YEAR 3 HIRISE OBSERVATIONS OF SUBLIMATION OF THE NORTHERN SEASONAL POLAR CAP ON MARS. C. J. Hansen[1], M. Bourke[1], A. McEwen[2], M. Mellon[3], A. Pommerol[4], G. Portyankina[4], N. Thomas[4], [1]Planetary Science Institute, Tucson, AZ, cjhansen@psi.edu, [2]University of Arizona, Tucson, AZ, [3]Southwest Research Institute, Boulder, CO, [4]University of Bern, Switzerland.

Introduction: The High Resolution Imaging Science Experiment (HiRISE) on the Mars Reconnaissance Orbiter has been used to image seasonal processes on Mars since 2006. Spring on Mars is a time of active change at latitudes covered by seasonal CO_2 ice. This is the third northern spring that we have collected images as the seasonal CO_2 cap sublimates. In the first spring observed our emphasis was to characterize the types of seasonal activity extant in northern spring. With images from the second Mars year we identified morphological changes on the dunes of the north polar erg, including new alcoves and debris aprons, caused by seasonal processes [1]. In this third year we are systematically investigating the factors influencing the efficacy of seasonal activity such as slipface orientation and dune morphology.

Types of Seasonal Activity: The vast north polar erg manifests numerous seasonal phenomena. Seasonal activity shows up as dark blotches and fans on top of the relatively bright seasonal CO_2 ice layer as shown in Figure 1. Dark material often comes from cracks in the ice or the crests of the dunes. Our working hypothesis in the north polar region is that, like in the south, seasonal CO_2 ice is at times translucent, allowing sunlight to penetrate and warm the ground below (the "Kieffer model" [2]). The ice layer then sublimates from the bottom, trapping gas, which flows to the nearest opening. The gas mobilizes sand, carrying it out to the top of the ice layer. When this sand is blown downwind or slides downhill it appears as a dark fan, otherwise just as a localized dark blotch.

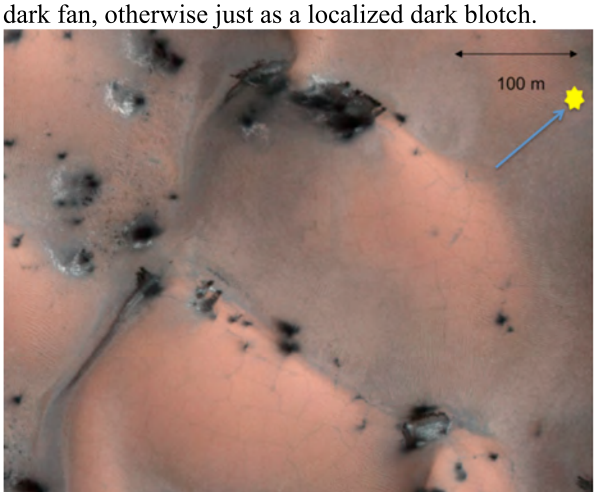

Figure 1. *ESP_016513_2555 at 75N / 317E. Dark material on top of seasonal ice is sand propelled up from the dark dune below the seasonal ice layer by escaping gas. Faint polygonal cracks can be seen in the ice, consistent with pressurized gas from basal sublimation causing the overlying ice layer to crack [3, 4]. South is up. Arrow shows direction to sun.*

Onset of seasonal activity: We began this third campaign much earlier than in the past two Mars years (the polar hood is only intermittently an issue and the spacecraft was not in safe mode, concerns in previous years). With this early data we can now report that fans show up on the substrate (ground beneath the dune) first, but quickly disappear. For example at 80N /122.5E we previously reported no activity on the substrate at all, however it turns out that the substrate fails first. In this third year we see fans on the substrate at $L_s = 7.5$ that are no longer visible by $L_s = 27$, the earliest previous image.

An example of spring "blossoming" on the dunes at 80N / 217E is shown in Figure 2. Fans erupt sometime between $1 < L_s < 14$. Seasonal CO_2 ice covers the entire terrain at these early times.

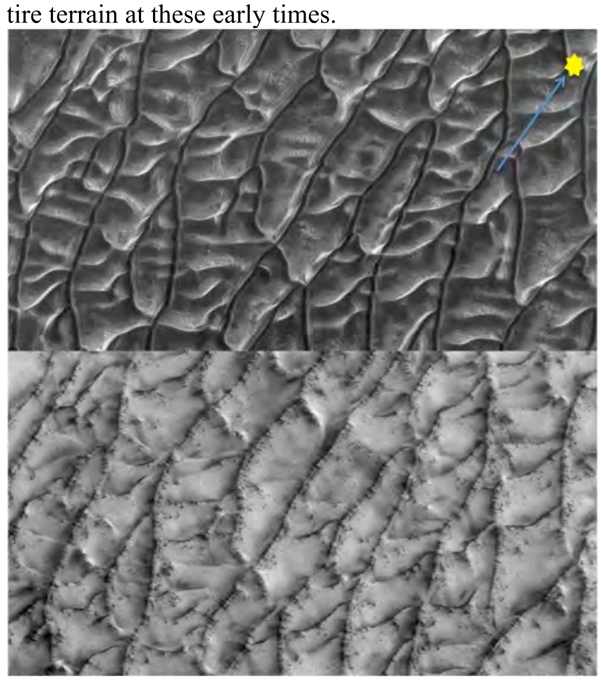

Figure 2. *Dramatic differences can be seen between the top image, ESP_024072_2605, taken at L_s = 1 and the bottom image is ESP_024428_2605, taken at L_s = 14. This image is ~4.4 km wide.*

Activity at dune-substrate interface and sub-ice conduits: Frequently, as shown in Figure 3, seasonal activity is concentrated around the dune – substrate interface. This is a defining characteristic of widely separated barchan dunes, but is commonly found even in regions with abundant sand where there is an opening of the dunes to the substrate.

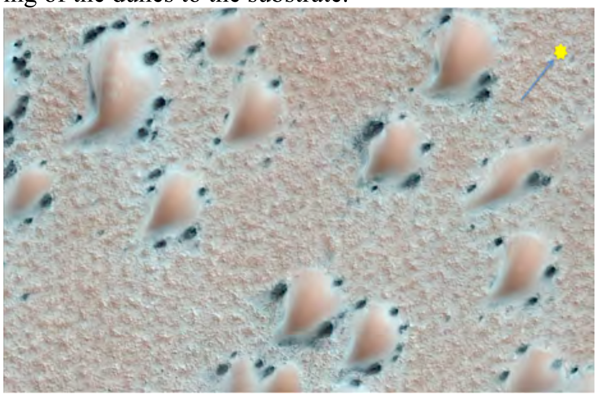

Figure 3. *Outbreaks of sand propelled by trapped gas ring dunes at the interface of the dune to the substrate as shown in this image taken at 73N / 355E in ESP_024621_2535, at L_s = 21. This image is 1.3 km wide. South is up.*

We can correlate these outbreaks with tiny channels, as shown in Figure 4. Invoking the Kieffer model, we propose that the gas trapped under the seasonal ice carves small furrows to the edge of the dune and ruptures the ice along the edge of the interface with the substrate. Sand is then propelled out. Some of these channels persist from one year to another, others do not [5]. The polygonal cracks in the ice that often are seen on the stoss side of the dunes form somewhat later than the outbreaks around the dune edges but sand emerges from both concurrently. The exodus of sand is not a single occurrence, suggesting that gas continues to flow through the furrows for an extended period of time.

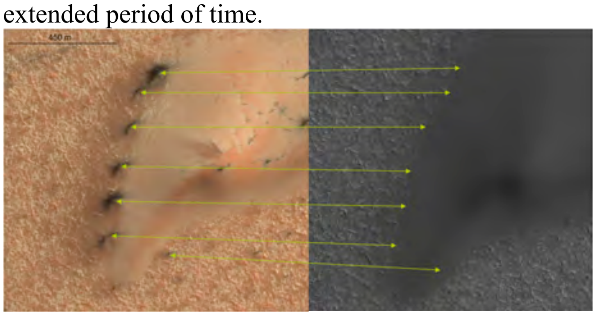

Figure 4. *At 80N / 122.5E, on the left sub-image of ESP_016032_2600, at L_s = 30, outbreaks of sand line the edge of the interface of the dune to the substrate. The outbreaks can be correlated when the seasonal ice is gone with tiny channels visible on the sand on the dune as shown in the sub-image on the right, ESP_018445_2600, taken in the summer at L_s = 113. South is up.*

Mass wasting evidence: On dune slipfaces we observe dark streaks extending from the crest to the bottom of the dune. Although flow of liquid salty brine or interfacial water has been proposed [6, 7] we favor simple gravity-driven flow of dark dry sand [1]. A "mini-avalanche" that kicked up a cloud of dust was observed in the first Mars spring from the crest of a dune. Was that however a one-time event from an oversteepened dune or an explanation for all the streaks we see? With our most-recent images we find more evidence for the latter, as shown in Figure 5. False color HiRISE images processed from data with very good exposures, resolution and lighting show evidence for dust raised at the foot of the slopes for many events. We postulate that dark sand falling or sliding from the crest of the dune raises brown-colored dust at the bottom as illustrated:

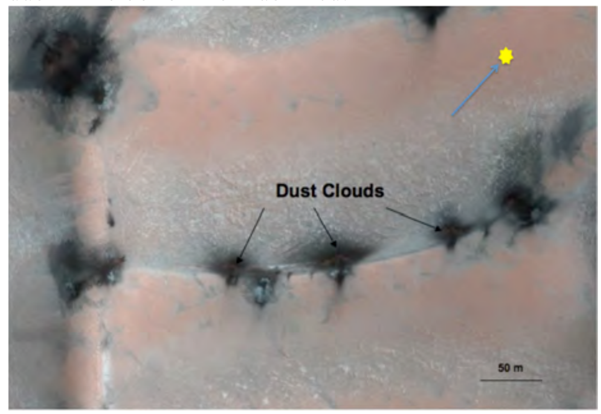

Figure 5. *Pink-ish colored seasonal ice covers the dunes in this image acquired at 80N / 217E, ESP_025061_2605, L_s = 37. Dark sandfalls from the crest of the dunes raise brown-colored dust at the foot of the slipface. The brown dust is only observed in conjunction with the dark streaks, and only at one time in a temporal series. South is up.*

Notes: L_s, the true anomaly of Mars in its orbit, is a standard way of defining the season on Mars. Northern spring begins when the sun crosses the equator at Ls = 0.

References: [1] Hansen, C. J. et al. (2011) *Science* 331, 575-578. [2] Kieffer, H. H. (2007) *JGR* 112, E08005. [3] Piqueux S. and Christensen P. (2008) *JGR, 113,* doi:10.1029/2007JE003009. [4] Portyankina, G. et al, (2011) *JGR* in press doi:10.1029/2011JE003917. [5] Bourke, M. C. and Cranford A. (2011) *Mars Polar Conference* Abstract LPICo1323.6059B. [6] Kereszturi, A. et al (2009) *Icarus* 201, 492-503. [7] Kereszturi, A. et al (2010) Icarus 207, 149-164.