Response to Reviewer #1

We thank the reviewer for the careful evaluation of our manuscript and for the constructive comments and suggestions. Our point-by-point responses are provided below, with reviewer comments shown in blue and our replies in black.

The paper of Mijling et al. presents ground-based measurements of NO2 in a poorly sampled region in Africa with a low cost but reliable technique. The study is well conducted, the dataset and findings are relevant for the research as well as for the local community, and the paper is pleasant to read, so I highly recommend publication after the authors have considered the remarks below.

My only major comment on the content is the strong statement in the abstract 'TROPOMI underestimates the tropospheric NO2 column densities by a factor of roughly 2.5...'. The parametrization method to reach this 2.5 number is clearly described and seems reasonable, but there s no validation of it. It seems to me that this could have been done with MaxDOAS at European sites. Did the authors consider doing that? I would simply add something like 'Using a parametrization method based on our ground-based measurements and TROPOMI' at the beginning of the sentence to improve this point. The formulation on the conclusion reads good on the other hand.

We refined our statement on the underestimation of TROPOMI by revising the end of the abstract to "*Using a parametrization method based on ground-based measurements and TROPOMI retrievals, we find that TROPOMI underestimates tropospheric NO_2 column densities by roughly a factor of 2.5 in March 2025. (…).*"

We agree that the proposed parametrization method would gain confidence if properly validated. This could be done using MAX-DOAS measurements in Europe, as suggested. We feel that conducting such a thorough validation study is beyond the scope of the current paper, as it would divert focus from our main findings, but we plan to consider this in future investigations.

Beside that, I have mainly minor comments.

L.61: 'To the best of our knowledge, there are currently no operational AQMs openly reporting NO2 measurements in Sub-Saharan Africa (OpenAQ, 2025).' What about South-Africa? (https://saaqis.environment.gov.za/)

Thank you for this suggestion. We are aware that South Africa operates an active monitoring network. From Gwaze & Mashele (2018), we understand that there are 130 fully automated air quality monitoring stations in South Africa, some of which measure NO_2. However, the data does not appear to be openly accessible. We attempted to access the website on several occasions between 6 and 16 March 2026 without success. Although the website includes a login option, it is unclear how new users can register. In addition, the data shown in the Dynamic Tables do not indicate from which monitoring station the data is derived. We therefore decided to leave our statement unchanged.

In the intro, the authors could add that Palmes tube were used in citizen science projects in Europe, for instance in Antwerp with the curieuzeneuzen project, the data were used in scientific publication e.g.

D. Voordeckers, F.J.R. Meysman, P. Billen, T. Tytgat, M. Van Acker, The impact of street canyon morphology and traffic volume on NO2 values in the street canyons of Antwerp, Building and Environment, Volume 197, 2021, 107825, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2021.107825.

We agree that including this reference highlights how Palmes tubes meaningfully fill gaps in otherwise undersampled areas. We have therefore added: "*PDTs have also been used in citizen science monitoring campaigns across Europe, for example to measure local air quality and evaluate the street canyon effect in the city of Antwerp, Belgium (Voordeckers et al., 2021)*"

Also, the validation of TROPOMI in Kinshasa from Yombo et al. could be added as there are not many of such works in this region

Yombo Phaka, R., Merlaud, A., Pinardi, G., Friedrich, M. M., Van Roozendael, M., Müller, J.-F., Stavrakou, T., De Smedt, I., Hendrick, F., Dimitropoulou, E., Bopili Mbotia Lepiba, R., Phuku Phuati, E., Djibi, B. L., Jacobs, L., Fayt, C., Mbungu Tsumbu, J.-P., and Mahieu, E.: Ground-based Multi-AXis Differential Optical Absorption Spectroscopy (MAX-DOAS) observations of NO2 and H2CO at Kinshasa and comparisons with TROPOMI observations, Atmos. Meas. Tech., 16, 5029–5050, https://doi.org/10.5194/amt-16-5029-2023, 2023.

We agree with the reviewer that the work of Yombo et al. is relevant for our study, as it shows that the NO_2 retrieval product must be handled with care for African cities. We have added in the Introduction: "*In one of the few validation studies for sub-Saharan tropical cities, Yombo Phaka et al. (2023) show that incorrect a priori profile information in the TROPOMI retrievals leads to significant underestimation of the NO_2 column densities over Kinshasa.*"

On all the maps of Kumasi, I would add the North direction.

North direction added to Figure 7 and Figure 9.

L.91 and 94 Nitrate -> Nitrite?

Corrected

L.189 'true column density' -> I would remove 'true', reads tautological.

Done

Why is it 'campaign' in L.217 and 'campaigns' in L. 218, and again without s in L 237?

Plural changed to singular.

L.239 'Mounting height is approximately 2 meters (see Fig. 4).'-> already stated above, L.228

Removed

L 296 'contribute less significantly to ambient NO2 levels in these areas' -> less than what?

Clarified to "suggesting that industrial emissions are not a major contributor to ambient NO_2 levels in these areas".

Fig 9: unclear what the map on the right adds. The roads could be added to the column map and the right map deleted.

We prefer to keep the right panel as is. In addition to providing orientation by showing the road network, it distinguishes built-up areas (associated with NO_x emissions) from unbuilt areas (associated with lower emissions). This information would become cluttered if the left panel were overlaid semi-transparently.

L.338 'Elevated NO2 levels in upwind regions are not readily apparent in surface measurements, although they might be detectable with a more extend ground-based monitoring network that includes more urban background stations' -> I dont follow, did you mean 'downwind'?

Corrected to "*The elevated NO$_2$ levels found in downwind regions are not readily apparent in the surface measurements, (…)*".

L. 381 'coarse a priori NO2 profiles from TM5-MP'-> what about the realism of the profile, even at low spatial resolution in Africa? Again it would be good to refer to Yombo et al here since they studied the profile effect.

We decided not to included this reference here in order to avoid interrupting the flow of text, but instead add it to the Discussion and Conclusion section. Here we included the sentence: "*This confirms earlier studies by Yombo Phaka et al. (2023), showing the large impact of the a priori profiles on NO2 retrievals over sub-Saharan tropical cities.*"

L 453 'we apply a factor of 0.69 is applied' -> I suggest the active voice

Passive voice removed.

Reference

Gwaze, P., & Mashele, S. H. (2018). South African Air Quality Information System (SAAQIS) mobile application tool: bringing real time state of air quality to South Africans. Clean Air Journal, 28(1). https://doi.org/10.17159/2410-972X/2018/v28n1a1