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Sensitivity Analysis of a Source Partitioning Method for H_2O and CO_2 Fluxes via Large Eddy Simulations

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For an assessment of the role of soil and vegetation in the climate system, a further understanding of the flux components of H_2O and CO_2 and their interaction with physical conditions and physiological functioning of plants and ecosystems is necessary. Scanlon and Sahu (2008) and Scanlon and Kustas (2010) proposed a source partitioning method (SK10 in the following) to estimate the flux components transpiration, evaporation, photosynthesis, and respiration on the ecosystem scale obtained by the eddy covariance method. High frequency time series are needed, and the source partitioning is estimated based on the separate application of the flux-variance similarity theory to the stomatal and non-stomatal components of the regarded fluxes, as well as on additional assumptions on water use efficiency (WUE) on the leaf scale. The estimated WUE has been found to exert a strong influence on the performance of the partitioning method.
Evaluations of SK10 with field observations suffer from the fact that the real source partitioning is usually unknown, and that various disturbances may influence the correlation between H_2O and CO_2 fluctuations at study sites. Therefore, we conducted Large Eddy Simulations (LES), simulating the turbulent transport of H_2O and CO_2 under consideration of contrasting vertical sink-source-distributions in the canopy, and of soil sources with varying magnitudes. SK10 was applied to these synthetic high-frequency data and the partitioning performance could be evaluated depending on canopy type, measurement height, and given sink-source-distributions. For a satisfying performance of SK10, a certain degree of decorrelation of the H_2O and CO_2 fluctuations was needed, which was enhanced for observations within the roughness sublayer, as well as by a clear separation between soil and canopy sources. The expected dependence of the partitioning results to the WUE input could be observed, where an incorrect estimation of WUE affected the flux components of soil sources stronger than components of the canopy sink/source. As a new finding, our LES study indicated that next to a precise WUE estimation, the validity of the key assumptions made by Scanlon and Sahu (2008) in the method's derivation is a crucial point for a correct application of SK10. Therefore, a thorough assessment of the conditions at study sites affecting the validity of these assumptions would be necessary.

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, https://doi.org/10.1029/2008WR006932.

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, https://doi.org/10.1016/j.agrformet.2009.09.005.