A NINE YEAR RECORD OF INTERANNUAL VARIABILITY OF SEASONAL ACTIVITY IN MARS' SOUTH POLAR REGION DUBBED "MANHATTAN". C. J. Hansen[1], K-M. Aye[2], G. Portyankina[3], M. Schwamb[4], T. Michaels[5], L. Tamppari[6]; [1]Planetary Science Institute, 1700 E. Fort Lowell, Tucson, AZ 85719, USA, cjhansen@psi.edu; [2]Freie Universitaet Berlin, Institute of Geological Sciences, Berlin, Germany; [3]Deutsches Zentrum fuer Luft und Raumfahrt, Berlin, Germany; [4]Oxford Astrophysics, Oxford, UK; [5]University of Wisconsin, Madison, WI, USA; [6]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA.

Introduction: The Mars Reconnaissance Orbiter (MRO) began science observations in 2006, Mars Year (MY) MY28. Several sites at high latitudes in the southern hemisphere were selected for seasonal monitoring by the High Resolution Imaging Science Experiment (HiRISE). As Mars' seasonal cap sublimates in the spring a number of exotic phenomena are observed [1]. These phenomena are well-described by the Kieffer model which postulates that energy from insolation penetrating translucent ice combined with subsurface heat cause the seasonal CO_2 ice to sublimate from the bottom of the slab [2, 3, 4, 5, 6, 7, 8]. Gas is trapped under pressure until a rupture occurs. Escaping gas carves radially-organized channels in the surface under seasonal ice, forming araneiform terrain. The entrained surface material is deposited in fans on top of the seasonal ice layer. HiRISE has now imaged the same sites over 9 Mars years, to MY36.

The fans that are deposited on the surface of the seasonal ice mark the direction and speed of the ambient wind at the time of the gas release. The numbers of fans and when they emerge are affected by the surface-ice energy balance. A factor is the amount of dust on the surface and in the atmosphere. This in turn suggests that regional and global dust storms may play a role in the number and timing of the fans.

Manhattan interannual variability: One of the sites selected for routine monitoring every Mars year was a region dubbed "Classic Manhattan" at lat / lon 86.4S / 99.0E. Images from Mars years MY28 to MY36 are compared in Figure 1. The difference in MY28 compared to MY29 is striking. The MY28 global dust storm began in very late southern spring after sublimation of the seasonal cap was largely complete. Even more fans are observed at the same time in MY30. MY31 and MY32 show a return to fewer fans emerging by orbital longitude L_s 195. MY33 has a jump up in numbers again, with no intervening global dust storm. Intense regional "A"-type dust storms took place in late spring in MY29 and MY32 [9], suggesting that regional storms also play an important role. The lack of significant differences between MY34 and MY35 suggest that the timing is key, since this global dust storm took place right at the beginning of southern spring.

The role of regional dust storms: Regional dust storms have been categorized as Type A (onset L_s 205-240), Type B (onset L_s 245-260), and Type C (onset L_s 305-320), occurring in years with no global dust storm [9]. Type A dust storms occur when seasonal activity is well underway. Dust that settles out from Type A dust storms will land on top of the remaining seasonal ice. This dust is likely to hasten sublimation of the top of the ice by absorbing solar radiation while also blocking the sunlight from penetrating the seasonal ice layer to promote basal sublimation. Type B storms occur mostly after seasonal activity has slowed or ceased entirely. Most of the dust elevated by the storm settles on the surface or just a thin layer of remaining ice. Type C storms happen after the seasonal ice is gone.

Quantification of differences. Rather than relying on visual inspection, the Planet Four (P4) citizen science task is uniquely suited to quantify the effects of dust storms. P4, started in 2013, at https://www.planetfour.org, presents a volunteer with a subframe of a HiRISE image and requests that they outline each fan that they see. Statistical analysis of the measurements by the volunteers and a catalog of the identified fans are described in Aye et al. [10].

Figure 2 shows fans / sq km as a function of L_s for the first 5 Mars years, extracted from the catalog. As expected MY29 and MY30 stand out at early L_s. MY30 has more fans at all times. The lack of measurements from L_s 230 to 260 in MY31 and MY32 make it difficult to know whether the large peak in that range in the other years is normal.

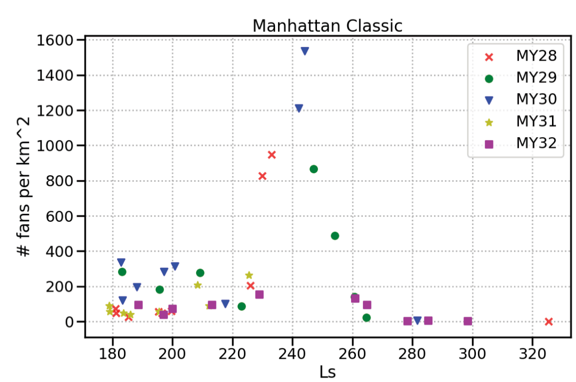

Figure 2. The number of fans per sq km are compared as a function of orbital longitude L_s.

Another metric is the area of the fans as a function of L_s, shown in Figure 3. The area covered by a fan is related to the speed and duration of the jet exiting the seasonal layer of ice, thus can be considered a proxy for the energy. Early in spring in MY29 and MY30 the small number of large fans stands out.

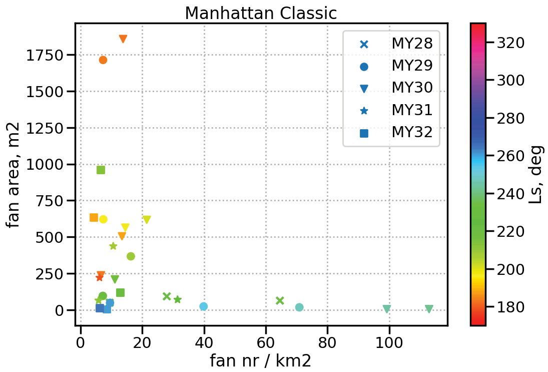

Figure 3. The area of fans vs number of fans compared as a function of orbital longitude L_s.

Summary: Why is it that a layer of dust settling out of the atmosphere after a global or regional dust storm in late southern spring has such a remarkable influence on the seasonal processes in the subsequent year? Plausibly the effect is that the uppermost material on the surface is less consolidated, thus easier to erode. If the surface thermal inertia is lower then perhaps energy for basal sublimation of seasonal ice could be increased.

Acknowledgements: This research was partially funded by the Mars Reconnaissance Orbiter Project managed by the Jet Propulsion Laboratory, California Institute of Technology.

References: [1] Malin, M. C. and Edgett, K. S. (2001) *JGR*, 106, 23429-23570. [2] Kieffer, H. (2000) *LPI Contribution* #1057. [3] Piqueux, S., et al., (2003) *JGR* 108, (E8):3-1. [4] Aharonson, O., et al. (2004) *JGR* 109:E05004. [5] Kieffer, H. (2007) *JGR* 112, E08005. [6] Hansen, C. J. et al., (2010) *Icarus* 205:283-295. [7] Thomas, N. et al., (2010) *Icarus* 205:296-310. [8] Portyankina, G. et al., (2010) *Icarus* 205:311-320. [9] Kass, D., et al., (2016) *GRL* 43:6111. [10] Aye, K.-M. et al., (2019) *Icarus* 319:558.

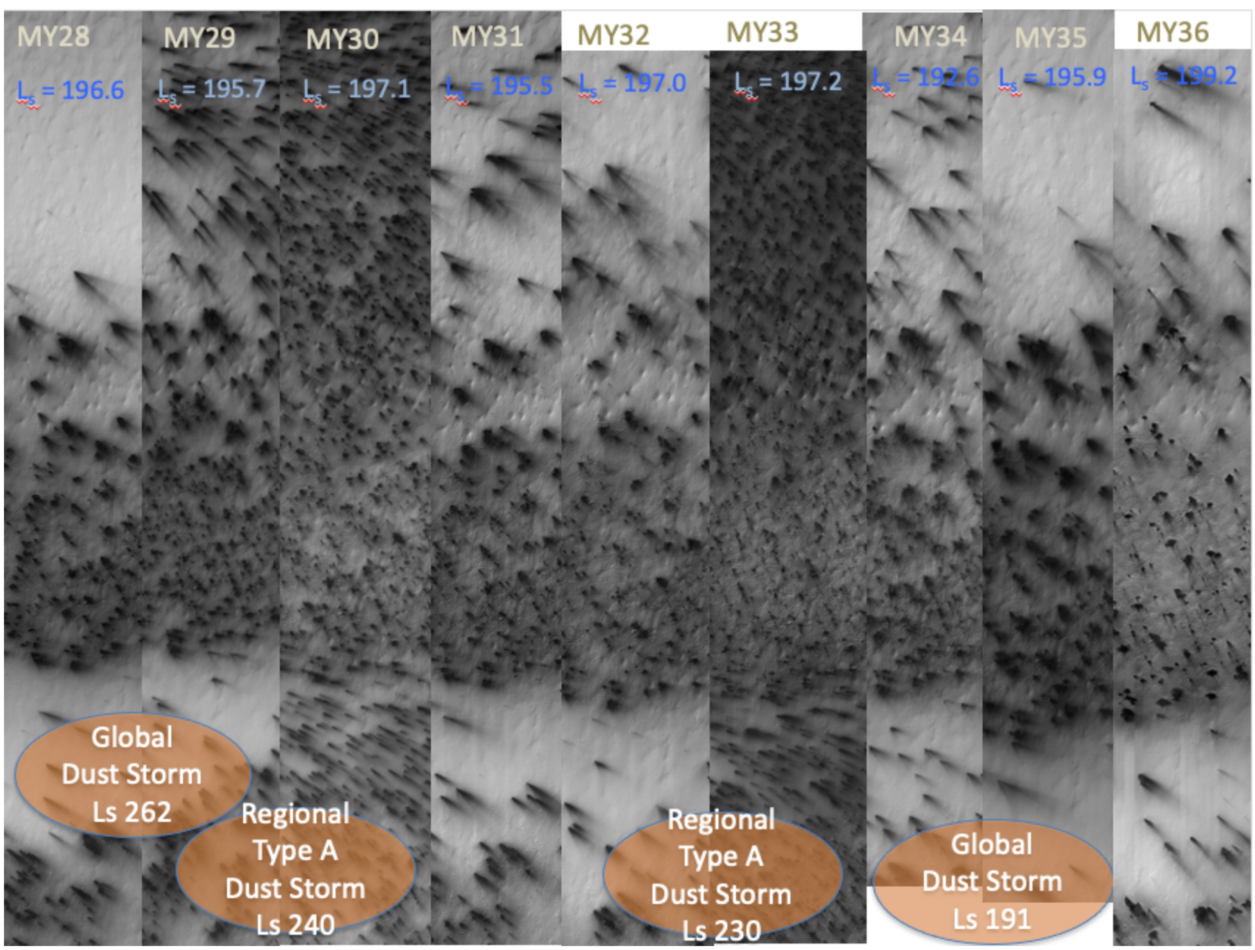

Figure 1. The same area in "Manhattan" was imaged every Mars year in the L_s interval 193 to 199.