

Dendrochronological network analyses of Central European chronologies: a conceptional approach of a new project

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Introduction

The reconstruction of past climate conditions is an important goal of dendroclimatological investigations. Normally such reconstructions are based on tree-ring data of one or more species that grow in a spatially limited area. In order to be able to use tree-ring series as proxies for climate reconstruction, the non-climatic environmental signal(s) should be removed from the series. Dendroclimatological studies have shown that the signals in tree-ring series may differ widely. Supplementary and sometimes even dissimilar climatic signals may occur in the growth patterns of trees from the same site (e.g. Bräker 1981). The reason is that different species of trees have different ecological demands (Ellenberg 1996, Schütt *et al.* 1984, Ott *et al.* 1997), meaning that they show a species-dependent sensitivity to their environment (Schweingruber 1996). Therefore, similar climatic events can trigger dissimilar responses in tree growth (Desplanque 1997).

Based on these statements, we postulate that dendroclimatologists should: (a) sample more trees from different species; (b) select more sampling sites that cover the whole ecological spectrum; (c) study more tree-ring parameters; and (d) apply a wider variety of methods. In addition, raw tree-ring data used in dendroclimatological studies should to be prepared in a uniform way, using the same method(s) for all series.

At present, we are in the process of applying this approach to Central European tree-ring data, in order to answer questions such as:

- Can dendroclimatological results be transferred from one location to another?
- Is it possible to assess growth-limiting and growth-promoting factors over larger regions in relation to climate and site ecology?
- Do the climate signals contained in tree-ring series have a spatial and ecological range?
- What are the criteria and rules for defining this dendroclimatological range?

In this context, we are building a Central European network of tree-ring chronologies. Using tree-ring parameters such as ring width, maximum X-ray density, and relations of stable carbon isotopes, we intend to compute pointer years and interannual and decadal growth variations. For the 20th century, we will analyze the patterns of these chronologies spatially in terms of known climate anomalies and with regard to various ecological site conditions and species-specific growth responses.

Our research will be focussed on:

1. The distribution of intra-regional and inter-regional pointer years;
2. Climate signals in tree rings at an interannual and decadal level;
3. Environmental growth factors, differentiated by means of climatical and site-ecological criteria;
4. The spatial and ecological range of climate signals in tree rings;
5. The factors and rules that define this dendroclimatological range.

In this paper we present a description of the database and of the applied methods, and preliminary results based on pointer-year analysis.

Material

Our network consists of over 650 chronologies from Central Europe, which we define as the area between 5° to 17° E and 42° to 55° N. These chronologies represent nine different tree species: *Abies alba*, *Fagus sylvatica*, *Larix decidua*, *Picea abies*, *Pinus cembra*, *Pinus sylvestris*, *Pinus uncinata*, *Quercus petraea*, and *Quercus robur*. The latter two species, *Quercus robur* and *Quercus petraea*, are very similar in terms of wood structure and ecological demands, and therefore were condensed to a single class. As a result, in this study we differentiate between eight classes of tree species.

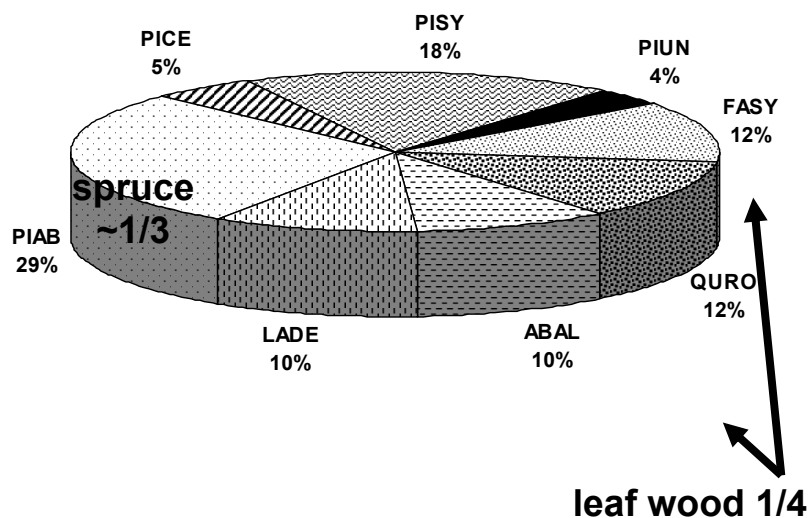


Fig. 1: The ratio of tree species in percentages.

Almost a third of the chronologies in our network are of spruce, whereas deciduous trees only make up one quarter of the collective (Fig. 1). Not shown here, but also important, is the fact that nearly 80% of all chronologies represent tree-ring width, about 20% are density chronologies and only 1,4% are isotope chronologies. Given this unequal distribution, additional chronologies will have to be collected in order to balance the data set.

Methods

The common signal in the raw tree-ring series underlying the chronologies was checked with NET (Esper *et al.* 2001). NET is a new parameter for estimating the signal strength of mean tree-ring chronologies that have an annual resolution. It combines the coefficient of variation, v , and the “Gleichläufigkeit”, GI ., which are variables that are widely known from the statistical and dendrochronological literature respectively (e.g., Bahrenberg, Giese 1975; Eckstein, Bauch 1969). At a NET threshold value of 0.8, both the common variance and the value for GI indicate some common signal. As the strength of the common signal increases, the value for NET decreases towards a minimum value of 0.

In our study, chronologies with $NET > 0.8$ were removed from the data set. The raw ring-width series of the remaining chronologies were standardised after Cropper (1979), implying that for each tree-ring series and for each year a so-called z-value was calculated according to the formula:

$$z_i = \frac{x_i - \text{mean}[\text{window}]}{\text{stdev}[\text{window}]} * 1000$$

with window := $\{x_{i-2}, x_{i-1}, x_i, x_{i+1}, x_{i+2}\}$.

(see Meyer (1999) for a further explanation of this procedure). By averaging the annual z_i -values of the individual tree-ring series in each chronology, we produced mean series of so-called Cropper values. We transformed the Cropper series to a d-base format, and subsequently imported them into the geographical information system ARC VIEW 3.2. Using the digital terrain model (DGM) G-TOPO 30, we created a digital map of the research area, on which we plotted the geographical distribution of Cropper values. We choose the Inverse Distance Weighted (IDW) interpolation method with eight nearest neighbours, which is a standard interpolation procedure in ARC VIEW 3.2, to transform the point data into surface data. The IDW interpolator assumes that each input point has a local influence that diminishes with distance. It weights the points closer to the processing cell more severely than those that are further away. To simplify the presentation, the annual Cropper values were classified according to their distance from the mean (< -3 to $> +3$ standard deviations (σ), 7 classes in total).

Preliminary results

The removal of chronologies with a NET value over 0.8 reduced the data set from 650 to 308 chronologies. The remaining chronologies cover the period AD 1880 to 1980. Figure 2 shows their average Cropper values for the years 1933 (a), 1948 (b), and 1975 (c), with blue colours representing negative deviations, and red colours representing positive deviations from the annual mean of radial growth. Various spatial patterns can be discerned. The years 1933 and 1975 seem to be very similar, showing a colour transition from red in the North, corresponding to positive growth anomalies, to blue in the South, corresponding to negative pointer years. 1948 on the other hand shows a decrease from the Southeast to the Northwest. We tentatively conclude that there exists no direct relationship in our material

between radial tree growth and latitude. Further research is needed to ascertain the validity of this conclusion.

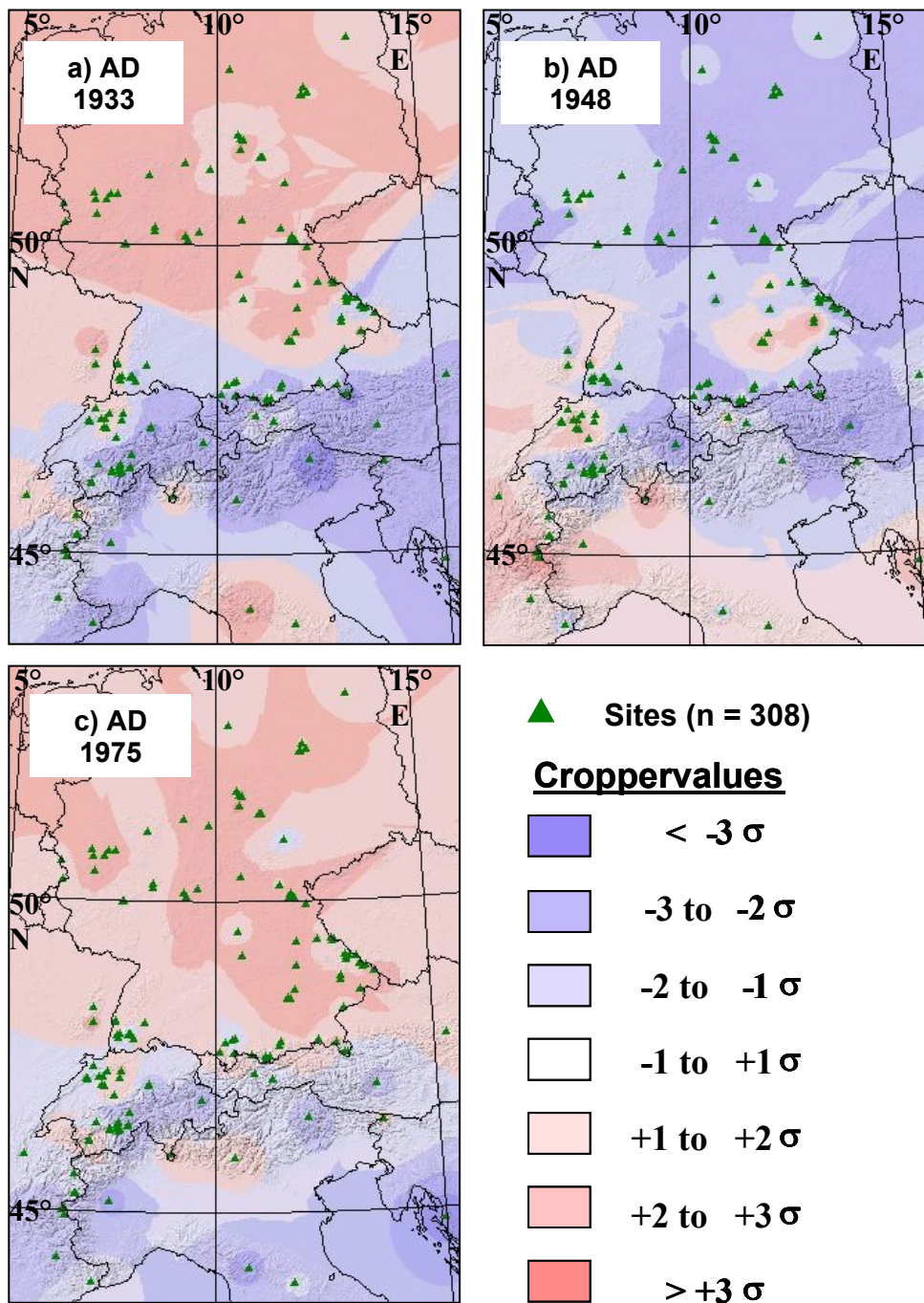


Fig. 2: Spatial patterns of pointer years in Central Europe presented as deviations from average Cropper values for AD 1933, 1948, and 1975.

Future perspectives

As stated above, we intend to determine (1) the distribution of intra-regional and inter-regional pointer years; (2) climate signals in tree rings at an interannual and decadal level; (3) environmental growth factors, to be differentiated by means of climatological and site-ecological

criteria; and (4) the spatial and ecological range of climate signals in tree rings. In order to achieve our goals, first of all we will compare the Cropper values with climatological data (for example the frequency of westerly "Großwetterlagen") and topographical data (elevation, exposition), using cluster analysis (part of the statistical software package SPSS). This should result in a classification of the data into groups with (a) similar data combinations, and (b) similar spatial growth patterns. The combination of tree-ring data with climatological and topographic data will help us to explain the various groups and, allowing for the various ecologically-determined site conditions and species-dependent responses, to determine which environmental growth factors determine the spatial distribution of the patterns.

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