

Sources of ice block falls at the Martian north polar scarps: detection from multi-temporal HiRISE image sets

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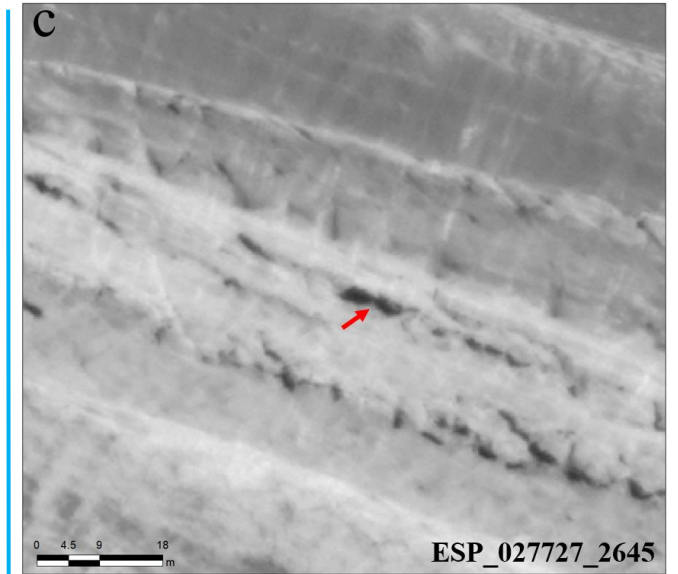
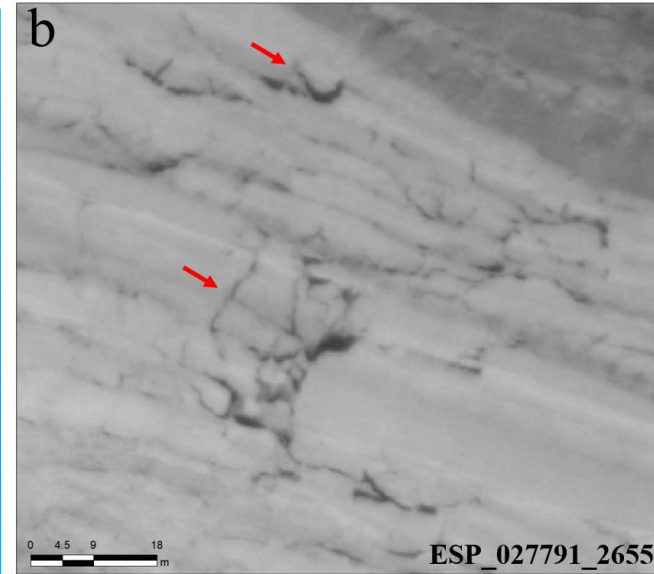
² Institute of Planetary Research, DLR, Berlin, Germany

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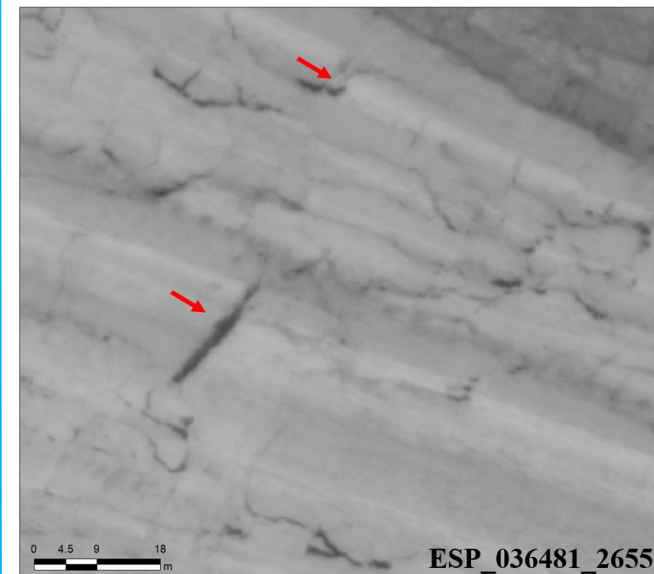
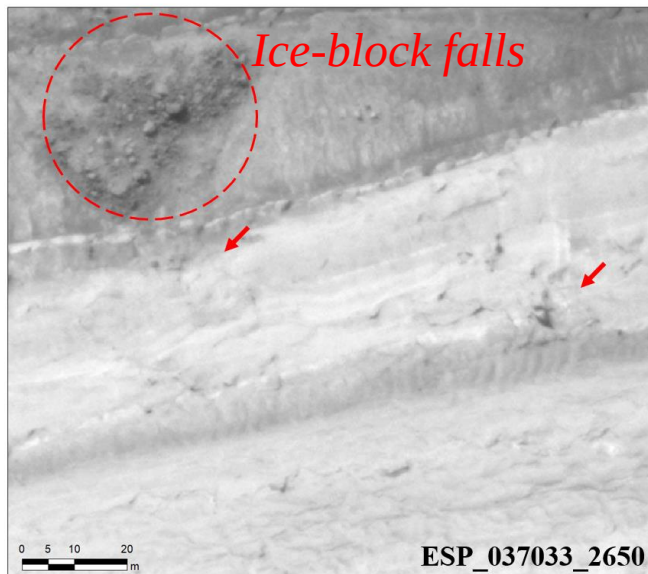
Contact: shu.su@campus.tu-berlin.de

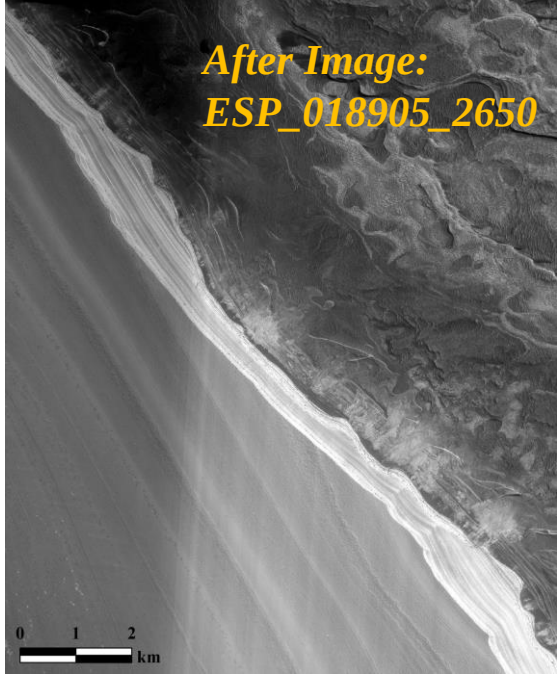
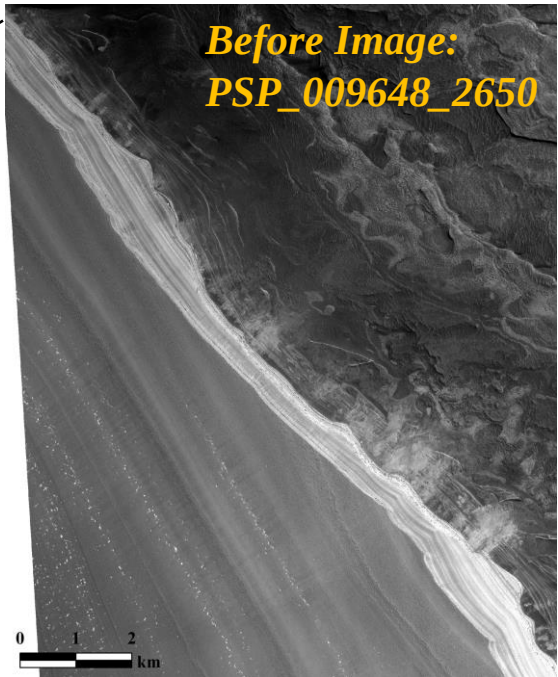
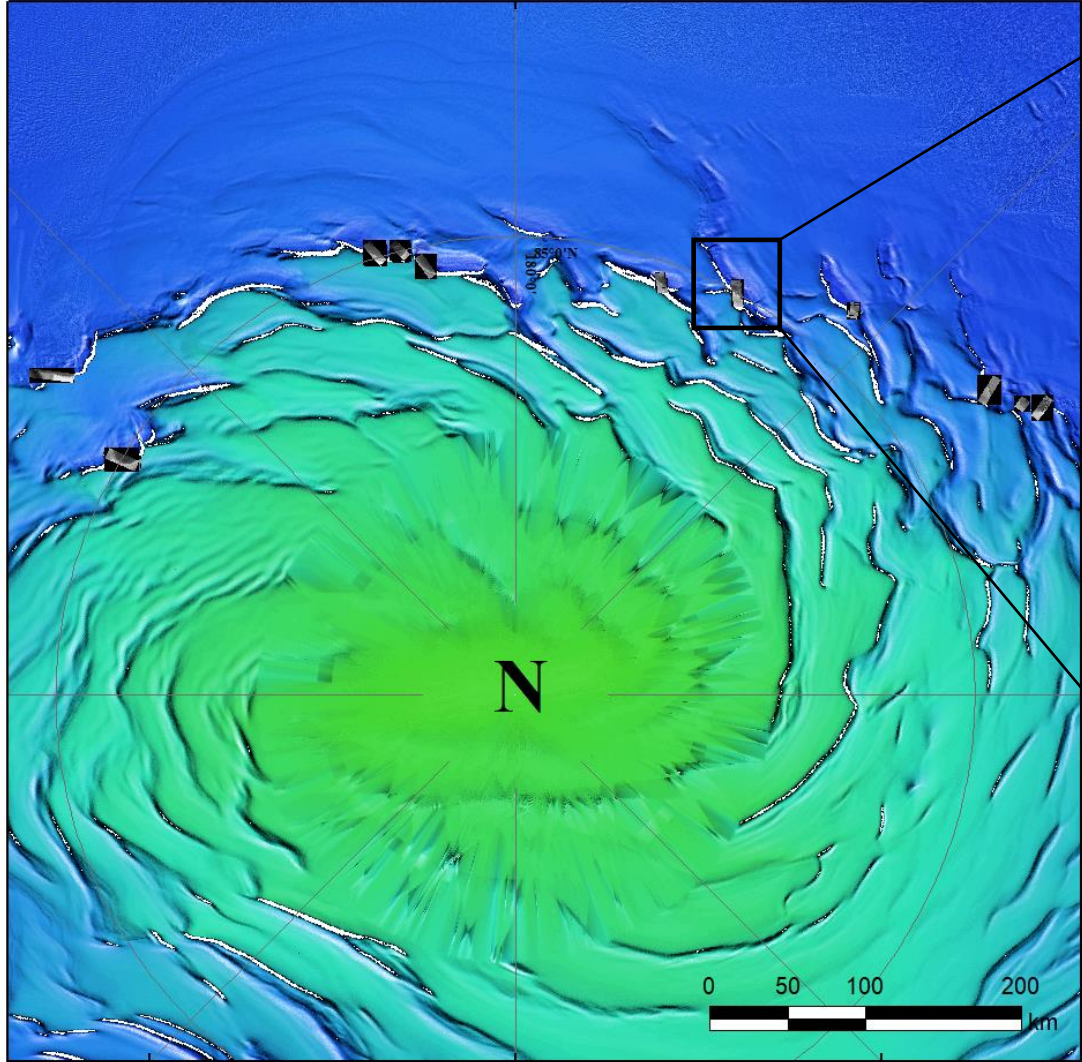
red arrows : ice-fragments
red circles : ice-block falls

Mars Year 31

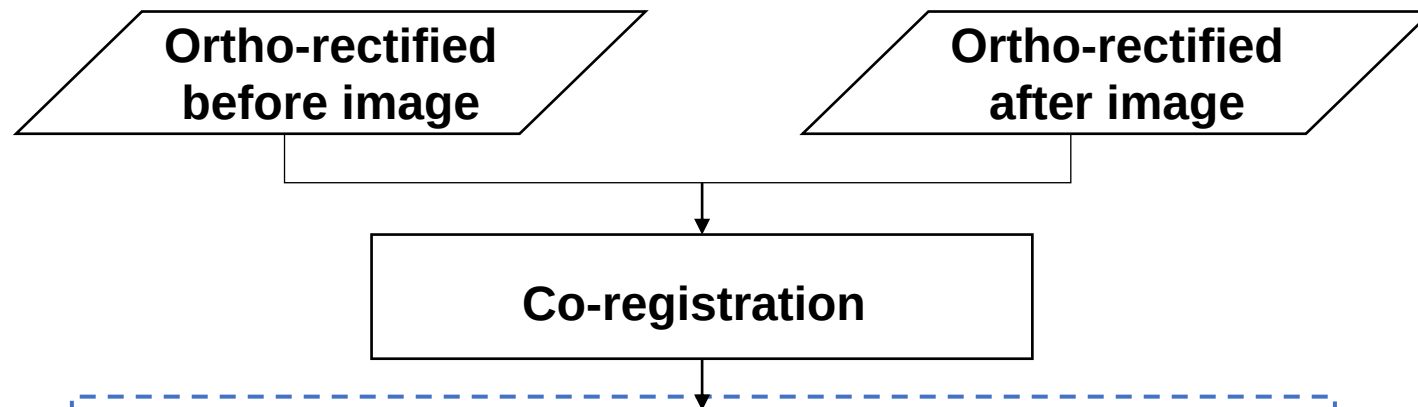


Mars Year 32



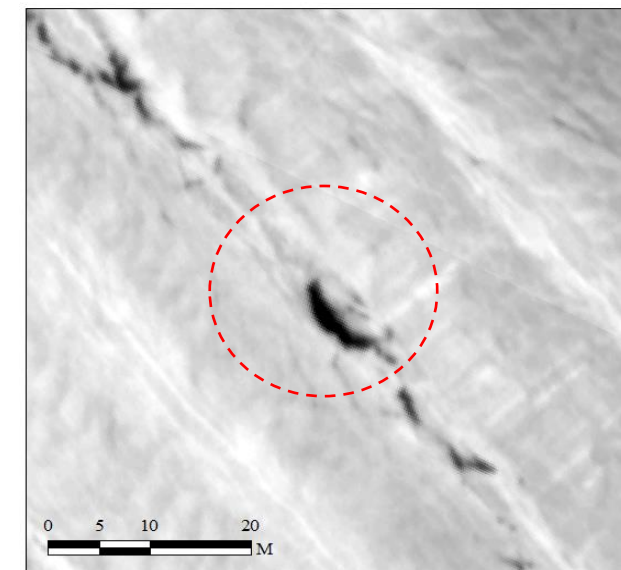
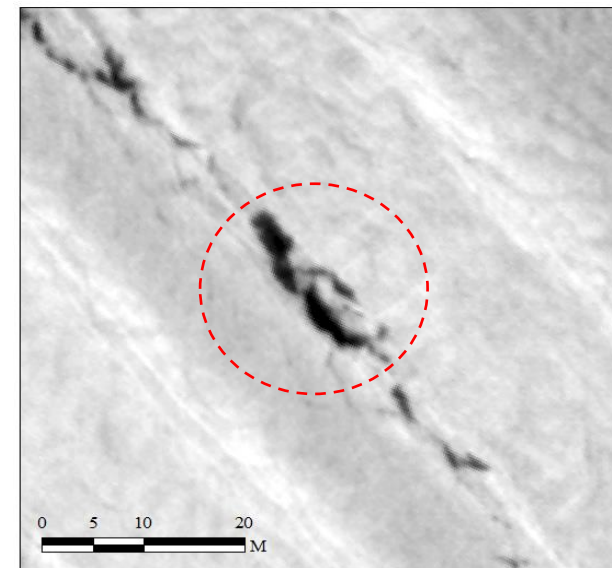


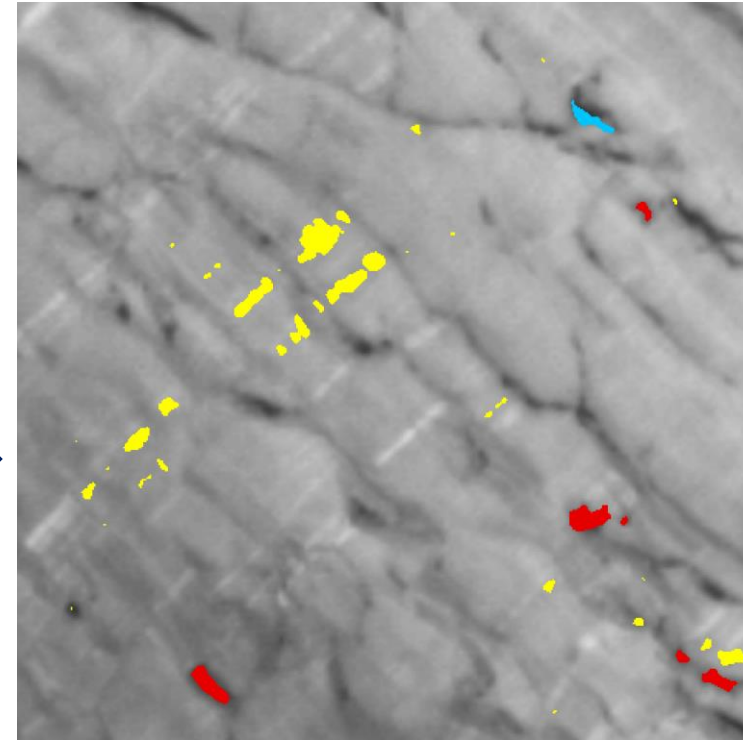
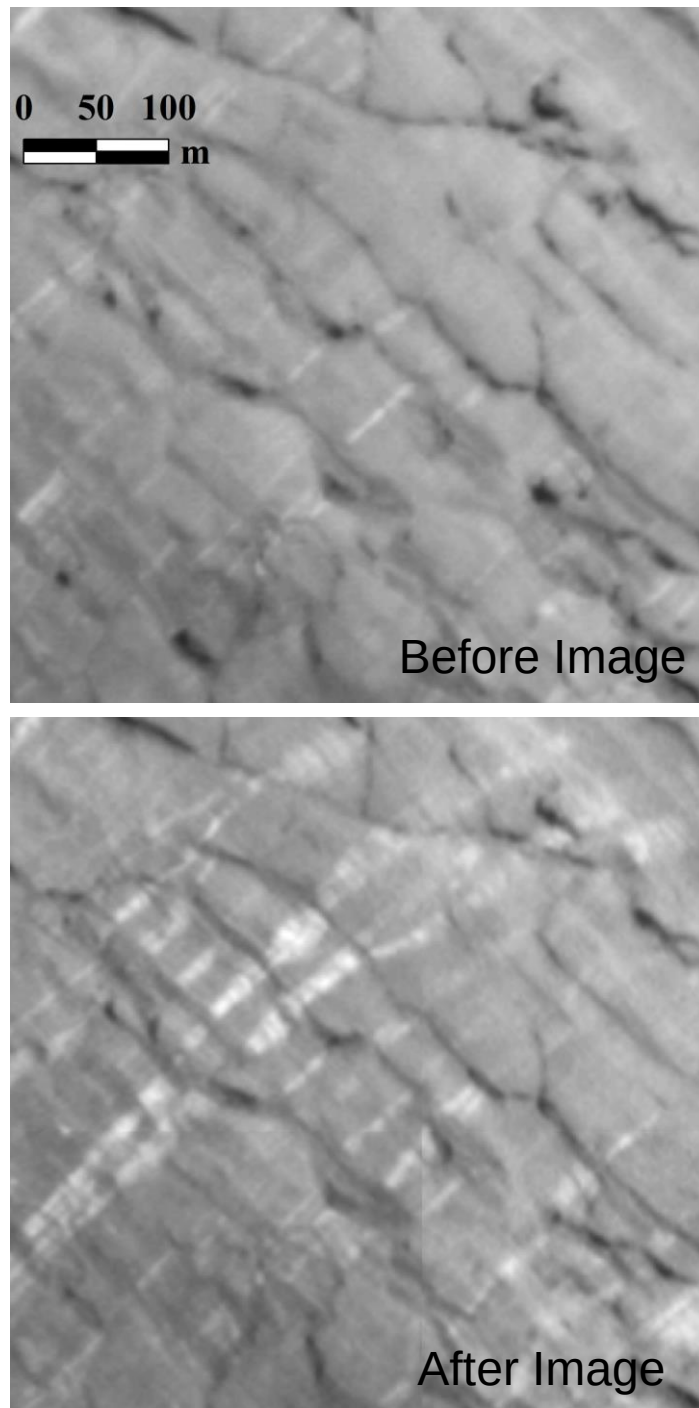
Fractured scarps at the lower part of North Polar Layered Deposits
(Images: HiRISE; Basemap: Mars MGS MOLA Global Color Shaded Relief)
Fanara, L., et al.(2020). Icarus, 342, 113434.



Change Detection Idea

- Before the ice-fragments collapse, they have shadows due to their sizes and sunlight incidence; while after the ice-fragments fall, the original shadows disappear.
- ◆ Based on this finding, we detected the changed shadows, by comparing the relative grayscale difference between the same location of the two images. Then according to the shadows, we can further extract the entire boundaries of the ice-fragments.

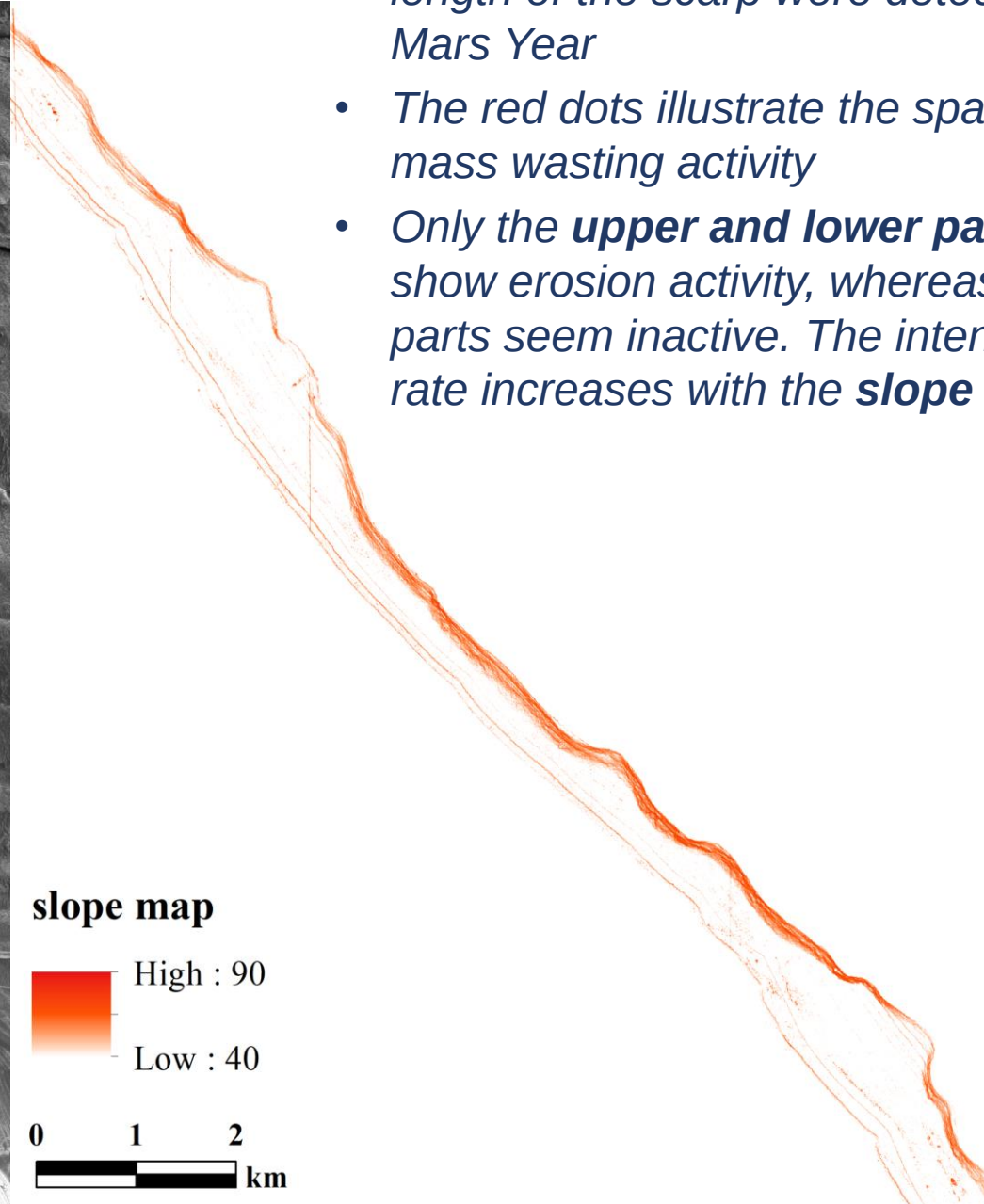
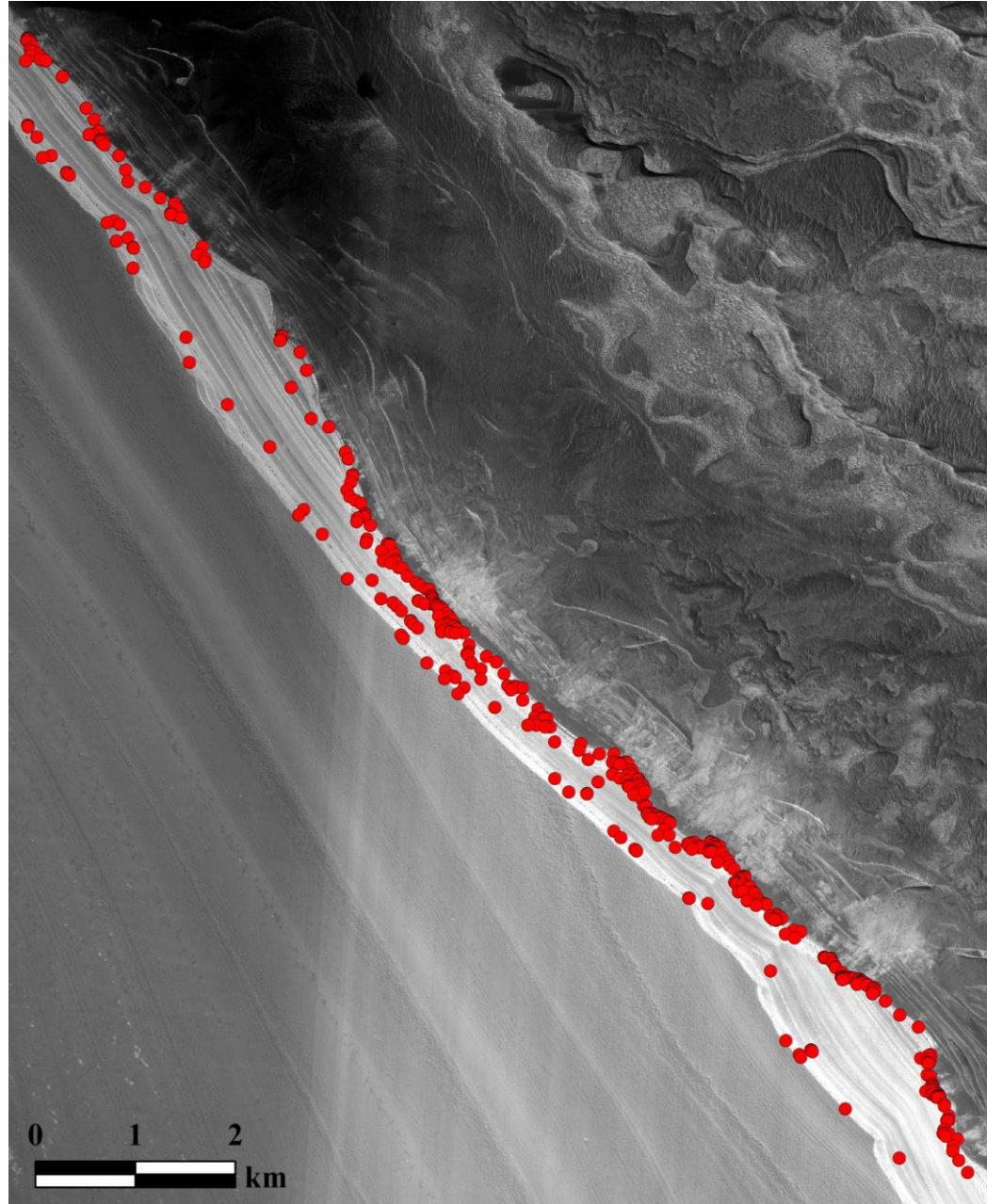




Detailed views of change detection process:

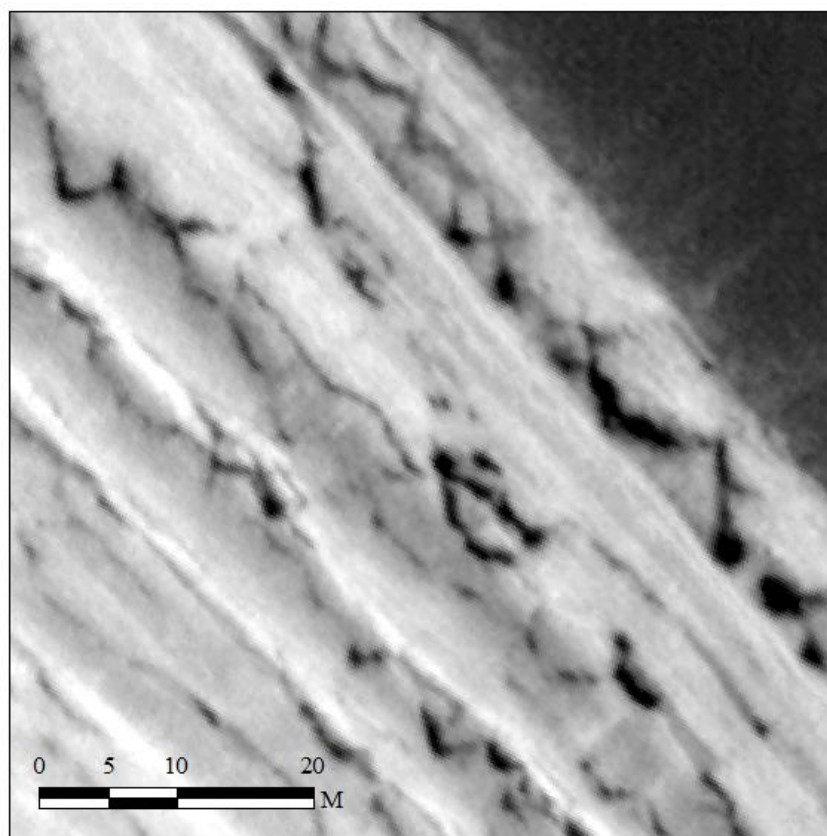
- *in yellow are the detections that are automatically eliminated as false detections due to seasonal CO₂ ice*
- *in blue are the detections that are automatically eliminated as false detections caused by shadow deformation*
- *in red are the final detections of the method.*

Change Detection Results

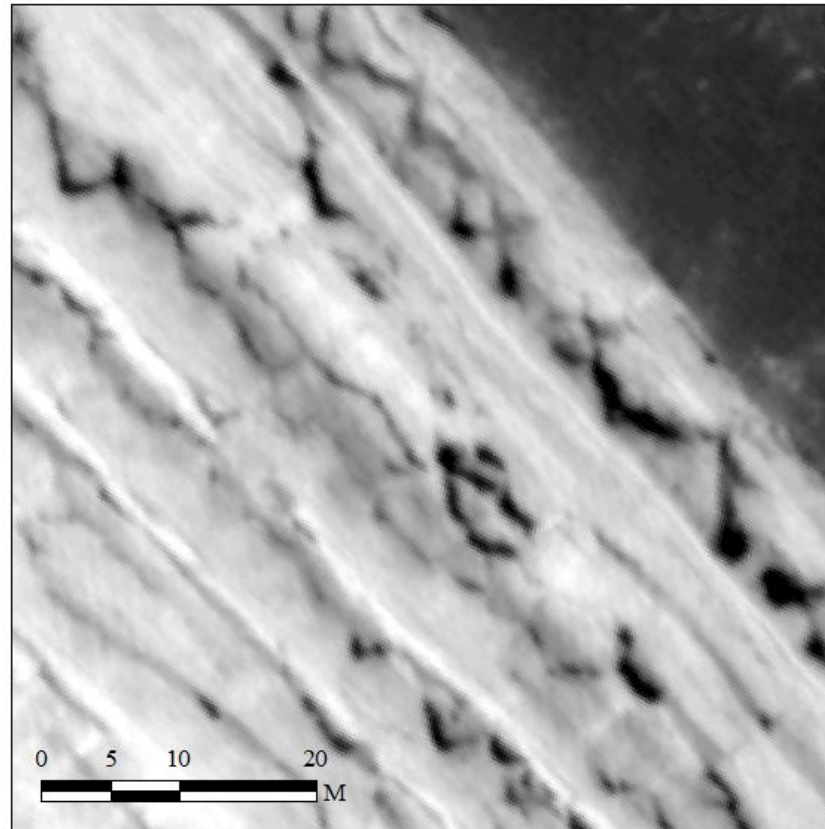


- 440 sources of block falls covering the whole length of the scarp were detected within one Mars Year
- The red dots illustrate the spatial distribution of mass wasting activity
- Only the **upper and lower part** of this scarp show erosion activity, whereas the intermediate parts seem inactive. The intensity of erosion rate increases with the **slope steepness**.

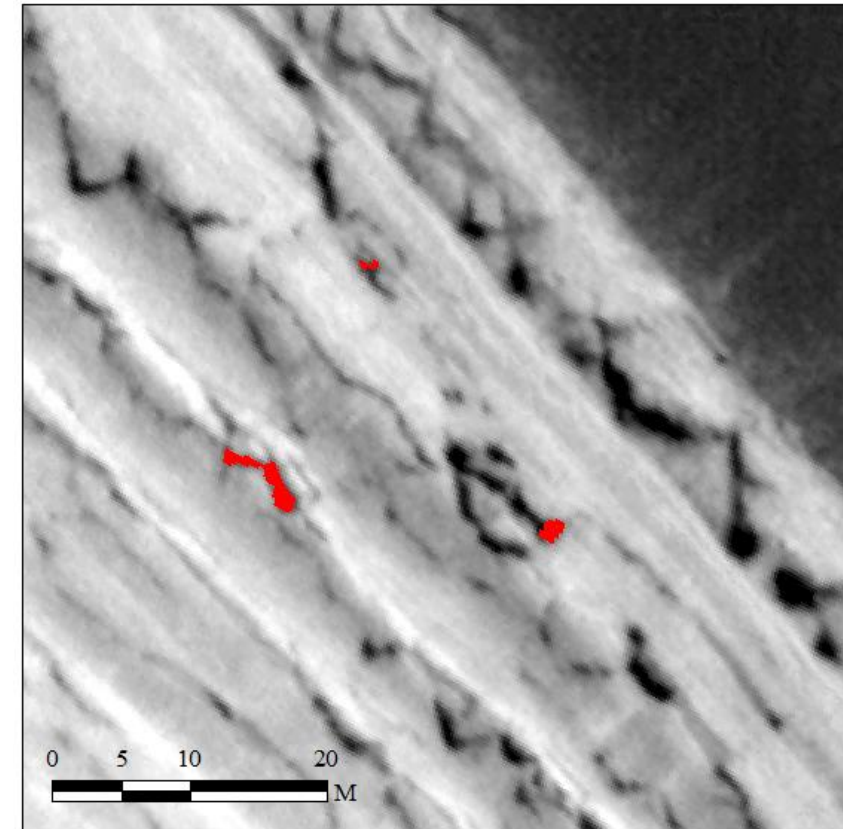
An example from the lower part of the scarp



Before Image

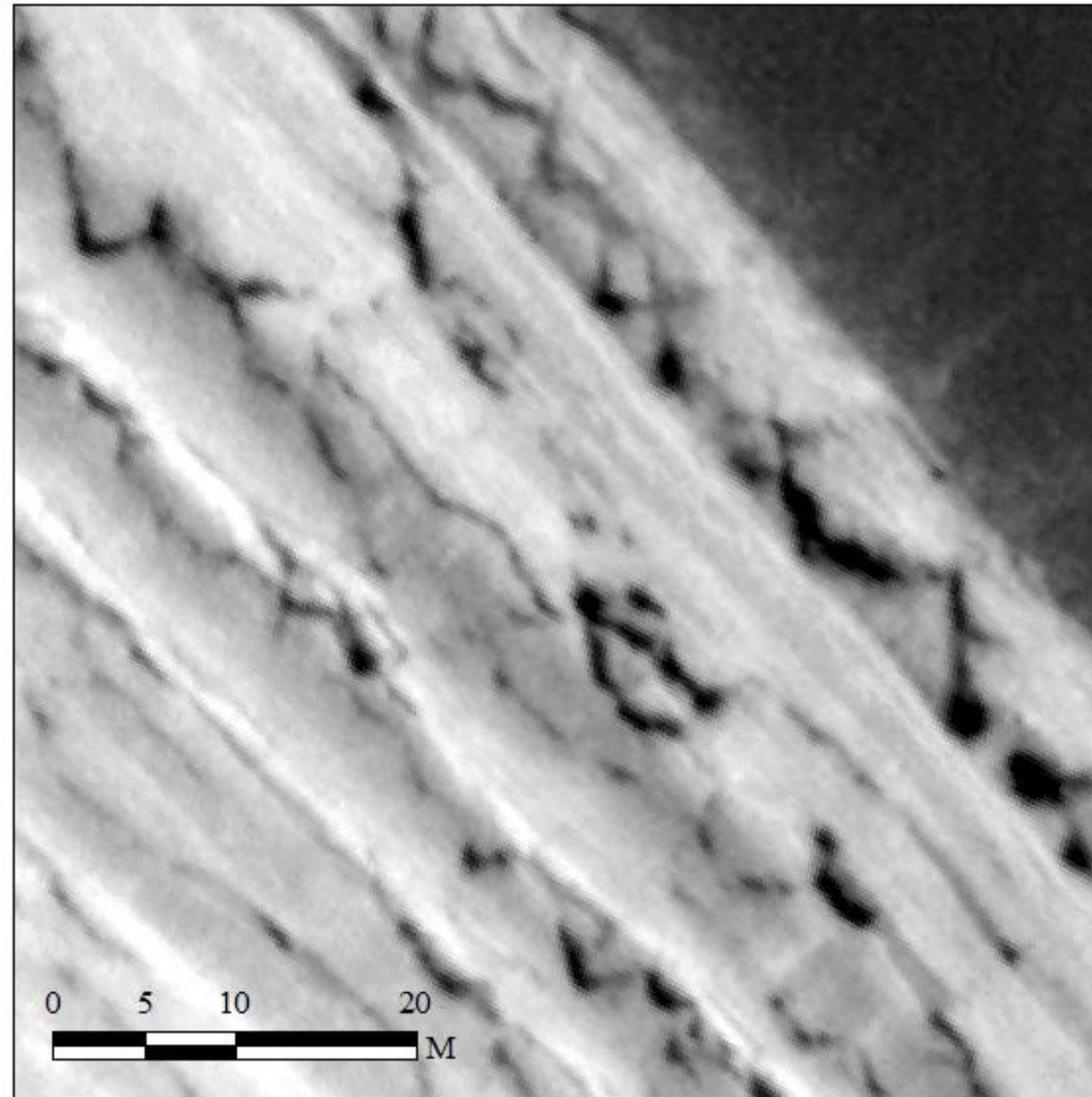


After Image

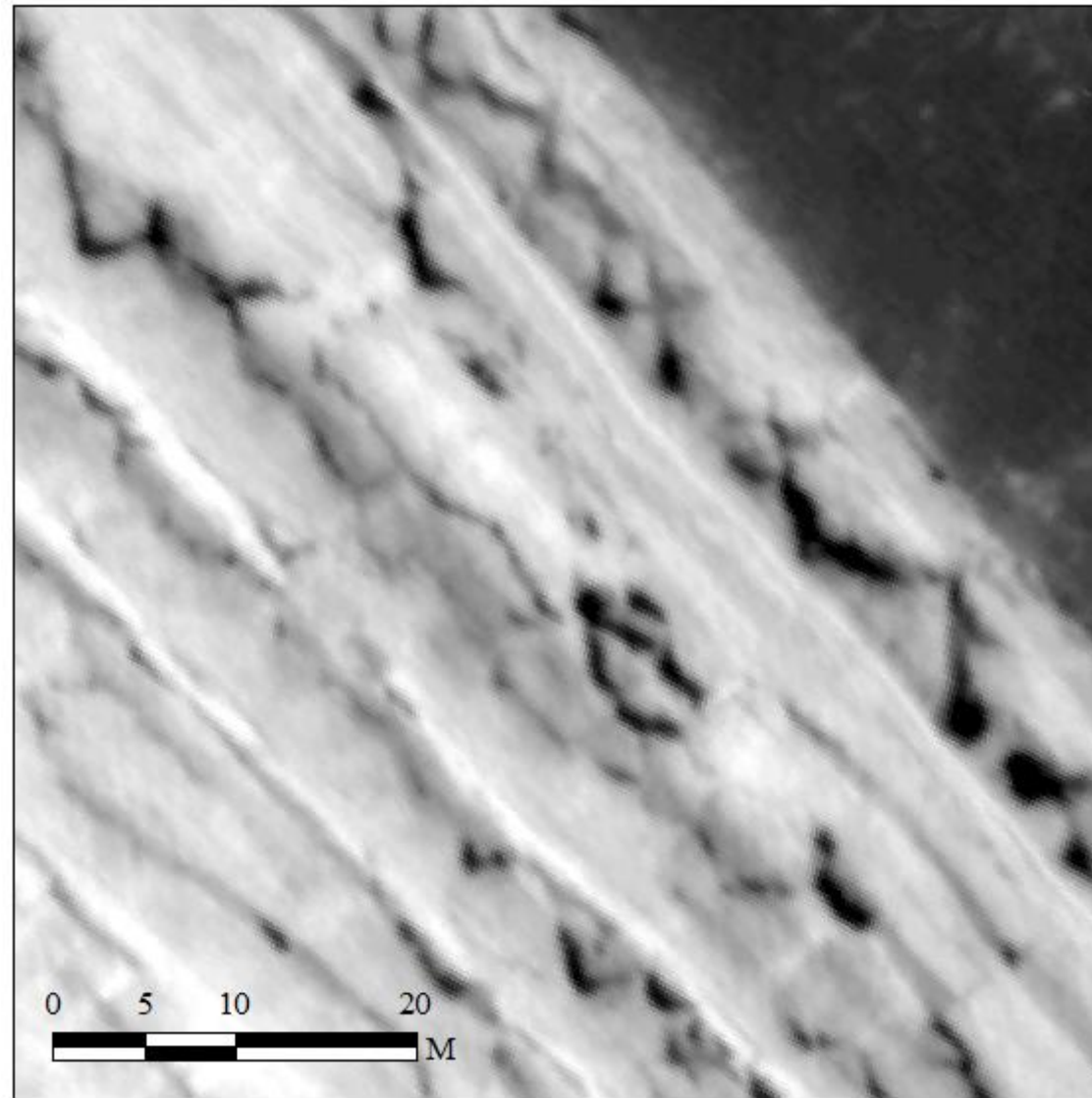


Changed Area

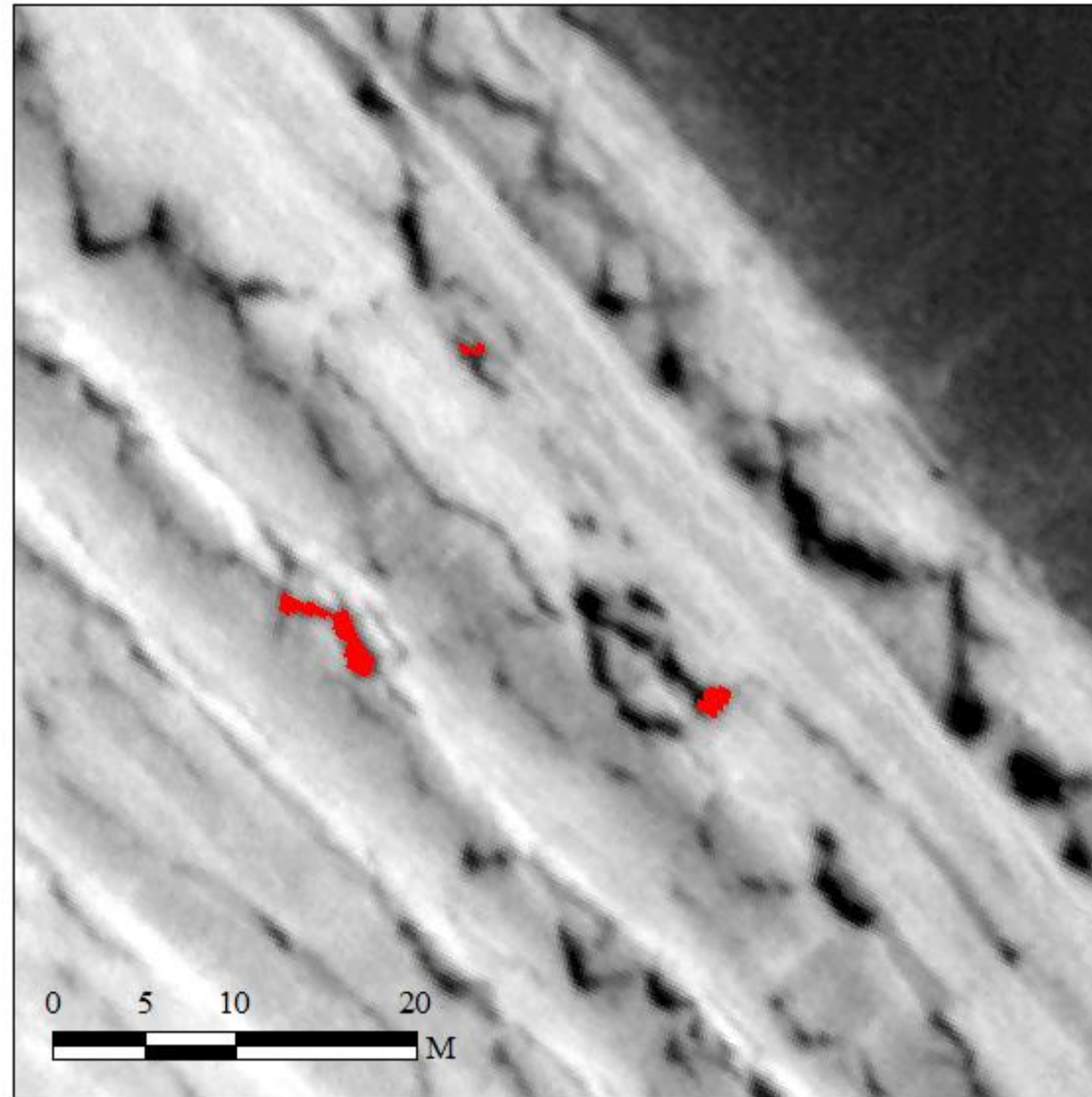
Before collapse



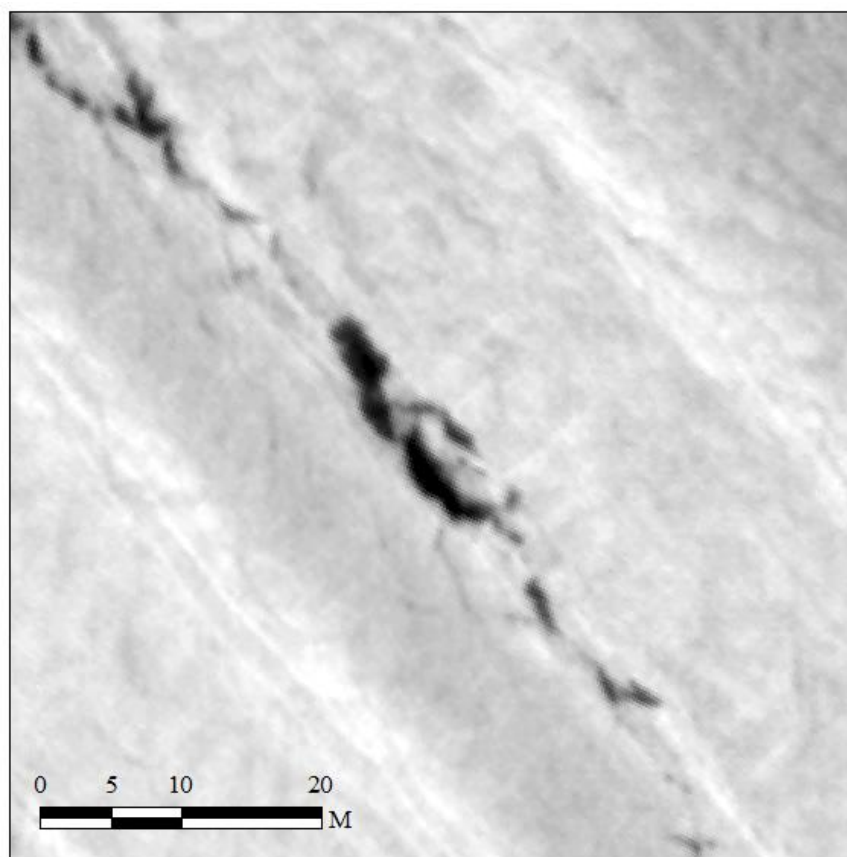
After collapse



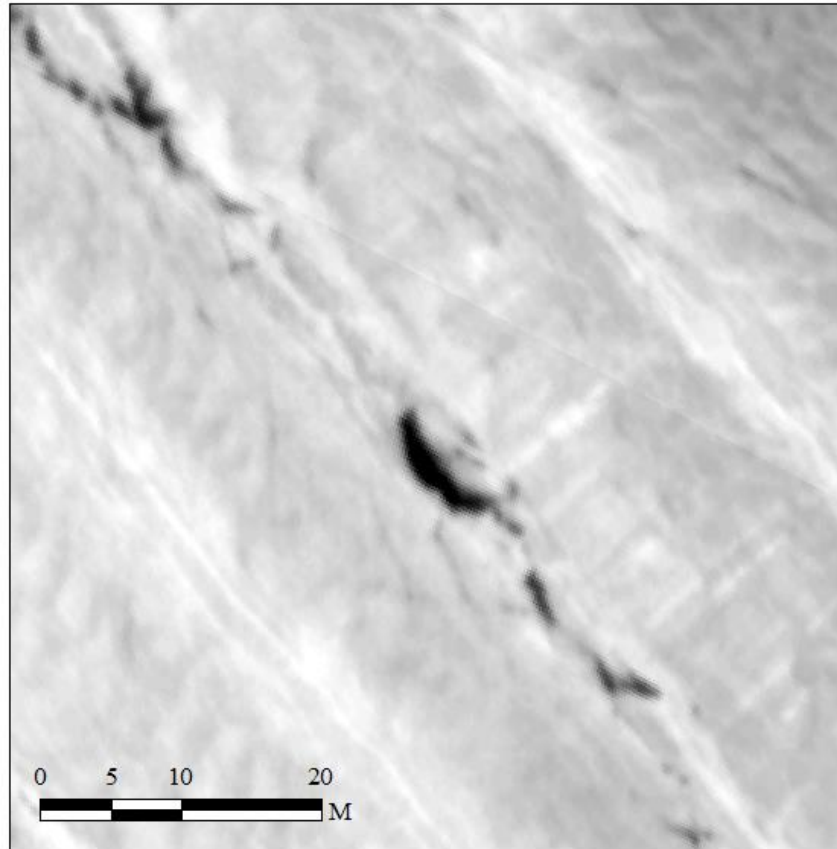
Changed areas



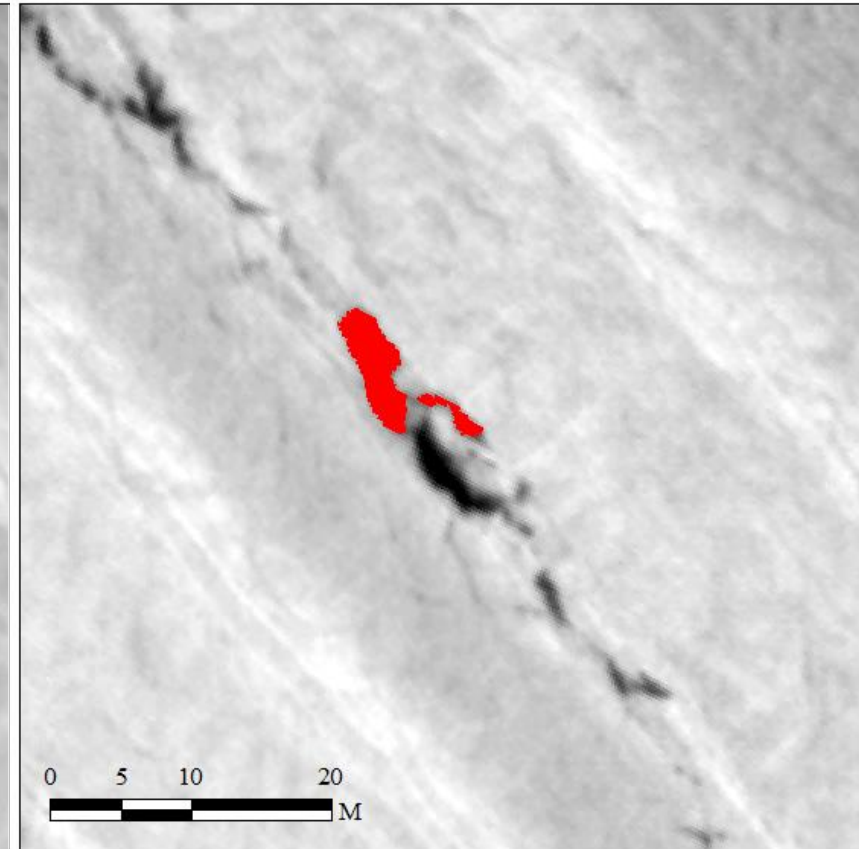
An example from the upper part of the scarp



Before Image

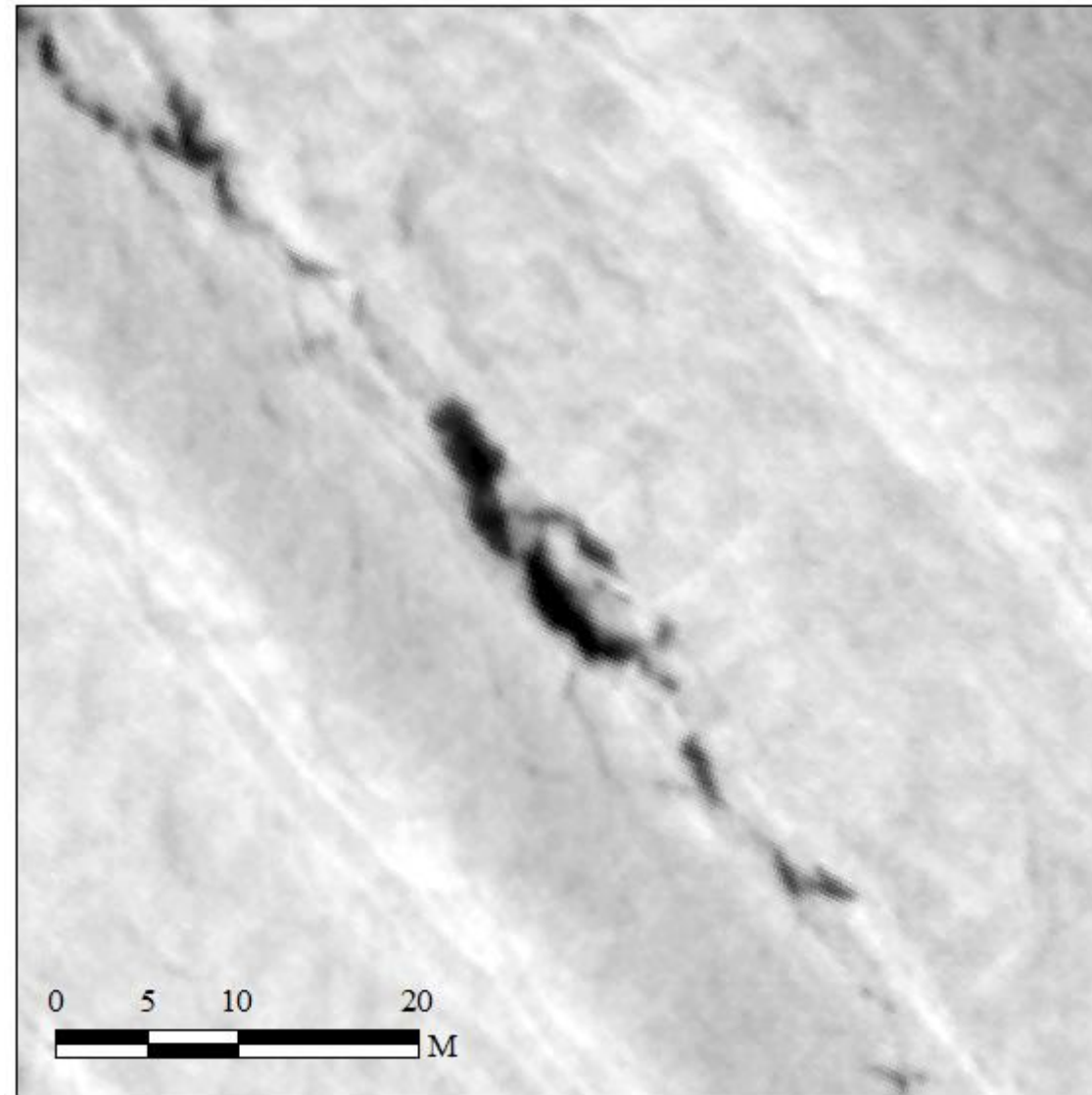


After Image

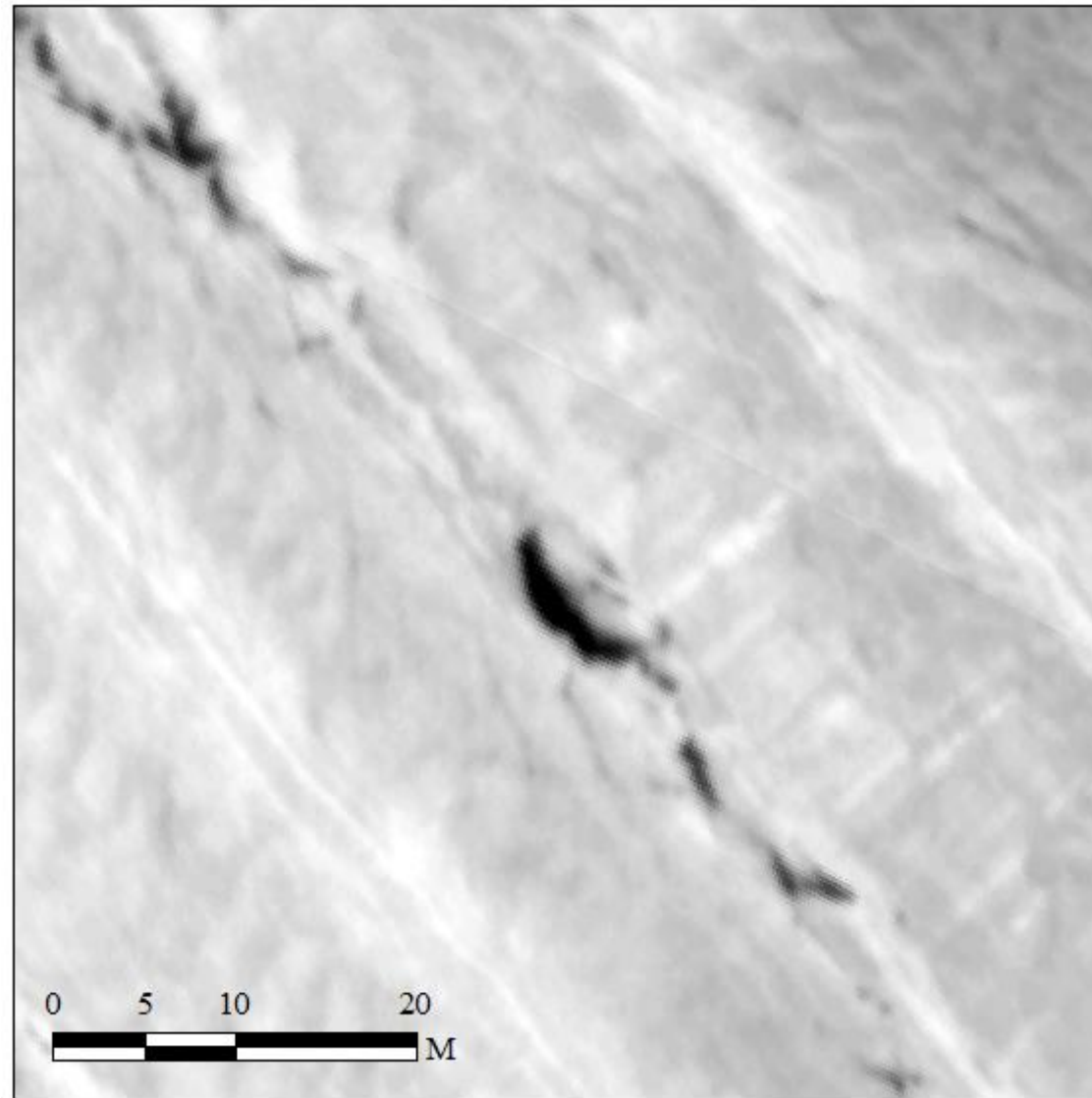


Changed Area

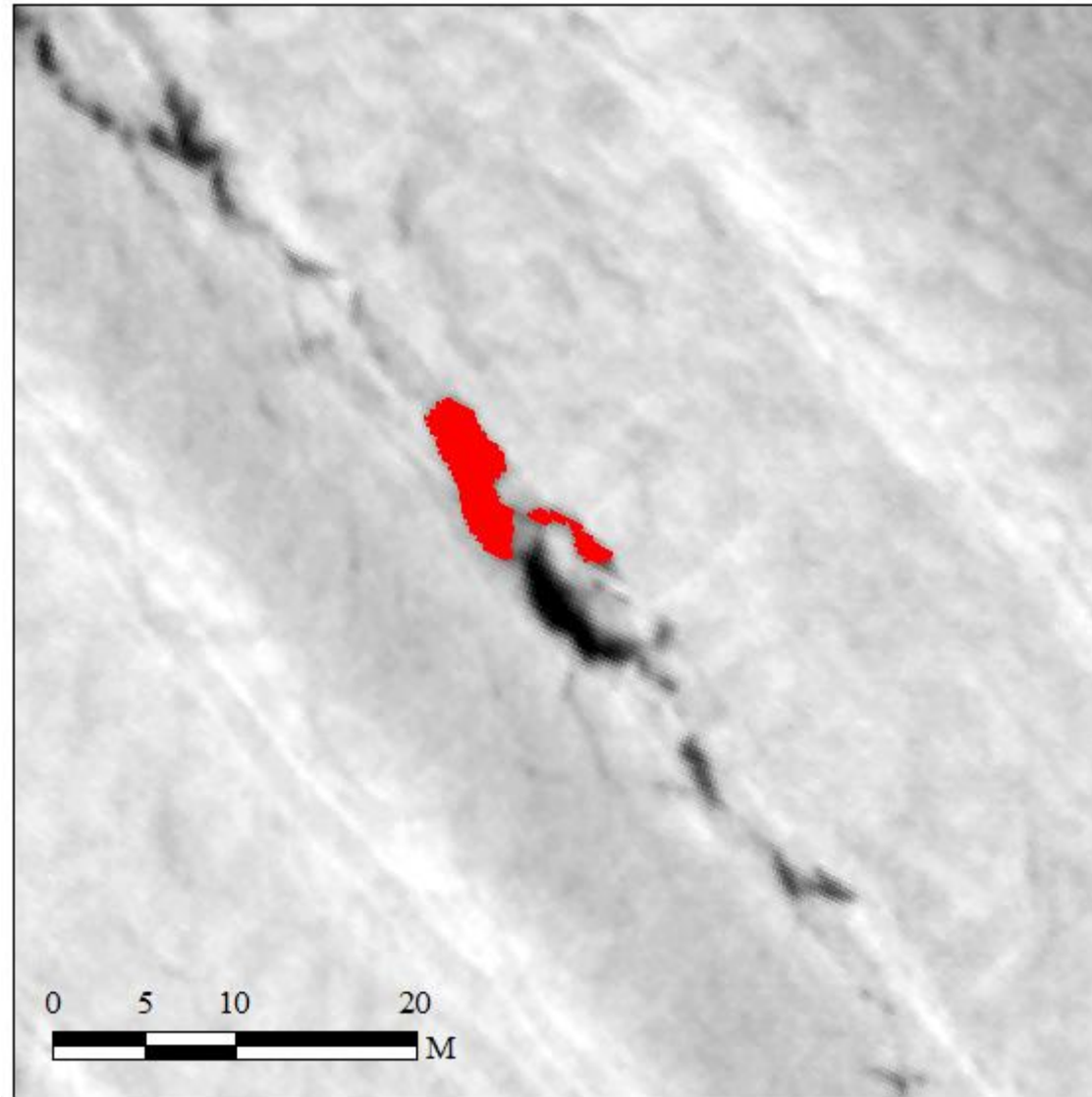
Before collapse



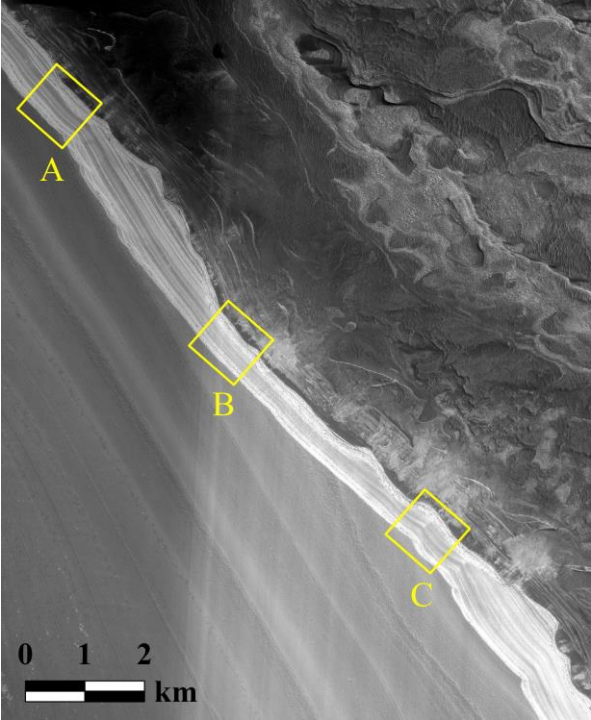
After collapse



Changed area



	True positives	False positives	False negatives
A	16	5	1
B	27	6	1
C	39	10	1



	True positive rate	False discovery rate	Quality of detection method
	$TPR = \frac{TP}{TP + FN}$	$FDR = \frac{FP}{TP + FP}$	$Q = \frac{TP}{TP + FN + FP}$
A	94.1%	23.8%	72.7%
B	96.4%	18.2%	79.4%
C	97.5%	20.4%	78.0%

- An automated change detection method was developed to trace the sources of block falls at the Martian North Polar
- The collapsed ice-fragments and the changed shadows can be helpful:
 - estimating mass wasting at the scarps
 - investigating erosion seasonality
 - understanding the ice behavior and the evolution of the NPLD scarps.



Thanks for watching!
