Response to the reviews on "Influence of natural and anthropogenic aerosol on cloud base droplet size distributions in clouds over the South China Sea and Western Pacific"

We would like to thank both reviewers for providing comments and suggestions to this manuscript. Reviewer comments are in black text, responses to comments is in red text, and added text to the manuscript is in blue text.

Reviewer 1 comments:

General comments:

This paper discussed the different aerosol sources' influence on cloud base droplet size distribution using a comprehensive dataset from P3 airplane. The data is extremely valuable for improving the current understanding of the aerosol-cloud interaction, especially over the South China sea and the western pacific. The paper is well written and made an excellent measurement report. However, the data analysis did not use the full potential of such a rich dataset nor provide new insight into the aerosol-cloud interaction. Thus, if authors are willing to explore the linkage between the meteorological and climate features in the southeast Asia region and the observation. This paper can contribute more as a research article. Otherwise, it is in good shape as a measurement report after addressing the comments below.

We added a paragraph describing the meteorology over the sampling region during the campaign. We also added a reference to Reid et al., 2023, a comprehensive summary of the CAMP^{2}Ex project which includes a discussion of the meteorology during CAMP^{2}Ex. The winds during CAMP^{2}Ex did not vary much day to day in each of the two monsoon periods, so we did not think it was necessary to describe the meteorology for each day during the project. The new paragraphs are given below:

"The first part of CAMP2Ex (Aug 24 - Sept 22, 2019) occurred when the southeast Asian monsoon trough was located north of the Philippines, and the flow was directed from the maritime continent northeastward, transporting aerosol associated with biomass burning toward the sampling region. The second part of CAMP2Ex (Sept 23 - Oct 5, 2019) occurred after the monsoon trough retreated south of the archipelago and northwest monsoon flow moved across the sampling region (see figure 2 in Reid et al., 2023). The monsoon flow during CAMP2Ex was impacted occasionally by the passage of tropical cyclones which moved westward north of Luzon along the monsoon trough.

During both monsoon periods, clouds over the sampling regions were primarily small maritime cumulus, with deeper convection, and associated cold pools developing, for example, by heating over local islands or lifting along cold pool outflows."

Specific comments:

Abstract: "three primary sources influenced the aerosol chemical composition: marine (ocean source), industrial (Southeast Asia, Manila, and cargo and tanker ship emissions), and biomass burning (Borneo and Indonesia)." The industrial is misleading. The paper discussed ship emissions.

Our definition of industrial appeared in the abstract of the original paper on line 30 and included aerosol from Southeast Asia, Manila, and cargo and tanker shipping emissions. The chemical signatures of industrial emissions from Manila were shown on Figure 5B in the original paper, with a discussion of the Manila aerosol chemistry on original lines 283-290. The long range transport of anthropogenic aerosol from south east Asia was discussed on lines 35,135, 151, 311-319, 351-355, 468-472 of the original paper. These discussions are now located on lines XX (add after done). We believe that we were clear on what we meant by industrial.

Introduction: The current result is consistent with the previous studies the author quoted in the introduction. "The impact of anthropogenic aerosols such as sulfate, nitrate, and BC has been a main topic of interest for many years as they lead to an increase of CCN that increases the cloud droplet number concentration (Nd) and decreases the effective radius (re) of the droplets, producing more reflective clouds for the same liquid water path.

For example, Radke et al., (1989) observed an increase in total cloud droplet concentrations, but a decrease in cloud droplet sizes in clouds over shipping lanes. Cloud droplet number has also been reported to increase with aerosol loading over the East China Sea (Bennartz et al., 2011)." It is more scientifically significant if the authors can further explore the current results.

We used all the available data from the aircraft and shipping data in the paper. We have added information about the meteorology of the region. Our group is exploring other aspects of the data related to remote sensing, cloud dimensions and geometry, aerosol and cloud retrievals from satellites, radar, lidar. These will appear in other publications (e.g. Fu et al., 2022). We believe the work in this paper provides a clear scientific analysis of the impact of aerosol chemistry on cloud base properties. We don't believe the paper fits into the category of a measurement paper.

Page 6, lines 121-129. How are those meteorological and climate features related to the aerosol-cloud interaction? It will be very insightful to make the linkage.

We added the paragraph explaining the meteorology during the CAMP^{2}Ex project. The HYSPLIT trajectories in figure 6 show the change of the flows into the sampling area during the southeast and northwest monsoon periods

Page 8, section 2.1. How many flight hours or data points were collected in each category?

The information the review results is in Table 1 and is referenced at the first sentence of the results section (section 4).

What criteria do you use to characterize the influence of each aerosol source? Hysplit trajectory? Aerosol concentration? or chemical loading? Or combination?

We used the aerosol chemistry measurements below cloud base to characterize the aerosol types summarized on figure 7. We confirmed these with Hysplit trajectories to ensure our interpretations were consistent with source regions. This is described in results section 4.

Page 11, line 203. Please define "nearest", as one hour apart or 10 hours apart? Will that affect the distribution in figure 3?

The procedure we used to calculate the mean LCL was poorly described. We revised this section. The phrase the reviewer flagged is no longer there.

Page 13, section 2.5. How does this hysplit data link to three aerosol sources?

The link between the HYSPLIT trajectories and the aerosol source regions is described in the results section 4 beginning on page 19 line 329 and ending on page 22 line 371 in the original paper and is shown on figure 6 of the original paper.

Figure 4, line 246-251. It is hard to separate the thick and dashed lines in the figure. Maybe use a different color for the altitude < 466 or >466? Maybe also use a larger ring size.

In developing this figure we experimented with a number of different lines thicknesses and approaches to showing the ship tracks. This was the best version we came up with after quite a bit of experimentation. We also developed the animation in the supplement based on this best solution. Since we already explored this other options we decided to keep the figure as is.

Line 256. AMS has a 30-second resolution. Why do you exclude anything shorter than 10 mins?

Our choice of 10 minutes was based on recommendation from the Langley aerosol research group based on their experience using the aerosol mass spectrometer. We added the following sentence:

The instrument team recommended a minimum 10-minute averaging interval (20 data points) to obtain representative chemical signatures.

Line 261. How does the MBL passes related to the cloud base passes? At the same region? Altitude/longitude boundaries? Please clarify.

Line 404 on the original paper states the following: "Nearly all cloud base passes were completed in the same region immediately following MBL passes (Fig. 2). There were two legs with cloud base passes over the southern Sulu Sea where the cloud base passes were delayed to sample growing clouds to the north. The aircraft then returned to the location of the MBL passes and sampled the cloud base."

In addition, here used 1416 passes and later, 1416 seconds were used. Please correct. For 112 MBL passes, how long does each pass last?

The text was corrected and the information added. The sentence now reads:

"A total of 112 10-minute MBL passes and 1416 seconds of cloud base passes were recorded."

Line 305. I am confused about the procedure for determining the suspected source regions. Please clarify. How many backward trajectories do you run for each pass? Why choose 100 hours? How do you separate the long-term transport influence from regional influence with 100-hour trajectories?

We chose 100 hour trajectories to ensure that the trajectories reached aerosol source regions over land, either the maritime continent or East Asia. For short trajectories, the trajectories remain over the ocean and source regions cannot be identified. In some cases even after 100 hours the trajectories were still over the ocean and not near any land mass suggesting a marine source of aerosol. Aside from shipping emissions, and the Manila metro, there are no other regional influences except for small islands.

Table 1. Please correct. Number of passes or seconds? Please consider adding information about linking each MBL pass with cloud passes, such as the latitude range when sampling. For example, if MBL passes took 490 mins and their corresponding cloud passes only 747 seconds (about 12.5 mins). Does the result meaningfully capture the influence? Please explain.

 Table 1 was correct. The text on line 261 was incorrect and was fixed.

Figs 5 and 7 provide similar info. Please explain the significant scientific contributions for including both or move one to a supplemental document.

Figure 5 shows individual 10-minute MBL pass data. Figure 7 shows the average of all the 10-minute MBL passes in each of the three categories.

Page 23, section 5.1. HSRL and RSP were discussed here but not included in the Methodology section like FCDP. Please provide more info about the operation.

We added a short section introducing the instruments and provide references to the instruments and a reference to Fu et al., 2022. In Fu et al., 2022 the procedure to determine cloud transect length is described in detail. The following section was added:

2.3 Remote Sensing Instrumentation

Cloud transect length was determined three ways, using the FCDP, the NASA High Spectral Resolution Lidar (HSRL-2, Burton et al., 2018; Sawamura et al., 2017), and the Research Scanning Polarimeter (RSP, Cairns et al., 1999). The use of the instruments in CAMP2Ex and the approach to determine cloud transect length is presented in detail in Fu et al., 2022.

Line 398-400. What is the median updraft for the different aerosol-influenced clouds? Please consider re-characterize the cloud category to link them with the aerosol category.

We added a figure showing the distribution of updraft speeds for the different aerosol influenced clouds, and a discussion of the figure.

Reviewer 2 comments:

L29. Add s to show. Insert that before three.

The typo was corrected.

L31. Insert clean before marine.

Clean added.

L36-7. Move based on chemical signatures to the beginning of the sentence. Comma after emissions. Change The ship emissions to which.

Change made.

L41. Delete sizes with. Insert clean before marine.

Change made.

L77, 260 & 386. Three different symbols for droplet concentrations. Use only the last one, Nc. Nd should be reserved for drizzle drop concentrations, which you say will be the subject of your next paper.

Change made.

L87. Delete on a. Delete basis. Add ly to constant.

Change made.

L88. Add Durkee et al. (2000).

Reference added.

L98. Add Hudson et al. (2000).

Reference added.

L115. Aircrafts singular.

Change made.

L116-119. Discussion of the Learjet is not needed.

Discussion deleted.

L133. Add comma after fires.

Comma added.

L207. Remove also.

Change made.

L223. Change in to is.

Change made.

L228 and other lines. At least somewhere denote local time at least relative to UTC.

Philippine local time noted in the paper.

L253. Change daytime to daylight. Note local time.

Change made and time added.

L258-9. Move at 1 Hz resolution (Fig. 3B) before above. Insert and right before above.

Change made.

Figure 5. I can see the median lines in some but not all. Not in BB ORG & SO4 and Industrial SO4.

Figure updated to show median lines.

L302. Insert done after all.

Change made.

L316. Delete and.

Change made.

L318. Add n to Asia and then move Asian in front of origin followed immediately by mainland. Delete from.

Change made.

L329. Concentration plural.

Change made.

Figure 7. Can't see median line in BB NO3.

Figure updated.

L428. Explain normalized.

Figure 11. Explain normalized. Is the ordinate dN/dlogD? Or what is it? At least it must be per cm3

L448. Change in to of.

L461. Change microstructure to microphysics.

Appendix is difficult to follow.

L524. Define MMSI.

L535-6. Duration and of time are redundant.

L537. Is this going into port?

L540. Time progressed is redundant.

L541. Explain given its reported speed.

L545. Was reached seems unnecessary. Just say At 22:00 UTC.

L554. Change discretely to separately. The former sounds like a secret.

L556. In could be deleted.

L557. Explain geodesic.