

- Ammonia EC measurements
- Damping problem at Dronten

• Albrecht Neftel, Christoph Hani, Andreas Ibrom,  
Arjan Hensen, Chris Flechard, Michael Bell, Pim  
van den Bulk

• EGU Vienna

• 24 April 2017

• [www.ecn.nl](http://www.ecn.nl)

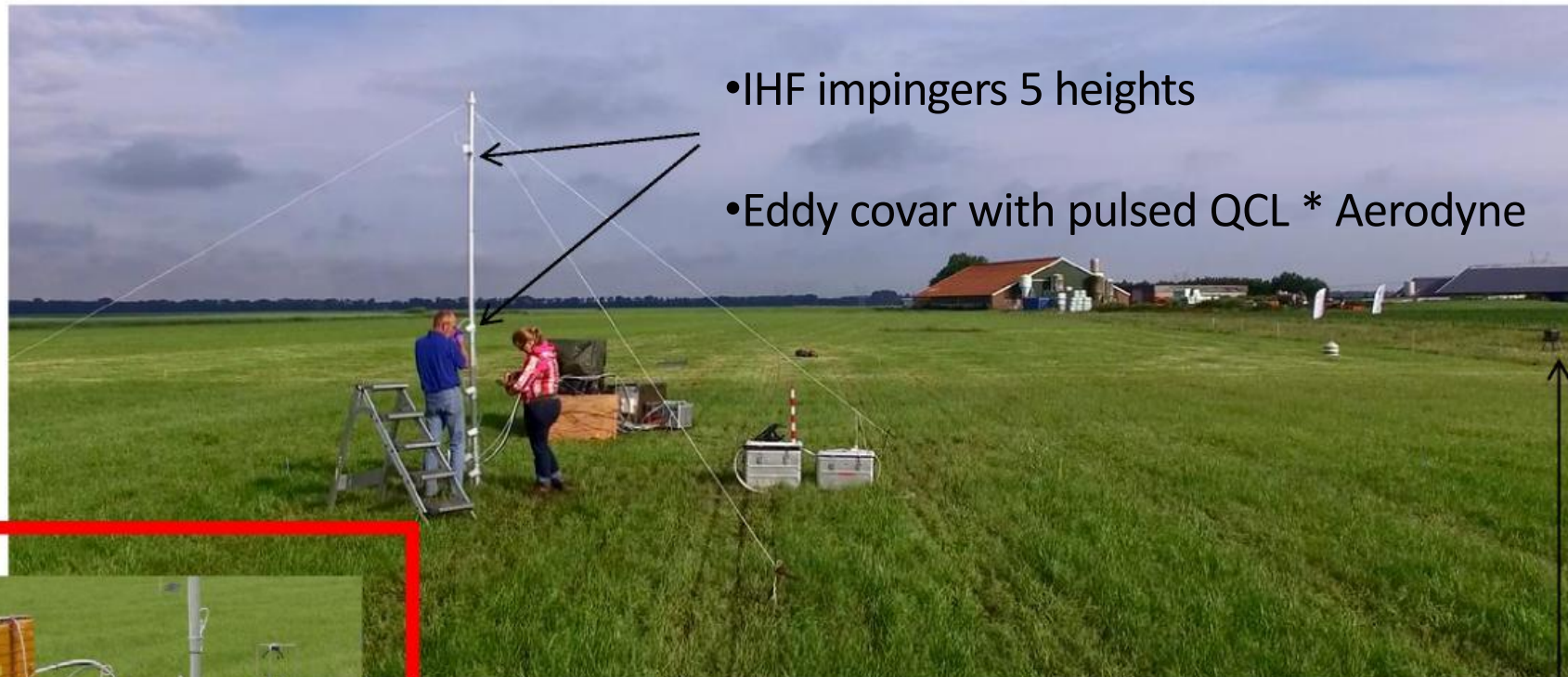


- Gill
- WMPPro
- + virtual
- impactor inlet

- 4 m inlet
- heated & at
- 0.1 barr

- Aerodyne CH<sub>4</sub>-N<sub>2</sub>O-H<sub>2</sub>O-NH<sub>3</sub> QCL

# •Plot North: Injected

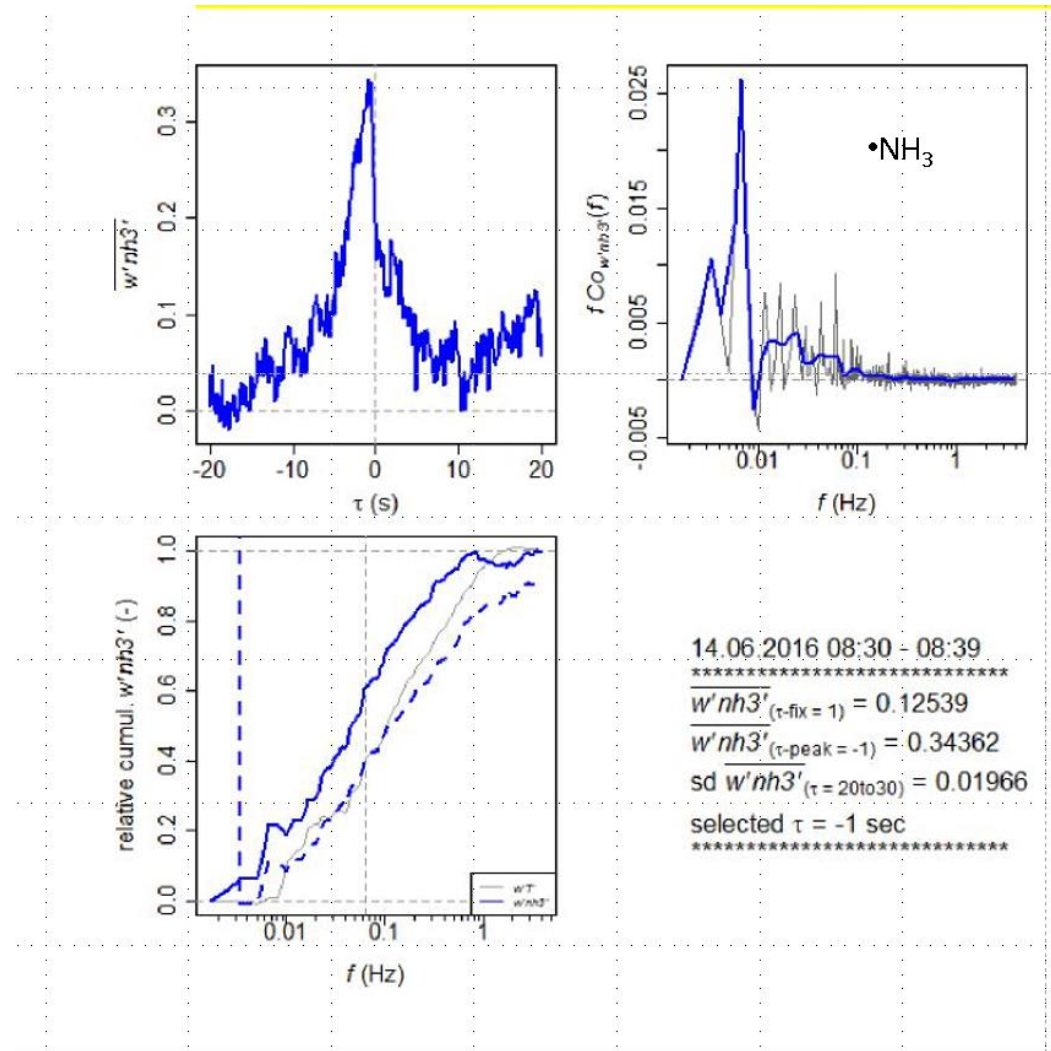


- Downwind mini doas

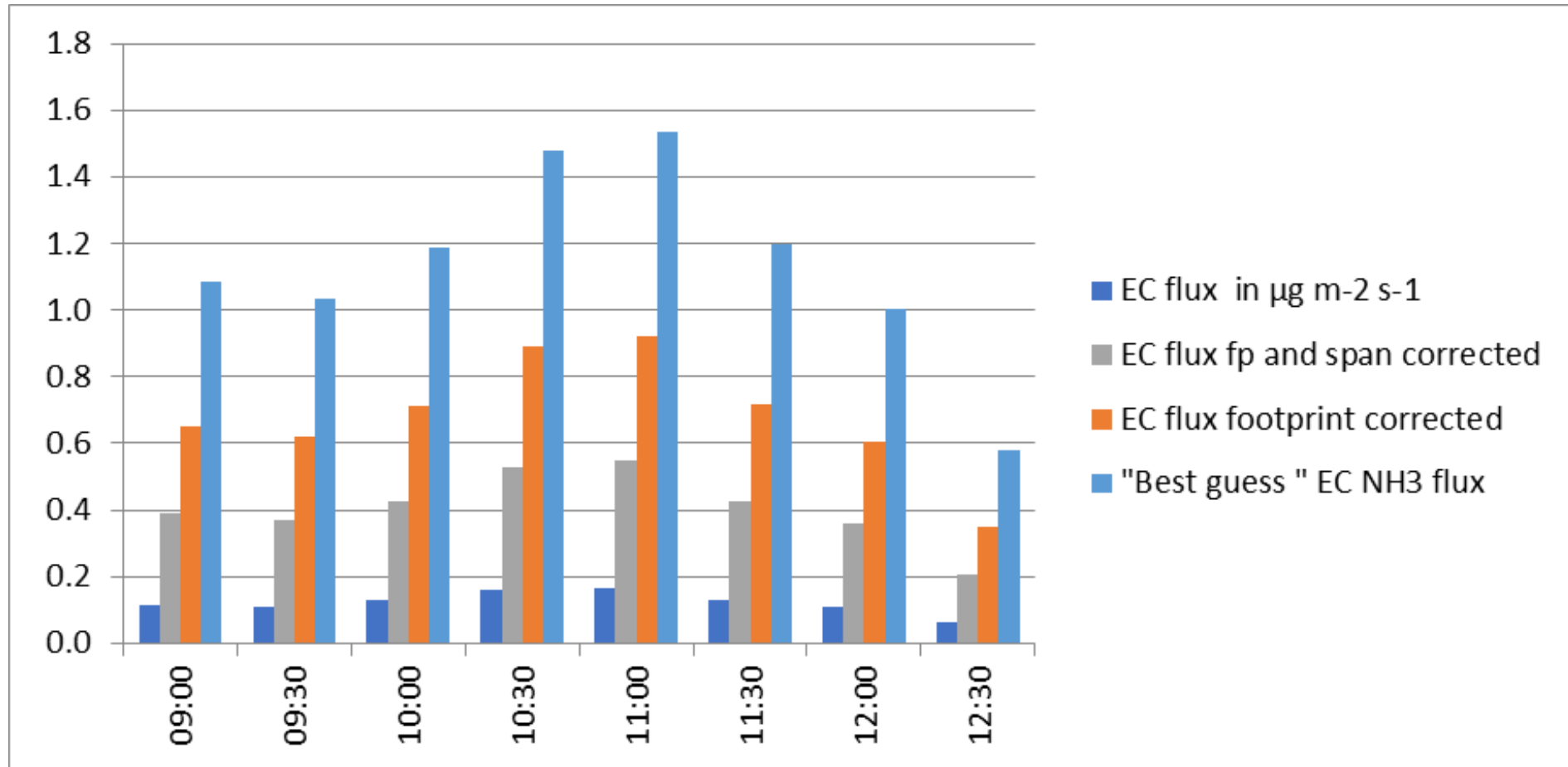
- Amanda wet chemical



# NH<sub>3</sub> eddy vertical flux: An example of a covariance function



# Eddy data in 30 minute blocks

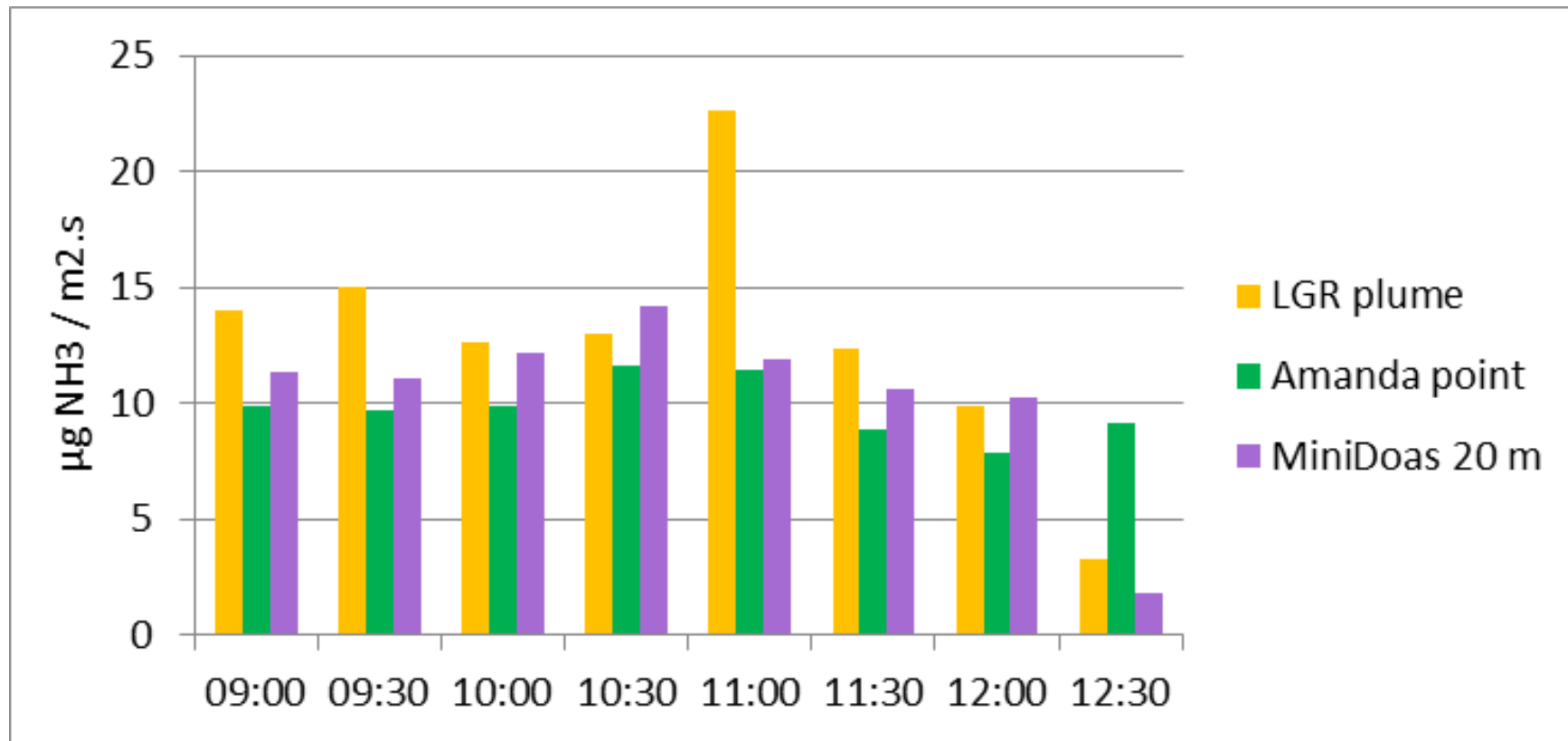




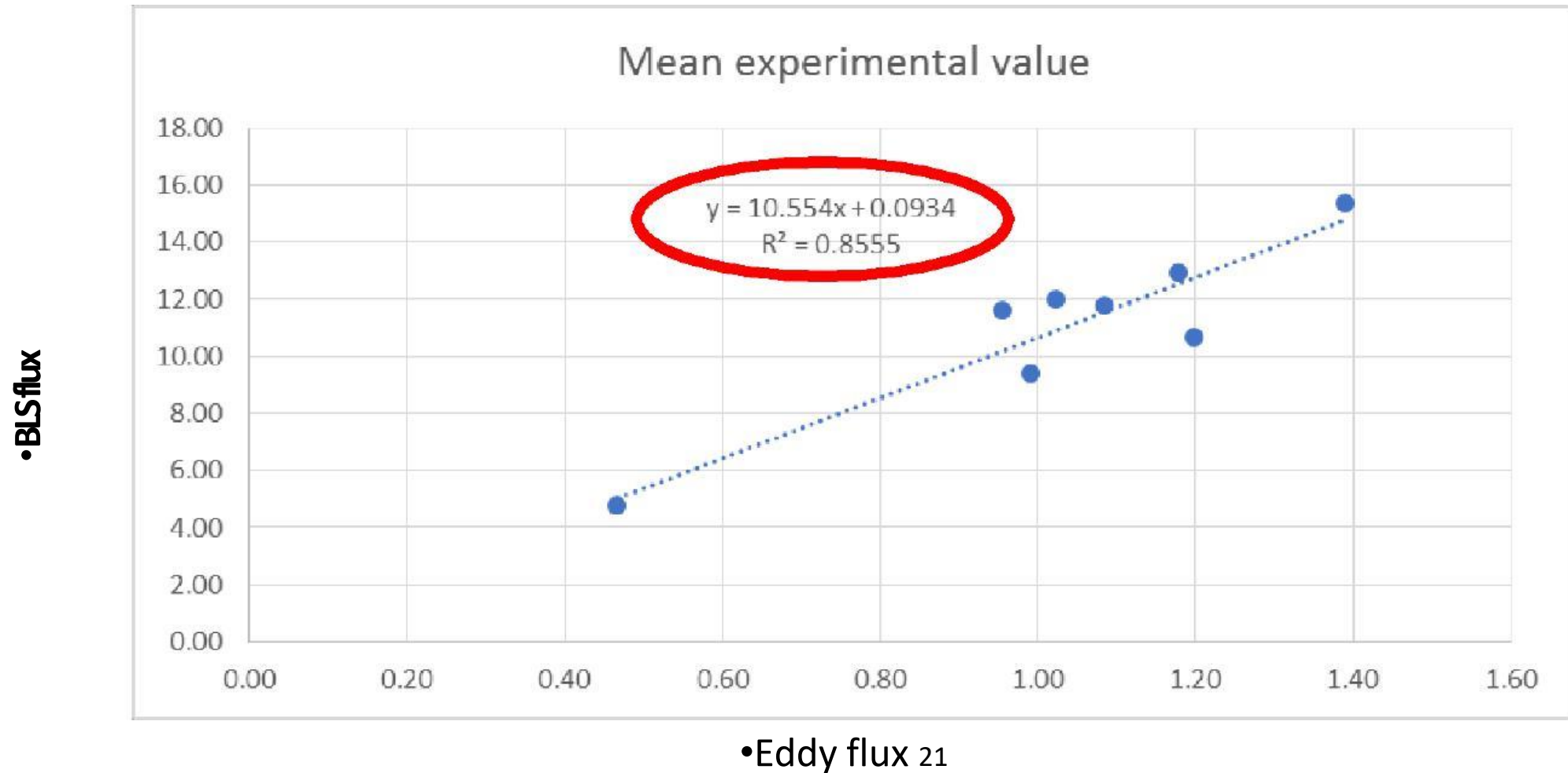
Compare Eddy and other flux: It shows roughly one order of magnitude too low EC fluxes

---

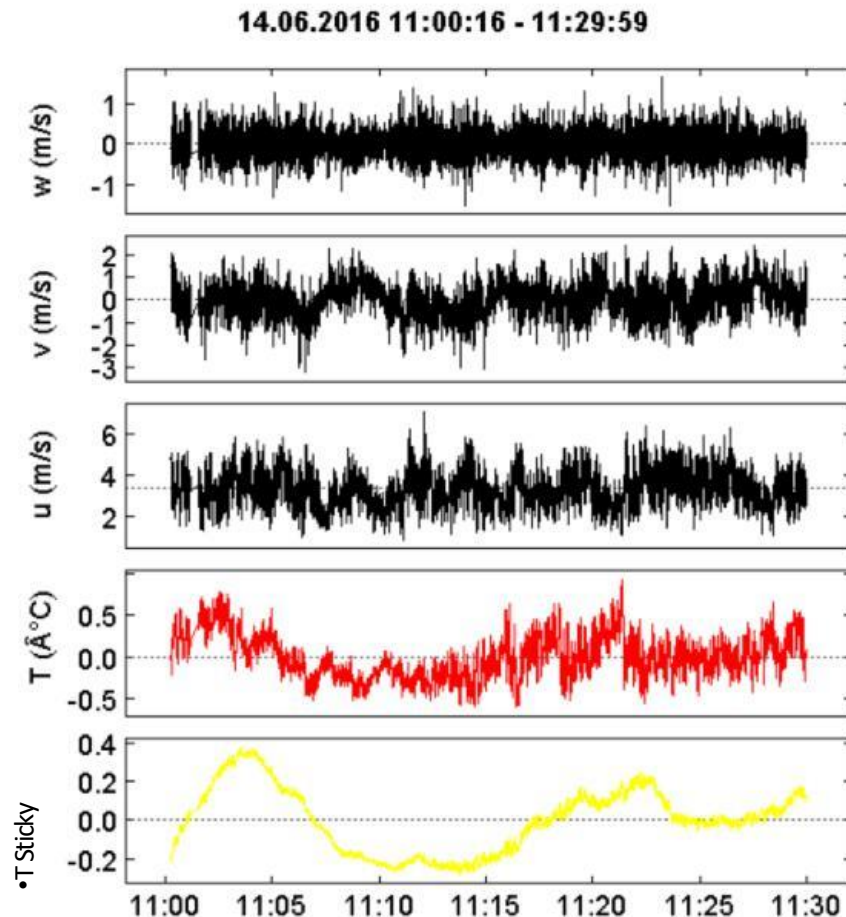
- The three bls based estimates



- Or in an x-y graph



# Hypothesis: decoupling effect at the inlet



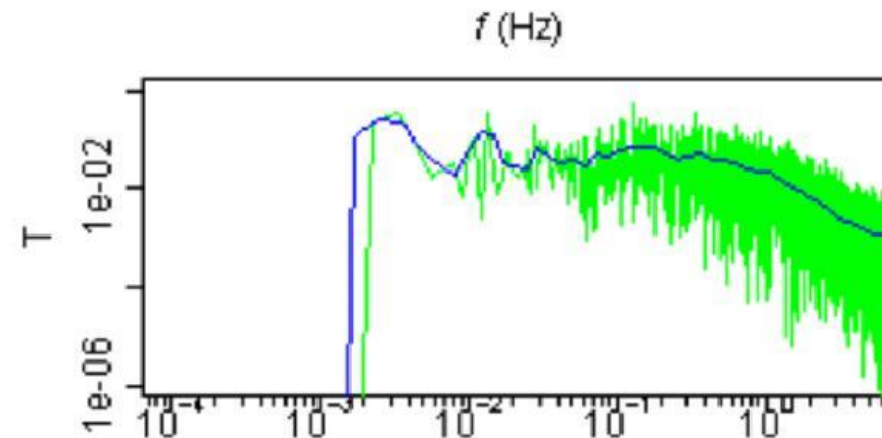
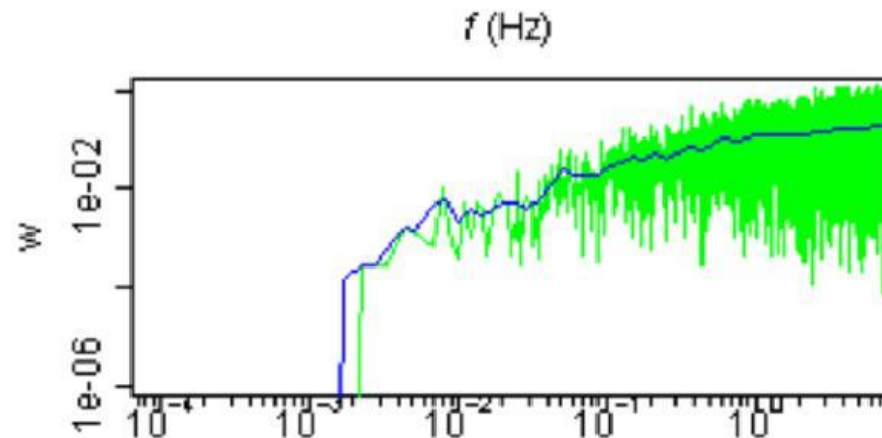
- Assume „Sticky“ or decoupled signal:

- 10% of the signal passes undamped
- 90% of the signal is damped with a
- recursive filter (low pass) and shifted

- R-code: `data_int<-rawdata$T`
- `tempfraction<-0.1*`
- `data_int+0.9*recursive.filter(vector.s`
- `hft( data_int,750),700)`
- `rawdata$T<-tempfraction`



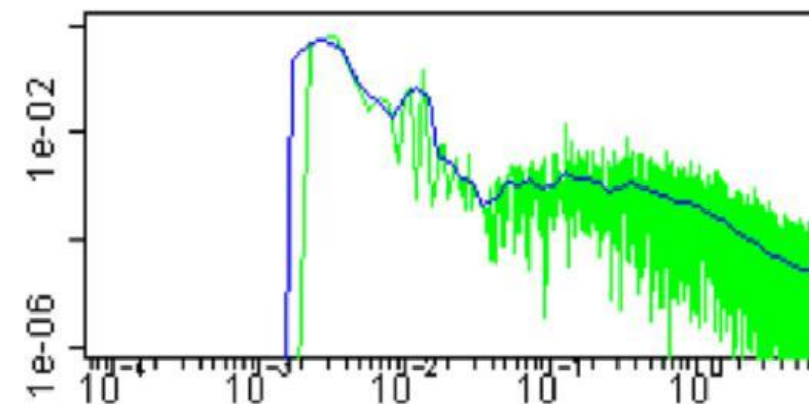
# •Decouple effect on power spectra:



•Original

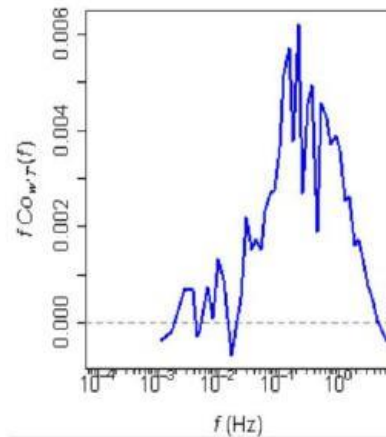
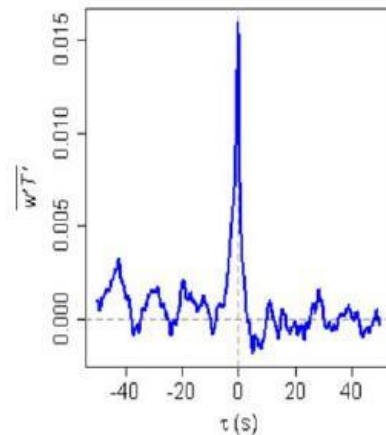
•Decoupled

•T siticky



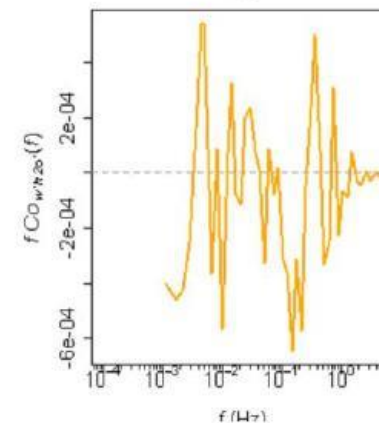
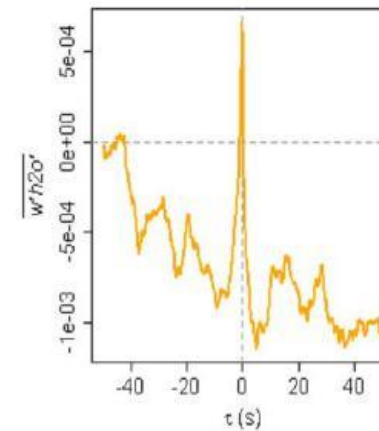
# Effect on covariance functions

## •Original Heathflux



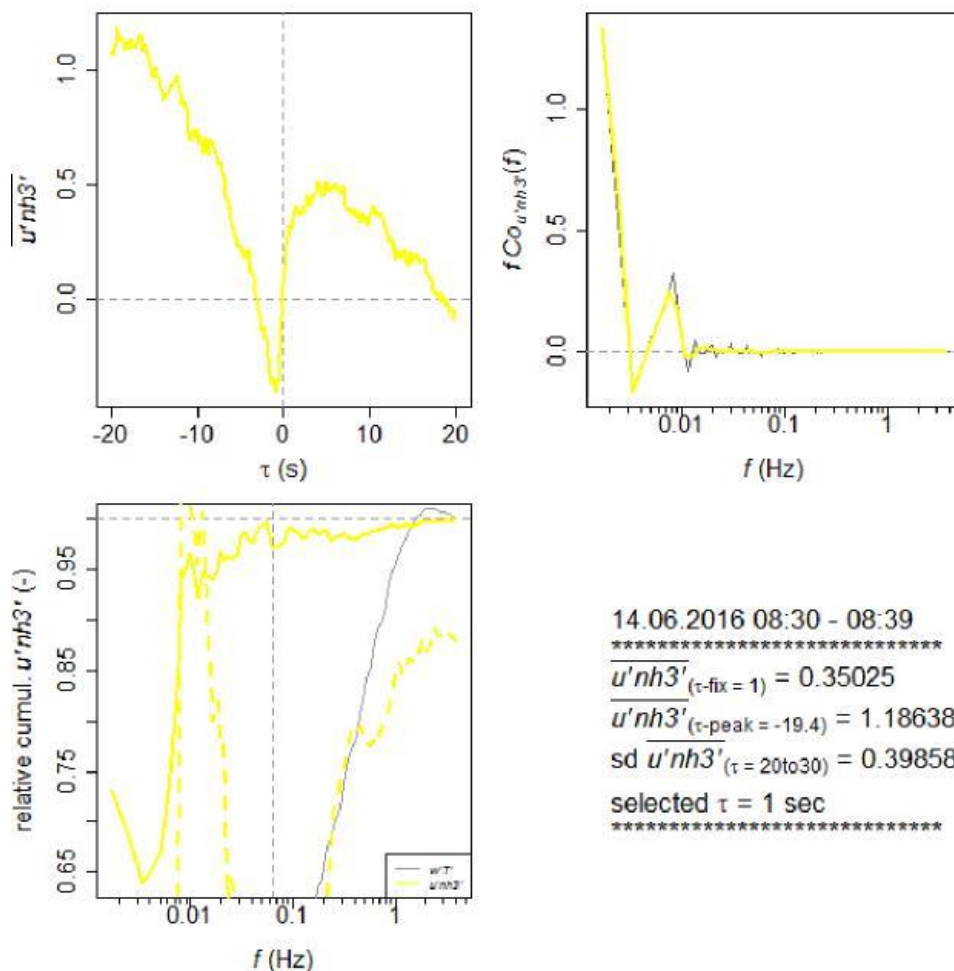
14.06.2016 11:00 - 11:29  
 \*\*\*\*\*  
 $\overline{w'T'}_{(\tau\text{-fix}=0)} = 0.01275$   
 $\overline{w'T'}_{(\tau\text{-peak}=-0.2)} = 0.01593$   
 $sd \overline{w'T'}_{(\tau=50\text{to}80)} = 0.00015$   
 selected  $\tau = -0.2$  sec  
 \*\*\*\*\*

## Decoupled Heathflux (replaced in the program the water flux)



14.06.2016 11:00 - 11:29  
 \*\*\*\*\*  
 $\overline{w'h2o'}_{(\tau\text{-fix}=-0.6)} = 0.00041$   
 $\overline{w'h2o'}_{(\tau\text{-peak}=4.9)} = -0.00114$   
 $sd \overline{w'h2o'}_{(\tau=50\text{to}80)} = -0.0003!$   
 selected  $\tau = -0.6$  sec  
 \*\*\*\*\*

# •horizontal..... $u'c'$ turbulent



- Damping correction needed
- if vertical eddy flux = IHF flux
  - (use footprint)
- Then  $u'c'/u_{avg}C_{avg}$ : about 10%

### Conclusions

- Horizontal turbulent flux  $\langle u'c' \rangle$ : 15-20% bias
- Relatively small, but one sided (bias error)
- Rather robust, but
- Tbd: influence of atmospheric stability, wind speed, geometry (R,h) and Reynolds number.

OVERESTIMATE

UNDERESTIMATE

Detailed Numerical Simulations of Atmospheric Turbulence can yield insight in the mechanisms.

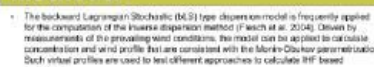
TU Delft

Albrecht Neftel<sup>1</sup>, Arjan Hensen<sup>2</sup>, Christoph Häni<sup>3</sup>, Michael Belf<sup>4</sup>, Christoph Flechard<sup>4</sup>, Pim van den Bulk<sup>2</sup>, Danielle van Dinther<sup>2</sup>, Arnaud Frumau<sup>2</sup>  
<sup>1</sup>Nettel Research Expertise, Wohlen B, Bern, Switzerland; <sup>2</sup>Energy research centre of the Netherlands ECN, Petten, The Netherlands; <sup>3</sup>Bern University of Applied Sciences; School of Agricultural, Forest and Food Sciences, Zollikofen, Switzerland <sup>4</sup>INRA, Agrocamous Ouest, UMR 1069 SAS, Rennes, France

- The integrated/horizontal flux (IHF) method is a simplified mass balance approach frequently used to determine  $\text{N}_2$  emissions from confined source areas, e.g.  $\text{NH}_3$  emissions from slurry spread to a circular plot (Donnadieu, 2006). With a mask in the centre of the circle with radius  $X$ , the total flux  $F$  of the upward emitted  $\text{NH}_3$  is approximated from the measured vertical ( $z$ ) profiles of concentration ( $c$ )
- and horizontal wind speed ( $u$ ) as (Donnadieu 1983):

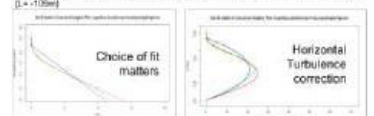
\* where  $c_{\text{background}}$  is the "background" concentration upwind of the emitting area and  $x_{\text{plume}}$  is the maximum height of the emission plume (where the concentration  $c$  equals  $c_{\text{background}}$ ).

\* The IRF method is a robust approach, as it is independent of surface characteristics and the state of atmospheric diffusion (Denneved, 2008; Loubach 2010). Ryden and Mohrén (1984) published guidelines on how to evaluate IRF measurements, which have been used in many investigations that followed. In the following we analyse systematic biases that might occur by applying different recipes to both modelled concentration profiles as well as measured profiles from a recent field experiment in the Netherlands.



	integral				
	logit	exit	double-exit	Stepwise no horizontal diffusion connection	stepwise connection of horizontal diffusion
incomplete: $L=100\%$ $\sigma^2=0.3$ sec-1	51	15	21	23	20
complete: $L=323\%$ $\sigma^2=0.1$ sec-1	52	17	23	24	20

„Classical“ experimental approach with 6 heights: 0.2m, 0.4m, 0.8m, 1.6m, 3.2m, 4.8m



True value equal fetch corresponds to the radius of Red dots: u/c.

MODEL WORLD SUGGEST:

Logit: Overestimation of 56%	On top of that:
Expit: Overestimation of 5.5%	Turbulent correction
Doublesplit: Overestimation of 16%	EFFECTIVE = 56%

- \*  $\text{NH}_3$  emission factors describing  $\text{NH}_3$  losses after application of organic manure are partially based on field measurements using micrometeorological techniques. They can be classified as i) Mass balance approaches such as integrated horizontal flux measurements [1,2], ii) Vertical flux measurements (eddy covariance, Aerodynamic Gradient Technique [3]) iii) Horizontal concentration gradients across an emitting surface in conjunction with a dispersion model [4]

\* In June 2016 NHG emissions of two simultaneously emitting circles of 40m diameter have been determined in a field experiment in Dronen (NL) using a combination of all three micrometeorological techniques. This unique dataset allows a systematic investigation of the occurrence of differences between the

methods (see e.g. <https://www.youtube.com/watch?v=Sz8FQeW5X0Q>).



Figure 1 illustrates the experimental design, showing a sequence of steps: 'get (randomly) from 1 to 100', 'get (randomly) from 1 to 100', 'get (randomly) from 1 to 100', and 'get (randomly) from 1 to 100'. The first three steps are grouped under a box labeled 'get (randomly) from 1 to 100'. The final step is labeled 'get (randomly) from 1 to 100'.

Figure 1. Probability density function of calculated one-season return with 9.5% of randomly generated profiles assuming a normal distribution with a an RGEI of 0.9%.

	GEI 1.0	GEI 0.95	GEI 0.9	GEI 0.85	GEI 0.8	GEI 0.75	GEI 0.7
lognormal 1	6	3	10	23	5.2	20.1%	14.6%
lognormal 2	16	12	16	28	8.4	12.9%	5.7%
lognormal 3	18	15	16	21	9	13.9%	1.9%
lognormal 4	14	10	15	12	9.4	9.7%	20%
lognormal 5	9	7	9	5	11.8	8.9%	20%

- IHF method is robust, but the result depends on the fit chosen
- The Ryden and McNail recipe (published in 1998) tends to overestimate the emission between 10% and 30%
- The correction needed for fundamental emission is of the order of 10%

according to the bis - model and depends on stability, the extension of the source, and location of the sensors.

## References:

Figure 2.6. Variable  $z_{10}$  (aka Application of the recommended best-practice network for determination of an existing facility's greater search area) of

Q3: Which language developed by Christian Monks in medieval times? (Latin, German, English, French)

- 29