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EGU 2020 – HS6.1

Evapotranspiration estimation using remote sensing and in-situ methods

Different methods to derive evapotranspiration from lysimeter measurements

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Background

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- **Weighing lysimeters** are able to precisely measure **actual evapotranspiration** and **precipitation**

- A common approach ("Method 1") uses precipitation measurements by **external standard gauges** and determine $ET = P_{PG} – L – \Delta S$ for certain time steps

  - This method implicates **precipitation gauge errors** which are transferred to ET calculation (e.g., due to wind loss, wetting loss, evaporation loss and due to in- and out-splashing water drops)

  - Measuring errors can be reduced by a larger area of the measuring gauge´s surface and positioning the collecting vessel at ground level → **measuring P with lysimeter**

P…Precipitation *ET…Evapotranspiration*
L…Leachate *ΔS… Diff. soil water storage*
P_{PG}…P measured with precipitation gauge

Background

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- Large weighing lysimeters are integrated into their typical surrounding and **avoid oasis effects**. Thus, lysimeter provide a **perfect situated measuring tool** for quantifying **precipitation** by measuring the **positive mass changes** as well as **evapotranspiration** by measuring the **negative mass changes** of the upper boundary fluxes in high accuracy and temporal resolution
- **Leachate** is measured separately
- This method implicates **external effects** (background noise, influence of vegetation and wind) which **affect the mass time series**.
- While the **background noise of the weighing is rather well known** and can be filtered out of the mass time series, the **influence of wind**, which blows through the vegetation and affects measured lysimeter mass, cannot be corrected easily since there is **no clear relation between wind speed and the measured outliers of lysimeter mass**. Moreover, the influence of random noise is dependent on the evaluation interval, lysimeter design, load cells etc.

Aim

- The aim of the presented work is to compare and **evaluate different methods** for the determination of **evapotranspiration out of lysimeter** measurements and how to deal with the **associated challenges**
- In the results a comparison of 2 different methods for a 3 year period of a lysimeter from Wagna test site (Austria) is given

Method 1

external precipitation gauge

$$ET = P_{PG} - L - \Delta S$$

Problem

measuring errors of P gauge are transferred to ET-calculation

This method implicates precipitation gauge errors (e.g., due to wind loss, wetting loss, evaporation loss and due to in- and out-splashing water drops), which are transferred to ET calculation.

P…Precipitation
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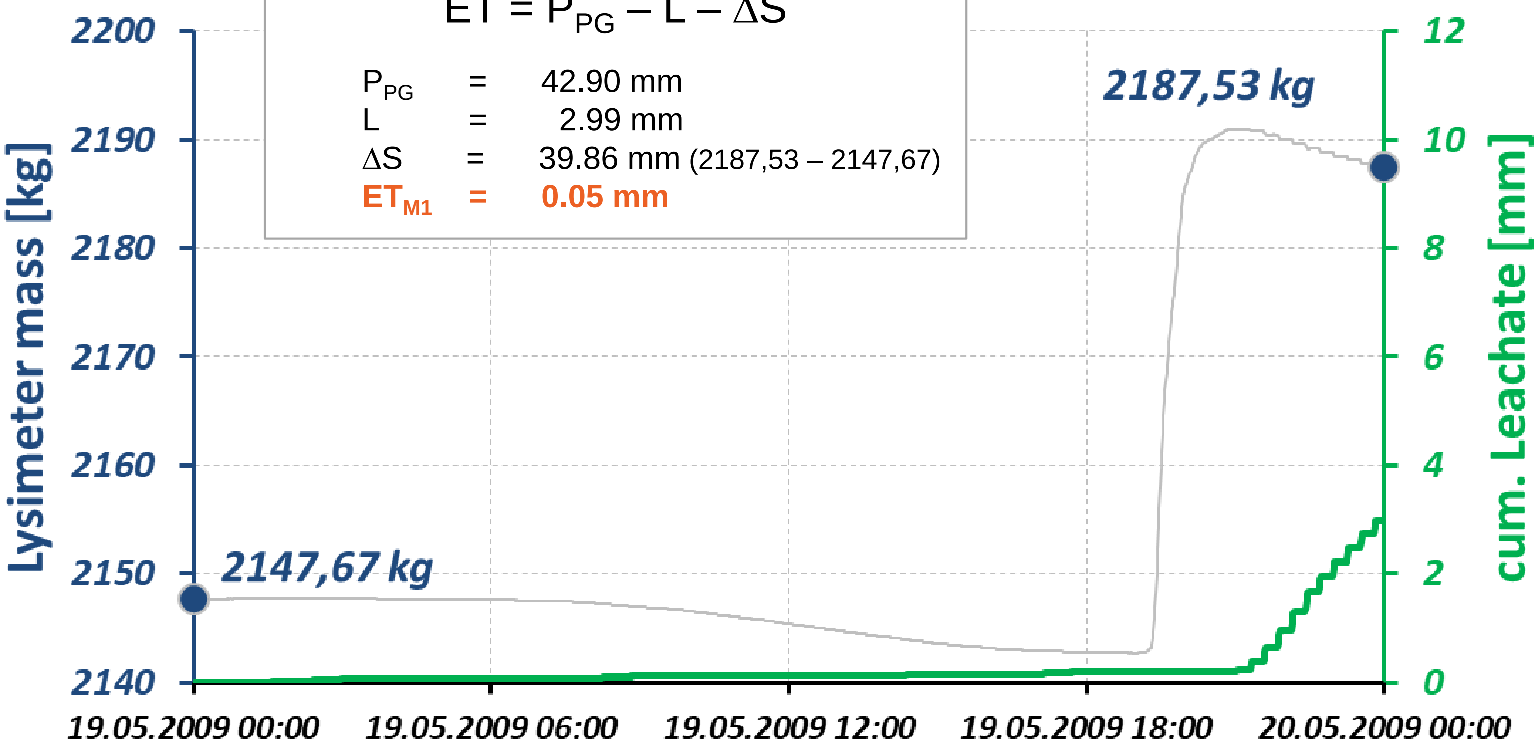
L…Leachate
ΔS… Diff. soil water storage
P_{PG}…P measured with precipitation gauge

Method 1

This is an example for the ET calculation using an external P gauge. ΔS is determined by means of the lysimeter masses at the beginning and the end of the considered time step. Leachate is measured separately. ET according to this method would result in 0.05mm.

$$ET = P_{PG} - L - \Delta S$$

P_{PG}	=	42.90 mm
L	=	2.99 mm
ΔS	=	39.86 mm (2187,53 – 2147,67)
ET_{M1}	**=**	**0.05 mm**



P…Precipitation
L…Leachate
P_{PG}…P measured with precipitation gauge
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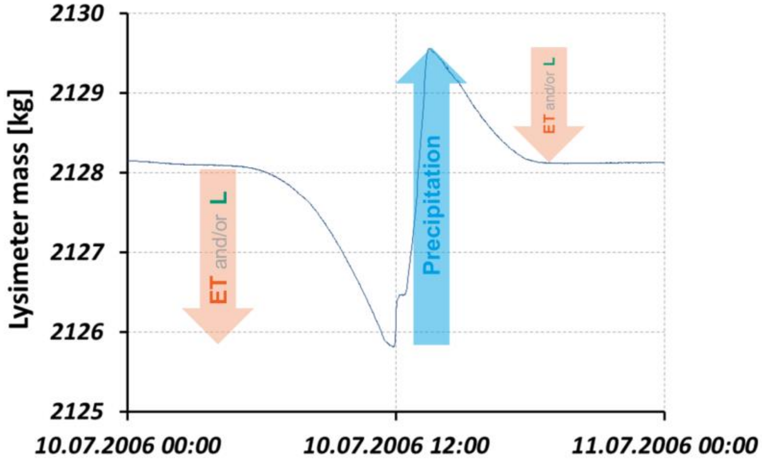
Method 2

P and ET measured with lysimeter

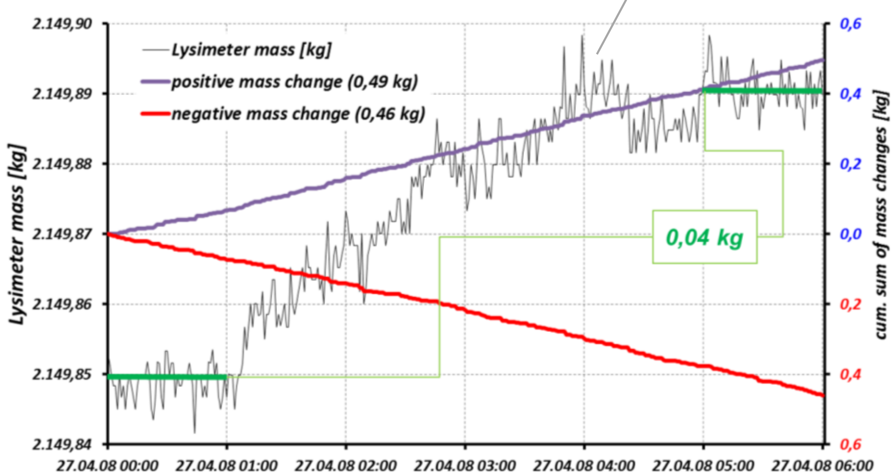


Problem

background noise of mass time-series

→ Smoothing & filter required

noisy mass time-series



A filter is required to separate background noise from real lysimeter mass changes. Without applying a filter, the pos. mass changes in the example above would result +0.49 kg and the neg. mass change would result -0.46 kg, which is equal to 0.49mm P and 0.46mm ET (no leachate recorded in this example). In fact, there was no ET (→ night) and also no precipitation was recorded by nearby standard gauges. The +0.04kg real mass increase between 0am and 6am resulted from dew.

Smoothing & Filter routines

P and ET measured with lysimeter

Method 2a
Smoothing
(e.g. moving average)

Method 2b
Threshold
(mass change smaller threshold → noise)

Method 2c
Combination:
Smoothing & Threshold
(fixed window & fixed threshold)

Method 2d
AWAT
(adaptive window & adaptive threshold)

According to Fank (2013) and Schrader et al. (2013) a combination of smoothing the mass time-series and defining a threshold value, which separates noise from real lysimeter mass changes, is recommended. However, this approach cannot cover all possible mass changes (smooth evapotranspiration, heavy precipitation) and noise behavior (no/strong wind, no/high vegetation) due to a fixed window width and fixed threshold. The AWAT filter (Peters et al., 2014; Peters et al. 2016; Peters & Durner, 2019) uses adaptive window widths and adaptive threshold values which are depending on the extend of the mass changes and noise.

AWAT-Filter

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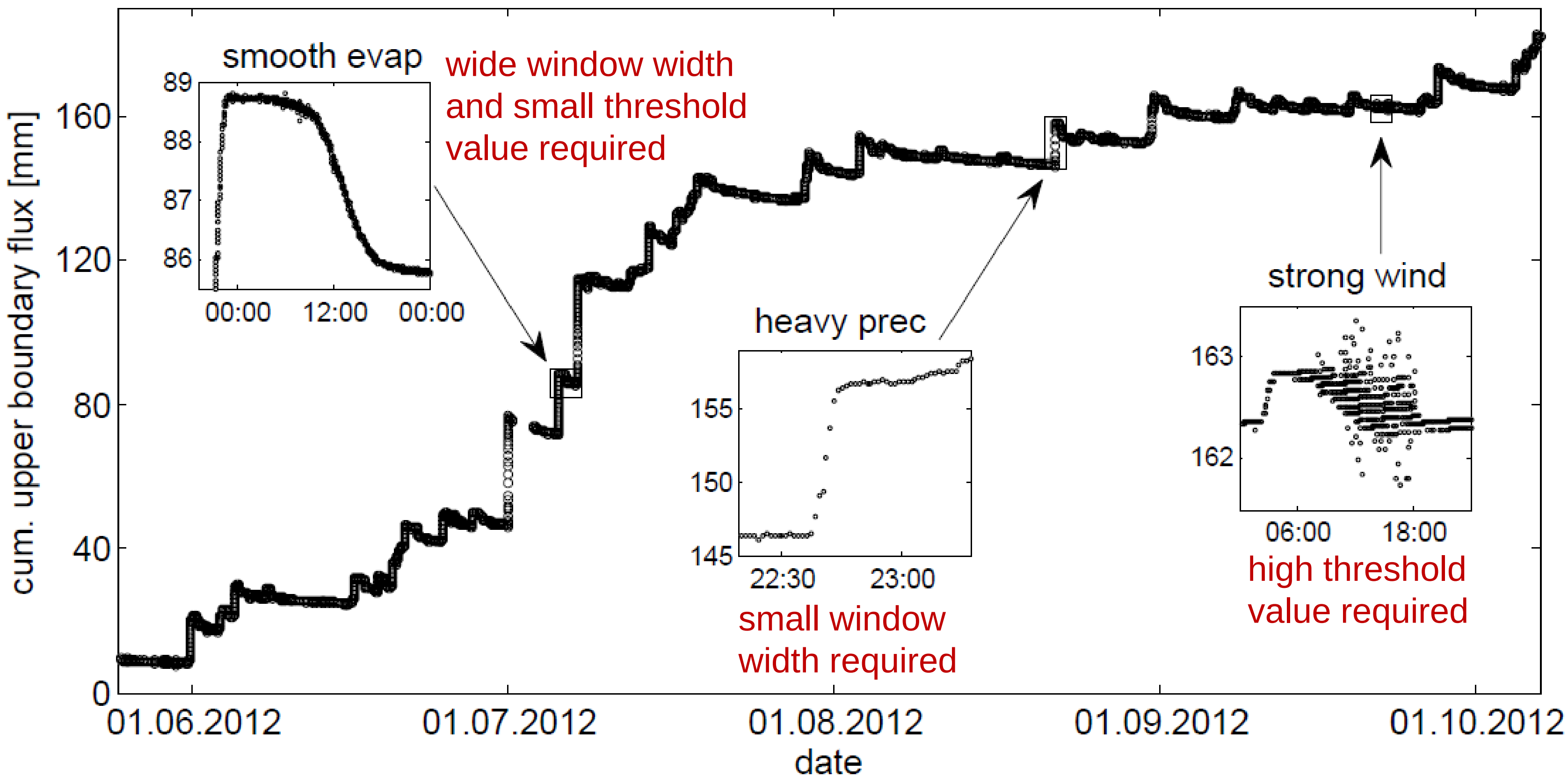

Peters et al. (2014)

Due to the adaptive window width and the adaptive threshold, the AWAT filter is able to account for all occurring types of weight changes and noise. The figure above shows examples for smooth evapotranspiration, heavy precipitation and strong wind. Fixed parameters for window width and the threshold value would either only work for strong wind OR heavy precipitation events.

Peters A., Nehls T., Schonsky H., Wessolek G. (2014) Separating precipitation and evapotranspiration from noise – a new filter routine for high-resolution lysimeter data. Hydrology and Earth System Sciences 18, 1189-1198.

Weighable Lysimeter

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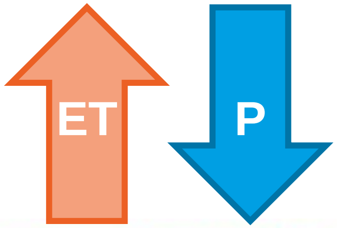
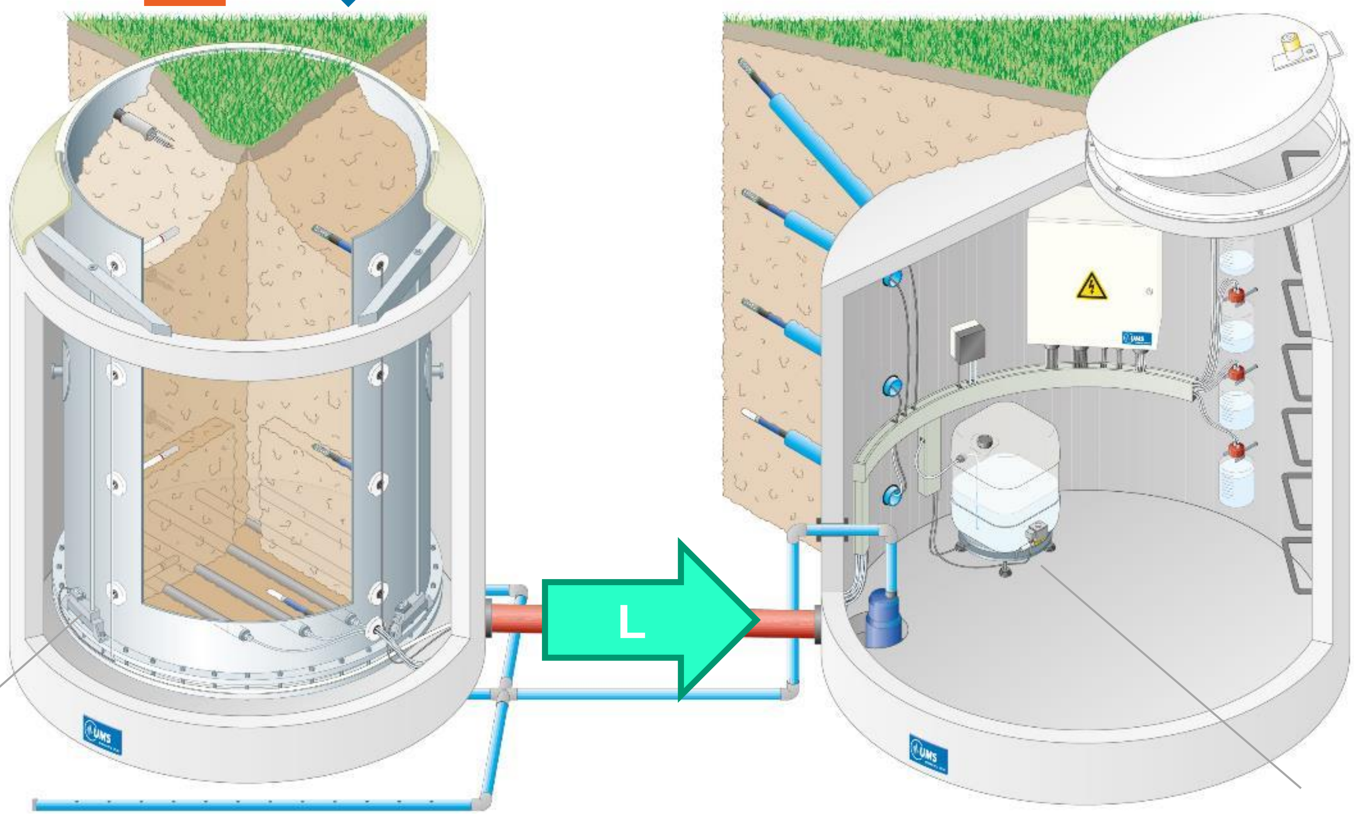
State-of-the-Art lysimeter system with tension controlled lower boundary and high precision load cells. The amount of leachate is quantified by weight measurement with a separate balance (recording interval of weight measurements of both lysimeter and leachate 1min).
http://www.aquaconsol.at/leistungen/lysimeter

Upper boundary flux





<u>Pos. mass changes</u>:
→ P

<u>Neg. mass changes</u>:
→ ET an/or L

Load cells
resolution of weighing system 10g → 0,01mm

Leachate Tank on balance for measuring leachate separately

P…Precipitation
L…Leachate

ET…Evapotranspiration
ΔS… Diff. soil water storage

Lysimeter data evaluation

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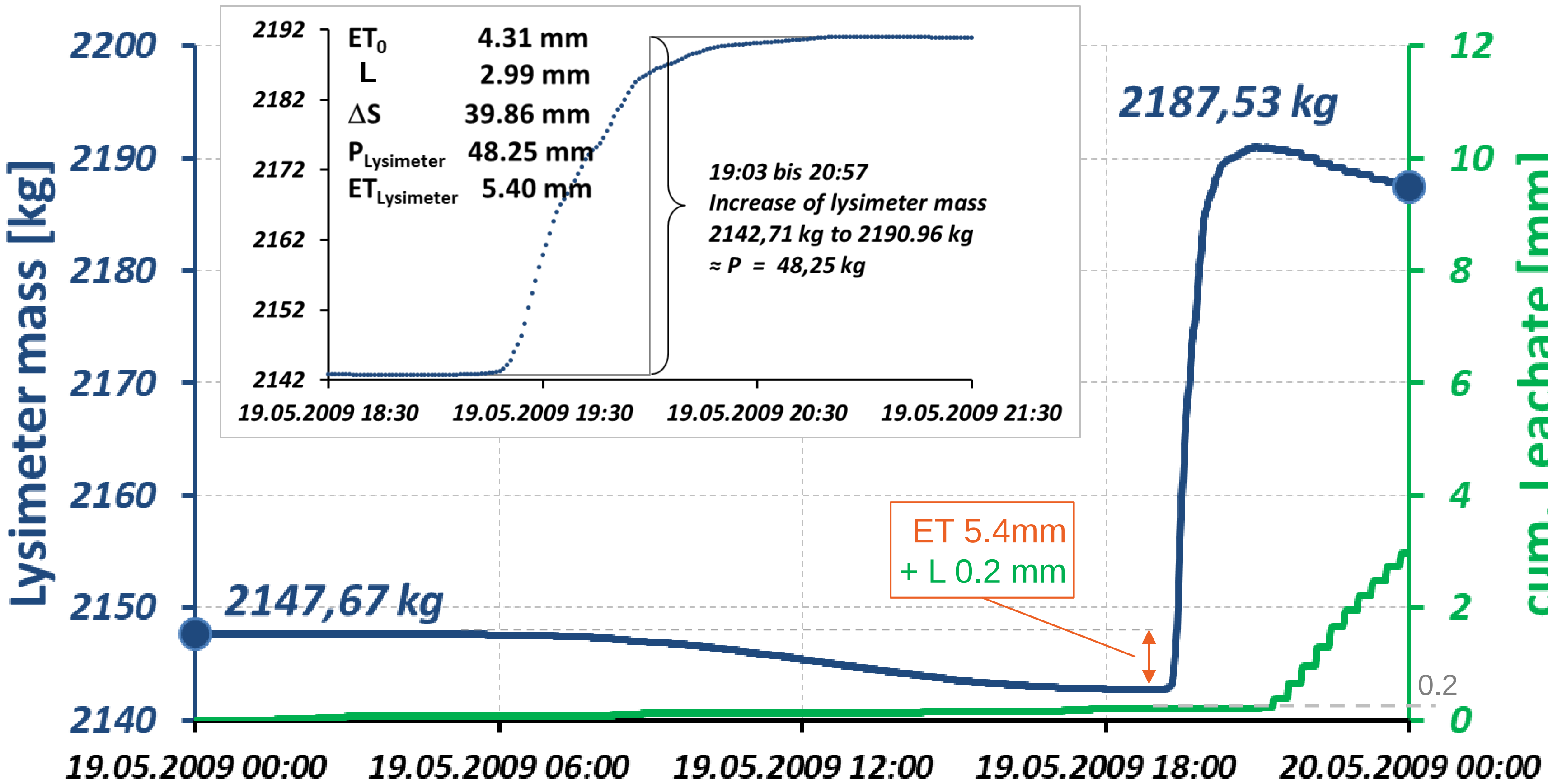
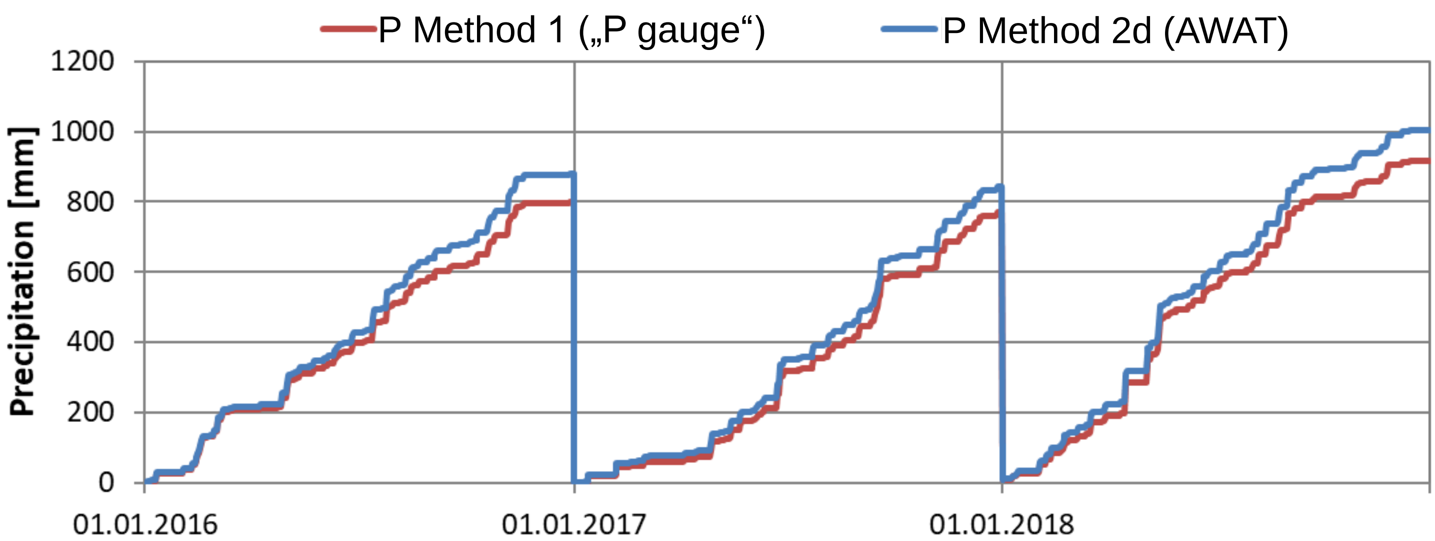
The determination of ET based on the lysimeter+leachate mass time series results in an ET = 5.4mm/d for the presented example. Compared to the calculated ET = 0.05mm/d with Method 1 (“P gauge”) this is an significant difference, which means that results of Method 1 have been influenced by a precipitation gauge error of 5.35mm.



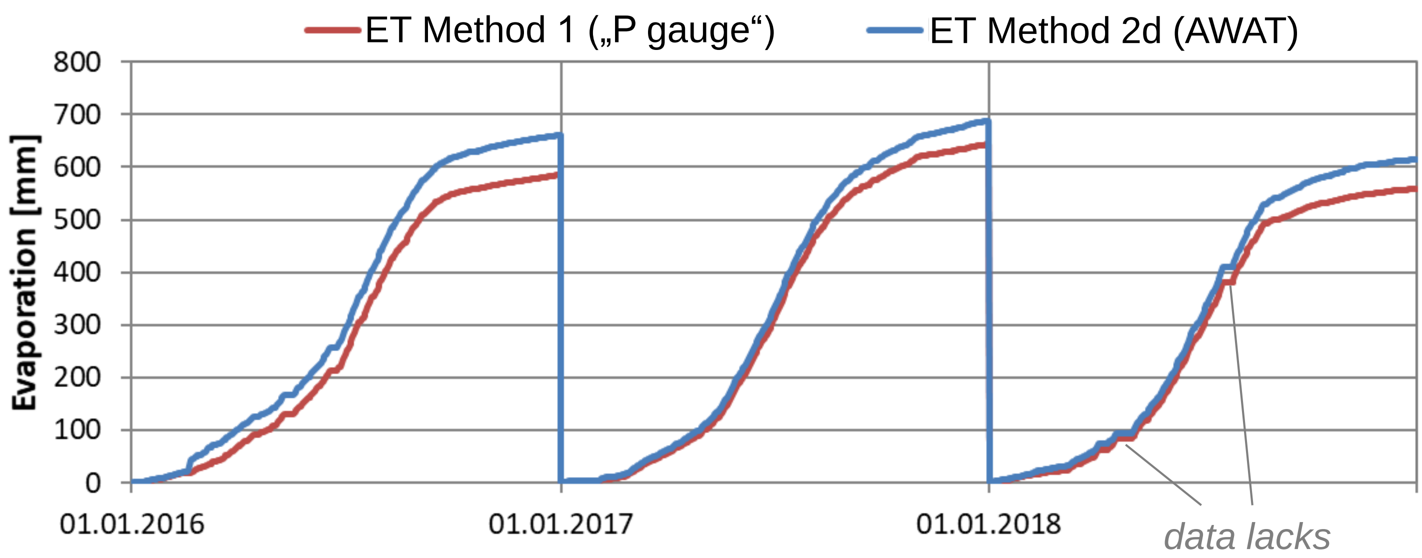
Results
PRECIPITATION



PRECIP	*Method 1 „P gauge“ [mm]*	*Method 2d AWAT [mm]*	*Diff. „M1 minus AWAT" [mm]*	*[%]*
2016	799	881	-82	-9%
2017	769	843	-74	-9%
2018	918	1005	-87	-9%

Results presented for a lysimeter installed in an agricultural test plot in Wagna/Austria (only for Method 1 and 2d).

Results
EVAPOTRANSPIRATION



EVAP	*Method 1 „P gauge“ [mm]*	*Method 2d AWAT [mm]*	*Diff. „M1 minus AWAT" [mm]*	*[%]*
2016	585	661	-76	-12%
2017	644	688	-44	-6%
2018	559	615	-56	-9%

Results presented for a lysimeter installed in an agricultural test plot in Wagna/Austria (only for Method 1 and 2d).

Conclusions

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- Common precipitation gauges underestimate the precipitation due to precipitation gauge errors
- This leads to an underestimation of ET in the range of 6 to 12% compared to AWAT
- Using high precision weighing lysimeters enable to **derive ET directly from the lysimeter + leachate mass** time series → **background noise** must be **filtered**
- The **AWAT-method** according to **Peters et al.** (2014) represents a highly **sophisticated routine**, with which it is possible to **handle all occurring influences** on the weight measurement

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Thank you for your attention!

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