Response to Referee #2 comments

The manuscript "Tropospheric Ozone Assessment Report (TOAR): 16-year ozone trends from the IASI Climate Data Record" presents and validates the IASI-CDR O_3 product, a reprocessed and homogenized version of IASI-FORLI, providing a consistent dataset of tropospheric ozone spanning 2008–2023. The dataset is validated through comparisons with the TROPESS-CrIS product globally and with ozonesonde measurements at selected sites. A comprehensive trend analysis is conducted across multiple vertical layers using 16 years of observations. The manuscript is well-structured, and it is informative, offering a valuable contribution to the understanding of tropospheric ozone dynamics and trends over the past two decades. Below, I provide several comments for the authors to consider before the manuscript can be recommended for publication:

We thank the Referee for taking the time to review the manuscript. The comments have been addressed in the revised manuscript. We would also like to highlight that, in response to suggestions of CC2 and CC3, Section 4 has been substantially reorganized to improve clarity and coherence, but the results remain unchanged. Below is a point-by-point response to each of the Referee comments.

1. The authors employ a 1° × 1° gridded resolution for comparing IASI and CrIS datasets. Given that both instruments have native spatial resolutions on the order of 12–14 km at nadir, it would be helpful for the authors to justify the use of this relatively coarse grid. Was this choice driven by data availability, computational efficiency, or other methodological considerations?

The choice of a 1° × 1° grid is appropriate for global and seasonal-scale validation. Both IASI and CrIS have native footprints of 12–14 km at nadir, but their spatial resolution degrades with increasing scan angle. For example, at 48° off-nadir, IASI expands to about 40 km across-track and 20 km along-track, while CrIS also experiences footprint enlargement at the edges of its swath. Given these variations, a 1° × 1° grid ensures sufficient data density for robust statistical analysis while providing computational efficiency. This grid size is well-suited for comparing seasonal patterns across both instruments at the global scale.

The manuscript has been revised as follows:

"The comparison between IASI and CrIS is carried out for both total and tropospheric columns over the common time period 2016–2022. A spatial grid of 1° × 1° is employed to facilitate this comparison. While this resolution might initially appear coarse, it is well suited for a global and seasonal-scale analysis. Both IASI and CrIS have native spatial resolutions of approximately 12–14 km at nadir. However, the effective resolution degrades at larger scan angles. For instance, at a 48° scan angle, the IASI footprint becomes significantly elongated due to the oblique viewing geometry, reaching up to ~40 km across-track and ~20 km along-track. This spatial degradation supports the use of a coarser aggregation grid. The choice of a 1° × 1° grid is further justified by two main considerations. First, it ensures sufficient spatial sampling within each grid cell, which would not be guaranteed with finer resolutions, especially at global scale. Second, it enables efficient processing of large datasets while preserving the spatial representativeness needed for robust statistical analysis."

2. Was validation at finer spatial resolutions considered? The authors might comment on whether such an approach was explored and how it might influence the interpretation of inter-satellite differences.

Validation at finer spatial resolutions was not considered, as the validation was performed on a seasonal scale, making the 1° x 1° grid more suitable. A finer resolution would not provide enough pixels within each 1° x 1° grid cell to ensure reliable results, given that the pixel size is 12-14 km.

3. The trend analysis is performed using quantile regression at the 50th percentile (median), which is robust. However, applying the same method to higher percentiles would help assess whether the trends differ when considering extreme ozone events. This would be especially relevant considering the reported decreasing trends in tropical regions, which diverge from findings using UV-based instruments like OMI that often suggest stable or increasing trends in similar regions.

Thank you for the insightful comment. Following your suggestion, we extended our quantile regression analysis to higher percentiles (0.9 and 0.95). The results reveal notable differences compared to the median trends, particularly in regions affected by biomass burning such as South America, South Asia, Indonesia, and Australia. While median trends in these areas are near zero or slightly negative, trends at higher percentiles are clearly positive, suggesting an increase in the frequency or intensity of extreme ozone events likely linked to episodic biomass burning emissions.

Interestingly, the positive trends at higher percentiles observed in South Asia show improved agreement with OMI-MLS observations (Dunn et al., 2024), which report the strongest positive ozone trends above South and East Asia over 2004–2023. This convergence likely occurs because extreme ozone enhancements caused by intense biomass burning events impact both the lower troposphere (captured by IR instruments) and the full column (captured by UV instruments like OMI). Thus, despite differences in vertical sensitivity and retrieval techniques, both instruments detect the influence of extreme events in these regions.

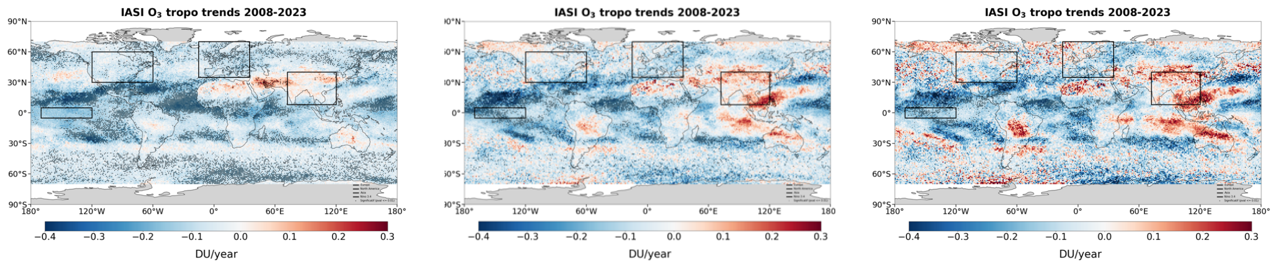

Figure 1: Regional ozone trend estimates at the 50th(left), 90th (middle), and 95th (right) percentiles. Increasing the percentile reveals positive trends mainly in biomass burning regions (South America, South China, Indonesia, Australia), indicating a rise in extreme ozone episodes, while other regions, in particular in the tropical region, consistently show negative trends across all quantiles.

The manuscript has been revised as follows:

"Extending the trend analysis using quantile regression at the 90th and 95th percentiles over the same period offers further insight into ozone behavior, especially regarding extreme ozone episodes. As shown in Figure C1 (Appendix C), biomass burning regions such as South America, South Asia, Indonesia, and Australia show near-zero or slightly negative median (50th percentile) ozone trends, but positive trends at higher percentiles, indicating an increased frequency or intensity of extreme events linked to episodic biomass burning. In contrast, other regions generally display consistent negative trends across all quantiles."

4. The use of 1° × 1° resolution in the trend analysis may mask finer-scale changes, especially in urban regions where surface ozone levels are known to be increasing in many parts of the world. Since urban areas occupy a small fraction of a 1° grid cell, their signal could be diluted by surrounding lower-concentration regions, potentially biasing the trend analysis toward decreases. Could this resolution choice be contributing to the observed negative trends? Discussing this potential limitation would strengthen the interpretation of the trend results.

We thank the reviewer for this thoughtful comment. While it is true that a 1° × 1° resolution may dilute localized signals such as urban ozone enhancements, we emphasize that the primary focus of this study is on global and regional trends, rather than city-scale or local analyses. At these broader spatial scales, the 1° × 1° resolution provides a suitable balance between spatial detail and statistical robustness, especially when working with satellite-based datasets that are inherently limited in their ability to resolve fine-scale features.

Nonetheless, we agree it is helpful to acknowledge that finer-scale trends, particularly in urban areas, may not be fully captured at this resolution, and we have added a sentence in the discussion to that effect.

The manuscript has been revised as follows:

"While the 1° × 1° resolution is appropriate for assessing global and regional trends, it may not fully capture localized changes, particularly in urban areas where surface ozone concentrations can exhibit sharper gradients due to factors such as traffic, industrial emissions, and local meteorological conditions."

5. Lines 360-365. The manuscript notes that differences in tropospheric ozone columns between IASI and CrIS are partly driven by the a priori information used—fixed for IASI and seasonally/latitudinally variable for CrIS. Given the importance of the a priori in shaping retrievals, particularly under conditions of low sensitivity, could the authors comment on what might constitute a more optimal or standardized approach? For example, would using dynamic, seasonally and geographically resolved climatologies for both instruments help reduce inter-product differences?

We thank the reviewer for the insightful comment.

We have conducted an additional analysis to investigate this point more deeply. Specifically, we applied the IASI a priori (fixed in latitude, not seasonally resolved) to the TROPESS retrieval algorithm, which normally uses a spatially and seasonally varying a priori. The results indicate that the choice of a priori profile clearly influences the retrieved ozone profiles. However, the differences observed between the IASI and TROPESS products are smaller than the differences between their respective a priori profiles. This is further illustrated by Figure 1 showing that the difference between the priors (right maps) is larger than the difference between the retrieved TROPESS and IASI columns (left maps). Additionally, the difference between the priors (right maps) is also larger than the difference observed when swapping the priors (middle maps). While the left and middle maps have comparable magnitudes, their spatial distributions differ to some extent. These findings suggest that the a priori alone does not fully explain the discrepancies between the datasets. Moreover, the retrieval process is not strictly linear with respect to the a priori assumptions, indicating that a complete retrieval using the IASI a priori would be necessary to accurately quantify its impact (Kulawik et al., 2008). We will update the manuscript to include this analysis and discussion and emphasize that differences in retrieval methodologies, such as the treatment of prior covariance matrices and the representation of vertical ozone profiles, likely contribute significantly to the observed inconsistencies.

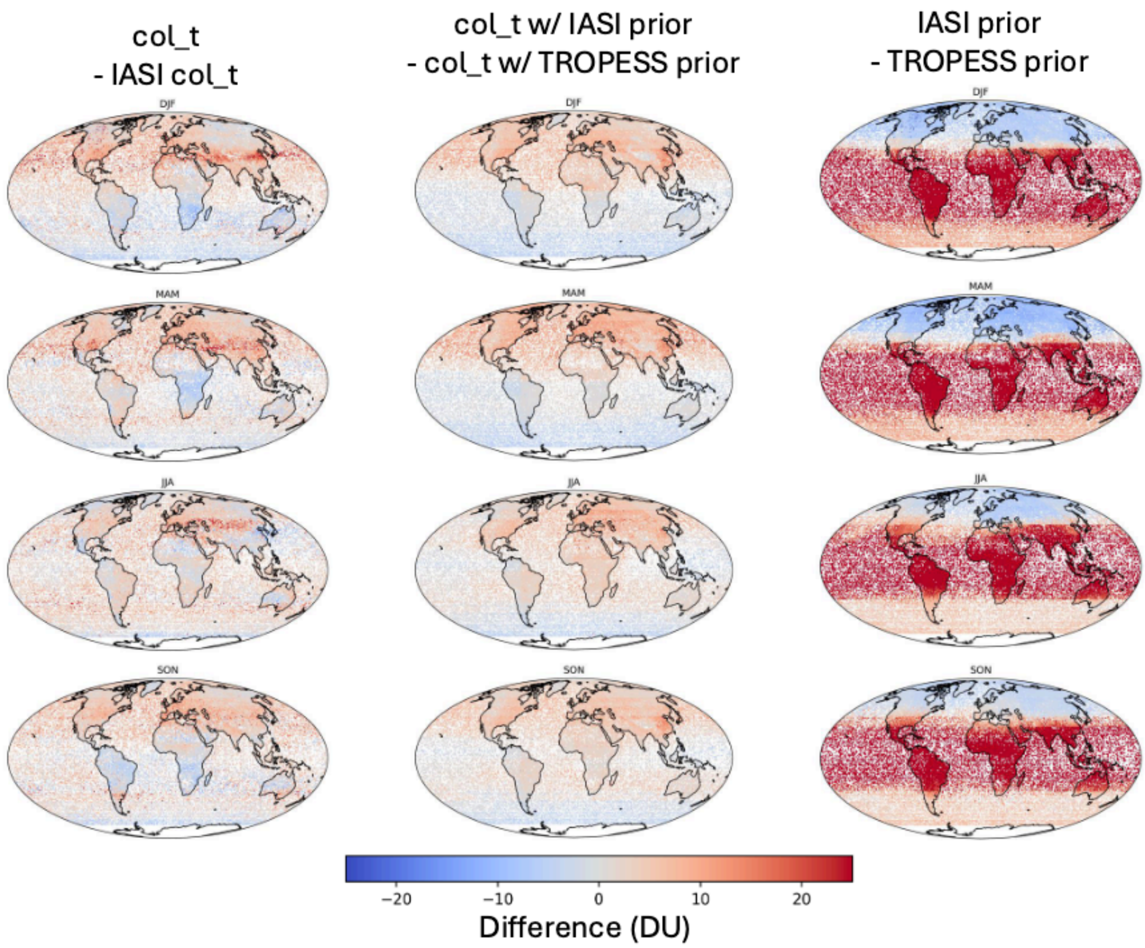

Figure 1. Spatial distribution of tropospheric ozone (Dobson Units) over the period 2016-2022: left: difference between CrIS (TROPESS) and IASI retrievals; middle: difference between CrIS retrievals using the IASI and TROPESS a priori; right: difference between the IASI and TROPESS a priori.

6. In Figure C1, the most pronounced positive trends in lower tropospheric ozone appear in arid regions of Africa and Australia. It would be helpful for the authors to comment on the possible drivers behind these trends briefly. Are they associated with natural emissions (e.g., soil NO_x), biomass burning, or transport processes?

It should be noted that retrievals over arid and desert regions, such as those in parts of Africa and Australia, are subject to well-documented issues related to surface emissivity (Boynard et al., 2018). These limitations can adversely affect the accuracy of lower tropospheric ozone estimates in these areas. Consequently, the observed positive trends are likely biased and should be interpreted with caution. We have clarified this point in the revised manuscript and advise against attributing these trends to physical processes such as soil NO_x emissions, biomass burning, or long-range transport.

The manuscript has been revised as follows:

"Over arid and desert regions, such as parts of Africa and Australia, retrievals may be affected by surface emissivity issues (Boynard et al., 2018), potentially introducing biases in the trend estimates. Therefore, the positive trends observed in these regions should be interpreted with caution."

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