REPLY TO REFEREE #2 – SECOND ITERATION

We thank the referee for carefully reviewing our manuscript in this second iteration and for noting that most initial comments have been addressed. We also thank the referee for drawing our attention to the following remarks, which we address below. Referee comments are reproduced in black, and our replies are given in blue.

The authors did sufficiently address most comments made in the initial review. There are still a few outlying concerns from some of the new text to bring up though and they mainly pertain to the SWING+ data discussion. Referred lines are in the tracked changes version of the document:

Major concerns:

(1) Citing unpublished work as in the footnote on page 11 is not good practice as underlying information needed to trust the data for validation in this work is within work that is not currently accessible. Appropriately needed information (especially data validation) should be added either to this paper or the paper should be delayed until that paper is publicly accessible and citable.

We removed the footnote and added more details on the validation of SWING instruments to the first paragraph of Section 2.2.3:

"SWING instruments have since been deployed on crewed aircraft for validation flights alongside ground-based DOAS instruments and larger airborne imagers over Berlin, Germany (Tack et al., 2019), and over Bucharest and an isolated power plant in Romania (Merlaud et al., 2020). Observations with SWING instruments demonstrated their capability to resolve urban and industrial plumes, ranging from 10^{15} to 20×10^{15} molec.cm^{-2} in Berlin, and up to 80×10^{15} molec.cm^{-2} in Romania. In both intercomparison studies, Pearson correlation coefficients exceeded 0.9, and linear regression slopes were close to unity with intercepts below 10^{15} molec.cm^{-2}. Over Bucharest, SWING biases were estimated within 28% (accounting for temporal lags with the satellite overpass; Merlaud et al., 2020), indicating its suitability for TROPOMI tropospheric NO_2 validation, as this falls below the satellite mission requirement of 50% (Veefkind et al., 2012)."

We have also added missing details on the retrieval algorithm and revised the structure of Section 2.2.3 to address this comment as well as minor comments (1), (2), and (3) below. We now provide additional information ensuring data quality, including the filtering applied in the first DOAS step:

"*SWING+ measurements are filtered based on the DOAS optical depth fit; measurements with root mean square (RMS) residuals greater than 5×10^{-3} are rejected.*"

We also clarified the origin of the AMF error estimation:

"*Errors in AMF calculations are then mainly driven by surface albedo, NO_2 vertical profiles, and aerosol properties. For the SWING+ campaign, this uncertainty is estimated at 15.2%, based on a sensitivity analysis by Tack et al. (2017).*"

(2) Line 234-235 states that all flights are cloud free because strict flight planning guaranteed that. That is not the reality. In fact, looking at Suomi-NPP imagery (which is within minutes of the TROPOMI overpass so during the flight window) on the flight dates provided in the tables, four days were found to have the the likely chance for cloudy impacts. Specific comments on three of them:

a. *05/07/2021, there is a cumulus field in the region. It even shows up as holes in the flight in the supplement.*
b. *A lot of discussion is put into explaining the poor comparisons on 23/12/2021 (e.g., on page 26) and this was also a cloudy day and could explain this.*
c. *Another day that sticks out on Figure 9 is 05/11/2021. Also clouds in the region on this day.*

Finding a way to filter this data could actually improve the regressions performed. They cannot be ignored.

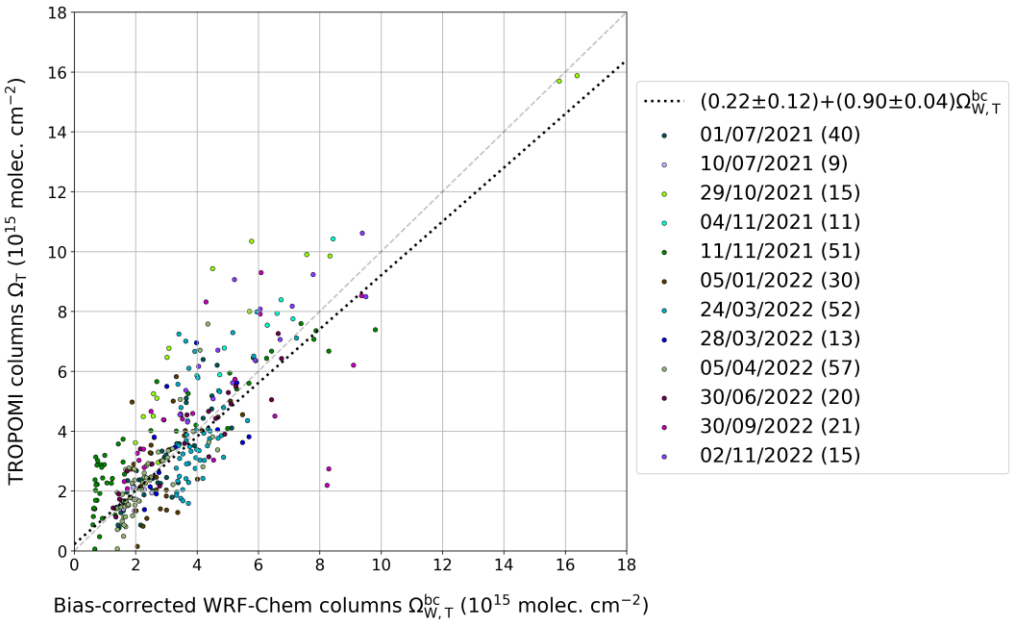
The reviewer is correct that clouds were observed over Bucharest near the TROPOMI overpass times on several dates. Based on the Suomi NPP VIIRS product, clouds were present on 4 of the 17 flight dates (05/07/2021, 05/11/2021, 23/12/2021, and 15/04/2022). We have revised the text accordingly in Section 2.3.1.

To assess the robustness of our conclusions, we repeated the bias estimation of TROPOMI NO_2 columns (Sect. 3.3.2) while excluding these dates from the analysis. In the following and in Supplement 5, we reproduce Figures 10 and 11, which represent the core of the analysis. The differences with respect to the original regression lines remain within, or close to, the original uncertainty bounds, except for winter in Figure 11, which has already been discussed in the manuscript.

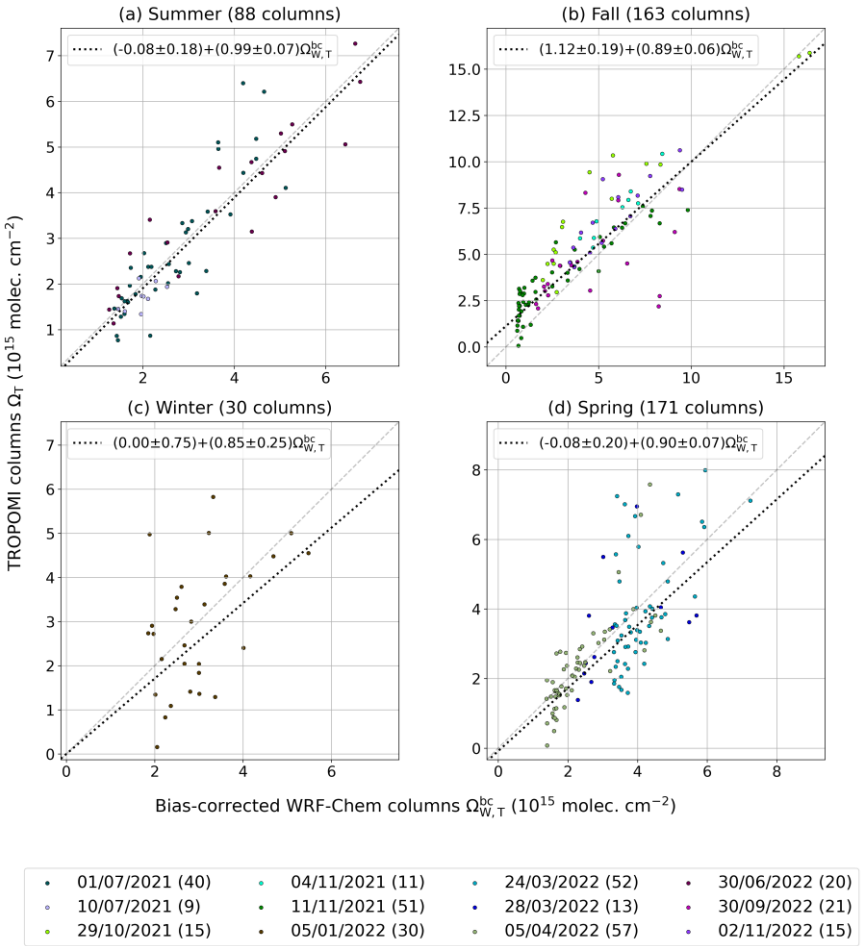
For example, applying the methodology of Section 3.3.2, the updated regression yields TROPOMI biases of 12%, −5%, and −9% for columns of 10^{15}, 4×10^{15}, and 15×10^{15} molec. cm^{-2}, respectively. These are consistent with the biases reported in the manuscript (20±52%, −6±18%, and −13±13%).

We therefore added the following sentence to the revised manuscript in Section 3.3.2:

"Due to partial cloudiness on 4 flight dates (05/07/2021, 05/11/2021, 23/12/2021, and 15/04/2022), a sensitivity analysis was performed by repeating the analysis shown in Fig. 10 and Fig. 11, excluding these dates (Supplement 5). Only minor differences are observed, except in winter, which has already been discussed."



New Figure S17 (reproduction of Figure 10 of the main manuscript), excluding dates with partial cloud cover: 05/07/2021, 05/11/2021, 23/12/2021, and 15/04/2022.



New Figure S18 (reproduction of Figure 11), excluding dates with partial cloud cover: 05/07/2021, 05/11/2021, 23/12/2021, and 15/04/2022.

Minor comments/concerns:

(1) Line 215-217: Can the authors comment quantifying the validation results from SWING from previous campaigns rather than just generally state they are validated. (2) Line 242: where does the number 15.2% come from? (3) Paragraph starting on line 229 should be after the DOAS discussion as its relevant for AMFs.

Specific answers to (1) and (2) are provided in response to the major comments above. Suggestion (3) has been implemented.

References

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LIST OF CHANGES

- **Section 2.2.3:** Details on the validation of SWING instruments, the retrieval algorithm, and AMF calculation have been added.
- **Section 3.3.2:** A comment on the treatment of days with partial cloud cover has been added at the end of the section.
- **Supplement 5:** Figures S17 and S18 have been added to support the treatment of days with partial cloud cover.