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Influence of large-scale atmospheric circulation on climate variability in the Greater Alpine Region of Europe

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[1] The climatic variability in the Greater Alpine Region (GAR) of Europe has a diverse character: it exhibits differences between winter and summer, and between its individual subregions. The large-scale atmospheric circulation, as expressed by the mean sea level pressure (MSLP) patterns in the wider Euro-Atlantic region, plays a significant role in the climate variability in winter, but less in summer. In winter, high-altitude temperatures are markedly linked with the Northern Hemisphere (NH) zonal circulation, as expressed by the NH annular mode (NAM), whereas the low-level temperature field is associated more with the circulation over the NE Atlantic. The Alpine mountain chain delimits the different winter precipitation regimes between the northern and southern side of the GAR. While a British Isles-centered pressure pattern plays the principal role in influencing northern Alpine precipitation, the North Atlantic Oscillation (NAO), and in particular its Mediterranean component, is the large-scale atmospheric mode affecting precipitation over the southern Alpine region. The impact of the El Niño/Southern Oscillation (ENSO) phenomenon on GAR climate is weak, though it is distinctly manifested within intermittent multidecadal periods. The most pronounced impact is found for late-autumn and early-winter temperature and late-winter precipitation. In these cases, GAR climate exhibits significant correlations with ENSO state of the preceding early autumn and late summer. The ENSO impact is associated with atmospheric pressure anomaly patterns in the European region indicating modifications of large-scale circulation whose effects are also found in the climates of larger areas of Europe.

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1. Introduction

[2] The Greater Alpine Region (GAR; 4°E–19°E, 43°N–49°N) of Europe (Figure 1a) has a complex climate; it is under the influence of phenomena that prevail over the Atlantic, the European Continent, and the Mediterranean Basin [*Wanner et al.*, 1997]. Our present understanding of GAR climate and its variations stems from many studies, which have focused on the Alpine mountain chain (as a whole or in parts), or analyzed the climate of the surrounding geographical regions: west, central, or southern Europe, and the Mediterranean Basin. Most of these studies have been based on the analyses of meteorological observations taken during the 20th century. Recently, however, reconstructions of climatic fields for earlier centuries (back to 1500) have been developed, based on long instrumental series, documentary evidence, and natural proxies providing an extended view of European climate variability (surface air temperature [*Luterbacher et al.*, 2004; *Xoplaki et al.*, 2005], precipitation [*Pauling et al.*, 2006], sea level pressure [SLP; see *Luterbacher et al.*, 2002; *Ansell et al.*, 2006], and 500 hPa geopotential height fields [*Casty et al.*, 2005a]). The spatial coverage and density, duration, and quality of the data sources used defines the geographical extent, spatial and temporal resolution and accuracy of the data sets developed and, hence, the capabilities and limitations for scientific analysis of European climate.

[3] In this study, we take advantage of recently developed instrumental data sets for the GAR [*Auer et al.*, 2005, 2007], the global land surface [*Mitchell and Jones*, 2005], and the North Atlantic-European atmospheric pressure field [*Ansell et al.*, 2006] to examine several aspects of the GAR climate (temperature and precipitation) interannual variability for the 19th and 20th centuries. The study focuses on (1) the geographical extent of the relation between the GAR climate variability and that of the European continent, (2) the relation of the GAR climate with the primary atmospheric circulation modes of the Euro-Atlantic region, and (3) the impact of the El Niño/Southern Oscillation (ENSO). Before proceeding to the presentation of the

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