Summer Temperature Variations in the European Alps, A.D. 755–2004

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ABSTRACT

Annually resolved summer temperatures for the European Alps are described. The reconstruction covers the A.D. 755–2004 period and is based on 180 recent and historic larch [*Larix decidua* Mill.] density series. The regional curve standardization method was applied to preserve interannual to multicentennial variations in this high-elevation proxy dataset. Instrumental measurements from high- (low-) elevation grid boxes back to 1818 (1760) reveal strongest growth response to current-year June–September mean temperatures. The reconstruction correlates at 0.7 with high-elevation temperatures back to 1818, with a greater signal in the higher-frequency domain ($r = 0.8$). Low-elevation instrumental data back to 1760 agree with the reconstruction's interannual variation, although a decoupling between (warmer) instrumental and (cooler) proxy data before ~1840 is noted. This offset is larger than during any period of overlap with more recent high-elevation instrumental data, even though the proxy time series always contains some unexplained variance. The reconstruction indicates positive temperatures in the tenth and thirteenth century that resemble twentieth-century conditions, and are separated by a prolonged cooling from ~1350 to 1700. Six of the 10 warmest decades over the 755–2004 period are recorded in the twentieth century. Maximum temperature amplitude over the past 1250 yr is estimated to be 3.1°C between the warmest (1940s) and coldest (1810s) decades. This estimate is, however, affected by the calibration with instrumental temperature data. Warm summers seem to coincide with periods of high solar activity, and cold summers vice versa. The record captures the full range of past European temperature variability, that is, the extreme years 1816 and 2003, warmth during medieval and recent times, and cold in between. Comparison with regional- and large-scale reconstructions reveals similar decadal to longer-term variability.

1. Introduction

For the European greater Alpine region (GAR), much progress in the last decade has been made in reconstructing climatic variations through studies of long instrumental observations (Auer et al. 2005, 2006, hereafter A06; Böhm et al. 2001; Camuffo and Jones 2002; Moberg et al. 2000), documentary evidence (Brázdil et al. 2005; Chuine et al. 2004; Glaser 2001; Le Roy Ladurie 2005; Menzel 2005; Pfister 1999), tree-ring data (Frank and Esper 2005b; Frank et al. 2005; Wilson and Topham 2004; Wilson et al. 2005), and multiproxy compilations (Casty et al. 2005c; Guiot et al. 2005; Luterbacher et al. 2004; Xoplaki et al. 2005). Atmospheric circulation patterns are also quite well documented for the European Alps (Wanner et al. 1997) and the North Atlantic/European sector (Casty et al. 2005a,b; Cook et al. 2002; Hurrell et al. 2003; Jacobeit et al. 2003; Luterbacher et al. 1999, 2002; Pauling et al. 2006; Raible et al. 2006), with particular emphasis toward the winter half-year. Nevertheless, evidence is generally restricted to the recent centuries as there are few data for the medieval period. Longer-term understanding of European temperature variations is limited to a handful of records, such as the low-resolution evidence for a European Medieval Warm Period (MWP) and Little Ice Age (LIA) reported by Lamb (1965). Further evidence of the MWP has been derived from annually resolved tree-ring width (RW) and maximum latewood density (MXD) data (e.g., Briffa et al. 1990, 1992; Büntgen et al. 2005a; Grudd et al. 2002; Helama et al. 2002; Kalela-Brundin 1999; Schweingruber et al. 1988). However, due to paucity of data in both space and time, the occurrence of the LIA, and particularly the MWP, is still debated (e.g., Bradley 2003; Bradley and Jones 1993; Broecker 2001; Crowley 2000; Grove

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