

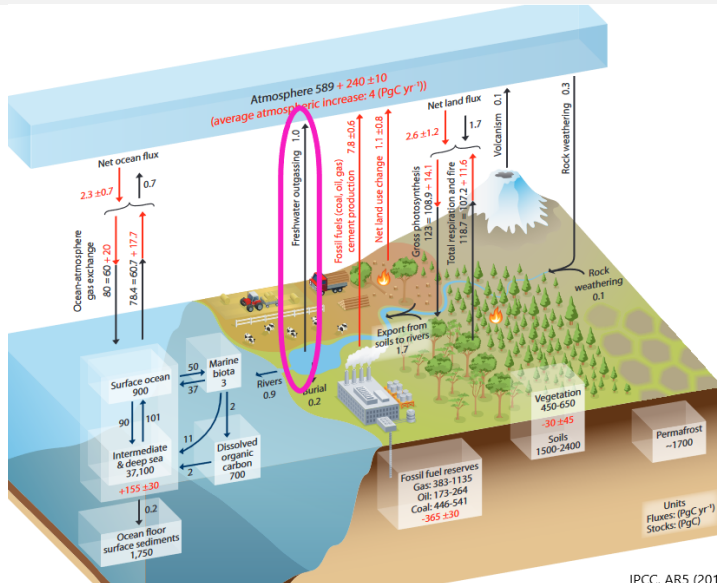
# The effect of non-local processes on eddy covariance air-lake gas fluxes at Lake Erken

Leonie Esters

GTWS meeting, Plymouth

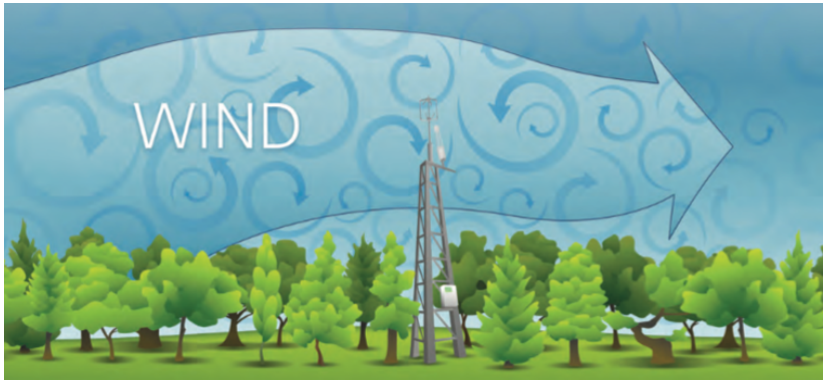
18.05.2022

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IPCC, AR5 (2018)

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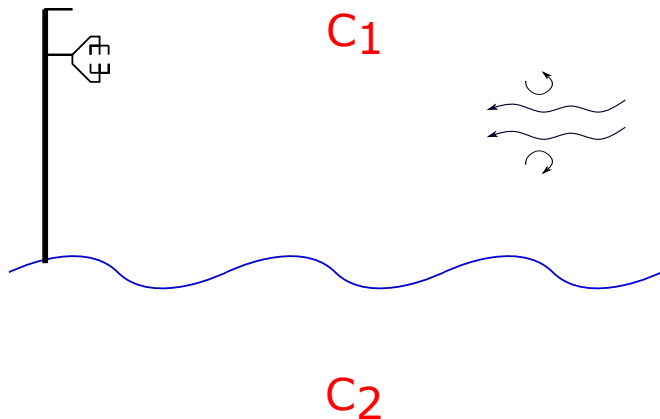


- Flow consists of numerous turbulent vortices (eddies).
- Eddies carry air parcels that contain a specific gas/humidity concentration.

→ Flux  $\propto \overline{w'c'}$

$w$ : vertical wind component,  $c$ : gas concentration, **prime**: deviations from mean

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- Flux  $\propto \overline{w'c'}$

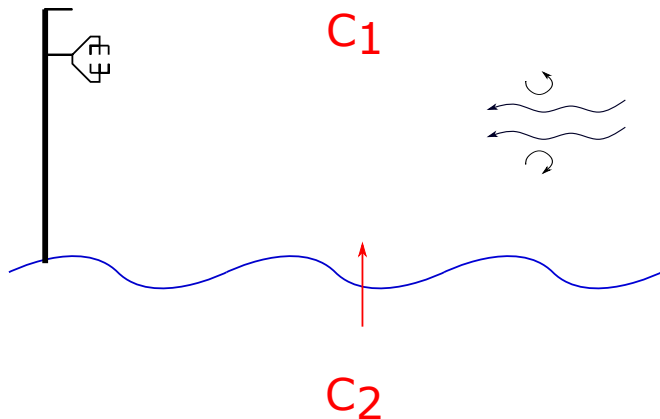
w: vertical wind component

c: gas concentration

**prime**: deviations from mean

- Atmospheric concentration  $C_1$  is constant.

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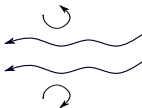
**prime**: deviations from mean

- Atmospheric concentration  $C_1$  is constant.

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$C_1$



- Flux  $\propto \overline{w'c'}$

w: vertical wind component

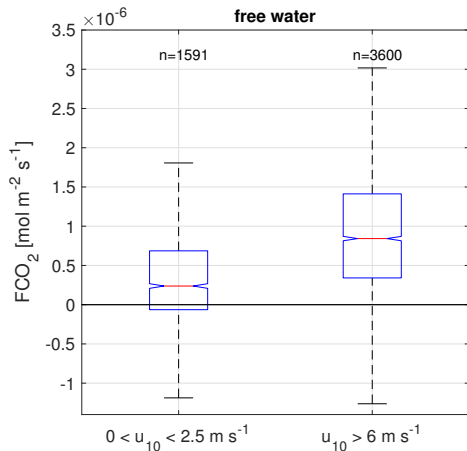
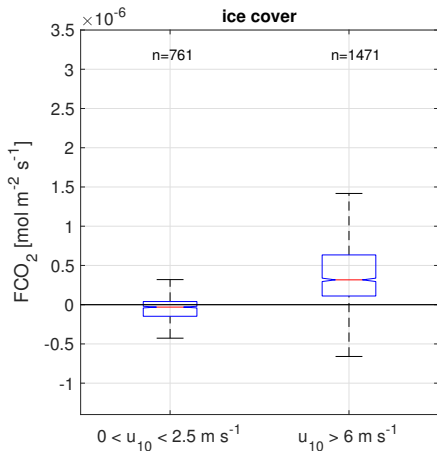
c: gas concentration

**prime**: deviations from mean

- Atmospheric concentration  $C_1$  is constant.

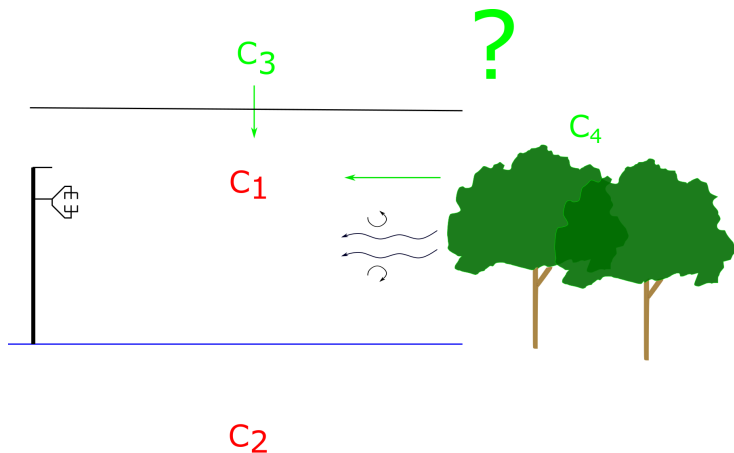
$C_2$

# The effect of non-local processes on eddy covariance air-lake gas fluxes at Lake Erken?



→ Why are there fluxes even when the lake is ice-covered?

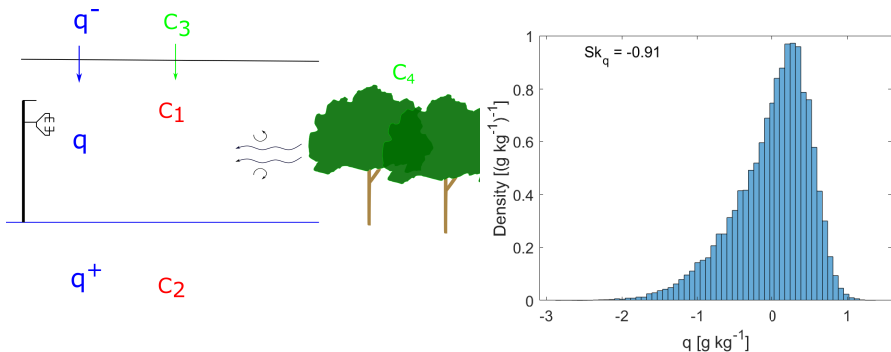
# The effect of non-local processes on eddy covariance air-lake gas fluxes at Lake Erken?



→ Could  $\text{CO}_2$  be vertically entrained or horizontally advected?



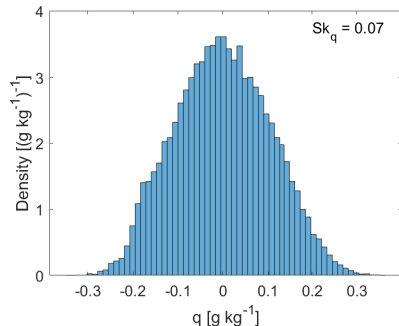
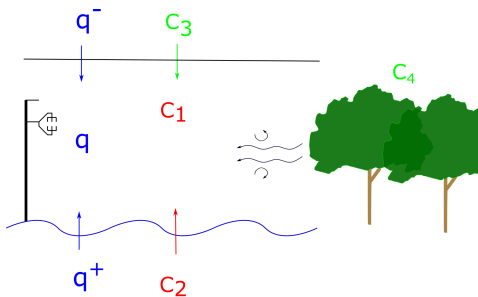
# The effect of non-local processes on eddy covariance air-lake gas fluxes at Lake Erken?



Following van de Boer et al. (2014):

- Negative humidity skewness: Non-local processes

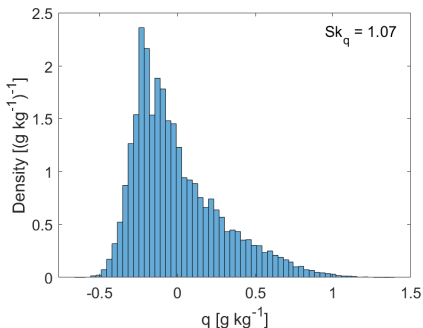
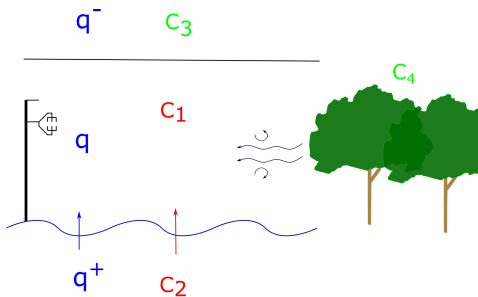
# The effect of non-local processes on eddy covariance air-lake gas fluxes at Lake Erken?



Following van de Boer et al. (2014):

- Humidity skewness close to zero: Both non-local and local processes

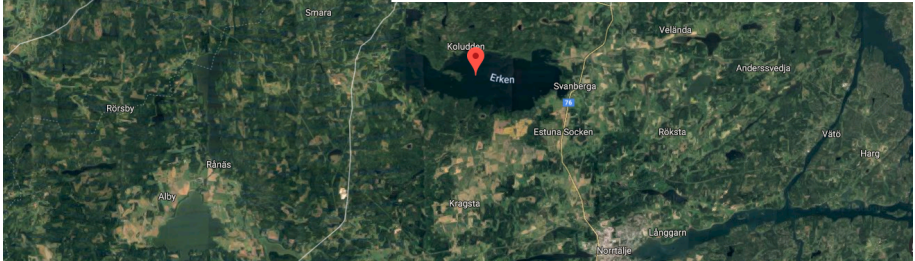
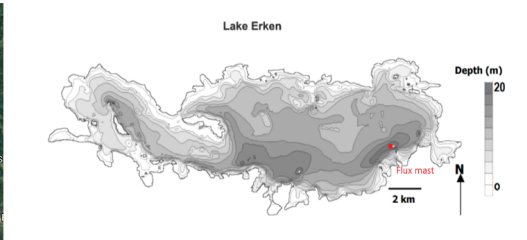
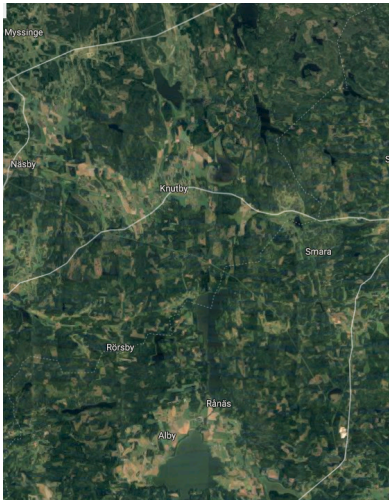
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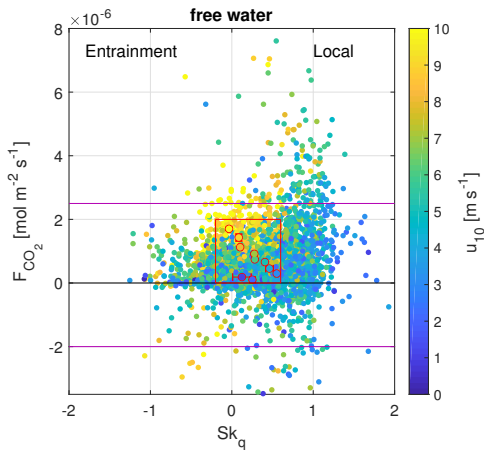
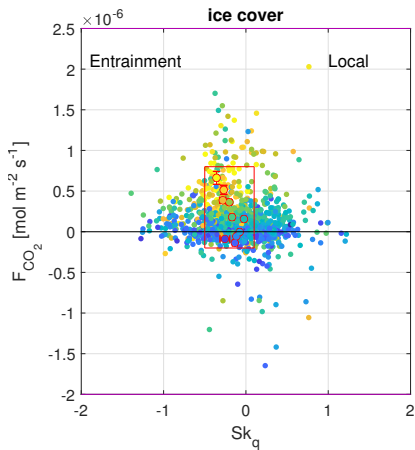
Following van de Boer et al. (2014):

- Positive humidity skewness: Local processes

# The effect of non-local processes on eddy covariance air-lake gas fluxes at Lake Erken?

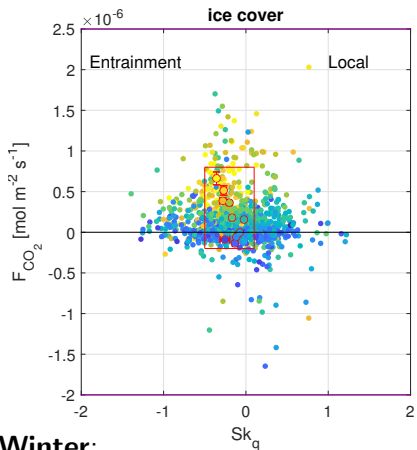


# Humidity skewness versus CO<sub>2</sub> flux



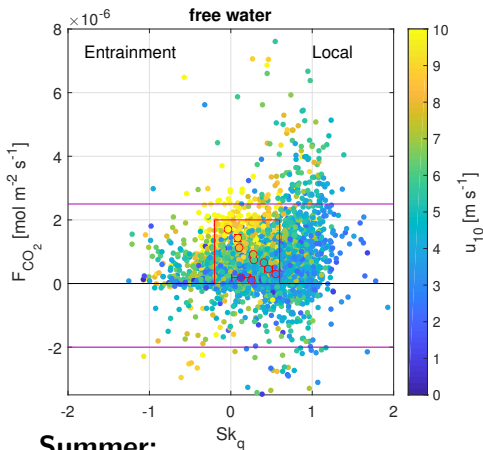
- **Winter:** higher fluxes for negative  $Sk_q$ : **Non-local processes!**
- **Summer:** highest fluxes for positive  $Sk_q$ : Local processes.

# Humidity skewness versus CO<sub>2</sub> flux



**Winter:**

$$\text{Flux} = \text{Flux}_{nonlocal}$$



**Summer:**

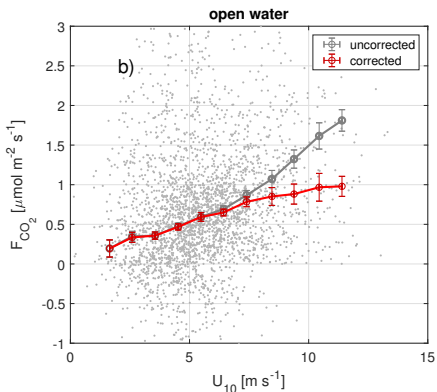
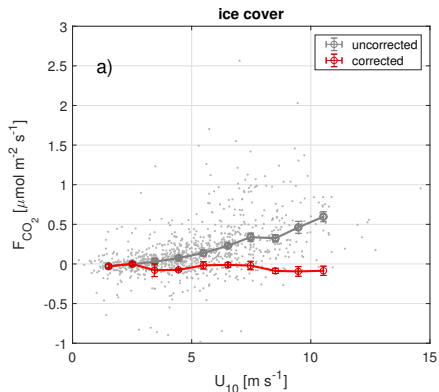
$$\text{Flux} = \text{Flux}_{nonlocal}$$

$$\text{Flux}_{nonlocal} + \text{Flux}_{local}$$

$$\text{Flux}_{local}$$

→ Correct fluxes for non-local effects.

# Flux correction - all data



Winter:

$$\text{Flux} = \text{Flux}_{\text{entrain}} - \text{Flux}_{\text{entrain}} = 0$$

Summer:

$$\begin{aligned} \text{Flux} &= \text{Flux}_{\text{entrain}} - \text{Flux}_{\text{entrain}} = 0 \\ &= (\text{Flux}_{\text{entrain}} + \text{Flux}_{\text{local}}) \\ &\quad - \text{Flux}_{\text{entrain}} = \mathbf{\text{Flux}_{\text{local}}} \end{aligned}$$

# Corrected gastransfer velocity

- From the gas flux the gastransfer velocity,  $k$  can be determined:

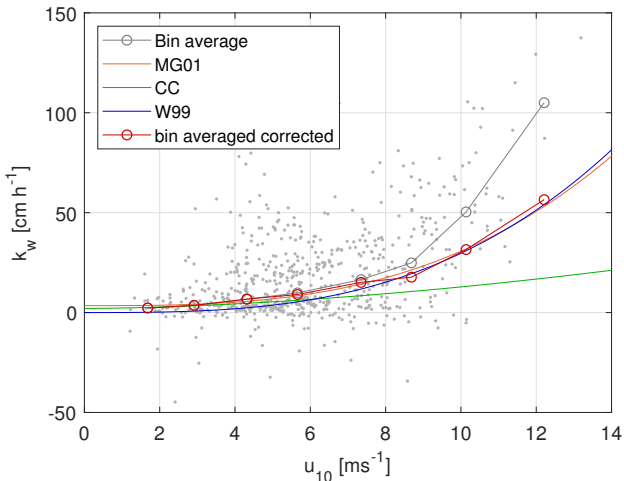
$$F = k(C_w - \alpha C_a)$$

$C_w$ : concentration in water

$C_a$ : concentration in air

$\alpha$ : solubility

- The corrected flux determines a reduced  $k$





# Summary


- Entrainment/advection is suggested to drive unexpected CO<sub>2</sub> fluxes during ice-covered periods.
- CO<sub>2</sub> fluxes for free-water periods can be corrected for the entrainment/advection effects.
- The corrected gas transfer velocity  $k$  falls closer to commonly used parametrisations.

Boundary-Layer Meteorology  
<https://doi.org/10.1007/s10546-020-00565-2>

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RESEARCH ARTICLE

## Non-local Impacts on Eddy-Covariance Air–Lake CO<sub>2</sub> Fluxes

Leonie Esters<sup>1</sup>  · Anna Rutgersson<sup>1</sup> · Erik Nilsson<sup>1</sup> · Erik Sahlée<sup>1</sup>

Thanks for your attention!