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A simple, single-substrate model to interpret intra-annual stable isotope signals in tree-ring cellulose

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High-resolution intra-annual measurements of the carbon and oxygen stable isotope composition of cellulose in annual tree rings ($\delta^{13}C_{cellulose}$ and $\delta^{18}O_{cellulose}$, respectively) reveal well-defined seasonal patterns that could contain valuable records of past climate and tree function. Interpreting these signals is nonetheless complex because they not only record the signature of current assimilates, but also depend on carbon allocation dynamics within the trees. Here, we present a simple, single-substrate model for wood growth containing only 12 main parameters. The model is used to interpret an isotopic intra-annual chronology collected in an even-aged maritime pine plantation growing in the South-West of France, where climate, soil and flux variables were also monitored. The empirical $\delta^{13}C_{cellulose}$ and $\delta^{18}O_{cellulose}$ exhibit dynamic seasonal patterns, with clear differences between years and individuals, that are mostly captured by the model. In particular, the amplitude of both signals is reproduced satisfactorily as well as the sharp ^{18}O enrichment at the beginning of 1997 and the less pronounced ^{13}C and ^{18}O depletion observed at the end of the latewood. Our results suggest that the single-substrate hypothesis is a good approximation for tree ring studies on *Pinus pinaster*, at least for the environmental conditions covered by this study. A sensitivity analysis revealed that, in the early wood, the model was particularly sensitive to the date when cell wall thickening begins (t_{wt}). We therefore propose to use the model to reconstruct time series of t_{wt} and explore how climate influences this key parameter of xylogenesis.