Leaf wax isotopic response to seasonal changes in climate in the Sonoran Desert

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Sonoran Desert

- A biodiverse region despite extreme climate.
- 50-80% of total annual rainfall falls during the North American Monsoon (NAM) in late summer.
- Native plant species have adapted to this precipitation regime.

How do leaf wax isotopes vary between Sonoran Desert species?

What is the leaf wax isotopic response to intra-annual variations in climate?

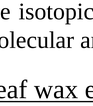
Collection and Measurement

Physiognomy and physiology

***Aristida ternipes* – Spidergrass**
C_4 grass

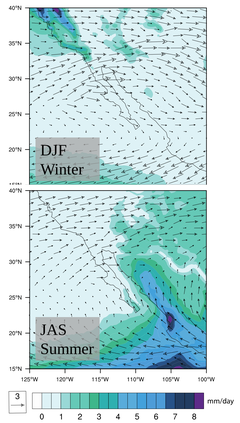
***Olneya tesota* – Ironwood**
C_3 tree

***Prosopis velutina* – Velvet Mesquite**
C_3 tree



***Simmondsia chinensis* – Jojoba**
C_3 shrub

Wind and precipitation



Sonoran Desert native plants

All samples were collected at the Arizona-Sonora Desert Museum. We use isotopic tracers recorded in leaf wax molecules (*n*-alkanes) to trace molecular and isotopic responses to monsoonal precipitation.

Leaf wax extraction

- 0.5 g dried leaf
- Thermo Scientific Dionex ASE 350
- 9:1 ratio of dichloromethane:methanol
- Added known mass of internal standard (5α-Androstane) to total lipid extract

n-alkanes

- Isolated using column chromatography
  - SiO_2 stationary phase
  - Hexane mobile phase
- Concentrations: based on the area of the internal standard using a Thermo Scientific TRACE 1310 GC-FID
- δ^2H and $\delta^{13}C$ ratios: Thermo Scientific Delta V Plus GC-IRMS

P.C.M., **M.G.**, and **J.E.T.**: University of Arizona, Department of Geosciences
T.B.: Syracuse University, Department of Earth Sciences

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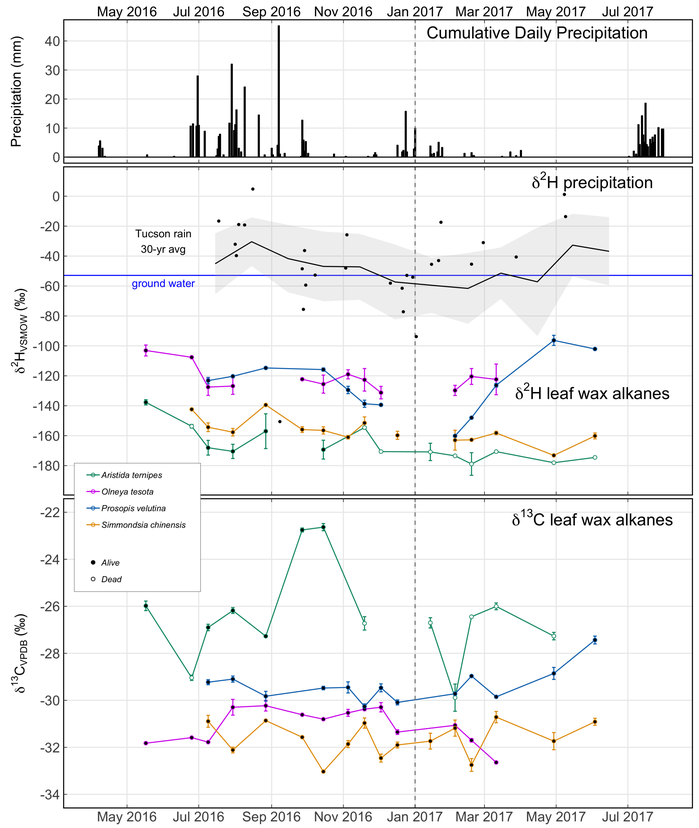
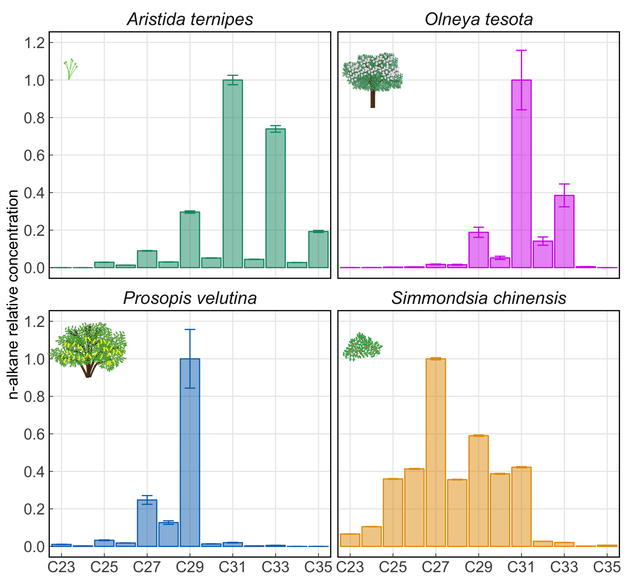
Results



Alkane Concentration Distribution

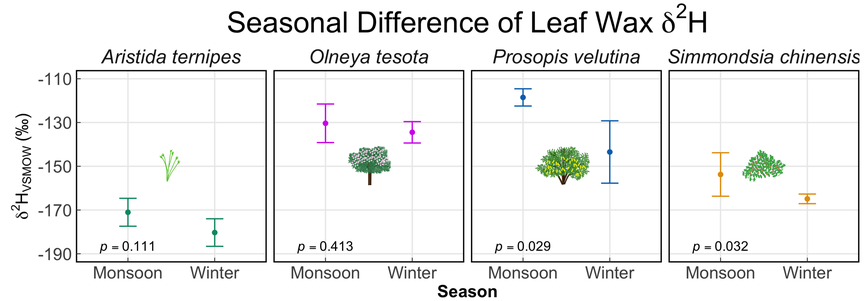


Environment and Leaf Waxes

δ^2H: precipitation signals and plant responses

- Individual rain events closely follow the 30-year monthly average.
- High vapor pressure deficit (VPD) in the atmosphere increases evaporation and transpiration, leading to more positive δ^2H values.

- δ^2H values of leaf wax in *P. velutina* become more positive in early summer: taproot allows transpiration during periods of high VPD.
- Most negative values found in *A. ternipes*: C_4 pathway allows stomata aperture to remain smaller, limiting transpiration during periods of high VPD.



- Neither *A. ternipes* nor *O. tesota* leaf wax development responds to summer vs. winter precipitation
- *P. velutina* and *S. chinensis* leaf waxes do show a seasonal signal

$\delta^{13}C$: plant responses to water stress

- Both *P. velutina* and *S. chinensis* show $\delta^{13}C$ enrichment during the early summer of 2017: more positive $\delta^{13}C$ values in C_3 plants is often a result of water stress.
- Highly variable signal in *A. ternipes*: $\delta^{13}C$ values should be more positive due to C_4 pathway, but measurement is complicated by sampling; new growth may reflect a more immediate environmental signal, but this grass was often senesced due to drought conditions.

n-Alkane distributions

- Highly variable between species.
- We analyzed isotopes on the C_{29} alkane for consistency.

Patterns in δ^2H vs. $\delta^{13}C$

For C_3 species, enrichment in one isotope system should be strongly associated with enrichment in the other.

- *P. velutina* is more positive in both $\delta^{13}C$ and δ^2H during the pre-monsoon season.
- *O. tesota* is more positive in δ^2H and more negative in $\delta^{13}C$ during the pre-monsoon
- *S. chinensis* shows a positive relationship between $\delta^{13}C$ and δ^2H, but no seasonal pattern emerges from the data.
- *A. ternipes* has no trend in δ^2H, while $\delta^{13}C$ is highly variable.