Detecting Transient Surface Features via Dynamic Landmarking

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AISR PI Meeting, 5/5/08

Image credit:
HiRISE, 2/19/2008

Outline

- Goal: Detect transient surface features
  - Pixel-Based Change Detection
  - Landmark-Based Change Detection
- Features: dark slope streaks, dust devil tracks on Mars
- Current Results
- Next Steps

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Transient Surface Features

June 12, 2000

April 12, 2002

Image credit: MOC

Transient Surface Features

June 12, 2000

April 12, 2002

Image credit: MOC

Pixel-Based Change Detection

- Register two images
  - Derive mapping from SIFT features
- Detect pixel changes
  - Create difference image
  - Threshold on difference image

Pixel-Based Change Detection

Image 1

Image 2

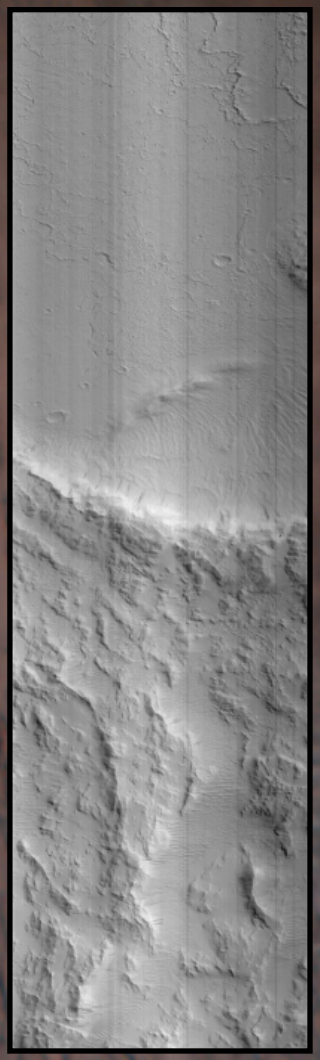


Image credit: MOC

Pixel-Based Change Detection

Image 1

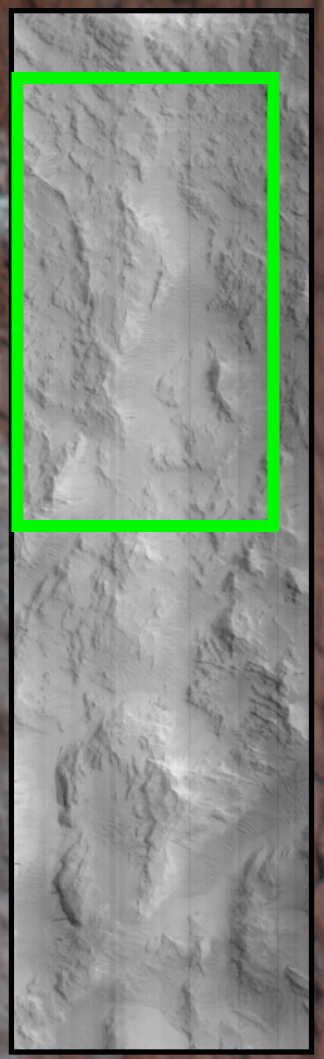


Image 2

Image credit: MOC

Pixel-Based Change Detection

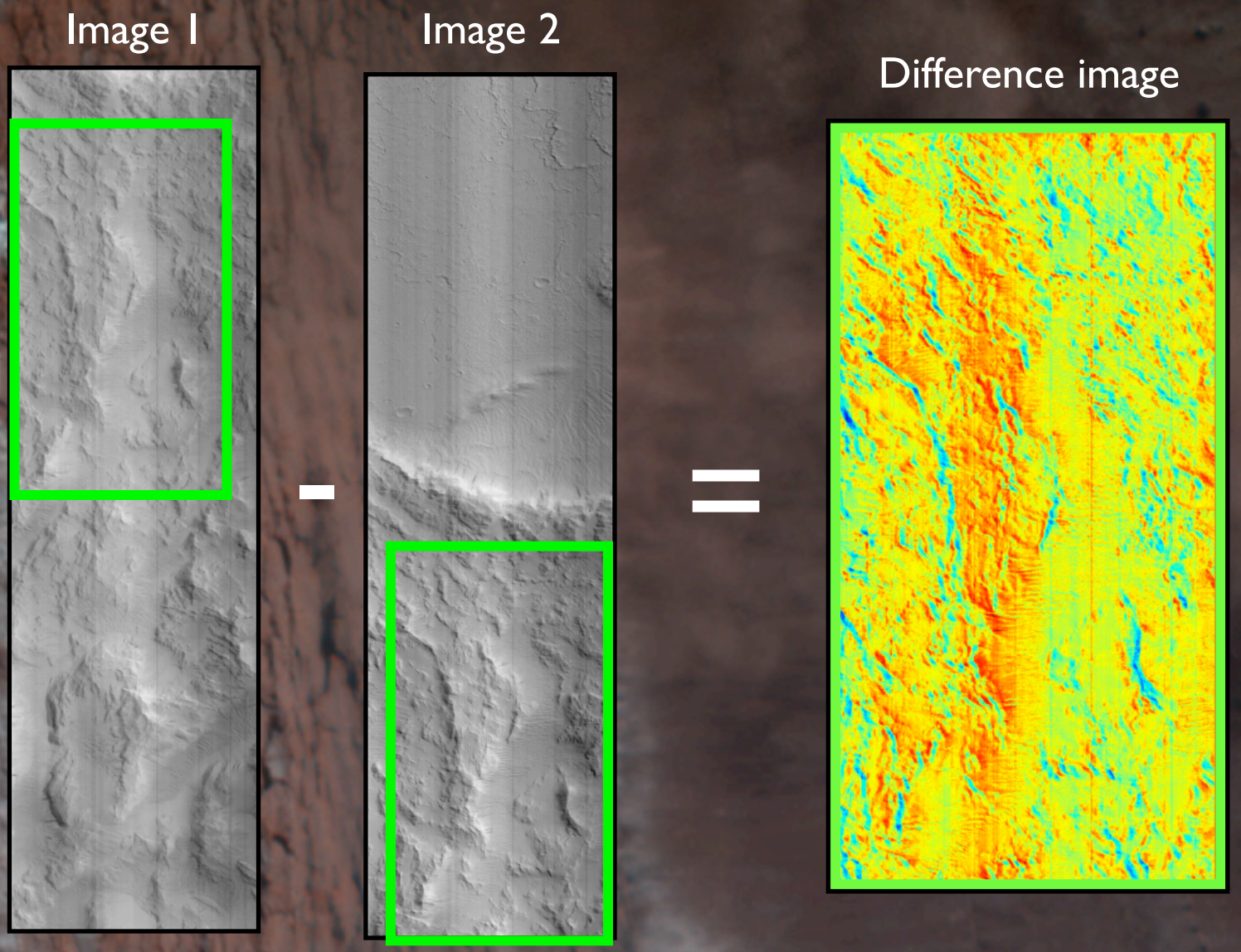


Image credit: MOC

Adnan Ansar

Pixel-Based Change Detection

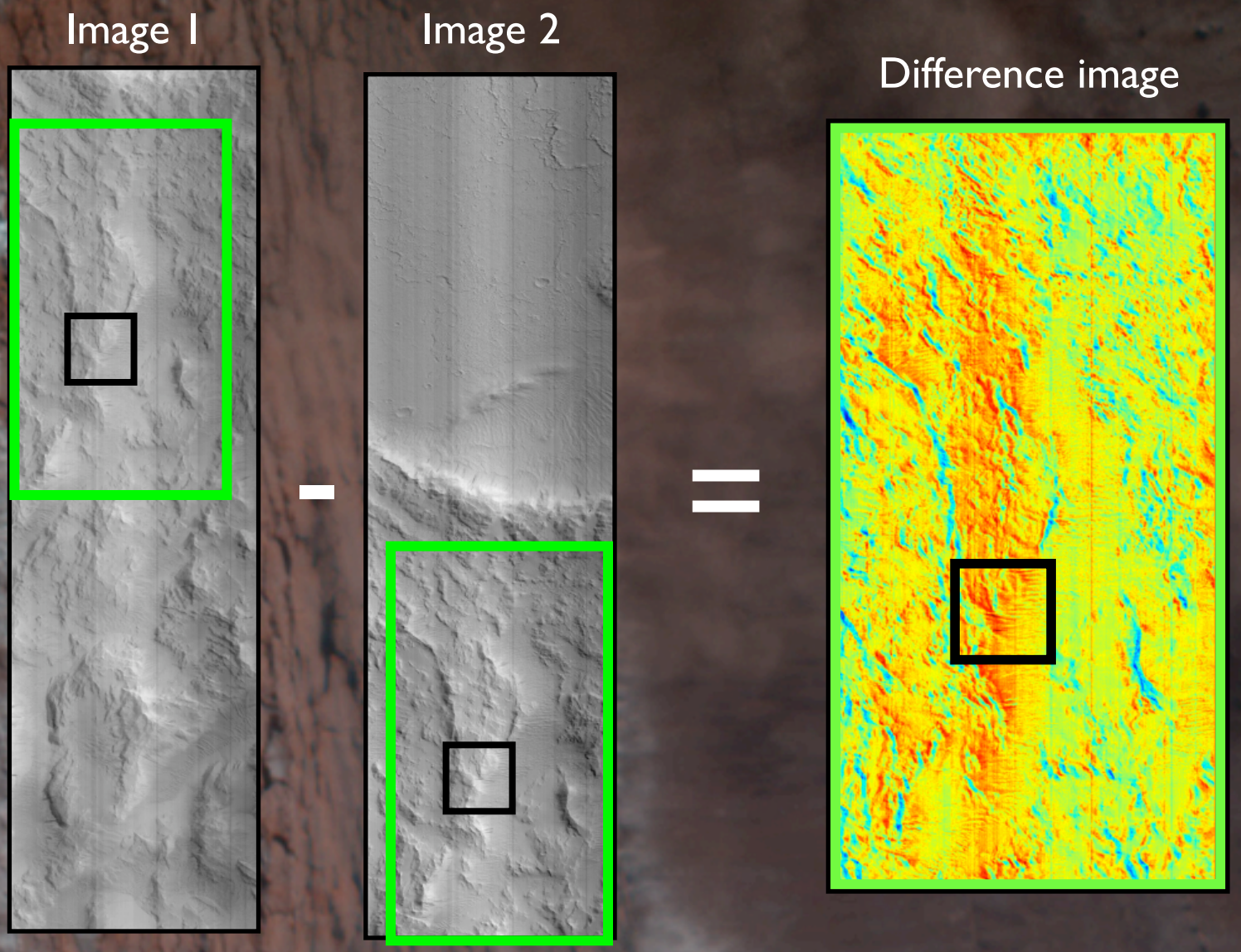


Image credit: MOC

Adnan Ansar

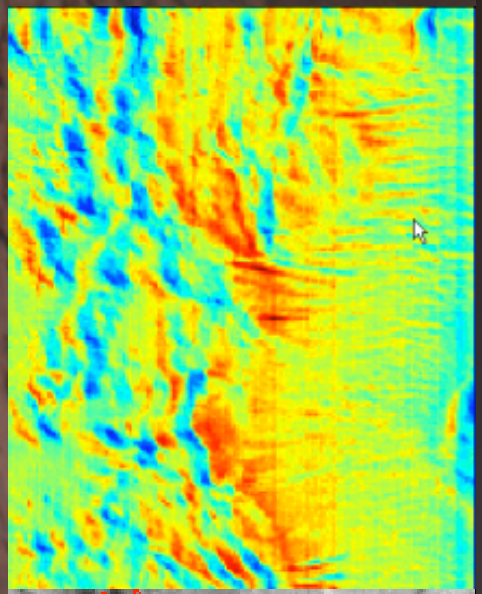
Registration Improvements

False color indicates magnitude of change

Automatic labeling of changed pixels using dynamic threshold

Global match

Difference image



Changed pixels

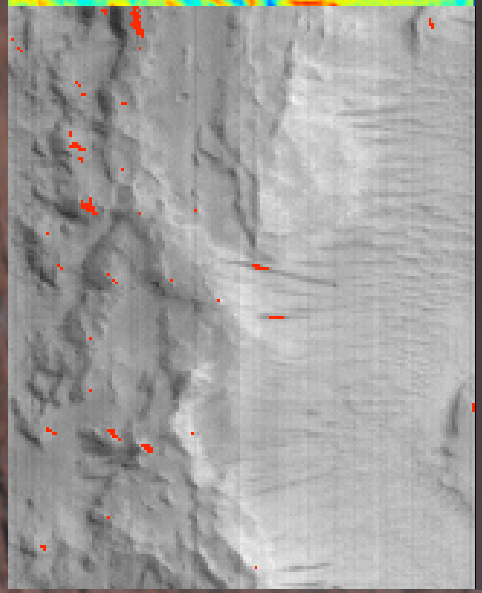


Image credit: MOC

Registration Improvements

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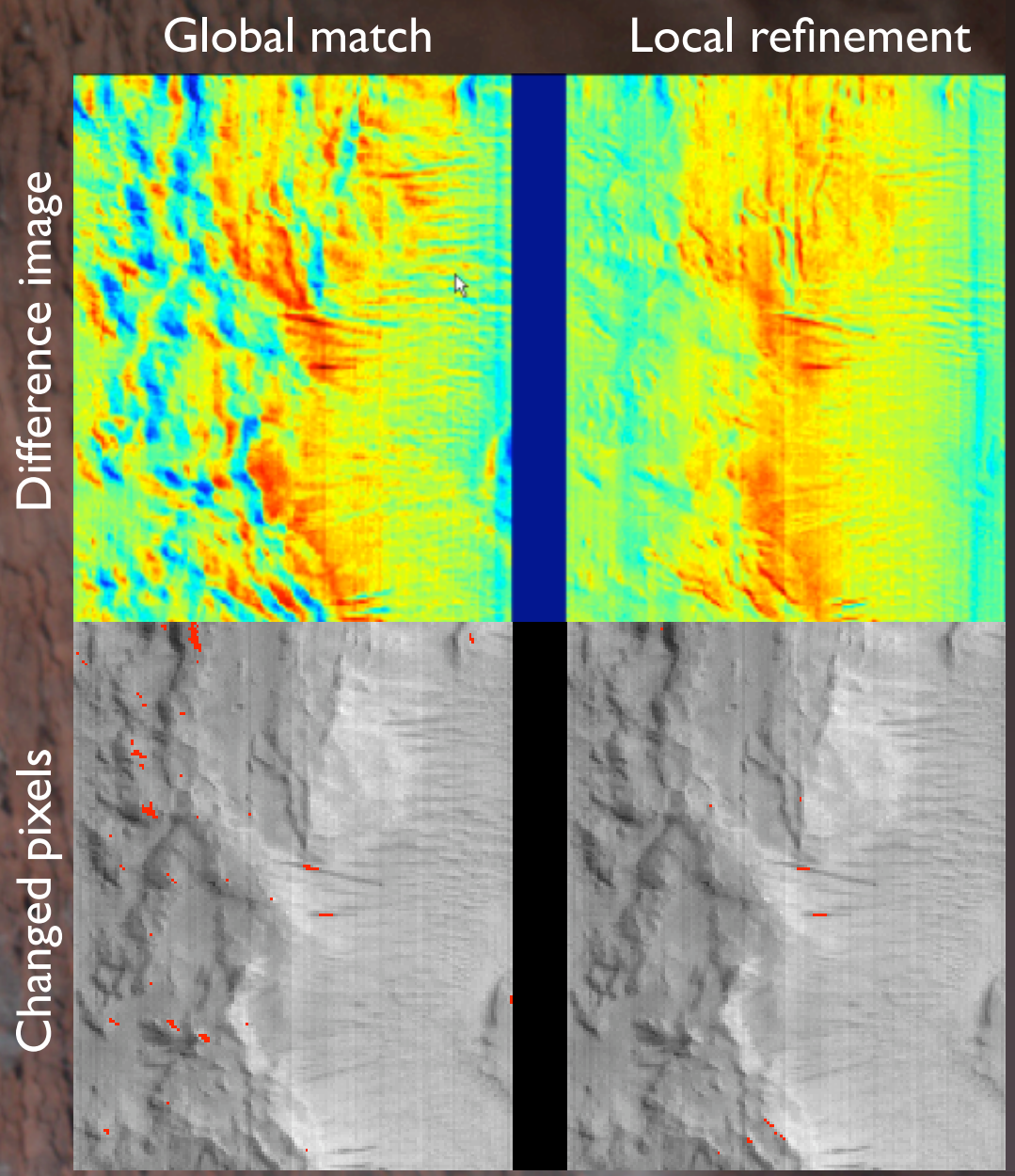

Image credit: MOC

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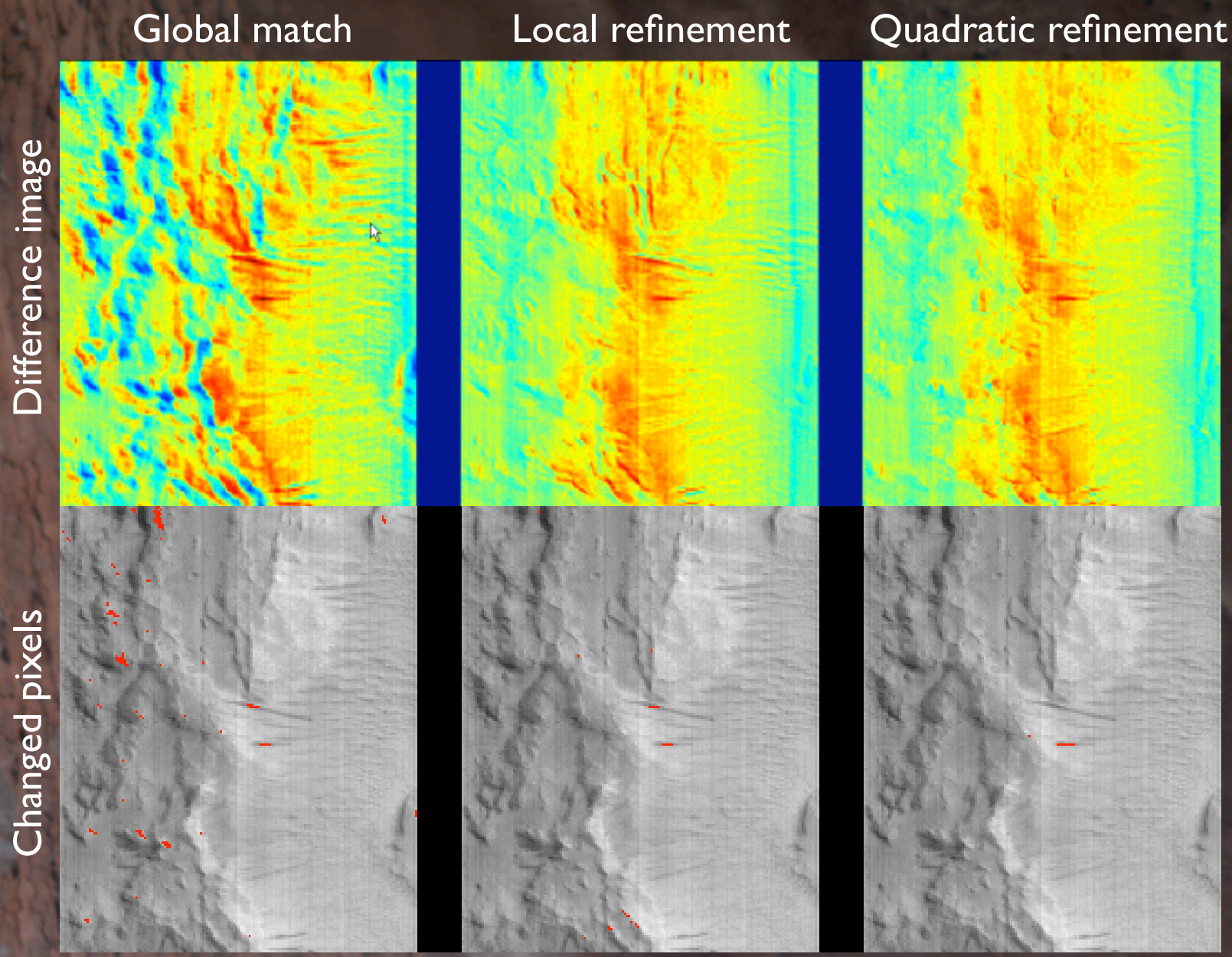
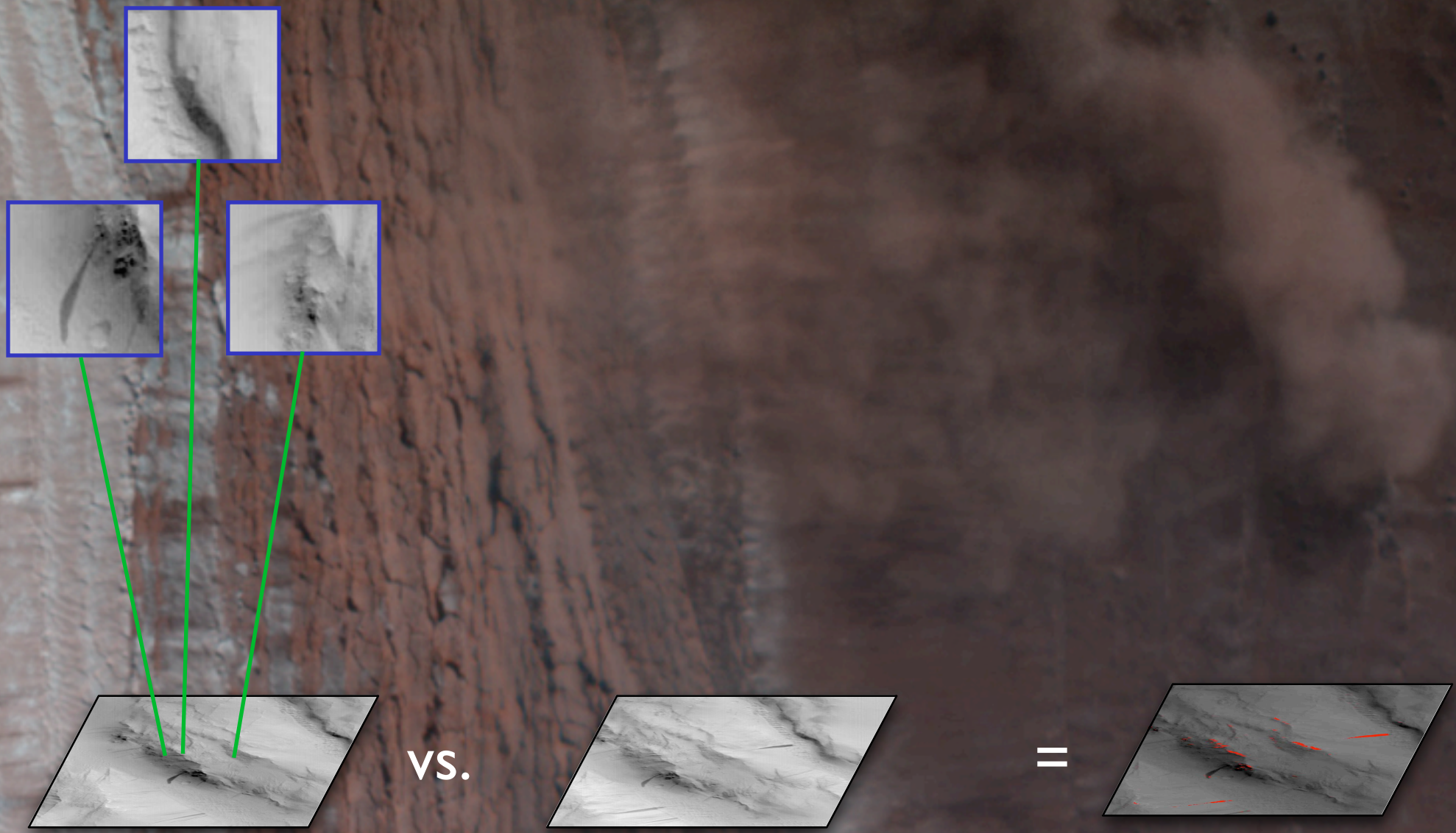


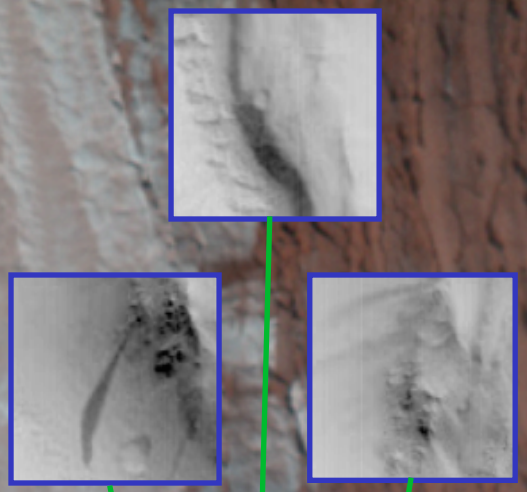
Image credit: MOC

Landmark-Based Change Detection

Landmark-Based Change Detection



Landmark-Based Change Detection



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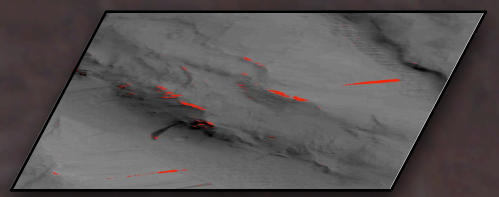
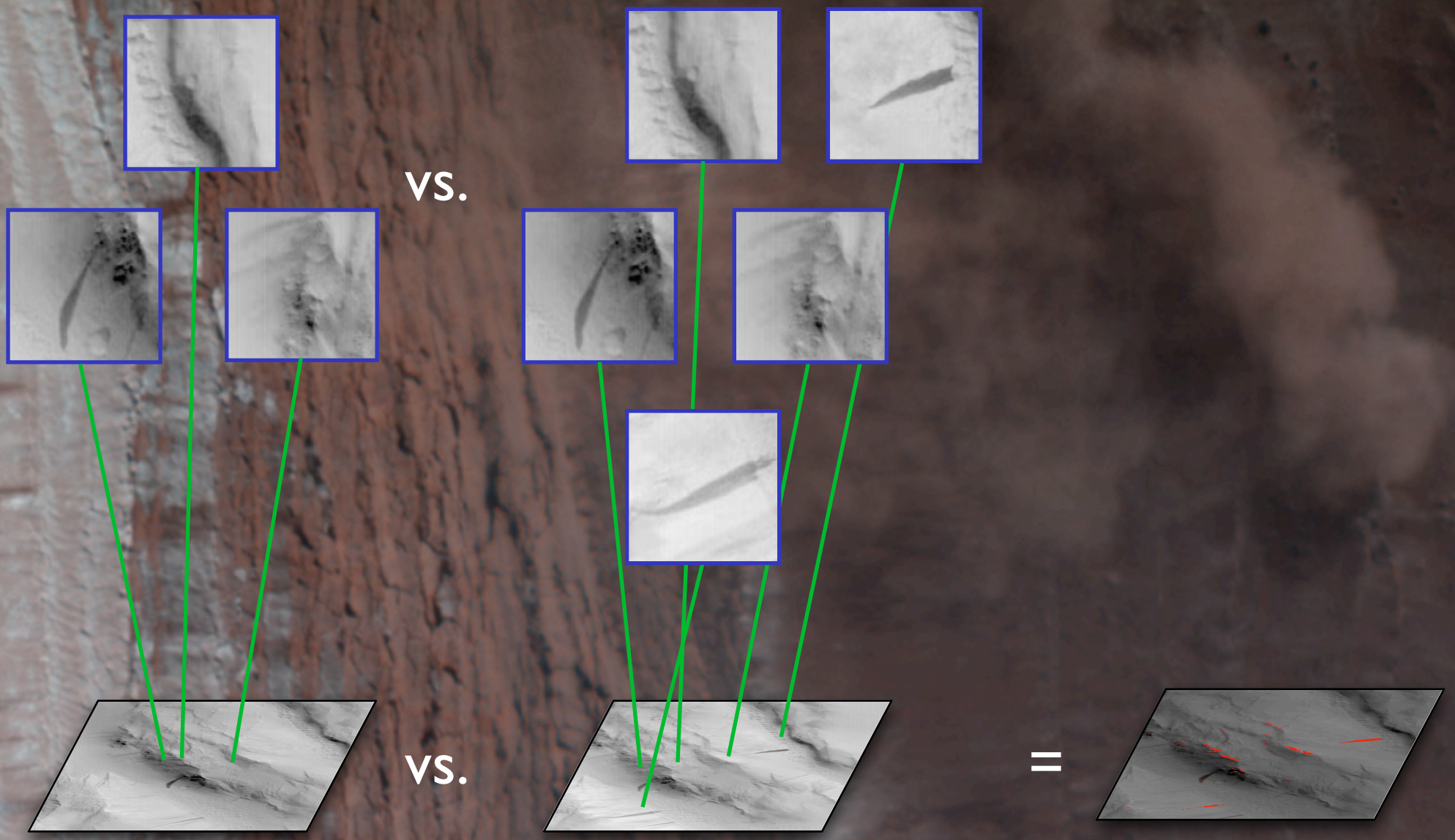
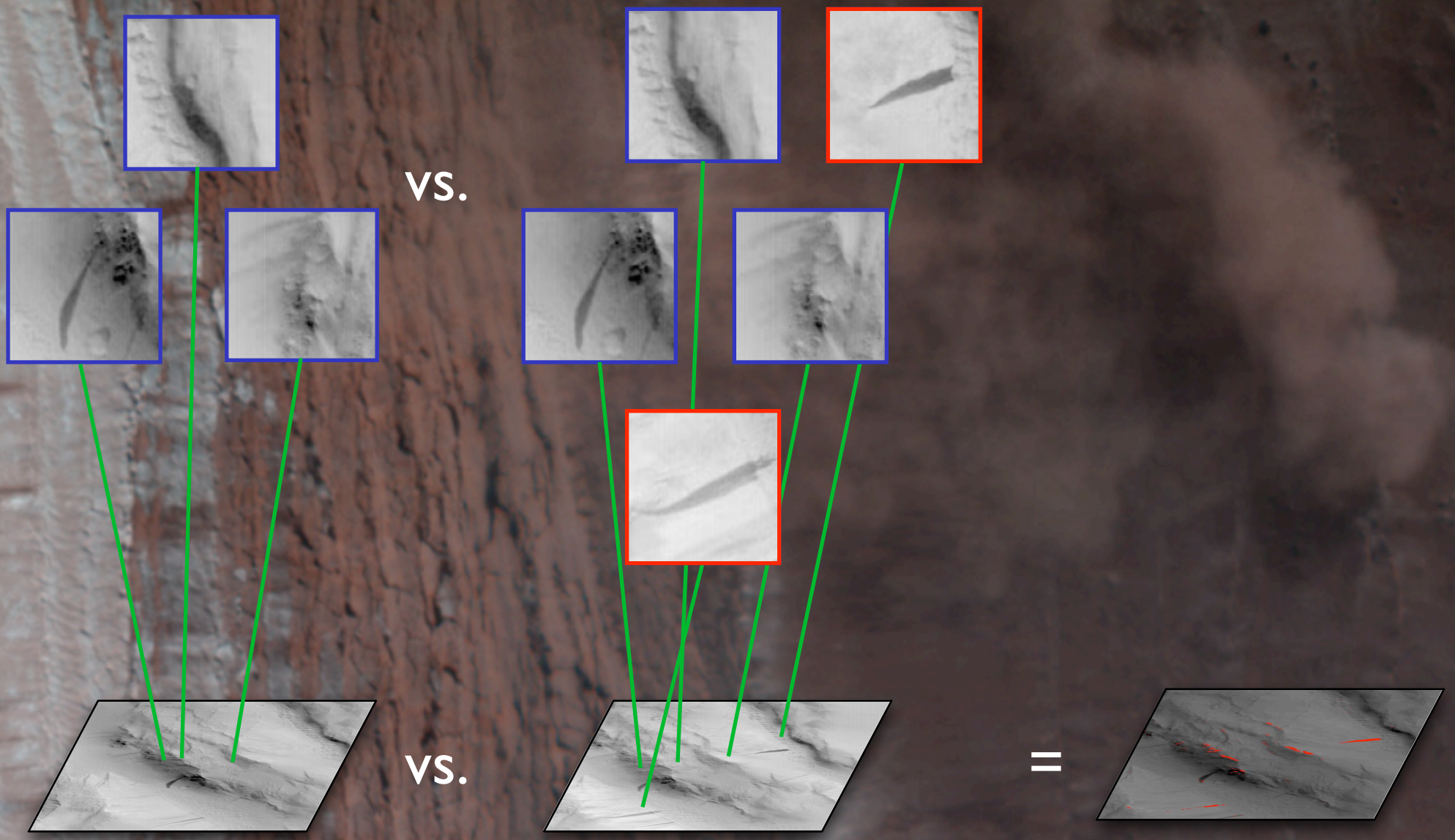


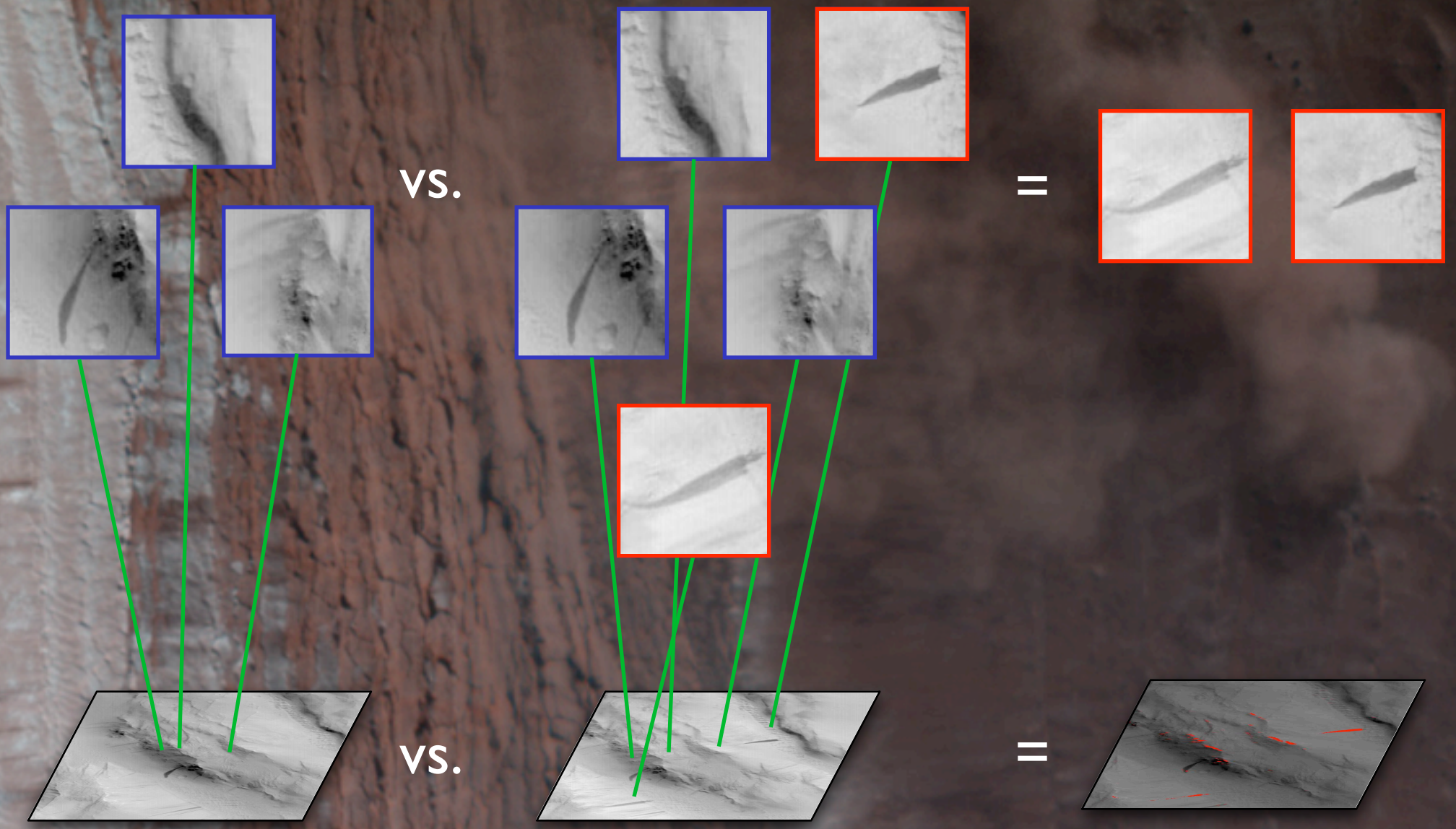
Landmark-Based Change Detection



Landmark-Based Change Detection



Landmark-Based Change Detection



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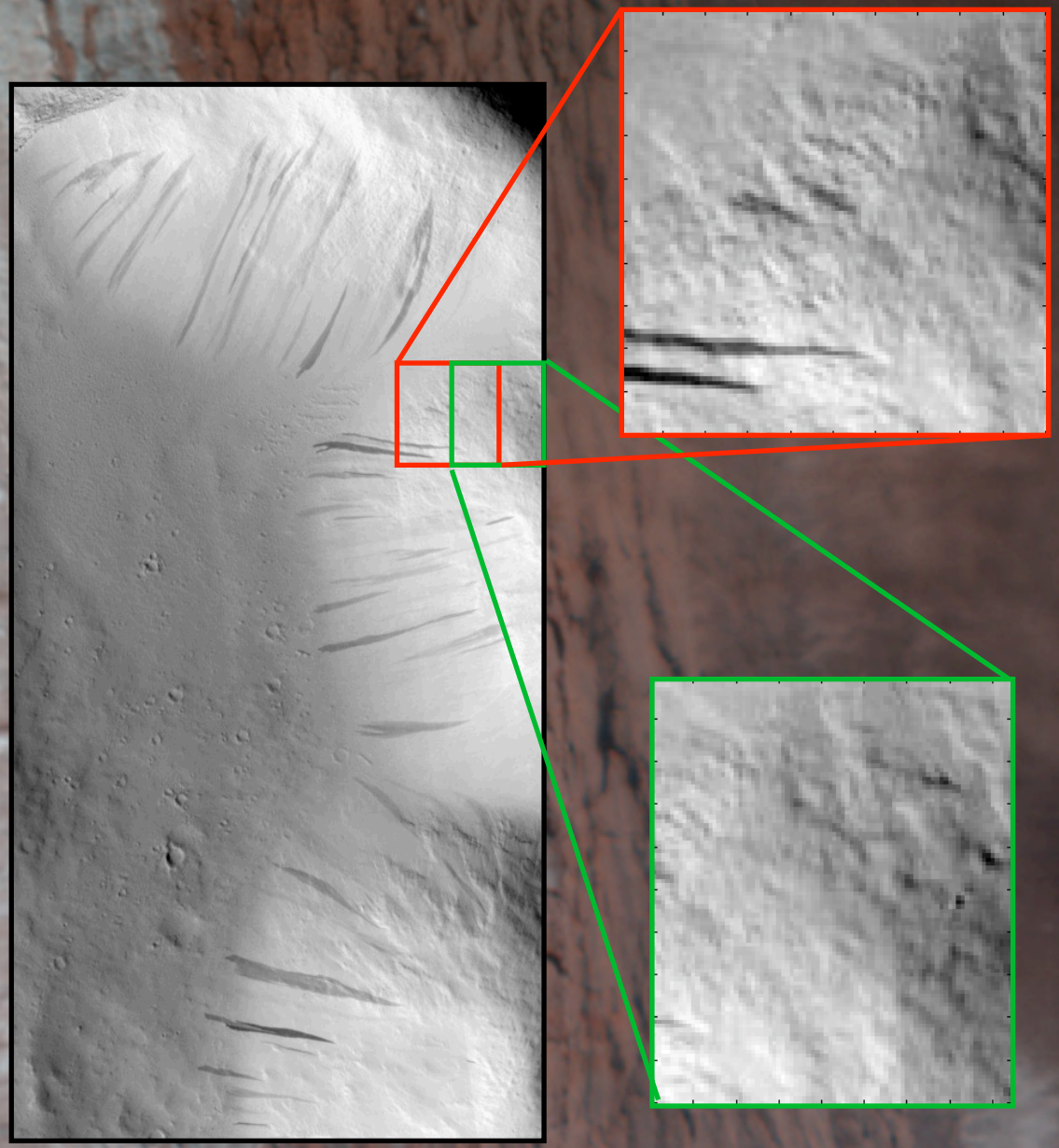
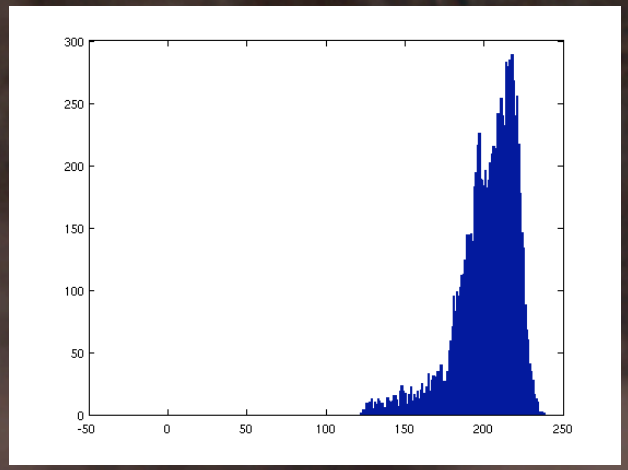
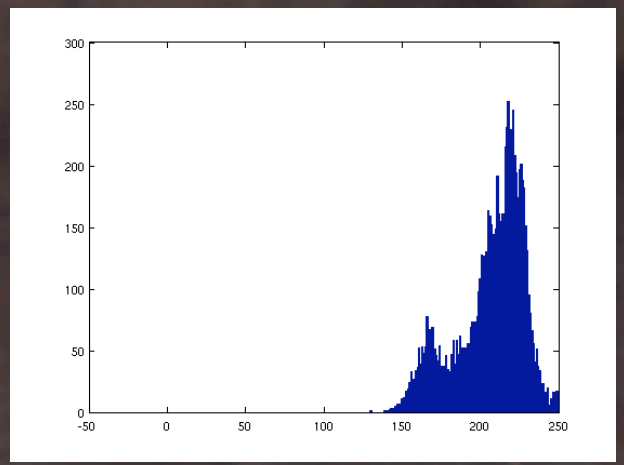
Intensity Histograms



HiRISE PSP_003570_1915



w_1



w_2

Salient Landmark Selection

- How much does a window stand out from its neighbors?

$$D_{KL}(w_1||w_2) = \sum_i w_1(i) \log \frac{w_1(i)}{w_2(i)}$$

- Sort windows by their average KL-divergence salience (across all neighbors)
- Evaluation:
  - One-to-one matching of detected landmarks and manual annotations for each feature
    - Thank you to science collaborators!

Early version presented at 2007 Fall American Geophysical Union Meeting

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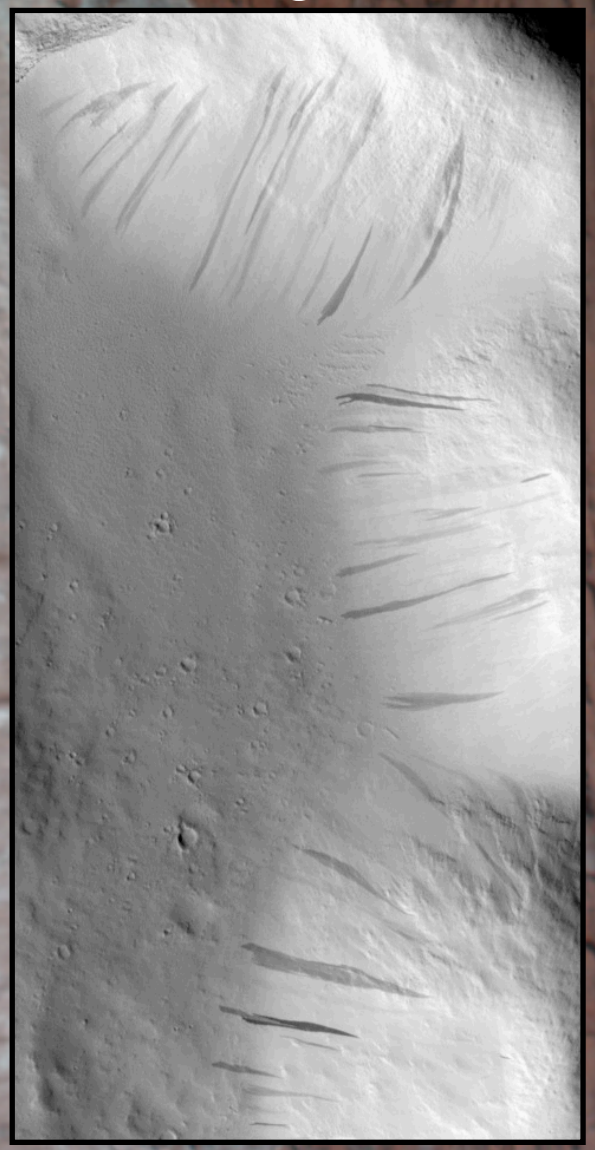
Dark Slope Streaks

Detections given salience threshold

Original



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Dark Slope Streaks

Detections given salience threshold

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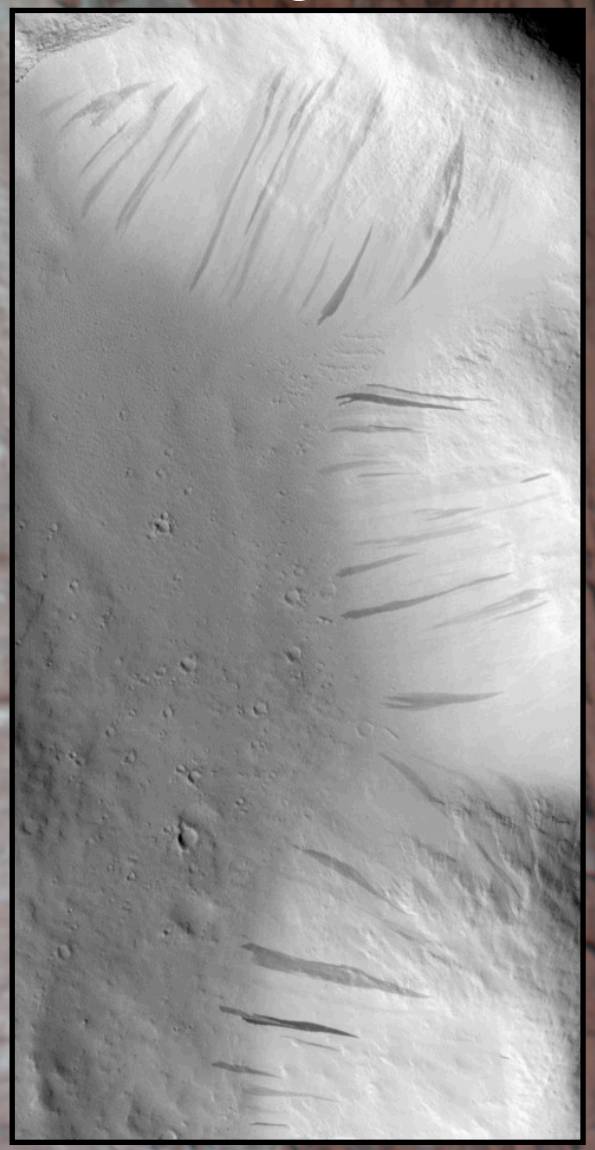
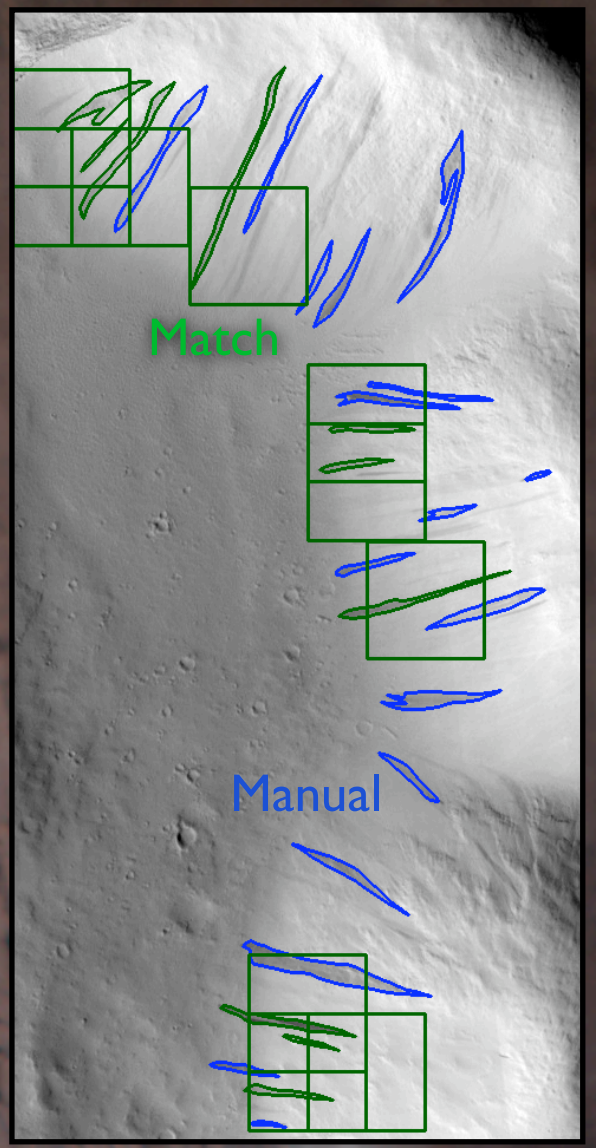


>= 1.89



HiRISE PSP_003570_1915

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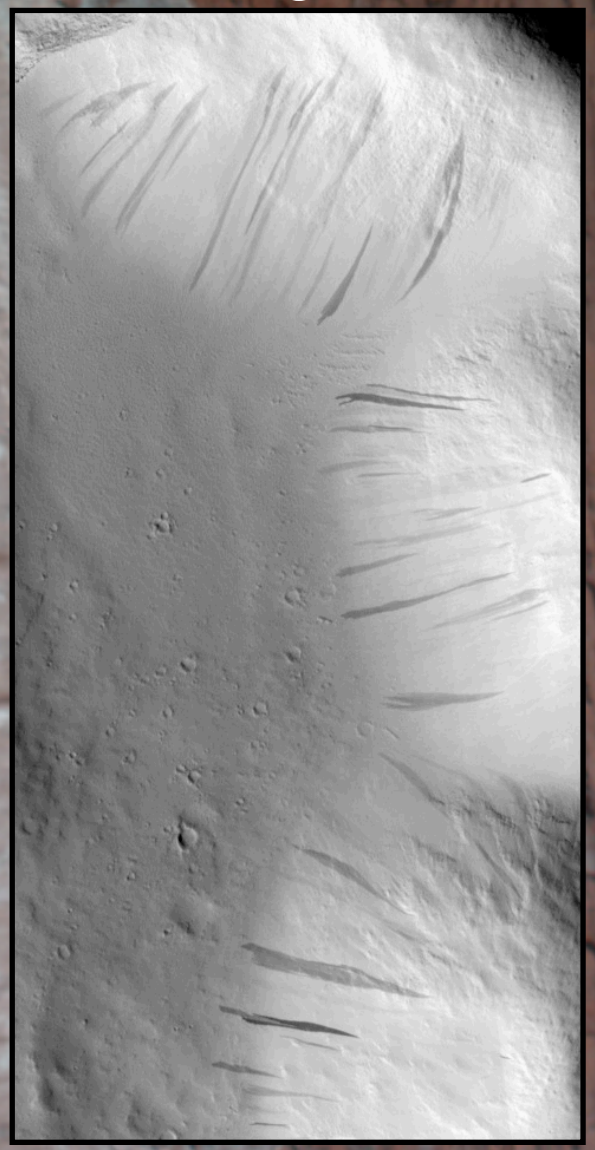
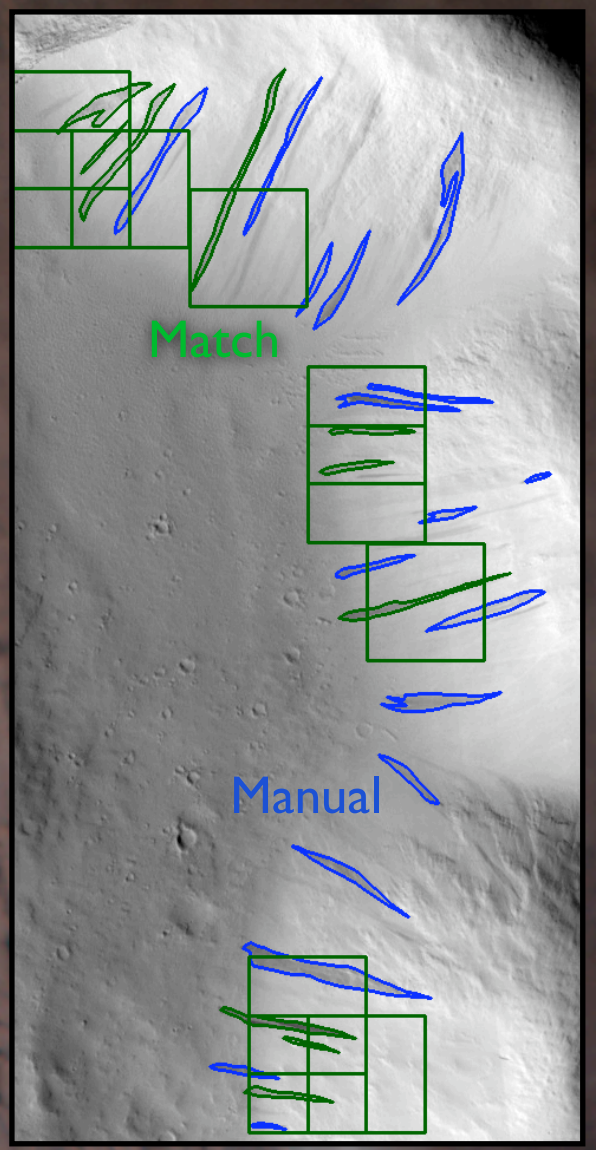
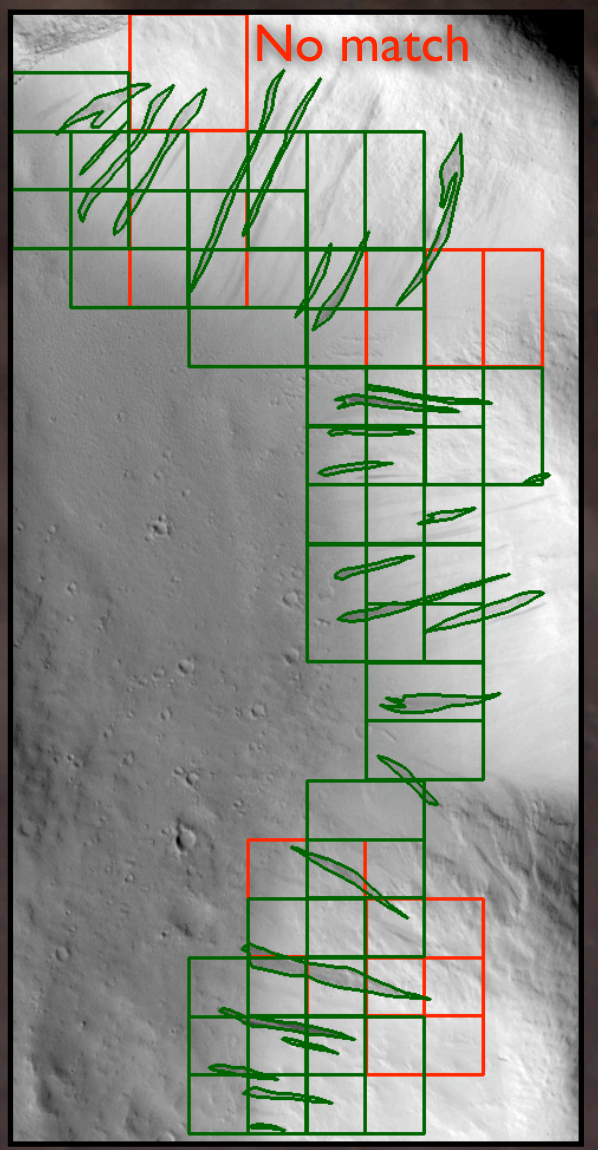


>= 1.89



>= 1.45



HiRISE PSP_003570_1915

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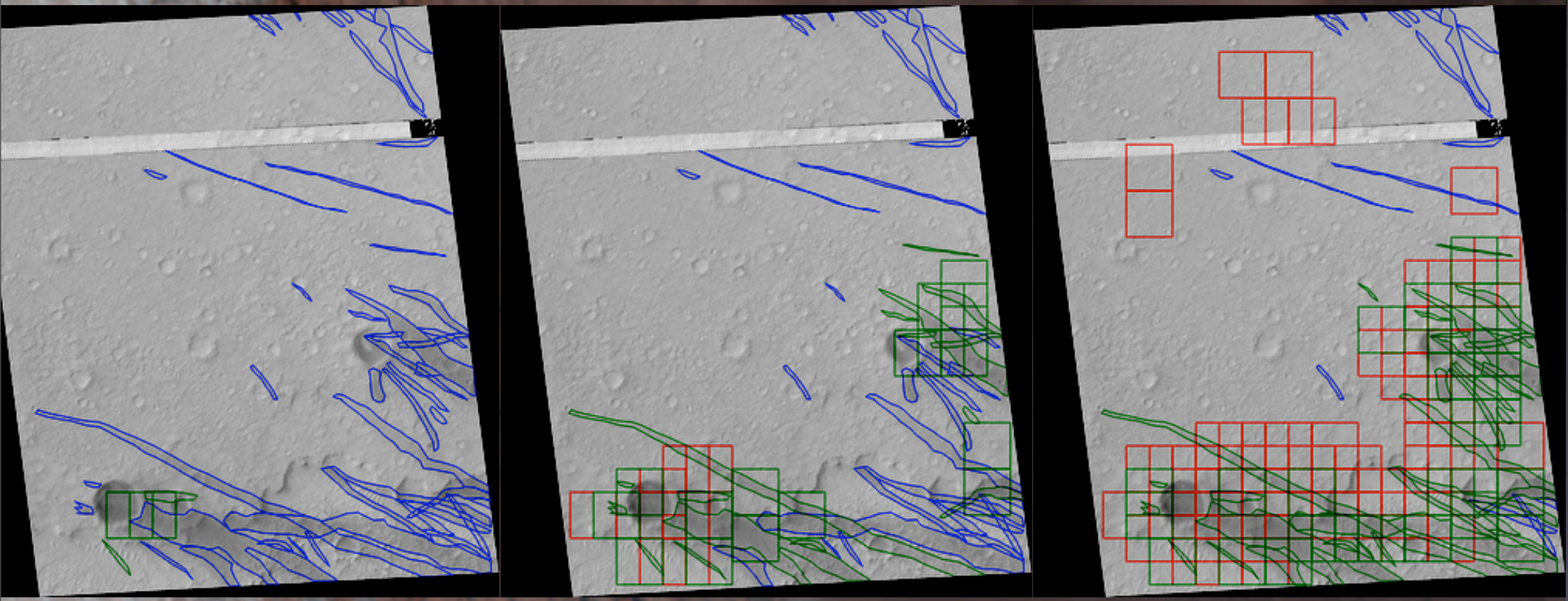
Dust Devil Tracks

Detections given salience threshold

>= 1.96 >= 0.81 >= 0.28

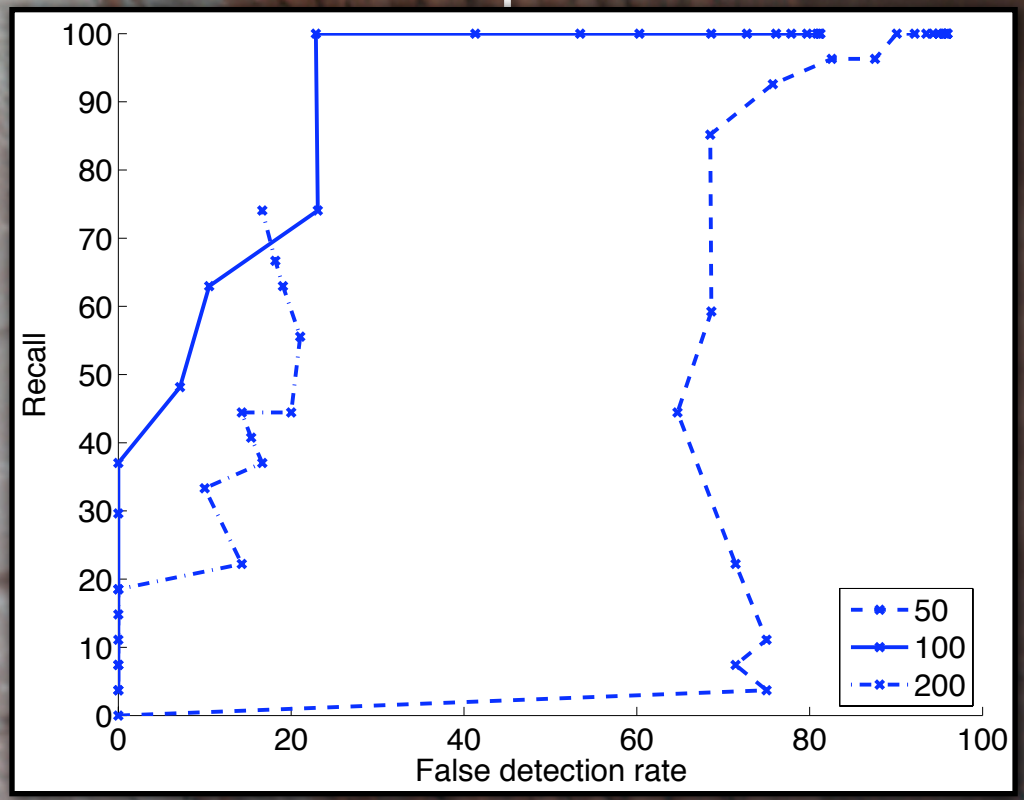


MOC R0201153

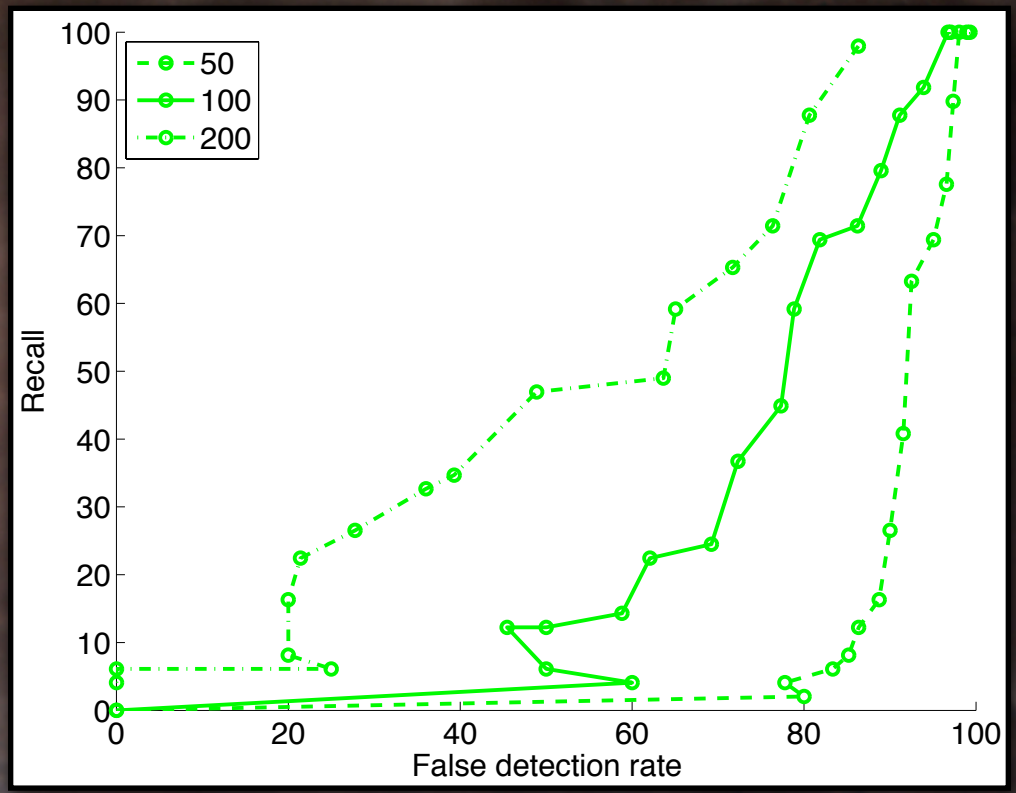
Dust devil track annotations by Melissa Bunte (ASU)

ROC Curves

Dark Slope Streaks



Dust Devil Tracks

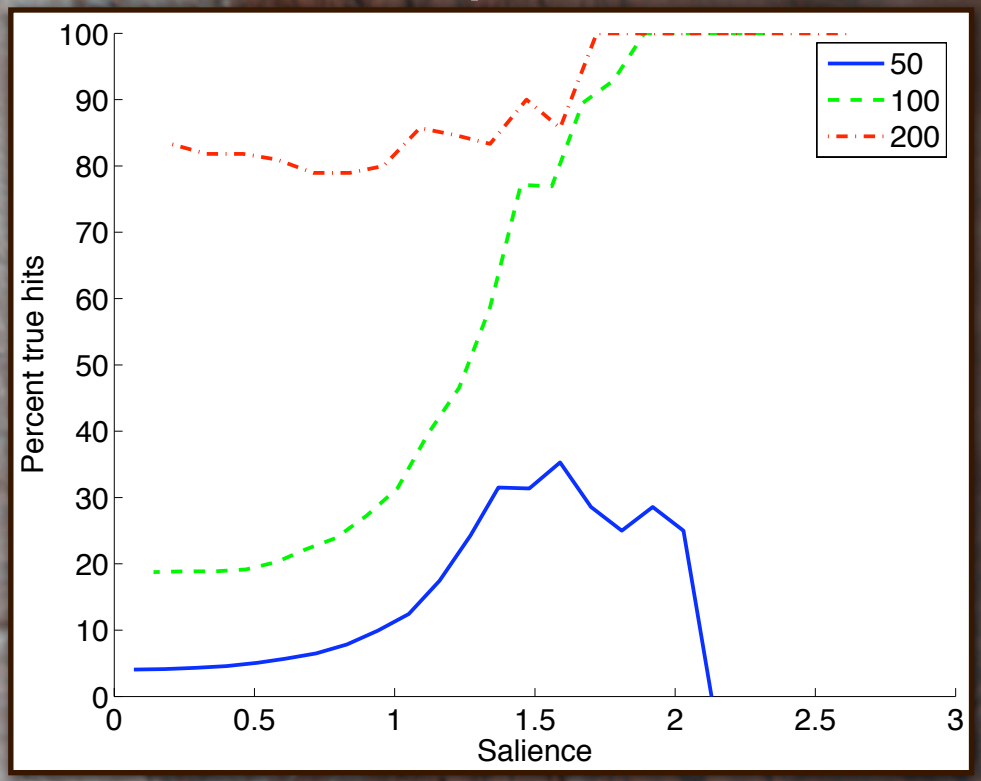


- Dark slope streaks easier to detect reliably
- Window size affects results
- Improve on one-to-one mapping?

Landmark Salience

as a function of window size

Dark Slope Streaks



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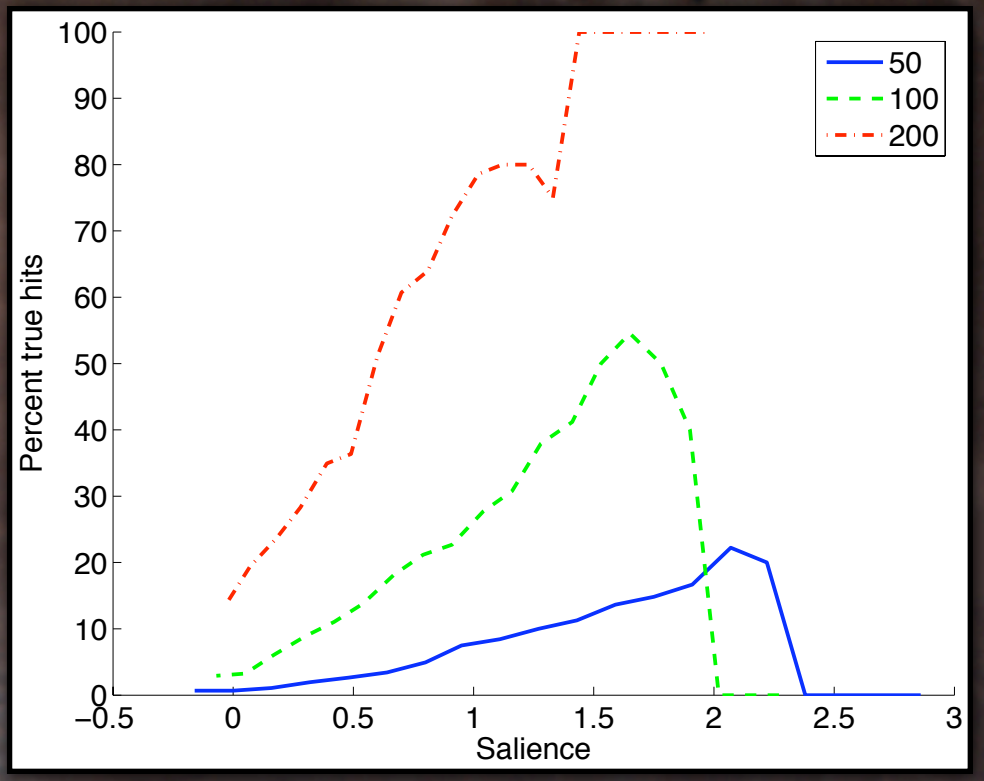

- Dark slope streaks more salient than dust devil tracks

Next Steps

- Change Detection
  - Use mutual information to mark changes
  - Apply landmark detection to difference image
- Landmark Detection
  - Improve efficiency, extend to rectangles
    - Integral Histogram computation [Porikli, 2005]
- Landmark Type Classifier
  - Ridge, crater, streak, track, gully, etc.
  - Summer student: Julian Panetta (Caltech)

Thank you! Any questions?

Email: kiri.wagstaff@jpl.nasa.gov