Short term dynamics of the debris-covered Miage Glacier

University of Worcester

Fyffe, C. L.[1], Brock, B. W.[2], Kirkbride, M. P.[3], Mair, D. W. F.[4], Smiraglia, C.[5] and Diolaiuti. G.[5]

[1] **c.fyffe@worc.ac.uk**, Institute of Science and the Environment, University of Worcester, Worcester, United Kingdom, [2] Department of Geography, Northumbria University, Newcastle, United Kingdom, [3] School of the Environment, University of Dundee, Dundee, United Kingdom, [4] School of Environmental Sciences, University of Liverpool, Liverpool, United Kingdom, and [5] Department of Earth Sciences 'Ardito Desio', University of Milan, Milan, Italy.

1. Introduction

Figure 1 The roving dGPS receiver, sitting within the spray painted outline.

The short-term glacier dynamics of the debris-covered Miage Glacier, Western Italian Alps were determined from repeat occupation of up to 22 points (see Figures 1 and 2) using a differential GPS system over two melt seasons. Meteorological, hydrological and water chemistry data were collected over the same time periods, and the nature of the hydrological system was studied using dye tracing, to allow the short term variations in glacier dynamics to be understood in terms of the likely glacial drainage system and its evolution.

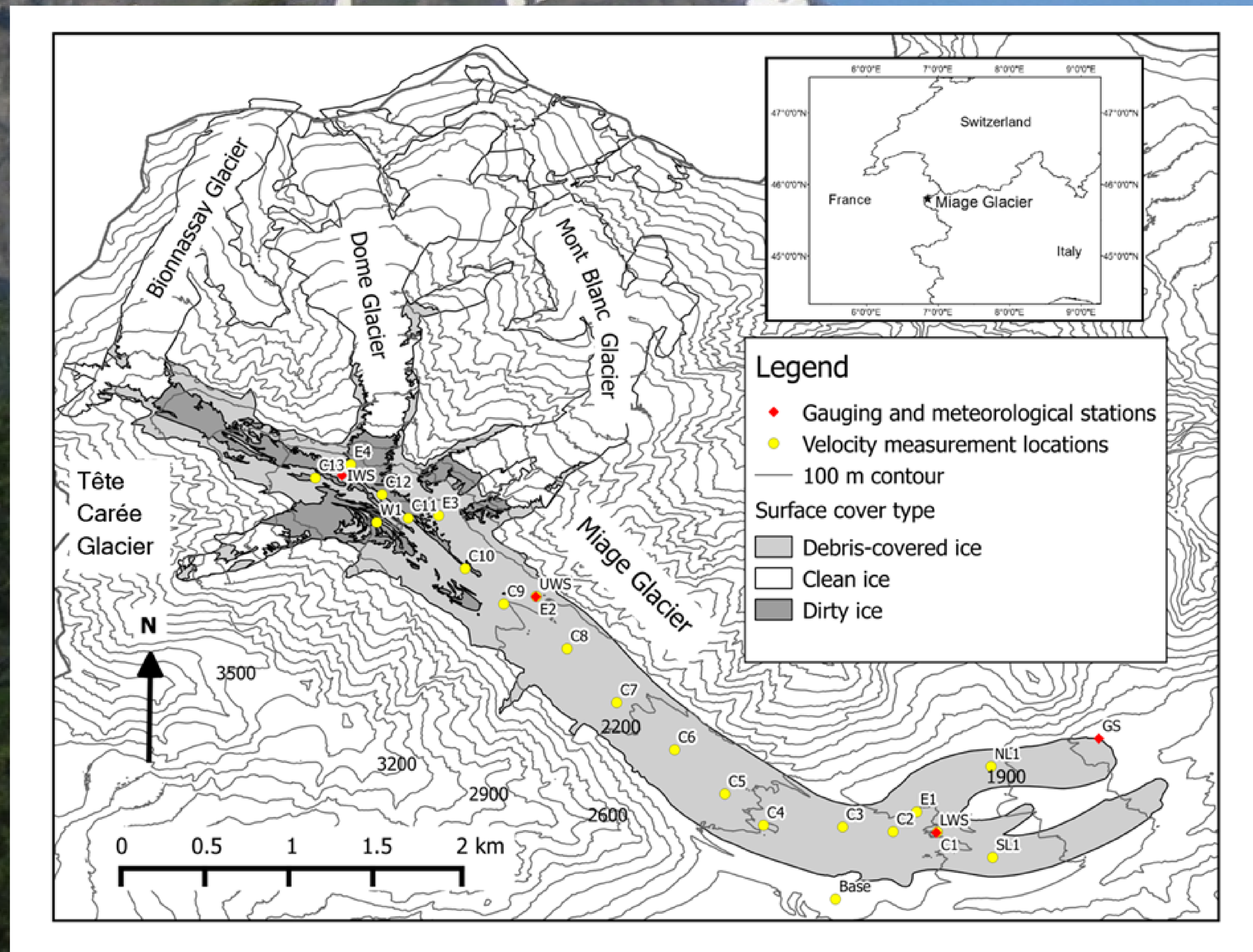
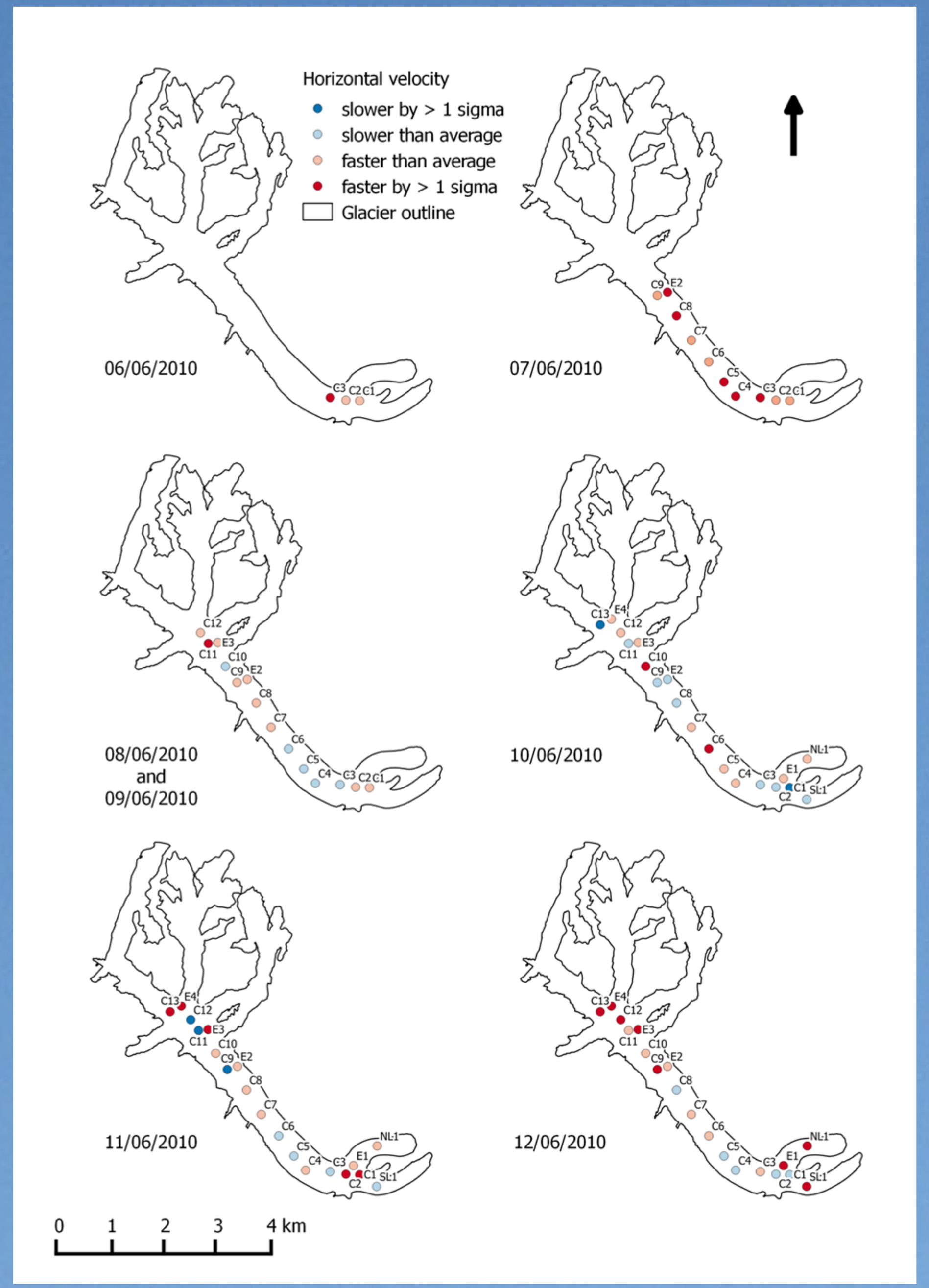


Figure 2 Miage Glacier showing the location of the gauging and meteorological stations as well as the locations of the glacier velocity measurements. The inset shows the location of Miage Glacier in the Alps.



2. Short term variations

Short term speed up events were recorded in the spring and mid-summer of both 2010 and 2011. On the 7th of June glacier velocities were above average over the whole glacier, with 5 points measured to have significantly positive vertical velocities (Figures 3 and 4), indicating that the warm weather had led to inputs overwhelming the channel system. A region of faster movement progressed downglacier between the 8th and 12th of June, suggesting the downwards progression of a region of high water pressure. Evidence that water had temporarily covered a large proportion of the bed was given by the peak in conductivity, SSC, sulphate and bicarbonate ion concentrations in the proglacial stream on the 9th of June.

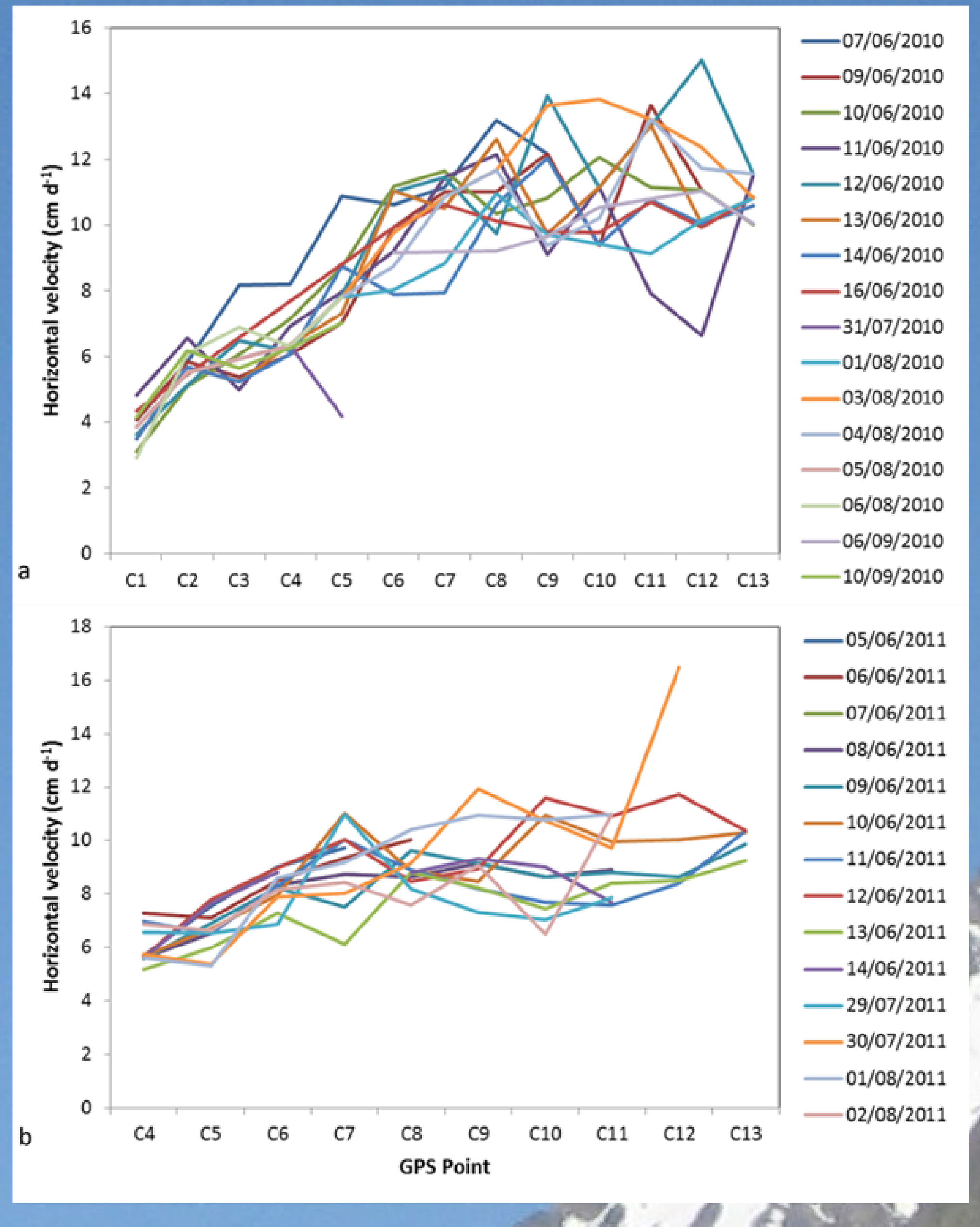
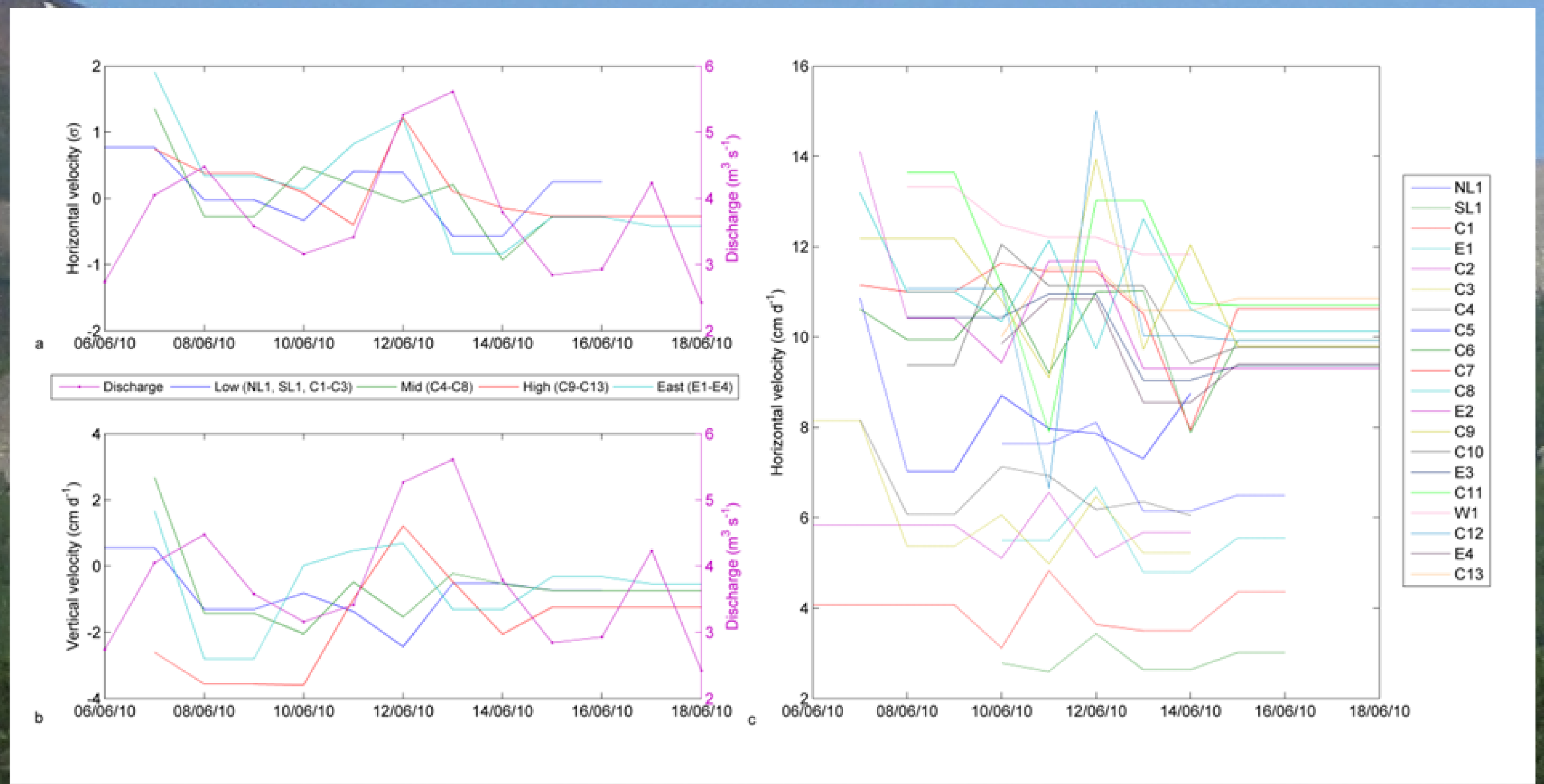


Figure 5 All daily net horizontal velocity measurements along the centreline in a) 2010 and b) 2011.



Above left: Figure 3 Spatial patterns in horizontal glacier velocities from 06/06/2010 to 12/06/2010.

Left: Figure 4 a) Averaged horizontal velocity anomalies in June 2010, with average daily proglacial discharge on the secondary axis, b) averaged vertical velocities in June 2010, adjusted to remove the influence of surface slope, with average daily proglacial discharge on the secondary axis, and c) horizontal velocities in cm d^{-1} for all measured points in June 2010.

3. Influence of the debris

The highest and greatest range in glacier velocities was found on the mid-glacier, close to a group of large moulins (Figures 5 and 6). High melt rates of the dirty ice above these moulins could result in inputs which were occasionally large enough to overcome the channel system. Glacier velocities were lower and had a smaller range on the lower glacier, not because of a more efficient hydrological system, but because of the smaller and less variable inputs from the debris-covered lower tongue. Significant speed-ups of the lower glacier were rare, and occurred only due to the subglacial transfer of excess water from upglacier.

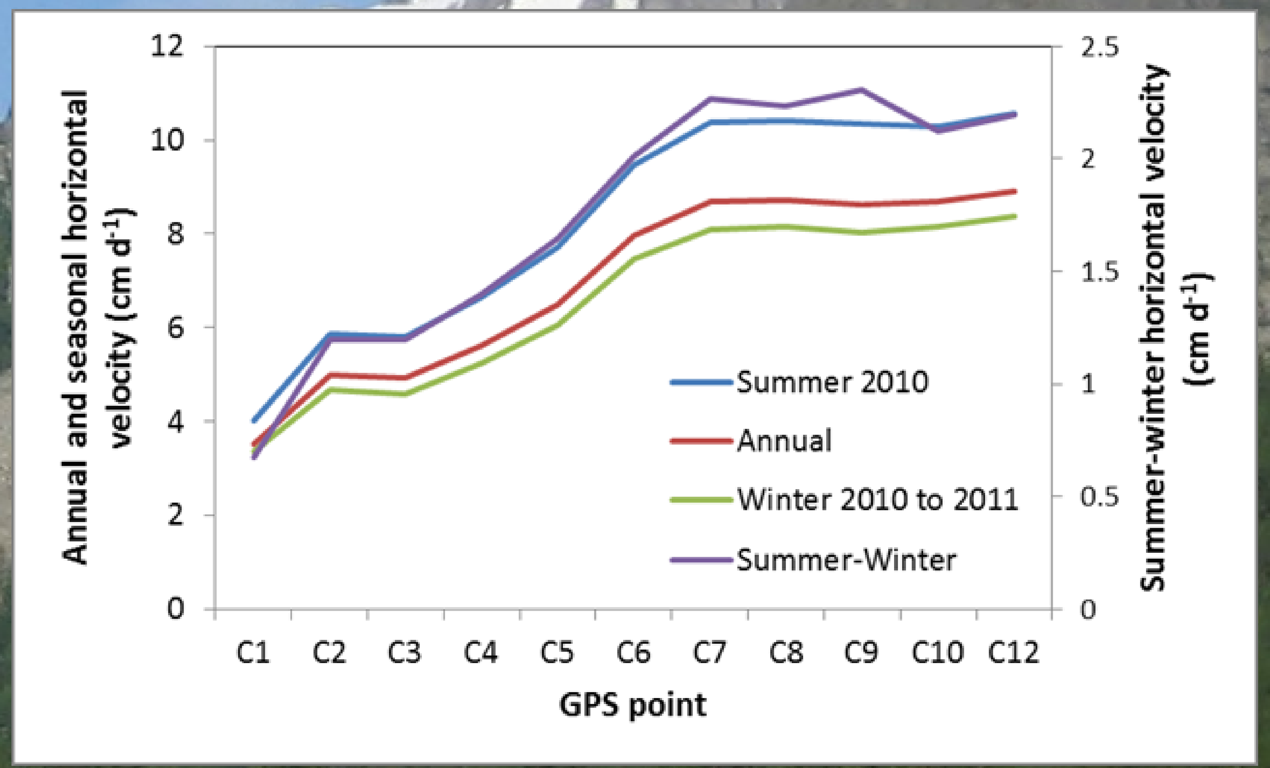


Figure 6 Annual, summer, winter (y-axis to left), and difference between summer and winter net horizontal velocities (y-axis to right) along the glacier centreline.

4. Conclusions

a. The velocity of the mid-glacier, near a cluster of moulins, was higher and more variable due to speed-up events observed in spring and mid-summer.

b. The velocity of the debris-covered lower glacier was lower and less variable, with significant speed-up events rare.