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An attempt to close the surface energy balance using spatially-averaged flux measurements

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Single-tower eddy-covariance measurements only represent the complete surface flux of a scalar under idealized conditions. Therefore, an underestimation of energy fluxes expressed as a lack of energy balance closure at many sites is frequently found. In this study, a multi-tower approach to measure the atmospheric energy fluxes based on spatial averaging is evaluated and possible mechanisms causing a lack of energy balance closure are analysed. It is shown that application of this multi-tower technique does not close the energy balance either for our site, a research farm in Ottawa, Canada, likely because the assumption of horizontal homogeneity is violated. Heterogeneity-induced and buoyancy-driven quasi-stationary circulations, which occur only during daytime, are probably the dominant processes causing the flux underestimation. A dependence of the energy balance residual on stability is found, with residuals close to zero for stable stratification, a maximum under unstable-near neutral conditions and relatively large residuals for stronger instability. Assuming the processes transporting energy and CO2 are similar, the implications for long-term CO2-flux measurements are analysed. Mostly the fluxes during daytime periods of net CO2-uptake are underestimated while periods of net CO2-release are much less affected by this bias. The resulting selective systematic error of cumulative net ecosystem exchange estimates for agricultural regions such as ours can be of the order of more than 100%.