Glacier fluctuations in western and central Alps AD 1500-2050: an interdisciplinary approach using new historical data and neural network simulations.

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Glaciers are sensitive indicators of past climate and are thus valuable sources of climate history. Although glacier length is an indirect and delayed signal of climate information, it is a useful tool for the examination of the glacier-climate relationship. Unfortunately, direct determinations of glacier changes (length variations and mass changes) did not start with increasing accuracy until just before the end of the 19th century. Therefore, interdisciplinary approaches that contain both historical and physical methods have to be used to reconstruct the behaviour of glaciers for the preceding time of the Little Ice Age (LIA).

The Unterer Grindelwaldgletscher (central Alps, Switzerland), and the Mer de Glace (Mont Blanc area, France), are examples of well-documented Alpine glaciers with a wealth of different historical sources (e.g., drawings, paintings, prints, photographs, maps) that allow reconstruction of glacier length variations for the last 400-500 years.

For the Mer de Glace (Mont Blanc area), there exists a glacier length curve for the period from 1590 to 1911, made by Mougin (1912). In the present study, we revise and refine the existing glacier length curve for the Mer de Glace, using newly available documentary data (Nussbaumer et al. in prep.). Excellent examples of glacier representations of the Mer de Glace are given by the drawings of Jean-Antoine Linck and Samuel Birmann, and the maps by James David Forbes and Eugène Viollet-le-Duc. The revised glacier length curve for the Mer de Glace dates back to 1570 and is in good agreement with the curve made by Mougin (1912). However, significant differences occur around 1850, when the glacier extent seems to be much more extensive than assumed by Mougin. The largest glacier extension, documented by several archive texts and moraines, occurred around 1644. The largest glacier advance in the 19th century culminated in 1821 and is just slightly smaller than in 1644. Other major glacier advances are documented around 1600, 1720, 1778, and 1852. Since the 1850s, the glacier has retreated more or less continuously (except for some minor advances, e.g. in 1995) by more than 2 km until the present-day.

Comparing the Mer de Glace with the Unterer Grindelwaldgletscher (Zumbühl 1980), we focus on the 19th century glacier maxima which are documented by representations made by the same authors for both glaciers. The first maximum extent around 1820 has been documented by drawings from Samuel Birmann, and the second maximum extent around 1855 is shown by photographs of the Bisson brothers. These pictorial sources are among the best documents of the two glaciers for the 19th century. Finally, we compare the length fluctuations of both glaciers for the 16th century until the present. The comparison yields an astonishing simultaneity between the glaciers, despite the different settings in the western and central Alps. Both glaciers had their maximum LIA extent in the first half of the 17th century, and two minor peaks in the 19th century. However, in contrast to the Unterer Grindelwaldgletscher, which culminated in 1855/56, the Mer de Glace had its relative maximum extent in 1821.

A new suitable statistical approach to simulating glacier variations is the application of a neural network model (NNM), especially in combination with high-resolution climate data (Steiner et al. 2005). In the present study, a non-linear back-propagation NNM is successfully applied to the Mer de Glace, using multiproxy reconstructions of seasonal temperature and precipitation back to 1500 (Casty et al. 2005). Future glacier length variations of the Mer de Glace are simulated using two climate scenarios. The first scenario assumes no changes in mean climate, the second scenario accounts for higher temperature and changing precipitation values. Confronting current climate change, the more likely scenario 2 shows a continuous and remarkable retreat of the Mer de Glace until the end of the simulation period in 2042. For both scenarios, the simulation shows a very good accordance between the simulated curve and the measured glacier front values for the 20th century (Nussbaumer et al. in prep.). Finally, this non-linear statistical approach is a new contribution to the various investigations of the complex climate-glacier system.

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