

A spatial high resolved climate reconstruction from recent and historical tree-ring data in the Rheinische Schiefergebirge since ad 1500

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Introduction

Tree- ring growth in Central Europe is affected by the interaction of many different climatological and non-climatological factors. In contrast to high-elevation tree sites, where temperature is the main limiting growth factor, temperature generally does not limit the growth of most of the main European tree species in the temperate Rheinische Schiefergebirge, with altitudes varying from 100 to 1000 m a.s.l.. From a synoptic point of view, the Rheinische Schiefergebirge represents an orographical barrier for air pressure masses moving from west to northeast. Hence, at specific ecological sites, precipitation seems to be the dominant growth-limiting factor.

By combining recent and historical oak ring width series, we intend to analyse the signals of temperature and precipitation on tree-ring growth, in order to reconstruct precipitation patterns in the Rheinische Schiefergebirge for the last 500 years.

Initial dendrochronological investigations in Windeck (Siegtal/NRW), a commune in the middle of the research area, document the strong influence of precipitation on the growing-patterns of the oaks at this site.

The analysis of historical oak wood of a half-timbered house first of all serves to define the year of construction of the building, and furthermore provides the material, which, in combination with recent data, makes the development of an oak chronology possible.

Thus, in this first study, a lot of interests on different scientific fields were set up:

- the year of house construction and further building periods
- the development of an oak chronology for this area
- the relationship between climatic forcing factors and tree-ring growth.

The prime aim was the analysis of the influence of precipitation and temperature on recent trees. These results point to the potential for climate reconstructions derived from trees of this site.

Material and Methods

The original dataset consists of cores taken from two buildings and recent trees. These trees are located on a slope close to the buildings in Windeck.

To set up the local chronology and anchor each core in time, we cross-dated the sampled cores among themselves and compared the dataset with different chronologies provided from B. Schmidt (Westerwald, Cologne, Germany) and S. Bonn (combination of sites in the northern German Mid Hills).

We were working with the programs TSAP and COFECHA by using the threshold $GLK > 60$, $t\text{-Wert} > 3,0$, $\text{Cross-Dating-Index} > 100$ (Rinn 1996) and $NET < 0,8$ (Esper et al., 2001) to assign the single cores.

B. Schmidt's site chronology Westerwald served as basis for the dating of two cores by calculating for each potential position in time the GLK (Schweingruber 1983), $t\text{-Wert}$ (Schmidt 1987) and the Datingindex (Schmidt 1987).

For further verification, the dataset was compared with other Central European chronologies. Therefore, the parameters mentioned above parameters were calculated between the indexed chronologies.

The meteorological data are taken from two climate stations: Bonn- Friesdorf (temperature and precipitation) and Windeck-Dattenfeld (precipitation). The combination of data from both stations guarantees the proximity to the sampling places, a dataset with high resolution in time and a long, comprehensive data base.

The time interval chosen for the analysis comprises the period 1900-1990.

Some cores which consist of less than 40 rings were eliminated from the chronology.

The study was focused on the analysis of the interannual relationships between the chronology and the meteorological dataset (monthly, summer periods, annual values). Therefore, the ratios of the 5-year moving average were set up and after indexation, correlation coefficients between the resulting chronology and climate data were calculated.

Results and Interpretation

Site chronology

From the selected 79 cores, a comprehensive local chronology spanning the time period AD 1491-2002 was developed. Due to the fact that 2-4 cores were sampled from one tree or beam, the chronology consist of 46 raw series, which characterize the dynamics of growth of one single tree or beam.

The mean segment-length is 99 years, with a dispersion between 44 to 187 years. The replication varies very strongly over time. The beginning of the chronology until 1500 is only occupied by two series, whereas the 20th century, consisting of the recent tree series, is defined by a number of 18. The time period 1500-1900 is characterized by a very strong variation in the number of replication. Finally, the chronology is comprehensive and useful for an analysis in this site, but further replenishment is necessary for representing a well defined chronology.

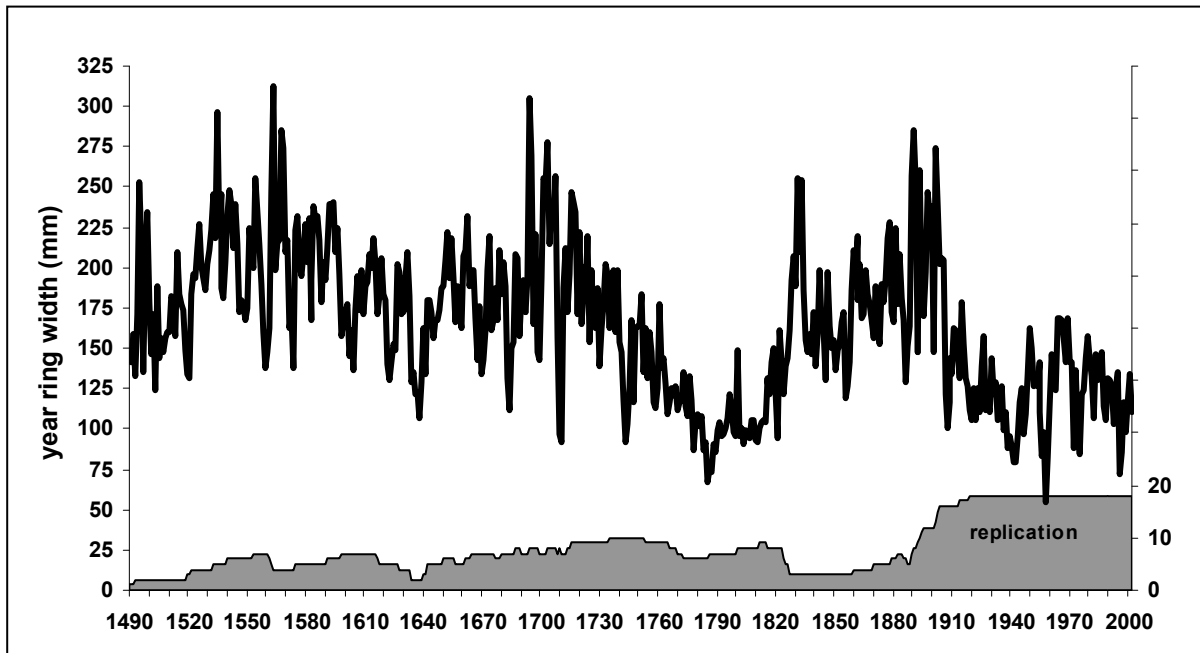


Figure 1: Local oak chronology Windeck AD 1491-2002

The comparison between the different regional chronologies demonstrates a high level of similarity. The calculated statistical parameters, as shown in Table 1, lie above the defined thresholds. From the comparison between the Bonn and the Windeck chronologies result higher values than between the Windeck and the Schmidt chronology, although the Schmidt chronology is closer to our research area. The analysis emphasizes an indication of teleconnective relationships in Central Europe.

Table 1: Statistical comparison between the chronologies; SCHMIDT chronology = Cologne (Königsforst), BONN chronology = Mittelgebirge (mean-curve of different sites)

Parameter	Windeck- BONN	Windeck- SCHMIDT	SCHMIDT-BONN
	1776-1972	1752-1994	1776-1972
t-value	46,0	41,9	34,2
GLK	91	90	87
CDI	3702	3349	2529
NET	0,30	0,27	0,25

Dating results of "Haus Lütz"

After generating the original dataset collected of "Haus Lütz", 81 cores were left for reconstructing the history of construction of this half-timbered house. 52 cores were successfully dated. The dating-rate is 64% and according to F. Schweingruber (1983:87), this

can be categorized as a good result. These 52 dated cores are sampled out of 32 beams part of three different housewalls. The cross-dating process yields to two separate sub-datasets, both consisting of 16 beams. Thus, at least two periods of construction can be identified for “Haus Lütz”.

To define the year of construction and further building periods, the established method “ year of felling= year of construction or rather year of felling +1 = year of construction” (Schmidt, 2000) was used for the interpretation of the dated beams.

In three beams of the first building period, the last developed tree ring is still preserved, which is necessary to define the year of felling. The last tree ring of the youngest beam is dated in 1679, while the other beams both end in 1677.

The three beams described above all end their last tree ring with latewood, which verifies the felling of the trees in autumn or winter. Thus, due to the fact that the beams are dated in 1677 and because of their position and function in the building, the construction of “Haus Lütz” began in the following year 1678, as usual in Central Europe (Hollstein 1980).

The third beam dated in 1679 has the function of a moulding. Mouldings are mainly fixed in the end of a building period or even separately (Großmann 1998). Taking this into consideration, the year 1680 could be interpreted as the end of the first construction period.

For the second building period, 5 beams which include the last developed treering were found. The construction timber was felled in a time interval: Two beams were felled in the year 1824, one in 1825, and two beams in 1827.

Based on these data, it is not possible to define the exact year of the beginning of the second period of construction. There are two different ways of interpretation.

First possible interpretation: sometimes timber of several years of felling are collected before the building period begins (Wrobel et al. 1993), which indicates the year 1827 as the beginning of the second building period (earlywood found).

Second interpretation: due to the different positions of the beams in the building, it is possible that the beams belong to different time intervals of the second period of construction. The period started in 1825 (1824 has latewood) in the ground floor and ended 1827 in the top floor, in which two dated beams belong. For further interpretation, a historian of construction is needed.

Dendroclimatological analyses

Figure 2 shows a significant relationship between climate and tree-ring growth for both precipitation and temperature. The analysed climatic parameters differ in the sort of influence: correlations between precipitation and growth are most extensively positive, while temperature and tree-ring growth show mainly negative relations. Precipitation has the strongest positive influence on ring width during the summer period (May-August), whereas temperature is negatively high correlated with tree growth during the vegetation period (April-October).

Apart from the influences of precipitation and temperature during the vegetation period, correlations to ring-width during the winter period, especially February, and the prior year were found.

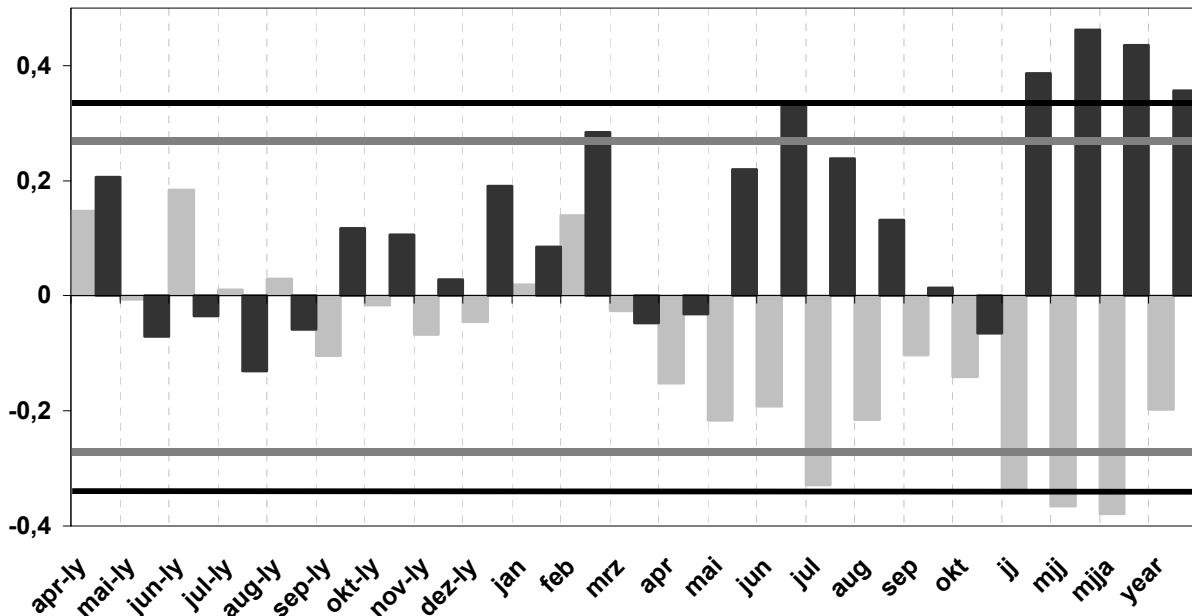


Figure 2: Correlation coefficient between indexed year-ring width and monthly means of temperature and precipitation. The time periods: from April of the year prior to growth until October of the year of growth, summer periods, annual; light beams = temperature correlation, dark beams = precipitation correlation; significant levels: grey = $p > 1\%$, $r^*_{99} = 0,27$; black = $p > 0,1\%$, $r^*_{99,9} = 0,34$

Precipitation in February falls in Windeck as snow. It has a strong positive correlation to growth due to the fact that snow can be regarded as a support of humidity at the beginning of the growing season.

The analysis confirms the influence of the climate conditions of the prior year on tree-ring growth (Spurk, 1997). The values calculated for correlations between the months of the prior year and growth are not highly significant, but correlations on a low significant level are provable. Especially oaks, which transport water only in the latest ring, have to build up a new ring every year, in order to guarantee sufficient water-supply. Thus, the climatic conditions of the prior year, in which nutrients for building up the next year-ring are collected and stored, are important for growth.

The annual sums of precipitation are highly significant positiv, as the several values for the summer periods, which emphasises the strong influence of this climate parameter on growth. Temperature has a high influence on growth as well, but the values are in general not as high as for precipitation, which is demonstrated by the lower influence on annual basis.

Thus, the correlations to climate parameters on a monthly, seasonal and annual basis emphasise that precipitation is the dominant growth-limiting factor for the planar collin oaks in this region.

Conclusion and outlook:

Our first results of dendroclimatological analyses in the Rheinische Schiefergebirge confirm the strong climatological influence (especially that of precipitation) on recent tree-ring growth. Furthermore, Schmidt & Gruhle (2003) found high precipitation signals in historical datasets in the West-German-regions. Therefore, the potential for climatic reconstructions can be assessed. The nature of the relationship allows to get information about precipitation by analysing tree-ring data.

In later investigations, the changing signal-strength due to changing climatological conditions over time (IPCC 2001) will be analysed in order to reconstruct the varying relationship between precipitation and tree-ring growth over the last 500 years. Taking this relationship into consideration, the precipitation reconstructions can be established.

Another factor which must be considered is the high spatial variability of precipitation. Due to this variability, a dense network of sites is necessary. Therefore, ring width data from recent trees and historical construction timber at multiple sites within the Rheinische Schiefergebirge will be used.

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