Up-scaling methods of greenhouse gas fluxes between the soil and the atmosphere using a measuring tunnel as well as open-path measurement techniques for the flux-gradient method

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Problems

Insufficient knowledge of the net greenhouse gas (GHG) fluxes from different soil types

High spatial variability of GHG emissions even with one soil type

➔Up-scaling of the source and sink measurements of GHG necessary

Measurement methods for GHG fluxes:

- chambers or boxes (1 m^2) – accumulation of emissions, sampling of enclosed air
- chambers or boxes with up to 1000 m^2 desirable for site-integrated fluxes
- eddy covariance method (1000 m^2) – micro-meteorological measurements (turbulence), open-path measurements for CO_2 and H_2O only, closed-path for other gases, assumptions on footprint
- flux-gradient method (1000 m^2) – local measurement of vertical concentration gradients, assumptions on exchange coefficients and footprint
- mass balance method (1 ha) – path-averaged (FTIR, DOAS) upwind / downwind (plume) measurements, limited emitting area must be known
- flux gradient method for 1 ha to 10 ha desirable for larger and inhomogeneous sites
- inverse dispersion modelling (1 km^2) – downwind concentration measurements and Backward Lagrange dispersion modelling

available path-averaging optical remote sensing techniques:

• FTIR absorption spectrometry (N_2O, CO_2, CH_4, CO, H_2O),

• DOAS (NO, NO_2, O_3, SO_2, NH_3, BTX, HCHO)

DOAS

FTIR

Karlsruhe Institute of Technology

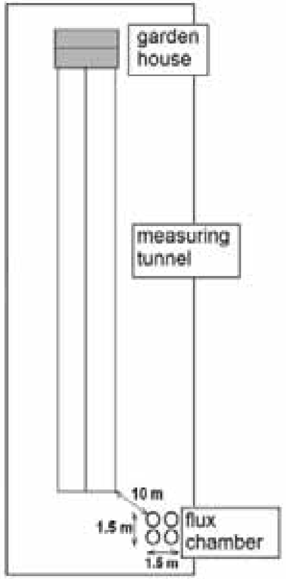
possible solutions to be analysed here

(1)
large tunnel with path-averaged concentration measurements

(2)
gradient method based on path-averaged concentration gradients

(1) large tunnel

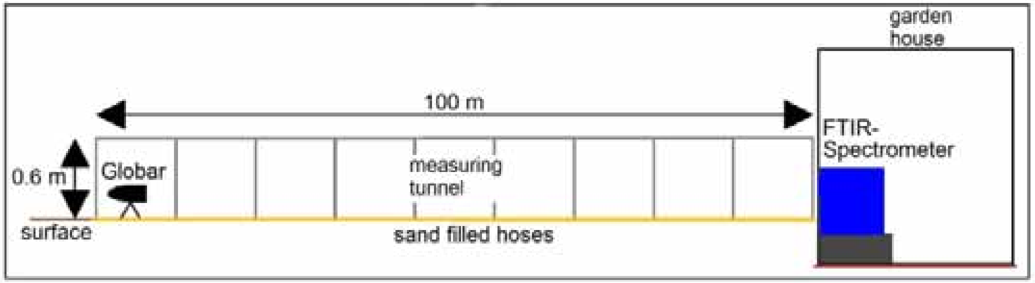
large tunnel with path-averaged FTIR measurements of N_2O



arrangement of tunnel and a few conventional flux chambers for comparison

up-scaling area:

several hundreds of m^2



(1) large tunnel

Problems with the tunnel:

inside conditions different from ambient conditions (temperature, humidity, turbulence (no fan available))

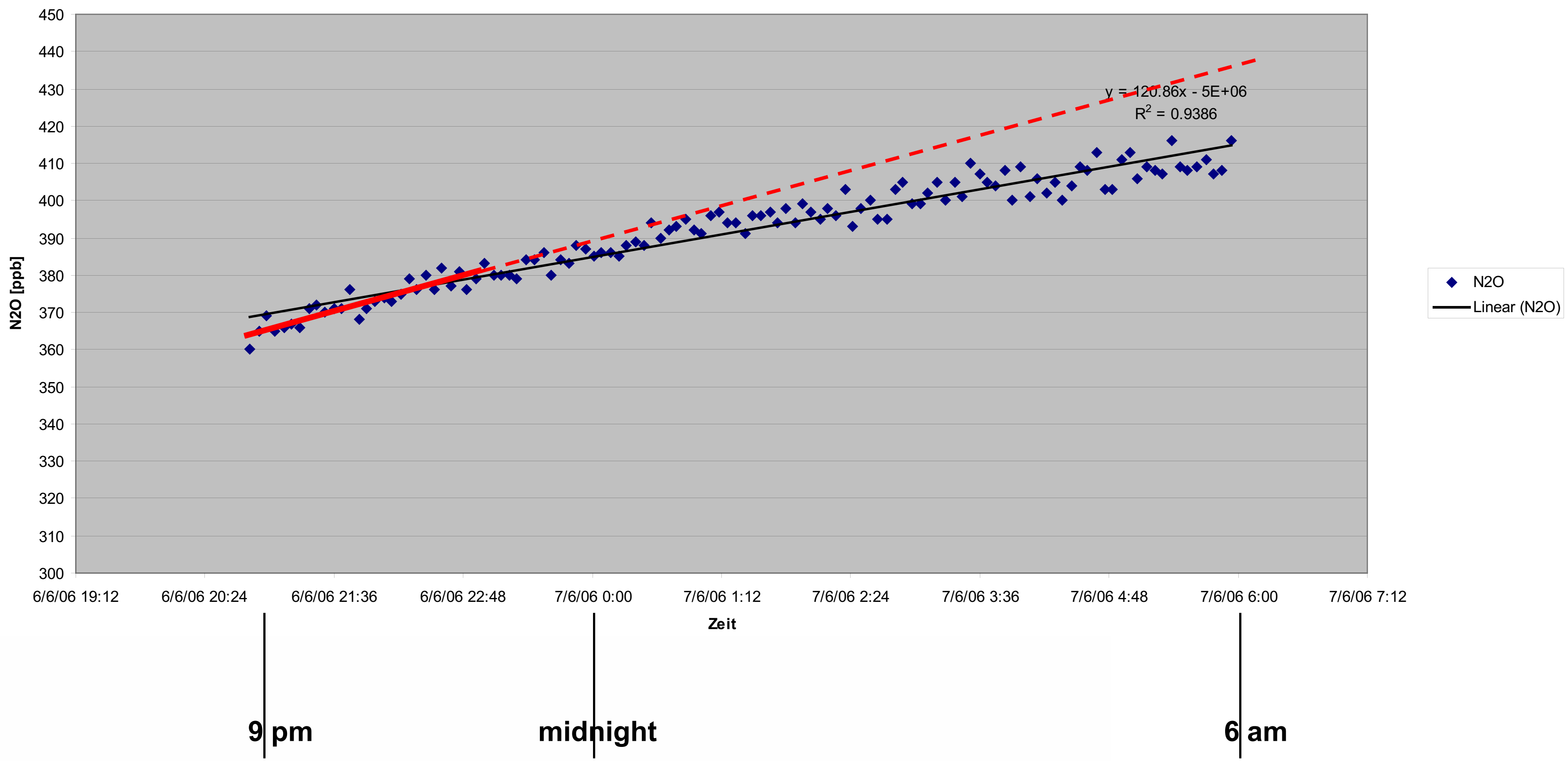
possible leakages of the tunnel cover

saturation of N_2O concentrations after longer times

➔ measurements were made at night time
➔ periods with linear concentration increase were selected for evaluation

(1) large tunnel

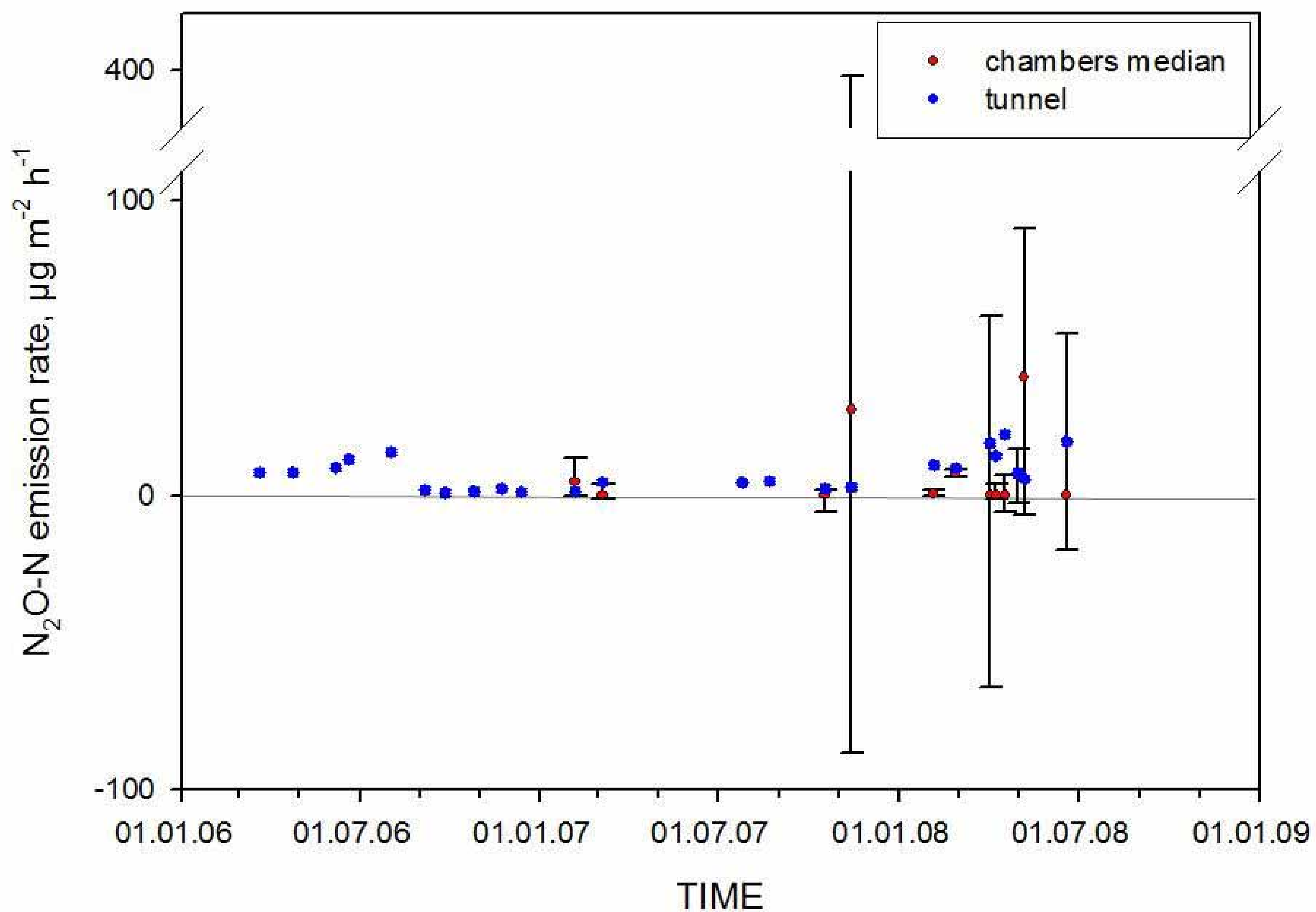
Example: nocturnal increase of N_2O concentration in the tunnel



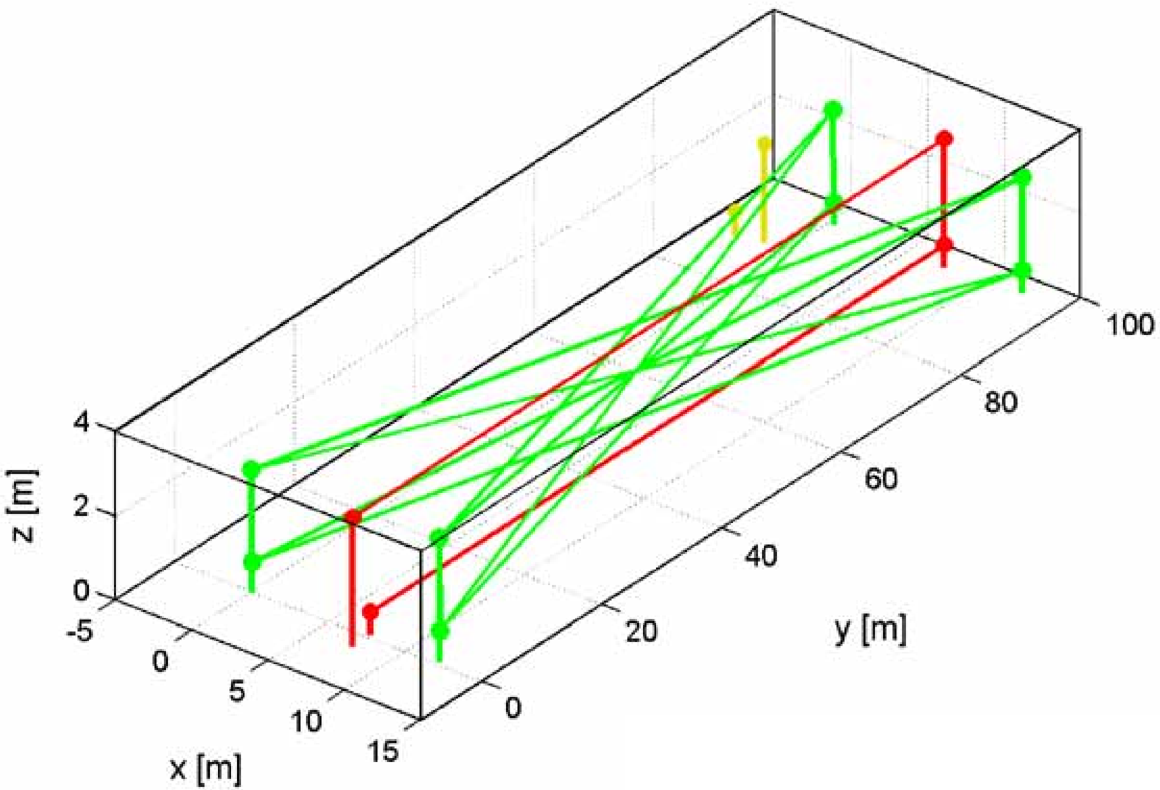
(1) large tunnel

Measurement results with measuring tunnel

Tunnel 2 - 42 µg N_2O-N m^{-2} h^{-1}, chamber 0.6 - 40 µg N_2O-N m^{-2} h^{-1}



Up-Scaling of N_2O flux measurements using the flux-gradient method



0.50 m and 2.70 m above surface

red:
FTIR for N_2O concentrations (low wind speed required)

green:
Acoustic tomography (area averaging) for horizontal winds / friction velocity

October 2007, June 2008

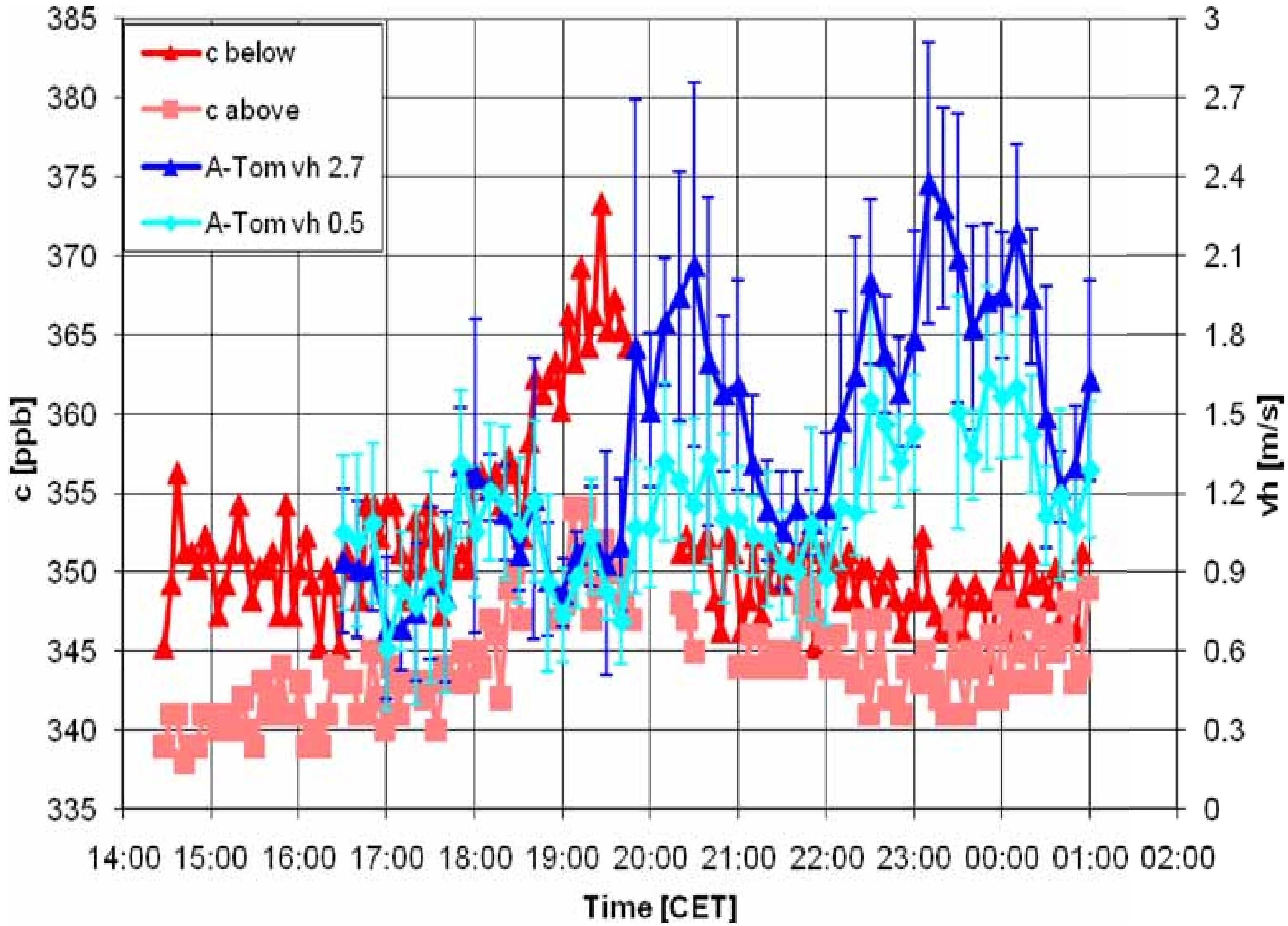
(2) flux gradient method with path-averaged measurements

Up-scaling area about 27,000 m^2

(2) flux gradient method with path-averaged measurements

Measurements of open-path flux-gradient method

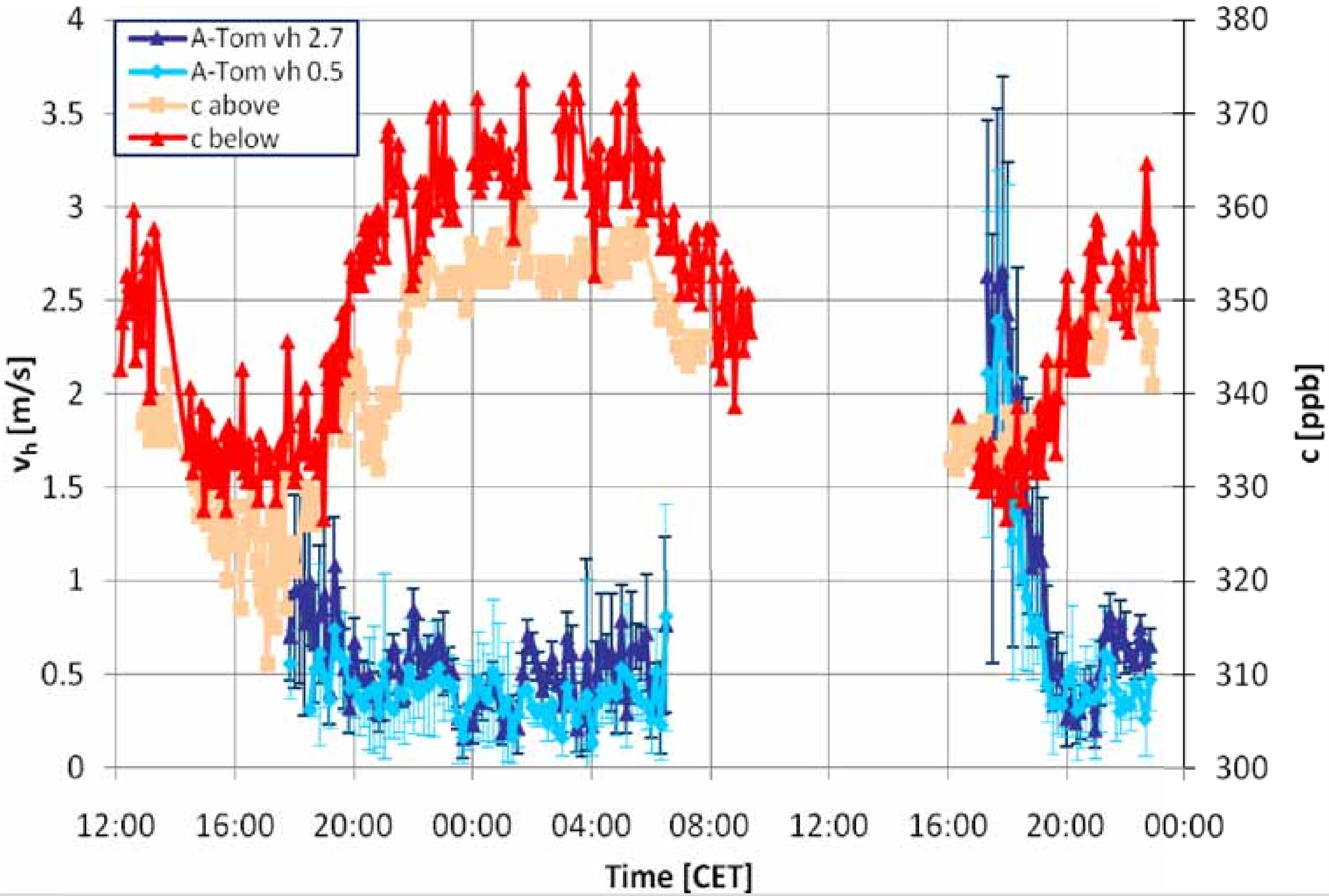
October 2007



(2) flux gradient method with path-averaged measurements

Measurements of open-path flux-gradient method

June 2008



(2) flux gradient method with path-averaged measurements

Problems with the flux gradient method:

large vertical concentration differences only with very low wind speeds,

then probably the turbulence is too low to apply the flux gradient method

➔ a correction is necessary

Diffusivity (from measurements): $$\nu = \frac{u_*^2}{\frac{\partial u}{\partial z}}$$ $$\nu_{crit} = 0.15$$

$$\nu_{norm} = \frac{\nu}{\nu_{crit}}$$

(2) flux gradient method with path-averaged measurements

a comparison between the fluxes from the flux gradient method and the mean value of the fluxes from the tunnel measurements yielded a dependence (R^2=0.29) on the observed diffusivity:

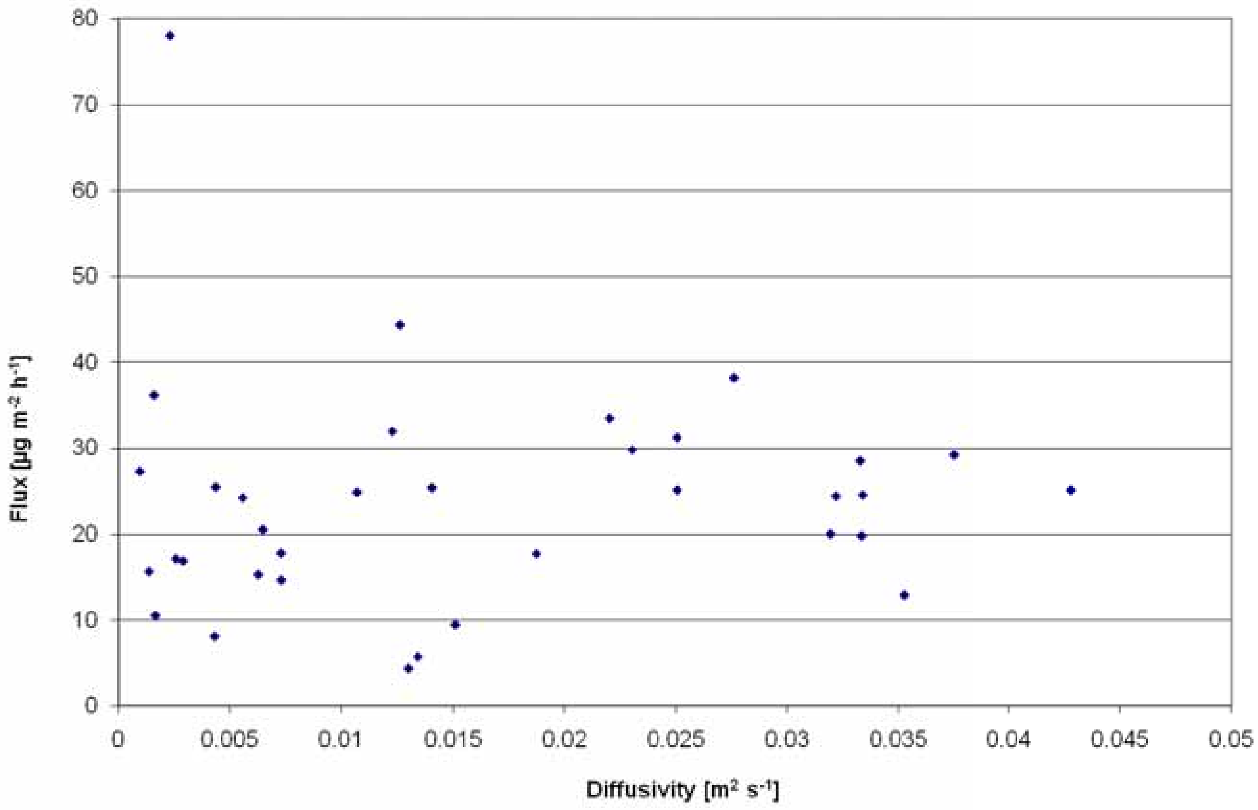
$$F_{norm}^{N_2O} = \frac{F_{FGM}}{F_{tunnel}} = a v_{norm} + b$$

with a = -34 and b = 41. Thus the following correction was applied:

$$F = \frac{F_{FGM}}{a v_{norm} + b}$$

(2) flux gradient method with path-averaged measurements

diffusivity-corrected N2O flux



(2) flux gradient method with path-averaged measurements

The evaluation indicated, that in cases of vanishing winds and turbulence at night:

Molecular diffusion and turbulent transport are important

Further experimental studies necessary to define the parameters a and b

Conclusions:

two additional area-integrating (up-scaling) flux measurement techniques have been tested

☺ the tunnel gives reliable values for areas of several hundreds of m^2

☹ the flux gradient method with path-averaged concentration measurements for nitrous oxide still needs further refinement

- **vertical concentration gradients are large enough for low wind speeds only**
- **low wind speeds mean low turbulence**
- **in case of low wind speeds flux seems to depend on a combination of molecular and turbulent diffusivity**

Thank you for your attention!

Acknowledgement

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