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# Active, inactive, relict: Tracking the evolution of the Bleis Marscha rockglacier (Val d'Err, Grisons) with cosmogenic nuclide dating and finite-element modelling

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## Abstract

This work aims at reconstructing the evolution of the *Bleis Marscha* rockglacier in the Val d'Err, Grisons (Switzerland). It is a one-kilometre long, multi-unit talus rockglacier with an active upper part, a relict snout, and a furrow-and-ridge microrelief. The timing of formation of each unit is investigated with surface exposure dating with $^{10}Be$ and $^{36}Cl$. Insights into mechanical properties and internal structure is gained with numerical finite-element modelling. The model is constrained with the horizontal surface velocity field obtained from feature-tracking of multitemporal orthorectified aerial images. The illumination-invariant orientation correlation method overcomes most of the difficulties posed by different lighting on a rugged rockglacier surface, and is a simple, yet powerful tool to capture the horizontal surface kinematics. The overarching aim is to place the development of the *Bleis Marscha* rockglacier within the Holocene climate history and to constrain the timing of glacial and periglacial processes and the relevant mechanical parameters that shaped the formerly glaciated Piz Bleis Marscha cirque.

**Keywords:** rockglacier; image correlation; feature tracking; numerical modelling; inverse problem

## Introduction

The *Bleis Marscha* rockglacier is a talus rockglacier originating in a cirque of Piz Bleis Marscha in the Val d'Err, Grisons, Switzerland. It is more than one kilometre long, exhibits a furrow-and-ridge microrelief in the lower parts and is divided by steep front scarps into several units. Field observations such as lichen coverage and iron staining as well as results from multitemporal aerial image correlation suggests that the lower units below 2500 m a.s.l. are inactive to relict. Several previous studies have obtained exposure or luminescence dates on moraines and rockglaciers in nearby valleys, and the Holocene climate history is well established for the area (Ivy-Ochs *et al.*, 1996; Fuchs *et al.*, 2013).

## Aim and methods

In the presented work, the different units of the *Bleis Marscha* rockglacier are exposure-dated with $^{10}Be$ and $^{36}Cl$, as an aid to reconstructing the development of the rockglacier. Furthermore, the present-day dynamics is modelled with a numerical two-dimensional finite-element approach to gain insights into mechanical and material properties. The deformation above the shear zone is well captured by a linearly viscous (Newtonian) flow law (Frehner *et al.*, 2015). The model is constrained with horizontal surface velocities obtained from a feature-tracking analysis of multitemporal orthorectified aerial images with the Matlab tool "ImGRAFT" (Messerli & Grinsted, 2015).

## Preliminary results

Slight differences in lighting, illumination direction or cloudiness suffice to make the rugged, bouldery surface of the rockglacier appear differently on aerial image such that a common normalized cross-correlation approach may perform poorly. The cross-correlation of orientation images is illumination invariant (Fitch *et al.*, 2002) and yields a connected displacement field all over the rockglacier. The correlation inherently fails near steep slopes, involving rotational movement of boulders, and on snow patches.

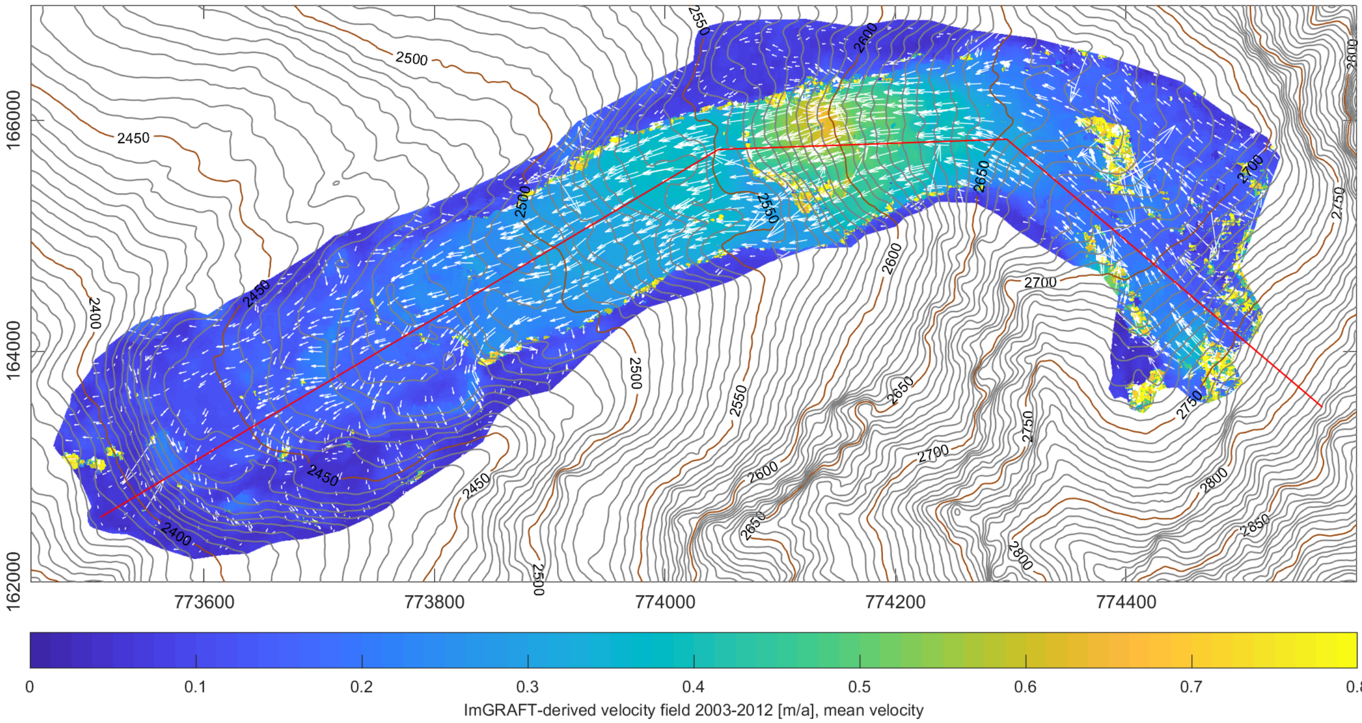


Figure 1. Horizontal surface velocity on the *Bleis Marscha* rockglacier as obtained from a feature-tracking analysis of orthorectified aerial images from 2003 and 2012. Magnitude shown by colours, direction by white arrows. The colorbar is fixed at 0.8 m/a. Higher velocities are most likely artifacts such as rotational movement of blocks at scarps or correlation problems. The red line traces the section along which the 2D numerical model is defined. Coordinates in CH1903 grid, unit in meter. Aerial images © swisstopo.

Preliminary results support the subdivision of the rockglacier into units of varying degree of activity based on field observation: the upper unit is characterized by a unidirectional downslope directed creep, with increasing velocity towards the front of the upper lobe (up to 0.8 m/a, Fig. 1). The over-steepened, failure-prone front scarp shows that this unit is overriding the lower, inactive to relict units of the rockglacier, which exhibit a more "patchy" flow field of slightly varying directions and smaller velocities (<0.4 m/a). This data is used to constrain the numerical model, reproducing the deformation on a longitudinal section along the central flowline of the rockglacier (red line in Fig. 1). The model parameters that will be tested are rockglacier thickness, effective viscosity, viscosity contrast to the low-viscosity basal shear zone and thickness of a rigid blocky mantle. In a series of numerical experiments, the influence of different parameter configurations on the modelled horizontal surface velocity is tested, and plausible configurations that reproduce the observed velocities within their error margins represent solutions to this inverse problem.

We will present a detailed analysis of the horizontal surface flow field, its relationship to the microrelief, rockglacier activity status and changes throughout the recent years.

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