EGU21-14464
https://doi.org/10.5194/egusphere-egu21-14464
EGU General Assembly 2021

Revising the high frequency response correction of scalar fluxes measured by closed-path eddy covariance systems

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Eddy covariance (EC) scalar flux loss at high frequency is due to the incapability of the measurement system to detect small-scale variation of atmospheric turbulent signals. This systematic bias is particularly important for closed-path systems, and it is mainly related to inadequate sensor frequency response, sensor separation and the air sampling trough tubes and filters. Here, we investigate the limitations of current approaches, based on measured power spectra (PSA) or cospectra (CSA), to empirically estimated the spectral transfer function of the EC system needed for the frequency response correction of measured fluxes. We performed a systematic analysis by using EC data from a wetland and forest site for a wide range of attenuation levels and signal-to-noise ratio. We proposed a novel approach for PSA that uses simultaneously the noise and the turbulent signals present in the power spectrum, providing robust estimates of spectral transfer function for all conditions. We further theoretically derived a new transfer function to be used in the CSA approach which specifically accounts for the interaction between the low-pass filtering induced phase shift and the high frequency attenuation. We show that current CSA approaches neglect such effect, giving a non-negligible systematic bias to the estimated scalar fluxes from the studied sites. Based on these findings, we recommend that spectral correction methods, implemented in EC data processing algorithms, are revised accordingly.