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Evaluation of multi-week large-eddy simulations by means of observations

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Large-eddy simulation (LES) models are used to study atmospheric boundary layer flows with rather idealized boundary conditions. However, more realistic turbulence fields are of great interest for example for parameterization development or environmental applications like wind engineering. To make a step towards less-idealized flows, processes occurring on larger scales than those covered by LES have to be considered. Large-scale tendencies are incorporated by coupling LES with mesoscale model output in terms of prescribing advective forcing and applying continuous nudging. This setup provides the opportunity to step from single-day LES case studies to continuous LES of weeks, months and even years. The present work evaluates whether this approach is able to provide a realistic boundary layer representation.

Two LES models, PALM and UCLA-LES, are used to simulate a continuous period of 2.5 weeks during the observational campaign of the HD(CP)2 (High Definition Clouds and Precipitation for Advancing Climate Prediction) project in April and May 2013 in Jülich, Germany. The simulations are initialized with profiles from analysis data of the mesoscale model COSMO-DE (Consortium for Small-scale Modeling). Time-dependent advective tendencies as well as surface temperature and humidity are prescribed and continuous nudging towards the COSMO data is used to incorporate meteorological forcing. A comparison of turbulence and cloud related statistics with the multi-sensor observations is presented. Sensitivities in terms of chosen averaging domain, temporal resolution of the forcing data and relaxation time scale of the nudging are further explored.

The simulated boundary layer depth agrees well with the observations while a correct representation of shallow cloud layers is difficult to achieve. The results depend strongly on the forcing, however, there is a convergence if the averaging domain for the forcing data is large enough. Nudging time scale and higher temporal resolution of the forcing affect the boundary layer development only slightly.