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Isotopic equilibrium between precipitation and water vapor in Northern Patagonia and its consequences on δ18Ocellulose estimate

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Modelling of the oxygen isotopic composition ($\delta^{18}O$) of tree-ring cellulose rely on the isotopic equilibrium assumption between the atmospheric water vapor and the tree source water, which is frequently assimilated to integrated precipitation. We explore the veracity of this assumption based on observations collected ($\delta^{18}O$ of rain, rivers, leaves, tree-rings) or monitored ($\delta^{18}O$ of water vapor) during a field campaign in Río Negro province, Argentina, in late summer 2017 (February-March). We examine, firstly, how the $\delta^{18}O$ of water vapor deviate from the equilibrium with precipitation and, secondly, what is the impact of the isotopic equilibrium assumption on the calculation of the isotopic composition of tree-ring cellulose.

For oxygen, the isotopic disequilibrium between rain and vapor range between -2.0 and 4.1‰. Rain drops re-evaporation during their fall, evaporation of soil water and vegetation transpiration (resulting in transpired water accounting for 14 to 29% of ambient water vapor) could produce this disequilibrium. The small value of the disequilibrium at the study site is likely due to the high level of relative humidity (from 70 to 96%) favoring the isotopic diffusive exchanges between the two water phases and thus promoting the isotopic equilibrium.

A perfect agreement between observed and calculated isotopic composition of cellulose is obtained if the source water is assumed to be in isotopic equilibrium with the measured water vapor. This hypothetical source water has a significantly higher $\delta^{18}O$ than the expected averaged isotopic composition of precipitation over the growing period or than the groundwater (river value). The veracity of the hypothesis of the isotopic equilibrium between water vapor and source water in tree-ring paleoclimate studies is discussed in light of these results.