Experimental assessment of storage variability for different GHGs

implications for eddy covariance measurements

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Non–CO_2 Greenhouse Gases
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Questions

- Are the storage flux terms of different gases related?
- How much are important the vertical and horizontal variability?
- Which is the impact of the storage measurement setup on the fluxes?

What is the storage term?

Scalar Budget Equation (simplified one dimensional)

- the measurement system is placed in a horizontally homogeneous equilibrium layer
- all horizontal gradients in are negligible
- concentration and turbulent fluxes measured on the tower are representative of the volume

Net Ecosystem Exchange

$$NEE = Fc + Sc$$

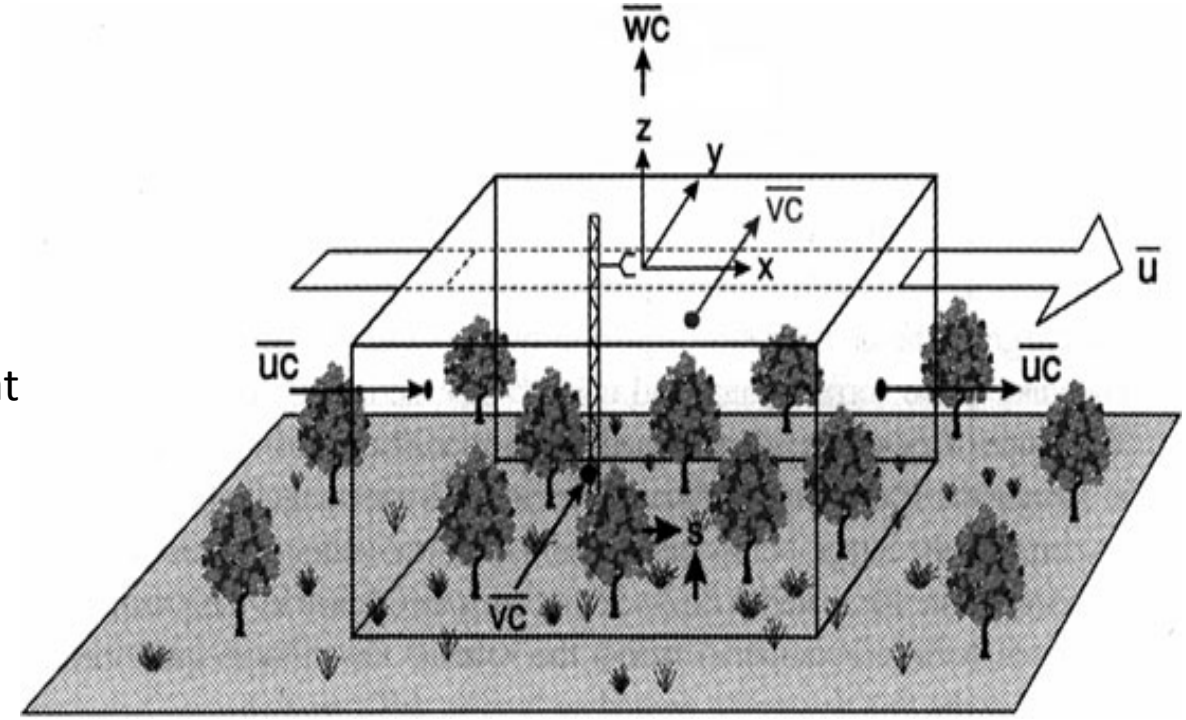
Eddy flux

$$Fc = \overline{w'c'}$$

Storage flux

Accumulation of air in the lower part of the air space that does not reach the EC measuring point

$$Sc = \frac{Pa}{RTa} \int_{z=0}^{h_m} \frac{\partial \overline{c}}{\partial t} dz$$



(Finnigan et al. 2003)

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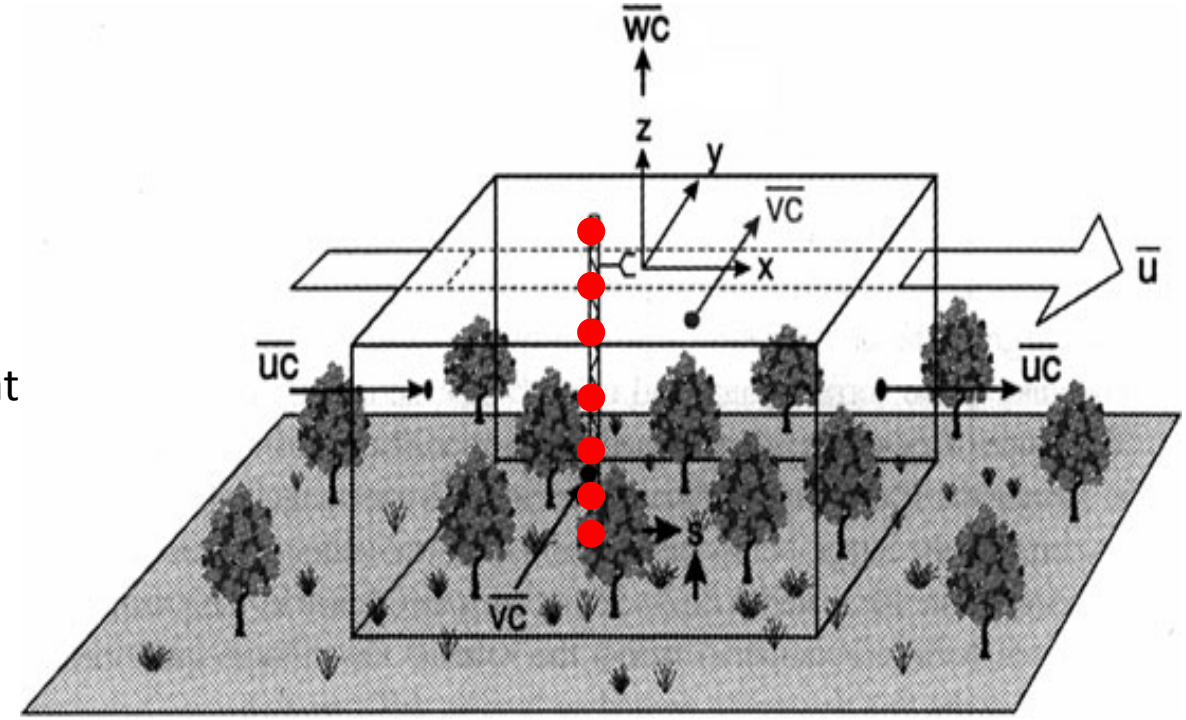

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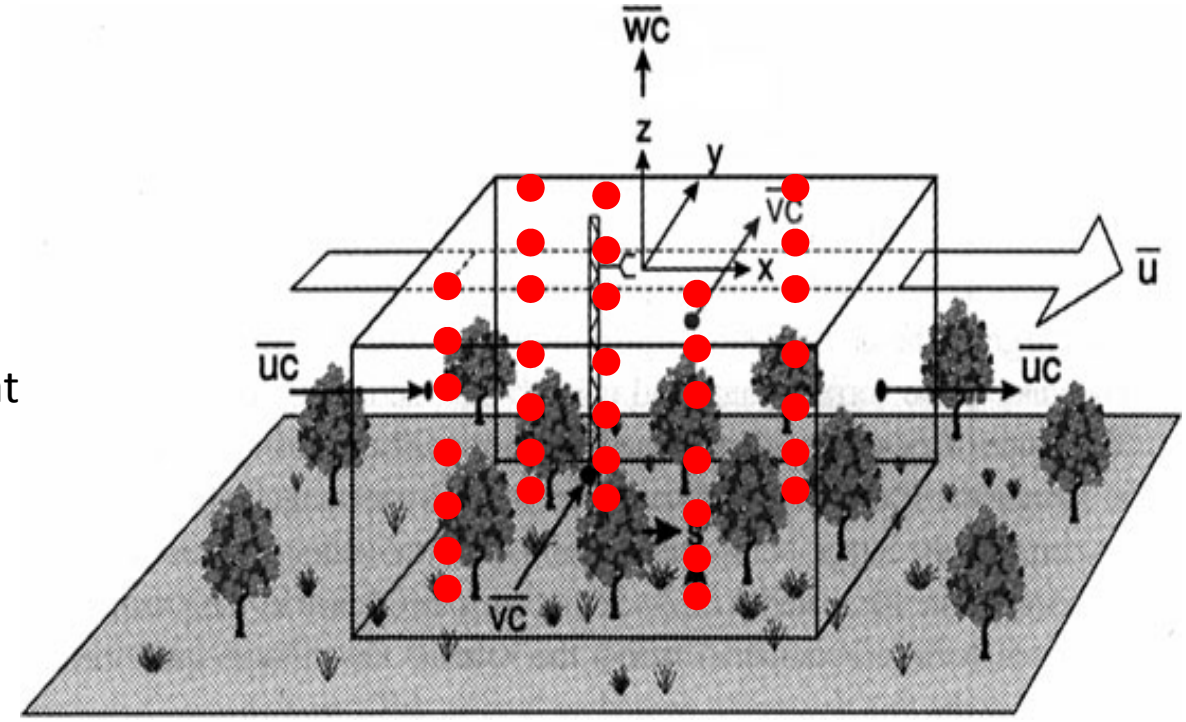

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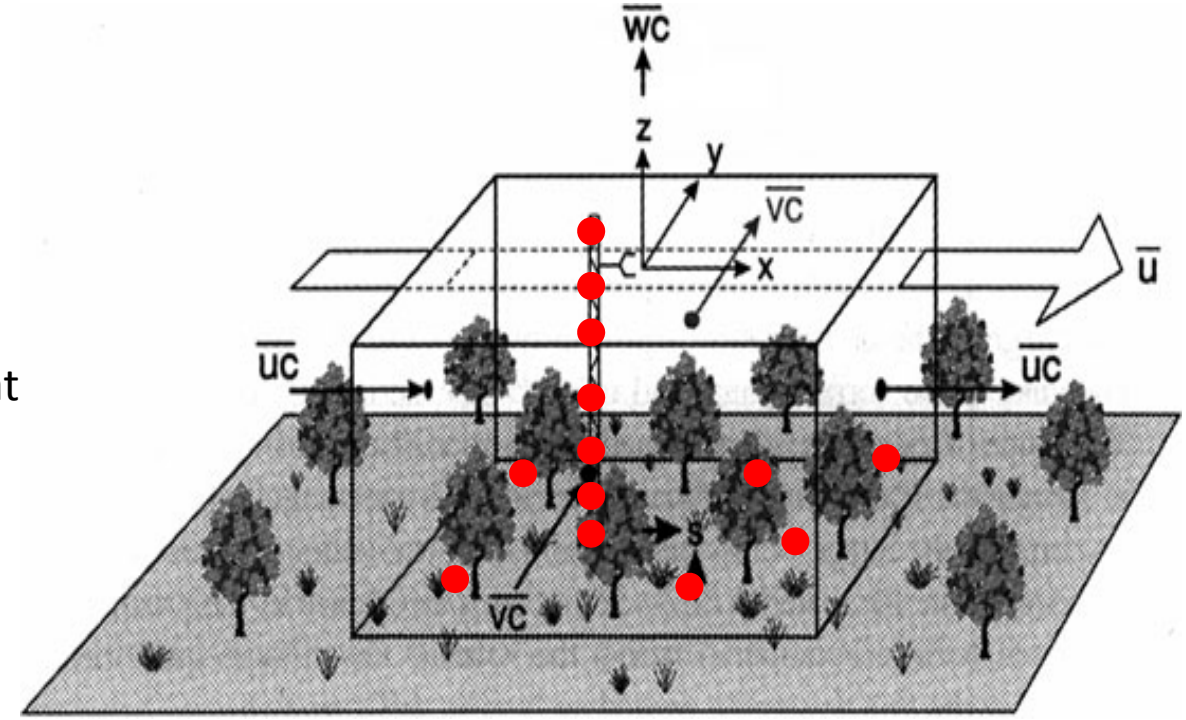

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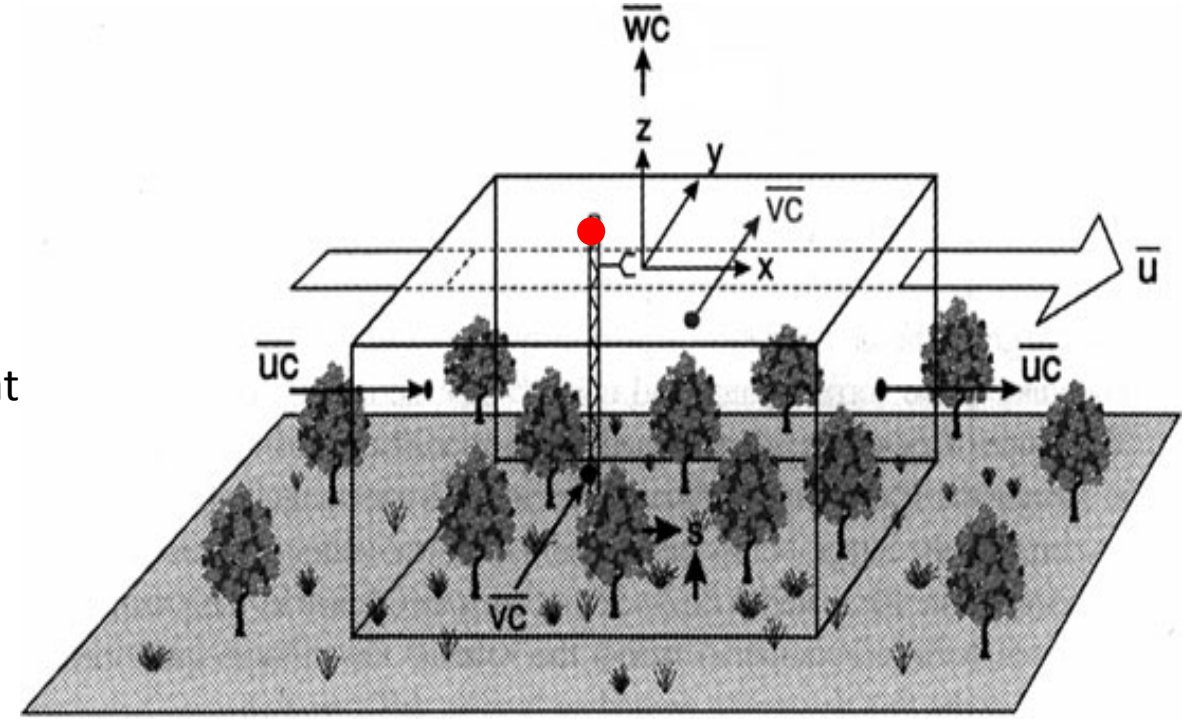

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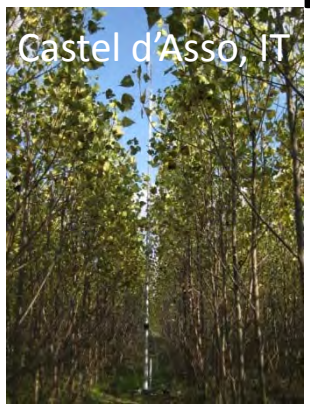
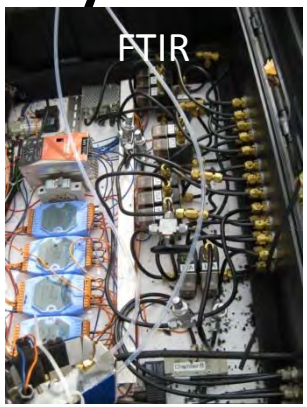
Assessment strategy

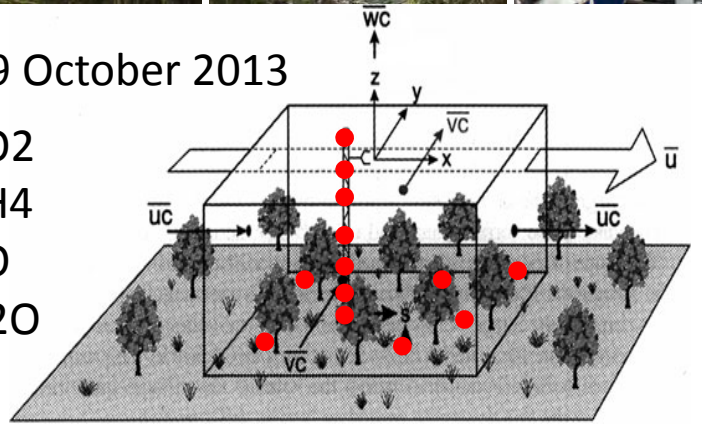
Poplar survey





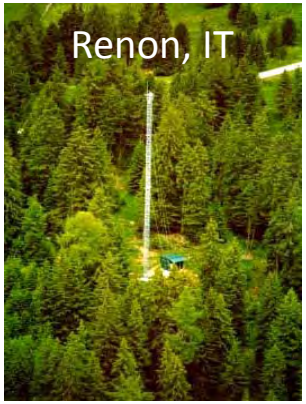
1-29 October 2013

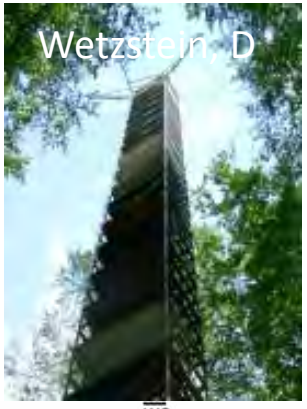
CO2
CH4
CO
N2O



12 inlets were measured every 1.5 hours
7.5 min per inlet (6 vertical + 6 horizontal):
evacuating of cell (15 s)
ushing of sampling line and cell (15 s)
evacuating of cell (2 min)
filling of cell (2 min)
settling of cell (30 sec)
measurement (3 min-spectra, static)

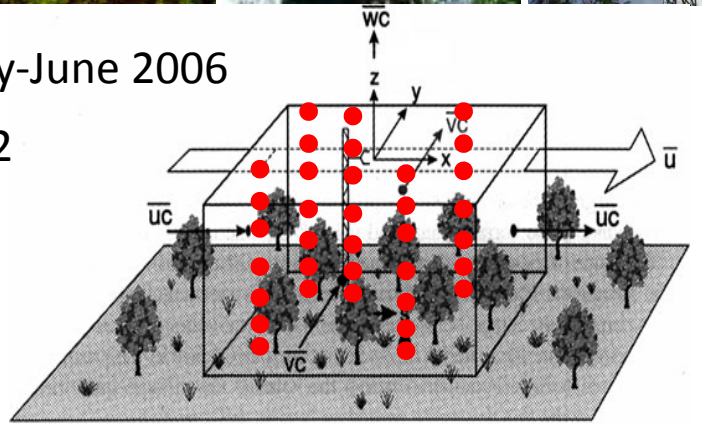
ADVEX data





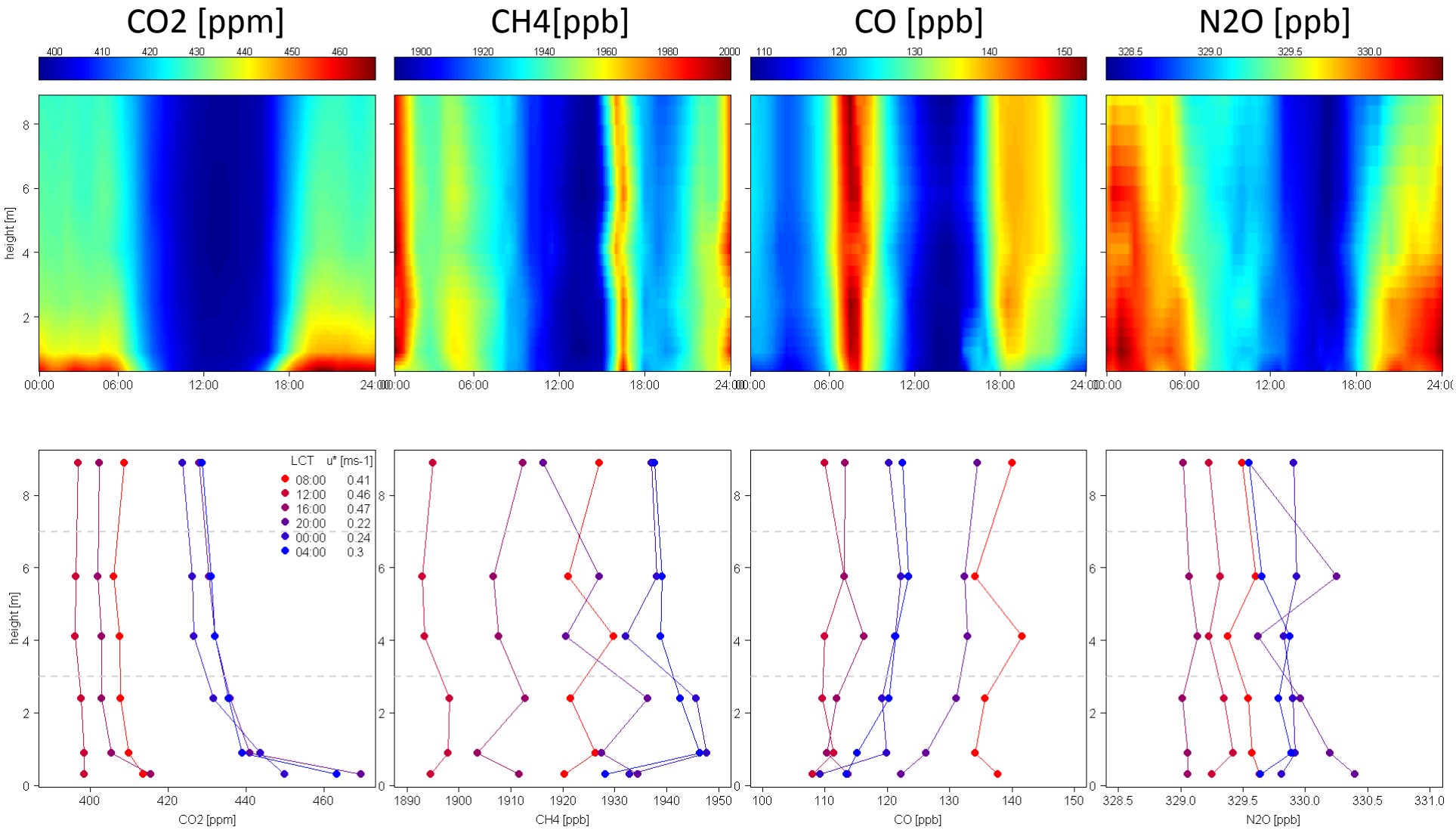
May-June 2006

CO2

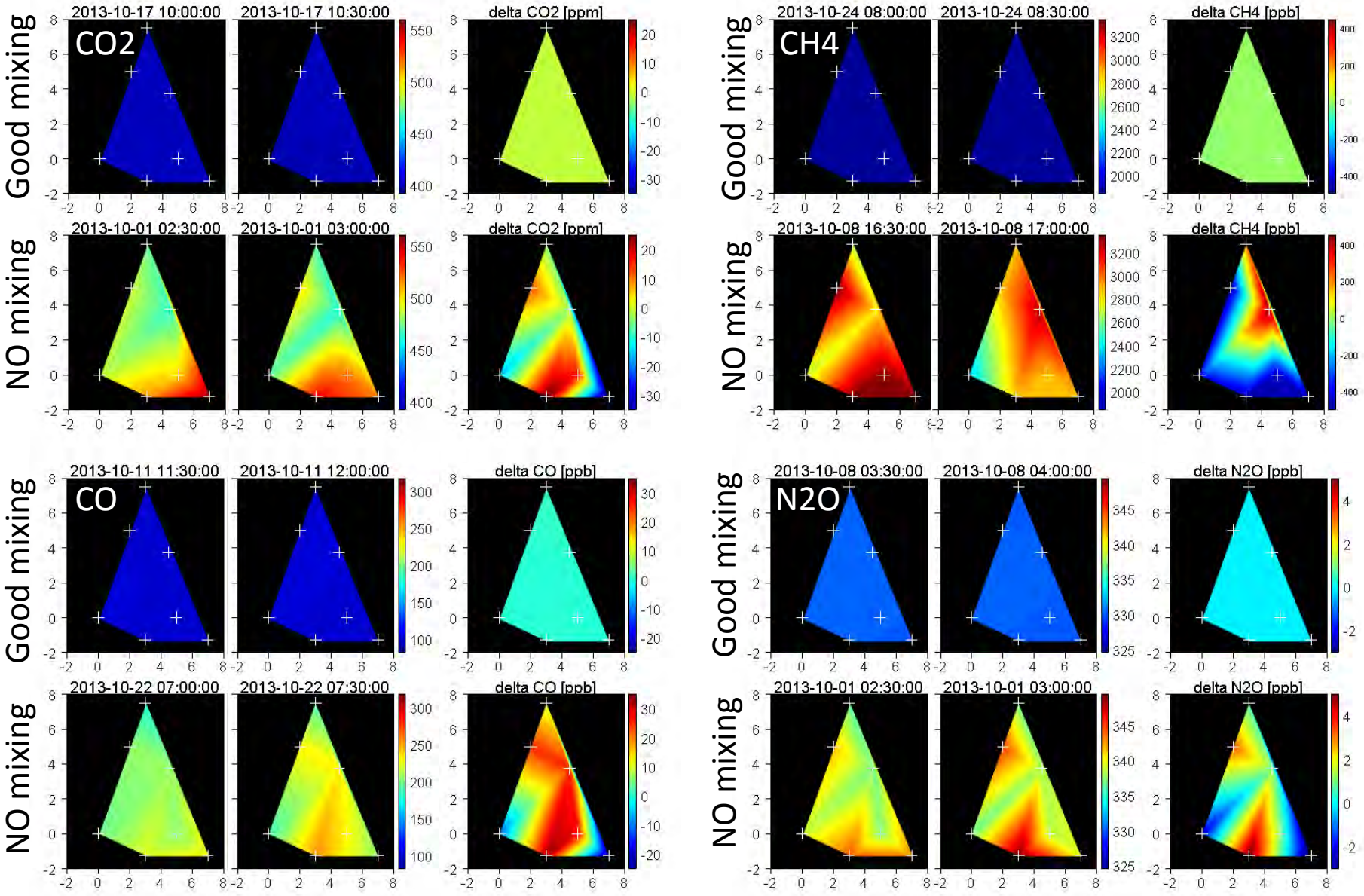


e.g. Feigenwinter et al., 2008;
Aubinet et al., 2010;
....

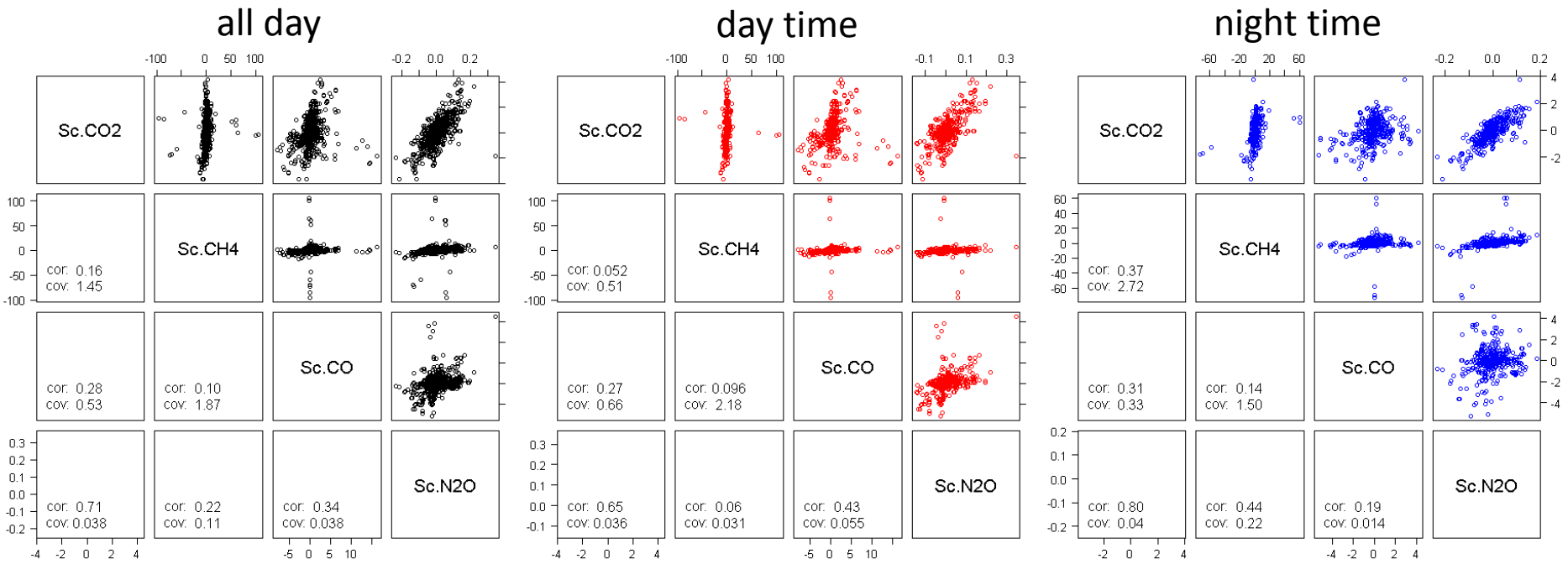
Poplar – concentration vertical variability



Poplar – concentration horizontal var



Poplar – Sc_s cross-correlation



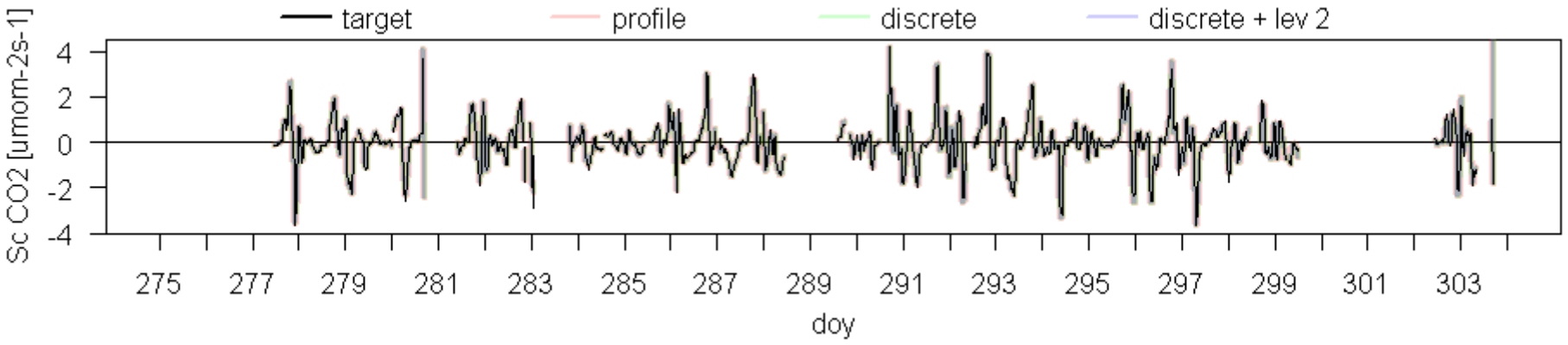
Storage fluxes of different GHGs are poorly correlated

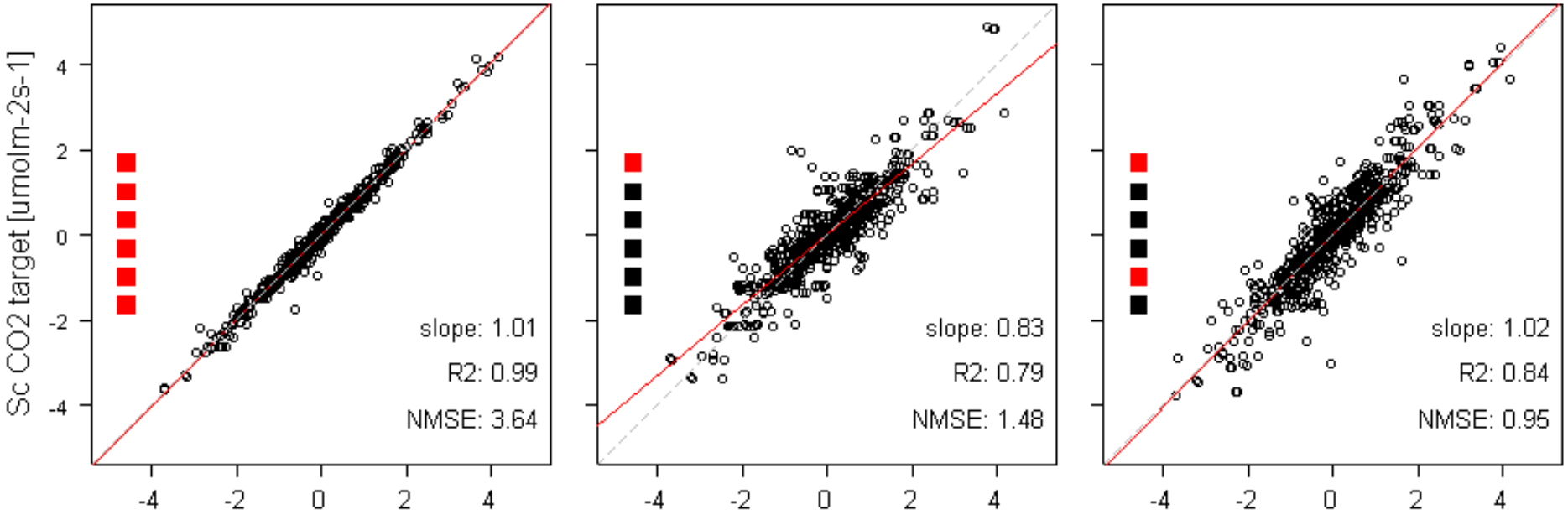
extreme values drive the relations in particular for CH4

CO2 and N2O show some correlation?

Poplar – vertical sampling effect

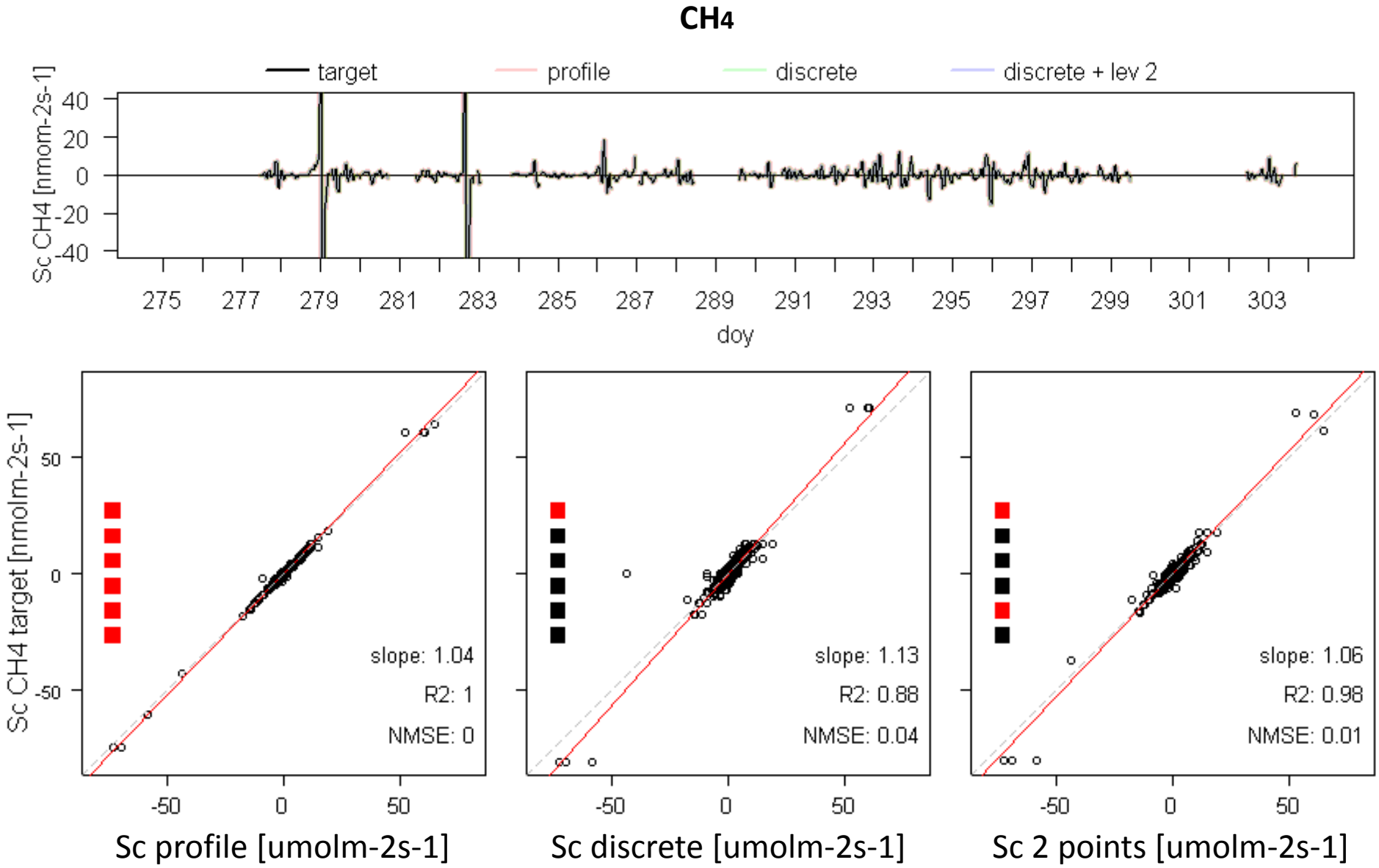
CO_2





Sc profile [umolm-2s-1] Sc discrete [umolm-2s-1] Sc 2 points [umolm-2s-1]

Poplar – vertical sampling effect



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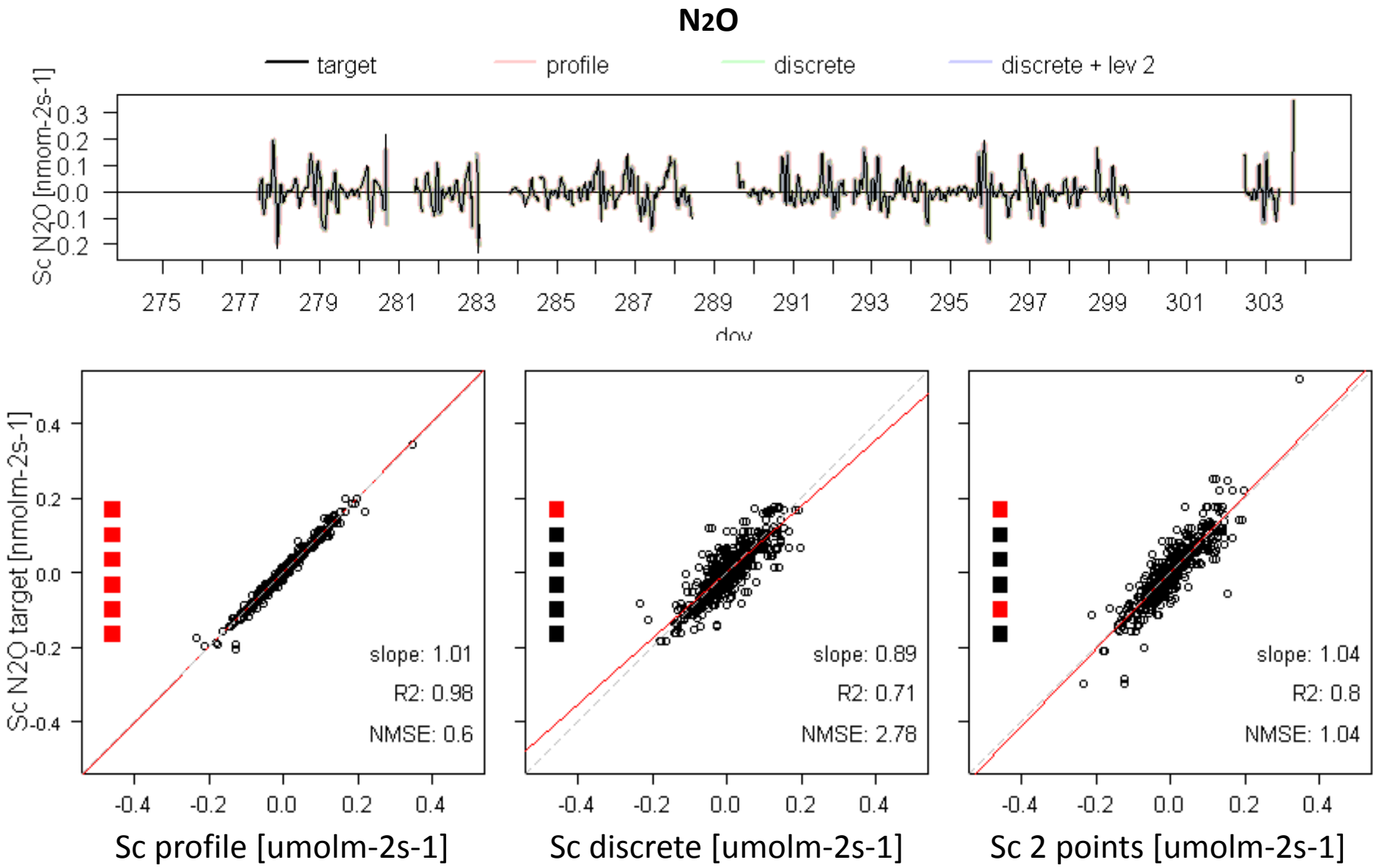
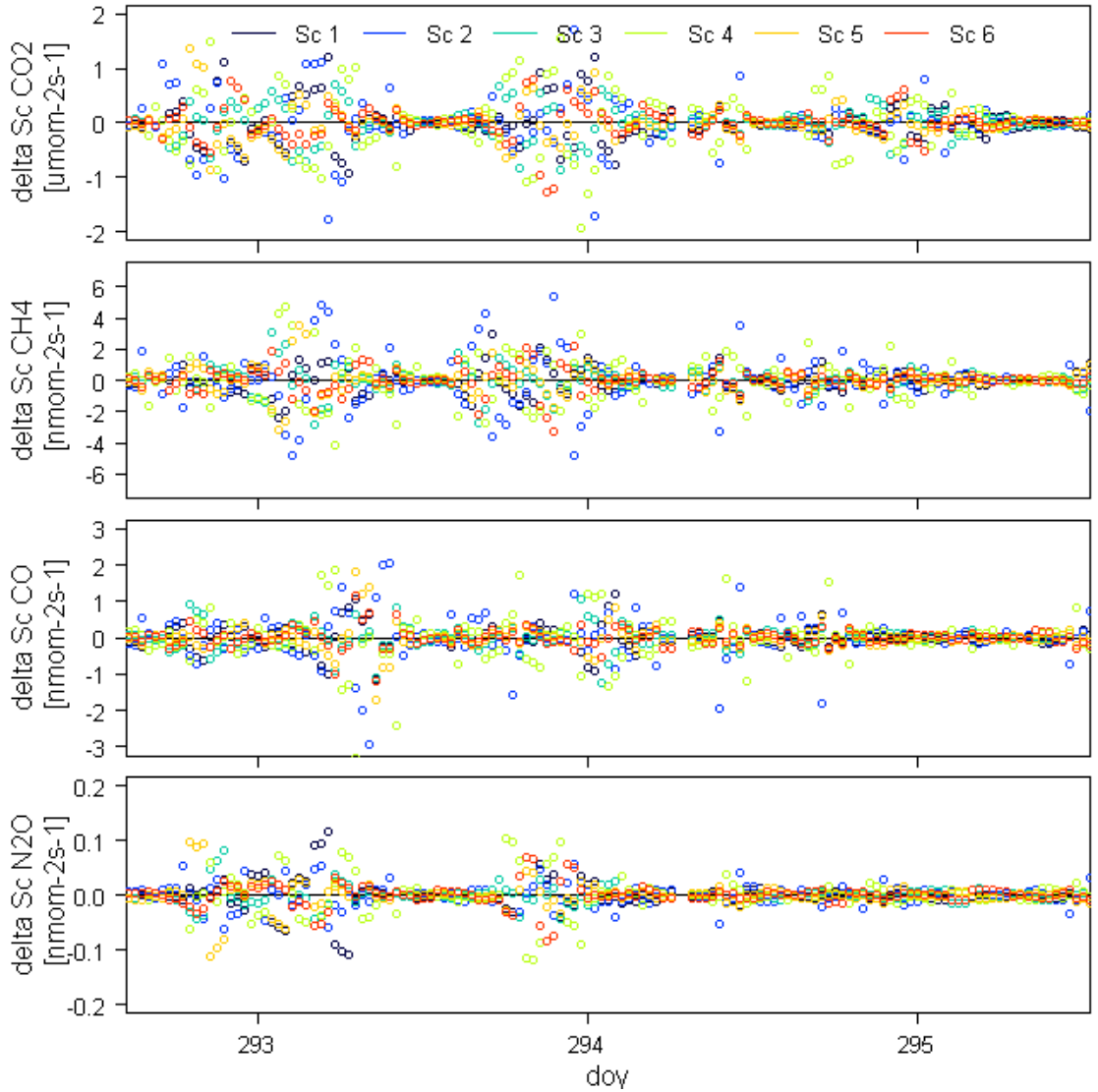


Sc profile [umolm-2s-1] Sc discrete [umolm-2s-1] Sc 2 points [umolm-2s-1]

Poplar – Sc horizontal variability

Sc 2-points horizontal comparison – differences around mean

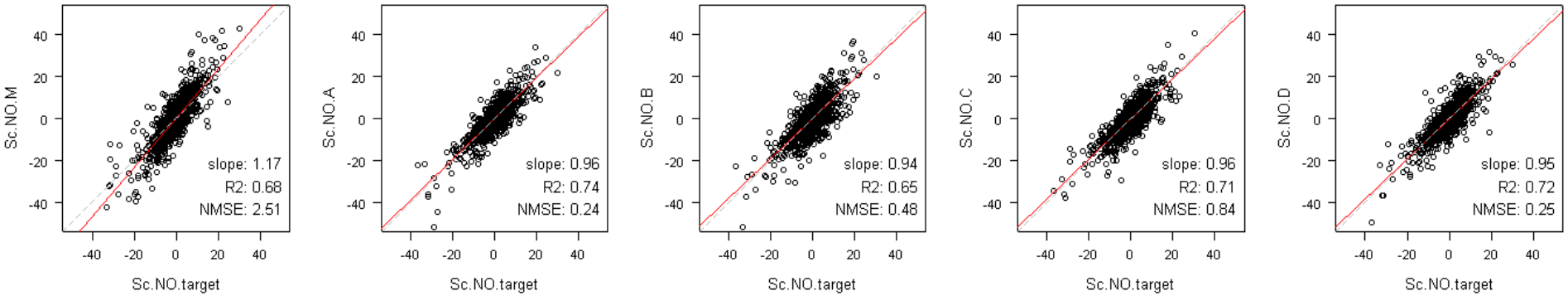
Uncertainty due to 2-points profile location

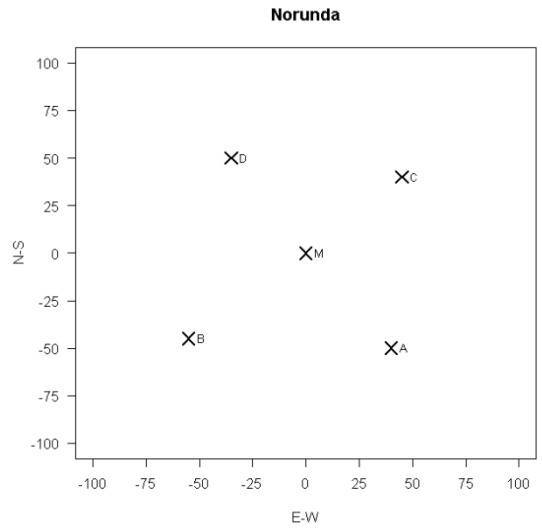


Maximum uncertainty up to 30-60% of Fc during night time

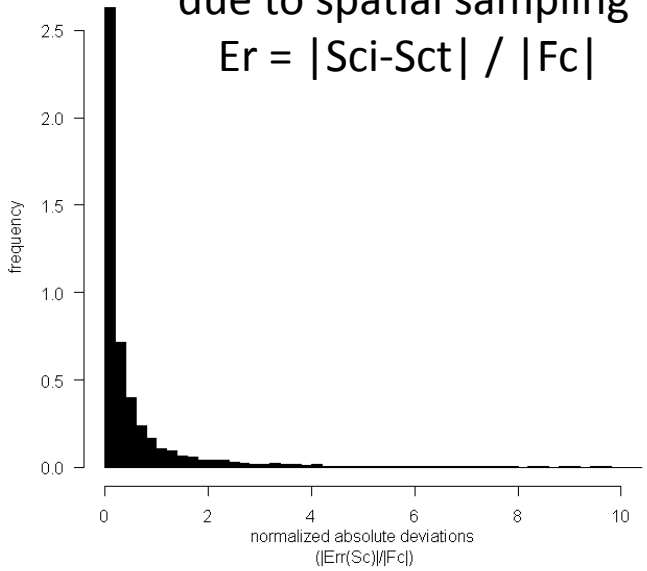
Advex data - Norunda

Target Sc vs profile Scs

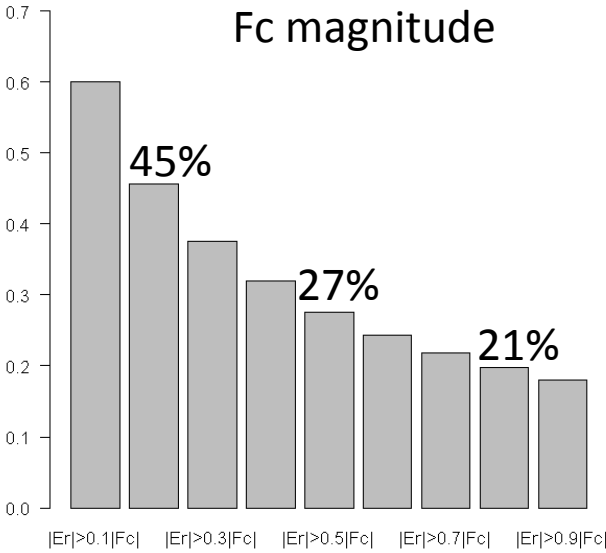




Sc relative error
due to spatial sampling
Er = |Sci-Sct| / |Fc|



Comparison with
Fc magnitude



Answers

- storage flux terms of different gases related are scantly related
- relations driven by extreme events of non CO2 gases
- we found a weak correlation between ScCO2 and ScN2O, but, further analysis are needed

>> Difficult to predict them by ScCO2

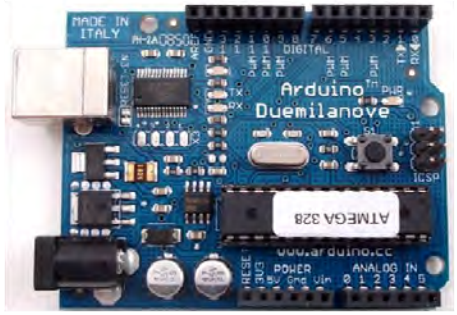
Answers

- Vertical variability seems to have a minor impact
- Horizontal variability seems to have an important impact, especially considering the flux magnitude
- Considering the horizontal variability, it could be high
- Errors up to 20-60 % of Fc in certain conditions (10-30% of data)

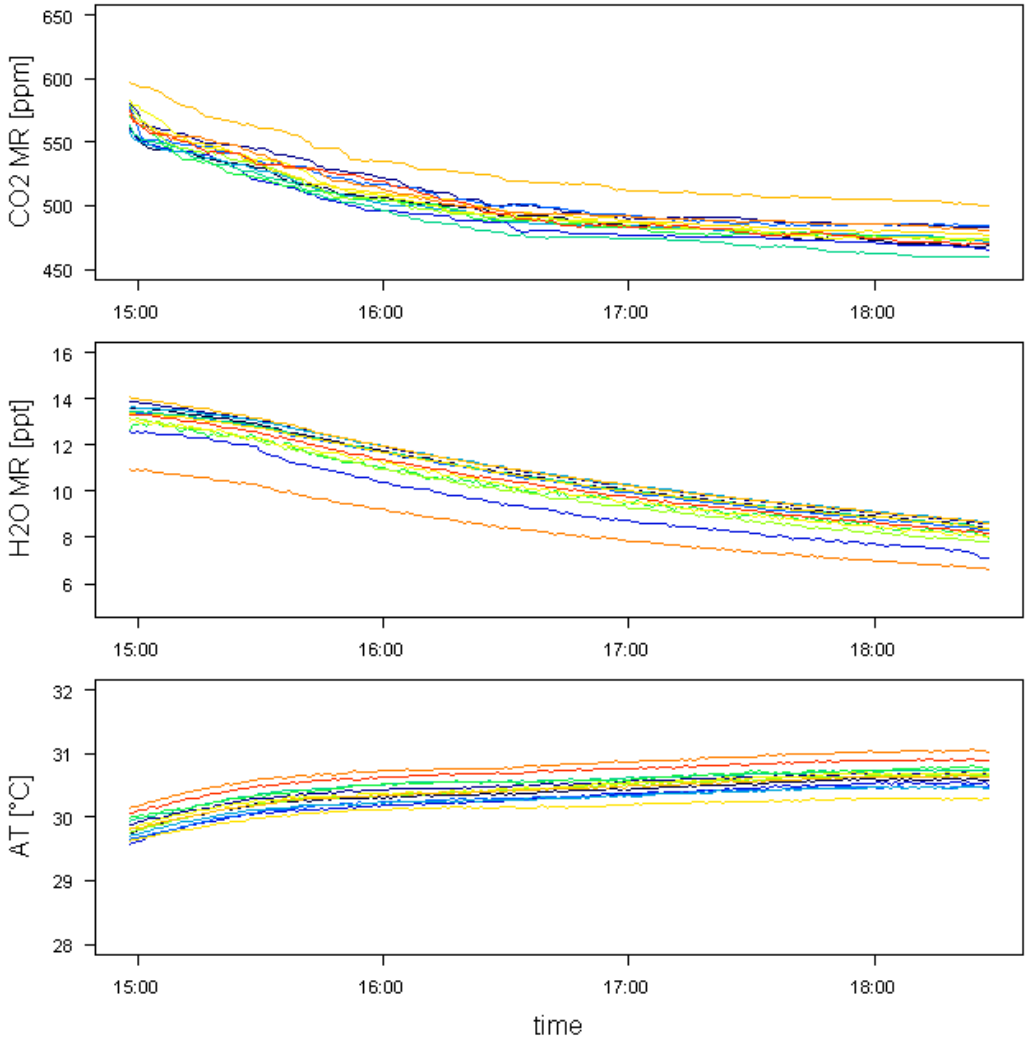
Under test… Storageino

Low cost (100 euro)
but also low accuracy/precision sensors

Could however sample the footprint extensively



CO2 Engine
K33-LP T/RH



Thanks

References

1. Finnigan JJ, Clement R, Malhi Y, Leuning R, Cleugh HA (2003) A re-evaluation of long-term flux measurement techniques, Part I: averaging and coordinate rotation. Bound LayerMeteorol 107:1–48
2. Milborrow S. (2011) Derived from mda:mars by T. Hastie and R. Tibshirani Earth: Multi-variate Adaptive Regression Splines, 2011. R package.
3. Aubinet M, Feigenwinter C, Heinesch B, et al (2010) Direct advection measurements do not help to solve the night-time CO2 closure problem: Evidence from three different forests. Agric For Meteorol 150:655–664. doi: 10.1016/j.agrformet.2010.01.016
4. Feigenwinter C, Bernhofer C, Eichelmann U, et al (2008) Comparison of horizontal and vertical advective CO2 fluxes at three forest sites. Agric For Meteorol 148:12–24. doi: 10.1016/j.agrformet.2007.08.013

Thanks

Precision		LOD	
CH4/CO	0.4 ppb	CH4	2 nmolm-2s-1
N2O	0.1	CO	3 nmolm-2s-1
		N2O	0.1 nmolm-2s-1