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Influence of subgrid-scale parameterizations on the boundary layer development in ICON-LEM

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To understand the development of shallow cumulus clouds is a task intensively focused in todays research because these clouds have various effects on the atmospheric flow. Large-eddy models (LEM's) are widely used to analyze processes connected to the evolution of these kinds of clouds by simulating motions in the atmospheric boundary layer and the entrainment zone. Because LEM's tend to be very sensitive to the turbulence closure, one of the most challenging tasks is to parameterize the subgrid-scale (SGS) motions adequatly.

In the LES mode of the Icosahedral Nonhydrostatic model (ICON-LEM), the by default used turbulence parameterization is based on a diagnostic Smagorinsky type subgrid viscosity formulation, which is base on resolved scale information only. Simulations based on the prognostic turbulent kinetic energy (TKE) SGS model (Deardorff models) are known to perform better than the Smagorinsky-type models, because they explicitly account for advective and diffusive transport as well as time-rate-of-change terms in the TKE equation. Especially in the entrainment zone these terms are of leading order and they allow the SGS TKE to compensate for changes in the resolved scale fluxes which therefore tend to influence the evolution of clouds by modifying the entrainment rate. For this reason a turbulence closure scheme based on the prognostic TKE was implemented into ICON-LEM to account for compensating SGS fluxes due to the increased production of SGS TKE in the entrainment zone. The performance of the newly implemented scheme will be shown.