PROBING THE MARTIAN SOUTH POLAR WINDS BY MAPPING CO_2 JET DEPOSITS.

K.-Michael Aye[1], Megan E. Schwamb[2], Ganna Portyankina[1], Candice J. Hansen[3], Chris J. Lintott[4], Brian Carstensen[5], Christopher Snyder[5], Michael Parrish[5], Stuart Lynn[5], Chu-Hong Mai[6], David Miller[5], Robert J. Simpson[4] and Arfon M. Smith[5]; [1]Laboratory for Atmospheric and Space Physics, University of Colorado at Boulder, CO 80303, USA (Michael.Aye@lasp.colorado.edu); [2]Gemini Observatory, Northern Operations Center, 670 North Aohoku Place, Hilo, HI 96720, USA; [3]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719, USA; [4]Oxford Astrophysics, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK; [5]Adler Planetarium, 1300 S. Lake Shore Drive, Chicago, IL 60605, USA; [6]Institute for Astronomy and Astrophysics, Academia Sinica; 11F AS/NTU, National Taiwan University, 1 Roosevelt Rd., Sec. 4, Taipei 10617, Taiwan

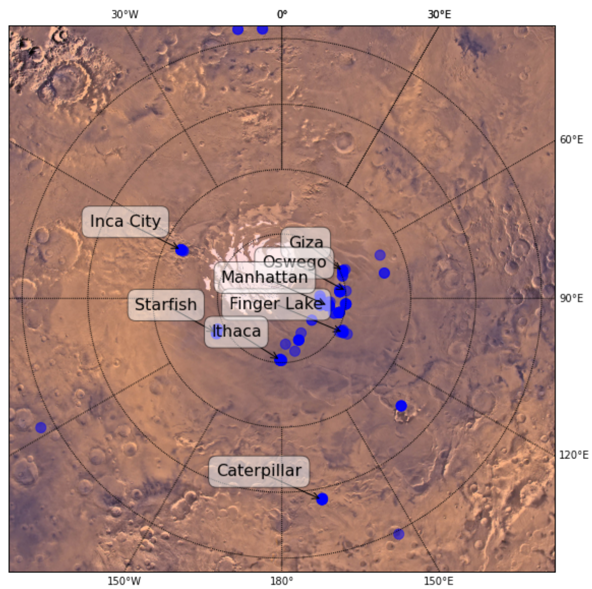

Figure 1: Overview of the locations of the regions of interests covered by the Planet Four dataset.

Introduction: Every local spring, CO_2 gas jets erupt at the south pole of Mars through the seasonal CO_2 ice layer [1]. Depending on if winds were present at the time of eruption, these jets deposit material from underneath the ice on top with either a fan-shaped or an elliptical blotch-shaped outline, previously studied with MOC images in [2]. The HiRISE camera on MRO has been monitoring areas with active seasonal polar processes and we have observed the directions of deposits to change seasonally and annually. We contend that the observed changes in direction of the deposits can be used as proxies for changes in prevalent wind directions at the surface.

Methods: A set of 221 good quality HiRISE images of the Polar Seasonal Processes Monitoring Campaign from Martian Years (MY) 29 and 30 were selected to enter a Citizen Science project called Planet Four (https://www.planetfour.org). Figure 1 shows an overview of the regions of interests (ROIs) used for this study. The project's volunteers have mapped out fans, blotches and interesting objects and the science team has now fully reduced the mappings to fan and blotch catalogs. The set of 221 HiRISE images was split up into 42 904 screen-sized tiles of size 840×648 pixels for the Planet Four project. The Citizen Science volunteers have been marking visible objects in the tiles either as fan-shaped, blotch-shaped (no clear alignment), or "interesting feature". Almost 2.7 million fan markings and more than 3.4 million blotch markings have been clustered together, separately for each Planet Four tile, using the DBSCAN algorithm [3].

Results We have produced a catalog of 159 288 clustered fan and 250 355 blotch objects. The catalog contains all relevant metadata for further analysis, like latitude/longitude for all objects, fan length, orientation, and opening angle, blotch semi-major radii and orientation. As an example of the information content of the catalog we discuss the fan lengths in the produced catalog. 96 % of all the observed fans have a length below 100 m. The average fan length is at 33.1 m, while the median is 24.1 m. This picture prevails when splitting the data by the examined Martian years, with the median lengths of 24.2 m and 23.8 m respectively. The three largest fans measured are all from the same region of interest called Manhattan (Lat $-86.39°$, Lon $99°$), having lengths of 373 m, 368 m and 361 m respectively. The highest two of these three fan markings are even identifying the same fan, but at different times in the season. Interesting differences appear when studying the temporal behavior across different ROIs, as shown in Fig. 2. While the ROIs Ithaca and Inca show no discernible difference between season 2 (= MY29) and season 3 (= MY30), both ROIs Manhattan and Giza show different fan length distributions for these two seasons, with opposite trends, i.e. Manhattan's most prevalent fan length reduced from season 2 to season 3, while Giza's most likely fan length apparently doubled.

Wind directions Results from a wind direction analysis using the Planet Four catalog for the Giza ROI, MY 29, in early spring is shown in Fig. 3. The data indicate a clear change in the most prevalent wind directions between the very earliest jet eruptions at Ls 185° and the next set of observations around Ls 200°. Because wind directions are indicated by fans that do not necessarily vanish fast over time, the clean new distribution at a later

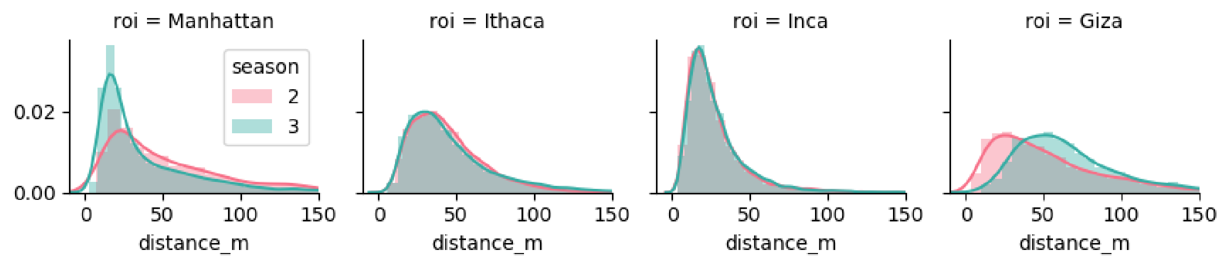

Figure 2: Normalized fan length histograms, split up over the four ROIs Manhattan, Ithaca, Inca and Giza and for MRO seasons 2 and 3, i.e. MY 29 and 30. The closed line displays a kernel density estimator for easier comparison between the shape of each distributions. To show the most likely values better, the x-axis has been limited to $150\,\mathrm{m}$, while, especially in the case of Giza and Manhattan, the distributions are tailing out up to over $300\,\mathrm{m}$.

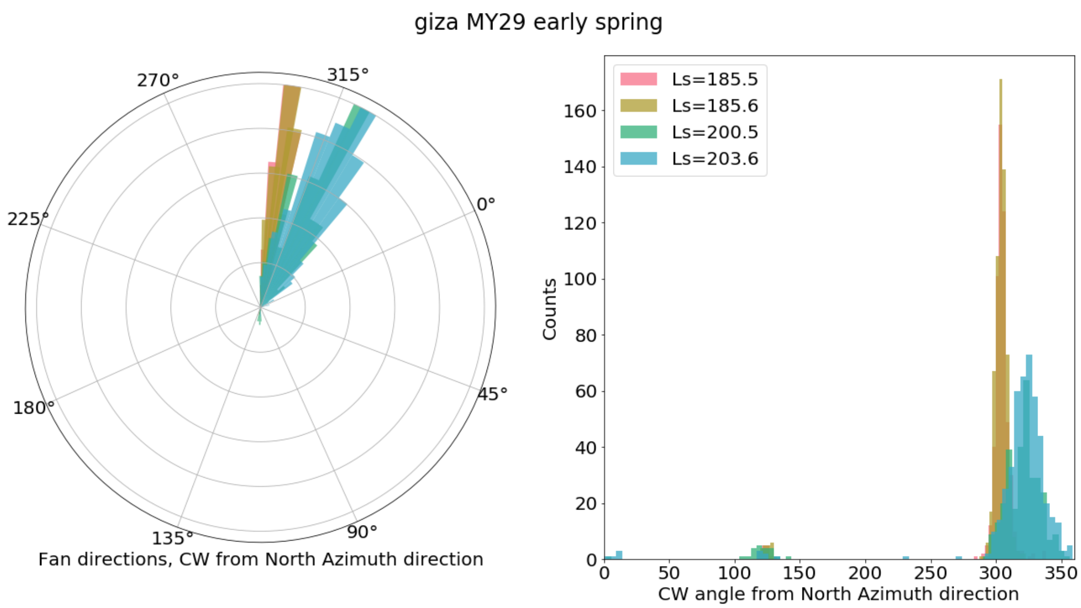

Figure 3: Example of the Planet Four catalog capabilities. We plot the histogram of mapped wind directions for fans in the Giza ROI for MY29, early spring only. CW means clock-wise angles, the wind-rose diagram has been rotated to align with the HiRISE images' North Azimuth direction for easy comparison. We resolve the change in most prevalent wind directions between Ls $185.5°$ (rose and brown color) and Ls $200.5°$ and $203.6°$ (green and blue). A very clear new distribution of wind directions has appeared.

date in the spring is remarkable, indicating a near complete vanishing of the initial fans.

Conclusions We have finished the data reduction of the Planet Four data-set, derived from 221 HiRISE images of MYs 29 and 30. Initial science analyses using the catalog are very promising, indicating excellent reproducibility of fan lengths between MY29 and 30 in some ROIs, but also showing exciting variations for ROIs Giza and Manhattan. The wind directions are reliably reproduced for all ROIs between these two years, for three ROIs we see a slow shift eastwards along the spring season, in both years. We have shown that the analytic human power of Citizen Science projects is very well applicable for planetary science and have produced a catalog that provides the first polar-scale wind measurements for the Martian surface.

References: [1] Kieffer, HH. *Journal of Geophysical Research*, 112:08005 (2007). doi:10.1029/2006JE002816. [2] Diniega, S, Richardson, MI, Ewald, SP, et al. *Lunar and Planetary Science Conference*, vol. 34 (2003). [3] Ester, M, Kriegel, HP, Sander, J, et al. *Kdd* (1996).