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The dependence of energy budget components on idealized surface characteristics: a parameter study

F. De Roo (1) and M. Mauder (2)

(1) Institute for Meteorology and Climate (Atmospheric Environmental Research), Karlsruhe Institute of Technology, Garmisch-Partenkirchen, Germany (frederik.deroo@kit.edu), (2) Institute for Meteorology and Climate (Atmospheric Environmental Research), Karlsruhe Institute of Technology, Garmisch-Partenkirchen, Germany

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. The influence of surface heterogeneities on the atmospheric boundary layer was intensively investigated about one to two decades ago. It was found that heterogeneities of the boundary layer scale or larger are most effective in influencing the boundary layer turbulence. Subsequent large-eddy simulations showed that also the turbulent fluxes are influenced by turbulent structures in the boundary layer. However, the precise influence of the surface characteristics on the energy imbalance and its partitioning is still unknown.

To investigate the influence of surface characteristics on all the components of the flux budget under convective conditions, we have set up a systematic parameter study by means of large-eddy simulation. For the study we use a virtual control volume approach, which allows to also characterize advection, flux-divergence and storage terms of the energy budget at the virtual measurement site, in addition to the standard turbulent flux.

We focus on the heterogeneity of the surface fluxes and keep the topography flat. The surface fluxes vary locally in intensity and these patches have different length scales. Intensity and length scales can vary for the two horizontal dimensions but follow an idealized chessboard pattern. Our main focus lies on heterogeneities of length scales around 1.5 km (the boundary layer depth) and around 200 meter (one decade smaller). In addition, we have run simulations with different Bowen ratios and different geostrophic wind speed. In each simulation, virtual measurement sites were located at functionally different positions (e.g. downdraft region, updraft region, at border between domains). We seek atmospheric correlators for the energy balance ratio and the residual, e.g. by investigating their correlation with measurable atmospheric quantities as u*, temperature and moisture gradients and boundary layer depth.