Tree rings and stable isotopes to assess role of trees and forests in the hydrological cycle

Aster Gebrekirstos, A.gebrekirstos@cgiar.org

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Stable isotopes (oxygen, hydrogen, carbon)

Water vapor gradually more depleted during transport overland-rainout of heavy isotopes (larger during years of high amounts of precipitation amount) along the air parcel trajectory.
Seasonal δ¹⁸O in tree rings mirrored trends in the source water, including recent precipitation and soil water pools.

Treydte et al. New phytologist 2014
New research gives the first observational evidence that the southern Amazon rainforest triggers its own rainy season using water vapor from plant leaves. The new study helps explain why deforestation in this region is linked with reduced rainfall.

The study analyzed water vapor data from NASA’s Tropospheric Emission Spectrometer (TES) on the Aura satellite, along with other satellite measurements, to show that at the end of the dry season, clouds that build over the southern Amazon are formed from water rising from the forest itself. The research will be published in the journal Proceedings of the National Academy of Sciences (PNAS). (In press) Jonathon S. Wright et al., “A Rainforest-initiated wet season onset over the southern Amazon,” PNAS (2017).

www.pnas.org/cgi/doi/10.1073/pnas.1621516114
Precipitation signal- Local and regional recycling of summer monsoon precipitation

Oxygen isotope variations in earlywood (open circle and open triangle) and latewood (closed circle and triangle) of *P. kesiya* (PIKE) and *P. armandii* (PIAR)

-The δ¹⁸O in the EW and LW of *P. armandii* represent pre-monsoon precipitation and late monsoon precipitation signals

-Local and regional recycling of summer monsoon precipitation (evaporation and reprecipitation) might influences the isotopic composition of precipitation at the end of summer monsoon

Reconstruction of hydro climate history

Mokria, Gebrekirstos, Abyiu, VanNoordwijk, Bräuning (2017) Multi-century tree-ring precipitation record reveals increasing frequency of extreme dry events in the upper Blue Nile River catchment (GCB)
Spatial correlations between TANA tree-ring chronology and wet-season (JJAs) rainfall (a) and mean maximum temperature (b).
signal correlates negatively with basin wide precipitation and Amazon river discharge - mixture of local precipitation intensity and large scale influence - gradual rainout processes of $\delta^{18}O$ (Rayleigh distillation) in air parcels during westward transport across the basin (depletion of heavy isotopes larger during wet years) along the air parcel trajectory - recycling of rain water by vegetation - continuous recycling adds more water vapor to the airstream traveling westward (recycling may contribute to more than half of precipitation in the western part of the basin) 

Brienen et al. PNAS 2012
Plants can potentially maintain the ratio $c_i/c_a$ by reducing stomatal conductance, in consequence reducing moisture loss per unit of carbon gained (increasing their water-use efficiency).

How long will it continue? Potential thresholds to response over longer spatial and temporal scales?

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