Spatial reconstruction of summer temperatures in Central Europe for the last 500 years using annually resolved proxy records: problems and opportunities

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Most palaeoclimate studies in Central Europe, utilizing annually resolved proxies such as tree-ring and documentary sources to reconstruct past temperatures, have focused mainly upon single sites or regional studies. The combined information of published summer temperature reconstructions from the Alpine region show a generally coherent picture of cool conditions for the periods *c*. 1450–1475, 1575–1610, 1660–1710, 1800–1850 and 1875–1925. These reconstructed cool periods can be partly explained by external forcing (e.g. low solar activity and volcanic events). However, these reconstructions, in their present form, cannot be used to comparatively assess spatial summer temperature variability through the region due to methodological differences in their development and the fact that many of them were not originally developed to emphasize spatial patterns. We propose that a network of tree-ring chronologies which have been processed in a consistent way would allow the robust reconstruction of spatial summer temperature variability for high elevations in Central Europe. Unfortunately, most living tree-ring chronologies only go back into the 18th century – so restricting the length of reconstruction. As a possible solution, we introduce a historical database of ring-width series, measured from string instruments, that could be used to extend high elevation spruce chronologies in Central Europe back for at least 500 years.

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Over the past three decades, the Alpine region of Central Europe has been the focus of many palaeoclimate studies to reconstruct past temperatures using high resolution annually resolved proxies such as tree-ring and documentary sources (e.g. LaMarche & Fritts 1971; Schweingruber *et al*. 1978; Eckstein & Aniol 1981; Briffa *et al*. 1988; Pfister 1995; Nicolussi & Schiessling 2001; Wilson & Topham 2004; Luterbacher *et al*. 2004; Frank & Esper in press; Büntgen *et al*. in press; Casty *et al*. in press). Central Europe is unique for palaeoclimate research in that several long (>150 years), high-quality meteorological records (Böhm *et al*. 2001) are available to calibrate and verify palaeoclimate proxies. The Alpine region is specifically important as it incorporates a 'climate divide' between Atlantic, continental and Mediterranean influences that result in a varying spatial signal of temperature over the region (Wanner *et al*. 1997). One of the key aims of the European palaeoclimate community, therefore, is not only to reconstruct climate using single local proxies, but also to develop a spatial reconstruction of climate variability through time. This aim has led to great emphasis on multi-proxy studies due to differences in seasonal response and geographical coverage of the various proxy types (Mann *et al*. 2000; Pauling *et al*. 2003; Luterbacher *et al*. 2004).

This article describes and compares several summer temperature proxy reconstructions for the Alpine region of Central Europe and highlights periods of synchronous reconstructed warm and cold periods between the records. Although these records can be combined to provide a reasonably coherent picture of past summer temperature variability for high elevations in Central Europe, we indicate that these data, in their present form, are not ideal for exploring spatial summer temperature variability through the region due to differences related to (1) the development of the proxy series themselves (i.e. differences between data types (e.g. tree-ring and documentary), processing methods and reconstructed seasons), and (2) the fact that these reconstructions are local or regional in extent and were mostly never developed to emphasize spatial patterns. We detail the limitations of these temperature proxies and propose an ideal scenario that should be sought when aiming to reconstruct spatial climate variability. We conclude by introducing a proxy data set, utilizing ring-width series measured

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