

Eddy-Covariance Measurements – A Short Introduction

GEO2310 – Oblig 2: PBL
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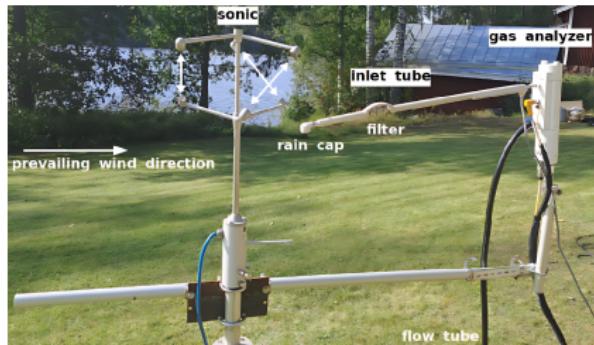
Eddy-covariance measurements to study land-atmosphere exchange processes: examples of sites



Eddy-covariance measurements

Setup

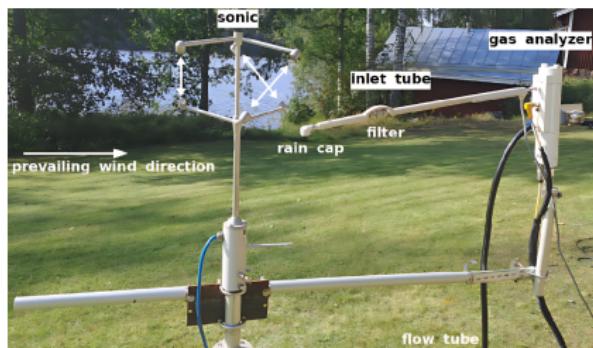
- ▶ sonic: u, v, w, T
- ▶ gas analyzer: H₂O, CO₂ (... CH₄, NO, particles)
- ▶ high sampling frequency (e.g. 20 Hz)



Eddy-covariance measurements

Setup

- ▶ sonic: u, v, w, T
- ▶ gas analyzer: H_2O, CO_2 (... CH_4, NO , particles)
- ▶ high sampling frequency (e.g. 20 Hz)



Eddy-covariance method

- ▶ Reynolds averaging:

$$x = \bar{x} + x', \quad \bar{x} := \frac{1}{t_s} \int_0^{t_s} x \, dt$$

- ▶ flux calculation:

$$\begin{aligned}\overline{xy} &= \bar{x} \bar{y} + \bar{x} \overline{y'} + \overline{x'} \bar{y} + \overline{x'} \overline{y'} \\ &= \bar{x} \bar{y} + \overline{x' y'}\end{aligned}$$

usually:

w : vertical velocity

x : scalar

$\overline{x' w'} = cov(x, w)$: vertical flux of x

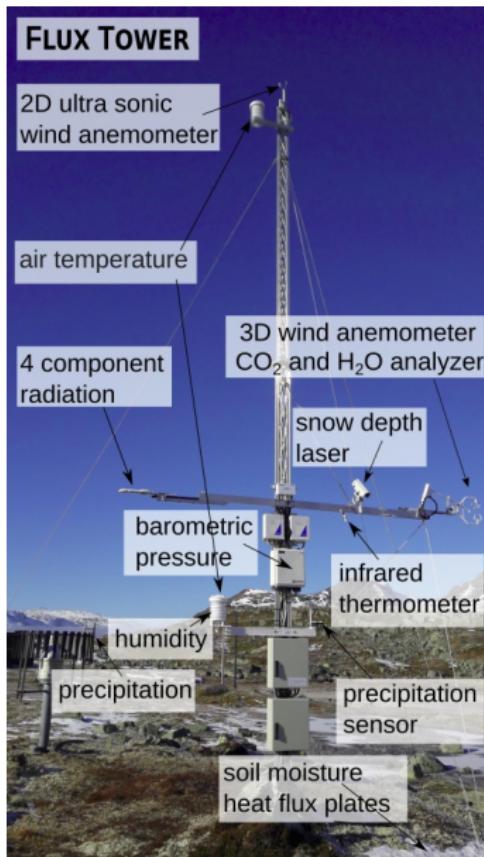
- ▶ (a lot of post-processing)
- ▶ How to determine the averaging time?
→ here: use 30 min

Eddy-covariance site @ Finse

data used in the assignment:

- ▶ eddy-covariance measurements:
 u, v, w, T, H_2O, CO_2
(frequency: 10 Hz → average to 30 min)
- ▶ radiation measurements
(from pyranometers)
 $SW \downarrow, SW \uparrow, LW \downarrow, LW \uparrow$
- ▶ ground/soil heat flux measurements
 G

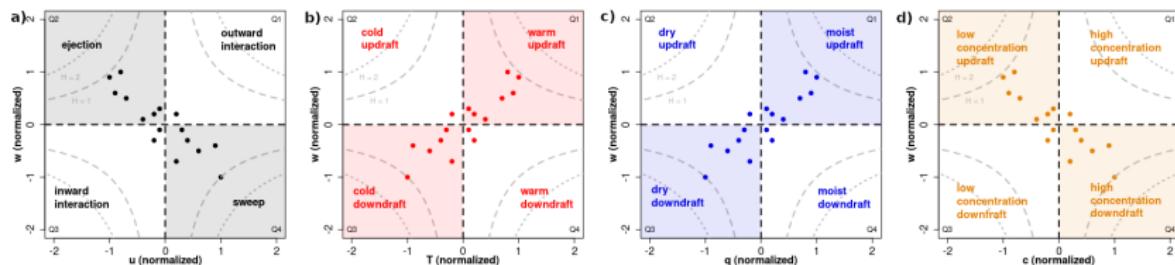
(picture: <https://www.mn.uio.no/geo/english/research/groups/latice/infrastructure/>)



Quadrant analysis

quadrant analysis = scatterplot of two normalized (measured) quantities

► normalization $\hat{x} = \frac{x - \bar{x}}{\sigma_x}$



Surface energy balance

surface energy balance:

$$R_{net} - G = SH + LH + I_{SEB}$$

$R_{net} = SW \downarrow - SW \uparrow + LW \downarrow - LW \uparrow$: net radiation

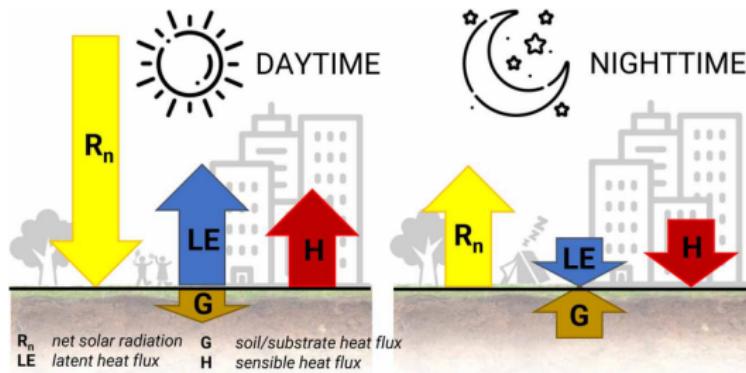
G : ground heat flux

$SH = \rho c_p \overline{w' T'}$: sensible heat flux

$LH = \rho L_v \overline{w' q'}$: latent heat flux

I_{SEB} : residual

$$I_{SEB} \begin{cases} = 0 \rightarrow \text{closed} \\ \neq 0 \rightarrow \text{unclosed} \end{cases} \quad \text{and} \quad CR := \frac{R_{net} - G}{SH + LH} \begin{cases} = 1 \rightarrow \text{closed} \\ \neq 1 \rightarrow \text{unclosed} \end{cases}$$



(Probst et al., 2022)