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Simulation of a True Eddy Accumulation System

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The true eddy accumulation (TEA) method was proposed by Desjardins in 1972 as an alternative to the state-of-the-art eddy covariance (EC) method which requires a fast-response gas analyzer to resolve relevant frequencies of trace gas variances.
For the TEA method, slow-response gas analyzers are sufficient, it requires that air is sampled at a high frequency and samples are collected and partitioned into updraft and downdraft reservoirs based on the sign of the vertical wind velocity and proportional to its magnitude. The fluxes are calculated from the measured difference in accumulated sample concentration weighted by mean wind speed over the averaging period.
In this study, we simulated a number of operational parameters for the TEA system implemented by (Siebicke, 2016) in the Hainich National Park, Germany. We used wind data and CO_2 concentrations measured at 20 Hz frequency.
We developed an R package for simulating and calculating TEA fluxes. The simulated TEA fluxes were compared with measured fluxes of TEA and eddy covariance methods. The study tested the effects of the sampling method (traditional bag-based system versus a continuous flow-through operation), system dynamic range, the size of the buffers, the displacement volume ahead of the sampling inlets, and sensors time lag.
The simulation showed that the two tested sampling methods had a negligible effect on the resulting fluxes. Increasing the buffer size showed an averaging effect on the resulting daily fluxes but has preserved the flux recovery for longer periods. The existence of a displacement volume had little effect on the fluxes even when it comprised a large ratio of the sampled volume.
TEA method showed to be particularly sensitive to time lag between sensors. The response time of the sampling mechanism should be fast enough and in close physical proximity to the wind anemometer. Time lag had a strong effect on the resulting fluxes with more than 10% of the fluxes lost at 300 ms lag and a loss of 50% of the fluxes at 1.5 seconds.
The simulation of system dynamic range showed that it's possible by scaling the sample volume with a reference wind speed calculated from the past wind data to achieve high recovery ratio close to complete recovery of the fluxes in comparison EC measured fluxes.