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# Average length extension and its effects on the eddy-covariance measurements during the LITFASS-2003 experiment

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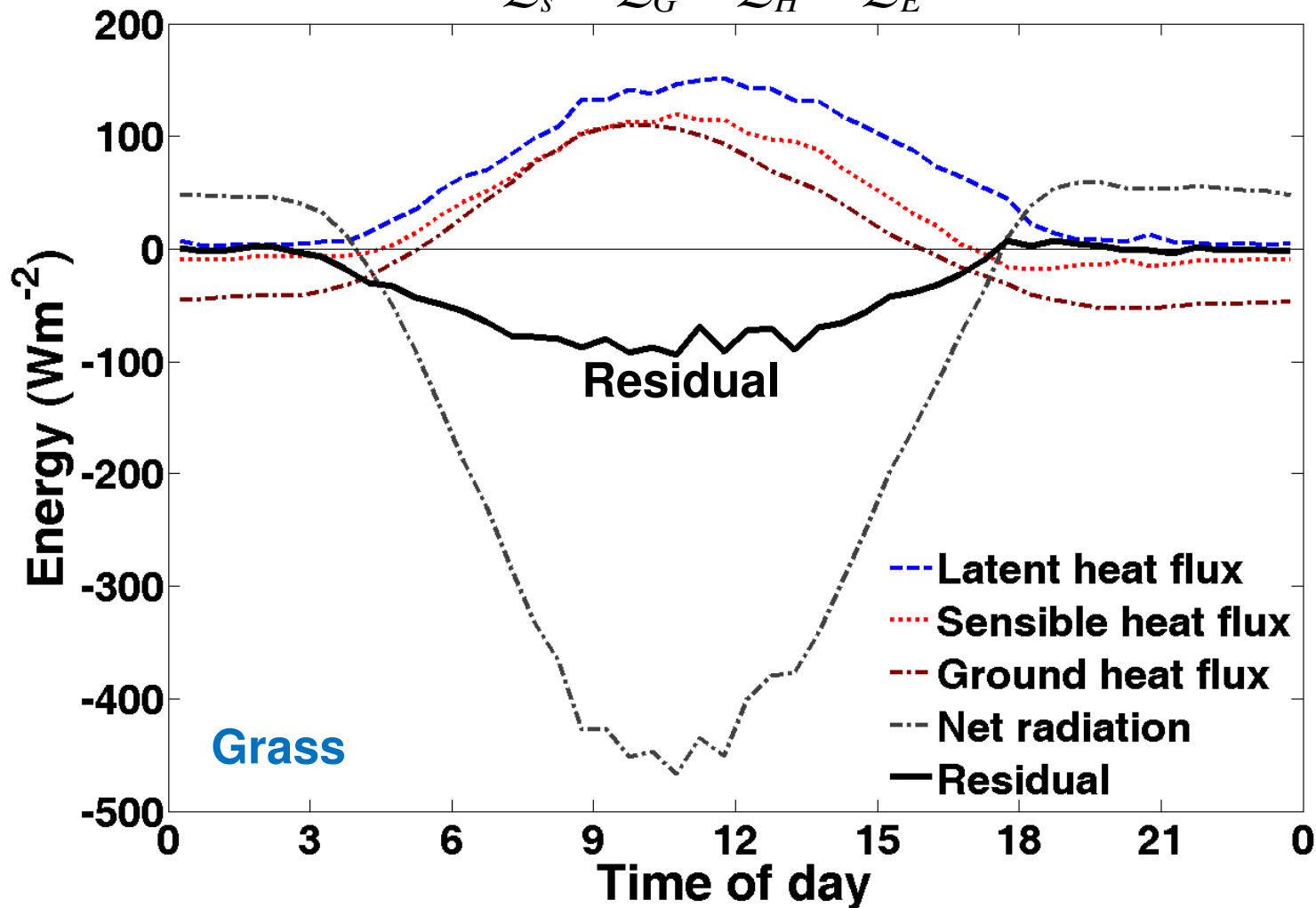
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## Outline

- Energy balance closure problem
- LITFASS-2003 experiment
- Ogive analysis
- Modified ogive analysis
- Ensemble block average
- Conclusions

# Energy balance closure problem

$$\text{Res} = Q_s^* - Q_G - Q_H - Q_E$$



# Energy balance closure problem

## *Possible main reason for un-closed energy balance*

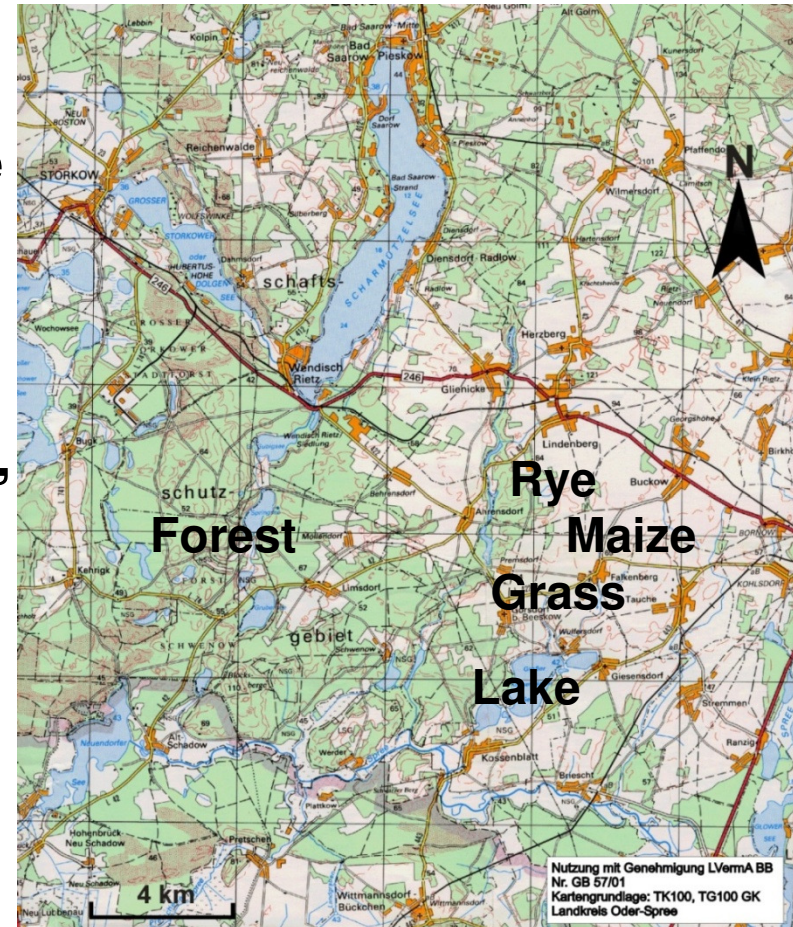
- Related to the secondary circulation (slow and large eddies), which is caused by the heterogeneity of the surface.
- Hypothesis: Eddy-covariance calculation over 30 minutes may not be enough to capture these eddies.

**Average length  
extension**

- Ogive analysis
- Ensemble block average

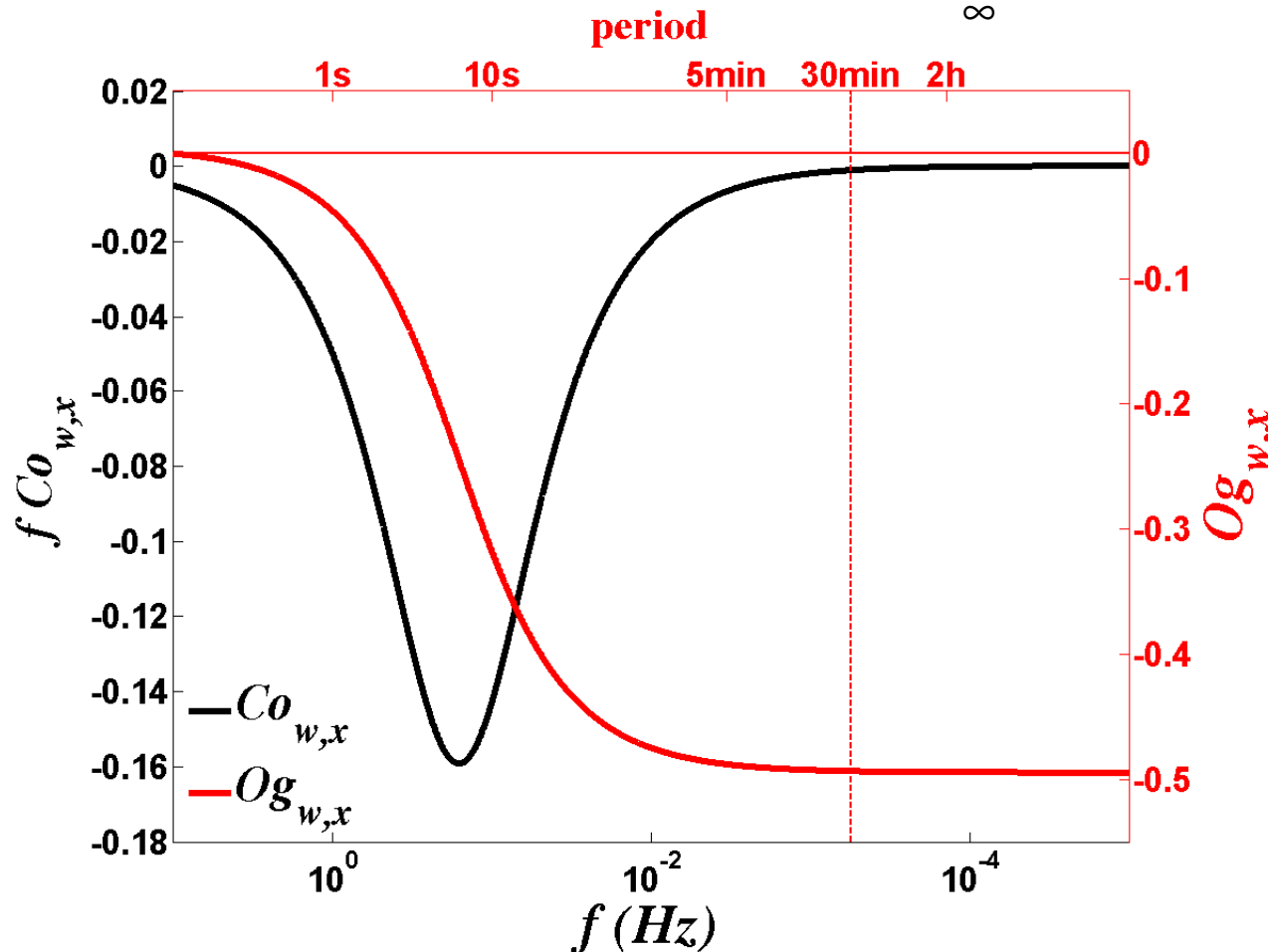
## LITFASS-2003 experiment

- May – June 2003
- Near German Meteorological Service in Lindenberg, SE of Berlin
- Area: 20 x 20 km<sup>2</sup>
- 14 measuring stations over 13 sites
- Selected stations: Grass, Maize, Rye, Lake and Forest
- Data selection
  - Undisturbed wind sector
  - Data quality control (Foken and Wichura 1996)



## Ogive analysis

$$Og_{w,x}(f_0) = \int_{\infty}^{f_0} Co_{w,x}(f) df$$

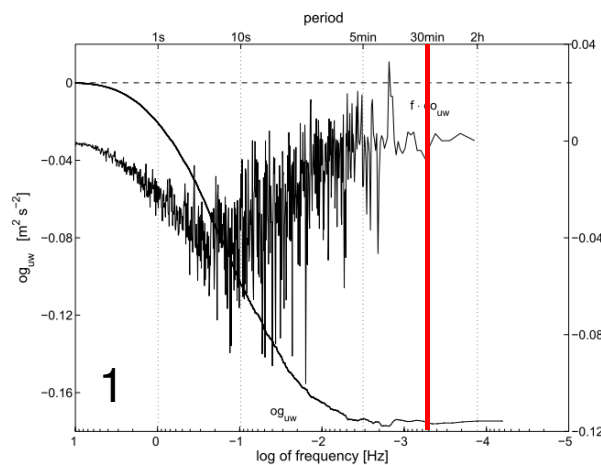


- Cumulative integral of cospectra starting from the highest frequency
- To investigate the flux contribution from each frequency range

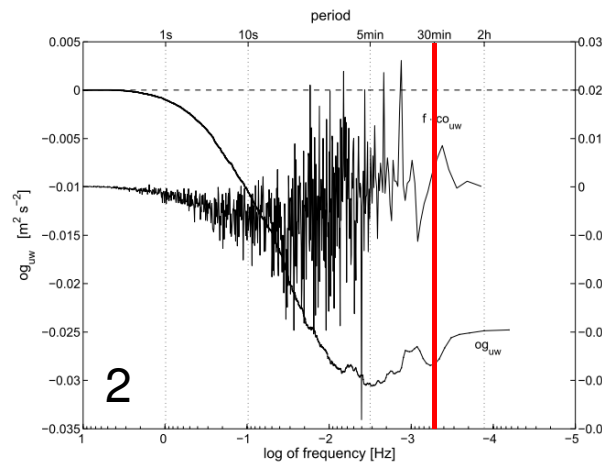
# Ogive analysis

- Earlier analysis: applied to the raw 20 Hz data from maize station in LITFASS-2003
- Calculate cospectra over 4 hours period
- Selected days 7-9.06.2003
- 3 ogive cases
- Majority: case 1

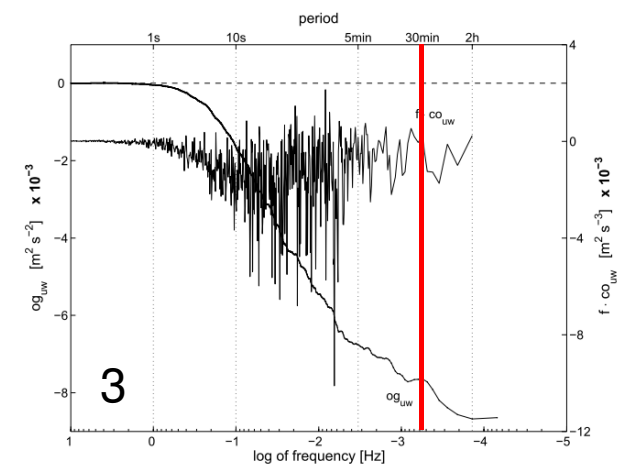
Convert with in 30 min



Peak

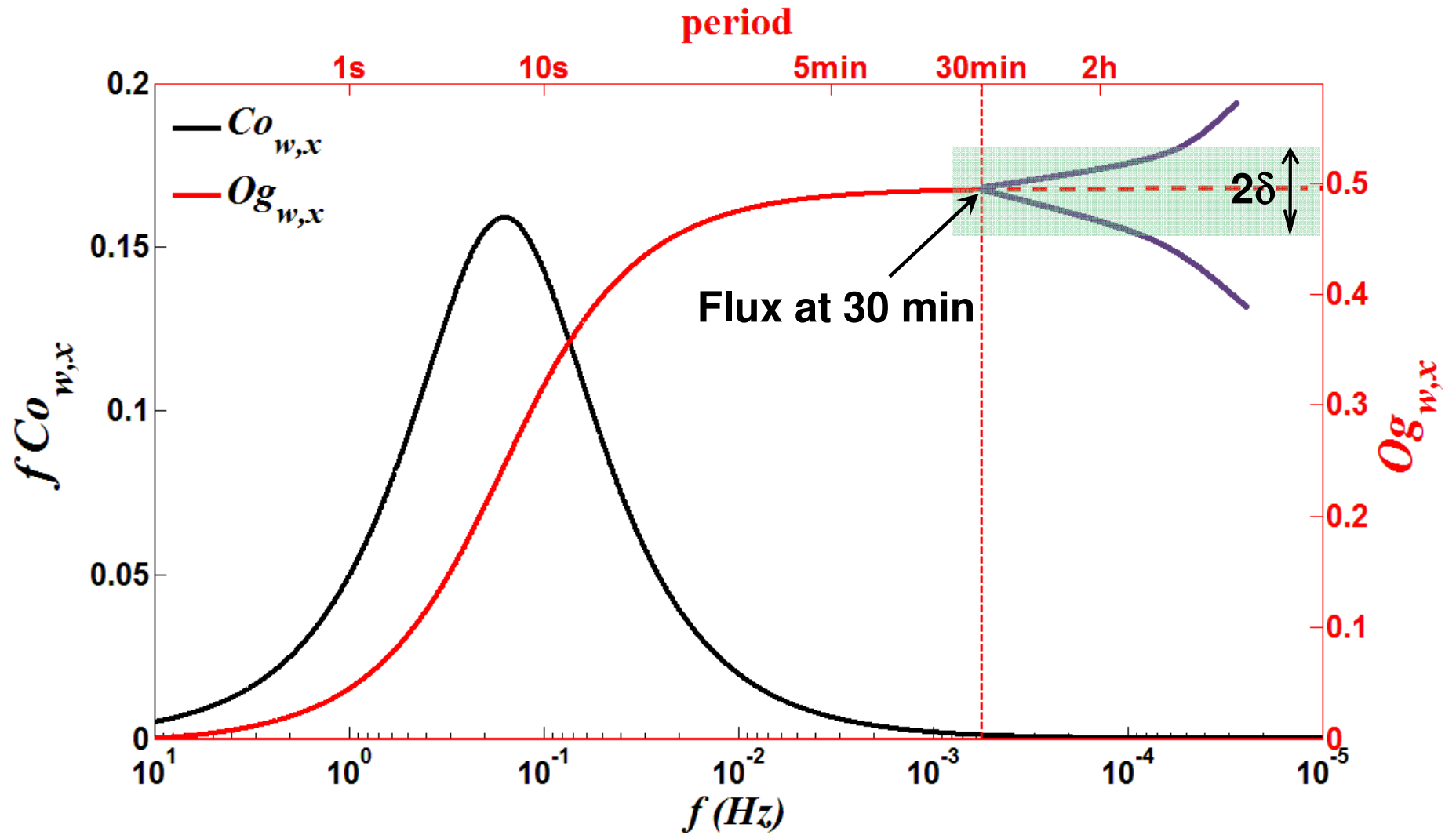


Not convert with in 30 min





# Modified ogive analysis





## Modified ogive analysis



**CASE 1**

Converged with in 30 min

$$\left\| \frac{\Delta \text{Flux after 30 min}}{\text{Flux @ 30 min}} \right\| \geq \delta$$



**CASE 2**

Peak

$$\delta = 10\%, 20\% \text{ or } 10, 20 \text{ Wm}^{-2}$$



**CASE 3**

Not converged with in 30 min

$\delta=10\%$ or 10 $\text{Wm}^{-2}$	flux	Case 1		Case 2		Case 3		
		$ Q_{@30} $	#	$ Q_{@30} $	#	$ Q_{@30} $	$ \Delta Q_{\max} $	#
Forest	Qh	257	72%	181	5%	218	33	23%
	Qe	103	44%	125	10%	116	27	46%
Lake	Qh	42	98%	36	1%	31	11	2%
	Qe	162	89%	114	10%	121	14	2%
Low canopy	Qh	127	87%	92	5%	96	23	8%
	Qe	136	89%	100	4%	124	20	7%

$\delta=20\%$ or 20 $\text{Wm}^{-2}$	flux	Case 1		Case 2		Case 3		
		$ Q_{@30} $	#	$ Q_{@30} $	#	$ Q_{@30} $	$ \Delta Q_{\max} $	#
Forest	Qh	248	94%	170	3%	206	62	3%
	Qe	108	75%	121	5%	123	40	19%
Lake	Qh	41	100%	N/A	0	N/A	N/A	0
	Qe	159	98%	90	2%	N/A	N/A	0
Low canopy	Qh	124	97%	81	1%	74	37	8%
	Qe	134	97%	103	1%	124	28	7%

## Results: Modified ogive analysis

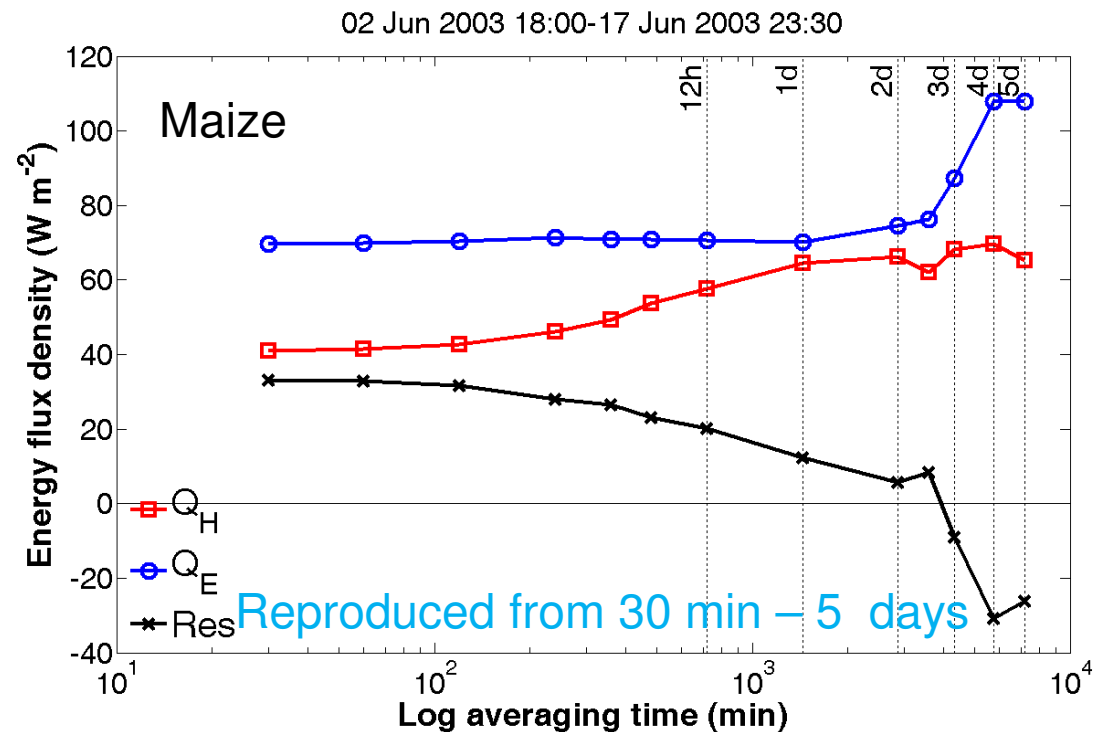
- **Majority: Case 1, 30 minutes average length is enough.**
- **$Q_H$  and  $Q_E$  increase the most over the forest, but could not close the energy balance.**
- **Less effect over low canopy**
  
- **Remarks: significant numbers of runs in case 3 are mostly have one or more of these conditions:**
  - **Very weak wind**
  - **Near neutral condition**
  - **Transition period**

## Ensemble block average (Finnigan et al 2003)

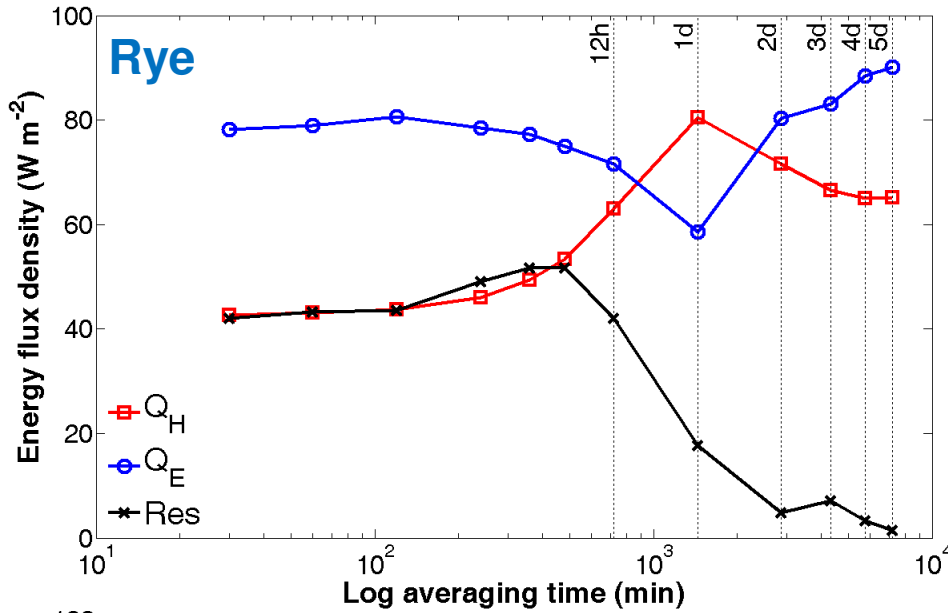
- Ensemble block average is suggested for flux calculation over long period (several hours – several days).
- Energy balance may be closed over the long period.

Mauder and Foken 2006 applied this method to the LITFASS-2003 data measured over the maize field.

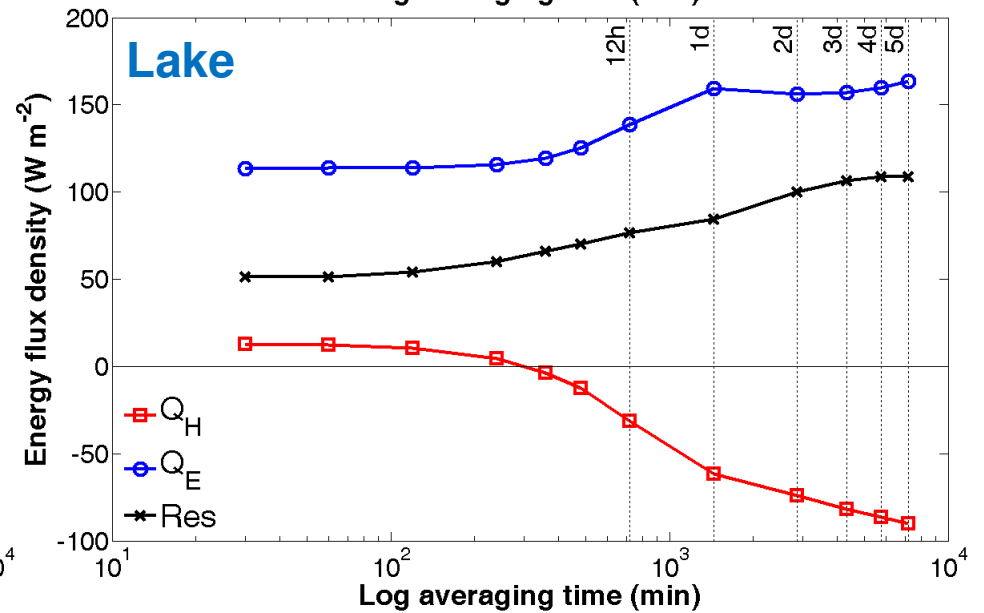
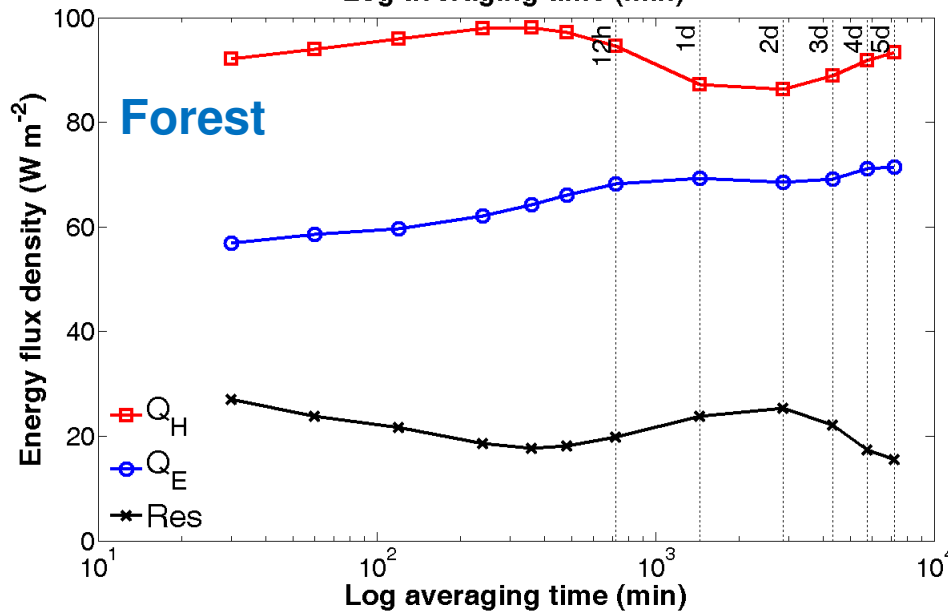
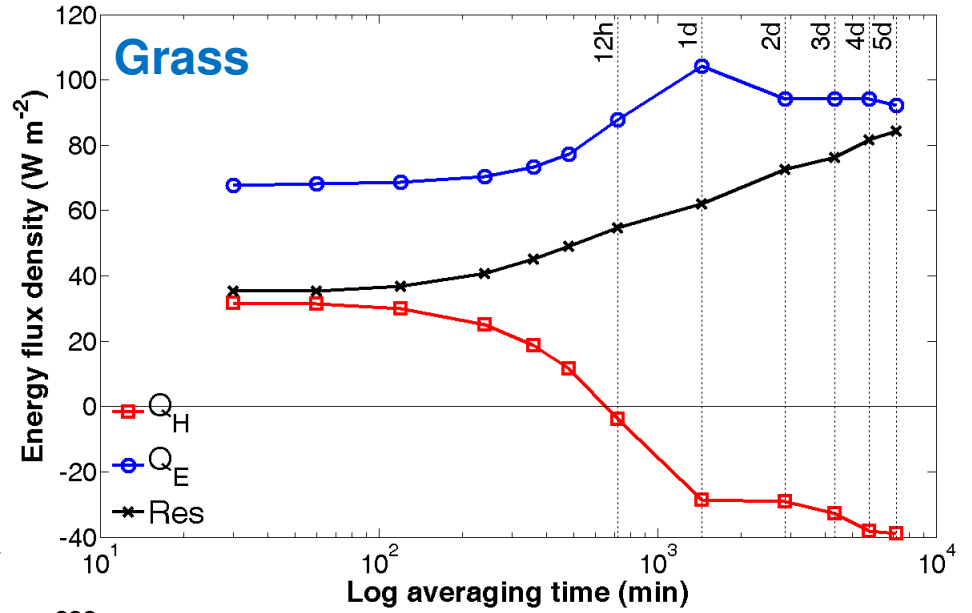
- Selected 15 days
- Ensemble block average from 5 min to 5 days
- Residual goes to zero after half a day, which should be caused by the increasing of  $Q_H$  at the longer period.



02 Jun 2003 18:00-17 Jun 2003 23:30



02 Jun 2003 18:00-17 Jun 2003 23:30





# First results for ensemble block average over several days

- Closure after 12 hours or 1 day was found only in some periods and not uniform for all sites
- It does not generally close the energy balance
- Only small effects were found for lake and forest
- Probably the change was larger for sensible heat than for latent heat



## Conclusions

- **Modified ogive analysis: 30 minutes average length is generally enough to measure most of the fluxes.**
- **Ensemble average: sensible and latent heat flux do change over very long period, but it could not help in closing the energy balance for all site.**
- **Sensible heat flux play more important roll in closing the energy balance.**

# THANKS