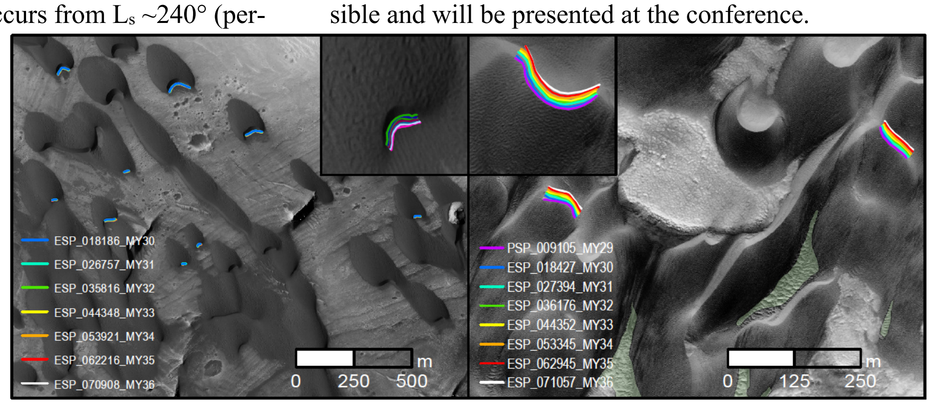

Fig. 1. Dune fields monitored over multiple Mars years with (left) Capen crater and (right) Olympia Cavi reentrant. Sites have 7 and 8 Mars year's worth of images, respectively.

Results: Capen crater (14.0°E, 6.3°N; **Fig. 1**) provides a typical example of a low-latitude dune field with near average migration rates for Mars (0.3 m/EY) based on an earlier study (*4*). Unambiguous advancements of lee fronts are observed in all the annual observations. During the surveyed time steps, median annual rates ranged between 0.14-0.25 m/yr of migration and 1-1.7 m^3/m/yr of fluxes (**Fig. 2**). The median sand fluxes appear to decrease from Mars year 30-35 then increase slightly in the last time step (**Fig. 2c**).

Mapping at the north polar Olympia Cavi reentrant (232.9°E, 84.0°N; **Fig. 1**) was complicated by the large slip face alcoves and slumps which regularly occur there (*16*) requiring crest mapping. Nevertheless, the sand transport is far greater there than most locations on Mars (*17*) as both dunes and megaripples can be easily tracked advancing between 1-4 m/Mars year. The smaller, swifter protodunes found in the upwind areas show remarkable dynamics where slip faces may form, expand, or get buried by advancing ripple patches. Protodunes here may evolve from modest sand mounds to prominent barchans with slip faces several meters tall within 3-5 annual cycles.

Future direction: Early results hint at annual and seasonal variability of sand fluxes, but greater statistics are needed to obtain a coherent picture. Currently 19 global bedform sites possessing 6-8 annual images are being evaluated for this study. Although annual mapping of dune faces are relatively labor intensive they are likely more representative of whole-dune fluxes and more informative for annual trends in wind strength. However, in sites of moderate dune fluxes such as Capen, COSI-Corr displacement maps have good quality and can be informative for the influence of topography and any spatial variability. Full sand flux results of these sites will be presented at the conference.

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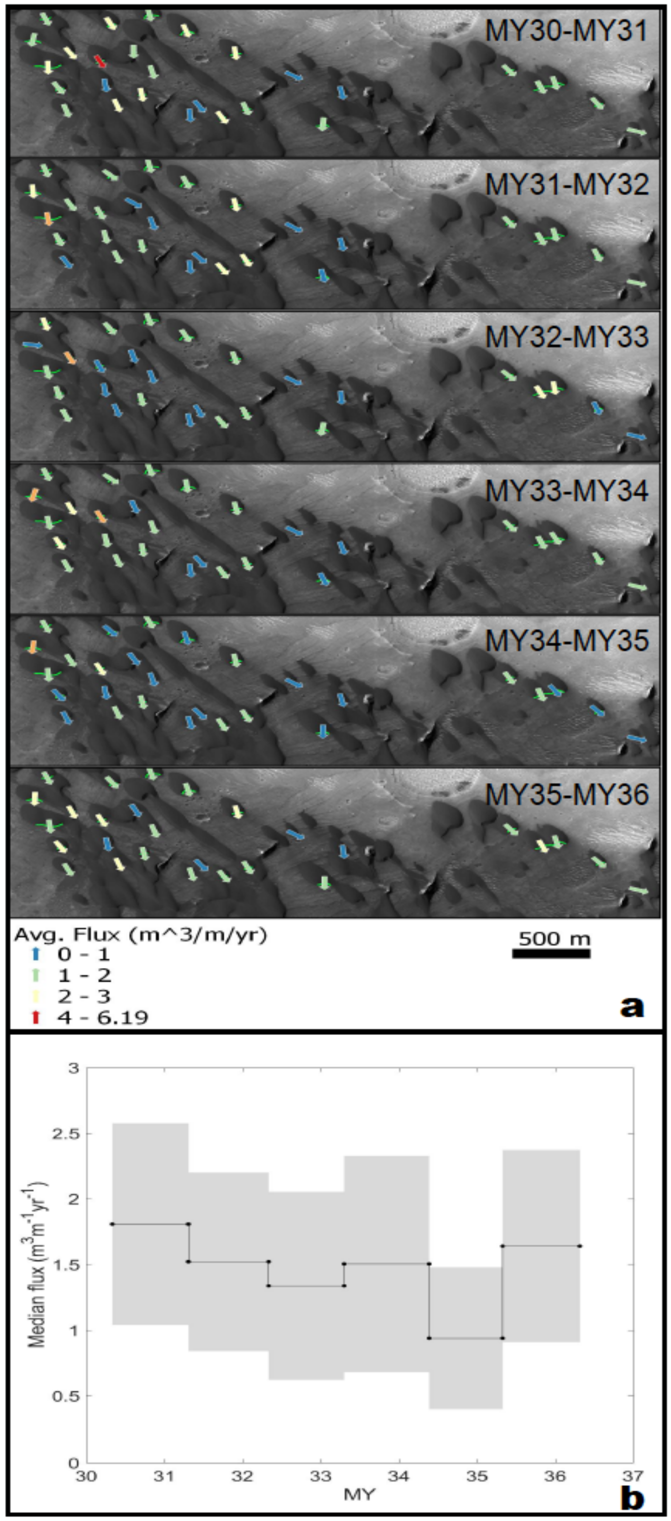

Fig. 2. (right) Temporal trends of Capen crater dunes with (a) sand flux spatial distributions and (b) median sediment flux values plotted with respect to time (gray area represent median absolute deviations).