The first principal component of a high-elevation ring-width network from the western and central Alps

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Introduction

Tree-ring data play a vital role in assessing climate variability prior to the instrumental time period. Relying upon the expected temperature sensitivity of high-elevation tree sites, we have compiled a multi-species network of 53 ring-width sites from the central and western-European Alps with the objective of reconstructing regional temperature variations.

Material

Data contributions from P. Bebi, W. Elling, H. Fritts, W. Huesken, B. Neuwirth, R. Niederer, C. Rolland, F. Schweingruber, F. Serre, and L. Tessier were incorporated into the network and are gratefully acknowledged. All sites are from elevations at or above 1500 m a.s.l. The network is composed of four species: *Picea abies*, *Abies alba*, *Larix decidua* and *Pinus cembra* (herein abbreviated as PCAB, ABAL, LADE & PICE, respectively), with PCAB being highly dominant and ABAL being well represented although concentrated in the southern and western parts of the network.

Methods

Site chronologies were made by using an adaptive power-transform to stabilize the variance of the raw ring-width data (Cook and Peters 1997). Age trends were then removed by taking residuals from 300-year splines (Fritts 1976; Cook 1985). The detrended series were averaged on a site-by-site basis and the site chronologies truncated at a minimum of 5 series. Principal components (PC's) of the 45 of 53 chronologies sharing the 1850-1973 common period were computed. In Principal Components Analysis (e.g., Peters et al. 1981), as done here, the variance of the correlated variables (chronologies) is expressed in terms of new uncorrelated variables (PC's), where the first PC is defined to explain the maximum amount of variance possible, and each successive PC explaining less and less variance. At a minimum, the 1^{st} PC explains more variance than any of the initial variables (chronologies). Factor loadings of the initial variables (chronologies) onto a PC represent their correlation or common variance with this PC.

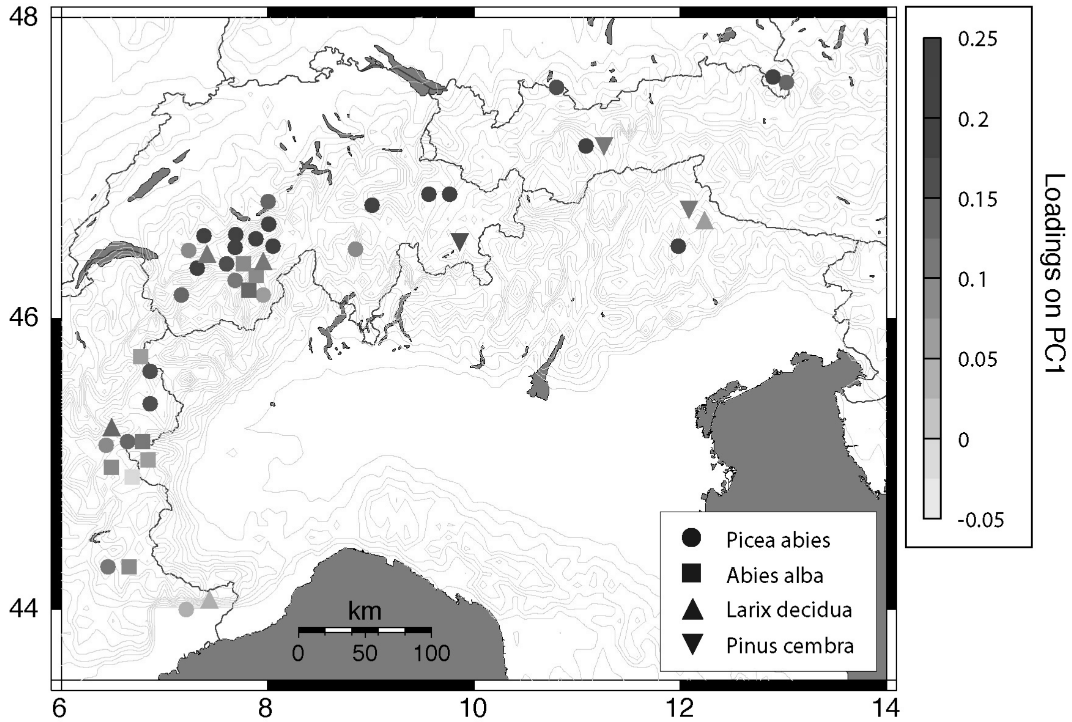

Figure 1: Factor loadings of chronologies on the 1st PC.

Results and interpretation

The 1st principal component explains 20% of the network's variance. All chronologies (except for a single ABAL site) have positive loadings on this PC (Fig. 1), indicating that this component represents a common dominant signal across the network. Chronology loadings on this PC seem to be related to the species (and perhaps their prevalence within the network) and their geographical location. Highest loadings tend to occur in southwestern Switzerland where the most dense concentration of chronologies exists. These high correlations extend to fairly great distances eastward along the alpine arc, but diminish more rapidly southward towards the more Mediterranean influenced portion of the network. The PCAB, LADE and PICE chronologies tend to have higher loadings, whereas the ABAL chronologies, in general, have lower loadings. Part of the tendency for the lower ABAL loadings can be explained by their concentration towards the southwestern portion of the network, where generally lower loadings from PCAB and LADE occur as well. However, the low loadings of ABAL, that even occur within the dense concentration of chronologies in southwestern Switzerland, suggests that this species displays a more unique signal than PCAB, LADE and PICE.

To assess the common climatic forcing captured by this principal component, comparisons with temperature data were expected to be (and were) relevant. Correlations over the 1850-1973 period were computed between this first PC and monthly temperature data from a single high-elevation grid point (47°N, 9°E) from the Böhm et al. (2001) dataset (Fig. 2).

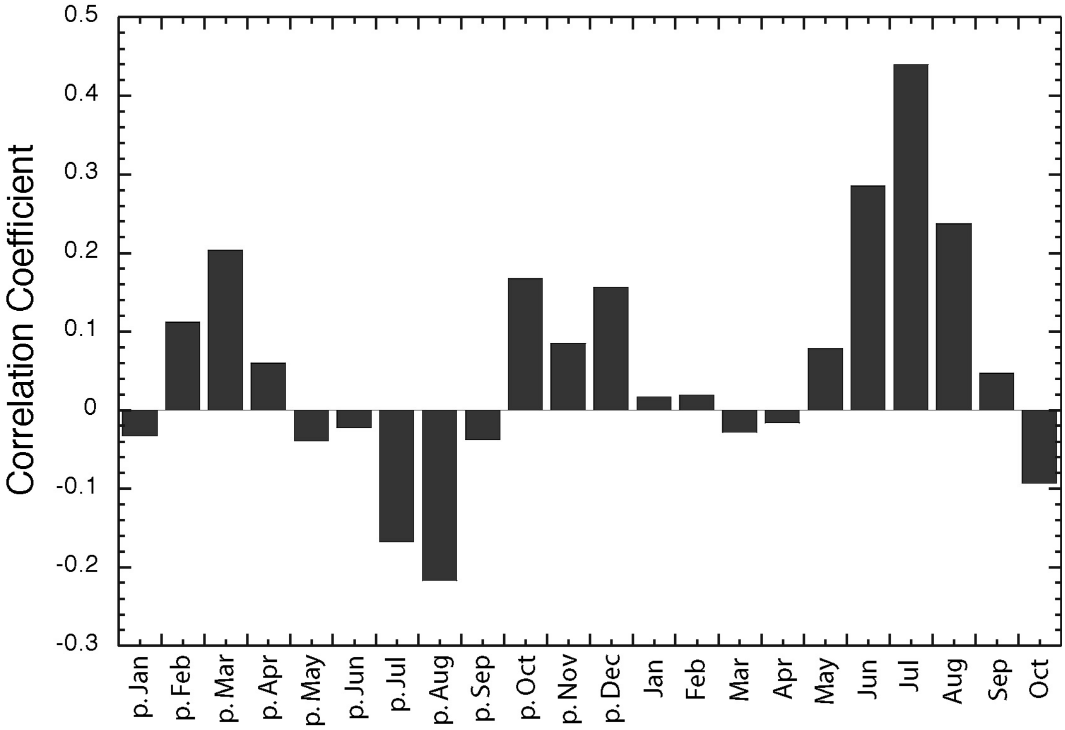

Figure 2: Correlations of the 1st PC with monthly temperature. (p.= previous year)

Highest correlations with July temperature of the current growing season are obtained, with significant ($p < 0.05$) correlations during the surrounding June and August, indicating a positive response to current growing season temperatures. Correlations with temperature in the months prior to the current growing season are not significant at $p < 0.05$, except for the previous August and March. From this correlation analysis (and comparisons with precipitation data – not shown) we conclude that summer (June-August) temperatures are the dominant common influence in PC1 and hence over the network.

Figure 3 shows a comparison of PC1 and average June-August temperatures from the single gridpoint (Böhm et al. 2001) for the 1850-1973 common period. The relationship between PC1 and average June-August temperatures is evident visually, and statistically is characterized by a correlation coefficient of 0.54.

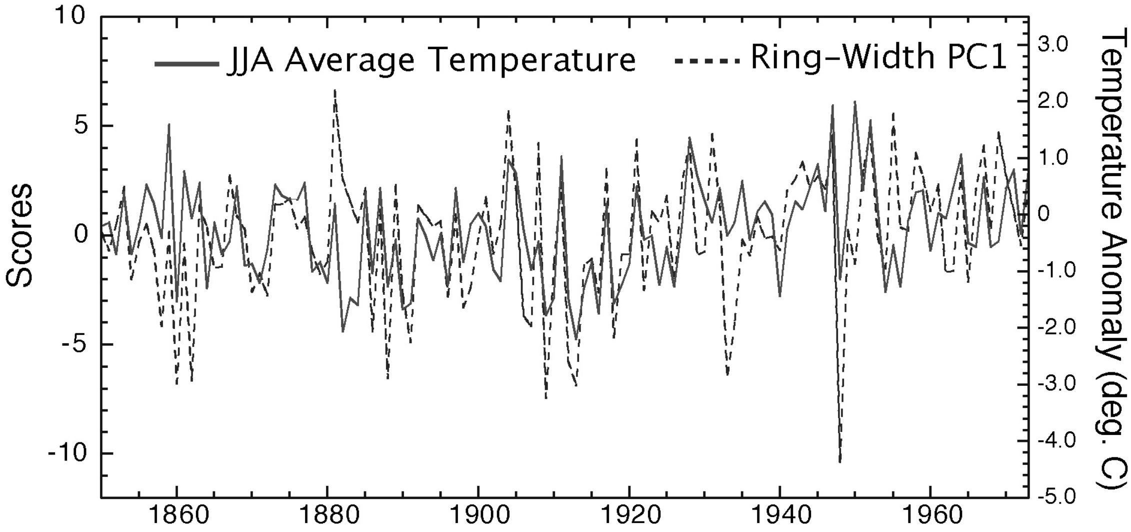

Figure 3: Comparison of the 1st PC with average June-August temperatures

Conclusions

These results indicate the common temperature signal across this high elevation central-western Alp tree-ring network. In addition, they demonstrate the potential of using Principal Components Analysis to extract the dominant common signals within this network for the purpose of climatic reconstruction.

References

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