

**INTERANNUAL VARIABILITY OF SEASONAL ACTIVITY IN MARS' SOUTH POLAR REGION DUBBED "MANHATTAN".** C. J. Hansen<sup>1</sup>, K-M. Aye<sup>2</sup>, G. Portyankina<sup>2</sup>, M. Schwamb<sup>3</sup>, <sup>1</sup>Planetary Science Institute, 1700 E. Fort Lowell, Tucson, AZ 85719, [cjhansen@psi.edu](mailto:cjhansen@psi.edu); <sup>2</sup>LASP, University of Colorado, Boulder, CO 80303; <sup>3</sup>Gemini Observatory, Northern Operations Center, 670 North A'ohoku Place, Hilo, Hawaii, 96720.

**Introduction:** The Mars Reconnaissance Orbiter (MRO) began science observations in 2006, Mars Year (MY) MY28. Several sites 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<sub>2</sub> 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 7 Mars years, to MY34.

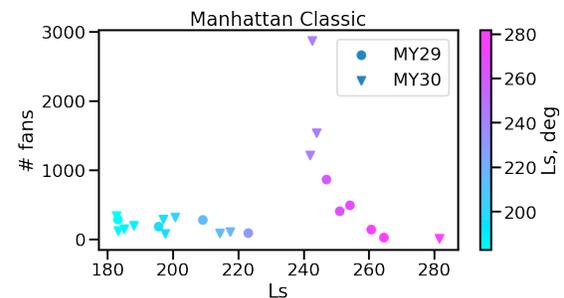
The fans that are deposited on the surface of the seasonal ice mark the direction and speed of the ambient wind at the time of the gas release. The numbers of fans and when they emerge are affected by the surface-ice energy balance. A likely factor is the amount of dust on the surface and in the atmosphere.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

The Planet Four (P4) citizen science task is uniquely suited to analyze this hypothesis. 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 in that sub-image. Statistical analysis of the measurements by the volunteers and a catalog of the identified fans are described in Aye et al. [9].

**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 MY34 are compared in Figure 4. 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. The number of fans in MY30 suggests that if the global dust storm was responsible for the increase in fans that the effects linger for two Mars years. 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.

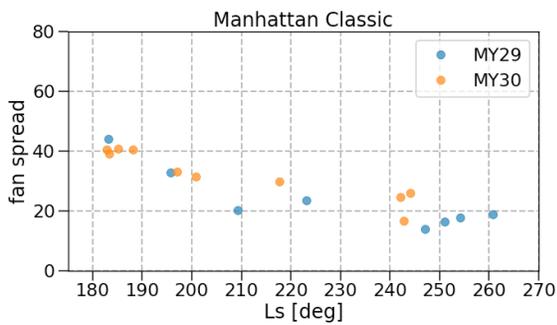
Pronounced regional "A"-type dust storms took place in late spring in MY29 and MY32 [10], suggesting that regional storms could also play a role, possibly explaining the increase in number of fans in MY30. MY34 has a reduced number of fans. It will be interesting in future MY35 images to see the effects of the MY34 global dust storm, which started after the initial spring images of Manhattan were acquired.

*Quantification of differences.* A quantitative comparison of numbers of fans and fan properties is possible using the P4 fan catalog. At this time only MY29 and MY30 are available, however other years are being analyzed. The plots shown in Figures 1, 2 and 3 illustrate examples of the types of investigation possible. As expected from visual inspection of the images there are no significant differences in the numbers of fans at  $L_s \sim 195$  between MY29 and MY30 in Figure 1. A large jump occurs around  $L_s$  240 in MY30, however at that time in the spring enough terrain is ice-free that it was possible that there were patches of bare ground being interpreted as fans by the citizen scientists. Whenever results seem out-of-family we visually inspect the images. In this case the outlier is from an adjacent overlapping site, with enough difference in terrain coverage that it should be excluded from the analysis.



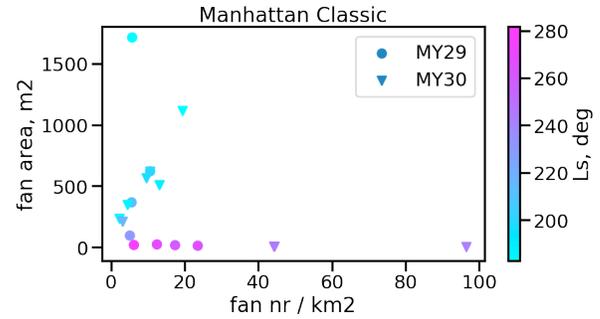
**Figure 1.** The number of fans per sq km are compared between MY29 and MY30 as a function of orbital longitude  $L_s$ .

Another metric is the spread of the fans as a function of  $L_s$ , shown in Figure 2. This is also consistent with the visual inspection of the images for MY29 and MY30. The spread in fans is probably due to the change in wind direction over the course of the event, thus related to its duration and gas supply available from sublimation, a factor in estimating energetics.



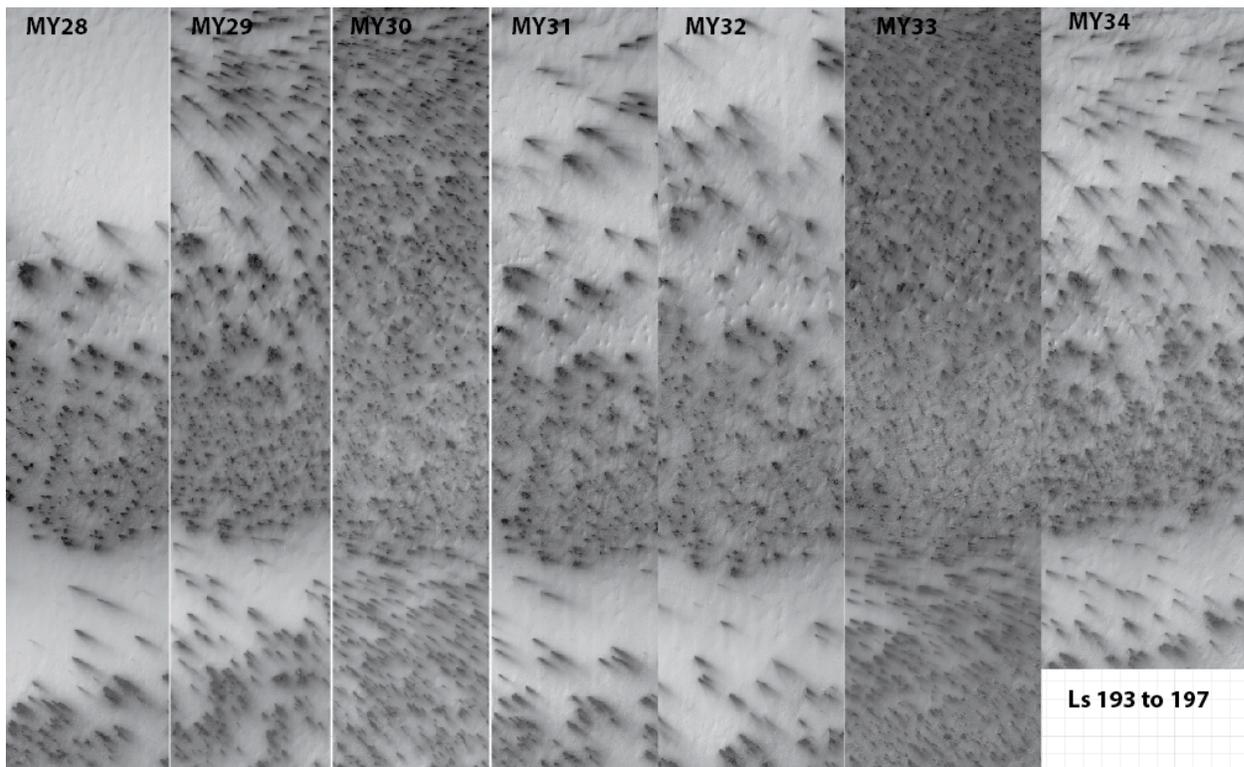
**Figure 2.** The spread of fans (opening angle) are compared between MY29 and MY30 as a function of orbital longitude  $L_s$ .

Possibly more useful for analysis of the energetics involved is comparison of the area covered by the fans, if the amount of material eroded, blown out, and deposited can be connected to how much energy reaches the bottom of the seasonal ice layer. Comparative area covered by individual fans and numbers of fans are depicted in Figure 3.



**Figure 3.** Fan area vs. the number of fans is similar for MY29 and MY30 early in spring.

**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] Aye, K.-M. et al., (2019) *Icarus* 319:558. [10] Kass, D., et al., (2016) *GRL* 43:6111.



**Figure 4.** The same area in “Manhattan” was imaged every Mars year in the  $L_s$  interval 193 to 197. The number of fans jumped up in MY29 after a global dust storm in MY28 that started after the MY28 image was acquired. A regional dust storm between the images taken in MY32 and MY33 may be responsible for the increased number of fans in MY33.