Glacier length fluctuations in southern Norway back to the 17th century based on historical data: opposite behaviour compared to the Alps?

S. U. Nussbaumer (1, 2), J. Luterbacher (1, 2, 3), A. Nesje (4, 5), H. Wanner (1, 2) and H. J. Zumbühl (1)

(1) Institute of Geography, University of Bern, Switzerland
(2) Oeschger Centre for Climate Change Research, University of Bern, Switzerland
(3) Department of Geography, Climatology, Climate Dynamics and Climate Change, Justus Liebig University, Giessen, Germany
(4) Bjerknes Centre for Climate Research, Bergen, Norway
(5) Department of Earth Science, University of Bergen, Norway

The understanding of past and present glacier variations is a key task for evaluating current climate change. Historical and proxy-records have documented a partly asynchronous evolution in temperature, precipitation and glacial variations between European regions during the Little Ice Age (LIA), with the causes of these temporal anomalies yet being poorly understood *(e.g. 1)*. The comparison between the Alps and Scandinavia allows an assessment of the spatial distribution of glacier fluctuations in the studied areas during the last few centuries.

Here we present temporally highly resolved glacier reconstructions for southern Norway covering the period back to the 17th century, based on newly discovered historical material. Length changes were determined by the interpretation of high-quality historical documents such as drawings, paintings, prints, photographs, maps and written sources that are abundant for selected glaciers in the area (Folgefonna, Jostedalsbreen). Historical material is only available in adequate quantity for those glaciers which drew the attention of travellers, scientists and artists through their reputation and scenic attraction, reflecting also the perception of glaciers at that time. A critical quality check of the documentary data was necessary in order to get reliable information on past glacier extents. The glacier extents obtained were finally compared with existing moraine findings in the glacier forefield.

Results from outlet glaciers from Folgefonna (Bondhusbreen, Buerbreen) and Jostedalsbreen (Briksdalsbreen, Bøyabreen, Suphellebreen, Bergsetbreen, Nigardsbreen, Lodalsbreen) indicate a highly different glacier evolution compared to the Alps. According to the historical record, the maximum glacier extent occurred at Folgefonna at around 1870/1890, and at Jostedalsbreen at around 1750. In the Alps, existing glacier length records (e.g. for Unterer Grindelwaldgletscher, Switzerland, or Mer de Glace, France) show glacier advances around 1600, 1640, 1780, 1820 and 1850 *(2, 3)*.

In combination with climate reconstructions for the European Alps and for Scandinavia, this can give a better understanding of the influence of European climate dynamics on glaciers during the last half millennium. Annual net mass balances of maritime (coastal) glaciers in southern Norway are largely controlled by the amount of winter precipitation

from westerly air flow and thus mainly in phase with the winter NAO index *(4, 5)*. On the other hand, annual mass balances of glaciers in the western and central Alps show rather complex relations to the NAO dynamics. A more meridional air flow (from the North/Northwest) in winter is most favourable for high accumulation rates on Alpine glaciers. However, annual mass balances in the Alps are finally controlled to a large part by the temperature signal during the ablation season. The cause for the different glacier behaviour and timing of LIA glacier maxima in western Scandinavia and in the Alps may thus be related to differences in temperature and precipitation distribution which themselves are determined by changes in the large-scale atmospheric circulation over the northern North Atlantic/European and western Russian area, and possibly also by SST changes at low frequency timescales.

Key references:

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