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Quantitative climate reconstructions in mountain areas: problems and perspectives.

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Transfer functions are an efficient tool for the reconstruction of past climate from low to mid elevation pollen sites. On the opposite, the application of current methods on high-altitude pollen sequences yields unreliable results (Cheddadi *et al.*, 1997; Peyron *et al.*, 1998).

The standard "best modern analogue" method (Guiot, 1990) is applied to two high altitude pollen sequences to provide quantitative estimates of the Late-Glacial and the Holocene climate. Both pollen sequences (Laghi dell'Orgials, 2130 m, S-W exposition and Lago delle Fate, 2240 m, E exposition) (Ortu *et al.*, in press) are located in the Subalpine belt, on both sides of the St. Anna di Vinadio Valley (Italian Maritime Alps).

Reconstruction of palaeoclimate yields different results for the two sequences. The differences mainly concern the reconstruction of palaeotemperature (mean temperature of the coldest month and the warmest month, average annual temperature), which show notable differences in the values and trends obtained at each site. Biases particularly concern the reconstruction of temperatures at the beginning of the Holocene, for which the two sequences show, respectively, a local and a regional pollen record.

We can attribute these biases to: 1) a lack of high elevation "best modern analogues" in the present modern data base, 2) the problem of multiple floristically similar, but climatically dissimilar analogues, dominated by taxa that may be found in phytocenoses growing under different climates, 3) problems relied to the complexity of mountainous ecosystems, such as the phenomenon of tree pollen blown uphill by wind, percentages of which vary depending on local physiographic conditions.

A first attempt to reduce these biases concerns the modern pollen database. It has been improved by the addition of new high altitude pollen samples. Furthermore, the modern analogues that appeared unreliable, due to anthropogenic modification of the landscape have been removed. The second attempt concerns the method. We applied a biome constrain (Guiot *et al.*, 1993) to only use modern samples that had compatible biomes with any given fossil sample. These measures yielded a considerable improvement of the reconstructed climatic parameters, and resulted in curves with more consistent trends. Nevertheless, the temperature values are abnormally high (3-4 ˚C more than present values) all along the two sequences, excepted for periods dominated by local taxa.

To further reduce the observed biases and thus improve the palaeoclimatic reconstruction, 90 new recent pollen samples have been collected from different vegetation belts in the Alps, with a focus on sample collection from areas that have suffered little anthropogenic impact. New climate reconstructions using these data show a further improvement, and illustrate the need for more precise selection strategies when using modern samples for climate reconstruction in high-altitude mountain sites.

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