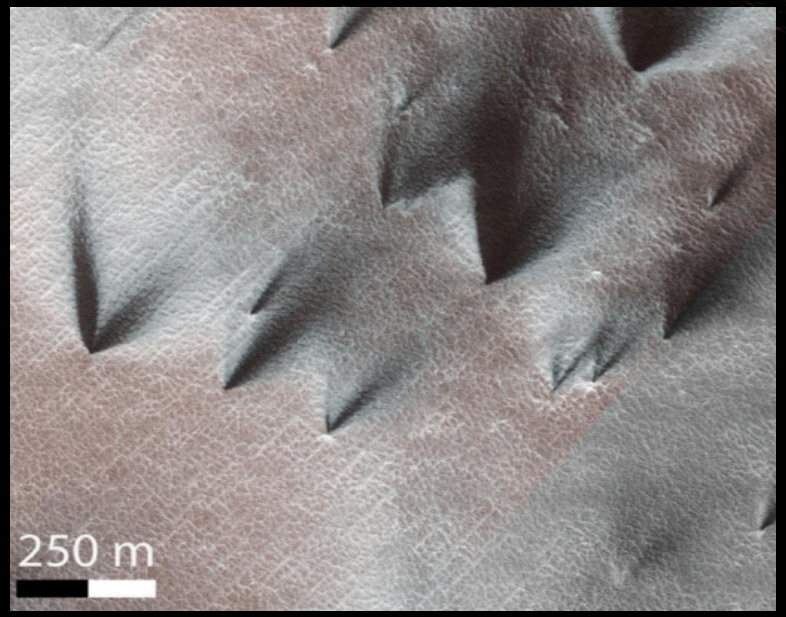
Planet Four: CO_2 jets formed by basal sublimation in Mars' southern polar regions

Shahad Badri

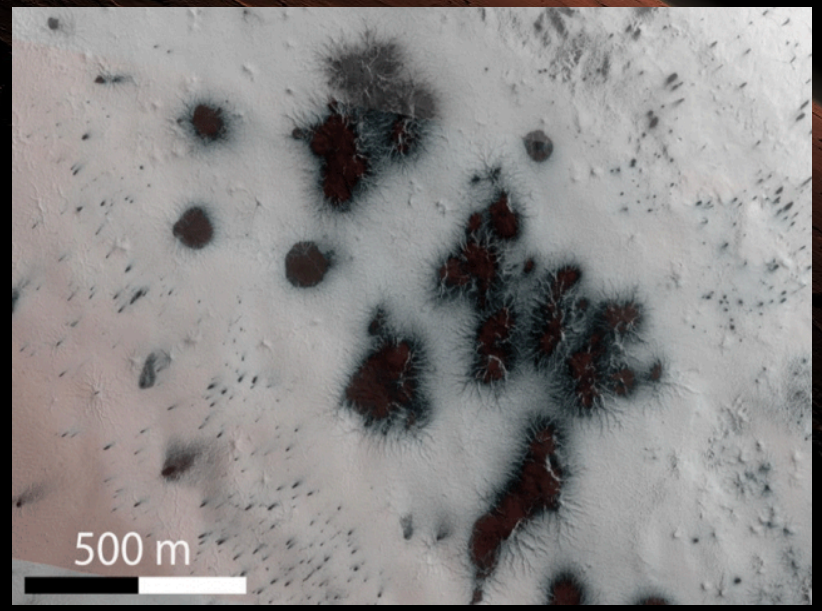
Mentors: Dr. Michael Aye, Dr. Ganna Portyankina

Mars southern seasonal polar CO_2 ice cap

Atmospheric CO_2 condenses → basal sublimation of the polar ice cap → gas jet erupts → deposits fans and blotches



Directed shape
Influenced by local winds and eruption physics



Elliptical shape
Influenced by eruption physics

The blotches:

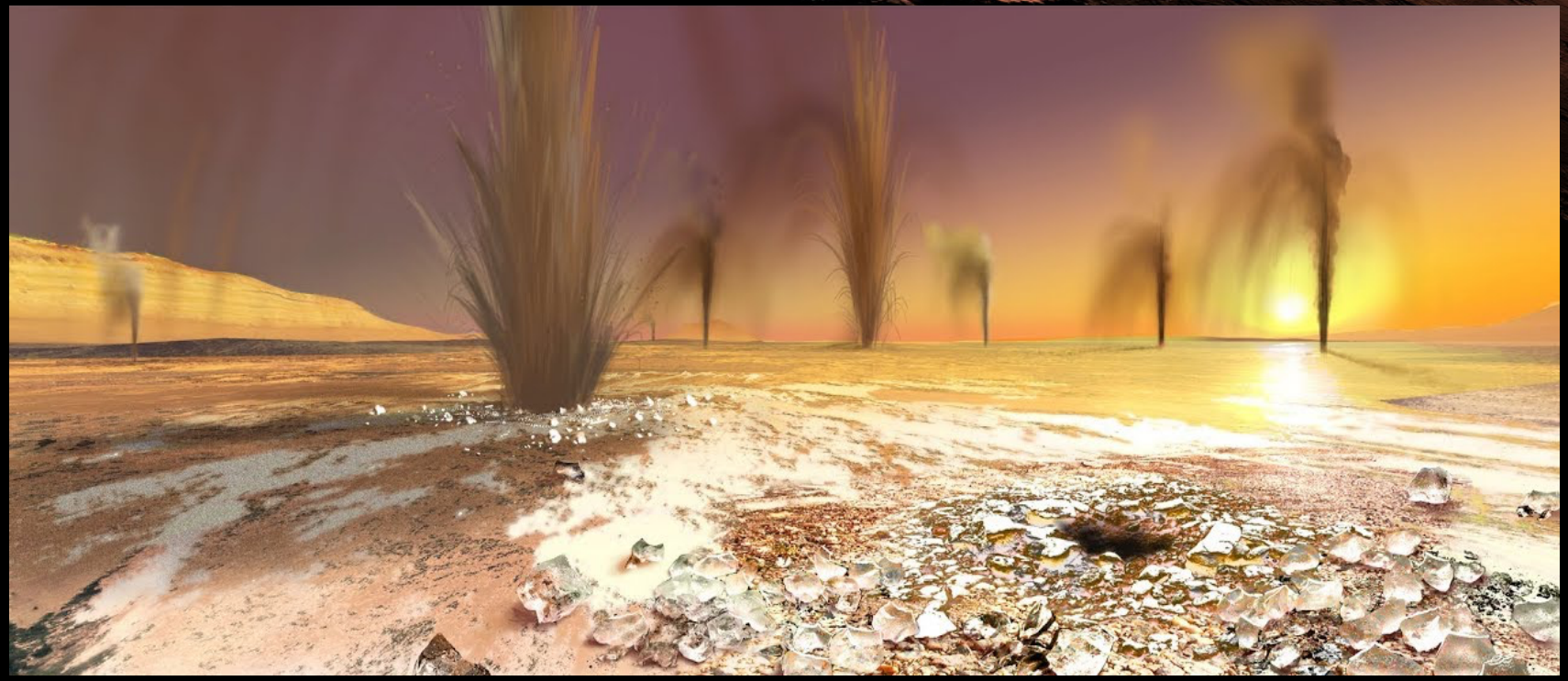
- Number
- Time history
- Area
- Eccentricity

Help us understand:

- sublimation and eruption process
- spring winds

Quantify the relationship between the timing of seasonal activity to global dust storm

Describe the physical appearance of the blotches in the most precise way so those descriptions can be used by models



Artist Ron Millers' concept showing CO_2 jets erupting from Martian geysers, published by NASA

Questions we want to answer:

- Hypothesis: deposits interact with ice

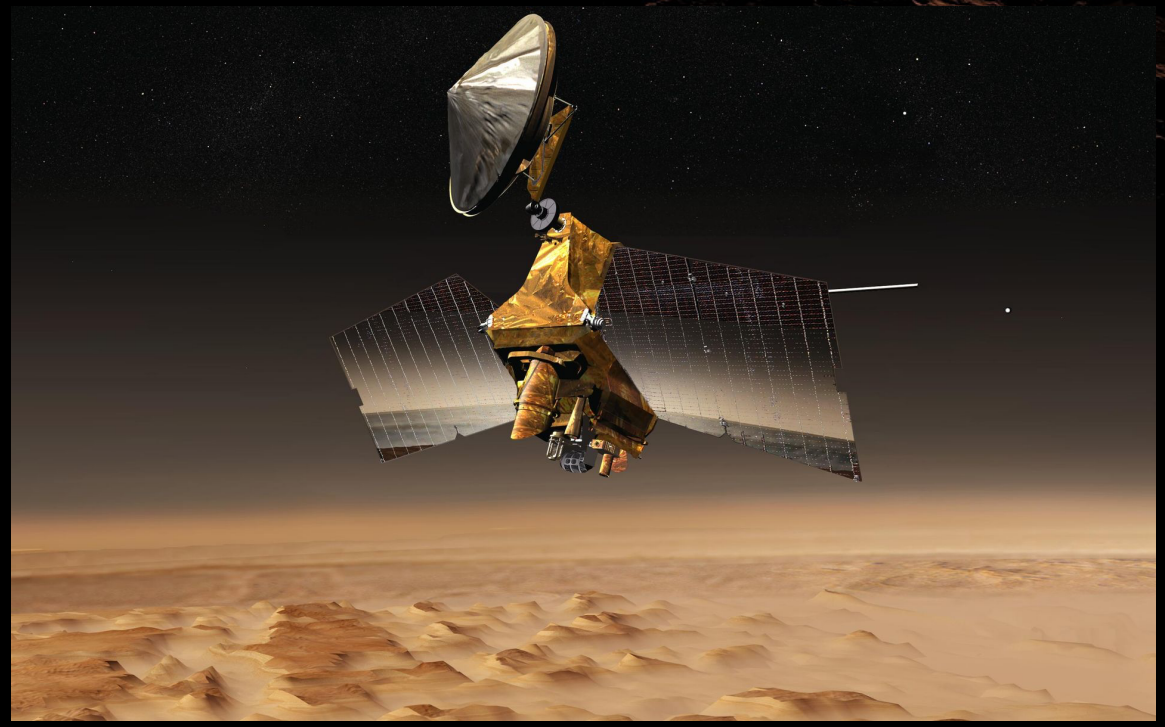
  Do blotches look different over time?

- Hypothesis: differences in CO_2 ice layer quality affect jet eruption physics

  Do blotches look different at the same time in different locations?

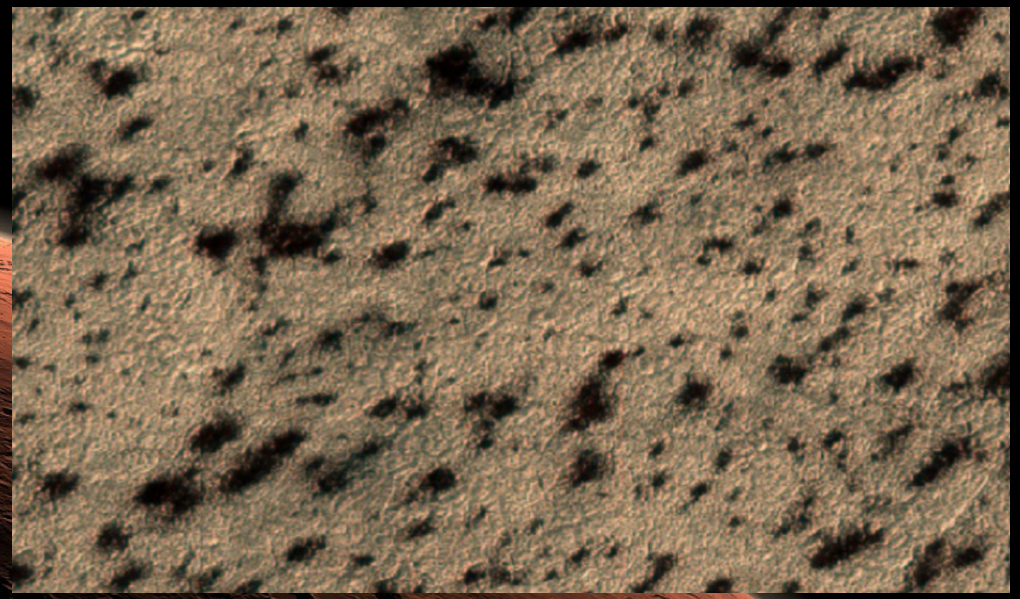
Mars Reconnaissance Orbiter's (MRO) High Resolution Imaging Science Experiment (HiRISE) camera

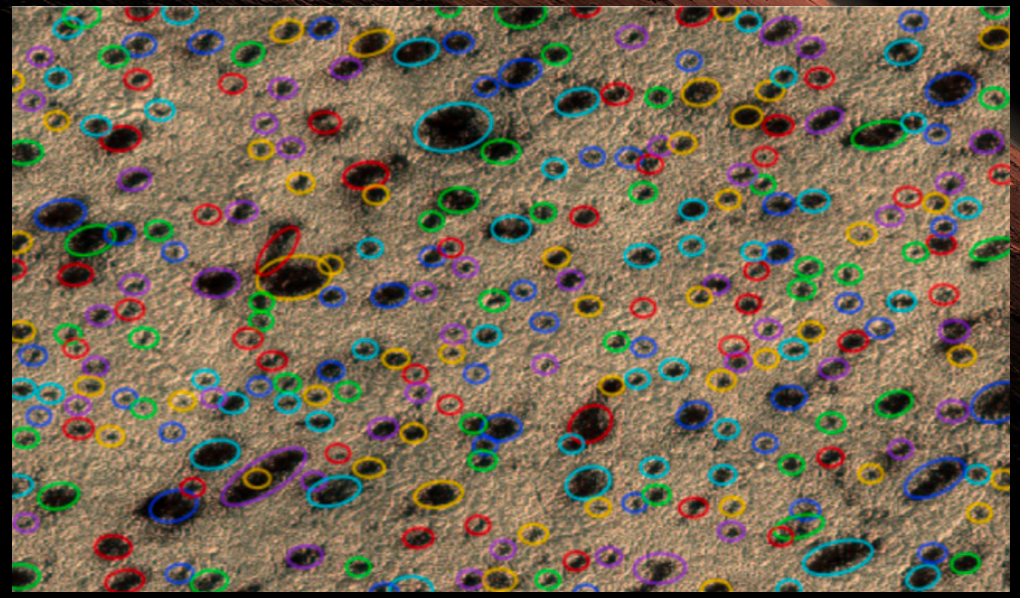
Data taken in southern spring during Mars Years 29 and 30 (2008-2009/2010-2011)



Planet Four catalog

- Online citizen science project
- Systematic mapping of shapes and sizes of blotches

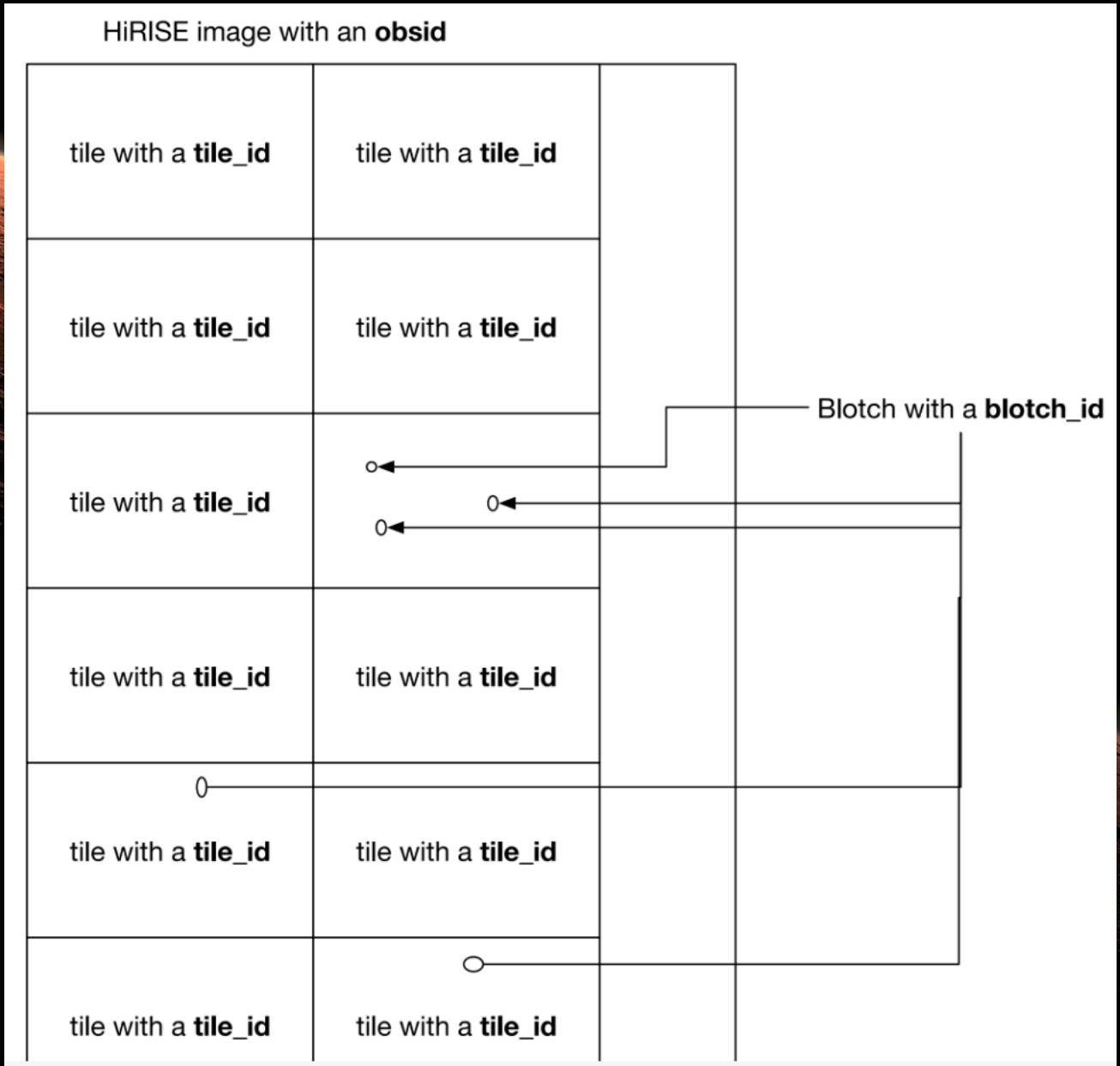


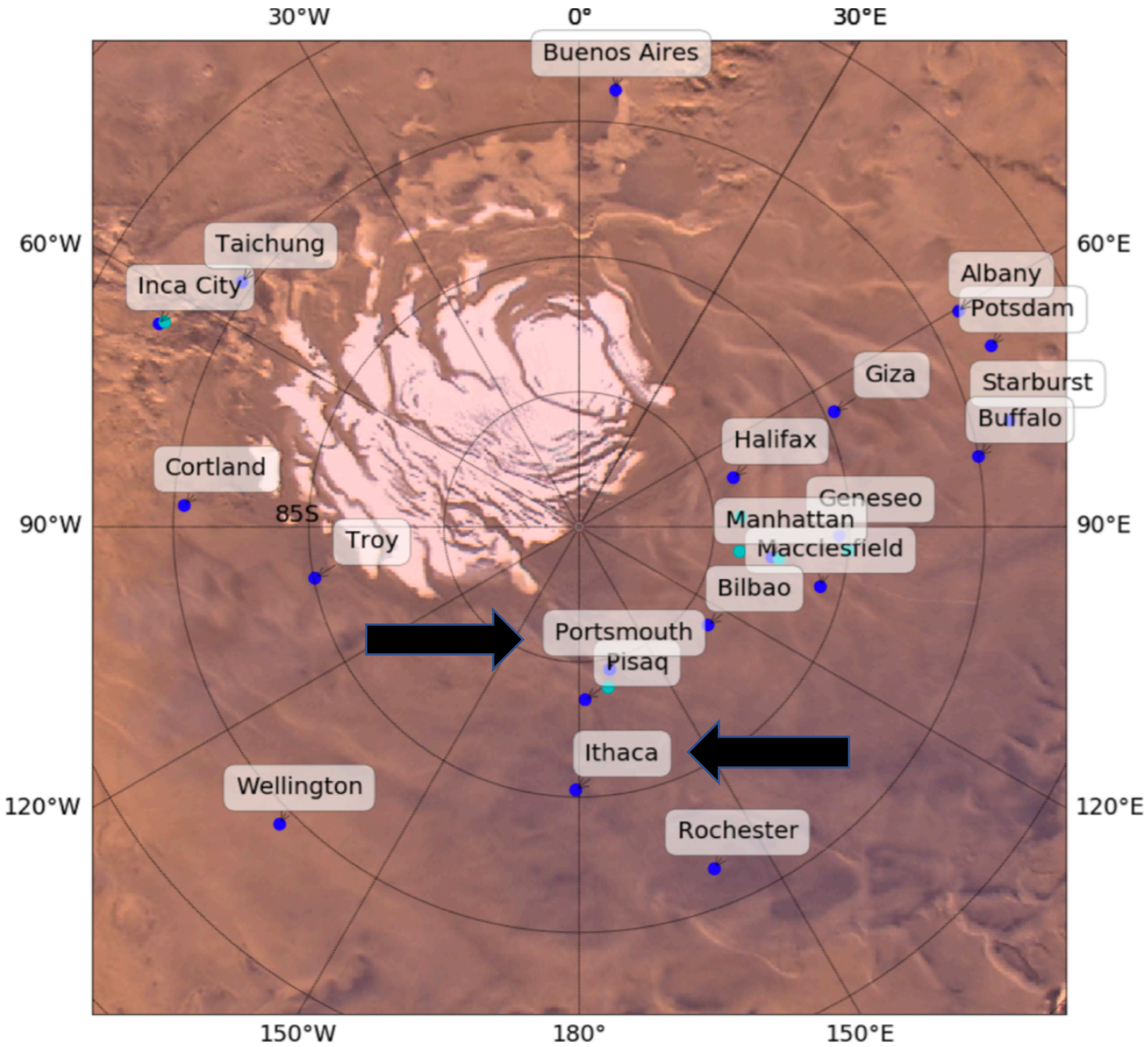


Aye, K.-M.,2019. Planet Four: Probing springtime winds on Mars by mapping the southern polar CO2 jet deposits. Icarus, 319, 558–598.

Planet Four catalog

- Each HiRISE image (obsid: ESP_020146_0950) is divided into sub-images called “tiles”
- Each tile_id contains many blotches



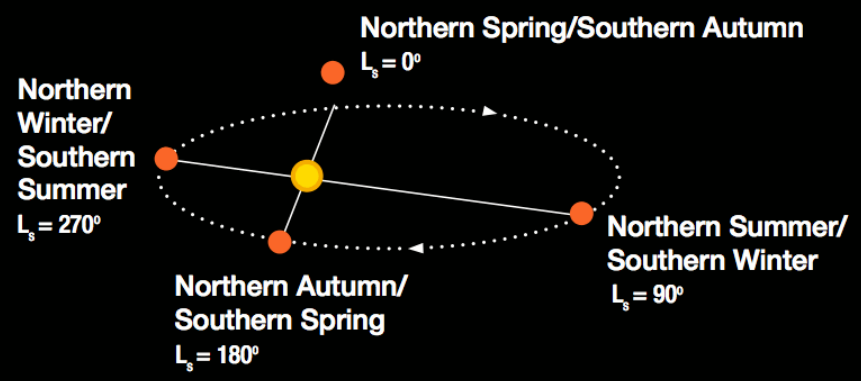


Map overview of the regions of interest in south polar region for the seasonal monitoring campaign of HiRISE.

- Ithaca
- Portsmouth
- Manhattan
- Oswego
- Starburst
- Giza
- Inca City
- Potsdam
- Buenos Aires
- Macclesfield

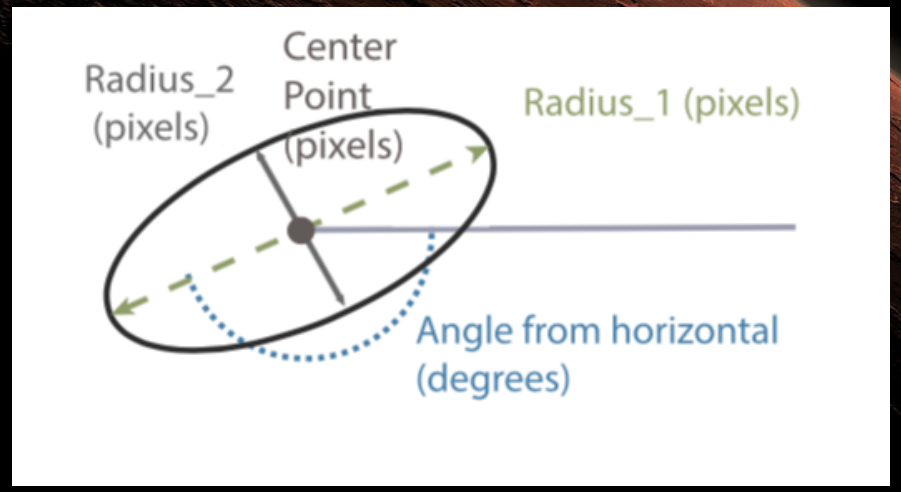
Measured parameters

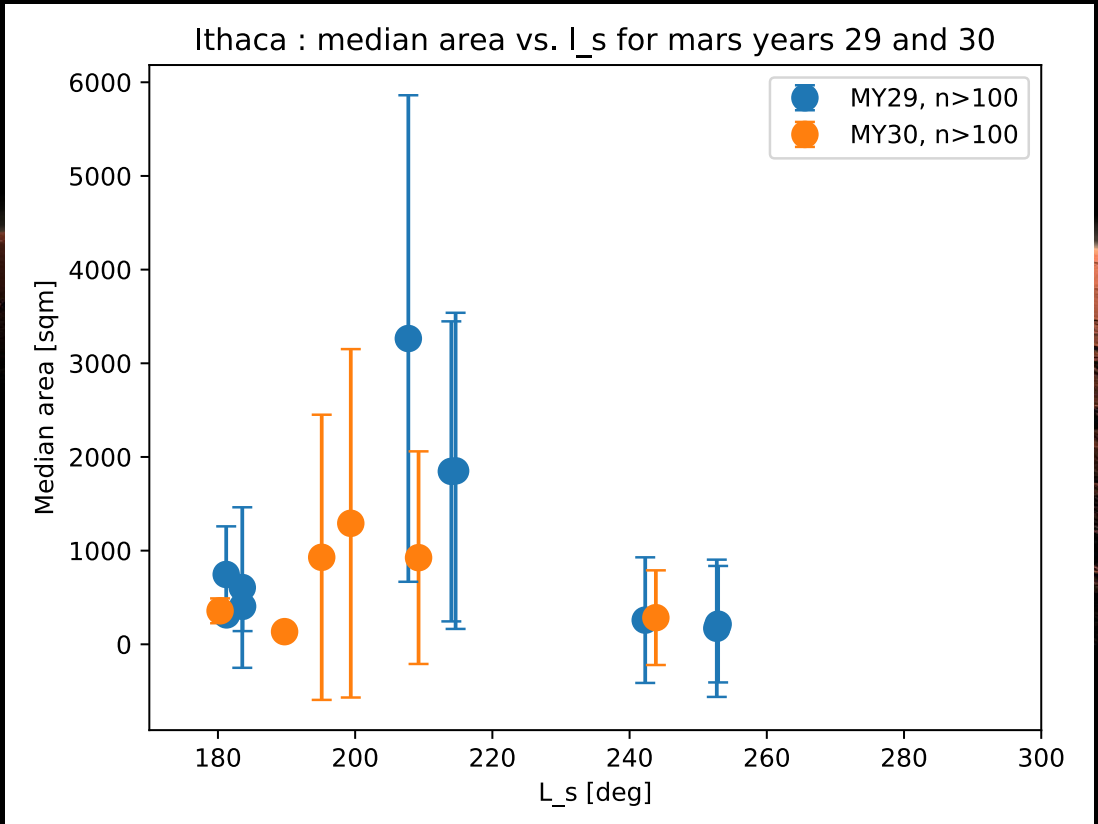
- Solar longitude (Ls) – Martian year divided into 360°. Southern spring starts at 180°

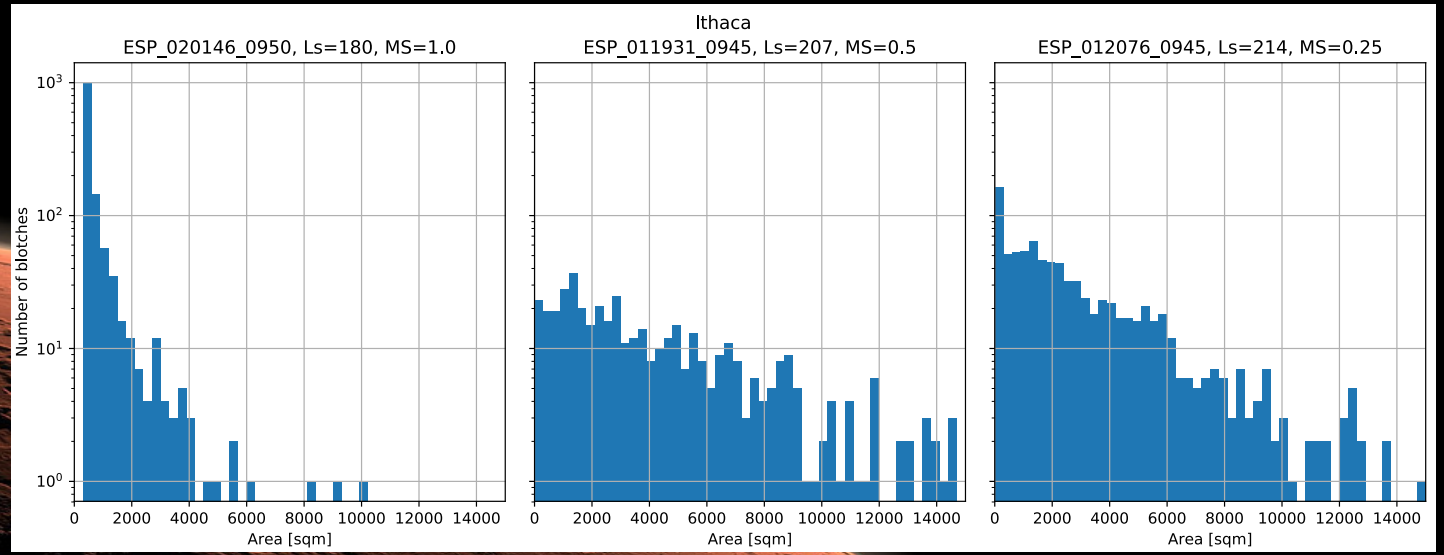


- Map scale (MS) – sampling size varies from HiRISE data

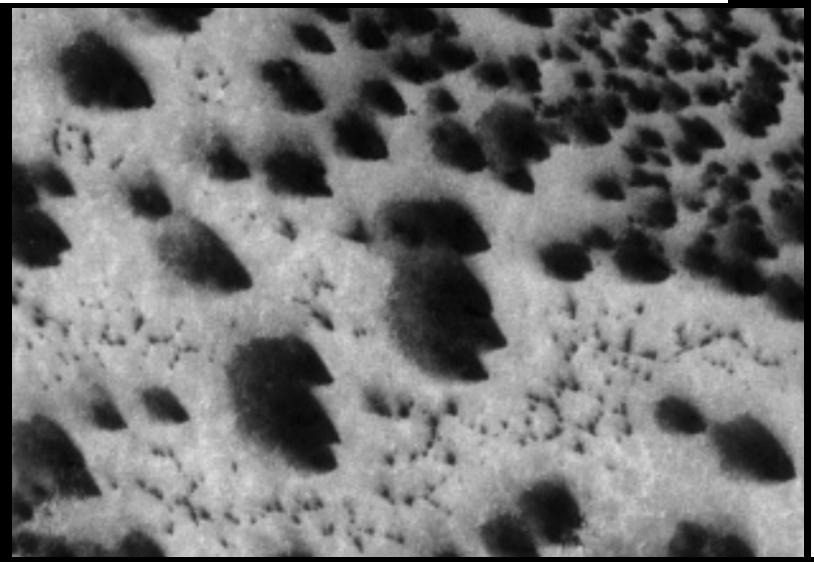
- Area = $\pi \times radius\_1 \times radius\_2$
- Eccentricity = $\sqrt{1 - \frac{(radius\ 2)^2}{(radius\ 1)^2}}$

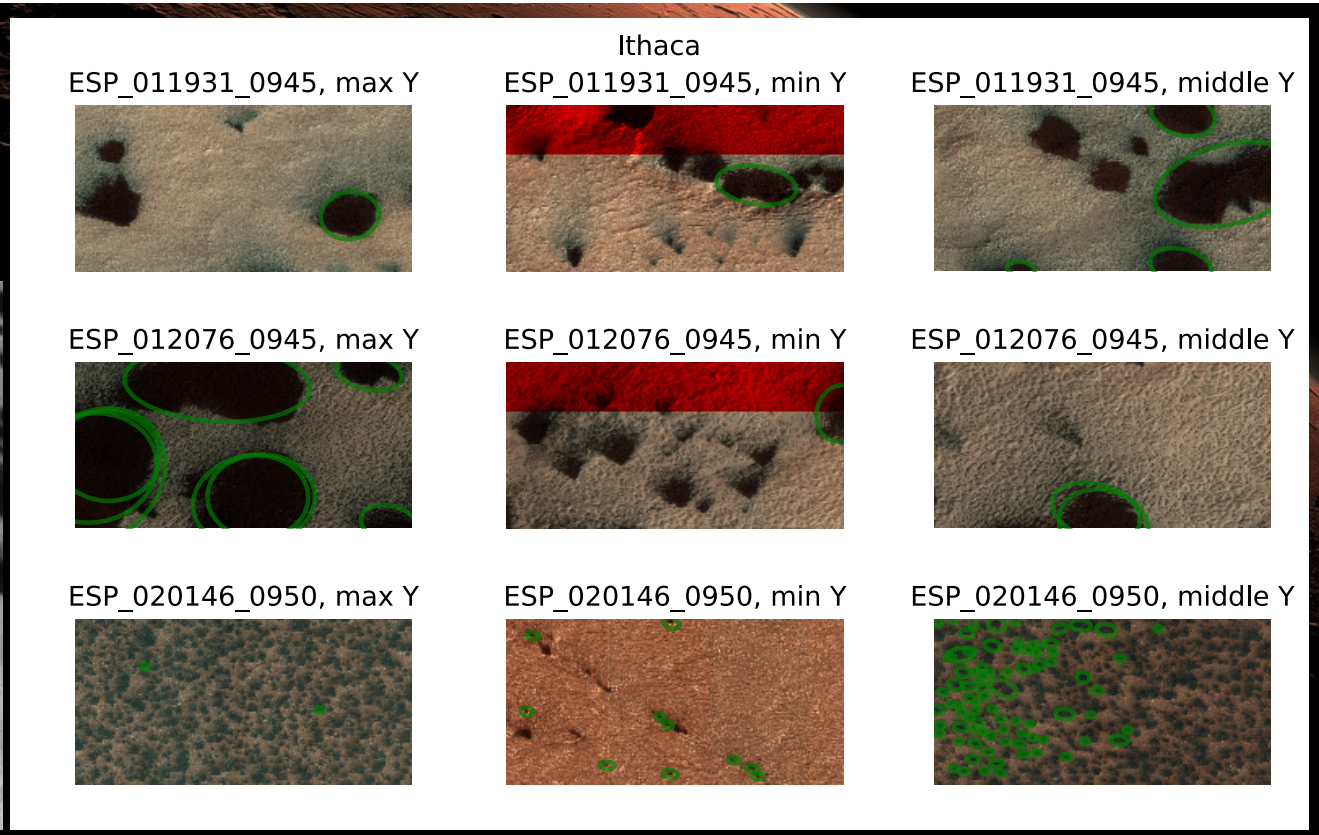


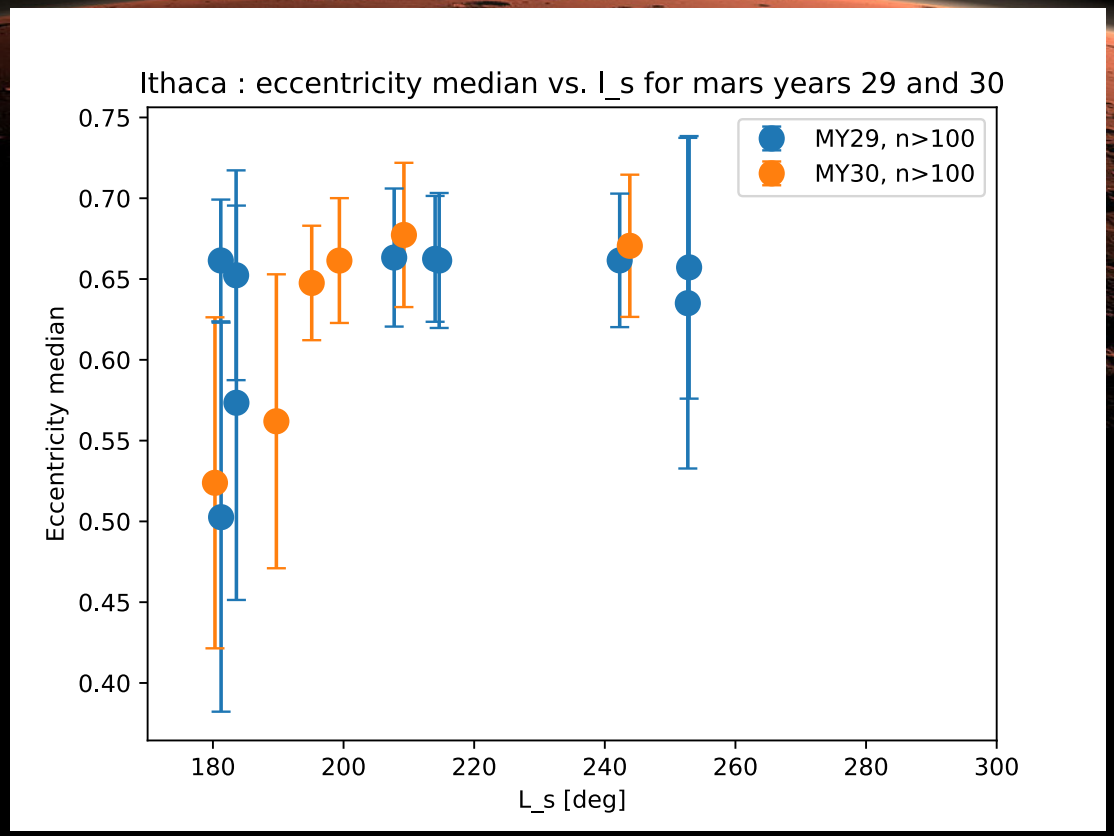

Ithaca : median area vs. l_s for mars years 29 and 30
MY29, n>100
MY30, n>100
Median area [sqm]
L_s [deg]
6000
5000
4000
3000
2000
1000
0
180
200
220
240
260
280
300

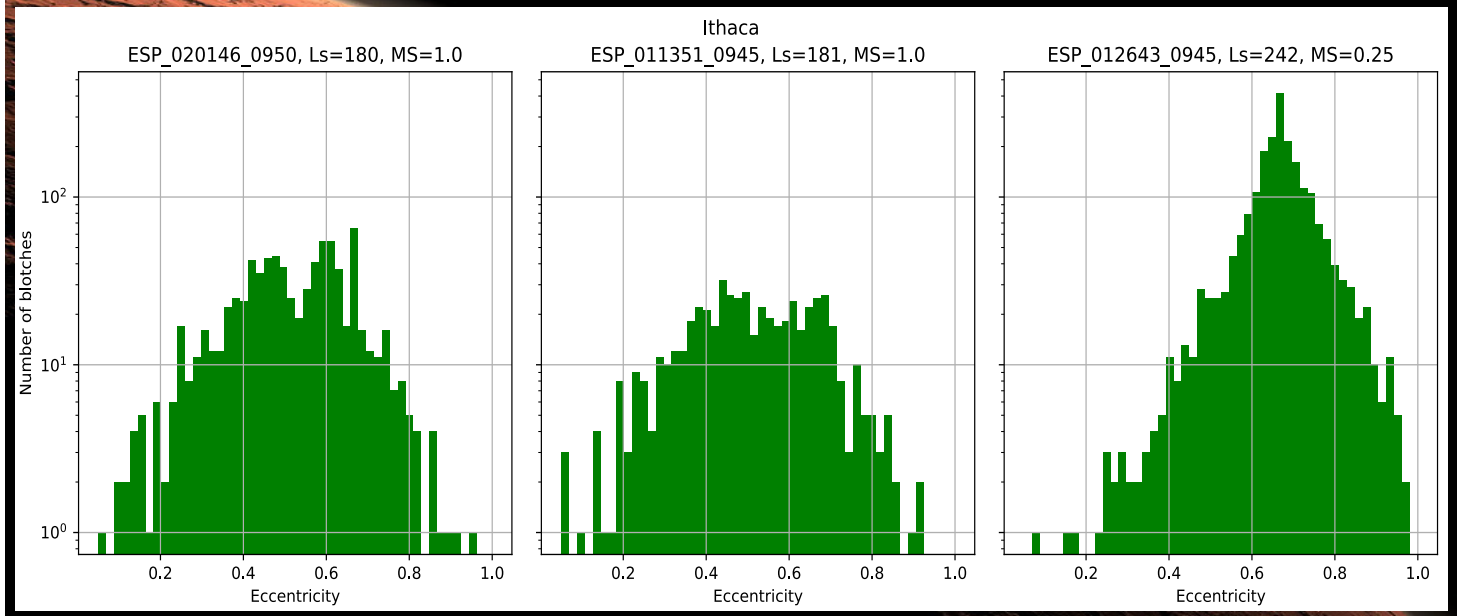

Ithaca
ESP_020146_0950, Ls=180, MS=1.0
ESP_011931_0945, Ls=207, MS=0.5
ESP_012076_0945, Ls=214, MS=0.25
Number of blotches
Area [sqm]
0
2000
4000
6000
8000
10000
12000
14000

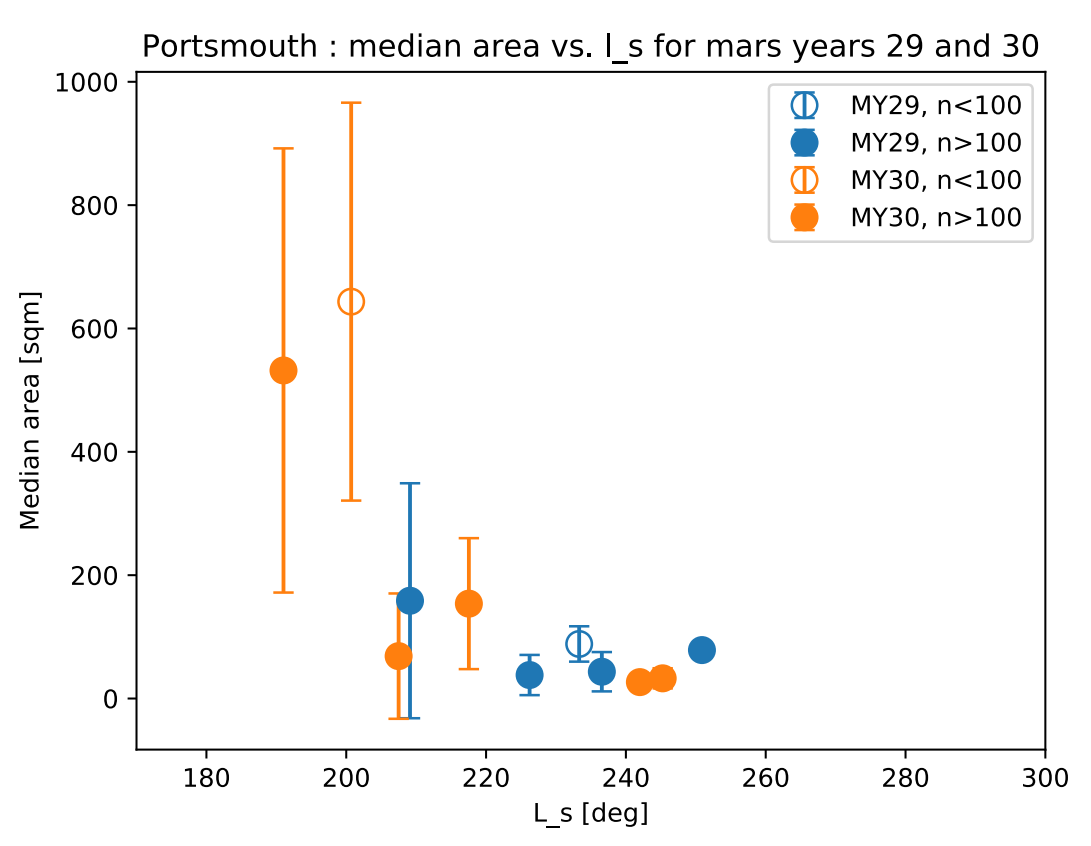
ROI: Ithaca

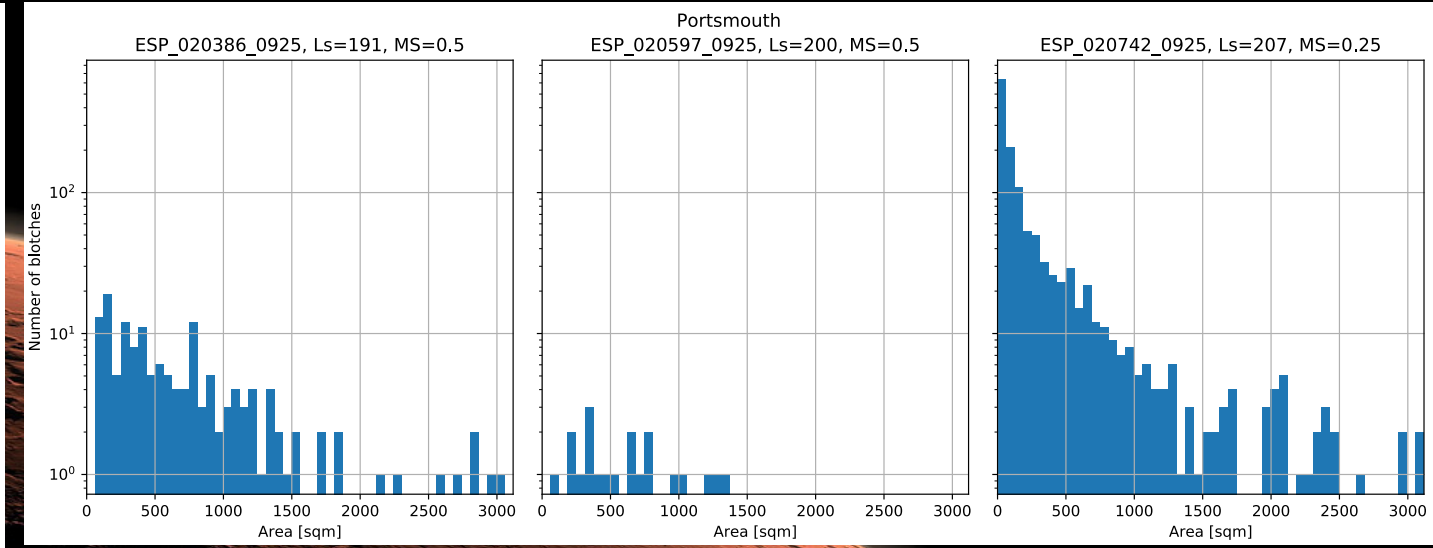


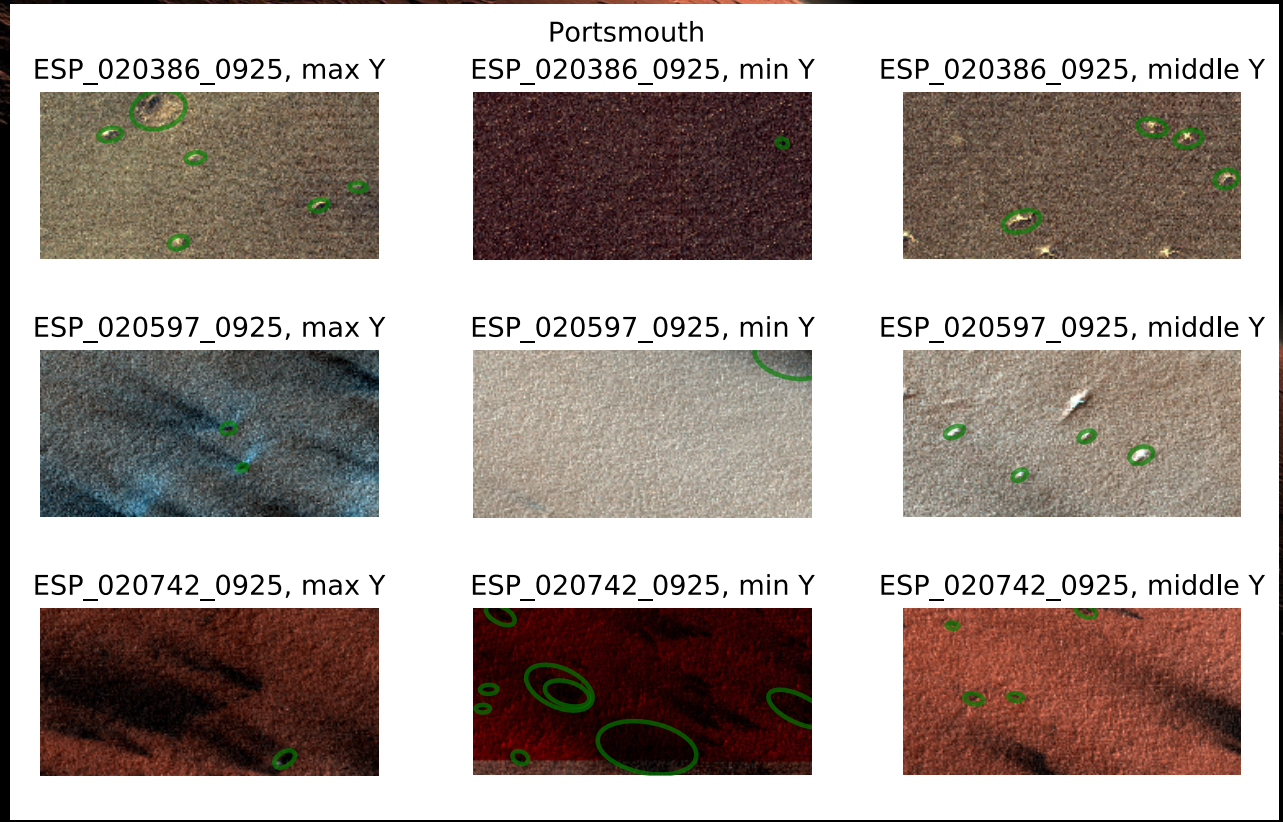

Ithaca
ESP_011931_0945, max Y
ESP_011931_0945, min Y
ESP_011931_0945, middle Y
ESP_012076_0945, max Y
ESP_012076_0945, min Y
ESP_012076_0945, middle Y
ESP_020146_0950, max Y
ESP_020146_0950, min Y
ESP_020146_0950, middle Y


Ithaca : eccentricity median vs. l_s for mars years 29 and 30
MY29, n>100
MY30, n>100
Eccentricity median
L_s [deg]
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
180
200
220
240
260
280
300

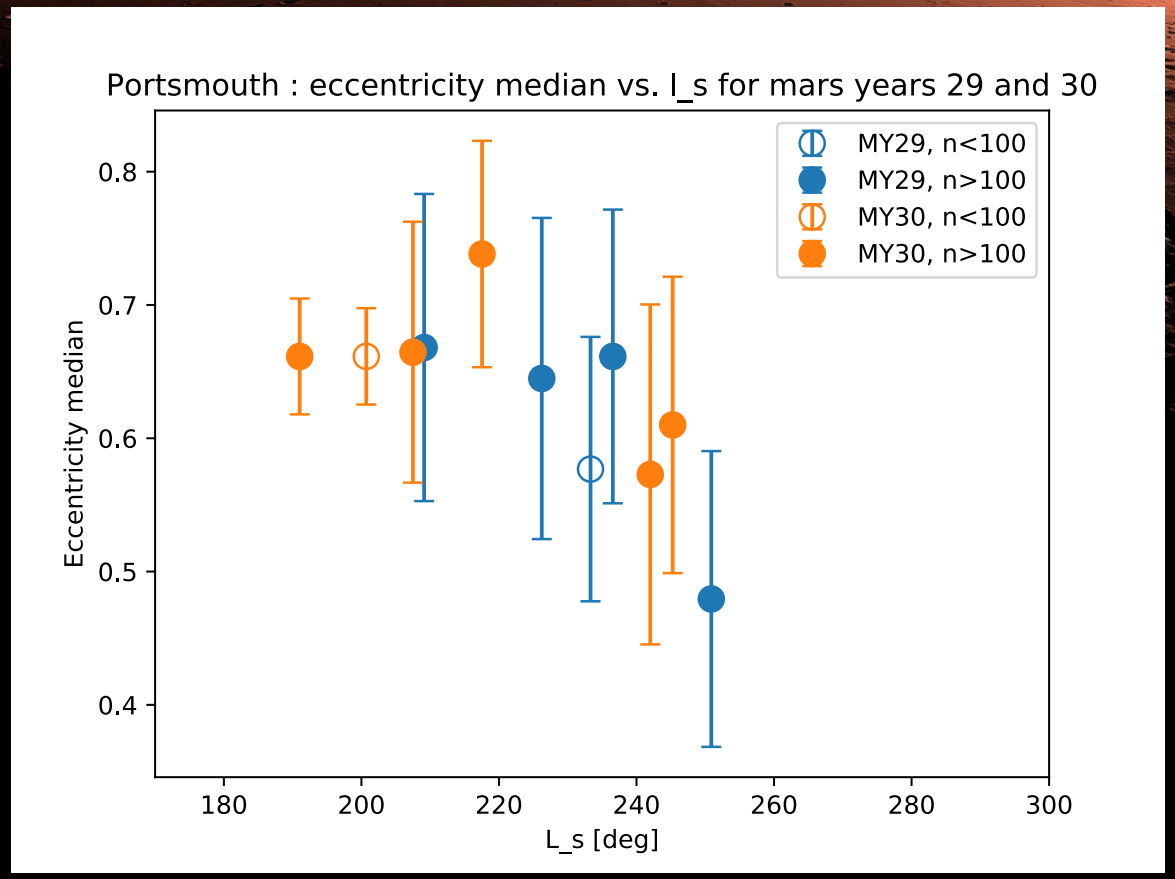

Ithaca
ESP_020146_0950, Ls=180, MS=1.0
ESP_011351_0945, Ls=181, MS=1.0
ESP_012643_0945, Ls=242, MS=0.25
Number of blotches
Eccentricity
Eccentricity
Eccentricity

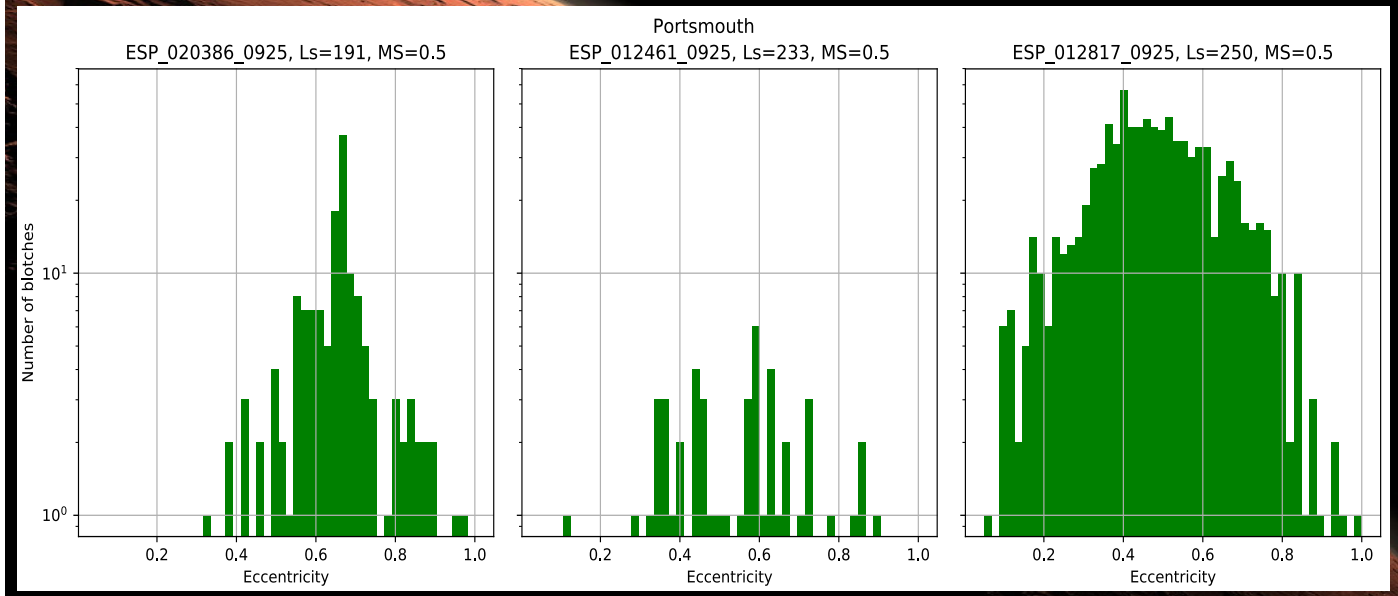




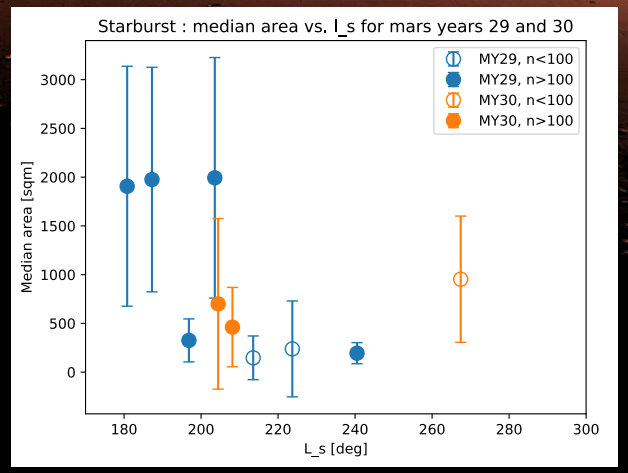


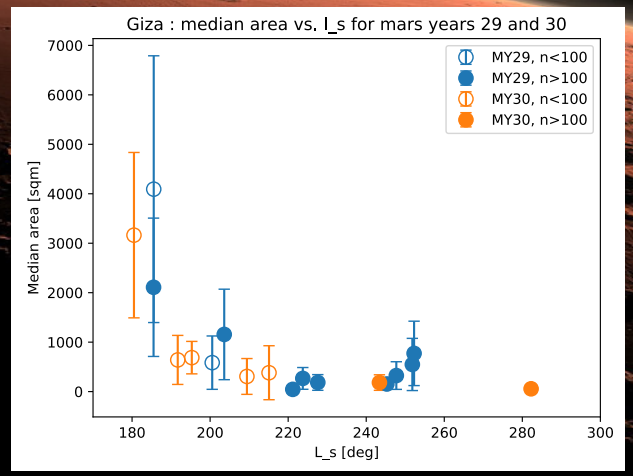
ROI: Portsmouth

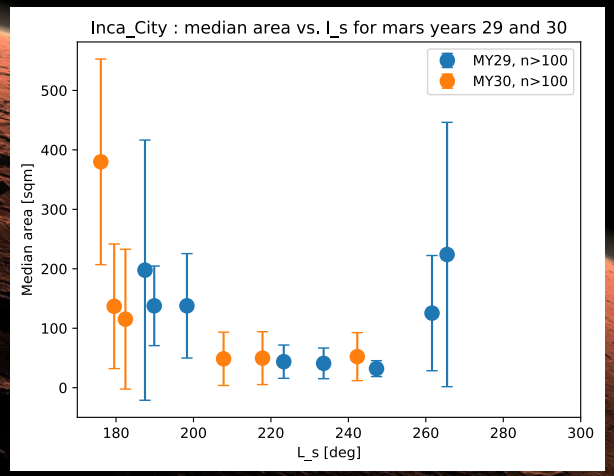

Portsmouth : eccentricity median vs. l_s for mars years 29 and 30
MY29, n<100
MY29, n>100
MY30, n<100
MY30, n>100
Eccentricity median
0.8
0.7
0.6
0.5
0.4
180
200
220
240
260
280
300
L_s [deg]

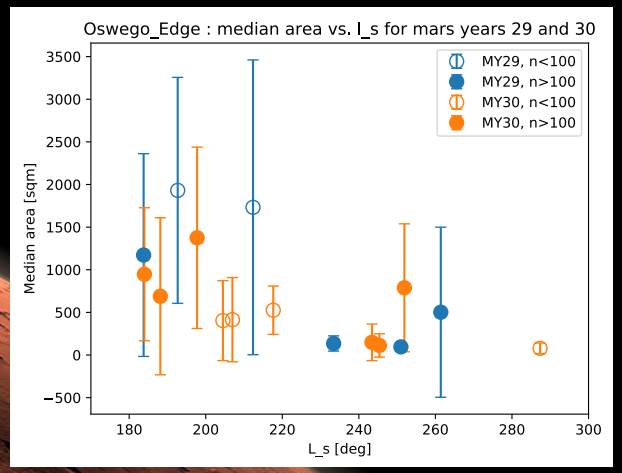

Portsmouth
ESP_020386_0925, Ls=191, MS=0.5
ESP_012461_0925, Ls=233, MS=0.5
ESP_012817_0925, Ls=250, MS=0.5
Number of blotches
10^1
10^0
0.2
0.4
0.6
0.8
1.0
Eccentricity

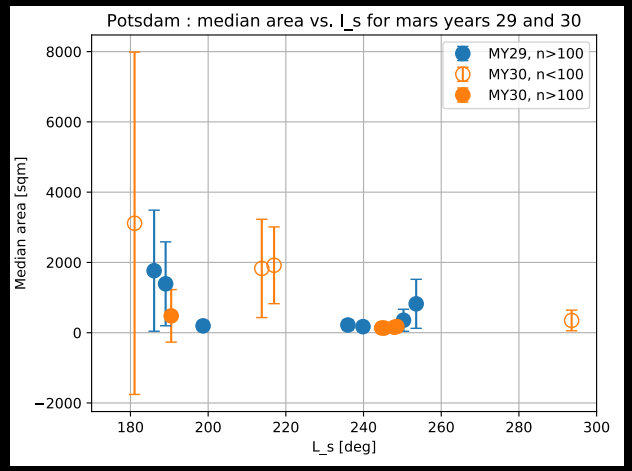
Median areas over time

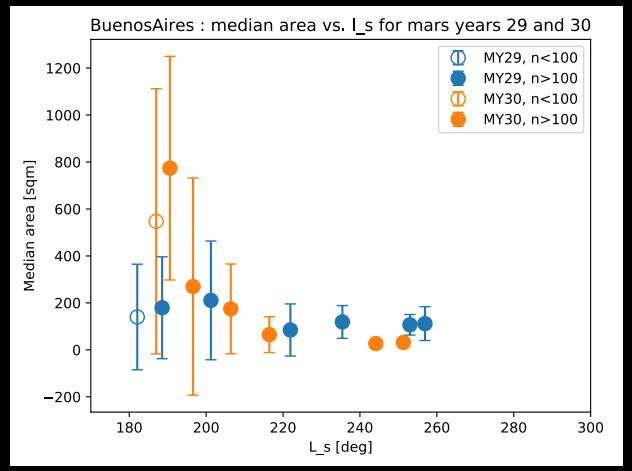


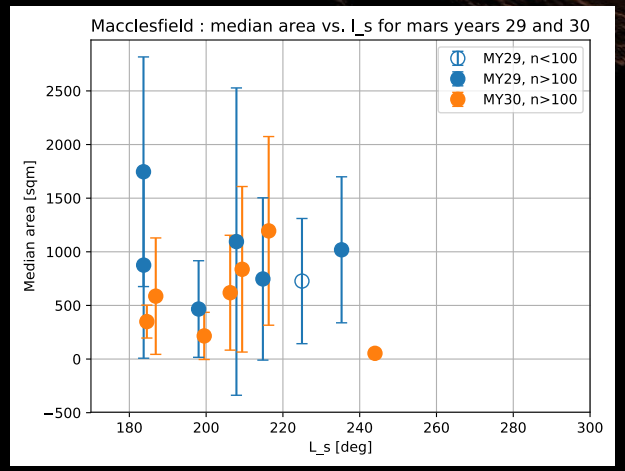


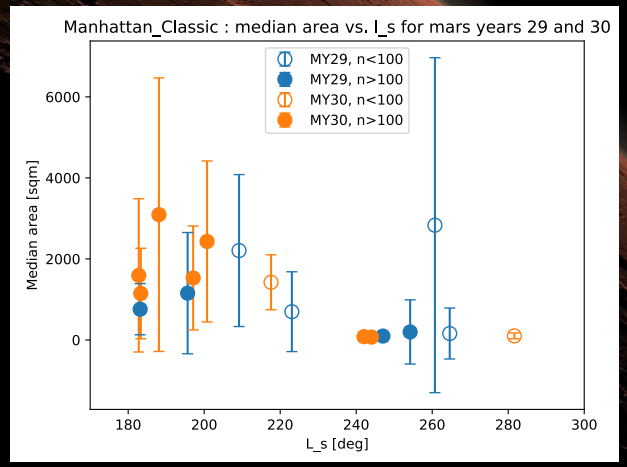












Conclusions

- Hypothesis: differences in CO_2 ice layer quality affect jet eruption physics
  - Trend comparable in many regions → **quality of ice similar**
- Hypothesis: deposits interact with ice
  - Size of blotches vary → **interactions of deposits with ice**

- Most plots show similar trends for both Mars years 29 and 30 → **spring sublimation is a constant, yearly-repeating process**
- Most plots show both similarities but also clear, distinctive trends for different regions → **region of interest affects the number, area, and eccentricity of blotches that form**
- Inclusion of wind ground transport → **wind might also affect blotches, data showed more complexity than expected**