Measurement of advection of carbon dioxide over grasslands in complex terrains in the Alps

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Background

Estimates of net ecosystem exchange (NEE) have been attracting a lot of attention because of the important role of CO_2 on global warming. The contribution of advection is often ignored in the estimation of NEE; however, some studies reported that more realistic estimates of night-time NEE could be gathered if horizontal and vertical advections are included. In a preliminary simplified study, advection showed an important contribution to NEE during night time at a sub-alpine grassland site.

Objectives

- To quantify the contribution of advection to the NEE at several grassland sites situated in complex terrain in the Alps.
- To quantify the effect of spatial scale of advection measurements with a given experimental setup.

Methods

We are going to carry out field campaigns at four sites which cover a range of terrain types typical for mountains with varying degrees of complexity. Observations will follow the ‘advection completed mass balance’ (ACMB) approach and will take place in a notional control volume with a length varying from 5 m to 50 m at each site in order to quantify the effects of horizontal spatial scale on advection estimates.

The ACMB approach is applied as follows:

1. the storage of CO_2 is calculated from the concentration measurement,
2. the vertical turbulent transport is measured by eddy-covariance method and post-processed with the state-of-art quality-control methods,
3. the vertical advection as well as
4. the horizontal advection is obtained by sampling the air at multiple positions across the faces at three heights of the control volume, and
5. NEE is measured by chambers. While most of previous advection experiments have been conducted in forest ecosystems and conceptually hampered by a lack of “ground-truth”, our study on grassland ecosystems has a great advantage as a quantitative estimate of ecosystem-scale NEE could be realized so that the sum of ACMB components could be compared against.

Expected results

- quantitative vertical and horizontal advection estimates for short-statured ecosystems
- assessing whether the limitations of previous advection experiments at forested sites apply to short canopies as well
- systematic assessment of the effects of spatial scale on advection experiments

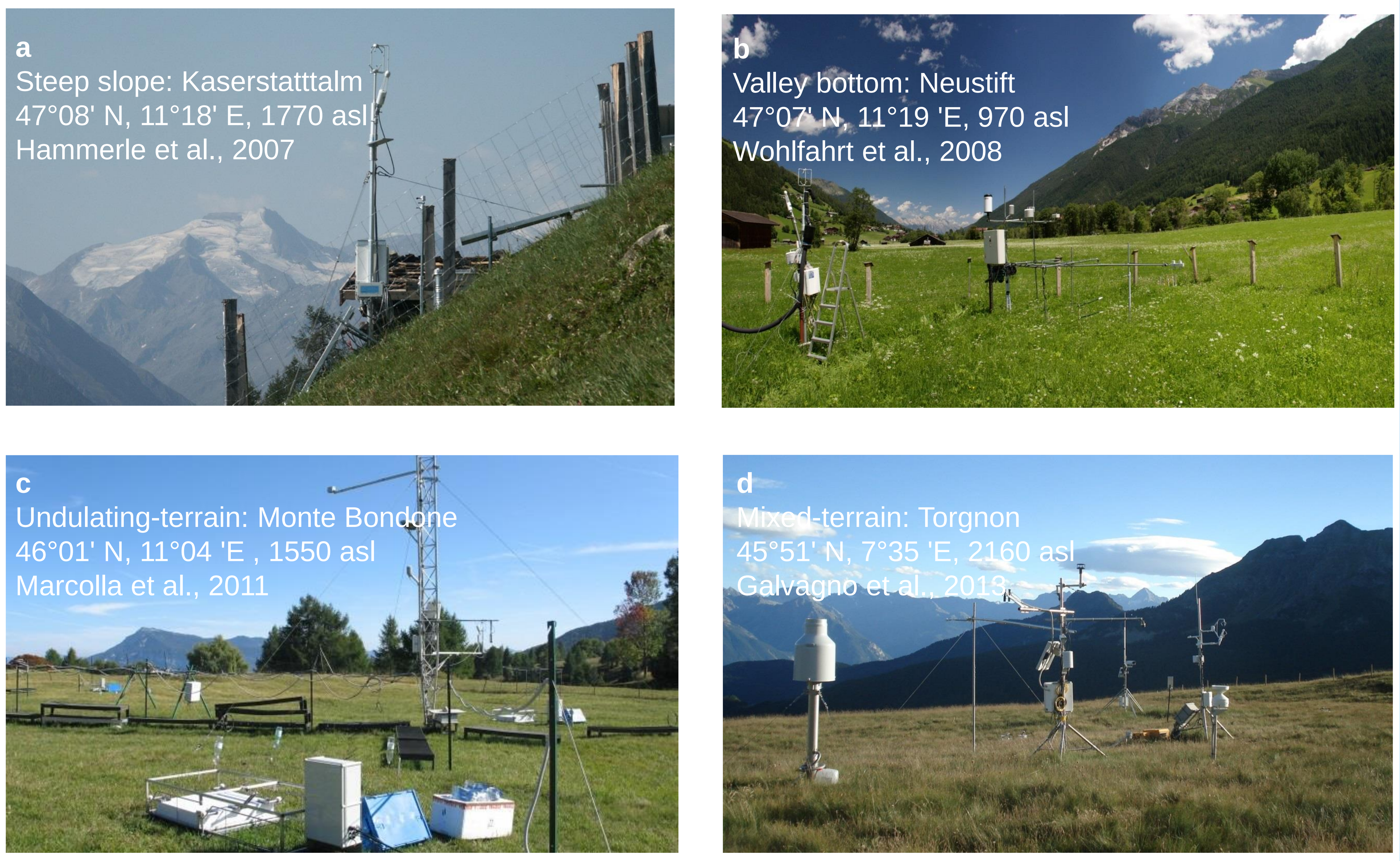

Figure 1: Photographs of the research sites.

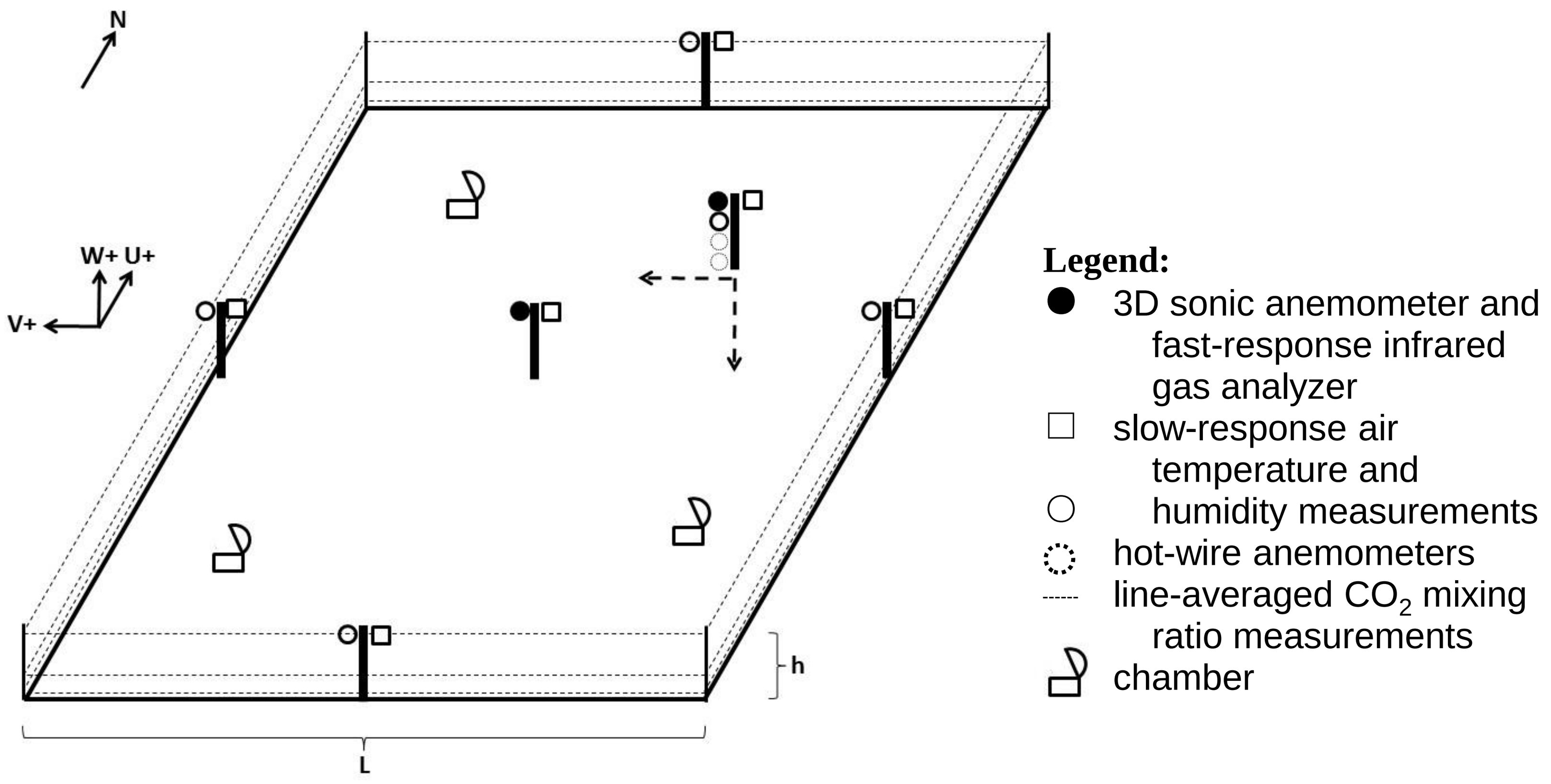

Figure 2: Sketch of planned experimental setup.

Equations

$\bar{F}_{c,t} = \overline{c_d}\,\overline{w'\chi'}\vert_h$ **Turbulent flux**	**Storage** $\bar{F}_{c,s} = \frac{\overline{c_d}}{\Delta t}\left(\sum_{j=1}^{3} \langle \chi_{c,j} \rangle \Delta z \vert_{t=\Delta t} - \sum_{j=1}^{3} \langle \chi_{c,j} \rangle \Delta z \vert_{t=0}\right)$
Vertical advection flux $\bar{F}_{c,v} = \overline{c_d}\langle \overline{w_c}(h) \rangle \left(\langle \overline{\chi_c}(h) \rangle - \frac{\sum_{j=1}^{3} \langle \overline{\chi_{c,j}}(z) \rangle S_j \Delta z}{\sum_{j=1}^{3} S_j \Delta z}\right)$ $S(z) = \frac{u(z)}{u_h} = \frac{v(z)}{v_h}$	**Horizontal advection flux** $\bar{F}_{c,h} = \frac{\overline{c_d u_h}}{L}\left(\sum_{j=1}^{3} W_j \langle \overline{\chi_{c,j}} \rangle \vert_{x=L} - \sum_{j=1}^{3} W_j \langle \overline{\chi_{c,j}} \rangle \vert_{x=0}\right) + \frac{\overline{c_d v_h}}{L}\left(\sum_{j=1}^{3} W_j \langle \overline{\chi_{c,j}} \rangle \vert_{y=L} - \sum_{j=1}^{3} W_j \langle \overline{\chi_{c,j}} \rangle \vert_{y=0}\right)$ $W_j = S(z_j)\Delta z_j$

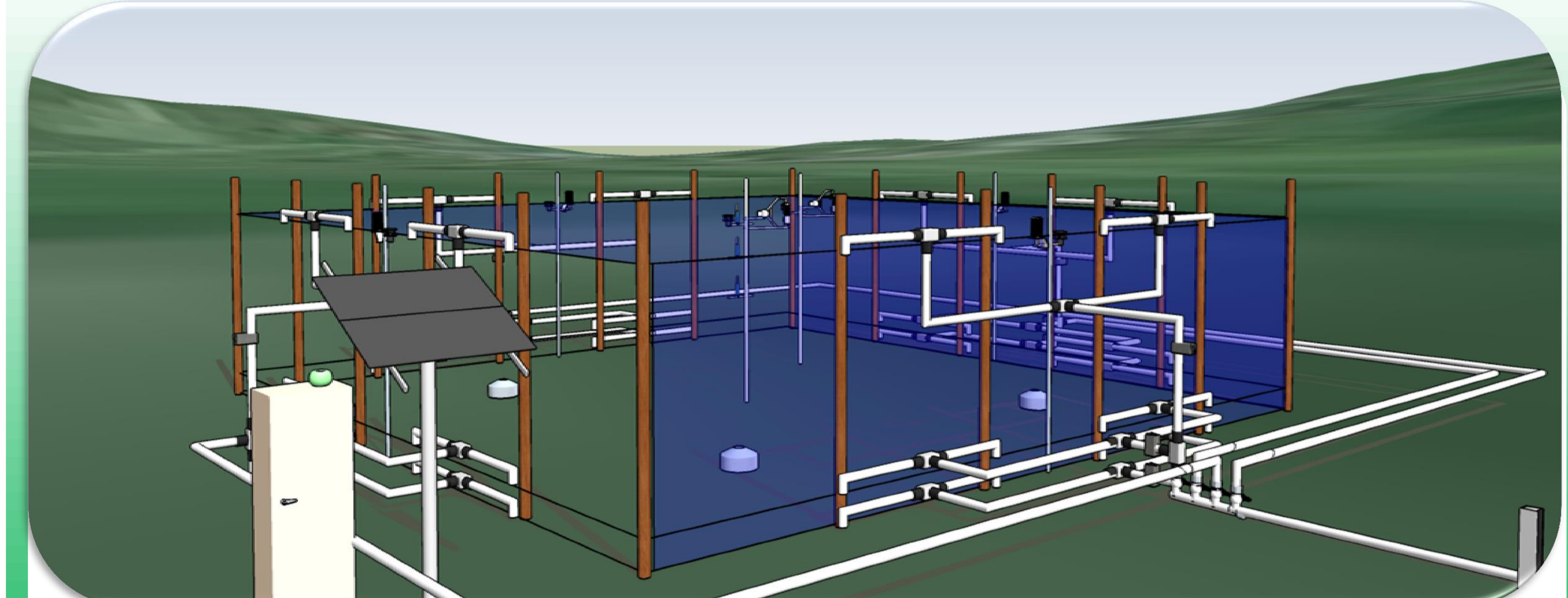

Figure 3: 3D sketch of the experimental setup.

Acknowledgements

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