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Performance of a TKE diffusion scheme in ECMWF IFS Single Column Model

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Numerical Weather Prediction models (NWP) as well as climate models are used for decision making on all levels in society and their performance and accuracy are of great importance for both economical and safety reasons. Today's extensive use of weather apps and websites that directly uses model output even more highlights the importance of realistic output parameters. The turbulent atmospheric boundary layer (ABL) includes many physical processes which occur on a subgrid scale and need to be parameterized. As the absolute major part of the biosphere is located in the ABL, it is of great importance that these subgrid processes are parametrized so that they give realistic values of e.g. temperature and wind on the levels close to the surface.

GEWEX (Global Energy and Water Exchange Project) Atmospheric Boundary Layer Study (GABLS), has the overall objective to improve the understanding and the representation of the atmospheric boundary layers in climate models. The study has pointed out that there is a need for a better understanding and representation of stable atmospheric boundary layers (SBL). Therefore four test cases have been designed to highlight the performance of and differences between a number of climate models and NWP:s in SBL. In the experiments, most global NWP and climate models have shown to be too diffusive in stable conditions and thus give too weak temperature gradients, too strong momentum mixing and too weak ageostrophic Ekman flow. The reason for this is that the models need enhanced diffusion to create enough friction for the large scale weather systems, which otherwise would be too fast and too active.

In the GABLS test cases, turbulence schemes that use Turbulent Kinetic Energy (TKE) have shown to be more skilful than schemes that only use stability and gradients. TKE as a prognostic variable allows for advection both vertically and horizontally and gives a "memory" from previous time steps. Therefore, e.g. the ECMWF-GABLS workshop in 2011 recommended a move for global NWP models towards a TKE scheme.

Here a comparison between a TKE diffusion scheme (based on the implementation in the ARPEGE model by Meteo France) is compared to ECMWF:s IFS operational first-order scheme and to a less diffusive version, using a single column version of ECMWF:s IFS model. Results from the test cases GABLS 1, 3 and 4 together with the Diurnal land/atmosphere coupling experiment (DICE) are presented.