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Parameter studies on the energy balance closure problem using large-eddy simulation

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The imbalance of the surface energy budget in eddy-covariance measurements is still a pending problem. A possible cause is the presence of land surface heterogeneity. Heterogeneities of the boundary layer scale or larger are most effective in influencing the boundary layer turbulence, and large-eddy simulations have shown that secondary circulations within the boundary layer can affect the surface energy budget. However, the precise influence of the surface characteristics on the energy imbalance and its partitioning is still unknown. To investigate the influence of surface variables on all the components of the flux budget under convective conditions, we set up a systematic parameter study by means of large-eddy simulation. For the study we use a virtual control volume approach, and we focus on idealized heterogeneity by considering spatially variable surface fluxes. The surface fluxes vary locally in intensity and these patches have different length scales. The main focus lies on heterogeneities of length scales of the kilometer scale and one decade smaller. For each simulation, virtual measurement towers are positioned at functionally different positions. We discriminate between the locally homogeneous towers, located within land use patches, with respect to the more heterogeneous towers, and find, among others, that the flux-divergence and the advection are strongly linearly related within each class. Furthermore, we seek correlators for the energy balance ratio and the energy residual in the simulations. Besides the expected correlation with measurable atmospheric quantities such as the friction velocity, boundary-layer depth and temperature and moisture gradients, we have also found an unexpected correlation with the temperature difference between sonic temperature and surface temperature. In additional simulations with a large number of virtual towers, we investigate higher order correlations, which can be linked to secondary circulations. In a companion presentation (EGU2017-2130) these correlations are investigated and confirmed with the help of micrometeorological measurements from the TERENO sites where the effects of landscape scale surface heterogeneities are deemed to be important.