Source Partitioning Based on High Frequency Eddy Covariance Data

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Introduction

The BMBF-funded project "*Instrumental and Data-driven Approaches to Source Partitioning of Greenhouse Gas Fluxes: Comparison, Combination, Advancement*" (IDAS-GHG) aims at comparing and improving existing methods for partitioning of CO_2 and H_2O fluxes into their respective raw components.

→ *Data-driven approaches*: use existing (raw or processed) data of typical eddy covariance stations.

→ *Instrumental approaches*: require additional measurements at different parts of ecosystems and different methods, e.g. soil-flux chamber measurements, profile measurements or tracer measurements (isotopes).

Method

Scanlon and Sahu (2008), and Scanlon and Kustas (2010) proposed an interesting method to estimate the contributions of photosynthesis, soil respiration (autotrophic and heterotrophic sources), transpiration and evaporation using measured high-frequency time series of CO_2 and H_2O fluxes. This method is based on the dissimilarities of sources and sinks of CO_2 and water vapor among the sub-canopy, canopy, and atmosphere, which lead to unique "signals" in the eddy covariance measurements for air transported from differing locations. Thus, the flux-variance similarity theory is separately applied to the stomatal and non-stomatal components of the regarded fluxes. The discrepancy between the water use efficiency (WUE) at leaf level and the correlation between H_2O and CO_2 fluctuations is used to determine the relative strength of each flux component.

First Results

Figure 1 and 2 show first results of the source partitioning of the H_2O and CO_2 fluxes, respectively, for two test sites in Western Germany (winter wheat and a clearcut with heterogeneous regrowth).

The H_2O partitioning gives reasonable results, whereat transpiration T exceeds evaporation E by the threefold in the winter wheat field. In general, the relative relationships between the two different test sites are reasonable. The CO_2 partitioning still overestimates the fluxes for most time steps, which becomes even clearer in the comparison with chamber flux measurements of soil respiration and with other source partitioning methods (Reichstein et al., 2005; Lasslop et al., 2010).

Acknowledgment

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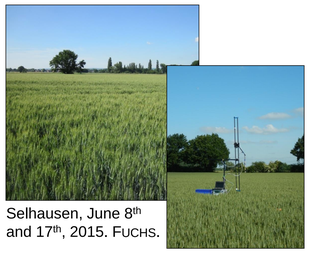
Mitglied der Helmholtz-Gemeinschaft

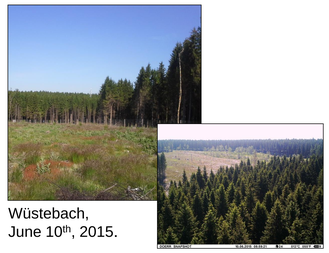
First Results

Test site A – Selhausen
winter wheat



Selhausen, June 8th and 17th, 2015. Fuchs.

Test site B – Wüstebach
deforested area



Wüstebach, June 10th, 2015.

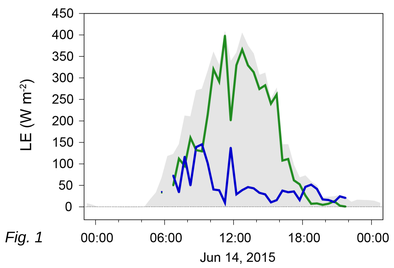
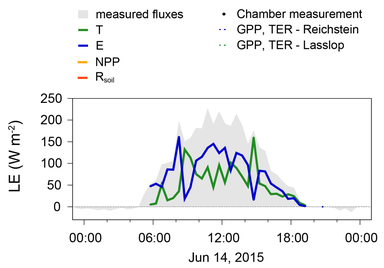


Fig. 1



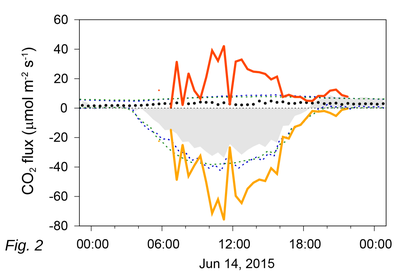
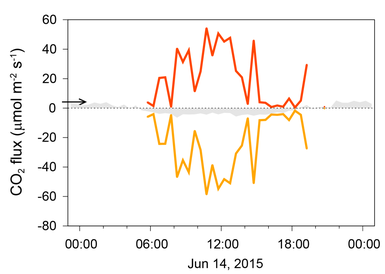


Fig. 2



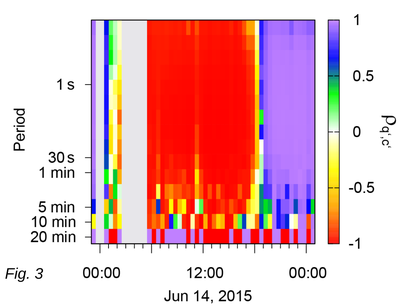


Fig. 3

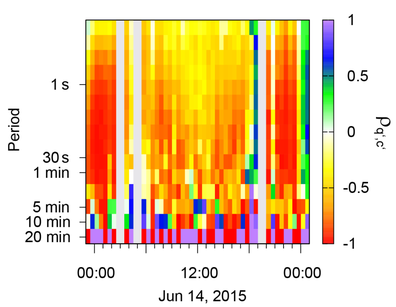


Fig. 1,2: Source Partitioning of the H_2O or CO_2 fluxes, respectively, in Selhausen (winter wheat, *left*) and in Wüstebach (clearcut with heterogeneous regrowth, *right*) (Western Germany) for June 14th, 2015 (UTC)
(grey area: measured latent heat flux LE or net ecosystem exchange NEE, respectively; T: transpiration, E: evaporation, NPP: net primary production, Rsoil: soil respiration, GPP: gross primary production, TER: total ecosystem respiration, arrow: mean spatial and temporal magnitude of chamber flux measurements in Wüstebach on June 10th, 2015).

Fig. 3: Diurnal dynamics of the correlation of H_2O and CO_2 ($\rho_{q',c'}$) across scales of turbulent eddies; determined by Wavelet Transform with the discrete Haar Wavelet in Selhausen (winter wheat, *left*) and in Wüstebach (clearcut with heterogeneous regrowth, *right*) (Western Germany) for June 14th, 2015 (UTC).

Outlook

A

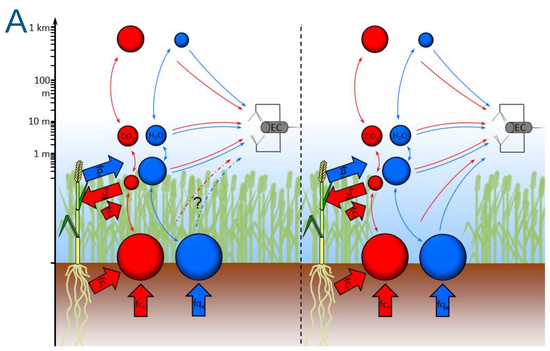
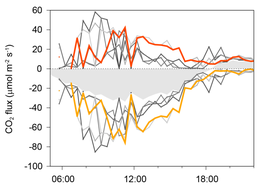
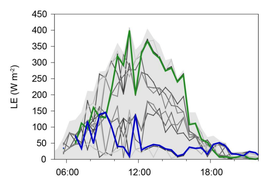


Fig. 4: Sketch of a working hypothesis on the success and failure of source partitioning methods based on the observed turbulent covariation of CO_2 and H_2O. In a dense uniform plant canopy (*left*), air carrying the properties of soil surface fluxes respiration f_{c_r} and evaporation f_{q_e} is unlikely to pass the leaf level unaltered, and Eddy Covariance (EC) instrumentation „sees" one homogeneous source of NEE (f_{c_r} + photosynthesis f_{c_p}) and ET (f_{q_e} + transpiration f_{q_t}). We expect the methods to be more robust with increasing coarseness or patchiness of the canopy (*right*), which would be in agreement with findings by Thomas et al. (2008) for a similar method applied to different forests.

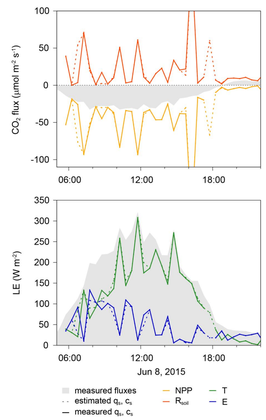
B

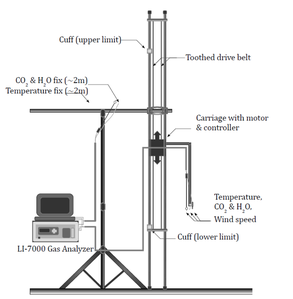
Fig. 5: Better performance and a conception of the uncertainty can be achieved by using multiple approaches and different types of implementations of the source partitioning method. E.g. by considering only certain eddy scales, using different methods to sustain a solution (c.f. Palatella et al., 2014) etc. an "ensemble" of solutions can be created.





C





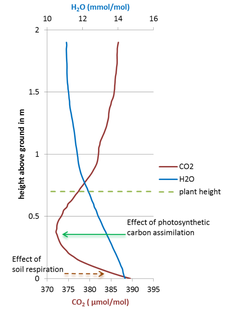


Fig. 6: Using a profile-measurement system with a continuously up and down moving elevator, CO_2 and H_2O concentrations can be measured at a high vertical resolution (*middle*, *right*). WUE can be determined more accurately with the resulting actual measurements at leaf level (q_s, c_s). However, the effect on the performance of the source partitioning method was weak on a sample day (preliminary results, *left*).

References

Lasslop et al., 2010. Separation of net ecosystem exchange into assimilation and respiration using a light response curve approach: critical issues and global evaluation. Global Change Biology 16 (1), 187-208.

Palatella et al., 2014. Towards a flux-partitioning procedure based on the direct use of high-frequency eddy-covariance data. Boundary-Layer Meteorology 153, 327-337.

Reichstein et al., 2005. On the separation of net ecosystem exchange into assimilation and ecosystem respiration: review and improved algorithm. Global Change Biology 11 (9), 1424-1439.

Scanlon, T.M., Kustas, W.P., 2010. Partitioning carbon dioxide and water vapor fluxes using correlation analysis. Agricultural and Forest Meteorology 150 (1), 89-99.

Scanlon, T.M., Sahu, P., 2008. On the correlation structure of water vapor and carbon dioxide in the atmospheric surface layer: A basis for flux partitioning. Water Resources Research 44 (10), W10418, 15 pp.

Thomas et al., 2008. Estimating daytime subcanopy respiration from conditional sampling methods applied to multi-scalar high frequency turbulence time series. Agricultural and Forest Meteorology 148 (8-9), 1210-1229.