Airborne Eddy Covariance for Estimating Regional Turbulent Matter and Energy Fluxes in NE Germany

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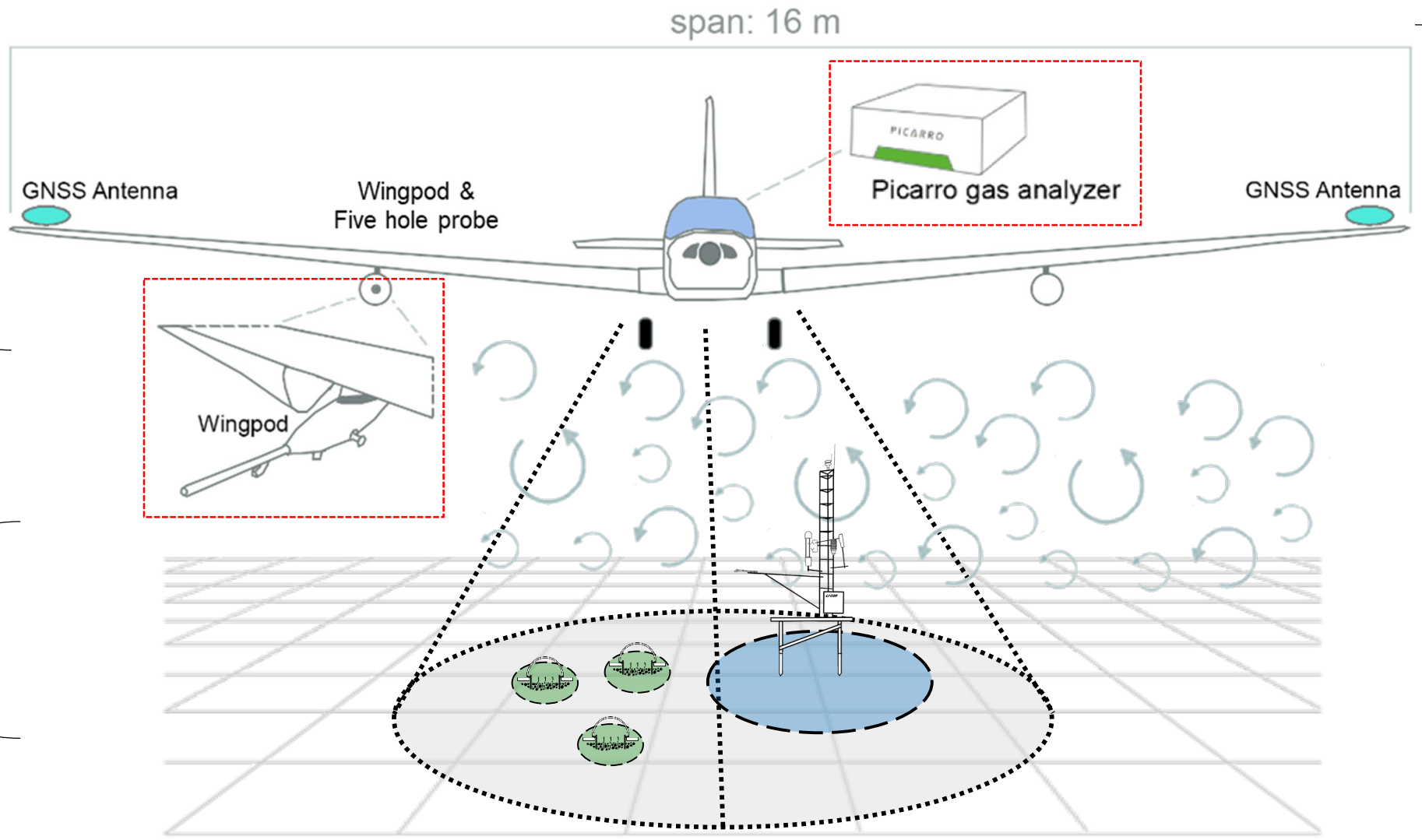
AWI

Airborne EC – from Local to Regional Measurements

ASK-16 Motorized Glider

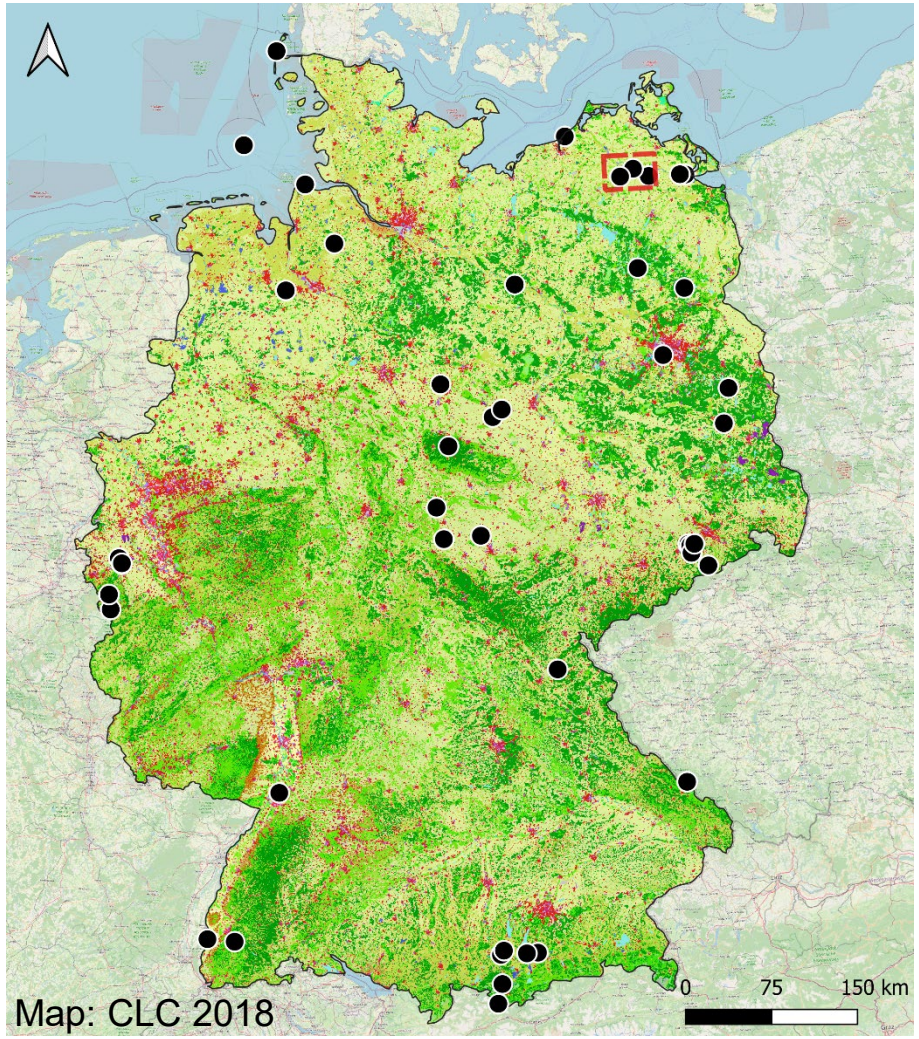


EC tower

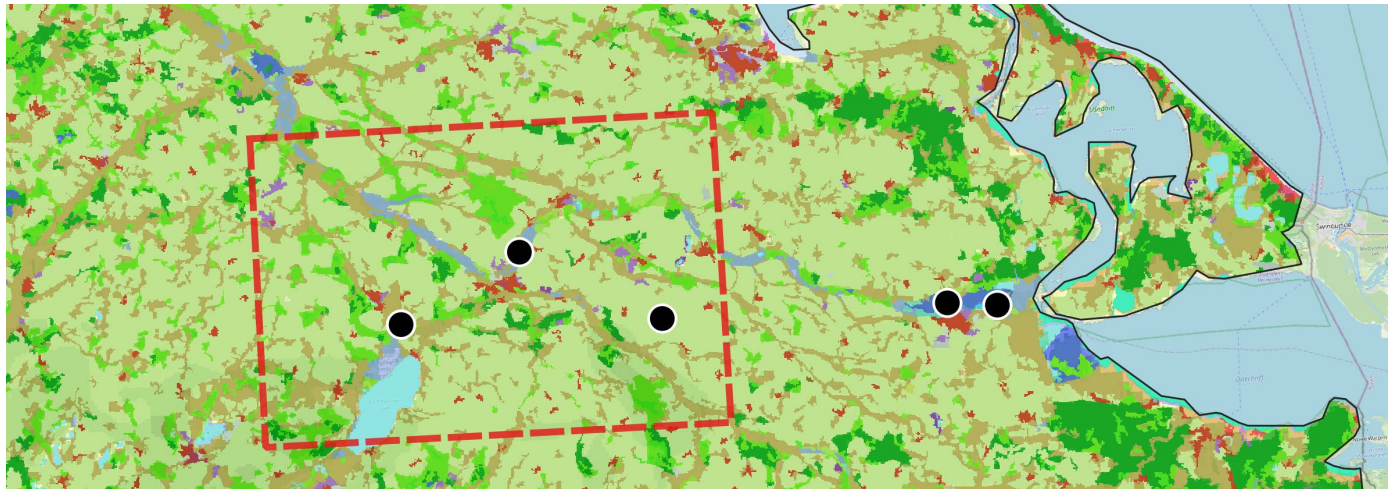
Spatial Fluxes
&
Footprints

Airborne Eddy Covariance – From Local to Regional Scale

EC sites (ICOS, FLUXNET, MoorFlux)

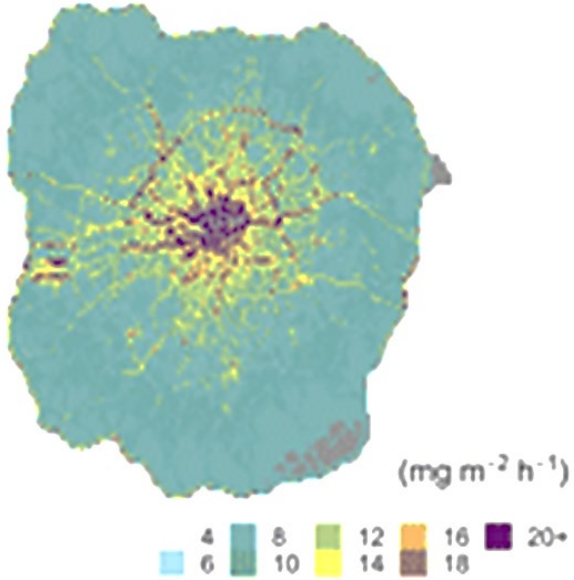


- From local to regional scale – heterogeneous landscapes
- Complement/ combined with tower measurements to gain information content (Metzger et al., 2021; Zulueta et al., 2011).
- High spatial flexibility & measure turbulent fluxes in landscapes that are normally difficult to access.

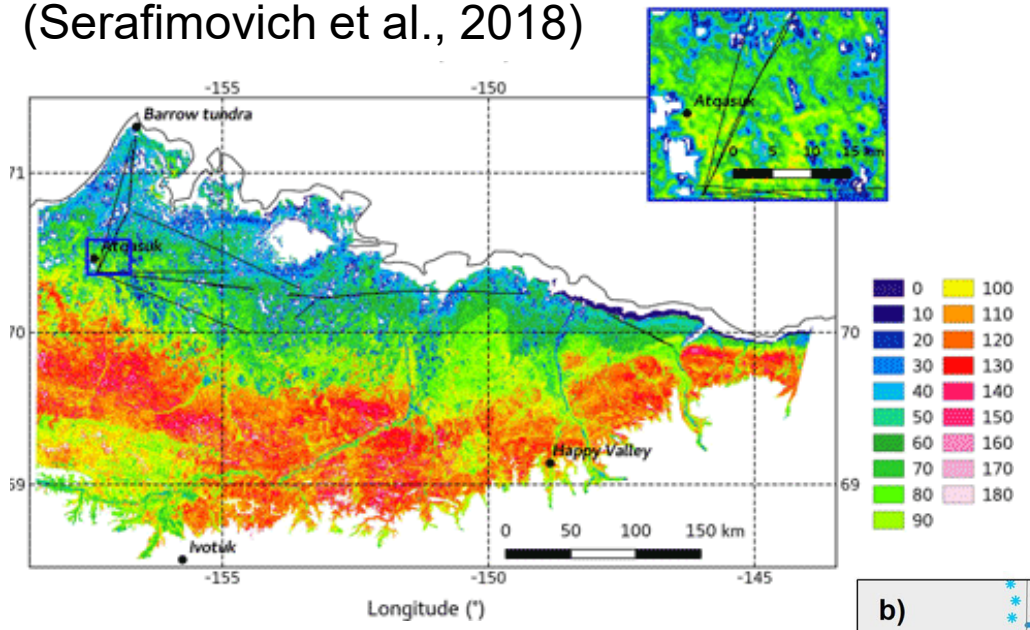


Examples Airborne Eddy Covariance …

NO_x @ London
(Vaughan et al., 2021)

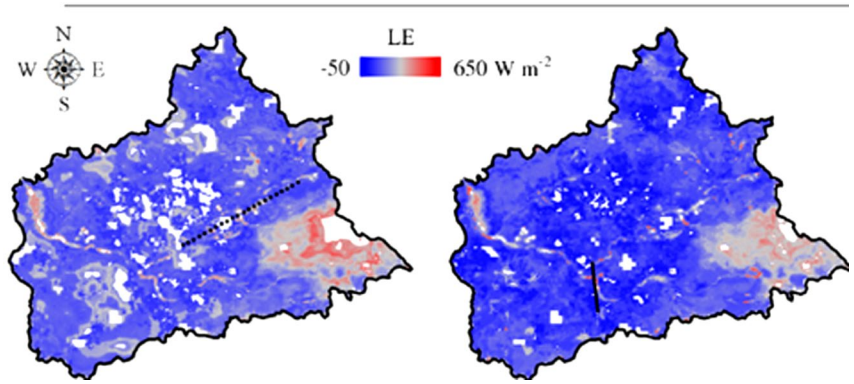


LE (Latent Heat), @ Alaska
(Serafimovich et al., 2018)

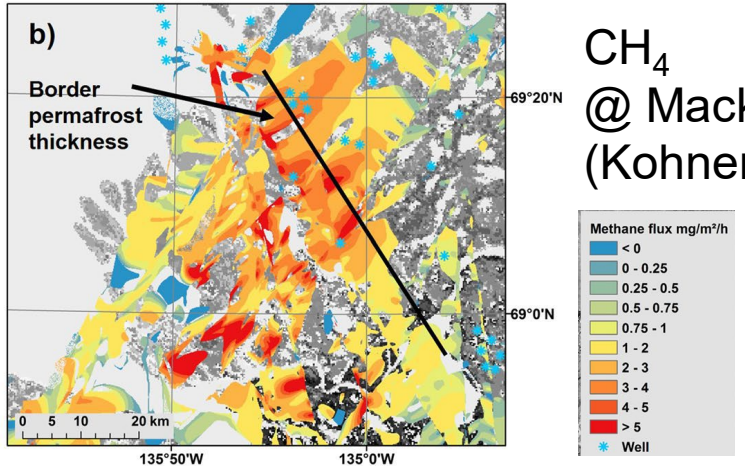


LE, H and CO_2 @ the Netherlands
(Hutjes et al, 2010)

LE (Latent Heat),
@ Mongolia China
(Metzger et al., 2013)

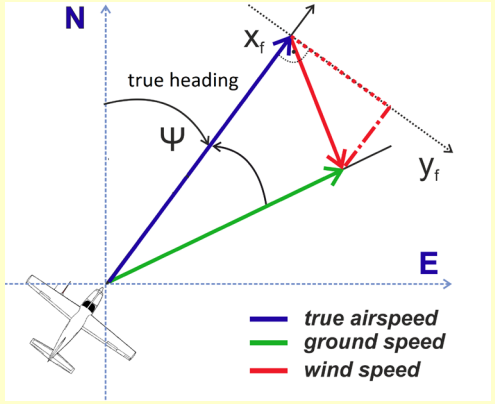


CH_4
@ Mackenzie, CA
(Kohnert et al., 2018)



Materials and Methods: Workflow

Wind Calculation

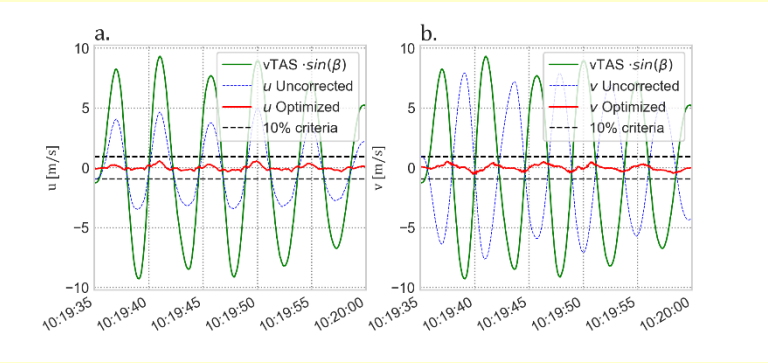


Raw Wind

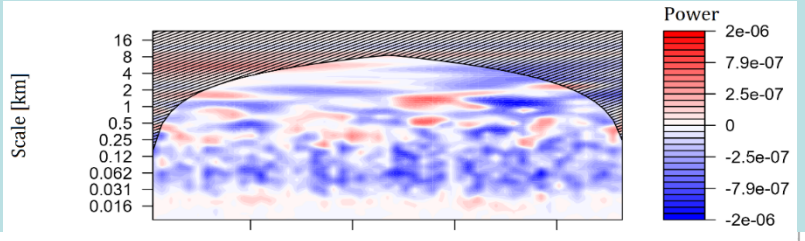
Calibration Parameters

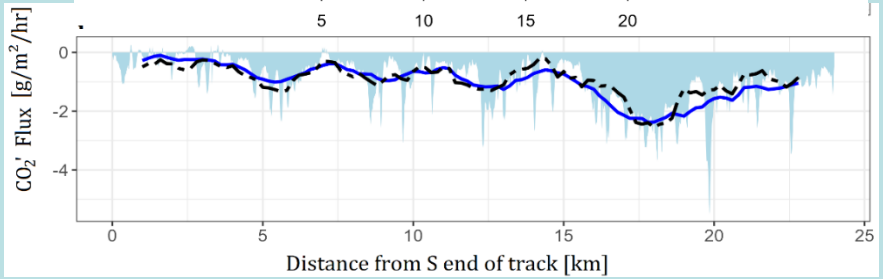
Calibrated Wind

Wind Calibration



Flux Calculation



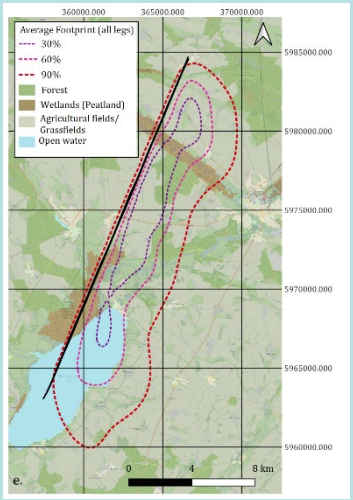


Flux

Footprint Calculation

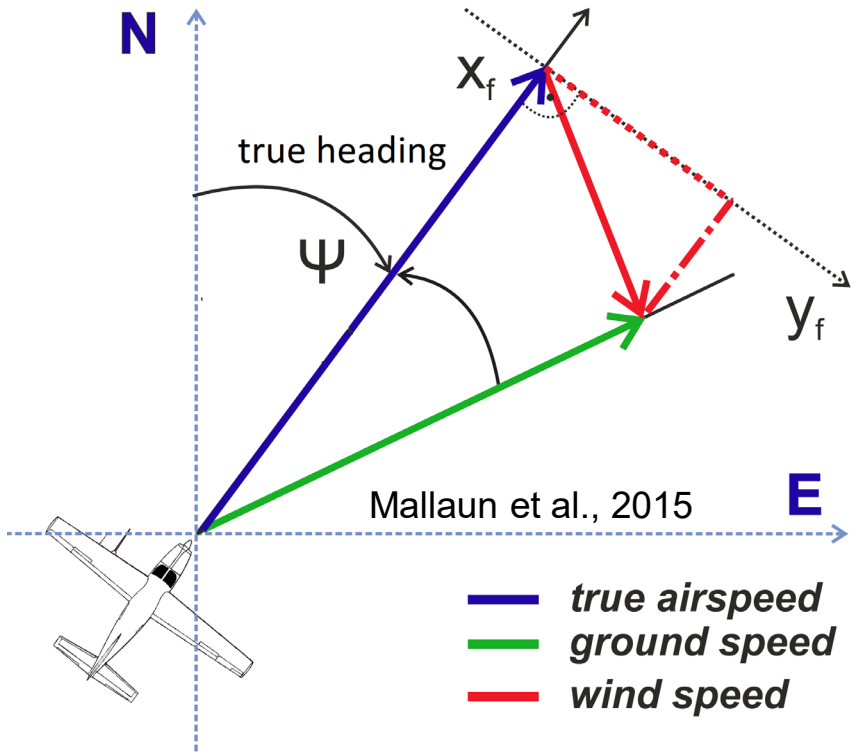
Footprint

Flux Footprint



Methodology – Wind Calculation and Calibration

Wind calculation



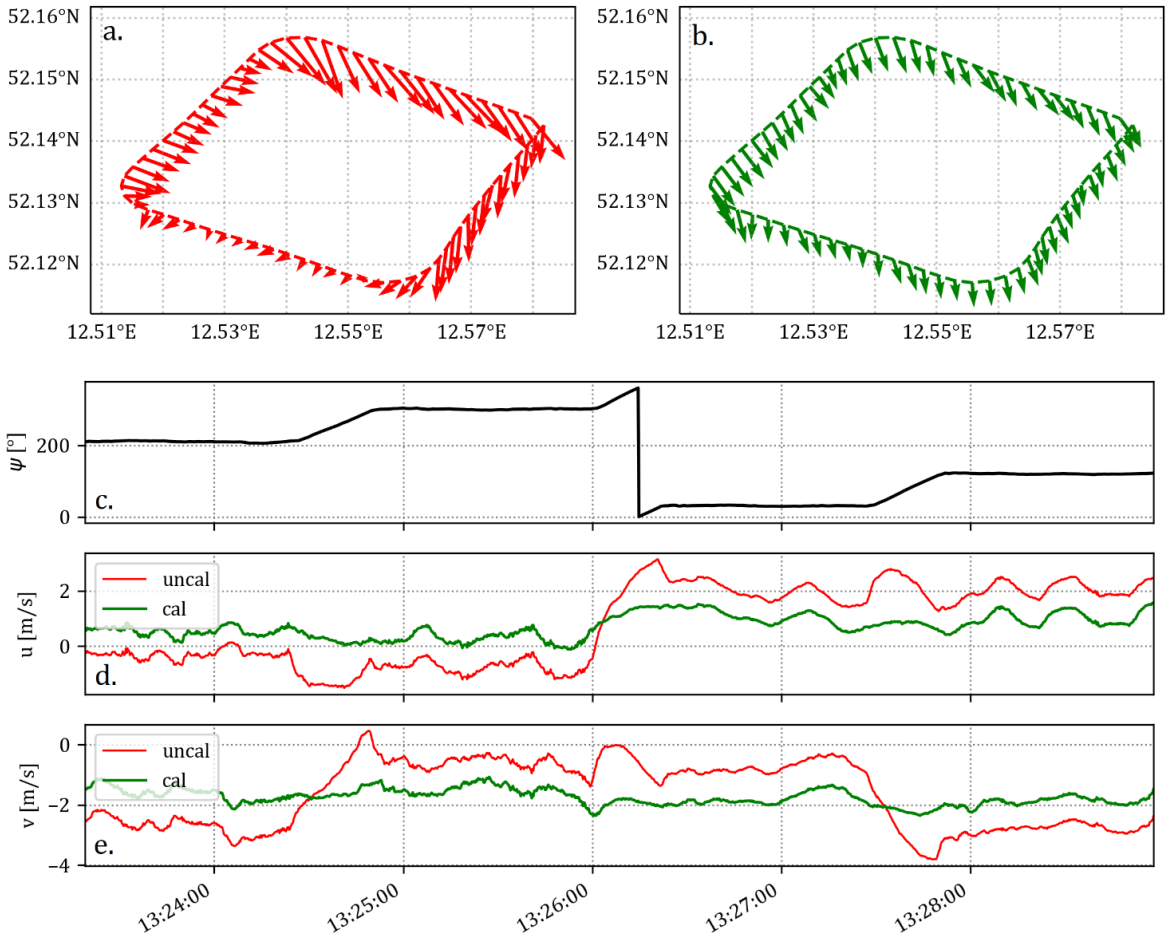
$$v_{wind} = v_{gs} - v_{tas}$$

- Need for data from 5 hole probe AND INS-GNSS
- Calibration is needed to AVOID effects of aircraft movement on wind product
- Only straight tracks are used for reliable flux measurements

Methodology – Wind Calculation and Calibration

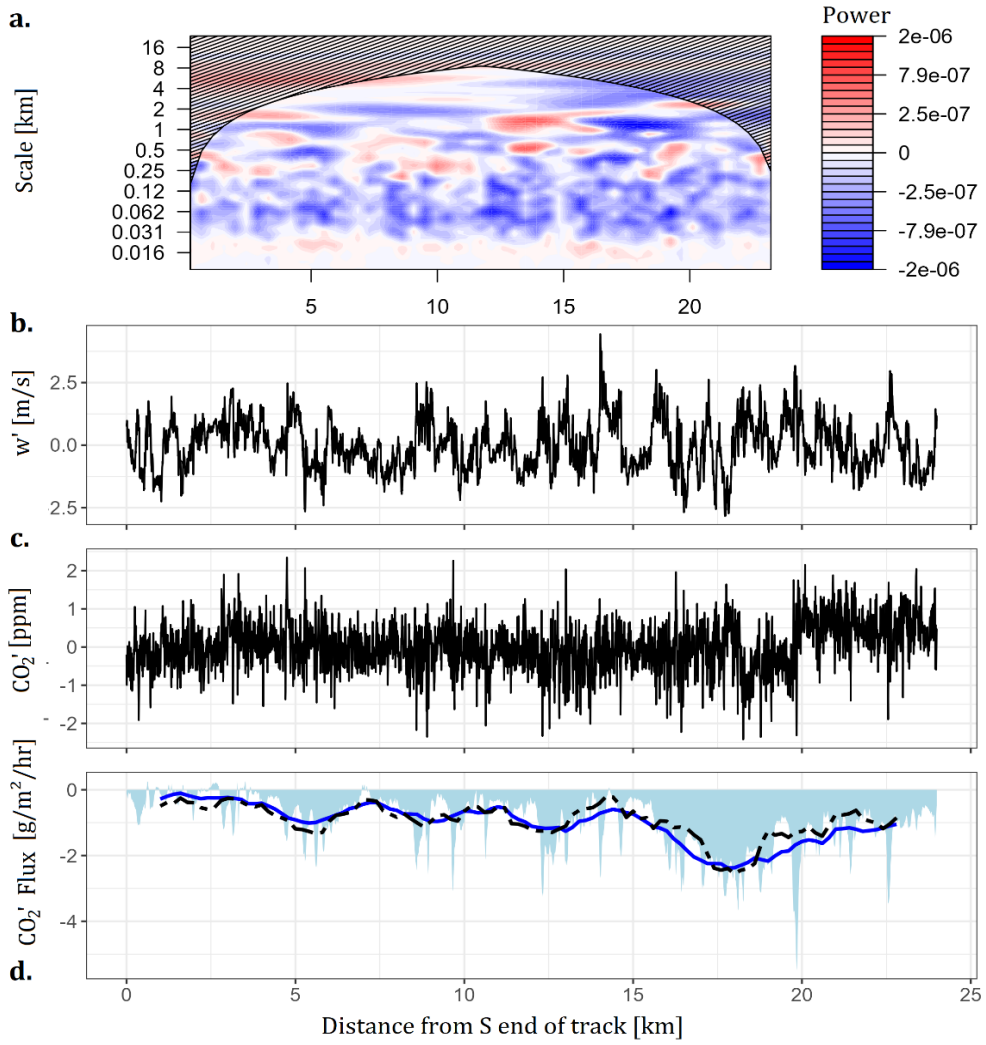
Wind calculation

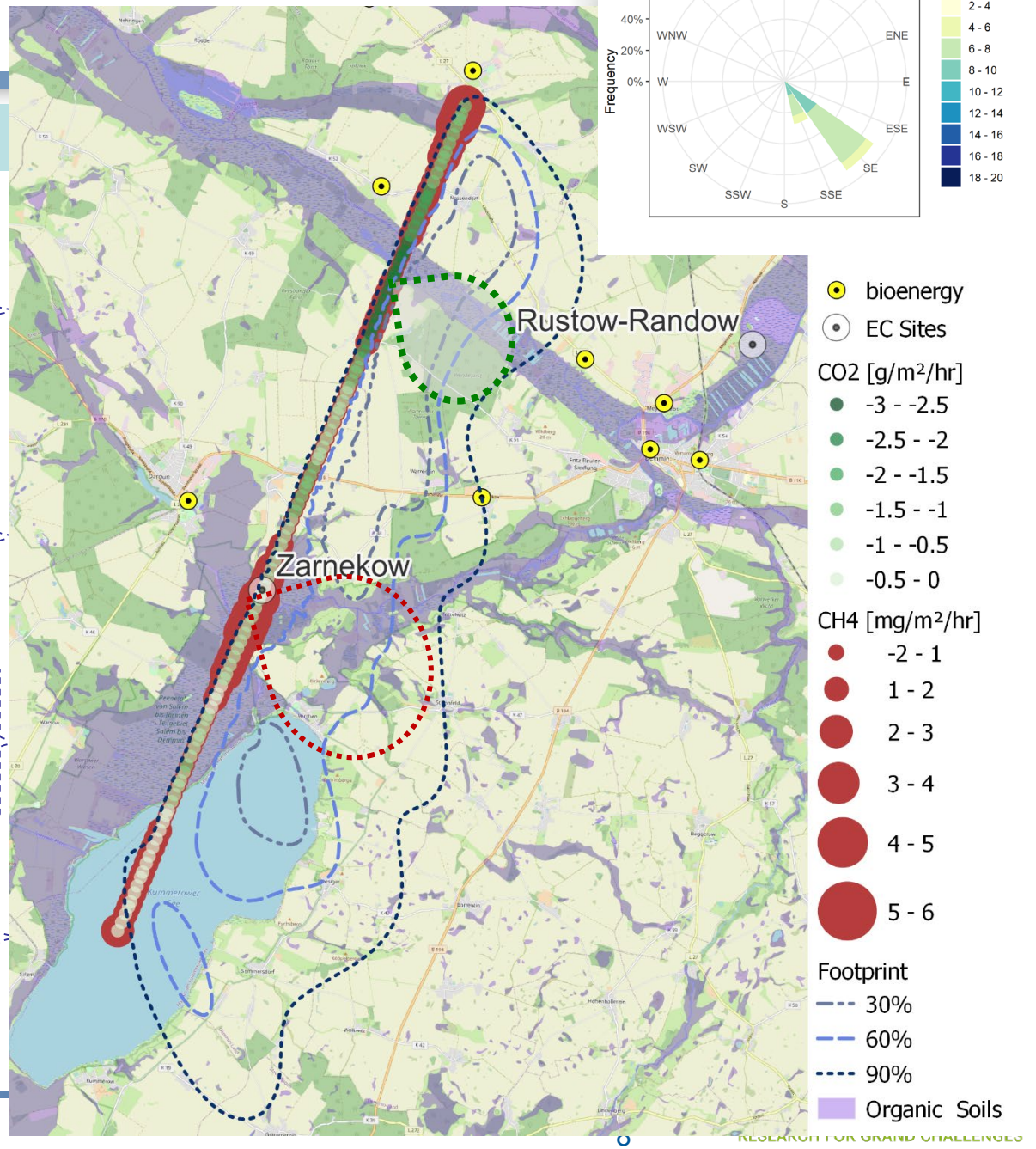
- Box patterns at „constant altitude“
- Assumption: constant horizontal wind
- Assumption 2: changes in wind are artificial and are caused by aircraft movement
- Proof of concept: more homogeneous wind after calibration



Wiekenkamp et al., in prep.

Methodology – Wavelet-based Fluxes





Wiekenkamp et al., in prep.

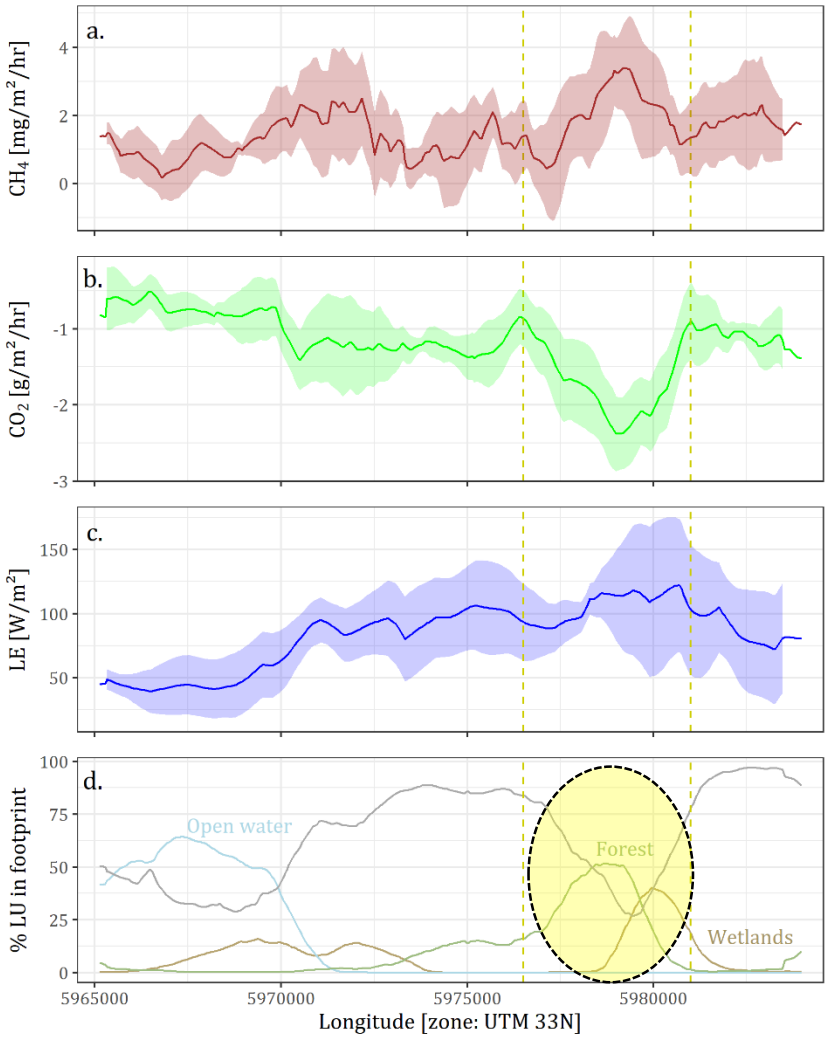
Fluxes and Footprint – Transect

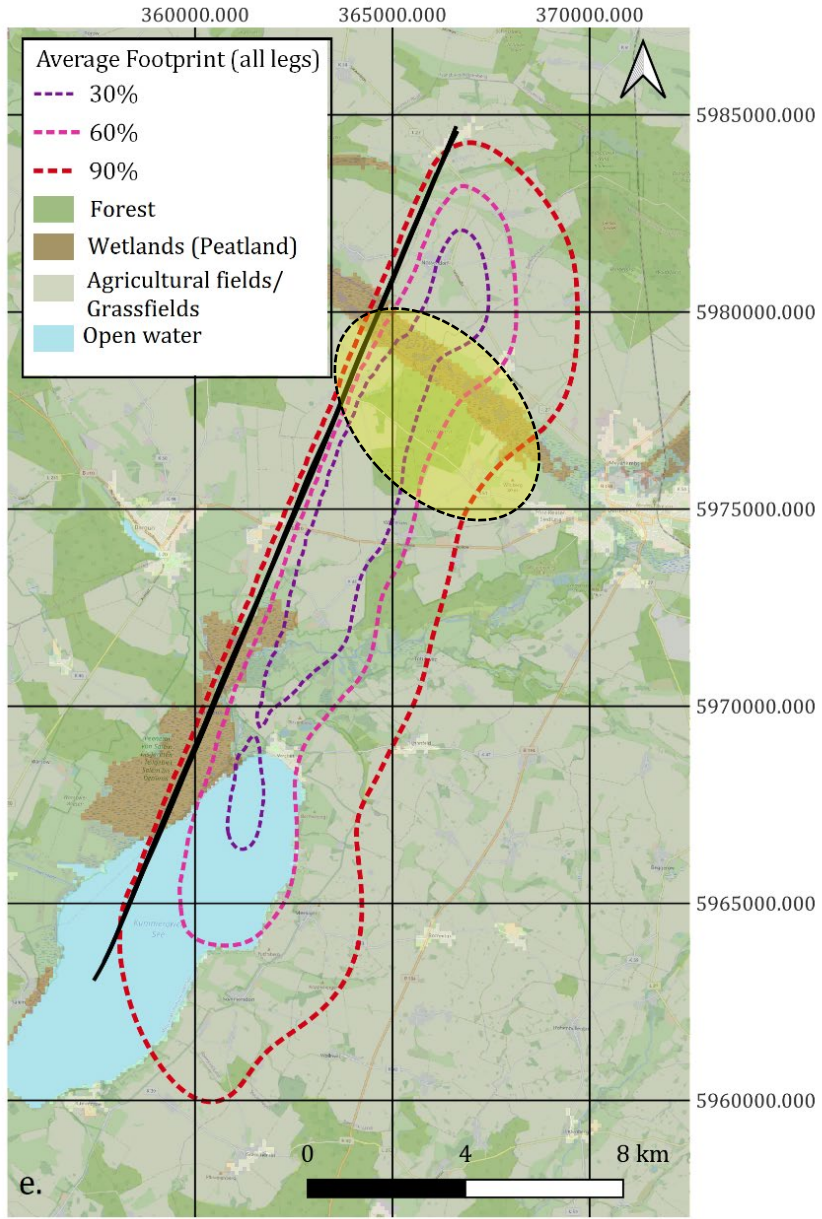
CH_4

CO_2

LE

Landuse



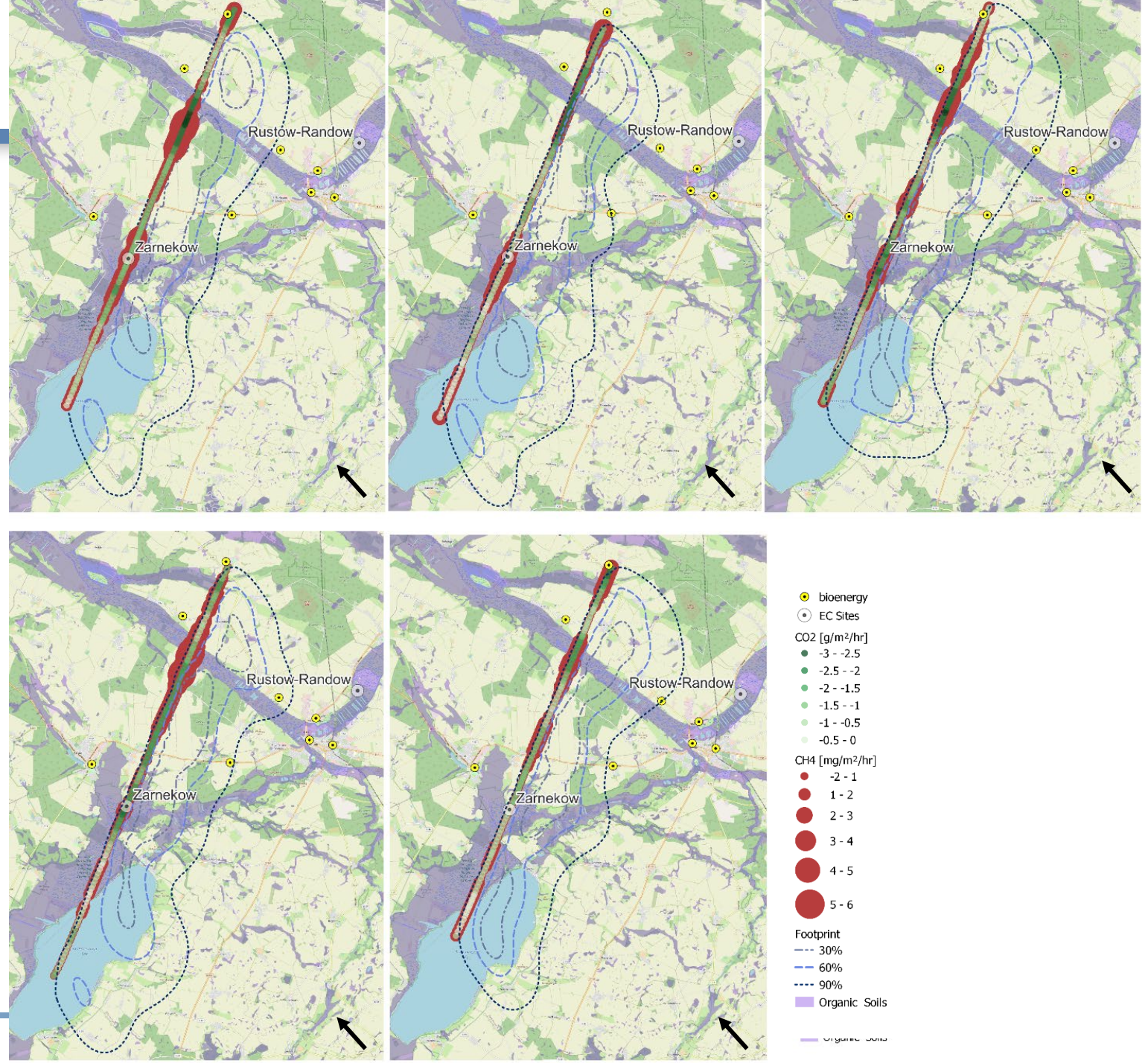


Wiekenkamp et al., in prep.

Fluxes and Footprints

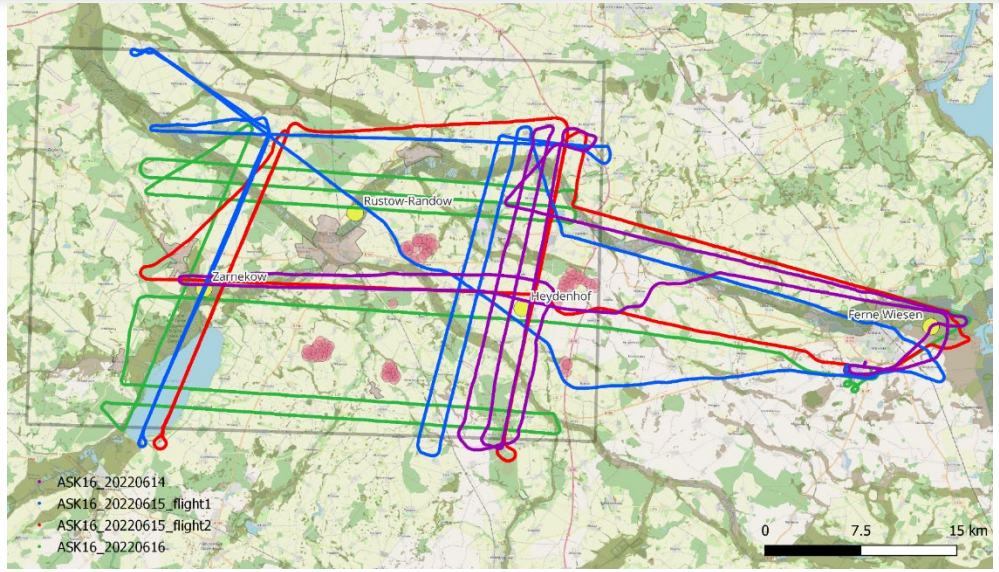
Variability of CO_2 and CH_4:

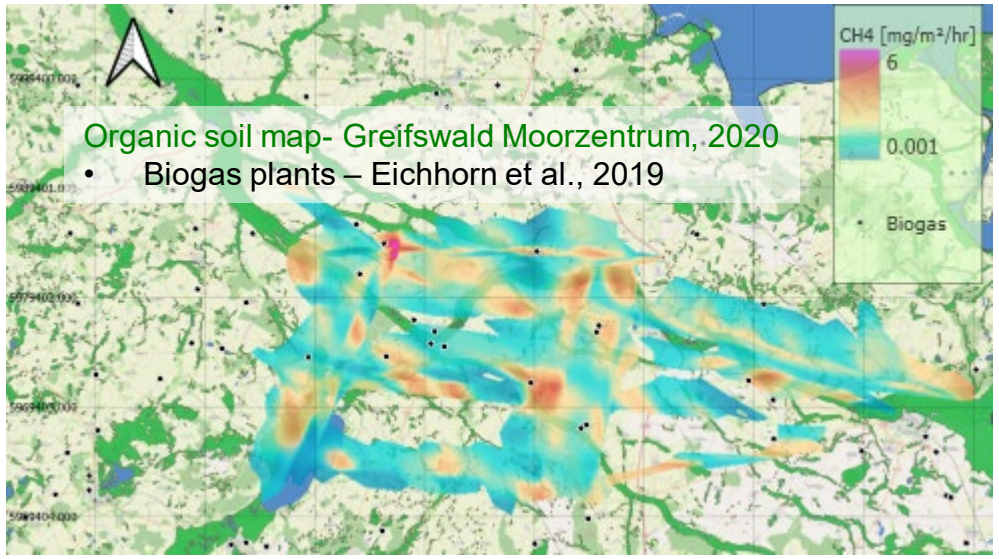
- Patterns vary over time … but there are clear consistencies
- Related to vegetation and/ or soil(s)



Conclusions & Outlook

- Wind Calibration – success shown with wind squares + other maneuvers
- Spatial Patterns: Fluxes are calculated using wavelets to get higher spatial resolution
- Fluxes from different legs over same area show
  - Consistencies (vegetation/ soil)
  - Temporal ariability
- Prelim. CH_4: First results suggest pattern between organic soils and emissions. Also biogas plants might be a predictor (but not always)





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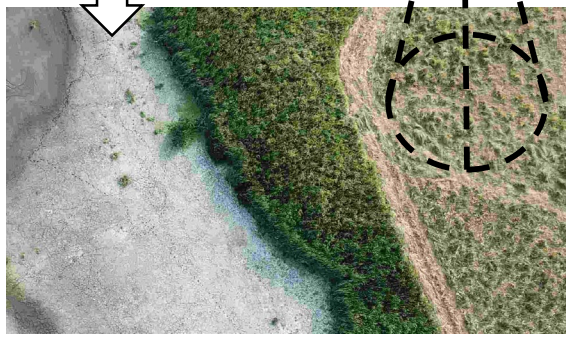
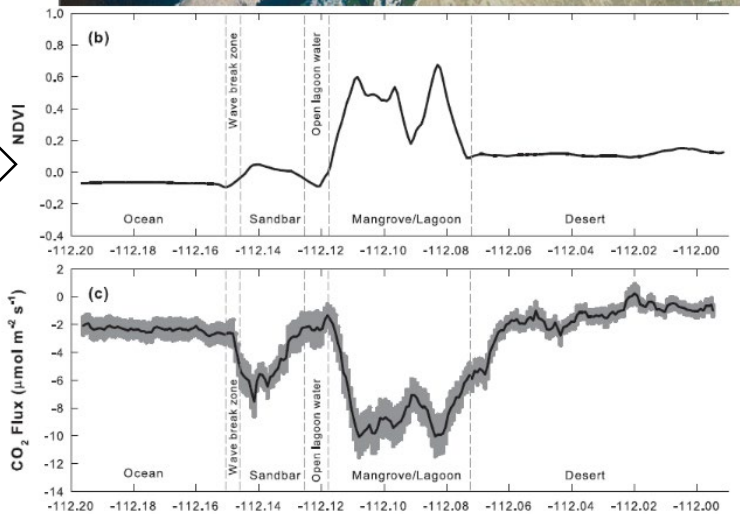
Outlook

From local to regional fluxes



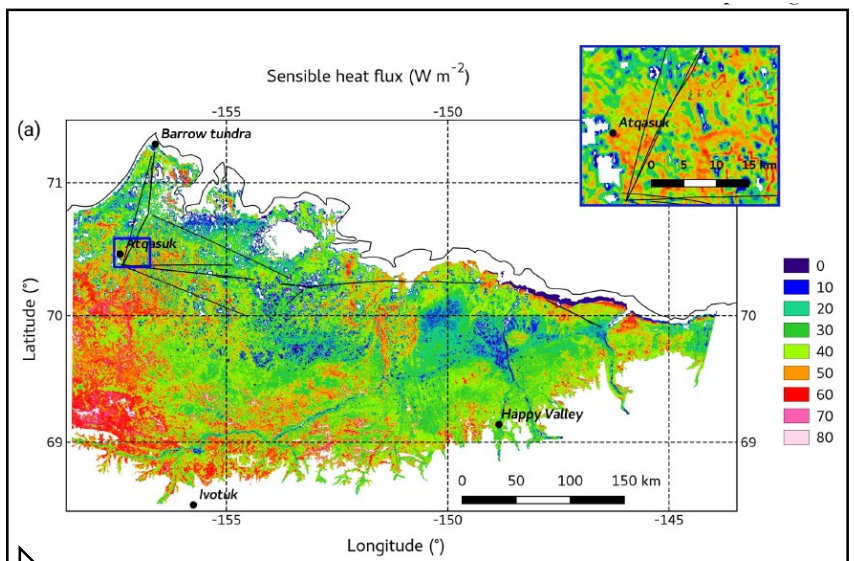
Connection fluxes – satellite data



Zulueta et al., 2013

- Fluxes + Footprint + Satellite data
- Multiple Linear Models or Machine Learning

Project fluxes – spatial mapping



Serafimovich et al., 2018

Output:

- Spatial maps of fluxes
- (Ultimately) better process understanding