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Numerical simulation of the evening transition in the atmospheric boundary layer using LES and RANS models

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This study investigates the dynamics of the evening transition in the atmospheric boundary layer (ABL) diurnal cycle, specifically the decay of the turbulent kinetic energy (TKE) taking place there. Generally, the TKE decay is assumed to follow the power law $E(t) \sim t^{-\alpha}$, where E(t) and t are normalized TKE and normalized time, respectively, and the parameter α determines the decay rate.

Two types of ABL numerical modeling are compared: three-dimensional large-eddy simulation (LES) models and one-dimensional Reynolds-averaged Navier-Stokes (RANS) models. The evening transition is simulated through facilitating the formation of the convective boundary layer (CBL) by having a constant positive surface heat flux, and the subsequent decay of the CBL when the surface heat flux is decreased.

Several features of this process have been studied in relative depth, in particular the TKE decay rate at different stages of the evening transition, the sensitivity of the results to the domain size, and the dynamics of the large- and small-scale turbulence during the transition period. LES experiments with different setups were performed, and the results were then compared to those obtained through RANS experiments based on the k-epsilon model (a two-equation model for TKE and dissipation rate, where model constants are chosen to allow for correct simulation of SBL main properties [1], as well as CBL growth rate [2]).

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