Recent research and development within turbulence parametrization of the ALARO Canonical Model Configuration (CMC)

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ALARO-CMC utilizes the Third Order Moments Unified Condensation Accounting and N-dependent Solver for turbulence and diffusion (TOUCANS), which is an integral part of the ALARO-1 package of physical parametrizations. TOUCANS is a 1D scheme with 2,5 level type of closure, which unifies several ideas into its framework: non-existence of the critical Richardson number, inclusion of the impact of unisotropy of turbulence, prognostic treatment of Turbulence Kinetic Energy (TKE) and Turbulence Total Energy (TTE), treatment of moisture impact on turbulence, Third Order Moments (TOMs) parametrization enabling counter-gradient transport, as well as the possibility of prognostic treatment of mixing length and 3D turbulence parametrization (1D+2D).

Key component of the scheme is a solver for a pair of the above mentioned turbulence energies, whose ratio is used as a stability parameter instead of gradient Richardson number. The scheme is quite sensitive to the selection of mixing length formulation. Currently TOUCANS utilizes Geleyn-Cedilnik Prandtl type formulation, which is basically a smooth Planetary Boundary Layer (PBL) height-dependent function. Its shape in the PBL and asymptotic behaviour at the model top can be adjusted by modification of three additional tuning parameters. Here we focus on testing the performance of a newly implemented TKE-based buoyancy-shear (BS) formulation, where mixing length is computed as a displacement of an air parcel from particular model level initialized by TKE and stopped by joint buoyancy and shear effects. The latter one enables the usage of BS formulation across different stability regimes and it is expected to improve the model performance in stable stratification, as well as near the neutrality. The model configuration we utilized is a hydrostatic version of the ALARO-CMC at 4,7 km grid spacing, with 87 vertical levels of the hybrid-pressure coordinate and time-step of 180 s. The simulations were run throughout the 72-hour forecast window for a summer convection case and a stable winter case, wherein the verification is done using available surface and upper-air measurements.

With most of the RC LACE countries moving towards 2 km grid spacing, or even less, there is an emerging question of the adaptability of current turbulence parametrization, as well as its compliance with the grid-point part of the Semi-Lagrangian Horizontal Diffusion which mimics the horizontal effects of turbulence. Moreover, around 1 km grid spacing and less we should enter the "grey zone" of turbulence or "terra incognita", where turbulent motions are partly resolved and partly still sub-grid. Within the "grey zone", 1D turbulence schemes should be converted to 3D and carefully adapted to interact properly with the resolved turbulence (model dynamics). As a first step we need to identify where the ALARO-CMC is in the context of the "grey zone". For this reason we created four different meshes, covering the same area and differing only in grid spacing, which was set to 4, 2, 1 and 0,5 km respectively. Preliminary analysis of the post spin-up part of 24-hourly non-hydrostatic simulations showed that the resolved part of TKE becomes important already at 1 km grid spacing, i.e. the "grey zone" is reached.

Key words: ALARO-CMC, TOUCANS, turbulence parametrization, mixing length, grey zone, resolved turbulence