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A calibration study of the climate signal recorded by the stable oxygen and carbon isotopes in Swiss stone pine (Pinus cembra L.) tree-ring from the Eastern Carpathians, Romania and its relevance for paleoclimatic reconstructions

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The aim of this study is to assess the paleoclimatic potential of the stable isotope composition of tree ring cellulose in Pinus cembra (Călimani Mts., Northern Romania) by 1) analyzing the relationship between the stable isotope (oxygen and carbon) composition of cellulose and main climatic parameters; 2) evaluating the juvenile-effect and biological trend on the isotopic variations; 3) testing the hypothesis that a nearby sulfur exploitation has not altered the climatic signal recorded by the stable isotope composition of tree rings, contrary to the similar one recorded by tree-ring width (TRW).
We have analyzed wood samples of Pinus cembra from four living and eleven dead trees from Călimani Mts., growing between 1400 and 2012 AD. Whole-ring samples were prepared to [U+F061]-cellulose by the modified Jayme-Wise method. Stbale isotope compositions of the samples were than analyzed with a Thermo Delta V isotope ratio mass spectrometer coupled to a high-temperature pyrolysis system (Thermo Quest TC-EA) at the Institute for Geological and Geochemical Research, Budapest, Hungary. A ring by ring approach was followed since age-related trends are by definition intrinsic to individual tree-ring series so pooling of rings may distort the detection of the trends. Raw measured δ13C values have been corrected for changes in the atmospheric CO_2 regarding by (Leuenberger, 2007; Schubert and Jahren, 2012).
Tree-ring cellulose δ18O values showed a significant positive correlation with summer (June, July and August, JJA) maximum (r = 0.61) and mean air temperature (r = 0.45), and negative correlation with precipitation amount (r = -0.64) and SPEI drought index (r = -0.61). Tree-ring cellulose δ13C values showed a significant positive correlation with JJA minimum air temperature (r = 0.54). Correlation coefficients between TRW and the similar climatic elements, were always less than 0.3, thus showing the superior potential of the stable isotope compositions for palaeoclimatic reconstructions. Since temporal stability of the proxy-climate correlation is maintained also over the most intensive period of sulphur exploitation (1974 – 1986) when the TRW-climate relationship was found to break down (Kern et al., 2009), we conclude that the opencast exploitation did not disturb the climate signal archived in the oxygen isotope composition of cellulose, while carbon composition is slightly influenced.
Alignment of the δ13C data by cambial age revealed a relatively short period ($\sim$30 years) of systematic $\sim$1‰ enrichment in 13C over a 30 year-long period after germination. In contrast, hardly any systematic juvenile pattern or any long-term trend was detected in the δ18O data.
Based on these data, we suggest that both δ18O and [U+F064]13C are most promising prarameter for future climate reconstruction, compared to TRW, with a slight “advantage” for [U+F064]18O, due to its higher degree of correlation with climatic parameters and lack of issues with calibration and or juvenile effects. However, as they record different climatic parameters, their combined use could prove advantageous, as it would allow for the construction of a complex picture of past climatic changes.

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