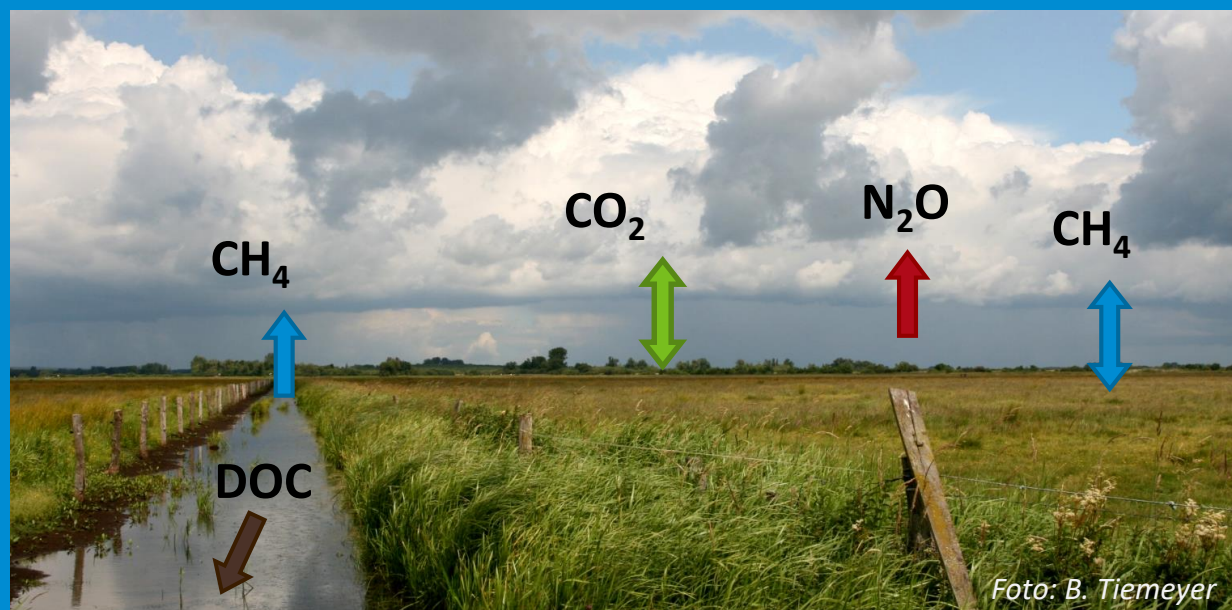


Measuring greenhouse gas emissions of peatlands

Bärbel Tiemeyer · Peatland Research Group at the Thünen-Institute of Climate-Smart Agriculture



05.09.2023

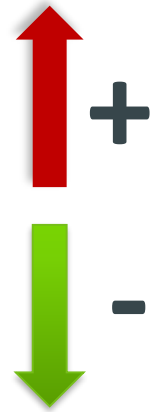
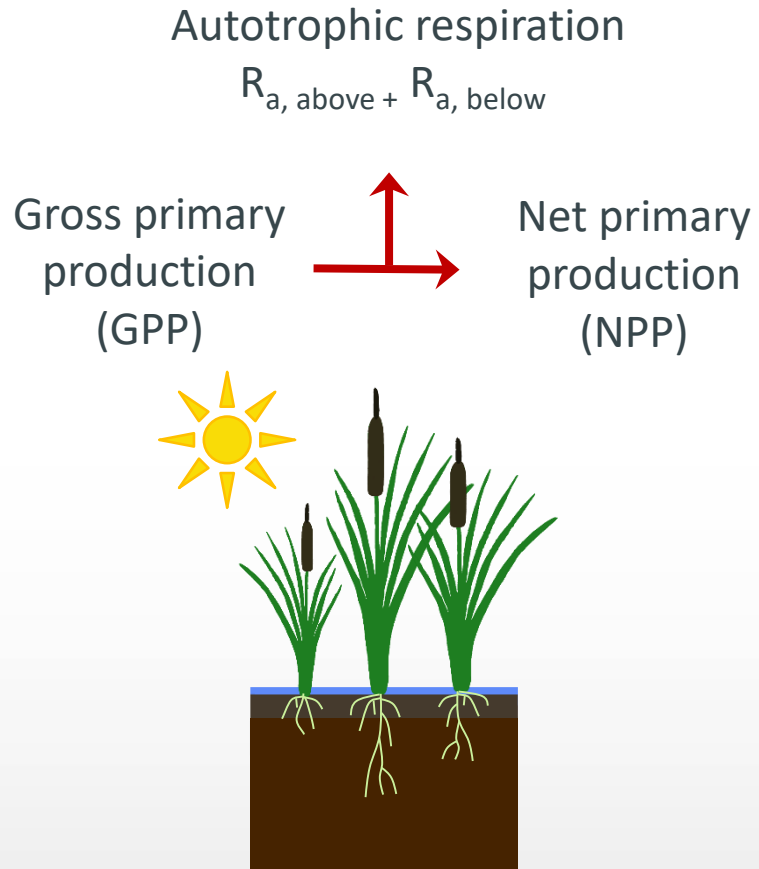
baerbel.tiemeyer@thuenen.de
@ThuenenPeat

Online-Workshop
„Peatland Perspectives“

Why measure? Don't we know enough?

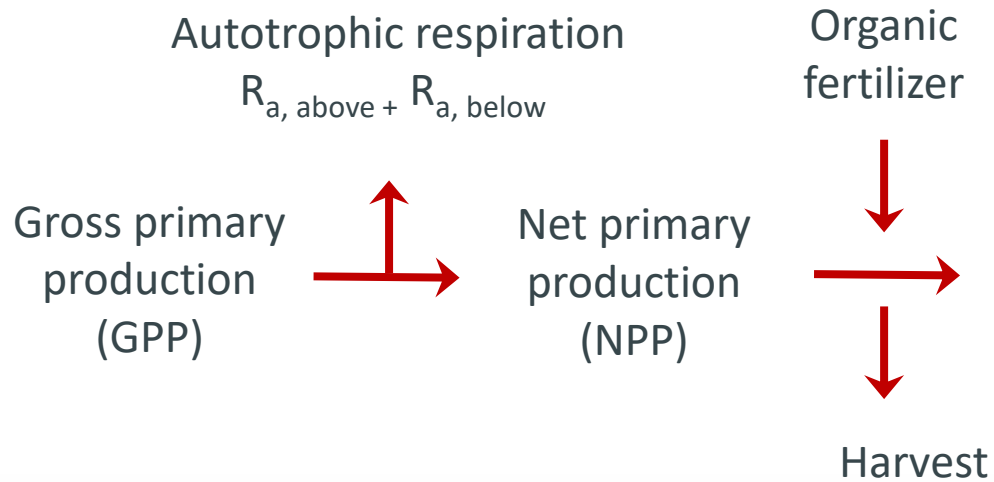
- There might always be surprises
- Paludicultures are novel systems
- Technical improvement, i.e. portable methane analysers

The carbon and greenhouse gas balance of soils (I)



Adapted from Schulze et al., 2009

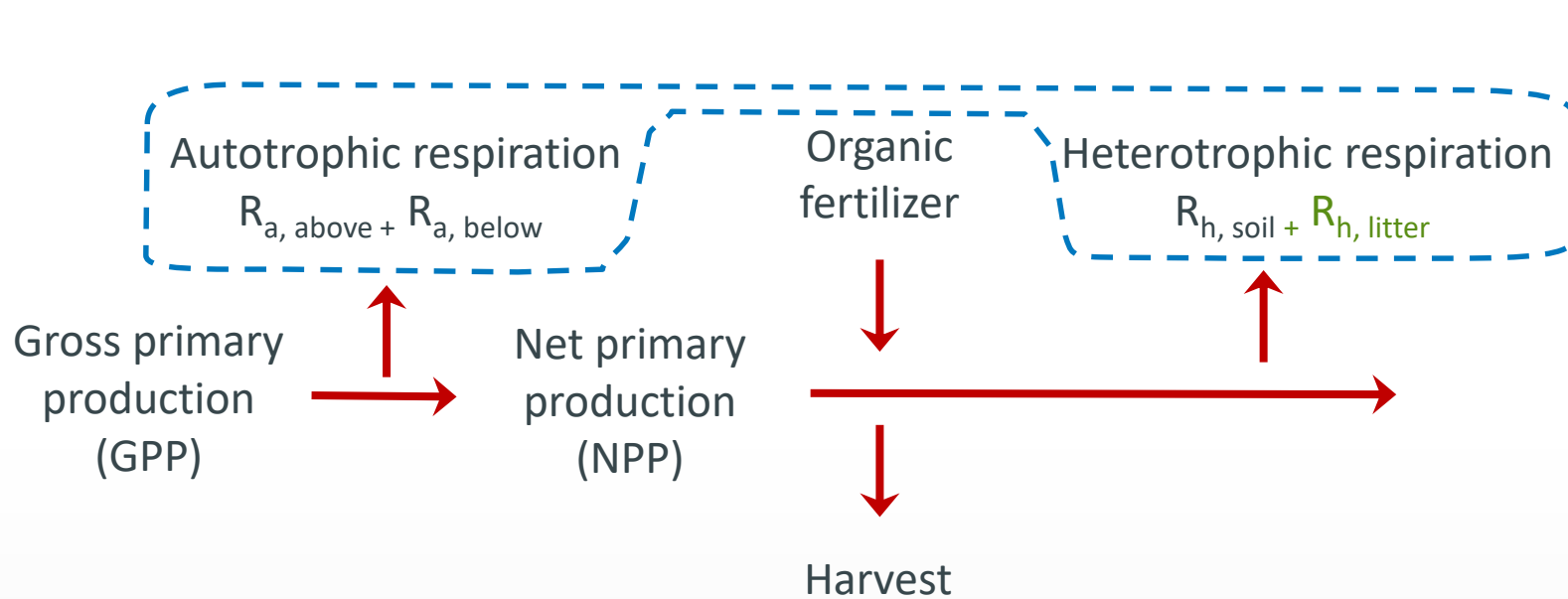
The carbon and greenhouse gas balance of soils (II)



- Always define system boundaries!
- Carbon in (non peat-forming) plants is a (very) short term pool!

Adapted from Schulze et al., 2009

The carbon and greenhouse gas balance of soils (III)

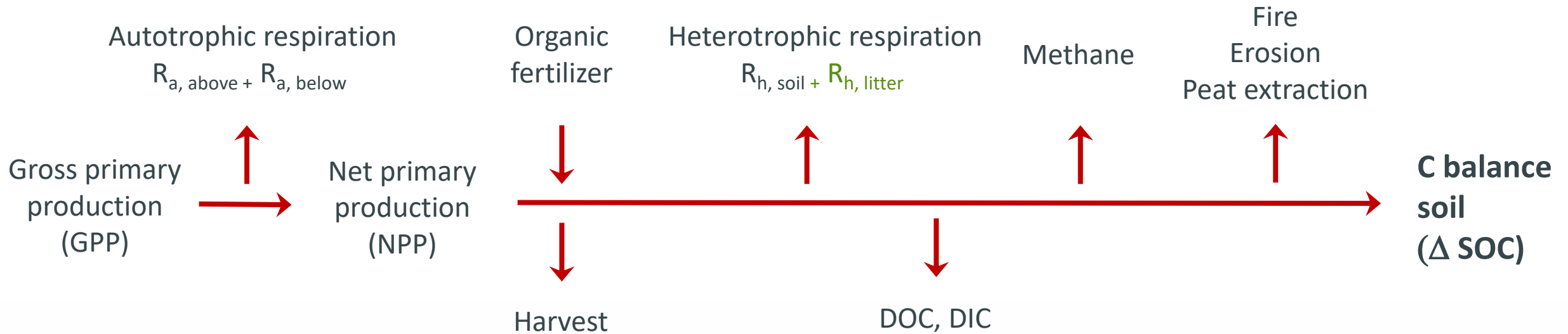


Ecosystem respiration (R_{eco})
= Autotrophic + heterotrophic
respiration

Net ecosystem exchange (NEE)
= $GPP + R_{\text{eco}}$

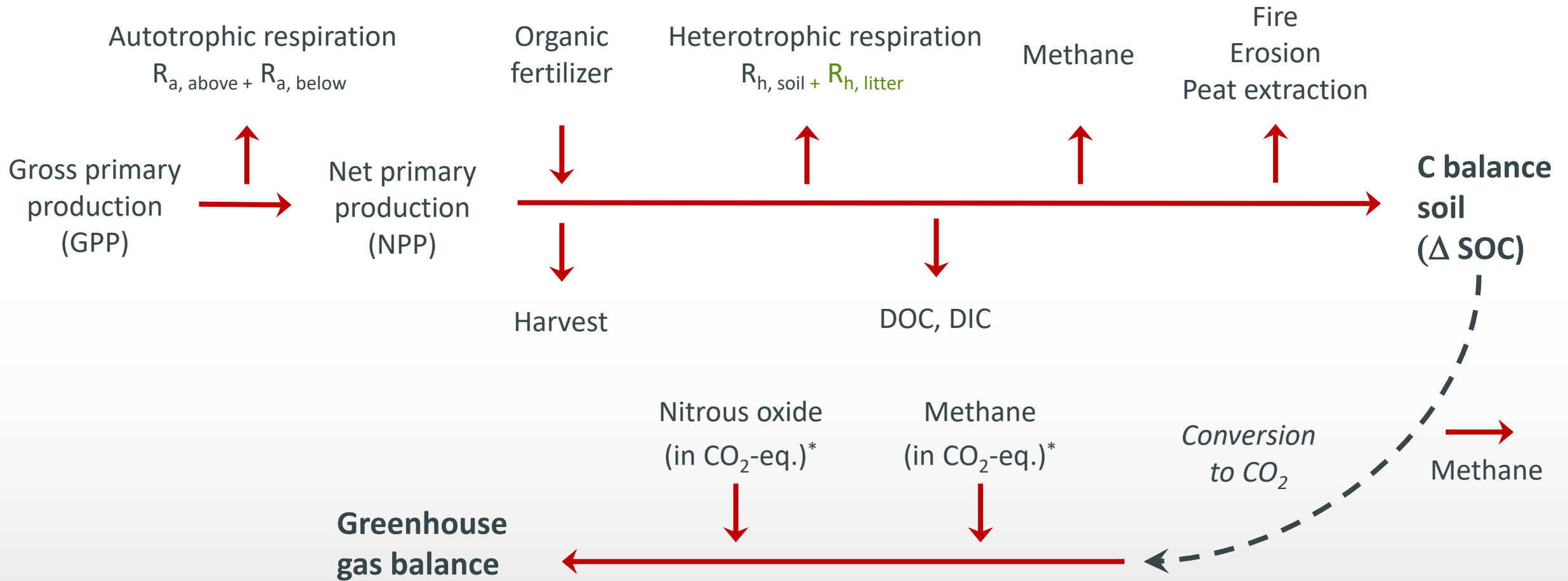
Adapted from Schulze et al., 2009

The carbon and greenhouse gas balance of soils (IV)

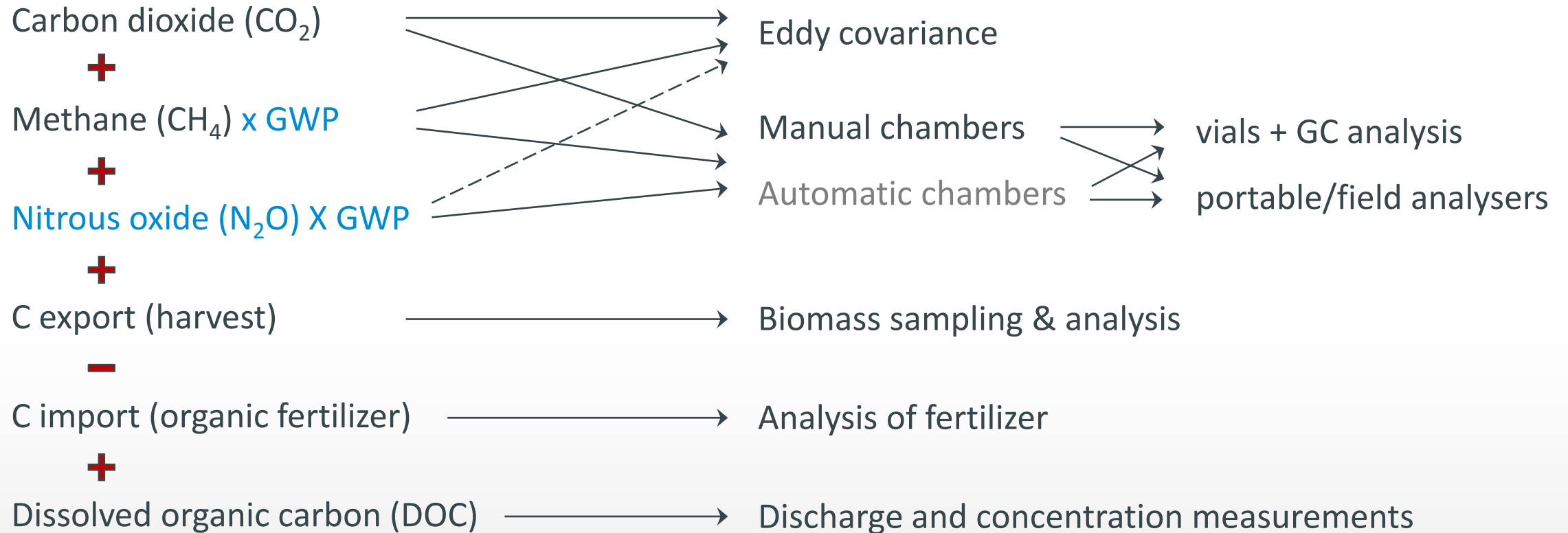


Adapted from Schulze et al., 2009, Fotos (f.l.t.r.): B. Tiemeyer, J. Oestmann, http://www.esa.int/esaKIDSen/SEMWOR9ATME_Earth_1.html, www.yppartnership.org.uk, B. Tiemeyer

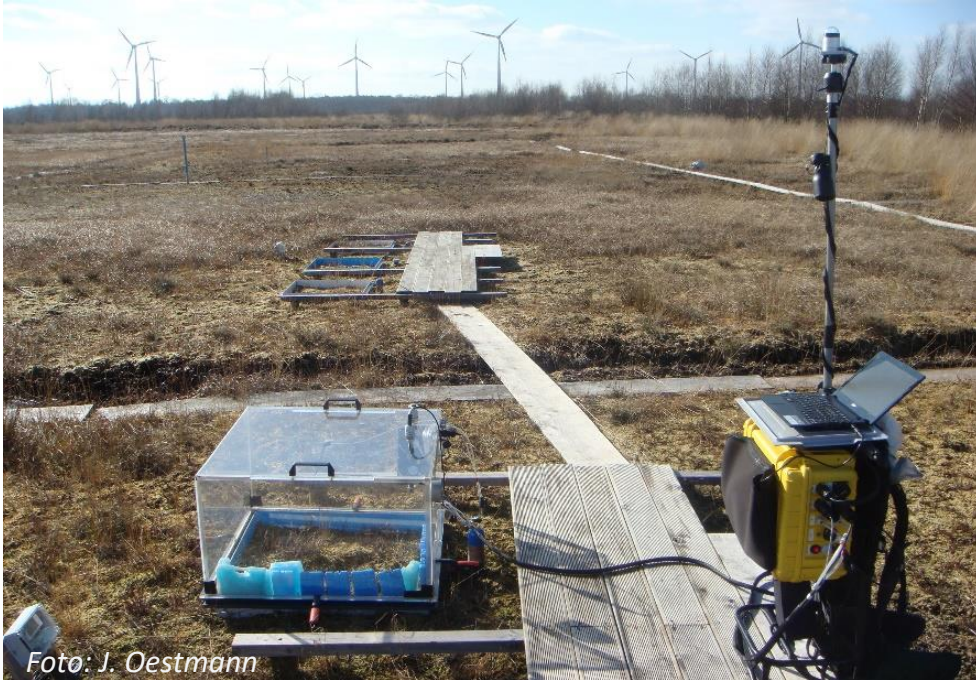
The carbon and greenhouse gas balance of soils (V)



Measurement of the components of the C and the GHG balance



Carbon dioxide (NEE)



Manual approach with chambers
and portable analyser

Micrometeorological method
("eddy covariance")



Chamber method: measurements and flux calculation

Ökosystematmung (R_{eco})

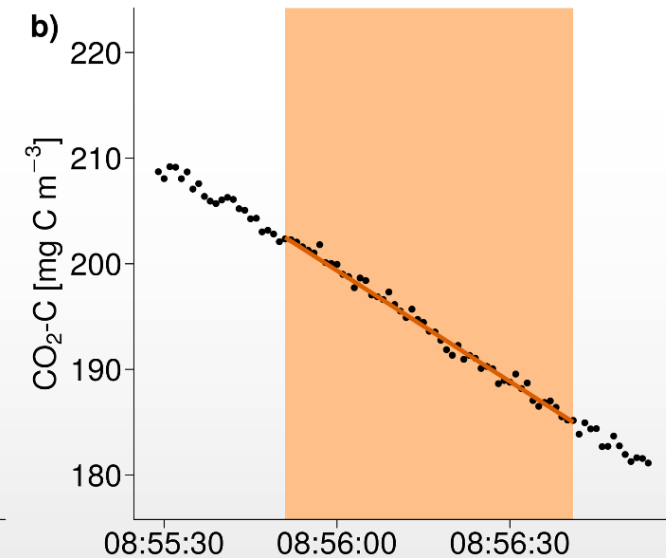
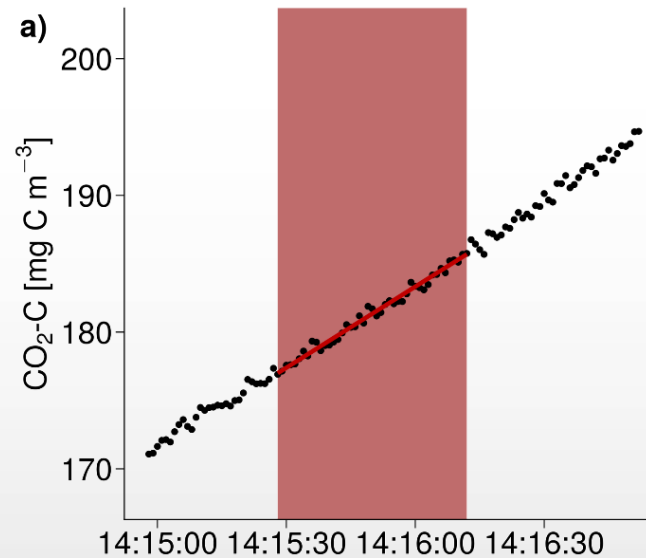
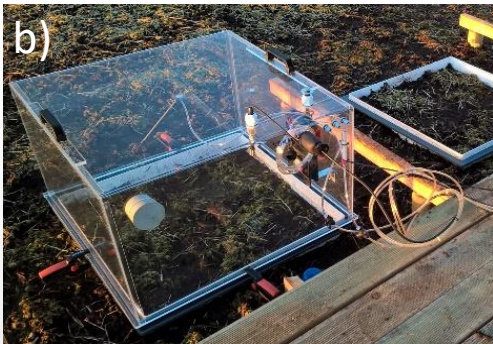


Linear flux
calculation (*moving
window approach*)

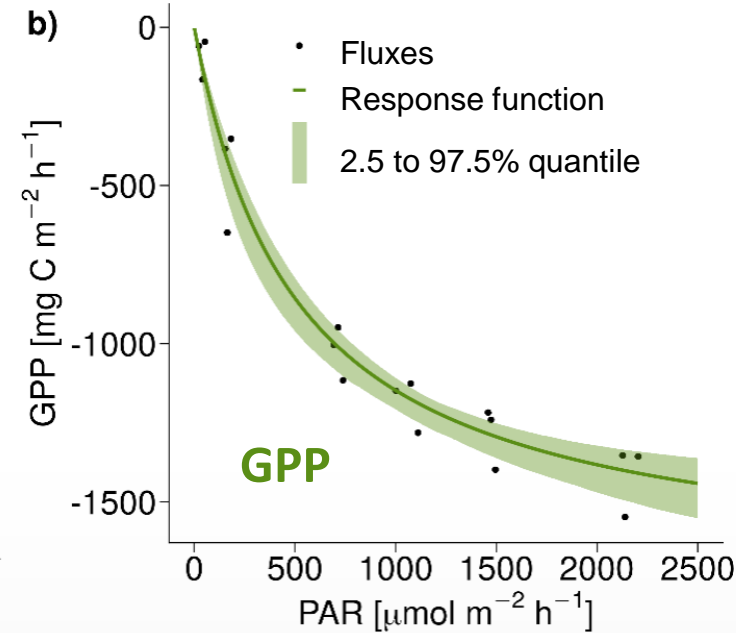
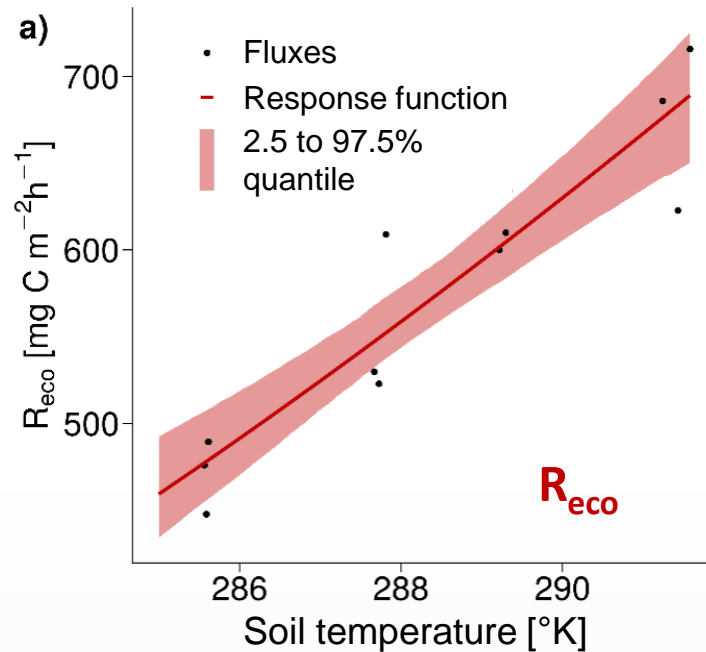
Gross primary production (GPP)

$$= NEE - R_{eco}$$

Netto-Ökosystemaustausch (NEE)



Chamber method: interpolation of annual balances (I)



$$GPP = NEE - R_{eco}$$

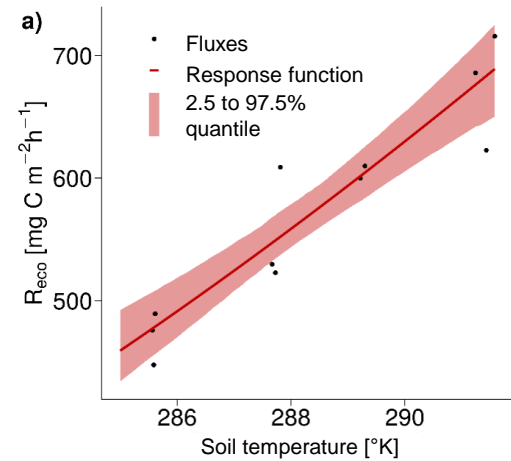
Figures: U. Dettmann

Measurement of diurnal cycles

→ Respiration depends on soil temperature and development stage of the plants (e.g. Lloyd & Taylor, 1994)

→ Photosynthesis depends on radiation and development stage of the plants (e.g. Falge et al., 2001)

Chamber method: interpolation of annual balances (II)



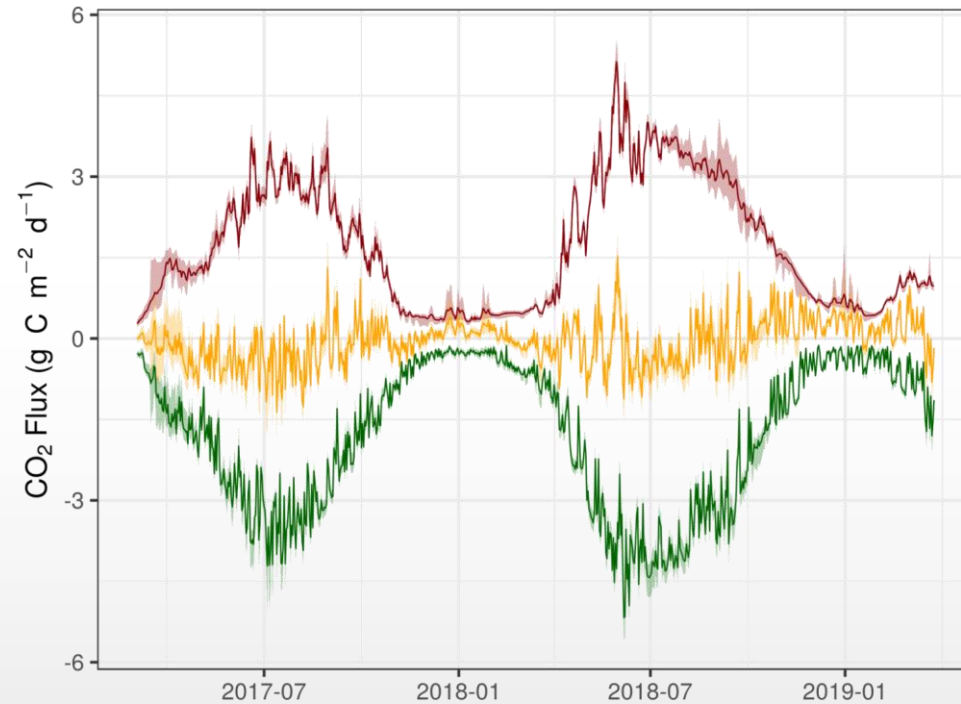
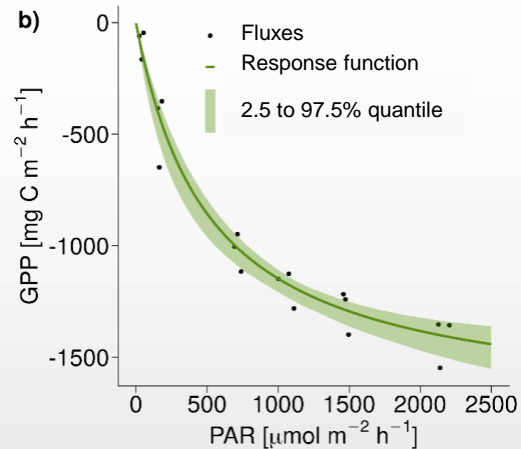
Calculation of half-hourly fluxes using photosynthetically active radiation and soil temperature



emissions



uptakes

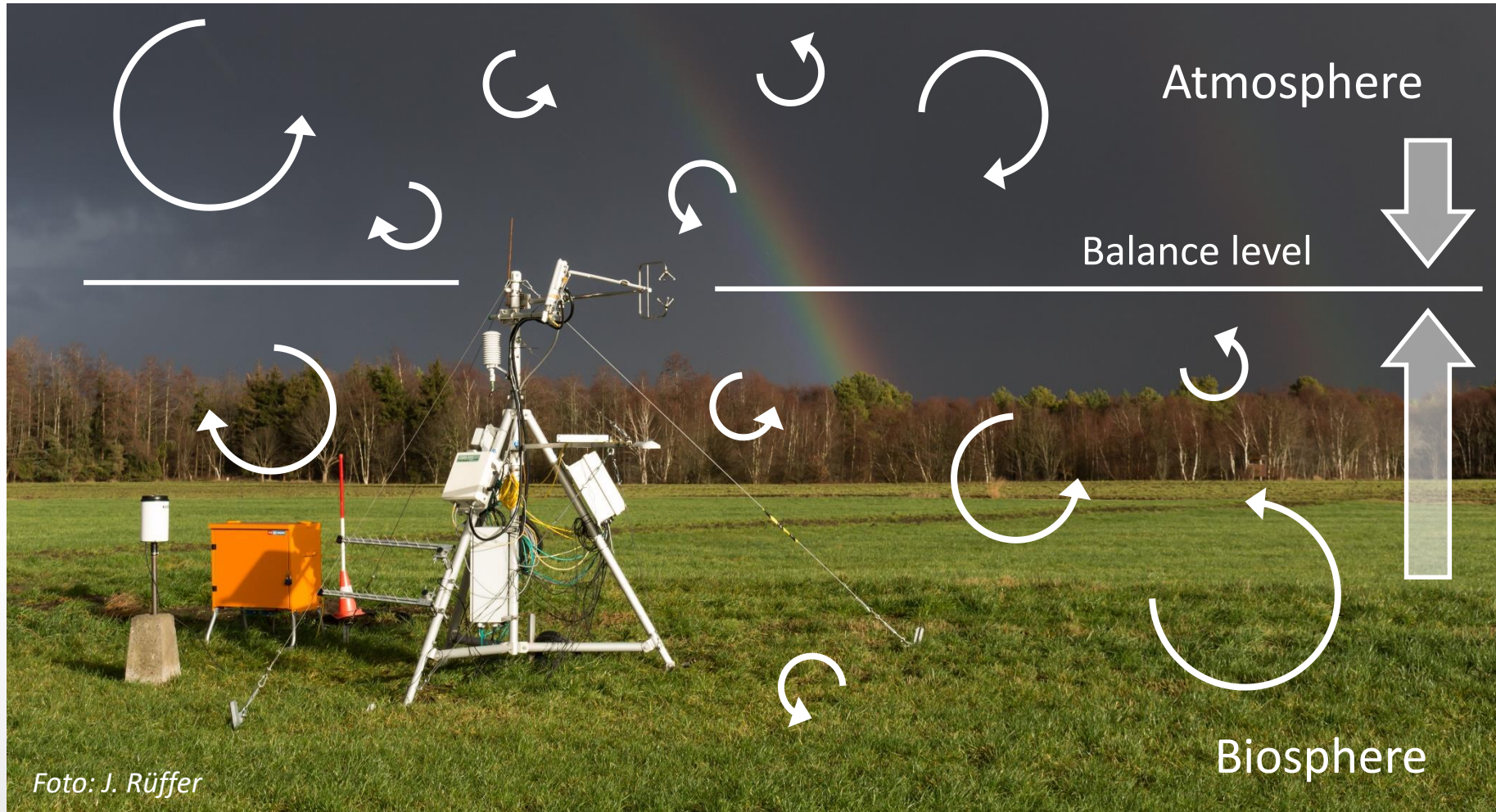


- NEE (net ecosystem exchange)
- GPP (gross primary production)
- R_{eco} (ecosystem respiration)

Figures: U. Dettmann

Carbon dioxide (NEE)

Eddy covariance



Carbon dioxide (NEE)

Eddy covariance

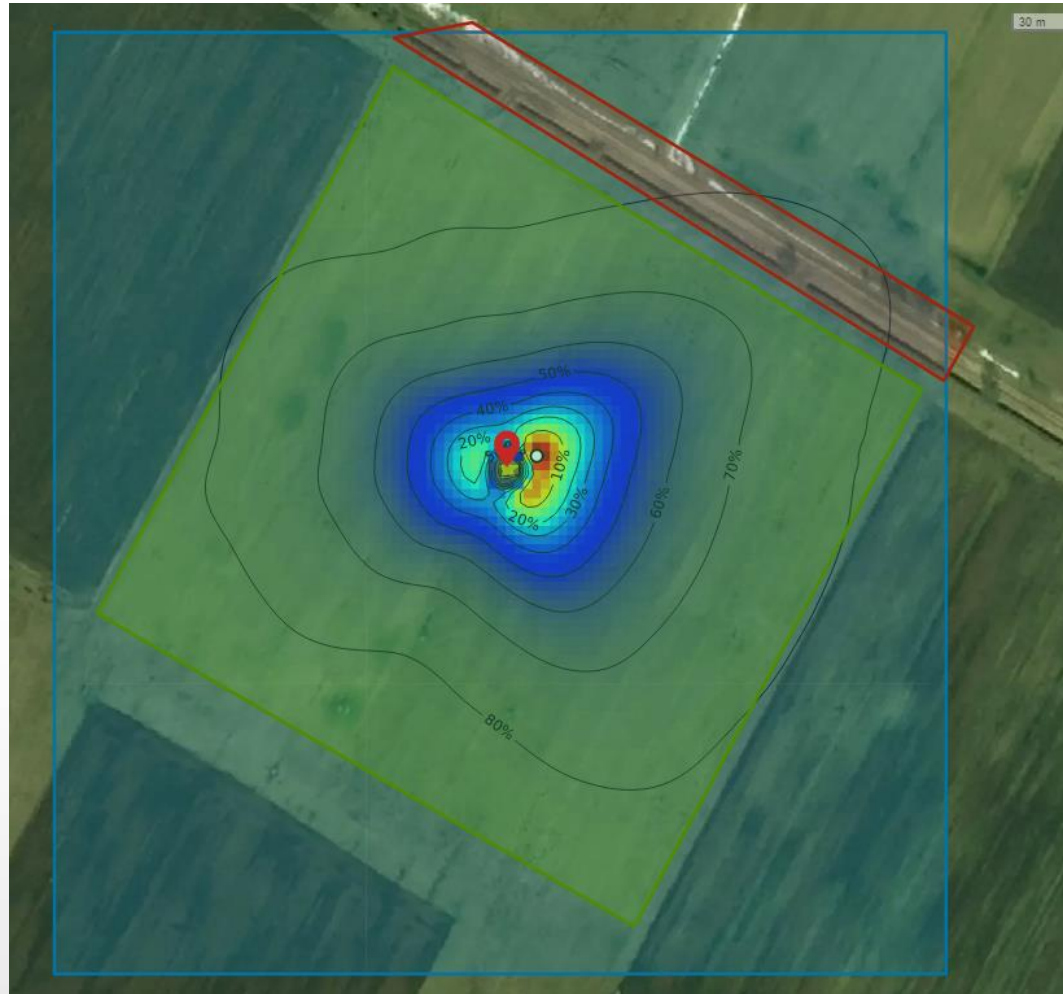
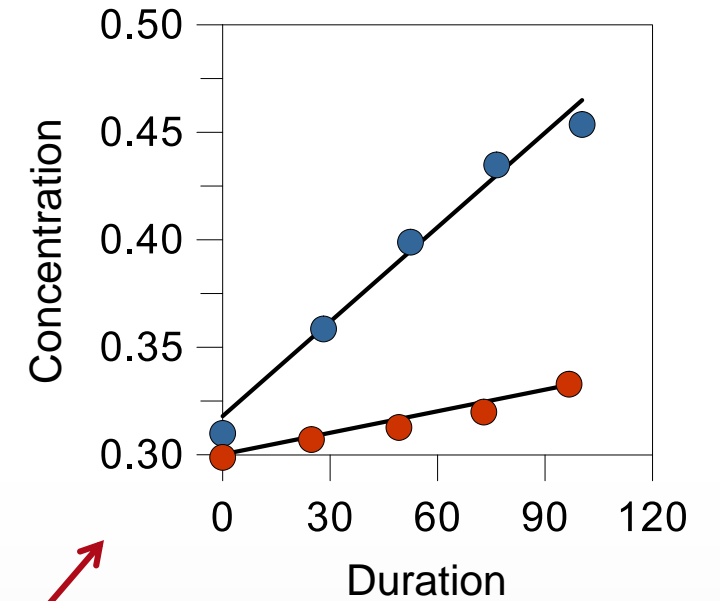


Abbildung: P. Wintjen

N₂O and CH₄: chamber method + GC analysis



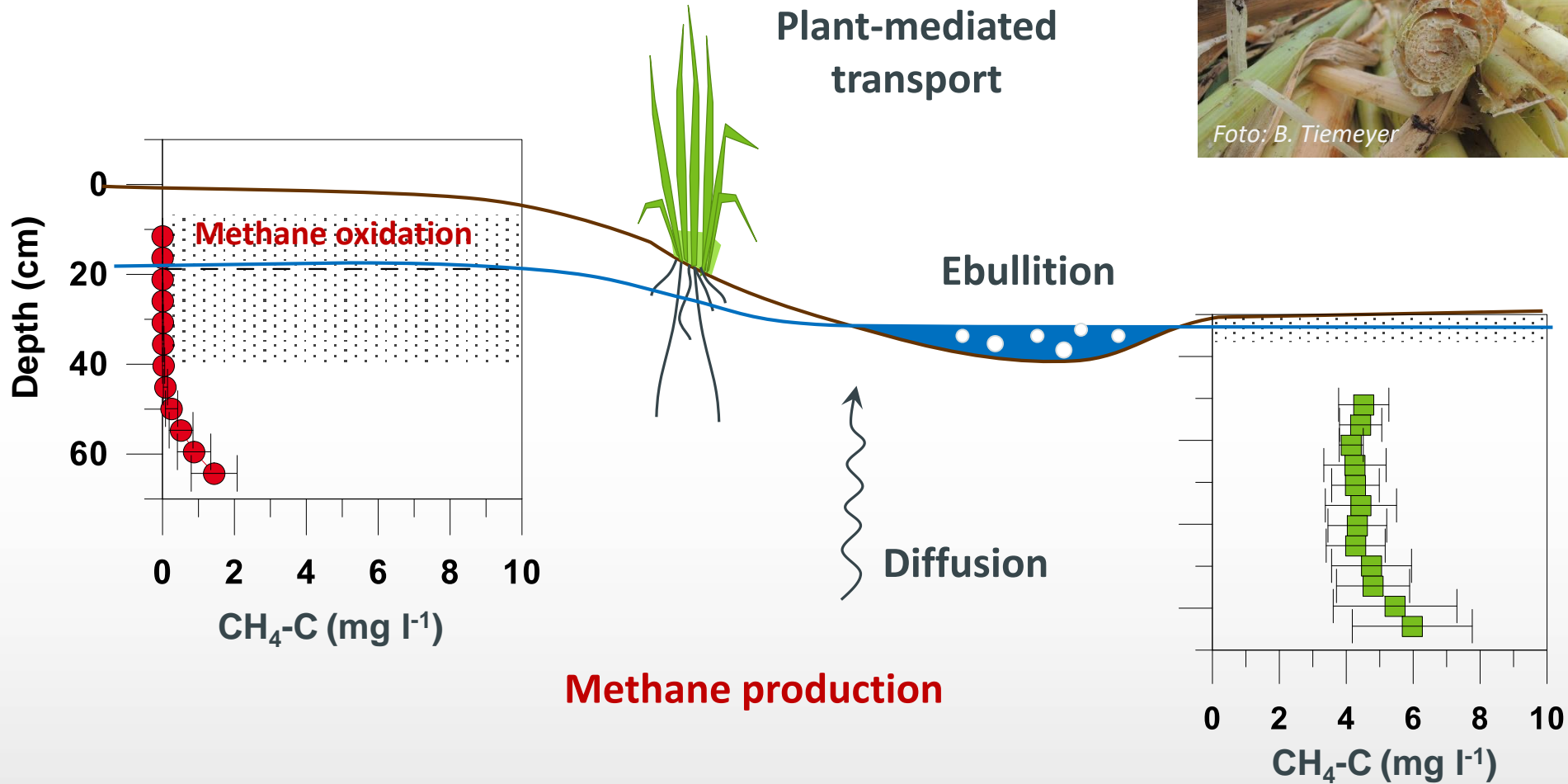
Fotos: B. Tiemeyer



Interpolation of
annual balances

Methane production and transport

(why portable analysers)



(N₂O and) CH₄: chamber method + portable analysers

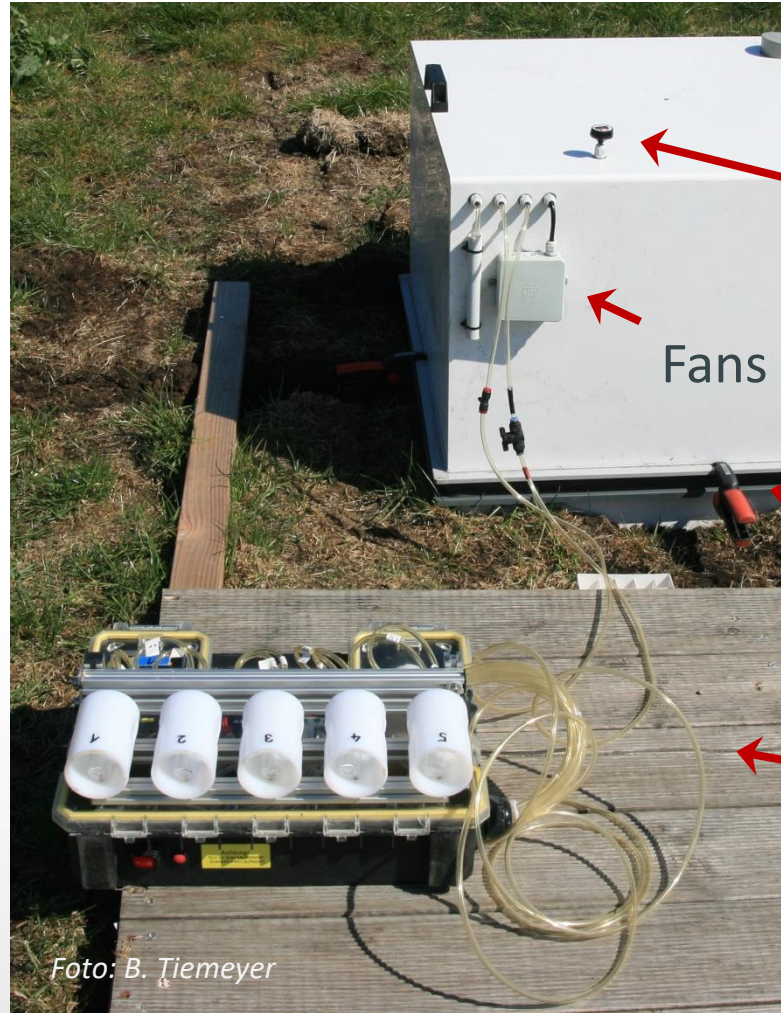


(Some) data quality issues

Number of replicates
and temporal resolution
(fertilisation!)

Standardized flux calculation
(incl. outlier detection, linear
vs. non-linear fluxes)

Usefulness of results depends
on well determined
explanatory variables!

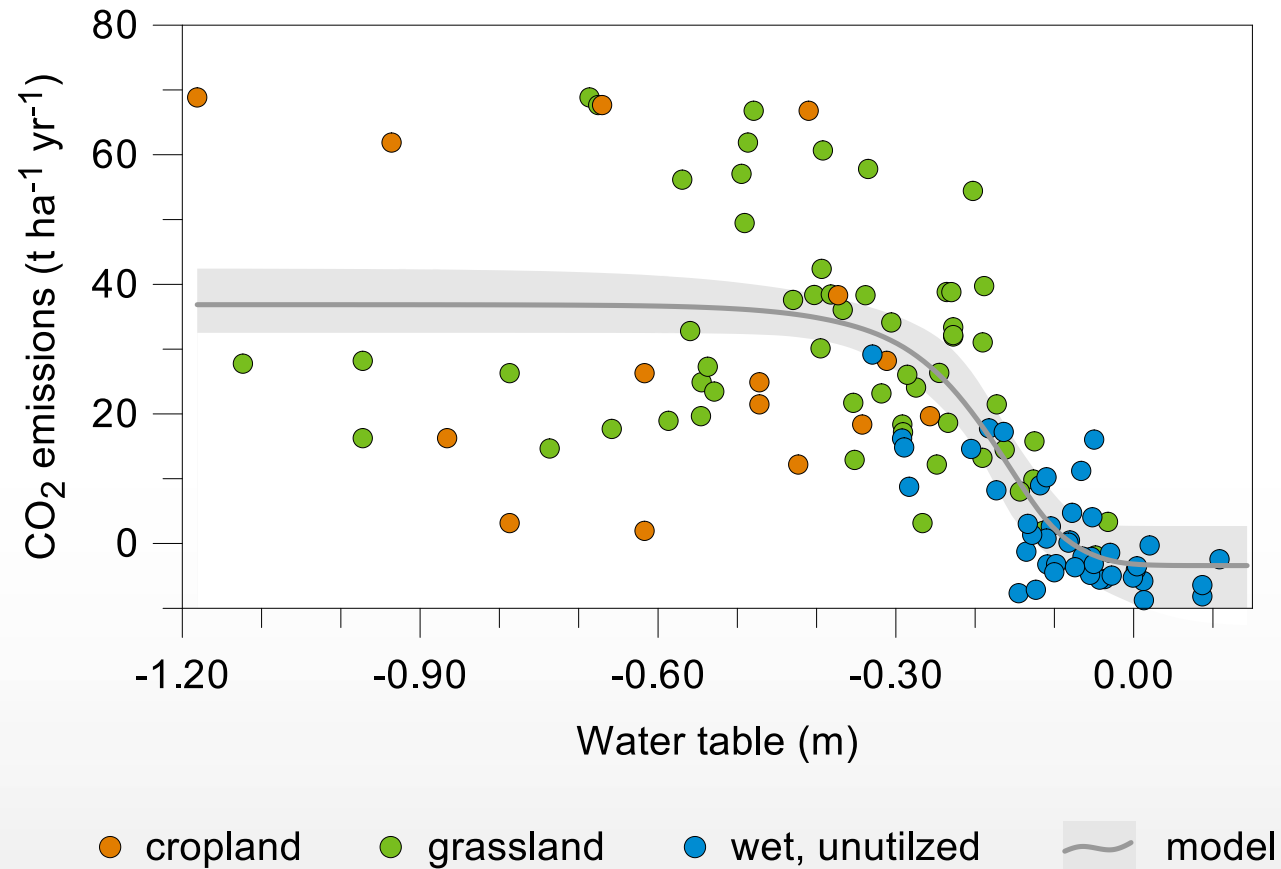


Pressure equalisation
Temperature measurements
(and control)

Gas-tight connection to
soil frames

Board walks

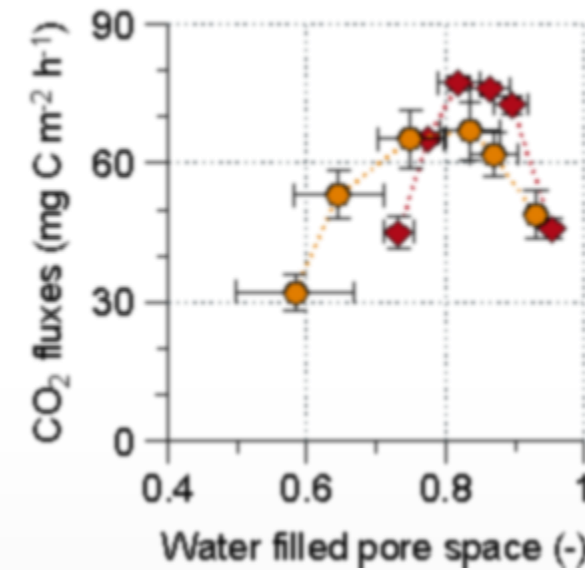
... and this means not only the (mean annual) water level!



Potentially relevant environmental variables

- ✓ intra-annual distribution of water levels
- ✓ soil moisture or water filled pore space

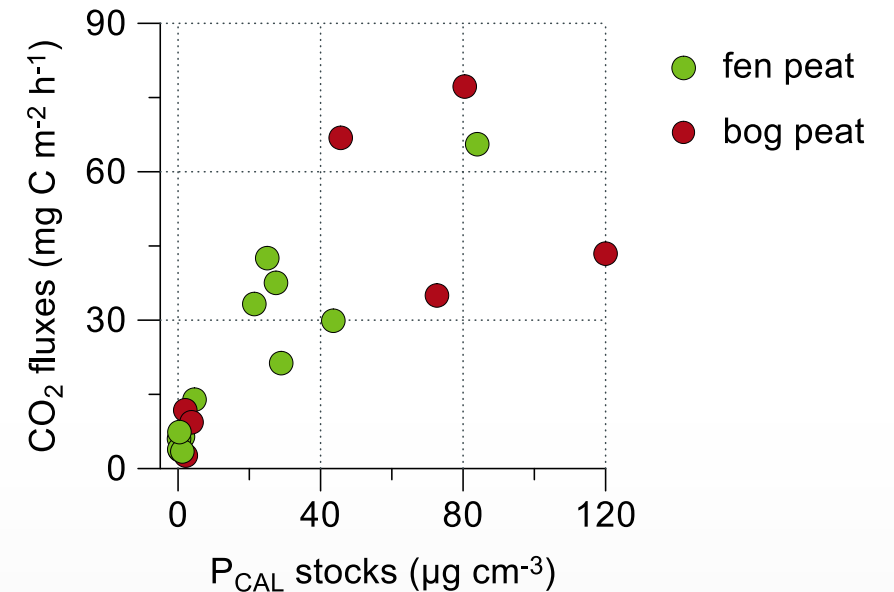
Strongly decomposed *Sphagnum* peat (H10)



Data from Säurich et al. (2019), *Soil Biology and Biochemistry* 135: 71-84

Potentially relevant environmental variables

- ✓ intra-annual distribution of water levels
- ✓ soil moisture or water filled pore space
- ✓ soil physical properties
- ✓ (aerated) SOC and/or N_t stocks
- ✓ nutrient supply (e.g. fertilisation rates, plant-available phosphorus or nitrate in the soil solution)



Data from Säurich et al. (2019), *Soil Biology and Biochemistry* 135: 71-84

Potentially relevant environmental variables

- ✓ intra-annual distribution of water levels
- ✓ soil moisture or water filled pore space
- ✓ soil physical properties
- ✓ (aerated) SOC and/or N_t stocks
- ✓ nutrient supply (e.g. fertilisation rates, plant-available phosphorus or nitrate in the soil solution)
- ✓ peat properties (degradability), labile organic matter, microbial community, enzyme activity...
- ✓ vegetation composition

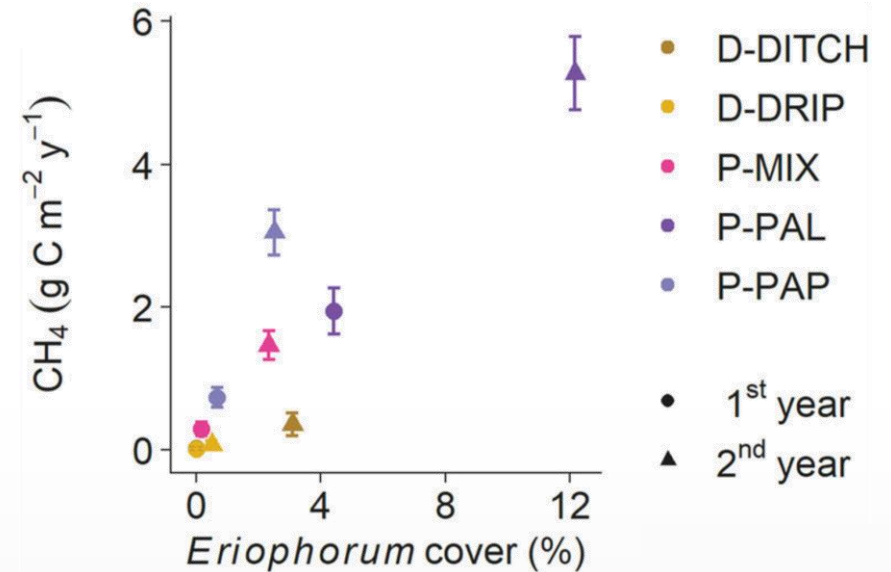


Figure from Oestmann et al. (2022): *Ecosystems* 25: 350-371

Summary

Requirements	Eddy Covariance	Chamber + portable analyser	Chamber + gas chromatography
Plot scale measurements with treatments	-	√	√
Field scale experiments (and forests)	√	-	-
Temporal resolution	√	(√)	((√))
Carbon dioxide	√	√	-
Methane	√	√	(√)
Nitrous oxide	(√), power supply!	-	√
Costs, expertise, efforts	Instruments: very high, technical expertise: very high, time in the field: low	Instruments: high, technical expertise: high, time in the field: high	Instruments: low (w/o lab), technical expertise: average, time in the field: high

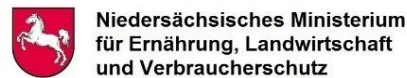
→ always consider and plan costs and time for explanatory variables (and lateral fluxes)!

Thanks!

... for the invitation to this online workshop!

... all funding agencies, project partners and colleagues of the projects “Organic soils in emission reporting”, KlimDivMoos, German Agricultural Soil Inventory and Gnarrenburger Moor!

... farmers, nature protection agencies and everyone in the field and the laboratories!



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