Geophysical Research Abstracts, Vol. 9, 02387, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-02387

Glacier-climate models as palaeoclimatic information sources - examples from the Alpine Lateglacial period

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Spatial patterns of precipitation and precipitation change in a mountain range like the European Alps are the result of distinct patterns of the general circulation of the atmosphere. Glacier-climate models (analytical, statistical) relate climatic factors governing ablation and accumulation at the equilibrium line altitude (ELA) of the glaciers. Fluctuations of the ELA can thus be interpreted in terms of climatic fluctuations. This allows the quantitative reconstruction of past spatial precipitation patterns for periods with wide-spread glacier advances. The analytical approach, which is based on the perturbation analysis of the mass- and energy balance equation, and various statistical relations need summer temperature data from external (non-glacial) sources as input variables to calculate precipitation at the ELA. Various proxy-data can be used, among which timberline fluctuations seem to be most suitable. Results for the Younger Dryas (Greenland Stadial 1) maximum advance of alpine glaciers ("Egesen Stadial") show that under the assumption of a summer temperature drop of -3.5 K annual precipitation was reduced by -20 to -30 % in the continental interior of the Alps, whereas it was rather similar to present-day values or even slightly higher along the northern fringe of the Alps. The reconstruction of mass balance gradients from simple glacier flow models allows a direct calculation of accumulation. It requires simple glacier topographies and reasonable assumptions of the amount of basal sliding of the glacier tongue. This approach shows that during the "Gschnitz Stadial" (Greenland Stadial 2a, Heinrich-1 - event) the Central Alps received only about 30 % of the present-day precipitation. Summer temperatures were in the order of 8 - 10 K lower than today.