Responses to Referee's Comments

We appreciate the reviewers' constructive and insightful comments. We have carefully checked and addressed all comments and questions.

We have written the referee's comments in black and our responses to the comments in blue and italics. The revised sentences and paragraphs related to these comments are shown in red. Please note that the numbering of the figures and tables has been changed in the revised manuscript.

Referee #1:

The paper describes the comparison of the GEMS formaldehyde retrievals with those of TROPOMI and ground observations.
In addition sensitivity analyses are performed. It is a useful and complete manuscript but difficult to read sometimes, since it lacks precision in its formulations or because of the many grammar or style mistakes. After improving the writing style I would recommend it for publication.

1. Line 21: "...has monitored Asia." This is very vague. What has been monitored for Asia?

We have added "atmospheric chemical compositions" to the sentence to clarify its meaning.

L20: The Geostationary Environment Monitoring Spectrometer (GEMS) onboard GEO-KOMPSAT 2B was launched in February 2020 and has been monitoring atmospheric chemical compositions over Asia.

2. Line 29: "..over the latitude.." What is meant by this?

We have deleted the sentence.

3. Line 30: "..between the two is.." Between the two what ?

We have modified the sentence by adding "GEMS and TROPOMI" instead of "the two".

L26: We found that the agreement between the GEMS and TROPOMI was substantially higher in Northeast Asia (r=0.90), encompassing the Korean Peninsula and East China.

4. Line 96: "by applying air mass factor" => "by applying an air mass factor"

We have made the necessary changes to this part.

L93: Finally, post-processing performs background corrections using model columns from unpolluted clear areas and converts from SCD to VCD by applying an air mass factor (AMF) (Palmer et al., 2001).

5. Line 101: "Variables of GEMS HCHO Level 2 product" => "Variables of the GEMS HCHO Level 2 product"

We have made the necessary changes to this part.

L99: Variables of the GEMS HCHO Level 2 product are listed in Table S1.

6. Line 120-121: "..and Japan and could affect the background contributions to VCD" => "..and Japan, which can affect the background contributions to the VCD"

We have made the necessary changes to this part.

L122: The new reference sector partially includes polluted areas in East China, Korea, and Japan, which can affect the background contributions to the VCD.

7. Line 245 "who reported that cloud-free assumption" => "who reported that the cloud-free assumption"

We have made the necessary changes to this part.

L264: These results are highly similar to those of De Smedt et al. (2021), who reported that the cloud-free assumption could greatly reduce existing biases when comparing satellites over South Asian regions and perform less effectively in mid-latitude polluted areas.

8. Line 255 and 257 : what does %p mean?

We intended to show the changes in two percentages as percent point (%p) unit, but this notation should be replaced by percent (%) in the current context.

We have made the necessary changes to this part.

L274: Figure S7 shows the same comparison between GEMS and TROPOMI except for the VCD_0. In Southeast Asia, TROPOMI showed 10–15 % higher contributions of VCD_0 to VCDs than GEMS did, showing consistent correlation coefficients of r=0.51–0.73. However, in Northeast Asia, the difference in VCD_0 contributions between TROPOMI and GEMS widened by 70 %

9. Line 262-264: I think I understand the procedure you followed here for averaging the GEMS observations, but the description is very unclear.

We have revised the sentence for improved readability. In addition, we have added a brief description of the temporal collocation methods.

L282: We set a spatial grid of 0.4° × 0.4° centered around the ground observatory and averaged GEMS observations within the grid. The effective size of the sampling grid was adopted from De Smedt et al. (2021), who determined a similar radius circle as the optimal value in the TROPOMI and MAX-DOAS HCHO comparisons. For temporal collocation, the MAX-DOAS and FTIR datasets were averaged to hourly data by a satellite observation time window of approximately 30 min.

10. Line 264-266: This is also an unclear description. Didn't you simply apply the averaging kernel of GEMS to the MAX-DOAS profile?

We complemented an explanation regarding the necessity for vertical smoothing and their brief process.

L294: The FTIR and MAX-DOAS products use different HCHO a priori profiles than the GEMS does, resulting in model dependencies when comparing their VCDs (Vigouroux et al., 2020; De Smedt et al., 2021; Kwon et al., 2023). To create inter-comparable datasets among GEMS and ground observations, we replaced the a priori profiles of the ground-based observations with those of GEMS interpolated by the same vertical grid based on

a smoothing method (Rodgers and Connor, 2003) and Eqs. 2 and 3 of Vigouroux et al. (2020).

11. Line 285: "GEMS pixel observing the MAX-DOAS station covers a much larger area, leading ..." => "The GEMS pixel covering the MAX-DOAS station has a large area, leading ..."

We have made the necessary changes to this part.

L317: The GEMS pixel covering the MAX-DOAS station had a large area, leading to diluted HCHO VCDs, especially when the observation area had a high HCHO concentration.

12. Line 290-291: ".. with the previous result from De Smedt et al. (2015), with the increasing trend.." => ".. with previous results from De Smedt et al. (2015), showing an increasing trend.."

We have made the necessary changes to this part.

L323: The diurnal variation of VCDs from the GEMS is consistent with previous results from De Smedt et al. (2015), showing an increasing trend of HCHO VCDs during the day.

13. Line 299: "was started by" => "was made by"

We have made the necessary changes to this part.

L340: The first geostationary satellite observation of HCHO was conducted by the GEMS, which enabled the investigation of the diurnal variability of HCHO over East Asia.

14. Line 323: " the large pixel size dilutes an error from the problematic area". Please rewrite this sentence.

We have deleted the sentence regarding scene heterogeneity problem.

15. In general, I think the conclusions section is a summary with a lot of repetition. I would expect also to see some statements about the precision and accuracy of the GEMS formaldehyde product in the conclusion.

We have added a sentence regarding the precison and accuracy of GEMS HCHO.

L358: We found high correlations between GEMS and TROPOMI HCHO VCDs and a good representation of seasonality with the regional characteristics of GEMS HCHO among the major cities, showing active emissions from biogenic and anthropogenic sources over East Asia.