18th ALPINE GLACIOLOGY MEETING

TEST OF A METHOD TO DELIMITE SUPRAGLACIAL DEBRIS COVERS IN 1999 AND 2005 IN AOSTA VALLEY

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STUDY AREA AND OBJECTIVES

The Aosta Valley is an alpine region in the North-Western part of Italy. The Glacier Inventory of Aosta Valley reports 215 glaciers covering 153 km^2 in 1999 and 209 glaciers covering 135 km^2 in 2005. For these two periods, the Aosta Valley Region has colour ortophotos with a ground resoloution of 1 m and 0,5 m respectively.

To improve knowledge of the Aosta Valley glaciers, Fondazione Montagna sicura wanted to evaluate the debris cover on glaciers and its evolution. This was the aim of a traineeship of a Université de Savoie student.

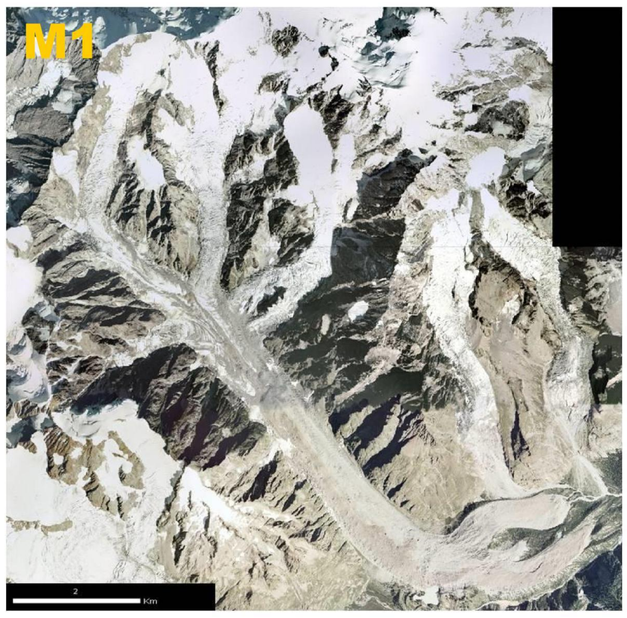
A semi-automatic method to delimit the extension of supraglacial debris covers was tested on a large debris-covered glacier (Glacier du Miage, Mont Blanc massif), and a small glacier the debris cover of which develops recently (Glacier du Grand Neyron, Gran Paradiso massif).

METHOD

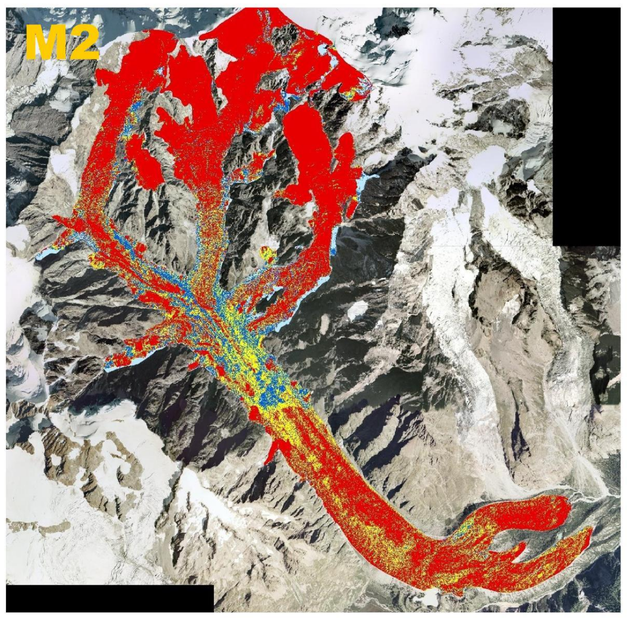
To detect the debris cover on glacier, we used a semi-automatic colorimetric procedure in ESRI ArcGis 9.3. Using the "slice" tool, we divided a range of pixel values of the input cells of a raster by natural breaks.

1. We extracted the glacier part of the orthophotography to only consider its surface when processing pixels (M1 and G1).
2. The software performs the classes based on natural grouping inherent data. Points breaks are identified by choosing classes that group the most similar values to maximize the differences between these classes. We chose to make 4 categories corresponding to snow, ice, debris, and "other." The latter class is used to avoid errors due to shadow on snow or on ice covered with snow (M2 and G2).
3. We transformed the pixels related to debris in polygonal shapefiles (M3 and G3).
4. We manually corrected erroneous areas (M4 and G4).

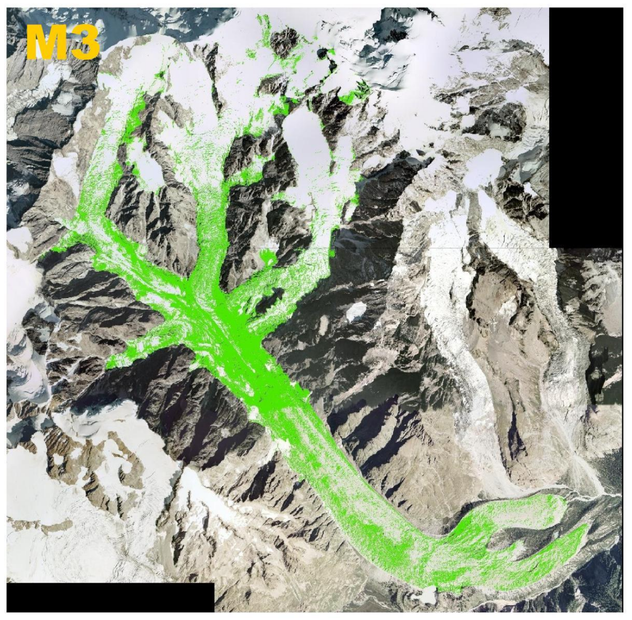
We performed this study on orthophotos 1999 and 2005 and we compared the results.



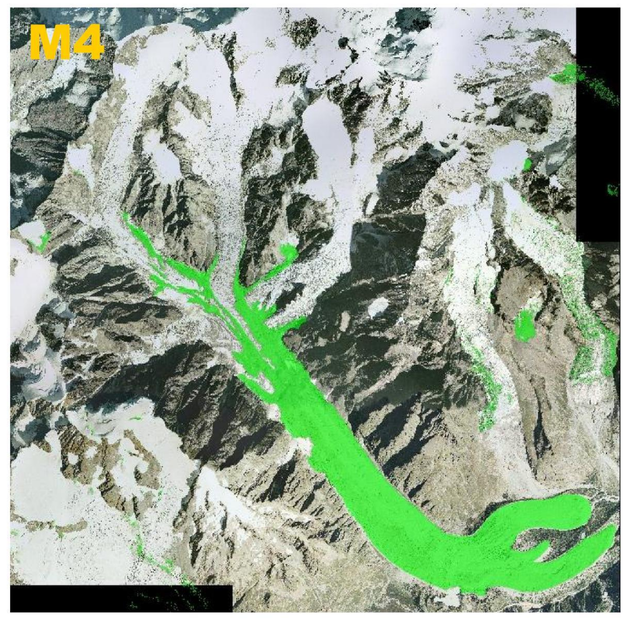
M1: Orthophoto of Glacier du Miage, Mont Blanc massif (1999)



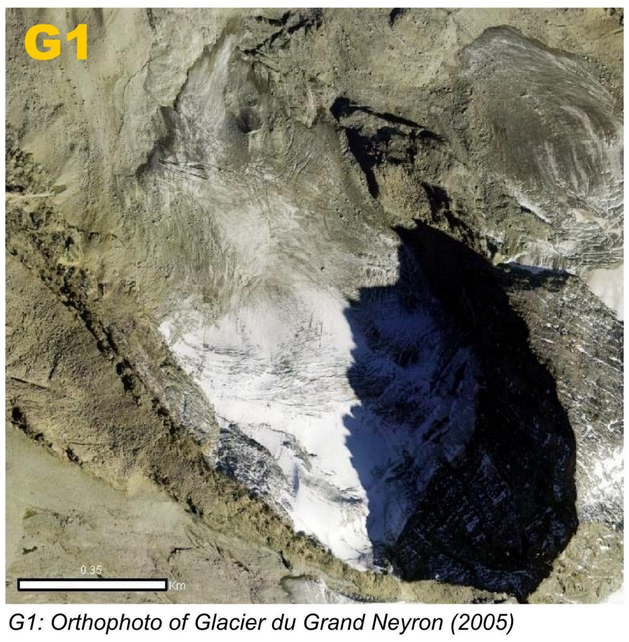
M2: Four classes resulting from the semi-automatic analysis



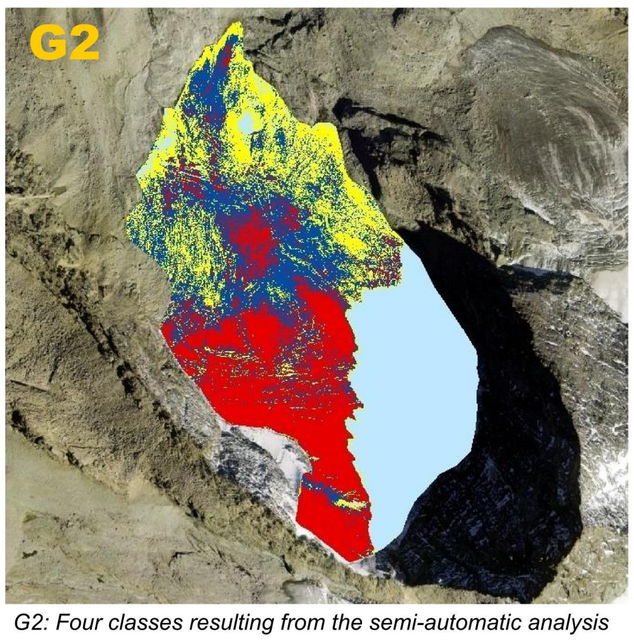
M3: Image after merging classes with debris



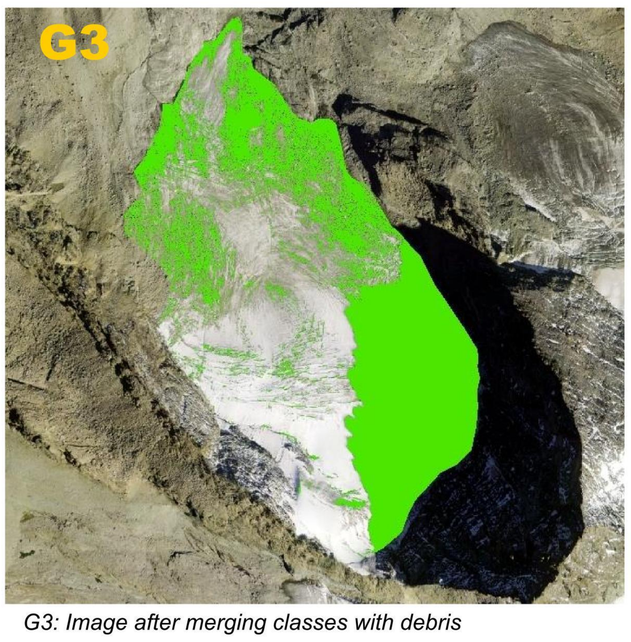
M4: Supraglacial debris cover after manual correction



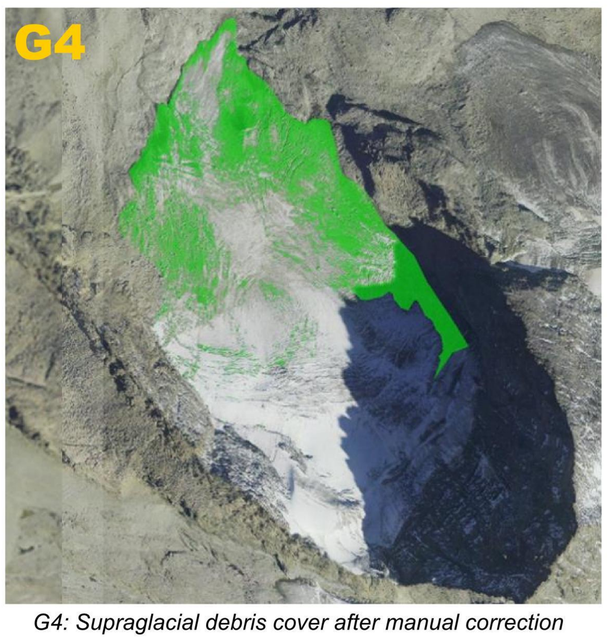
G1: Orthophoto of Glacier du Grand Neyron (2005)



G2: Four classes resulting from the semi-automatic analysis



G3: Image after merging classes with debris



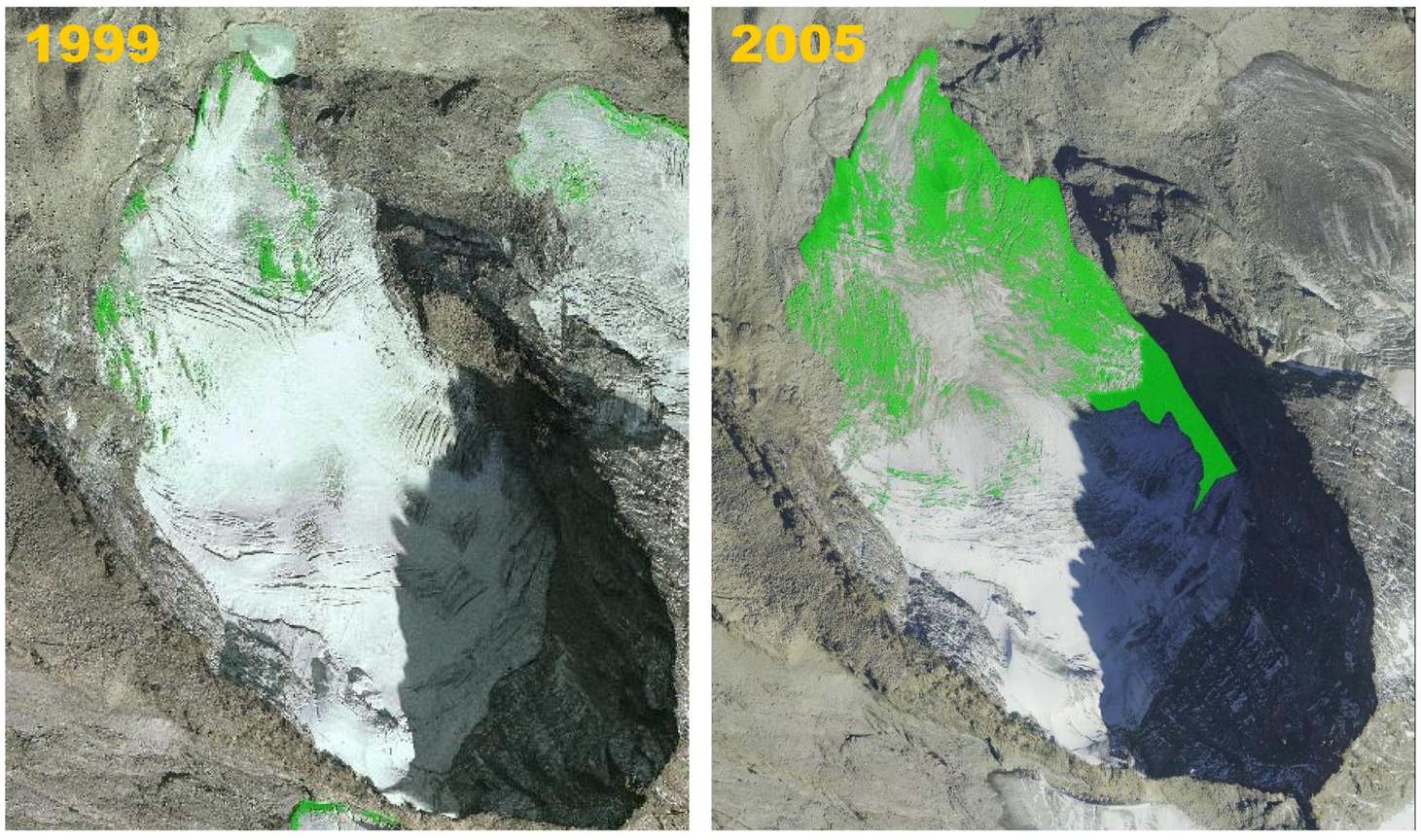
G4: Supraglacial debris cover after manual correction

ANALYSIS OF SEMI-AUTOMATIC DETECTION

Glacier du Miage (10.8 km² in 1999) is one of the largest debris-covered glacier in the Alps: debris are covering 35.2 % of its surface area (3.8 km²). This results from the frequent rockfalls and rock avalanches that detach from the steep, high rock walls of its large basin. Although the red class in Image M2 is supposed to correspond only to snow and clean ice surfaces, it also corresponds to the main part of the debris cover, because of its slight colour (see M1). Moreover, very high-elevated small areas are classified in dark blue (M2), supposed to be a part of the debris cover, because corresponding to rock walls included in the glacier perimeter, crevasse area, snow in the shadow, or summer debris deposits in the accumulation zone. Therefore, merging yellow and dark blue classes give a very distort representation of the debris cover (M3). This implies a manual work: if it was rapid to include the very continuous lower area of the debris cover, the 'cleaning' of the upper areas was a heavy job to obtain a correct representation of the Miage debris cover extension (M4). On the other hand, few manual work was necessary for the small Glacier du Grand Neyron (0.56 km² in 2005), as its debris cover fits well with the yellow class (Image G2). The main manual correction was on the light blue class: (i) small darker patches in the distal area are part of the debris cover (G2 and G3), as (ii) a debris band in the shadow on the NE margin (G1 and G4) once the shadow excluded (G3 and G4). Small summer debris bands in the accumulation zone were also excluded (G1 and G4).

ANALYSIS OF THE DEBRIS COVER EVOLUTION OF GLACIER DU GRAND NEYRON

While the surface area of the Glacier du Grand Neyron reduced from 0.66 to 0.56 km² in 6 years, its debris cover expanded from 2.3% to 15.4% of the surface area respectively in 1999 and 2005. This does not result from rockfall occurrence during this short period, but rather from englacially-transported debris that have rapidly emerged at the glacier surface since 1999 because of the present accelerated glacier ablation. This dynamics is in accordance with what has been modelled and observed on several studied debris-covered glaciers: a period of negative glacier mass balance generates an extension of the debris cover because of the combination of decreasing ice velocity and increasing glacial ablation.



The semi-automatic detection applied on Glacier du Grand Neyron orthophotos of 1999 and 2005.

CONCLUSION

Having high quality, colour orthophotos, the semi-automatic method allows to easily map supraglacial debris covers. The results here presented are however counter-intuitive: while detection of recent and dispersed debris cover on small glaciers is rapid, it needs a heavy work for large well-identified debris-covered glaciers. This of course is partly due to the difference in the debris cover size, but the stronger colour contrast between recent debris cover (even discontinuous) and ice and snow surfaces participates to this result.

This stronger contrast illustrates the difference regarding the debris-cover dynamics between Glacier du Miage and Glacier du Grand Neyron, and more generally between large glaciers with a well-developed debris mantle, stabilized for a long time, and small, neo debris-covered ones. While the dynamics of the first ones is few impacted by changes that are small relative to the debris cover area, there is an increasing negative feedback on small shrinking glaciers that are rapidly becoming debris-covered. This has major consequences on the timing of the future glacier evolution, and therefore with respect to water resources, natural hazards, or touristic value. This highlight the importance to get a better view of the present and recent extension of supraglacial debris covers, especially in well glaciated Alpine regions like the Aosta Valley.

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