Seasonal isotope hydrology of a coffee agroforestry watershed in Costa Rica

J. Boll[1], K. Welsh*[1,2], O. Roupsard[2,3]

[1]University of Idaho, Moscow, ID, USA; [2]Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica; [3]UMR Eco&Sols, CIRAD, Montpellier, France

H21F-0794

Introduction

In the tropics, the "amount effect" has been recognized as one of the primary influences on stable isotope values in tropical precipitation for monthly samples (Figs 1 and 2). However, when examining event-based precipitation events at a regional scale, lifting condensation levels and surface relative humidity have a greater influence (Sánchez-Murillo *et al*. 2014). **The main goals of this research** were to examine what microclimate factors influence local stable isotope ($\delta^{18}O$ and δD) values and whether stable isotopes can be used to trace seasonality in this region at different temporal

Methods

- Sampled precipitation (event-based samples), groundwater (weekly samples), and stream water (weekly samples at 4 locations) for 2+ years.
- Micrometeorological data were collected at an eddy-flux tower located on site.
- **Study Site**: The Mejías watershed (Cartago, Costa Rica) is an agroforestry microwatershed (0.9 km^2) located on the Aquiares Coffee Farm.

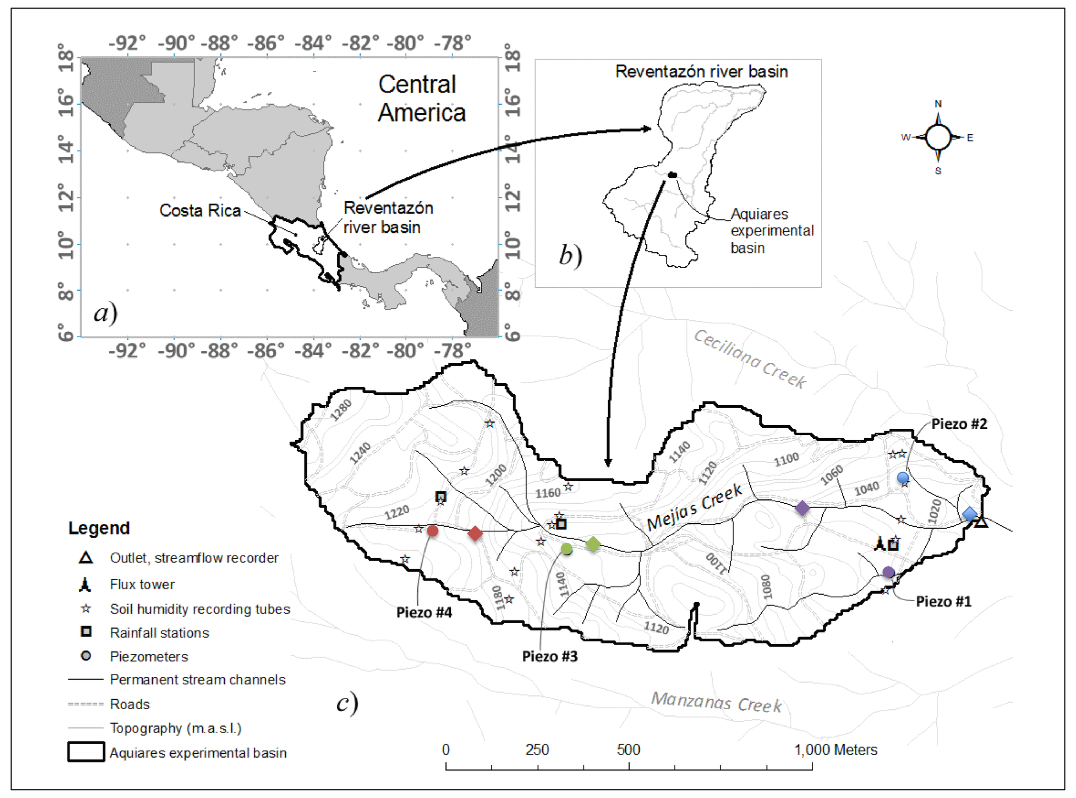

Fig. 1. Location of study site. *Source: Gómez-Delgado et al. 2011*

Fig 2. The land cover at the site is dominated by *Coffea arabica coffee* plants interspersed with *Erythrina poeppigiana* shade trees.

Fig 3. The study site is part of the global network of FLUXNET micrometeorological sites.

Results

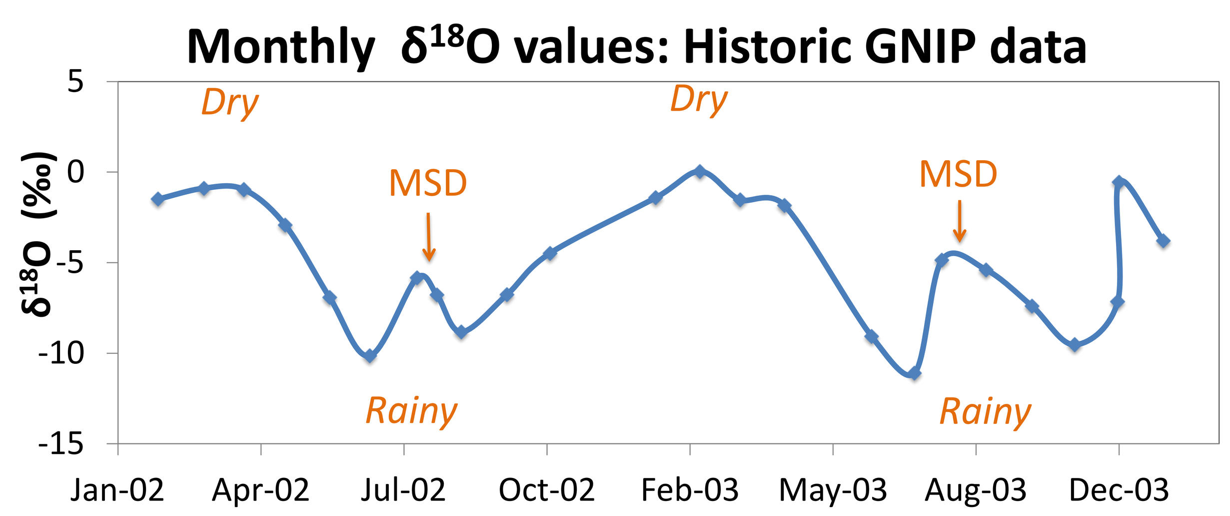

Fig. 4. Monthly averaged values of $\delta^{18}O$ in precipitation from historic GNIP database for Turrialba. MSD = Mid-Summer Drought.

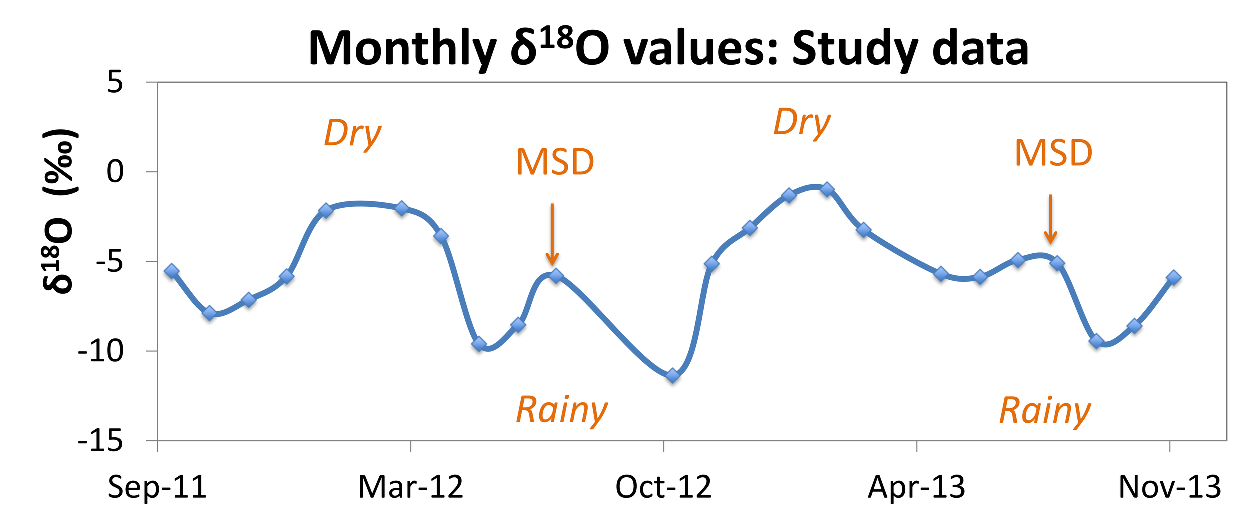

Fig. 5. Monthly averaged values for $\delta^{18}O$ in precipitation at the study site. Precipitation isotope values were correlated with air temperature, wind speed, and wind direction.

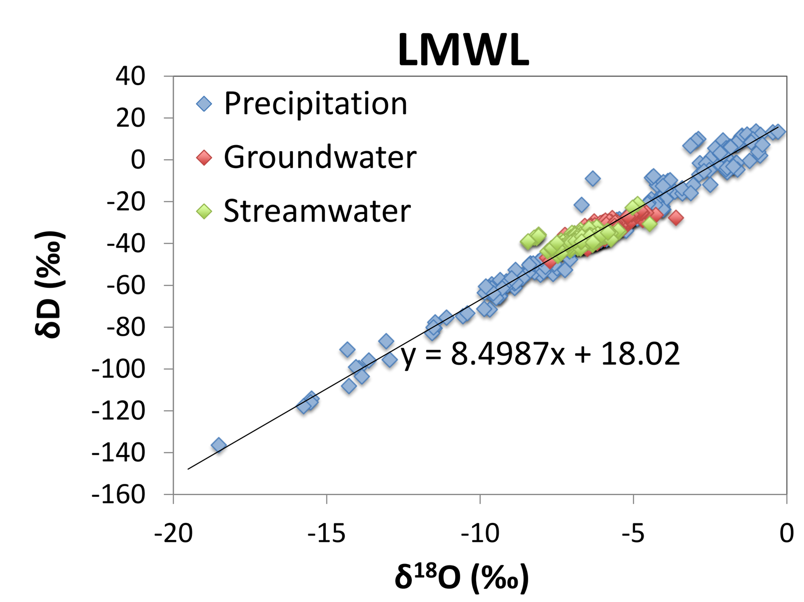

Fig. 6. The Local Meteoric Water Line (LMWL) for precipitation samples (collected between Aug 2011 and Dec 2013) for the watershed.

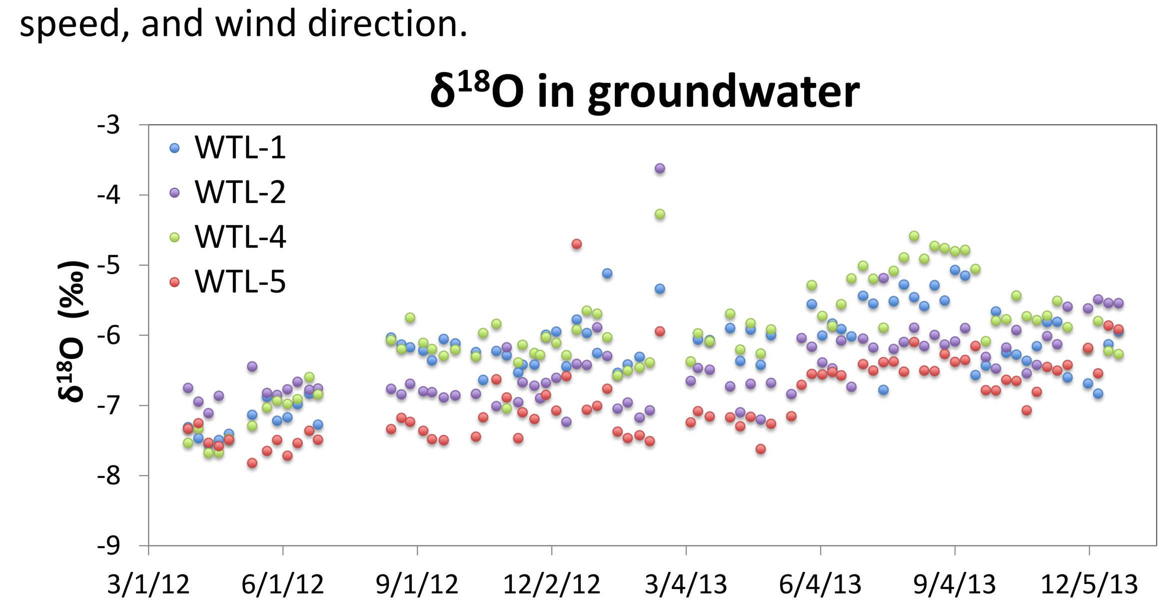

Fig. 7. $\delta^{18}O$ values in groundwater (weekly samples) at four groundwater wells: WTL-1 and WTL-2 (low elevations), WTL-4 (mid-elevation), and WTL-5 (high elevation).

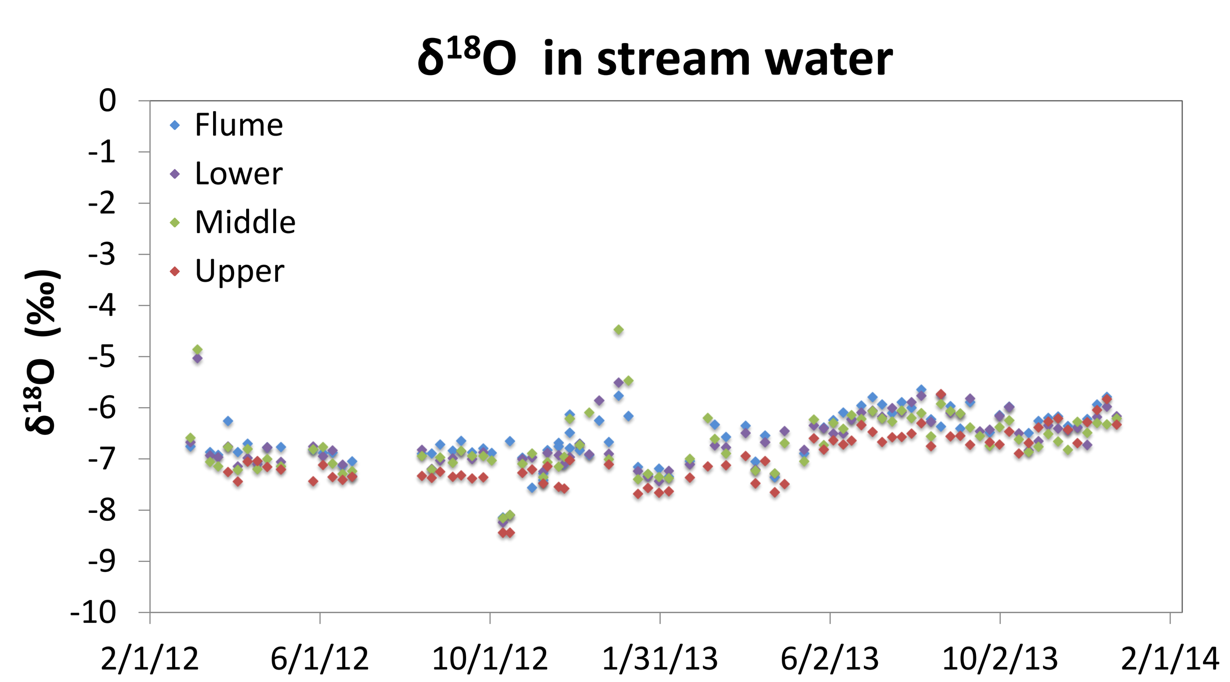

Fig. 8. $\delta^{18}O$ values in stream water (weekly samples) at four locations in the watershed. Values generally become enriched in $\delta^{18}O$ from upper elevations to lower elevations.

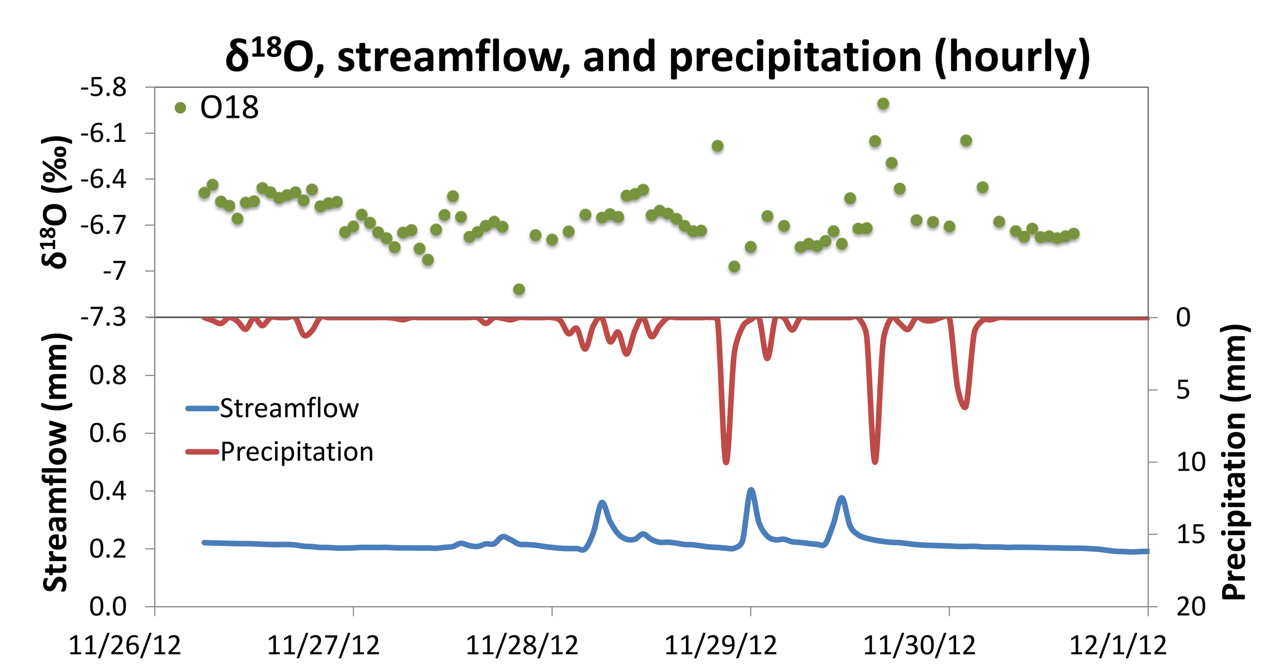

Fig. 9. Hourly values of $\delta^{18}O$ (‰) measured in stream water (11/26/12 – 12/1/12), compared with stream flow and precipitation levels. Both $\delta^{18}O$ and δD are positively correlated with precipitation amount (p=0.02 and 0.00005).

Fig. 10. Intermittent springs (a) and road and path runoff (b) at the site contribute significantly to storm flow.

Fig. 11. Low flow conditions compared with storm flow conditions at the flume.

Discussion

- For monthly averaged samples (Figs 4 and 5), dry season precipitation is enriched with respect to the rainy season, but at an hourly or daily basis other trends are evident, such as correlation with meteorological measurements and stream response to precipitation events (Fig 9).
- Air temperature, wind speed, and wind direction are all significantly correlated with $\delta^{18}O$ and δD values in precipitation, which could be due to seasonal differences in air mass sources.
- Examining stream water $\delta^{18}O$ and δD values at a finer scale (Fig. 9) shows how streams respond to precipitation, as the stream becomes more enriched with higher amounts of rain due to source contribution of groundwater and overland flow from spring and roads (Figs. 10 and 11).
- Stable isotopes are useful for examining seasonality and watershed dynamics when examined at different temporal scales. For example, measuring isotopes in stream samples during storm events assists in our understanding of when storm flow reaches streams.
- Further work will include partitioning stream water sources and quantifying spring contribution to storm flow.

References

Gómez-Delgado, F., et al. 2011. Modelling the hydrological behaviour of a coffee agroforestry basin in Costa Rica. *Hydrology and Earth System Sciences* 15(1): 369-392.

Sánchez-Murillo, R., et al. 2014. Spatial and temporal variation of stable isotopes in precipitation across Costa Rica: An analysis of historic GNIP records. *Open Journal of Modern Hydrology* 3: 226-240.

Acknowledgments

This work was funded by an NSF IGERT (Integrative Graduate Education and Research Traineeship) and a U.S. Borlaug Fellowship in Global Food Security. The CoffeeFlux project provided site infrastructure and the Aquiares Farm provided site access. The authors would like to thank Alvaro Barquero, Alejandro Barquero, Alexis Pérez, and Amilkar Moncada for field assistance.

*Contact: Kristen Welsh
wels8152@vandals.uidaho.edu

University of Idaho Environmental Science & Water Resources

CATIE Solutions for environment and development / Soluciones para el ambiente y desarrollo

cirad