Parameterization of boundary-layer turbulence in the AROME non-hydrostatic numerical weather prediction model

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Current high-resolution numerical weather prediction (NWP) models run at a horizontal resolution of 2-3 km. Even at this high resolution turbulence in the Planetary Boundary Layer (PBL) and shallow convection are not resolved explicitly on the grid scale, thus these processes have to be parameterized. The first part of the talk gives a short overview about turbulence parameterizations in state-of-the-art NWP models. Two main approaches are applied: in most models the Reynolds-averaged Navier–Stokes equations (RANS) are solved while a small number of models use similarity theory considerations.

In the second part, the parameterizations of the AROME model, which is run operationally at the Hungarian Meteorological Service, are described. For small scale turbulence, AROME applies a 1.5-order RANS-type closure, which carries a prognostic equation for Turbulent Kinetic energy. At 2.5 km resolution the one-dimensional scheme is used, thus horizontal turbulent fluxes are neglected. The scheme is formulated in terms of the conservative variables liquid water potential temperature and total water content, consequently, phase changes (boundary-layer clouds) are treated implicitly. Cloud cover is diagnosed separately using a statistical cloud scheme. To adequately simulate the non-local nature of the Convective Boundary Layer (CBL), the AROME model applies the Eddy Diffusivity Mass Flux (EDMF) approach, which combines the local turbulence scheme with a mass flux approach. With the use of the EDMF scheme it is possible to simulate the counter-gradient heat fluxes present in the middle part of the CBL.

In the last part of the talk the impact of different PBL parameterizations on the resolved deep convection in the AROME model is investigated. When applying separate parameterizations for boundary-layer turbulence and shallow convection the AROME model tends to overestimate the number and intensity of small convective cells. An assumption is made (based on verified profiles of temperature and humidity) that the underestimation of PBL mixing is the cause of the overestimated convective activity in the model. The application of the EDMF scheme increases PBL mixing and decreases the number of convective cells, thus improving the simulation.