

Gorner jökulhlaups: Results of the field campaigns 2004-2006.

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The glaciology section of VAW conducted intensive field studies in the years 2004, 2005 & 2006 on Gornergletscher (Switzerland) in order to investigate the jökulhlaups of Gornersee. The study showed that the drainage of Gornersee is highly variable from year to year. This presentation aims to give an overview of the obtained results. Others, focusing on more specific aspects of this project, will also be given in this session.

Ice dammed lakes can exhibit instabilities in their drainage pattern: they fill up and then drain rapidly in a so called 'outburst flood' or 'jökulhlaup'. This phenomenon is fairly common and found in most glaciated regions. The most famous of these lakes is Grímsvötn, beneath Vatnajökull ice cap in Iceland. In Switzerland there is currently only Gornersee exhibiting such behavior.

Gornersee is situated in the confluence area of Gorner- and Grenzgletscher, bounded on two sides by those glaciers and on one side by the Monte Rosa massive. When filled it reaches about 1km of length, 200m of width, 40m of depth and contains about $4.5 \times 10^6 \text{m}^3$ of water. It fills annually in spring and early summer and then normally drains in three to six days as a jökulhlaup.

Several aspects of our understanding of jökulhlaups are still wanting, among others: flood initiation, peak outflow, different flood types. Hence, the aim of the field measurements is to compile a comprehensive set of data about the glacier before, during and after a jökulhlaup event. This will help to understand the points mentioned above. Furthermore, the change of the ice flow due to the perturbation of the basal properties during the jökulhlaup gives insights into basal processes.

The following measurements were conducted during the three campaigns: lake level and geometry, water temperature, discharge at the outlet, surface ice flow measurements with GPS and theodolite at up to 30 stakes, climate data, ablation and snow depth, basal water pressure in several bore holes, ice temperature, internal ice deformation, water tracer experiments, surface topography with aerial photographs, radar measurements of bed topography, passive and active seismic measurements, etc.

The most striking feature of the observed jökulhlaups is that they differ significantly from year to year:

2004, the lake filled completely and then drained by flotation of the ice dam. Peak outflow ca. $18 \text{m}^3/\text{s}$.

2005, the lake started to drain when only about a third full. The drainage mechanism was channel enlargement. Peak outflow ca. $10 \text{m}^3/\text{s}$.

2006, the lake filled completely and did not drain as a jökulhlaup but emptied superficially into a moulin over the course of several weeks. Peak outflow ca. $5\text{m}^3/\text{s}$.

Further data showed: During the jökulhlaup, up to 10^6m^3 of water are temporally stored underneath and within the glacier and water pressure at the bed rises to overburden pressure. This causes an uplift of the glacier surface of up to 0.2m as well as a speedup of the ice flow. In 2004, the ice damming the lake was lifted up by as much as 2m, whereas in 2005 and 2006 this did not happen. The ice near the lake showed 'elastic' properties. During the outburst increased seismic activity was measured. However in 2004, less deep events were detected once the flood started. In 2005 tracer experiments revealed the transition to an efficient drainage system near that lake just before the jökulhlaup, suggesting a causal relationship.

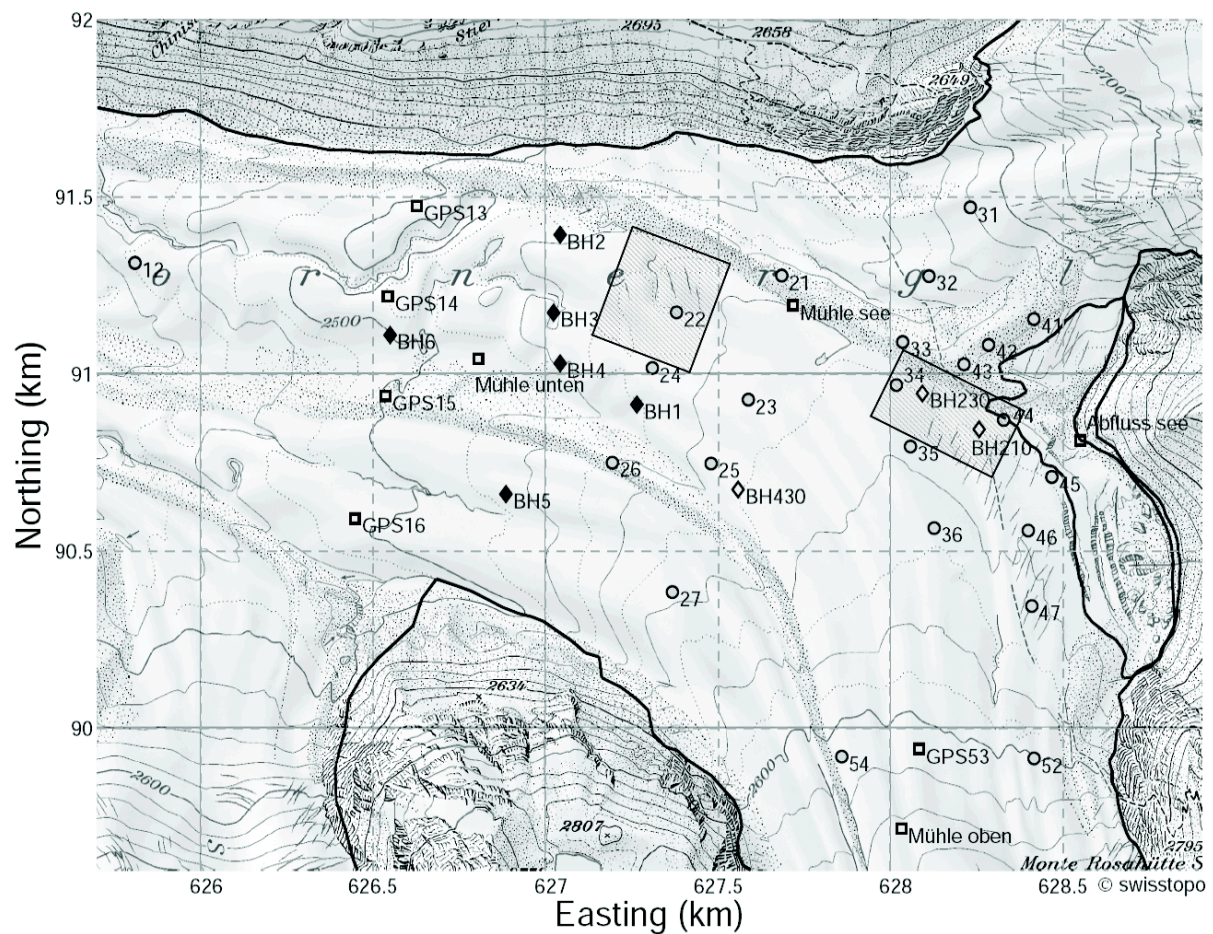


Figure 1. Overview of the study site in 2005 on the tongue of Gornergletscher. The lake contour is on the right, circles mark theodolite stakes, squares GPS stations and moulin used for tracer injections, diamonds mark bore holes with pressure transducers and the shaded areas are the seismic networks (2004 & 2006 right, 2005 left).