Comparison of lysimeter and scintillometer data with reference evapotranspiration

Lysimeter and soil water management: drought – irrigation – yield stability

19th Lysimeter conference,13.-14. April 2021, AREC Raumberg-Gumpenstein

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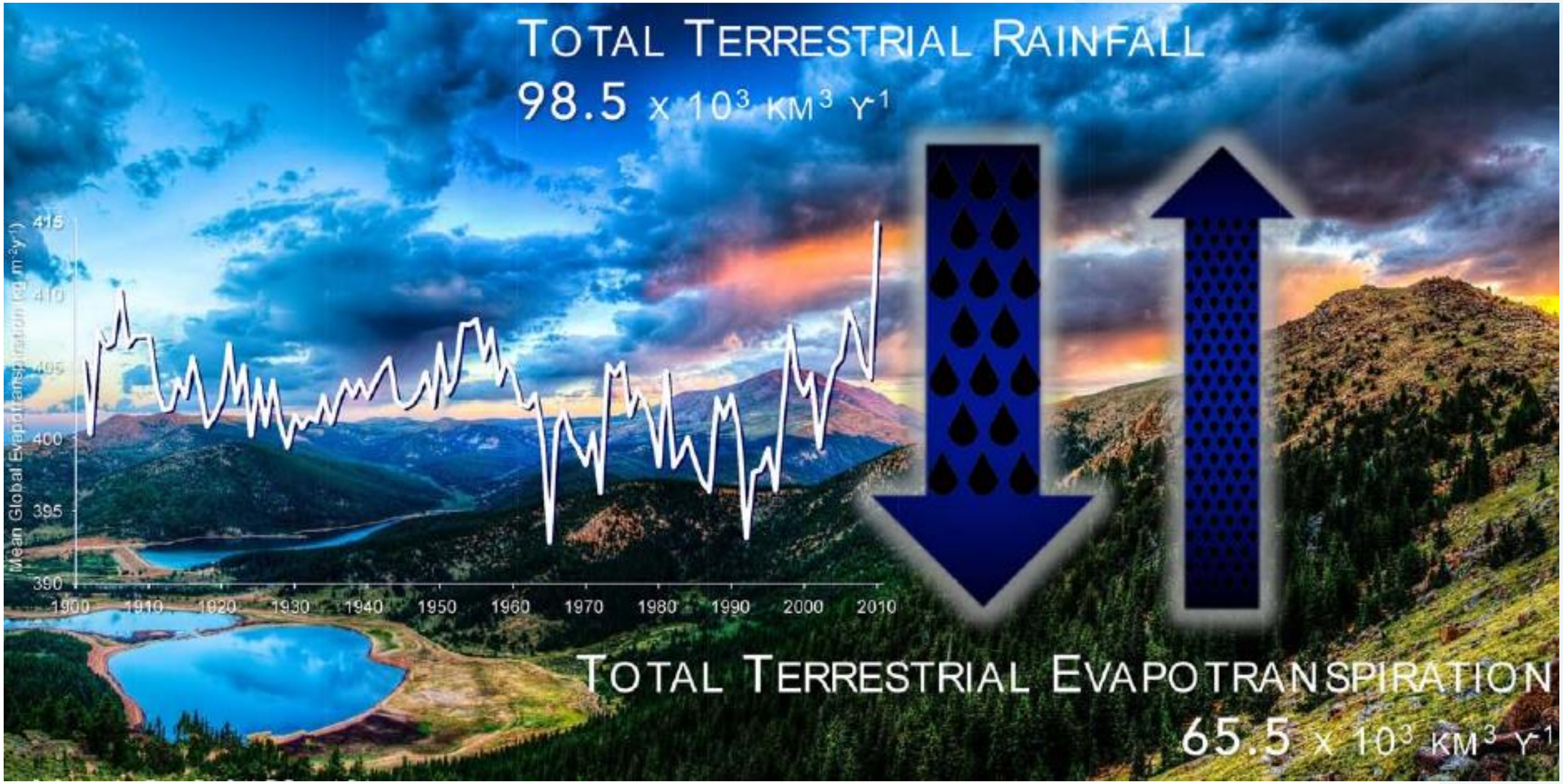
Irdning-Donnersbachtal, 13. April 2021

Motivation

Terrestrial evapotranspiration (ET) consumes two-thirds of total global terrestrial precipitation



Fisher et al. 2013

Motivation

Evapotranspiration (ET)-based science cross-cuts across all the five U.S. National Research Council Decadal Survey panels and all five of the working groups

PANELS

WORKING GROUPS	*ET relevance*	I Weather: Minutes to Sub-seasonal	II Climate Variability & Change	III Marine & Terrestrial Ecosystems	IV Global Hydrological Cycle & Water Resources	V Earth Surface & Interior
A	Extreme Events	Latent heat flux	Ecosystem resilience	Drought-induced mortality	Flash droughts	
B	Water Cycle	Cloud formation, turbulence	Latent heat flux, surface wetting/drying	Plant functioning	Land-atmosphere water flux	Reduction from volcanic CO_2 degassing
C	Carbon Cycle	Surface roughness	Ecosystem resilience	Transpiration-photosynthesis tradeoff	Ecosystem regulation of water cycle	Reduction from volcanic CO_2 degassing on soil respiration
D	Technology & Innovations Cross-Cut	Thermal infrared, VSWIR	Thermal infrared, VSWIR	Thermal infrared, VSWIR	Thermal infrared, VSWIR	Thermal infrared, VSWIR
E	Applications' Science Cross-Cut	Improving weather predictions	Ecosystem management	Agriculture, rangeland management	Water resources management	Advance detection of volcanic activity

Fisher et al. 2013

Evapotranspiration

Computational approaches

1. Direct approaches

A. Field Water Balance Approach → **Lysimeter**

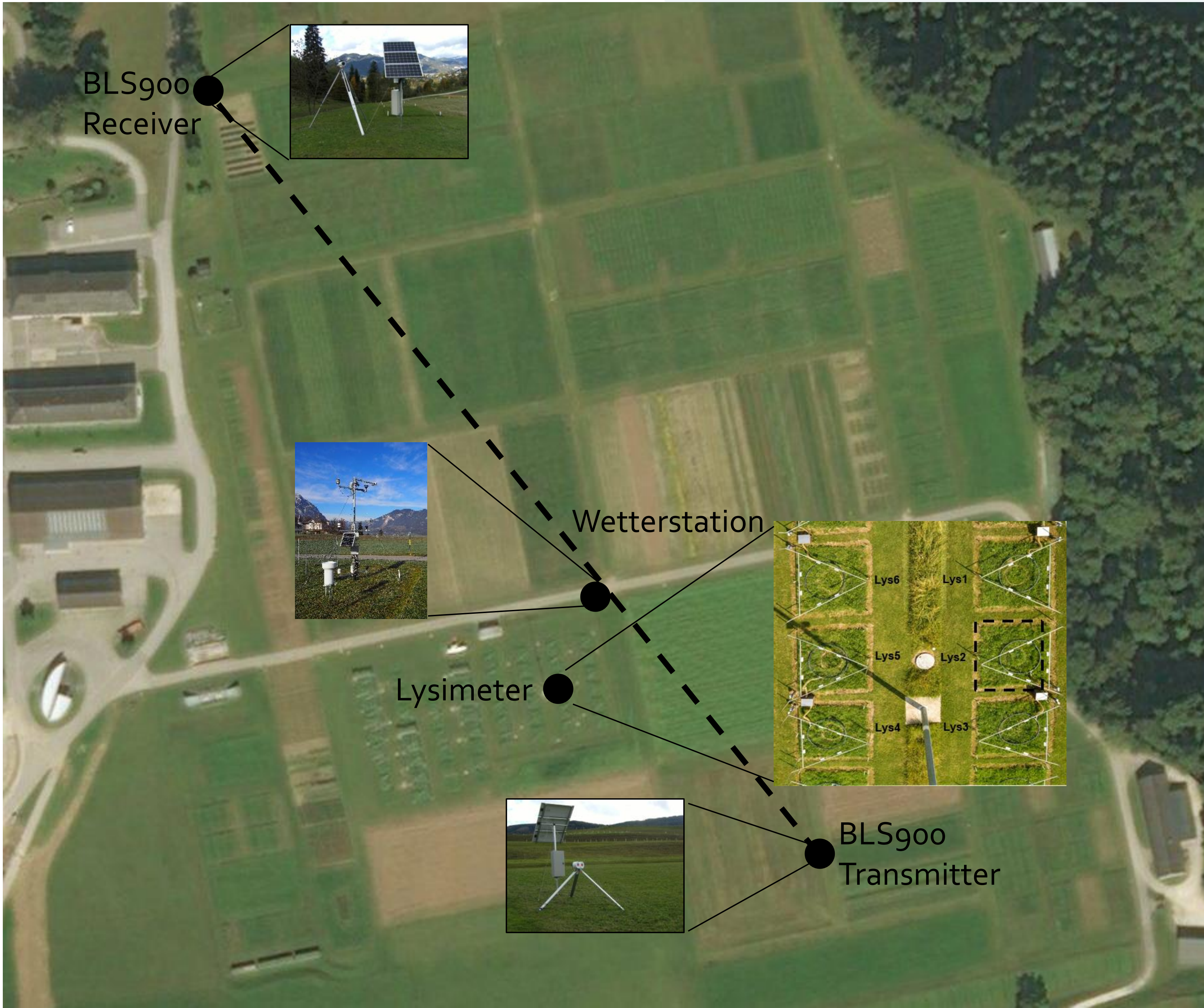
B. Soil Moisture Depletion Approach

2. Indirect approaches

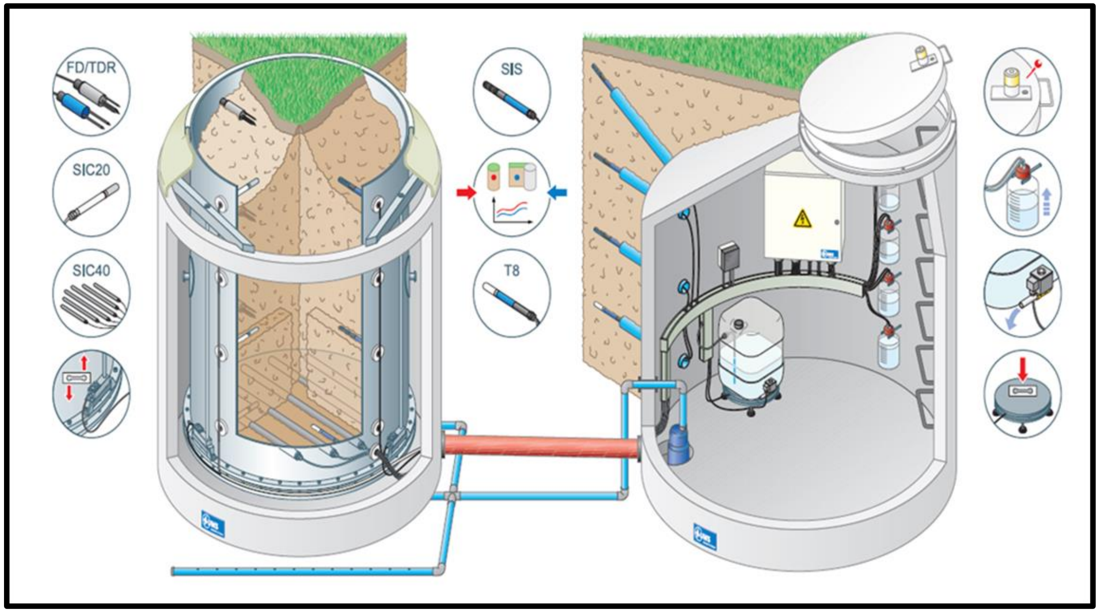
A. Empirical/ Statistical Methods

B. Micrometeorological methods → **Scintillometer** – energy balance; **Penman-Monteith equation** – ET_o, ET_c

C. Remote Sensing Methods


BLS900
Receiver
Wetterstation
Lys6
Lys1
Lys5
Lys2
Lys4
Lys3
Lysimeter
BLS900
Transmitter

Lysimeter



→ Seepage water weight via a 50 liter tank
→ Temporal resolution 1 min
→ Precision 100 g

Scintillometer

Scintec BLS900 Large Aperture Scintillometer

Transmitter

$$LE = R_n - H - G$$

LE is the latent heat flux

R_n is the net radiation,

H is the sensible heat flux

G is the soil heatflux

$$ET = LE/\lambda$$

λ is the latent heat of vaporization

Penman-Monteith equation

Crop evapotranspiration (ET_c):

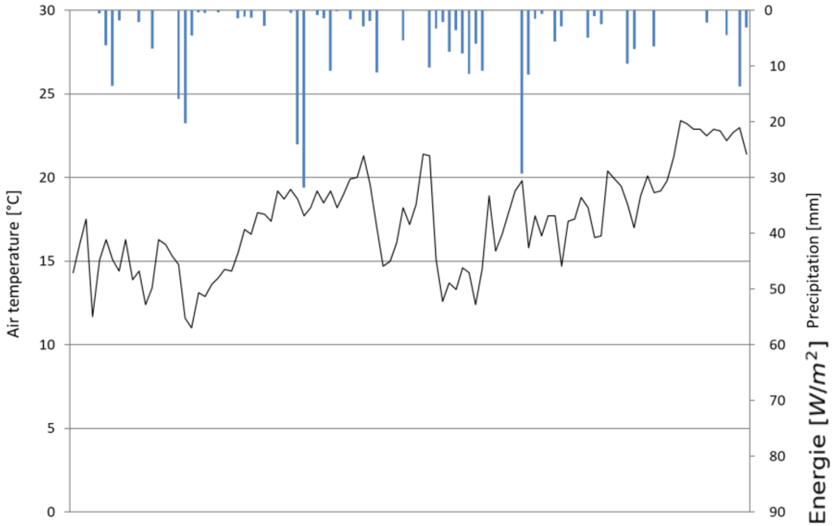
$$ET_c = \frac{\Delta(R_n - G) + \rho_a c_p (e_s - e_a)/r_a}{\lambda\left[\Delta + \gamma(1 + \frac{r_s}{r_a})\right]} \quad (1)$$

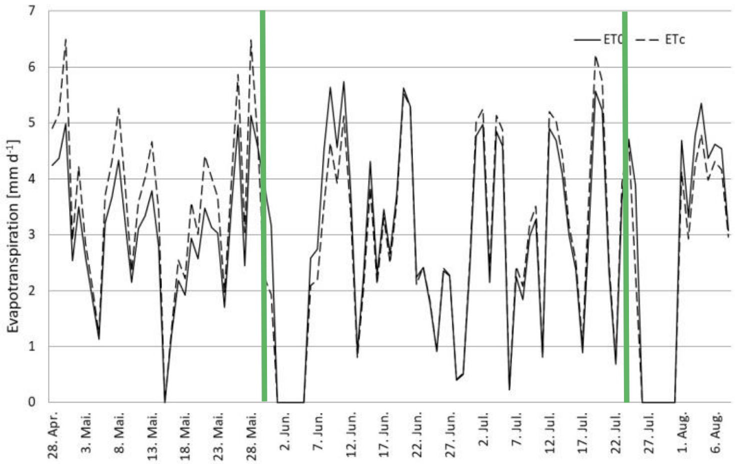
where ET, R_n and G are in MJm^{-2} d^{-1}; Δ is the slope of the saturation vapor pressure temperature relationship (kPa°C^{-1}); ρ_a is the air density (kg m^{-3}), c_p is the specific heat of air (MJkg^{-1}°C^{-1}); γ is psychrometric constant (kPa°C^{-1}); r_a and r_s are the aerodynamic and surface resistances (ms^{-1})

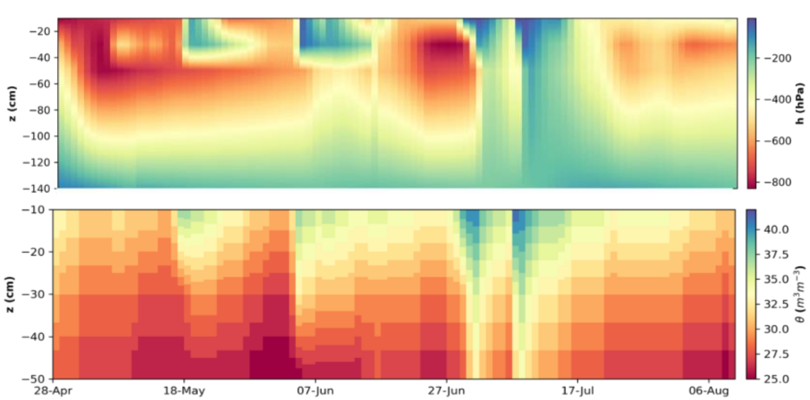
Reference evapotranspiration (ET_o):

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{37}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (2)$$

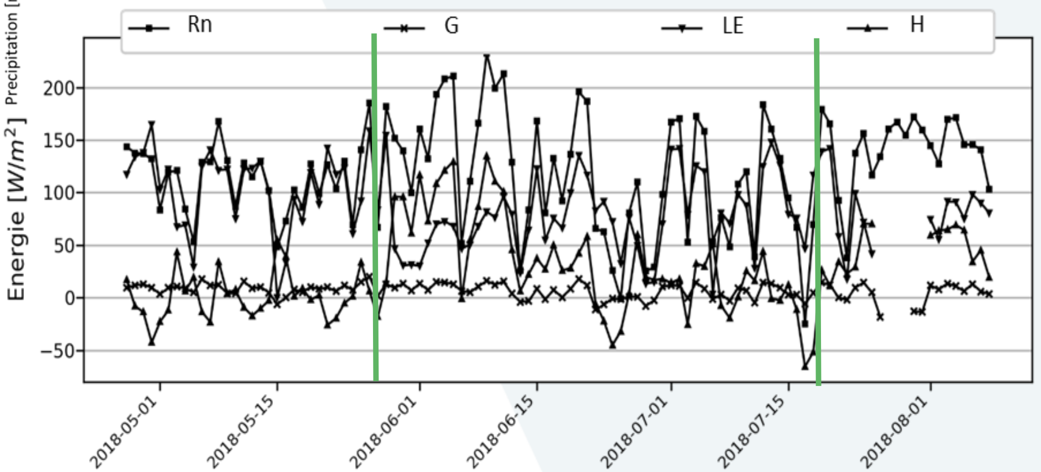
ET_o is derived from equation 2, assuming a grass height of 12 cm, LAI of hcrop * 24 and rs of 70 (sm-1):





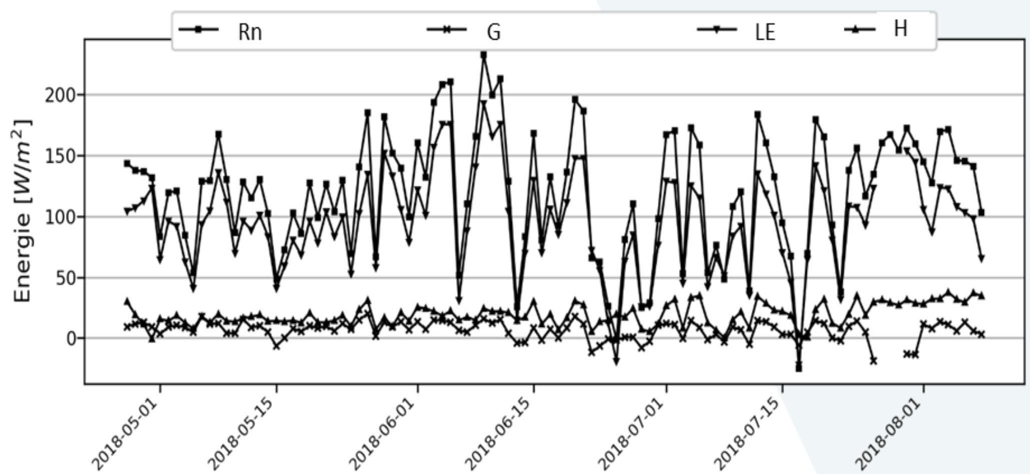


Lysimeter



Rn net radiation; G soil heat flux; LE latent heat flux, ; H sensible heat flux

Scintillometer



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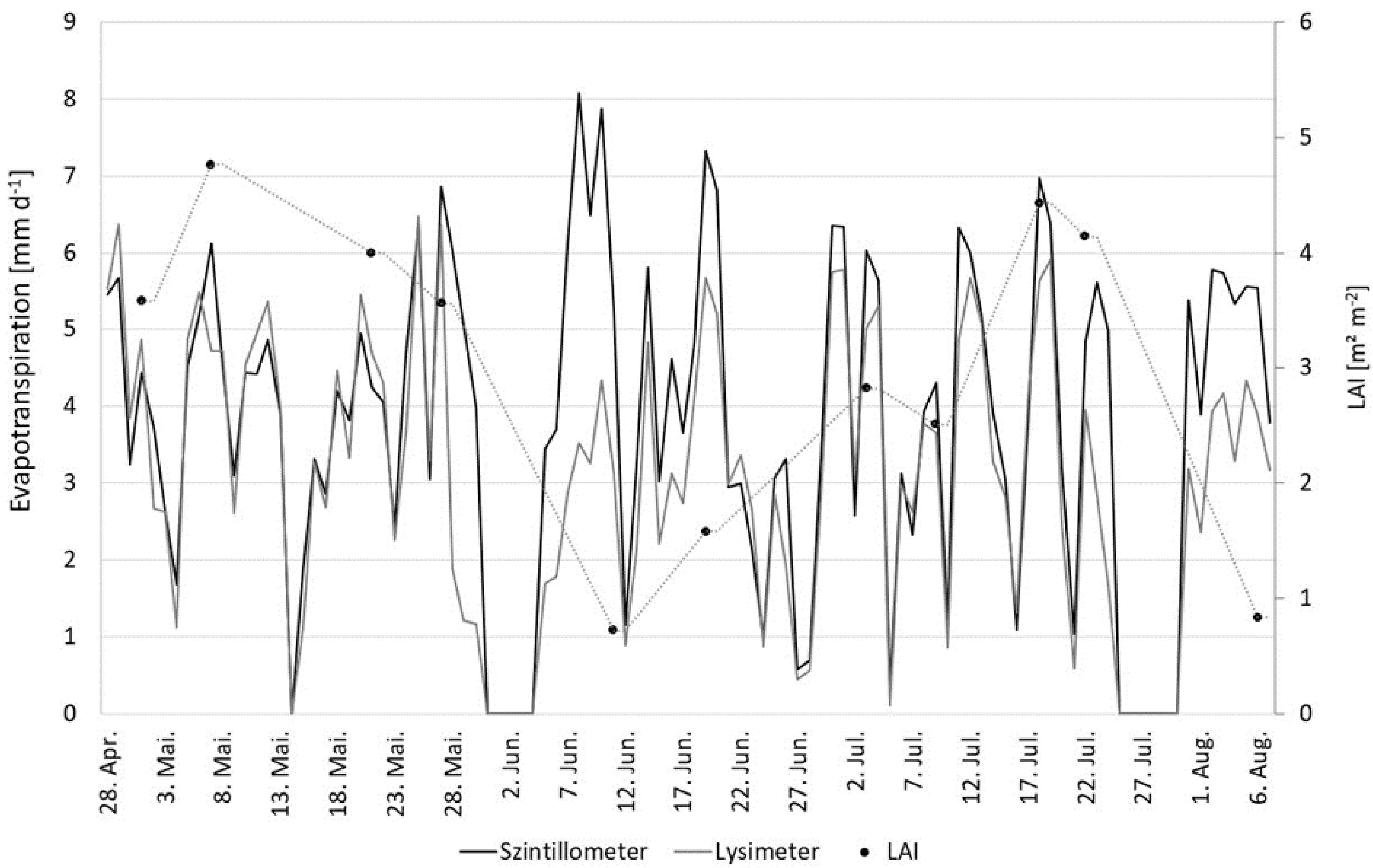
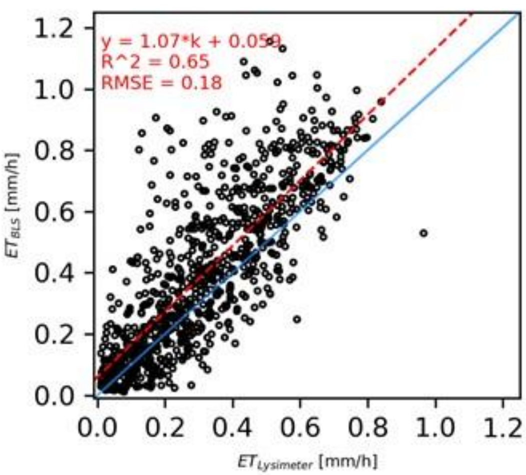
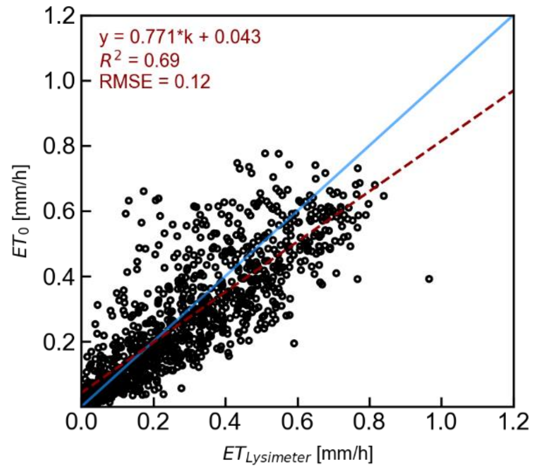
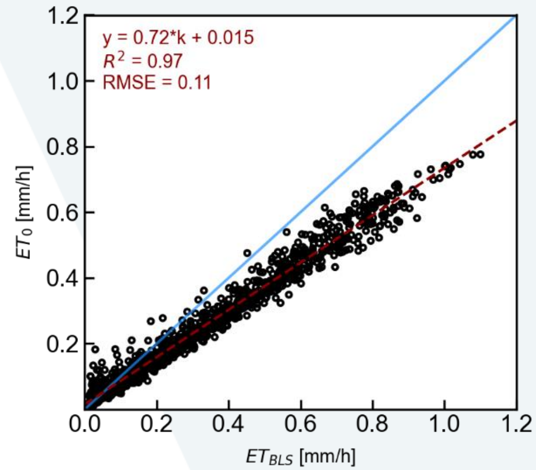
Results and Discussion

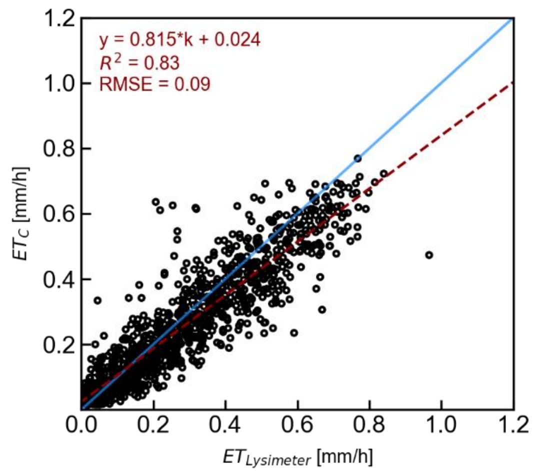


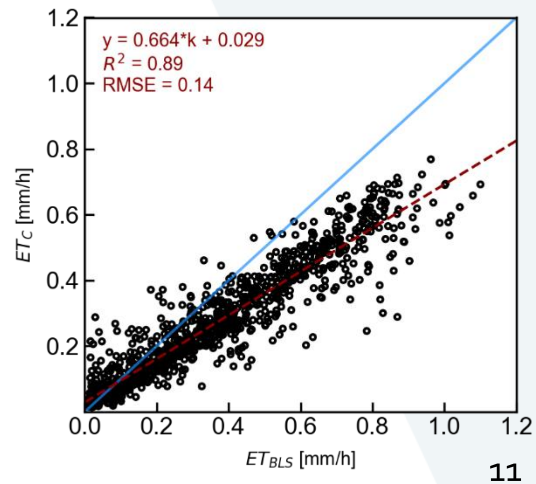
Results and Discussion











Conclusions and outlook

- Data from a lysimeter and a scintillometer were compared with data from two reference evapotranspiration methods (ET_c, ET_0)
- In the period April-August 2018, ET_c showed the best fit with the lysimeter ET (r^2=0.83), whereas ET_0 correlated best with the scintillometer ET (r^2=0.97)
- These relationships can be attributed to the different consideration of the LAI and the growth height in the two different methods
- As a possible consequence, the ET_0 method could be used to estimate ET for heterogeneous grassland stands and ET_c for homogeneous ones

→ further datasets must be analysed to be able to consolidate this conclusion

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Thank you for your attention!

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