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Inter-comparison of chamber and eddy-correlation flux measurements

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Abstract

At various sites in the Netherlands closed gas chamber measurements and eddy correlation measurements are carried out in order to determine greenhouse gas fluxes (CH4, N2O and CO2). For this purpose various measurement set-ups and devices are used. The results of all these measurements are used to understand small scale processes that generate the fluxes as well as to upscale the greenhouse gas balance. However, using varying measurement techniques for these analyses the question of comparability rises. In this research exercise, an attempt is being made to develop a measurement protocol that covers all measurement devices and methods available in our group(*), in order to guaranty the comparability of further analyses.

All measurements are done during two measurement campaigns of three days each at two well know research locations in the Dutch peat meadow area (Horstermeer site and Reeuwijk site). Additionally, we work on the construction of a calibration tank for experimenting with the various flux chamber techniques. Six different types of chamber set-ups are compared in this study; including various box-designs, filtering of air, and closed or open boxes. Measurement devices consisted of two Photo Acoustic Field Gas-Monitors, two Licor 7500 open path infrared gas analysers, a QCL, a TDL and a DLT-100 Fast Methane Analyzer.

In order to compare the measurement devices and set-ups and detect differences in the functioning, all data are processed with identical flux calculation programs. The build-up of gas concentrations in the chambers is studied in detail, before final flux-calculations are done. Additional to the comparability-analysis, a precise analysis of the variability of the fluxes in time and space can be done, using the multitude of measurements collected in the experiment. Final results are still in progress, but will be available at the time of the Carbo Europe Meeting in November 2006.

Inter-comparison of GHG measurement methods

"Different measurement methods, different fluxes?"

Petra Kroon (ECN), Dimmie Hendriks (VU), Arina Schrier (WUR)

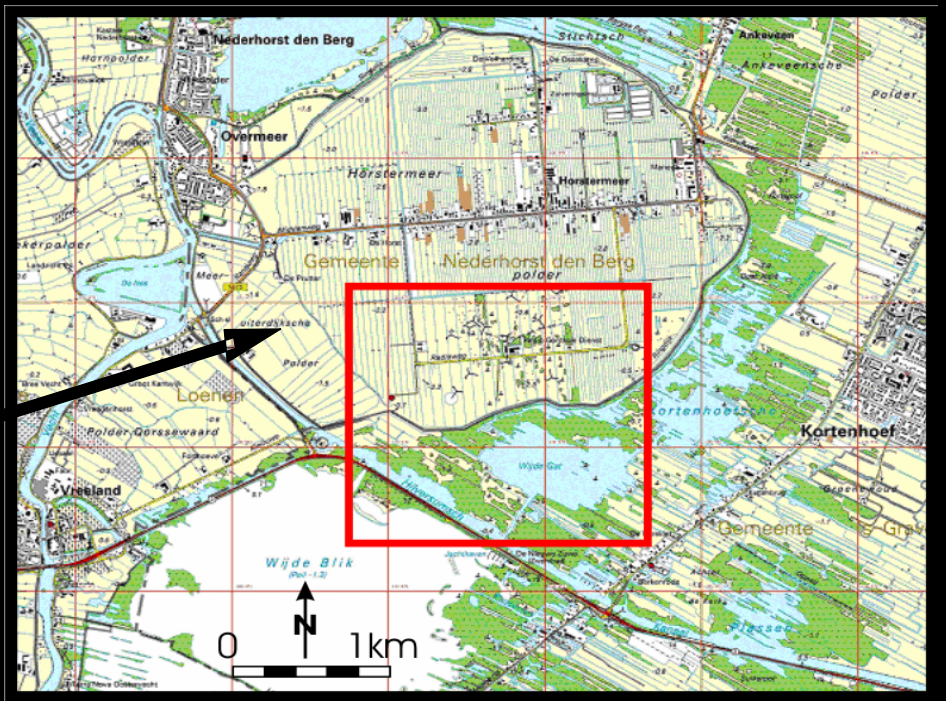
Purpose of the research

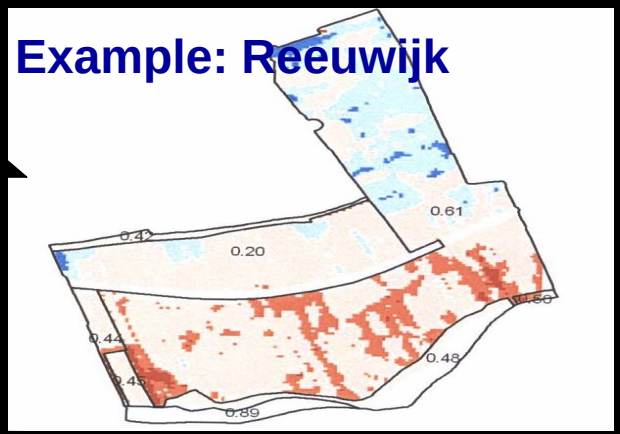
- How comparable are our measurement configurations?
- What is the comparability of the various types of chambers?
- What is the comparability of the various instruments?
- How well do the eddy-correlation and chamber measurements correspond?

In this talk:

1. Purpose of the research
2. Description of measurement locations, instruments and set-ups
3. Chamber types and their properties
4. Comparing chamber measurements
5. Comparing eddy correlation with chamber measurements
6. Preliminary conclusions

Measurement locations
Reeuwijk site and Horstermeer site






Overview Reeuwijk


Reeuwijk site


Horstermeer winter


Horstermeer summer

Experimental set-up

Measurements at Reeuwijk:

- 150 measurements taken in 3 days
- 7 measurements points
- 3 configurations

+ 1 day comparing static leak free and non leak free

Measurements at Horstermeer:

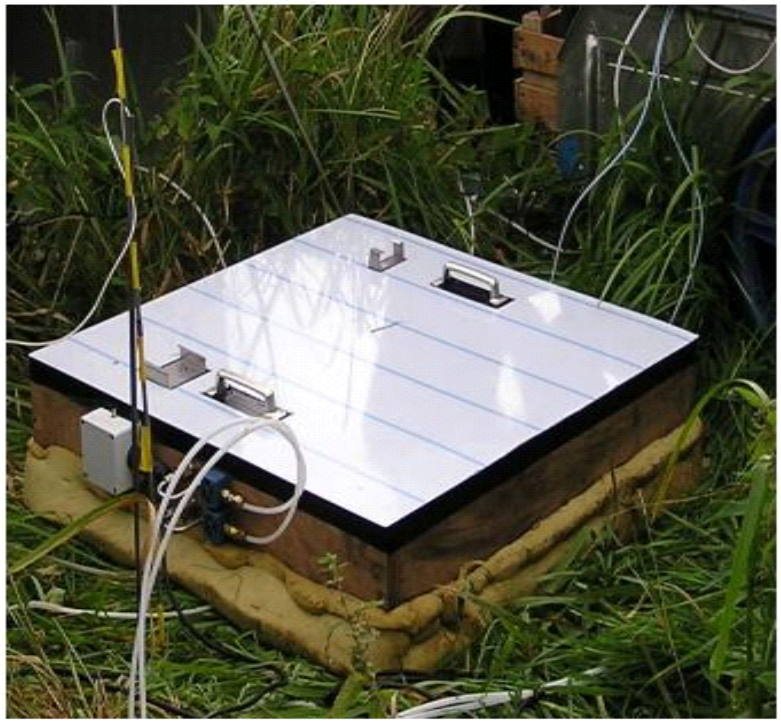
- 45 measurements points in 2 days
- combining 2 chamber types with 3 instruments

Measurement devices and set-ups

device		measurement type	gases measured
Innova 1	Photo-acoustic gas monitor (methane filter for low range)	chamber meas.	CO_2, CH_4, N_2O
Innova 2	Photo-acoustic gas monitor (methane filter for higher range)	chamber meas.	CO_2, CH_4, N_2O
TDL	Tunable diode laser	chamber meas.	CO_2, CH_4
QCL	Quantum cascade laser	chamber meas.	CH_4, N_2O
Licor 7500	Open path Licor	EC meas.	CO_2
DLT-100	Cavity ringdown spectroscopy	EC meas.	CH_4

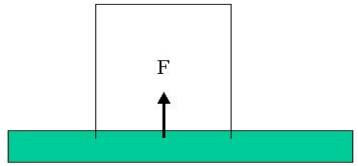
- Fans are installed in the chambers
- All chambers are dark (no sun light can enter)
- Vegetation is NOT cut before installing the chambers
- External filters for CO_2 and water vapor for Innova measurements
- Simultaneous calibrations of all devices for chambers measurements

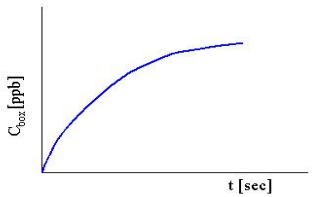
Chamber types and their properties



Chamber types

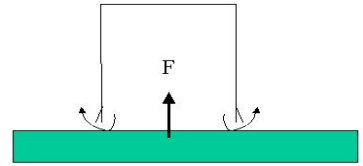
Static leak free

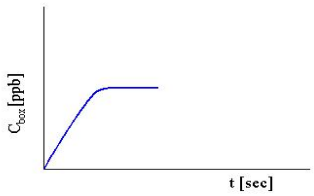




$$\phi = \frac{(V_{box} + V_{tube})}{A_{box}} \left. \frac{dC_{box}}{dt} \right|_{t=0}$$

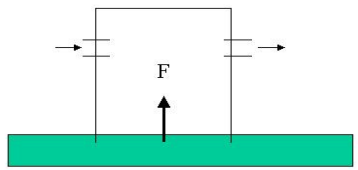
Static no leak free

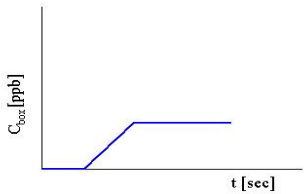




$$\phi = \frac{(V_{box} + V_{tube})}{A_{box}} \left. \frac{dC_{box}}{dt} \right|_{t=0}$$

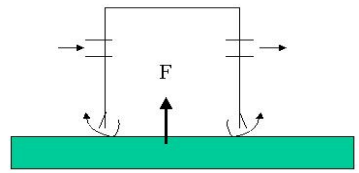
Dynamic leak free

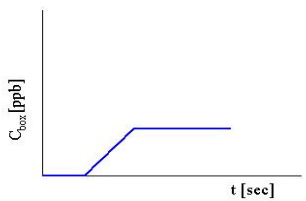




$$\phi = \frac{\phi_V (C_{box} - C_{air})}{A_{box}}$$

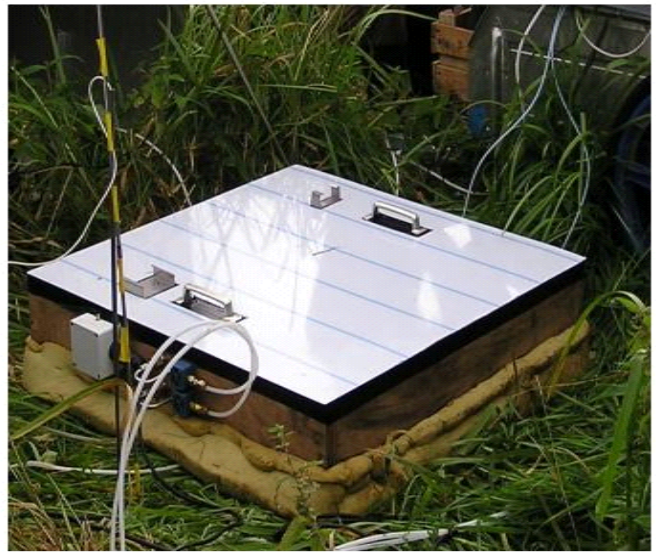
Dynamic non-leak free

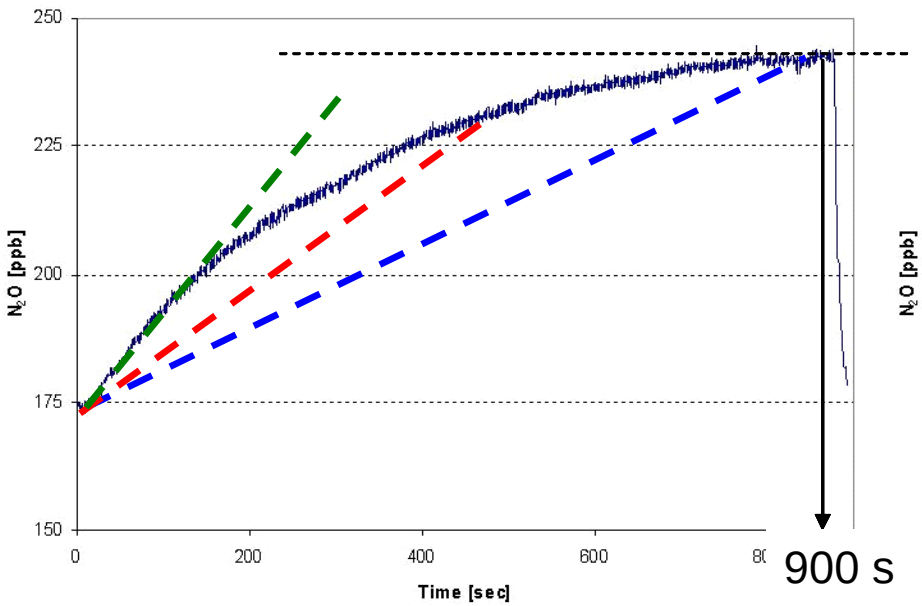


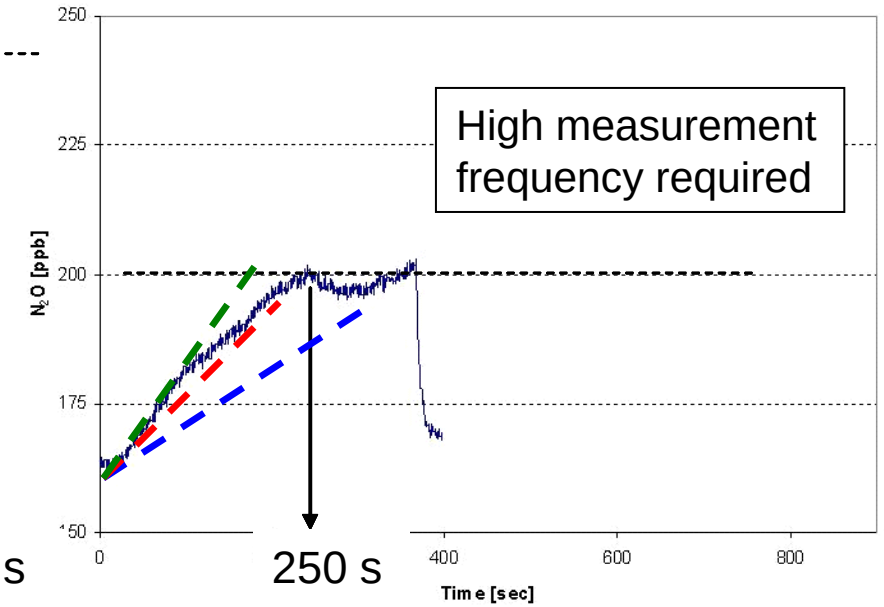


$$\phi = \frac{\phi_V (C_{box} - C_{air})}{A_{box}}$$

Leak free versus non-leak free







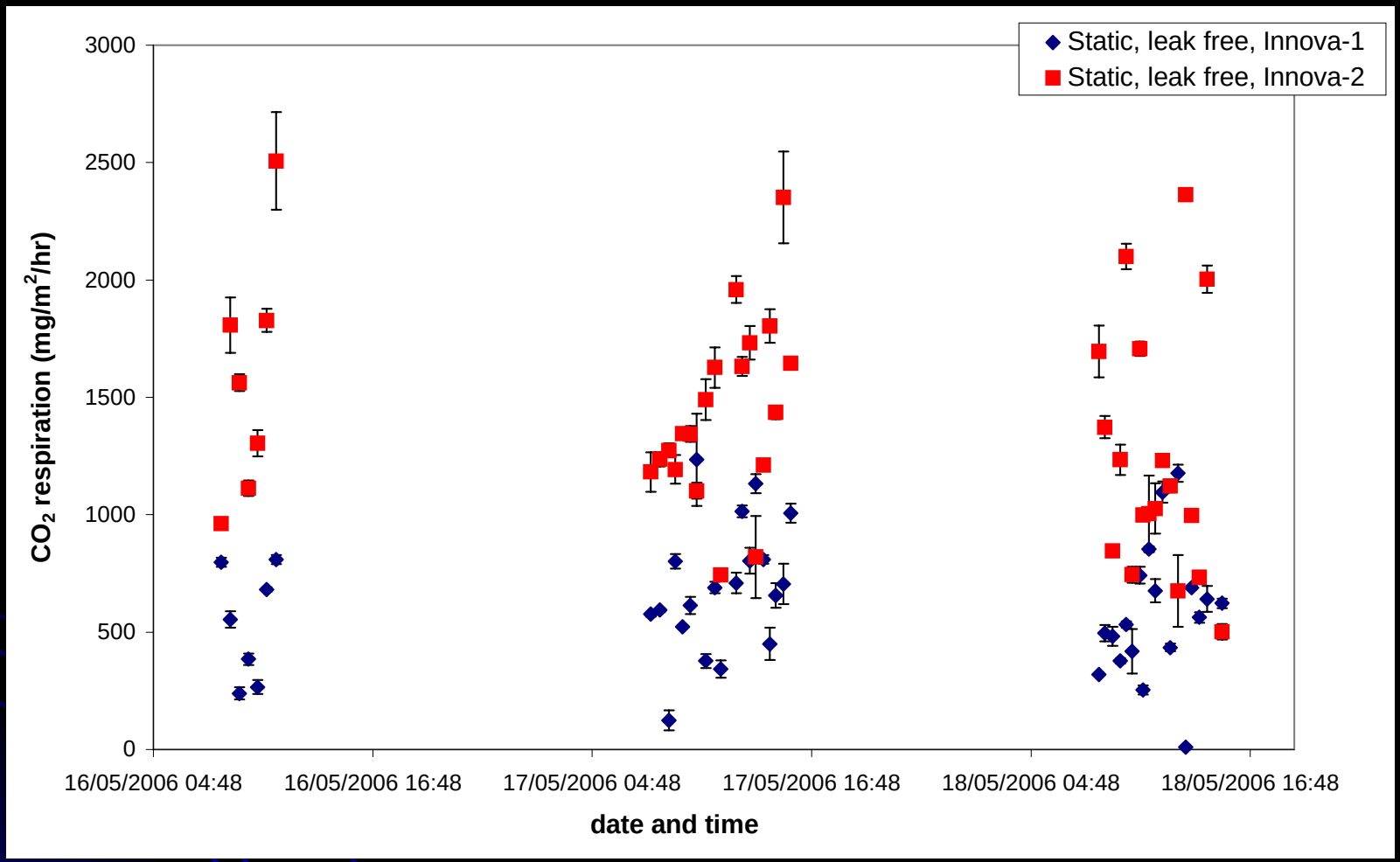
Properties chamber types

Type	Accuracy	Sampling frequency	Location flexibility
Static leak free	++	~ 5 min	-
Static non-leak free	+	< 15 s	++
Dynamic leak free	-	No restriction	-
Dynamic non-leak free	-	No restriction	++

Comparing chamber measurements

time series of 3 configurations

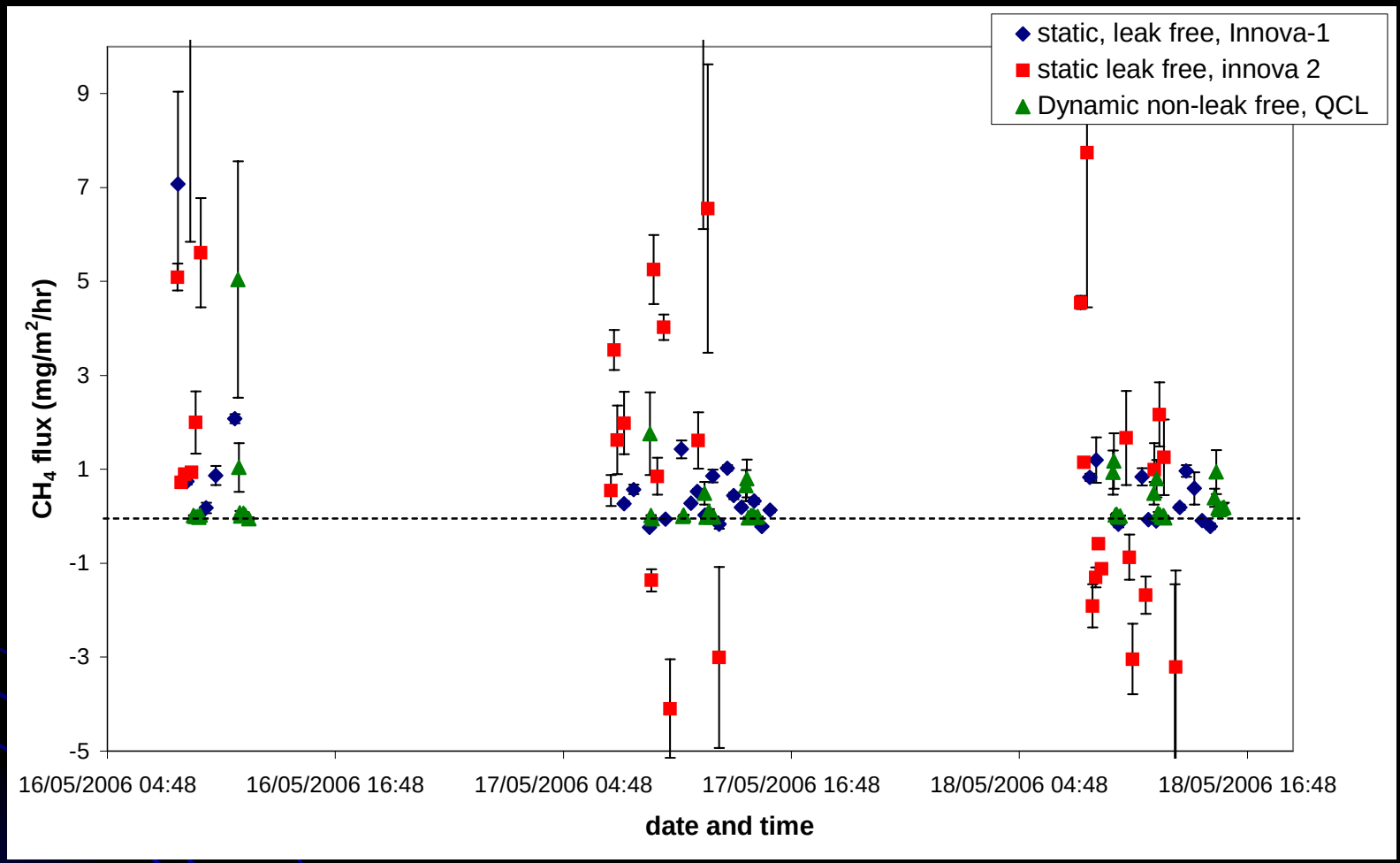
CO_2 time series of chamber measurements



Innova-2 measures higher fluxes than Innova-1c, possible reasons:

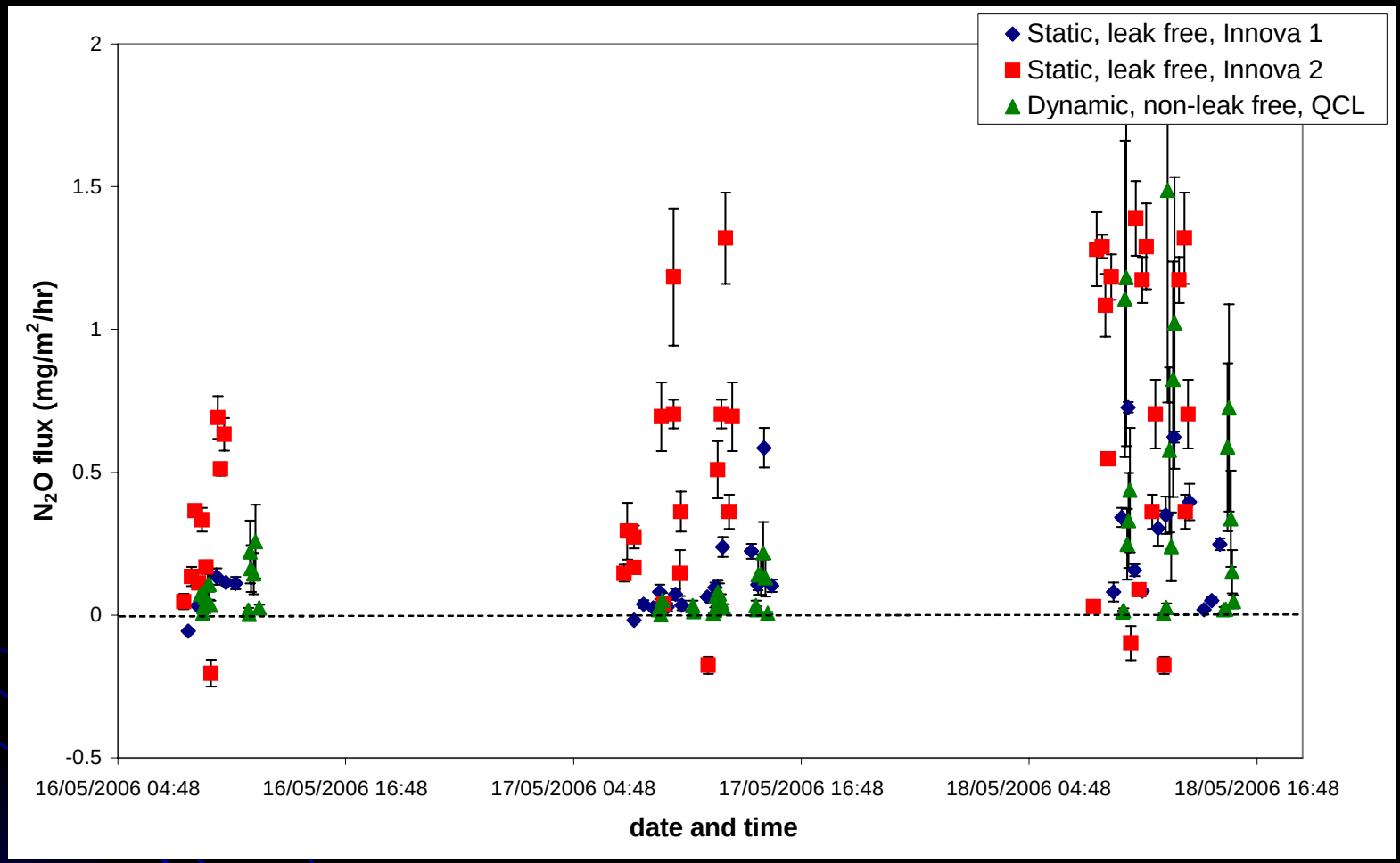
- different measurement time
- with/without fan

CH_4 time series of chamber measurements



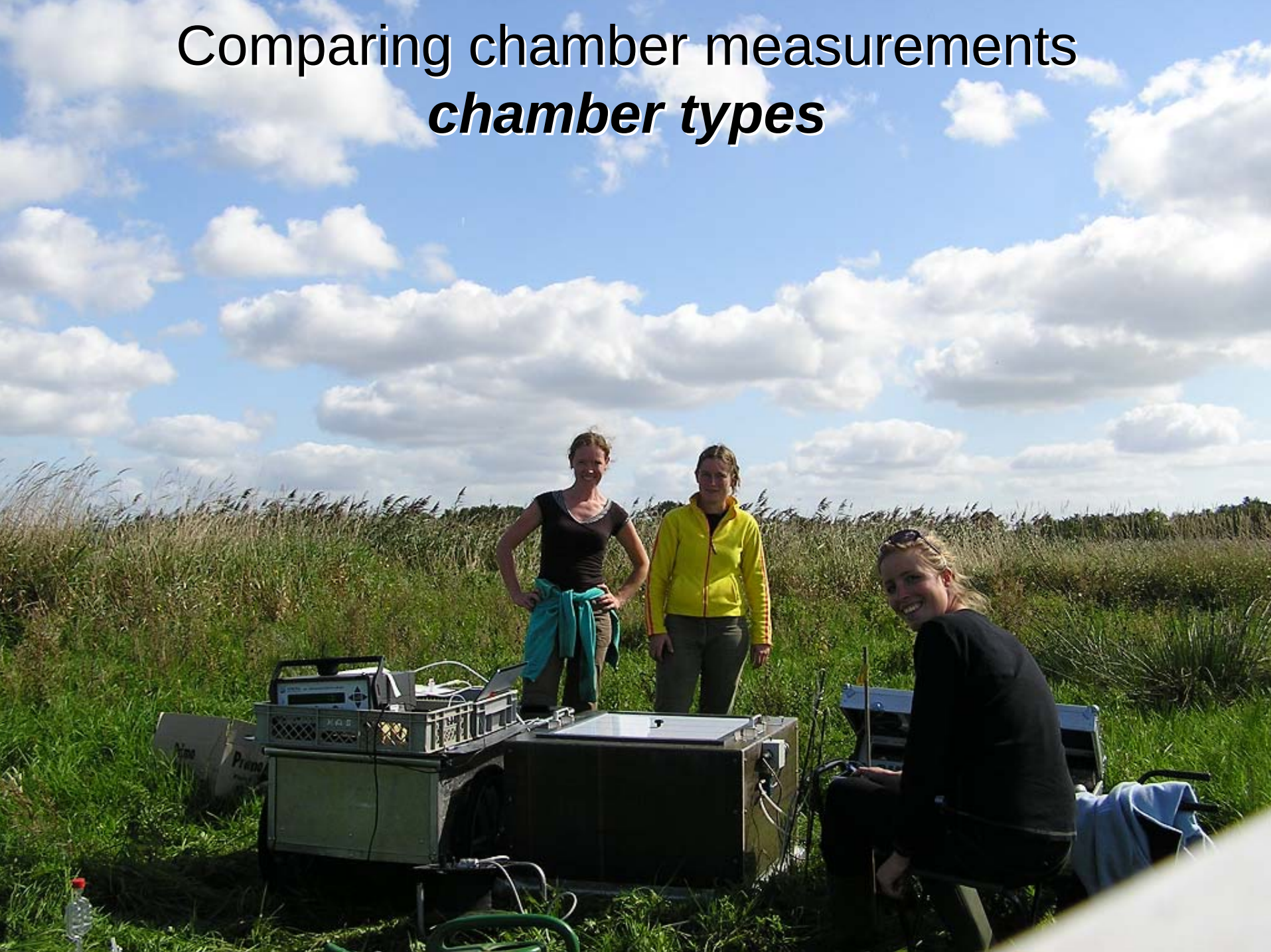
- Innova-1 and QCL in same range
- Innova-2 gives generally higher flux-values, but negative outliers at low flux conditions → might be caused by limited optical filters and lack of external CO_2 and H_2O filter

N_2O time series of chamber measurements

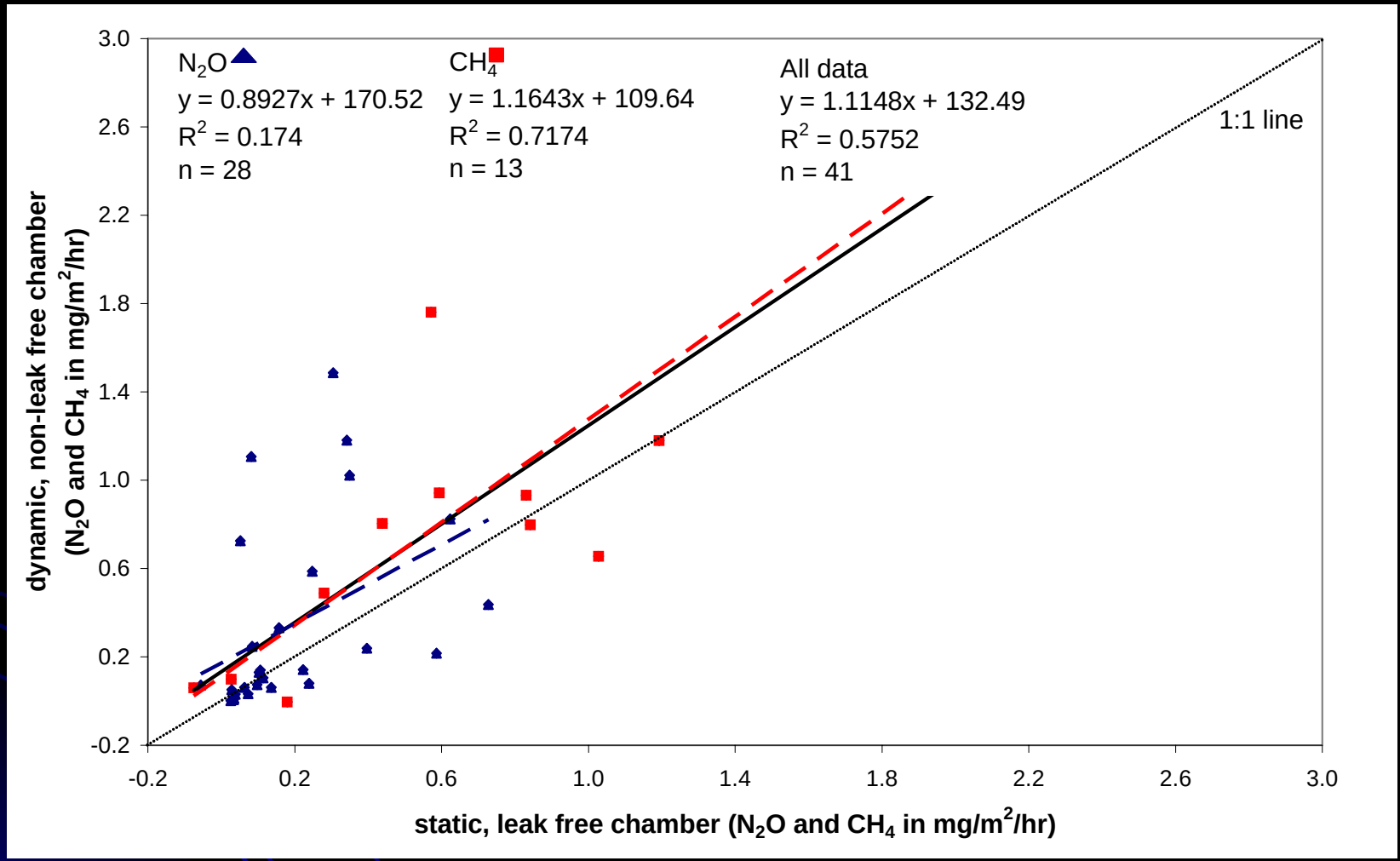


- Innova-1 and QCL in same range
- Innova-2 gives generally higher flux-values, but also negative outliers at low flux conditions → might be caused by limited optical filters and lack of external CO_2 and H_2O filter

Comparing chamber measurements
chamber types



dynamic non-leak free versus static leak free



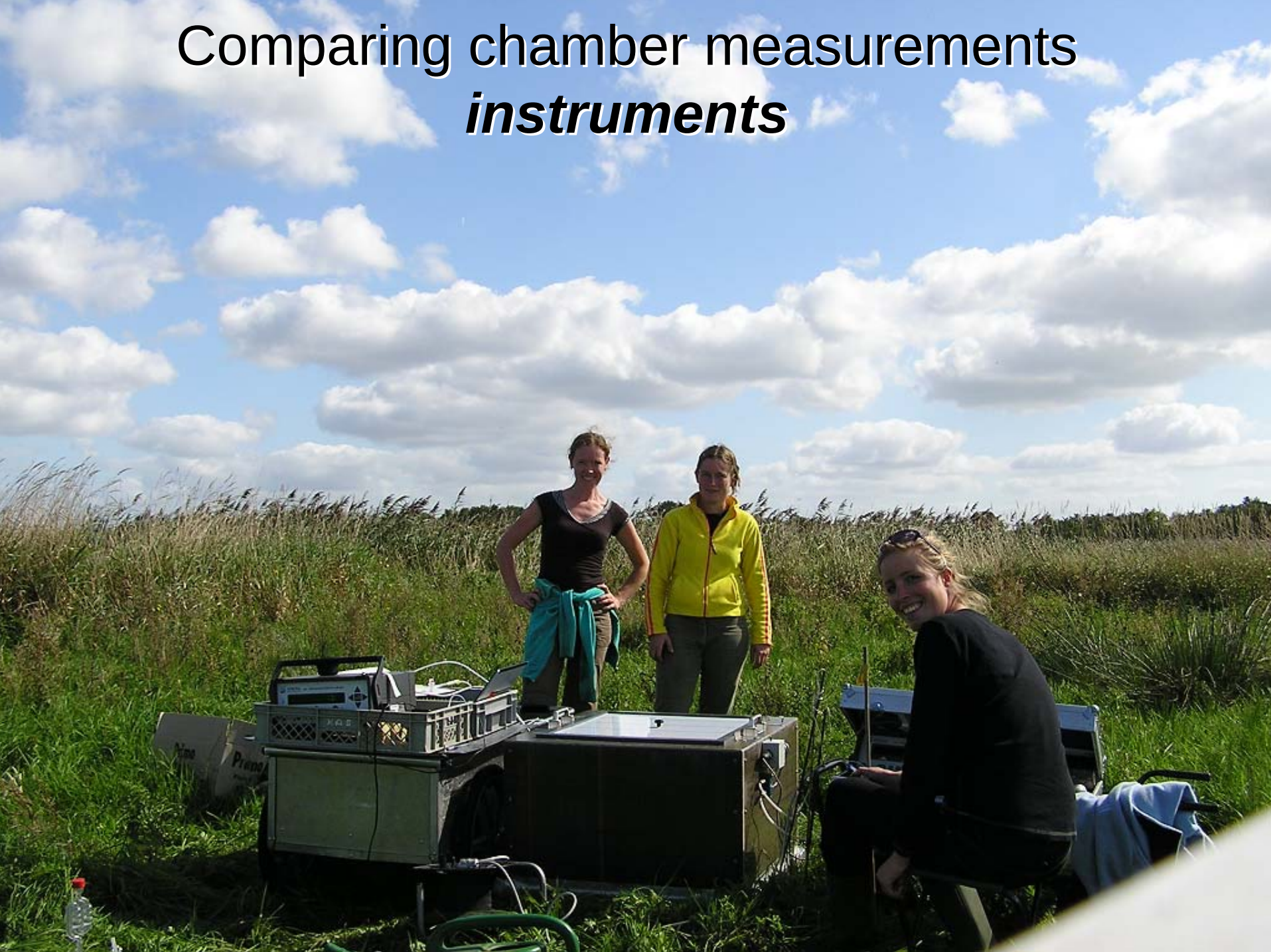
R^2 of correlation small for N_2O (0.17) but high for CH_4 (0.72)

→ comparability varies; generally good (R^2 = 0.57)

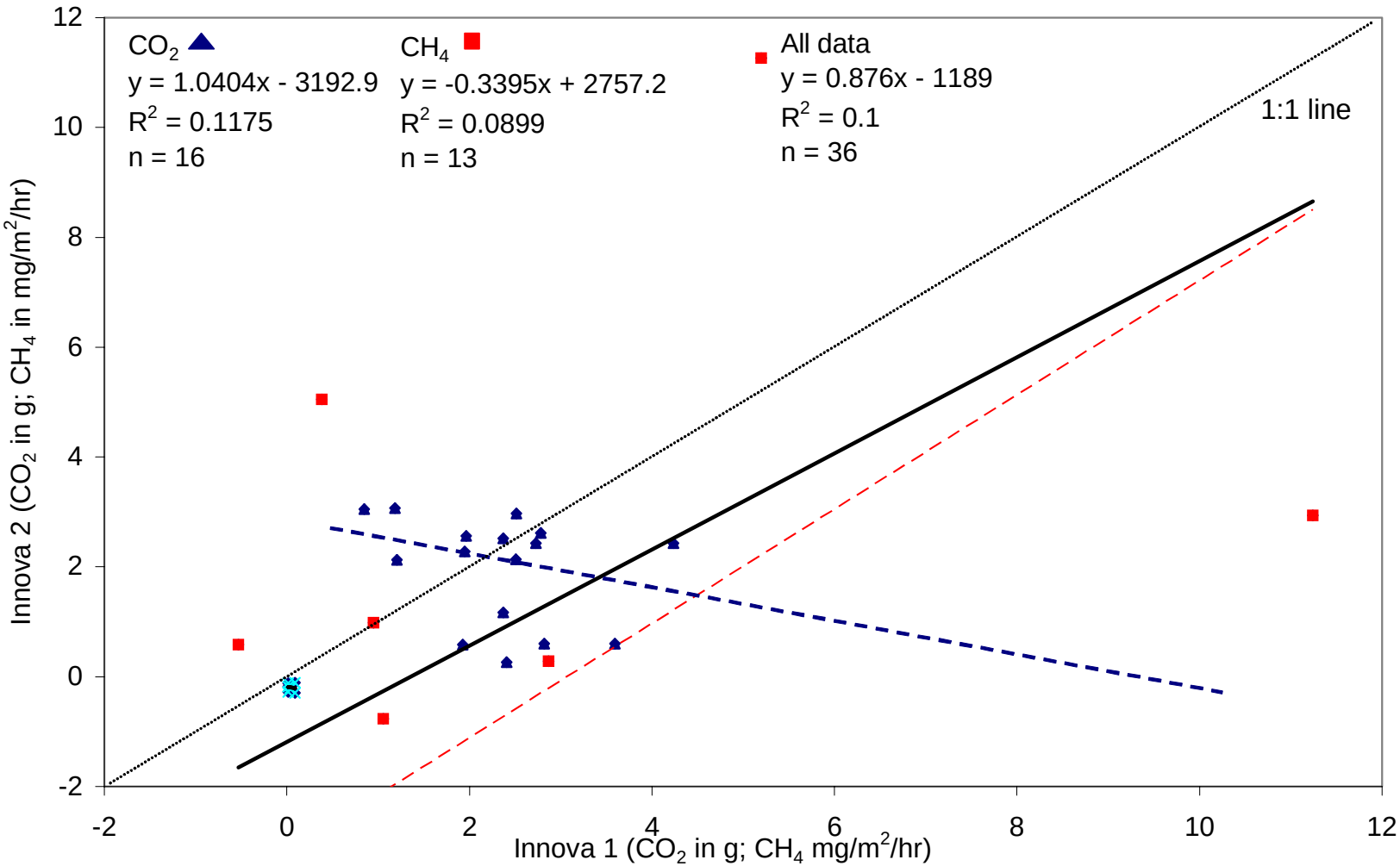
→ dynamic non-leak free app. 12% higher

Comparing chamber measurements

instruments

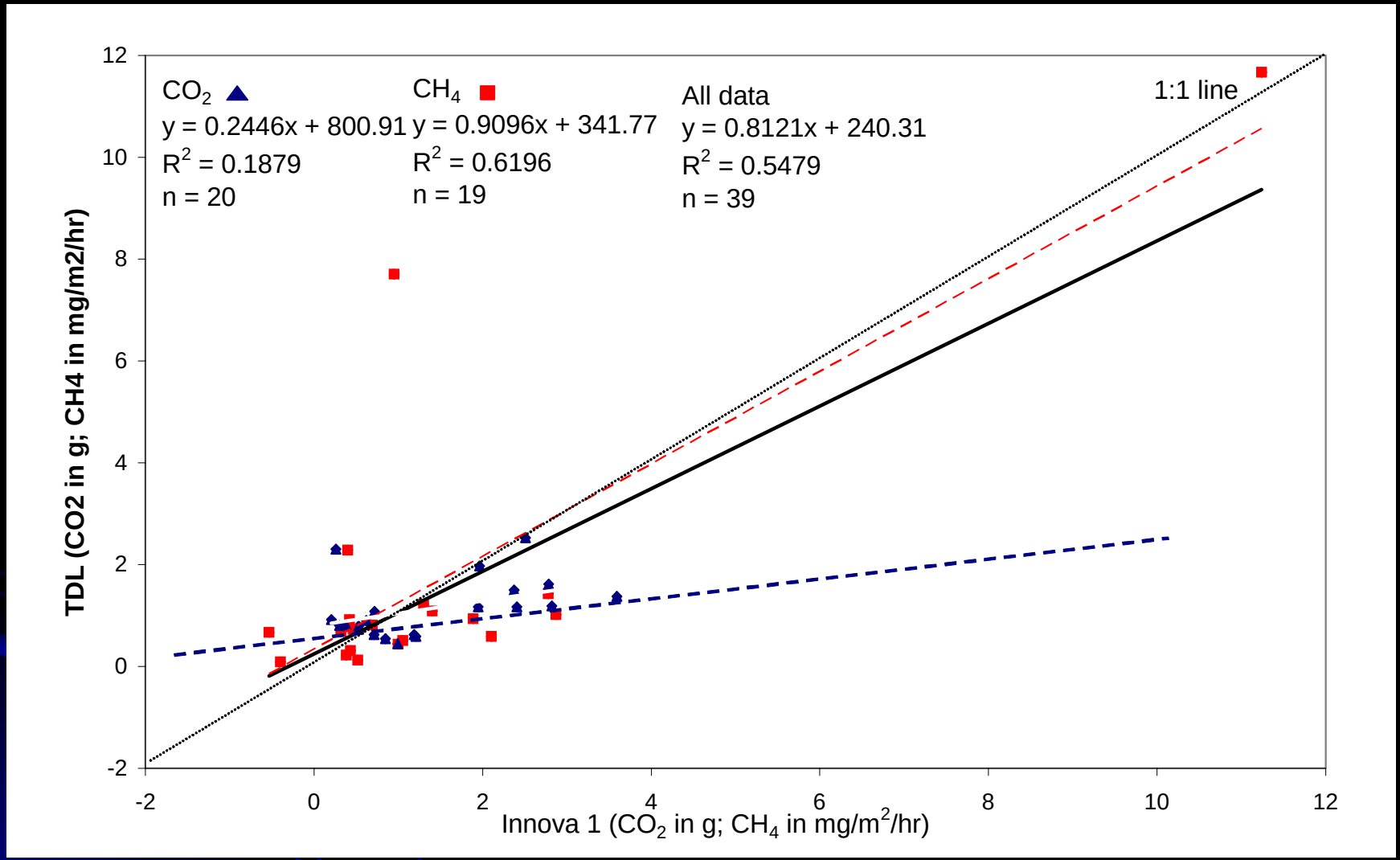


Comparing Innovas (static chambers)



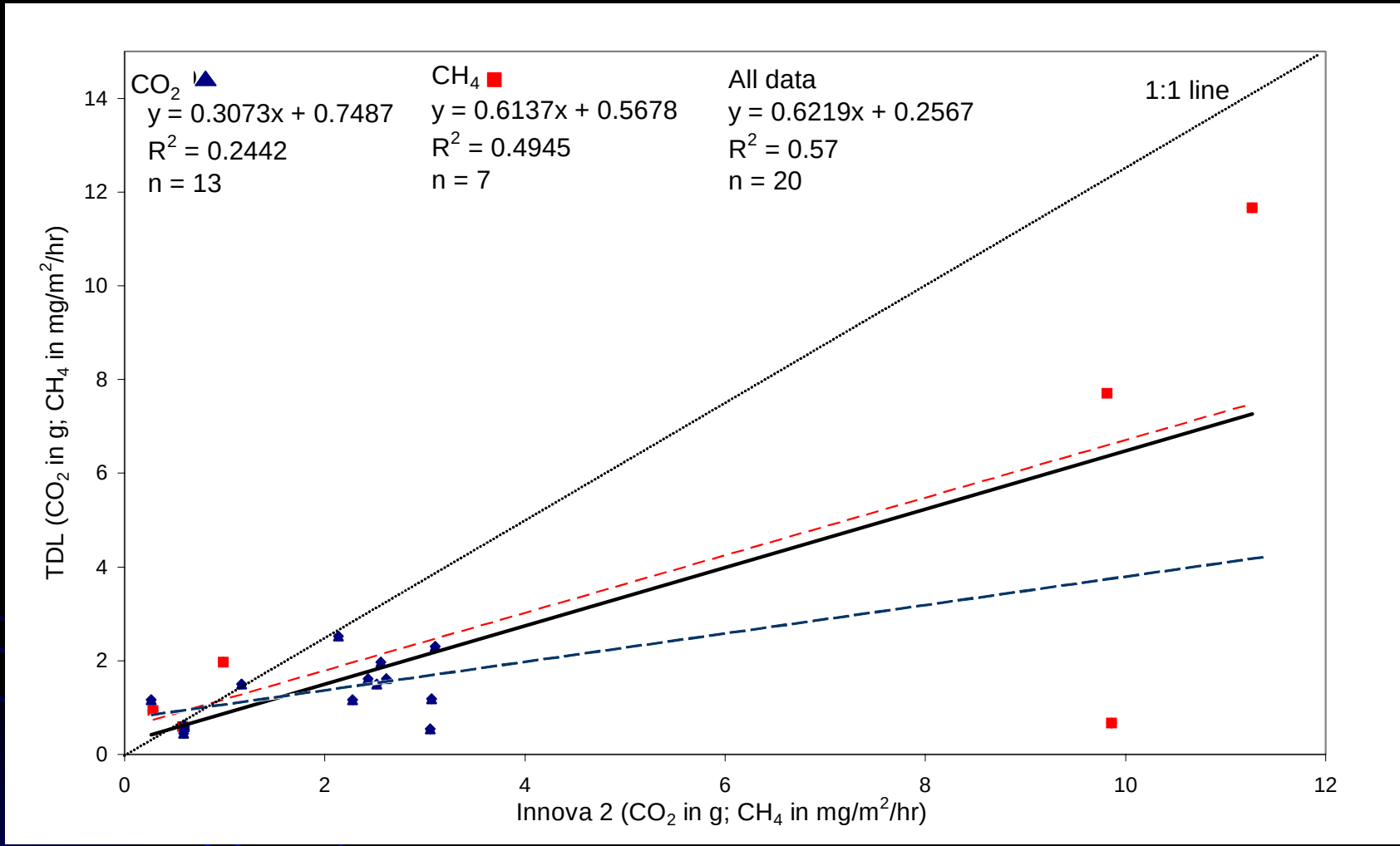
- R^2 of correlation small: 0.1 → comparability not very good
- **Optical filters…?**

Comparing Innova-1 and TDL (static chambers)



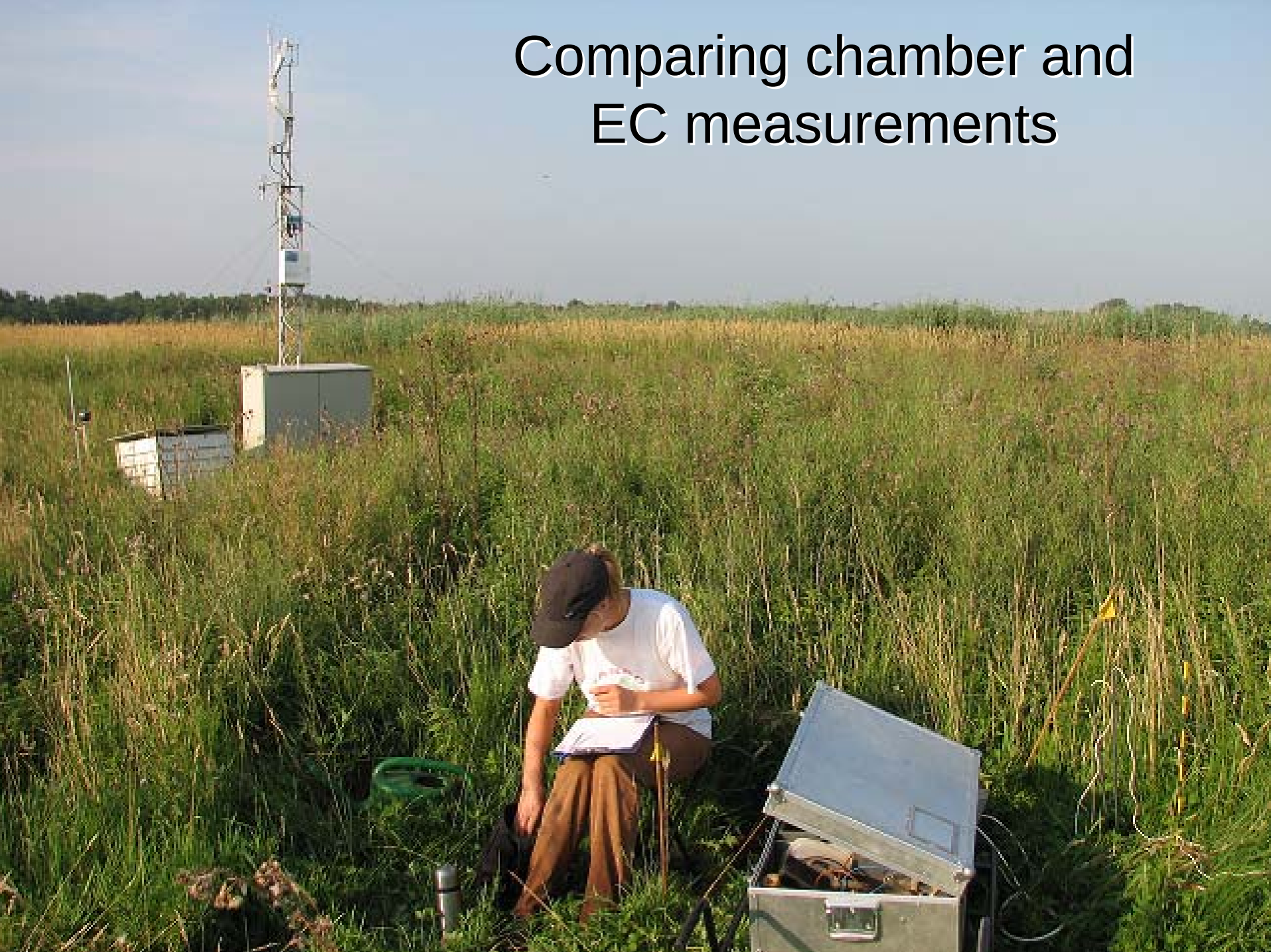
- R^2 of correlation small for CO_2 (0.19) but high for CH_4 (0.62) → comparability varies
- Fluxes of TDL generally lower

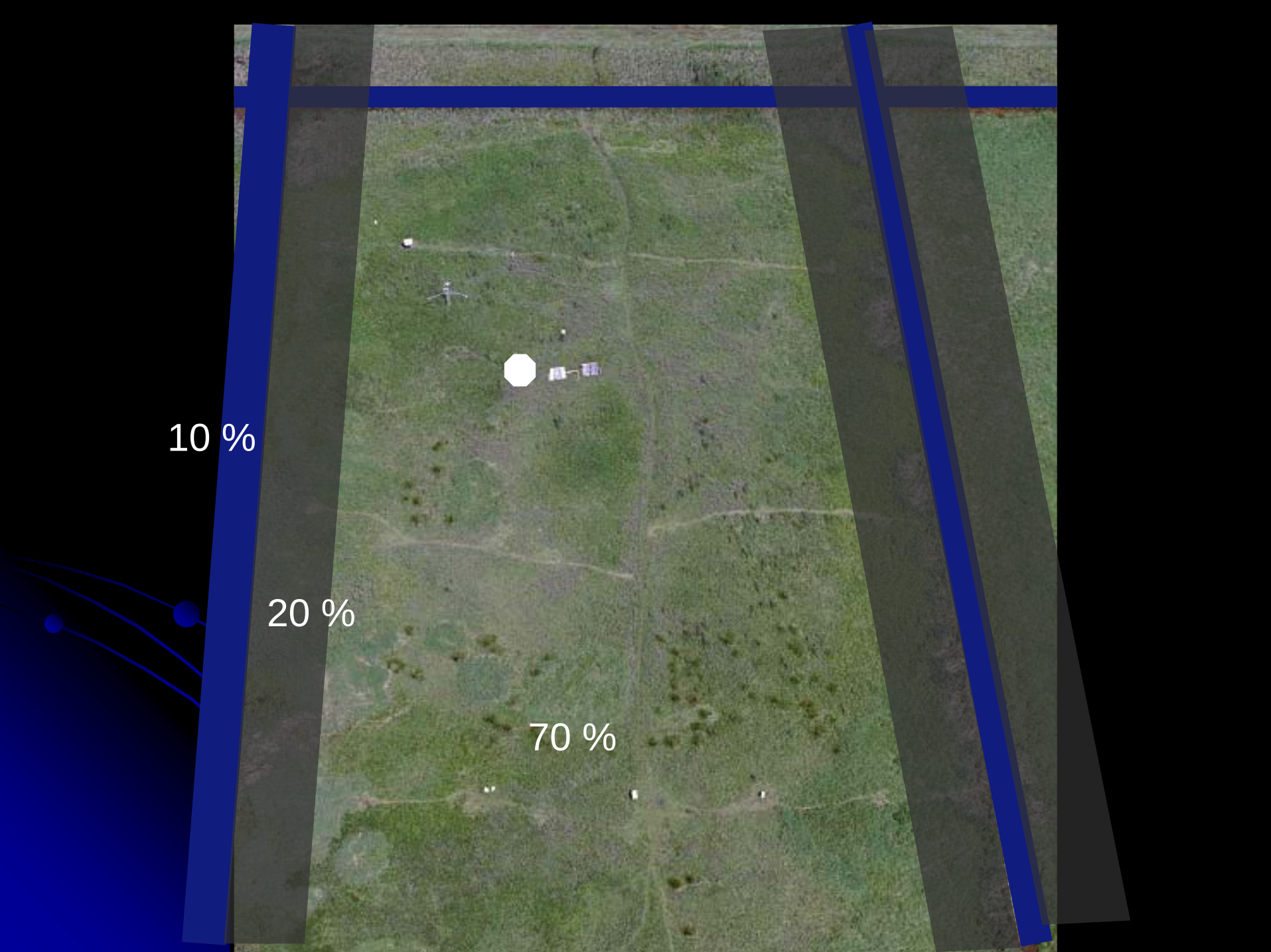
Comparing Innova-2 and TDL (static chambers)



- R^2 of correlation small for CO_2 and CH_4 → comparability varies
- Spikes removed → comparability improves!
- Fluxes TDL generally lower

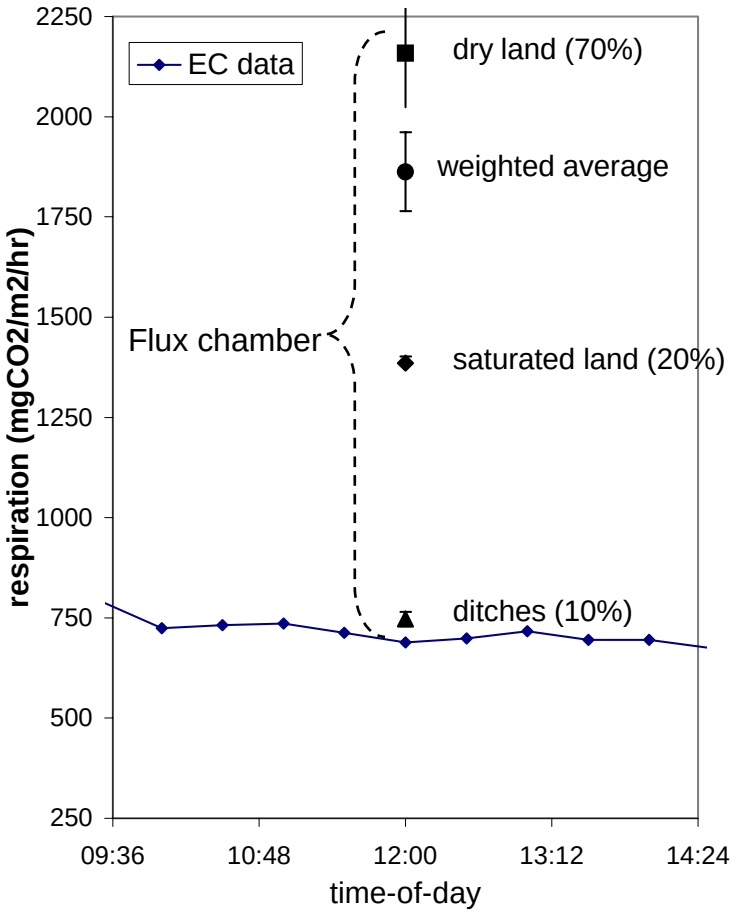
Comparing chamber and EC measurements



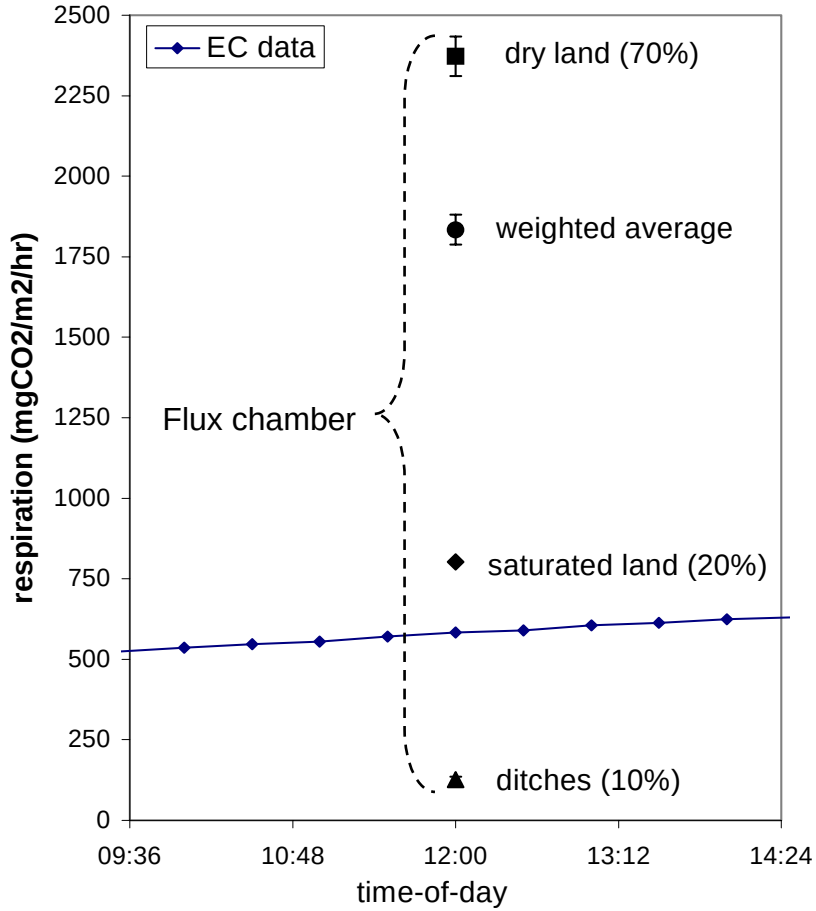

10 %
20 %
70 %

Comparing CO_2 fluxes from EC and chambers

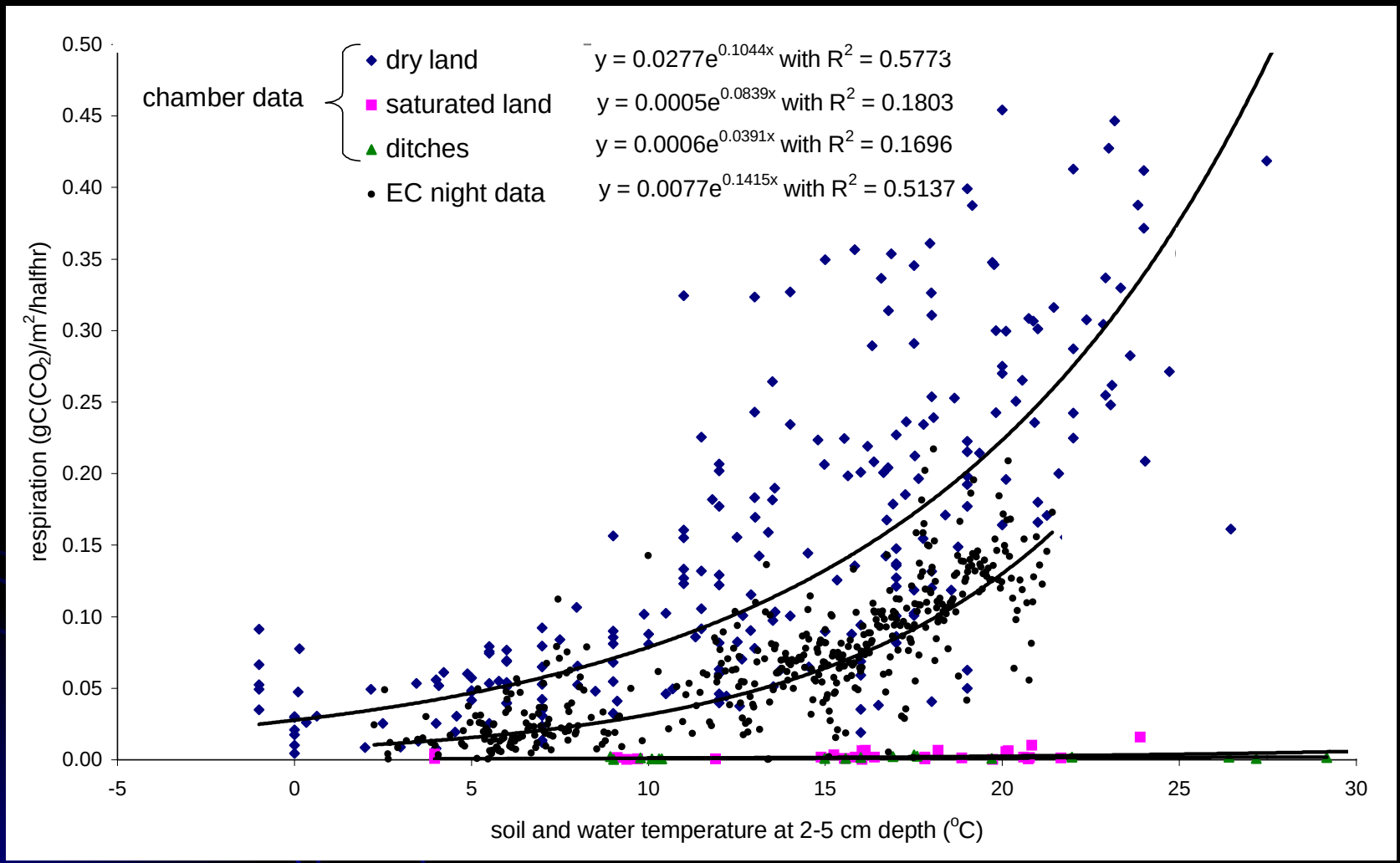
May 29th 2006



July 25th 2006



Respiration: chambers and nightly EC values



Model by Reichstein et al. (2005) uses Lloyd&Taylor (1994)

$$R_{eco}(T) = R_{eco,ref} \cdot e^{E_0 \left(\frac{1}{T_{ref} - T_0} - \frac{1}{T - T_0} \right)}$$

T_{ref} = 10°C (reference temperature)
T_0 = – 46.02°C (constant)
T = air temperature
R_{eco} = ecosystem respiration
$R_{eco,ref}$ = ecosystem respiration at reference temperature
E_0 = activation-energy parameter

NEE, Reco and GPP*

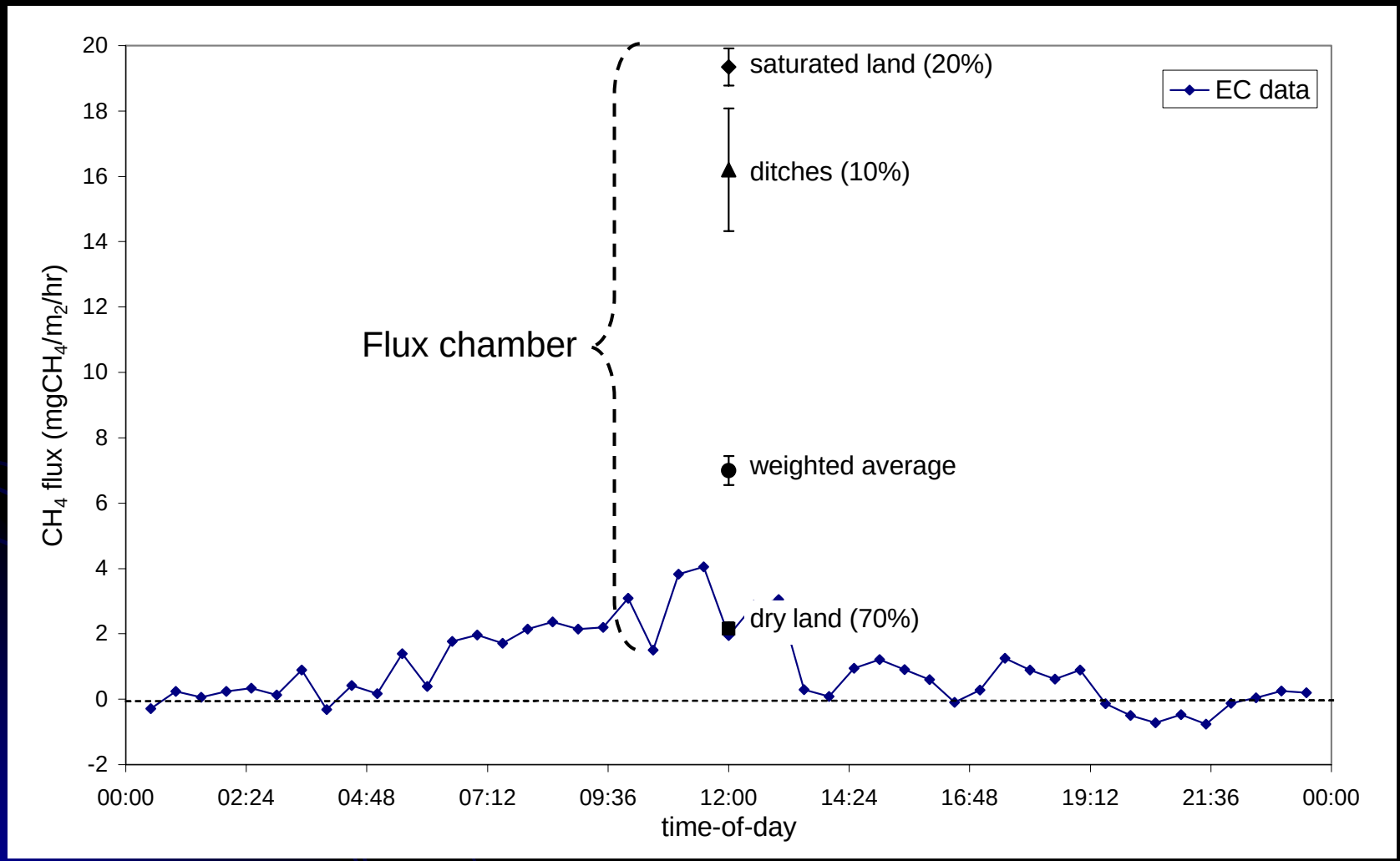
(from chambers, ECnight and model)

method	2005 NEE	Reco	GPP
chambers	3.11	12.8	-15.92
EC-night	3.11	8.66	-11.77
Model Reichstein	3.11	8.23	-11.35

(*) All numbers in tonC(CO_2/ha/year)

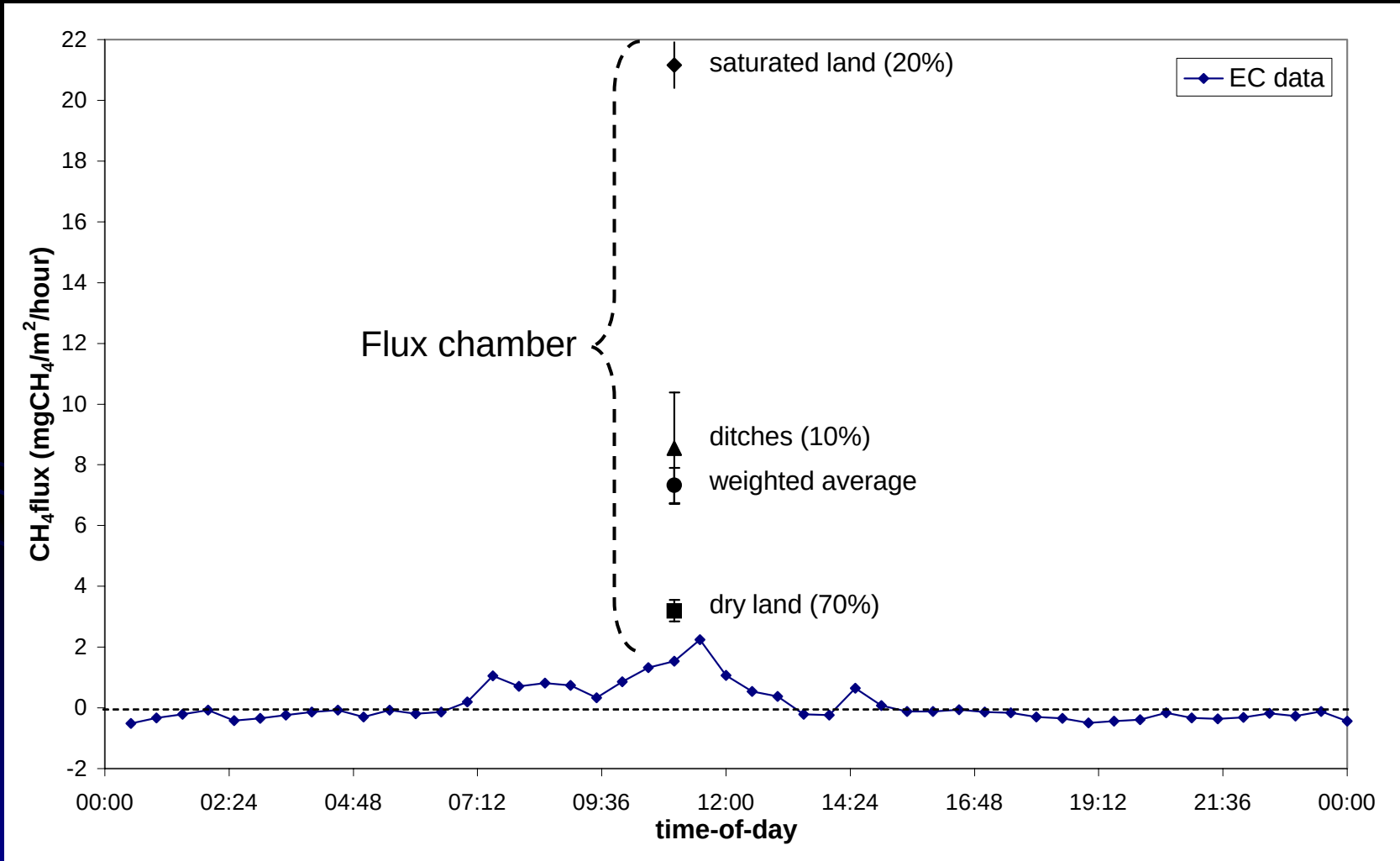
Comparing CH_4 fluxes from EC and chambers

July 10th 2006



Comparing CH_4 fluxes from EC and chambers

June 24th 2006



Conclusions and discussion (1)

- Comparability of Innova, TDL and QCL varies: needs to be checked before data-sets are compared!!
- Innova gives generally higher flux values than TDL (20-40%)
- QCL and TDL have high measurement frequence and high precision
- Innova is not suitable for static non-leak free chamber (measurement frequency too low)
- Choose the appropriate optical filters for the Innova
- Use external filters for H_2O and CO_2 for the Innova

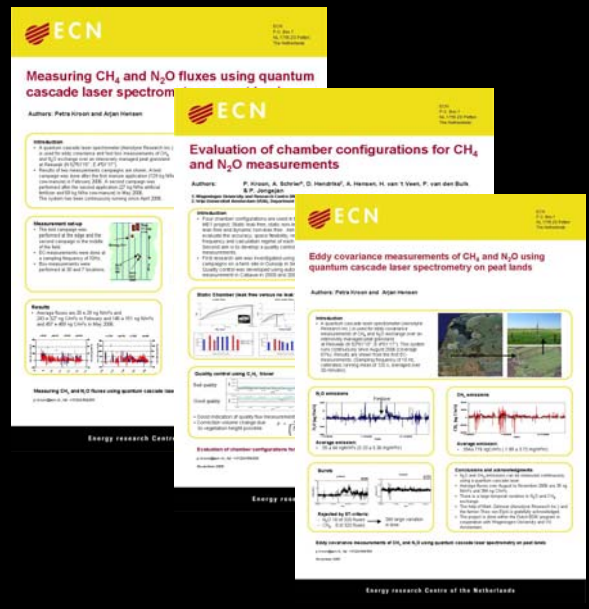
Conclusions and discussion (2)

- Dynamic and static chambers give comparable results
- Leak free and non-leak free chambers give comparable results
- Static leak-free chamber is most accurate
- Static non-leak free requires high measurement frequency
- Calculating the flux: “Intercept method” is more precise and results in apparently higher fluxes than other methods
- Chamber fluxes appear to give higher fluxes than EC fluxes (for CO_2 and CH_4)

Posters

Board 119

- Evaluation of chamber configurations for CH_4 and N_2O measurements (ECN)
- Measuring CH_4 and N_2O fluxes using quantum cascade laser spectrometry on peat lands (ECN)
- Eddy covariance measurements of CH_4 and N_2O using quantum cascade laser spectrometry (ECN)



Board 157

- Full GHG Budget of a Peat Meadow (VUA)
- Eddy Correlation set-up for CH_4 Measurements
  Using off-axis Integrated Cavity Output Spectroscopy (VUA)