

## ***Interactive comment on “Error characterization of CO<sub>2</sub> vertical mixing in the atmospheric transport model WRF-VPRM” by R. Kretschmer et al.***

**Anonymous Referee #2**

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In this paper the errors of simulated CO<sub>2</sub> mixing ratios associated with the PBL vertical mixing in a high resolution mesoscale transport model is examined. Two different commonly used PBL parameterization schemes are used in simulations with the WRF-Chem model equipped with an online coupled simple biosphere model VPRM.

The article is generally well written and is well suited for publication in ACP after some minor improvements, corrections and modifications for which I included suggestions that are listed below. The article is a bit lengthy and could be shortened a bit. For example I would suggest to shorten section 2.4 by 50%. Breaking up long sentences and checking the text with a native speaker could improve the clarity.

A general comment is that in this paper the reference 'truth' scheme is YSU to which the MYJ is compared. It should be stated somewhere that it is not clear from this synthetic

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experiment which scheme actually is better, when looking at the differences one could expect there should be a clear winner. It might well be that the YSU scheme is too diffusive, especially over ocean surfaces. That both schemes, though delivering quite different MLH, work pretty well for PBL meteorology might be caused by compensating effects in for example wind speeds and surface heat fluxes. Timing of ML growth is an important parameter that can help us to discriminate the better PBL scheme when observations of MLH are available.

For some of the stations used in this study actual observations of MLH (and CO<sub>2</sub> observations (vertical gradient along the tower, which allows to check for the well mixed condition and approximate the true CO<sub>2</sub> MH when this is below the tower top level))) should be available in the study period...

Textual Comments:

p28179 l10: causal link -> relation represented by -> approximated with

p28172 l1-6: This is too general, in winter conditions in mid-latitude temperate climate and in (sub)arctic climate (even more generally during conditions with subsidence at large synoptic scale), also during daytime not always a CBL develops. Entrainment occurs at every upward change of the CBL top, not only by thermal overshoots. The mixed in air is not always free tropospheric air but might be from (stable) residual layers where emission signals remain from previous day or night. The effects of entrainment can be much larger than several ppm.

l14: after sunset no incoming radiation heats the surface any more, the earth loses heat because of long wave transmission and the surface and surface air cools down leading to a stable stratification of the PBL. Turbulence does not cease but is reduced. There is still vertical diffusion though it is strongly reduced. Strong winds due to synoptic conditions or orography may cause sustained mechanical turbulence preventing the development of a stable PBL.

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p28173 l5: variations->variation better would be to use the term "multi-annual trend" here, is-> could be

l9: typically 3 ppm during summertime in the temperate zones of NW Europe

l12: to a -> at

l25: reference and correct version number for EDGAR emission data and resolution deployed is missing

p28175 l7: you mean a 10 cells (i.e. 100km) thick border zone excluded on all sides of the inner domain?

l15: which->that

p28176 l1-4: In principle there is a feedback between vertical mixing and the surface temperature, latent heat and following cloud development (influencing radiation) and thus on assimilation rates, this would complicate the comparison as the focus is on influence of the MLH on concentrations, but this still should be mentioned

p28177 l3: CO2 fluxes -> net CO2 fluxes (NEE)

p28178 l1: I would prefer not to do this simplification, as application of the hydrostatic equation is very simple to derive the height dependent molar air densities. This simplification introduces artefacts up to 20% in the correction factors which is simply too large

p28181 l14: there are many tall towers that measure profiles up higher than 100m, even up to >330m agl

p28181 l18: arising for -> rising in

p28183 l5: observation sites-> existing observation sites

l7: influences -> influence

l14: more common is to use 50m as lower boundary for MLH, half of grid cell height in  
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a particular setup does not seem like a rational choice

p28135 l25-28: this effect might also be explained by advection of day time depleted air masses reaching the site, during the well mixed conditions during the day the uptake is accumulated in the ML. Local NEE does not need to play a big role.

p28186 l1: It is known for Cabauw that observed MH are below 200m for 60% of the time, in August nighttime MH is usually 50m or lower. So a night time offset of 300-400m allows to falsify the 'truth' values. Anthropogenic emission influence in the Cabauw model grid cell depends strongly on exact grid cell configuration of WRF and the EDGAR grid as the city of Utrecht is at relatively small distance.

l 12; reduced -> reduced with

p28187 l4: each -> all

l5-l10: please rephrase

l21-23: please rephrase

p28188 l6: fluctuation->fluctuations

l15: to a first order -> in first order/mainly

l20 observation based -> observed

l21 But probably more -> More

l23 currently -> currently being

l26 comes as no -> does not come as a

p28189 l17: ongoing research and refer to a 12 year old publication?

p28190 l8-l10: lagrangian methods are as good as quality of the underlying meteorological fields allows, the vertical movements in frontal systems not resolved in e.g. WRF are not generated by the lagrangian transport models themselves. The lagrangian

method might be able to resolve better the local flow field. But after improvement by assimilation of MLH observations by the mentioned methods also lagrangian models will improve further

p28190 l5: being discussed -> are planned

p28192 l15: would be better to express the bias relative to the source signal

l29: an -> a

p28193 l16: known -> presumably better constrained (???)

Fig 3 :  $\mu\text{moles}$ -> $\mu\text{mol}$ . To avoid confusion I would suggest to pick other line colours for the right graph

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 28169, 2011.