TOWARDS THE PSEUDO 3D TURBULENCE WITHIN THE ALARO CMC

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First, the functionality of scripts with the baseline code was ensured on CY46 as there were some problems related to the environment. It also appeared that the baseline code (local CY46 + Petra's developments in dynamics) "carried" problems/limitations with the memory, i.e., more than 45 NODE-s needed to be used while running integration (otherwise job was "hanged").

After ensuring a bit identical results of the baseline with respect to Petra's and operational code, Goger et al. (2018, 2019) developments were phased from the CY43, ensuring the reproducibility of the reference setup. However, the comparison of the resolved and the subgrid TKE on two cycles showed considerable differences, wherein the amount of both energies was smaller on the CY46. Three sources of differences were identified and tested: i) NSITER=2 and LQCPL=F in the CY46 experiment (small impact), ii) not using stabilized TKE/TTE solver and not diffusing TTE in the CY43 experiment and applying the antifibrilation scheme (some impact on both resolved and subgrid TKE) and iii) other changes in physics (prognostic graupel, Lopez scheme, roughness treatment, etc.; strong impact in the cloud layer). The first source of differences was included by mistake, while other two sets were accepted as added value between the two cycles. There was still some small difference after modifying the above, which is attributed to other developments "coming with the executable".

New references were computed for each resolution on the CY46, i.e., 4, 2, 1 and 0.5 km, wherein the conclusions remained the same as on CY43, i.e., there is too much resolved and total TKE, while subgrid is probably too much decreased (problems already start at 1 km). The most influential tests were repeated at 0.5 km, confirming some benefit from tuning the reduced spectral diffusion (RSD; increasing its strength overall and applying it at lower levels) and a huge impact of 3MT. The question arises whether 3MT can be somewhat improved, thus further reducing the amount of resolved TKE; switching it off introduces a lot of noise seen in most of the fields, increases the amount of precipitation and resolved TKE. To further test the role of RSD, we tried to replace it with spectral nudging utilizing the settings of AROME-MF at 500 m. The simulation was unstable after ~ 1.5 hours and KE spectra analysis pointed to abundance of energy at all spatial scales (above the level 30). Therefore, we concluded that the RSD settings are satisfactory and it can't be replaced by spectral nudging just like that. Any related attempts are stopped for the time being.

Further, the focus was on different approaches to 3D turbulence, including the testing of Goger et al. (2018, 2019) approach and inspection of 1D+2D turbulence code, as well as checking the possibility and location where the Leonard terms would be included. The impact of Goger et al. (2018, 2019) scheme was found too big at first, which was attributed to the scaling factor “s” in the Wang (2021) formulation, used to compute the horizontal turbulence length scale (HTLS; they utilized a constant value of Δ, while ours was resolution-dependent, leading to higher values of HTLS). Setting the same value of “s” resulted in reducing the impact of the scheme, seen both in resolved and subgrid TKE.

On the other hand, few bugs were found in the 1D+2D scheme. First, the C_K, computed locally in ACTKECOEFKH, was multiplied with 4 instead of being powered to 4. Second, the L3DTURB in the ACMRIP was hard-coded locally as .FALSE., thus the true horizontal stability functions were never computed. Further, the existing HTLS option was replaced with Wang (2021) to be consistent with Goger et al. (2018, 2019) scheme (both use the same formulation) and computed locally with a new subroutine ACMIXLENH. Its protection is done outside ACMIXLENH, with the grid-box size, i.e., c_s*SQRT(ΔxΔy). c_s is Smagorinsky’s constant. The fixes are also done on the dynamics side (Petra’s work) by fixing the way how horizontal second derivatives are computed using the properties of Semi-Lagrangian interpolators. Finally, the most appropriate place to introduce Leonard’s terms is after the call of TOMs. i.e., following the ACDIFV3 subroutine. More research/discussion is needed regarding the potential variables on which they would be applied.

Following that, the experiments with 1D+2D turbulence scheme and Wang (2021) HTLS were performed, with impact being comparable to the Goger et al. (2018, 2019) scheme: both used reduced “s” from Wang et al. (2021) formulation. **The impact of both was found to be small. Therefore, a combined experiment, i.e., with both 1D+2D and Goger et al. (2018, 2019) schemes was launched. In both these schemes, the Wang (2021) HTLS was used. As shown in Fig. 1, the resolved TKE was slightly reduced (compared to the reference; positive), while the subgrid TKE was increased (compared to the reference). Finally, the impact of subgrid TKE predominates, resulting in a small increase in the total TKE (slightly negative, except near the surface).**

Further work will focus on testing the sensitivity of both above schemes to the magnitude of the exchange coefficients, including contributions from its integral components (length scale, TKE, stability functions and C_K), accounted through a single parameter encompassing all of them (for simplicity). Additionally, Petra prepared the code to compute the gradients of the horizontal wind on iso-z surfaces, which are sharper and larger in magnitude than those on iso-η surfaces. The latter shall be combined with the above 3D turbulence components, once their reasonable setup is achieved.

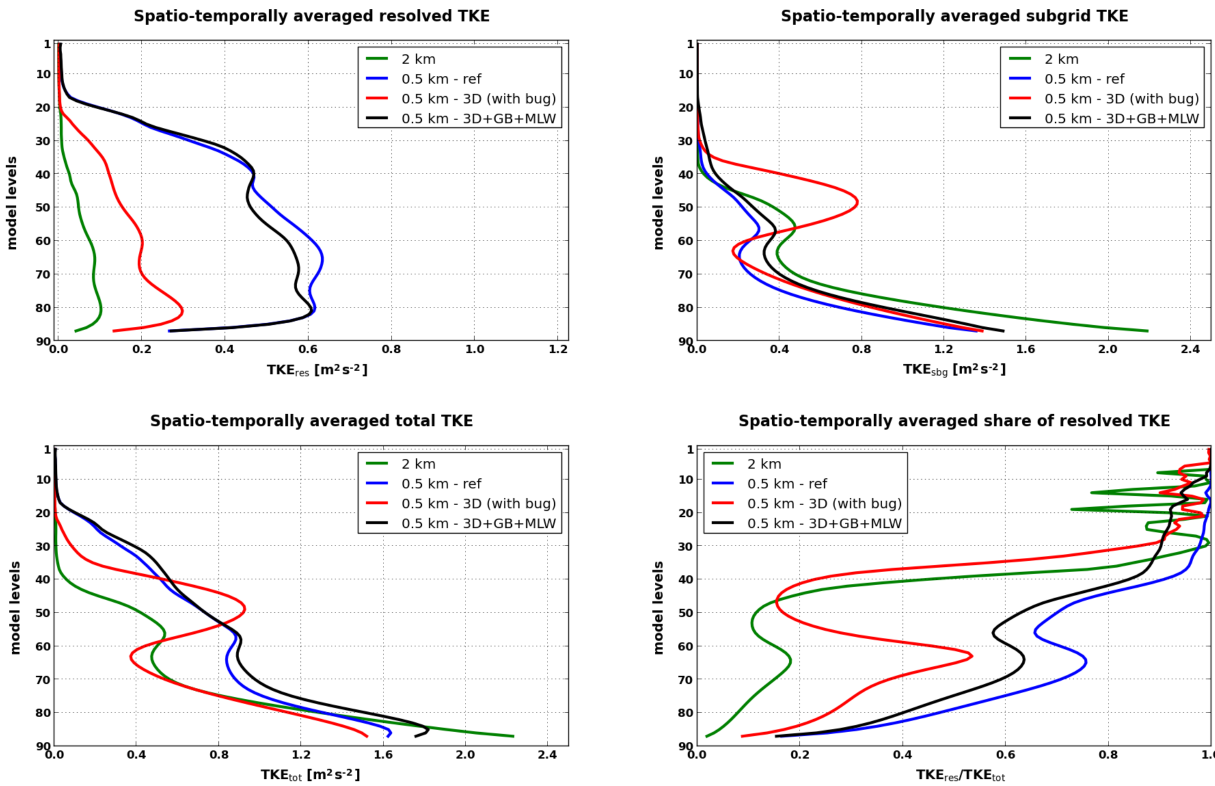

Fig. 1. The comparison of resolved TKE (top left), subgrid TKE (top right), total TKE (bottom left) and share of resolved TKE in total TKE (bottom right) for the ALARO-CMC. Green line: Δx=2 km with default setup, blue line: Δx=0.5 km with default setup, red line: Δx=0.5 km with the old version of the 1D+2D turbulence scheme (with bug), and black line: Δx=0.5 km with the new version of the 1D+2D turbulence scheme, Goger et al. (2018, 2019) scheme and Wang (2021) horizontal turbulence length scale formulation.

NOTE: This text shall be used as the basis for the final RC-LACE stay report, following the second two-week long stay in the December. In the meantime, Mario will agree with Petra on plots that are interesting for showing at the LSC and EWGLAM meetings. During the summer, i.e., before the autumn LSC, the goal is to set up the horizontal length scale configuration (namely its scaling and link to vertical TOUCANS length scales) and combine it with the latest approach to compute horizontal wind gradients. Later on, the possible optimization of the 3MT at 500 m should be investigated.