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

Shu Su 1,*, Lida Fanara 1,2, Xin Zhang 3, Klaus Gwinner 2, Ernst Hauber 2, Jürgen Oberst 1,2

1 Institute of Geodesy and Geoinformation Science, Technical University of Berlin, Berlin, Germany
2 Institute of Planetary Research, DLR, Berlin, Germany
3 College of Surveying and Geoinformatics, Tongji University, Shanghai, China

Contact: shu.su@campus.tu-berlin.de
Research Background — examples of ice-fragments

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)
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.
• 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 collapse
After collapse
Changed areas
An example from the upper part of the scarp
Before collapse
After collapse
Changed area
## Validation

### True positives, False positives, False negatives

<table>
<thead>
<tr>
<th></th>
<th>True positives</th>
<th>False positives</th>
<th>False negatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>16</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>27</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>39</td>
<td>10</td>
<td>1</td>
</tr>
</tbody>
</table>

### True positive rate, False discovery rate, Quality of detection method

<table>
<thead>
<tr>
<th></th>
<th>$TPR = \frac{TP}{TP + FN}$</th>
<th>$FDR = \frac{FP}{TP + FP}$</th>
<th>$Q = \frac{TP}{TP + FN + FP}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>94.1%</td>
<td>23.8%</td>
<td>72.7%</td>
</tr>
<tr>
<td>B</td>
<td>96.4%</td>
<td>18.2%</td>
<td>79.4%</td>
</tr>
<tr>
<td>C</td>
<td>97.5%</td>
<td>20.4%</td>
<td>78.0%</td>
</tr>
</tbody>
</table>
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!