

- 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

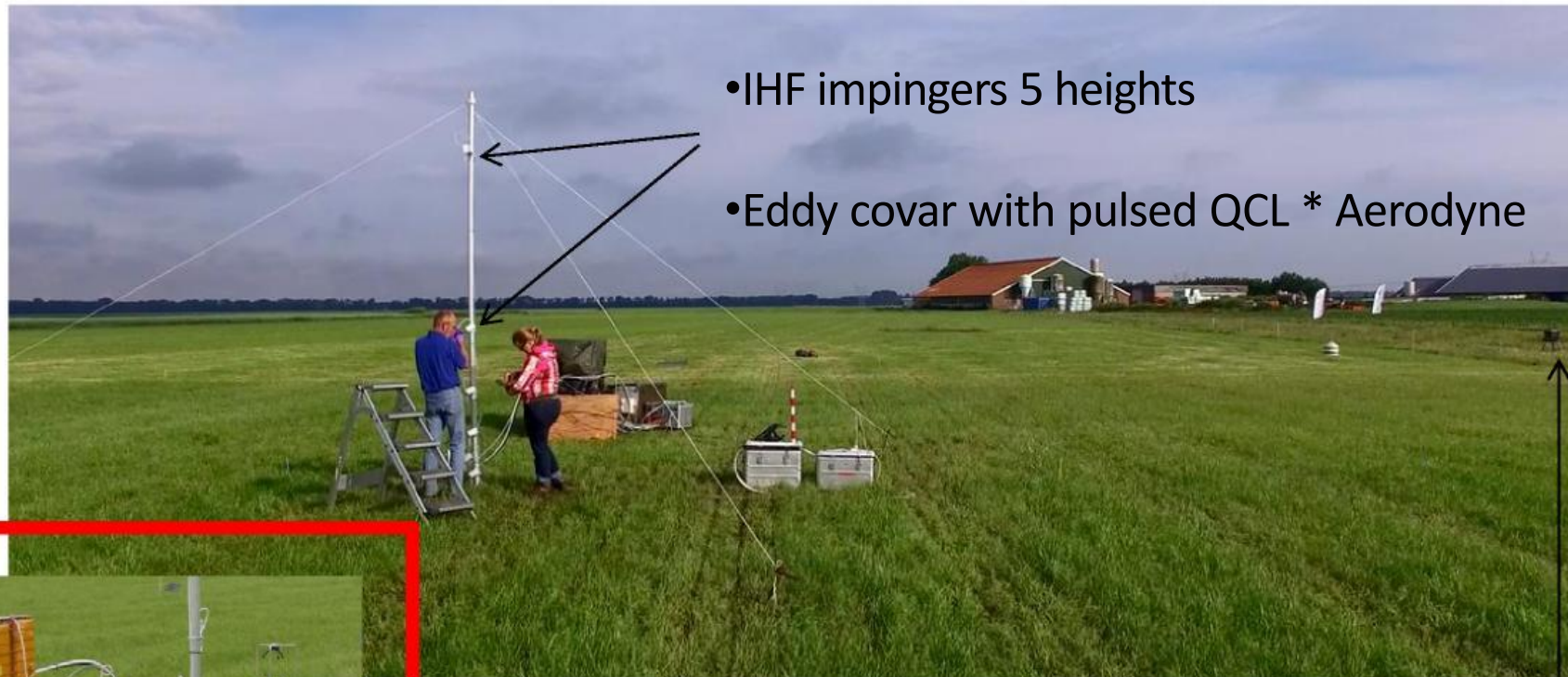
• 24 April 2017

• www.ecn.nl



- Gill
- WMPPro
- + virtual impactor inlet
- 4 m inlet
- heated & at
- 0.1 barr
- Aerodyne CH₄-N₂O-H₂O-NH₃ QCL

•Plot North: Injected



•IHF impingers 5 heights

•Eddy covar with pulsed QCL * Aerodyne



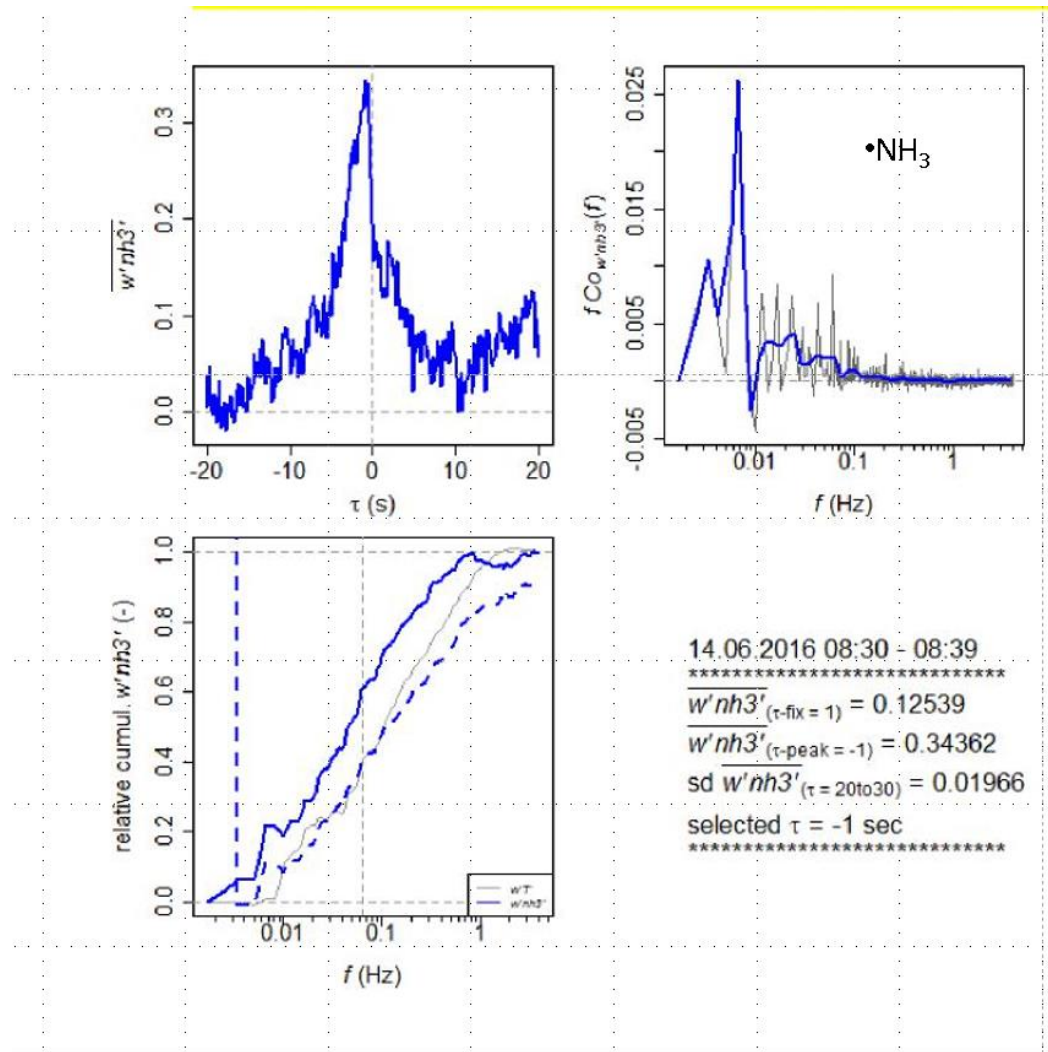
•QCL

•□ Downwind mini doas

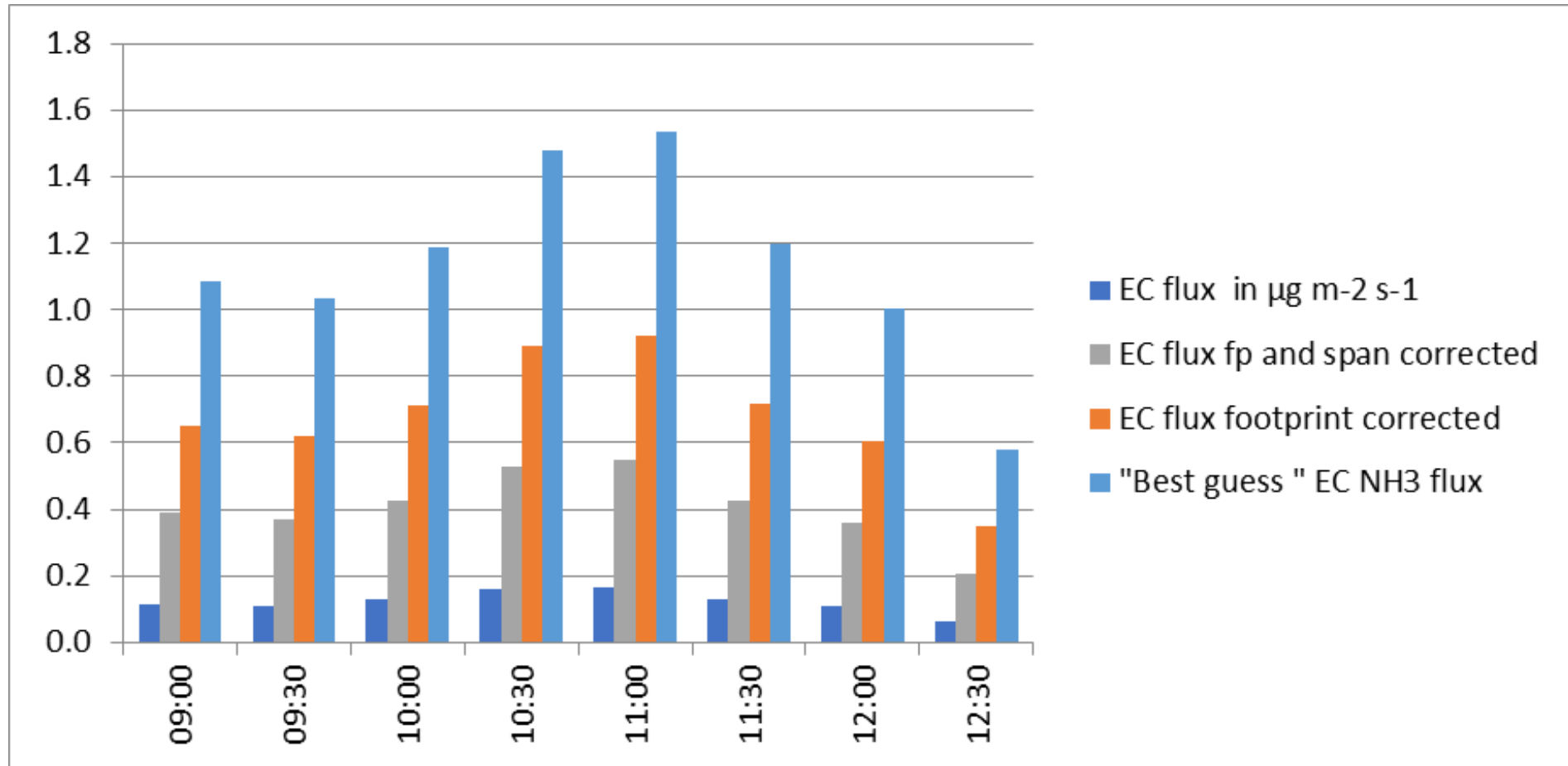
•Amanda wet chemical □



NH₃ eddy vertical flux: An example of a covariance function

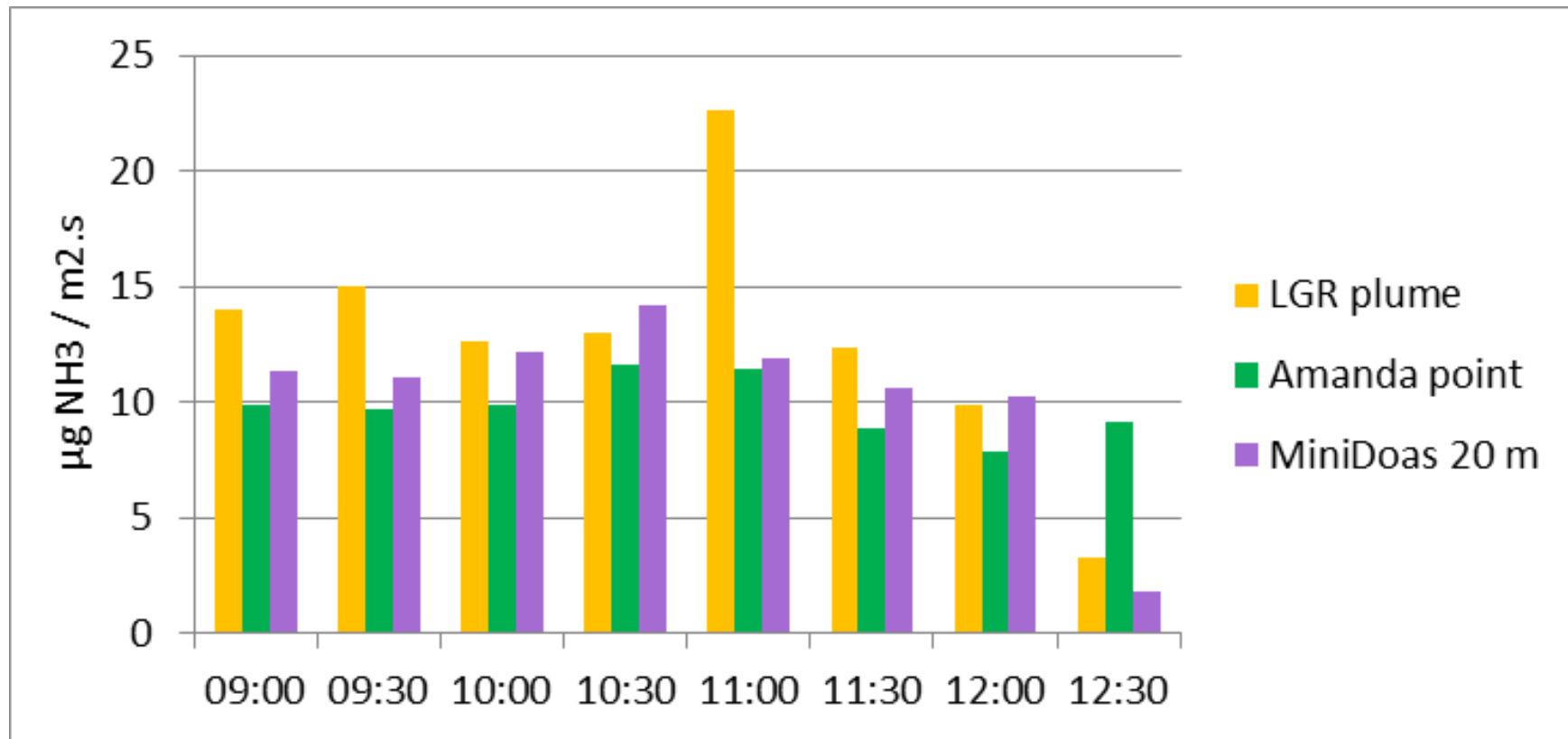


Eddy data in 30 minute blocks

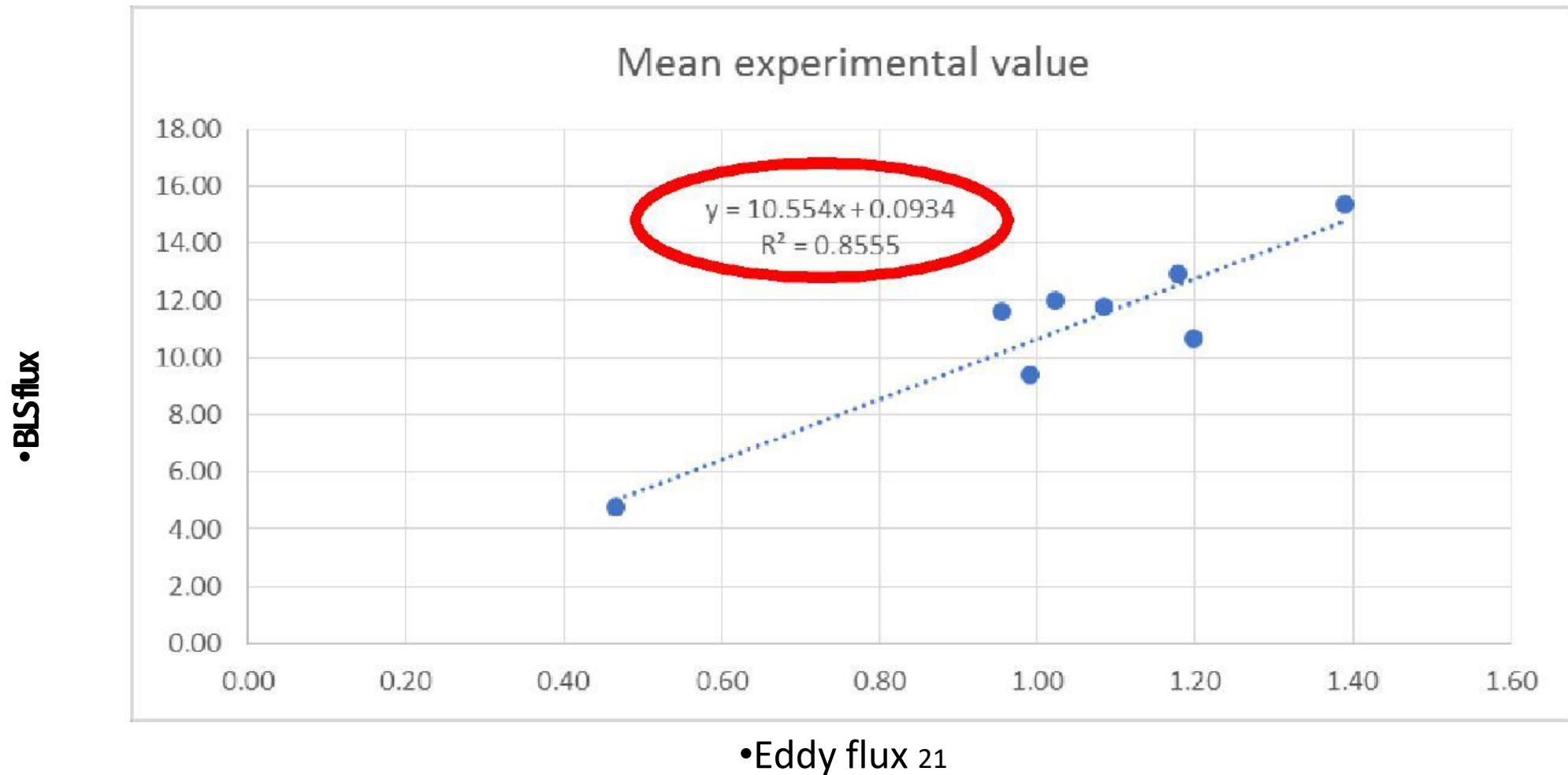


Compare Eddy and other flux: It shows roughly one order of magnitude too low EC fluxes

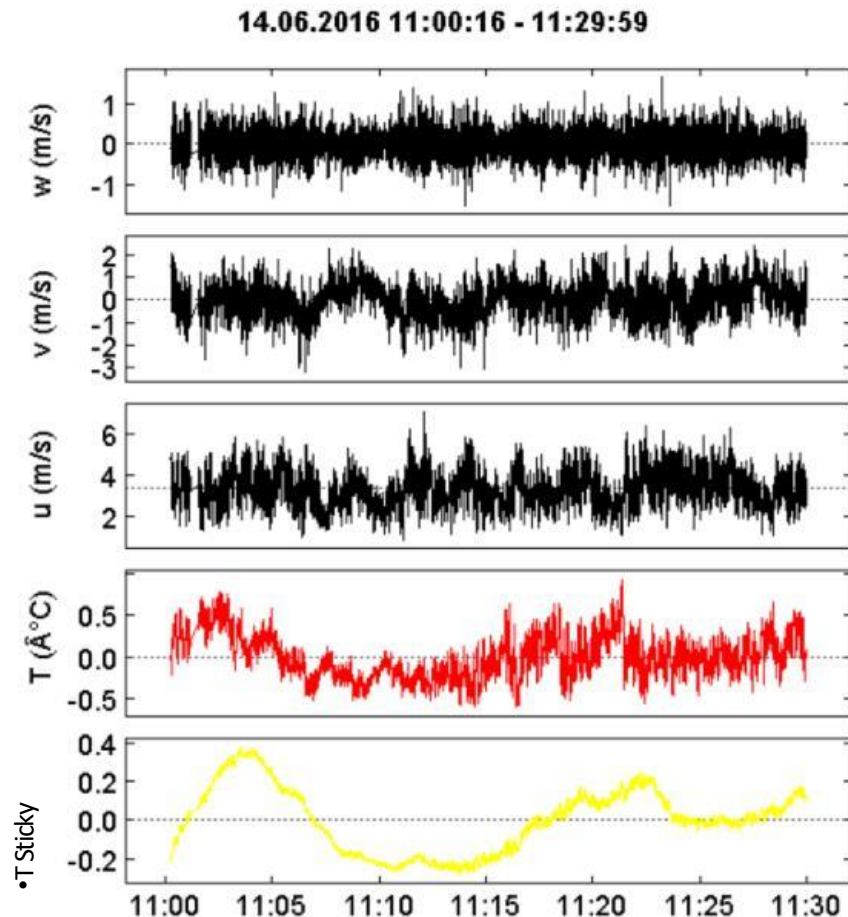
- The three bls based estimates



- Or in an x-y graph



Hypothesis: decoupling effect at the inlet

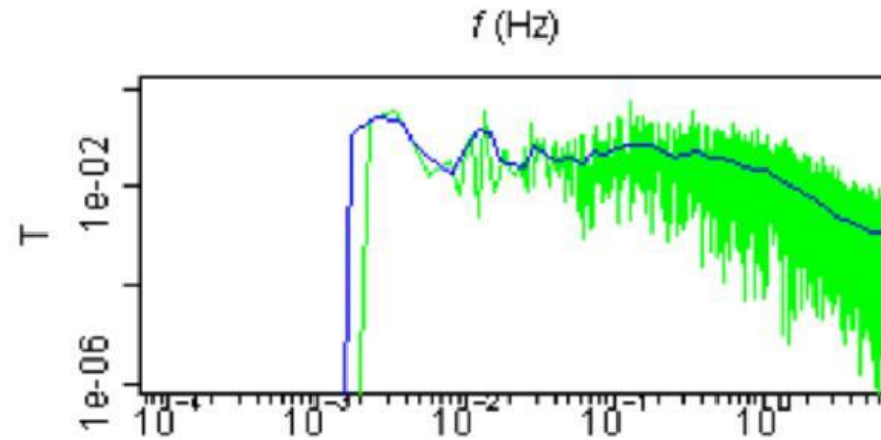
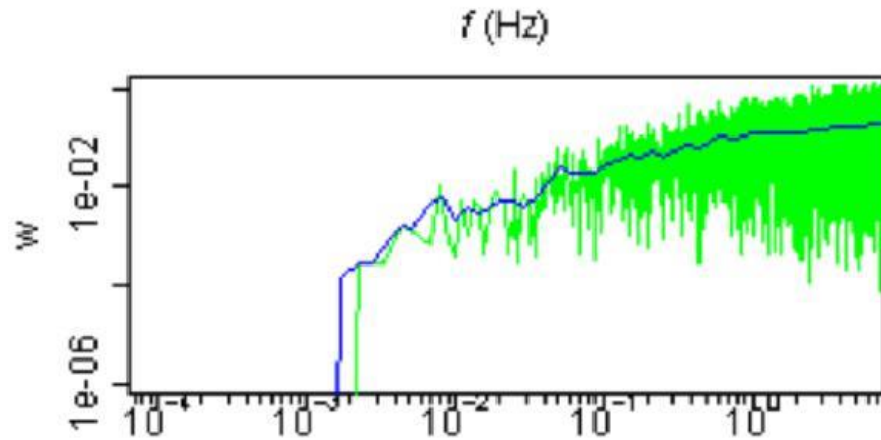


- Assume „Sticky“ or decoupled signal:

- 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`

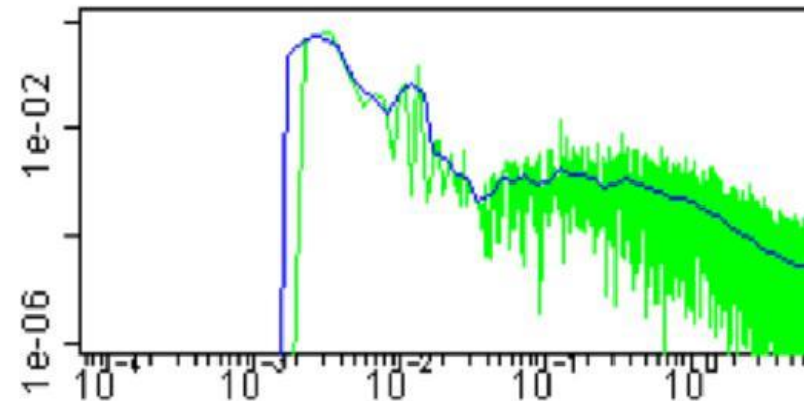
•Decouple effect on power spectra:



•Original

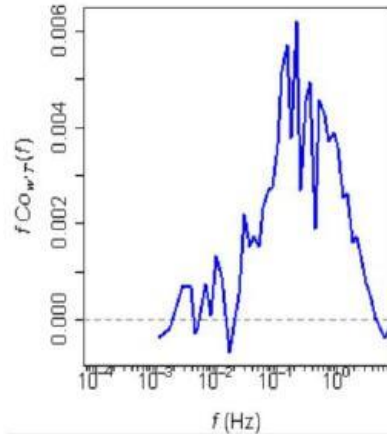
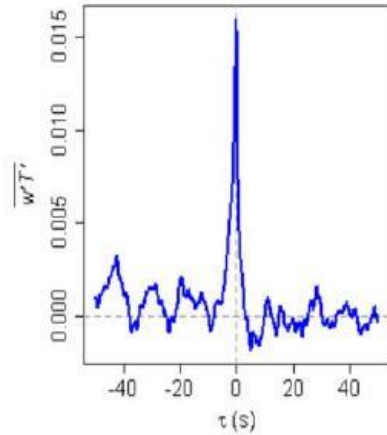
•Decoupled

•T siticky



Effect on covariance functions

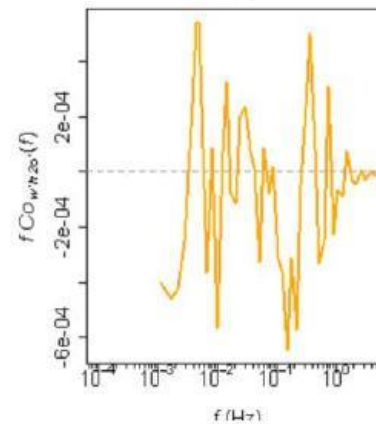
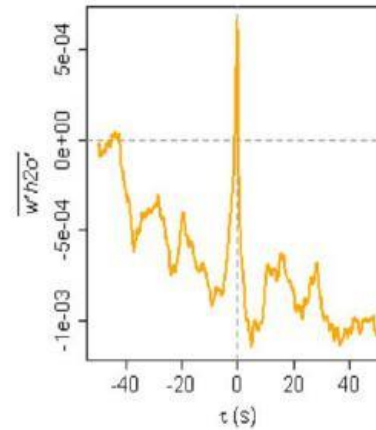
•Original Heathflux



14.06.2016 11:00 - 11:29

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

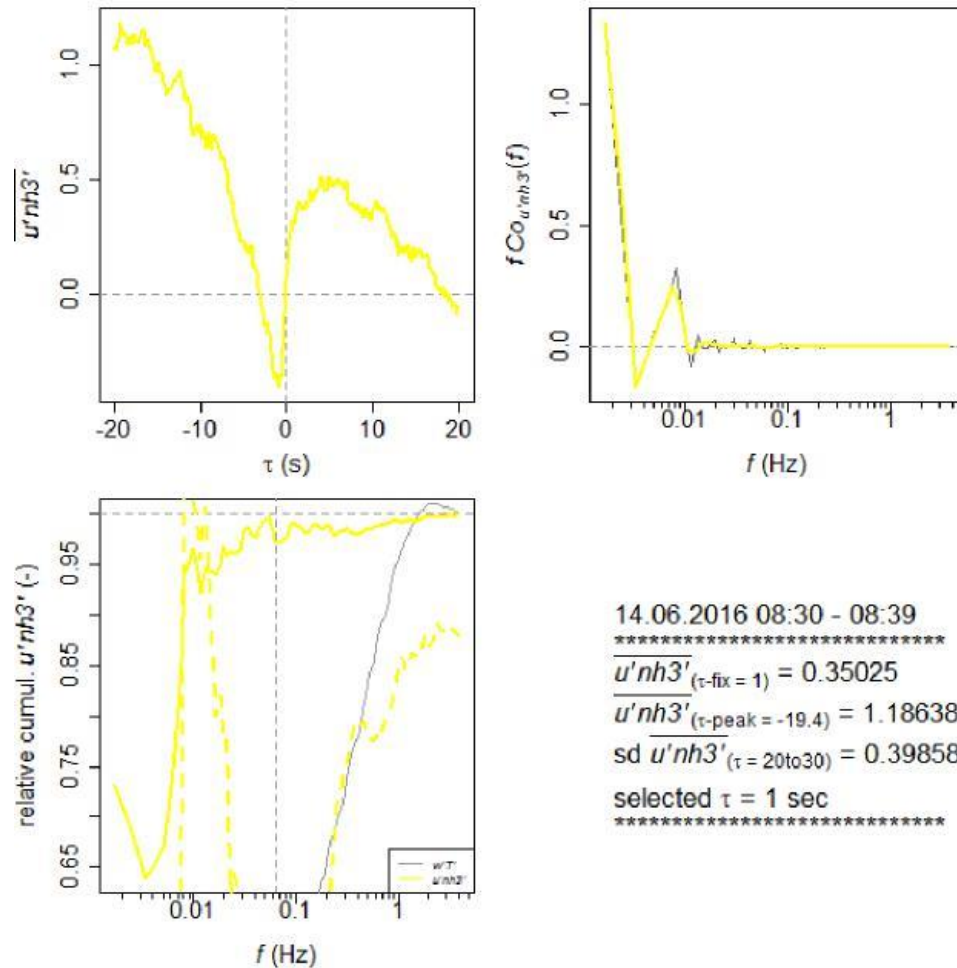
Decoupled Heathflux (replaced in the program the water flux)



14.06.2016 11:00 - 11:29

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

•horizontal.... u'c' turbulent




- Damping correction needed
- if vertical eddy flux = IHF flux
 - (use footprint)
- Then $\overline{u'c'}/u_{avg}c_{avg}$: 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 Detailed Numerical Simulations of Atmospheric Turbulence can yield insight in the mechanisms.

 TU Delft

•Check poster for more!

Reevaluation of the integrated horizontal flux approach

Albrecht Neftel¹, Arjan Hensen², Christoph Häni³, Michael Bell⁴, Christoph Flechard⁴, Pim van den Bulk², Danielle van Dinther², Armond Frumau²
¹[Nefel Research Expertise, Wohlen b. Bern, Switzerland], ²[Energy research Centre of the Netherlands ECN, Petten, The Netherlands], ³[Bern University of Applied Sciences; School of Agricultural, Forest and Food Sciences; Zollikofen, Switzerland] ⁴[INRA, Agrocampus Ouest, UMR 1069 SAS, Rennes, France]

Introduction

- The integrated horizontal flux (IHf) method is a small scale mass balance approach frequently used to determine emissions from confined source areas, e.g. NH₃ emissions from dairy farms to a circular plot (Dennefeld, 2008). With a mass air flow meter of the circle with radius X, the total flux F of the upwind emitted NH₃ is approximated from the measured vertical (z) profiles of concentration (c) and horizontal wind speed (u) as (Dennefeld 1983):

$$F = \frac{1}{2\pi X} \int_{z_0}^{z_{top}} u(z) (c(z) - c_{bg}) dz$$

where c_{bg} is the "background" concentration on upwind of the emitting area and z₀ is the maximum height of the emission plume (where the concentration c equals c_{bg})

- The IHf method is a robust approach, as it is independent of surface characteristics and the state of atmospheric diffusion (Dennefeld, 2008; Loulich 2010). Ryden and McNail (1994) pointed out that issues have to arise with IHf measurements, which have been used in many field studies that followed. In the following we analyze systematic biases that might occur by applying IHf designs to both modelled concentration profiles as well as measured profiles from a recent field experiment in the Netherlands.

Methods:

- The backward Lagrangian Stochastic (BLD) type dispersion model is frequently applied for the computation of the inverse dispersion method (IDM) at 2010. Chosen by measurements of the prevailing wind conditions, the model can be applied to calculate concentration and wind profile that are consistent with the 10-min 10-m tower generation. Such virtual profiles are used to test different approaches to calculate IHf based emissions.

MODEL WORLD

No generated Concentration/Emission profiles (j=1000)

Height	logfit	expt	double-expt	dispers	no horizontal diffusion	inverse correction of horizontal diffusion
measble: L=100m, v ² =0.3 m ² s ⁻²	51	15	21	23	20	
measble: L=300m, v ² =0.2 m ² s ⁻²	52	17	22	24	20	

Choice of fit matters

Horizontal Turbulence correction

True value equals flux corresponds to the radius of the emitting circle = 20m

Red dots: u², green dots: u²c²

MODEL WORLD SUGGESTS:

Logfit: Overestimation of 58%
 Expt: Overestimation of 5.5%
 Double split: Overestimation of 16%

On top of that:
 Turbulence correction EFFECT = -16%

Results IHf approach Dronten

Fluxes by diversity functions of calculated emission rates with a set of randomly generated profiles assuming a normal distribution with an RMSD of 8.8%

	BLD (M)	BLD (M) + double split	BLD (M) + double split + turbulence correction	expt	ratio exp	ratio exp
Experiment 1	8	3	10	15	5.2	281%
Experiment 2	16	12	16	19	6.4	335%
Experiment 3	18	15	16	21	26	123%
Experiment 4	16	11	11	17	6.4	37%
Experiment 5	7	7	9	5	5.8	40%
Mean	14	10	14	18	5.2	112%

Conclusions

- 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 50%
- The correction needed for horizontal diffusion (u²c²) is -10 to -50% according to the fit - model and depends on stability, the extension of the source and location of the sensors.

References:

Dennefeld, G. J. (1983) A summary of the use of the inverse dispersion method for the estimation of emissions from agricultural sources. *Journal of Agricultural Science, Cambridge*, 91, 1-10.

Dennefeld, G. J. (2008) A summary of the use of the inverse dispersion method for the estimation of emissions from agricultural sources. *Journal of Agricultural Science, Cambridge*, 142, 1-10.

Ryden, J. A., McNail, J. L., Smith, R. F., and Evans, R. J. (1998) A summary of the use of the inverse dispersion method for the estimation of emissions from agricultural sources. *Journal of Agricultural Science, Cambridge*, 131, 1-10.

Loulich, F. (2010) A summary of the use of the inverse dispersion method for the estimation of emissions from agricultural sources. *Journal of Agricultural Science, Cambridge*, 141, 1-10.

Neftel, A., Häni, C., Hensen, A., Bell, M., Flechard, C., van den Bulk, P., van Dinther, D., Frumau, A. (2017) A summary of the use of the inverse dispersion method for the estimation of emissions from agricultural sources. *Journal of Agricultural Science, Cambridge*, 148, 1-10.

The Dronten field experiment

- NH₃ emission factors describing NH₃ losses after application of organic manure are partially based on field measurements using micrometeorological techniques. They can be classified as a mass balance approaches such as integrated horizontal flux measurements [1, 2], or vertical flux measurements (eddy covariance), Anemometric Technique [3] or Horizontal concentration gradients across an emitting surface in conjunction with a dispersion model [4].
- In June 2016 NH₃ emissions of two simultaneously emitting circles of 40m diameter have been determined in a field experiment in Dronten (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=Z8fQm5Qv2W0>)

- Poster in Session
- AS2.2/SSS9.26 - Air-Land
- Interactions (General Session)
- (co-sponsored by iLEAPS) (co-organized):
- EGU2017-4929
- 1 Reevaluation of the integrated horizontal flux approach by Albrecht Neftel et al.