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Characterization of model-data mismatch of CO2 concentrations due to misrepresentation of mixing layer height in high resolution WRF-VPRM simulations

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Estimating surface-atmosphere exchange of greenhouse gases at regional scales is important for understanding feedbacks between climate and the carbon cycle, but also for verifying climate change mitigation such as emission reductions or carbon sequestration. One way to quantify greenhouse gas budgets on regional scales is to use atmospheric mixing ratio measurements in combination with high resolution inverse modeling tools. An important aspect of this top-down approach is that mismatches between observations and model results for mixing ratios are not solely due to uncertainties in surface-atmosphere exchange fluxes that are targeted by the inversion, but also due to errors in the transport models used for inverse modeling. One of the dominant uncertainties in this context is related to vertical mixing associated with turbulence near the surface, which causes trace gases to be mixed within the atmospheric mixing layer. The mixing height, up to which trace gases emitted from the surface get vertically mixed within about an hour, provides a good diagnostic to assess vertical mixing. Uncertainties of mixing heights (zi) as represented in the transport model can result in uncertainties of CO2 mixing ratios of several ppm during summertime, much larger than measurement uncertainties. The goal of our study is to systematically quantify and reduce these uncertainties in a high resolution model by using observation based estimates of zi.

We make use of the WRF-VPRM modeling framework, which couples the Weather Research & Forecasting (WRF) transport model with the diagnostic biosphere Vegetation Photosynthesis and Respiration Model (VPRM) at high horizontal resolution (10 km) over Europe. To asses the influence of differences in simulated vertical mixing we set up our model with two different PBL schemes. We used a model independent method to derive the mixing layer heights from both runs for the month of August 2006 during day time. Simulated zi were also compared against zi derived from radiosoundings, in future we also target remote sensing information on zi from satellite and ceilometers networks to be included in our study. On average the results indicate bias in zi of about 10% between the two runs which was found to be consistent with comparisons against radiosounding derived zi. To assess if simulated CO2 fields can be corrected for known errors in mixing height, we perform a pseudo data experiment using one simulation as known truth, and apply a mass balance approach to adjust the CO2 profile of the second simulation to match the "true" mixing height while holding the column amount fixed. The same approach is applied using measurement based mixing heights to correct output of the WRF-VPRM simulation. Here we show first results from the comparison of corrected model CO2 concentrations with concentrations observed at several measurement sites within the model domain and also with CO2 profiles from airborne measurements made at the Bialystok observatory. We conclude by making suggestions on how to mitigate the negative effects of wrong zi representation in the transport models in current inversion modeling frameworks.