Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2016-31-AC1, 2016

Atmospheric Measurement Techniques Discussions
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Interactive comment on "Random uncertainties of flux measurements by the eddy covariance technique" *by* Ü. Rannik et al.

Ü. Rannik et al.

ullar.rannik@heuristica.ee

Received and published: 14 June 2016

We thank the reviewer for the critical assessment of our paper. The reviewer refers to two main limitations of the paper: lack of novelty in results and omitting of one of the alternative methods proposed by Salesky et al. (2012) to estimate the random flux error. Whereas we agree with the last comment (see the answer below), we do not agree with the general statement that the paper has no value. Our main aim was to bring clarity among the methods frequently used for evaluation of random flux errors. We approached this in a systematic way giving theoretical overview of all methods as well as numerical evaluation. In our opinion different flux error estimation methods have been used in literature without clear understanding how different methods relate to each other and what is the error estimate produced by each of the methods. In summary, we thank the reviewer for bringing into our attention important deficiency of our paper while omitting the method by Salesky et al. (2012). We will amend the paper with respective theory subsection and results. We believe that after such revision the scientific community working with EC flux measurements will benefit from this paper when interpreting the flux data and associated random errors as estimated by different methods.

General comments

Referee Comment (RC): This paper compares different methods for estimating the random error of eddy covariance flux estimates. Although the paper is well written, the novelty of the presented research remains unclear. I cannot find substantial new insights compared to the study of Billesbach (2011). Indeed, the Wienhold et al. (1995) has also been compared, but only to reach at the conclusion that it gives almost the same error estimate as the well-established method of Finkelstein and Sims (2001).

Author Response (AR): Yes, we agree that the paper by Billesbach (2011) compares different flux error evaluation methods. Billesbach proposes also the method that, according to the author, measures the instrument uncertainty. In the current manuscript we evaluate the method in comparison to the method first proposed by Lenschow et al. (2000) and demonstrate both theoretically and empirically by using measured data that it produces a different error estimate.

RC: With respect to the error for instrumental noise, it was already proposed by Mauder et al. (2013) to apply the approach of Lenschow et al. (2000) for eddy-covariance measurements and not only for lidar data, for which it had been developed. So, this aspect is also not really innovative.

AR: The authors refer to Mauder et al. (2013) in connection to the method proposed by Lenschow et al. (2000). The contribution of our manuscript to the method by Lenschow et al. (2000) and Mauder et al. (2013) is to evaluate and present the applicability range of the method which clearly depends on SNR.

RC: Moreover, one other important method for estimating the random flux error has not been considered at all. Salesky et al. (2012) proposed a promising method that is based on local flux decomposition and demonstrated clearly its advantages over other existing methods, such as the ones of Finkelstein and Sims (2001), because it does not require an estimate of the integral time scale. However, the Salesky paper is not even cited anywhere in the manuscript. In summary, due to the lack of novelty and due to an incomplete consideration of existing literature, I cannot recommend this manuscript for publication in this journal.

AR: The method by Salesky et al. (2012) has been unfortunately out of our attention. After careful examination of the method, we recognise that it is certainly a good alternative to the other methods. In addition, it does not require estimation of the integral time scale and has an advantage compared to the methods which do so. As a comment, the method proposed by Lenschow and Kristensen (1985) and in a discrete form by Finkelstein and Sims (2001) does not require either direct evaluation of the time scale but just integration of the products of the co-variance functions over sufficiently long time exceeding the integral time scale. The method by Salesky et al. (2012) is a novel approach by introducing filtering method in error evaluation. However, the method stems from the same theory and is therefore expected to result in the same error estimates as Finkelstein and Sims (2001) under stationary conditions.

While avoiding direct calculation of the integral time scale, it is indirectly embedded in the method by Finkelstein and Sims (2001) and the estimation result is also affected by the uncertainty that the non-stationarity introduces. The same applies to the method by Salesky et al. (2012) because the instantaneous turbulent flux w'c'(t) is also affected by non-stationarity. It was demonstrated by Salesky et al. (2012) that under non-stationery conditions their method performed better than the other methods involving direct evaluation of the integral time scale, namely the methods by Lumley and Panofsky (1964) and Lenschow et al. (1994).

We believe the method proposed by Salesky et al. (2012) is by no means a very promising method and a reliable alternative for flux error evaluation. However, its superior performance is not directly evident compared to the method by Finkelstein and Sims (2001). The theory of turbulent flux and flux error calculation relies on the assumption of the stationarity. Non-stationary conditions introduce additional uncertainty in time-averages. In the revised MS we present the results also for the method by Salesky et al. (2012) and compare with the results produced by the method by Finkelstein and Sims (2001) to see if and under what conditions the methods deviate.

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Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-31, 2016.