OBJECT-BASED GLACIER MAPPING IN THE HOHE TAUERN MOUNTAINS OF AUSTRIA

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Background

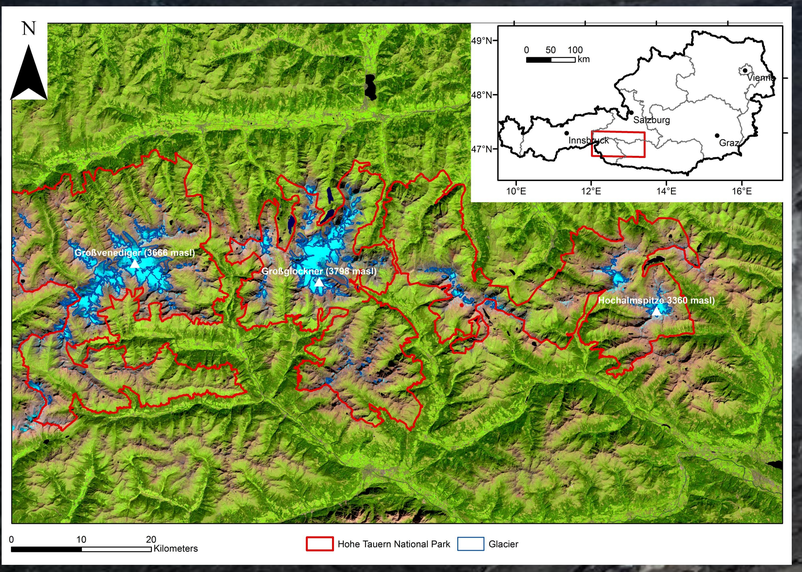
Up to date glacier outlines are required within many areas of glaciology, (for example, area, volume and velocity analyses, modelling and hydrology resource estimations). While clean glacier ice can be mapped in an automatic and robust manner (such as thresholded band ratios) debris covered glacier ice is notoriously difficult to automatically map due to its spectral similarity to paraglacial debris and other surrounding material.

Object-Based Image Analysis (OBIA) provides a means to combine different data sources in one classification, weigh them based on their importance and classify them based on spectral, contextual, geometric and hierarchiel criteria.

Here, we show automated mapping of clean ice and debris covered ice as well as extracting the snowline based on Landsat optical imagery from 2013, 2003 and 1985 and a 10 m DEM.

Study area & data

The study area is the Hohe Tauern National Park in the Central Eastern Alps, Austria. The national park contains approximately 120 km² of glacier ice including Pasterze Glacier, the largest glacier in the Eastern Alps. Although much of ice in the study area is clean ice, significant amounts of glacier debris can be found.



Methodology

Multi-resolution segmentation (MrS)

(Blue, Green, NIR, Pan, Red, SWIR1, SWIR2, Temperature, Slope)

Clean Ice

-NIR/SWIR Ratio

- Slope

-Elevation

-Normalised Difference Water Index

-Green spectral band

-SWIR1

Debris Covered Ice

-Edge detection based on slope

-MsR (edge detection, NDVI, Slope, Temperature)

-NDVI

-Elevation

-Red spectral band

Temperature

-Compactness

-Mean difference in NIR/SWIR1 to neighbours

Include steep debris if within 300 m to glacier tongue

Snowline

-Spectral difference segmentation based on NIR

-Intensity of RGB NIR, SWIR1, Red

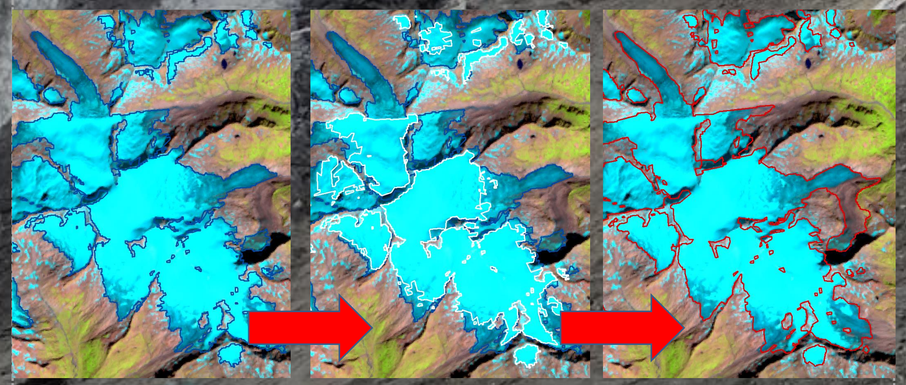
Glacier

-Smooth border

-Remove glacier objects smaller than 0.0075km²

Clean up

-Remove debris not connected to clean ice

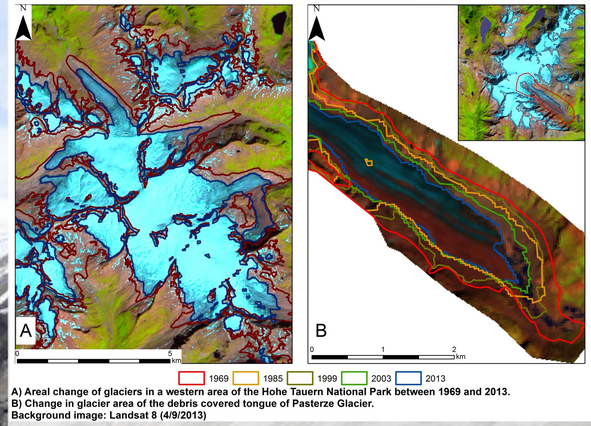


Mapping of clean ice | Snowline extraction | Mapping of debris-covered ice

Results and Discussion

Decadal scale change

The classification results were compared with two glacier inventories from 1969 and 1999 made available by the University of Innsbruck.



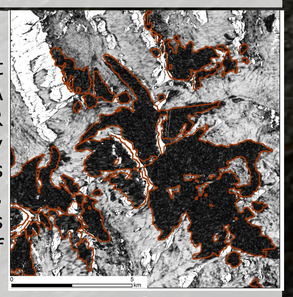
A) Areal change of glaciers in a western area of the Hohe Tauern National Park between 1969 and 2013.
B) Change in glacier area of the debris covered tongue of Pasterze Glacier.
Background image: Landsat 8 (4/9/2013)

Year	Area Total (km²)
2013	120,64
2003	122,75
1999	182,89
1985	199,96
1969	206,08

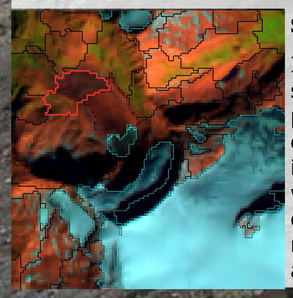
During this time the total glaciated area within the National Park decreased by 41% between 1969 and 2013, although it is important to note that some eastern areas of the national park were influenced by seasonal snow in the 2013 image. The debris covered area reduced by approximately half the rate of the total glaciated area between 1985 and 2013.

Validation with ALOS Coherence Data

Given that debris-covered ice can be difficult to identify spectrally, outlines from the OBIA were preliminarily compared with SAR coherence data. The agreement was generally good, although in a few places the debris cover extended further than was mapped. Caution had to be taken as many landslides and rock falls also contributed to a loss of coherence.



Sensitivity to image segmentation



It was found that the initial image segmentation is one of the most instrumental parts of the entire process. The size of the objects used in the classification was critical in excluding false positives. Problems arose when objects contained multiple classes and object boundaries did not represent glacier margins. Much time needs to be taken to find appropriate segmentation settings.

Conclusion

This study demonstrated that OBIA can be used effectively to map both clean ice and debris-covered ice automatically over large areas if sufficiently accurate elevation data is available. Ideally, elevation and optical data from the same acquisition would be used.

Acknowledgements

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