Response to referee #2's comments

The author would like to thank Anonymous referee #2 for the constructive and helpful suggestions on this manuscript.

We replied to 4 main comments and 25 minor comments

Main Comment

C1. GEMS ozone profile algorithm is applied to OMI BUV measurements. It should be explained why GEMS radiances has not been simulated instead and what is the impact of using LEO measurements for a GEO instrument.

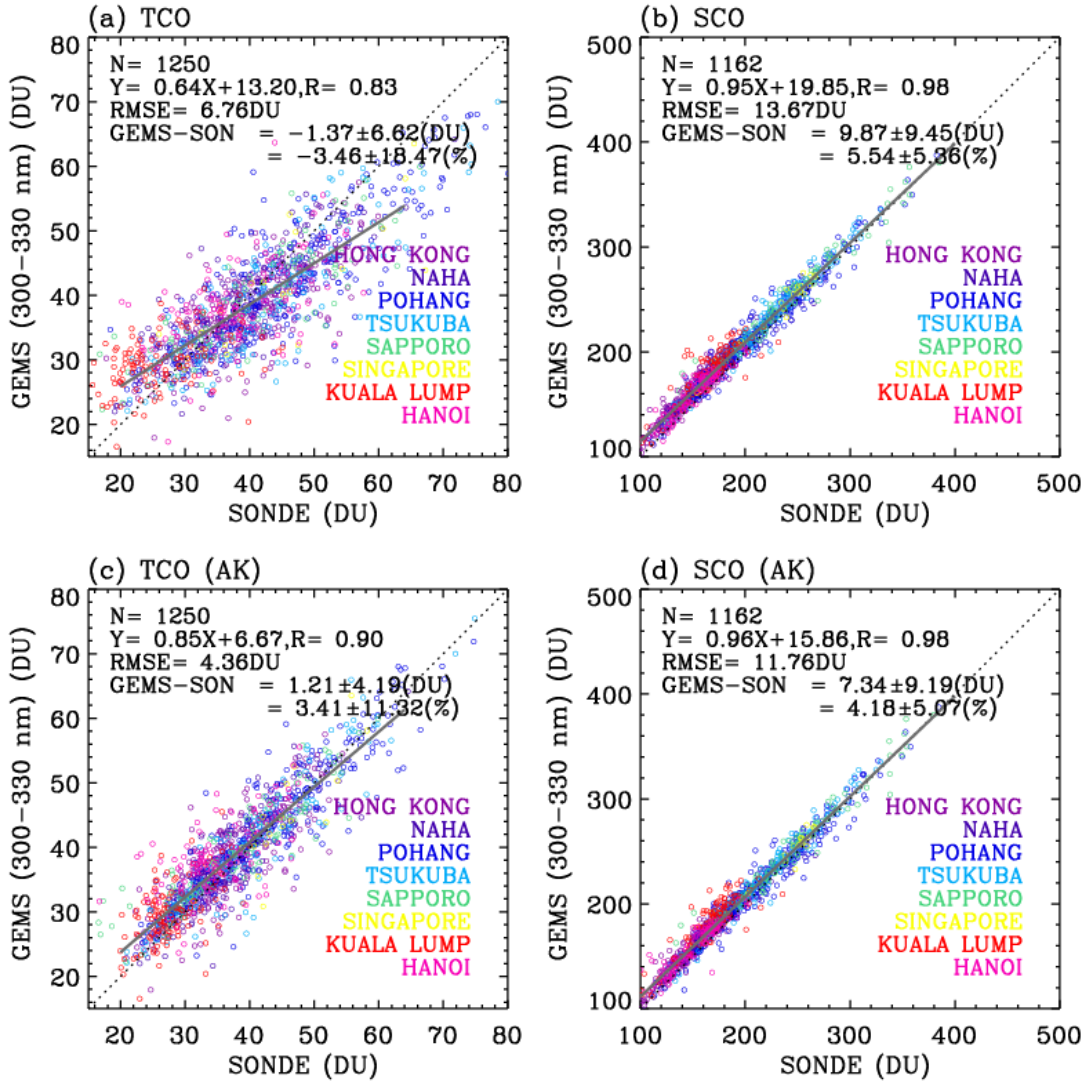
R1. The development of the GEMS L2 algorithm has been in progress with OMI measurements because the simulation of the GEMS radiances using the forward model has not been fully implemented. Two main differences in GEMS and LEO (OMI) data processing could be expected: 1) OMI use a depolarizer to scramble the polarization of light. However, GEMS has polarization sensitivity (required to be less than < 2%) and performs polarization correction using RTM-based look-up table of atmospheric polarization state and pre-flight characterization of polarization sensitivity in the level 0 to 1b data processing. The GEMS polarization correction is less accurate and hence additional fitting process might be required in the level 2 data processing, especially for ozone profiles that have more significant retrieval sensitivity to the polarization error compared to other trace-gases. 2) GEMS has a capability to perform diurnal observation and hence the diurnal meteorological input data are required to account for the temperature dependent Huggins band ozone absorption. Hence the numerical weather prediction (NWP) model analysis data will be transferred to the GEMS science data processing center (SDPC). This response has been also included in the revised manuscript, also according to the comment #4 from reviewer 1.

C2. The use of OMI measurements makes the title of the paper confusing as the validation is of OMI using GEMS algorithm, but not of GEMS. This needs to be changed.

R2. This reply is also corresponding to comment #1 from reviewer 1, the title of this paper is changed to "Cross-Evaluation of GEMS tropospheric ozone retrieval performance using OMI data and the use of ozonesonde dataset over East Asia for validation".

C3. Simulated GEMS retrievals are used to verify the ozonesonde observations, i.e., to identify the good stations, and in turn, these stations are used to validate the simulated GEMS retrievals. Using this approach it is hard to expect bad results for the simulated GEMS retrievals. The ozonesonde observations should be considered as the truth, and if they need to be validated and screened, this should be done using an independent dataset, but not the same dataset that we intend to validate, in this case the simulated GEMS retrievals.

R3. Understanding the quality of the reference dataset and then selecting a good reference is a very important process in validating satellite or other in-situ measurements and then in better characterizing the retrieval accuracy and error. Satellite measurements of tropospheric ozone have previously been utilized to disclose problems in ozonesonde observations (e.g., Liu et al., 2006; Huang et al., 2018). We are also using retrievals here to identify ozonesonde measurements with significant errors. However, the station-to-station based quality control has not been typically applied in previous validation works. The figure below demonstrates how much the accuracy of the simulated GEMS retrievals from OMI measurements is underestimated if the station-to-station based quality control is not applied. We also apply the parallel validation for two independent OMI ozone profile products, OMPROFOZ and OMO3PR, respectively, demonstrating that our ozone retrievals are in comparable or better agreement with ozonesondes. As we mentioned in R1 to C1, the simulation of the GEMS radiances using the forward model has not been fully implemented.



S1. Same as Figure 7, but for including all ECC measurements.

C4. According to the results shown, the time frame established of +-12 hours seems too large for the evaluation of tropospheric ozone, especially for mid-latitudes location where a stronger daily cycle can be found.

R4. Based on the previous papers, the collocation of satellite pixel to ozonesonde stations have been performed within 6 to 24 hours. As clarified in Sect. 2.3 such as "The coincidence criteria between satellite and ozonesonde are: $\pm 1.0^{o}$ in both longitude and latitude and ±12 hours in time and then the closest pixel is selected. The Aura satellite carrying OMI crosses the equator always at ~ 1:45 pm LT and thereby OMI measurements are closely collocated within 3 hours to ozonesonde soundings measured in afternoon (1-3 pm LS)," OMI measurements are closely collocated within 3 hours to ozonesonde soundings measured in afternoon (1-3 pm) from Japanese stations, Pohang, Hong Kong, Hanoi, and Trivandrum. In this paper, the time collocation criterion is set to be 12 hours to include other stations existing over the GEMS domain.

Minor comments

C1. Line 50: Satellite name should be Sentinel-4

R1. This name has been corrected to "Sentinel-4"

C2. Line 75: ":: : have yet to be not been ..." please correct this

R2. It has been corrected to "has not been".

C3. Line 178: Among ECC stations

R3. It has been corrected to "Among ECC stations".

C4. Line 183: "Kula lump", please correct. Also all along the paper, the name of this station is written in different ways (Kuala lump, Kuala Lumpur). Please homogenize the station names in the text, figures and tables.

R4. We carefully checked what this reviewer indicated. This station name has been corrected to "Kuala Lumpur" across the manuscript.

C5. Line 221: biased -> bias

R5. It has been corrected to "bias".

C6. Line 225: Please specify the units

R6. RMS does not have the unit and thereby "RMS (i.e., root mean square of fitting residuals relative to measurement errors) less than 3" has been kept in the revised manuscript.

C7. Line 231: troposphere -> stratosphere

R7. It has been corrected to “stratosphere”.

C8. Line 234: Should be photons?

R8. It has been revised to “photons”.

C9. Line 242: xa should be placed after (1-A)

R9. Eq. 3 has been revised to “$\hat{x}_{sonde} = A \cdot x_{sonde} + (1 - A)x_a$”

C10. Line 282: Please rephrase, maybe “of” -> “with values ranging from”

R10. According to this comment, “satellite retrievals show the distinct seasonal TOC variations with the amplitude of ~ 35-40 DU” has been edited to “~ seasonal TOC variations with the values ranging from ~35 to ~ 40 DU”

C11. Line 290: “Japanese stations” or “stations from Japan”. Same in Line 296.

R11. It has been revised to “stations from Japan”

C12. Line 314: Please unify or explain the differences between LT, LS and LST across the paper

R12. There is no difference. It has been unified to “LT (Local time)”

C13. Line 322: “oznesonde” -> “ozonesonde”

R13. This word has been corrected.

C14. Line 324: Please list stations after “mid-latitude” and refer to Figure justifying this and the following statements.

R14. It has been clarified such as “mid-latitude (Pohang, Tsukuba, and Sapporo)”

C15. Line 326: “- a few %” please rephrase this

R15. It has been corrected to “a few percent”

C16. Line 338: 4.2 -> 3.2.

R16. It has been changed to “3.2”.

C17. Line 358: “... gives the good information ...” please rephrase. SOC has not been defined

R17. It has been corrected to “gives the good information on Stratospheric Ozone Column (SOC)”

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C18. Line 367: “espeically” -> “especially”. “TCO” -> TOC.

R18. The relevant sentence has been corrected to “especially in the TOC comparison”

C19. Line 308: Shouldn’t it be “latitudinally” as it is used in other parts of the manuscript? Same in Line 398 and Line 400 (in this case, why capital L?)

R19. “latitudinally” was used at lines, 27, 286, 308, 398, and 400, respectively. These have been revised as followings,

- At 27, “compared to latitudinally adjacent stations with Carbon Iodine (CI) and Electrochemical Condensation Cell (ECC).” to “Carbon Iodine (CI) and Electrochemical Condensation Cell (ECC) dataset measured in similar latitude regime”
- At 308, “latitudinally adjacent station, Hong Kong” to “neighboring station, Hong Kong”
- At 398, “latitudinally adjacent Japanese 398 ECC measurements at Tsukuba and Sapporo” to “Japanese ECC measurements at Tsukuba and Sapporo located in mid-latitudes (> 30 °)”
- At 400, at Naha and Hong Kong stations located in similar latitude regime.

C20. Line 399: Extra s “is similarly”

R20. This indicated one (is s similarly) has been corrected (is similarly)

C21. Figure 2: Latitudes and Longitudes are not correct.

R21. This figure has been revised.

C22. Figure 3: Please explain what is CF(O) and CF(X). Even if no CF is applied to MF sondes, it would be interesting to add them in Figure 3.

R22. To clarify, the legend in the figure has been revised to “Solid: with CF, Dash: w/o CF”. The corresponding caption has been revised to “Effect of applying a correction factor (CF) to (a) ECC and (b) CI ozonesonde measurements, respectively on comparisons with simulated GEMS ozone profile retrievals. Solid and Dashed lines represent the comparisons with and without applying a CF, respectively, at each Japanese station.”

C23. Figure 4: Please specify how you differentiate the different type of sondes. Is it using diamonds, full dots and empty dots? Which one is which? Also indicate what is the horizontal axes, eg. “time (years)”

R23. This figure has been revised to clarify the symbols and the title of x-axis.

C24. Figure 6: I would suggest rewritting the last sentence as follows “The relative difference (in %) is defined as 100 X (SONDE AK – GEMS) / (A priori)”. Why is multiplied by 2?

R24. This equation has been corrected to “100 X (SONDE AK – GEMS) / (A priori)”

C25. Figure 7 and 8: Please replace TCO -> TOC and SCO -> SOC to be consistent with the text.

R25. This figure has been revised to accept this comment.