Notes to Editor and Reviewers:

We sincerely thank the Reviewers for their insightful and constructive comments and suggestions.

1. In the following response, the reviewers' comments are presented in *black*, our responses are in black, and the corresponding revisions in the manuscript are highlighted in *italic blue*.
2. A detailed, point-by-point response to each comment is provided below.

Reviewer #1:

This manuscript investigates the impact of a tropical cyclone on aerosols, cloud condensation nuclei activity, and cloud microphysics over the South China Sea, utilizing a combination of shipborne observations, satellite data, and 0-D cloud parcel model simulations. The results demonstrate that the tropical cyclone amplifies the influence of anthropogenic emissions on aerosol-cloud interactions within this region. These findings are interesting and advance understanding of aerosol-cloud interactions under specific weather conditions. I recommend this manuscript for publication after addressing the following comments:

Response: We thank the reviewer for taking the time to read our manuscript and for providing valuable suggestions. In the revised manuscript, we have improved the Methods section to make it clear and added further details and discussion on the selection of cloud model simulation parameters and the associated uncertainties. Our point-by-point responses to the reviewer's comments are provided below.

Major comments:

1. *The authors demonstrate that the tropical cyclone amplified the anthropogenic influence on aerosol cloud interactions over the South China Sea, which is evidenced by the observed increase in organic aerosol concentrations and backward trajectories. However, tropical cyclone-induced precipitation simultaneously leads to the aerosol wet scavenging. Could the authors clarify the spatial extent of the impacts driven by both the precipitation scavenging and the*

circulation-induced enhancement of anthropogenic influences? Alternatively, it would be highly beneficial to include a brief discussion on this matter in the manuscript.

Response: We thank the reviewer for this helpful comment. We agree that tropical cyclone-induced precipitation can lead to aerosol wet scavenging, which may counteract the circulation-driven enhancement of aerosol concentrations and anthropogenic influences. We have therefore clarified the effects of these two processes and discussed their potential spatial extent in the revised manuscript.

During the observation period, the location of research vessel remained on the western side of TC Chaba and came within approximately 446 km of its center. No significant precipitation occurred during most of the observation period, except on 1 July, when precipitation caused substantial wet scavenging and pronounced decreases in aerosol number and mass concentrations. This suggests that wet scavenging affected the observed aerosol properties during the precipitation event but did not dominate the overall changes observed during the study period. We have added this discussion to Lines 279–282 of the revised manuscript.

"*It should be noted that no significant precipitation occurred during the observation period under the influence of TC Chaba, except on 1 July. The precipitation during this period resulted in substantial wet scavenging of aerosols, leading to pronounced decreases in both aerosol number concentration and mass concentration.*"

We have also added a discussion of the spatial extent of TC-induced precipitation and its associated wet scavenging. The inner and outer rainbands generally extend to approximately 200 and 500 km from the TC center, respectively, although their extent and structure vary considerably among TCs (Addington et al., 2025). Previous studies have further shown that moisture conditions can affect the coverage and precipitation area of outer rainbands at distances of 200–500 km from the storm center, with substantial variability among individual TCs (Hence and Houze, 2012; Addington et al., 2025). Therefore, the distance from the TC center

alone cannot determine whether a region is affected by precipitation-induced wet scavenging. The discussion has been included in Lines 517-526 of the revised manuscript:

"*However, TC-related precipitation can counteract circulation-driven increases in aerosol concentrations through wet scavenging. The inner and outer rainbands typically extend to approximately 200 and 500 km from the TC center, respectively, although their size and structure vary considerably among TCs (Addington et al., 2025). During our observations, the vessel approached within approximately 446 km of Chaba's center, but no prolonged period of substantial precipitation occurred. Although previous studies have reported extensive outer-rainband precipitation 200–500 km from TC centers, particularly under favorable moisture conditions (Hence and Houze, 2012; Addington et al., 2025), the limited precipitation during our campaign suggests that the observed aerosol changes primarily reflect TC-related transport and associated atmospheric processes rather than sustained wet removal. Nevertheless, precipitation may have affected aerosol properties during individual periods, as observed on 1 July.*"

Reference:

Addington, K. D., Zick, S. E., Wood, K. M., et al.: Variations in Tropical Cyclone Size and Rainfall Patterns Based on Synoptic-Scale Moisture Environments in the North Atlantic, J Geophys Res-Atmos, 130, e2024JD043135, 2025.

Hence, D. A. and Houze, R. A.: Vertical Structure of Tropical Cyclone Rainbands as Seen by the TRMM Precipitation Radar, Journal of the Atmospheric Sciences, 69, 2644-2661, 2012.

2. *The authors conducted a Positive Matrix Factorization (PMF) analysis on organic aerosols; however, the manuscript lacks a description of how the resolved factors were defined. The authors should first detail the identification process and criteria used to determine the distinct primary organic aerosol and secondary organic aerosol factors before proceeding to discuss their characteristics and implications.*

Response: We thank the reviewer for this valuable comment. We have reorganized

the Methods section into separate subsections and provided a detailed description of how the different organic aerosol factors were identified in Sect. 2.3.1 (Lines 141-156):

"*2.3.1 Organic aerosol positive matrix factorization*

In this study, PMF was applied to the organic aerosol (OA) mass spectra measured by the SV-ToF-ACSM which was described detailly in Text S3; thus, the analysis is referred to as OA PMF. Diagnostic plots used to evaluate the PMF solution are shown in Fig. S5. Three OA factors were resolved, including two primary OA factors—hydrocarbon-like OA (HOA) and seasalt-related OA—and one secondary OA factor, oxygenated OA (OOA) (Fig. S6). OOA constituted the largest fraction of OA, accounting for 82.6% (Fig. S7a). Its oxidation indicator, the fraction of m/z 44 (CO2+, f44), was 0.31—similar to the f44 value of LVOOA (0.31) observed over the SCS in 2018 (Liang et al., 2021), and slightly lower than that of OOA (0.33) measured in 2019 (Fig. S7b) (Sun et al., 2023). HOA was the second largest contributor (15.6%). Its mass spectrum is characterized by prominent C_nH_{2n-1} *and* C_nH_{2n+1} *ion series (e.g., m/z 41, 43, 55, 57, 69, and 71) (Fig. S6a1), consistent with the mean HOA profile reported by Ng et al. (2011). The mass spectrum of sea-salt-related OA showed peaks at m/z 58 and 60, which may be associated with chloride-containing ions. Van Den Born et al. (2026) experimentally demonstrated that CV-ToF-ACSM can detect a fraction of NaCl. Although NaCl is generally difficult to vaporize in SV-ToF-ACSM, a small fraction may still be detected (1.7%). Given its small and relatively stable contribution, this factor was interpreted as a mixture of sea salt and OA and was therefore named Sea-salt-related OA in this study.*"

3. *In the 0-D cloud Pyrcel model simulations, the authors state that 'κ at 0.7% SS and 0.4% SS were assumed to represent hygroscopicity of the Aitken and accumulation modes, respectively.' Are there relevant references to support the assumption that supersaturations of 0.7% and 0.4% adequately represent the state of Aitken and accumulation mode particles? Alternatively, could the authors explain why selecting these specific supersaturation levels to represent these two modes.*

Response: We have reconsidered the method used to select hygroscopicity values. The selected supersaturation (SS) levels were not assumed to correspond universally to the Aitken and accumulation modes. Instead, following the approach of Pöhlker et al. (2016), they were selected based on how closely the D_{50} at each SS level matched the geometric mean diameter of each mode.

During the pre-TC Chaba period, the geometric mean diameters of the Aitken and accumulation modes were 57 and 156 nm, respectively, while during the post-TC Chaba period, they were 60 and 123 nm. The D_{50} values at 0.4 % and 0.2 % SS were 54 and 87 nm during the pre-TC period and 74 and 127 nm during the post-TC period, respectively. The D_{50} at 0.4 % SS was therefore closest to the Aitken-mode geometric mean diameter in both periods, whereas the D_{50} at 0.2 % SS was closer to the accumulation-mode geometric mean diameter, particularly during the post-TC period.

Although the D_{50} at 0.2 % SS was smaller than the accumulation-mode geometric mean diameter during the pre-TC period, the size-dependent hygroscopicity showed relatively little variation over the relevant particle-size range. We therefore considered the hygroscopicity measured at 0.2 % SS a reasonable representation of the accumulation mode. We have clarified the rationale for selecting these SS levels in the revised manuscript (Lines 199-207).

"*During pre-TC Chaba and post-TC Chaba periods, the geometric mean diameters of the Aitken and accumulation modes were 57 and 156 nm and 60 and 123 nm, respectively. The D_{50} values at of 0.4 % SS and 0.2 % SS were 54 and 87 nm during pre-TC Chaba period and 74 and 127 nm during post-TC Chaba period, respectively. Following Pöhlker et al. (2016), we selected the SS level with a D50 closest to the geometric mean diameter of each mode to represent its hygroscopicity. Although the D50 at 0.2 % SS was smaller than the accumulation-mode geometric mean diameter during pre-TC Chaba period, the size-dependent hygroscopicity varied relatively little as particle size increased after 54 nm. Thus, the hygroscopicity measured at 0.2 % SS was considered representative of the accumulation mode.*"

Reference

Pöhlker, M. L., Pöhlker, C., Ditas, F., et al.: Long-term observations of cloud condensation nuclei in the Amazon rain forest – Part 1: Aerosol size distribution, hygroscopicity, and new model parametrizations for CCN prediction, Atmos. Chem. Phys., 16, 15709-15740, 2016.

4. *Furthermore, since the updraft velocity could not be directly measured, the authors prescribed a range of 0.1-2 m s^{-1} for the simulations based on literature reporting conditions approximately 400 km from the tropical cyclone center. The authors justify this by noting that the minimum distance between the research vessel and the tropical cyclone was 400 km. However, is this updraft velocity range still representative at greater distances? The authors should address and clarify this point in the manuscript.*

Response: We sincerely thank the reviewer for raising this important point. We agree that the research vessel was often at distances greater than 400 km from the tropical cyclone (TC) center during the observation period.

To address this concern, we have clarified the spatial relationship between our observations and the TC structure in the revised manuscript. During most of the observation period, the distance between the center of TC Chaba and the vessel ranged from 400 to 800 km, and it exceeded 800 km after the evening of 3 July. Considering that the typical size of a tropical cyclone is about 700–800 km (Pérez-Alarcón et al., 2021), our observations predominantly fell within the outer regions of the TC.

Previous studies have demonstrated that updraft velocities in these outer regions of tropical cyclones typically remain within the range of approximately 0.1–2 m s^{-1} (Black et al., 1996; Pérez-Alarcón et al., 2021). Therefore, the prescribed velocity range of 0.1–2 m s^{-1} is not limited to the 400 km minimum distance but is broadly representative of the varying distances sampled during the campaign.

We have revised the text in the manuscript at Lines 210-216:

"*During most of the observation period, the distance between the center of TC*

Chaba and the research vessel ranged from 400 to 800 km. After the evening of 3 July, this distance exceeded 800 km as the cyclone moved farther away from the vessel. Previous studies have reported updraft velocities of approximately 0.1–2 m s-1 in the outer regions of tropical cyclones and typical cyclone sizes of 700–800 km. Considering the distance between the vessel and the cyclone center, together with the reported updraft velocities in the outer regions, we prescribed updraft velocities ranging from 0.1 to 2 m s^{-1} in the simulations."

Reference

Black, M. L., Burpee, R. W., and Marks, F. D.: Vertical Motion Characteristics of Tropical Cyclones Determined with Airborne Doppler Radial Velocities, J. Atmos. Sci., 53, 1887-1909, 1996.

Pérez-Alarcón, A., Sorí, R., Fernández-Alvarez, J. C., et al.: Comparative climatology of outer tropical cyclone size using radial wind profiles, Weather and Climate Extremes, 33, 100366, 2021.

5. *I noticed that the time series of the aerosol chemical composition measured by the ACSM exhibits several data gaps. However, the manuscript does not provide an explanation for these missing data periods. The authors are requested to add a brief clarification regarding these discontinuities.*

Response: We thank the reviewer for carefully examining the time series data and pointing out that the data gaps were not explained in the original manuscript. We apologize for this omission.

The prolonged gap in the ToF-ACSM data before 27 June was caused by technical issues with the instrument during the early stage of the observation period. In addition, a temporary data gap in the SMPS measurements from 28 to 29 June resulted from a data acquisition software failure.

We have added a clarification of these data gaps to the revised manuscript to ensure that the reasons for the missing data are clear to readers (Lines 136-139):

"*During the measurement period, technical issues with the ToF-ACSM resulted in a prolonged data gap before 27 June, while a data acquisition software failure*

caused a data loss in the SMPS measurements from 28 to 29 June."

6. *Section 3.2 details the linear parameterization between aerosol hygroscopicity and the organic mass fraction. The slope obtained under marine influence during the pre-TC period is noted to be lower than that reported for remote marine environments. It would be helpful to explicitly state in the discussion if this implies a consistently higher background of anthropogenic or ship-related emissions in the SCS even prior to the direct influence of the tropical cyclone.*

Response: We thank the reviewer for this valuable suggestion. We agree that the lower slope of the κ–f_{OA} relationship under marine influence during the pre-TC Chaba period may indicate that the aerosol background over the SCS was already affected by anthropogenic emissions before the direct influence of TC Chaba.

To address this point, we have expanded the discussion in the revised manuscript by incorporating evidence from previous long-term observations and aircraft measurements. Long-term AERONET observations have shown that the SCS is not a purely marine aerosol environment and is affected by continental aerosol transport, with substantial fine-mode aerosol contributions, particularly in the northern SCS (Chen et al., 2023). In addition, aircraft measurements have identified industrial emissions, including cargo and tanker ship emissions, and biomass burning as important sources of aerosols over the SCS and surrounding marine regions (Miller et al., 2023).

These studies support our interpretation that the relatively low slope observed under marine influence may reflect a less pristine aerosol background before Chaba's direct influence. The relevant discussion has been added to the revised manuscript (Lines 366–371):

"*Notably, the slope obtained under marine influence in this study is lower than that reported for remote marine, likely reflecting the relatively less pristine background conditions of the SCS even before the influence of TC Chaba. This interpretation is supported by long-term AERONET observations showing continental aerosol*

influence over the SCS and aircraft measurements reporting substantial anthropogenic aerosol contributions from industrial emissions, ship emissions, and biomass burning in the region (Chen et al., 2023; Miller et al., 2023)."

Reference:

Chen, J., Zhu, W., Liu, Q., et al.: Temporal Evolution and Regional Properties of Aerosol over the South China Sea, Remote Sens., 15, 501, 2023.

Miller, R. M., Rauber, R. M., Di Girolamo, L., et al.: Influence of natural and anthropogenic aerosols on cloud base droplet size distributions in clouds over the South China Sea and West Pacific, Atmos. Chem. Phys., 23, 8959-8977, 2023.

Specific comments:

1. *In the methodology section, the various methods are presented together without clear divisions, which makes it quite difficult for readers to follow. The authors are requested to divide this section into appropriate subsections with clear headings to improve readability and organization.*

   Response: We thank the reviewer for this comment. To improve clarity for readers, we have reorganized the Methods section into separate subsections and provided more detailed descriptions of the methods used.

2. *Please ensure that all mathematical variables within the equations and the surrounding text (e.g., R, T) are italicized consistently to strictly adhere to ACP formatting guidelines.*

   Response: We thank the reviewer for this comment. We have checked the entire manuscript to ensure that all symbols are formatted correctly.

3. *Line 276: The name of tropical cyclone is wrong.*

   Response: We have corrected the name from "Chapa" to "Chaba".

4. *Line 161: The format of citation is wrong.*

   Response: We have corrected the format of citation.

5. *Line 196: The location of citation is wrong.*

   Response: We have corrected the location of citation.

6. *Line 246: The symbol "P" should be italicized. Please check the whole manuscript carefully.*

   Response: We have checked the entire manuscript to ensure that all symbols are formatted correctly.

7. *Line 256: The location of the citation is wrong again, please check the whole manuscript carefully.*

   Response: We thank the reviewer for this comment. We have checked the entire manuscript to ensure that all in-text citations are formatted correctly.