**DYNAMIC SEASONS ON MARS – POLAR IMAGES AND INVESTIGATIONS.** C. J. Hansen[1], K.-M. Aye[2], S. Diniega[3], P. Hayne[2], A. McEwen[4], G. Portyankina[2], M. E. Schwamb[5], [1]Planetary Science Institute, 1700 E. Fort Lowell, Tucson, AZ 85721, cjhansen@psi.edu; [2]LASP, University of Colorado, Boulder, CO 80303; [3]Jet Propulsion Laboratory / California Institute of Technology, Pasadena, CA 91109; [4]University of Arizona, Tucson, AZ 85719; [5]Astrophysics Research Centre, Queen's University Belfast, Belfast BT7 1NN, UK.

**Introduction:** The activities associated with seasons on Mars are arguably the most dynamic processes in Mars' current climate. Multiple investigations are underway, enabled by multi-year datasets. We will highlight the status of a few of these polar areas of research.

The Mars Reconnaissance Orbiter (MRO) has been in orbit for 7 Mars years observing the changes in the seasons, and inter-annual variability. With the High Resolution Imaging Science Experiment (HiRISE) on MRO we have the advantage of routinely pointing off-nadir to get repeat imaging of dynamic processes, and a high signal-to-noise ratio that enables imaging when the sun is low on the horizon [1]. The MRO Mars Climate Sounder (MCS) retrieves atmospheric temperature profiles and detects snowfall by combining limb observations which detect clouds, with measurements of the brightness temperature [2], which reveals ongoing or recent snowfalls [3].

**Spring sublimation and surface modification:** In the fall snowstorms and direct condensation deposit a layer of seasonal $CO_2$ frost on the surface [3, 4]. Over the winter the frost anneals to ice [5] setting the stage for action in the spring. The Kieffer model [described in detail in 6] postulates that when the sun rises in the spring sunlight penetrates the impermeable translucent ice and warms the ground below. The ice sublimates from the bottom and gas is trapped under increasing pressure, eventually rupturing the ice and escaping. Entrained particulates fall onto the top surface of the ice in fan-shaped deposits. Throughout the Mars year the transport of $CO_2$ into and out of the atmosphere drives winds, and the seasonal fans, like windsocks, mark its direction as spring progresses.

Gas escaping from under the seasonal ice layer entrains surface material, eroding channels into the surface [8]. The nature of the surface erosion is in part controlled by the friability of the surface. Furrows on dunes form in one Mars spring [9, 10]. Erosion, aided by sand, has been observed to form "spiders" (araneiform) in just a few Mars years [11]. Mature araneiform terrain development may take thousands of years [12]. A wide variety of configurations of troughs has been observed – the escaping $CO_2$ gas will find the path of least resistance [13, 14], as shown in Figure 1.

The Planet Four citizen science project (www.terrains.planetfour.org) is using MRO Context Imager (CTX) images to map out where araneiform terrain has been carved in the south polar region to improve our correlation of terrain-types with its formation [15]. Why don't we see araneiform terrain in the north polar regions, (other than furrows on dunes)? Is it due to the nature of the surface, or that the winter conditions are different due to Mars' elliptical orbit?

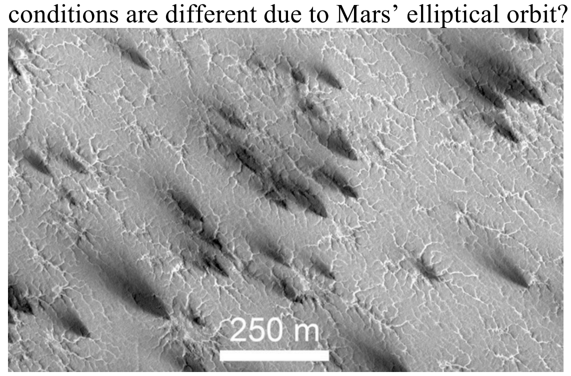


*Figure 1. Image ESP_055604_0930, taken at 86.9S / 170.5E, $L_s$ 188.9, shows araneiform terrain under a conformal coating of $CO_2$ ice with seasonal fans on top.*

**Fall frost condensation and alcove formation:** HiRISE images of the north polar erg in the fall and spring show the development of new alcoves on the dunes [15]. Comparison of our standard sites in different Mars years shows considerable variability in how many new alcoves form over one Mars winter and how large they are (see Figure 2).

A single MY32 image taken in the fall after the first bright frost appears shows that the formation of the alcoves appears to be connected to the onset of frost condensation. It is difficult to image the dark dunes as polar night falls and the polar hood forms so we have just a few images to compare to the MCS data. The MCS data show that there is inter-annual variability in exactly when the $CO_2$ begins to condense, the amount of time between condensation and the first snowfall, and how great the first snowfall is at a given site. These are factors that could influence the stability of the dune brink – for example, a significant amount of ice build-up would armor the dune against fierce autumn winds and may stabilize it against a later mass loading of snowfall that otherwise could oversteepen the slope. New images of alcove formation in MY33-MY34 are being analyzed for three sites, planned after the discovery from the single MY32 image that fall was the important timeframe. We are also collecting data at more sites, but it will take a few Mars years to develop a record for alcove formation at the new sites.

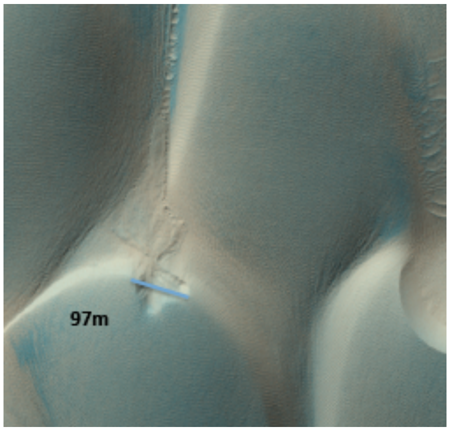


*Figure 2. A large new alcove was observed at a site known informally as "Buzzel" in ice-free image ESP_036387_2640 at 84N / 233E acquired in MY32. There were more large new alcoves in this Mars year than other years, at the same site.*

**Interannual Variability:** Atmospheric conditions appear to influence alcove formation on the north polar erg. In the southern hemisphere dust storms are implicated in the timing, number and size of the seasonal fans that appear on the seasonal cap.

The Planet Four citizen science fans project volunteers outline fans in HiRISE image cutouts (http://www.planetfour.org). We now have a catalog of seasonal fans for multiple Mars years [16]. The catalog allows us to quantify differences in Mars years with metrics as a function of time such as numbers of fans, sizes of fans, area covered, and orientation (which tells us about the local wind direction).

In years with preceding dust storms (both global and regional) fans emerge earlier in spring. As shown in Fig. 3 they are smaller and there are more of them. Global dust storms do not occur every Mars year but regional dust storms do. These storms are categorized as "A", "B", and "C"-type storms, differentiated primarily by when they begin and their latitudinal extent [16]. Pronounced regional "A"-type dust storms took place in late spring in MY 29 and MY32 [16], suggesting that regional storms could also play a role in lofting dust into the atmosphere that in turn influences the seasonal activity in the subsequent spring. With the hypothesis that both global and Type A regional dust storms affect seasonal activity, we would expect an increase in the number of fans in MY29, following the global dust storm of MY28; in MY30 following the intense type A storm in MY29; and in MY33 following the Type A storm in MY32 [17].

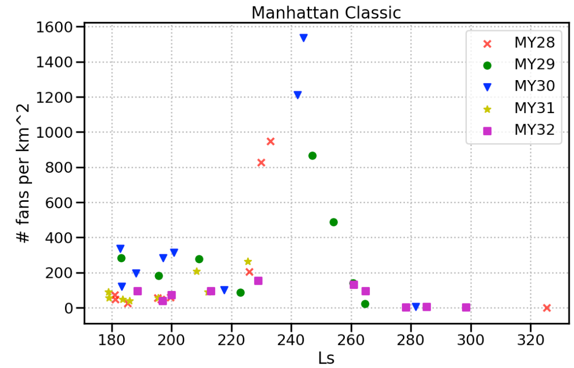


*Figure 3. Early in spring the number of fans in MY29 and MY30 are clearly higher than other Mars years.*

**Summary:** Multi-year datasets are enabling investigations of dynamic processes that go beyond being a snapshot in time. While combining datasets that provide different points of view to the same phenomena are important for short-term studies, this is crucial for understanding long-term relationships between short-, long-term and transient phenomena. These correlation studies with the use of extended datasets are instrumental for understanding the physics behind dynamic processes that repeat yearly for decades.

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