



Intercomparison of eight state of the art eddy covariance methane gas analysers

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**EGU General Assembly
Vienna
10.4.2013**

Motivation



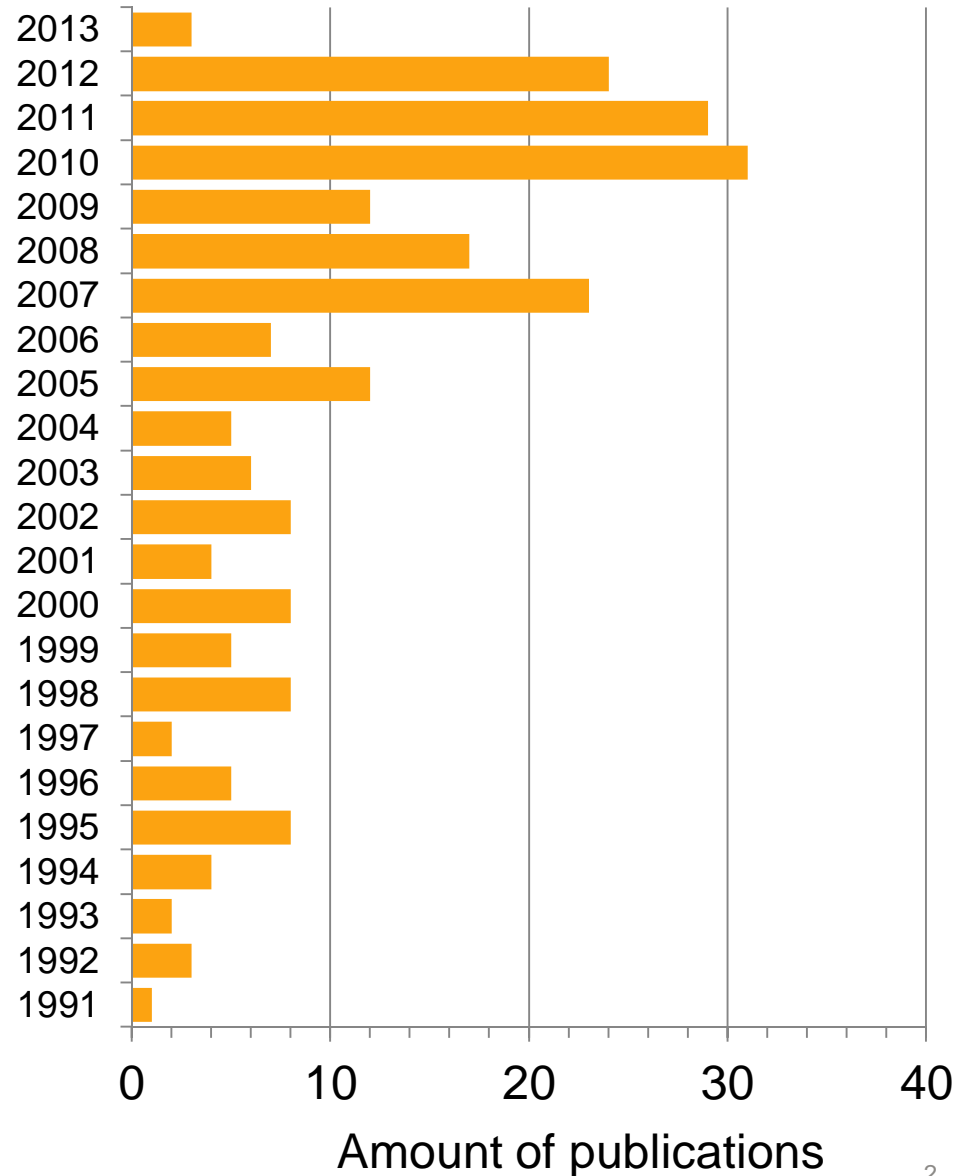
Many new CH₄ flux analysers are available on the market

⇒ **Intercomparison is needed in order to know if they agree and how they compare with each other**

Some intercomparison studies already exist

Tuzson et al. (2010) in AMT

Peltola et al. (2012) in BGD, in review for BG



Where and when?

The CH₄ intercomparison campaign was organized within InGOS FP7 infrastructure project

Where: Cabauw, The Netherlands

When: 6.6.-27.6.2012



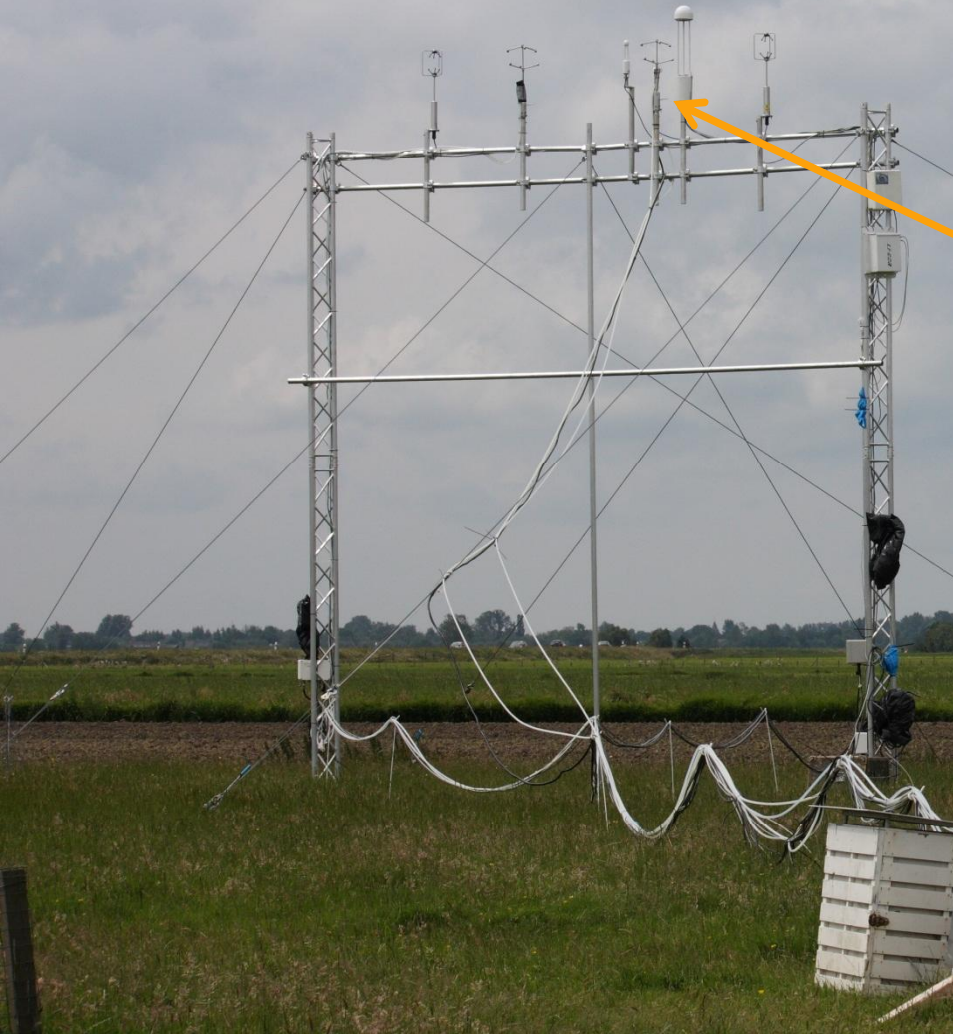
Site & instruments



6 m

~30 m

Site & instruments



Anemometer: METEK USA-1

Gas analysers:

- **LI-7500 (LI-COR)**
 - $\text{H}_2\text{O}, \text{CO}_2$
- **LI-7700 (LI-COR)**
 - CH_4
- **G2311-f (Picarro)**
 - $\text{CH}_4, \text{CO}_2, \text{H}_2\text{O}$
- **FGGA (Los Gatos)**
 - $\text{CH}_4, \text{CO}_2, \text{H}_2\text{O}$
- **DLT-100 (Los Gatos)**
 - CH_4

Site & instruments

Anemometer: METEK USA-1

Gas analysers:

- **LI-7000 (LI-COR)**
 - $\text{H}_2\text{O}, \text{CO}_2$
- **FMA (Los Gatos)**
 - CH_4
- **G1301-f (Picarro)**
 - CH_4, CO_2
- **FMA (Los Gatos)**
 - $\text{CH}_4, \text{H}_2\text{O}$
- **pulsed QCL (Aerodyne)**
 - $\text{CH}_4, \text{N}_2\text{O}$

Anemometer: METEK USA-1

Gas analysers:

- **LI-7500 (LI-COR)**
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 - $\text{CH}_4, \text{CO}_2, \text{H}_2\text{O}$
- **FGGA (Los Gatos)**
 - $\text{CH}_4, \text{CO}_2, \text{H}_2\text{O}$
- **DLT-100 (Los Gatos)**
 - CH_4

Site & instruments

CH₄ gas analysers:

Los Gatos Research

DLT-100

FMA

FGGA

Picarro

G1301-f

G2311-f

LI-COR

LI-7700

Aerodyne

pulsed QCL

Anemom

Gas ana

- LI-700

- H₂

- FMA

- C

- G130

- C

- FMA

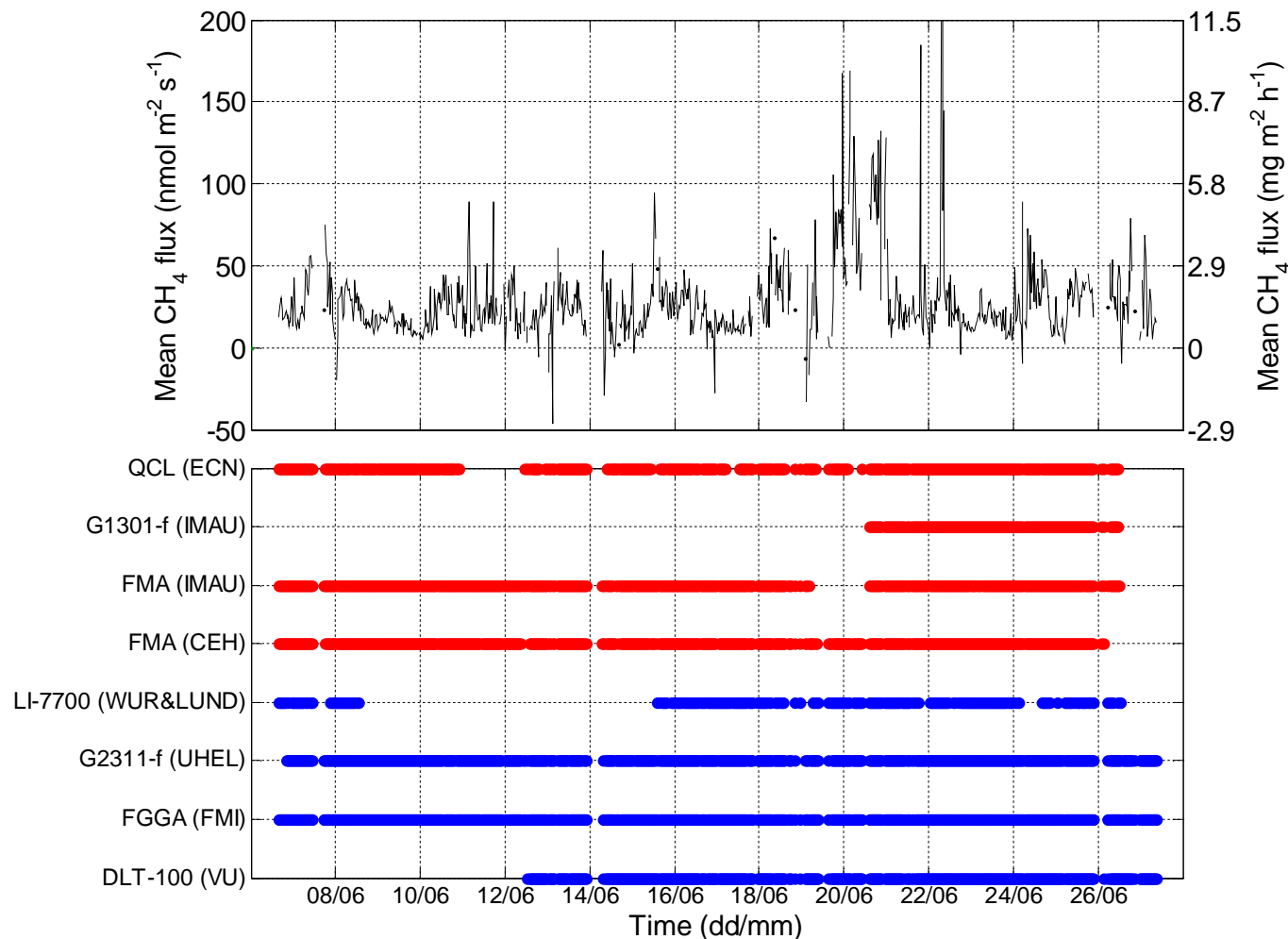
- C

- pulse

- CH₄, N₂O



Data coverage



Kroon et al. (2010):
At Oukoop CH_4 -flux $\sim 15 \dots 20 \text{ nmol m}^{-2} \text{ s}^{-1}$

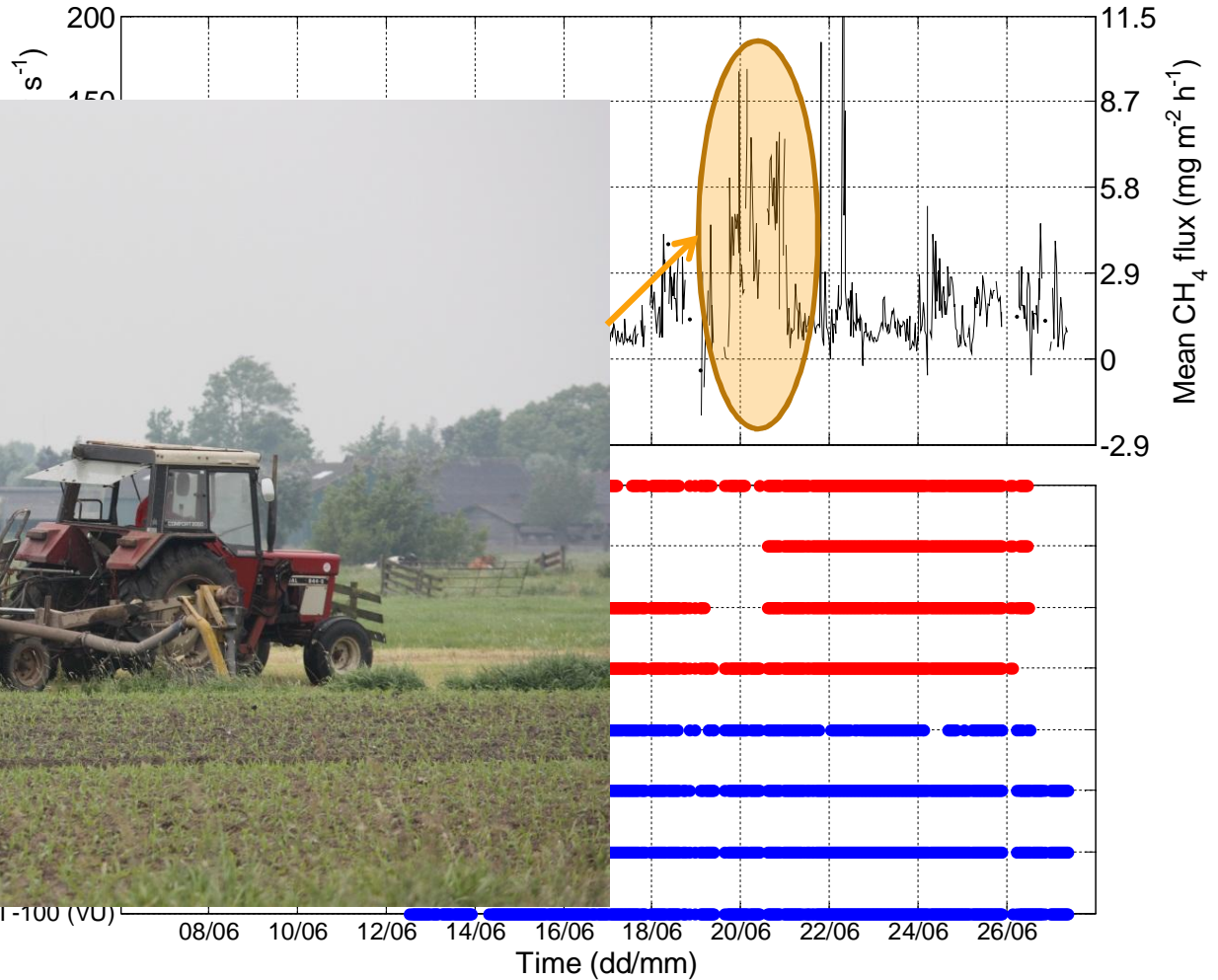


Data coverage

21.6.2012

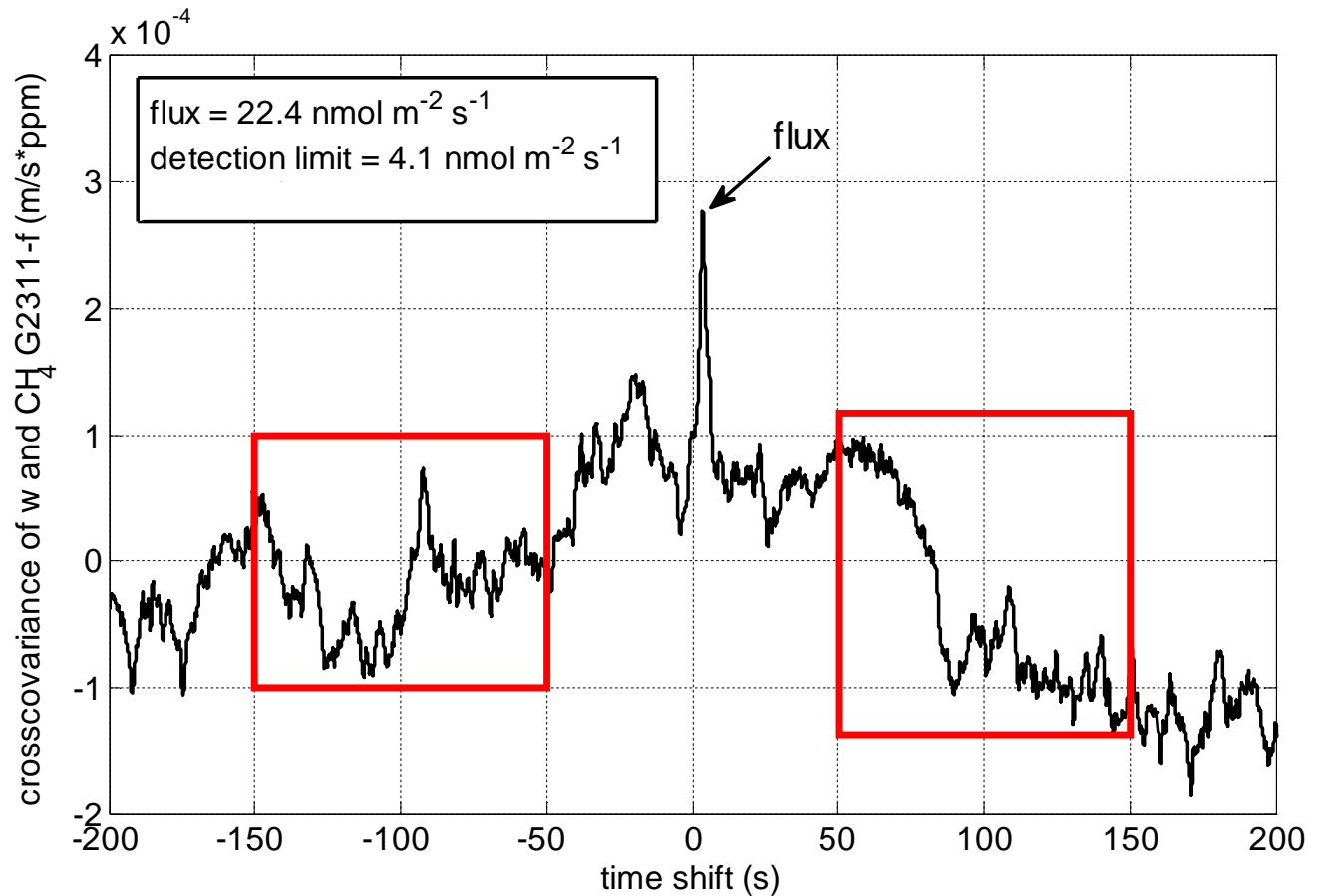


DLI-100 (VU)





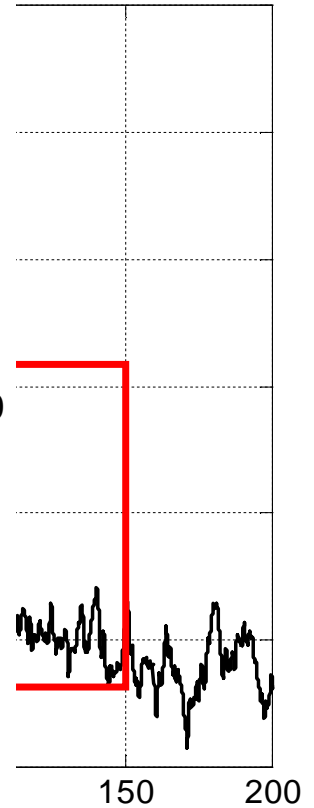
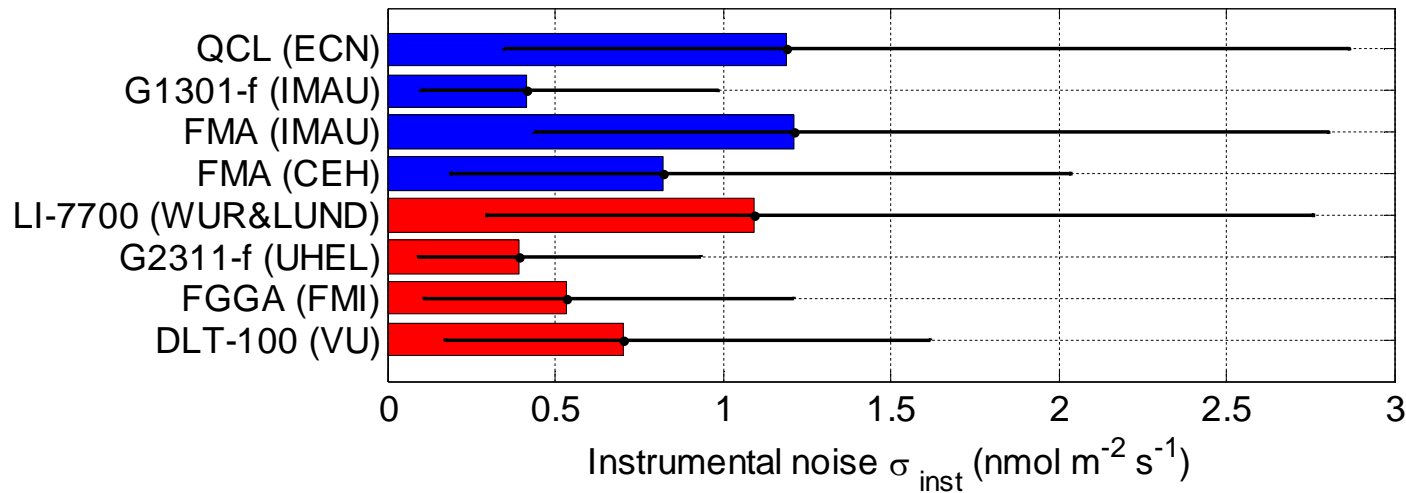
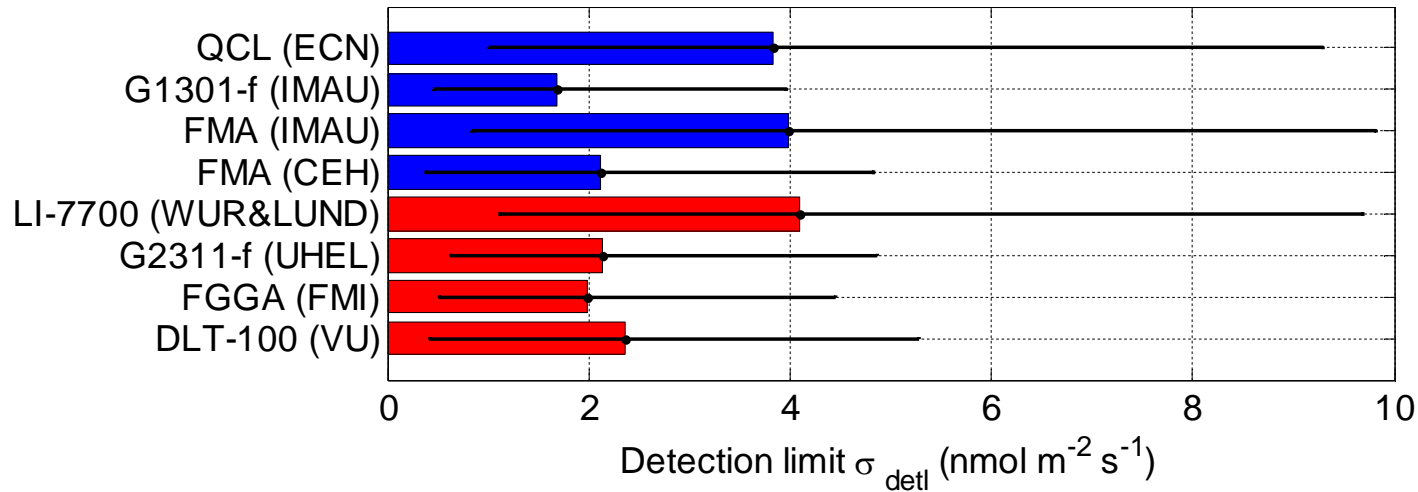
Detection limit



Detection limit calculated
according to Wienhold et al. (1994)



Detection limit

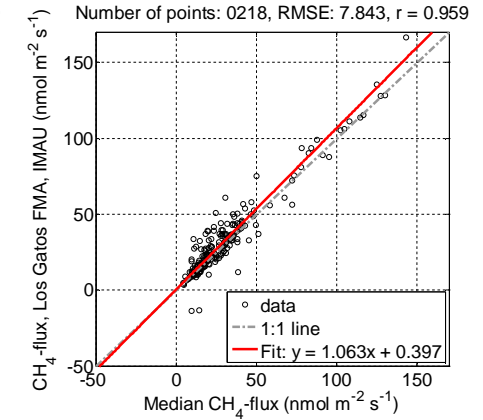
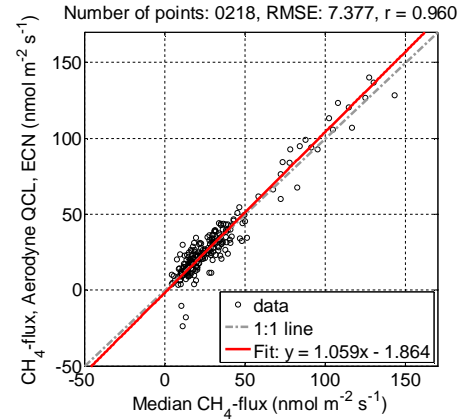
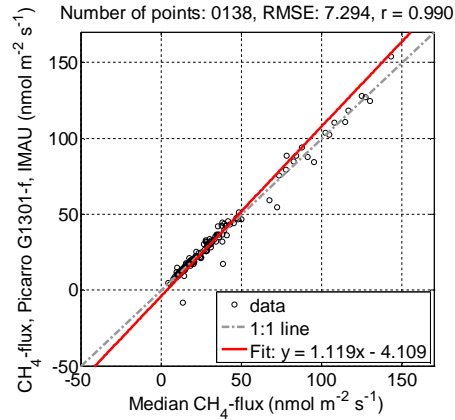
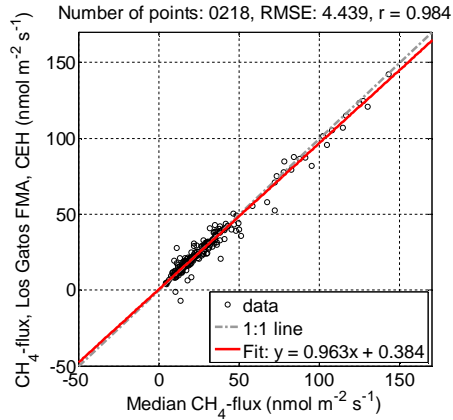


Detection limit:
Wienhold et al. (1994)
Instrumental noise:
Billesbach (2011)

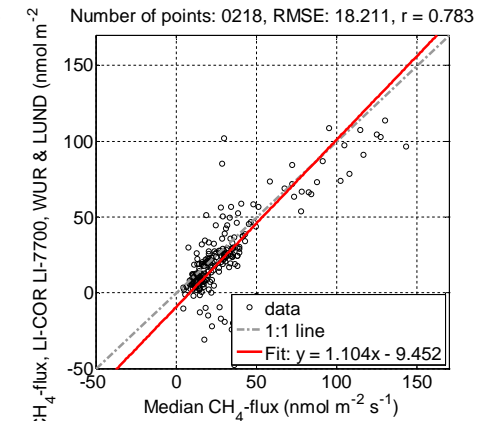
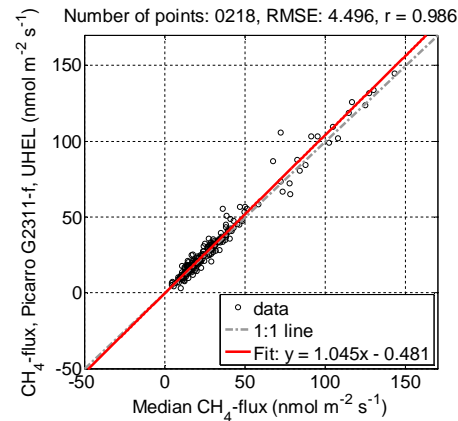
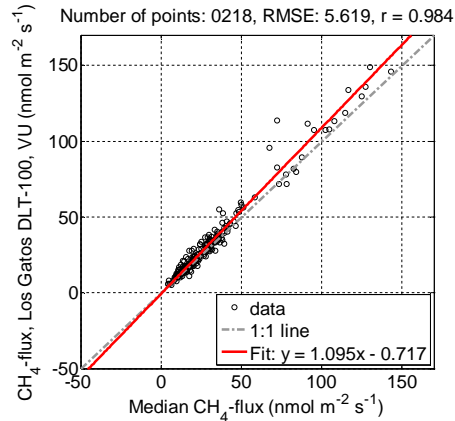
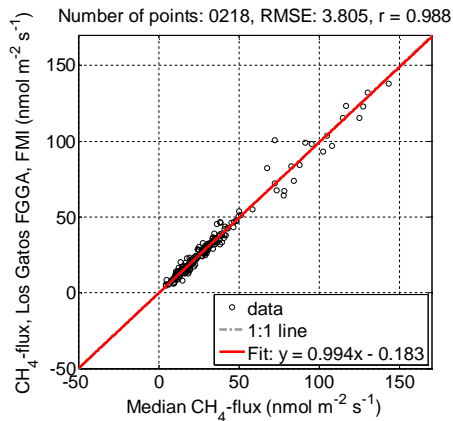


1:1-plots

Methane fluxes calculated with CEH METEK:



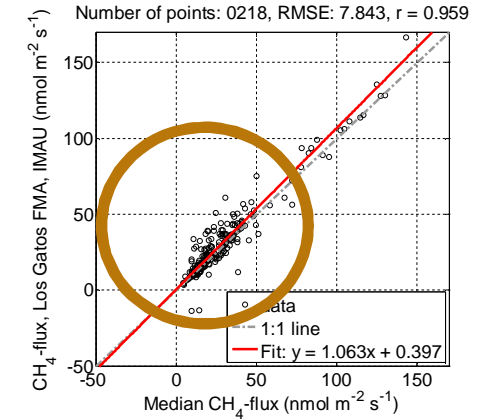
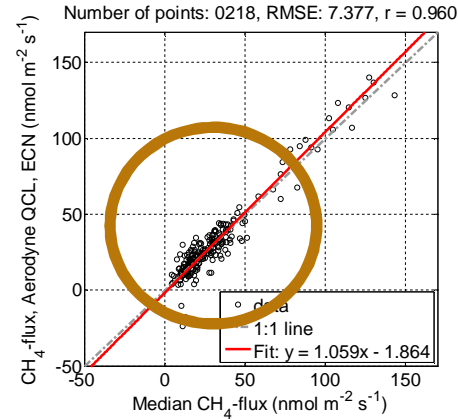
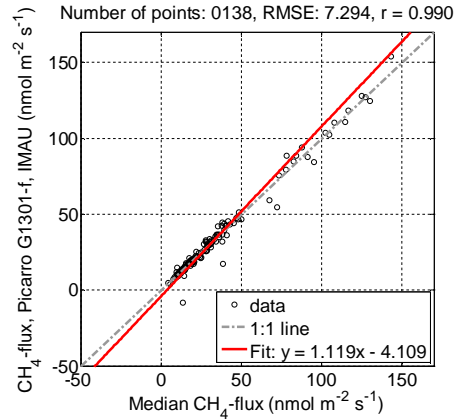
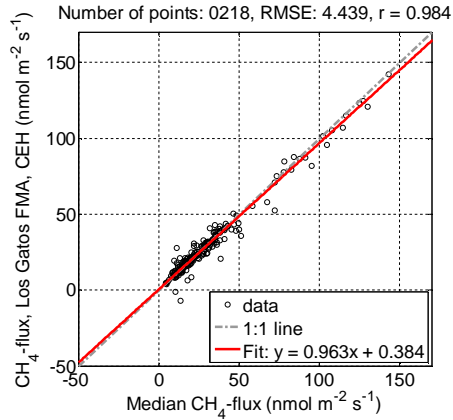
Methane fluxes calculated with UHEL METEK:



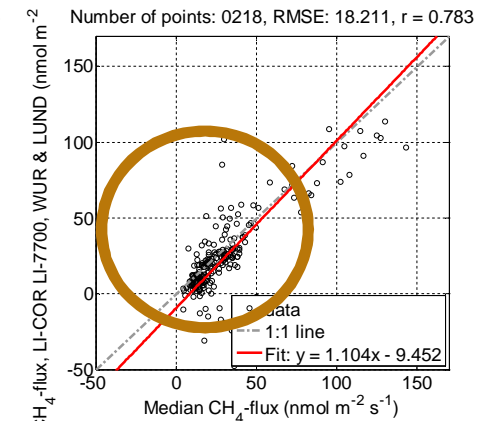
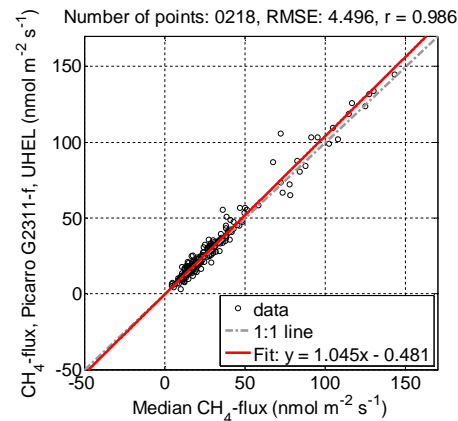
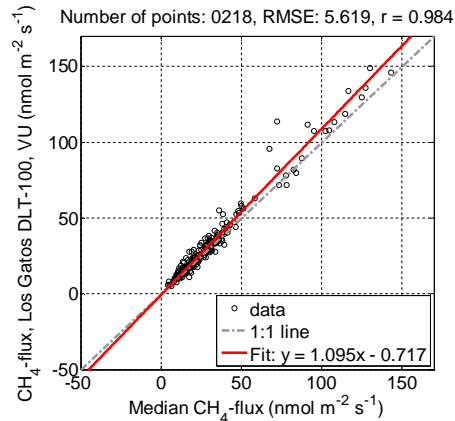
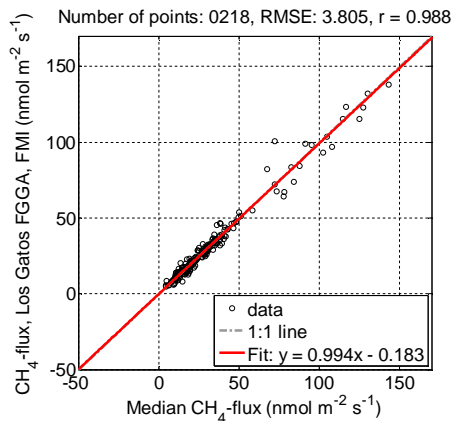


1:1-plots

Methane fluxes calculated with CEH METEK:



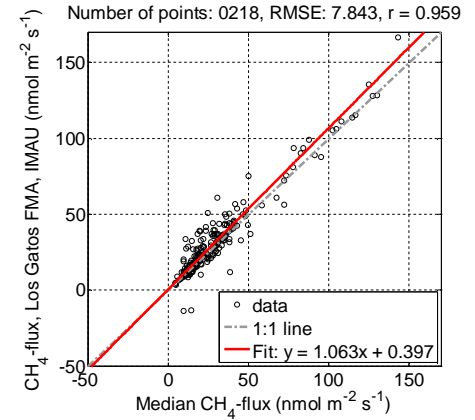
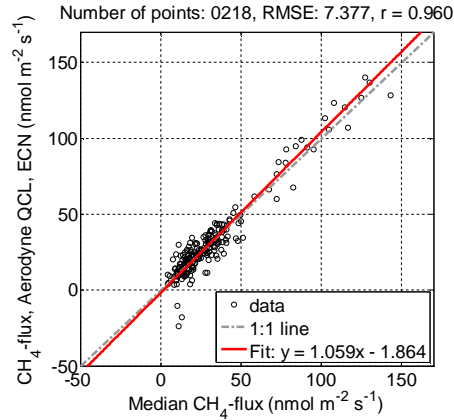
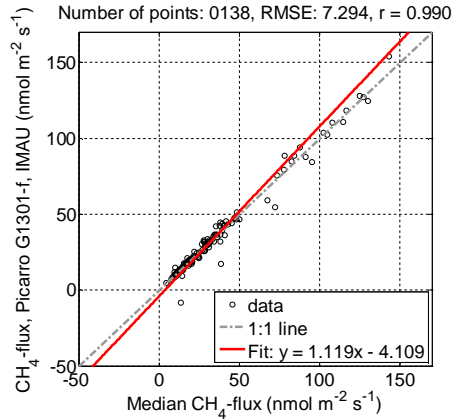
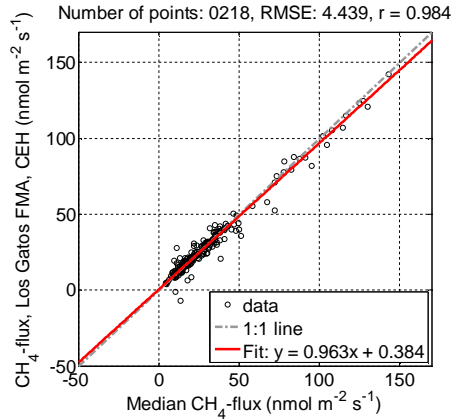
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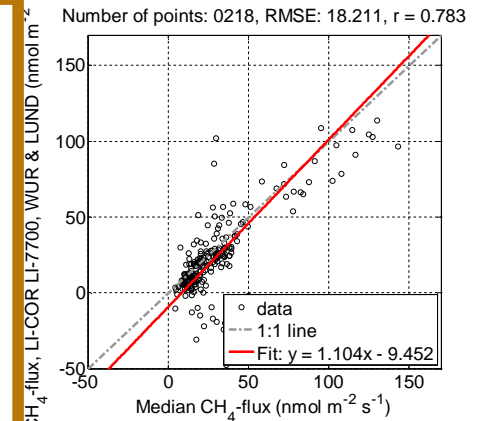
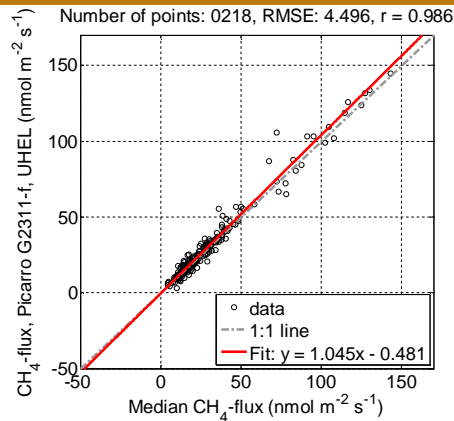
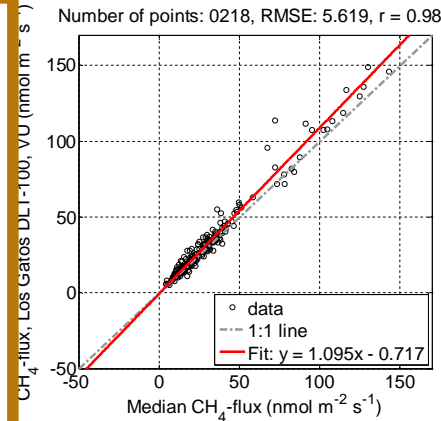
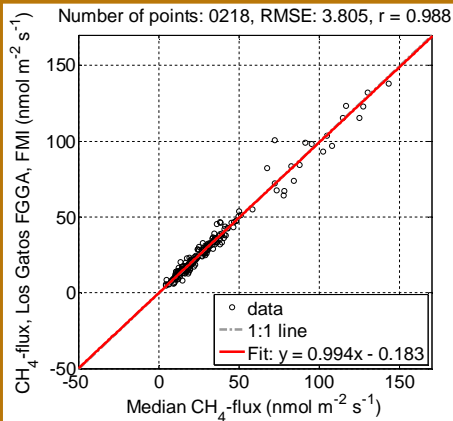


1:1-plots

Methane fluxes calculated with CEH METEK:

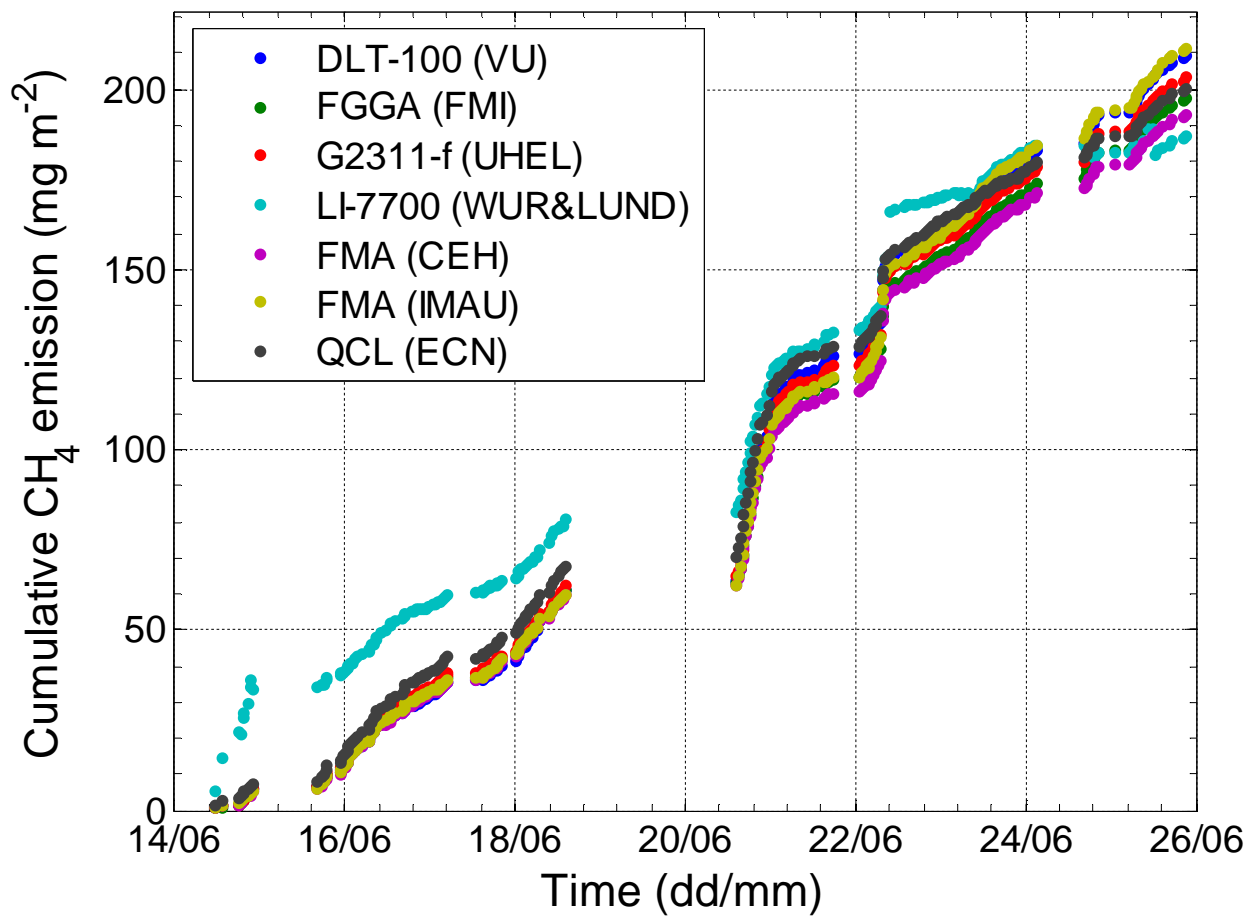


Methane fluxes calculated with UHEL METEK:



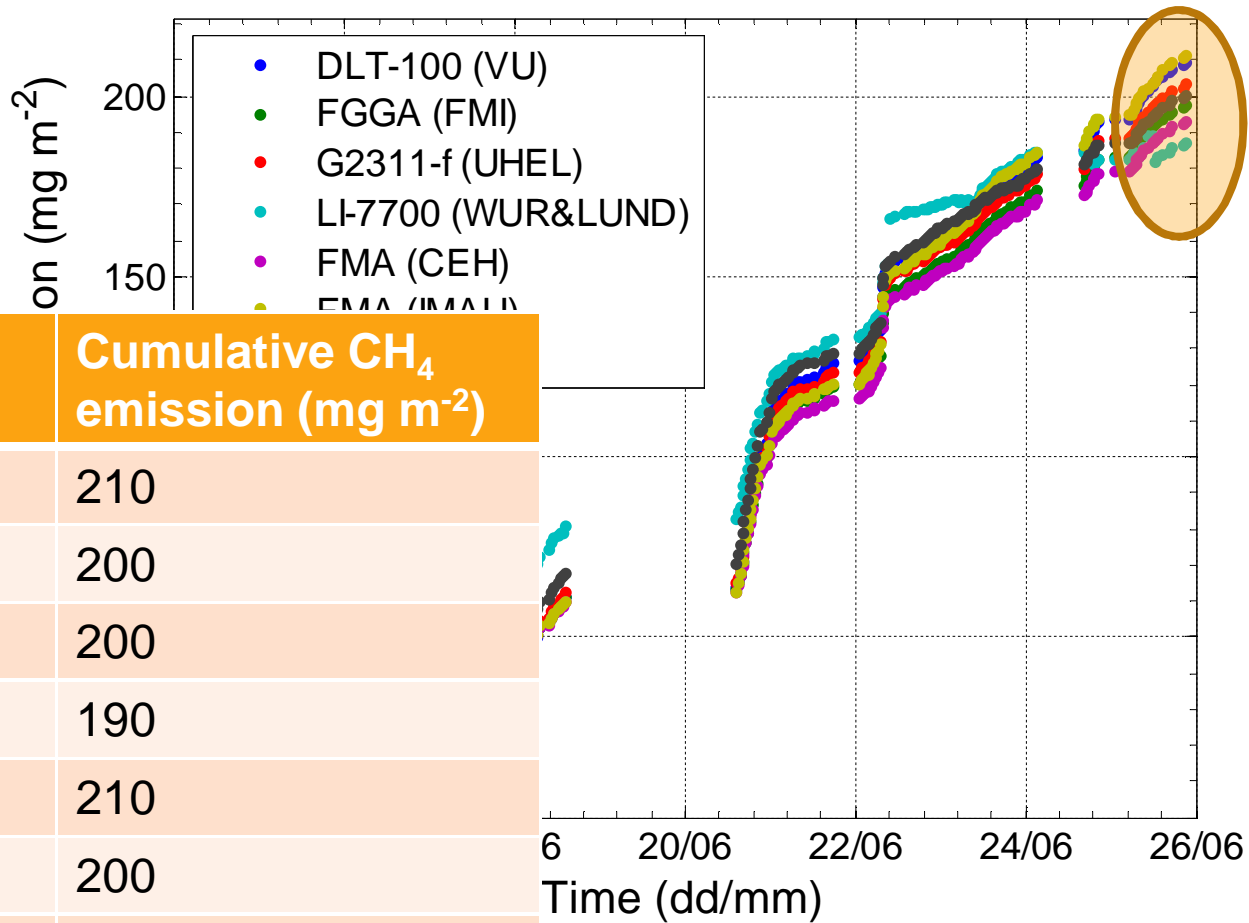


Cumulative sum





Cumulative sum



	Cumulative CH ₄ emission (mg m ⁻²)
DLT-100 (VU)	210
FGGA (FMI)	200
G2311-f (UHEL)	200
FMA (CEH)	190
FMA (IMAU)	210
QCL (ECN)	200
LI-7700 (WUR&LUND)	190



Conclusions

- **G2311-f and FGGA functioned most reliably during the campaign**
- **CH₄ fluxes from the tested instruments were similar**
- **Detection limit and instrumental noise were the highest for QCL, FMA and LI-7700**
- **Cumulative sums of CH₄ fluxes were practically the same**
- **G2311-f, FGGA and G1301-f can measure also H₂O (also FMA after upgrading)**

=>cross-interference to CH₄ is straightforward to correct



Integrated non-CO₂ Greenhouse gas Observing System

THANK YOU FOR YOUR ATTENTION!

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) in the InGOS project under grant agreement n° 284274

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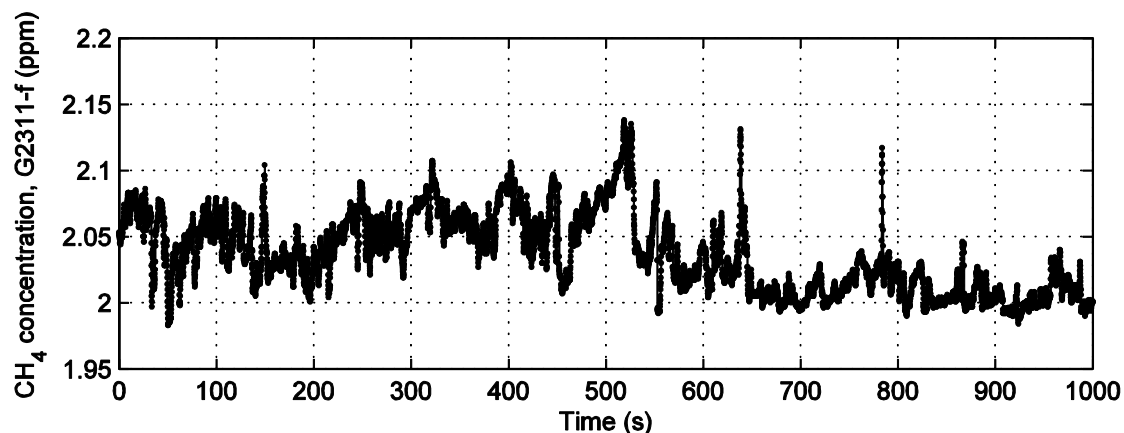
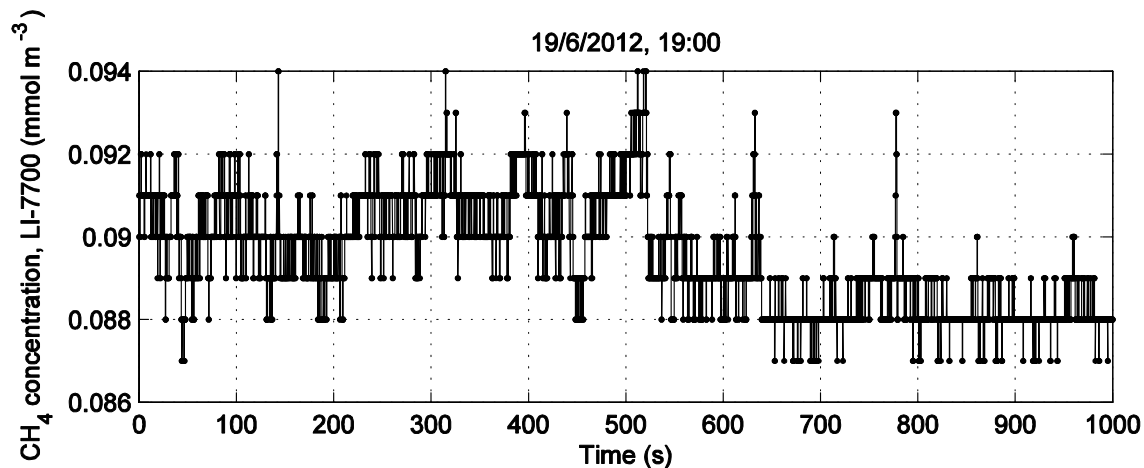
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LI-7700 data logging problem

- **LI-7700 data was not saved with high enough resolution**
 - Small variation in LI-7700 measurements was lost
- => this intercomparison does not tell much about the real performance of LI-7700





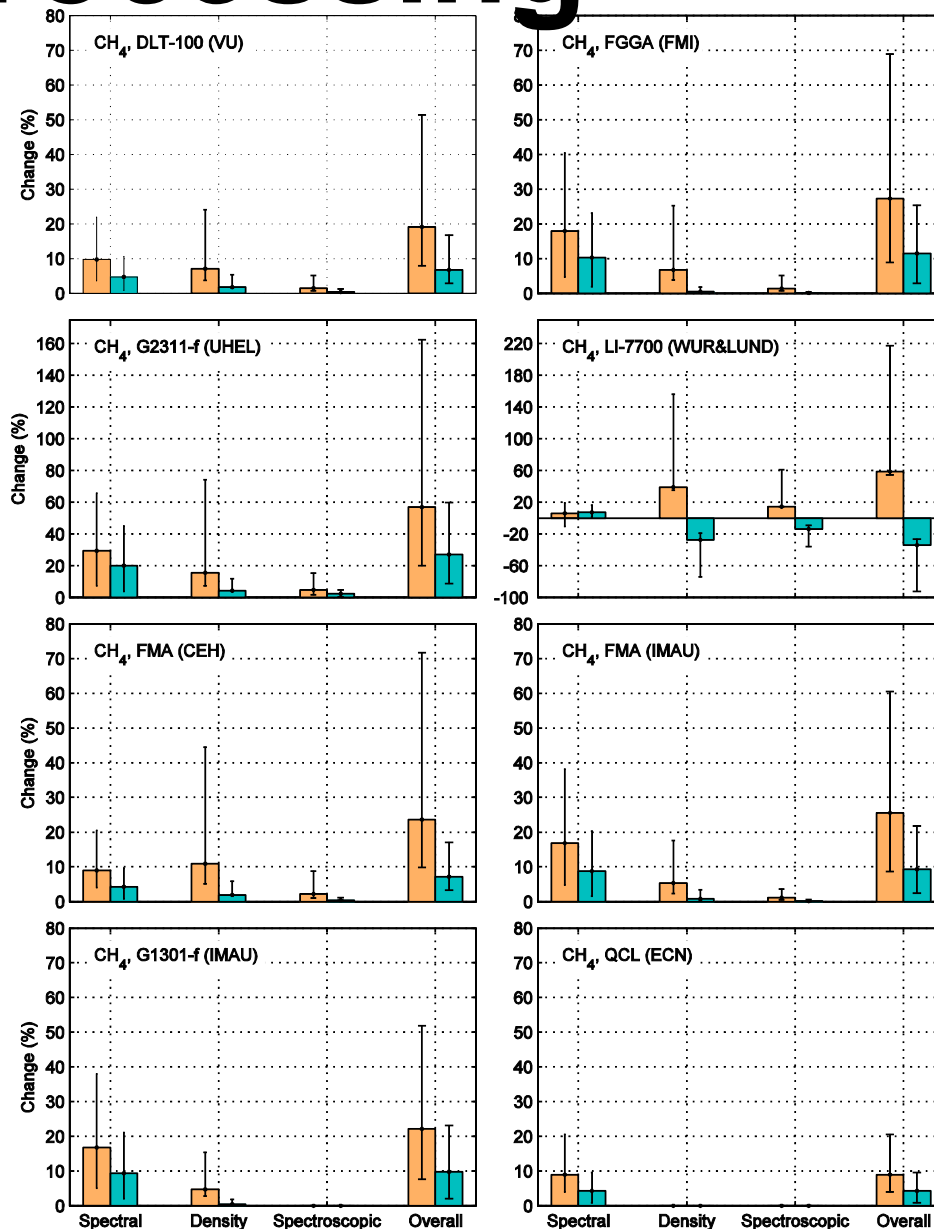
Data processing

Data was processed with EddyUH

(http://www.atm.helsinki.fi/Eddy_Covariance/EddyUHsoftware.php)

Used methods:

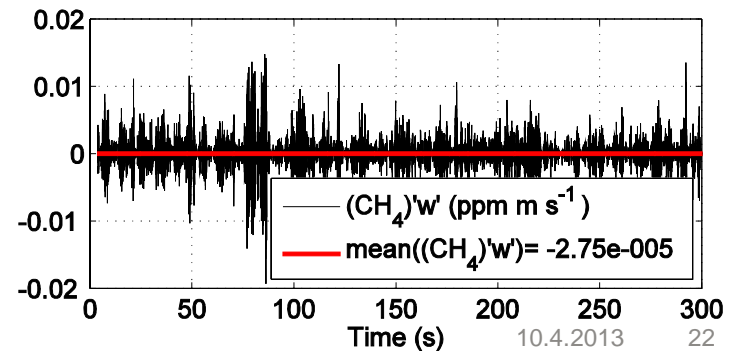
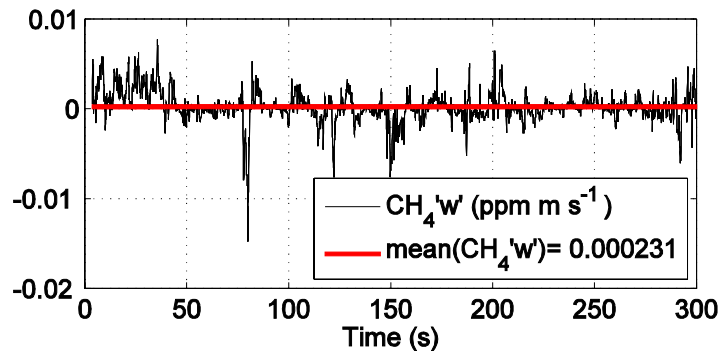
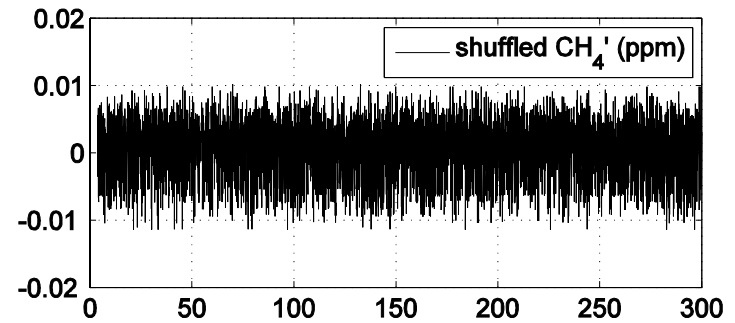
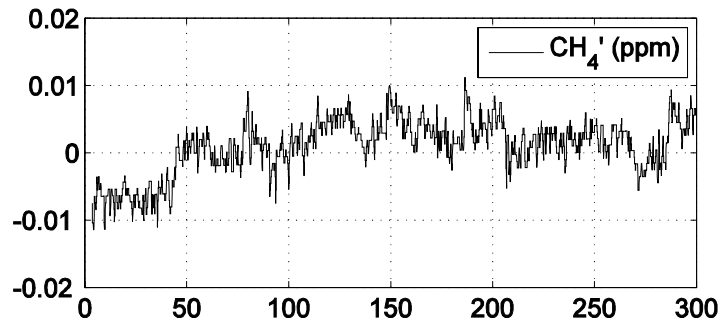
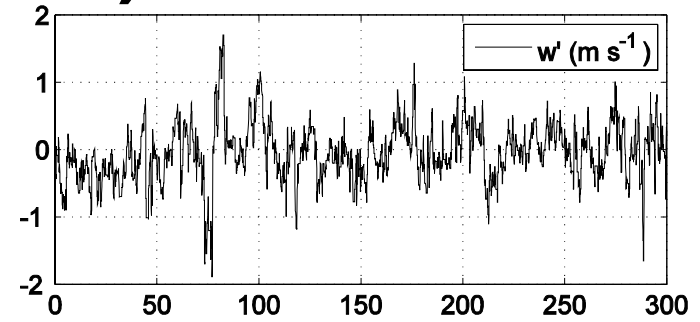
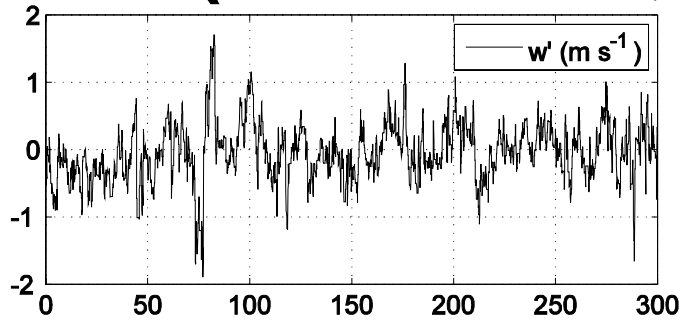
- Linear detrending
- 2d-coordinate rotation
- Spectral corrections
 - TF_{LF} theoretical, TF_{HF} experimental
- WPL (open: Webb et al., 1980; closed: Ibrom et al., 2007)
- Spectroscopic corrections (open: McDermitt et al., 2010; closed (LGR): Tuzson et al., 2010)





Instrumental noise

(Billesbach, 2011)





H2O corrections

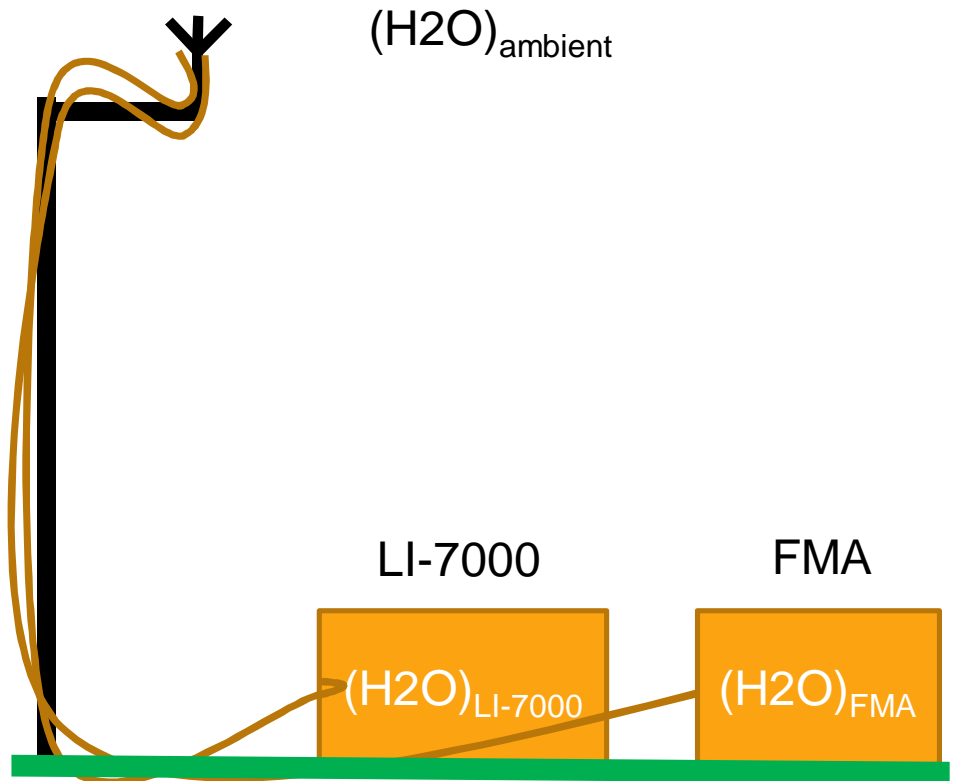
Root of the problem:

$$(H_2O)_{\text{ambient}} \neq (H_2O)_{\text{LI-7000}} \neq (H_2O)_{\text{FMA}}$$

Therefore $(H_2O)_{\text{LI-7000}}$ or $(H_2O)_{\text{ambient}}$ cannot be used as such in correcting FMA CH_4 data

Method now in use (Ibrom et al., 2007)

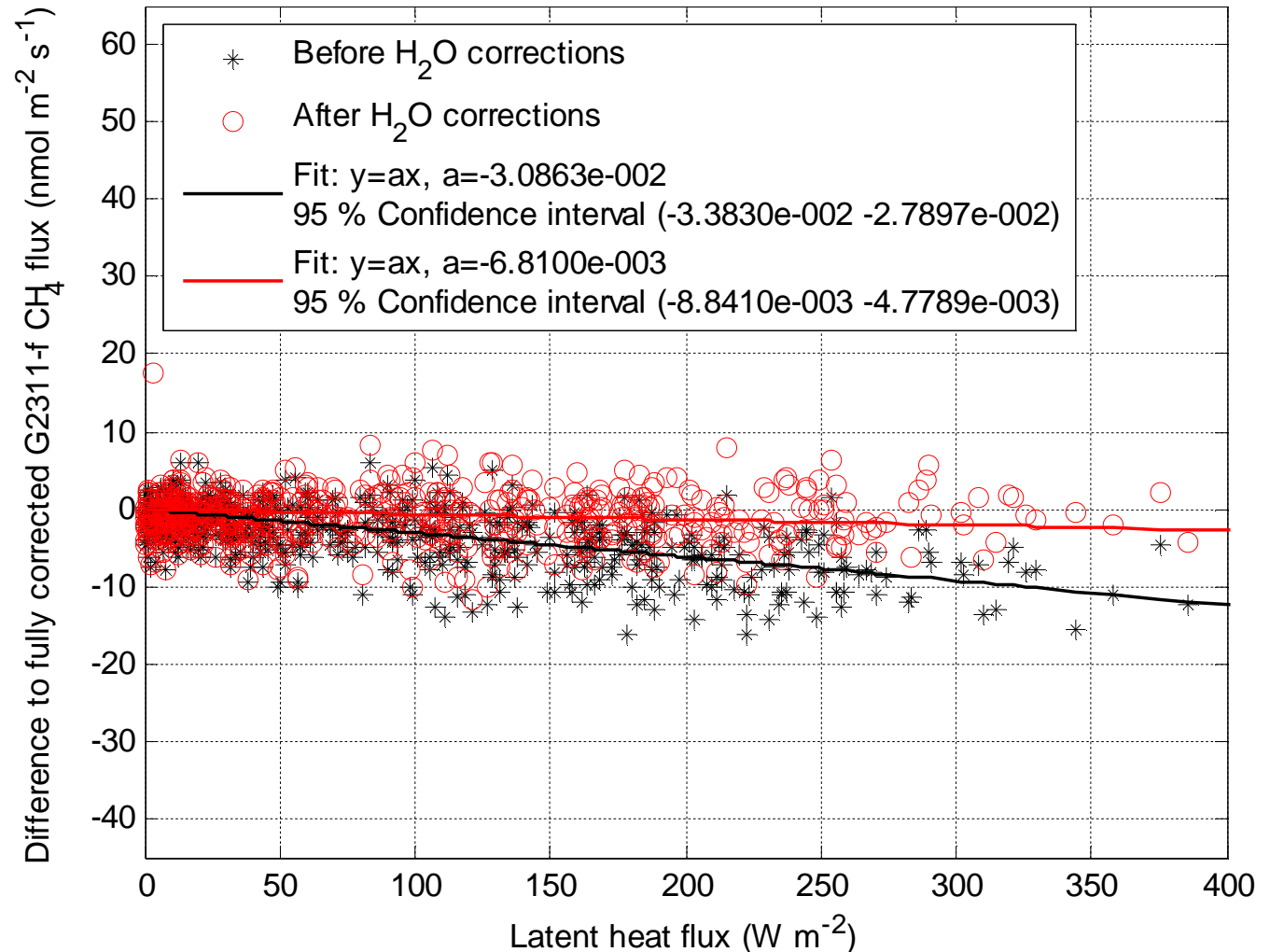
$$F_c = \frac{\overline{\chi'_c w'} + \bar{r}_c (\overline{\chi'_v w'})_{c \text{ lag}}}{\overline{v_{mol}}}$$

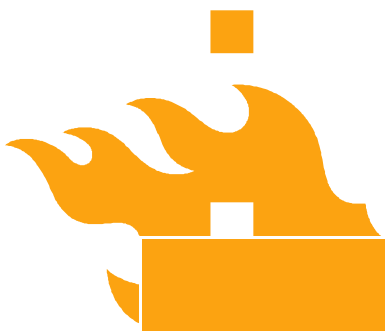




H2O corrections

CH₄, FGGA (FMI)

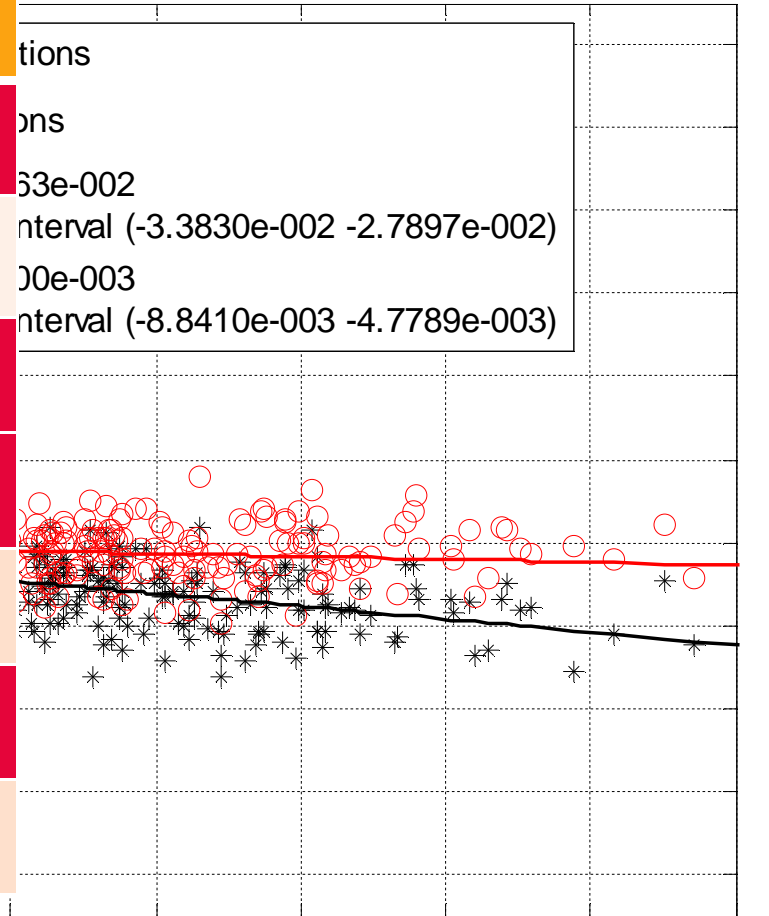




H2O corrections

CH₄, FGGA (FMI)

	Slope
LGR FGGA (FMI)	-6.8e-03
LI-COR LI-7700 (WUR&LUND)	-2.9e-02
LGR FMA (CEH)	-1.3e-02
LGR DLT-100 (VU)	7.9e-03
LGR FMA (IMAU)	4.9e-03
Picarro G1301-f (IMAU)	-2.1e-02
Aerodyne pulsed QCL (ECN)	-3.9e-03



Red cells: Difference to zero is statistically significant

100 150 200 250 300 350 400

Latent heat flux (W m⁻²)