

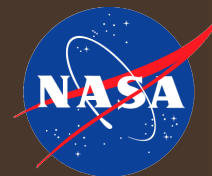
# Change Detection in Mars Orbital Images using Dynamic Landmarking

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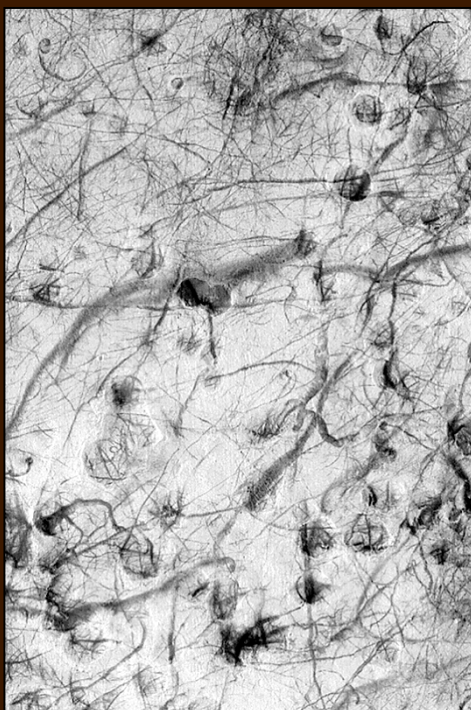
Contact: [kiri.wagstaff@jpl.nasa.gov](mailto:kiri.wagstaff@jpl.nasa.gov)

LPSC, March 5, 2010



# Surface Changes on Mars

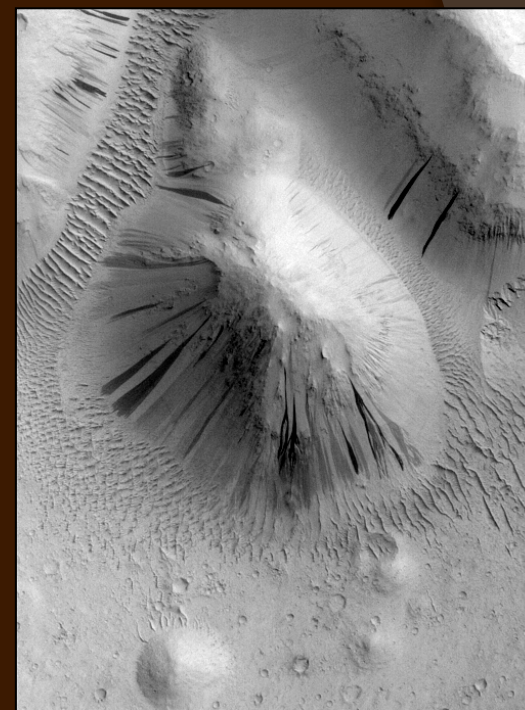
- Dec. 09: >1.5 million orbital images of Mars in PDS



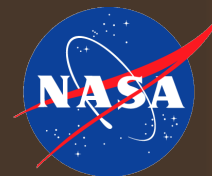
MOC E11-02045 (May 03)



HiRISE PSP\_010625\_2360 (Nov. 08)

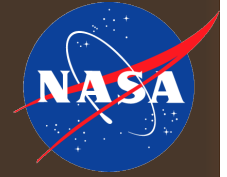


MOC S13-00818 (Dec. 06)



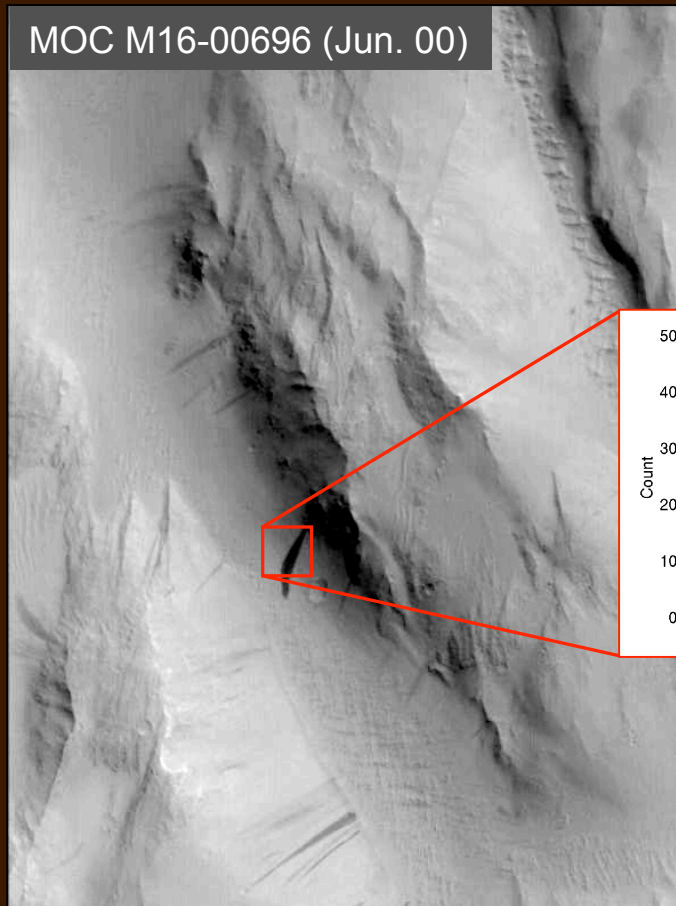
# How to Find Changes?

- Traditional: register two images, compute pixel difference
  - Sensitive to pixel noise, poor registration
  - Still needs interpretation
- Dynamic Landmarking: identify landmarks, then compare landmark sets
  - Focus attention on salient regions
  - Work with landmarks, not individual pixels
  - Output has semantic meaning

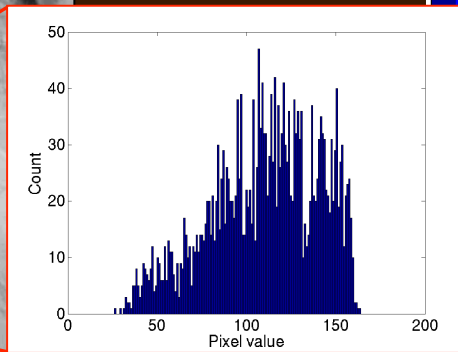


# Dynamic Landmark Identification

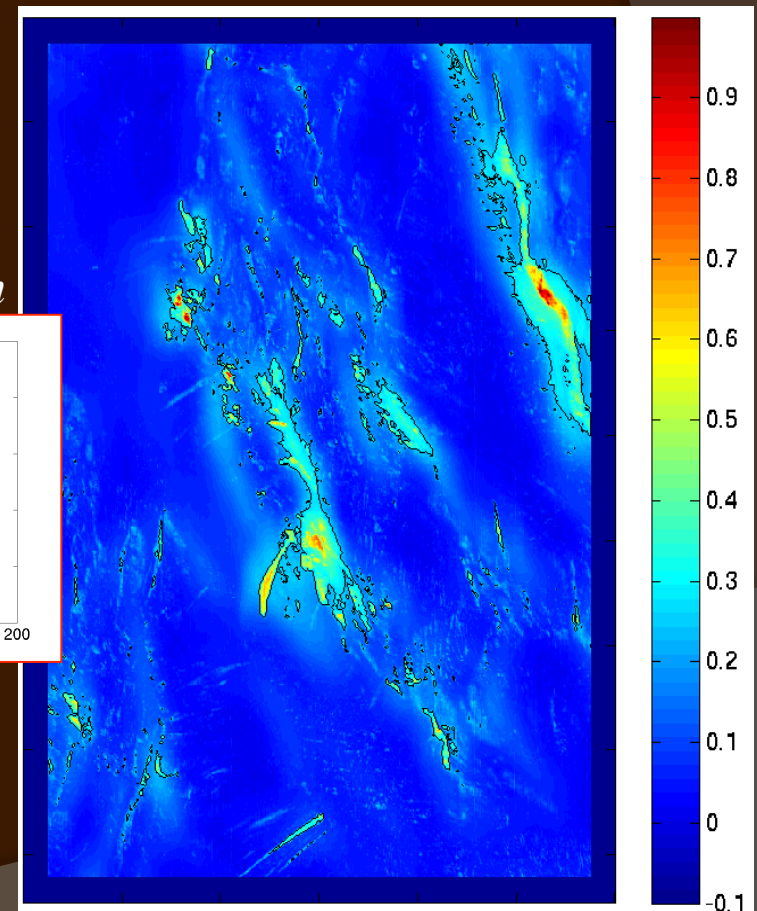
- Landmark Detection
  - Move from pixels to regions

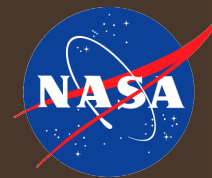


Intensity histogram  $h$



Saliency Map (win=50x50)

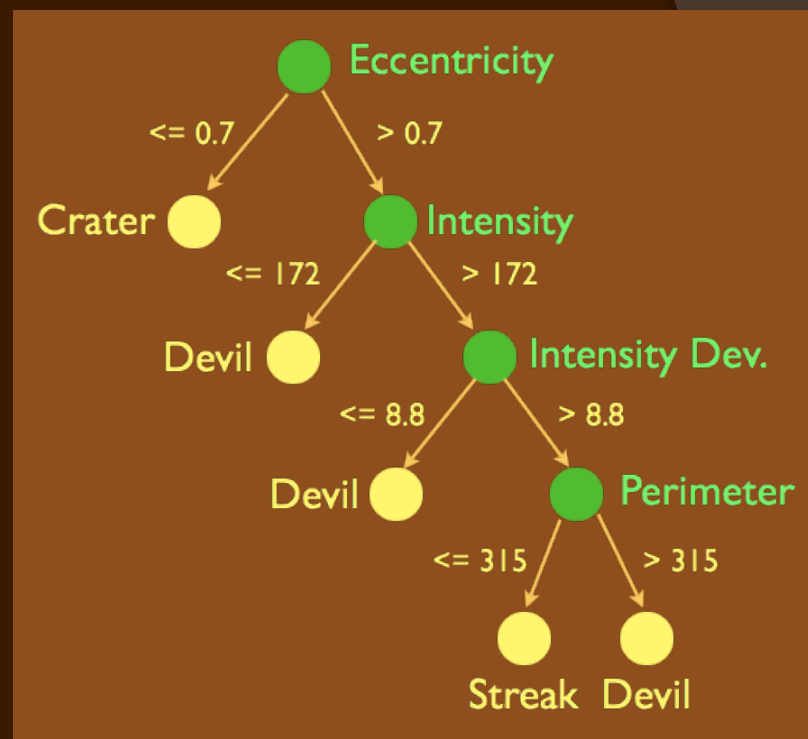




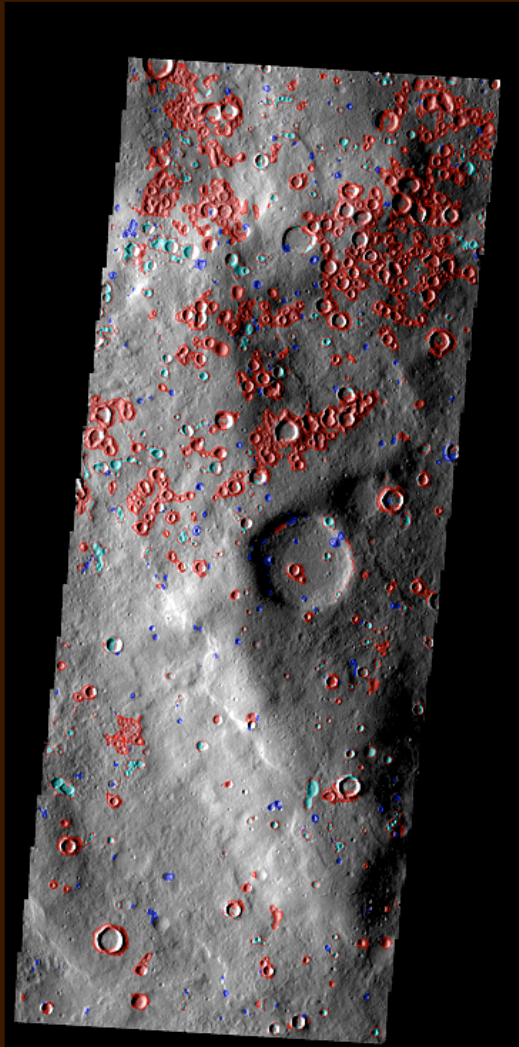
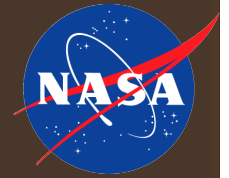
# Dynamic Landmark Identification

- Landmark Detection
  - Move from pixels to regions
- Landmark Classification
  - Compute attributes
    - Size, shape, orientation, intensity
  - Assign type
    - Crater, dark slope streak, dust devil track, unknown
  - Automatically learned decision tree

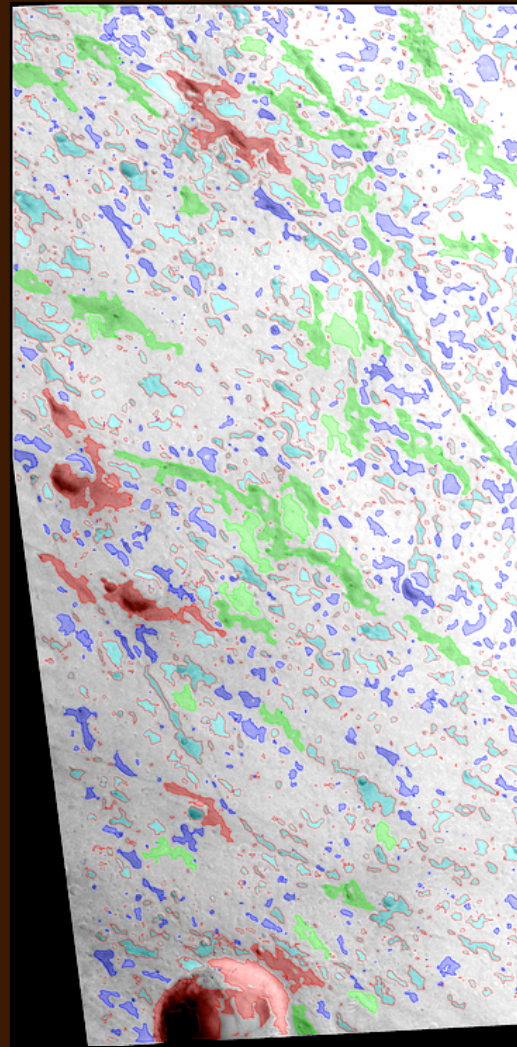
Learned Decision Tree



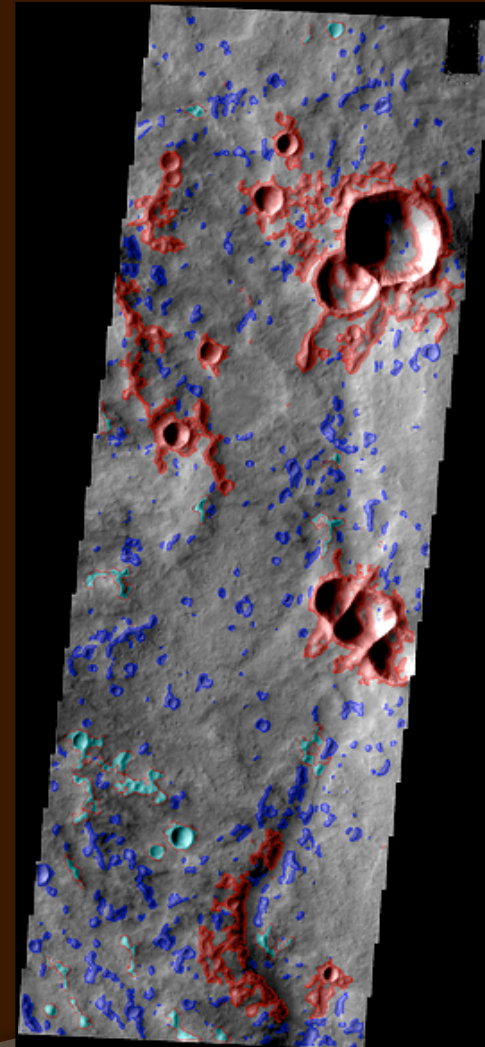
# Classified Landmarks



THEMIS



MOC R10-01596

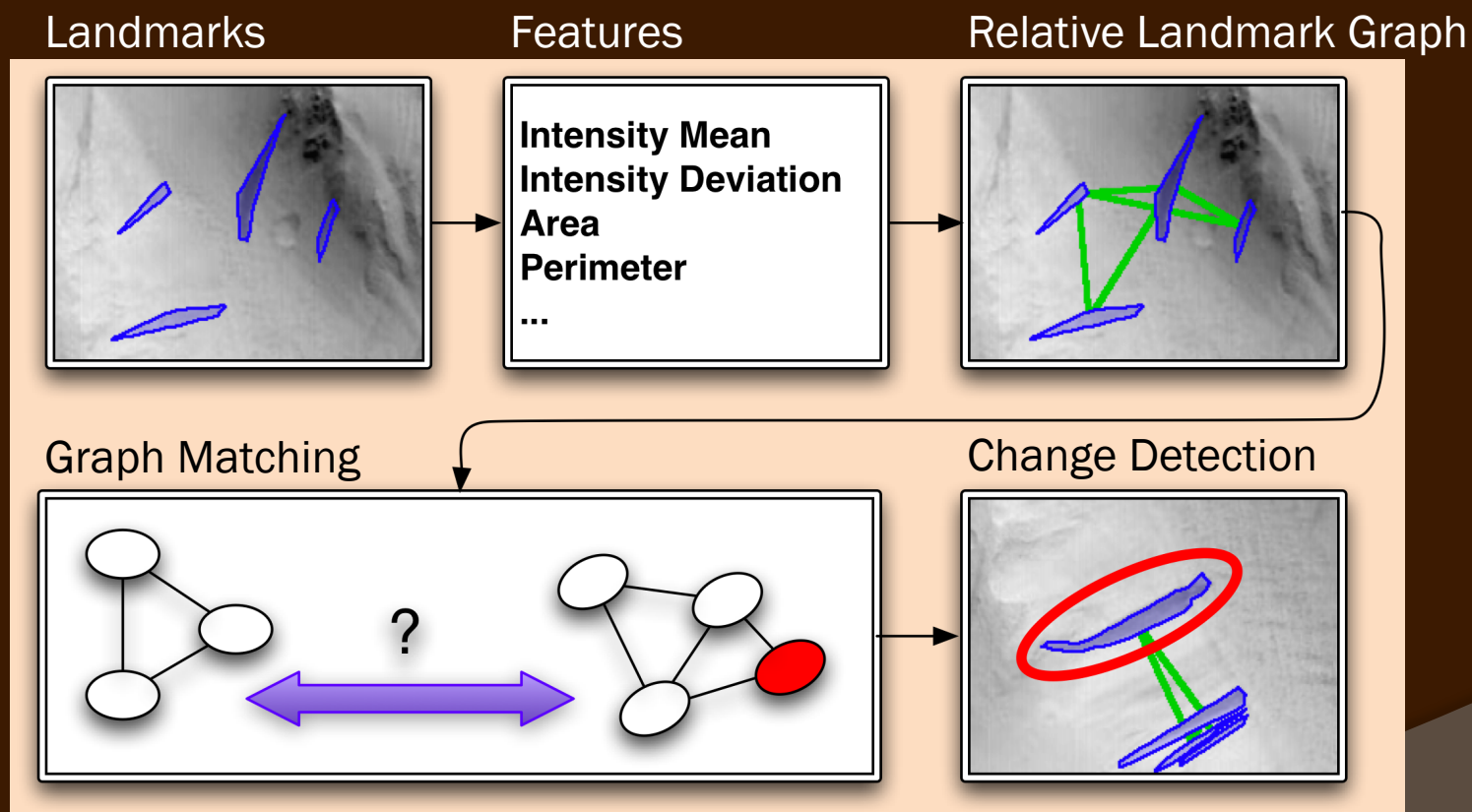


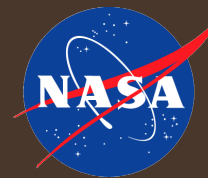
THEMIS

Crater  
Devil  
Streak-like  
Unknown

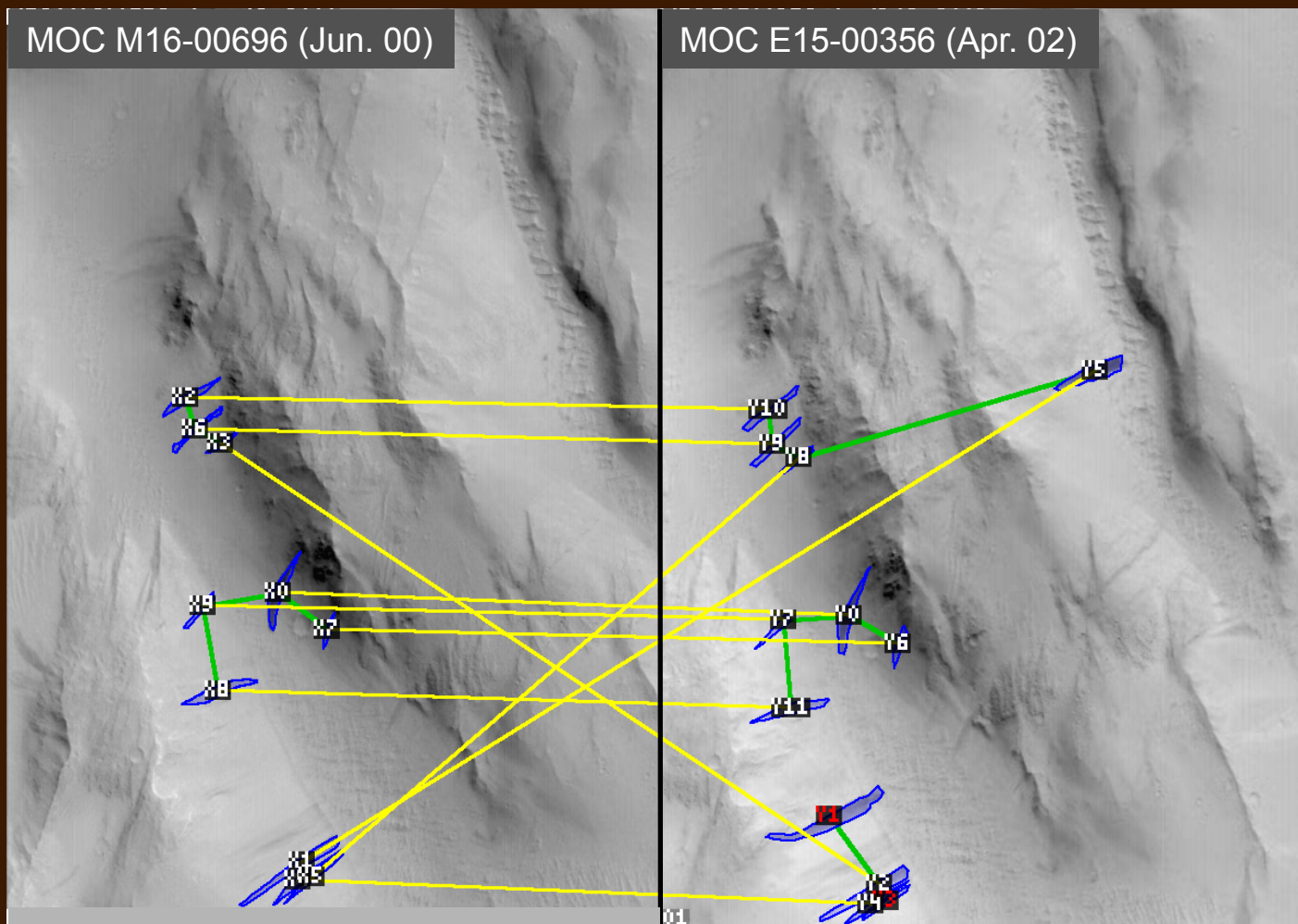
# Change Detection

- Compare landmarks from each image





# Change Detection Example



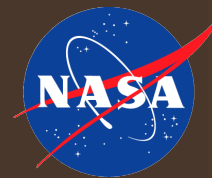
RLG Edges  
Matching  
New

7/10 correct matches

1/2 correct changes

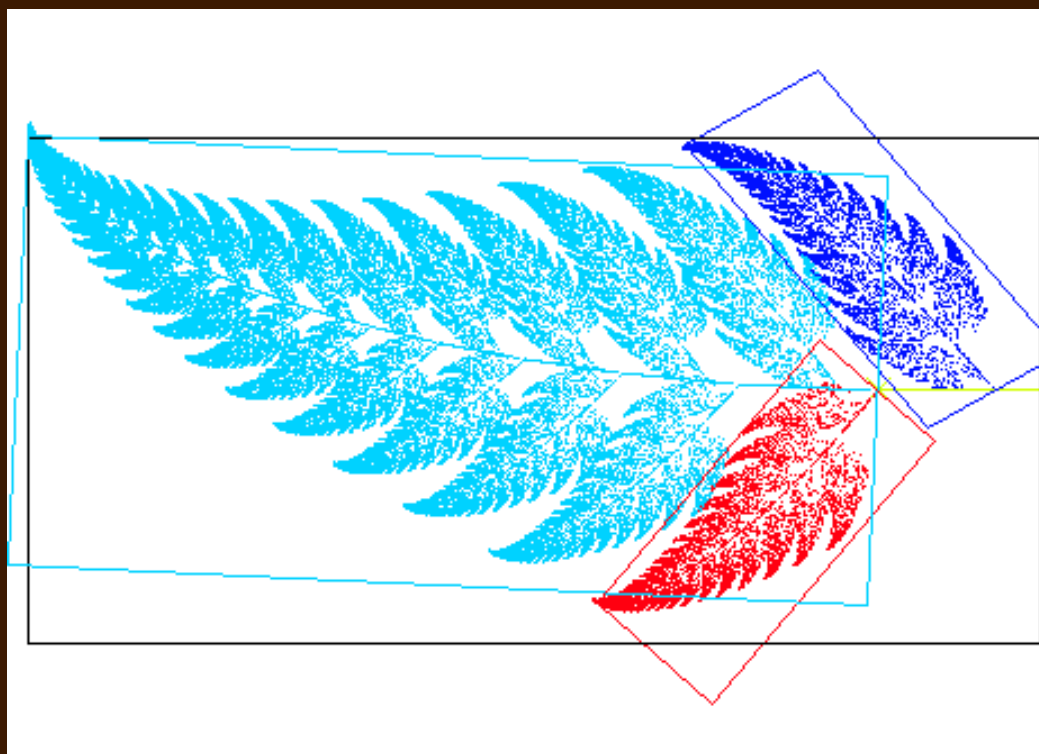
2 new streaks

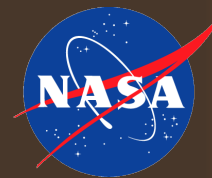




# Affine Transformation Constraint

- Mars and landmarks form a rigid surface
  - Landmarks cannot arbitrarily move around
  - Affine: rotation, translation, scaling, shear
  - Can be applied to unprojected images





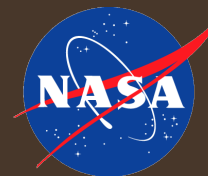
# Change Detection Example

MOC M16-00696 (Jun. 00)

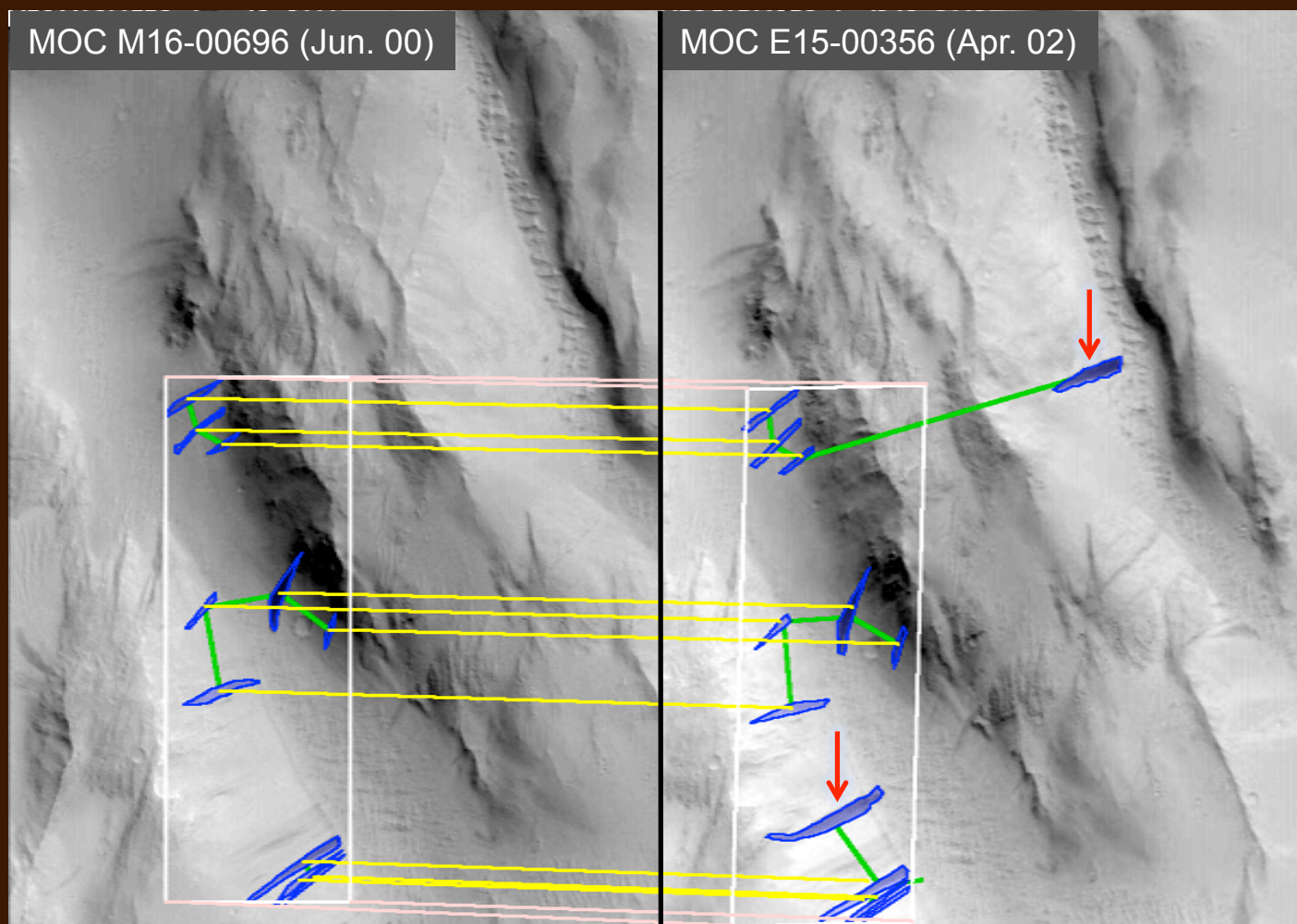


MOC E15-00356 (Apr. 02)





# Changes w/Affine Constraint

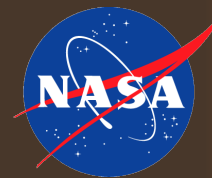


RLG Edges  
Matching  
New  
Transform

10/10 correct  
matches

2/2 correct  
changes

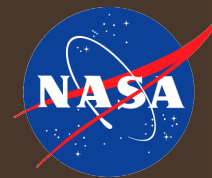
2 new streaks



# Detect New Landmarks

- CTX on MRO (June 4 to August 10, 2008)



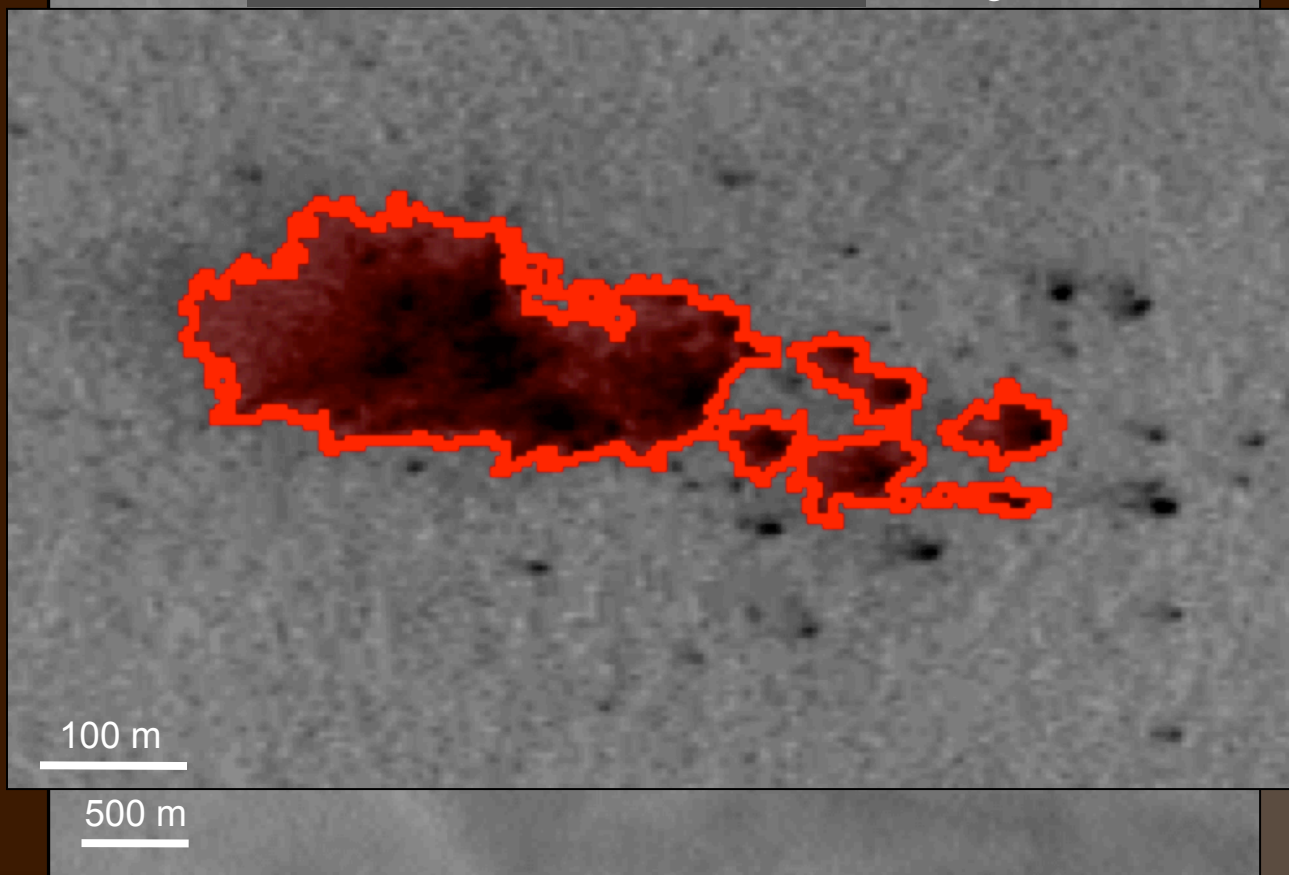


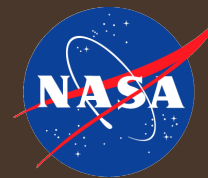
# Detect New Landmarks

- CTX on MRO (June 4 to August 10, 2008)

New Impact Craters

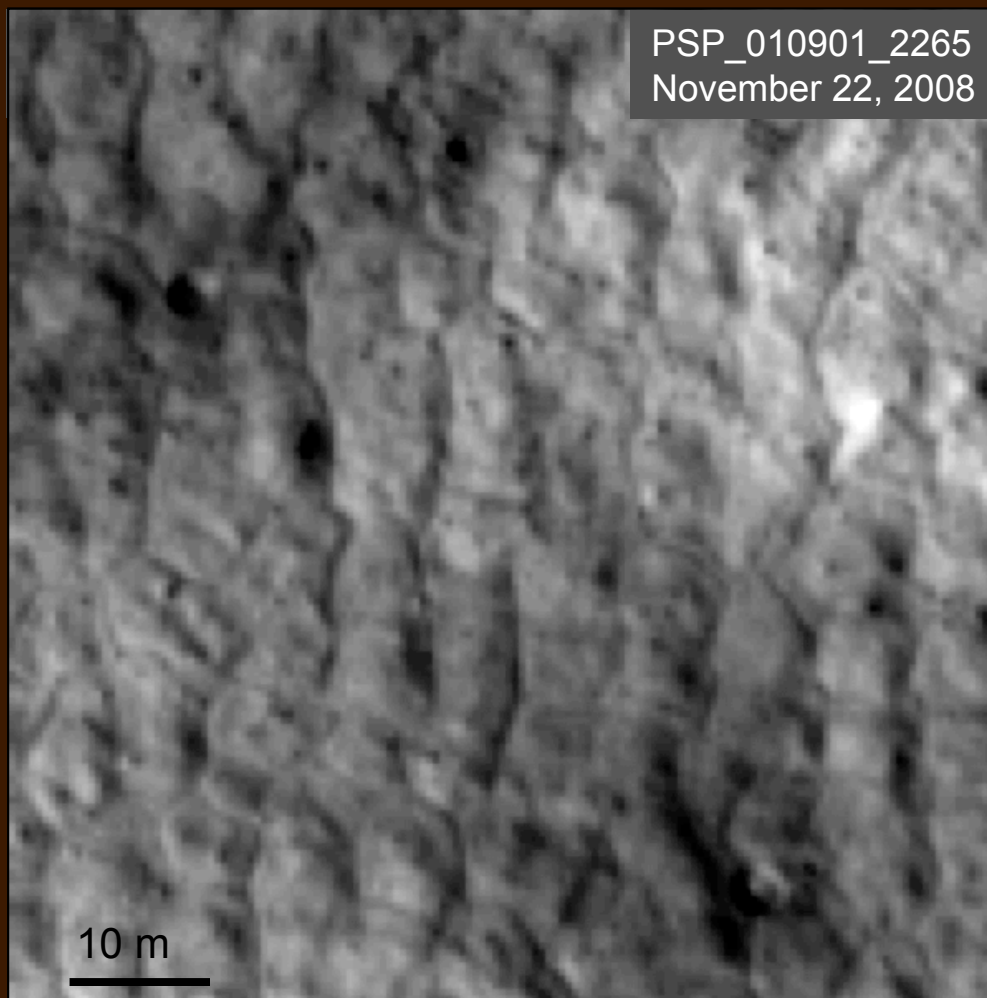
CTX P22-009556  
August 10, 2008

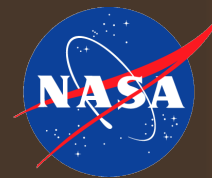




# Detect Vanished Landmarks

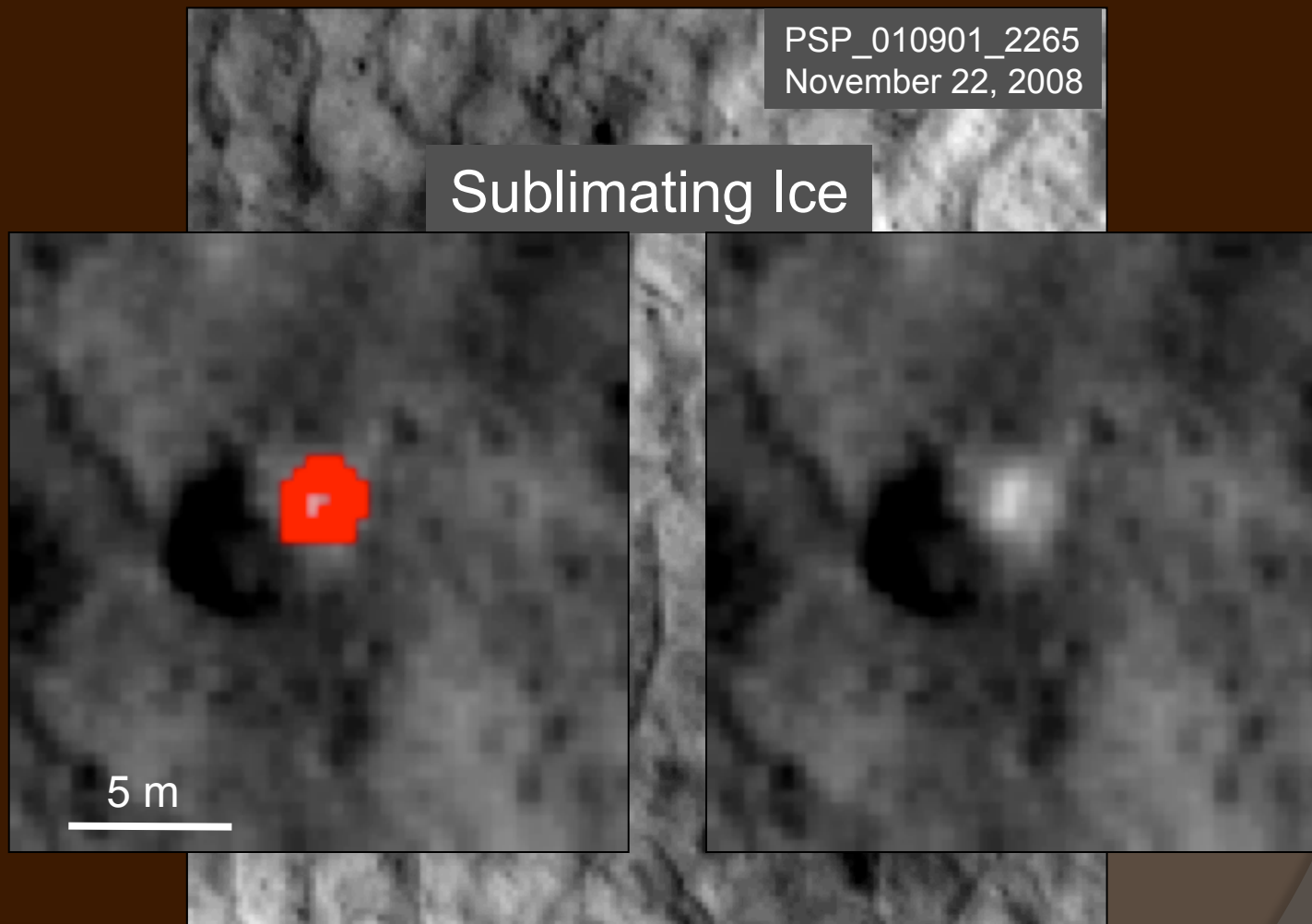
- HiRISE on MRO (September to November, 2008)

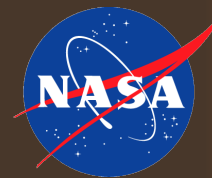




# Detect Vanished Landmarks

- HiRISE on MRO (September to November, 2008)





# Summary

- ⦿ Dynamic Landmarking: find interesting content in image
- ⦿ Change Detection: compare landmarks between images taken at different times
  - Affine transformation constraint
  - Can detect new and vanished landmarks
  - Sensitive to salience threshold, landmark size filter
- ⦿ Next: Multi-instrument change detection
- ⦿ For more information: <http://landmarks.jpl.nasa.gov/>
- ⦿ Thank you: NASA Applied Information Systems Research Program

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