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Uncertainty characterization of tracer vertical mixing in the atmospheric transport model WRF-VPRM

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Large uncertainty of air quality modelling lies in the representation of vertical mixing of tracers in the planetary boundary layer (PBL). For the atmospheric transport of greenhouse gases (GHG) such as carbon dioxide (CO_2) studies have shown that imperfect representation of vertical mixing in the transport model can lead to substantial bias of the simulated CO_2 distribution which makes the interpretation of data difficult. One of the current objectives in carbon cycle science is to relate carbon source/sink processes to external forcing on sub-continental scales. This so-called top-down approach tries to inversely link atmospheric CO_2/CH_4 mixing ratio measurements to sources and sinks in order to infer flux strengths by using atmospheric transport models. To make predictions by the top-down method more reliable model errors in the simulation of PBL mixing have to be quantified.

In the current study we applied a transport model that is widely used for air pollution modelling studies: WRF-Chem which we apply as part of the WRF-VPRM modelling framework. The model was set up with a horizontal resolution of 10 km and 41 vertical levels to simulate CO_2 transport over large parts of the European continent for a one month period in summer 2006. Two simulations were conducted employing different parameterizations of the PBL: the Mellor-Yamada-Janjic (MYJ) and the Yonsei University (YSU) scheme. To asses the uncertainty in the vertical mixing we compared the mixed layer height (z_i) up to which CO_2 gets mixed within several minutes up to an hour. The z_i is an important variable in air quality modelling because it directly determines the integration volume for pollutants emitted from the ground. Since photosynthetic uptake of CO_2 and PBL growth are correlated a wrongly simulated PBL height might also give rise to additional bias due to rectifier effects. In our experiment z_i differs significantly for both schemes with a bias of 200-500 m for day and nighttime. We also present comparison results for both schemes to observed z_i, such as radio sounding measurements. To be able to relate z_i errors to errors in CO_2 we developed a method to correct modeled CO_2 fields by using information on the true height of the mixed layer. We will show the results of a pseudo-data experiment in which we defined YSU as known truth and corrected MYJ simulated CO_2 offline.