The relationship of precipitation recycling to climate in the tropics through stable isotopes

Kurt C. Solander1, Brent D. Newman1, Nicolette Gonzales1, Scott Jasechko2 and Chonggang Xu1

1 Los Alamos National Laboratory, Earth and Environmental Sciences Division, Los Alamos, NM
2 University of California, Santa Barbara, Bren School of the Environment, Santa Barbara, CA

Contact information: ksolander@lanl.gov

Abstract

The study of stable precipitation isotopes is important to tropical ecohydrology due to the potential for moisture source detection, climate zone seasonality characterization and moisture recycling quantification (e.g. local re-precipitation of water vapor derived from ET). In this study, we used monthly precipitation isotope data from 395 sites within the IAEA Global Network of Isotopes in Precipitation (GNIP) database to assess the characteristics of δ2H and δ18O in precipitation at the pan-tropical scale (+/-30° North Latitude). We focus our efforts on investigating spatial patterns of d-excess calculated from this data due to its strong sensitivity to precipitation recycling. We employed a geospatial interpolation method to get a spatially continuous estimate of mean monthly d-excess across this latitudinal range and further classified these estimates into the three main Köppen-Geiger (KG) climate zones that occur within the tropics (e.g. tropical, temperate and arid) based on differences in d-excess values. Our results show the KG climate zones derived from D-excess match reality in greater than 60% of the land surface at 1° spatial resolution. Spatial matching was highest over larger continental land masses and lower where data was too sparse to appropriately resolve the interpolation as well as where regions where precipitation was more seasonally controlled. We aim to improve upon these estimates by investigating the role of specific climate and geospatial variables on d-excess values that include distance from ocean, precipitation, temperature and evapotranspiration as well as how these relationships vary seasonally. Such an effort will be useful to integrate precipitation recycling into Earth System Models (ESMs) to determine how the spatial variability of moisture sources might be changing under a warming climate.

Background

What is Precipitation Recycling?

Precipitation recycling refers to the portion of evaporated transpired water from precipitation events that is re-precipitated. The ratio of locally derived precipitation to total precipitation is known as the recycling ratio.

Why is recycling important?

• Estimates of the recycling ratio vary from ~10-50% depending on method and region, making recycling a significant part of the terrestrial water cycle (Eltahir and Bras, 1996)
• Vegetation-regulated moisture recycling is a critical ecosystem service that must be quantified and evaluated for its importance (Keys et al., 2016)
• Changes in climate and ecosystem disturbance may alter recycling ratios (Li et al., 2016)

Methodology and Data Sources

Calculation of d-excess

- d-excess values of precipitation are sensitive to recycling, making them a good indicator of this process
  - High values (>10) indicate greater recycled precipitation, often found in less arid climates where relative humidity is higher
  - Low values (<10) indicate less recycled precipitation, often found in more arid climates where relative humidity is lower (Bershaw, 2018)
- Equation: d-excess = δ18O + 8 * δ2H (Froelich et al., 2008)

Results and Discussion

Mean Monthly δ18O

- Above shows zonal statistics of d-excess for major KG Climate Zones of Tropics
- Previous studies show precipitation recycling substantial when D-excess > 10%
- 14-15% of D-excess above 15 % across Af, Am and Aw indicating not much difference in precipitation recycling across these regions

Krigged Mean Monthly D-excess

- Re-categorization of KG Climate Zones into 3 Groups
- Re-categorization of D-excess into 3 KG Climate Zone Groups

References and Acknowledgements


This work was supported by the U.S. Department of Energy, Office of Biological and Environmental Research as part of the NGE-Tropics.