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A 400 year reconstruction of July relative air humidity for the region Vienna (eastern Austria) based on carbon and oxygen stable isotope ratios in tree-ring latewood cellulose of oaks

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Stable isotope chronologies and correlation to climate. We present the stable isotope chronologies of carbon ($\delta^{13}C_{lw}$) and oxygen ($\delta^{18}O_{lw}$) for the period from 1600 to 2003 respectively of non-exchangeable hydrogen ($\delta^{2}H_{lw}$) for the last century constructed base upon tree-ring latewood cellulose from oaks (*Quercus petraea* Matt. Liebl.) grown in the region Vienna (Austria). The stable isotope ratios correspond mainly to the summer climate conditions. For the calibration period (1900-2003) we found high significant correlations ($p < 0.001$) between $\delta^{13}C_{lw}$ and relative air humidity (RH) of July (-0.66), between $\delta^{18}O_{lw}$ and RH_{VI-VII} (-0.61) and between $\delta^{2}H_{lw}$ and $RH_{VI-VIII}$(-0.56). In the case of temperatures high significant correlations between the growing season temperature and $\delta^{13}C_{lw}$ (0.55), between the annual mean temperatures and $\delta^{18}O_{lw}$ ratios (0.45) and between summer mean temperatures (June to August) and $\delta^{2}H_{lw}$ values (0.49) were estimated.

Modeling. Various univariate and multivariate linear regressions models were proved for the reconstruction of summer relative air humidity and temperature. We found that establishing of robust models had several uncertainties:

- using common linear transfer functions which oversimplify the complexity of relations;

- using of pooled material and neglecting of different reactions from individual trees to climate;

- high-order autocorrelations in the isotope time series;

- climatic trends in the investigated region which are different in the first and in the second half of 20^{th} century;

- temporal instability of climate signals in the isotope ratios of tree ring cellulose.

In the case of temperature no valid model could be estimated caused by temporal instabilities of signal strength. For relative air humidity two bivariate models

$RH_{VII} = (-4.3 \pm 0.7) * \delta^{13}C_{lw} + (-2.8 \pm 0.5) * \delta^{18}O_{lw} + 44$ [1]

and

$RH_{VII} = (-4.7 \pm 0.7) * \delta^{13}C_{lw} + (-0.35 \pm 0.07) * \delta^{2}H_{lw} - 68$ [2]

were found as verifiable and applicable to reconstruct RH_{VII}. Using of $\delta^{2}H_{lw}$ instead of $\delta^{18}O_{lw}$ enhances significantly the model verification. Unfortunately the data of non-exchangeable hydrogen were available only for the last 100 years. Therefore the reconstruction of July relative air humidity was carried out only with eq. [1].

Reconstruction. The predicted RH_{VII} values oscillate in the period from 1600 to 2003 around a mean of 74.7±4.4%. The course of RH_{VII} during this time seems to be periodic with wetting and drying periods in a cycle of approximately 130 years. Predominant wet conditions could be reconstructed for the periods 1690-1710, 1765-1820 and 1900-1960, predominant dry periods for the periods from 1715 to 1730, from 1830 to 1870 and from approximately 1960 to recent. These results correspond in general with the European Alpine moisture variability for the period 1800-2003 reported by van der Schrier et al. (2006).

Extreme wet summer conditions could be reconstructed for 1663, 1795, 1816, 1906, 1915 and 1926. Exceptionally dry summers were supposed for 1616, 1636, 1637, 1751, 1822, 1857, 1863, 1990, 1992 and 2001. These results correspond to instrumental data and can be well verified by independent reconstructions (Glaser 2001; Casty et al. 2005).

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