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Flux corrections for eddy accumulation methods

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Micrometeorologial flux measurements of trace gases are affected by simultaneous transfer of heat and water vapor. Fluctuations of temperature and water vapor lead to density fluctuations, resulting in an apparent flux of the atmospheric constituent of interest.

For the eddy covariance (EC) method, Webb et al. (1980) proposed a correction for the apparent flux caused by density effects due to heat and water vapor transfer, known as "WPL" correction.

For the relaxed eddy accumulation (REA) method, based on the work by Webb et al. (1980), Pattey et al. (1992) proposed three versions of a correction for density effects, the versions being specific to the measured quantity, i.e. for when the constituent is measured as a density, as a molar ratio, or as mass, respectively.

For the true eddy accumulation (TEA) method, actual field studies are few and little is published on flux corrections. Particularly, we are unaware of a formulation of flux corrections specifically for the TEA method which correct for the effects of density fluctuations due to heat and water vapor transfer.

In the present work we derive such density fluctuations corrections for TEA flux measurements based on work by Pattey (1992) for the REA method.

Turnipseed et al. (2009) published a correction for the mismatch of the sample volumes accumulated during updrafts and downdrafts, respectively, which we here refer to as volume mismatch correction. However, we are unaware of a combination of the density and the volume mismatch correction.

The original contribution of the current work is to (1) Derive a density fluctuation corrected version of the TEA constituent flux equation, previously only available for REA, (2) Combine the density corrected flux equation with the volume mismatch correction, separately for the TEA and REA methods, (3) Derive integrated equations for constituent fluxes, separately for the TEA and the REA methods, which correct the flux both for density fluctuations due to heat and water vapor transfer and also for volume mismatch, and further expand the correction of density fluctuations to the volume mismatch correction term itself.

The implementation of above flux corrections and other common data processing steps specific to the TEA and REA eddy accumulation methods and their disjunct derivatives in software is ongoing, working towards an integrated, standardized, and extensible package for reproducible flux processing.

More studies are needed to (1) validate proposed eddy accumulation flux corrections and assess their relevance under a range of atmospheric and surface conditions in the field, (2) derive further eddy accumulation specific corrections, including corrections for the effects of the spatial separation of the sonic anemometer and the point of air sampling, and (3) to establish a common and more complete set of data processing and flux correction operations, similar to what exists for the eddy covariance method today, for application in true eddy accumulation and relaxed eddy accumulation studies.