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Large-eddy simulation modeling of the unstable boundary layer over sea

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The diurnal evolution of the atmospheric boundary layer (ABL) observed during an experimental campaign realized on the island of Anholt in the Kattegat sea (Sempreviva and Gryning, Boundary-Layer Meteorology 2000) is studied numerically using a Large-Eddy Simulation (LES) model. This is a modified version of Moeng's model (Moeng, Journal of the Atmospheric Sciences 1984), since it includes the virtual potential temperature integration and an improved eddy viscosity closure near the bottom surface (Sullivan et al., Boundary-Layer Meteorology 1994). The model is initialized with mean wind, temperature and humidity vertical profiles based on data from early in the morning of June 16,1992. Simulations for this case study are performed with two forcings: matching the time evolution of the surface heat and humidity fluxes in one case, and matching the temperature and humidity measured at the sea level in the other case. Results from the model are compared with those from the experimental campaign. LES mean profiles are in good agreement with the experimental ones for the first hours of the simulated day, when the ABL is dominated by convection. Mean profiles of temperature and humidity indeed show a well-defined mixed layer reaching up to 2000 m. However, the simulated results and the observations present differences for the afternoon, when the experimental ABL suddenly collapses and strong temperature and humidity inversions appear at about 400 m above the sea level. An explanation for such differences is found performing a synoptic analysis of the meteorological conditions of the day under investigation. Turbulent statistics from model and data are also compared to characterize the ABL evolution.