RATES AND TRENDS OF CIRCUM-POLAR AEOLIAN DUNE EVOLUTION. M. Chojnacki[1], J. Bapst[2], I. B. Smith[3], and K. E. Herkenhoff[4]. [1]Lunar and Planetary Lab, University of Arizona, Tucson, AZ (chojan1@pirl.lpl.arizona.edu), [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA, [3]York University, Toronto, Ontario, Canada, [4]U.S. Geological Survey, Flagstaff, AZ.

Introduction: The north polar region of Mars displays a range of ongoing seasonal and annual surface processes that constantly reshape the local landscape. Recognized in the last decade as a prominent region for active bedform movement (*1–3*), dunes surrounding the polar layered deposits (PLD) and residual cap also display the greatest migration rates and fluxes – ~50% greater than on average for Mars (11.4 vs. 7.8 $m^3 m^{-1} yr^{-1}$)(*4*). These higher values are despite a limited sediment state caused by seasonal autumn/winter CO_2/H_2O ice accumulation that restricts dune migration for most of the year by reducing interaction with wind. Sand becomes ice-cemented while winter-time CO_2 ice buries dunes and then slowly sublimes through the Northern spring/summer until bedforms are "frost free" and mobile by summer (*2*, *5*). Some ice-cemented bedforms do not appear to regain mobility and are deposited into the geologic record.

The purpose of this work is to quantify and characterize major elements of polar landform evolution, such as sand dune formation, bedform dynamics, and deposition of sand into the polar sedimentary record.

Datasets and methods: The main dataset utilized to assess aeolian activity at a global scale consists of images acquired by the High Resolution Imaging Science Experiment (HiRISE) camera (0.25–0.5 m/pix)(*6*). Bedform dynamics were assessed with image orthorectification from stereo-photogrammetry (*4*, *7*).

Sand sources through proto-dune development: The steep (>30°), heavily fractured PLD cliffs commonly avalanche in Spring (L_s 8 - 48°), as observed by HiRISE (*8*). Variably sized (10-70 m) blocks of the PLD and basal unit, liberated by thermally-driven expansion and contraction, cascade onto lower slopes (*9*, *10*). With greater frequency in the spring and summer, smaller mass-wasting events of the basal unit (BU) occur – a major source of dune and ripple-forming sand (*10*).

BU sand sources emanate from the cliffs and travel downwind in several forms (**Fig. 1d**). Sand may develop into ripple patches or larger nascent proto-dunes (e.g., dome dunes, sand streamers) then migrate downwind until sand supply is sufficient to form fully-developed dunes or broad sand sheets (**Fig. 1b**). These proto-dunes can migrate up to 2-4X faster (~2 m/Earth year) than mature dunes in similar locations, due to their smaller sizes and the relatively unencumbered atmospheric flow that drives them. Alternatively, we see evidence that suggests large amounts of sand saltates across bedrock surfaces downwind of BU sources without forming bedforms until entering the erg system (**Fig. 1d**). Proto-dunes which are variable in width (20-100 m) have sediment fluxes on the order of 10 $m^3 m^{-1} yr^{-1}$. These values are generally higher than the estimated erosion rates of some polar scarps (~0.3 m^3 per Mars year per meter along one scarp) (*11*).

Circumpolar sand dune activity and sediment fluxes: The most active dune regions on Mars occur within ergs of Olympia, Abalos, Siton, and Hyperborea Undae (**Fig. 1a**). Sand fluxes are greatest at: 1) the upwind edge adjacent to some of the steepest (>30°) PLD/BU scarp exposures, and 2) in mid-erg locations where >50 m-tall mega-dunes migrate. Numerous 20-30 m-tall dunes translate at relatively high rates (~1 m/yr) tangentially away from the poles and steered zonally by Coriolis-force directed winds (12). Moderate sand fluxes are observed along distal locations of the southern erg margin where multiple wind regimes converge (*4*, *5*, *12*).

A variety of atmospheric and geologic processes interact and modify polar dunes. Mesoscale model simulations indicated that spring and summer katabatic winds are driven by the retreat of the seasonal CO_2 and increasingly large thermal and albedo (15-25%), along with topographic variations between the ergs and polar cap (*12*, *4*). Periods of frost-free sand (late spring – end of summer) also coincide with the timing of peak of water vapor (*13*, *14*) and dust-laden storm frontal events (*15*). The apparent correlation of these processes with periods of highest sand movement is being investigated. Seasonal CO_2 ice appears to contribute to up to 20% of the local sand movement by forming large slipface alcoves that develop as the result of overburden along dune crests (**Fig. 1c**)(*4*, *16*). This apparently unique martian process occurs in the autumn or winter possibly related to CO_2 snowfall (*16*).

Aeolian deposition into the polar stratigraphic record: The deposition and storage of sandy materials take a variety of forms and in numerous polar locations. Sand pathways adjacent to PLD lower flanks show stabilized mature duneforms under meters of water ice deposits (*1*, *5*, *17*). Other central erg sites show dunes with limited mobility and subdued lee faces, indicating a lack of sand transport. These trends are due to restrictive boundary conditions (e.g., lower winds, greater frost), that may lead to further deposition and sand storage. For example, inter-dune areas of Hyperborea and Olympia Undae show aeolian cross-strata under migrating barchans (*5*, *18*). Craters on the southern edges of the polar erg also show evidence for aeolian deposition. Louth crater, for example, has migrating dunes where active sand-ice deposition is occurring (**Fig. 1e**), although water-ice mounds appear to be in equilibrium (*19*). Over ~6 Mars years of observations ice-cemented aeolian strata can be observed at Louth to be deposited at 0.18 m/yr – if stacked vertically these rates over time would result in nearly ~200 m per kyr. These examples forming under the modern climate may be similar to the large deposits of water ice and sand beneath Olympia Planum which formed under past climates (*17*).

Conclusion and future direction: The north polar circumpolar erg shows the highest rates of sand dune formation, migration, deposition, and sediment fluxes on Mars indicating the current polar climate is quite conducive to a very active sedimentary cycle. Future efforts will utilize additional constraints from the Mars Polar Climate Database and seasonal trends obtained from various MRO data (*12*, *20*). This will include determining the predominant sand flux orientation(s) from dunes to be compared with mesoscale modeling and better constrain the dominant wind direction(s) per season.

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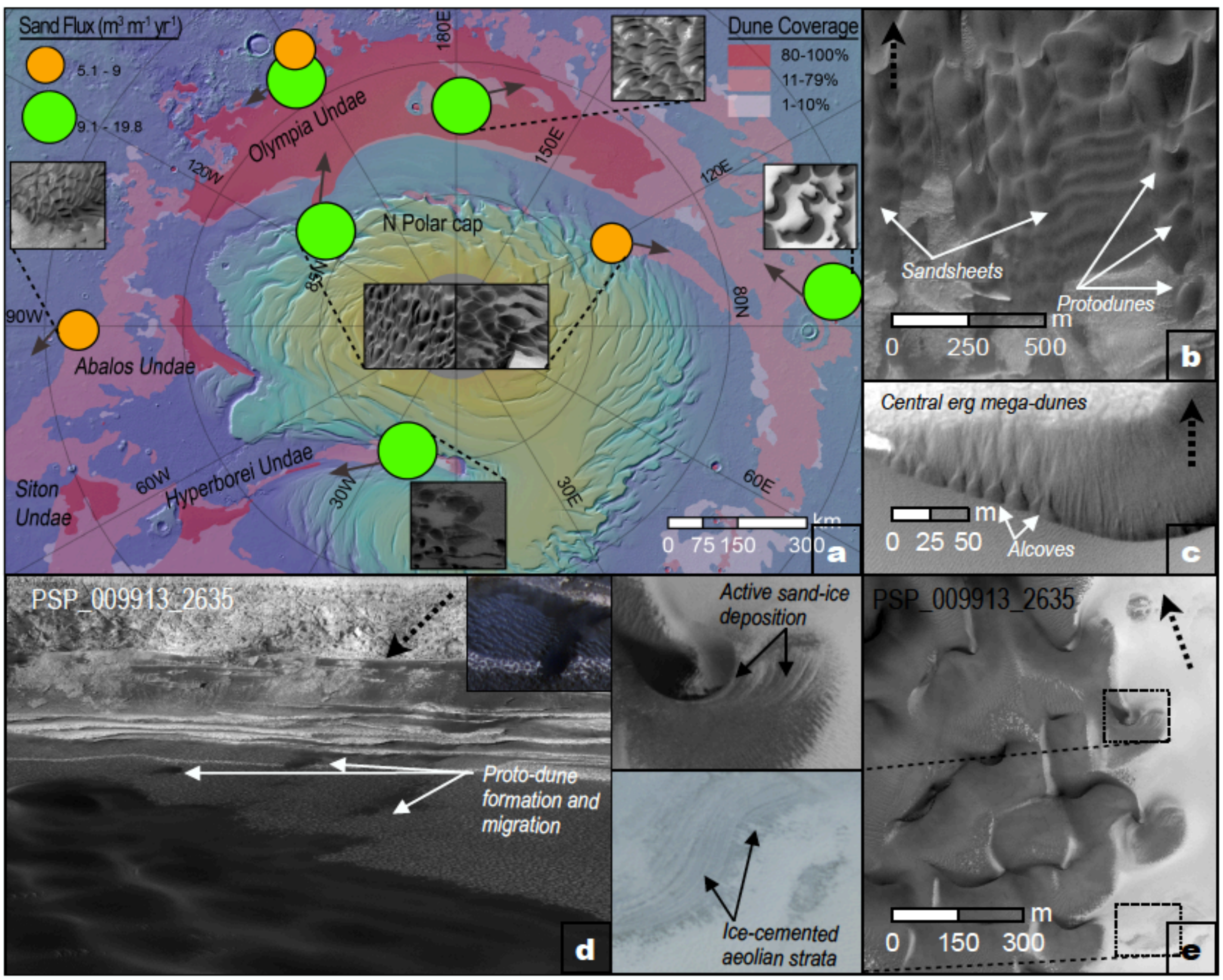

Figure 1. a) Sand flux measurements of polar dune fields (graduated circles) and their distribution (red polygons). Average dune migration vectors are represented by black arrows for each dune field. Inset HiRISE images are ~2-km-wide. b) Proto-dunes and sand sheets near sand sources in Olympia Undae. c) Alcoves that form on steep lee-faces. d) Oblique view of polar scarps where basal units layers source proto-dunes (inset upper right), which eventually develop into dunes (1b). Scene is ~1.1-km-wide. e) Louth crater where dunes slowly migrate and deposit sands and ice into the crater floor units. Insets are ~170-m-wide.