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Parameterization of vertical diffusion and the atmospheric boundary layer height determination in the EMEP model

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Abstract. This paper introduces two changes of the turbulence parameterization for the EMEP (European Monitoring and Evaluation Programme) Eulerian air pollution model: the replacement of the Blackadar in stable and O'Brien in unstable turbulence formulations with an analytical vertical diffusion profile ($K(z)$) called Grisogono, and a different mixing height determination, based on a bulk Richardson number formulation (Ri_B). The operational or standard (STD) and proposed new parameterization for eddy diffusivity have been validated in all stability conditions against the observed daily surface nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and sulphate (SO_4^{2-}) concentrations at different EMEP stations during the year 2001. A moderate improvement in the correlation coefficient and bias for NO_2 and SO_2 and a slight improvement for sulphate is found for the most of the analyzed stations with the Grisogono $K(z)$ scheme, which is recommended for further application due to its scientific and technical advantages. The newly extended approach for the mechanical eddy diffusivity is applied to the Large Eddy Simulation data focusing at the bulk properties of the neutral and stable atmospheric boundary layer. A summary and extension of the previous work on the empirical coefficients in neutral and stable conditions is provided with the recommendations to the further model development. Special emphasis is given to the representation of the ABL in order to capture the vertical transport and dispersion of the atmospheric air pollution. Two different schemes for the ABL height determination are evaluated against the radiosounding data in January and July 2001, and against the data from the Cabauw tower, the Netherlands, for the same year. The validation of the ABL parameterizations has shown that the EMEP model is able to reproduce spatial and temporal mixing height variability. Improvements are identified especially in stable conditions with the new ABL height scheme based on the Ri_B number.

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