PLANT FUNCTIONAL TYPE-SPECIFIC AND TEMPORALLY RESOLVED ISOTOPIC ET-PARTITIONING

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SCIENTIFIC BACKGROUND

Representation of processes

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TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Research question

Can a better representation of ET partitioning using water stable isotopes improve CLM 5.0 simulations for ecosystems representing specific plant functional types (PFT)?

- Agricultural land - temperate — DE – TERENO/ICOS Selhausen
- Agricultural land - mediterranean — FR – OZCAR/ICOS ass. Auradé
- Evergreen forest - temperate — DE – TERENO/ICOS Wüstebach
- C3 - Grassland — DE – TERENO/ICOS Rollesbroich

OZCAR eLTER FRANCE

SCIENTIFIC BACKGROUND

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Ecosystem ET, E and T

$$ET = E + T$$

Partitioning of $ET \rightarrow \frac{T}{ET}$ $[-]$

E, T, and ET spatially and temporally variable

High global $\frac{T}{ET}$ uncertainty $(13\%$ to $90\%)$ depending on data source and modelling method (Rothfuss et. al 2021)

MEASUREMENT METHODS

Representation of processes

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Measurement approach

Measurements of δ_E, δ_T and δ_{ET} for PFTs (^{18}O and ^{2}H)

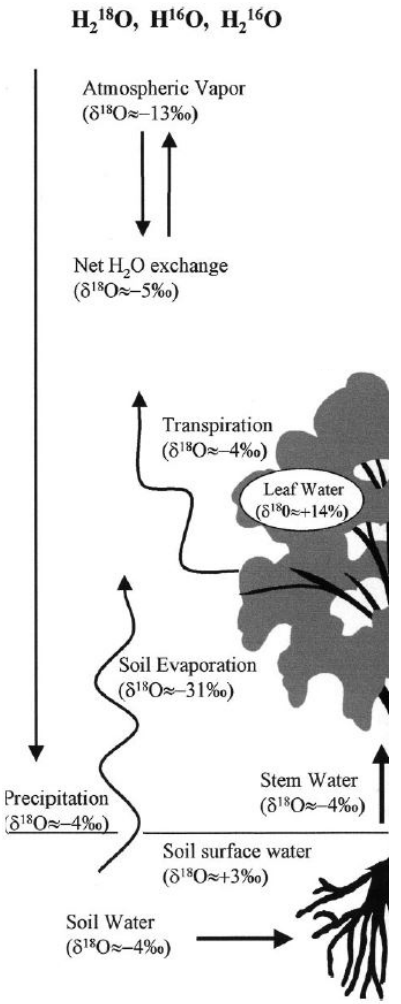
Thermodynamic and kinetic fractionation → heterogenous δ_E, δ_T distributions

Water balance + isotopic mass balance (Yakir and Sternberg, 2000):

$$ET = E + T$$

$$\delta_{ET} = \left(1 - \frac{T}{ET}\right)\delta_E + \left(\frac{T}{ET}\right)\delta_T$$

$$\frac{T}{ET} = \frac{\delta_{ET} - \delta_E}{\delta_T - \delta_E}$$



Yakir and Sternberg (2000)

MEASUREMENT METHODS

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Measurement approach

δ_E estimation

- Phase 1: Soil sampling → cryogenic extraction
- Phase 2: Semipermeable tubing

δ_T estimation

- Phase 1: Plant xylem sampling → cryogenic extraction
- Phase 2: Gas exchange plant chambers

MEASUREMENT METHODS

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Measurement approach

δ_{ET} estimation (spatiotemporal)

- Vertical and horizontal in-canopy air sampling
- Direct measurements with Picarro L2140-i IRIS
- Calibration with isotopically depleted water and tap water as standards

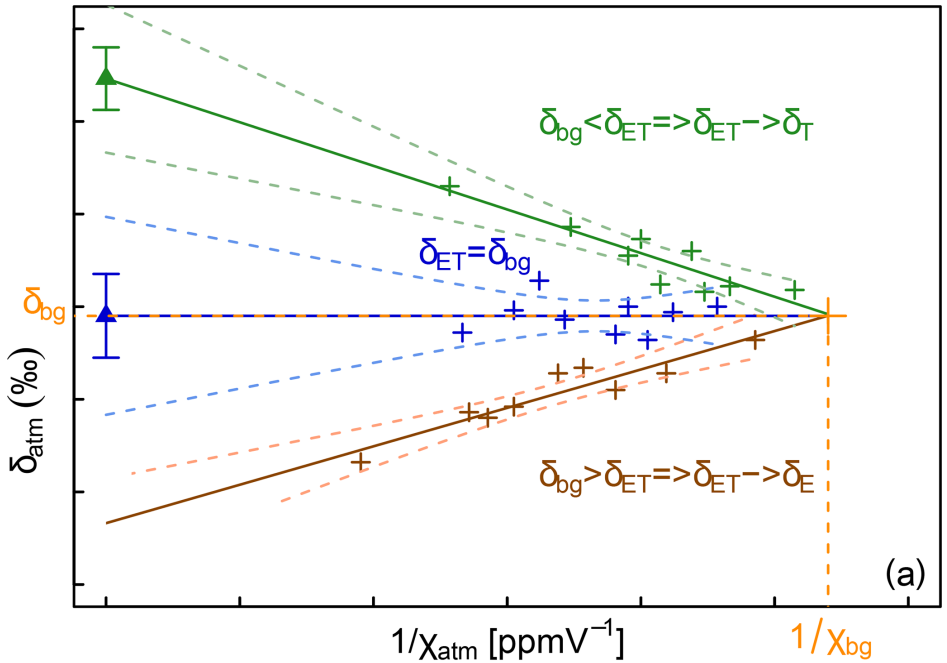
MEASUREMENT METHODS

Keeling plot technique

$$\delta_{atm} = \frac{1}{X_{atm}}[X_{bg}(\delta_{bg} - \delta_{ET})] + \delta_{ET}$$

Slope:

- Positive → δ_{ET} dominated by δ_E
- 0 → δ_{ET} equal to δ_{bg} (atmospheric background air)
- Negative→ δ_{ET} dominated by δ_T



(Rothfuss et. al, 2021)

FIRST RESULTS

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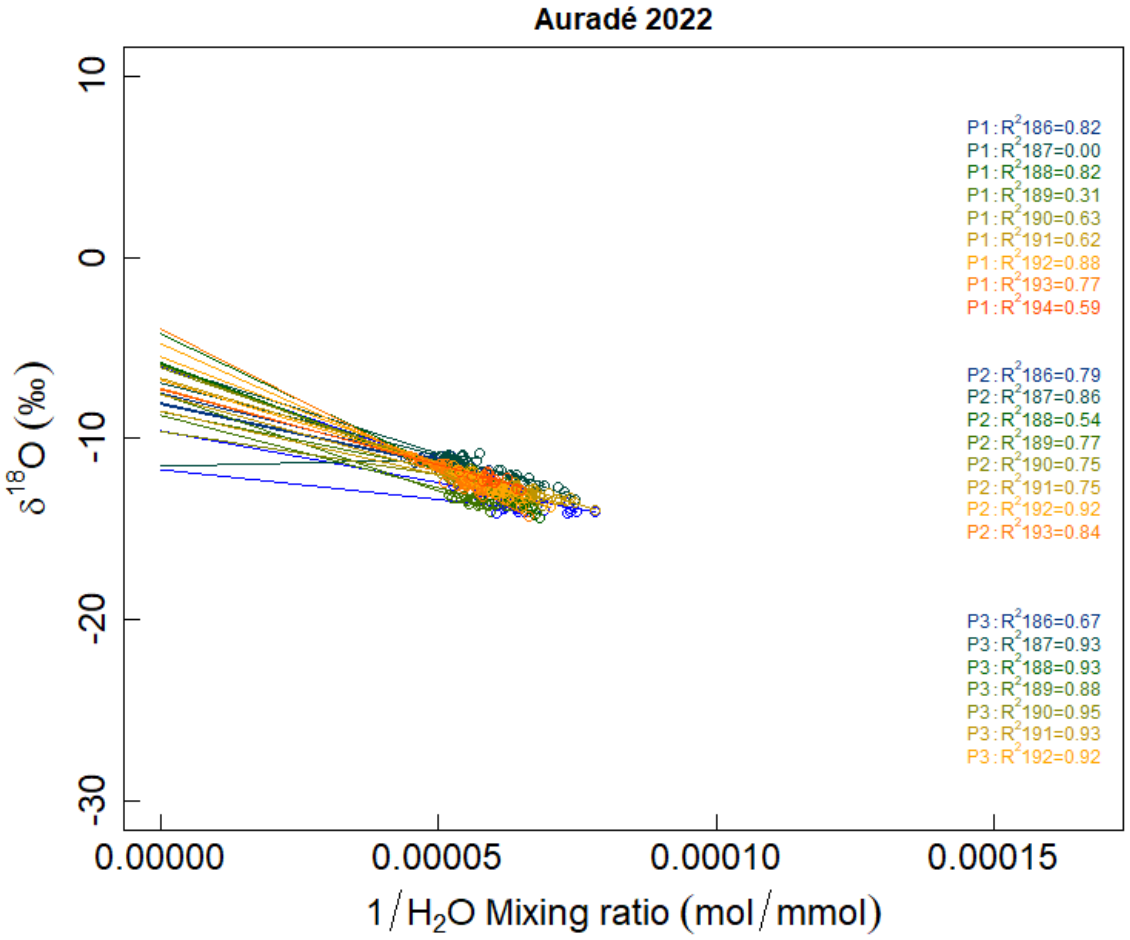
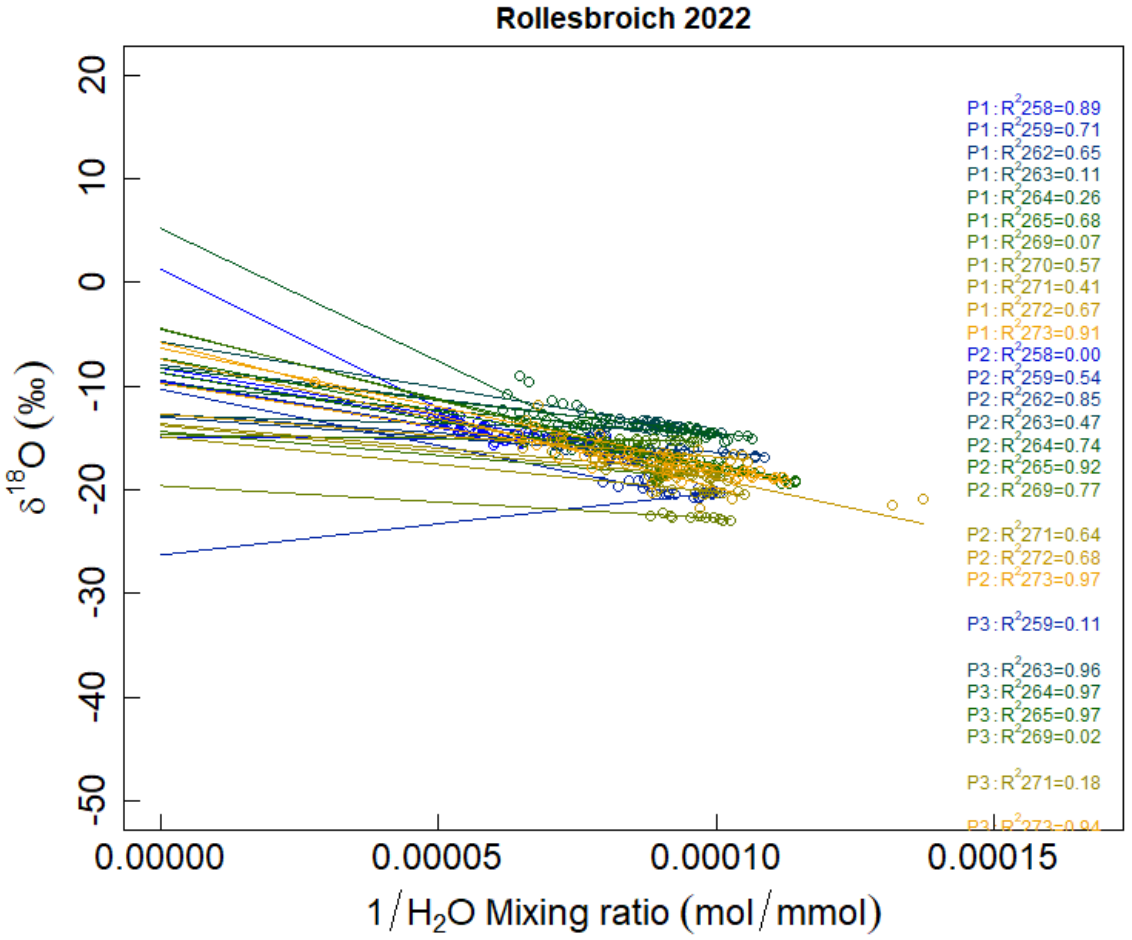
Keeling plot - example



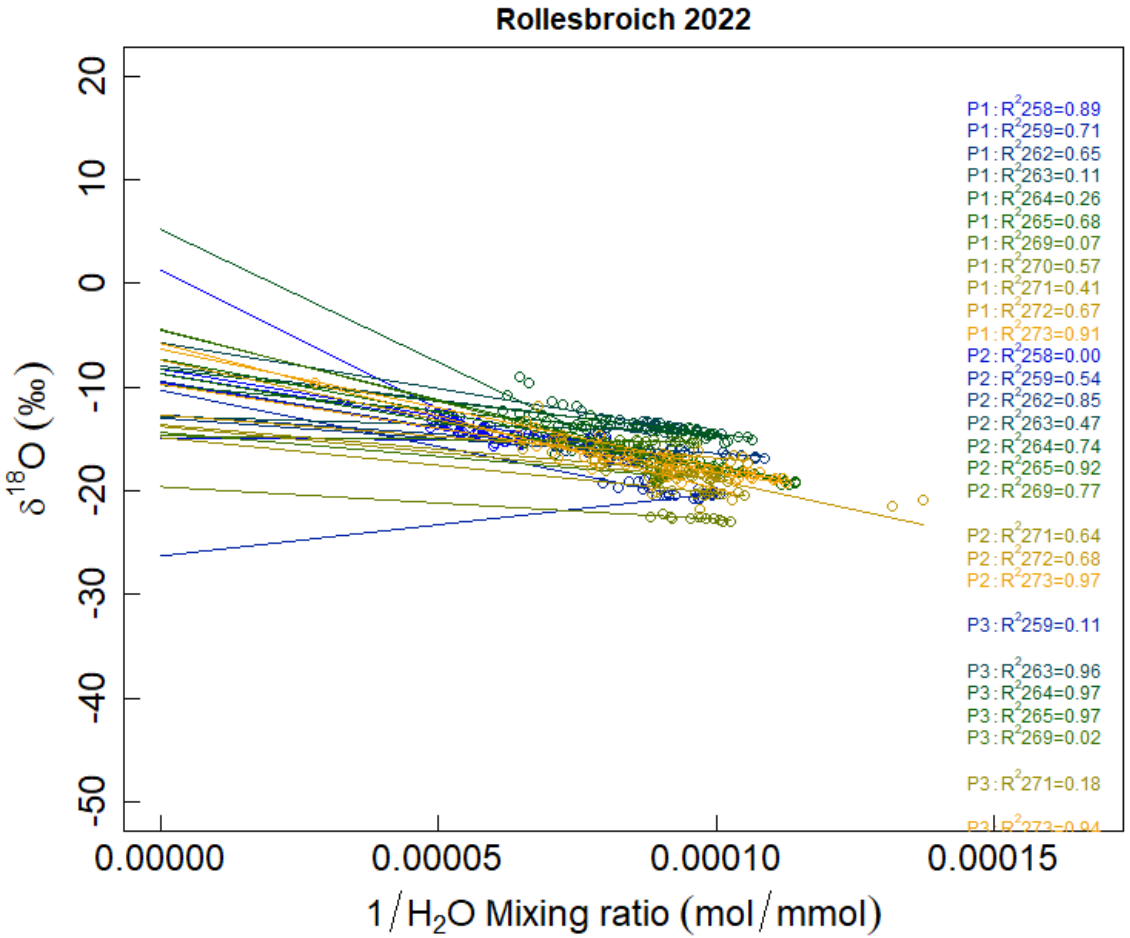


FIRST RESULTS

Keeling plot - example

Selection of meaningful profiles for δ_{ET}:

- Measured water vapor concentrations
- $R^2 > 0.9$



FIRST RESULTS

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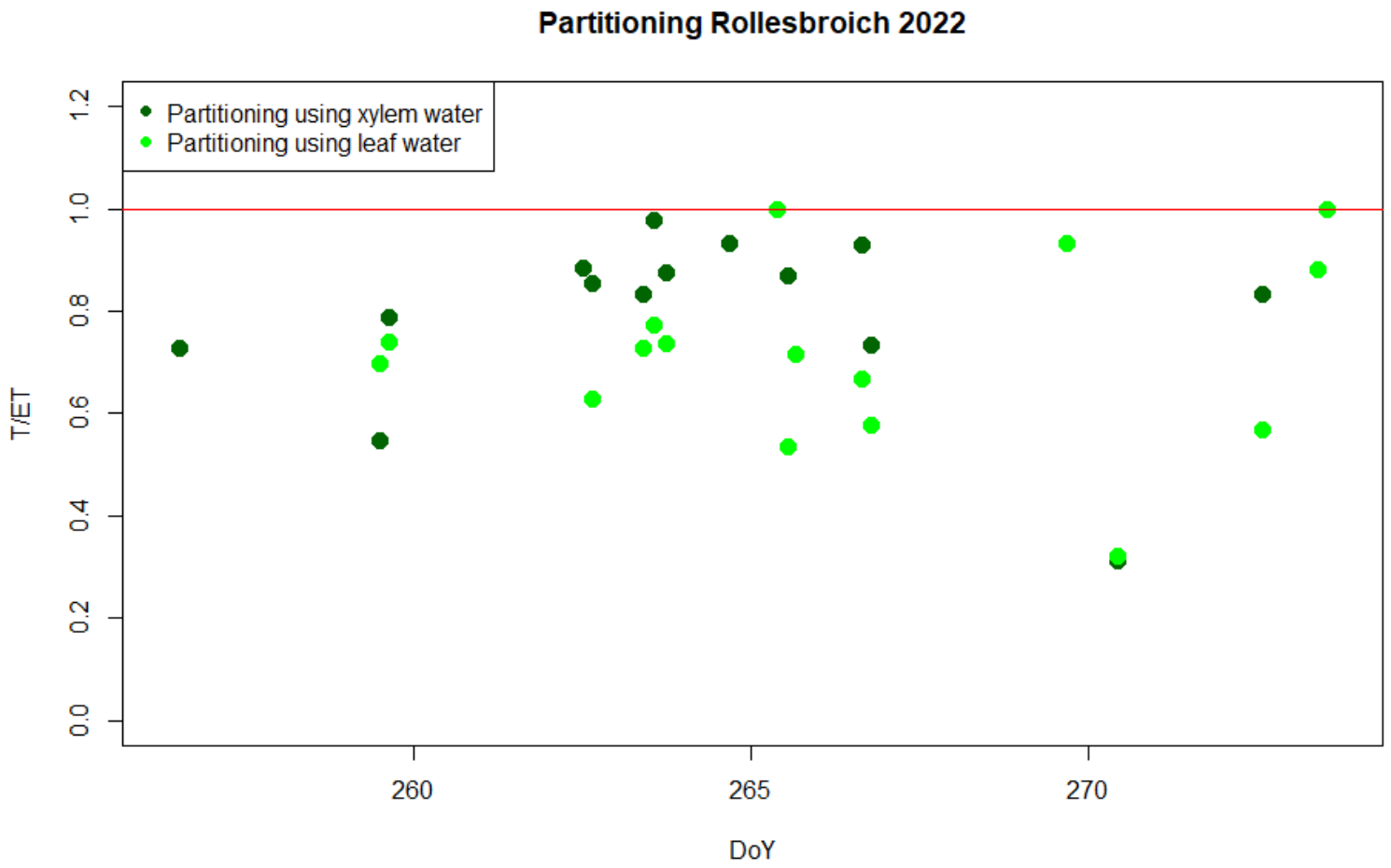
Partitioning

Keeling-plot: δ_{ET}

Sampling, cryogenic extraction and offline isotopic analysis:

δ_E and δ_T

$$\frac{T}{ET} = \frac{\delta_{ET} - \delta_E}{\delta_T - \delta_E}$$



GOING FORWARD

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Data analysis

- Verification using non-isotopic measurements (micro-lysimeters, sap flow)
- EC high-frequency H_2O/CO_2 time series measurements (Scanlon and Kustas 2010)
- WUE → CO_2-uptake (photosynthesis) and H_2O-loss (transpiration) relationship
- Relationship between WUE and water vapor/CO_2 concentrations → $\frac{T}{ET}$ partitioning

GOING FORWARD

Representation of processes

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Field campaigns

- Implementation of non-destructive measurement techniques for δ_E and δ_T
- Continuation of field campaigns $\rightarrow \frac{T}{ET}$ - seasonal continuous time series for PFTs

THANK YOU FOR YOUR ATTENTION!

QUESTIONS?

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