



On the role of advection for the net ecosystem carbon dioxide exchange of a subalpine grassland



Georg Wohlfahrt¹,

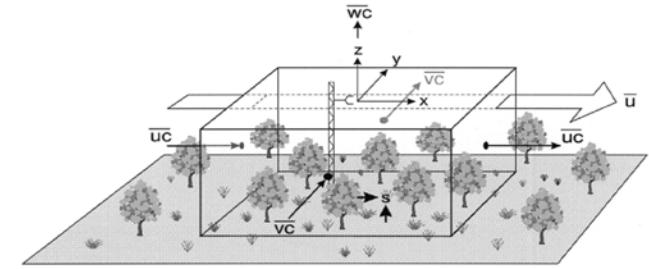
Marta Galvagno², Edoardo Cremonese², Umberto Morra di Cella²

¹ Institut für Ökologie, Universität Innsbruck, Austria

² Agenzia Regionale per la Protezione dell'Ambiente del Valle di Aosta, Italy



Background



$$\bar{F} = \frac{1}{L^2} \int_0^L \int_0^L \int_0^h \bar{c}_d \frac{\delta \chi}{\delta t} dx dy dz +$$

Storage term

$$\frac{1}{L^2} \int_0^L \int_0^L \int_0^h \left[\bar{u} \bar{c}_d \frac{\delta \chi}{\delta x} + \bar{v} \bar{c}_d \frac{\delta \chi}{\delta y} + \bar{w} \bar{c}_d \frac{\delta \chi}{\delta z} \right] dx dy dz +$$

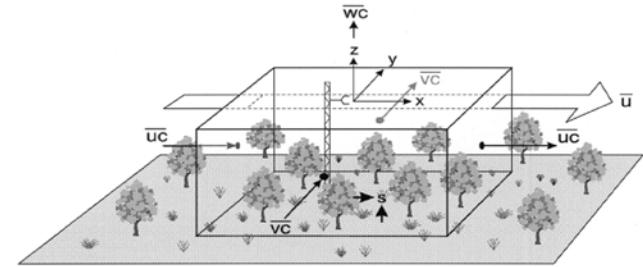
Advection terms

$$\frac{1}{L^2} \int_0^L \int_0^L \int_0^h \left[\frac{\delta \bar{c}_d \bar{u}' \bar{\chi}'}{\delta x} + \frac{\delta \bar{c}_d \bar{v}' \bar{\chi}'}{\delta y} + \frac{\delta \bar{c}_d \bar{w}' \bar{\chi}'}{\delta z} \right] dx dy dz$$

'Eddy' terms



Background



$$\bar{F} = \int_0^h \overline{c_d} \frac{\partial \chi}{\partial t} dz + \overline{c_d w} \overline{\chi}$$



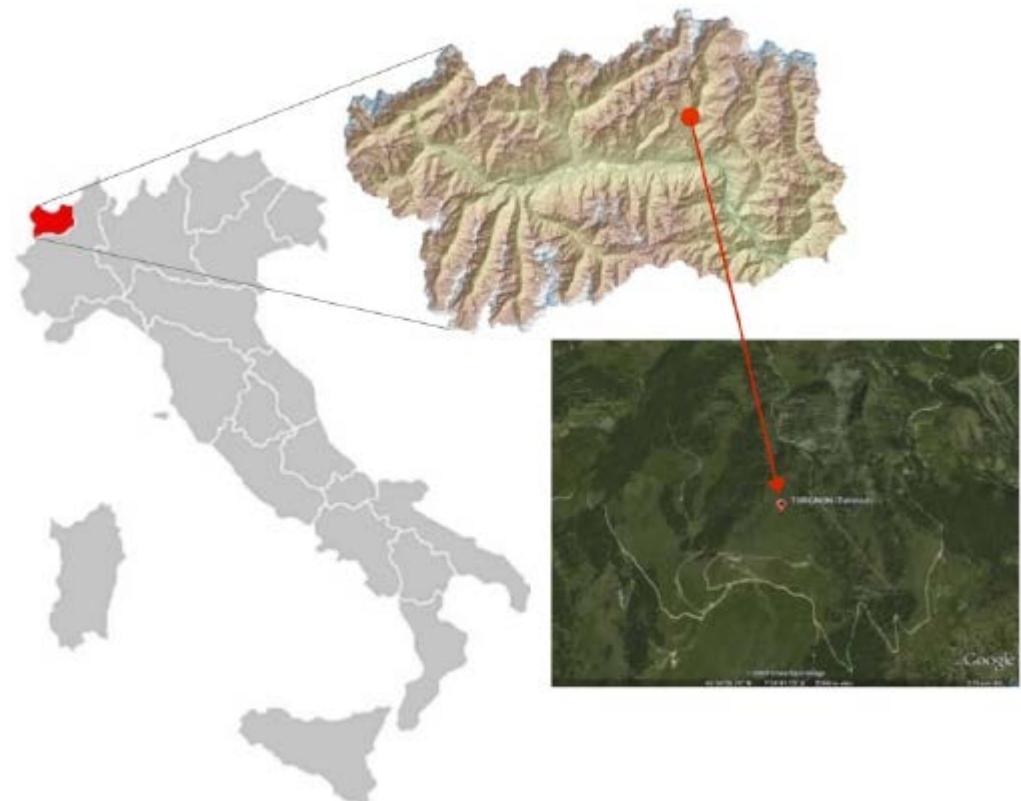
Objectives/hypothesis

- The overarching objective of this study was to quantify the contribution of advection to the CO₂ mass balance of a mountain grassland in complex topography.
- The main hypothesis underlying this work is that during calm and stable nighttime conditions advection contributes significantly to the CO₂ mass balance and neglecting it causes the mass balance to be biased towards net CO₂ uptake.



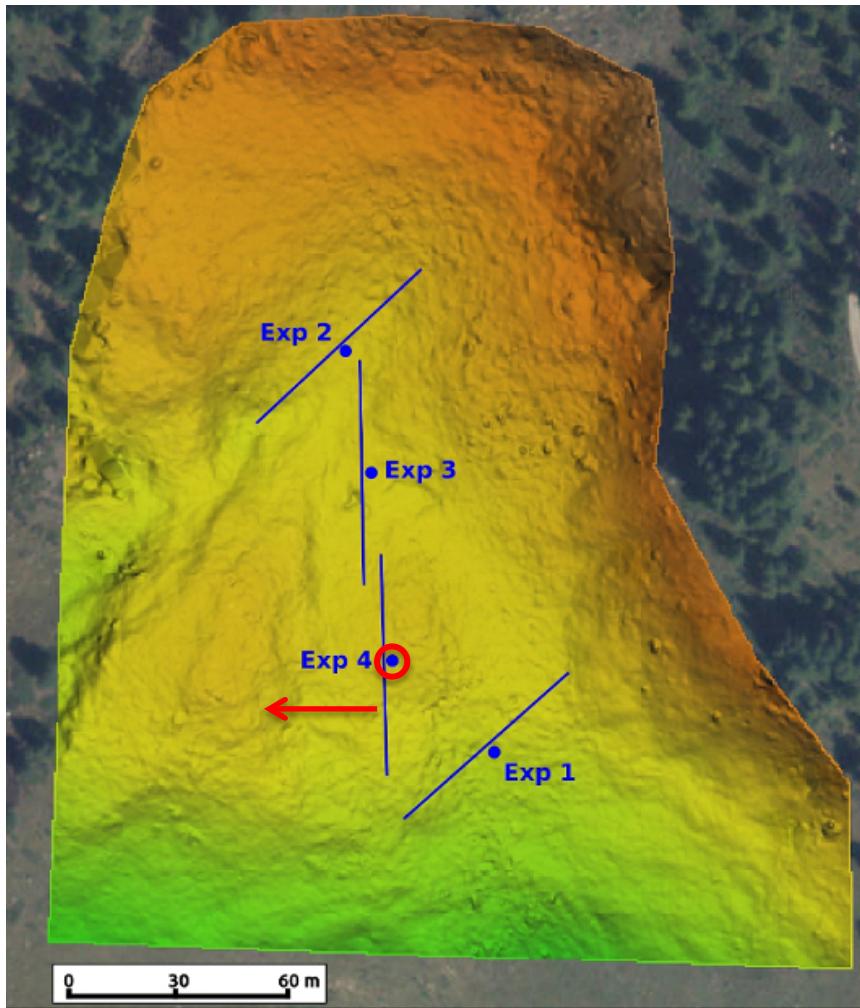
Study site

- Study site: Torgnon
- Subalpine grassland (2160 m)
- EC site on little plateau, bounded by steep slopes
- Complexity at all spatial scales
- Short canopy (20 cm)



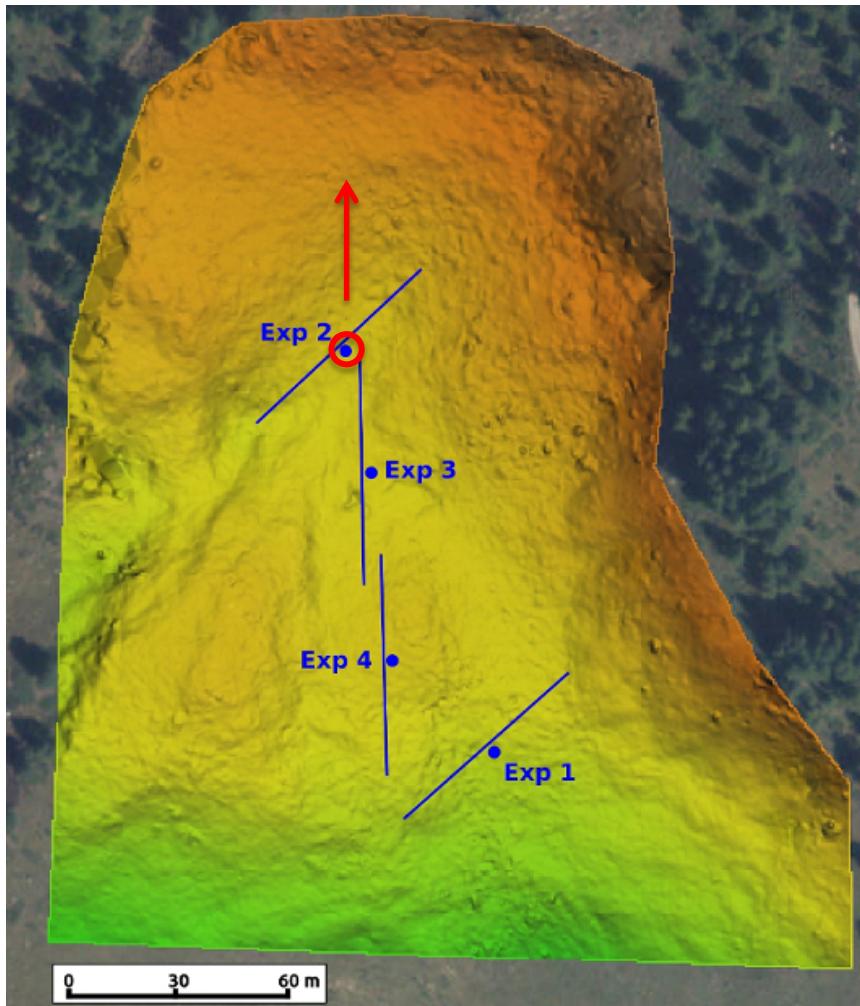


Study site



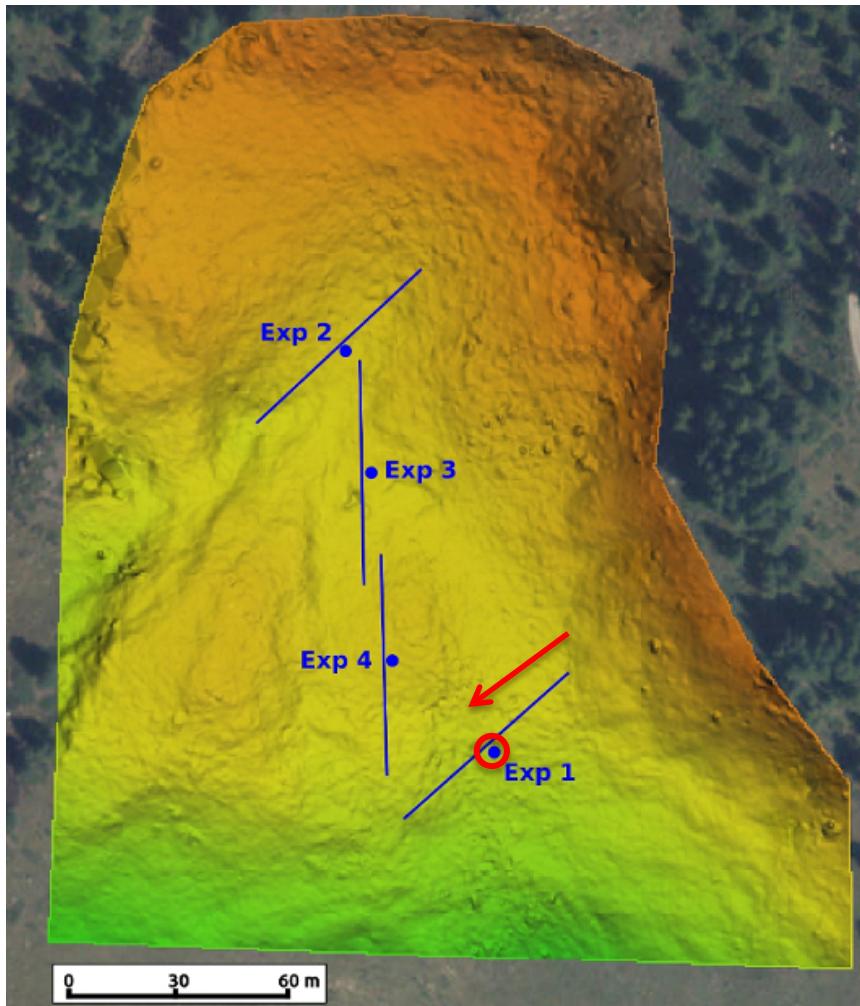


Study site





Study site





Methods



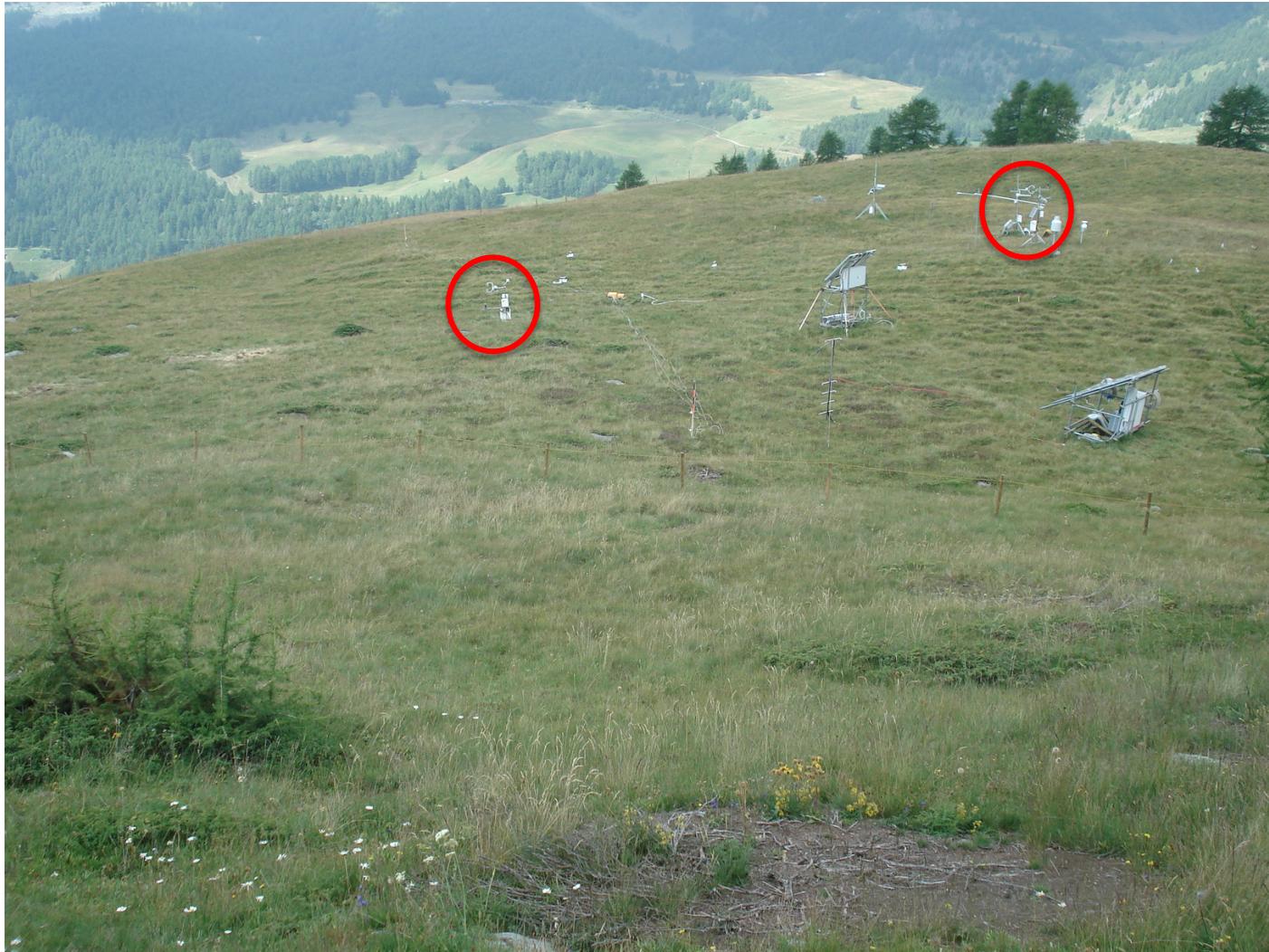
2D mass balance

$$F_c = \overline{c_d} \overline{w} \overline{\chi}$$

Vertical eddy flux



Methods





Methods



2D mass balance

$$F_c = \overline{c_d} \overline{w} \overline{\chi}$$

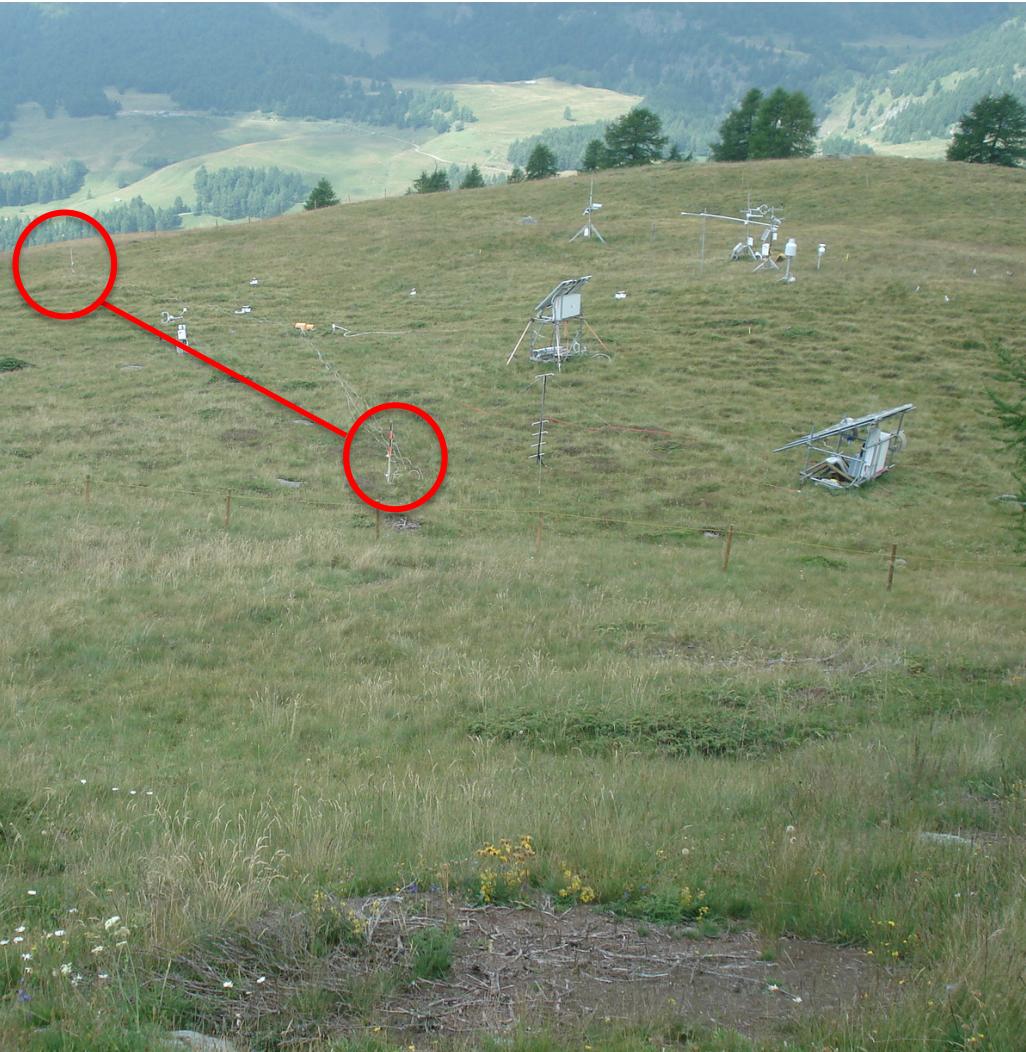
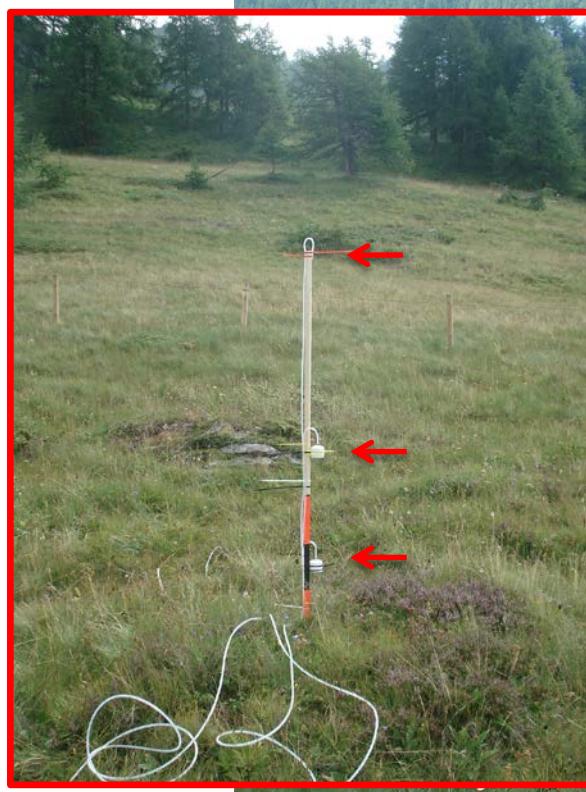
Vertical eddy flux

$$F_s = \overline{c_d} \int_0^{1.65} \frac{\overline{\delta \chi}}{\delta t} dz$$

Storage flux



Methods





Methods



2D mass balance

$$F_c = \overline{c_d} \overline{w} \overline{\chi}$$

Vertical eddy flux

$$F_s = \overline{c_d} \int_0^{1.65} \frac{\overline{\delta \chi}}{\delta t} dz$$

Storage flux

$$F_{ha} = \overline{c_d} \int_0^{1.65} \overline{u} \frac{\overline{\delta \chi}}{\delta x} dz$$

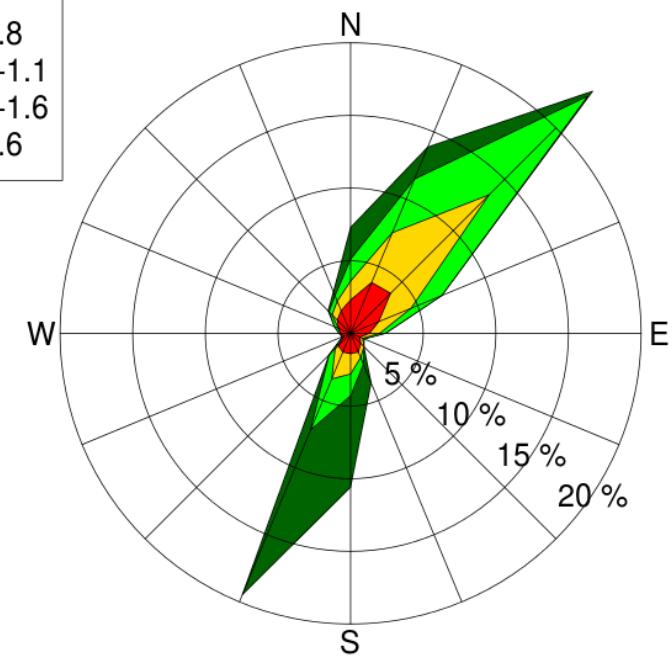
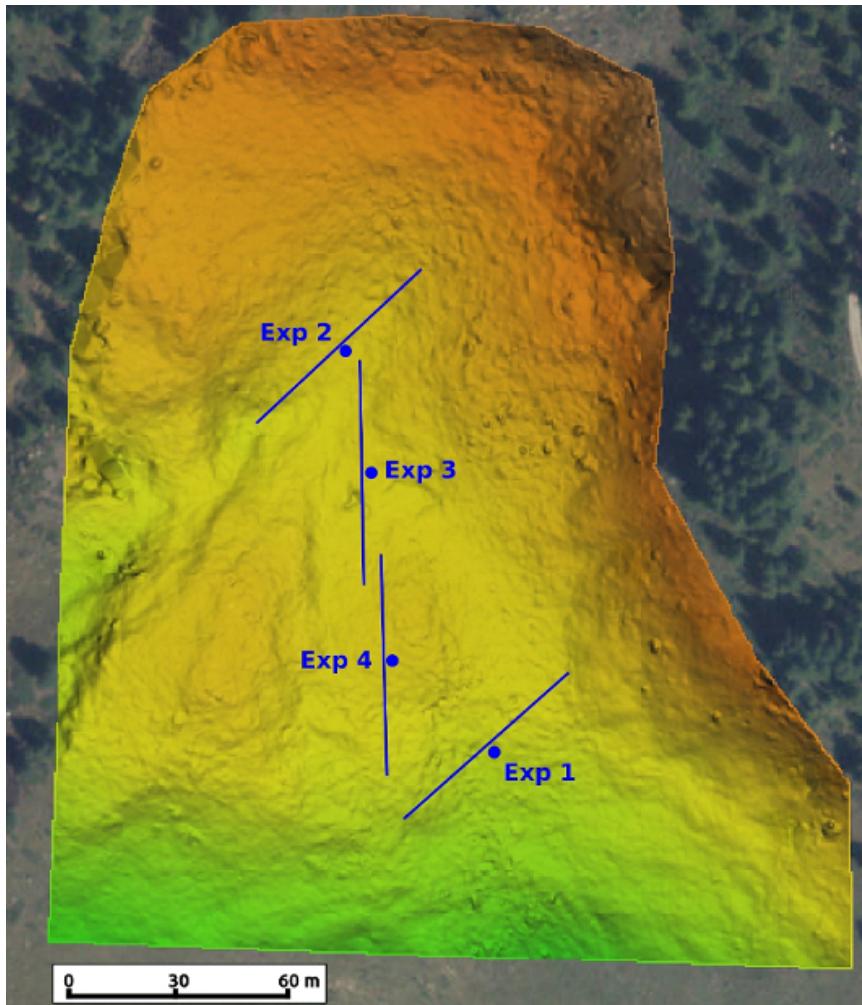
Horizontal advection

$$F_{va} = \overline{c_d} \overline{w}_{1.65} \left(\overline{\chi}_{1.65} - \langle \overline{\chi} \rangle \right)$$

Vertical advection

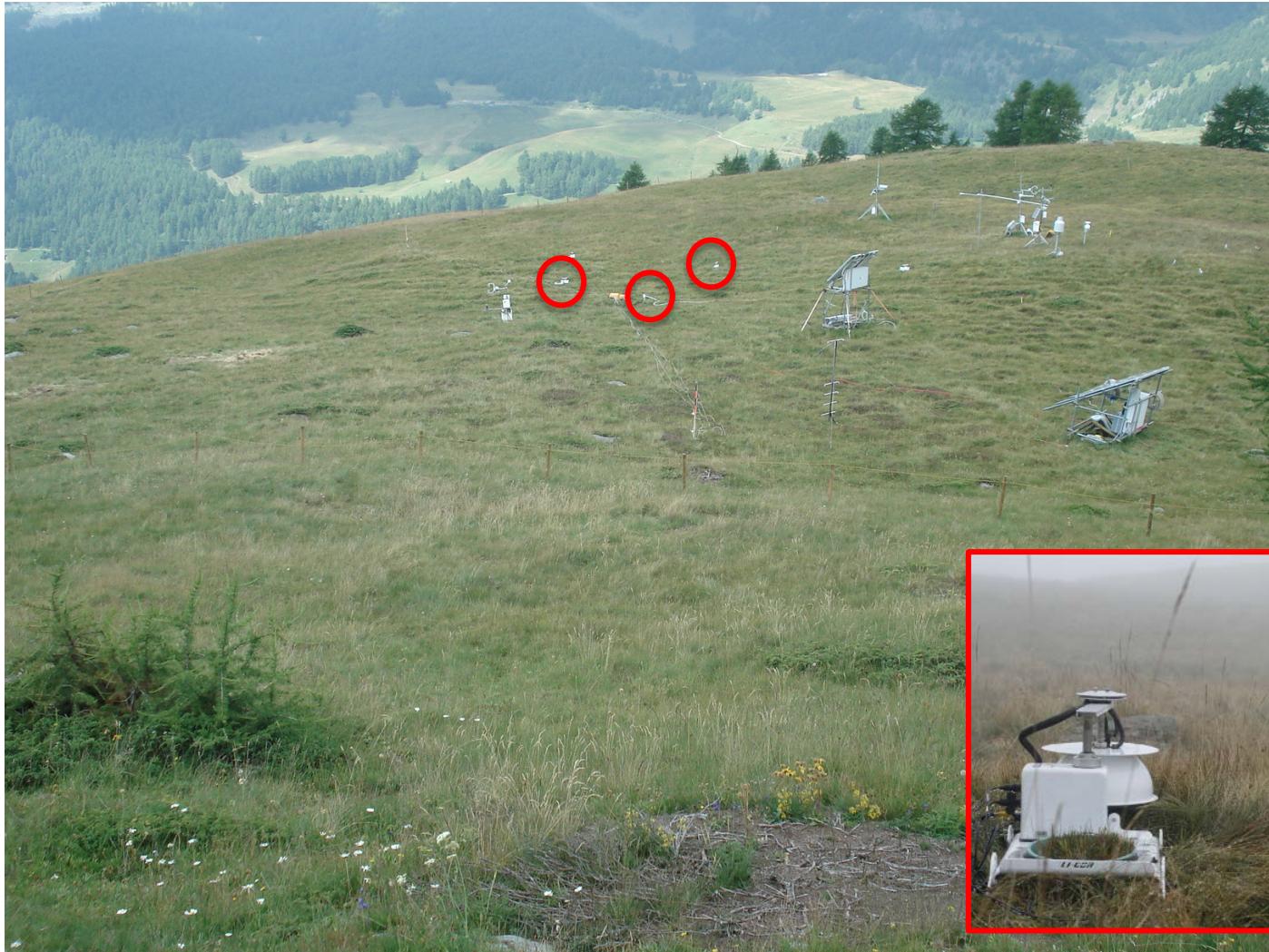


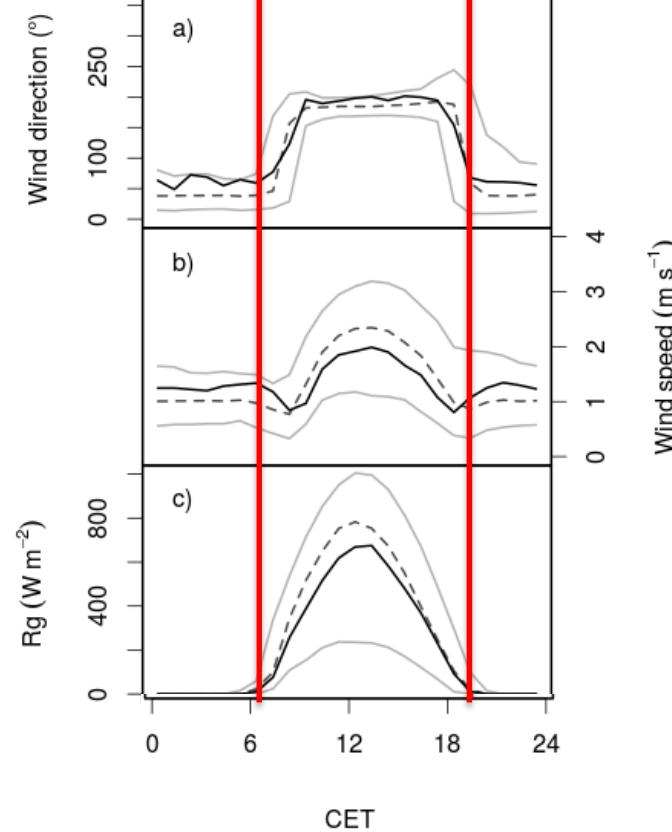
Methods



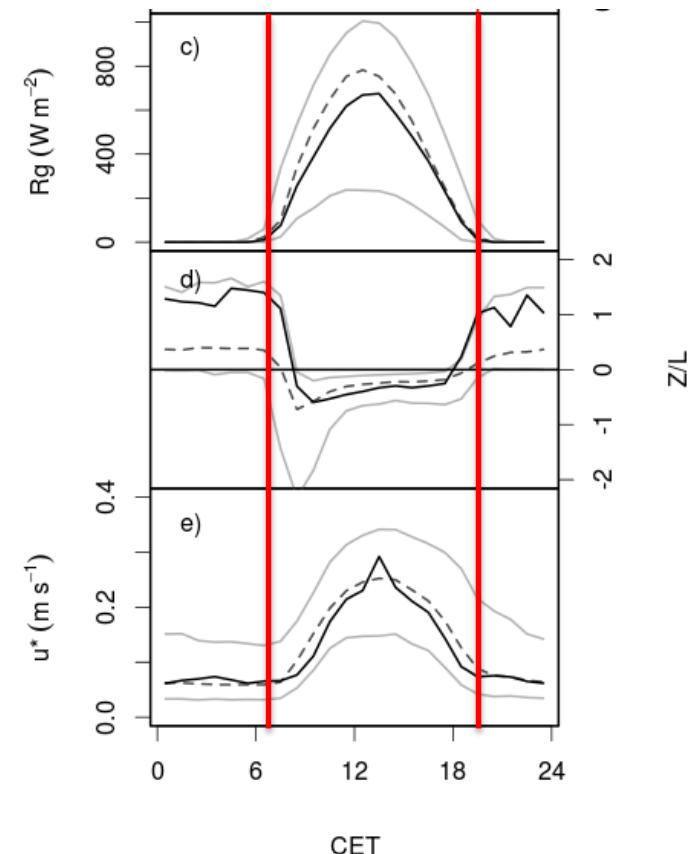


Methods



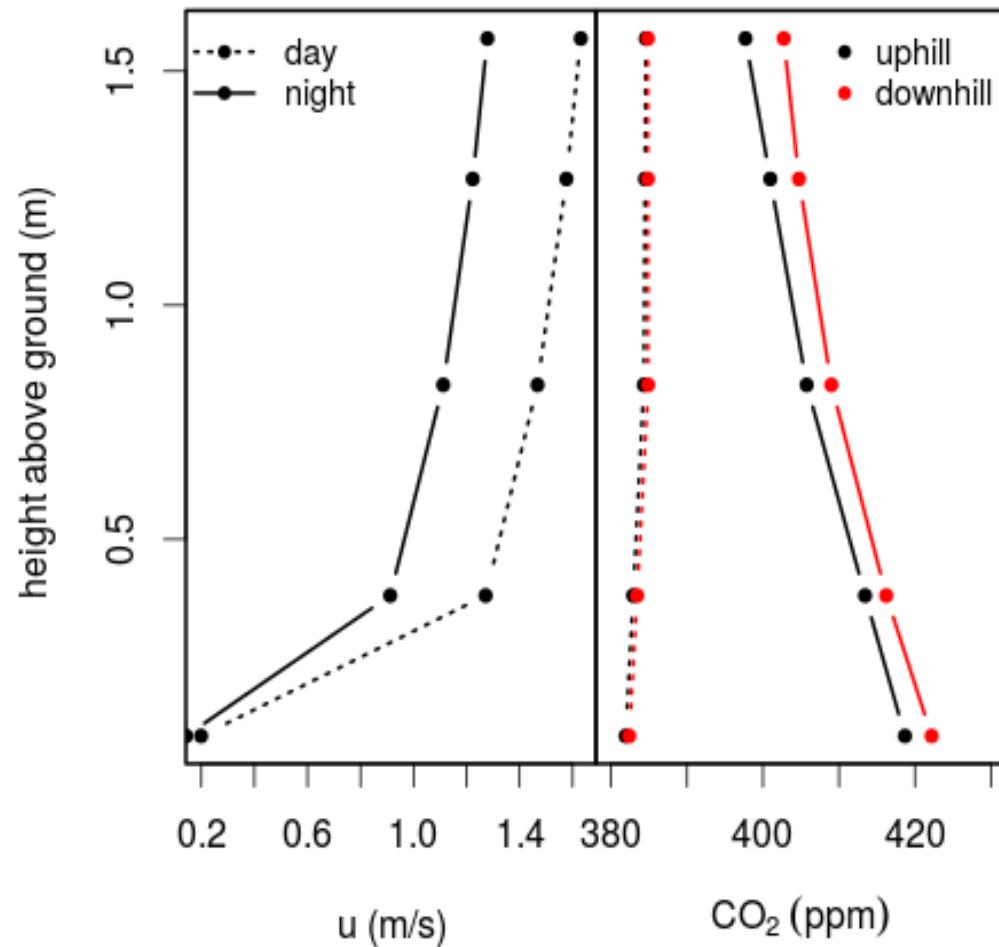


Results



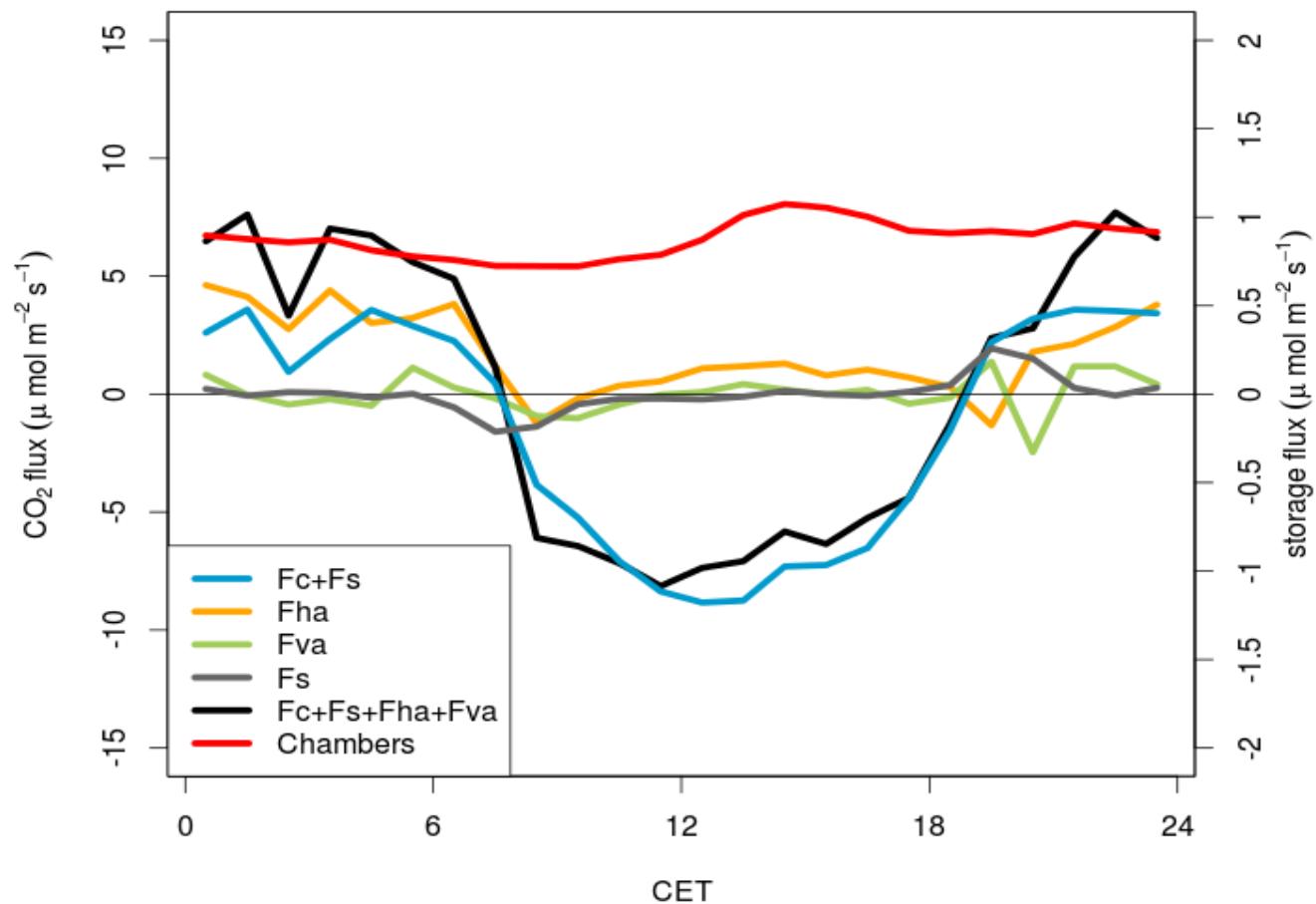


Results





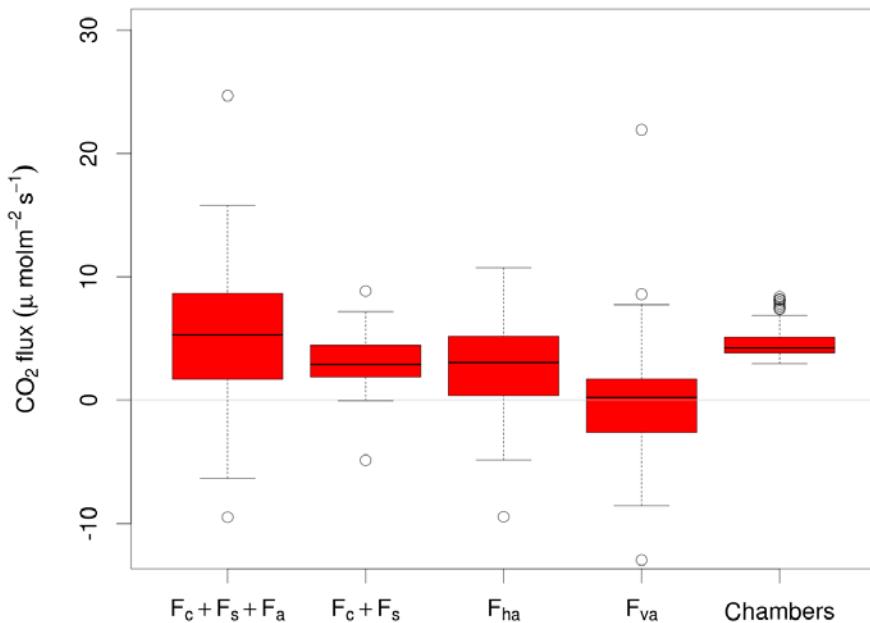
Results



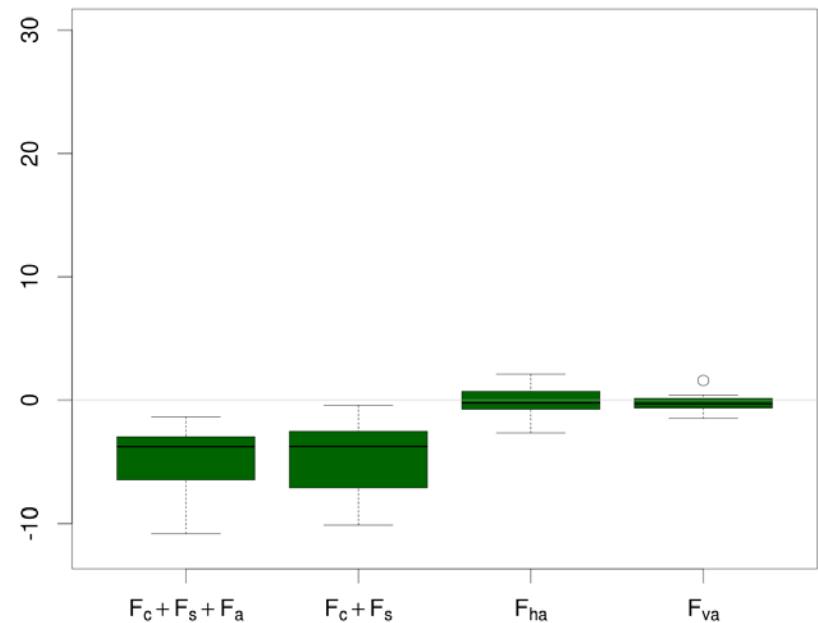


Results

Nighttime



Daytime





Conclusions

- The sum of the vertical covariance term and the storage term considerably underestimated nighttime ecosystem respiration as measured by the automated ecosystem chambers.
- Advection measurements indicated that both horizontal and (less so) vertical advection were important terms of the mass balance during nighttime.
- The NEE calculated by taking advection into account closely resembled nighttime ecosystem respiration as measured with the automated ecosystem chambers.
- During daytime, advection appeared to make a negligible contribution to NEE.
- Large spatial variability in the vertical eddy covariance term within short distances.



Acknowledgments



Der Wissenschaftsfonds.



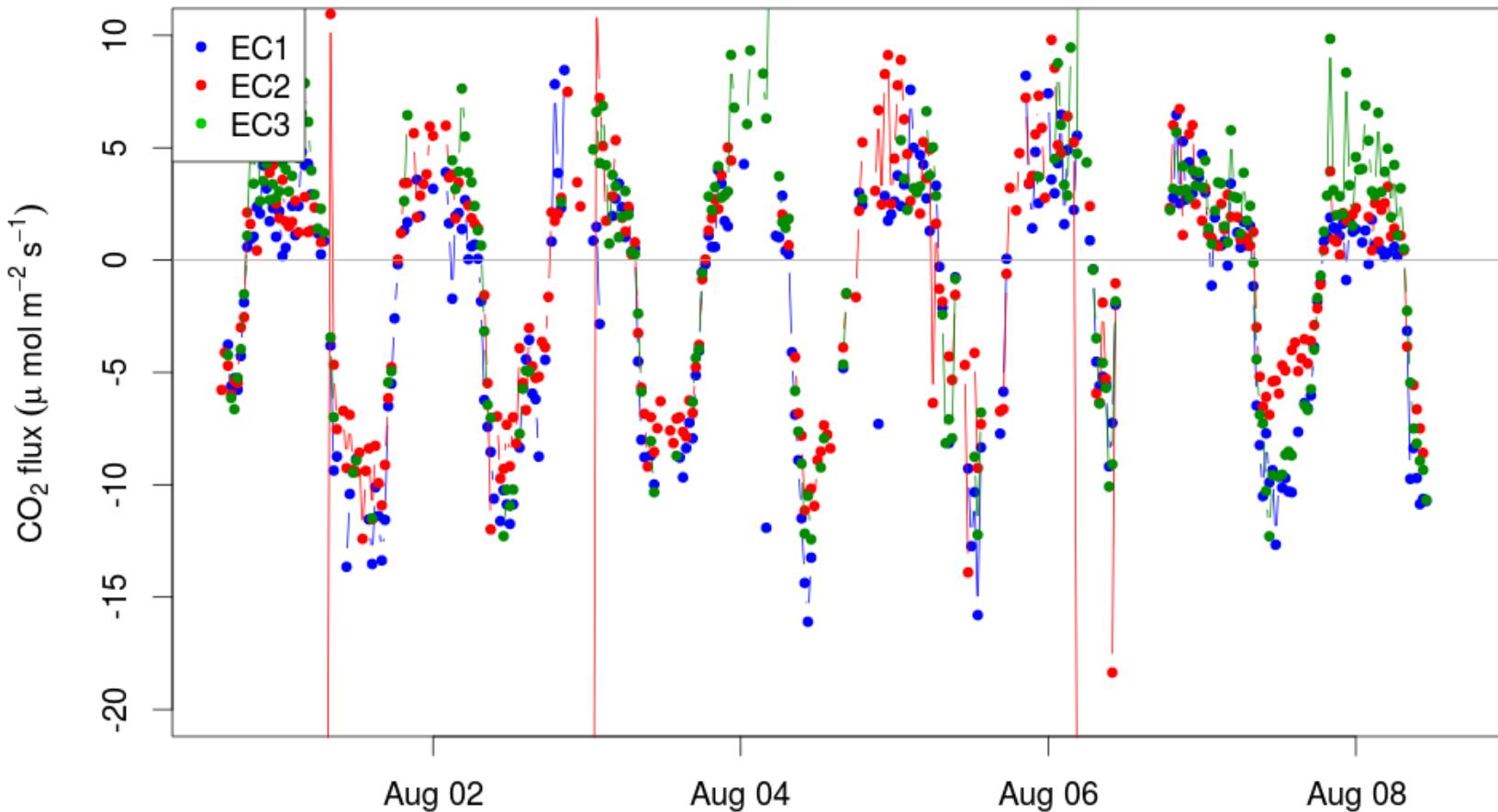
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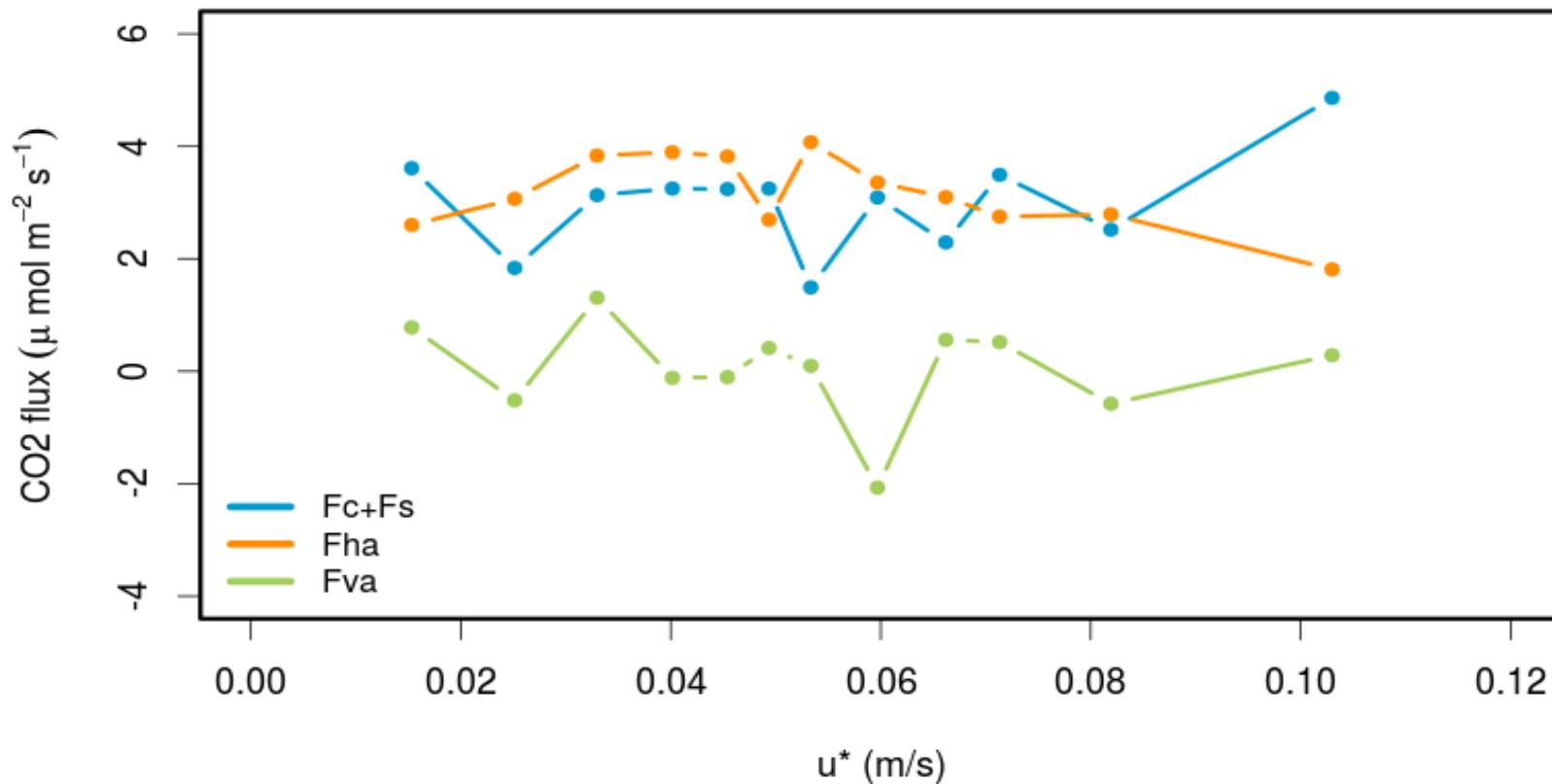


Results





Results





Fog experiment



<http://youtu.be/cPcYVSKRcSI>