CO_2 Jets and Wind Patterns on Mars

Chase Hatcher[1]; Michael Aye, PhD[2]; Ganna Portyankina, PhD[2]
[1]The University of North Carolina at Chapel Hill, [2]University of Colorado Boulder

What can we learn about Mars' weather from sediment deposits on its surface?

Dark markings appear on Mars' south pole in spring and summer as a result of geyser-like processes related to CO_2 sublimation. Some of these markings seem to be aligned in a specific direction, most likely due to wind, weather, or other physical processes.

Surface Features

- Martian poles are covered by a slab of transparent CO_2 ice every winter
- Dark substrate under the ice is heated by the sun, sublimates surrounding CO_2, building up pressure under the ice
- Ice cracks and a mix of gas and regolith spews out like a geyser and settles on the surface

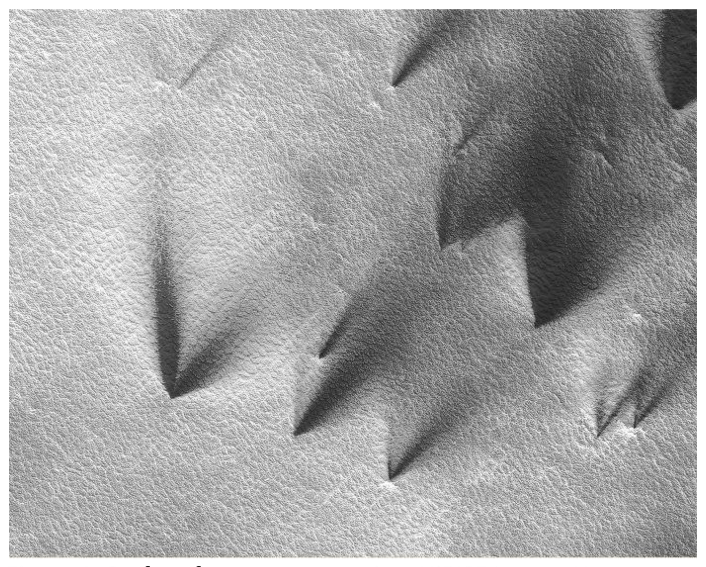

Figure 1: Surface features as seen in a HiRISE image. Here we can see two jets coming from the same point, in different directions. We believe this is due to vents re-sealing and erupting again later in the season.

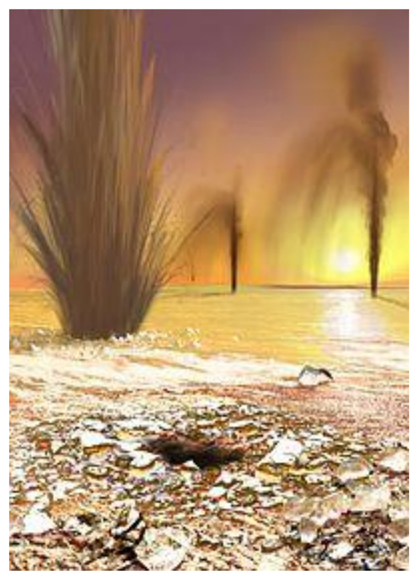

Figure 2: Artist's (Ron Miller) rendition of what the geysers might look like

Identifying Surface Features

We use a citizen science website called Planet Four to identify the markings on the surface. Users are shown a small section of a HiRISE image and asked to identify any markings as either blotches (ellipses) or fans (ice-cream cone shape). The responses of users are averaged and we are left with a dataframe of all the objects and their size, shape, orientation, and position.

Figure 3: A screenshot of the Planet Four user interface. A blotch is marked on the left, a fan is being marked on the right

Lengths and Areas Over Time

- For objects identified as fans, fan length is proportional to wind strength and the amount of material that was released from the ice
- For objects identified as blotches, blotch area is related to the amount of material released from the ice as a jet and jet physics

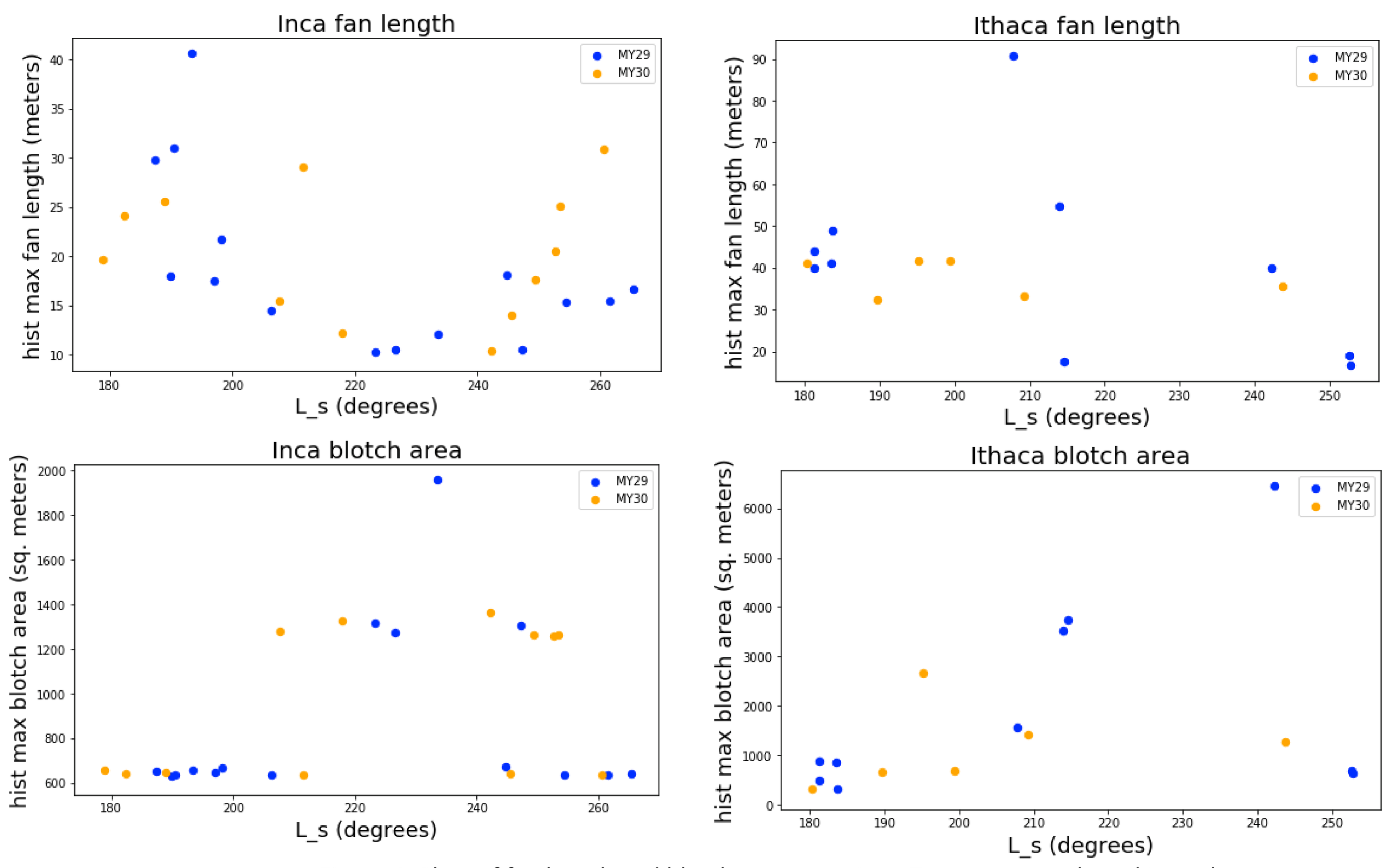

Figure 4: Plots of fan length and blotch area over time. Two years are plotted in each.

Coverage Over Time

- Total area covered by dark sediment deposits relates to the jet activity of a region
- Sediment coverage changes the way a region absorbs sunlight, influencing local weather
- Using shapely to represent the markings as polygons, we then calculate the union of all the objects in an image
- Union represents the total unique area covered by jet deposits

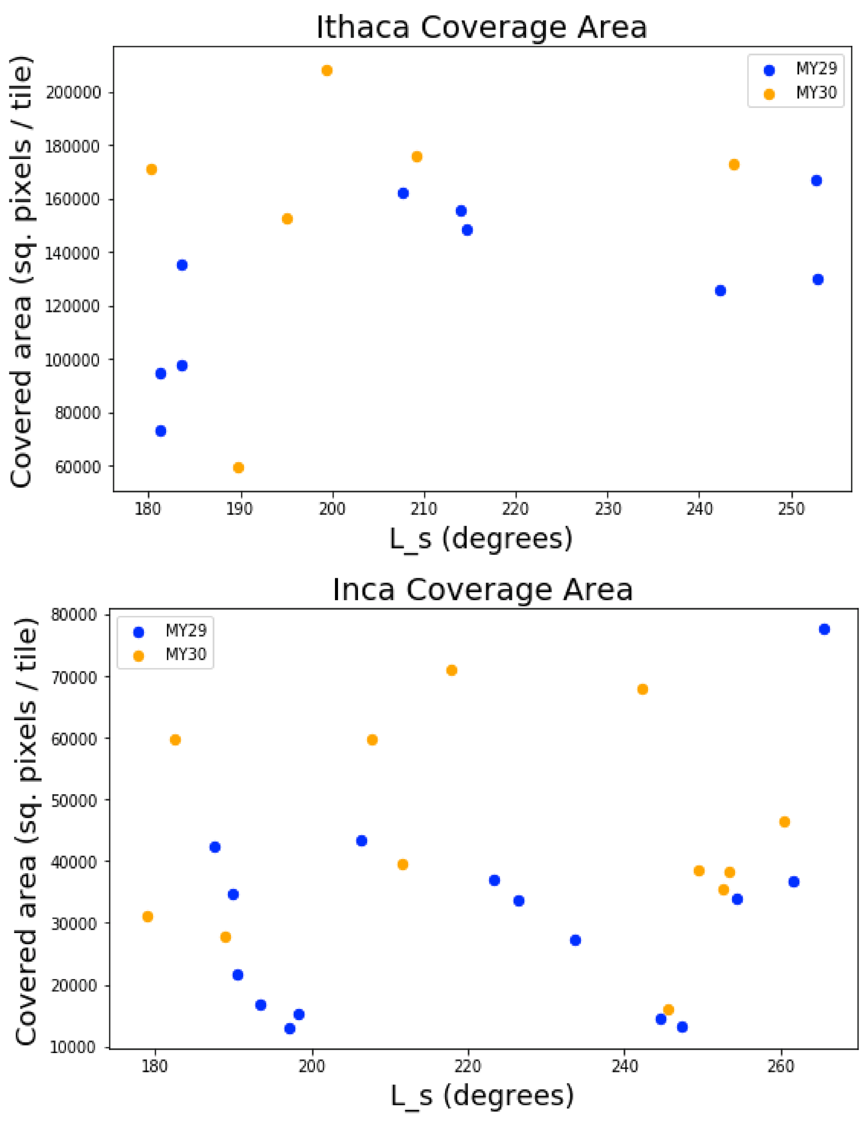

Figure 5: Plots of covered area per tile considered over time

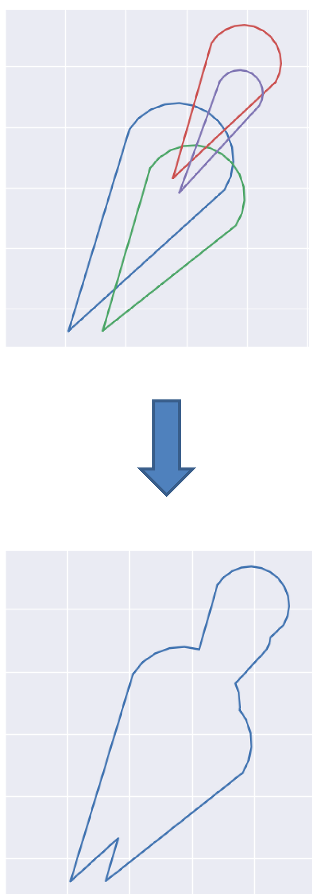

Figure 6: On the left is a collection of objects rendered as polygons in shapely. On the right is the union of those objects.

Machine Learning

- We are in the process of creating a machine learning procedure to identify surface features automatically
- Difficult because each object must have type, size, shape, and orientation labeled
- A Mask R-CNN is the best procedure to use
- Can identify different types of objects in the same image (fans and blotches)
- Can identify each pixel included in each object (giving size, shape, orientation)

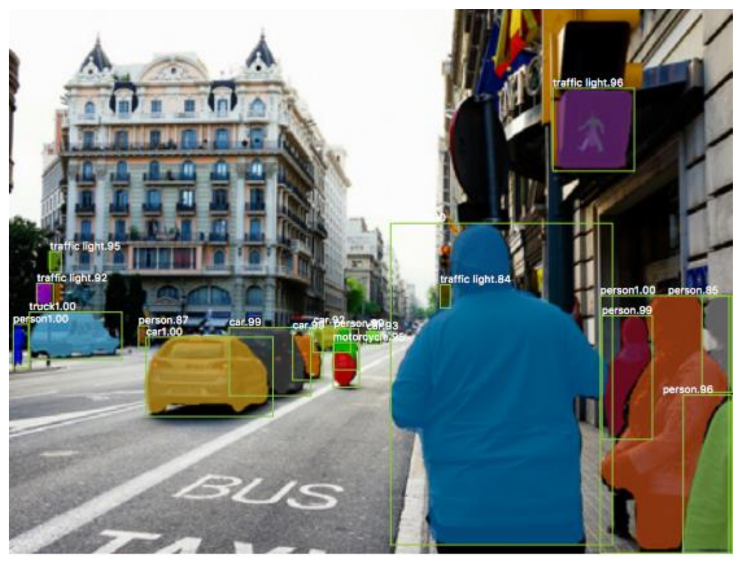

Figure 7: The output of a Mask R-CNN. Different objects are identified spatially in the same photo

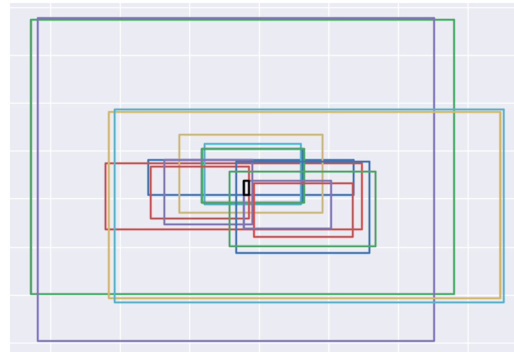

Figure 8: Outlines of HiRISE images of Ithaca, section of most image overlap outlined in black

Discussion

Citizen Science requires a certain amount of clean-up, removing objects that don't meet quality criteria.
Other filtering occurs due to differing instrument observation modes that would otherwise skew the results.
A further complication is that most observations do not overlap completely. This work resulted in significant progress in that it facilitates the comparison of data that actually covers the same ground area. We do this so that trends are analyzed in the exact same place on Mars, not just the same general region. Without highly accurate models of sublimation, jet eruption, and weather on Mars it is difficult to determine exactly which physical processes are causing the trends we see in the data, but we are still able to make general conclusions.

Conclusions

- We see similar trends in the first and second survey years in most plots, so we conclude that the combination of jet physics and weather is a stable, yearly-repeating process
- Ithaca always has larger fans and blotches and more coverage than Inca. Inca has a much different topography than Ithaca, which is why we conclude that topography affects the jet eruption and dispersion process in Inca, probably slowing it
- Blotches tend to be less numerous than fans in both regions, so we conclude that wind is active and is an important factor in determining deposit shape
- Jumps in coverage area may be due to reciprocating relationship between ground covered by dark, heat-absorbing sediment and local weather

Contact

Chase Hatcher
Email: chatcher@live.unc.edu

Acknowledgments

- Thank you to Dr. Martin Snow and everyone in the LASP Summer 2017 REU program
- Thank you to the National Science Foundation for funding the project
- This project was made possible through the use of open source software and programs