

# Glaciological investigations on Grosser Aletschgletscher

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## 1. Project description

Long-term glacier observations have been carried out in the frame of Glacier Monitoring in Switzerland (GLAMOS) in order to document variations of Grosser Aletschgletscher with evaluations of annual length change measurements since 1880, accumulation and mass balance measurements starting in 1918, and glacier volume change based repeated map or aerial photograph surveys, respectively. In the ongoing project the length, area, volume, and mass changes are continuously observed applying modern remote sensing techniques, as well as direct field measurements. The research activities are focused on long-term trends and seasonal fluctuations.

Mass balance components including snow accumulation and firn or ice melt are measured in detail at seven sites distributed along a longitudinal transect from the Jungfrauoch to the glacier tongue. Seasonal observations at the end of winter and end of summer are performed. During winter snow accumulation is the dominating process while ablation of snow, firn and ice occurs in the summer period. Thus, results from seasonal mass balance measurements allow separating the processes of accumulation and ablation. First measurements of firn accumulation and ablation started more than a century ago in 1918 at Jungfraufirn and are still continued. Between 1950 and 1985 an extensive network of measurements distributed over the entire glacier surface was maintained. Readings in roughly by-weekly interval of the measurement site on Jungfraufirn by the staff of the Jungfrauoch research station allows inferring the seasonal evolution. Since 2020, a webcam to monitor daily ice ablation and snow accumulation has been in continuous operation at an elevation of 2250 m asl with the same aim.

For the second period in a row, glaciers experienced extreme mass losses in the last observation period (2022/2023). The period was characterized by a winter with very low snow accumulation followed by a summer with above average temperature causing intensive melt rates. Snow fall events were scarce throughout the entire Swiss Alps in the winter season and lasting low amounts of snow accumulation resulted. Only in spring the conditions

improved for a short period when a warm and dry period in June initiated the depletion of winter snow layer.

Figure 1 shows the transient evolution of the mass gain and losses as inferred by a model constrained with the measurements acquired on Grosser Aletschgletscher. The course of the mass balance between October 2022 and September 2023 is compared to the 10-year average 2010-2020. The two last observation periods experienced an opposite evolution. While the evolution in the last period reached minimal values in winter, the snow accumulation started on average during the winter in the previous period 2021/2022 and was followed by an early and abrupt begin of the summer melting season. Due to extraordinary high melt rates, the snow and ice melted rapidly and the evolution remained on the most negative level on record until the end of the observation period.

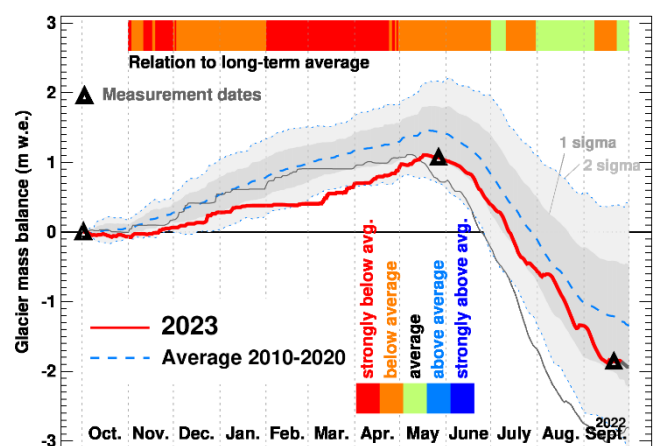


Figure 1. Evolution of the mass balance (in meters water equivalent) of Grosser Aletschgletscher. Comparison of the evolution during the past observation period from October 2022 until September 2023 (red) with the long-term average 2010-2020 (dashed blue and grey area). The evolution during the previous period 2021/2022 with record loss is also indicated.

The mass change of the entire glacier is evaluated from all available individual measurements at different locations and the periodical assessment of the ice volume change by comparison of digital elevation models (DEMs) representing the surface topography. Accurate DEMs exist for 1927, 1957, 1980, 1999, 2009 and 2017 over the last 100 years, respectively.

The glacier-wide mass balance of Grosser Aletschgletscher since 1927 is presented in Figure 2. The seasonal and annual components of the individual periods as well as the cumulative mass evolution is shown. The evolution of the largest glacier in the Alps over the last 100 years is characterized by two continuous periods of first a moderate and later an accelerated ongoing mass loss over several decades. The two trends are interrupted during about two decades from the mid-1970s until the end of the 1980s when the glacier gained slightly some mass. Besides this period with several

consecutive positive years in a row, only a few singular annual periods of positive or at least less negative balance exist. Each of these singular periods was quickly outranged by the following one or two negative years. As on other glaciers in the Swiss Alps with mass balance records, the most negative observation period of 2021/2022 of the entire record is complemented by another very negative period in 2022/2023. On many glaciers 2022/2023 was registered as the second or third negative period. On Grosser Aletschgletscher the past period does not rank among the five most negative periods. We attribute this less extreme result to the special setting of Grosser Aletschgletscher with a glacier tongue that reaches an altitude below 2000 m asl. where similar high melt rates are observed in each year over the past three decades, and a smaller snow deficit in winter compared to other glaciers. However, the ice loss of the largest glacier in the Alps continues without interruption (Figure 2).

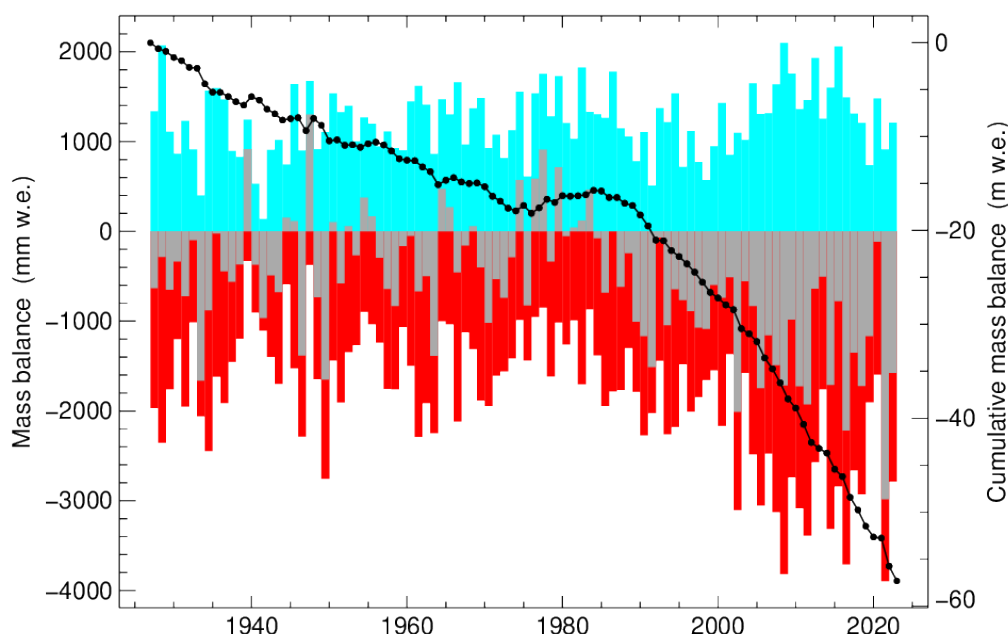


Figure 2. Glacier-wide winter (blue), summer (red) and annual (grey) mass balance (in millimetres water equivalent) of Grosser Aletschgletscher since 1927 and the first detailed mapping of the entire surface topography. Area averaged cumulative mass balance (in meters water equivalent) is given in black.

#### Internet data bases

<http://www.glamos.ch>  
<http://www.gliaciology.ethz.ch>

#### Collaborating partners / networks

Maurus Bamert, Martina Oettli, Pro Natura Zentrum Aletsch, Villa Cassel, Riederalp  
 Dr. André Streilein, Dr. Philip Joerg, Roberto Artuso, swisstopo, Wabern

#### Scientific publications and public outreach 2023

##### Data books and reports

Huss, M., C. Marty, A. Bauder, J. Nötzli, C. Pellet, Das Extremjahr 2022; Kryosphärenbericht – Schnee, Gletscher und Permafrost 2021/22, Die Alpen – Les Alpes – Le Alpi, 2023.  
<https://www.sac-cas.ch/de/umwelt/kryosphaerenbericht-2022-40340/>

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“Gletscherschmelze: Die Gradwanderung”, Die Zeit, September 29, 2023.  
<https://www.zeit.de/2023/41/gletscherschmelze-klimawandel-erderwaermung-glaziologie-forschung>

#### Radio and television

“Gletscherforscher: Wir verlieren das Eis”, ZDF, heute, August 2, 2023.  
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