# Reply to Anonymous Referee #3

We thank the referee for their time and effort in critically reading and reviewing our manuscript. Below we reproduce the questions/comments in bold and address them in plain text. Changes in the manuscript are marked in different colors. In response to the overall reviews, we have expanded the manuscript to include

- joint retrieval results in which we adopt the MAP-band concept (section 7), and
- discussion on the retrieved aerosol properties in Appendix B.

**General Comments:**

**The manuscript by Rusli et al. with the title *"Anthropogenic CO2 monitoring satellite mission: the need for multi-angle polarimetric observations"* investigates the added value of multi-angle polarimeter (MAP) measurements in the context of the Copernicus candidate mission for anthropogenic CO2 monitoring (CO2M).**

**Scattering by aerosols and cirrus are the main sources of uncertainties in retrieving XCO2 from solar backscattered radiation. Additional MAP observations are expected to provide information about aerosols that are useful for improving XCO2 accuracy. Two different MAP instrument concepts are considered in this analysis: MAP-mod and MAP- band. The authors determine the instrument specifications for both concepts that are required to achieve XCO2 accuracy and precision that align with the requirements of the mission.**

**Adopting the derived MAP instrument specifications, a retrieval exercise using a spectrometer only and spectrometer + MAP joint retrieval is performed. The study shows that the MAP auxiliary information help to reduce XCO2 errors below mission requirements.**

**The manuscript is well written and structured in a clear and sensible fashion. It is suitable for publication in AMT after some minor corrections listed below.**

Thank you for your positive remarks and careful reading.

**Specific comments:**

**[1] P2 L36: "*The CO2M mission is designed as a constellation of up to 3 satellites with imaging capabilities and a revisit time of 2-3 days for latitudes (poleward of) 40 degrees.*"**

**What is the revisit time between 40S and 40N?**

The global revisit time (including 40S-40N) is 5 days. We adjusted the corresponding sentence in the manuscript to include this information (page 2 lines 38-39).

**[2] P2 L39: "*As opposed to currently operational CO2 missions that are designed to observe natural CO2 fluxes, with the exception of OCO-3***

***(Basilio et al., 2019), the CO2M mission is intended to measure anthropogenic emissions (Pinty et al., 2017).*"**
**Earlier in the manuscript you mention that the primary sounders are nadir-looking, very similar to currently operational CO2 missions. What makes the CO2M mission better suited to measure anthropogenic emissions compared to other missions?**
CO2M has an imaging capability, as mentioned in the introduction (line 38), with a large swath (250 km). Combined with a global coverage within a week, this allows us to observe extended emission plumes with a single overpass (e.g. Kuhlmann et al. 2019 - complete reference is available in the manuscript).

[**3] P5 L142:** ***"Atmospheric vertical profiles of temperature, H2O, CO2, and CH4 are provided as input."***
**Please specify the source/origin of the vertical profiles.**

**P6 L168:** ***"We take the input vertical profiles of the trace gases as a given and retrieve the total columns via scaling factors."***
**See above (please specify the source/origin of the vertical profiles).**

The atmospheric vertical profiles, as well as the trace gases originate from the AFGL profiles, with CO2 scaled up such that XCO2 = 400 ppm.
We added this information to the manuscript (section 4 page 11 lines 300-302).

**[4] P14 L357:** ***"With a PSD above 2 ppm, XCO2 retrievals based on only spectrometer measurements do not meet the mission requirements by a very wide margin (note that we do not apply post-retrieval filtering here)."***
**How does PSD change after a post-retrieval filtering is applied? Does it help to fulfill mission requirements?**
When we filter out the converged runs with retrieved aerosol optical depth (at 765 nm) > 0.3, the $P_{SD}$ reduces to 1.95 ppm. Lowering the AOD threshold to 0.2 decreases $P_{SD}$ further to 1.66 ppm. Mission requirements are still not fulfilled after such post-retrieval filtering.
This information has been added to the manuscript (section 5 page 15 lines 376-379).

**[5] P22 L473:** ***"We adopt the baseline MAP-mod setup to simulate MAP observations and we consider the ensemble of 500 simulated scenes (as outlined in section 4) for this joint retrieval exercise."***
**Why only for the MAP-mod setup and not also for the MAP-band setup? It would be interesting to see a similar figure to Fig. 7 showing MAP-band results.**
We have now performed joint retrievals using the MAP-band baseline setup. The analysis is presented in section 7 which also includes a similar figure to Fig. 7 but for MAP-band results.

**Technical comments:**

**[6] P5 L135: "spetrometer" -> spectrometer**

Corrected (now line 145).

**[7] P5 L138: "The measured radiances are simulated by convolving..."**

**The word "measured" might cause confusion here.**

We removed the word 'measured' (now page 6 line 148).

**[8] P12 L312: "simulated measurements"**

**It's either simulated or measured, not both.**

We replaced "simulated measurements" with "synthetic measurements" (now page 13 line 332).

**[9] P16 L406: " ⟨*ΔXCO2*⟩ *can be as high as ~2.4 ppm for the highest ΔI/I and ΔDLP considered here."***

**Looks more like ~2.6 ppm to me.**

It is actually 2.52 ppm. The text now (page 17 line 432) reads:

" ⟨ΔXCO2⟩ can be as high as 2.52 ppm for the highest ΔI/I and ΔDLP considered here."