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Large-eddy simulation of the energy balance closure problem: a case study for a field campaign with multi-scale observations

Sha Zhang (1), Frederik De Roo (1), Rieke Heinze (2), Fabian Eder (1,4), Sadiq Huq (1), Marius Schmidt (3), Matthias Mauder (1,4)

(1) Institute of Meteorology and Climate Research, Atmospheric Environmental Research (IMK-IFU), Karlsruhe Institute of Technology (KIT), Garmisch-Partenkirchen, Germany, (2) Institute of Meteorology and Climatology, Leibniz University of Hannover, Hannover, Germany, (3) Agrosphere (IBG-3), Jülich Research Centre, Jülich, Germany, (4) Institute of Geography and Geoecology (IfGG), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

As a well-known issue in eddy-covariance method for surface fluxes measurement, the mechanisms causing the energy balance closure problem are still under debate. Recent evidence suggests that the low-frequency turbulence contributes significantly to the residual of turbulent fluxes.
In this study, a large-eddy simulation with synoptic scale forcing is used to investigate the influence of the large-scale organized turbulent transport on the surface energy imbalance. The vertical profiles of wind and potential temperature, and the third and the fourth moments of vertical wind are analyzed. A comparison with Doppler-lidar observations from the HD(CP)2 project in 2013 shows good agreement. Furthermore, the diurnal cycles of vertical motion, coherent structures and horizontal divergence fields for two contrasting days are investigated. In order to gain insight into partitioning between sensible and latent heat flux of the energy balance residual, we further employed a control volume method within the numerical simulation. This method also allows us to compare simulated imbalances from virtual measurement with real-world imbalance from two eddy-covariance stations in the model domain.