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Mars' Seasonal Fans measured by Citizen Scientists

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Abstract

Tens of thousands of citizens of planet earth have helped catalog fans in images taken in spring in the south polar region of Mars, via the web portal "Planet Four" at http://www.planetfour.org. This website is part of the Zooniverse collection of online citizen science projects. At the time of this submission (6 May 2013) the total number of citizen scientists that have participated was 70610.

1. Introduction

In the spring the south polar region of Mars exhibits a host of exotic phenomena associated with sublimation of the seasonal CO_2 polar cap. Images from the Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) document activity best described by the "Kieffer" model [1, 2]: In the winter the CO_2 forms a translucent slab of impermeable ice. Penetration of sunlight through the ice, which warms the ground below, results in basal sublimation of the ice. Trapped gas escapes through ruptures in the ice, eroding and entraining material from the surface below. When this dust-laden gas is expelled into the atmosphere the dust settles in fan-shaped deposits on the top of the ice in directions oriented by the ambient wind, as shown in Figure 1 [3, 4].

The number, time history, area covered and changes of the fans provide a wealth of information on the spring sublimation process. The length, width, and direction are snapshots in time of the local wind direction. But the sheer number of fans in HiRISE images from multiple locations and times over 3 Mars years was a daunting data set to process.

Fortunately there is a community of "citizen scientists" available to help, and so we launched the "Planet Four" project under the auspices of the Citizen Science Alliance.

1.1 The Zooniverse

The Citizen Science Alliance is dedicated to involving the public in science and data analysis. They provide the web portal and technical expertise for involving large numbers of volunteers in research projects online (the Zooniverse, described at http://www.zooniverse.org). They have 15 currently active projects. The zooniverse team developed the Planet Four web portal to engage citizen scientists in the task of cataloguing fans in images from the first 3 southern springs on Mars imaged by HiRISE.

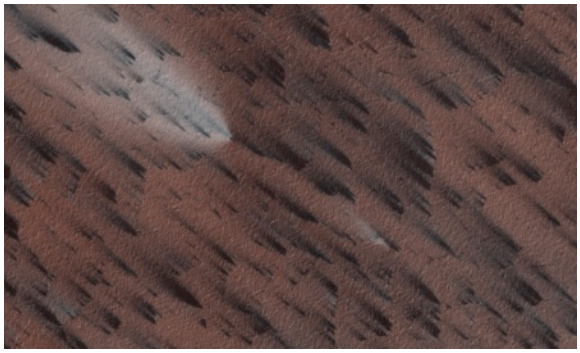

Figure 1: Fans in HiRISE image ESP_011960_0925, acquired at 87.3S / 167.8E.

2. Planet Four Project

2.1 Science Goals

The science goals enabled by cataloging fans fall into two categories:

1. Extend our understanding of the sublimation process and its efficacy as an agent of change on the martian surface. The number of fans as a function of time record sublimation activity while the overlying ice thickness and insolation change during the season. The areal coverage of the fans allows us

(with reasonable assumptions about particle size) to estimate the amount of material eroded from the surface on seasonal timescales.

2. Enhance our understanding of spring winds and global circulation models. Fans provide a snapshot in time of wind direction and speed. Changes in the orientation of the fans records changes in wind direction. These markers can be compared to predictions from global circulation models.

2.2 The Citizen Scientist Tasks

HiRISE images are large, typically several Gb. High quality images first from the second and third spring seasons imaged, then from the first spring, were selected. These were subdivided into cutouts that are manageable by web-browsers. The sub-images were then served up on the Planet Four website. Once 100 volunteers have classified fans in a sub-image it is considered finished.

A tutorial on the website walks the volunteer through the process of identifying and measuring fans. The citizen scientist is provided with tools to locate and outline the fans, shown in Figure 2. Sometimes the fan has an indeterminate direction, in which case it is identified as a blotch. Although less useful for wind regime studies the blotches are sites where the ice has ruptured and released material, so they are important to goal #1.

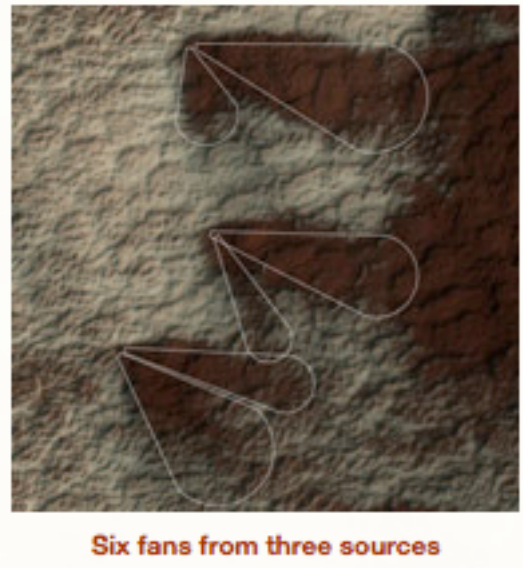

Figure 2. Example of fan tool from the Planet Four tutorial

3. The Planet Four Community

One of the most rewarding aspects of undertaking a citizen science project is to experience the warmth and enthusiasm of the community of eager amateur scientists. The Planet Four website has discussion boards, a blog, FAQs, and a place for introductions. Volunteer moderators keep the discussions going and answer straightforward questions. Behind the scenes the zooniverse technical staff keeps everything running.

4. Challenges and Results

We now have >5 million measurements of fans and blotches. The results from the individual classifiers will be combined, but how much do they agree with each other? How accurate are their measurements? This becomes a research project in its own right. Do their measurements vary with a Gaussian distribution? Do we pick a few experts and weight their measurements more? Do we need to define a sample set against which we can identify the more reliable volunteers? We are working now on how to filter the results and apply error bars. Then we will have a database of locations and physical properties of fans and blotches for 3 years in HiRISE images.

Acknowledgements

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References

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