CO_2 Sublimation and Wind Patterns on Mars
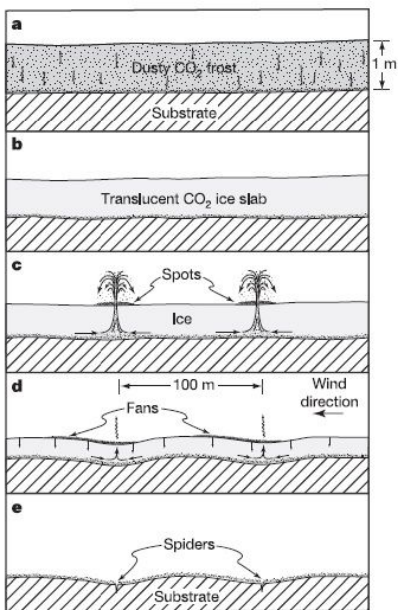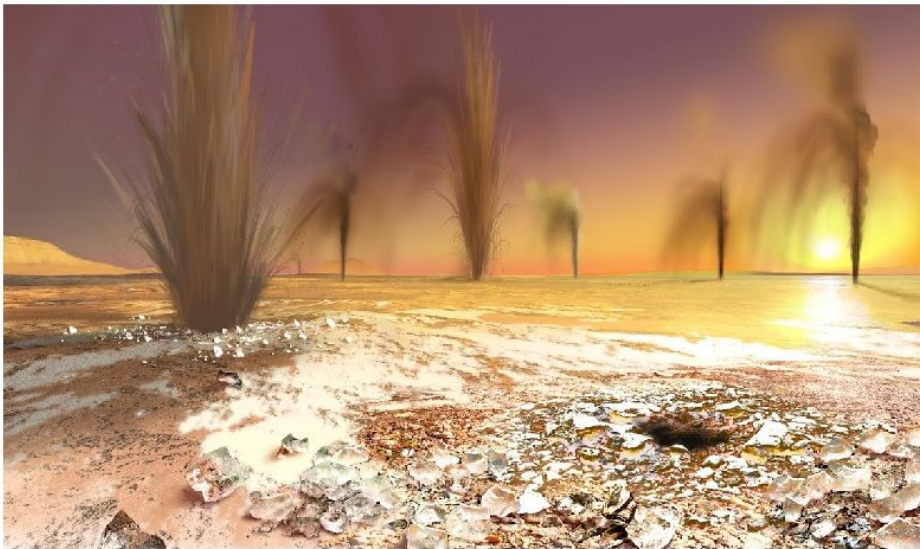
Chase Hatcher
Mentors: Dr. Michael Aye & Dr. Ganna Portyankina

Surface Features

- A layer of transparent CO2 ice up to one meter thick forms on Mars' poles in winter
- When the Sun returns in spring, dark substrate under the ice is heated faster than the surrounding ice and CO2 sublimes around it
- Pressure builds under the ice until it eventually breaks


Keiffer et al. 2006

Artist: Ron Miller

Surface Features

- The regolith and CO_2 mixture escapes through the break and spews out like a geyser
- The sediment settles back onto the surface, visible against the ice
- The deposit of sediment is pointed in a fan like shape in some cases, indicating that wind and/or other forces are directing it
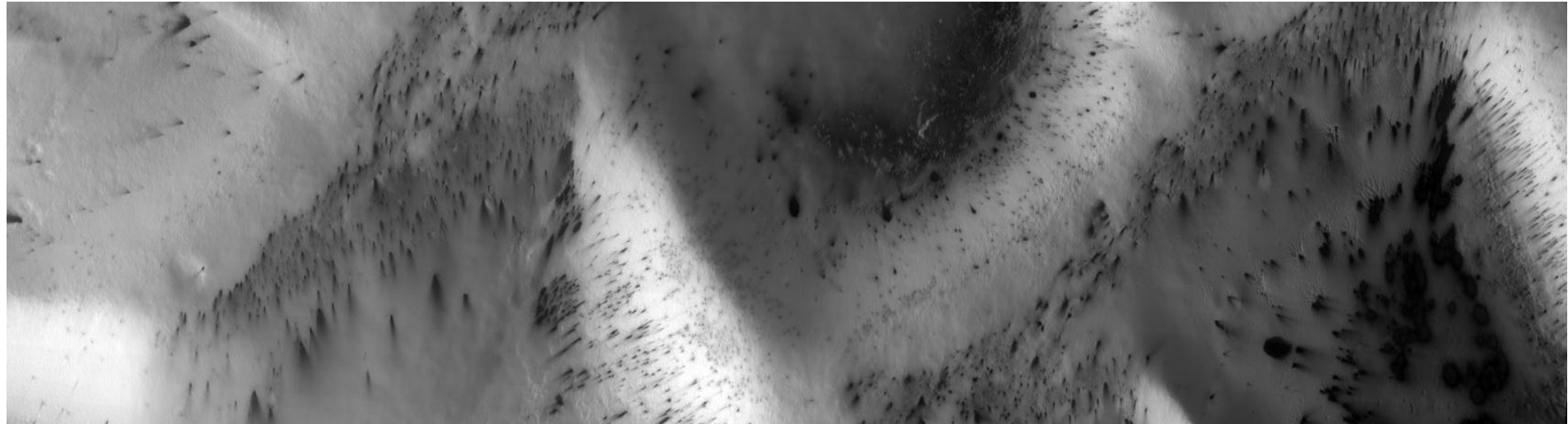
HiRISE Images

- HiRISE is a camera on board the MRO
- Takes images of Mars' surface
- Repeatedly takes images of particularly active regions, all slightly different
- The regions of interest are (informally) called Inca City, Ithaca, Manhattan, and Giza
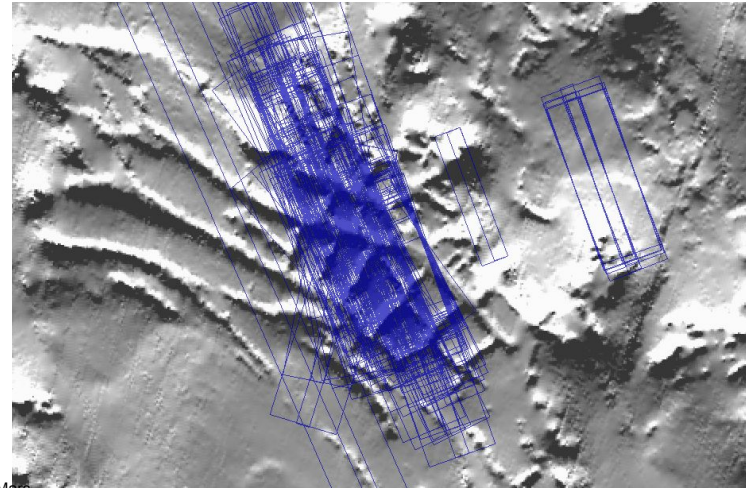
Inca City; photos from JMars

Identification of Features Using Planet Four

- HiRISE images are split up into smaller tiles and shown to Planet Four users
- The users identify blotches or fans on the surface, using a tool to mark shape, size, location, and direction


Taken from www.planetfour.org

Planet Four

- Planet Four tiles look very different
- Objects appear differently and against different backgrounds in every tile
- Color chosen to maximize contrast

Taken from www.planetfour.org
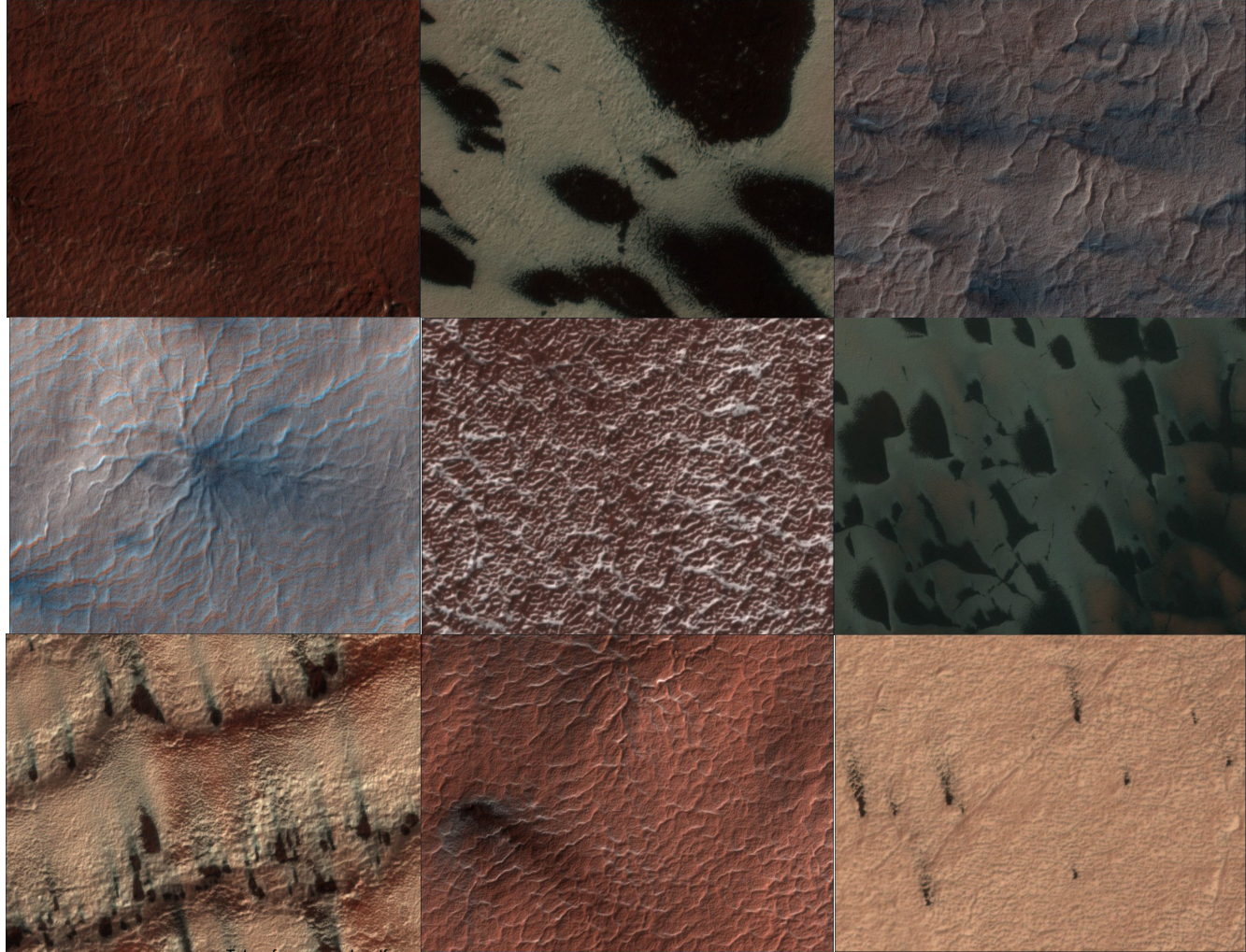
Cleaning the Data

- A pipeline is used to clean, average, and geo-locate the data
- Objects below a minimum size are removed
- Shapely is used to find the region of Mars most covered by the HiRISE camera

ROI: Ithaca
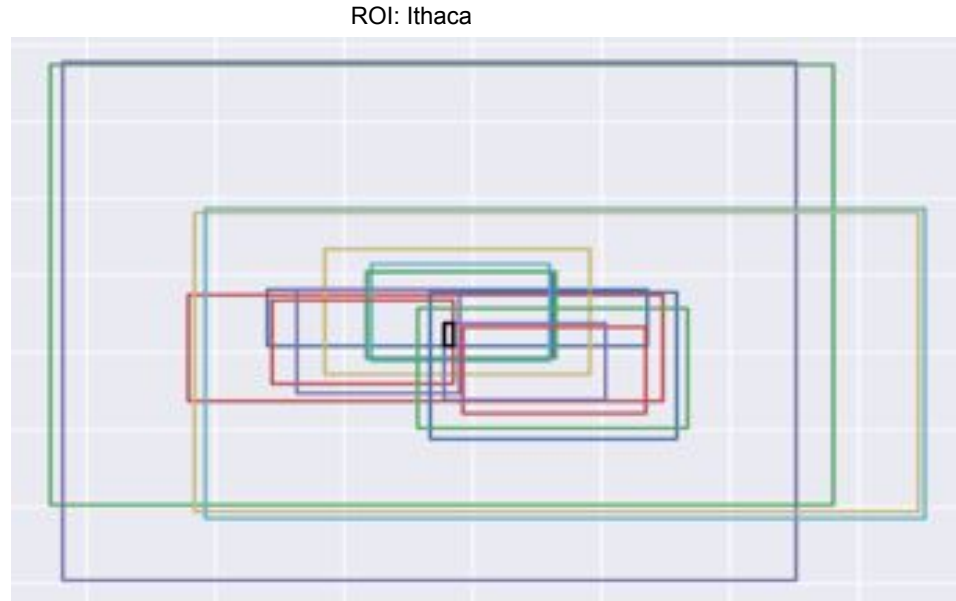
Fan Lengths

- Fan length distributions follow a Weibull fit
- Most fans are on the shorter side
- One tail extends into longer fan range

Plot made by Dr. Portyankina
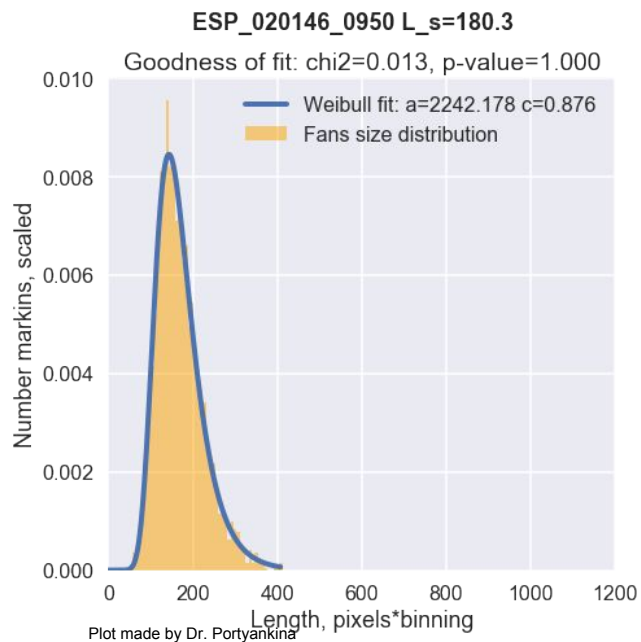

M07-01830 (Mars Orbiter Camera)

Fan Lengths

- Fan length is determined by wind, gravity, and/or eruption strength and direction
- Ithaca has longer fans than Inca
- Both seasons exhibit some similar trends in each region
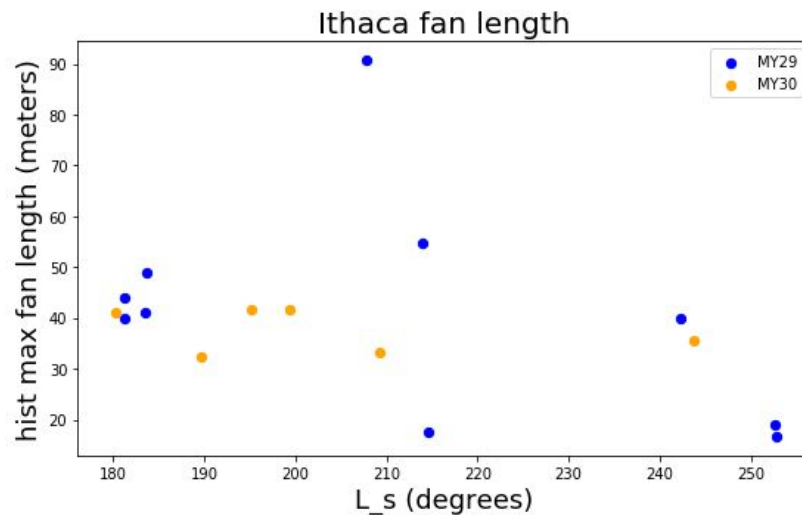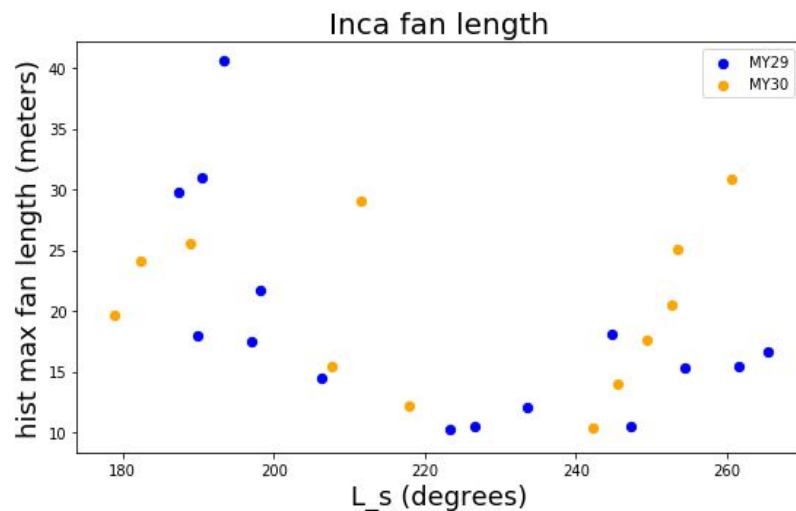
Blotch Area

- Blotch area determined by jet physics and eruption size
- Both regions have a jump in blotch area from L_s = 210 - 220
- Similar trends in both seasons, especially in Inca City
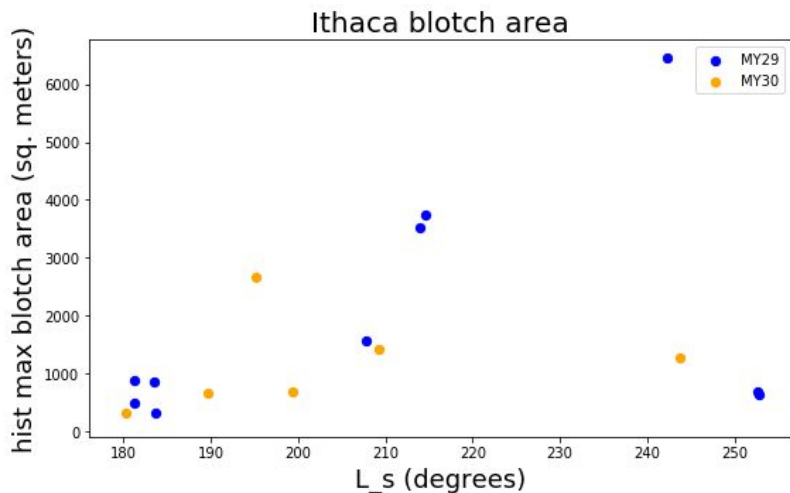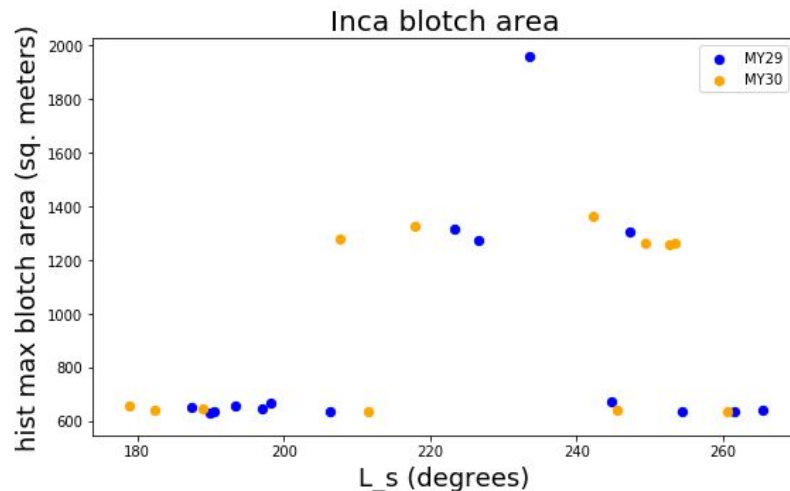
Covered Area

- Martian surface area which is covered by one or more sediment deposits
- We don't want to count overlapping objects multiple times in area calculation
- Use Shapely to calculate unions
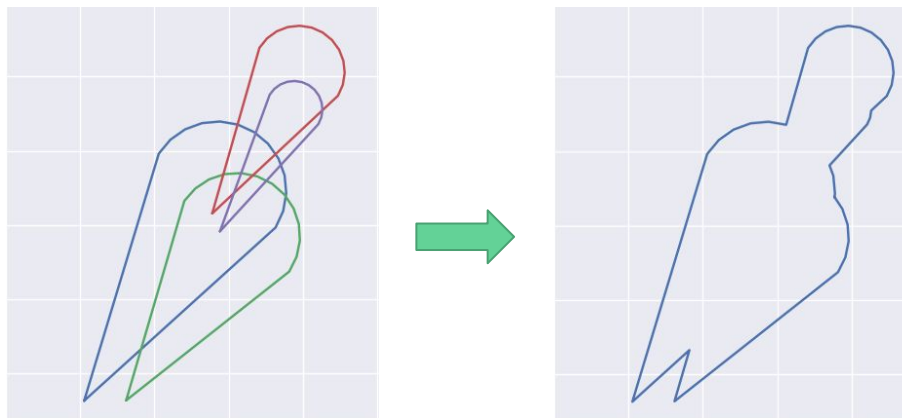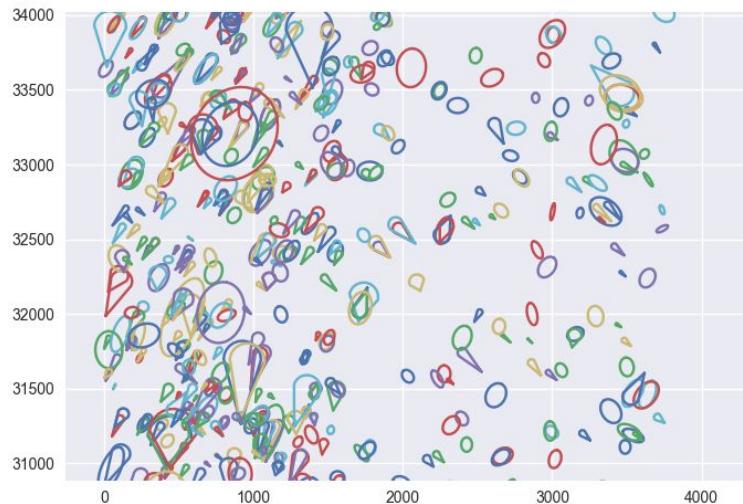
Covered Area

- Covered area is related to sublimation activity in a region
- Depends on how much sediment, how close the eruptions are, and how the ice breaks
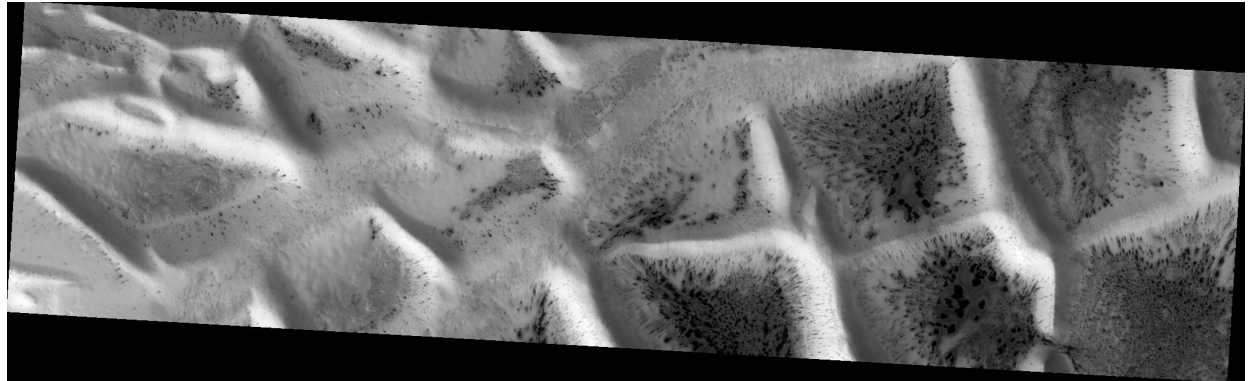- Wind and gravity may have an effect
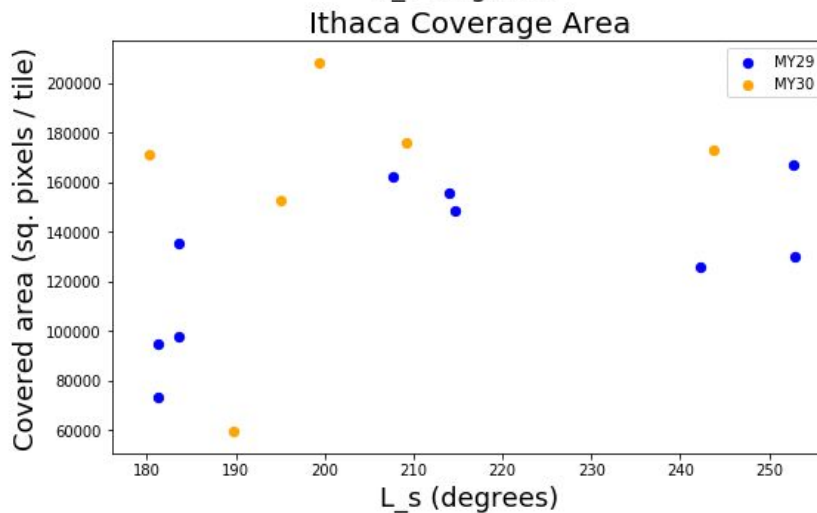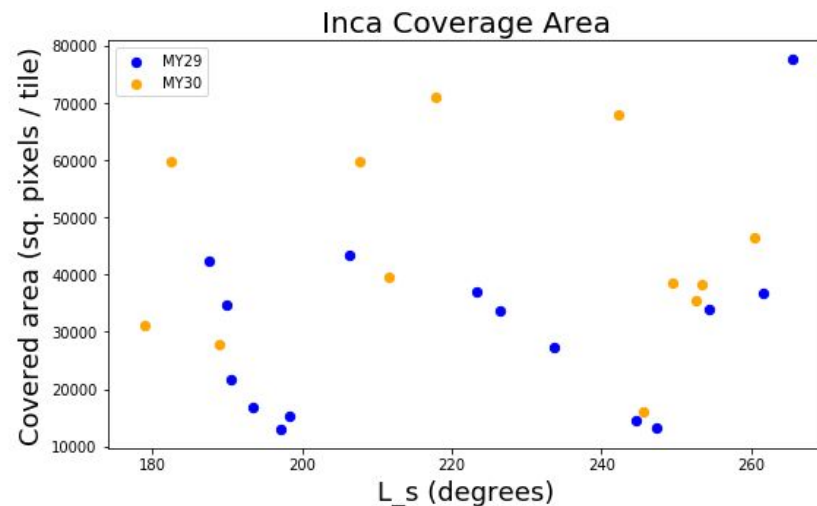
Covered Area

- The dark sediment has a different albedo than the ice
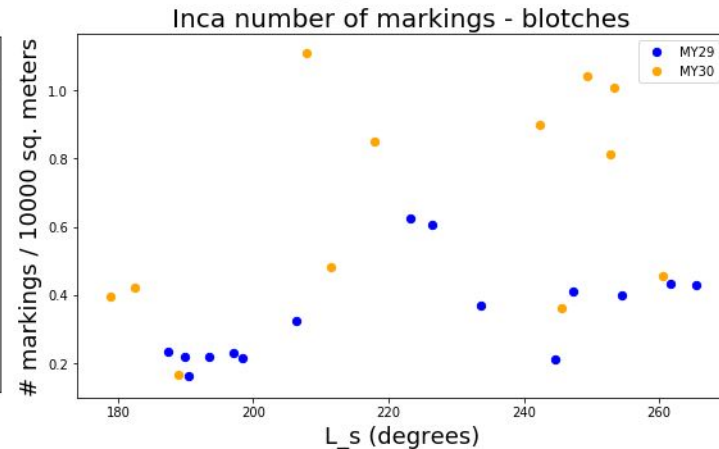- Coverage will affect weather in that area
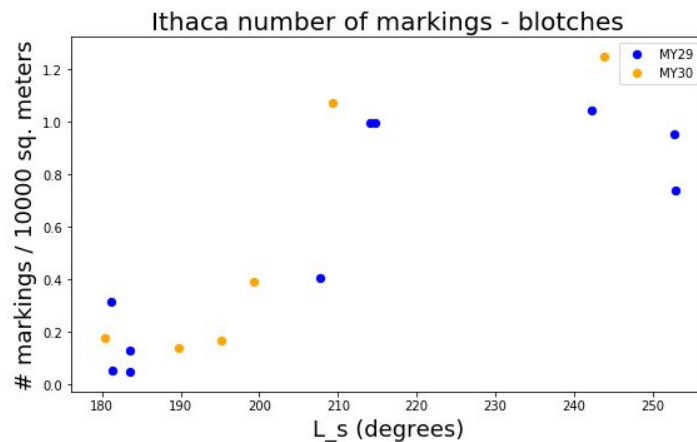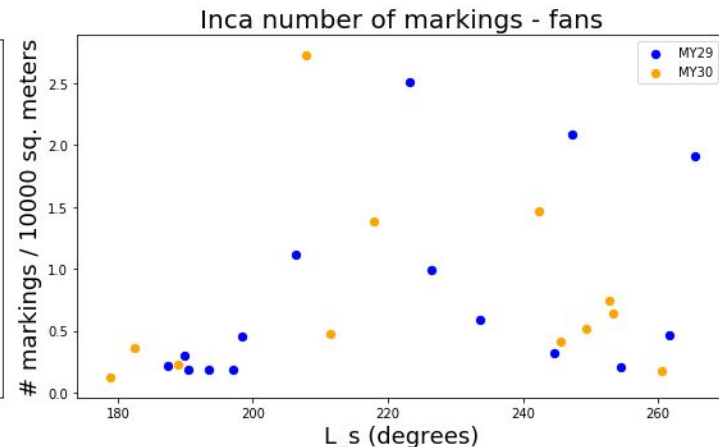- Atmosphere and weather then affect the jet eruptions
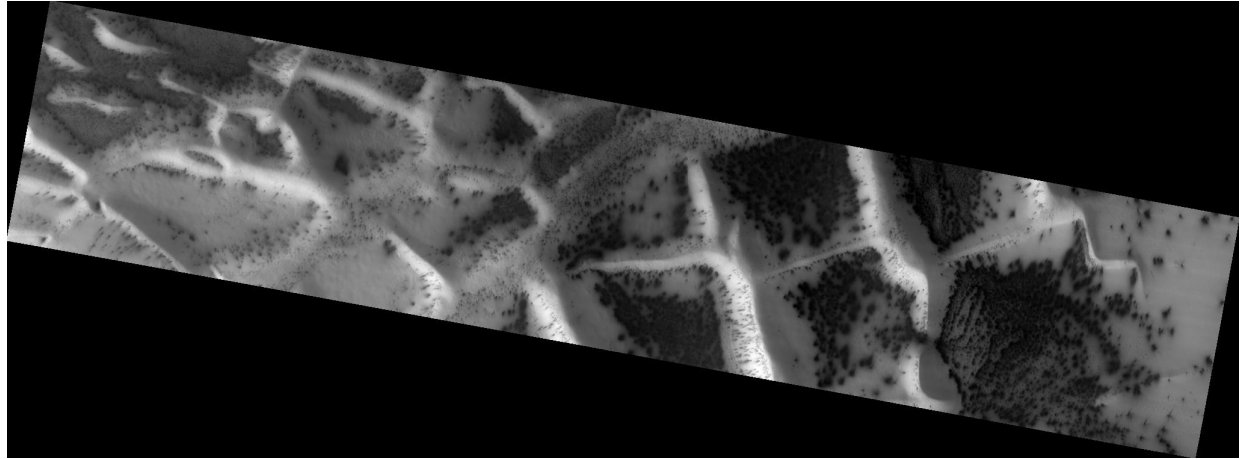
ESP_020339_0985

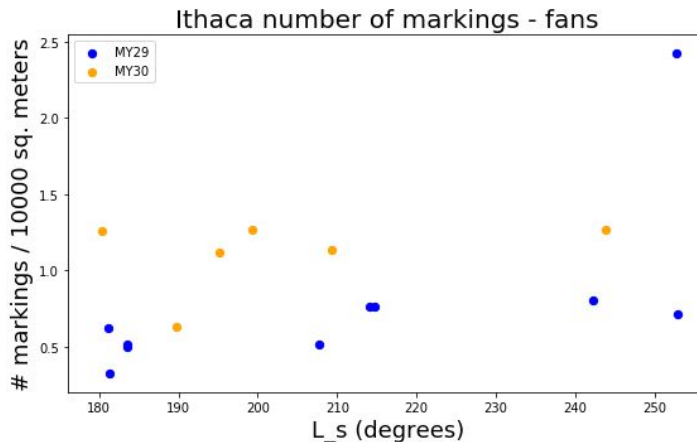ESP_021526_0985

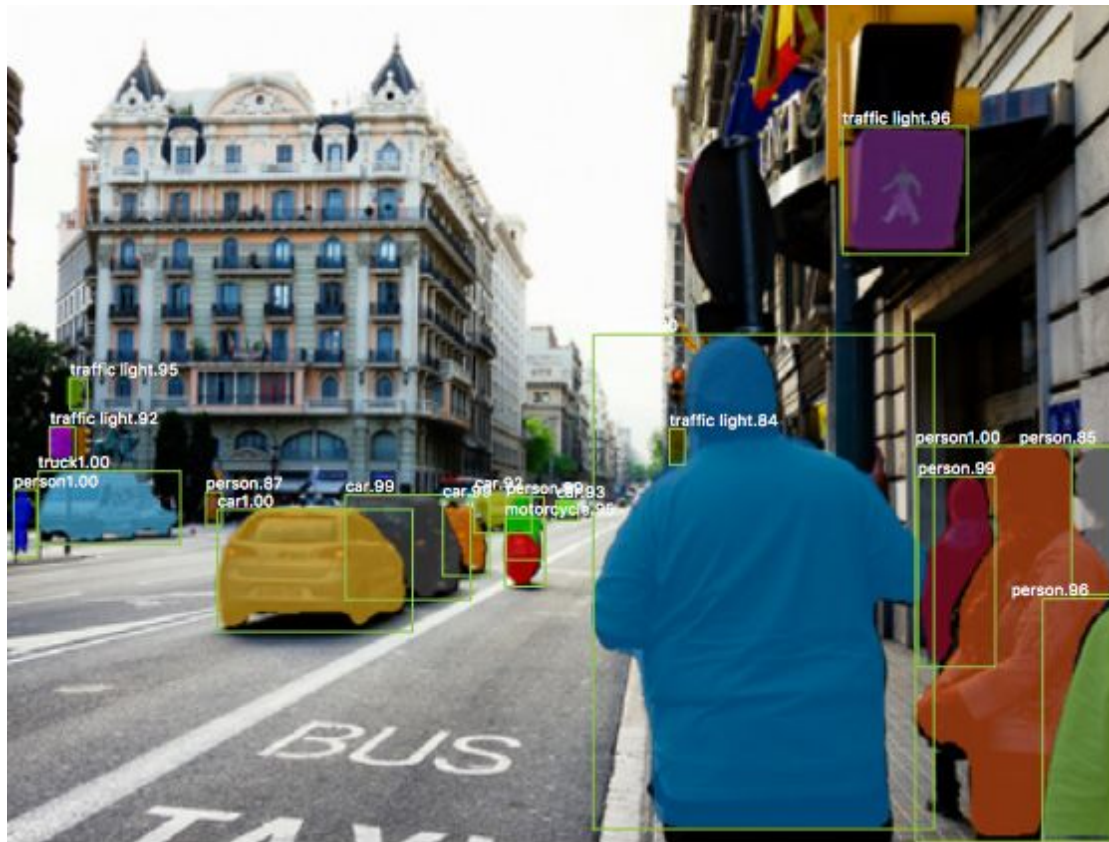# Number of Markings

- Similar to coverage, depends more on how ice breaks
- Fewer blotches than fans in both regions
- Both seasons similar in Ithaca

Machine Learning

- We are in the process of creating a machine learning procedure to identify the surface features
- The nature of the markings requires robust computer vision
- A Mask R-CNN is our best option

He et al. 2017

Mask R-CNN

- A mask regional convolutional neural network is able to identify different objects spatially in the same photo
- Looks at different regions of an image for single objects
- Iteratively improves prediction of object class, shrinks bounds of "box" containing object, and improves mask which specifies pixels belonging to that object

He et al. 2017
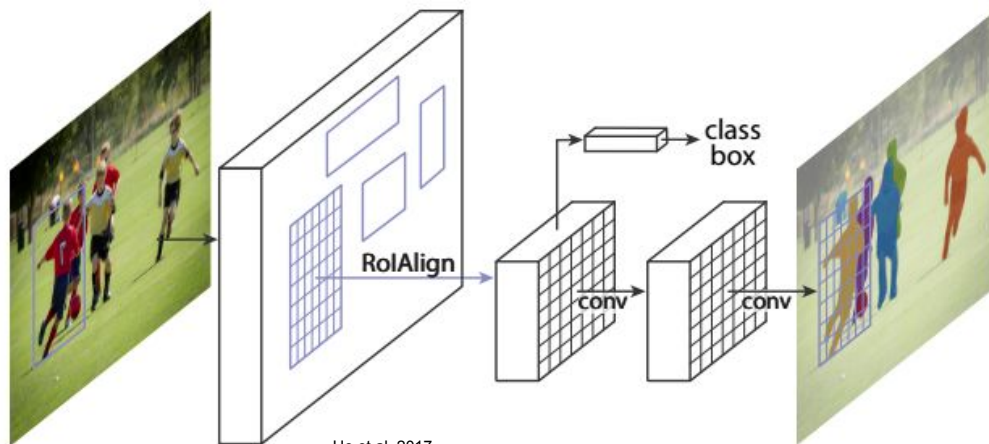
Conclusions

- 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

QUESTIONS ?