ANALYSIS PIPELINE AND RESULTS FROM THE PLANETFOUR CITIZEN SCIENCE PROJECT

K.-M. Aye[1], M. E. Schwamb[2], G. Portyankina[1], C. J. Hansen[3], [1]LASP, University of Colorado at Boulder, Michael.aye@lasp.colorado.edu, [2]Institute of Astronomy & Astrophysics, Academia Sinica (ASIAA), Taipei, [31]Planetary Science Institute, 1700 E. Fort Lowell, Suite 106, Tucson, AZ 85719

Introduction: PlanetFour is a Citizen Science project about analyzing surface images from the south pole of Mars (www.planetfour.org). Main objectives are studying the surface atmosphere interactions at the pole, especially during the local spring. CO_2 gas jets that are created by basal sublimation of the seasonal CO_2 ice layer deposit fine dust into the atmosphere and coarser regolith on top of the ice sheet in form of fan-shaped albedo features [1]. The fine dust that entered the atmosphere is believed to have an important effect on the atmospheric temperature profile. The seasonal removal of regolith over many years results in topographical features called araneiform. These are dendritic troughs that connect to a common center. Their constant modification represents ongoing change in the surface topography of Mars today [2].

A further objective is to map the orientations of the regolith deposits. These orientations are controlled by the local winds that existed at the time of jet eruption. Repeated surface observations constrain the time of eruption and are therefore able to provide wind data points for atmospheric meso-scale simulations.

Data: The image data used in the PlanetFour project comes from the HiRISE camera of the Mars Reconnaissance Orbiter. Planet Four citizens are asked to identify and outline fans in the presented tiles that are created by tiling up each large HiRISE observation in screen-sized tiles of approx. 800x600 pixel. We cluster the resulting markings into final locations using the DBScan clustering algorithm, after which the object coordinates are back-projected into latitude and longitude coordinates with a standard ISIS image calibration pipeline.

Outcomes are catalogs of object locations, estimated sizes and wind directions. With these catalogs we study the activity over time per region, compare these activity time-series between seasons and compare the strength of observed activity between different regions around the pole. The derived wind directions are used to improve atmospheric meso-scale simulations at Mars' south pole, which is part of an ongoing NASA SSW project. We will present results from the first publication of the PlanetFour project.

Reduction pipeline: The PlanetFour reduction and analysis pipeline consists of 4 main lines: 1. Data cleanup, 2. Clustering, 3. FNotching (combining fan and blotch markings), and 4. Ground Projection.

Data cleanup. High traffic caused a small percentage of the markings to be incomplete. Also a small percentage of the data was shown to the same user more than once. Ellipse markings have a drawing symmetry so they need to be normalized to avoid clustering on 180 degree shifted angles when two Citizens mark the same object starting from opposite sides. After processing these clean-up items, an indexed HDF5 database file is created that allows fast on-disk selection for analyses based on either HiRISE observation ID or PlanetFour image ID.

Clustering. We use the DBSCAN clustering [3] algorithm as provided by the scikit-learn library [4]. In the beginning we clustered only on the base coordinates x,y of either the base point of fan markings or the center of the ellipse markings for blotches. But it turned out to be necessary to cluster on the direction of the marking as well for a better reduction of noise markings (See Figure 2).

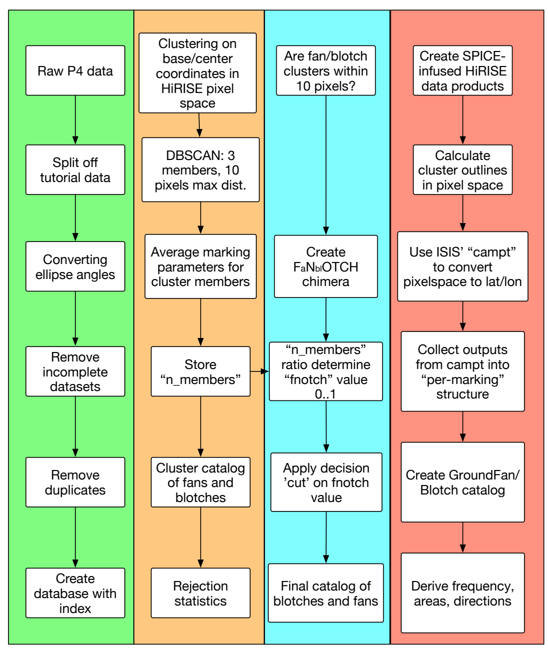

Figure 1 Reduction and analysis pipeline for the PlanetFour project

FNotching. When the terrain is hard to read, albedo features without clear geometrical features might be marked both as fans or blotches. A loop over the cluster-averaged markings determines if a fan and a blotch are so close to each other that they need to be merged. We call this object a fnotch, a chimera term created

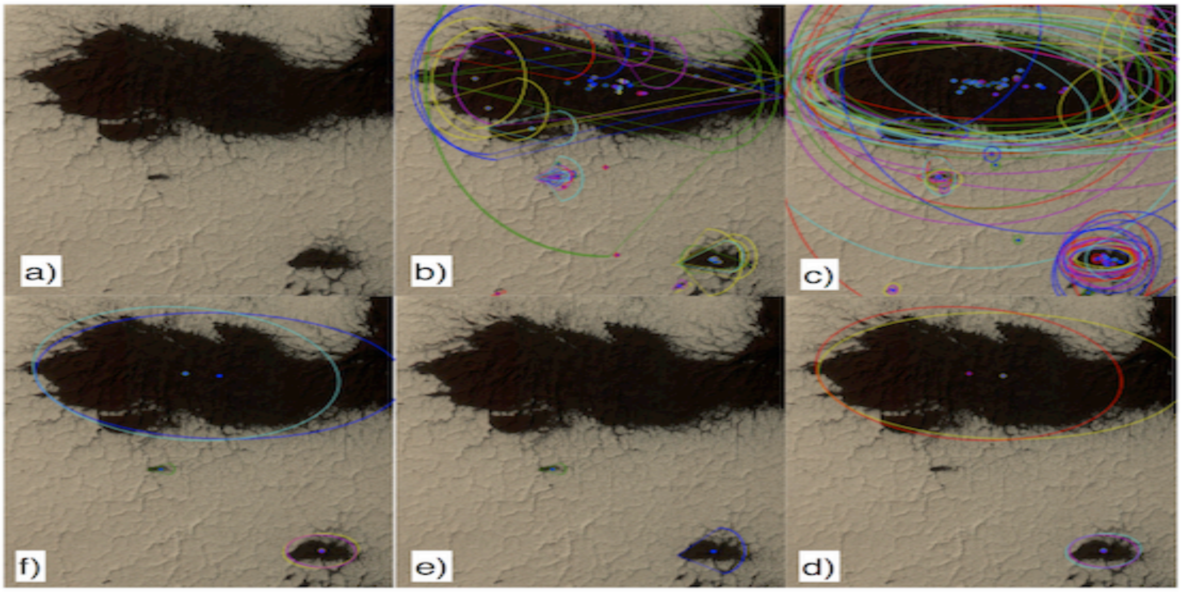

Figure 2 Example of PlanetFour pipeline including clustering on angle of the marking. Initial clustering pipelines were only clustering on x/y base coordinates of the markings (either the base point of a fan or the center of a blotch ellipse). This sometimes let noise markings survive. The inclusion of the angle parameter in the clustering process removes noise markings to a greater effect. a) The tile as presented to the Citizen scientists, b) the raw fan markings, c) raw blotch markings, d) blotch markings after clustering and averaging the cluster members, e) fan markings after clustering and avering of the cluster members, f) the final markings after combining fan and blotches into fnotches and cutting on a fnotch value of 0.5 (see text). This example shows 2 blotches survive that are close to each other in both present albedo features. Another loop over markings that are of the same kind, not done so far, will resolve this remaining ambiguity. Another possibility is to adapt the initial clustering distance parameter that determines if a marking belongs to a certain cluster.

from FaN and blotch. We keep track of the number of Citizens that marked for either type and calculate a fnotch value out of that. At production time of a final catalog or a catalog best fit to a certain problem, we can cut on that value and e.g. decide that we only take a marking as a fan if 75% of Citizens that marked that feature marked it as a fan.

Ground projection. For simplicity in the required back-end software to present ten thousands of images to hundred thousands of users, we decided early that we will use un-map-projected data due to tiling being easier with the rectangular CCD data. This required a post-processing pipeline that corrects the resulting wind directions for their true ground orientation. We have implemented a small sub-set of the original HiRISE ISIS processing pipeline to re-calculate the required SPICE headers and use ISIS tools to convert the marking coordinates into ground coordinates.

Resolution scaling. A last pipeline that needs to be developed in a stable fashion is to scale or filter the results for the initial HiRISE observation resolution (or binning), as the detection ability is influenced by this. A prototype for manual scaling exists.

Results: Preliminary results show good agreement between previous manually created seasonal activity graphs and those created from PlanetFour after ground projecting and manually scaling for observation resolution. Both activities show the same shape and peak around Ls 230°.

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