Evaluating hydroclimate change in the recent past with observed and modeled leaf wax hydrogen isotopes

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Reconstructions of hydroclimate over the past several centuries provide important context for current and future changes in precipitation. The D/H ratios of plant waxes (δD_{wax}) are particularly powerful because they reflect the δD of meteoric water, which is a tracer for the atmospheric water cycle. However, comparing δD_{wax} records with general circulation models in order to infer physical climate patterns requires modeling the physical and biochemical processes that influence δD_{wax} with a proxy system model (PSM [1]).

We present a new plant wax PSM (WaxPSM) and its first applications: evaluating large-scale hydrological changes since the 1800's, and particularly during the 20th century. WaxPSM is designed as an add-on to the water isotope-enabled Community Earth System Model (iCESM; National Center for Atmospheric Research, Boulder, CO), and can predict δD_{wax} from any modern, paleo-, or future climate experiment performed using iCESM's atmospheric and land components (iCAM5 and iCLM4). WaxPSM predicts δD values of the C_{29} *n*-alkane based on modeled precipitation, soil water, and leaf water δD, and apparent and biosynthetic fractionation values from field, transect, and greenhouse studies. WaxPSM explicitly accounts for observed plant-type differences in apparent fractionation [2]. Precipitation, soil water, and leaf water inputs to WaxPSM account for kinetic and equilibrium isotopic fractionation from precipitation, large-scale circulation, land-atmosphere feedbacks, soil water evaporation, and biophysical soil/vegetation properties.

In this study, we evaluate predicted and observed δD_{wax} in modern spatial transects and in paleo-timeseries from North America, Australasia, and Africa. Patterns in predicted δD_{wax} are discussed in the context of recent warming and changes in regional monsoons. We also present alternative approaches to modeling δD_{wax} and applications to longer paleo-timescales.

[1] Evans et al. (2013), *QSR* **76**, 16-28; [2] Sachse et al. (2012), *Ann. Rev. Earth Planet. Sci.* **40**, 221-249