

$\delta^{18}\text{O}$ of oak cellulose as useful proxy for reconstructing past summer drought in central France

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Understanding natural climate variability by documenting it during the preindustrial period is crucial for assessing climate variability and its drivers, improving the quality of simulation models, and specifying the anthropogenic contribution to climate change. In Europe, tree ring width (TRW) and maximum latewood density (MXD) have been widely used to reconstruct past temperature and precipitation variations, particularly in high-altitude or high-latitude regions. However, to correct age-related growth effects, analyses based on TRW and MXD require standardization procedures, which can affect long-term, low-frequency signals.

The study of variations in the oxygen isotopic composition in tree-ring cellulose ($\delta^{18}\text{O}$) offers a promising alternative. This isotopic proxy is sensitive to both temperature and water stress and is less or even not affected by age-related growth effects. Several climate reconstructions, based on stable isotopes or tree-ring width and covering the past millennium, exist across Europe. However, none have been conducted for low-altitude regions in France. Our long-term goal is to fill the gap in isotopic data, for the 1200-1400 CE period, of the quasi-millennial $\delta^{18}\text{O}$ chronology (1046-2007 CE) already existing in France (Etien et al., 2008; Labuhn et al., 2016).

Yet, in dendroclimatology as in dendroisotopy, climate reconstructions require regional transfer functions based on modern reference chronologies. Here, we present a new $\delta^{18}\text{O}$ chronology from oak trees sampled in the Bertranges forest (Nièvre department, central France) over the period 1910-2023 CE, enabling us both to extend the millennial chronology currently under construction and to update isotope-climate relationships during the instrumental period.

The relationships between $\delta^{18}\text{O}$ and monthly or seasonal instrumental data were assessed using bootstrapped Pearson correlations for the period 1910-2023. We confirm that oak cellulose $\delta^{18}\text{O}$ is a reliable proxy for reconstructing climate variables, including July maximum temperature ($r = 0.65$, $p < 0.001$), June-July precipitation ($r = -0.63$, $p < 0.001$) and, especially, June- July drought conditions (SPEI; $r = -0.75$; $p < 0.001$). Furthermore, our chronology aligns well with previous research in northern, western and southwestern France as well as central England. Additionally, spatial correlations with CRU TS4.08 SPEI gridded data highlight the strength of the isotopic signal, the robustness of the statistical relationships, and the regional climate coherence over Western Europe. These results provide a solid foundation for reconstructing past hydroclimatic variability in central France between 1200 and 1400 CE, offering an unprecedented insight into the climatic transition from the Medieval Climate Anomaly to the Little Ice Age in the lowland regions of France.

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Labuhn, I., Daux, V., Girardclos, O., Stievenard, M., Pierre, M., & Masson-Delmotte, V. (2016). French summer droughts since 1326 CE: a reconstruction based on tree ring cellulose $\delta^{18}O$. *Climate of the Past*, 12, 1101–1117.