

Environmental control of $\delta^{18}\text{O}$ values in plant cellulose

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The stable oxygen isotope ratio of leaf and stem cellulose ($\delta^{18}\text{O}_{\text{LC}}$ and $\delta^{18}\text{O}_{\text{SC}}$) has been regarded as a promising tool for the reconstruction of paleo-environments. The interpretation of $\delta^{18}\text{O}_{\text{LC}}$ and $\delta^{18}\text{O}_{\text{SC}}$ signals is, however, complicated as they are controlled by both an air temperature signal (T_{air}) coming from the isotopic composition of the plant's source water and a relative humidity signal (RH) introduced by the evaporative enrichment of the source water in ^{18}O in the leaf. Here, we used data from different climate zones on the Big Island of Hawaii to carefully parameterize a mechanistic isotope model to test the sensitivity of $\delta^{18}\text{O}_{\text{LC}}$ and $\delta^{18}\text{O}_{\text{SC}}$ to changes in RH and T_{air} . Leaf temperature (T_{leaf}) and the isotopic composition of atmospheric vapor ($\delta^{18}\text{O}_{\text{WV}}$) are two critical but poorly understood input parameters of the model. To allow a robust performance of the model, we specifically tested and formalized RH and T_{air} effects on T_{leaf} and $\delta^{18}\text{O}_{\text{WV}}$ across the different climate zones and incorporated the resulting relationships into the model. Our analysis revealed that $\delta^{18}\text{O}_{\text{LC}}$ and $\delta^{18}\text{O}_{\text{SC}}$ values are equally sensitive to RH and T_{air} and that variation in $\delta^{18}\text{O}_{\text{LC}}$ and $\delta^{18}\text{O}_{\text{SC}}$ alone cannot distinguish between these two environmental drivers. Nevertheless, our analysis shows that $\delta^{18}\text{O}_{\text{LC}}$ or $\delta^{18}\text{O}_{\text{SC}}$ signals reflect the evaporative environment of a plant. Using $\delta^{18}\text{O}_{\text{LC}}$ and $\delta^{18}\text{O}_{\text{SC}}$ values, e.g. in tree ring or other paleo-climatic studies therefore provides an exciting tool that allows reconstructing the evaporative environment that plants or ecosystems have experienced in past climates.