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Spatial representativity of air-temperature information from instrumental and ice-core-based isotope records in the European Alps

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ABSTRACT. Spatial correlations between Alpine high-elevation and European low-elevation instrumental air temperatures are computed to assess the spatial representativity of a high-Alpine ice-core isotope proxy temperature record. The correlation analyses indicate that air-temperature records at Alpine ice-core drill sites are representative for central Europe, particularly in summer. While Alpine ice cores generally show a large scattering in the conserved section of the year, long-term records from low-accumulation sites consist almost solely of summer precipitation and thus reflect isotope proxy summer-temperature variability. However, correlation between seasonal and annual instrumental air temperature indicates that summer temperature variability provides an adequate approach to annual temperature variability. Comparison of long-term ice-core $\delta^{18}O$ records from Colle Gnifetti (4450 m a.s.l.), Monte Rosa, Western Alps, with local instrumental summer temperatures inferred from an instrumental network shows good agreement in the long-term scale. Thus Alpine long-term ice-core $\delta^{18}O$ records are representative for central European air-temperature variability.

INTRODUCTION

Stable-water-isotope ice-core records from vast polar ice sheets are a well-recognized proxy for local condensation temperature (Jouzel and others, 1997). However, a major difference between the precipitation-sampling systems of polar ice sheets and mid-latitude ice-core sites must be stressed. Since the required cold-temperature regime at mid-latitude sites is maintained only at high altitude, the drill-site area will be relatively small and situated at an exposed (strongly wind-influenced) location. Consequently, several mid-latitude drill sites, such as in the European Alps, are subject to a substantial net loss of surface snow, especially during winter, rendering the ice-core records seasonally unrepresentative (Wagenbach, 1994).

When evaluating Alpine ice-core records, it is important to remember that the long-term net snow-accumulation rate is controlled by the upstream surface condition (Alean and others, 1984), making the conserved seasonal fraction of total precipitation systematically variable in space and time (examination of the impact of this effect is beyond the scope of this paper).

As with polar drill sites, a basic problem of stable-water-isotope records from Alpine sites concerns the spatial representativity of a given local temperature proxy signal. In the Alps this question is linked to the seasonal representativity of such ice-core records. The impact of climate-change-induced seasonality changes on the representativity of the recorded Alpine proxy temperature is discussed elsewhere (Auer and others, 2001b). Consequently, investigations into the spatial representativity of a potentially recorded local temperature signal at drill sites are to be evaluated for different seasons. It is also necessary to evaluate to what extent seasonal temperature records may reflect mean annual temperature variability, which is one of the key parameters in climate research.

To tackle these questions, within the European Union project ALPCLIM (focusing, among other things, on the extension of Alpine climate records beyond the instrumental period by Alpine ice-core proxies (Wagenbach and others, 1998), spatial correlation between instrumental air-temperature series is used to determine the spatial representativity of the ice-core stable-isotope-derived air-temperature signal. To overcome the problem of seasonal selectivity of ice-core records, the evaluation is divided into a summer and a winter period. The study underlines the favourable situation existing in Europe, where a dense network of long-term, well-documented instrumental climate records is available.

INSTRUMENTAL TEMPERATURE DATA

The network of Alpine long-term temperature time series was used to elaborate carefully homogenized gridded series of relative temperature changes in monthly resolution (Böhm and others, 2001). The dataset covers the region 43–49° N, 4–18° E with 1° latitude/longitude spatial resolution and dates back to 1765 (hereafter denoted as ALPCLIM dataset). To consider vertical differences of Alpine climate variability the ALPCLIM series have been subdivided into high-elevation (>1500 m a.s.l.) and low- elevation temperature series