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Long-term plant response to drought revealed by tree ring stable isotope analysis

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Our long-term predictions of energy, carbon and water budgets over forested areas remain uncertain. A major challenge is to obtain a mechanistic understanding of how repeated droughts alter tree photosynthesis, transpiration and growth. The carbon and oxygen stable isotope ratios of wood cellulose are good indicators of not only climate variability, but also plant physiology. Here, using a single-substrate process-based model, we show that tree-ring isotope signals, when measured at high-resolution (< 100 microns) integrate detailed carbon and water exchange dynamics over periods of ca. 10 days, and can be used to test hypotheses on the short- and long-term plant physiological response to drought. Using both isotope signals also allowed us to identify how the period of cellulose deposition varied from year to year and in response to drought. Recent developments regarding sample preparation and analysis for stable isotope composition have made such high-resolution measurements suitable for large scale and long chronology studies. These results demonstrate that tree ring isotope signals hold considerable potential as a tool for constraining carbon and water budgets of the past in response to drought events.