University of Zurich[UZH]

Department of Geography
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EARSeL

Global Assessment of Supraglacial Debris-Cover Extents

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1. Motivation

- Debris-covered glaciers act as conveyor belts of sediment
- Debris cover influences glacier mass balance
- Dynamic evolution of debris cover during climate change

2. Data

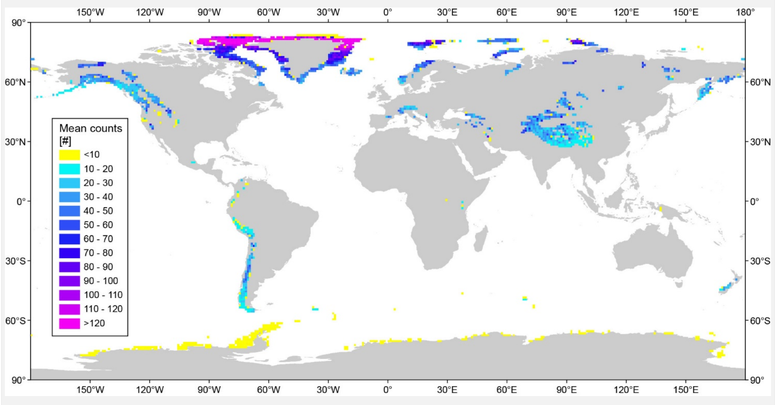

Fig. 1: Global data availability of Landsat 8 SR Tier 1 (2013-17)

- **Satellite imagery:** Landsat 8 & Sentinel-2
- **Glacier outlines:** Randolph Glacier Inventory v6.0 (RGI Consortium, 2017)
- **Digital elevation models**: SRTM 1-Arc DEM (60 N-60 S) and ASTER GDEM v2 (elsewhere)

3. Methods

Debris cover classification

- Debris-cover maps are based on RGI6.0 outlines and three band algorithms: RATIO, NDSI (index) and FDC (unmixing)

$$RATIO = \frac{Red}{SWIR1} \qquad NDSI = \frac{Green - SWIR1}{Green + SWIR1}$$

$$FDC = f(Red, Green, SWIR1)$$

Satellite image generation

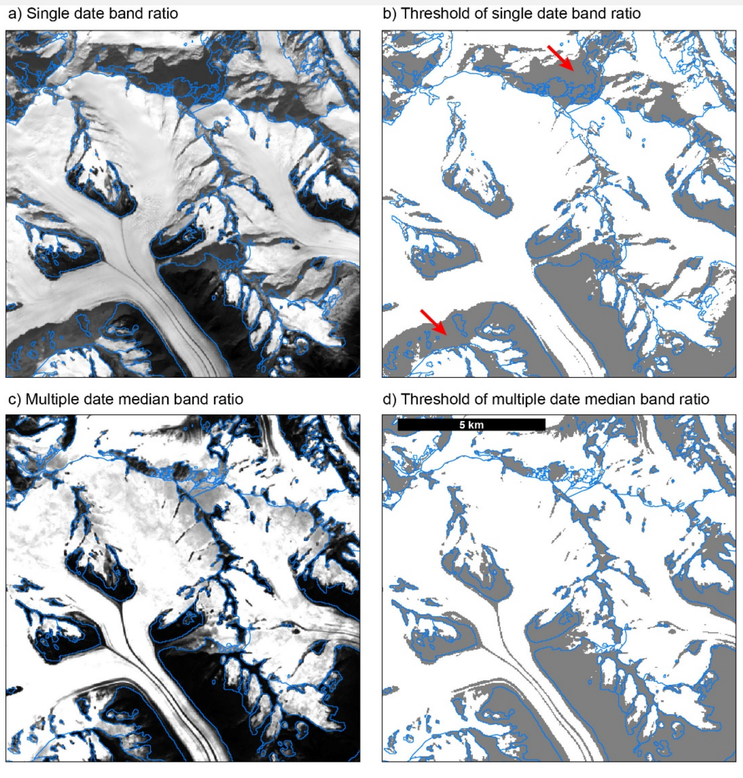

Fig. 2: Aletsch Glacier, Image vs. Pixel based composites

3. Methods

Satellite image generation

- Common issues with optical imagery are related to cloud cover, snow cover, and shadows
- We tackle these issues in the Google Earth Engine (Gorelick et al., 2017), by:
  - selecting only images from the melting season
  - filtering cloud cover and cloud shadows
  - creating a median image for each band

Classification thresholds

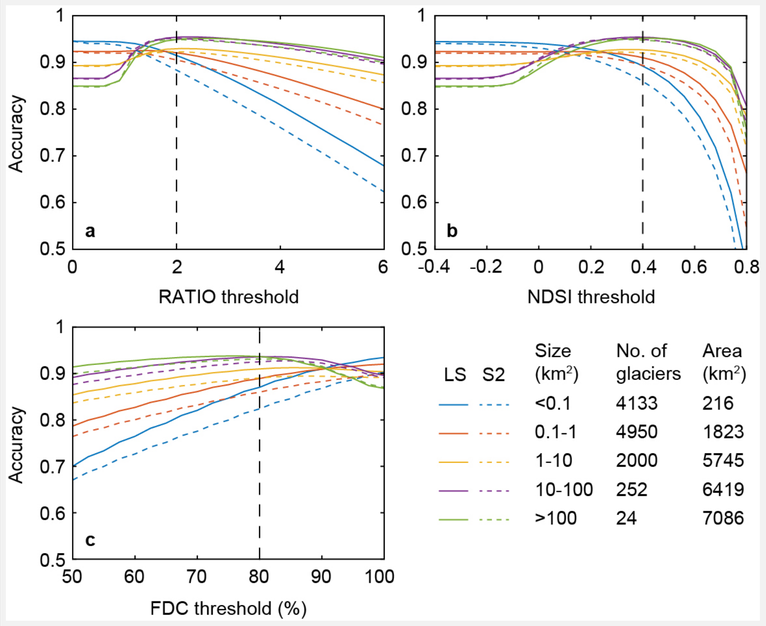

Fig. 3: Sensitivity analysis on classification threshold values.

4. Results

Method comparison

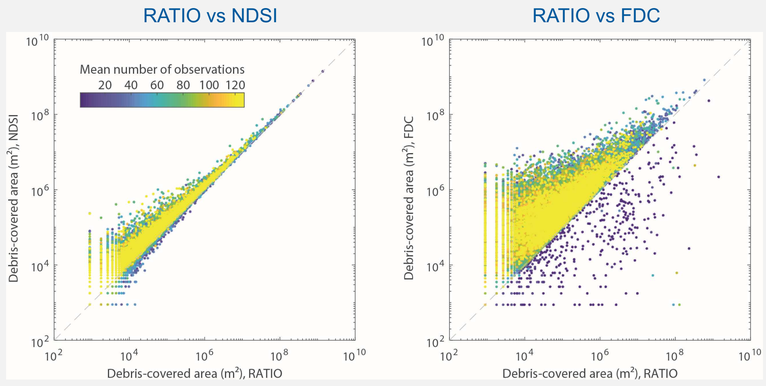

Fig. 4: Resulting area comparison using Landsat 8 data

Debris cover classification

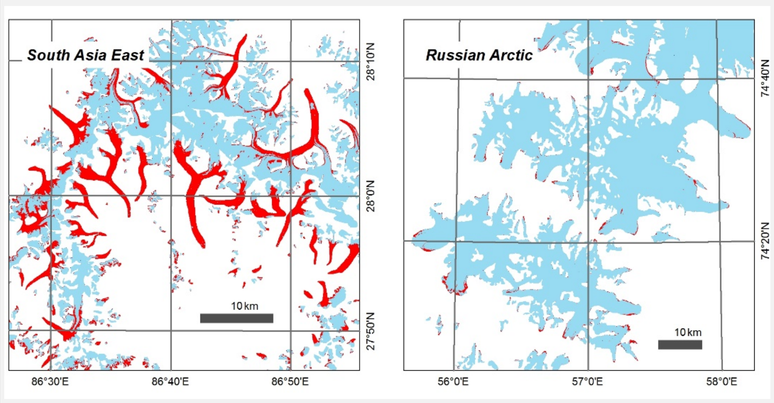

Fig. 5: Examples of debris cover classification using the RATIO

Global debris cover analysis

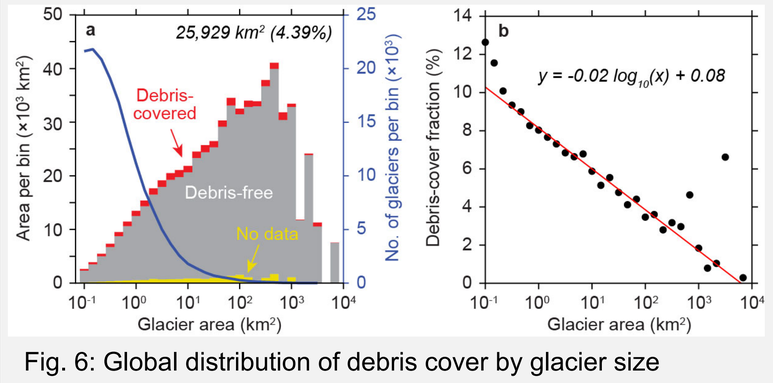

Fig. 6: Global distribution of debris cover by glacier size

Conclusions

Glaciers closer to the equator tend to have higher debris-covered percentages, as these glaciers are exclusively found in high mountain ranges that typically feature abundant steep rock walls. Glaciers closer to the poles show increasing ice cover percentages, as topographic relief decreases and therefore reduce potential source areas for debris (Figure 6).

Over time, we would expect the following changes:

- areal fraction of debris cover decreases during glacial periods, due to the much larger extent of glaciers
- debris-cover extents may vary considerably with climatic changes, if rates of debris supply to glaciers are influenced by temperature
- the influence of debris cover on glacier mass balances is expected to increase as glaciers continue to shrink

4. Results

Global debris cover distribution

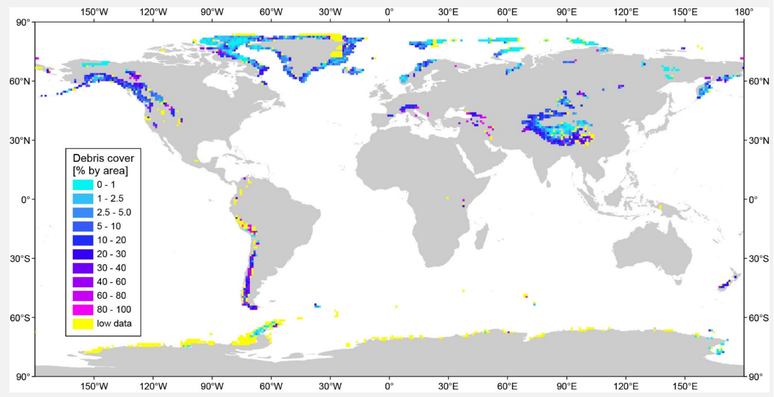

Fig. 7: Global distribution using Landsat 8 (2013-2017)

Regional debris cover analysis

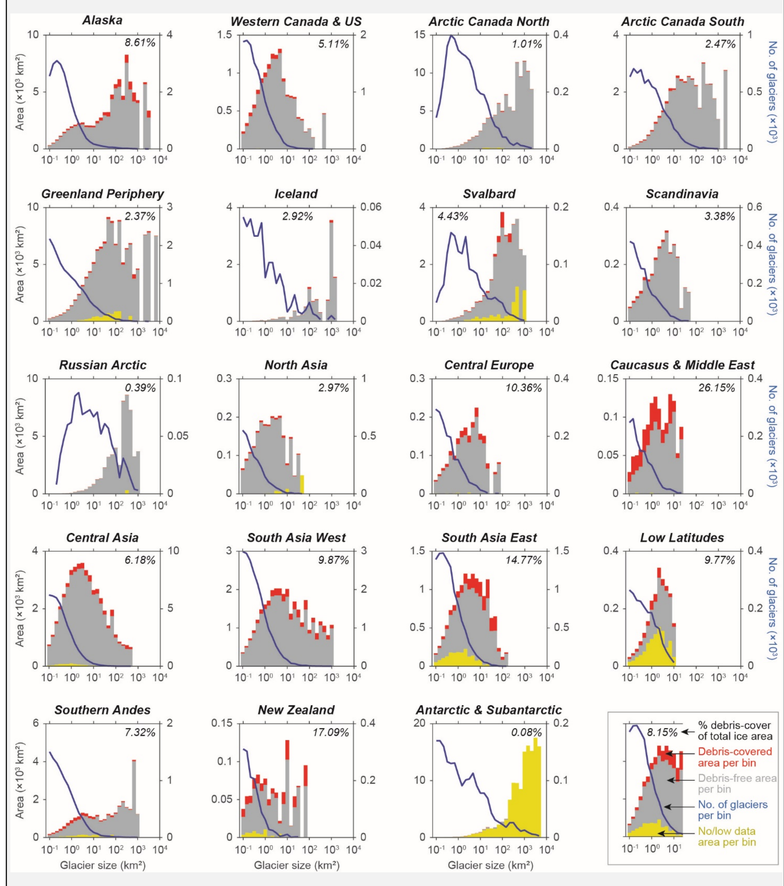

Fig. 8: Distribution of debris by RGI region and glacier size.

Publication

Scherler, D., Wulf, H., & Gorelick, N. (2018). Global assessment of supraglacial debris-cover extents. Geophysical Research Letters, 45. https://doi.org/10.1029/2018GL080158

References

1. Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. *Remote Sensing of Environment* 202, 18-27, doi:10.1016/j.rse.2017.06.031.
2. RGI Consortium (2017). Randolph Glacier Inventory (RGI) – A Dataset of Global Glacier Outlines: Version 6.0. Technical Report, Global Land Ice Measurements from Space, Boulder, Colorado, USA. Digital Media. doi:10.7265/N5-RGI-60.