Multi-instrument advection measurements in complex terrain

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Abstract

This poster presents the methodology and experiment setup of an advection and in-canopy flow study in heterogeneous terrain in a sloping forest. It is part of the EGER (ExchanGE processes in mountainous Regions) Experiment with observation periods in autumn of 2007 and summer of 2008.
For the FLUXNET station Waldstein Weidenbrunnen in Germany, the significance of horizontal and vertical advection was studied during the WALDATEM 2003 experiment. Whereas the design used during the WALDATEM 2003 experiment was based on a single analyzer switching valve system, which resulted in a temporal resolution not better than 15 minutes per cycle, the new design, presented by this poster, utilizes a multi instrument setup to measure continuous time series of carbon dioxide and water vapour concentration at 10 inlets with a temporal resolution of 1 second. This allows not only the analysis of gradients based on high resolution measurements, both in space and time, but also the study of time dependent flow phenomena within the forest canopy over a whole range of timescales.

Hypotheses

The in-canopy horizontal advection regime of carbon dioxide, water vapour and other scalars is not determined by a slope induced concentration gradient alone but is affected by sweep an ejection phases of coherent structures.

Method

- Measurement of horizontal gradients of carbon dioxide and water vapour as a continuous timeseries with 1 Hz temporal resolution and high spatial resolution to allow integrated analysis of horizontal transect and grid data with high resolution vertical profile data from eddy covariance systems. The continuous time series can be obtained with a multi-instrument setup, equipped with a refined automatic calibration proceedure.
- Analysis of coherent structures and short lived events at different spatial and temporal scales by wavelet analysis in addition to traditional gradient analysis.

Site

The experiment site is situated in a spruce forest in the Fichtelgebirge mountains at the FLUXNET station Waldstein Weidenbrunnen in Germany. Height above sea level: 775 m, canopy heigth: 23 m.

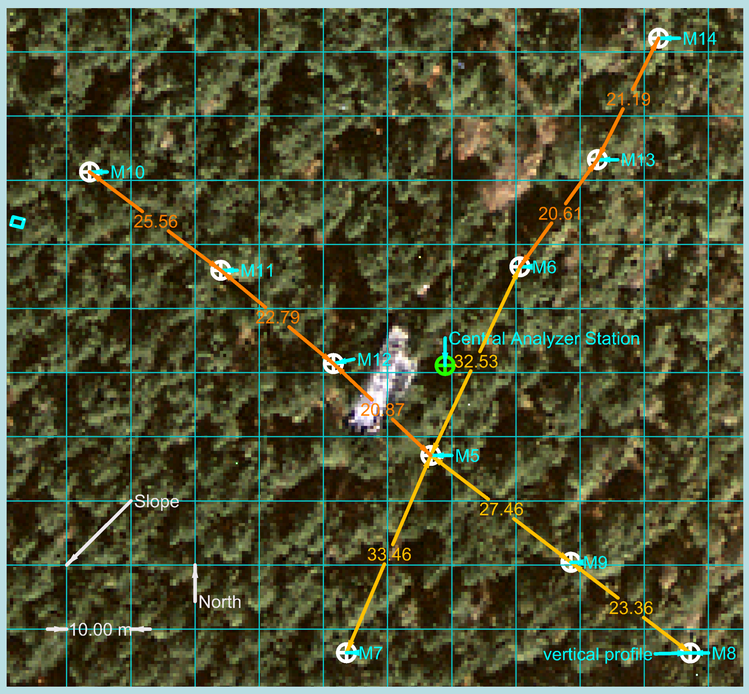

Figure 1: Position of sub-canopy masts "M5" to "M14" along horizontal transects, infrared gas analyzers ("central analyser station") and the tower ("vertical profile"). Units are given in meters [m].

Setup

The design, illustrated in Figure 1 has two measurement levels: 2.25 m (1 s resolution) and 1 m height (1 min resolution).

The 2.25 m level is equipped with:

- 10 horizontal sample points for CO_2 (7 of them with H_2O),
- 5 horizontal sample points parallel to the slope and 6 perpendicular to the slope,
- 10 infrared gas analyzers, (5x LI-6262 (LI-COR), 1x LI-6251 (LI-COR), 4x Binos (Leybold Heraeus)),
- 6 sonic anemometers, USA-1 (METEK),
- central analyzer station with automatic temperature control, flow control,
- automatic calibration system, calibration cycle: 4 hours.

The 1 m level is equipped with:

- 5 horizontal sample points for humidity (psychrometer),
- 5 horizontal sample points for wind speed (cup anemometer).

Figure 2: Sub-canopy advection mast equipped with sonic anemometer USA-1, CO_2 inlet, psychrometer and cup anemometer.

Figure 3: Infrared gas analyzers LI-6262 in a temperature controlled environment.

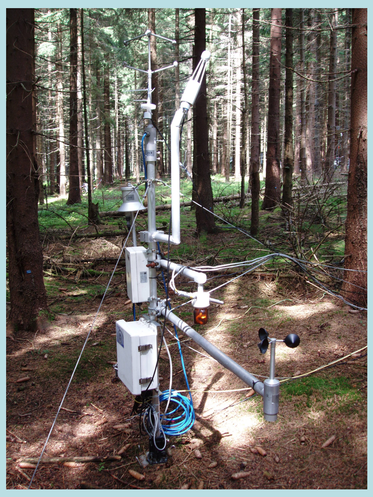

Figure 4: Sub-canopy advection mast equipped with LI-7500 open path IRGA and closed path IRGA inlet for inter system comparison (open versus closed path).

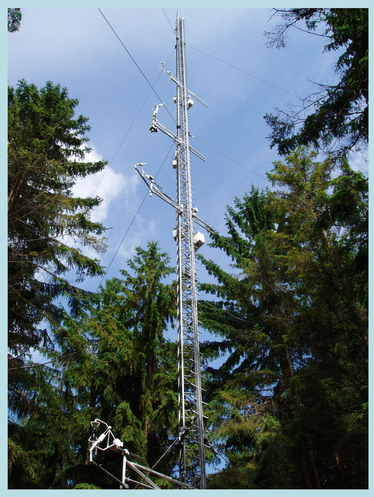

Figure 5: Vertical profile of wind, temperature, CO_2 and H_2O measurements using CSAT3 sonics and LI-7500 IRGA's. Measurement heights are 2, 5, 13, 18, 23 and 36 m.

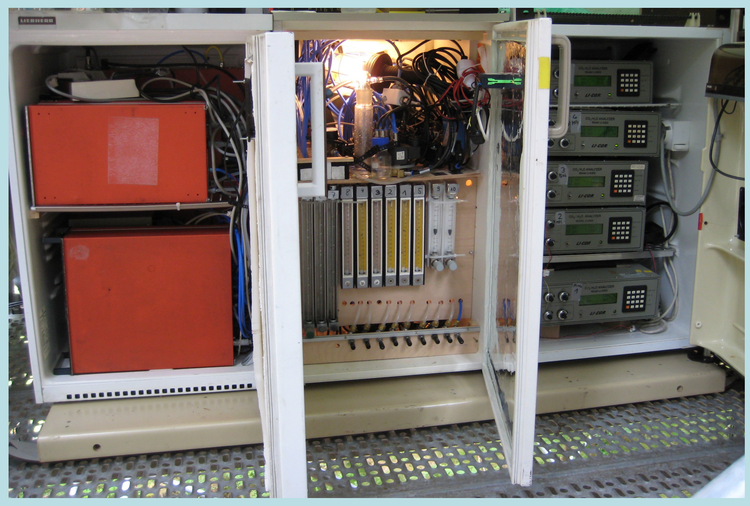

Figure 6: Central analyzer station holding 10 infrared gas analyzers, BINOS (left), LI-6262 (right), calibration and flow control unit (center).

Analysis

Wavelet analysis can be used to analyze coherent structures and their characteristic event duration in the vertical and horizontal profiles. Figures 7, 8 and 9 illustrate some of the steps performed during wavelet analysis to detect temporal structures and their characteristic length scales. Figures are given to illustrate the method only.

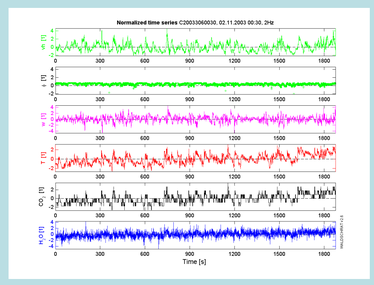

Figure 7: Normalized time series of windspeed (vh), wind direction (phi), vertical wind speed (w), sonic temperature (T), CO_2 and water vapour (H_2O).

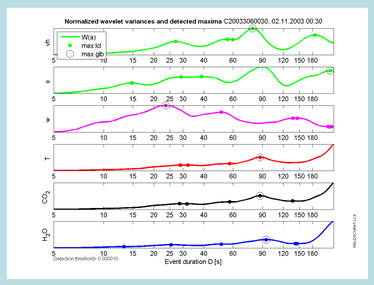

Figure 8: Detection of local and global maxima in wavelet variance, indicating event duration.

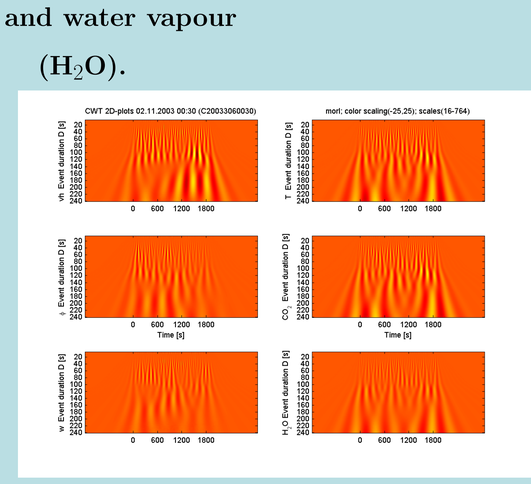

Figure 9: Wavelet spectra showing event duration over time.

Results and Conclusion

The study is currently in the middle of an intensive observation period. Data will be analyzed in the near future as soon as the measurements are completed. This is the reason why no results are given on this poster.

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