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Characterizing the turbulent higher-order moments in the convective boundary layer: Evaluation of large eddy simulations with high-resolution lidar observations

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Turbulent higher-order moments of the thermodynamic variables in the convective boundary layer (CBL) simulated within large eddy simulation (LES) models are evaluated using high-resolution simultaneous lidar measurements. With lidar, profiles of these variables can be observed simultaneously in the CBL including the interfacial layer (IL). The case study discussed here focuses on a clear-sky well developed CBL during the HD(CP)2 Observational Prototype Experiment (HOPE) in western Germany in spring 2013. Mean thermodynamic profiles, variances and third-order moments of potential temperature, and specific humidity as well as surface energy fluxes are discussed. The LES models used in this study were ICON and WRF. Significant differences were found in the estimation of sensible and latent heat fluxes between the observations and LES. Inside the CBL, both LES models are colder (by 2 – 3 K) and moister (0.3 to 0.5 g/kg) than the observations. The variance profiles of potential temperature and humidity of both LES models show a distinct peak at (or at least near) the CBL top which agrees well with the observations. The LES models could reproduce the non-skewed Gaussian distribution of turbulent fluctuations in the lower CBL. But the observed non-zero values of the third-order moments (TOMs) of specific humidity and potential temperature in the IL, could not be reproduced. We conclude that the verification of LES with new lidar observations is feasible and provides very helpful information on the model performances.