19th century glacier perception and fluctuations in the central and western European Alps – New methods and results

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INTRODUCTION

As sensitive indicators of climate variability the data of fluctuations of European Alpine glaciers provide important sources for climate history. Unfortunately, direct determinations of glacier changes (length variations and mass changes) started with increasing accuracy shortly before the end of the 19th century. Therefore, interdisciplinary approaches which contain both historical and physical methods have to be used to reconstruct glacier variability for preceding time periods.

The Lower Grindelwald Glacier, Switzerland, and the Mer de Glace, France, are examples of well-documented Alpine glaciers with a wealth of different historical sources (e.g. drawings, paintings, prints, photographs, maps). The Lower Grindelwald Glacier shows the most detailed and probably best-documented curve of glacier length variations for the 1535-1983 period (Zumbühl 1980; Holzhauser and Zumbühl 2003). Mougin (1912) was the first to reconstruct the length fluctuations of the Mer de Glace for the 1590-1911 period. Further investigations for the late Holocene have been made by Wetter (1987).

Besides an analysis of historical sources of the 19th century for both the Lower Grindelwald Glacier and the Mer de Glace, we study the sensitivity of the Lower Grindelwald Glacier to climate parameters (multiproxy reconstructions of seasonal temperature and precipitation) for selected advance and retreat periods in the 19th century using a new neural network approach (Steiner et al. 2005a). Furthermore a quantification of glacier changes of the Lower Grindelwald Glacier since the mid-19th century is made using old topographic maps (Steiner et al. 2005b).

Finally, the curve of Mougin (1912) will be revised and refined using new available documentary data.

RESULTS

The 19th century represents the last maximum extent for a variety of Alpine glaciers. Furthermore, it is also the time when artists, scientists and photographers showed an increasing interest in glaciers. Therefore, it is a unique opportunity to bring perception and maximum extension together (Steiner et al. 2005b).

It is also a chance to analyze the conditions of the last widespread glacier advance and following retreat. A sensitivity analysis based on neural networks has been used to study the significance of climatic inputs to a glacier system. We can show that the significant 1810-1820 advance of the Lower Grindelwald Glacier is mainly driven by low summer temperatures and a longer preceding period of high autumn precipitation. The rapid 1860-1880 retreat is then forced by high spring temperatures and decreasing autumn precipitation. Note that the neural network approach takes into account the varying reaction time (up to 45 years) of the Lower Grindelwald Glacier (Steiner et al. 2005a). Furthermore, since the mid-19th century the Lower Grindelwald Glacier shows a relative thickness change of -0.42 meters per year.

Historical pictorial sources are confirming the two well-documented 19th century glacier maximum extents around 1820 and 1855 for both the Mer de Glace and the Lower Grindelwald Glacier. The first maximum extent around 1820 has been documented by several colored pen-ink drawings by Samuel Birmann (1793-1847) for both glaciers (Mer de Glace: 1823; Lower Grindelwald Glacier: 1826).

The photographs by the Bisson Brothers (Louis-Auguste: 1814-1876; Auguste-Rosalie: 1826-1900) for the Mer de Glace (1854) and Lower Grindelwald Glacier (1855/56) document the glacier maximum extent around 1855 and are some of the first photographs of the selected glaciers. Note that both drawings from Birmann and the photographs by the Bisson Brothers are among the best historical sources of the two glaciers for the 19th century.

A refinement of the curve of Mougin (1912) for the Mer de Glace by new pictorial sources shows some differences to the original time series of Mougin. In particular, the maximum of the Mer de Glace in the early 1850s is probably more extensive than assumed so far, but still behind the well-known 1821 maximum extent. Nevertheless, there is a good agreement between the glacier fluctuations of the Lower Grindelwald Glacier and the Mer de Glace.

DISCUSSION AND CONCLUSIONS

The Lower Grindelwald Glacier and the Mer de Glace are among the best-documented glaciers with different kinds of historical sources. The high-quality drawings by Birmann and the first photographs by the Bisson Brothers are both outstanding examples of glacier representations from the last part of the Little Ice Age (LIA). Pictorial sources provide therefore insight into glacier changes as well as views on changing glacier perception. As a consequence, we are able to do comparisons of glacier representations and quantifications of glacier variations.

After an analysis of new documentary data we show that the (revised) time series of length fluctuations of the Lower Grindelwald Glacier and the Mer de Glace are very similar – despite the long distance between the glaciers.

Furthermore, a new neural network approach to analyze the sensitivity of the Lower Grindelwald Glacier to different climate parameters has successfully been applied. We show that different configurations of climate variables lead to advances/retreats of the Lower Grindelwald Glacier. Therefore, nonlinear neural network approaches seem to be powerful tools in glaciological context.

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