Analysis of Scale-dependent Spatial Correlations of Actual Evapotranspiration Measured by Lysimeters

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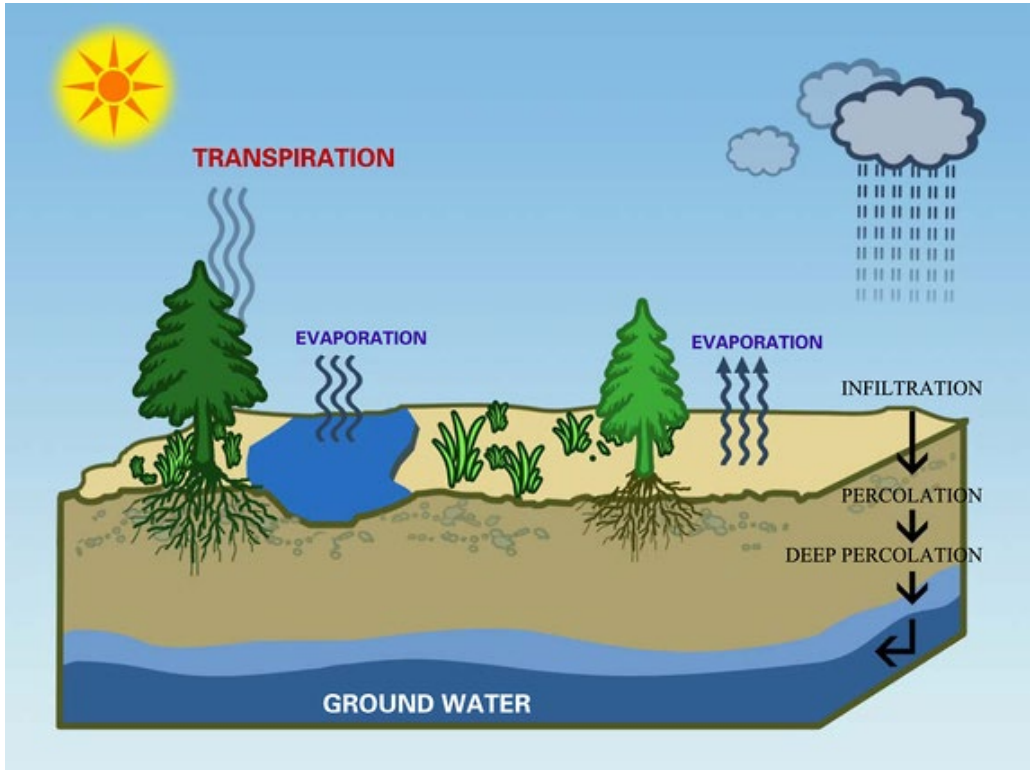
Background and Motivation



(Wang & Dickinson, 2012)

- Evapotranspiration (ET) is a central component of the global water cycle.
- Precise assessment of actual evapotranspiration (ETa) is important for a broad range of scientific disciplines, e.g. agricultural water management and drought monitoring.
- ETa is difficult to measure.
- Accurate determination of ETa rate remains a challenge.
- Limited availability of long-term ETa measurements.

Background and Motivation

- The **main objective** of this study was to investigate the information content of lysimeters regarding ETa for larger areas.
- Our **hypothesis** is that a lysimeter measurement provides information on ETa which is representative for a large area.

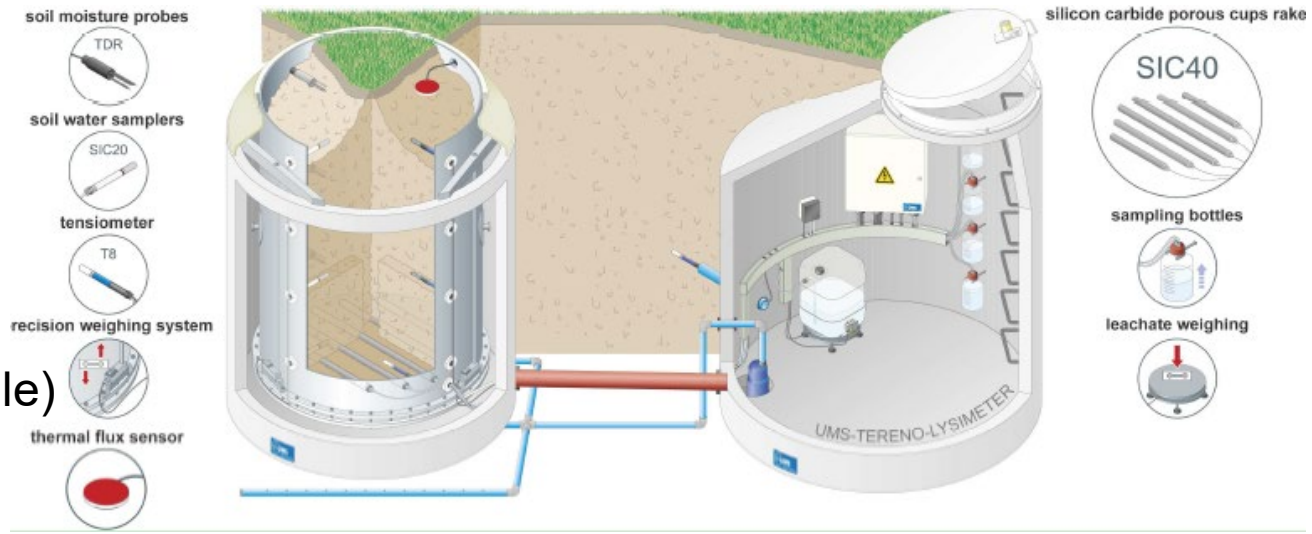
(www.licor.com)

Eddy covariance (EC) system:

- ⊕ a large footprint (field scale)
- ⊖ energy imbalance

Weighing lysimeter:

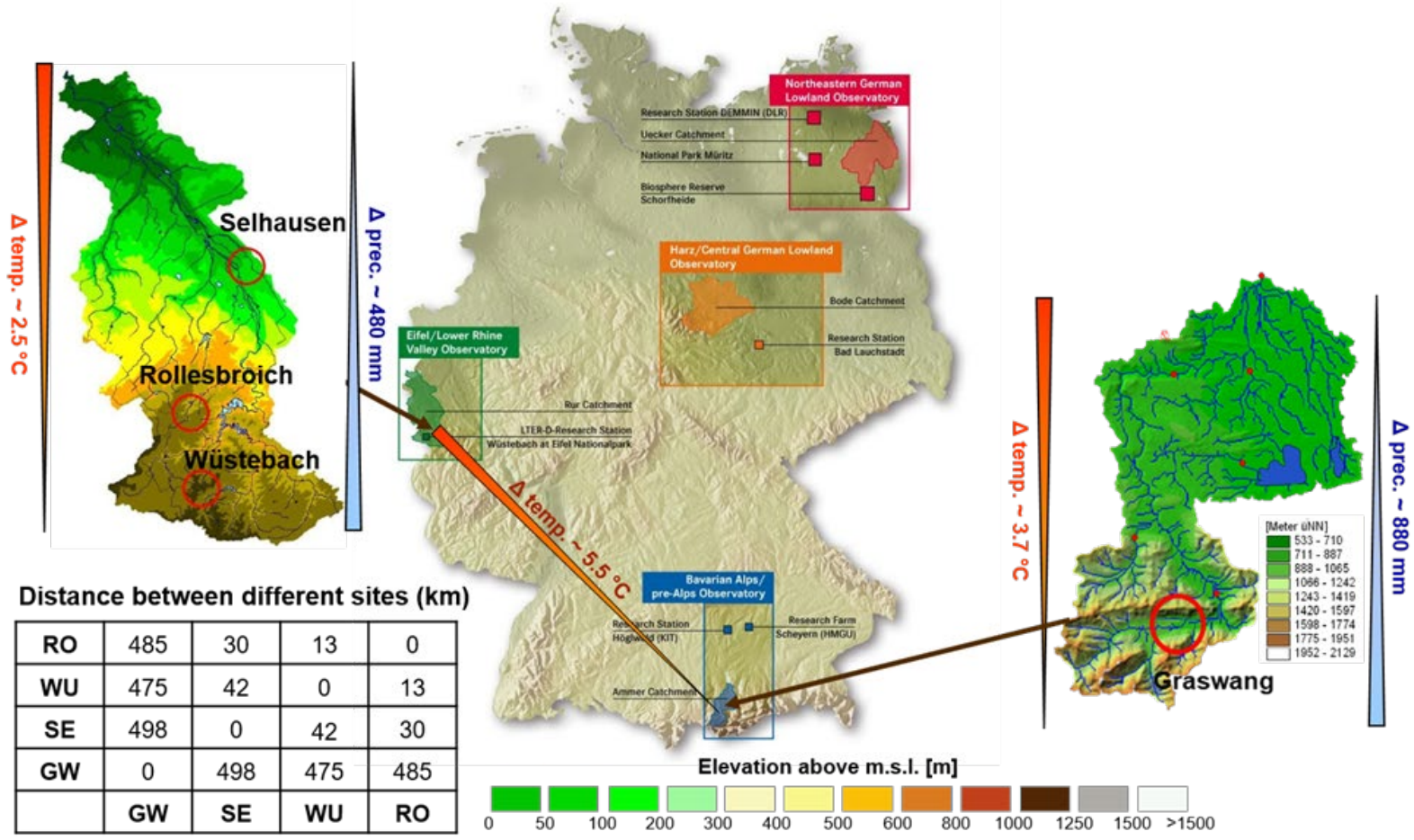
- ⊕ an accurate method
- ⊖ a small footprint (pedon scale)



(Pütz, T. et al. (2016): Environ Earth Sci 75)

Study Sites

TERENO-SOILCan Lysimeter Network



Distance between different sites (km)

RO	485	30	13	0
WU	475	42	0	13
SE	498	0	42	30
GW	0	498	475	485
	GW	SE	WU	RO

(modified from Pütz et al., 2016)

- ✓ 4 sites
- ✓ 23 lysimeters
- ✓ EC stations nearby
- ✓ Continuous daily data from 2015-2020

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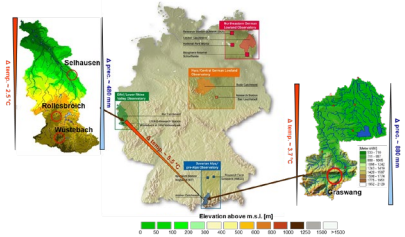
Study Sites

TERENO-SOILCan Lysimeter Network



Station	Elevation (m a.s.l.)	No. of lysimeters	Abbrev.	Soil location	Soil origin	Soil texture	Vegetation (Lysimeter)	Ecosystem (EC)
Selhausen	104	3	SEro	SE	RO	silty loam	grass	crop
		3	SEwu	SE	WU	silty clay loam	grass	
		3	SEse	SE	SE	silty loam	crop	
Rollesbroich	515	6	RO	RO	RO	silty loam	grass	grass
Wüstebach	625	6	WU	WU	WU	silty clay loam	grass	forest
Graswang	864	2	GW	GW	GW	clay	grass	grass

Statistical Analysis

1. **Pearson correlation coefficient (PCC)** of standardized anomaly of ETa (between sites) provides overall measure of correlation:

$$\Delta ET = ET_{a,i} - \overline{ET_{a,i}}$$

$$SA_{ET_a} = \frac{\Delta ET}{\sigma_{ET_a,i}}$$

ΔET - daily ETa anomaly

$ET_{a,i}$ - actual daily ET measurements on day i

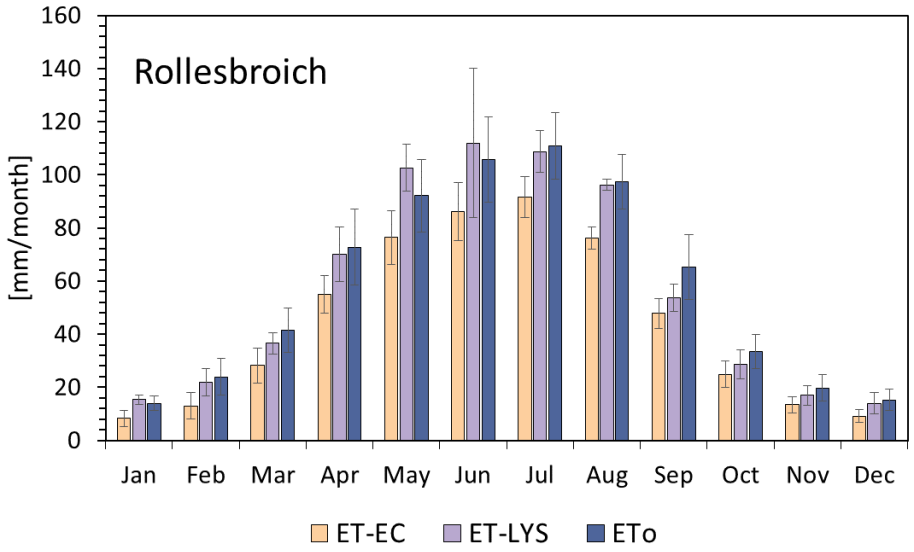
$\overline{ET_{a,i}}$ - long-term mean value of daily measurements (polynomial mean over 2015-2020)

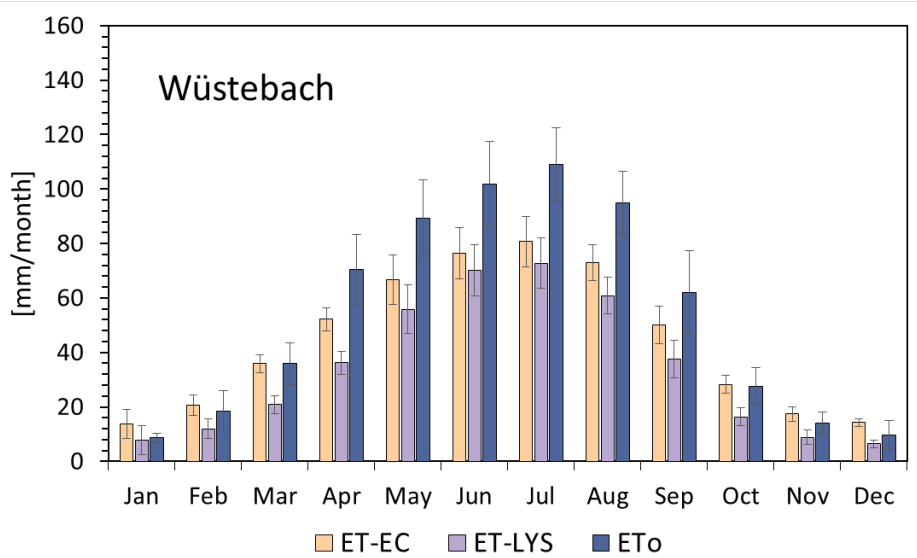
SA_{ET_a} - standardized anomalies of ETa

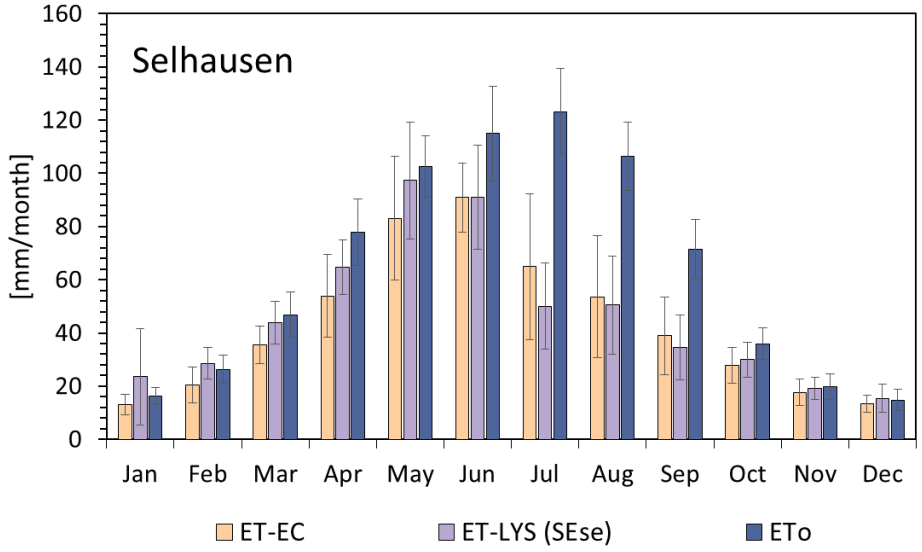
$\sigma_{ET_a,i}$ - long-term standard deviation (SD) of daily measurements (polynomial SD over 2015-2020)

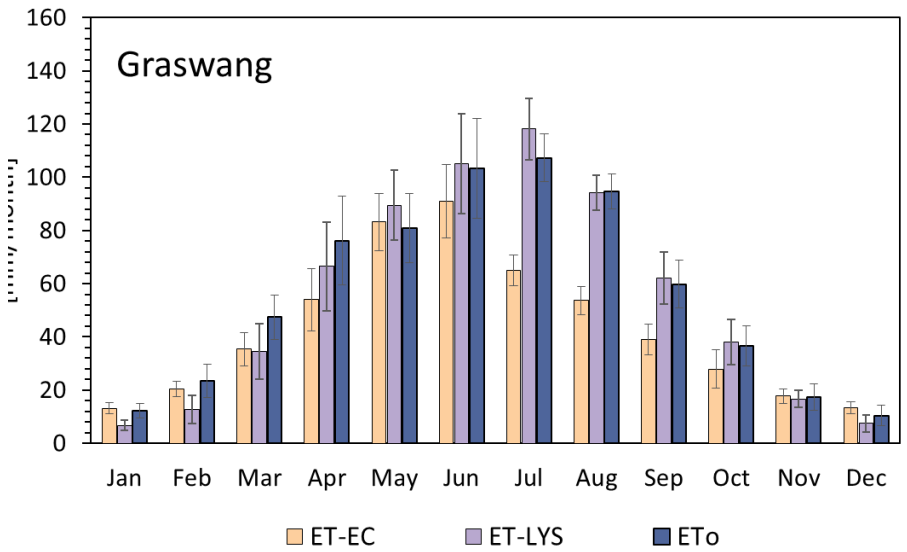
2. Wavelet transform coherence (WTC) analysis extends the analysis into time-frequency space, can analyze correlations at different temporal scales and for lagged responses.

Monthly sum of ET







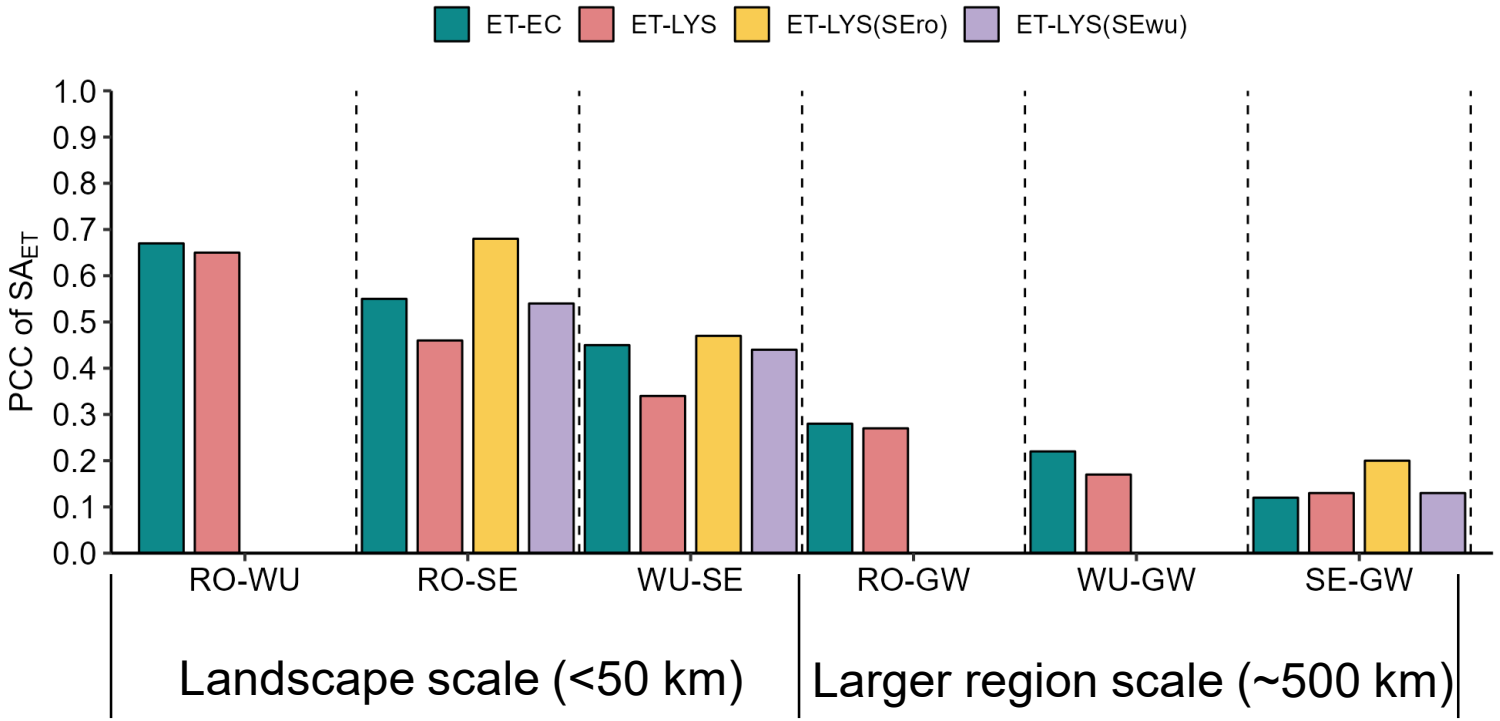


- Monthly ET-EC higher than ET-LY and ET_0 at WU.
- Different vegetation type at WU on the lysimeters (grass) and on the field (forest).
- The lysimeters at WU at the land surface receive less radiation than the EC tower while they are partly in the vegetation shadow.

Pearson Correlation of Standardized Anomalies of ETa

Plot scale

	RO	WU	SEse	SEro	SEwu	GW
PCC	0.96	0.93	0.92	0.92	0.88	0.96
Stdv	0.02	0.02	0.04	0.02	0.05	/



- At the plot scale (lysimeters at same site) SA_{LYS-ET} shows high correlations (>0.88). Measurements are representative at the plot scale.
- At landscape scale (< 50km distances) SA_{LYS-ET} correlations are still quite high (~0.5).
- At larger regional scale (~500 km distance), still some correlation left (~0.2).
- Correlations for lysimeters are not much lower (even higher) than for EC.

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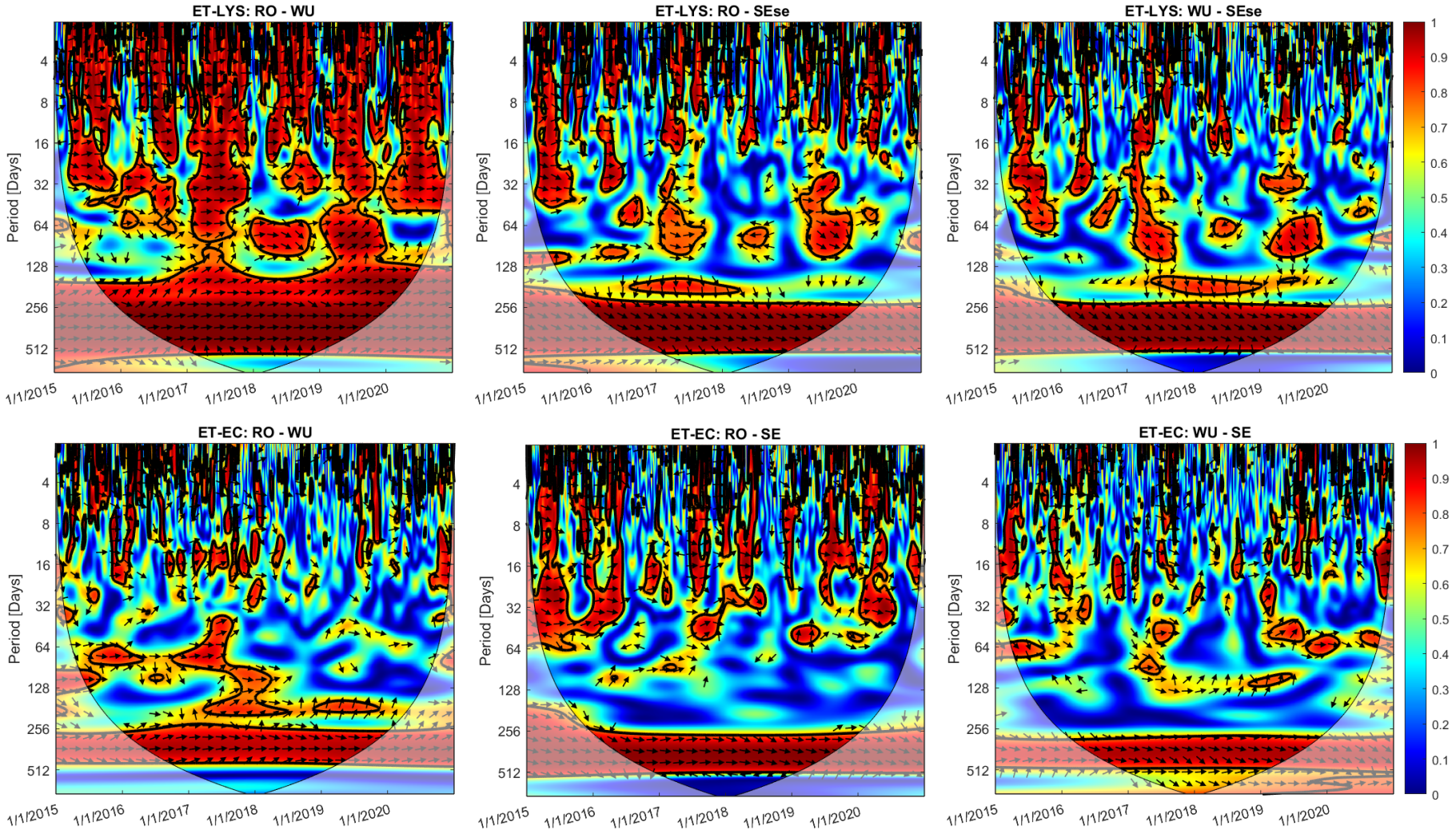
Wavelet Transform Coherence

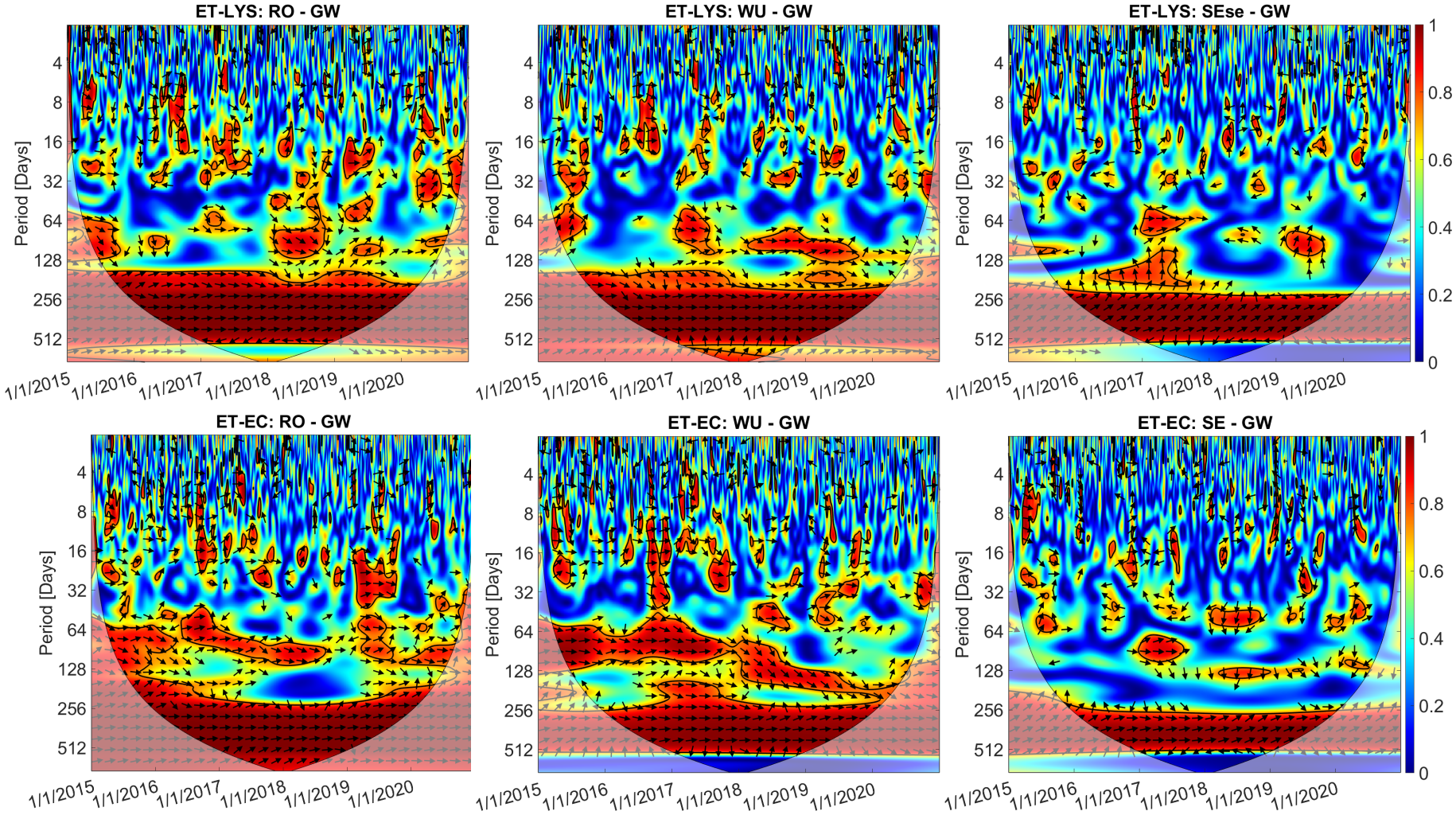
Landscape scale (< 50km)



- Strongest correlations for time scales <3months and yearly cycle
- Correlations at small time scales (<1 week) larger for LYS than for EC

Wavelet Transform Coherence

Larger regional scale (~500km)



- Strongest correlations for time scales at yearly cycle
- Less coherence than landscape scale at small time scales (<1 week)

Conclusions and Outlook

Can weighing lysimeter provide information on ETa which is representative for a large area?

- Six year daily ETa data sets from lysimeters and EC stations for 4 sites across Germany were explored using Pearson correlation coefficient and wavelet coherence.
- ETa measured by lysimeters showed similar spatial correlations (between sites) as ETa measured by EC towers despite the different sizes of measurement footprints for lysimeters and EC.
- Lower spatial correlations in winter and under drought condition.
- Overall, this work showed that weighing lysimeters are representative at plot scale, landscape scale and for a larger region.

➢ Next steps: disentangle the different attributions to the observed spatial correlation of ETa.

THANKS!

Any question?

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