Geophysical Research Abstracts
Vol. 18, EGU2016-3793, 2016
EGU General Assembly 2016

Toward finding a universally applicable parameterization of the β factor for Relaxed Eddy Accumulation applications

Teresa Vogl (1,2), Amy Hrdina (3), and Christoph Thomas (1)

(1) Micrometeorology Group, University of Bayreuth, 95440 Bayreuth, Germany, (2) Leibniz Institute for Troposphere Research, 04318 Leipzig, Germany, (3) Department of Chemistry, University of Toronto, Canada

The traditional eddy covariance (EC) technique requires the use of fast responding sensors ($\geq$ 10 Hz) that do not exist for many chemical species found in the atmosphere. In this case, the Relaxed Eddy Accumulation (REA) method offers a means to calculate fluxes of trace gases and other scalar quantities (Businger and Oncley, 1990) and was originally derived from the eddy accumulation method (EA) first proposed by Desjardins (1972). While REA lessens the requirements for sensors and sampling and thus offers practical appeal, it introduces a dependence of the computed flux from a proportionality factor β. The accuracy of the REA fluxes hinges upon the correct determination of β, which was found to vary between 0.40 and 0.63 (Milne et al., 1999, Ammann and Meixner, 2002, Ruppert et al., 2006). However, formulating a universally valid parameterization for β instead of empirical evaluation has remained a conundrum and has been a main limitation for REA.

In this study we take a fresh look at the dependencies and mathematical models of β by analyzing eddy covariance (EC) data and REA simulations for two field experiments in drastically contrasting environments: an exclusively physically driven environment in the Dry Valleys of Antarctica, and a biologically active system in a grassland in Germany. The main objective is to work toward a model parameterization for β that can be applied over wide range of surface conditions and forcings without the need for empirical evaluation, which is not possible for most REA applications.

Our study discusses two different models to define β: (i) based upon scalar-scalar similarity, in which a different scalar is measured with fast-response sensors as a proxy for the scalar of interest, here referred to as β_0; and (ii) computed solely from the vertical wind statistics, assuming a linear relationship between the scalar of interest and the vertical wind speed, referred to as β_w. Results are presented for the carbon-dioxide, latent and sensible heat fluxes across the contrasting environments.

First, the choice of an appropriate scalar to calculate β_0 is discussed considering the sources and sinks of each scalar with an emphasis on the carbon dioxide flux, which shows strongly dissimilar dynamics between the Antarctic ecosystem and the grassland. Secondly, the impact of atmospheric stability on both β models is investigated. In a next step, we attempt to find a physically meaningful explanation for the overestimation of the REA scalar fluxes compared to those from EC for using β_w. We do so by analyzing the probability density function (pdf) and its statistical moments for the vertical wind speed. We found its pdf to be non-Gaussian for the majority of cases, and detected a close to linear relationship of its kurtosis with β_w. Finally, in an attempt to provide practical guidance for field measurements, we integrate our findings and propose an enhanced model parameterization, and evaluate the differences between our new model and a constant β.

Ammann, C. and Meixner, F.X. (2002) Stability dependence of the relaxed eddy accumulation coefficient for various scalar quantities. J. Geophys. Res. 107. ACL7.1–ACL7.9 doi:10.1029/2001JD000649

Businger, J.A., Oncley, S.P. (1990) Flux measurement with conditional sampling. J. Atmos. Ocean. Tech. 7:349–352.

Desjardins, R. L. (1972) A study of carbon-dioxide and sensible heat fluxes using the eddy correlation technique, Ph.D. dissertation, Cornell University, 189 pp.

Desjardins, R.L. (1977) Description and evaluation of sensible heat flux detector. Boundary-Layer Meteorol. 11:147–154.

Katul, G., Finkelstein, P. L., Clarke, J. F., and Ellestad, T. G. (1996) An Investigation of the Conditional Sampling Methods Used to Estimate Fluxes of Active, Reactive and Passive Scalars. J. Appl. Meteorol. 35: 1835–1845.

Milne, R., Beverland, I. J., Hargreaves, K., and Moncrieff, J. B. (1999) Variation of the beta coefficient in the relaxed eddy accumulation method. Boundary-Layer Meteorol. 93: 211–225.

Ruppert, J. ATEM software for atmospheric turbulent exchange measurements using eddy covariance and relaxed eddy accumulation systems: Bayreuth whole-air REA system setup, Universität Bayreuth, Abt. Mikrometeorologie, Print, ISSN 1614-8916, Arbeitsergebnisse 28, 29 S, 2005

Ruppert, J., Thomas, C., and Foken, T. (2006) scalar similarity for relaxed eddy accumulation methods. Boundary-Layer Meteorol. 120: 39–63.