A historical perspective on glacial retreat

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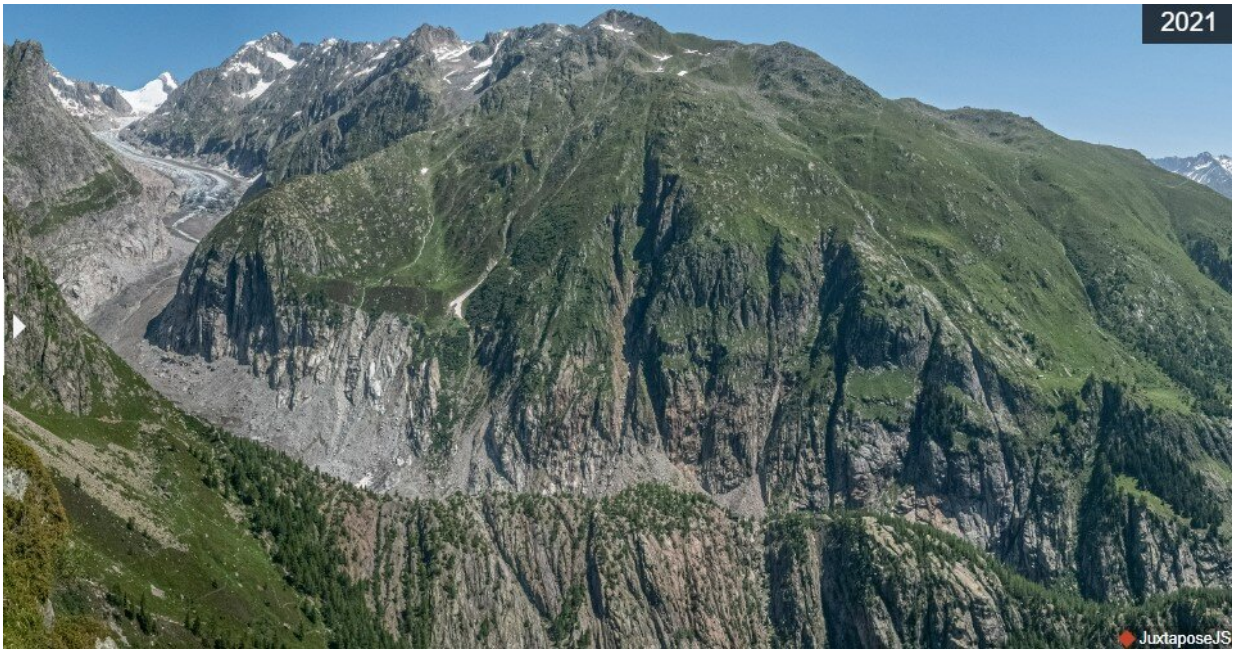
View of the Fieschergletscher as seen from Märjelenalp. Credit: swisstopo and VAW / ETH Zurich

Researchers at ETH Zurich and WSL have for the first time reconstructed the extent of Switzerland's glacier ice loss in the 20th century. For this purpose, the researchers used historical imagery and conclude that the country's glaciers lost half their volume between 1931 and 2016.

Glaciers are melting rapidly—and since the 2000s, scientists have been

recording and researching changes in their volume more and more precisely. In contrast, hardly anything is known about how glaciers changed during the 20th century. Although there are a handful of studies that reconstruct the surface topography of individual glaciers in the late 19th and early 20th centuries, these partially show large discrepancies with existing models when it comes to estimating the corresponding glacier volume.

In a study that has just been published in the scientific journal *The Cryosphere*, a team of researchers from ETH Zurich and the Swiss Federal Institute for Forest, Snow and Landscape Research WSL have reconstructed the topography of all Swiss glaciers in 1931. Based on these reconstructions and comparisons with data from the 2000s, the researchers conclude that the glacier volume halved between 1931 and 2016.



View of the Fiescherglетscher as seen from Märjelenalp. Credit: swisstopo and VAW / ETH Zurich

Old data, new insights

For their reconstruction, the glaciologists turned to what is known as stereophotogrammetry, a technique that can be used to determine the nature, shape and position of any object on the basis of image pairs. This technique has long been in use in Switzerland: from the First World War until the end of the 1940s, engineers from the Swiss National Survey—today swisstopo—surveyed large swathes of the Swiss Alps from some 7,000 locations using phototheodolites (a combination of a camera and an angle measuring device).

The resulting glass plate images, which swisstopo has digitized and enriched with metadata from field books, are now available to the public through the TerrA image archive. The researchers used the material from this image archive, which covers about 86% of the glacierized area of Switzerland. They analyzed about 21,700 photographs taken between 1916 and 1947.

"Based on these photos, we determined the glacier surface topography. If we know the surface topography of a glacier at two different points in time, we can calculate the difference in ice volume," explains lead author Erik Schytt Mannerfelt of ETH Zurich and WSL. Since the images were taken in different years, the researchers decided to use the mean year 1931 as a reference and reconstructed the surface topography of all glaciers for that year.

Not all glaciers are under observation

To date, the picture of glacier changes during the last century has been largely based on a combination of long-term glacier observations, measurements performed in the field and aerial photographs taken after

1960. From this information, glaciologists reconstructed the mass balance of individual glaciers—that is, the difference between mass gain and mass loss.

One way to determine a glacier's mass balance is through on-site measurements. But only a few Swiss glaciers—the Claridenfirn, for example—have been the subject of regular measurements. This means that long time series stretching over several decades are very rare. In addition, older mass balance series can accumulate errors from earlier, inaccurate or uncertain measurements, which can lead to large distortions.

Not all glaciers are equally affected

The study further shows that not all glaciers are losing mass at the same rate. The extent to which they have decreased in volume depends primarily on three factors: first, the altitude at which a glacier is located; second, how flat the glacier snout is; and third, the amount of debris on the glacier.

So have the glaciers just been receding every year? No. While the climate in the 20th century was generally unfavorable for glaciers, in the 1920s and 1980s there was sporadic glacier mass growth, with individual glaciers advancing. "While there may have been growth over short-term periods, it's important to keep the big picture in mind. Our comparison between the years 1931 and 2016 clearly shows that there was significant glacial retreat during this period," says Daniel Farinotti, Professor of Glaciology at ETH Zurich and WSL, and co-author of the study.

What's more, the total glacier volume is decreasing at an ever faster rate, as confirmed by the glacier monitoring network GLAMOS, which is managed by ETH Zurich. By way of comparison, while glaciers lost half their volume between 1931 and 2016, they lost a further 12% between

2016 and 2021—i.e., in just six years.

"Glacier retreat is accelerating. Closely observing this phenomenon and quantifying its historical dimensions is important because it allows us to infer the glaciers' responses to a changing climate. This information is needed to develop reliable scenarios for future glacier changes," Farinotti says.

More information: Erik Schytt Mannerfelt et al, Halving of Swiss glacier volume since 1931 observed from terrestrial image photogrammetry, *The Cryosphere* (2022). DOI: 10.5194/tc-16-3249-2022

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