# Leaf water enrichment in deuterium shapes leaf wax *n*-alkane δD values of terrestrial plants

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## Introduction

Leaf wax *n*-alkanes are long-chain hydrocarbons that can persist in sedimentary records over geological timescales. Since their hydrogen isotopic composition (δD) contains information on hydrological processes, leaf wax *n*-alkane δD values have been advocated as powerful hydrological proxies. What hydrological information is recorded in leaf wax *n*-alkanes remains, however, unclear because critical processes that determine their δD values have not been resolved. In particular the influence of leaf water evaporative deuterium enrichment (ΔD) on the δD values of leaf wax *n*-alkanes has not been resolved and remains controversial.

## Objectives

The objective of our work was to determine if leaf water evaporative D-enrichment influences the δD of leaf wax *n*-alkanes. In a three-part study, were we

1) performed experiments under controlled environmental conditions,
2) validated our experimental results along a natural climate gradient,
3) assessed the relevance of our finding on a global scale.

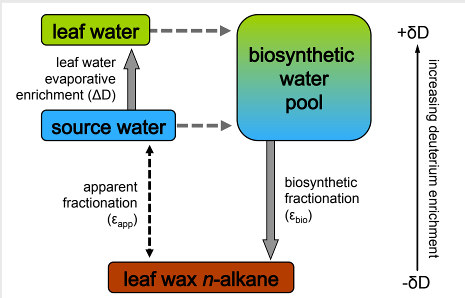



**Fig. 1:** Conceptual model summarizing the parameters that influence leaf wax *n*-alkane δD. In the model the δD of *n*-alkanes is driven by the δD of the biosynthetic water pool (BWP). If the BWP is influenced by the plant's source water and/or leaf water ΔD is the key question of this study. $\varepsilon_{bio}$ is the biochemical fractionation between the BWP and *n*-alkane δD. $\varepsilon_{app}$ is the difference between *n*-alkane δD and the δD of source water.

## Results & Conclusions

1) Our experiments show that leaf water ΔD has a critical impact on leaf wax *n*-alkane δD values.
2) Although this effect applies to all plants it is stronger for dicotyledonous plants than for monocotyledonous plants.
3) Our study implies that plant physiological processes need to be considered when leaf wax *n*-alkane δD values are interpreted as hydrological proxies.

## Experiment 1

To test the effects of leaf water ΔD on leaf wax *n*-alkane δD values we grew five plant species in two climate chambers that differed in atmospheric humidity (40% vs. 80% rh).

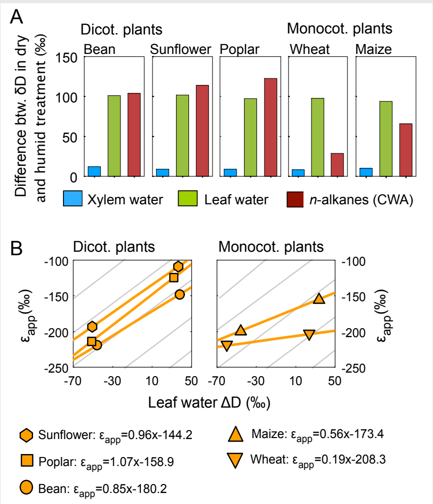



**Fig. 2: A)** Differences in xylem water, leaf water and concentration-weighed average (CWA) *n*-alkane δD values between the dry and the humid climate chamber for five plant species. **B)** The effect of leaf water ΔD on apparent fractionation ($\varepsilon_{app}$). The slope of the relationship indicates the fractional contribution of leaf water ΔD to the pool of biosynthetic water and illustrates thus the effect of leaf water ΔD on *n*-alkane δD (assuming a constant $\varepsilon_{bio}$). Grey lines indicate hypothetical 1:1 relationships between $\varepsilon_{app}$ and ΔD, where leaf water contributes 100% to the biosynthetic water pool.

## Experiment 2

To test if the our experimental results are also valid in "real world ecosystems" we assessed xylem water, leaf water and leaf wax *n*-alkane δD values along a natural climate gradient in Northern Australia.

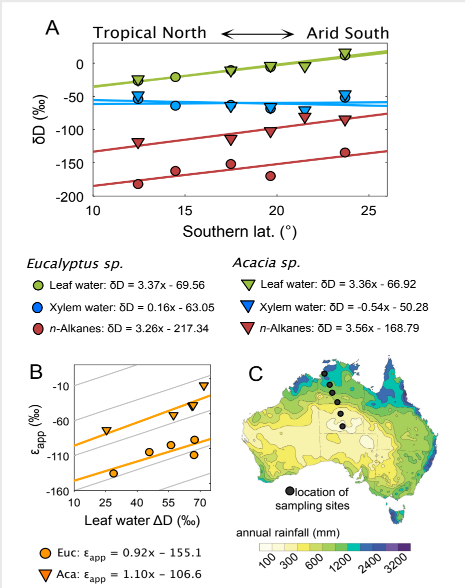



**Fig. 3: (A)** Leaf water, xylem water and *n*-alkane δD values for *Eucalyptus* and *Acacia* species along the North Australian climate gradient. Leaf water is the modeled mean growing season (Oct – Nov – Dec) midday leaf water. **(B)** The relationship between apparent fractionation $\varepsilon_{app}$ and leaf water ΔD for both genera (for explanations see also Fig. 2B). **(C)** Position of the six sampling sites along the gradient.

## Experiment 3

Since our experiments 1 and 2 indicated strong effects of leaf water ΔD on leaf wax *n*-alkane δD values, we tested the global relevance of this effect by simulating global patterns of leaf water ΔD.

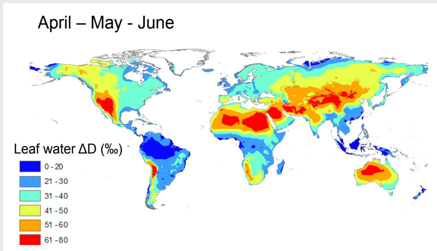



**Fig. 4:** Global variation of leaf water evaporative enrichment in deuterium (ΔD) for the northern hemisphere spring (Apr-May-Jun). Grid cells with mean monthly temperatures less than 0 °C not included. The predicted D-enrichment of leaf water is strongest in arid biomes (40-100‰), intermediate in temperate biomes (10-30‰) and least pronounced in tropical biomes (0-20‰). Hence we conclude that the influence of D-enriched leaf water on the δD of leaf wax *n*-alkanes is particularly strong in arid and temperate environments and weaker in humid tropical environments.

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