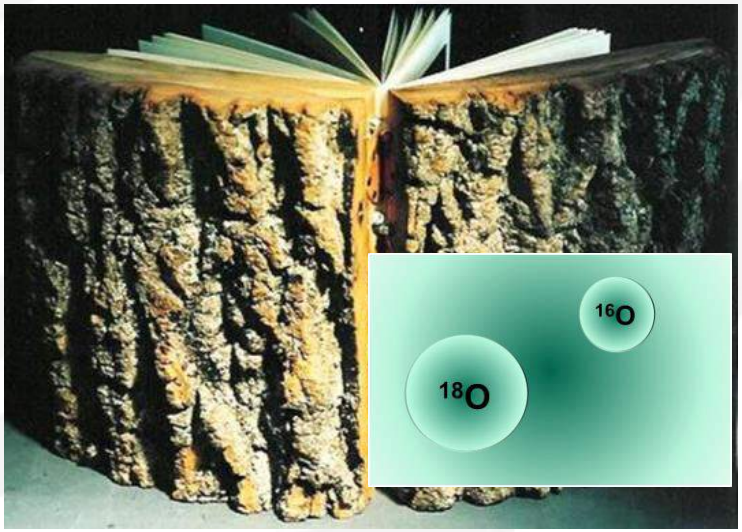
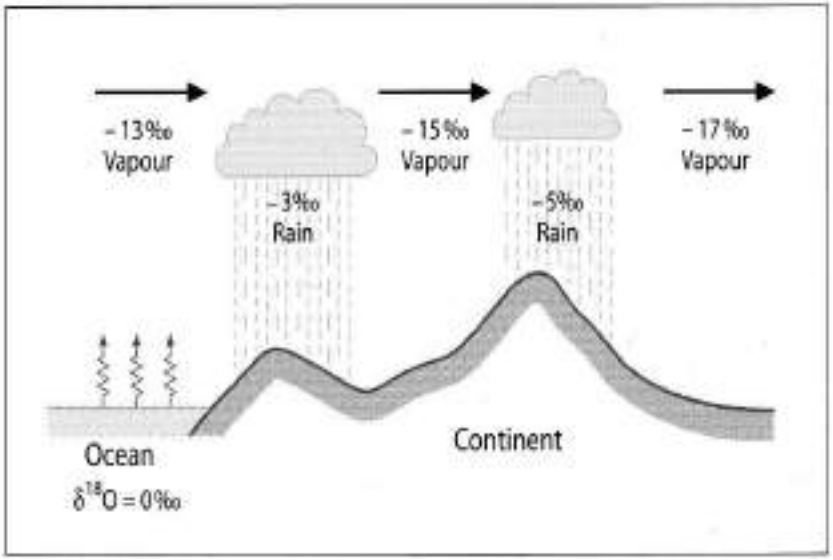
Tree rings and stable isotopes to assess role of trees and forests in the hydrological cycle

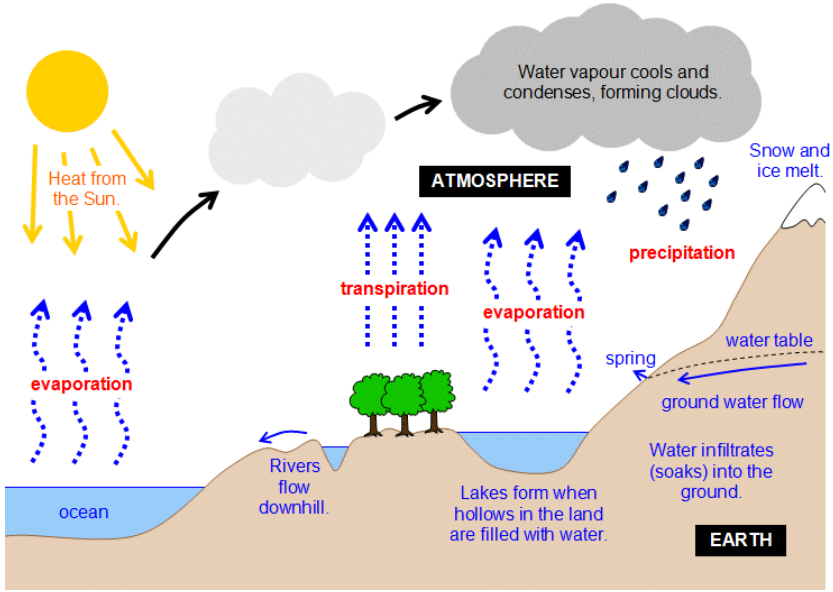


Aster Gebrekirstos, A.gebrekirstos@cgiar.org

Stable isotopes (oxygen, hydrogen, carbon

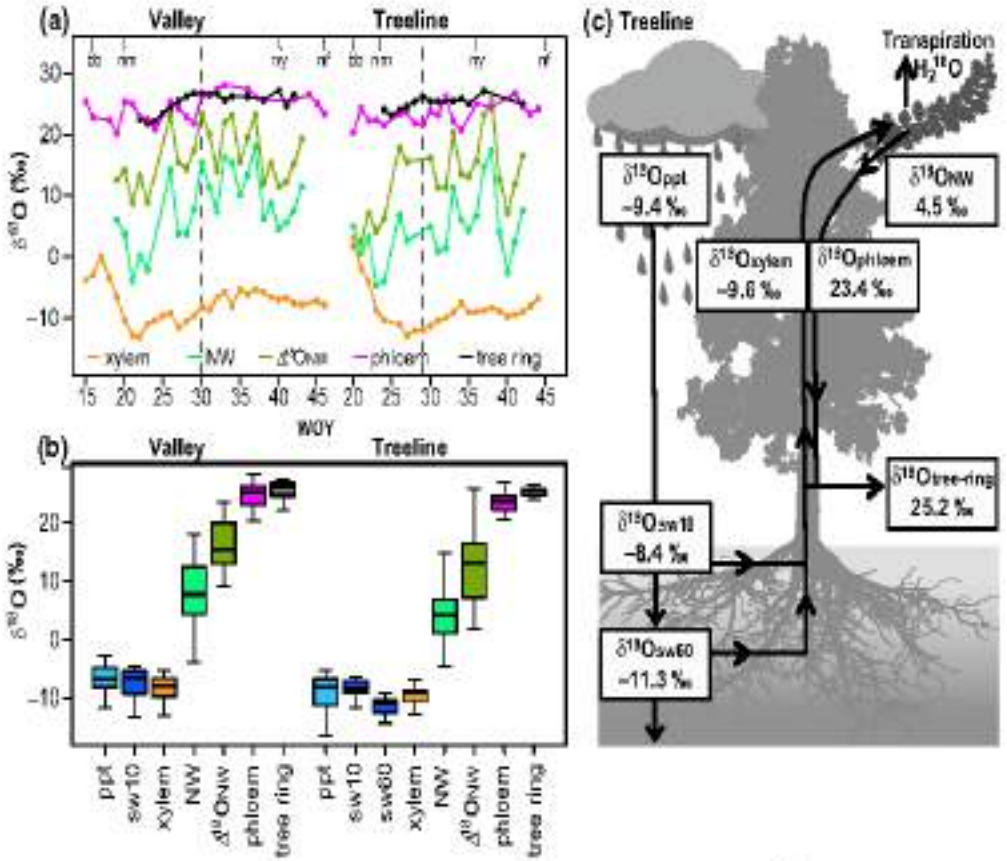


Modified after Hoefs, 2002



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 transfer of Oxygen isotopes from precipitation and soil to the tree rings



Seasonal $\delta^{18}O$ in tree rings mirrored trends in the source water, including recent precipitation and soil water pools

Treydte et al. New phytologist 2014

Fig. 3 Seasonal $\delta^{18}O$ variations of *Larix decidua* per site and parameter. (a) Weekly resolved records of $\delta^{18}O$ in xylem water ('xylem'), $\delta^{18}O$ in needle water ('NW'), the oxygen sotope enrichment of needle water above source water ('$\Delta^{18}O_{NW}$'), $\delta^{18}O$ in phloem organic matter ($\delta^{18}O_{phloem}$) and $\delta^{18}O$ in tree rings ('tree ring'). Dotted lines represent the transition between earlywood and latewood. bb, bud break; nm, needle maturing; ny, needle yellowing; nf, needle fall; WOY, week of the year. (b) $\delta^{18}O$ boxplots for all tree tissues, precipitation ('ppt') and soil water at 10 cm ('sw10') and 60 cm ('sw60') soil depth. The top, mid-line, and bottom of each box represent the 75th, 50th (median), and 25th percentiles, respectively. The vertical lines represent the 90th and 10th percentiles. Note that correlation analyses with xylem water were performed starting with minimum values at the beginning of the growing season (see text). (c) Mean values of source water and all tree tissues at the tree line.

Evidence That The Southern Amazon Rainforest Triggers Its Own Rainy Season

TOPICS: Amazon Climate Science Earth Science Rain Weather

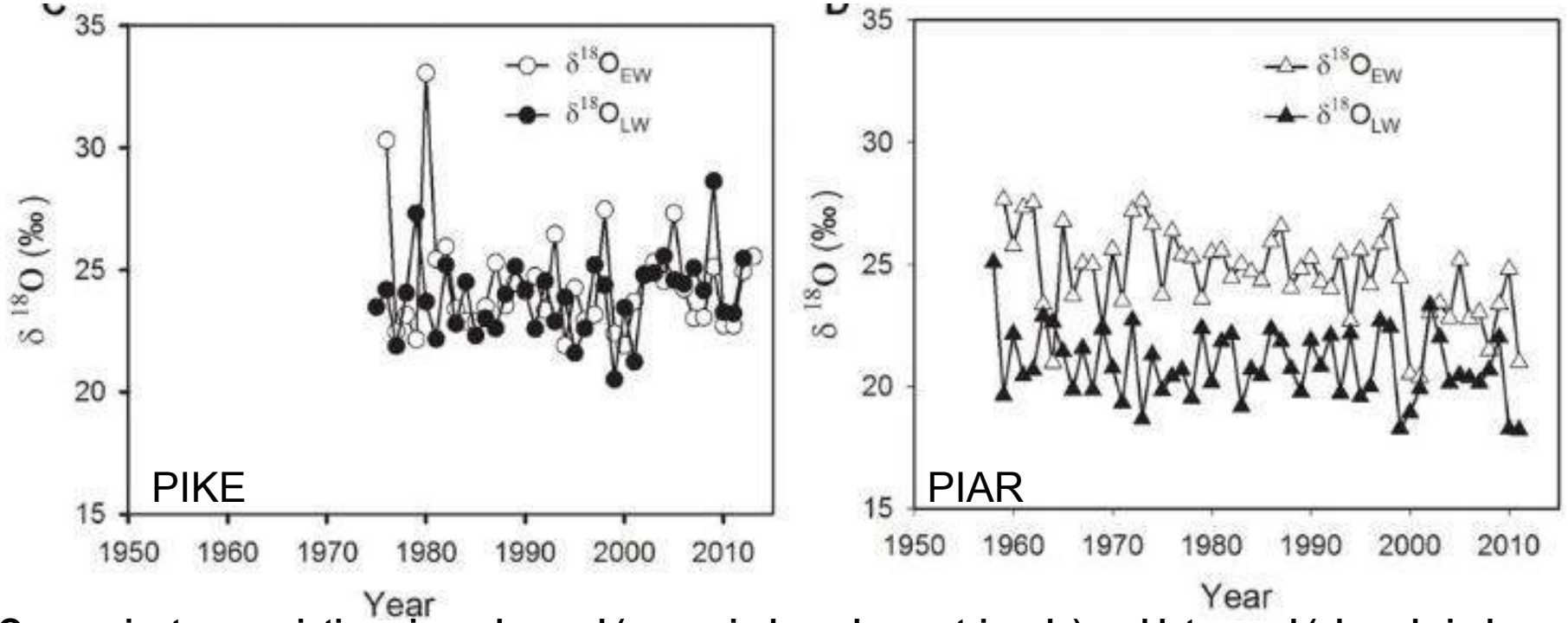
JULY 18, 2017

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 el 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



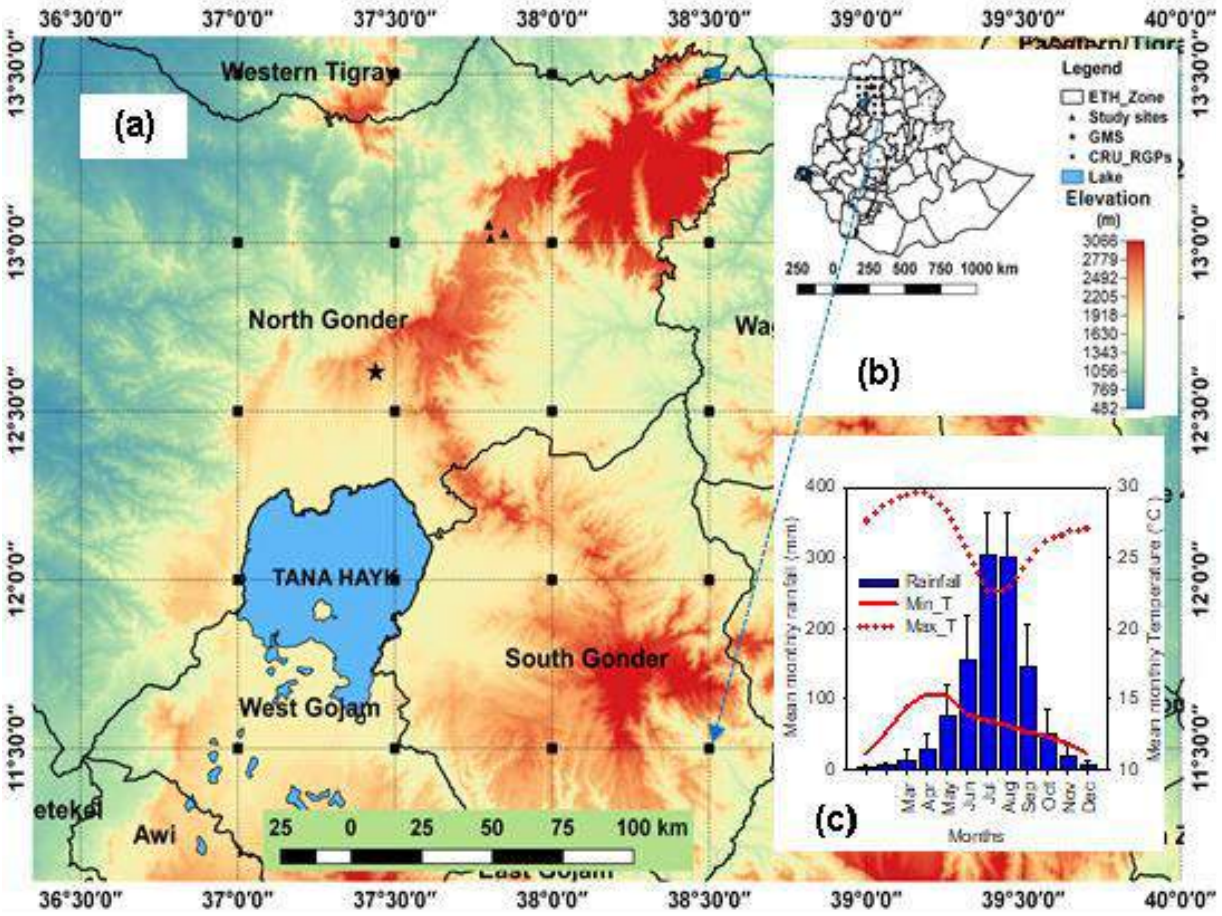
Oxygen isotope variations in earlywood (open circle and open triangle) and latewood (closed circle and triangle) of *P. kesiya* (PIKE) and P. armandii (PIAR)

-The $\delta^{18}O$ 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

Fu P-L, Grießinger J, Gebrekirstos A, Fan Z-X and Bräuning A (2017) *Front. Plant Sci.* 7:2050. doi: 10.3389/fpls.2016.02050

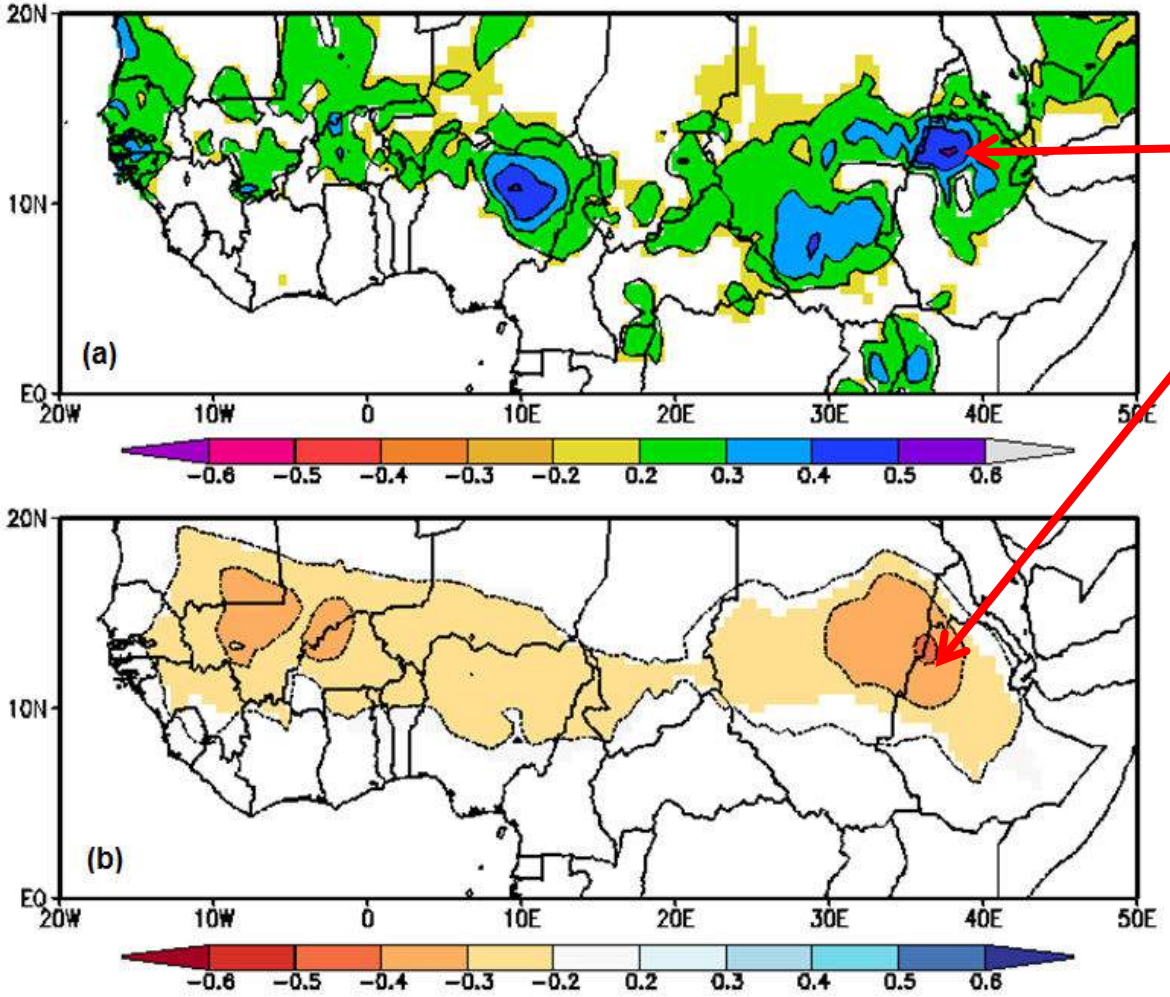
Reconstruction of hydro climate history



Juniperus procera (Ethiopia)

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)*

Tree ring width- hydroclimate information



Study site- upper Blue Nile

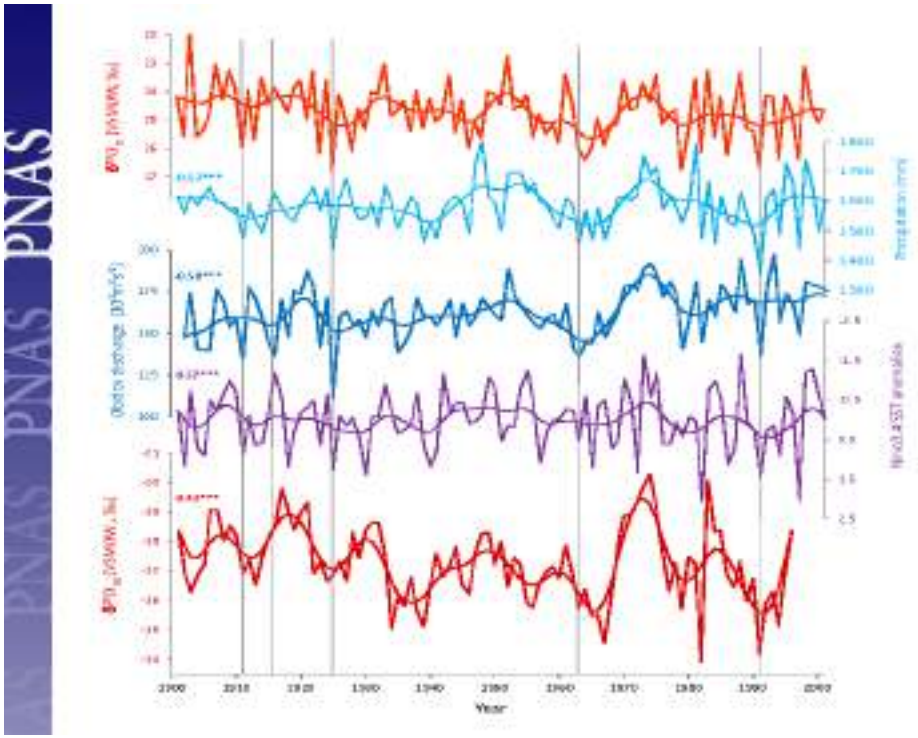
-TANA chronology has captured climate signals which represent nearly the whole northern Ethiopian highlands and parts of the Sahel belt, with possible recycling of atmospheric moisture from evapotranspiration.

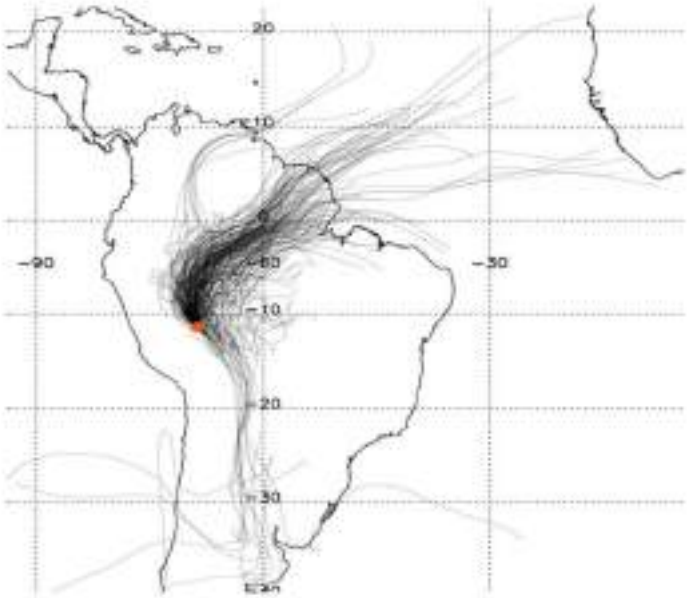
-Confirms the existence of large-scale atmospheric teleconnections to dry/wet changes

Spatial correlations between TANA tree-ring chronology and wet-season (JJAs)rainfall (a) and mean maximum temperature (b).

Mokria, Gebrekirstos, Abyiu, VanNoordwijk, Bräuning (2017) (*GCB)*

Oxygen isotopes- as proxy for Amazon precipitation and ENSO variability





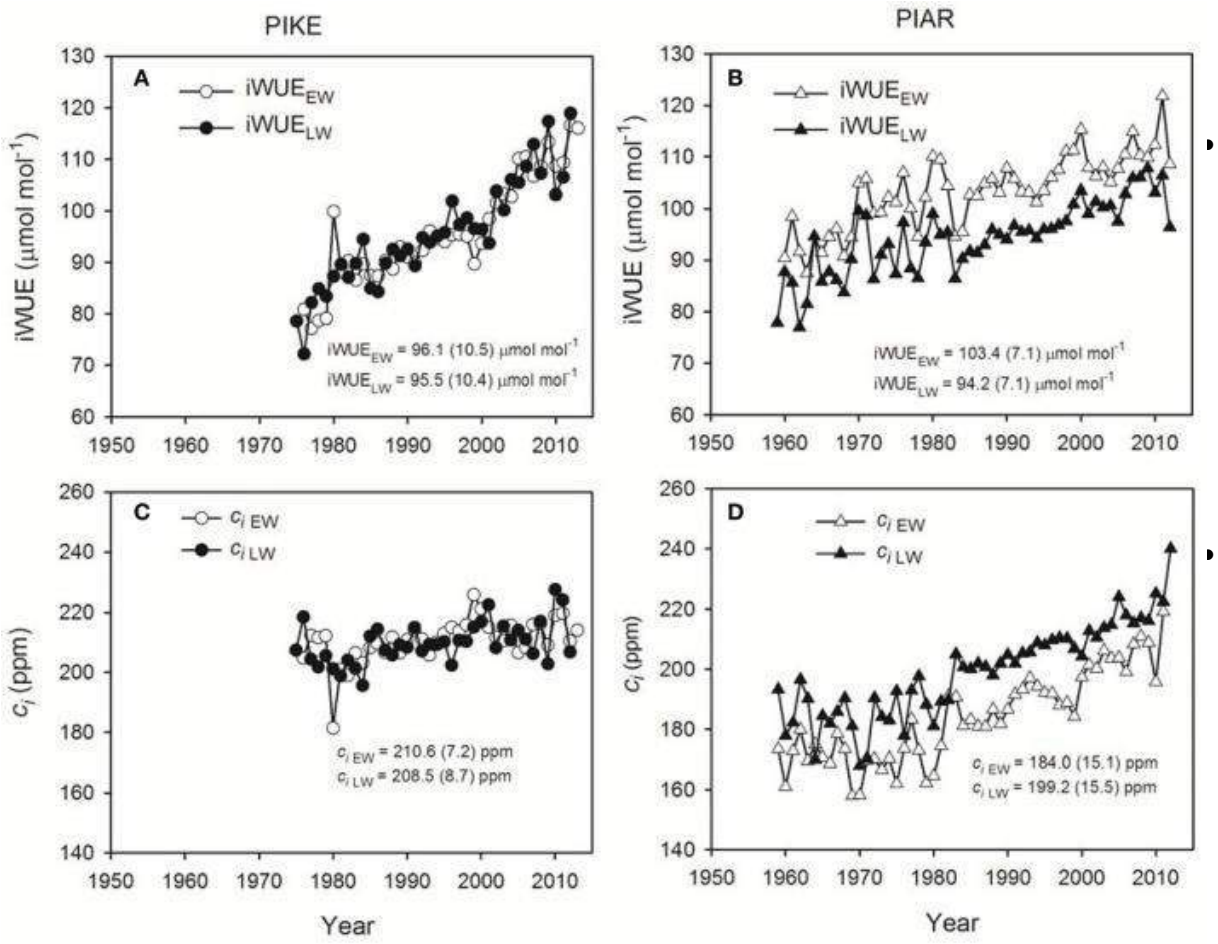
-signal correlates negatively with basin wide precipitation and Amazon river discharge -mixture of local precipitation intensity and Large scale influence

- 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

Stable Carbon isotopes- response to increasing CO_2 trends - intrinsic water-use efficiency



- 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?

Intrinsic water use efficiency (iWUE) for earlywood (iWUE$_{EW}$, open circle) and latewood of plantation pine *P. kesiya* (PIKE) (iWUE$_{LW}$, closed circle) (A) and Natural forest pine P. armandii (PIAR)

Fu P-L, Grießinger J, Gebrekirstos A, Fan Z-X and Bräuning A (2017) *Front. Plant Sci.* 7:2050. doi: 10.3389/fpls.2016.02050

Acknowledgments

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- BMZ and GIZ, for funding the project in Burkina
- Prof Achim Bräuning Erlangen Univ.for allowing as to use mass spectrometery

Thank you!!!