Long-term glacier mass balance of Gornergletscher in relation to ice temperature

Martin P. Lüthi[1]

[1] Geographical Institute, University of Zurich, Zurich, Switzerland

martin.luethi@geo.uzh.ch

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1. Project description

The glacier surface albedo has a strong influence on ice melt and thus on glacier mass balance. This effect can be ideally investigated in the lower ablation area of the Gornergletscher - Grenzgletscher system of glaciers. Very cold ice from the highest accumulation basins is transported into the ablation area where it melts out. Temperature of this ice is about -1 to -2 degrees (Ryser et al, 2013), even close to the glacier surface. Coincident with the cold surface ice is an exceptionally bright appearance of this bubble-rich ice. All impurities are washed into small potholes (cryoconite holes), thus leading to a very high effective albedo of the glacier surface. Just adjacent to this bright ice is temperate glacier ice with a dusty appearance and a much lower albedo.

The differential melt rate due to ice temperature, and thus the albedo, is important on a much bigger scale in the marginal zones of the Greenland ice sheet and many polar glaciers where similar effects are visible on a much bigger scale.

Glacier mass balance has been measured on a dense network of stakes during field campaigns between 2004 and 2007. In addition, the total ice melt of the lower Gornergletscher has been occasionally measured (every one to three years) on marked cables drilled into the ice. These cables, deployed during drilling campaigns in 2005 to 2009, penetrate the whole ice thickness and are ideally suited to determine long-term melt. About half of the cables were deployed in the cold ice zone, whereas the rest was drilled in temperate ice at the melting temperature.

By the above method we have already measured total ice losses of 60-100 meters at different sites within 14 years (2004-2018). Figure 1 shows one of the cables which are revisited every two to three years, marked at the surface, and tidied up. Surplus cable is continually removed to avoid pollution of the glacier. Since the measurement sites travel slowly downstream, we acquired a unique long-term record of Lagrangian ice melt with minimal investment.

This unique data set can be interpreted with detailed melt models to understand the influence of surface albedo on the melt of glacier ice. The occurrence of bright and dark ice at very similar conditions (elevation, exposition) in adjacent glacier parts allows us to investigate the relevant melt processes in a nearly ideal setting.

A preliminary data analysis, shown in Figure 2, yields a near-linear dependence between satellite-derived albedo and ice melt rate. These results hint to a very important effect which is currently being investigated quantitatively and in detail within the frame of a master thesis at UZH.

Figure 1. One of the ablation field sites on Gorner/ Grenzgletscher where long-term ice melt is measured on cables frozen into the ice. At this site, 65 meters of ice have melted since 2007.

Reference:

Ryser, C., Lüthi, M. P., Blindow, N., Suckro, S., Funk, M. and Bauder, A.: Cold ice in the ablation zone: its relation to glacier hydrology and ice water content. J. Geophys. Res., (F02006). doi:10.1029/2007JF000832, 2013.

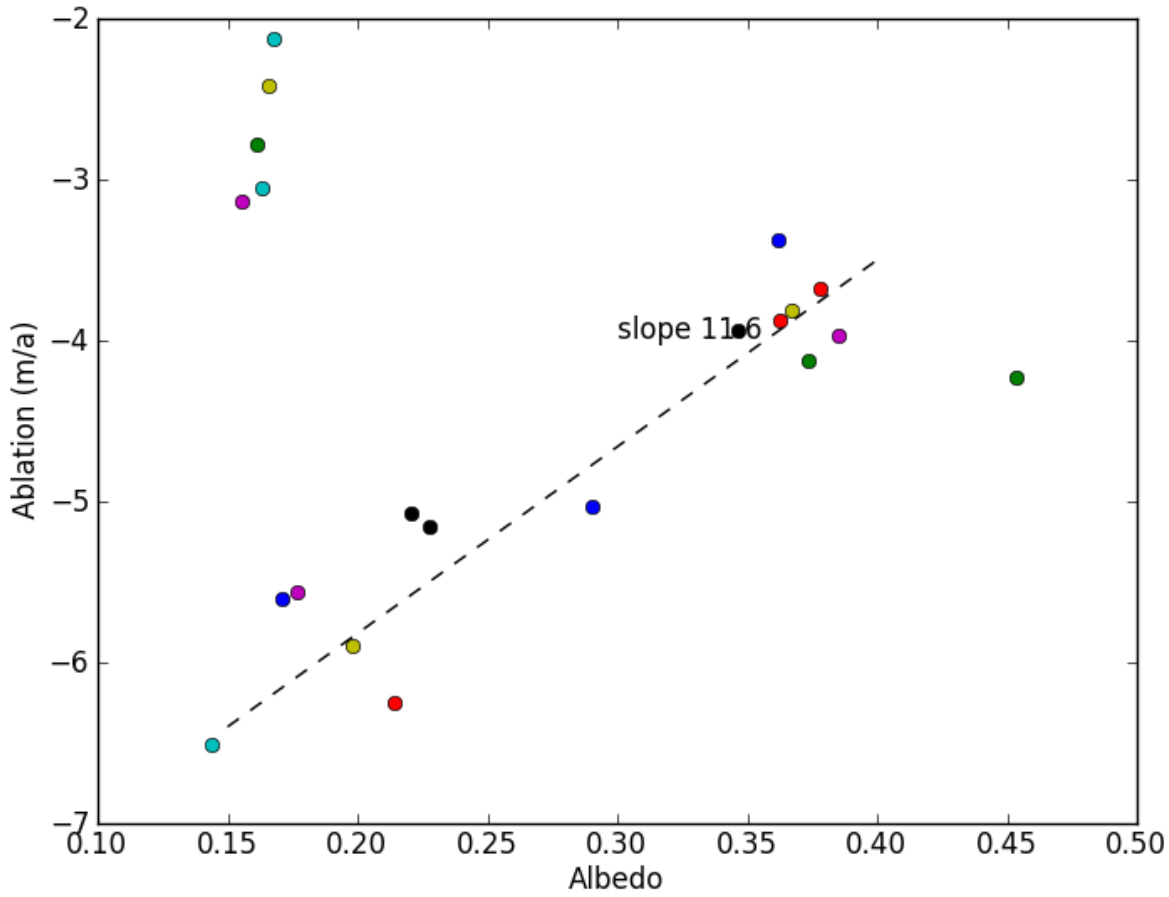

Figure 2. Comparison of mass balance measurements with satellite-derived albedo. This preliminary analysis shows an important effect of the cold ice in Gorner/Grenzgletscher on the glacier surface albedo, and thus on ice melt.

Collaborating partners / networks

Dr. Andreas Bauder, VAW, ETH Zurich
Dr. David Small, RSL, University of Zurich

Address

Department of Geography, 3G
University of Zurich
Winterthurerstrasse 190
CH-8057 Zurich
Switzerland

Contacts

Dr. Martin Lüthi
Tel.: +41 44 635 5146
e-mail: martin.luethi@geo.uzh.ch