

Author comments on the manuscript “TANGO CO₂ and NO₂ Observations: Synergistic Usage to Improve Emission Quantification and Characterize Atmospheric Chemistry”, Reviewer 1

We thank the reviewer for the careful and constructive reading of the manuscript. The comments have helped us to improve the presentation and physical justification of the model. In this document we provide our replies to all comments. The original comments are typeset in italic and bold face font, followed by our reply. Line numbers refer to the original version of the manuscript unless stated otherwise.

1 Technical and Minor Comments

1. ***L23-24: After the revision, this wording reads a little awkwardly: "emit substantial amounts of ... nitrogen dioxide (NO₂)" Given that NO_x is emitted primarily as NO, would it make more sense to move the definition of NO₂ to line 30?***

adjusted

We changed the text in the manuscript p1, l22–24 from "emit substantial amounts of carbon dioxide (CO₂), nitrogen oxides (NO_x), and nitrogen dioxide (NO₂), making them priority targets" to "emit substantial amounts of carbon dioxide (CO₂) and nitrogen oxides (NO_x), making them priority targets" and changed p2, l29–30 from "enabling detection and quantification of NO_x emissions" to "enabling detection and quantification of nitrogen dioxide (NO₂) and NO_x emissions".

2. ***L35, L559 and L562: I believe "2" in CO₂M is not subscripted.***

adjusted

We changed all three occurrences in the manuscript p2, l35; p19, l559; and p19, l562 from CO₂M to CO₂M.

3. ***L85: Maybe NO₂ -> NO_x***

adjusted

We changed the text in the manuscript p3, l85 from "monitoring NO₂ emissions" to "monitoring NO₂ and NO_x emissions".

4. ***L168: Here -> here***

adjusted

We changed the text in the manuscript p6, l168 from "Here, s denotes" to "here, s denotes".

5. ***L191: I am not 100% sure about this (new) part: "whereas they must be known a priori when working with the NO₂/NO_x ratio." I think fitted or calibrated could be used instead of known. On the other hand, I believe this may be related to the specific approach chosen by Meier et al. (2024) and may not be true in general. This statement could therefore be reworded or removed.***

adjusted

We changed the text in the manuscript p7, l190–191 from "whereas they must be known *a priori* when working with the NO₂/NO_x ratio" to "whereas they must be fitted or calibrated from additional information when working with the NO₂/NO_x ratio".

6. ***L280: I believe Kuhlmann et al. (2019) also used NO₂ for plume detection, and NO₂ is used for CO₂ plume detection in many other studies. The connection to previous studies could be clarified or alternatively removed: "The key distinction here is that our threshold is applied to the co-emitted NO₂ field rather than to the target species CO₂ itself, exploiting NO₂'s superior signal-to-noise ratio for spatially coherent plume delineation independent of CO₂ noise."***

adjusted

We changed the text in the manuscript p9, 1278–282 from "The key distinction here is that our threshold is applied to the co-emitted NO₂ field rather than to the target species CO₂ itself, exploiting NO₂'s superior signal-to-noise ratio for spatially coherent plume delineation independent of CO₂ noise." to "The use of NO₂ for plume detection has been explored in previous multi-species emission studies (Kuhlmann et al., 2019, Reuter et al., 2019). Here, our threshold is applied to the co-emitted NO₂ field rather than to the target species CO₂ itself, exploiting NO₂'s superior signal-to-noise ratio for spatially coherent plume delineation independent of CO₂ noise."

7. **L290:** *I would suggest removing the word "original" as the IME approach was already used by Frankenberg et al. (2016).*

adjusted

We changed the text in the manuscript p9, 1289–290 from "differs from the original Varon et al. (2018) implementation" to "differs from the Varon et al. (2018) implementation".

2 Additional corrections

We added the following statement to the data availability section:

"The microHH large-eddy simulation data used in this study are publicly available on Zenodo: Borsdorff et al. (2026), microHH large-eddy simulation data of reactive CO₂ and NO₂ plumes from an idealized industrial point source for four emission strengths, Zenodo [data set], <https://doi.org/10.5281/zenodo.20624504>. "

References

- Kuhlmann, G., Broquet, G., Marshall, J., Clément, V., Löschner, A., Meijer, Y., and Brunner, D.: Detectability of CO₂ emission plumes of cities and power plants with the Copernicus Anthropogenic CO₂ Monitoring (CO2M) mission, *Atmospheric Measurement Techniques*, 12, 6695–6719, <https://doi.org/10.5194/amt-12-6695-2019>, 2019.
- Reuter, M., Buchwitz, M., Schneising, O., Krautwurst, S., O'Dell, C. W., Richter, A., Bovensmann, H., and Burrows, J. P.: Towards monitoring localized CO₂ emissions from space: co-located regional CO₂ and NO₂ enhancements observed by the OCO-2 and S5P satellites, *Atmospheric Chemistry and Physics*, 19, 9371–9383, <https://doi.org/10.5194/acp-19-9371-2019>, 2019.
- Varon, D. J., Jacob, D. J., McKeever, J., Jervis, D., Durak, B. O. A., Xia, Y., and Huang, Y.: Quantifying methane point sources from fine-scale satellite observations of atmospheric methane plumes, *Atmospheric Measurement Techniques*, 11, 5673–5686, <https://doi.org/10.5194/amt-11-5673-2018>, 2018.