

## Historical glacier variations in southern South America since the Little Ice Age: examples from Lago Viedma (southern Patagonia) and Mendoza (central Andes)

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There is considerable historical evidence for European glacier dynamics over the past centuries. Evaluation of this information allows reconstructing glacier length variations from the Little Ice Age (LIA) until the present. For several glaciers, reconstructions with decadal or annual resolution can be achieved (e.g. Zumbühl *et al.*, 2008, Nussbaumer and Zumbühl, 2012). These revealed that there is a striking asynchrony between Alpine and Scandinavian glacier fluctuations, both during the LIA and in the 20<sup>th</sup> century. In South America, historical information is much less abundant, but early photographs and maps depict changes for selected glaciers before the onset of modern measurements.

Here we provide new evidence to the South American glacier history. Written documents and pictorial historical records (drawings, sketches, engravings, photographs, chronicles, topographic maps) have been critically analysed, with a particular focus on two regions: Lago Viedma (El Chaltén, southern Patagonia, 49.5°S, 73.0°W) and the Río del Plomo basin (Mendoza, central Andes, 33.1°S, 69.9°W).

For the Lago Viedma area, early historical data for the end of the 19<sup>th</sup> century stem from the expedition of the Chilean-Argentinean border commission (led by the Argentinean Francisco P. Moreno). Glaciar Viedma, an outlet glacier of the Southern Patagonian Icefield, is richly documented. In addition, the expedition by the German Scientific Society, conducted between 1910 and 1916, and the photographs by Alberto M. de Agostini, an Italian padre, geographer and ethnographer, give an excellent depiction of the glaciers (de Agostini, 2010).

For the Mendoza area, historical sources go back to the arrival of the Spanish conquerors, particularly related to the finding of new routes across the high Andes in the second half of the 18<sup>th</sup> century. In the beginning of the 20<sup>th</sup> century, Robert Helbling (1874–1954), a Swiss geologist and pioneer of alpinism, explored the Argentinean-Chilean Andes together with his friend Friedrich Reichert (Reichert, 1946). In the summer of 1909/10, they started a detailed survey of the highly glacierized Juncal-Tupungato mountains, leading in 1914 to the first accurate topographic map of the area. In 1934, the sudden drainage of a glacier-dammed lake in the upper Río del Plomo valley caused fatalities and considerable damage to constructions and the Transandine Railway. A similar event is reported to have occurred in 1786 according to historical records.

Finally we compare the observed glacier fluctuations of the two regions with other glacier reconstructions available (e.g. for northern Patagonia), to give an overview of the glacier evolution in southern South America since the LIA. According to historical evidence and dendro-geomorphological analyses, the LIA maximum occurred between the 16<sup>th</sup> and 18<sup>th</sup> century. However, there is a large spatial variability (Masiokas *et al.*, 2009). Those observations can be compared with recently developed, high-resolution multi-proxy temperature and precipitation reconstructions. This allows an assessment of the spatial pattern of glacier changes in southern South America, differentiating local effects from regional or larger-scale climate dynamics.

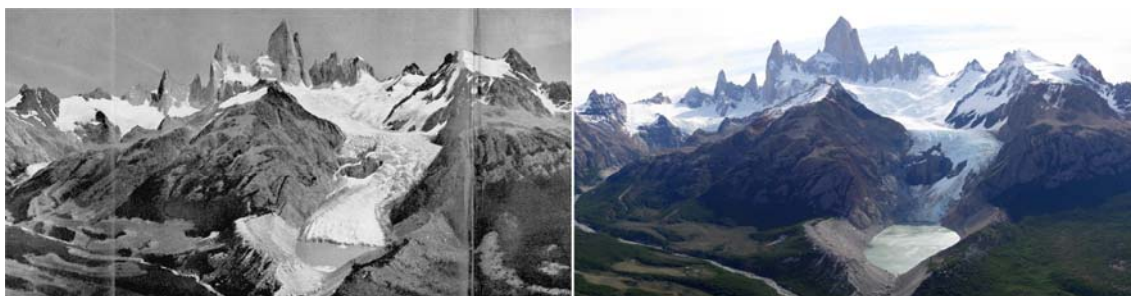


Figure 1. Comparison of Glaciar Piedras Blancas (El Chaltén, southern Patagonia) in 1931 (photo by A. M. de Agostini) and 2012 (photo by S. Nussbaumer).

## REFERENCES

- de Agostini, A. M. (2010). *Andes Patagónicos. Viajes de exploración a la Cordillera Patagónica Austral*. Tercera edición corregida y aumentada. Congregación Salesiana de Chile, Punta Arenas, 558 pp.
- Masiokas, M. H., A. Rivera, L. E. Espizua, R. Villalba, S. Delgado, and J. C. Aravena (2009). Glacier fluctuations in extratropical South America during the past 1000 years. *Palaeogeography, Palaeoclimatology, Palaeoecology* 281(3–4), 242–268.
- Nussbaumer, S. U. and H. J. Zumbühl (2012). The Little Ice Age history of the Glacier des Bossons (Mont Blanc massif, France): a new high-resolution glacier length curve based on historical documents. *Climatic Change* 111(2), 301–334.
- Reichert, F. (1946). *Auf Berges- und Lebenshöhe. Erinnerungen*. Ludwig, Buenos Aires, 2 Vols.
- Zumbühl, H. J., D. Steiner, and S. U. Nussbaumer (2008). 19<sup>th</sup> century glacier representations and fluctuations in the central and western European Alps: an interdisciplinary approach. *Global and Planetary Change* 60(1–2), 42–57.