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Role of post-field raw data processing: a multi-site and full factorial uncertainty analysis

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Uncertainties in the Eddy Covariance flux measurements are a fundamental issue not yet completely solved. The complexity of the method, involving many, not standardized processing steps is one among the source of such uncertainty. The goal of our work is to quantify uncertainties deriving from post-field raw data processing, needed to calculate fluxes from collected turbulence measurements. The methodology we propose is a full-factorial design, performed using as factors a number of selected processing steps. We applied this approach to 15 European flux stations representative of different ecosystems (forests, croplands and grasslands), climates (Mediterranean, Nordic, arid and humid) and instrumental setups (e.g. open vs. closed path systems). Then we processed one year of raw data from each of the selected stations so as to cover all possible combinations of the available options (levels) relative to all the critical processing steps, i.e: angle of attack correction; coordinate rotation; trend removal; time lag compensation; low- and high- frequency spectral correction; correction for air density fluctuations; and length of the flux averaging interval. The software we used is EddyPro^{TM}. At last we calculated the cumulative NEE (response) for each process, and performed an analysis of variance of the factorial design. In addition to the global uncertainty, from this statistical approach we obtain information about the factors that most contribute to the uncertainties, and also the most relevant two-level interactions between factors.

Here we present partial results from the first sites analysed. For the beech forest of Sorø, Denmark (Gill R2 anemometer and closed path GA, tube length = 50 m) the factor that most contributes to the variance in 2007 (40.4 %) is the trend removal, with an uncertainty of 7.5%. It is followed by the angle of attack (16.1 % of the total variability, uncertainty 3.5 %) and the interaction between trend removal and time lag compensation (11.42 % of variance explained). The overall uncertainty is about 8.7 % (cumulative NEE = -440.22 ± 38.36 g C m-2 year-1). The Oak forest of Roccarespampani, Italy (Metek anemometer and closed path GA, tube length = 22 m) was a sink in 2006. The coordinate rotation has the main influence on the variance (46.14 %, against an uncertainty of 4 %), then comes the average interval with 17.34 % (unc. 2 %), and their interaction (9.70 % of variance explained). The total uncertainty is 4.8 % (NEE = -515.19 ± 24.7 g C m-2 year-1). The mixed forest of Norunda, Sweden, in the year 2008 is a source of CO_2 (Metek anemometer and closed path GA, tube length = 8 m). For this site we found a strong influence of the coordinate rotation (74.02 %, with an uncertainty of 32.5 %), while the trend removal explains the 17.41 % of the variance (unc. 15 %), against a total uncertainty of about 26.8 % (155.04 ± 41.50 g C m-2 year-1).