

Response to Reviewers

Reviewer #3

Hereby I offer only one comment to complement other reviewer's comments on a rather important aspect of the paper. It is not true as the authors stated that "However, as far as we know, the influence of pressure on evaporative emissions has not been documented, posing a challenge to our comprehension of vehicular emissions in high-altitude regions."

In fact, this effect of evaporative emissions on altitude has been well documented, e.g., in MOVES model by the US EPA (US EPA, 2024, p20, Equation 3-6). Therein, the effect is clearly considered, i.e., "Tank vapor generated depends on the rise in fuel tank temperature (F), ethanol content (vol. percent), Reid vapor pressure (RVP, psi) and altitude". And there is also a table comparing model parameters appropriate for Denver, a city that is ~1700 meters above sea level versus those for at sea level.

Therefore, it is crucial for the authors to put their study in the context of what is already known, by changing the statement above to reflect the state of the science, and, more importantly to reconcile the measurement inferred altitude effect with those documented in the literature.

References

USEPA, 2024, Evaporative Emissions from Onroad Vehicles in MOVES5, November 2024, EPA-420-R-24-014, <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P101CTZI.pdf> (last accessed 8/10/2025).

Reply: Thank you for your critical and insightful comment. We sincerely apologize for the inaccuracy in our original statement regarding the documentation of altitude effects on evaporative emissions. As you correctly pointed out, the MOVES model (USEPA, 2024) indeed incorporates the effects of altitude (pressure) on evaporative emissions. However, empirical measurements under real-world high-altitude conditions remain scarce. In response to your feedback, We have added the suggested reference (USEPA, 2024) as well as another relevant study (Wang et al., 2018)

to the reference list. We have also revised the relevant statement in the manuscript to more accurately reflect the current state of knowledge, while highlighting the unique contribution of our study. The amended text now reads:

Section 1 Line 45-52: The evaporation of fuels and solvents is an equilibrium process involving hydrocarbon molecules transitioning between the gas and liquid phases, governed primarily by temperature and pressure conditions (Huang et al., 2022). Elevated temperatures and low pressures theoretically facilitate fuel evaporation (Huo et al., 2024; Wang et al., 2018). However, in plateau regions, low atmospheric pressure often coincides with cooler temperatures, resulting in competing influences that are not yet fully quantified. Computational models such as MOVES model estimate that tank vapor generation at 1,700 meters above sea level is approximately 1.4 times that at sea level, indicating potentially significant altitude-enhanced emissions (US EPA, 2024). They also underscore the critical need for empirical validation under real-world, high-altitude conditions, which remain severely limited.

In addition, we have updated the section 3.1 to better place our study in the context of existing knowledge on the subject.

Section 3.1 Line 128-132: When comparing the identical compositions, the average EF in plateau tunnels is 1.9 times higher than that in the Shing Mun tunnel in Hong Kong (50 m a.s.l.) (Ho et al., 2009). The determined ER is 3.9 and 1.9 times higher than those in the Shing Mun tunnel and the Chung-Liao tunnel in Taiwan (330 m a.s.l.) (Chiang et al., 2007), respectively. These results are significantly higher than the 1.4 times increase in fuel evaporation observed in Denver (1,700 m a.s.l.) relative to sea level (US EPA, 2024).

References:

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- Ho, K. F., Lee, S. C., Ho, W. K., Blake, D. R., Cheng, Y., Li, Y. S., Ho, S. S. H., Fung, K., Louie, P. K. K., and Park, D.: Vehicular emission of volatile organic compounds

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Huang, J., Yuan, Z. B., Duan, Y. S., Liu, D. G., Fu, Q. Y., Liang, G. P., Li, F., and Huang, X. F.: Quantification of temperature dependence of vehicle evaporative volatile organic compound emissions from different fuel types in China, *Sci. Total. Environ.*, 813, 9, <https://doi.org/10.1016/j.scitotenv.2021.152661>, 2022.

Huo, S., Zhang, X., Xu, W., Dang, J., Xu, F., Xie, W., Tao, C., Han, Y., Liu, X., Teng, Z., Xie, R., Cao, X., and Zhang, Q.: Updating vehicle VOCs emissions characteristics under clean air actions in a tropical city of China, *Sci. Total. Environ.*, 930, 172733, <https://doi.org/10.1016/j.scitotenv.2024.172733>, 2024.

US EPA, 2024, Evaporative Emissions from Onroad Vehicles in MOVES5, EPA-420-R-424-014, <https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockkey=P101CTZI.pdf> (last accessed: 8/10/2025)

Wang, H., Ge, Y., Hao, L., Xu, X., Tan, J., Li, J., Wu, L., Yang, J., Yang, D., and Peng, J. J. A. E.: The real driving emission characteristics of light-duty diesel vehicle at various altitudes, *Atmos. Environ.*, 191, 126-131, 2018.