Atmospheric Transport and Chemistry in Forest Ecosystems
Thurnau, Germany, October 5th – 8th 2009

UNIVERSITÄT BAYREUTH

BayCEER Bayreuth Center of Ecology and Environmental Research

Multilevel Investigation of Subcanopy Respiration by Conditional Sampling

TOBIAS GERKEN (1,2), ANDREI SERAFIMOVICH (1), THOMAS FOKEN (1)

(1) University of Bayreuth, Micrometeorology Department, Bayreuth, Germany
(2) University of Cambridge, Atmospheric Processes, Cambridge, United Kingdom

EGER

Introduction

Readily available Eddy Covariance (EC) measurements of vertical wind velocity, water vapor and CO_2 provide information about the net ecosystem exchange of ecosystems. Determining the components of CO_2 exchange results more difficult. We tested a newly devolved method for evaluating subcanopy respiration Thomas et al. 2008) during the first Intensive Observation Periods (IOP) of the EGER project (ExchanGE processes in mountainous Regions), which focused on the detailed quantification of relevant processes within the soil-vegetation-atmosphere system by observing diurnal and annual cycles of energy, water and trace gases. This method applies a conditional sampling of the information provided by EC systems. It is possible to classify eddies by quadrant analysis according to their respective CO_2 (c`) and water vapor (q`) signatures (Fig.1 – Scanlon and Albertson, 2001).

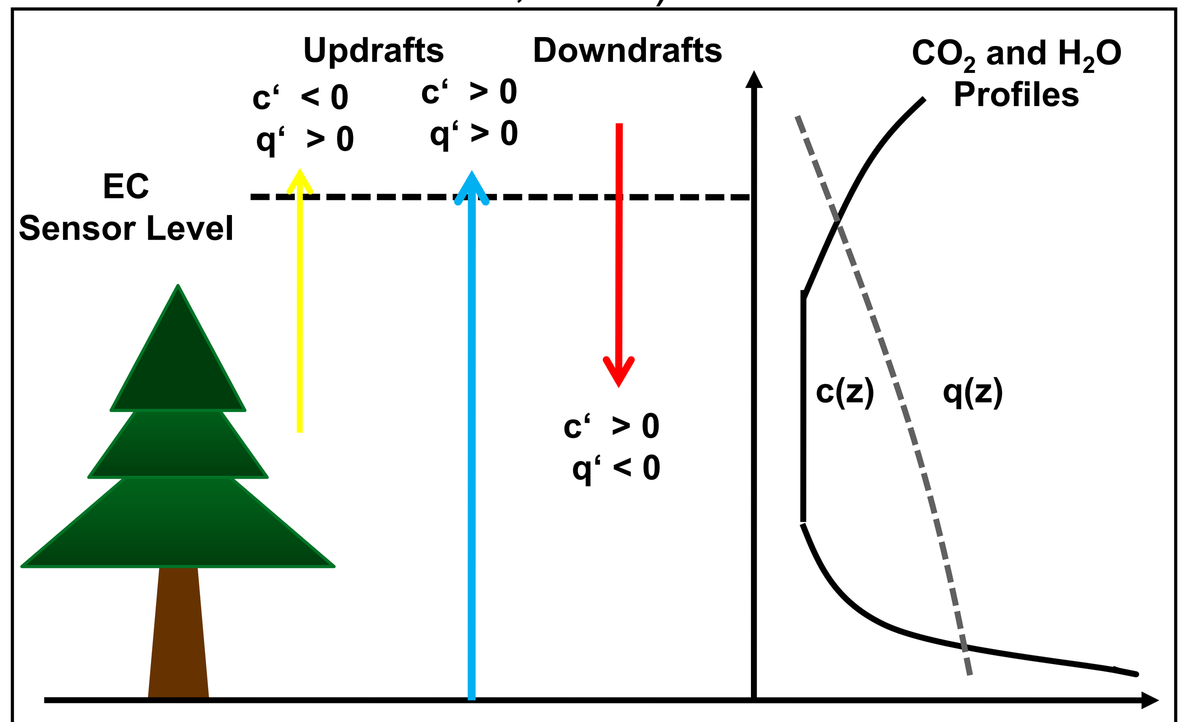

Figure 1: Conceptual model of CO_2 and water vapor relationships, during daytime conditions in a forest, making it possible to determine the origin of eddies

Eddies originating from close to the ground bear a positive c` and q` imprint due to the soil acting as a source for CO_2 and water vapor thus establishing a unique and identifiable characteristic. These eddies can be extracted trough an appropriate algorithm based on modified Relaxed Eddy Accumulation Technique (Businger and Oncley, 1990).

Subcanopy Respiration Results

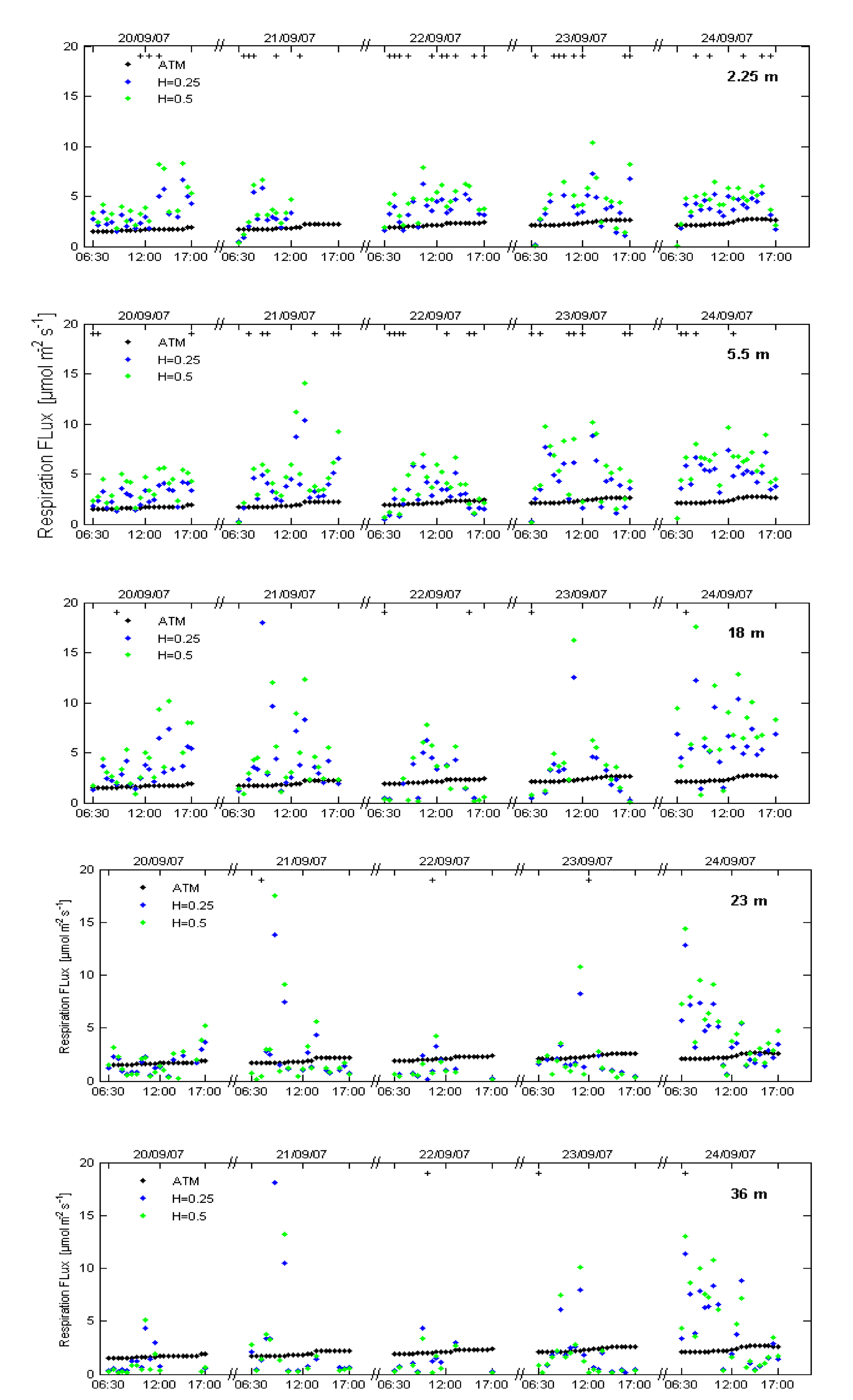

Figure 2: Determined subcanopy respiration rates at 5 heights with two algorithm specifications (H = 0.25 and 0.5) compared to a simple Arrhenius respiration estimate (ATM) during 5 days in September 2007

Figure 2 shows the determined daytime respiration rates during 5 days in Sep. 2007. We found that the below canopy EC systems (2.25 m /5.5 m) overestimated the respiration rates approximately by a factor of two whereas the sensors close to the top of the canopy level and in the air above the canopy agreed reasonably well with respiration estimates calculated by a temperature response function.

The failure of the method for below canopy systems is due to methodological constraints. We found that the determination of EC signatures is only meaningful for the upper systems as the lower sensors do not catch the canopy signal and therefore leading to false classifications in the conditional sampling.

Respiration Signal Transport

We also investigated the transport of the respiration flux information through the canopy. The respiration signal was very closely influenced by the timeshare of sampled respiration events. The abundance of respiration events was related to the occurrence of turbulence, indicated by greater values of u_* (Fig. 3). We also investigated the influence of coherent structures and the overall exchange state of the canopy. The canopy coupling regime seemed to have little influence on the exchange of the CO_2 efflux. This can be seen in Table 1. There have been no significant differences in the respiration fluxes for the more coupled states. Less coupled states were rarely present during the daytime making the results difficult to interpret.

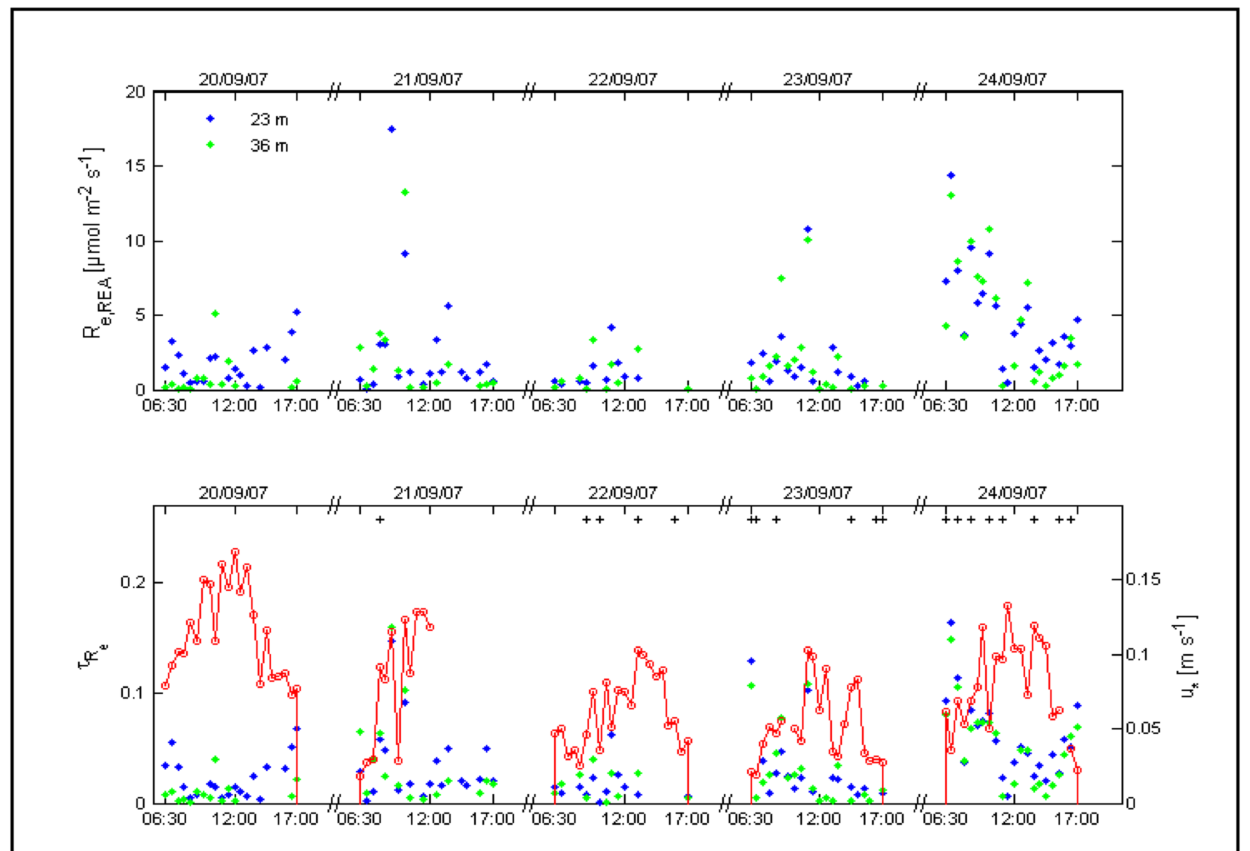

Figure 3: Subcanopy respiration flux at 23 m and 36 m (upper) and timeshare of respiration events (τ) displayed with friction velocity u_* at 5 m (red line)

Respiration Events and Durations

About 50 – 60% of all detected respiration events can be classified as small scale events with event durations (D_{Re}), defined as period of consecutive time series entries with eddy signatures corresponding to subcanopy respiration.
However there was also a number of longer events that were also of high importance for the magnitude

Table 1: *Mean respiration flux (R_e) and timeshare of respiration events (τ) for different canopy exchange regimes.*

	Exchange Regime	R_e [µmol m⁻²s⁻¹]	τ(R_e) [%]	No. of Events
C	fully coupled atmosphere – canopy system	3.1 4.1	3,6	13
Cs	partially coupled canopy	2.6 2.7	3,3	26
Ds	decoupled subcanopy	3.2 3.0	3,7	19
Dc	decoupled canopy	1.0 1.2	2,0	5
W	wave motion	1.3 0.8	7,8	2

of the respiration flux. Long events with timescales of more than 10 s made up less than 1% of all events, but remained of significant importance towards the subcanopy respiration signal. The maximum event timescales of 10 - 50 s were found to lie within the characteristic event durations of coherent structures at this location, highlighting the potential influence of coherent motions on trace gas transport (Figure 4).

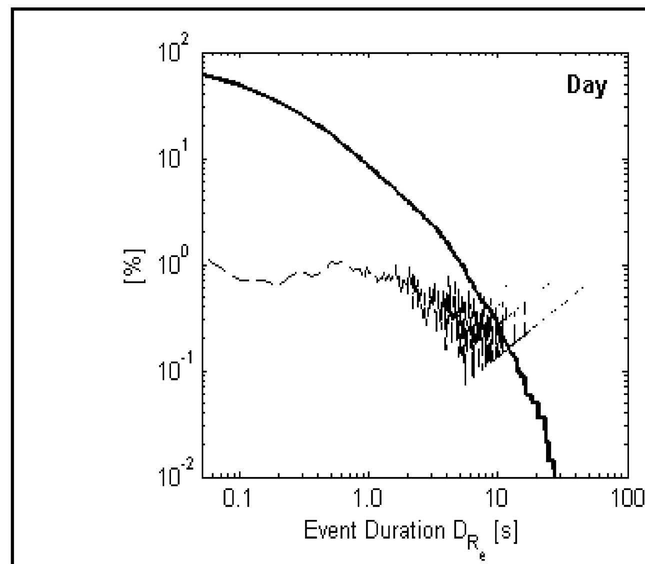

Figure 4: Cumulated distribution of respiration event durations (—) and overall influence on respiration (- - -)

Conclusion

The investigated method will potentially provide a valuable tool for the investigation of subcanopy on timescales similar to its micrometeorological and ecological drivers. However further work and testing is needed until the method can be used for field applications.

Contact: tobias.gerken@uni-bayreuth.de
www.bayceer.uni-bayreuth.de/mm

Businger, J.A., Oncley, S.P., 1990. Flux measurements with conditional sampling, J. Atmosph. Oceanic Techn. 7, 349–352
Scanlon, T.M., Albertson, J.D., 2001. Turbulent transport of carbon dioxide and water vapor within a vegetation canopy during unstable conditions: Identification of episodes using wavelet analysis, J. Geophys. Res. Atmosphere. 106, 7251–7262.
Thomas, C., Martin, J.G., Göckede, M., Siqueira, M.B., Foken, T., Law, B.E., Loescher, H.W., Katul, G.G., 2008: Estimating daytime subcanopy respiration from conditional sampling methods applied to mufti-scalar high frequency turbulence time series, Agric. Forest Meteorol. 148, 1210–1229

BayCEER