Challenges and opportunities of quantifying advection at a mountain forest in the Alps

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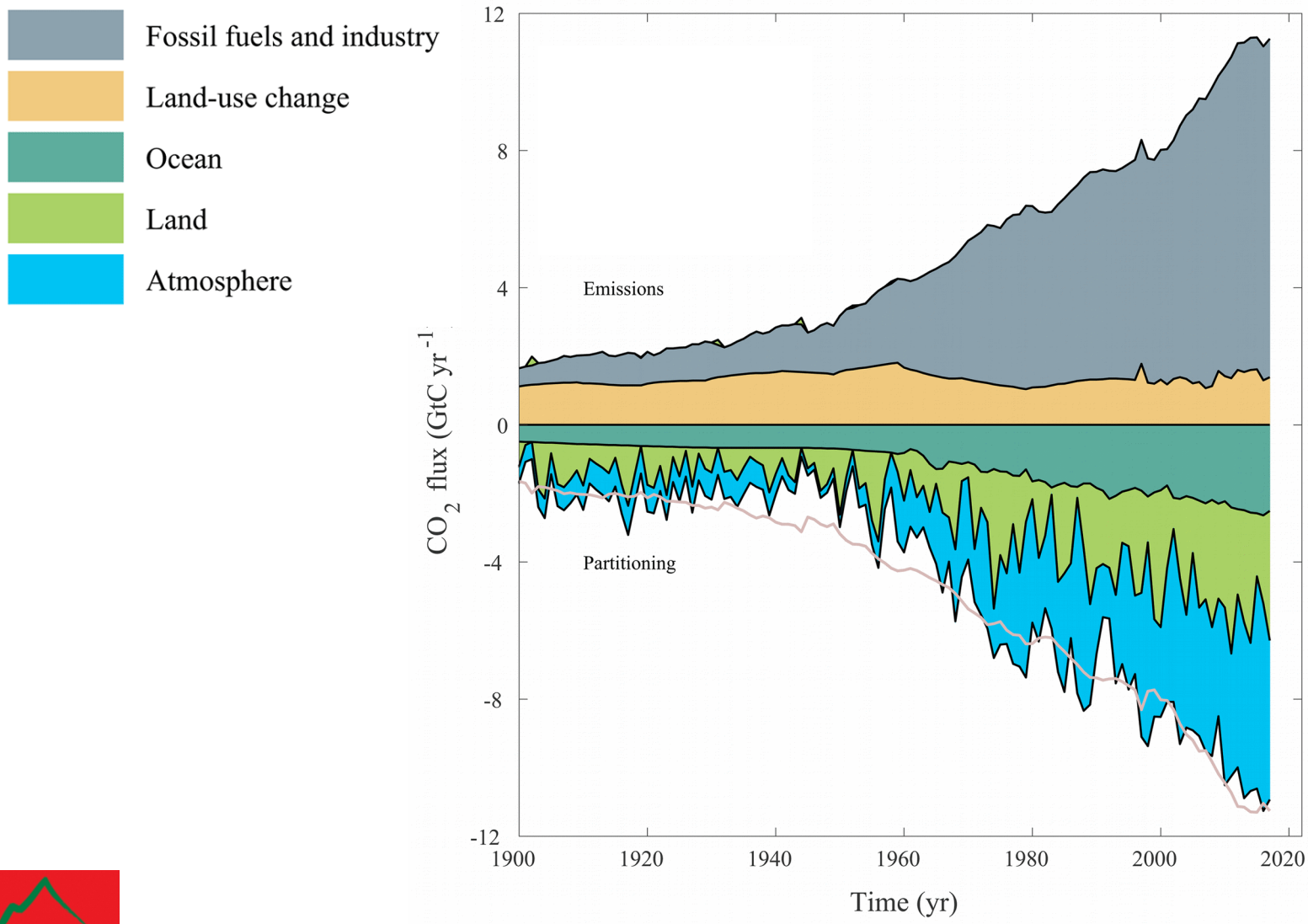

Le Quéré et al.: Global Carbon Budget 2018

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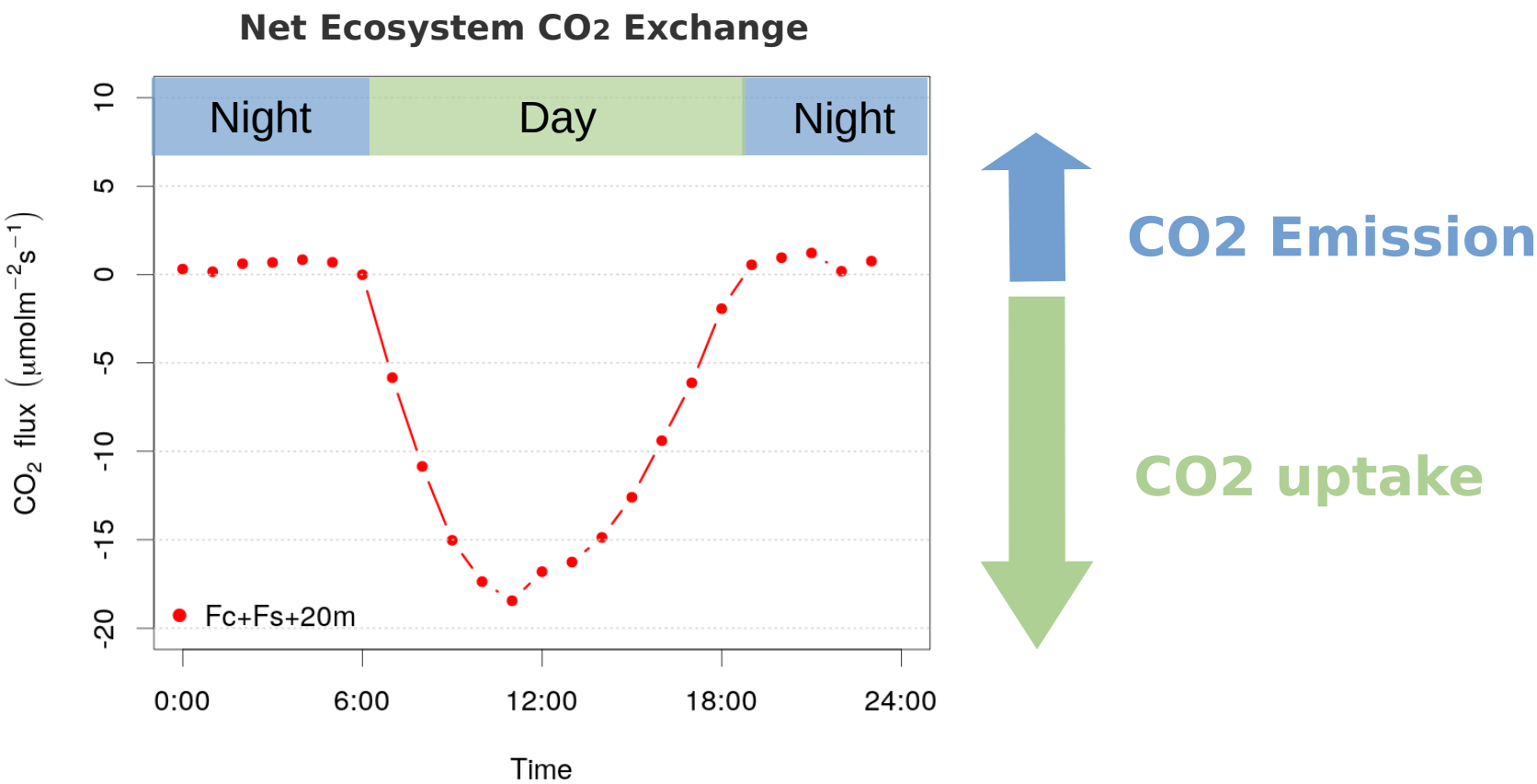

Challenges and opportunities of quantifying advection at a mountain forest in the Alps

- Instrumental set-up
- Spatial scale
- CO_2 sink/source heterogeneity
- Winter season
- Vertical advection

What is truth?

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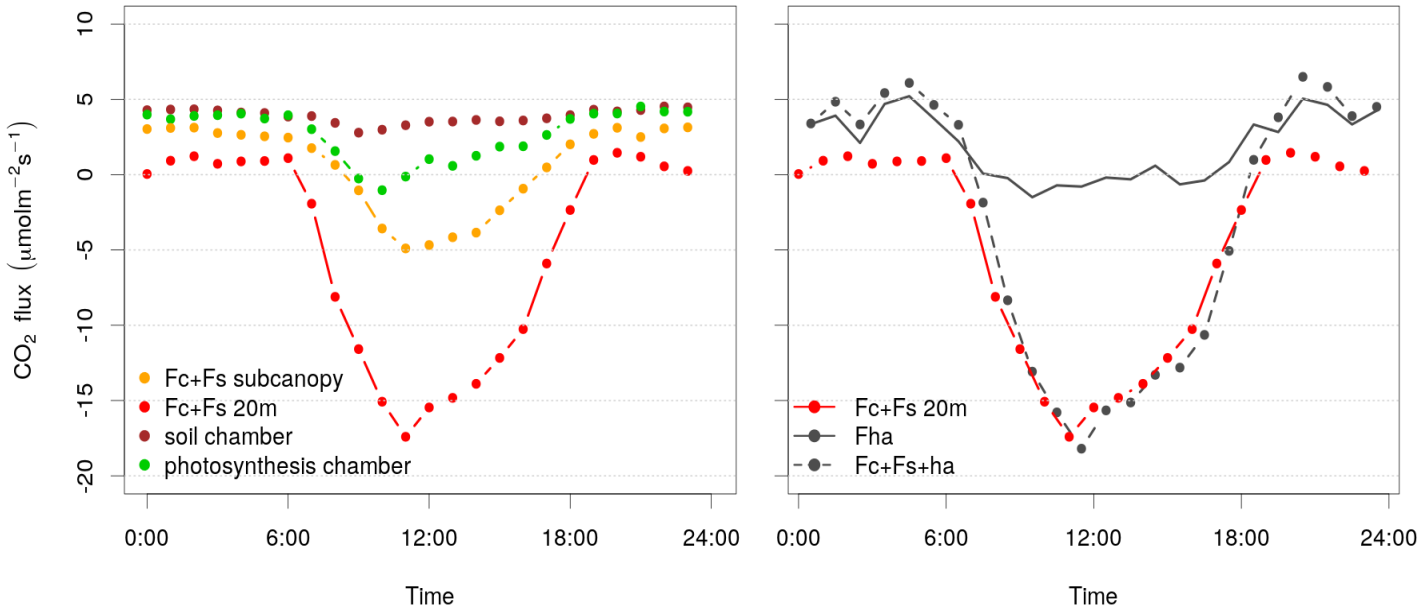
2018 advection field campaign

- Above canopy EC
- Below canopy EC
- Ecosystem chambers
- Advection setup
  (40 x 40 m control volume,
  solenoid valve system,
  multiple CO2 sampling inlets
  multiple 2D anemometers
  multiple T and RH sensors)



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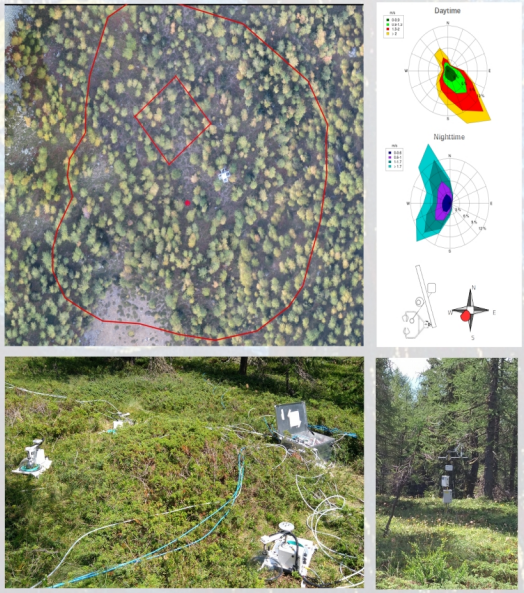
Background

The unaccounted presence of advective CO_2 fluxes has the potential to bias the daily and longer-term CO_2 fluxes, measured by the eddy covariance technique, towards unrealistic net uptake, a bias that urgently needs to be accounted for in order to reduce uncertainties related to role of mountain forests in the global carbon cycle.

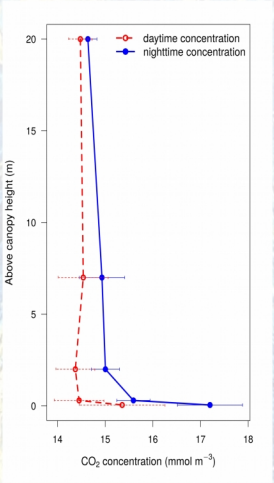
European larch eddy covariance forest site in the Alps (IT-Tfr, Valle d'Aosta, Italy)

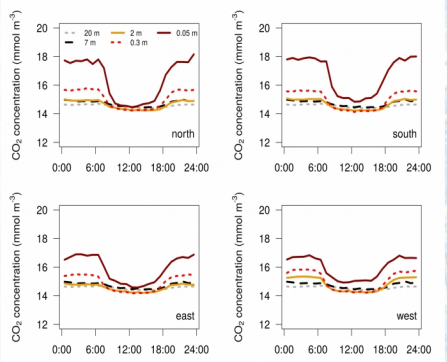
Eddy covariance and advection



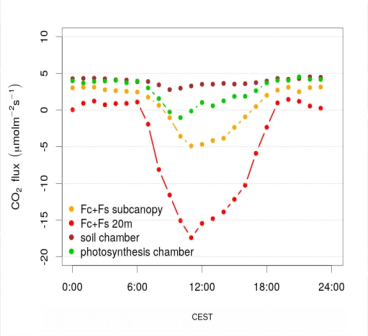
Advection set-up during the field campaign in 2018: (Above) The red square represents the 40x40m advection square, the red point is the location of the subcanopy EC system, the red contour represents the flux footprint (Xmax 85th percentile.; (Below) Multiplexer system for measuring CO_2 concentrations at 3 heights, soil chambers and eddy covariance subcanopy system

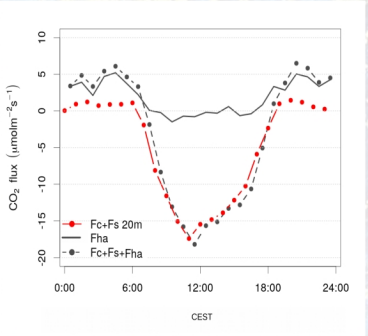
1. CO_2 gradients in advective conditions were shown to be higher at the lowest part of the canopy.





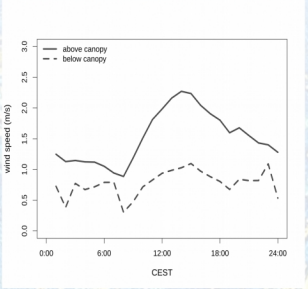
2. Including the horizontal advection term in the CO_2 mass balance improved estimates of NEE at 20 meters.

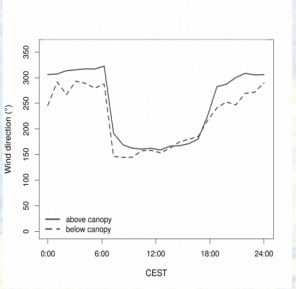




NEE=FC+Fs	*Eddy covariance Net Ecosystem Exchange*
NEE=FC+Fs+Fha+Fha	*Full CO2 mass balance*
Fc	*Mean vertical turbulent flux*
Fs	*Storage term*
Fha	*Horizontal advection term*
Fva	*Vertical advection term*

3. Wind field was typically bi-directional, while wind speed above and below the canopy were decoupled.





Summary and open questions

The main results of this experiment are:

- Eddy covariance measurements of NEE measured above the canopy should be representative of net photosynthesis of vegetation during daytime and of whole ecosystem respiration during nighttime. However, nighttime NEE measured at a single point above the canopy is clearly **underestimated**.
- Including the **horizontal advection** term in the CO_2 mass balance equation at 20m allowed to reach nighttime values close to those of respiration chambers and subcanopy NEE.
- Uncertainties related to the daytime CO_2 gradients are likely due to spatial variability in the **CO_2 sink/sources** within the experimental area
- We found a consistent diurnal pattern of **downslope wind** at night and upslope wind during daytime
- Coupling measurements of above and below canopy eddy covariance in mountain forest sites seems essential for detecting the unaccounted CO_2 flux. Spatial heterogeneity and differing footprints may partially contribute to the mismatch between **sub-canopy** EC and chambers.
- Further analysis will include also **vertical advection** into the mass balance equation, even if this term often results in unrealistic and highly erratic fluxes

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