1. Research question and study site

The Gugla-Bielzug rock glacier is located on the orographic right side of the Zermatt valley (Mattertal, Fig. 2). During spring 2013, several debris flows were triggered from its front and reached the valley bottom (between the 13th and the 20th of June 2013, Fig. 1). The steepness of the area, the high creep velocities (up to more than 25 m/year during the snow-melt period of June 2013) and the direct connection with a torrential gully emphasized this activity. The events observed at Gugla-Bielzug brought an important question:

What controls the sediment yield at the front of the Gugla-Bielzug rock glacier?

2. Methods

In order to get information about the spatial and temporal variability of the sediment yield at Gugla-Bielzug rock glacier, a panel of different methods were applied: observations (webcam images), movements measurements (GPS), LiDAR (3 campaigns during the summer 2013, just after the debris flow events of June) and photogrammetric analysis (based on 9 images between 1968 and 2011).

3. The sediment yield at the front of Gugla-Bielzug rock glacier

The photogrammetric analysis based on 9 orthorectified aerial images from SwissTopo provided information about the evolution of the surface velocity and the morphology of this rock glacier over the last 45 years. The results (Fig. 3) show that the velocities were stable and quite low until the middle of the years 2000. Since then, we observe a strong acceleration of the rock glacier, especially in the frontal part (zones 1 and 2, Fig. 3 & 4).

During this whole period, the position of the front did not significantly change (Fig. 4). This implies that the sediment yield of the rock glacier must have strongly increased during the last 10 years, as shown in Table 1. This table depicts estimations of the sediment yield for different periods (° = estimation for the future based on the remaining volume of the fast moving part of the rock glacier).

II. Summer 2013

LiDAR generated DEMs comparisons provided sediment transfer maps (Fig. 6 & 7) and volumes (Tab. 3) for the whole front and gully system for three time intervals: 25.06.2013-10.07.2013 and 10.07.2013-04.10.2013 and 25.06.2013-04.10.2013. The maps show that there are two main erosion zones located on the front of the rock glacier (Fig. 6 & 7: A), and one main deposition zone (Fig. 6 & 7: B), deviated by the outcrop of the bedrock located in the center of the gully (Fig. 6 & 7: C). The main erosion zones and the main deposition zone seem to be linked by three main sediment flux paths (Fig. 6 & 7: D). The comparison of the two time intervals also shows that the upper part of the gully seems to be an intermediate storage zone (Fig. 6 & 7: dotted line).

4. Outcomes

Our study tried to tackle the spatial and temporal variability of the sediment yield at the front of the Gugla-Bielzug rock glacier. The results, based on a multi-method and multi-temporal approach allows to get an idea on how the processes are working in this case:

- The current high intensity of the sediment transfer processes is related to the fast and strong acceleration of the rock glacier creep since 10 years. The cause of this acceleration is still unknown but it could come from a warming of the permafrost body.
- In 2013, the erosion rate at the front was higher during the snow-melt period. Water availability, and mainly snow-melt, seems to play a key role in the sediment yield, and in the triggering of debris flow.
- An important amount of sediment was progressively stored in the gully during the summer 2013 (around 3500 m3 in 101 days), and is now available for the triggering of future debris flow events.

Gugla-Bielzug is a typical case were the rock glacier provides sediment to a torrential channels and thus influences the triggering of debris flow events. In such cases, having a better understanding of what controls the sediment yield is fundamental to have a better capacity of response to the threats that represents debris flows. The continuation of such a study is then important to collect more information on what really controls the erosion of the front.