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Tracing dew and fog water inputs into temperate grassland using stable water isotopes in the extreme summer 2018

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Using stable isotopes of water to trace the water cycle during dew formation and shallow ground radiation fog deposition

- ✓ Non-rainfall water inputs into grasslands were traced by isotopic dynamics of near-surface atmospheric water vapor
- ✓ Near-surface atmospheric water vapor was the main but not the only pathway of non-rainfall water inputs
- ✓ Internal cycle of water: water vapor form soil condenses back on foliage

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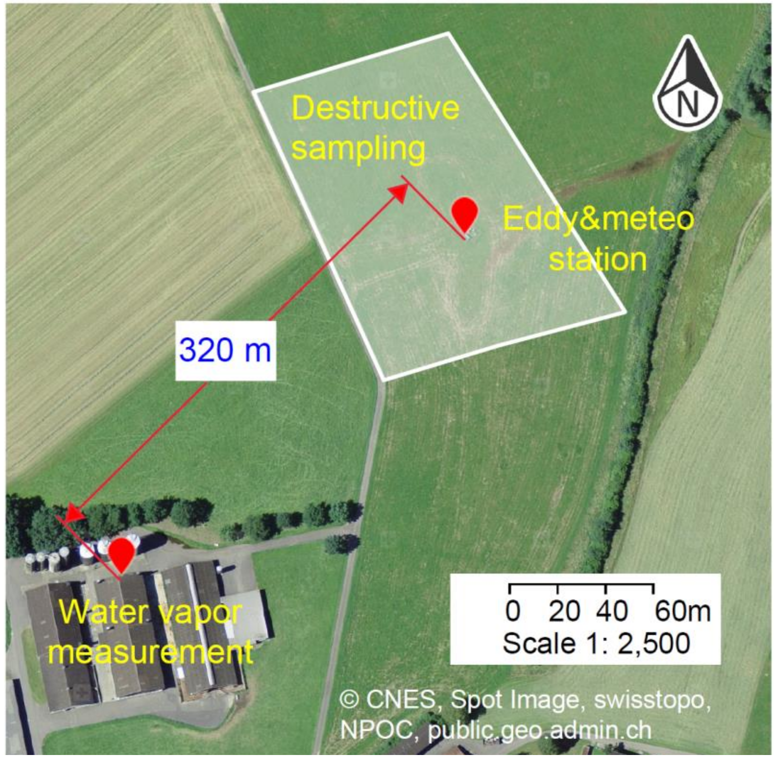
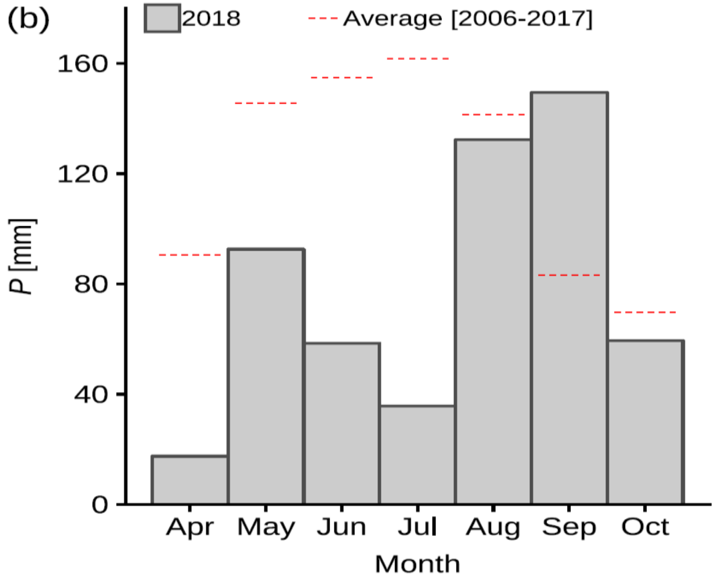
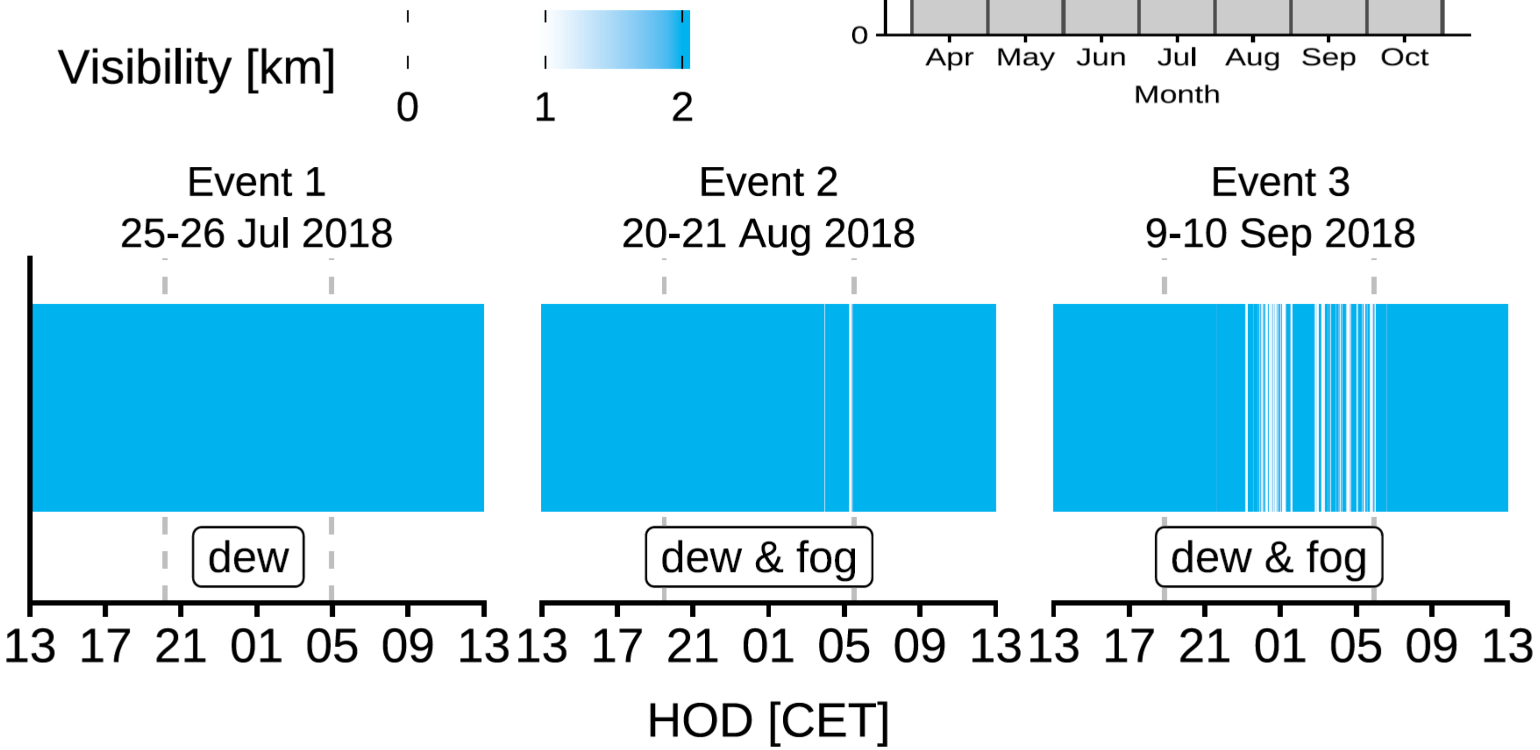
Experiment setup

- Study site: Swiss grassland in a valley bottom at 400 m a.s.l.
- Experiment setup
  - ✓ Isotopes of water vapor (6 m a.g.l.)
  - ✓ Isotopes of droplets on leaf
  - ✓ Eddy & meteo (2 – 2.4 m a.g.l.)
- Three observation campaigns in the extreme summer 2018



- Precipitation

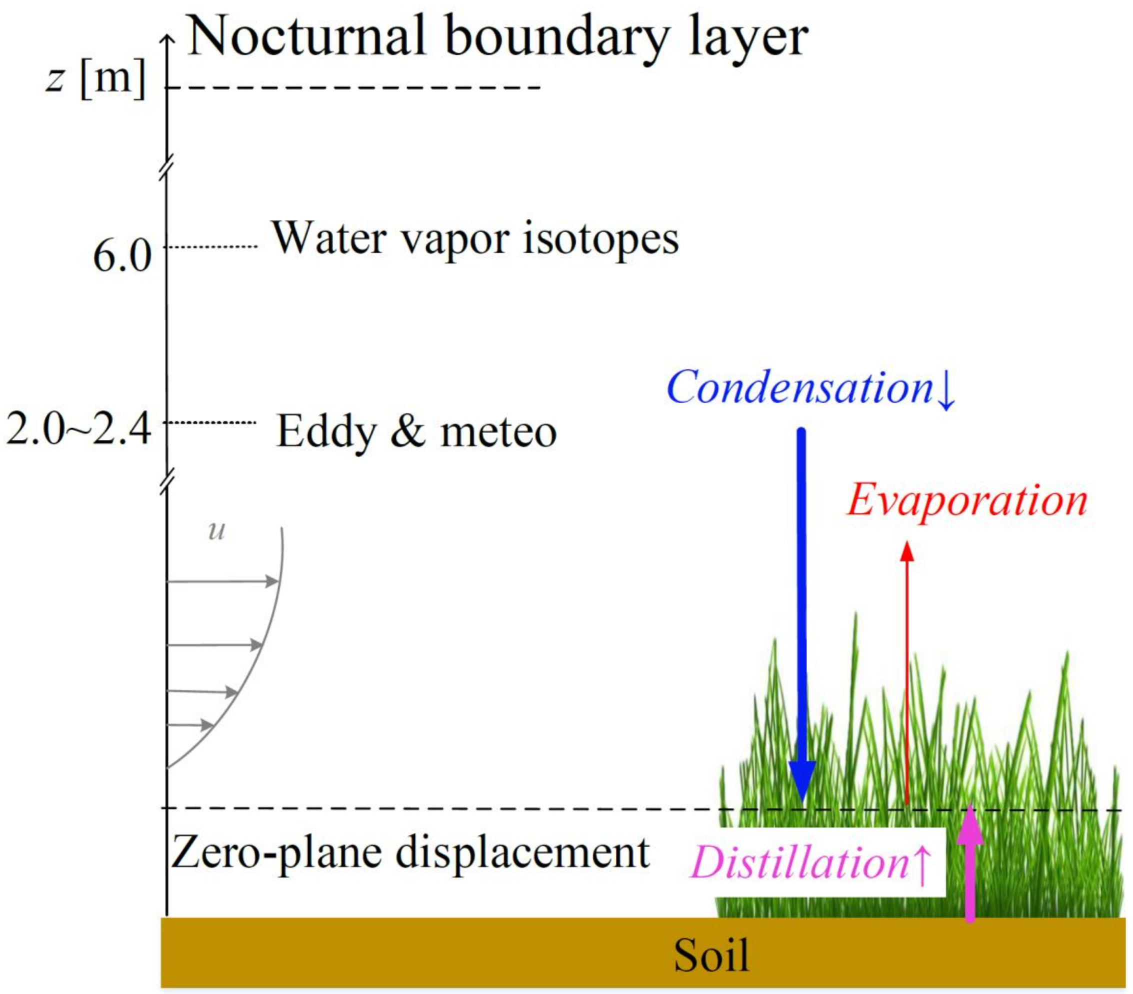




Water cycle during non-rainfall water inputs

During dew formation and shallow ground radiation fog deposition:

- Above zero-plane displacement, downward vapor flux from near-surface atmospheric water vapor condenses on leaf surfaces or close to ground atmosphere (*condensation↓*)
- Below zero-plane displacement, upward vapor flux from soil condenses on leaf surfaces (*distillation↑*)
- Condensation was accompanied by *evaporation* due to humidity gradient between surface and atmosphere

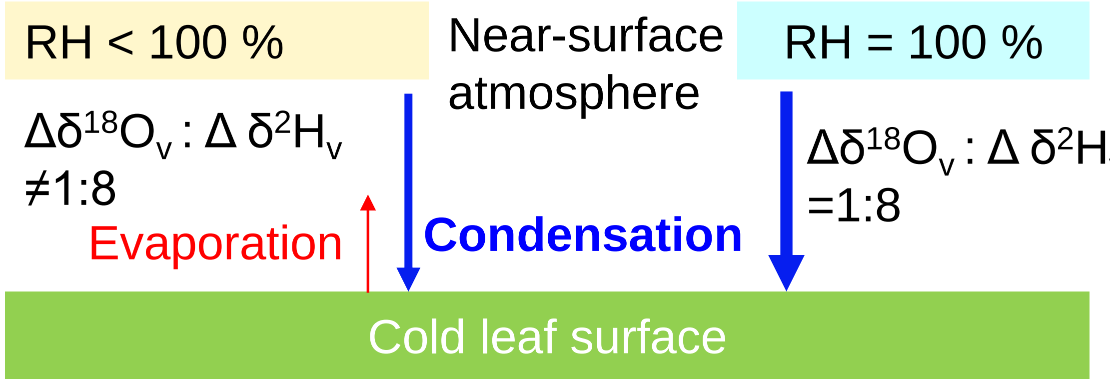


Isotopic dynamics of water vapor during non-rainfall water inputs

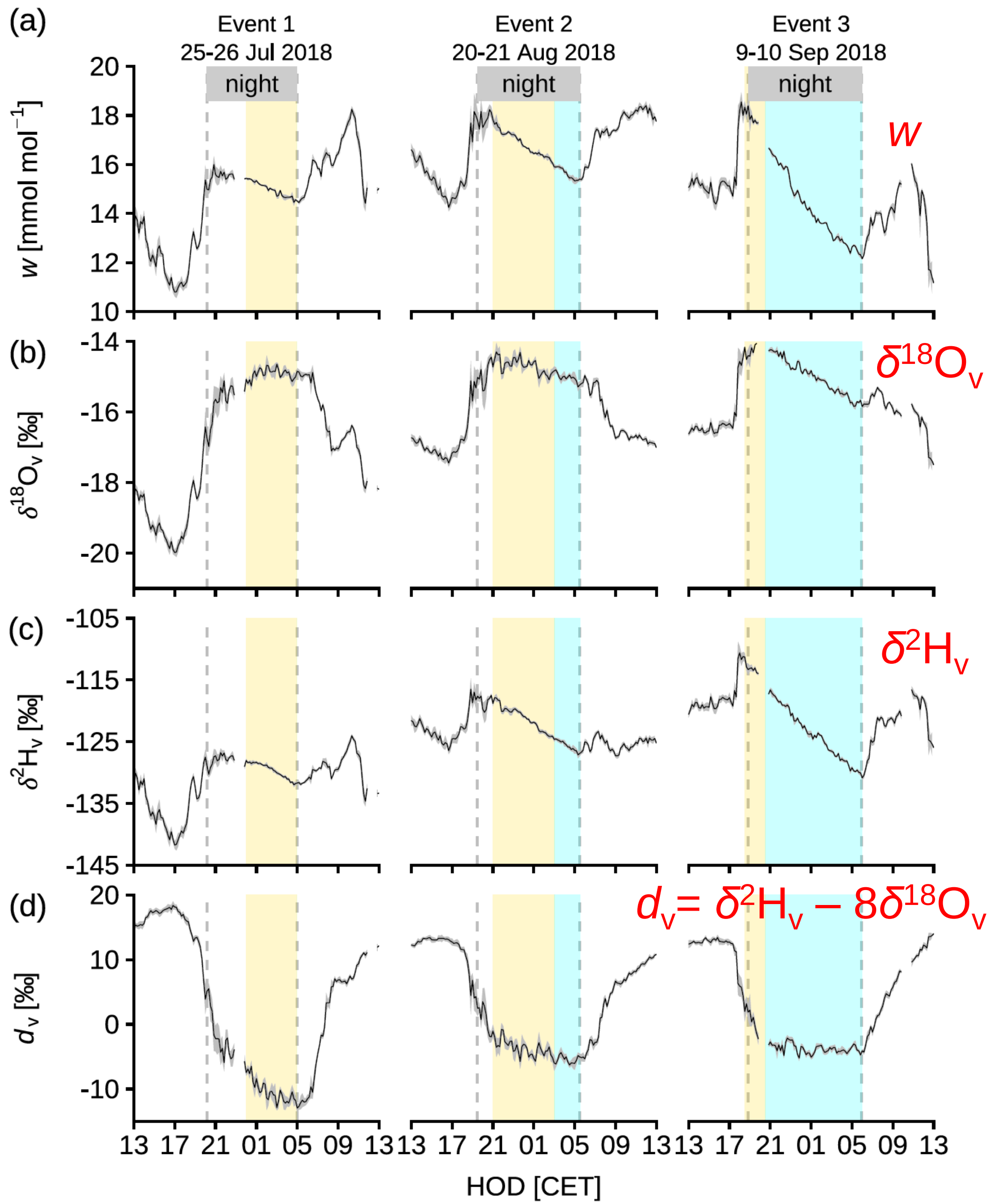
Non-rainfall water inputs into grasslands were traced by water vapor isotopes:

Water vapor	**nsaturated**	**saturated**
w (water vapor mixing ratio)	↓	↓
$\delta^{18}O_v$ *	Fluctuating	↓
$\delta^{2}H_v$*	Slight ↓	Faster ↓
d_V	↓	Constant

*In the roughly 2 h before sunset, decreased $\delta^{18}O_v$ indicated that evaporated vapor $\delta^{18}O_E$ was more enriched than $\delta^{18}O_v$, but evaporated vapor $\delta^{2}H_E$ was not significantly different from $\delta^{2}H_v$, thus under unsaturation, evaporation caused $\delta^{18}O_v$ fluctuation, but weak disturbance on $\delta^{2}H_v$.



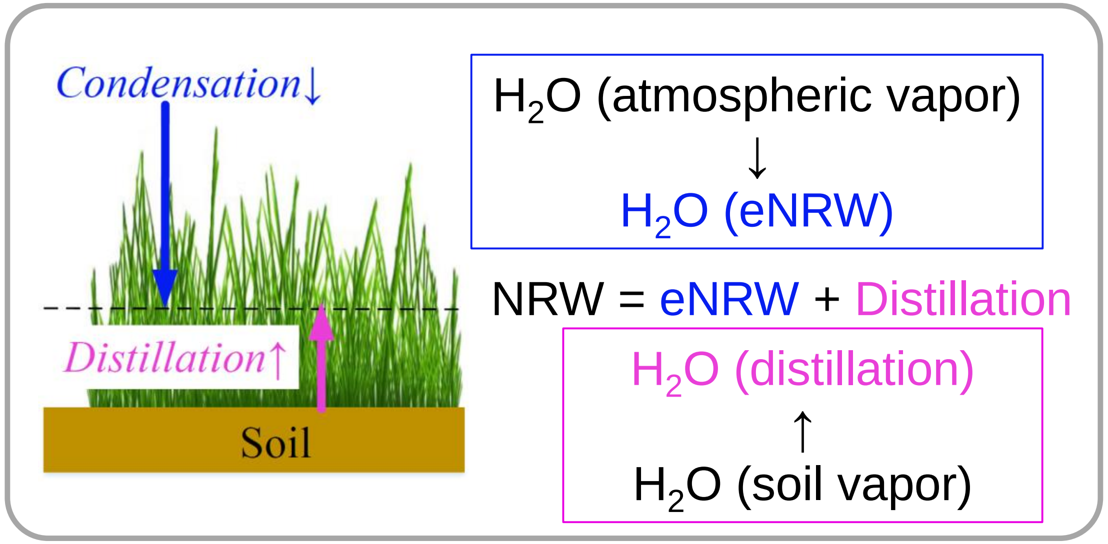
(Horita and Wesolowski, 1994; Majoube, 1971; Dansgaard,1964)



Two pathways of non-rainfall water inputs

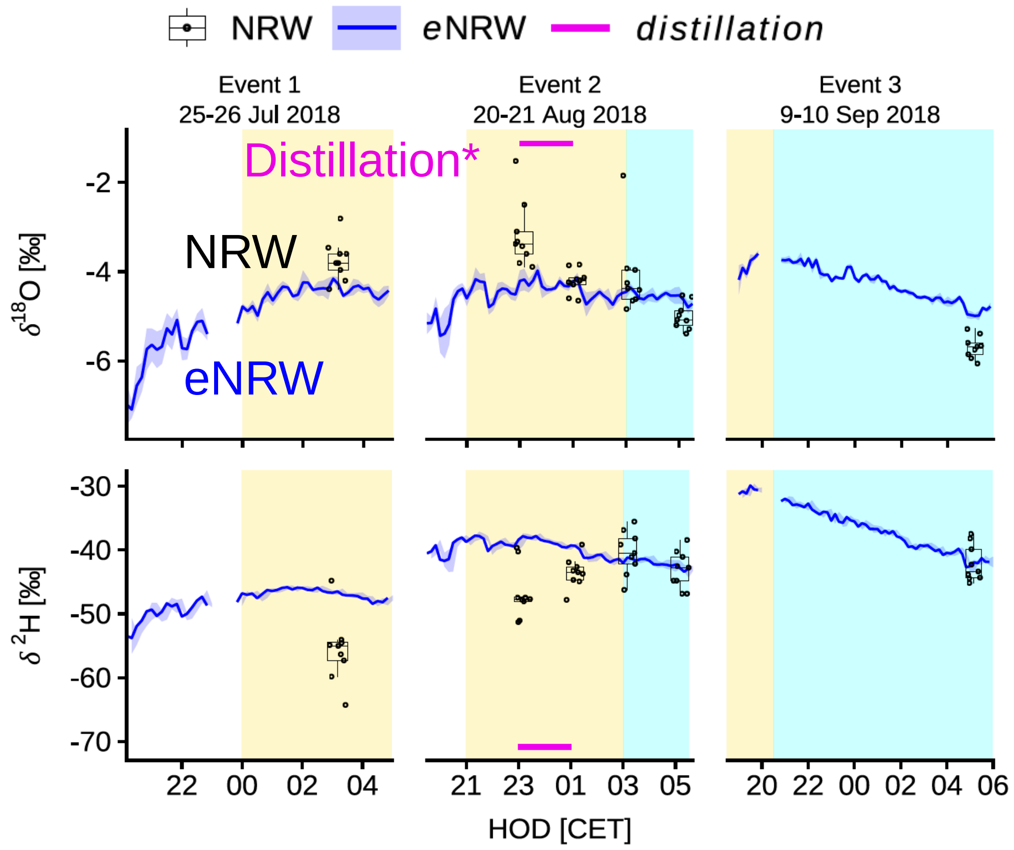
The difference of δ between NRW and eNRW indicated **two pathways of non-rainfall water inputs**:

- *Condensation*↓: flux from atmospheric water vapor (as main pathway)
- Distillation↑: vapor flux from soil (internal recycling)
- With increased RH, condensation↓ became stronger, thus Distillation↑ contribution became smaller due to stronger condensation↓



(Monteith, 1958; Horita and Wesolowski, 1994; Majoube, 1971; Stull, 1988)

- NRW: non-rainfall water taken from leaf surfaces
- eNRW: equilibrium liquids of atmospheric water vapor
- Distillation: vapor from soil condenses on foliage



*δ of distillation was estimated from the δ of NRW and eNRW under unsaturation, and was roughly assumed constant.

Conclusion

- **Dew formation and shallow ground radiation fog deposition** in temperate grassland under summer drought were confirmed by liquid and vapor isotopes

- Non-rainfall water inputs transform water source that are sparingly accessible by plants into water accessible to plants
  - ✓ Near-surface atmospheric water vapor as the main source
  - ✓ Water vapor from soil (distillation) — thus internal recycling of water — is expected to be more important than previously thought in dew formation

- Future study should investigate whether this internal recycling (distillation) is sufficiently important to make deeper soil water available to plants that would otherwise not be accessible via plant roots