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Ibrom, Andreas; Pilegaard, Kim

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Empirical CO_2 and H_2O flux uncertainty estimation through comparison of measurements from two heights

A. Ibrom and K. Pilegaard
Department of Chemical and Biochemical Engineering, DTU, Lyngby/Roskilde, Denmark

Although the eddy covariance technique is the only direct method to measure the turbulent matter flux through the atmospheric boundary-layer, the flux values are only reasonable approximations of the flux from the underlying surface to the atmosphere, if a couple of criteria are fulfilled. Most of these criteria, such as flux constancy over the averaging period, statistical stationarity of the time series, surface homogeneity, and height constancy of the flux, are in real world situations only partly fulfilled. Compromises between the measurement conditions and the theory of flux measurements will therefore introduce a yet unknown error, which is difficult to estimate by means of theory. Here we study whether and how eddy covariance measurements from two heights that are close to each other can be used to estimate at least part of the flux uncertainty and its relation to meteorological and site conditions.
One month of data was collected during December 2011 over the Danish beech forest site Sorø, Zealand, at 34 and 43 m height. The EC systems were virtually identical and were logged with the same data logging system. The highest trees were 30 m tall, the sum of displacement height and roughness length was ca. 20 m depending on wind speed. The fetch of forest area varied between 0.5 km and 1.6 km depending on direction (Pilegaard et al. 2011). It could be shown that both the spectral characteristics and even the absolute concentration measurment of the two infra read gas analysers were in very close agreement with the theory.
We found usually a very good match of the flux estimates from the two systems during day time. During night time differences were largest at stable stratification but as well at very high wind speeds. In addition to addressing the resulting uncertainty for winter CO_2 flux estimates at this site, we analysed periods when very strong differences between the systems occurred. During these periods the comparison indicated a flux divergence possibly as a consequence of the tall but aerodynamically transparent leafless winter canopy and the, depending on wind direction, sometimes close vicinity of forest edges. Finally, we used the findings from this study to derive empirical thresholds of meteorological variables for detecting periods with large flux uncertainty.

From this investigation we conclude that estimating turbulent matter and energy fluxes at two relatively close heights gives very useful empirical information on the uncertainty of flux measurements with the eddy covariance method.

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References:
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