

The movements of Alpine glaciers throughout the last 10,000 years as sensitive proxies of temperature and climate changes

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It is well known that the Holocene, i.e. the geological time period of the last 10,000 years following the end of the Ice Age, enjoyed relatively stable temperatures. But glaciers are sensitive proxies to even small temperature and/or climate changes. Thus, the globally observed retreat of Alpine glaciers and polar ice sheets since 1850 AD (the end of the so-called Little Ice Age) has been linked to the temperature increase caused by human activities, particularly due to the steady increase of CO₂ in the atmosphere [1]. On the other hand, it is now evident that considerable glacial fluctuations occurred already at much earlier times when human impact was negligible.

In a way, the interest in Alpine glaciers of the past started with the accidental discovery of the famous Iceman Ötzi in 1991, a naturally mummified body which was well preserved for 5200 years in the icy environment of a high mountain pass (3210 m a.s.l.) in the Ötztal Alps [2]. Since then, several forward and backward movements of glaciers in the European Alps and in the New Zealand Southern Alps throughout the last 10,000 years have been established with the help of dendrochronology, radiocarbon dating, surface exposure dating of rocks and moraines with various cosmogenic radionuclides (¹⁰Be, ¹⁴C, ²⁶Al, ³⁶Cl), and geomorphological considerations [3].

It is possible that small solar activity variations, enhanced by (hitherto largely unknown) feedback processes on Earth, caused the observed glacial fluctuations. These natural fluctuations constitute a “background”, which is now being modified in a complex way by human activities. It is hoped that research on the movement of Alpine glaciers before man’s influence may actually help to better assess the anthropogenic influence on climate change in our time.

[1] The Keeling Curve: <https://scripps.ucsd.edu/programs/keelingcurve/>

[2] W. Kutschera et al., The Tyrolean Iceman and his glacial environment during the Holocene, *Radiocarbon* **59/2** (2017) 395-405.

[3] A.E. Putnam et al., Regional climate control of glaciers in New Zealand and Europe during the pre-industrial Holocene, *Nature Geoscience* **5** (2012) 628-630.