

# Estimation of Mesoscale Contributions to Surface Flux Exchanges from Flux Tower Data Using the Continuous Wavelet Transform

Arquin Neo<sup>1</sup>, Guillaume Hac<sup>1</sup>, Jonathan Bitton<sup>1</sup>, Bernard Longdoz<sup>1</sup>, Catherine Charles<sup>1</sup> and Bernard Heinesch<sup>1</sup>  
<sup>1</sup>University of Liege, Gembloux Agro-Bio Tech, Belgium

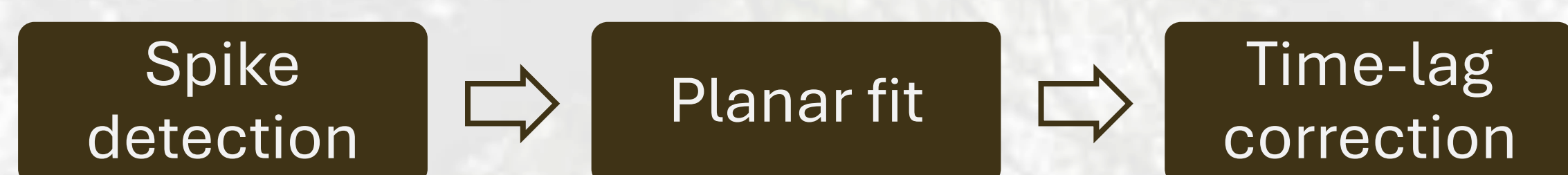
Tuesday, 16 September 2025 16:30-18:30 Board 12

## 1. EDDY COVARIANCE STUDY SITE

The raw data were collected at the **ICOS** site in Vielsalm, covered by a mixed temperate forest and flux measurements are performed at a height of **51 meters**.

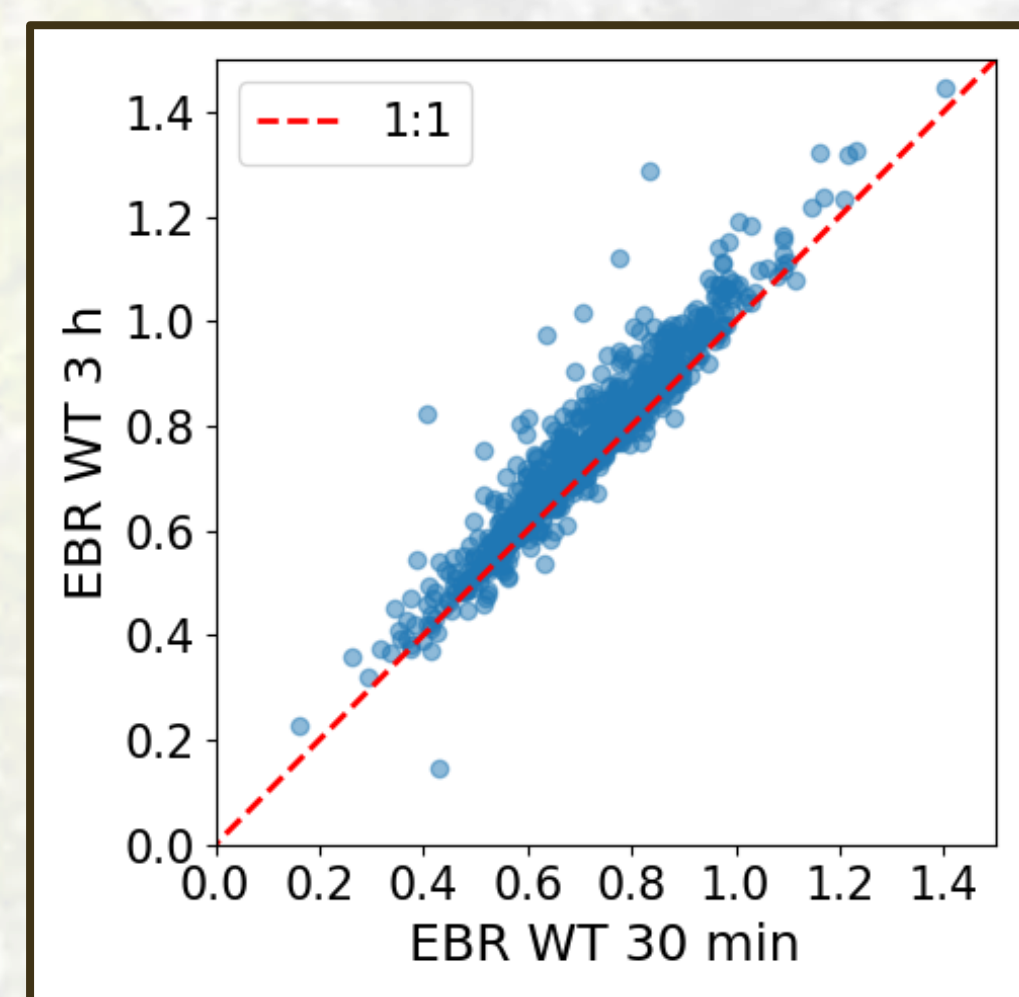


## 2. DATA PRE-PROCESSING



The dataset underwent a pre-processing chain to remove **outliers**, correct the anemometer **tilt**, and synchronize **wind and gas signals**.

## 5. IMPACT ON ENERGY BALANCE CLOSURE

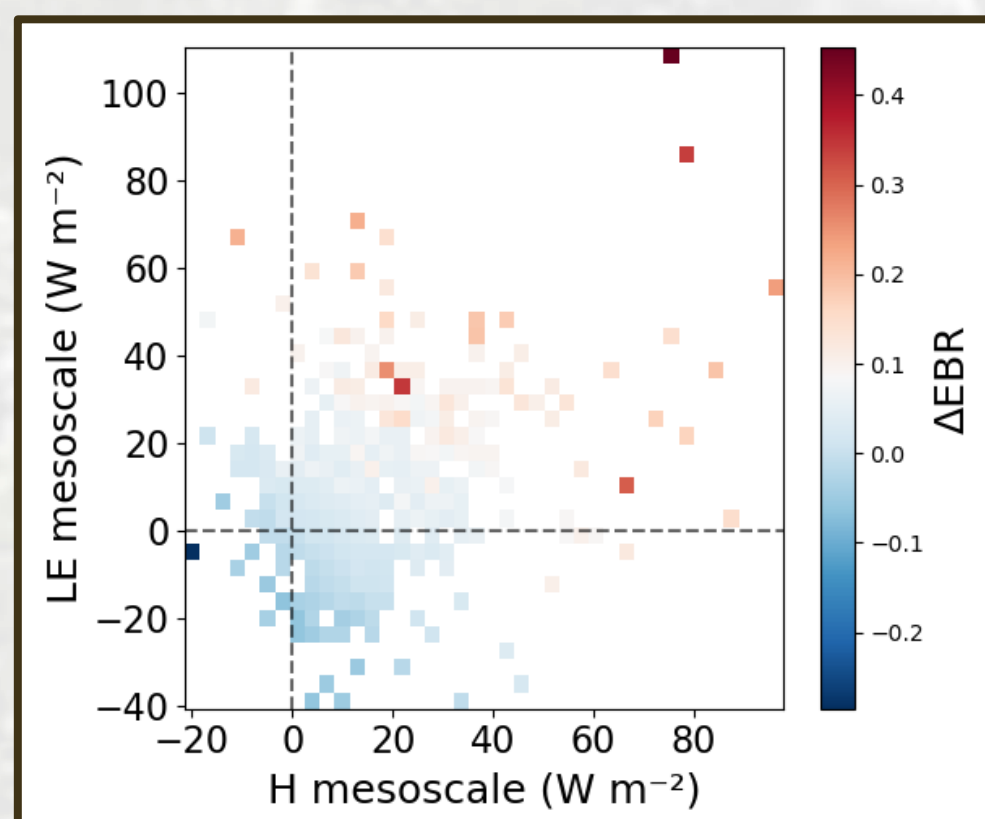


When taken into account, mesoscale contributions **improve the half-hourly EBR by 4.3 %** on average, increasing it from 0.71 to 0.75.

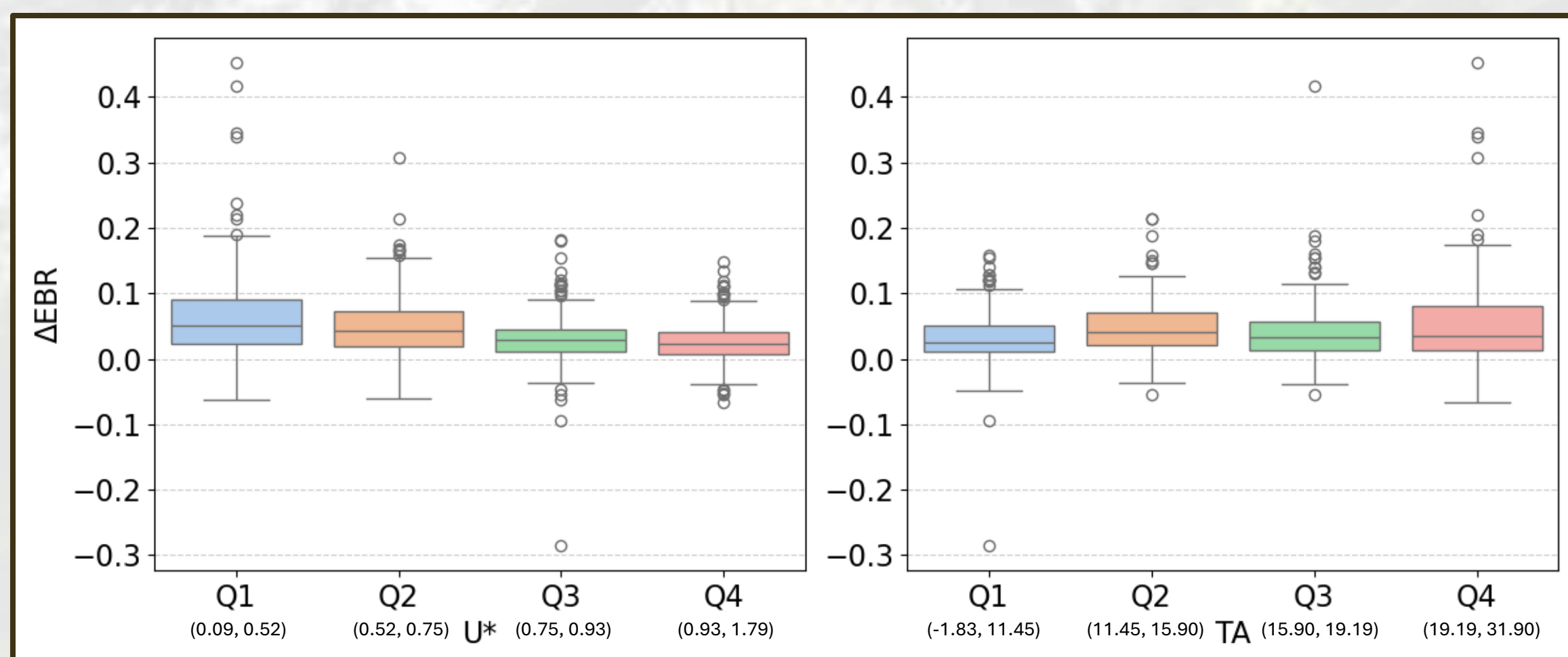
$$EBR = (H + LE) / (R_{net} - G)$$

$$\Delta EBR = EBR_{WT3h} - EBR_{WT30min}$$

The sum of mesoscale fluxes of H and LE is strongly correlated with  $\Delta EBR$  ( $r=0.83$ ,  $p<0.001$ ). **Positive mesoscale contributions tend to improve EBC, while negative ones are associated with poorer closure.**



The difference in EBR between the 30-min and 3-h timescales varies with **atmospheric conditions**.  $\Delta EBR$  is **higher under low mechanical turbulence ( $U^*$ )**, highlighting the importance of mesoscale motions when wind shear is limited. There is also a tendency for  $\Delta EBR$  to **increase with air temperature (TA)**, suggesting that large-scale processes contribute more during warm and unstable conditions.



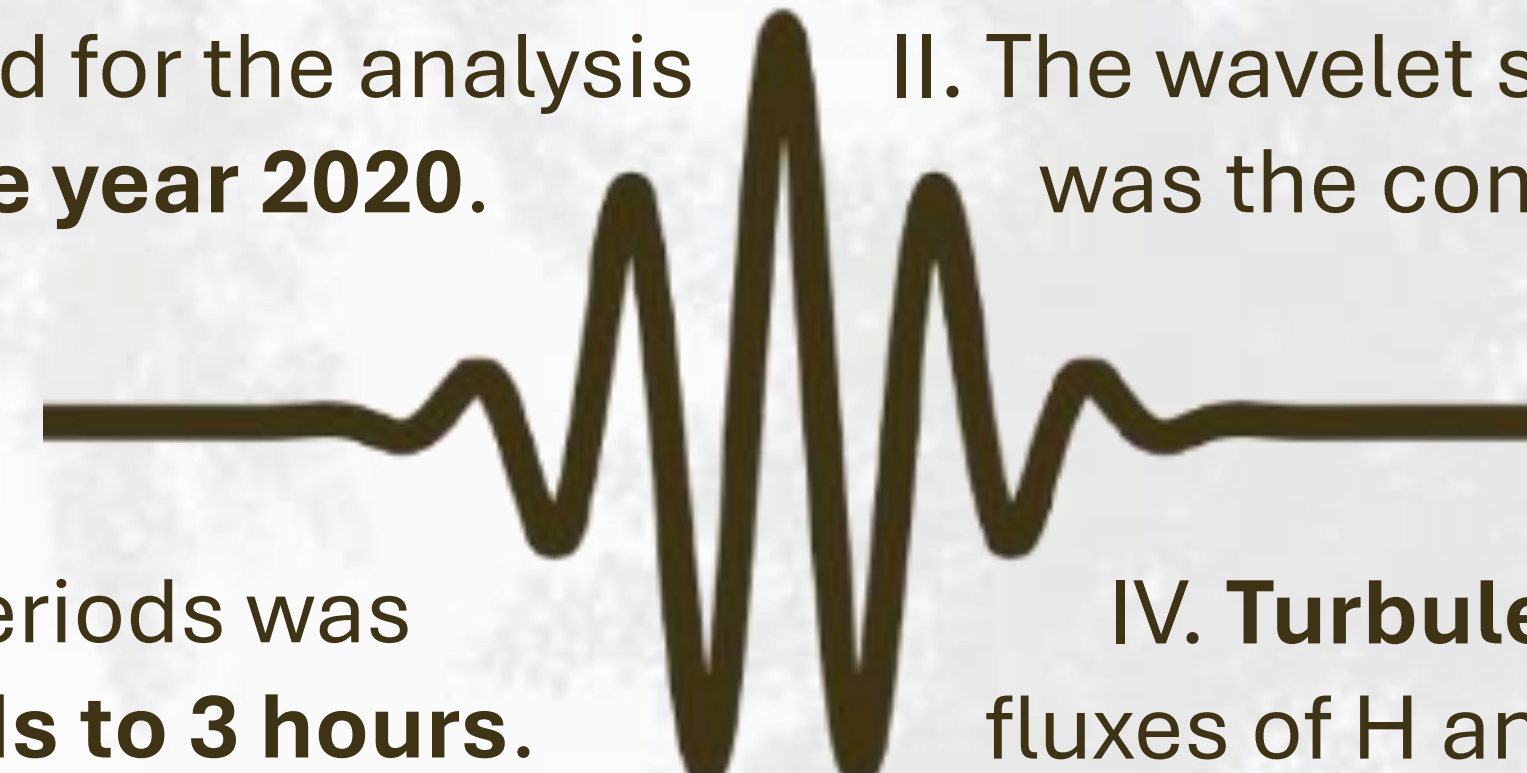
**While the wavelet approach slightly improved energy balance closure, it remains unable to capture the impact of quasi-stationary structures and the associated dispersive fluxes, as the analysis is constrained to a single EC tower.**

## 3. WAVELET TRANSFORM

I. The dataset used for the analysis covered the **entire year 2020**. II. The wavelet selected for this study was the complex **Morlet** wavelet.

III. The range of periods was from **0.05 seconds to 3 hours**.

IV. **Turbulent\*** and **mesoscale\*** fluxes of H and LE were compared.



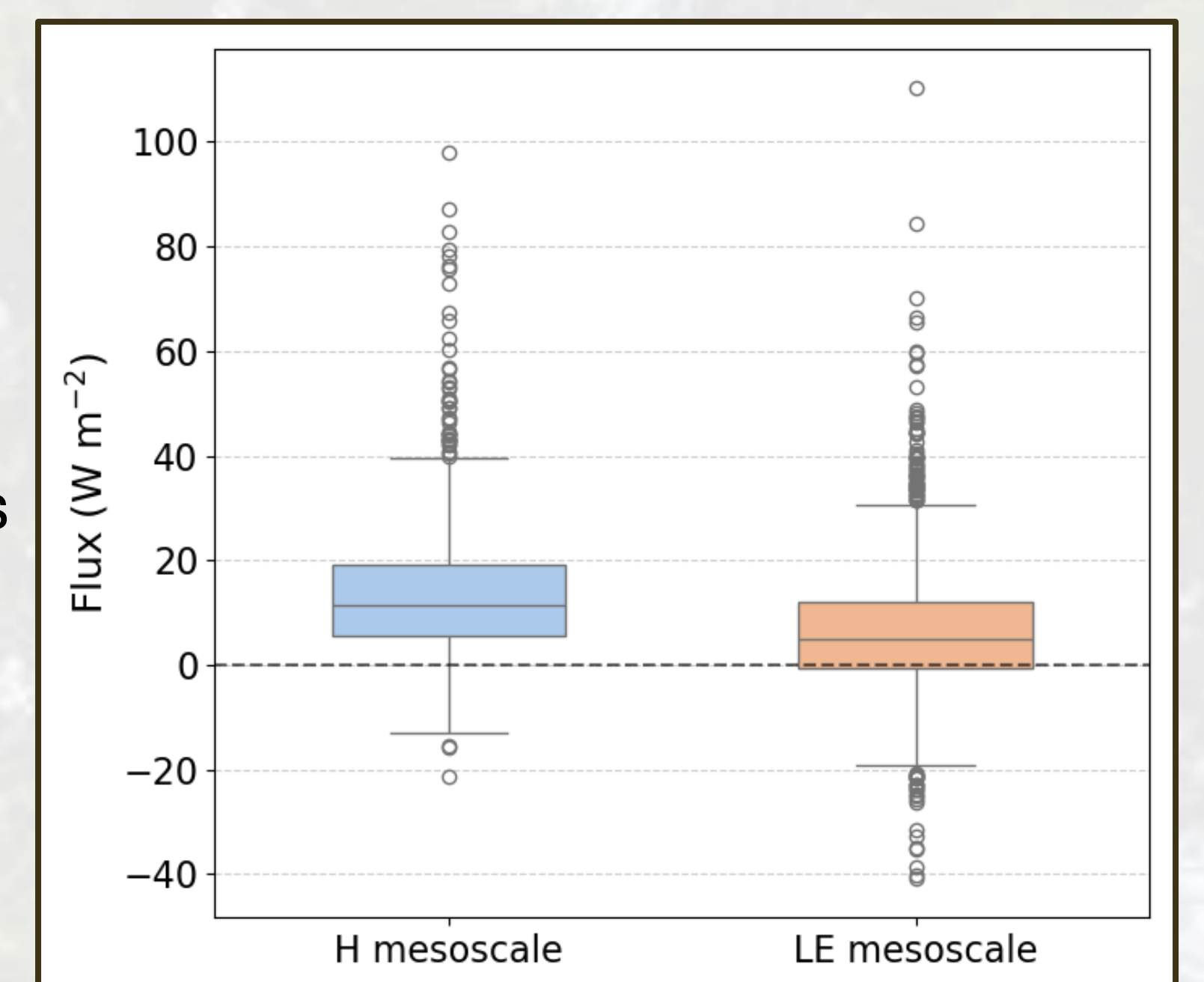
\* **Turbulent:** 0.05 s → 30 min  
**Mesoscale:** 30 min → 3 h

## 4. QUANTIFICATION OF MESOSCALE CONTRIBUTIONS

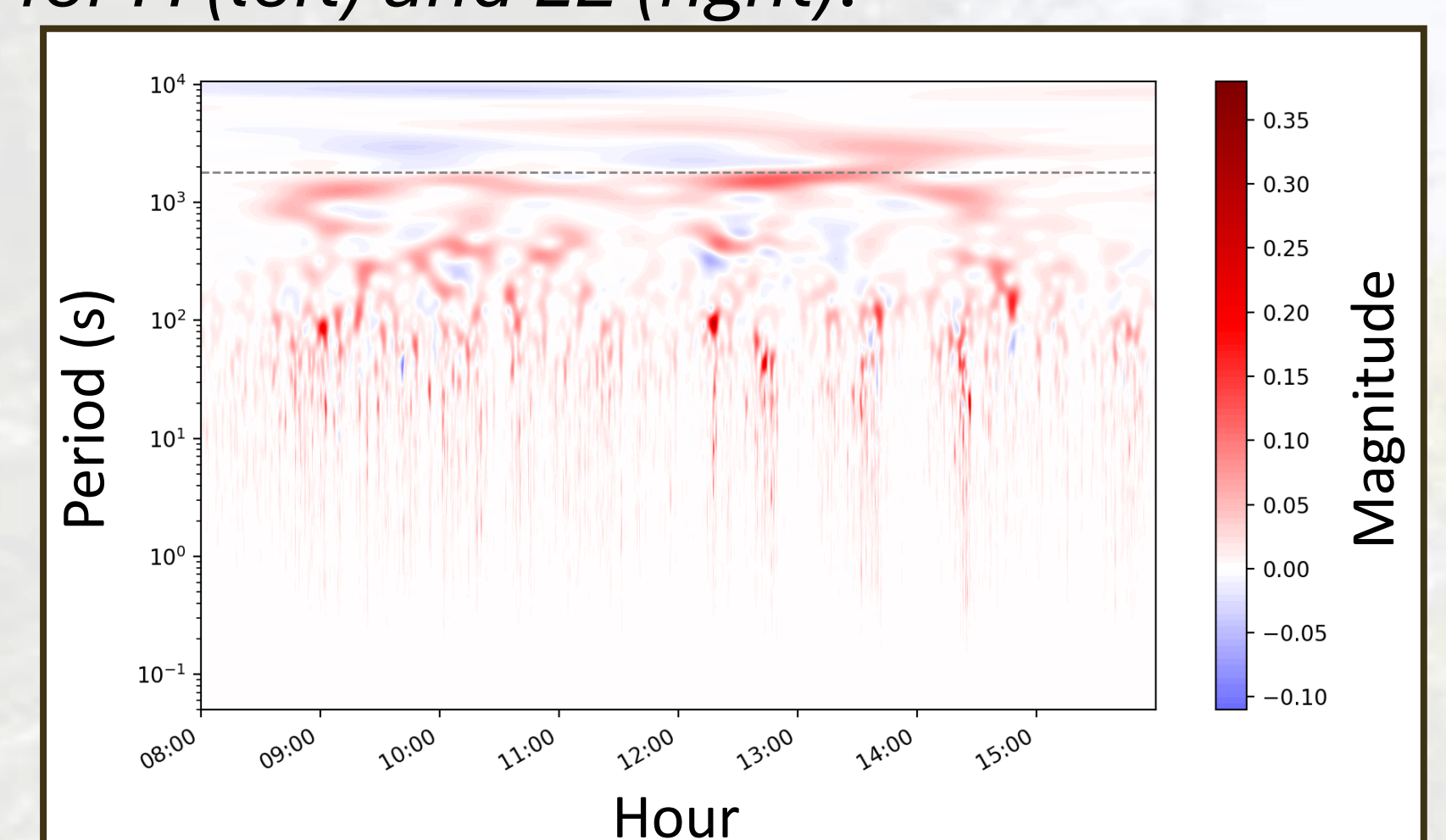
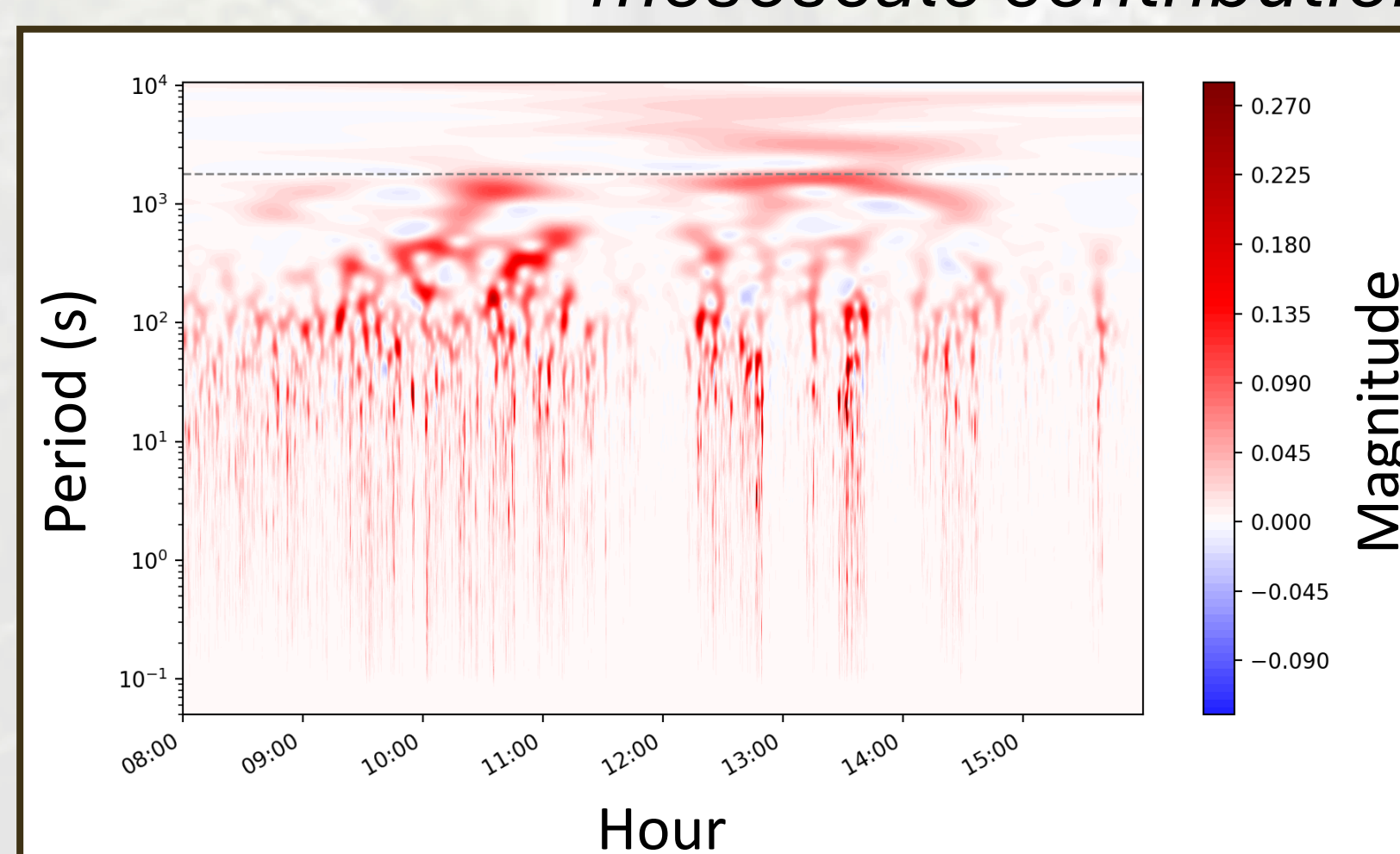
Flux	Period	Mean	Mesoscale
H	30 min	238.3 W/m <sup>2</sup>	
	3 h	251.7 W/m <sup>2</sup>	13.4 W/m <sup>2</sup>
LE	30 min	115.4 W/m <sup>2</sup>	
	3 h	122.1 W/m <sup>2</sup>	6.7 W/m <sup>2</sup>

Wavelet analysis shows that extending the integration scale from 30 min to 3 h **increases** the flux estimates by about **5.5 % for both H and LE** for hours between 10 am and 2 pm.

These median mesoscale contributions, **positive for both H and LE**, are aligned with the expected direction of the turbulent fluxes for the analyzed hours. The presence of wide interquartile ranges and numerous outliers indicates that **mesoscale motions can have variable, and in some cases even opposite, effects on energy flux estimates.**



Example of cross-scalograms on 13 July 2020, showing positive and negative mesoscale contributions for H (left) and LE (right).



## FUTURE TASKS

- Investigate the ICOS site in Lonzée (**patchy agricultural landscape**)
- Establish the link with the **landscape heterogeneity**
- Combine the effort within the framework of **AGROFLUX**

**AGROFLUX** combined measurements at the Lonzée site. The project also includes **LES** and model inversion (see Louis Alsteens' poster on Thursday, board 8).

