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Dendroclimatology in the Low Mountain Ranges, Germany

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Introduction

The world-wide precipitation amount increased at about 2% within the 20th century due to a changing atmospheric circulation (IPCC 2001). The spatial and temporal variability of this increase is not completely understood. Hence, for a profound assessment of the impact of global change on the regional scale, further spatial high resolution analyses are indispensable. Although earlier studies indicate that precipitation is a dominant growth-limiting factor at specific sites (Spurk 1997, Schweingruber & Nogler 2003, Neuwirth 2005), only few attempts have been made in Low Mountain Ranges of Central Europe to reconstruct precipitation from tree rings (Wilson et al. 2005).
In this study initial dendroecological investigations in the Rheinische Schiefergebirge confirm the strong influence of precipitation on growing-patterns of oak at several sites. They demonstrate that tree-ring/climate-relationships are not constant over the last century, which complicates a precipitation reconstruction.

Material

The research area consists of three parts, from west to east: the northern Eifel, the area close to Bonn, and the Sieg valley (Fig. 1).

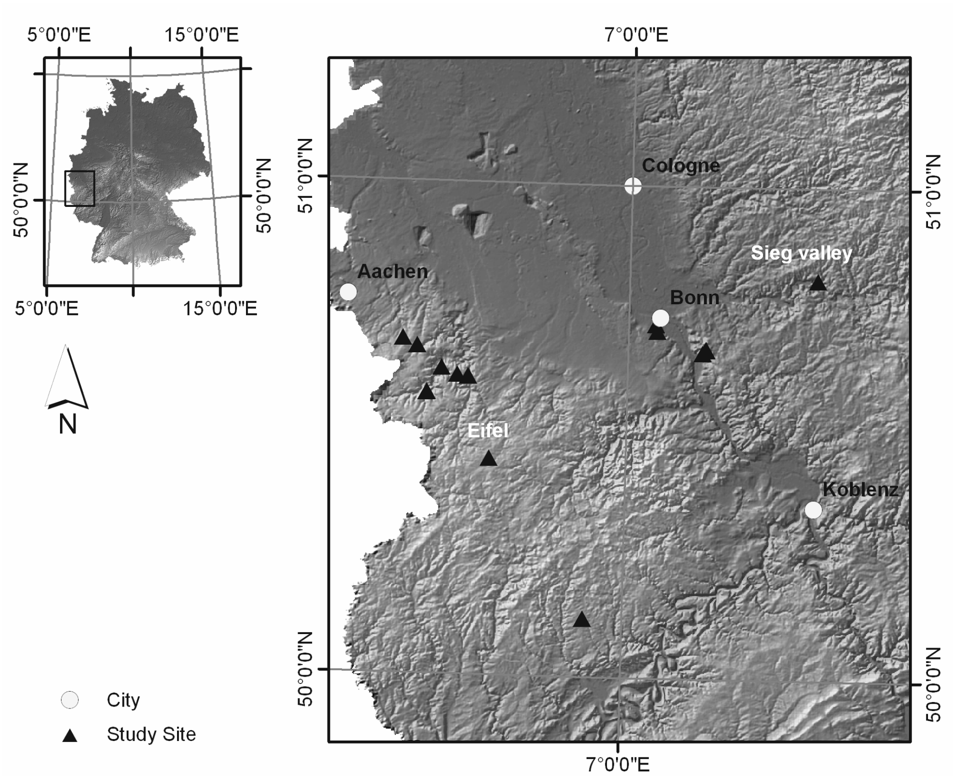

Figure 1: Location map illustrating the study sites.

The sites embrace different ecological conditions, for example the elevation varies from 120m in Bonn up to 570m in sites of the Eifel. Further parameters are the exposition, the inclination as well as the composition of species. For the climate/growth analysis oak cores from 13 sites were taken. Six sites are located in the northern Eifel, five in and close to Bonn and two 40 kilometres east from Bonn in the Sieg valley. The meteorological data is provided from the Tyndall Research Center, UK (Mitchell et al.2004). These data are high resoluted grids (10 minutes resolution) for the time period 1901-2000. Monthly temperature and precipitation values are used for this study.

Methods

Prior to climate/growth analysis the internal site homogeneity of the different tree-ring series was calculated to describe the common signal of trees in the low mountain areas. The chosen statistical parameters were: mean growth, standard deviation, variation coefficient, Gleichläufigkeit (Schweingruber 1983), interseries correlation $r_{xy,}$ autocorrelation (Bahrenberg et al. 1992), and NET (Esper et al. 2001). The parameter NET represents the coefficient of variation and Gegenläufigkeit, the defined threshold is 0.8. The chosen time interval for the investigation comprises the period 1920-2000, in consequence of the correlation coefficient.

By the processing of the climate data, the four closest grid points to a tree site have been selected to get representative climate information for each site. For the monthly values of precipitation and temperature the mean of the four grids was computed.

The raw series of climate and tree growth were both standardized by a 5-year moving average and ratios were calculated to emphasize the interannual signal.

Correlation coefficients between tree-ring width and climate data were calculated for each year with different temporal resolutions (monthly, periods and annual values). Due to the restriction of climate data over time, the research period covers the interval 1903 to 1998. In order to assess the behaviour and stability of the relationship in time, 31-year moving correlations were computed.

Results and Interpretation

The analysis of growth variability, carried out by the internal site comparison, leads to a high level of similarity in tree-ring growth in the research area. The values of all statistical parameters are under/above the defined thresholds and accordingly confirm site homogeneity. The minimum and maximum values are shown in table 1.

Table 1: Internal Site Analysis; minimum and maximum values based on all 13 sites; x = mean growth, s = standard deviation, v = variance, GLK = Gleichläufigkeit, corr = correlation, autocorr = autocorrelation; time period is from 1920 to 2000.

Value	x (mm)	s (mm)	V	GLK (%)	NET	corr	autocorr
Min.	1,09	0,29	0,27	75	0,49	0,49	-0,24
Max.	2,19	0,82	0,48	84	0,71	0,69	-0,38

The significance of the correlation coefficient in each site lies above the 95% level. The mean growth varies from 1,09 mm/y to 2,19 mm/y, which can be explained by the different site conditions. NET, which characterises the signal strength, is adequately below the threshold even in the site of the maximum value. Thus, high signal strength is given in the whole research area. All sites show significant relations to the climate parameters. The trees of some sites respond in different ways to precipitation and temperature. One group of sites including the one in the Sieg valley, shown in figure 2, reacts highly significant in several months and time resolutions; others react significantly only in a few months.
A spatial distribution is given, separating the sites of the northern Eifel from the rest. The Eifel sites react generally weaker to climate parameters compared to sites in Bonn and the Sieg valley. Temperature and precipitation differ in the type of influence, especially in the months of the actual growth year. Correlations between precipitation and growth are most extensively positive, while temperature and tree-ring growth show mainly negative relations.

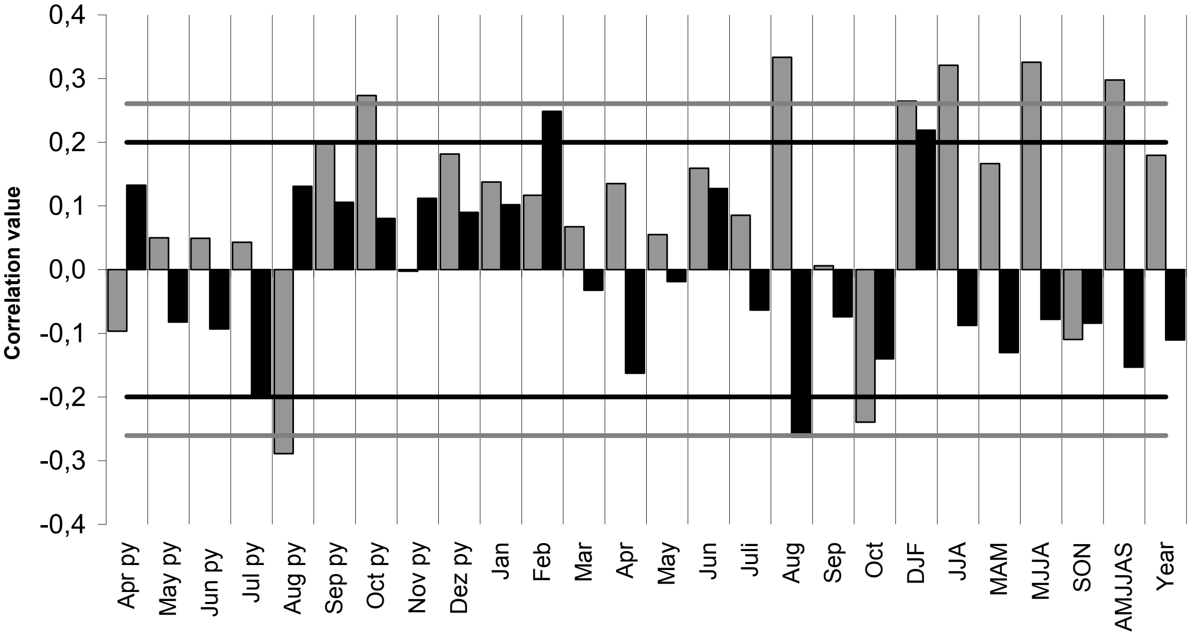

Figure 2: Correlation coefficients between growth and precipitation (light grey), growth and temperature (black). The 95% (black) and 99% (grey) significant levels are indicated by the horizontal lines.

Seven sites show significant positive correlations to precipitation for the time period of April to September, whereas only four of these sites react significantly with temperature. In order to get detailed information about the relationship of growth and the climate parameters in these sites the moving correlations were calculated. Three sites are illustrated in figure 3. The relation between growth and both climate parameters varies over time. Time periods without a significant correlation are found in several sites. Regarding the trend lines, the Sieg valley site (A) represents significant values over the whole time period for both temperature and precipitation. However, going back in time the trend decreases and the precipitation values are no longer on a significant level. The two other sites illustrate a contrary trend in the relationship of precipitation and growth. In both cases no significance in the present can be found and the values increase going back in time.

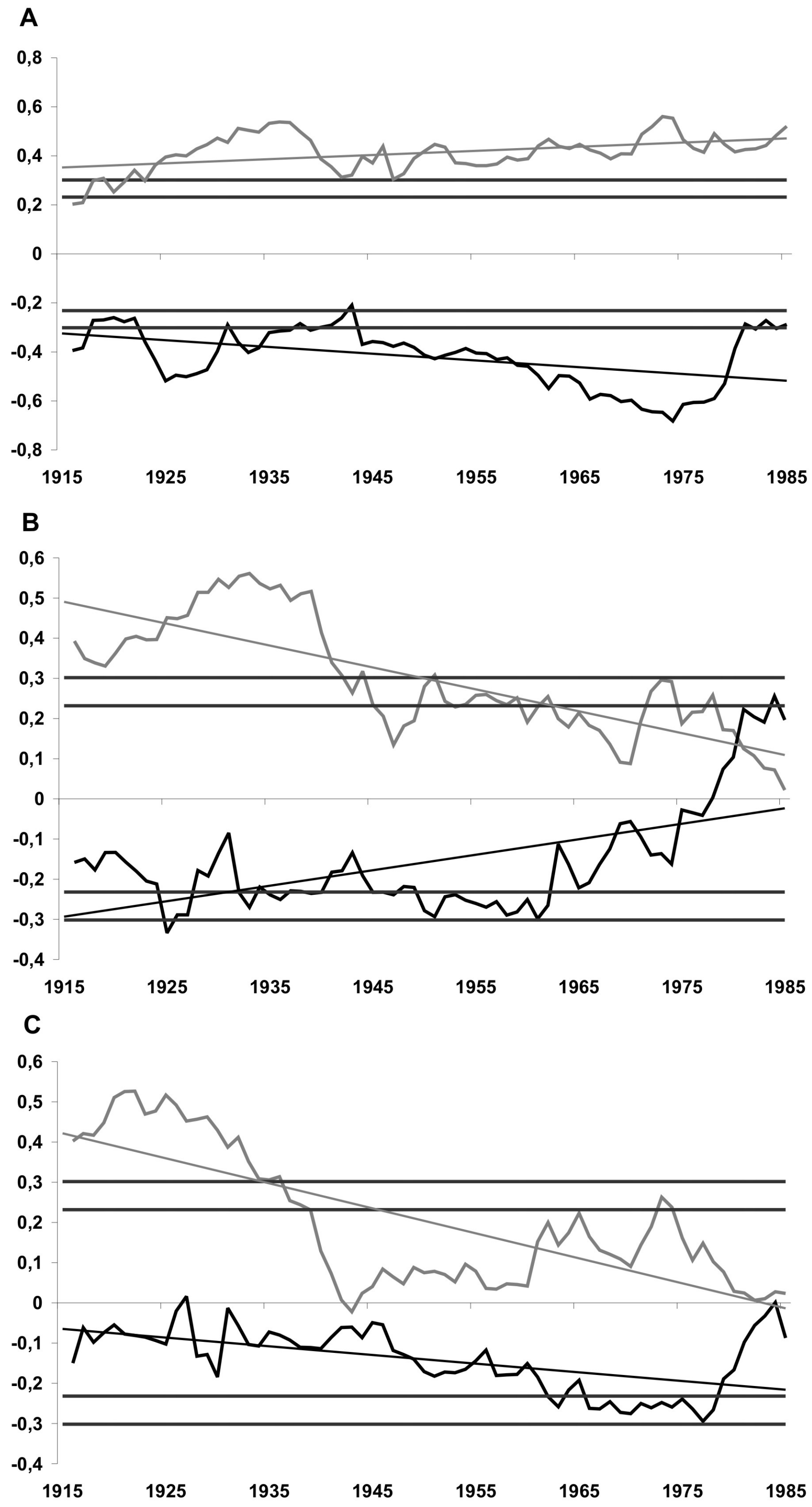

Figure 3: 31-year moving correlation with trend curve between growth and precipitation (grey curve) and temperature (black curve). The 95% (value +/- 0, 2319) and 99% (value +/- 0, 3017) significant levels are indicated by the horizontal lines. A: Sieg valley site, B: Bonn site, C: Eifel site

Thus, the influence of precipitation on ring growth was in the beginning of the century very strong, whereas precipitation in the present loses its importance as influencing factor. Temperature in the Eifel site is not only insignificant; it also has a contrary relation to ring growth than precipitation. Temperature influence decreases while the importance of precipitation rises. Hence, the precipitation represents a self-contained signal.

Conclusions and Outlook

Our first investigations confirm a strong relationship between climate parameters and ring growth in the low mountain ranges in Germany. The subdivision of the research area in regions of diverse climate/growth relations can be explained by the cooler and wetter conditions in the Eifel opposite to the warmer and drier conditions in the rest of the research area. These circumstances can either be caused by the regional climate situation or the ecological factors like elevation etc. Precipitation from the period of April to September is especially an influencing factor on tree-ring width in several sites. The influence of temperature is in most of the sites less important than precipitation. Both climate parameters have no constant influence on growth over time and their trends vary between the different sites.

A stabilisation of the relationship is necessary for reconstructing climate. One approach could be the grouping of several sites to achieve a stronger homogenous climate/growth relationship over time.

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