



## Evidence from the Archives of Societies: Historical Sources in Glaciology

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Glaciers have been recognized as key indicators of climate change. As such, changes in glaciers not only have relevance for climate policy but also affect popular global perceptions of climate change.<sup>1</sup> To assess the current decline in glaciers worldwide, their changes must be compared with the natural glacier fluctuations since the end of the last ice age.

Various methods with varying temporal resolution and accuracy allow researchers to reconstruct glacier fluctuations throughout the Holocene (ca. 9700 BCE–present). To reconstruct glacier changes over recent centuries, including the Little Ice Age (LIA) (see Chap. 23), historical methods have proven especially valuable. Where sufficient in quality and quantity, pictorial documents (drawings, paintings, prints, and photographs); cartographical documents (maps, cadastral plans, and reliefs); and written accounts (chronicles, church registers, land sale contracts, travel descriptions, early scientific works on Alpine research, etc.) can provide a detailed picture of glacier fluctuations, in particular frontal length changes. Using these data, we can achieve a resolution of decades or in some cases even individual years of ice margin positions.<sup>2</sup>

To reconstruct past glacier movements, researchers must handle historical data carefully and take local circumstances into account. In particular, the

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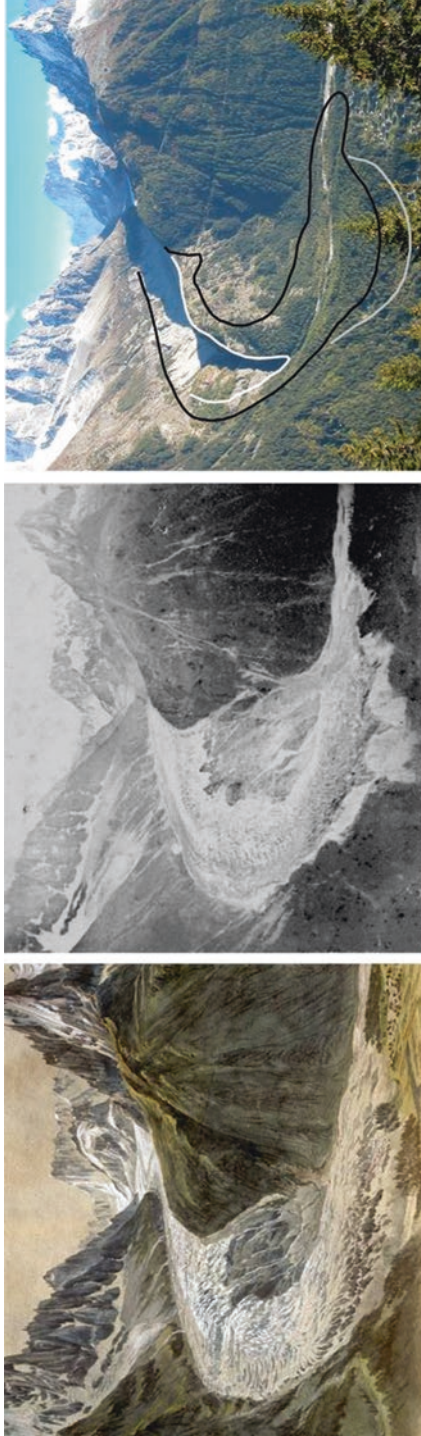
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evaluation of pictorial sources has to fulfill certain conditions in order to obtain reliable results concerning the former extents of glaciers (Fig. 8.1):

- First, the date of the document has to be known or reconstructed. That is, researchers have to know the exact date when the artist was visiting the glacier and making travel sketches or studies. Oil paintings might have been done on site, but they were quite often finished later, usually in the artist's studio.<sup>3</sup> Prints of artworks often bear a different date than their originals. Dating early glacier photographs can be especially difficult and often includes time-consuming archival work.
- Second, the glacier and its surroundings have to be represented in a manner that is realistic and topographically correct, something that requires particular skills of the artist. Some artists liked to compose motifs of their own in the foreground or omit unaesthetic frontal moraines, features that could obscure the true position of glaciers.
- In addition, the artist's topographic position should be known. The presence of prominent features in the glacier's surroundings such as rock steps, hills, or mountain peaks can facilitate the evaluation of historical documentary data.<sup>4</sup>

Iconic depictions of glaciers appear in the works of famous artists such as Caspar Wolf (1735–1783), Jean-Antoine Linck (1766–1843), Samuel Birman (1793–1847), and Thomas Ender (1793–1875). Their outstanding drawings and paintings have allowed the reconstruction of LIA glacier fluctuations in the European Alps in a uniquely precise way.<sup>5</sup>

Prior to 1800, the abundance of historical material in Europe depended mainly on the elevation of LIA glacier tongues and the threat that glacier advances posed to settlements and cultivated land.<sup>6</sup> Probably the earliest known representation of a glacier in the Alps is that of Vernagtferner (Ötztal, eastern Alps) in 1601: the drawing shows a dangerous glacial lake dammed by the advancing glacier.<sup>7</sup> Two emblematic glaciers with a wealth of historical (pictorial) documents are the Lower Grindelwald Glacier (Bernese Oberland, Switzerland) and the Mer de Glace (Mont Blanc area, France). Using historical data, researchers have reconstructed series of cumulative length changes for these glaciers that extend back to the sixteenth century. Those reconstructions show main glacier maxima around 1600 and 1640 and again around 1820 and 1850, as well as several smaller intermediate advances.<sup>8</sup> Reconstructions based on dendrochronology and radiocarbon dating confirm these pulses; moreover, they indicate a third LIA peak in the second half of the fourteenth century.<sup>9</sup> From the late 1840s, a rapidly increasing number of photographs depict the onset of glacier retreat, marking the end of the LIA in the European Alps.<sup>10</sup> In southern Norway and Iceland, historical evidence and instrumental measurements show a distinct glacier asynchrony when compared with the European Alps, with LIA maxima around 1750 and at the end of the nineteenth century, respectively.<sup>11</sup>



**Fig. 8.1** The Mer de Glace seen from the viewpoint of La Flégère, overlooking the valley of Chamoniex (Mont Blanc). Left: Drawing (water-colour, pencil) by Samuel Birman from 1823 (Kunstmuseum Basel, Kupferstichkabinett, reproduction by H.J. Zumbühl). Middle: Photograph taken by Henri Plaut in the 1850s (collection of R. Wolf, reproduction by S.U. Nussbaumer). Right: Current view with reconstructed glacier extents in 1644 (grey, largest extension), 1821 (black), and 1895 (white) (photograph by S.U. Nussbaumer)

Outside Europe, historical sources (before the late nineteenth century) are less abundant.<sup>12</sup> Nevertheless, resources exist for other regions, including southern South America and New Zealand.<sup>13</sup> Systematic worldwide observations of glacier fluctuations (regarding length, mass, volume) began at the end of the nineteenth century. Corresponding data are available from the World Glacier Monitoring Service. They deliver clear evidence that centennial glacier retreat is a global phenomenon, and that rates of early twenty-first-century mass loss are without precedent on a global scale—at least for the time period observed, but probably also for recorded history as indicated by historical sources.<sup>14</sup>

## NOTES

1. Orlove et al., 2008; Carey, 2010.
2. Zumbühl, 1980; Nussbaumer et al., 2007; Holzhauser, 2010.
3. An illustrative example is the exact oil painting of the Lower Grindelwald Glacier by Joseph Anton Koch, signed and dated in 1823. This artwork was initially misinterpreted, but Zumbühl (1980) could provide evidence that it is based on an original watercolour, drawn by Koch in the field in 1794. The oil painting, made twenty-nine years later in Rome, shows the glacier extent from 1794 (a reduced extent compared with 1823, when the glacier was strongly advancing), but in the foreground we can identify Mediterranean vegetation.
4. Zumbühl and Holzhauser, 1988.
5. Zumbühl, 2009; Nussbaumer et al., 2012.
6. Le Roy Ladurie, 1967.
7. Nicolussi, 1990.
8. Zumbühl, 1980; Zumbühl et al., 1983; Nussbaumer et al., 2007.
9. Holzhauser et al., 2005; Le Roy et al., 2015.
10. Zumbühl et al., 2016.
11. Nussbaumer et al., 2011; Hannesdóttir et al., 2015.
12. Grove, 2004.
13. Araneda et al., 2009; Purdie et al., 2014.
14. WGMS, 2017.

## REFERENCES

- Araneda, A. et al. “Historical Records of Cipreses Glacier (34°S): Combining Documentary-Inferred ‘Little Ice Age’ Evidence from Southern and Central Chile.” *The Holocene* 19 (2009): 1173–83.
- Carey, M. *In the Shadow of Melting Glaciers: Climate Change and Andean Society*. New York: Oxford University Press, 2010.
- Grove, J.M. *Little Ice Ages: Ancient and Modern*, Second ed. London: Routledge, 2004.
- Hannesdóttir, H. et al. “Variations of Southeast Vatnajökull Ice Cap (Iceland) 1650–1900 and Reconstruction of the Glacier Surface Geometry at the Little Ice Age Maximum.” *Geografiska Annaler: Series A, Physical Geography* 97 (2015): 237–64.

- Holzhauser, H. *Zur Geschichte des Gornergletschers: Ein Puzzle aus historischen Dokumenten und fossilen Hölzern aus dem Gletschervorfeld*. Bern: Geographisches Institut der Universität Bern, 2010.
- Holzhauser, H. et al. "Glacier and Lake-Level Variations in West-Central Europe over the Last 3500 Years." *The Holocene* 15 (2005): 789–801.
- Le Roy, M. et al. "Calendar-Dated Glacier Variations in the Western European Alps during the Neoglacial: The Mer de Glace Record, Mont Blanc Massif." *Quaternary Science Reviews* 108 (2015): 1–22.
- Le Roy Ladurie, E. *Histoire du climat depuis l'an mil*. Paris: Flammarion, 1967.
- Nicolussi, K. "Bilddokumente zur Geschichte des Vernagtferners im 17. Jahrhundert." *Zeitschrift für Gletscherkunde und Glazialgeologie* 26 (1990): 97–119.
- Nussbaumer, S.U. et al. "Fluctuations of the Mer de Glace (Mont Blanc Area, France) AD 1500–2050: An Interdisciplinary Approach Using New Historical Data and Neural Network Simulations." *Zeitschrift für Gletscherkunde und Glazialgeologie* 40 (2007): 1–183.
- Nussbaumer, S.U. et al. "Historical Glacier Fluctuations of Jostedalbreen and Folgefonna (Southern Norway) Reassessed by New Pictorial and Written Evidence." *The Holocene* 21 (2011): 455–71.
- Nussbaumer, S.U. et al., eds. *Mer de Glace – art et science*. Chamonix: Atelier Esope, 2012.
- Orlove, B. et al., eds. *Darkening Peaks: Glacier Retreat, Science, and Society*. Berkeley: University of California Press, 2008.
- Purdie, H. et al. "Franz Josef and Fox Glaciers, New Zealand: Historic Length Records." *Global and Planetary Change* 121 (2014): 41–52.
- WGMS. *Global Glacier Change Bulletin No. 2 (2014–2015)*. Zürich: World Glacier Monitoring Service, 2017.
- Zumbühl, H.J. *Die Schwankungen der Grindelwaldgletscher in den historischen Bild- und Schriftquellen des 12. bis 19. Jahrhunderts. Ein Beitrag zur Gletschergeschichte und Erforschung des Alpenraumes*. Basel: Birkhäuser, 1980.
- Zumbühl, H.J. "'Der Berge wachsend Eis ...' Die Entdeckung der Alpen und ihrer Gletscher durch Albrecht von Haller und Caspar Wolf." *Mitteilungen der Naturforschenden Gesellschaft in Bern* 66 (2009): 105–32.
- Zumbühl, H.J., and H. Holzhauser. *Alpengletscher in der Kleinen Eiszeit*. Bern: Schweizer Alpen-Club, 1988.
- Zumbühl, H.J. et al. *Die Kleine Eiszeit: Gletschergeschichte im Spiegel der Kunst. Sonderausstellung des Schweizerischen Alpen Museums, Bern, 24. August–16. Oktober 1983, und des Gletschergarten-Museums, Luzern, 9. Juni–14. August 1983*. Luzern/Bern, 1983.
- Zumbühl, H.J. et al., eds. *Die Grindelwaldgletscher – Kunst und Wissenschaft*. Bern: Haupt-Verlag, 2016.