Micrometeorological observations of CH_4 and N_2O at a managed fen meadow in the Netherlands

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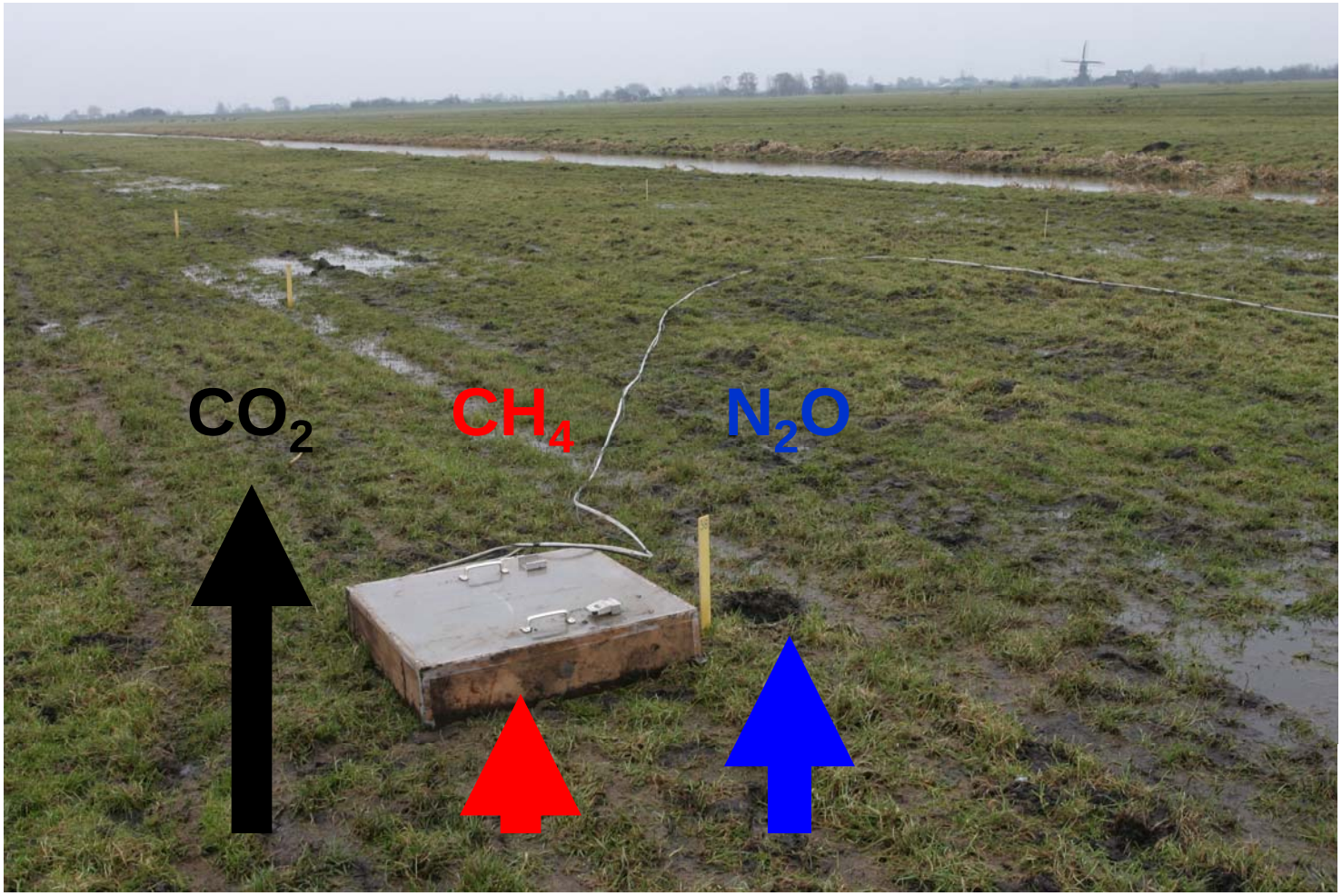
Outline

- Background
- Research question
- Systematic errors and uncertainties
- Accuracy of annual CH_4 and N_2O balance
- Conclusions

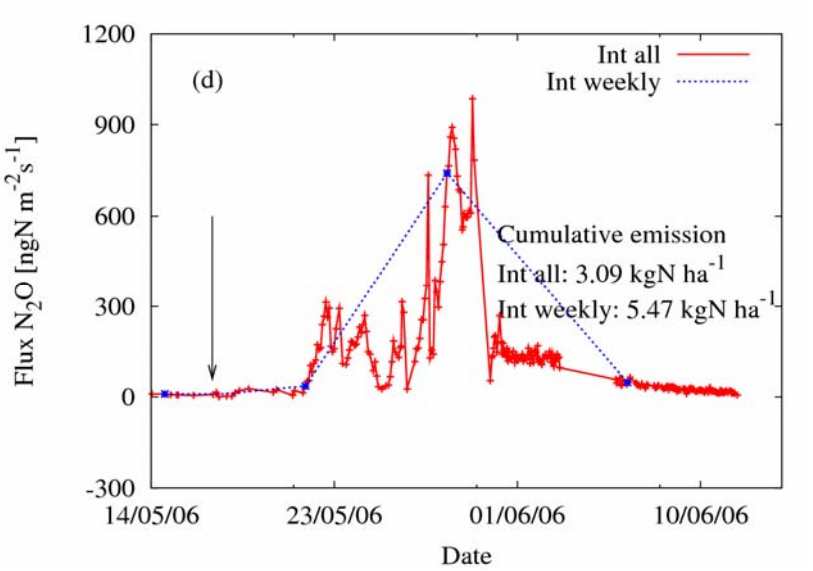
Background: GHG emissions from a managed fen meadow



Background: Lack of accurate annual sums

Due to temporal variation

Managed site in Reeuwijk in the Netherlands



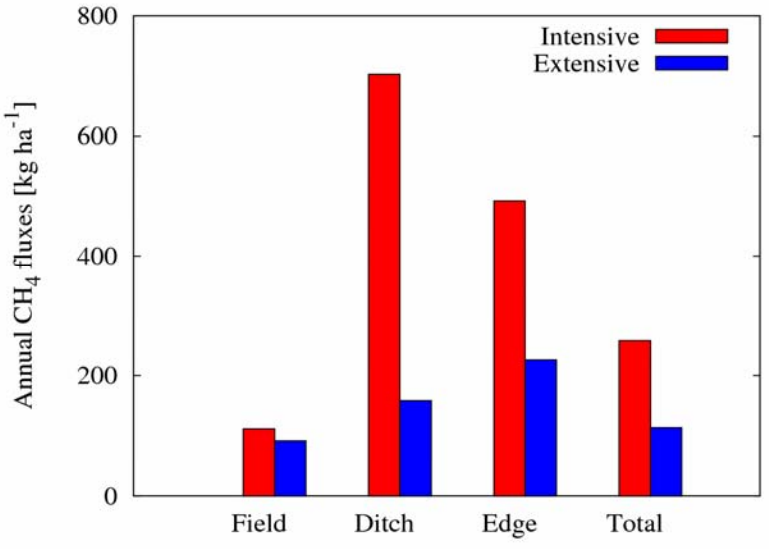
(Kroon et al., 2008)

Uncertainty in N_2O annual estimates derived by chamber may be as high as 50% (Flechard et al., 2007)

Background: Lack of accurate annual sums

Due to spatial variation

Top view Reeuwijk site in the Netherlands



(Based on Schrier-Uijl et al., 2008)

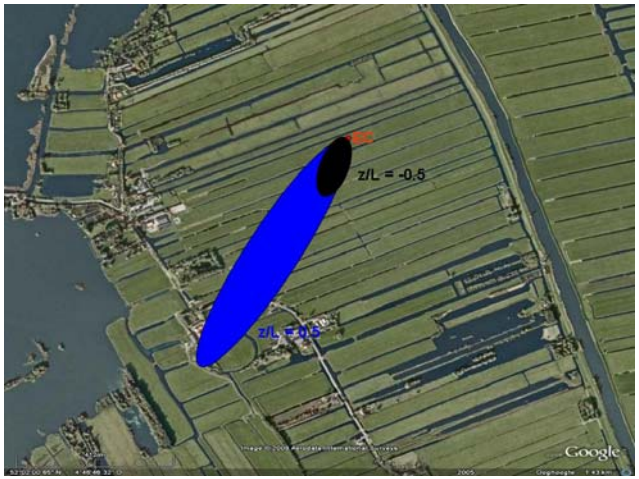
Background: Measurement techniques

Chamber

$$F_{wc} = h\frac{dC}{dt}\bigg|_{t=0}$$

Eddy Covariance

$$F_{wc} = \frac{1}{T_a}\int w'(t)C'(t)dt$$



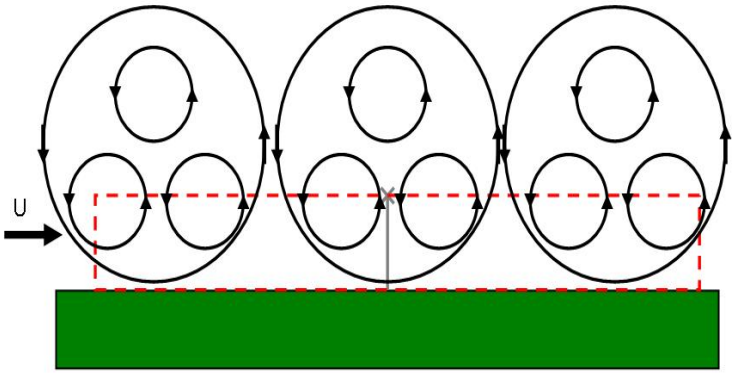
Background: Measurement techniques

Chamber

Eddy Covariance

Can EC measurements contribute to a decrease of the uncertainty in annual estimates of CH_4 and N_2O?

Eddy covariance flux theory



Tracer conservation equation

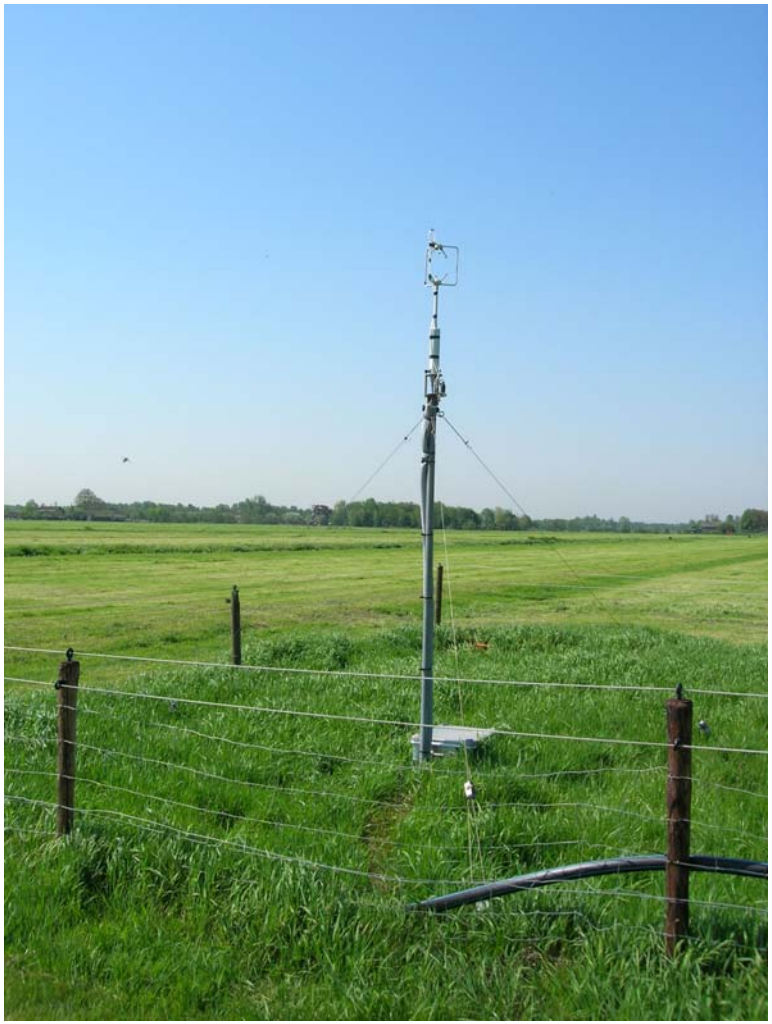
$$\underbrace{\frac{\partial \bar{c}}{\partial t}}_{\text{I}} + \underbrace{\bar{u}\frac{\partial \bar{c}}{\partial x} + \bar{v}\frac{\partial \bar{c}}{\partial y}}_{\text{II}} + \underbrace{\bar{w}\frac{\partial \bar{c}}{\partial z}}_{\text{III}} + \underbrace{\frac{\partial \overline{u'c'}}{\partial x} + \frac{\partial \overline{v'c'}}{\partial y}}_{\text{IV}} + \underbrace{\frac{\partial \overline{w'c'}}{\partial z}}_{\text{V}} = \underbrace{S}_{\text{VI}}$$

After Reynolds decomposition, integrating over the height and assuming:

- Horizontal homogeneity
- Flat terrain
- Negligible mean vertical wind speed

$$F_{wc} = \underbrace{\int_0^h \frac{\partial \bar{c}}{\partial t} dz}_{\text{St}_{wc}} + \underbrace{\overline{w'c'}\big|_{z=h}}_{\text{EC}_{wc}}$$

Errors and uncertainties in EC flux measurements



Sonic anemometer

Wind measurements

Tube connected to QCL

CH_4 measurements

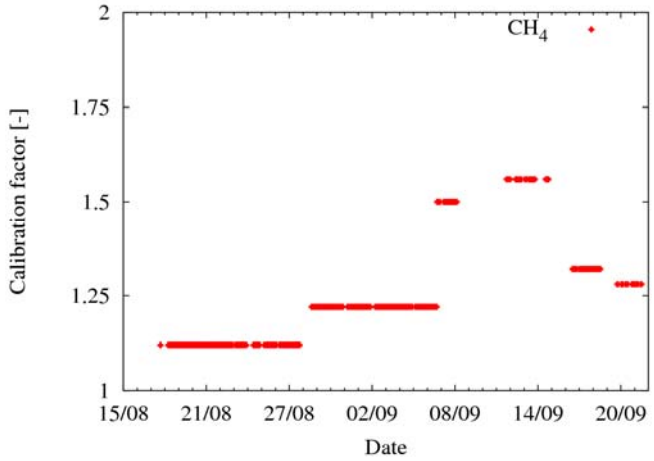
N_2O measurements

$$EC_{wc}^{meas} = \overline{w'c'}\Big|_{z=h}$$

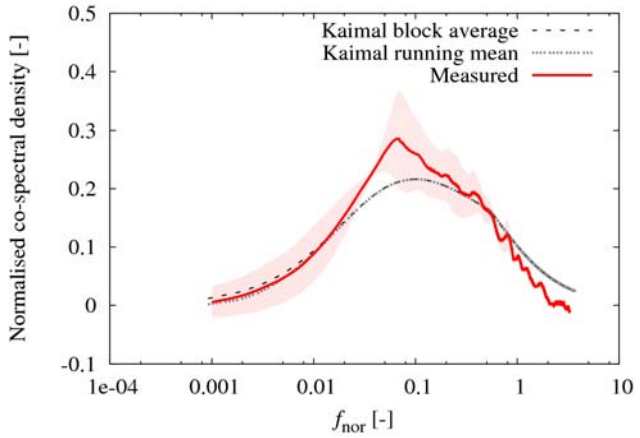
$$= ?$$

$$EC_{wc} = \overline{w'c'}\Big|_{z=h}$$

Systematic errors



(Kroon et al., 2007)



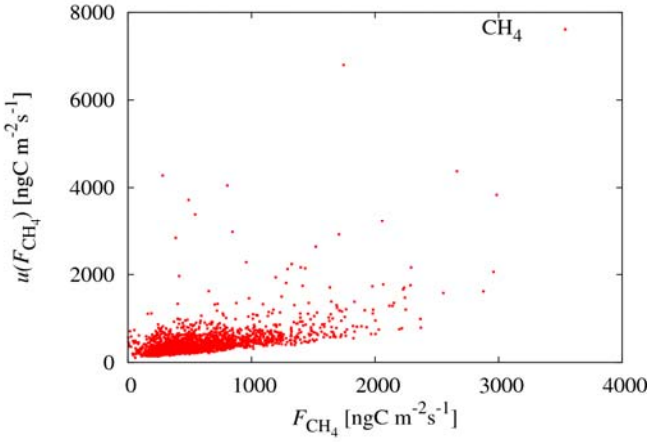
(Kroon et al., submitted)

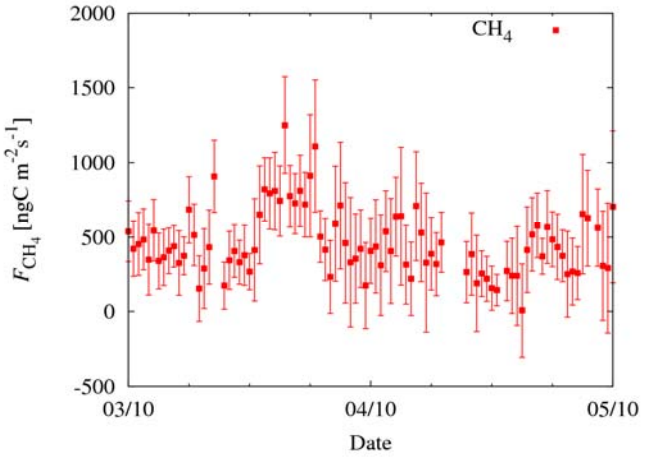
- Calibrations
- Alignment sonic anemometer
- Low frequency response losses
- High frequency response losses
- Density fluctuations

Rotation algorithm on *u*, *v* and *w*

$$EC_{wc} = \chi_{cal}\chi_{low}\chi_{high}EC_{wc}^{meas} + \chi_{cal}\chi_{Webb}$$

Uncertainties





Random uncertainty in correction algorithms:
- Calibrations
- Alignment sonic anemometer
- Low frequency response losses
- High frequency response losses
- Density fluctuations

Other random uncertainties:
- Drift in instruments
- Precision of instruments
- One point sampling

(Kroon et al., submitted)

90% of 30 min EC flux uncertainty is caused by one point uncertainty!

$$u_{op} = \frac{2}{\sqrt{M}}\sigma_{w'c'} = \sqrt{\frac{20z}{TU}}\sqrt{\overline{(w'c')^2} - \overline{(w'c')}^2}$$

Uncertainties

CH_4 uncertainty

	Low fluxes	Medium fluxes	High fluxes
Selection range [ngC $m^{-2}s^{-1}$]	100 - 300	300 - 500	700 - 900
Uncertainty 30 min [%]	150 (±100)	90 (±50)	70 (±40)
Uncertainty daily [%]	30 (±20)	20 (±10)	10 (±10)
Uncertainty monthly [%]	10 (±0)	10 (±0)	10 (±0)

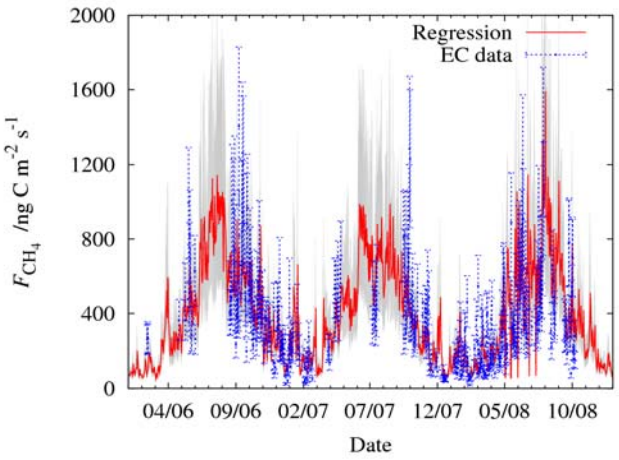
N_2O uncertainty

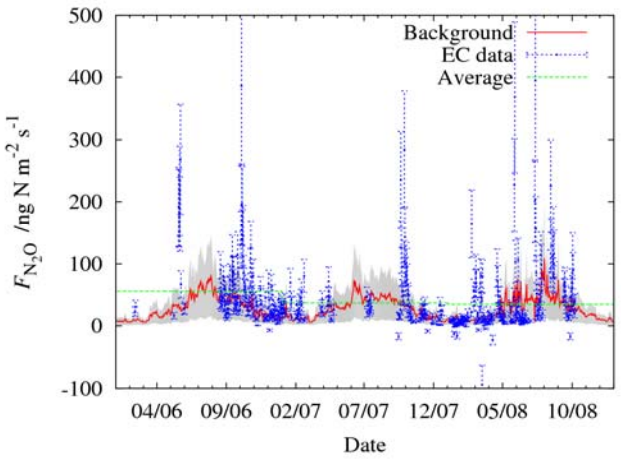
	Low fluxes	Medium fluxes	High fluxes
Selection range [ngN $m^{-2}s^{-1}$]	15 - 35	40 - 60	90 - 110
Uncertainty 30 min [%]	340 (±210)	210 (±120)	140 (±80)
Uncertainty daily [%]	50 (±30)	30 (±20)	20 (±10)
Uncertainty monthly [%]	10 (±0)	10 (±0)	10 (±0)

(Kroon et al., submitted)

Thus, EC flux measurements can possibly contribute to more accurate annual estimates of CH_4 and N_2O!!

Annual sums



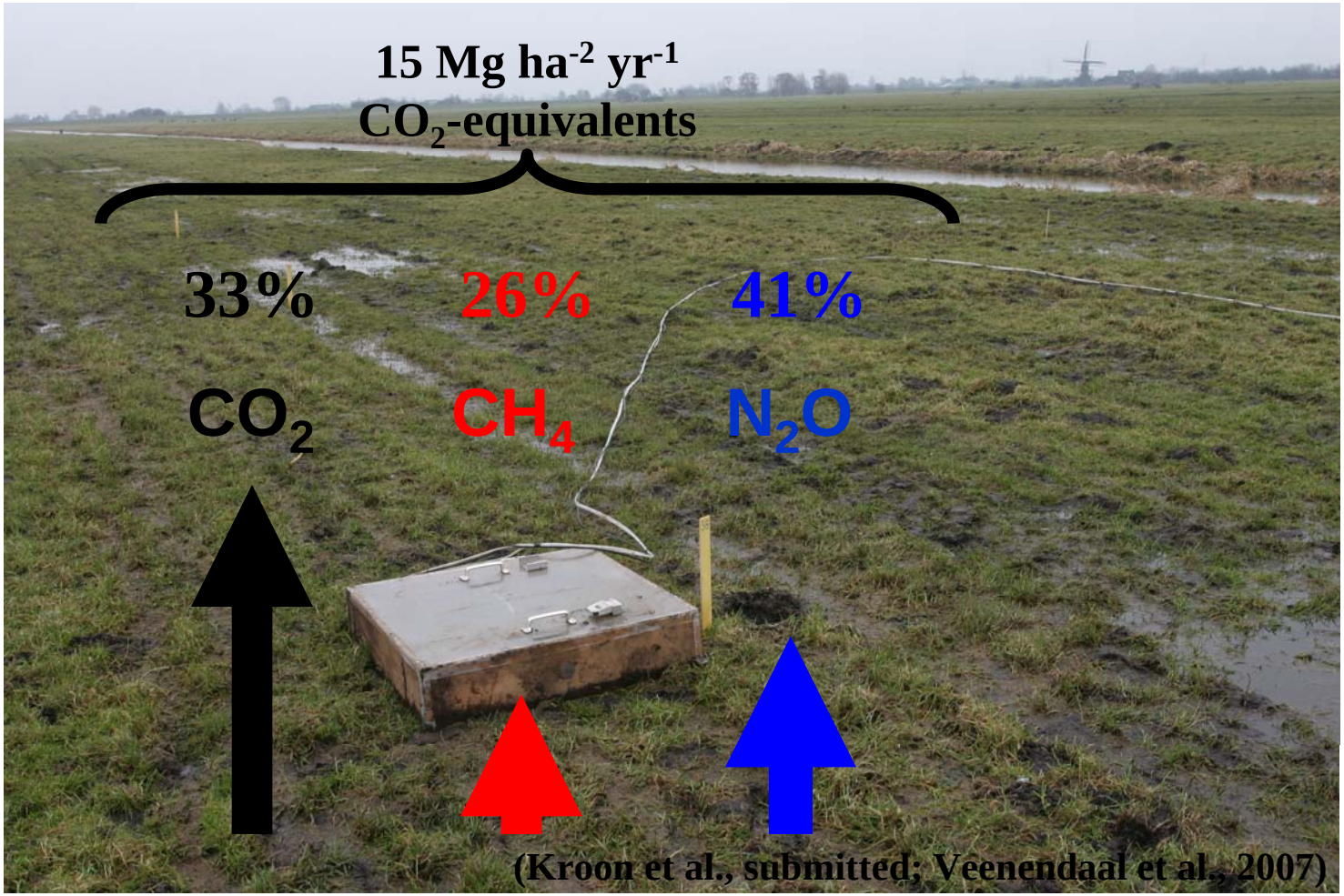


Average annual emissions over 2006 – 2008

	Static chamber	Eddy Covariance
CH_4 [kg CH_4 ha^{-1}]	170 (±32%)	165 (±13%)
N_2O [kg N_2O ha^{-1}]	NA	18 (±10%)

(Kroon et al., submitted; Schrier-Uijl et al., submitted)

GHG emissions from a managed fen meadow



Conclusions

• The annual emission estimates of peat areas are very uncertain

• Corrections should be applied for the systematic errors in EC flux measurements

• There are many uncertainties in EC flux measurements

• The uncertainty in a 30 min EC flux measurement can be even larger than 100%

• Assuming 100% data coverage, the uncertainty of a monthly EC flux average is smaller than 10%

• The total field emission is estimated at 15 Mg ha^{-2} yr^{-1} CO_2-equivalents (41% due to N_2O), however the emission will increase by more than 250% when biomass removal and farm based emissions are included

Thanks to …

Reeuwijk-team

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- Mark Zahniser (Aerodyne)
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