

Atmos. Chem. Phys. Discuss., referee comment RC1
<https://doi.org/10.5194/acp-2020-1243-RC1>, 2021
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Comment on acp-2020-1243

Anonymous Referee #2

Referee comment on "Vehicle-induced turbulence and atmospheric pollution" by Paul A. Makar et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-1243-RC1>, 2021

This study investigates the impact of kinetic energy from moving vehicles on the vertical distribution of combustion emissions and uses a VIT parameterization to account for the vertical transport of fresh mobile emissions in a 3D chemical transport model. This is an important topic as a better representation of vehicle emissions and mixing in atmospheric chemical transport models is crucial for an improved understanding of air pollutants. The manuscript is generally well written and aims to provide a way to improve mixing of mobile emissions in 3D regional modeling. Reasonable assumptions are made to parameterize vehicles with different sizes and running with distinct road conditions. However, the evaluation of the VIT parameterization is rather weak and there are a few major flaws in the manuscript.

- In the introduction section, it states that the LES models are typically employed at centimeter or meter level resolutions, while the mixing lengths associated with VIT are on the order of tens of meters. This incomplete review of LES studies is misleading as it indicates the vertical influence of VIT is between the scales of a LES and a 3D regional model. However, the following studies all applied LES coupled with chemistry at a horizontal resolution of tens of meters, and there are more similar LES studies not listed here.

Vinuesa and Vil.-Guerau de Arellano (2005) Atmos. Environ., 39(3), 445–461

Ouwensloot et al. (2011) Atmos. Chem. Phys., 11(20), 10681–10704

Li et al. (2016) J. Geophys. Res., 121(13), 8083-8105

Kim et al. (2016) Geophys. Res. Lett., 43(14), 7701-7708

As the VIT problem is actually on a LES scale and a LES model with chemistry has already taken into account turbulent mixing in the boundary layer, it might be more convincing to illustrate the impact of VIT on the vertical mixing of vehicle emissions if a LES model is employed.

- On line 635, it states that "An examination of all of the other possible sources of error in air-quality models is beyond the scope of this work." This is understandable. But 3D regional models typically have difficulties representing turbulence and vertical mixing, which cause a large portion of their model-observation discrepancies. Without considering errors related to boundary layer turbulence, it is hard to evaluate the VIT parameterization developed in this study. The manuscript states that "We also emphasize that the work does not identify a deficiency in existing meteorological boundary layer turbulence models." Does it mean the 3D model used in this study represents turbulence very well? Please clarify whether it refers to the 3D model used in this study and how "deficiency" is evaluated.
- Although the manuscript states that "The use of the VIT parameterization has been demonstrated to result in decreases in air-quality model error," this is not convincing as the changes in the metrics used to evaluate model performance are inconsistent and the differences in these metrics between the VIT simulation and No VIT simulation are quite small. It is necessary to show whether adding VIT actually leads to statistically significant differences. Statistical significance can be calculated based on the differences (VIT simulation - No VIT simulation) in daily averaged NO₂, PM_{2.5} and O₃ at each site. Alternatively, estimates of vehicle km travelled can be used as a criterion to select sites, then significance could be calculated based on the selected sites with similar traffic conditions and background meteorological conditions.
- To evaluate the VIT parameterization, using observations from surface monitoring sites only is not sufficient. Due to the limitations and uncertainties acknowledged in this study, it is actually better to develop and test the VIT parameterization based on a small domain, maybe city size, which has relatively simple traffic and meteorological conditions as well as observational vertical profiles of chemical species for evaluation. The manuscript shows vertical cross-sections in Figure 10. Without the observed vertical distributions of NO₂, PM_{2.5} and O₃, it is hard to determine whether using the VIT parameterization leads to an improvement.
- On line 108, the manuscript states "Here we make use of both the observational and LES modelling studies to devise a parameterization for VIT." This is the last place in the manuscript that LES is referred to, so it is rather confusing how LES modeling studies are used in this study. As discussed above, please acknowledge other LES studies, and also carefully elaborate how "LES modeling studies" are used here. If not used, please also clarify.