Geophysical Research Abstracts
Vol. 21, EGU2019-9950, 2019
EGU General Assembly 2019

Palaeoprecipitation and atmospheric circulation patterns from palaeoglaciers – insights from Younger Dryas glaciers in the Alps

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Surface exposure dating with terrestrial cosmogenic radionuclides of many moraines in numerous valleys of the Alps makes the „Egesen Stadial“ the best dated phase of glacier advances of the Alpine Lateglacial period. As the numerical dating give consistently (early) Younger Dryas (12.9 – 11.6 ka) ages for the stabilization of the moraines of the maximum advance, we may rather safely conclude that it occurred during the first few centuries of the Younger Dryas cold phase. Further, increasingly smaller, glacier advances lasted into the earliest Holocene. More recently, the first moraine ages from the Northern Alps could be obtained, indicating a widespread glacierization down to rather low altitudes along the northern fringe of the Alps. The success in dating the maximum advance in a variety of places between the Austrian Tauern mountains and the Maritime Alps in northwestern Italy supports the idea that the field methods for mapping and stratigraphical assignment of moraines give generally reliable results.

From our own field work and the rather extensive literature we obtained a dataset of presently almost 200 palaeoglaciers, their equilibrium line altitude (ELA) and the lowering of the ELA relative to the Little Ice Age (dELA) and modern values. The glaciers are localized between the western fringe of the Tauern mountains in the east, eastern France in the west, the Alps in Bavaria in the north and central Trentino and the Maritime Alps in the south. This ensures a good spatial coverage of wide areas of the Alps.

ELAs were highest (2600 – 2700 m) in the central, well sheltered valleys of the Alps and lowest (1700 – 1900m and probably even lower) in the north-facing valleys and cirques of the Northern Alps. The dELA in the Northern Alps was around -400 to -500 m, in the central valleys it was around -200 m. Together with summer temperature change as derived from alpine timberline lowering (-3.5 - -4.5°C), the ELAs form the basis for the reconstruction of palaeoprecipitation in the Alps during the early Younger Dryas and for estimation of precipitation change.

Precipitation change can be calculated with simple glacier-climate models, the heat- and mass balance equation or with positive degree day models. In any case the dELA values translate into fairly humid conditions similar to present-day conditions along the northern fringe of the Alps and the climate of a cool and dry steppe ecotone in the central valleys. This is well supported by the findings of palynological investigations. Such a spatial distribution of precipitation requires a dominantly westerly to northwesterly atmospheric circulation pattern. Advection of humid air masses should be normally restricted to lower altitudes, similar to present-day conditions during the winter half year.