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An improved procedure for determining random errors of eddy covariance measurements for data assimilation

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Errors in eddy covariance (EC) measurements can be categorized into random and systematic errors. The latter can be related e.g. to the energy balance closure problem. It is essential to quantify these errors for the assimilation of EC data into a model. The random error can be determined on the basis of differences between simultaneous flux measurements from two towers (which are approximately 1 km separated in space) as pointed out by Hollinger and Richardson (2005) (classical approach). Here we propose an improved procedure to estimate random errors from EC data based on the two-tower concept. First, we argue that it is important to account for errors linked to the energy balance closure problem before estimating random errors. In this work, it is assumed that the energy balance deficit is related to the underestimation of the turbulent fluxes and that the energy balance can be closed by distributing the residual error over the latent and sensible heat fluxes according to the evaporative fraction. Second, we argue that it is essential that differences of the evaporative fraction between two towers, which are for example related to differences in soil properties or vegetation characteristics (e.g., amount of undergrowth, tree age) are also corrected. Without these corrections the random error would erroneously include the random measurement error as well as errors related to small-scale heterogeneities and the energy balance closure error.

The classical approach and our modified procedure are tested for two sites with multiple EC towers. The Merken site in Germany (between Aachen and Cologne) has three EC towers, which are located on parcels with different crop types. The two EC towers at the Roccarespampani site have the same vegetation type (Hardwood). The two methods yield clearly different estimates for the random errors. In general, our method provides estimates of random errors which are smaller than the estimates obtained by the classical approach. In addition, the random errors depend only very weakly on the net radiation or turbulent flux magnitude, whereas the classical method shows a strong dependence. We also find that the three different two-tower comparisons that can be made at the Merken site give very similar results with our approach, but much larger differences for the classical approach.

Reference

Hollinger, D.Y. and A.D. Richardson. 2005. Uncertainty in eddy covariance measurements and its application to physiological models. Tree Physiology, 25, 873-885