Response to Reviewers

Reviewer #2:
"The manuscript addressed all reviewer's comments, and the manuscript is in much better shape now. I have a few remaining minor comments:

Authors' response: We appreciate your earlier and new feedback, the details from which helped us enrich the manuscript further. Please find our responses to your comments below:

Minor points:

Reviewer's comment	Author's response	Changes in manuscript
Title and abstract. It's still not clear from the title and abstract what are the products being used from each satellite. Please be specific that you are using NO_2 from TROPOMI and AOD from GEMS fusion product. Someone that only reads the abstract can still misinterpret that GEMS NO_2 is being used in this work. Abstract. First sentence is way too long and hard to understand. Please break it down and improve readability.	Thank you again for the detailed feedback. and accordingly, we have updated the title and abstract to address your concerns.	▪ Title: "… TROPOMI NO_2 product, and the Geostationary Environment Monitoring Spectrometer (GEMS) AOD data fusion product and its proxy" ▪ Abstract: "In response to the need for up-to-date emissions inventory and the recent achievement of geostationary observations afforded by the Geostationary Environment Monitoring Spectrometer (GEMS) and its sister instruments, this study aims to establish a top-down approach for adjusting aerosol precursor emissions over East Asia. This study involves a series of TROPOMI NO2 products, GEMS AOD data fusion products and their proxy product, and CTM-based inverse modeling techniques".
Figure 1 caption: You could mention that AERONET is displayed in the top panel and the rest in the bottom	We acknowledge that the display was not sufficiently reader-friendly, and we have added more details in the	▪ Figure 1 caption: "… AERONET sites are presented in the upper panel, and the rest of the

panel, it took me a while to figure out	caption.	air quality monitoring sites are below".
312. I think the authors are still including the misconception that observed OC from the Korean supersites ($PM_{2.5}OC$) is all primary. $PM_{2.5}OC$ likely contains a strong secondary component. Later in the results (lines 404-405, Table 2) this is again used as $PM_{2.5}OC$ was part of the primary aerosol. Since you can neither say this is primary or secondary (you would need an AMS instrument to do so) I would keep it in a separate category in Table 2. CMAQ also has both primary and secondary organic aerosol (not only primary). Please include this into the discussion of limitations on lines 406-415	Thanks for bringing this discussion point, and now we fully understood the previous concern. We have updated our main manuscript and supplement accordingly. Also, we added more details to the description for the $PM_{2.5}$ remaining undefined. As mentioned in your comment, we are aware that CMAQ considers organic carbon as primary and secondary organic carbon in a separate manner. During the primary PM emissions adjustment, in terms of organic carbon, we only adjust the primary organic carbons (namely POC in the model). We have clarified this in Table S2 caption.	▪ Lines 313-316: "… organic carbon (the total mass of both primary and secondary organic carbon), elemental carbon, the lumped summation of other PM species listed in Table S2, and the rest remaining undefined (the lumped summation of all unidentified species in 2.5 microns or less in diameter, which still constitute the total $PM_{2.5}$ mass)". ▪ Lines 407-409: "… the total of the remaining portion (46.74% on average) was mostly comprised of primary PM and some secondary aerosols such as the organic carbon category used in this study (Table 2)". ▪ Table 2 and caption: "… OC: primary and secondary organic carbon; EC: elemental carbon; Lumped PM: the lumped summation of PM species noted in Section 2.6, Unknown: undefined PM2.5 species noted in Section 2.6". ▪ Table S2 caption: "… Note that all emissions species listed are primary, and some corresponding species include both primary and secondary
313. Please mention how the undefined or unknow component is calculated. I'm guessing it's the different between $PM_{2.5}$ and all the rest.		

		forms of themselves".
331-337. It would be nice to add an additional panel to Fig S6 showing the NCP time series to support these sentences.	Thanks for pointing it missing out, and we added a panel that shows the time-series comparison over the NCP, accordingly.	▪ Line 302: "… 235 sites for 2019 and…" ▪ Figure S6 and caption: "…and the NCP region (235 MEE sites) …"
Section 3.1. Given the issues in NCP with NO_2 overpredictions after NO_x emission adjustments, it would be desirable to add to Fig S3 the CMAQ NO_2 after emission adjustment, to check what's the behavior of the updated NO_2 columns in these regions with issues. This is to verify that the DA algorithm is not doing something that it shouldn't.	Thanks for the concern, and we agree that spatial plots of the a-posteriori CMAQ NO_2 (after the NO_x emissions adjustment) will better present that the inversion process did not go wrong. We have updated Figure S3 accordingly.	▪ Figure S3 and caption: "Spatial distributions of (a) TROPOMI NO_2 columns (molec/cm^2) and CMAQ-simulated NO_2 columns (b) before and (d) after the NO_x emissions adjustment …"
440. This paragraph is missing an initial sentence. Something related to how GOCI-AHI shows better performance than AHI alone	Thanks for pointing it out, and we have added a leading sentence of the discussion.	▪ Lines 445-446: "Such an improvement in the quantity of observation references seemed to be beneficial for improving the model performance in AOD estimation".
411. fix the word "aerpsols"	▪ Line 415: "… aerosols …"	
465. Separate "2019To"	▪ Line 471: "… 2019. To …"	