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LES study of the imbalance problem with EC fluxes

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The presented large eddy simulation study, free of sensor errors and the uncertainties of field conditions, investigates the spatial variability of temporal eddy covariance fluxes and the systematic underestimation of representative fluxes linked to them. It extends a prior numerical study, as it uses a drastically increased spatial resolution that allows for virtual measurements down to a height of 4m (stable case)/ 20m (convective case), enabling an analysis of conditions for small towers and near-surface energy balance stations. It accounts for different convective regimes, as the wind speed, the near-surface heat flux and the large-scale subsidence are varied and for the first time an LES study on imbalances is extended to the neutral and stable boundary layer. For all cases the shortcomings of single site measurements and the necessity of horizontally-distributed observation networks become evident. The imbalances in the convective case are attributed to a locally non-vanishing mean vertical advection due to persistent turbulent organised structures. The strength of these structures and thus the magnitude of imbalances depends mainly on the observation height, the mean horizontal wind and the type of convection. During cell convection the smallest imbalance - one order of magnitude smaller than that observed in field experiments - is obtained with the strongest geostrophic wind at the lowest measurement level. The near-surface heat flux and a synoptic-scale subsidence also impact the imbalance. The imbalance statistics of passive scalar fluxes are similar to that of the sensible heat fluxes.

In contrast, in the stable and neutral boundary no turbulent organised structures and consequently no significant imbalances are observed.

Attempting to reduce the observed imbalances by filtering, it is pointed out that the linear detrending of time series even increases the imbalance. Thus, a new filter method is proposed and examined.