The dominant environmental driver of leaf water stable isotope composition differs for δ^2H compared to $\delta^{18}O$

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Background

- Several important isotopic biomarkers derive part of their signal from leaf water stable isotope composition (*e.g.*, leaf wax δ^2H, cellulose δ^2H and $\delta^{18}O$, lignin $\delta^{18}O$).
- In order to interpret these, it is helpful to know which environmental variable most strongly controls leaf water δ^2H and $\delta^{18}O$.
- Because the Craig-Gordon equation can be used to predict both leaf water δ^2H and $\delta^{18}O$, it is often assumed that they behave similarly.

Question

Do leaf water δ^2H and $\delta^{18}O$ mirror each other in their responses to environmental drivers, or do they capture different environmental information?

Approach

- We compiled observations of the stable isotope compositions of leaf water, xylem water, and atmospheric vapour, along with air temperature and relative humidity from published and unpublished sources.
- Our dataset comprises 690 observations from 35 sites with broad geographical coverage.
- We limited our analysis to daytime observations, when photosynthetic processes that incorporate leaf water isotopic signals take place.

Results

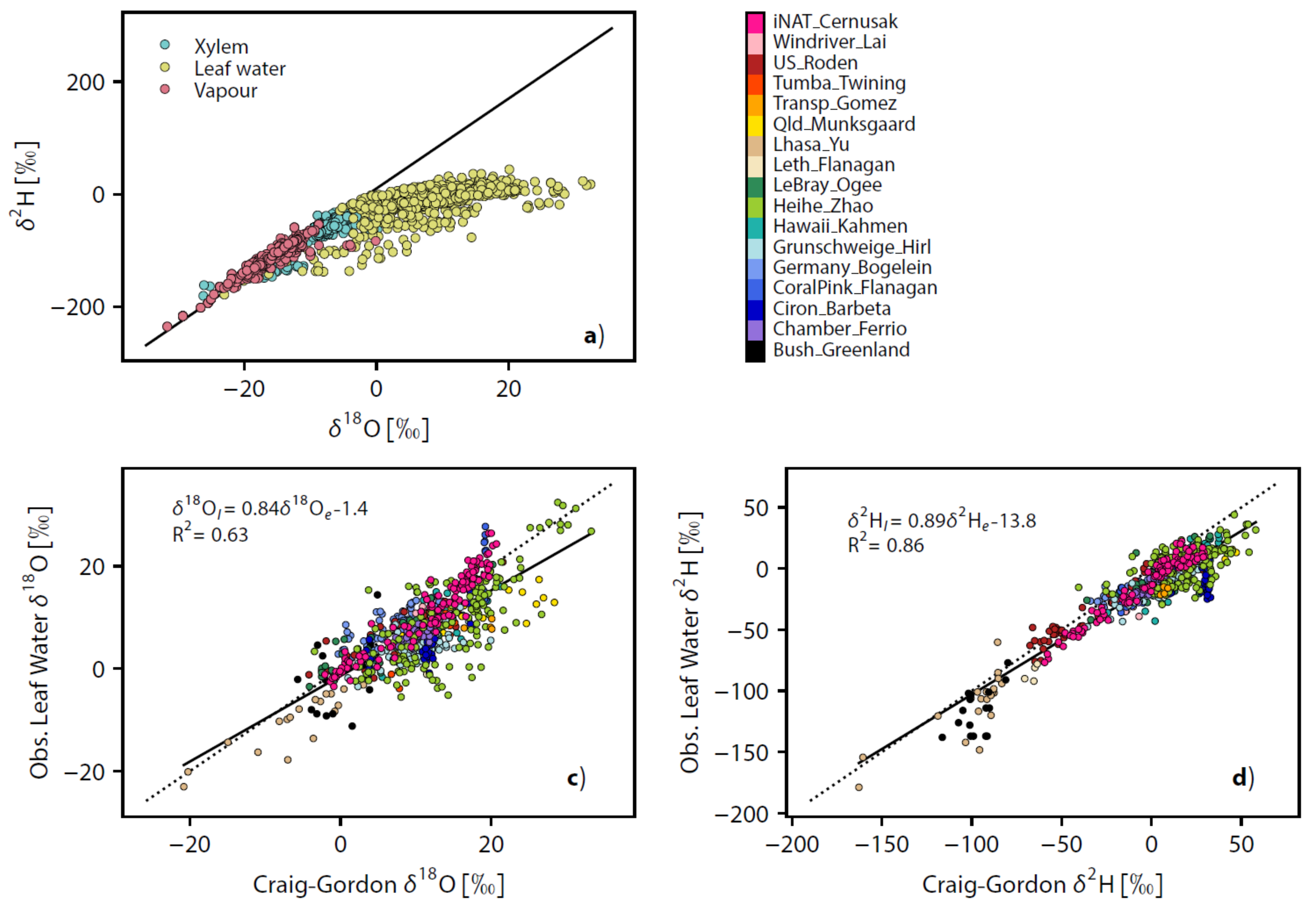

Figure 1. *(a) δ^2H plotted against $\delta^{18}O$ for xylem water, leaf water, and atmospheric vapour. Panels (c) and (d) show the observed isotopic composition of leaf water plotted against that predicted by the Craig-Gordon equation for $\delta^{18}O$ and δ^2H, respectively.*

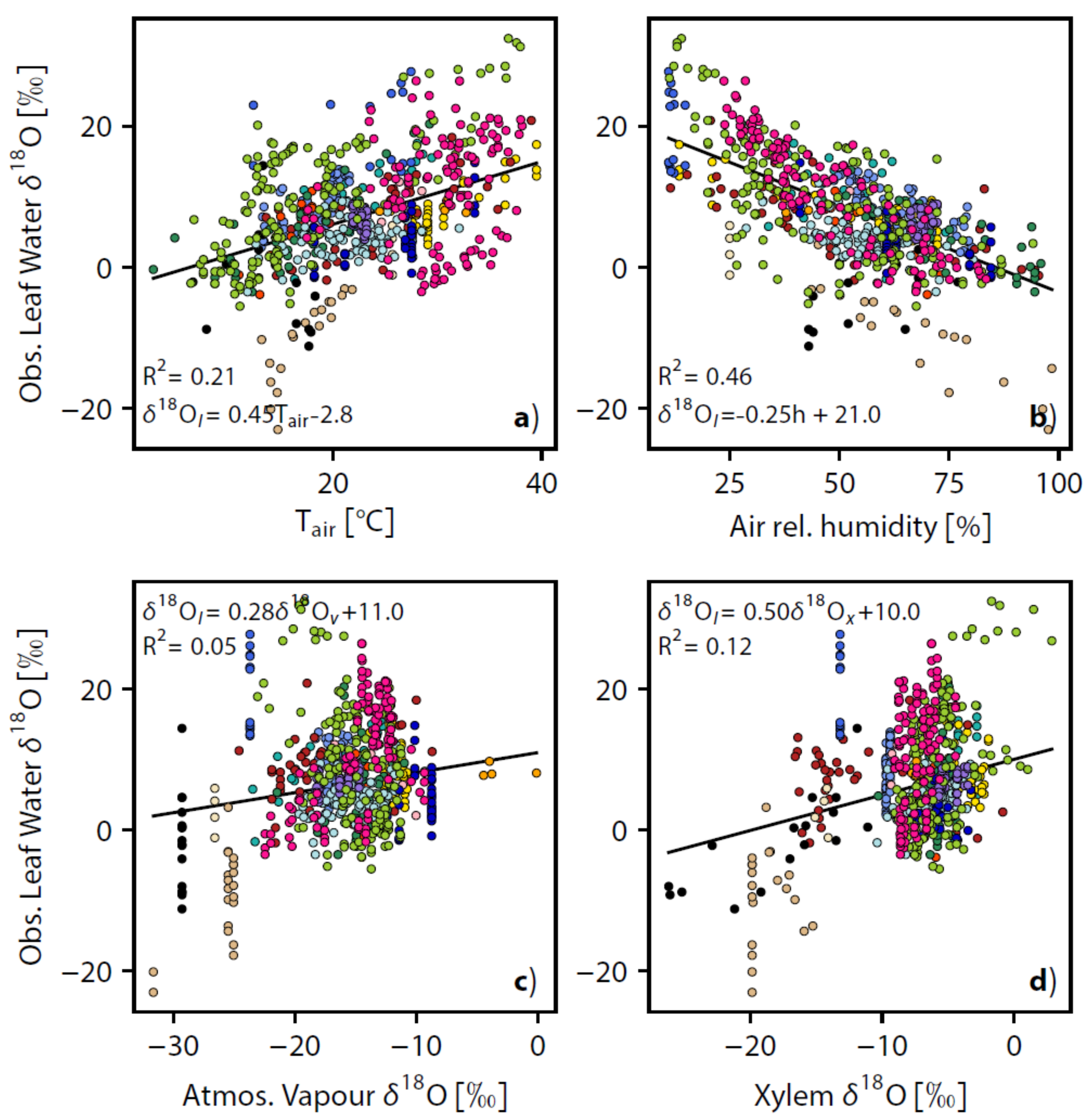

Figure 2. *Observed leaf water $\delta^{18}O$ plotted against the individual variables which enter the Craig-Gordon equation.*

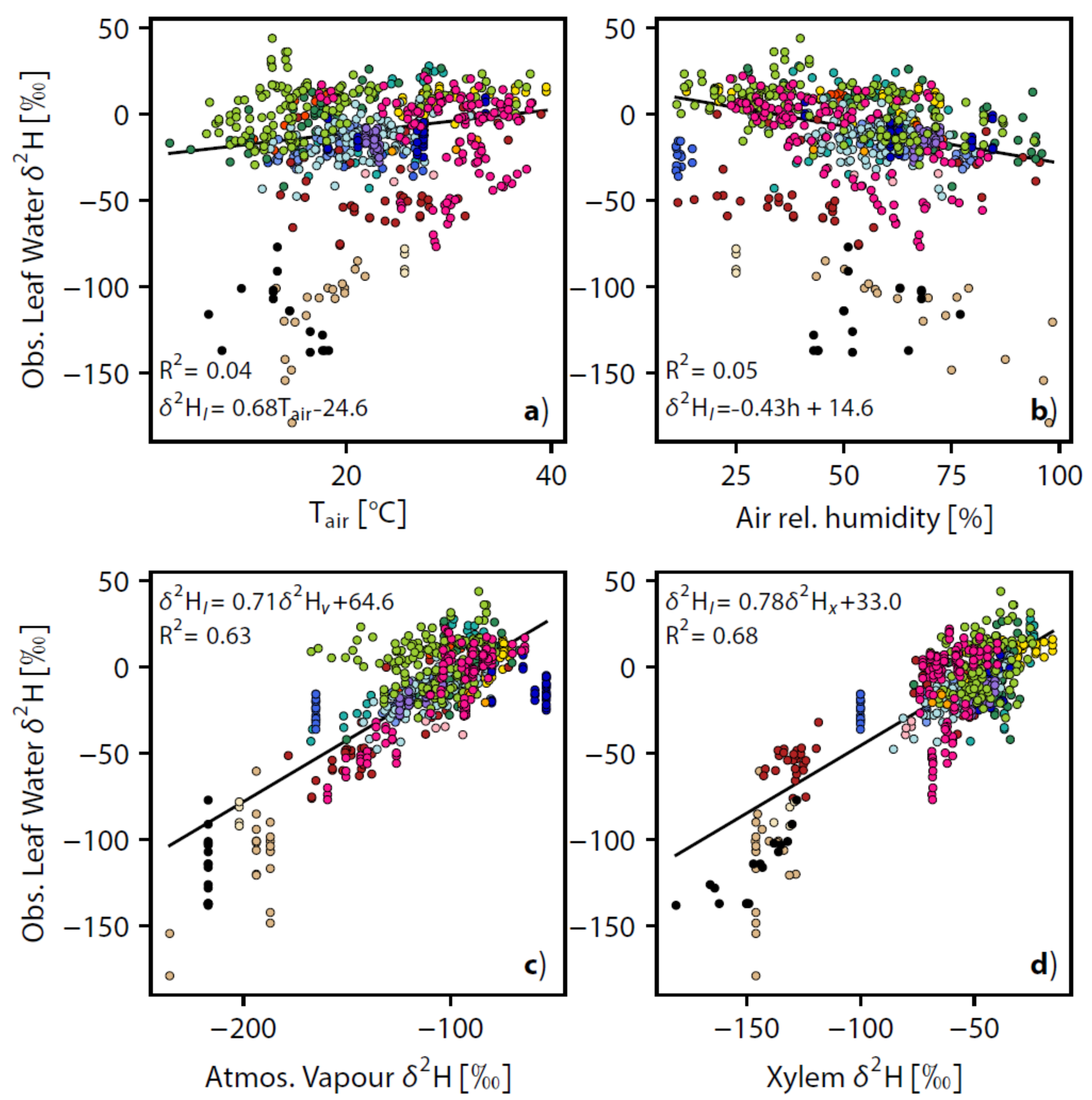

Figure 3. *Observed leaf water δ^2H plotted against the individual variables which enter the Craig-Gordon equation.*

Results contd.

- The Craig-Gordon equation was a good predictor of leaf water stable isotope composition, explaining 86% of variation in δ^2H and 64% of variation in $\delta^{18}O$ (Figure 1).
- The Craig-Gordon equation uses as inputs the isotopic composition of xylem water and atmospheric vapour, air temperature and relative humidity. We tested bivariate relationships between each of these and leaf water δ^2H and $\delta^{18}O$.
- For $\delta^{18}O$, the strongest relationship was with relative humidity (Figure 2). For δ^2H, the strongest relationship was with xylem water δ^2H (Figure 3).

Conclusions

- Leaf water δ^2H and $\delta^{18}O$ are not simply mirror images in the environmental information that they carry, with crucial implications for interpretation of downstream isotopic biomarkers.
- Leaf water δ^2H is most strongly influenced δ^2H of xylem water and/or atmospheric vapour, whereas leaf water $\delta^{18}O$ is most strongly influenced by relative humidity.

Further information


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