

We thank the reviewers for the patient and meticulous review of the manuscript. Following those comments, the manuscript has been carefully revised. We have addressed each of the reviewers' comments. All the modifications and corrections are marked in red in the manuscript text.

Below are our point-to-point responses to the reviewers' comments and suggestions, with the reviewers' comments (RC) in black, **our response in red**, and *the revised manuscript content in italicized blue font*.

Answer to Reviewer 3

Summary

RC3.1: This study reports on aerosol properties measured using a TSI aerodynamic particle sizer (APS) and their relationship to environmental parameters measured on a 1- month cruise in the South China Sea and from reanalysis data. The paper aims to characterize the differences in aerosol number concentrations and size distributions between coastal and open-ocean regions and the implications transport has on the variability of modal concentrations. They argue that areas more proximate to the coast have higher aerosol number concentrations. While offshore, wind speed, SST, and the difference between SST and 2-m temperature (SST-T2m) influence aerosol concentration positively (wind speed through mechanical generation) and negatively (SST and SST-T2m through changes in buoyancy and bubble viscosity).

Many of the claims and arguments presented in this work are unsupported or they have been given with vague descriptions and unclear relationships to previous literature. Because this is an interesting dataset in an under-sampled region and some interesting results are obscured within this study, I feel that instead of a full rejection, this paper should undergo substantial major revision before being considered appropriate to be considered for publication. Below I have provided detailed list of major concerns and many technical comments, however many editorial issues persist throughout. I recommend the authors employ these corrections to improve this paper.

Response: We appreciate the reviewer for the thorough reading and thoughtful comments and suggestions. These comments and suggestions made our study more targeted, structured, and understandable, which greatly improve the quality of the manuscript.

Major comments:

RC3.2: The writing in many places is very hard to read due to grammatical errors and the use of frequent platitudes making the paper very difficult to follow. In some places I noted where these were and made suggestions, but the issues were far too numerous to point out each one. Many details are missing, and the discussion is vague without

specific directed attention to the very detailed figures or putting the results in context with the broader literature context or studies within this region. The authors should make a concerted effort to carefully re-read the paper to ensure its clarity.

Response: We sincerely appreciate the reviewer's insightful comments on the readability, detail completeness, and discussion depth of our manuscript. These comments are crucial for enhancing the overall quality and academic rigor of our work. We have carefully addressed each concern through systematic revisions, and the specific measures are outlined as follows:

To improve readability, we have conducted a full-text review to correct grammatical issues (e.g., inconsistent tenses, improper use of articles, and disjointed sentence structures) and remove platitudes.

To address the "missing details" concern, we have added specific information and discussion to enhance the persuasiveness of our study.

To resolve the "vague discussion" issue, we have expanded the discussion section by integrating our findings with existing studies and regional characteristics of the SCS.

These revisions have significantly improved the clarity, completeness, and academic depth of our manuscript.

RC3.3: In many cases, there is an incorrect or superfluous use of the article "the" .

Response: Thank you for your careful review and valuable comment regarding the use of the article "the". We fully agree with your observation and have conducted a systematic check and revision of the entire manuscript to address incorrect or superfluous use of "the". We believe these adjustments have significantly improved the grammatical accuracy and readability of the manuscript.

RC3.4: There was also the use of "meanwhile" and "on the other hand" when the authors were trying to further describe findings or procedures. In many, if not all, of the cases that either of these phrases were used they were unnecessary and confound clarity. I recommend the authors remove these phrases.

Response: Thanks very much for the comment on the clarity of logical connectors. We fully agree that the unnecessary use of transitional phrases such as "meanwhile" and "on the other hand" may disrupt the readability of the text and obscure the core logical flow of findings or procedures.

Following your suggestion, we have carefully reviewed the entire manuscript to identify all instances where "meanwhile" and "on the other hand" were used. For each case, we evaluated whether the phrase was essential for conveying logical relationships. Where the phrase did not contribute to clarifying the connection between sentences or paragraphs, we have removed it. We appreciate your attention to this detail, as it has helped improve the overall readability and rigor of the manuscript.

RC3.5: The authors should use words like "the "correlations can explain", rather than declarative statements on correlations and other relationship because many of their claims are based on mostly visual comparisons and not substantive correlations or quantitative analyses.

Response: Thank you sincerely for pointing out this important issue regarding the language used to describe correlations or quantitative analyses in our manuscript. Your comment has helped us recognize that our previous phrasing was overly definitive. In the original manuscript, a large number of discussions were based on mostly visual comparisons, without effectively leveraging the substantive correlations or quantitative analyses of the observational data.

In response to your comment, we have thoroughly revised the relevant sections in the manuscript. Specifically, we have supplemented substantive correlation and quantitative analyses (including calculations of correlation coefficients or significance levels, and data comparison), and have based our key discussions on these results. Correspondingly, we have revised all declarative statements about correlations and quantitative analyses to adopt more cautious phrasing such as "the correlations can explain", "suggests a potential relationship", or "differences can explain".

Furthermore, we have taken great care to contextualize our findings within existing studies. Rather than presenting these findings as definitive conclusions, we have framed our observations as extensions or complements to prior studies, highlighting consistencies and discrepancies while acknowledging potential limitations. This approach, we believe, better reflects the incremental nature of scientific inquiry and ensures that our claims are appropriately contextualized.

RC3.6: It is the opinion of this reviewer that the word "production" or "emission" be used in place of "generation" when describing the marine sources of aerosol. In the way "generation" is used in this study, the authors are describing wind-generated aerosol production/emission, a more canonical use of the word. Either choice of terminology should be used consistently throughout the text.

Response: Thanks for this constructive suggestion, which helps standardize the terminology in our manuscript and align it with canonical academic expressions in the marine aerosol field.

We fully agree with your comment that "production" or "emission" is more appropriate than "generation" when describing the marine sources of aerosol. In the revised manuscript, we have uniformly replaced all instances of "generation" (when referring to marine aerosol sources) with "production" to ensure terminological consistency throughout the text.

RC3.7: Citations in the text and references list should be checked for correct formatting. In many cases the authors have only listed the first author of papers rather than conforming to the proper citation style of this journal. This should be corrected.

Response: Thank you for pointing out this formatting inconsistency, which is crucial for ensuring the manuscript adheres to the journal's academic standards. We sincerely apologize for the oversight in the initial submission where some in-text citations only listed the first author, failing to conform to the proper citation style of this journal.

To address this, we have thoroughly corrected all non-compliant citation content and conducted a meticulous check of the entire manuscript. After these revisions, we have verified that all citations in the text and references list now fully comply with the

proper citation style of this journal. We appreciate your attention to this detail, which has helped enhance the professionalism and standardization of the manuscript.

RC3.8: Abstract: The text in the graphical abstract is very difficult to read because the resolution is very poor.

Response: Thanks very much for the valuable comment. We apologize for the inconvenience caused by the poor readability of the graphical abstract in the initial submission. To address this, we have improved the resolution of the graphical abstract in the revised manuscript and attached the graphical abstract separately in this response, ensuring that the graphical abstract is clear and legible.

We appreciate your careful review and hope that the revised graphical abstract meets the required standards.

RC3.9: Introduction: The introduction lacks a clear narrative of the research problem and does not provide proper context that motivates the research questions. The current state of the introduction makes it hard for the reader to follow the motivation of this work. The authors should make sure to highlight what relevant prior has been that either supports or motivates why this work has been done. There is very little attention given to introducing the region, the region's sources of aerosol, and how this work will effectively fill in the gaps based on substantive research questions.

Response: Thank you for this constructive comment, which has guided us to significantly improve the clarity and contextual depth of the Introduction. We fully agree that the original Introduction lacked a clear narrative of the research problem, sufficient background to motivate the study, and detailed context for the research region. These issues have now been addressed through a comprehensive rewrite of this chapter.

The specific details of the revisions can be found in the author's tracked changes.

RC3.10: Were the aerosols dried before being sampled? Are you sampling rain drops thus leading to some of the effects presented? Prior work has often shown (e.g. (Petters et al., 2006; Zheng et al., 2018)) precipitation acts as a large sink for accumulation and large accumulation-mode aerosol. I'm not sure I follow or buy the conclusions about wave droplet induced increases in accumulation-mode particles presented in this work based on the available observations.

Response: Thank you for the critical comment. All aerosol were passed through a drying system before being sampled. In addition, the sampling inlet was equipped with a rain shield to prevent raindrops or large hydrometeors from being collected. The increased aerosol NC during rainfall periods was not caused by the sampling of raindrops.

We fully acknowledge prior studies (Petters et al., 2006; Zheng et al., 2018) that highlight precipitation as a major sink for accumulation mode particles. However, our cruise observational data still showed a significant increase in aerosol NC during rainfall periods after rain-shielding measures. We ruled out ship pollution by analyzing wind direction data, and thus we preliminarily speculate that rainfall caused

the significant increase in aerosol NC. Notably, this phenomenon aligns with findings from previous studies (Bird et al., 2010; Zhou et al., 2020), which reported transient increases in aerosol NCs during rainfall periods. Joung & Buie (2014) indicate that the droplets can release aerosols when they influence porous surfaces, and these aerosols can deliver elements of the porous media to the environment. Hence, after accounting for the observation environment and rainfall intensity (short-duration heavy rainfall), we deduce that short-duration heavy rainfall resulted in numerous raindrops impacting the ocean and ship surfaces, generating aerosol particles. Subsequently, APS captured some of these aerosol particles, ultimately contributing to the increased aerosol particle concentration, which can also be observed in Fig. 3 (the blue-shaded region). Consolidated evidence from prior research and current findings suggests that short-duration heavy rainfall may lead to a transient increase in accumulation mode particles.

We do not deny the mechanism by which rainfall can cause wet removal or deposition of aerosols. What is mentioned in this paper may merely be a special phenomenon, and there is no conflict between the two.

Reference:

Bird, J. C., de Ruiter, R., Courbin, L., and Stone, H. A.: Daughter bubble cascades produced by folding of ruptured thin films, *Nature*, 465,759-762, <https://doi.org/10.1038/nature09069>, 2010.

Joung, Y., Buie, C.: Aerosol generation by raindrop impact on soil, *Nat. Commun.*, 6, 6083, <https://doi.org/10.1038/ncomms7083>, 2015.

Zhou, K., Wang, S., Lu, X., Chen, H., Wang, L., Chen, J., Yang, X., Wang, X.: Production flux and chemical characteristics of spray aerosol generated from raindrop impact on seawater and soil, *J. Geophys. Res.-Atmos.*, 125, e2019JD032052, <https://doi.org/10.1029/2019JD032052>, 2020.

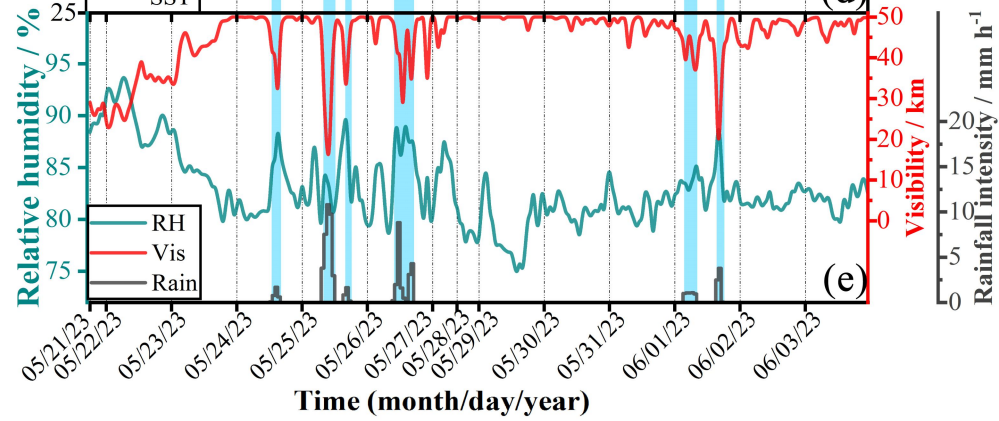
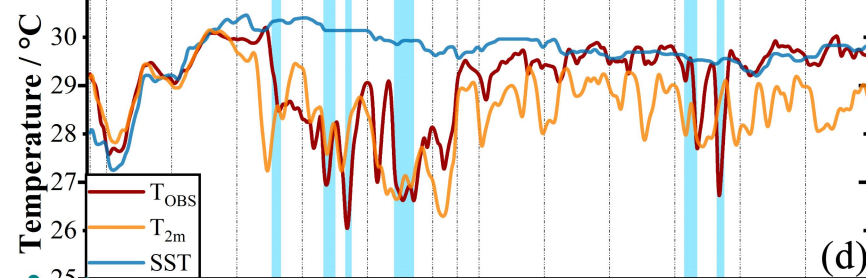
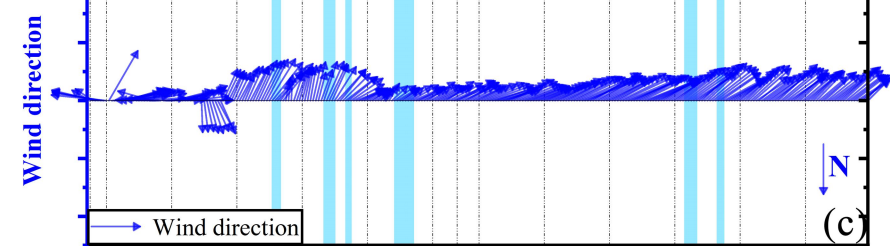
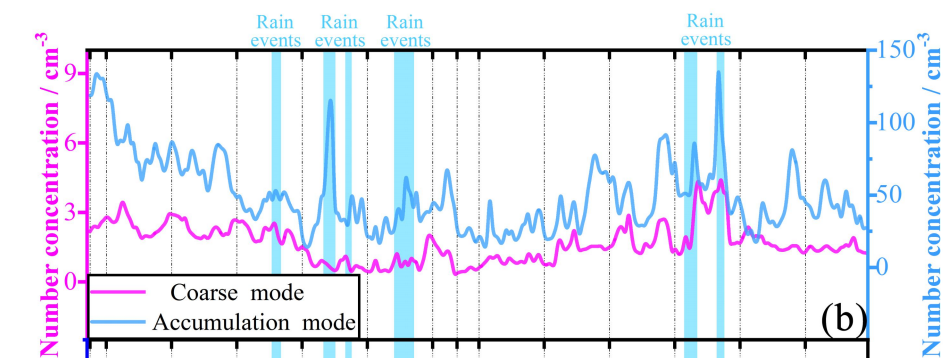
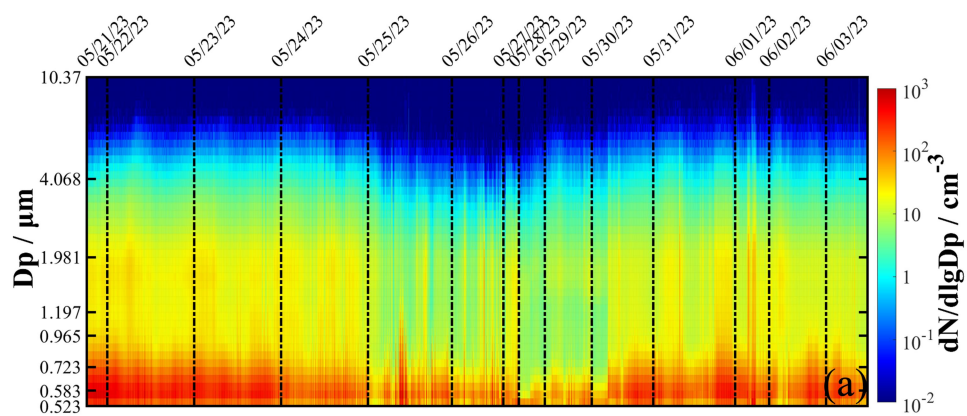


Fig. 3 The time series of the shipboard observations in the SCS from 21 May to 3 June 2023. The blue-shaded regions represented periods affected by rain events. (a) Trend of the aerosol size distributions. (b) Trends of NCs of the two aerosol particle modes (black solid line represented the NC of the coarse mode, and red solid line represented the NC of the accumulation mode). (c) Trend of the WD. (d) Trends of the TOBS (dark orange solid line), T2m (light orange solid line), and SST (blue solid line). (e) Trends in the RH (gray solid line), the VIS (red solid line), and the rainfall intensity (dark blue solid line).

RC3.11: Do the authors use aerosol composition from MERRA-2 in a similar size range of the APS? Many of the MERRA-2 aerosol species will have some non-negligible contributions from particles $<0.5 \mu\text{m}$ that cannot be explained with changes in the APS alone.

Response: Thanks very much for the insightful comment. We confirm that we used aerosol composition data from MERRA-2 within a size range comparable to the APS measurements, and we have added this clarification in the revised manuscript.

sea salt ($SEAS_{10}$; $D_p \leq 10 \mu\text{m}$), dust ($DUST_{10}$; $D_p \leq 10 \mu\text{m}$)

Many of the MERRA-2 aerosol species have some non-negligible contributions from particles $<0.5 \mu\text{m}$, and these contributions were not overlooked in our discussion of aerosol composition differences. While such contributions cannot be directly explained by changes in APS data (which focuses on $\geq 0.5 \mu\text{m}$ particles), we have provided preliminary inferences based on coastal vs. pelagic regional differences. For example, dimethyl sulfide (DMS) concentrations are higher in pelagic regions, likely due to greater phytoplankton biomass there, which emits more DMS. Increased DMS, can further lead to higher SO_2 through atmospheric chemical processes (e.g., oxidation reactions).

Additionally, it is important to clarify that MERRA-2 data was used as auxiliary data in this study, primarily to illustrate how continental transport drives differences in aerosol distributions between offshore and pelagic regions. These differences are ultimately partially reflected in aerosol size distributions ($0.5 \mu\text{m} \leq D_p \leq 10 \mu\text{m}$) and NCs (as measured by the APS).

RC3.12: Data screening: "Nucleation events" (Line 185 and in other passages) in the marine environment from new particle formation or otherwise are observable typically at sub-100nm sizes (in the nucleation, Aitken-mode range) and stop growing well below 500 nm. These are not measurable with an APS. How are the authors able to justify that such events can be adequately observed with their measurement limitations? I am not confident that a number concentration criteria for screening ship pollution or continental influence would be meaningful from an APS alone due to it measuring mostly coarse particles. Plots and discussion of such a justification should be provided so that the reader is confident that there is fidelity in such a screening. Further, new particle formation is not discussed as a potential effect or limitation on the findings of this work and this should be included.

Response: Thank you for the critical and valuable comment, which has helped us correct misleading descriptions and improve the scientific rigor of our manuscript. We apologize for the confusion caused by our inaccurate references to "nucleation events". As you noted, nucleation events and new particle formation in marine environments typically occur in the sub-100 nm size (in the nucleation, Aitken-mode range) and stop growing well below 500 nm. Since the APS measurement is limited to the 500-30000 nm range, it cannot detect particles in these smaller size ranges. Additionally, no studies have explicitly demonstrated that newly formed particles grow rapidly enough to affect marine aerosols in the >500 nm range measurable by the APS. Thus, our earlier implication that nucleation events could influence the observational data (e.g. NCs) was unsupported and incorrect.

To address this, we have removed all references to nucleation events and new particle formation in the revised manuscript. The data screening described in this section is solely intended to further exclude potential ship emissions, complementing the wind direction-based screening:

Under the stable meteorological conditions, aerosol NCs should remain relatively constant (Hoppel, 1979, 1985; Russell et al., 1996). When continental transport present, the continental transport would cause sustained high NCs over several hours (Saha et al., 2022; Wang et al., 2020). Therefore, the sharp increasing NCs data (one order of magnitude higher than the average at that time) without corresponding meteorological parameter changes or evidence of continental transport are might attributed to local ship emissions (either from our ship or nearby ships) and thus excluded. The further data screening based on the unreasonable NCs may further exclude the influence of ship emissions.

We agree that discussing new particle formation and nucleation events are inappropriate here, as such processes lie outside the detection range of the APS and cannot be validated with our data. Including such discussions would introduce unsupported inferences, undermining the robustness of our findings.

We appreciate your constructive feedback again, which has helped clarify these methodological details and prevent reader confusion. The revisions strengthen the accuracy and reliability of our manuscript.

Reference:

Hoppel, W. A.: Measurement of the Size Distribution and CCN Supersaturation Spectrum of Submicron Aerosols over the Ocean, *J. Atmos. Sci.*, 36, 2006-2015, [https://doi.org/10.1175/1520-0469\(1979\)036<2006:MOTSDA>2.0.CO;2](https://doi.org/10.1175/1520-0469(1979)036<2006:MOTSDA>2.0.CO;2), 1979.

Hoppel, W. A., Fitzgerald, J. W., and Larson, R. E.: Aerosol size distributions in air masses advecting off the east coast of the United States, *J. Geophys. Res.-Atmos.*, 90, 2365-2379, <https://doi.org/10.1029/JD090iD01p02365>, 1985.

Russell, L. M., Huebert, B. J., Flagan, R. C., and Seinfeld, J. H.: Characterization of submicron aerosol size distributions from time-resolved measurements in the Atlantic Stratocumulus Transition Experiment Marine Aerosol and Gas Exchange, *J. Geophys. Res.-Atmos.*, 101, 4469 – 4478, <https://doi.org/10.1029/95JD01372>, 1996.

Saha, S., Sharma, S., Chhabra, A., Kumar, K. N., Kumar, P., Kamat, D., Lal, S.: Impact of dust storm on the atmospheric boundary layer: a case study from western

India, Nat. Hazards, 113, 143 – 155, <https://doi.org/10.1007/s11069-022-05293-z>, 2022.

Wang, Y., Zheng, X., Dong, X., Xi, B., Wu, P., Logan, T., and Yung, Y. L.: Impacts of long-range transport of aerosols on marine-boundary-layer clouds in the eastern North Atlantic, Atmos. Chem. Phys., 20, 14741 – 14755, <https://doi.org/10.5194/acp-20-14741-2020>, 2020.

ii) Further data screening with unreasonable NCs. Aerosol NCs remain relatively constant under stable meteorological conditions (Hoppel, 1979, 1985; Russell et al., 1996). In the presence of continental transport, sustained high NCs would persist for several hours (Saha et al., 2022; Wang et al., 2020). Therefore, we excluded the sharp decrease and increase in NCs data in the short term without changes in meteorological parameters and influences of continental transport, and all excluded data had NCs that were one order of magnitude higher or lower than the average NC at that time. So as to further screen out the possible influences produced by the ship emissions.

Technical/Editorial Comments:

RC3.13: Abstract, Line 17: I believe "increase" would be a more appropriate word here than "elevation"; " ...a 120% [increase] in offshore aerosol number concentrations ..."

Response: Thanks very much for your suggestion. We have changed "elevation" to "increase".

RC3.14: Abstract, Lines 26-27: This sentence is written vaguely and should be improved for clarification. Are the authors saying that the results of this work provide evidence to support differences in the spatial variability of marine aerosol in the SCS, and further, these results can help improve understanding of production and transport? The authors should rework this sentence to ensure these points are coming across clearly.

Response: Thank you for your comments. We have written this sentence to enhance clarity.

The results of this study provide clear evidence for the impact of continental transport on the spatial variations of aerosols in the South China Sea (SCS). Meanwhile, the newly added SST-T_{2m}-NC relationship further improves the understanding of marine aerosol production. In summary, our results can improve understanding of marine aerosol transport and production.

The final revised abstract is as follows:

Marine aerosols critically influence Earth's radiation budget and climate dynamics through their spatial distributions and components due to their production and transport processes. However, in-situ observational datasets remain limited, particularly in the South China Sea (SCS). Based on our comprehensive shipborne measurements, this study presents a quantitative analysis of marine aerosol

distributions and compositional variations between offshore and pelagic regions over the SCS. Our data demonstrate a 120% increase in offshore aerosol number concentrations (NCs, $D_p < 10.37 \mu\text{m}$) relative to pelagic baselines, featuring 120% higher accumulation-mode particles ($D_p \leq 1.981 \mu\text{m}$) and 70% higher coarse-mode particles ($1.981 \mu\text{m} < D_p < 10.37 \mu\text{m}$), quantitatively confirming continental transport affects spatial distribution of marine aerosols. In contrast, in the pelagic regions, marine aerosols are virtually unaffected by continental source and distinctly represent characteristics of the local production. Meteorological analyses identified wind speed (WS) and sea surface temperature (SST) as primary regulators of NC. However, observed NC variations at fixed WS and SST values suggest additional controlling factors. We demonstrate that sea-air temperature differentials ($\text{SST}-T_{2m}$) exhibit a stronger correlation ($r = -0.82$, $p < 0.01$) with NC than the other meteorological parameters, where increased $\text{SST}-T_{2m}$ led to decreased marine aerosol production. This temperature gradient effect drives pronounced diurnal NC variations, with maximum differences of 35% observed between daytime, nighttime, and transition periods. These findings provide concrete evidence for the spatial and diurnal variability in marine aerosol distributions over the SCS, thereby further improving understanding of marine aerosol transport and production.

RC3.15: Line 46: I would revise the latter part of this sentence as, "...and climate change, [there has been an increasing research focus on marine aerosols over the last] forty years."

Response: Thanks very much for your suggestion. We have revised this sentence.

Due to their non-negligible influence on both radiation budget and climate change, there has been an increasing research focus on marine aerosols over the last forty years.

RC3.16: Line 47: "NC" is not defined before its first use here.

Response: We have provided the definition for "NC" when it first appears in the manuscript.

In addition to aerosol mass concentrations, researchers have also analyzed and reported on aerosol number concentrations (NCs);

RC3.17: Lines 47-49: The summary of findings in the Hoppel (1979, 1985) studies presented here are insufficient and vague. What do the authors mean by "associated with changes in meteorological parameters and oceanic air mass"? What meteorological parameters?

Response: Please see response to RC1.3.

We appreciate the reviewer's request for clarification regarding Hoppel's work (Hoppel, 1979; 1985). In these studies, Hoppel observed increased aerosol NC and the number size distribution with rising wind speeds off the U.S. East Coast. The term "significant changes in particle size distribution (PSD)" specifically refers to shifts toward higher concentrations across the size spectrum under high-wind conditions, compared to low-wind periods.

Meanwhile, we consider that this citation is inconsistent with the theme of this section - "Researchers' reports on aerosol mass concentration and number concentration". Therefore, we have removed this sentence and will cite it in the next section that discusses the influence of meteorological factors on aerosols.

RC3.18: Lines 49-57: This passage is not written clearly. The authors are attempting to provide a survey of mass concentration differences between different marine regions, but they are listed in a disjointed manner that makes it difficult for the reader to understand. I would recommend that this passage be shortened and combined in a way that illustrates the differences in reported aerosol mass in the different regions. Please also be cognizant of consistent unit usage, e.g. use $\mu\text{g m}^{-3}$ as it is the most common of your reported masses.

Response: Thank you very much for your valuable comment on improving the clarity, structure, and unit consistency of the manuscript. We highly appreciate your suggestion to streamline the content and explicitly illustrate regional differences in aerosol mass concentrations, and we have revised the manuscript accordingly.

Early observations by Prospero (1979) across multiple marine areas showed notable variations in marine aerosol concentrations, ranging from 3.34 to 8.71 $\mu\text{g m}^{-3}$. Subsequent reported measured data verify substantial regional marine aerosol concentration differences between different ocean areas. In polar regions, submicrometer aerosol ($D_p \leq 1000 \text{ nm}$) mass concentrations averaged 0.76 $\mu\text{g m}^{-3}$ in the Arctic (Leck & Persson, 1996) versus 3.15 $\mu\text{g m}^{-3}$ in the Antarctic (Savoie et al., 1993). In the Pacific Ocean, the $\text{PM}_{2.5}$ ($D_p \leq 2500 \text{ nm}$) concentration averaged $12.3 \pm 9.1 \mu\text{g m}^{-3}$ in the Western Pacific (Ma et al., 2022) versus $140 \pm 48.1 \mu\text{g m}^{-3}$ in the Bohai Sea (Han et al., 2019). In the Indian Ocean, Pant et al. (2009) observed that the average micrometer aerosols ($500 \text{ nm} \leq D_p \leq 10000 \text{ nm}$) mass concentrations were 8.89 $\mu\text{g m}^{-3}$.

RC3.19: Lines 57: Revise "For the China waters, ..." to "In marine regions off the coast of China, ..."

Response: We have revised this sentence in accordance with your comment.

RC3.20: Lines 60-63: The authors should clarify what is meant by "discrepancies in the marine aerosol concentrations and size distributions." Do the authors mean "differences"? The ending of this sentence also seems like a bit of a tangent and is not explained, ("especially from 10degN-20degN ...") Why is this included and what is its relevance to the rest of the passage?

Response: We sincerely appreciate this insightful comment. The "discrepancies" mentioned here refer to "differences".

To avoid misunderstandings among readers, we have removed "size distributions" and revised the expression "discrepancies in marine aerosol concentrations and size distributions" to "differences in marine aerosol mass concentrations and NCs".

The note on latitude at the end (, especially from 10° N-20° N) was indeed irrelevant to the main topic, which might have caused confusion for readers. Therefore, we have

also deleted this sentence.

The final version is as follows:

In summary, there are differences in marine aerosol mass concentrations and NCs between the different ocean areas; however, few studies exist on marine aerosol concentrations in the SCS (Kong et al., 2016; Su et al., 2022).

RC3.21: Lines 63-65: I think a more substantive take away from this paragraph is that shipboard measurements provide better spatial (and temporal) context for aerosol measurements in diverse marine regions such as off the coast of China and they can further help improve characterizations by being updated. Can the authors please revise the sentence they have written in these Lines to better convey that?

Response: Thank you for this constructive suggestion. We agree that emphasizing the value of shipboard measurements in enhancing aerosol characterizations is a more substantive takeaway. As recommended, we have revised the final sentences to highlight that shipboard observations can provide better spatial and temporal context (particularly in diverse marine regions like off the coast of China) and that expanding and updating such measurements would help improve aerosol characterizations, especially for the SCS where current data are sparse and outdated. This revision can provide a more substantive insight.

Given that shipboard measurements can provide better spatial and temporal context for marine aerosol measurements across diverse ocean areas such as offshore China, expanding and updating such shipboard observations have the potential to improve the characterization of marine aerosol in these regions.

RC3.22: Line 66: The sentence is written in a way that conveys a finding. If so, the authors need to provide support. I believe the authors are actually saying, "Aerosol generation and transport [can lead] to differences in marine aerosol concentrations and size distributions." Is that correct?

Response: We sincerely appreciate this valuable comment. This is indeed the exact meaning we intended to convey. We have revised this sentence accordingly.

Aerosol production and transport can lead to the differences in marine aerosol concentration and size distribution.

RC3.23: Line 67: Clarify "aerosol components."

Response: We have clarified "aerosol components" in the revised manuscript.
marine aerosol components (e.g. sea salt, dust, sulfate, organic carbon)

RC3.24: Line 68: Are "weather events" synoptic weather patterns, mesoscale weather events, storms? Please clarify.

Response: We acknowledge the reviewer's comment. In the revised manuscript, we have changed "weather events" to "mesoscale weather events" and provided a clarification.

mesoscale weather events (e.g. thunderstorm, sea breeze, typhoon)

RC3.25: Line 71: The authors have written "et al." after "relative humidity (RH)." Do they mean "etc."? "et al." or "etc." is not appropriate here. If there are additional pertinent meteorological parameters to include, please list them.

Response: Thanks very much for the helpful comments. The use of "etc." or "et al." here is indeed inappropriate, so we have removed "et al."

Furthermore, some key meteorological parameters of the air-sea interface could affect aerosol production and transport, such as wind direction (WD) and speed (WS), relative humidity (RH), and sea surface temperature (SST) (Carslaw et al., 2010; Hoppel, 1979, 1985).

RC3.26: Lines 71-75: The description of Tang RH effects on marine aerosol and the overall implication from the studies in the following sentence are not connected through the same logic. The authors are correct to note that RH changes can affect aerosol size through deliquescence and efflorescence, however, this is not related to the "wet deposition and dispersion" mentioned later. The RH effects on size come into play when the aerosol are being sampled, so if mentioning this point is to say that the previous work was inconsistent with their sampling procedures (drying, heating) and that makes comparison and aerosol characterization difficult, then that is what should be discussed here. Because the authors are instead discussing effects on generation and transport evidence of that effect should be discussed and not the Tang result.

Response: We acknowledge the reviewer's constructive comment. To address the logical disconnect noted, we have removed the reference to Tang et al., (1997), as their findings on RH affecting aerosol size through deliquescence and efflorescence are not relevant to the discussion of RH impacts on aerosol generation and transport. Meanwhile, the original descriptions on the impact of RH on aerosols was not sufficiently focused on its effects on aerosol production and transport, and the citations were not entirely pertinent. We have revised the paragraph accordingly. The revised text now specifically emphasizes RH influences on particle dry deposition rates and secondary aerosol formation, with supporting references provided. The dry deposition rates are important to the aerosol transport, as higher dry deposition rates reduce the residence time of aerosols in the atmosphere and shortens their transport distance therein. Additionally, the formation of secondary aerosols (e.g., nitrate and sulfate) directly affects aerosol production. We believe the new descriptions on the role of RH in aerosol production and transport is now appropriate and convincing.

Some studies revealed that rising RH increases particle dry deposition rates (Arimoto & Duce, 1986; Lo et al., 1999), which are important to aerosol transport, as higher dry deposition rates reduce the residence time of aerosols in the atmosphere and shorten their transport distance therein. Ding et al. (2021) found that elevated RH enhances secondary aerosol (e.g. nitrate and sulfate) formation, which directly affects aerosol production. Therefore, RH also affects aerosol transport and production.

RC3.27: The reference for Tang et al. (1997) is not properly cited in the main text or reference list. In the reference list, the authors have only provided the name of the first author.

Response: We sincerely apologize for this mistake in our manuscript. To address this issue, we have carefully corrected this error in both the main text and the reference list in the revised version.

RC3.28: Lines 75-78: The authors should specify what the relationships are between aerosol generation and wind speed from the studies cited. Is it the total aerosol concentration, are they size dependent?

Response: Thanks very much for the comments. These cited studies derived the source functions by analyzing the relationship between aerosol particle size distribution and WS, and finally obtained aerosol concentration through simulation based on this source function. We have rewritten this paragraph.

Some subsequent studies attempted to link NCs to observed WS (Andreas, 1998, 2010; Gong, 2003; Ovadnevaite et al., 2014; Smith et al., 1993; Yang et al., 2019). These studies derived source functions based on the relationship between aerosol particle size distribution and WS, thereby enabling the simulation of number size distribution and total aerosol NCs.

RC3.29: Line 79: "[They] explained that the SST ..." Please clarify what or who is meant by "They."

Response: We sincerely appreciate your detailed question. Our previous summary of SST effect on marine aerosol was insufficient and superficial; therefore, we have rewritten these sentences. In the revised manuscript, we provide an adequate summary of SST effect on marine aerosols and their production.

In addition, SST dramatically influences the production of marine aerosols by affecting bubble bursting time and jet drop production efficiency (Zábori et al., 2012a). Jaeglé et al. (2011) and Mårtensson et al. (2003) further revealed that warmer SST might reduce seawater density and surface tension, ultimately leading to higher marine aerosol production. The reduced surface tension increases wave breaking efficiency, entraining more air into seawater to form bubbles. In addition, the reduced seawater density leads to more bubbles rising back to the sea surface. As these bubbles reach the surface and burst, they subsequently form marine aerosols.

RC3.30: Lines 79-81: This is an inadequate summary of SST effects on aerosol properties. Please be specific based on the studies the authors have cited.

Response: Please see response to RC3.28.

RC3.31: The authors have made no mention of aerosol generation in the free troposphere (e.g. from new particle formation). This can have important implications for aerosol properties measured in the marine boundary layer and cannot be ignored in the discussion of important generation and transport drivers. Further, do they think, based on previous studies in this region, that new particle formation has any effect on the observed relationships?

Response: Thank you for highlighting this important point. We acknowledge that new particle formation (NPF) in the marine boundary layer is important for aerosol

production and transport. However, as you pointed out, the size range (nanometer scale) where new particle formation and growth processes occur is far smaller than the measurement range of the APS (0.5-30 μm). Meanwhile, no study clearly demonstrates that new particles exhibit a sufficiently high growth rate to exert a significant influence on accumulation mode aerosols. Thus, NPF processes do not directly affect the aerosol NCs or size distributions reported here. It also does not influence the specific relationships we observed between NCs and meteorological factors (e.g., wind speed, SST-T2m) in the measured size range (0.5-10 μm) for this study.

In addition, due to the size range limitations of the APS measurement instrument, we were unable to capture new particle formation events. If we had specifically mentioned the impact of new particle formation on aerosol production and transport in the Introduction, it might have caused misunderstanding and confusion among readers.

RC3.32: Line 66-88: Although I have provided rather detailed guidance on this entire paragraph, I believe the authors should completely rework this section. Very vague statements and disjointed thoughts persist throughout. The authors cite lots of work but don't use any of these citations for clear contextual support.

Response: Thanks very much for your valuable guidance on this paragraph. We have fully reworked this paragraph to address the issues of vague statements, disjointed thoughts, and insufficient contextual support from citations:

We clarified all the ambiguous expressions such as "aerosol components" and "weather events". We also restructured the logical framework of this paragraph to form a coherent and progressive structure: "Aerosol production and transport can lead to differences in aerosols \rightarrow influences of 'distance and meteorological events' \rightarrow the specific impacts of aerosol transport \rightarrow the specific impacts of aerosol generation (caused by meteorological factors such as WS, RH, and SST) \rightarrow potential effects of SST-T2m" \rightarrow research on diurnal variations (which may more clearly demonstrate the differences between aerosol transport and generation). In addition, we closely tied each citation to specific viewpoints to enhance contextual support.

Aerosol transport and production can lead to the differences in marine aerosol concentration and size distribution. Some studies revealed that marine aerosol components (e.g. sea salt, dust, sulfate, organic carbon) and particle size distribution are influenced by both the occurrence of mesoscale weather events (e.g. thunderstorm, sea breeze, typhoon) and continental transport (Athanasopoulou et al., 2016; Chen et al., 2018; Croft et al., 2021; O'Dowd & De Leeuw, 2007; Savoie et al., 2015; Sellegri et al., 2006). As one of the largest marginal seas, the SCS is located on the continental margin and separated from the open ocean by islands, or island arcs. It is significantly influenced by continental and anthropogenic aerosols transported through continental air masses. Previous studies reveal that continental and anthropogenic aerosols play an important role in determining aerosol concentration and size distribution (Braun et al., 2020; Wu & Boor, 2021). Liang et al. (2021) observed the increasing submicron aerosol NCs and different number size distribution

shape ($20 \text{ nm} \leq D_p \leq 400 \text{ nm}$) when observational data were influenced by continental transport in the SCS. Atwood et al. (2017) further found that under continental transport, the number size distribution exhibits a unimodal structure ($20 \text{ nm} \leq D_p \leq 500 \text{ nm}$). In contrast, a distinct bimodal size distribution ($20 \text{ nm} \leq D_p \leq 500 \text{ nm}$) emerges without continental transport. Due to limited observational data and the fact that previous studies focused on the submicron size range, conducting observational studies of the impact of aerosol transport on larger aerosol particles ($D_p \geq 500 \text{ nm}$) is crucial for gaining a more thorough comprehension of how aerosol transport influences size distributions.

Furthermore, some key meteorological parameters of the air-sea interface could affect aerosol production and transport, such as wind direction (WD) and speed (WS), relative humidity (RH), and sea surface temperature (SST) (Dasarathy et al., 2023; Carslaw et al., 2010; Hoppel, 1979, 1985). Previous studies found that WS is the major driver of production and transport of marine aerosols. Some subsequent studies attempted to link NCs to observed WS (Andreas, 1998, 2010; Gong, 2003; Ovadnevaite et al., 2014; Smith et al., 1993; Yang et al., 2019). These studies derived source functions based on the relationship between aerosol particle size distribution and WS, thereby enabling the simulation of number size distribution and total aerosol NCs. Some studies revealed that rising RH increases particle dry deposition rates (Arimoto & Duce, 1986; Lo et al., 1999), which are important to aerosol transport, as higher dry deposition rates reduce the residence time of aerosols in the atmosphere and shorten their transport distance therein. Ding et al. (2021) found that elevated RH enhances secondary aerosol (e.g. nitrate and sulfate) formation, which directly affects aerosol production. Therefore, RH also affects aerosol transport and production. In addition, SST dramatically influences the production of marine aerosols by affecting bubble bursting time and jet drop production efficiency (Zábori et al., 2012a). Jaeglé et al. (2011) and Mårtensson et al. (2003) further revealed that warmer SST might reduce seawater density and surface tension, ultimately leading to higher marine aerosol production. The reduced surface tension increases wave breaking efficiency, entraining more air into seawater to form bubbles. In addition, the reduced seawater density leads to more bubbles rising back to the sea surface. As these bubbles reach the surface and burst, they subsequently form marine aerosols. However, previous studies indicated that sea-air temperature differentials ($SST-T_{2m}$) influence the air-sea interaction through air-sea heat exchanges and turbulent mixing (O'Neill et al., 2010); meanwhile, it can comprehensively reflect the characteristics of the ocean and atmosphere near the sea surface (Jing et al., 2019; Ma et al., 2016). Hence, $SST-T_{2m}$ might affect marine aerosol production and transport, but the exact effects of $SST-T_{2m}$ on marine aerosols need further investigation. To better quantify and understand the effect of these meteorological parameters on marine aerosols, more thorough information about the variations of marine aerosol and these factors, especially regarding $SST-T_{2m}$, is needed in the SCS. In addition, the diurnal scale of marine aerosol variation can provide valuable information about their production and transport (Flores et al., 2021), and how these processes are influenced by meteorological parameters. Understanding the diurnal variation is also crucial for

improving atmospheric models. Studies on the scale of diurnal variation in marine aerosol remain scarce, and there is an urgent need to clarify the specific connection between these diurnal variation and meteorological parameters to better understand aerosol production and transport.

RC3.33: Line 89: Please revise, "...most [observational] data ..."

Response: Thank you for the constructive suggestions. We have corrected "observation data" to "observational data" and systematically reviewed and revised the relevant expressions throughout the text.

RC3.34: Line 89-96: I believe the authors should remove this passage up to the start of the motivation sentence, "To address these, ..." Everything prior is not needed and is discussed in the previous paragraphs.

Response: The previous content was indeed redundant and unnecessary, so we have removed these sentences in the revised manuscript.

RC3.35: Line 102: Remove the semicolon after "respectively." This should begin a new sentence.

Response: Thank you for the comments. We have removed the semicolon after "respectively".

According to these analyses, the specific relationships between the different meteorological parameters and marine aerosols were examined respectively. Finally, the overall results of marine aerosol particle size distributions and NCs in the SCS and the possible influence factors were given.

RC3.36: APS data: do the authors use all of the channels in 0.5-10 μm diameter range? I believe previous work has shown that the first channel in the APS has issues with counting efficiency and sizing accuracy. Can the authors please provide clarification on if this channel was used and justification for why it is appropriate to use here?

Response: Thanks for your question. In our study, we utilized all APS channels within the 0.5–10 μm diameter range to characterize aerosol size distributions. Regarding concerns about the first channel's counting efficiency and sizing accuracy, we have addressed this through a 15-day field inter-comparison experiment conducted recently, specifically designed to validate APS performance (especially for the first channel) against other aerosol instruments.

To verify the APS measurements, we performed a field inter-comparison experiment from 2 October to 17 October 2025 at a decommissioned wharf in Zhuhai, Guangdong Province, China (22°12' N, 113°37' E). This site is remote from industrial emissions and roads, with an unobstructed 180° view of the northern SCS, to ensure marine aerosol measurements are achievable. Three instruments were deployed side-by-side in an open environment with 10-cm long tubes. These tubes were fixed to the railing at 30° to the horizontal and faced the sea surface (to simulate the previous observation scenario and minimize terrestrial interference). The three instruments

comprised: a Model 3321 APS (measuring 0.5-20 μm) spectrometer (TSI Incorporated, USA), a Portable Optical Particle Spectrometer (POPS) (measuring 0.115-3.37 μm ; Handix Scientific, USA), and a Model 11-D Portable Aerosol Spectrometer (measuring 0.25-30 μm ; GRIMM, Germany). The aerosol data resolution was set to 10 min in this inter-comparison experiment. Key results included:

1. Consistency in number size distributions: The aerosol number size distributions measured by all three instruments showed high similarity (Fig. S2a) and low discrepancy, confirming general agreement in capturing particle size trends.
2. Concentration comparison for sub-2 μm particles: Since direct channel-to-channel matching was not feasible due to the differing size bins, we compared total concentrations within overlapping ranges relevant to our study's accumulation mode: 0.5–1.981 μm for APS, 0.475-1.99 μm for POPS, and 0.488-2.14 μm for GRIMM 11-D. All three instruments exhibited consistent diurnal trends (Fig. S2b). Strong correlations between APS and the other instruments ($R = 0.92$ vs. GRIMM 11-D; $R = 0.94$ vs. POPS) further validate the APS's accuracy (Figs. S3a, S3b).

Based on the accurate sub-2 μm aerosol concentration data and particle size distribution results, we can infer that the measurement results for the first particle channel of the APS (included within the sub-2 μm range) are accurate and reliable.

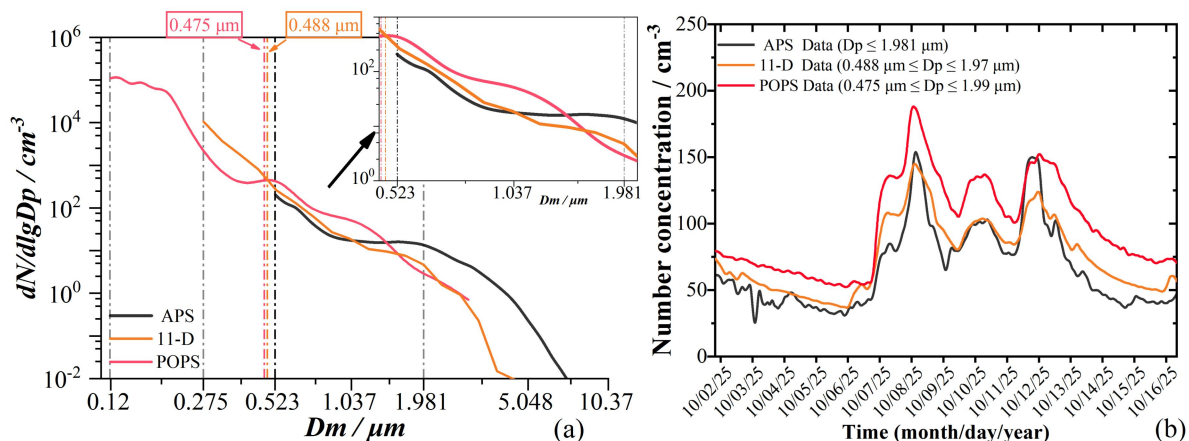


Fig. S2 (a) The NCs of average size distributions for different aerosol measurement instruments (black solid line represented the APS data, orange solid line represented the 11-D data, and red solid line represented the POPS data). (b) Trends of NCs for different aerosol measurement instruments.

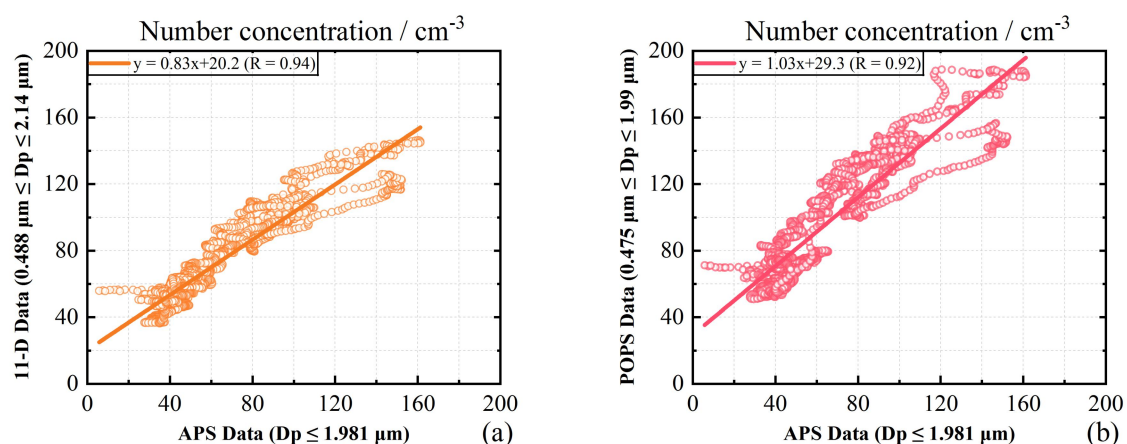


Fig. S3 The scatter plots of (a) NCs of 11-D data and APS data, (b) NCs of POPS data and APS data.

RC3.37: Line 119: delete "future."

Response: We have deleted "future".

RC3.38: Reanalysis data: For the atmospheric dynamic/thermodynamic properties (temperature, wind speed, etc...) was the ERA5 reanalysis, MERRA-2, or a combination of ERA5 and MERRA-2 used? The authors discuss ERA5 in the first part of Section 2.3.1., but then say, "Meanwhile, the MERRA-2 was ..." Why were two different datasets used for these variables? Why not use only MERRA-2 or ERA5? What motivated using two different datasets? I understand using MERRA-2 for the aerosol mass concentrations. Additionally, the authors should justify why they believe the coarse resolution of these datasets compared to the in situ cruise data are representative of the conditions measured where the ship is. Also, please provide a citation for MERRA-2 and spell out its acronym on the first use.

Response: Thanks very much for the comment. Initially, we planned to use the MERRA-2 dataset for both meteorological and aerosol parameters. However, Li et al. (2025) and Luo et al. (2020) evaluated the reliability of MERRA-2 and ERA5 reanalysis data in marine regions using satellite and in-situ observations. These studies found that ERA5 and MERRA-2 datasets show comparable precision for SST and T_{2m} (with MERRA-2 having a slightly smaller bias), but ERA5 datasets exhibited higher accuracy than MERRA-2 datasets for WS (with ERA5 having a smaller bias). The both datasets demonstrated strong correlation with in-situ observations ($R > 0.9$) for atmospheric dynamic and thermodynamic properties. Notably, unlike urban or terrestrial areas, atmospheric dynamic and thermodynamic properties in open marine areas do not undergo abrupt changes. Thus, despite their coarser resolution relative to in situ cruise data, these reanalysis datasets are still deemed representative of the conditions measured at the ship's location. To sum up, we ultimately selected ERA5 for dynamic properties (WS and WD) and MERRA-2 for thermodynamic properties (SST and T_{2m}) as the auxiliary data.

In the revised manuscript, we have spelled out MERRA-2 as "Modern-Era

Retrospective Analysis for Research and Applications, Version 2" on the first use, and added relevant citations for MERRA-2 (Gelaro et al., 2017; Randles et al., 2017).

Reference:

Li, S., Wang, K., Miao, H., Zhu, X., Liu, Y., Li, J., Wang, W., Zheng, X., Feng, J., and Wang, X.: Evaluation of surface wind speed over East Asia and the adjacent ocean in three reanalyses using satellite and in-situ observations, *Atmos. Ocean. Sci. Lett.*, 18, 5, <https://doi.org/10.1016/j.aosl.2024.100587>, 2025.

Nalli, N. R., Morris, V. R., Joseph, E., Smith, J. H., Pittman, J., Minnett, P. J., and Luo, B., Minnett, P. J., Szczodrak, M., Nalli, N. R., and Morris, V. R.: Accuracy Assessment of MERRA-2 and ERA-Interim Sea Surface Temperature, Air Temperature, and Humidity Profiles over the Atlantic Ocean Using AEROSOL Measurements, *J. Climate*, 33, 6889–6909, <https://doi.org/10.1175/jcli-d-19-0955.1>, 2020.

Gelaro, R., McCarty, W., Suárez, M. J., Todling, R., Molod, A., Takacs, L., Randles, C. A., Darmenov, A., Bosilovich, M. G., Reichle, R., Wargan, K., Coy, L., Cullather, R., Draper, C., Akella, S., Buchard, V., Conaty, A., Silva, A. M. da, Gu, W., Kim, G.-K., Koster, R., Lucchesi, R., Merkova, D., Nielsen, J. E., Partyka, G., Pawson, S., Putman, W., Rienecker, M., Schubert, S. D., Sienkiewicz, M., and Zhao, B.: The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2), *J. Climate*, 30, 5419 – 5454, <https://doi.org/10.1175/jcli-d-16-0758.1>, 2017.

Randles, C. A., Da Silva, A. M., Buchard, V., Colarco, P. R., Darmenov, A., Govindaraju, R., Smirnov, A., Holben, B., Ferrare, R., Hair, J., and Shinozuka, Y.: The MERRA-2 aerosol reanalysis 1980 onward. Part I, System description and data assimilation evaluation, *J. Climate*, 30, 6823-6850, 2017.

RC3.39: Line 203: The authors need to define the size ranges used for their quantification of accumulation and coarse modes.

Response: We have defined the size range for our quantification of accumulation and coarse modes.

the accumulation ($0.5\ \mu\text{m} \leq D_p \leq 1.981\ \mu\text{m}$) and coarse ($1.981\ \mu\text{m} \leq D_p \leq 10\ \mu\text{m}$) mode particle NCs.

RC3.40: Lines 202-203: I don't believe that it is appropriate for the authors to define aerosol number concentration integrated from the APS as the "total marine aerosol" or even the "total aerosol." A large portion of marine aerosol number concentrations come from substantial sub-500 nm particle contribution. As such, it would be much better suited if the authors revise this terminology; e.g. "APS integrated NC", "summed NC" .

Response: Thanks for the reviewer's constructive comments. It is inappropriate to define the aerosol number concentration obtained by integrating the APS data as "total marine aerosols" or even "total aerosols". To avoid the misunderstanding, we have revised all such expressions to "summed NC".

RC3.41: Table 2: define the size range for "accumulation mode." Clarify in the

caption that these are shipboard measurements or please specify the observational platform.

Response: We have added the particle size range of the "accumulation mode" in Table 2 and clarified in the table title that these data were all obtained from shipboard observations.

Table 2

Summary of the available study results on the shipboard observation of marine aerosol NC (cm^{-3})

Region	Time	Season	Latitude	Longitude	Parameter	Value	Parameter	Value	Reference
South China Sea	2023.05 - 2023.06	Spring	21°N - 8°N	115°E - 110°E	Accumulation mode (n ₅₀₀₋₂₀₀₀)	52.4 ± 35.0	n ₅₀₀₋₁₀₀₀₀	54.0 ± 35.3	This Study
South China Sea	2018.08	Summer	23°N - 19°N	118°E - 108°E	n ₄₀₀₋₃₂₀₀₀	61			Cai et al., 2020
South China Sea	2012.09 - 2012.10	Autumn	21°N - 20°N	118°E - 113°E	n ₁₂₀₋₁₀₀₀₀	175			Kong et al., 2016
South China Sea	2005.05	Spring	20°N - 18°N	118°E - 113°E	Accumulation mode (n ₅₀₋₂₀₀₀)	50.3 ± 19.5			Lin et al., 2007
East China Sea	2005.05	Spring	30°N - 26°N	122°E - 117°E	Accumulation mode (n ₅₀₋₂₀₀₀)	109.2 ± 51.8			Lin et al., 2007
East China Sea	2017.04 - 2017.05	Winter	28°N - 20°N	130°E - 120°E	n ₂₅₀₋₂₅₀₀	57.4 ± 40.9	n ₂₅₀₀₋₁₀₀₀₀	57.5 ± 41.3	Ma et al., 2022
Western Pacific	2017.04 - 2017.05	Spring	20°N - 0°N	180°E - 130°E	n ₁₀₀₋₁₉₈₀₀	83 ± 30			Flores et al., 2020

Note. In the column of the "Parameter", "n" indicated the NC and the subscripts indicated the particle size (nm); in the column of the "Latitude", "N" represented north latitude. The results of this study and these references were the overall average aerosol NCs.

RC3.42: Lines 206-207: The sentence "Due to the constraints ..." is not necessary and should be removed.

Response: Thanks very much for the useful comment. We have removed this sentence.

RC3.43: Lines 207-209: Delete "data recorded and" in the sentence "The shipboard observation data ..."

Response: Thanks very much for the useful comment. We have deleted "data recorded and".

RC3.44: Lines 211-214: I don't understand how the authors came to these conclusions or what evidence is being used to support these claims of new particle

formation being the cause of differences in accumulation-mode number concentrations. As I mentioned in one of my main comments, new particle formation and growth occurs at much smaller sizes than what is measured by the APS. The authors also do not provide any literature support for how they can argue this claim based on their measurements. Additionally, there is no discussion prior to or proceeding this sentence about westerlies and what that would mean for aerosol NC changes.

Response: Thank you for your constructive comments. As Reviewer 3 pointed out, the size range (nanometer scale) where new particle formation and growth processes occur is far smaller than the measurement range of the APS (0.5–30 μm). Therefore, the claim that new particle formation causes differences in accumulation mode (0.5–1.981 μm) NC is unreliable and cannot be supported by the measured data. No study clearly demonstrates that new particles exhibit a sufficiently high growth rate to exert a significant influence on accumulation mode aerosols. Nor is there any study clearly indicating that new particle formation is sparse in the SCS. Therefore, we have removed the claim that "new particle formation is the cause of differences in accumulation-mode number concentrations".

Instead, we have provided the reason for the difference in aerosol NCs between the East China Sea and the South China Sea: Aerosol emissions from the Yangtze River Delta region are higher than those from the Pearl River Delta region (Li et al., 2017). Due to the influence of aerosol transport, a greater amount of continental and anthropogenic aerosols from the Yangtze River Delta are delivered to the East China Sea compared to the amount transported from the Pearl River Delta to the South China Sea.

To improve accuracy, we have replaced the potentially misleading term "westerlies" with "aerosol transport."

Aerosol emissions from the Yangtze River Delta region are higher than those from the Pearl River Delta region (Li et al., 2017). Due to the influence of aerosol transport, a greater amount of continental and anthropogenic aerosols from the Yangtze River Delta were delivered to the East China Sea compared to the amount transported from the Pearl River Delta to the South China Sea.

RC3.45: Lines 213-216: I don't understand much of the discussion here or how it relates to the citation from the Atlantic. Did the Atlantic study measure the same size range? How can this study be used for comparison without mentioning these specific differences?

Response: Thank you for this insightful comment. We have reselected the measurement data from the Flores et al. (2020) experiment, which were collected in the Western Pacific. The South China Sea is one of the marginal seas of the Western Pacific; meanwhile, both our experiment and the Western Pacific experiment in Flores were conducted in spring and located in the tropical zone and westerlies. Therefore, we initially hypothesize that the aerosol number concentrations from the two measurements should be similar. We have revised this sentence.

The SCS is one of the marginal seas of the Western Pacific. The summed NC observed in this study (54 cm^{-3}) was slightly lower than NC in the Western Pacific (83 cm^{-3}) by Flores et al. (2020).

RC3.46: Line 248: replace "region" with "range" or "bin."

Response: Thanks for the comment. We have changed "region" to "range".

RC3.47: Figure 6: were these plots created using a fixed wind direction, relative humidity, precipitation, or other controlling factor? If not, how can the authors argue, especially based on the apparent low correlation and large scatter of the data, that wind generation is the primary mechanism for driving variability of this mode?

Response: These figures were created using wind direction (exclude wind directions ranging from 225° to 315°) and precipitation (rainfall intensity = 0) as control factors. The box plots in Figure 6 indicate a positive correlation between aerosol NC and WS. As WS increases, both the median and the 25th–75th percentiles of aerosol NC (represented by the box) increase. This correlation can be explained by the fact that wind generation drives variability of this mode. The remaining scatter of the data might caused by some particles forming through secondary processes.

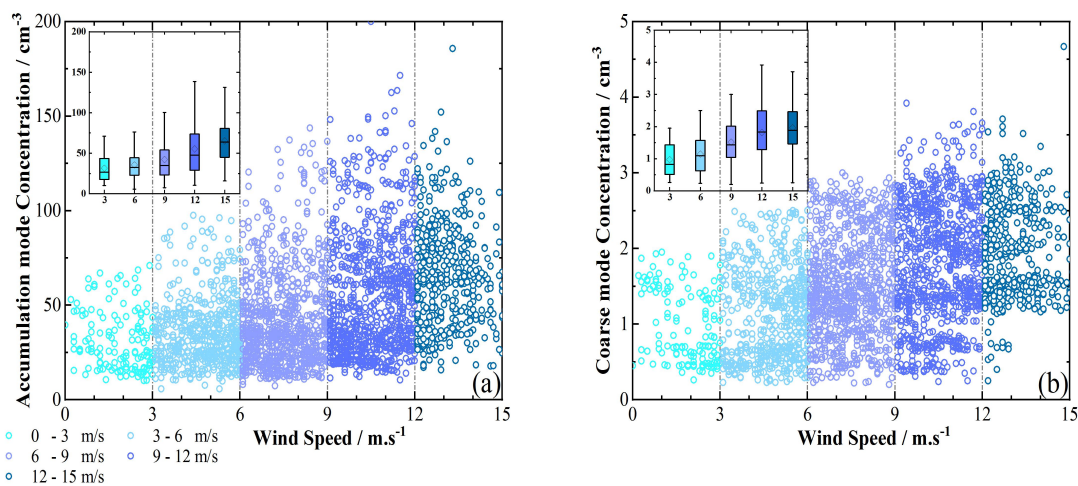
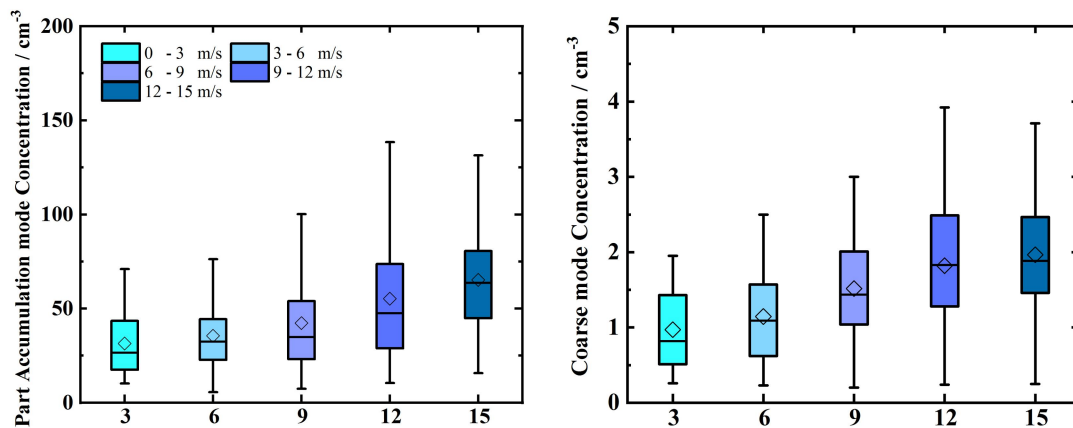


Fig. 5 The scatter plots of (a) NCs of the aerosol accumulation mode and WS, (b) NCs of the aerosol coarse mode and WS. The observational data were binned to the WS intervals equal to 3 m s^{-1} ; the boxes represented the 25th to 75th percentile value, the black whisker represented the 1.5 inter-quartile range, the black diamond marker represented the mean value, and the black horizontal line represented the median value in the box plots.



RC3.48: Figure 7a: What do the different colors of the boxplots represent? If they are offshore and pelagic, you should use the same color scheme throughout the whole figure.

Response: Thank you for this thoughtful comment. The different colors of the boxes represent the offshore and pelagic regions. In response to this suggestion, we have modified Figure 7 to ensure a consistent color scheme throughout.

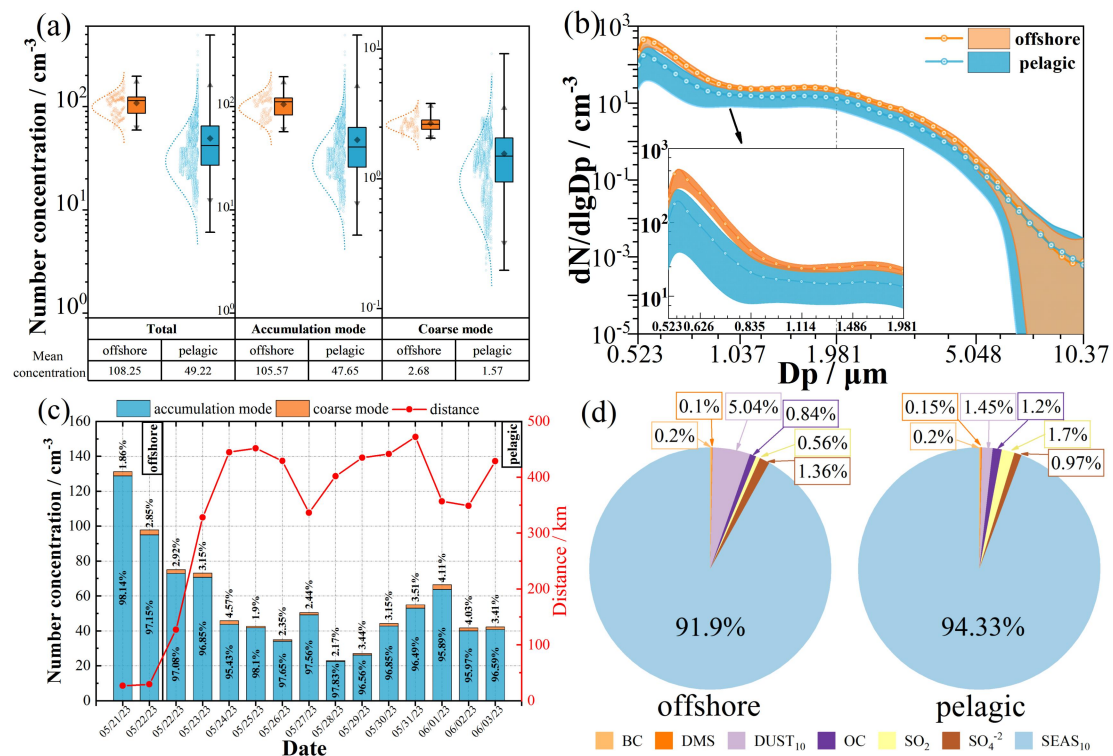


Fig. 7 Classification of the shipboard observation path in the SCS: (a) Accumulation and coarse mode particle sizes graded NCs in the offshore and pelagic regions. For the box plots, the boxes represented the 25th to 75th percentile value, the black whisker represented the maximum and minimum range, the black triangle represented the 1.5 inter-quartile range, the black diamond marker represented the mean value, and the black horizontal line represented the median value. (b) The NCs of average size distributions (the solid lines and circles) and standard deviations (the shaded

areas) for marine aerosols of 0.5 to 10 μm diameters in the offshore and pelagic regions. (c) The daily average variations of the proportions and the NCs of two aerosol particle modes were shown with the distances from coast. (d) The distributions of marine aerosol components in the offshore and pelagic regions. The pie charts showed the average aerosol composition based on the mass concentrations from the Merra-2 aerosol dataset during the whole cruise period.

RC3.49: Figure 7a: are the differences in pelagic and offshore number concentrations statistically significant for each mode and their sum?

Response: Thank you very much for your valuable comment. We have rewritten this part and clarified that these differences are statistically significant with $p < 0.001$. Below, we will explain why this differences are statistically significant:

For example, the NC difference for the accumulation mode between the offshore and pelagic regions is 57.92 cm^{-3} , then we compare it to the standard error (the denominator of the t-value):

$$\text{Standard error (SE)} = \sqrt{\frac{S_{\text{offshore}}^2}{N_{\text{offshore}}} + \frac{S_{\text{pelagic}}^2}{N_{\text{pelagic}}}} \approx 1.88$$

where S_{offshore} is the standard deviation of NC in the offshore regions, N_{offshore} is the number of samples in the offshore regions, S_{pelagic} is the standard deviation of NC in the pelagic regions, N_{pelagic} is the number of samples in the pelagic regions.

The difference (57.92) is approximately 31 times larger than the SE (1.88). This large ratio directly leads to a high t-value ($t \approx 31$), which far exceeds the critical threshold for $p < 0.001$ ($|t| > 3.29$). For the coarse and summed modes, they also both have high t-values ($t \approx 36$ and 31 respectively). In addition, the large sample size effectively suppresses random fluctuations in the shipboard observation data, strengthening the statistical significance of the mean difference. Therefore, the differences are statistically significant ($p < 0.001$).

RC3.50: Lines 295-296: How does the bimodality of the distributions reported here compare to previous literature? Given the counting uncertainty in the lower bin of the APS, I'm not sure I believe true bimodality is being observed here, nor do I believe it will be comparable to prior reports of bimodal marine size distributions such as in Hoppel et al (1986).

Response: The bimodality of the distributions reported in this study is consistent with previous studies (Andronache, 2003; Braun et al., 2020). The number size distributions in the oceans exhibited a bimodal distribution, and the peak values both occurred at approximately 0.5 and $1.981 \mu\text{m}$. Furthermore, the observed bimodality is reliable, as the accuracy of the APS data has been confirmed through recent multi-instrument comparative validation. In the original manuscript, we did not compare our findings with the marine aerosol bimodal distribution reported in the study by Hoppel et al (1986).

RC3.51: Line 297: Please clarify what is meant by the aerosols were "evenly

distributed in the 0.835 to 1.981 μm particle size range." Later in the text this term "evenly distributed" is mentioned again. It should be replaced with something more specific.

Response: Thank you very much for the comment. What we intend to express is that the dN/dlogDp values (representing the number size distribution) are relatively stable with no variations in the 0.835 to 1.981 μm particle size range. This sentence has been rewritten to convey this meaning clearly.

The number size distributions exhibited a relatively stable value in the 0.835 to 1.981 μm particle size range.

RC3.52: Line 298: Where do the authors describe a "transport effect" on the size distribution below 1.114 μm ? Please clarify.

Response: Thanks very much for your suggestion. We have changed "transport effect" to "the influence of aerosol transport", and have also added discussion on "the influence of aerosol transport".

Due to the influence of aerosol transport, the continental air masses carried continental and anthropogenic aerosols, which ultimately affected aerosol distributions in the 0.5-5.0 μm particle size range. The number size distributions in the offshore regions were obviously higher than in the pelagic regions in the 0.5-5.0 μm particle size range. The findings were consistent with the previous studies (Braun et al., 2020; Lorenzo et al., 2023).

RC3.53: Line 301-305: Is this discussion only about the accumulation mode, coarse mode, or sum? Please specify.

Response: We have rewritten this section. In the revised manuscript, we have expanded the discussion to include accumulation mode, coarse mode, and the total NCs.

Fig. 7c revealed a decreasing trend in NCs with increasing distance from the coast, and the correlation coefficients between the daily average NCs of accumulation mode, coarse mode, and the total NCs and the distance from the coast were calculated as $R = -0.87$, -0.67 , and -0.81 , respectively. The correlation analysis, based on hourly average NCs of accumulation and coarse modes versus the distance from the coast, yielded $R = -0.59$ and -0.50 for offshore regions, and $R = -0.28$ and -0.33 for pelagic regions. The same was true for the total NC; the correlation coefficient between the hourly average total NC and the distance was -0.56 in the offshore regions and -0.29 in the pelagic regions.

RC3.54: Lines 303-305: Were only 2 data points used for the offshore correlation? In Figure 7c, there are only 2 dates and two bars pertaining to offshore. 2 data points are not sufficient for a correlation. Did the authors use all data points for those days or just the average in the bar charts? Please clarify (1) what was used for the correlation and (2) what data is being shown in figure 7c; the caption says "diurnal variations" which is very vague.

Response: Thank you for your constructive comments. We have specified the

variables used to calculate the correlation coefficients in the revised manuscript. The overall correlation coefficients were calculated using the daily average aerosol NCs and the distances from coast.

Fig. 7c revealed a decreasing trend in NCs with increasing distance from the coast, and the correlation coefficients between the daily average NCs of accumulation mode, coarse mode, and the total NCs and the distance from the coast were calculated as $R = -0.87$, -0.67 , and -0.81 , respectively.

As you pointing out, the number of data points is insufficient for a correlation analysis when using daily averages in offshore and pelagic regions. Therefore, we used the hourly average aerosol NCs and distances to calculate the correlation coefficients for these regions.

The correlation analysis, based on hourly average NCs of accumulation and coarse modes versus the distance from the coast, yielded $R = -0.59$ and -0.50 for offshore regions, and $R = -0.28$ and -0.33 for pelagic regions. The same was true for the total NC; the correlation coefficient between the hourly average total NC and the distance was -0.56 in the offshore regions and -0.29 in the pelagic regions.

Additionally, we have revised the caption of Figure 7c, changing "diurnal variation" to "daily average variation" for accuracy.

RC3.55: Line 310: "meteorological element distributions" is a very confusion description. This should be revised to "meteorological parameters" as in the table header.

Response: Thank you very much for the comment. We have changed "meteorological element" to "meteorological parameters".

RC3.56: Line 310: The authors say the meteorological parameters are "significantly different" between offshore and pelagic areas. Based on the means and standard deviations this does not appear to be the case as the absolute differences are within only a few percent between the areas. The authors should please explain this claim and provide statistical evidence to support it.

Response: Thanks very much for your comments. We apologize for the misunderstanding caused by our incorrect use of the term "significant differences". This was a wording error. What we intended to express was the discrepancies in meteorological parameters between offshore and pelagic regions. Therefore, we have revised "significant differences" to "discrepancies".

We appreciate you pointing out this imprecision, which has helped us improve the rigor of our manuscript's language.

Table 3 revealed discrepancies in meteorological parameters between offshore regions and pelagic regions.

RC3.57: Lines 312-313: " In addition to the WS influence, the frequency ..." Where is this shown?

Response: Thank you for the comments. Through calculations, we found that the frequency of westerlies and southwest winds is basically the same in offshore and

pelagic regions, both around 80%. Therefore, the previous discussion is incorrect. Fig. 6 revealed that the distance from the coast is the main factor affecting continental aerosol transport, so we have rewritten this sentence to reflect that the difference in aerosol transport is caused by the distance from the coast.

In addition, the offshore regions were relatively close to the coastline (Fig. 6b). Compared to pelagic regions, southwest and west winds in offshore regions could directly transport continental and anthropogenic aerosols to the ship's location from Guangdong and Hainan, China. Therefore, aerosol transport was higher in offshore regions.

RC3.58: Lines 314-325: This passage and its discussion of effects on the aerosol is exceptionally inadequate. Significant jumps to conclusions are made throughout. (1) are the aerosols emitted from Guangzhou and Hainan and the "islands and countries surrounding SCS" expected to be observable in the size range of measurement of the APS? What evidence is there to support this? (2) "... underwent atmospheric transport, transformation, and deposition processes ..." is very vague and not an appropriate claim based on the available measurements and analysis of this study. Please provide specific description of processes that the authors think the aerosol experienced that can explain the differences.

Response: Thank you for your constructive comments. We have rewritten this section. We have also adjusted the position of this paragraph (now placed at the beginning of Section 3.2) based on Reviewer 2's comments.

In offshore regions, aerosols emitted from Guangzhou, Hainan, and some surrounding island countries can be observed within the particle size range measured by the APS. We have provided relevant literature (Braun et al., 2020; Wu & Boor, 2021) to confirm that the transport of continental and anthropogenic aerosols has influences on NCs and number size distribution of aerosols larger than 0.5 μm .

We conducted real-time analysis of the 72-hour backward trajectories of air masses at the ship's location (Fig. 6a, b). The backward trajectory analysis indicated that the air masses had last passed over continental areas on 22 May 2023, 11:00 local time (LT), at a point 50 km from the coast (the red solid lines in Fig. 6b). Consequently, for all sampling locations within this 50 km boundary, the air masses had directly passed over mainland areas. This meant they carried continental and anthropogenic aerosols that ultimately influenced the aerosol distributions (Braun et al., 2020; Wu & Boor, 2021).

We have clarified the processes that aerosol particles undergo, which ultimately prevent them from affecting the NC and number size distribution of aerosols in pelagic regions. In addition, the revised paragraph focuses primarily on explaining how to distinguish between offshore and pelagic regions, and no longer discusses the observed differences caused by these processes.

For regions more than 50 km from the coast, the backward trajectory results consistently showed that the air masses did not pass over any mainland areas before reaching the sampling site (the blue solid lines in Fig. 6a). The prevailing wind direction was primarily from the southwest (Fig. 3c) in these regions, so aerosols

could not be directly transported from the continent to the ship's location. Additionally, continental and anthropogenic aerosols, which were emitted from islands and countries surrounding the SCS, lost their original characteristics through the long-duration (over 72 hours) transport. These aerosols underwent atmospheric long-range transport, dry deposition, wet deposition, and aging processes. Such processes led to the removal of continental aerosols or their gradual dilution and mixing with natural aerosols (Hodshire et al., 2019; Ohata et al., 2016; Xu et al., 2021). Over time, the continental and anthropogenic aerosols transformed or integrated into the background aerosols. Hence, 50 km from the coast was taken as the boundary distance to distinguish offshore and pelagic regions in this study.

RC3.59: Line 325-327: The authors need to justify that the dust and sulfate aerosol are representative of continental aerosol sources by providing citable studies.

Response: Thank you for this insightful comment. We have supplemented the relevant references in the revised manuscript to explicitly justify that dust and sulfate aerosols are representative of continental aerosol sources.

The higher concentrations of dust and sulfate aerosols further indicate that continental aerosols have influenced the aerosol components in the offshore regions (Geng et al., 2023; VanCuren, 2003).

Reference:

Geng, X., Haig, J., Lin, B., Tian, C., Zhu, S., Cheng, Z., Yuan, Y., Zhang, Y., Liu, J., Zheng, M., Li, J., Zhong, G., Zhao, S., Bird, M. I., Zhang, G.: Provenance of Aerosol Black Carbon over Northeast Indian Ocean and South China Sea and Implications for Oceanic Black Carbon Cycling, *Environ. Sci. Technol.*, 57, 13067-13078, <https://doi.org/10.1021/acs.est.3c03481>, 2023.

VanCuren, R. A.: Asian aerosols in North America: Extracting the chemical composition and mass concentration of the Asian continental aerosol plume from long-term aerosol records in the western United States, *J. Geophys. Res.*, 108, 4623, <https://doi.org/10.1029/2003JD003459>, 2003.

RC3.60: Lines 327-330: Have DMS, OC, and SO₂ been shown to be in high concentrations in pelagic regions of the SCS? The "degree of [...] marine biological activity" is alluded to in the following section (Lines 355), but nothing related to this is discussed and how it might explain the differences between pelagic and offshore regions.

Response: We appreciate this comment. The mass concentrations of DMS, OC, and SO₂ were higher in pelagic regions (0.18, 1.44, and 2.1 $\mu\text{g m}^{-3}$, respectively) than in offshore regions (0.1, 0.91, and 0.61 $\mu\text{g m}^{-3}$, respectively) of the SCS.

In the revised manuscript, we have further elaborated on the mechanism: pelagic marine biological activity (e.g., phytoplankton metabolism) directly drives these concentration differences, with supporting literature.

Meanwhile, in the pelagic regions, the proportions of dimethyl sulfide (DMS), organic carbon (OC), and sulfur dioxide (SO₂) were 0.15 %, 1.2 %, and 1.7 %. These proportions were higher than those in the offshore regions (0.1 %, 0.84 %, and

0.56 %, respectively) due to the more frequent marine biological activities (e.g. phytoplankton metabolism) in the pelagic environments. For instance, phytoplankton releases DMS through cellular metabolism and lysis; DMS then undergoes atmospheric oxidation to form SO₂ (Kettle & Andreae, 2000). Additionally, phytoplankton also produces OC (O'Dowd et al., 2004). These marine biological activities directly contribute to higher proportions of DMS, SO₂, and OC in pelagic regions.

RC3.61: Line 357: " ...the meteorological parameters had obvious day-night differences." The word "obvious" should be removed here and replaced with "it is expected that there are diurnal differences." The differences are not "obvious" because they have not yet been shown.

Response: Thank you very much for the comment. This sentence has been rewritten as suggested.

Beyond that, many meteorological parameters, such as WS, T_{2m}, SST, and SST-T_{2m}, might influence the concentration and distribution of marine aerosols. It is expected that there are diurnal differences.

RC3.62: Line 359-363: The threshold of 120 cm⁻³ is not comparable to the Saliba et al. (2019). In that study the condensation nuclei concentration (particles >10 nm) was used, while this study is using mostly large accumulation and coarse mode aerosol. Please clarify the discrepancy and justify this choice of threshold. Were other thresholds tested and what support is available to make this choice?

Response: Thanks for the constructive comment, which has helped us clarify difference between our threshold selection and Saliba et al. (2019).

Saliba et al. (2019) did not explicitly justify their choice of total particle number concentrations threshold was 2000 cm⁻³. The threshold for NCs they established was not intended to exclude the influence of continental transport, but rather to eliminate the impact of ship's own stack emissions. We had conducted data screening in Section 2.4, where observational data during periods of ship pollution have been removed. In our original manuscript, the statement that "NC screening was used to exclude continental transport" was incorrect, and we apologize for this misrepresentation.

Regarding the original threshold of 120 cm⁻³, it was initially chosen based on statistical considerations (approximately the 99th percentile of a normal distribution of NCs in pelagic regions). We also tested other thresholds using 2σ and 3σ criteria. These tests showed only slight differences in NC values but no impact on the overall conclusions by using the different thresholds. The threshold of 120 cm⁻³ lacks a clear physical mechanism justification. Hence, we have removed the NC threshold of 120 cm⁻³, and the study (Saliba et al., 2019) have been properly cited in the revised manuscript. The 12 data points previously excluded (accounting for 0.4% of total observational data) have been reinstated. Reanalysis with these data included confirms that our core conclusions remain unchanged.

This revision eliminates readers' confusion regarding the selection of the threshold and ensures that the core conclusions of this study remain valid.

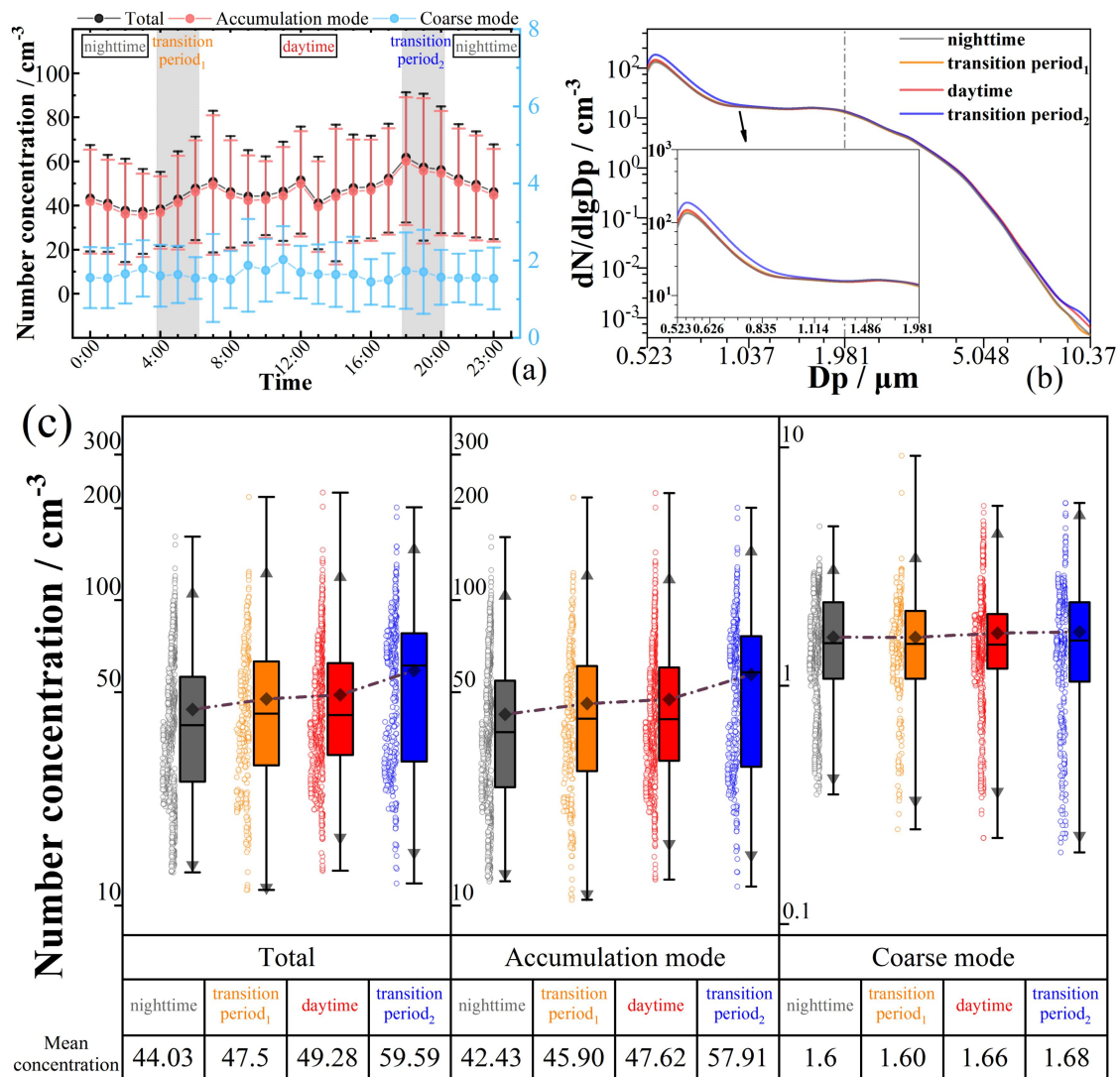


Fig. 8 (a) Diurnal variations of the total mean values of the NCs in the different aerosol particle modes. The vertical bars showed the standard errors (the shadow areas represented the transition periods between daytime and nighttime). (b) The NCs of average size distributions for marine aerosols of 0.5 to 10 μm diameters in different time periods. (c) The NCs of the different aerosol particle modes in different time periods. For the box plots, the boxes represented the 25th to 75th percentile value, the black whisker represented the maximum and minimum range, the black triangle represented the 1.5 inter-quartile range, the black diamond marker represented the mean value, and the black horizontal line represented the median value.

In pelagic regions, the sources of 72-h backward trajectory air masses were from the ocean, and observational data were processed to exclude the continental influence. These aerosol data conformed to clean marine periods, which were proposed by Saliba (2019) to extract relatively clean marine aerosol data

RC3.63: Lines 364-367: Please specify the hours used for each time.

Response: Thank you very much for the comment. This sentence has been rewritten as suggested.

RC3.64: Lines 367-383: I see no "clear diurnal variation" in Figure 9. Figure 9a shows a very minimal increase in mean accumulation mode aerosol and no change in coarse mode. The plots in 9c show basically similar medians with interquartile ranges that are nearly identical for each mode and their respective time periods. Have the authors tested if these differences are statistically significant? Again, differences in the mean concentrations here seem to vary by only 1-5%. What are the differences observed in the size distributions of Figure 9b? These are not discussed clearly in the text and as a I reader I see no real changes. These should be quantified as a change in peak diameter, width, number, etc.

Response: Thank you for this insightful comment. We acknowledge that the absolute numerical changes in Fig. 9a may appear small, but there is a gap of over 30 cm^{-3} between the maximum and minimum values (with an average of only 49.22 cm^{-3} in the pelagic regions). Moreover, there is an obvious shift in the trend of aerosol NCs during the day-to-night transition periods. For example, accumulation mode aerosol decreases continuously in night but increases continuously in the night-to-day transition (NDT) period. In summary, we consider there to be a clear diurnal variation. As for the accumulation mode in Figure 9c, the curves appear to show basically similar median distributions, with the interquartile ranges that are also almost identical. This is because the NC of local marine aerosols in the $0.5\text{-}1.981 \mu\text{m}$ range is inherently low (with an average of only 49.22 cm^{-3} in the pelagic region), and we use a logarithmic axis. This can make the changes seem insignificant, but the mean concentrations at the bottom of Fig. 9c clearly show an increasing trend.

For accumulation and total modes, we found that the differences in different periods are statistically significant ($p < 0.01$) by using the calculation method described in Response 3.49. The statements has been added in the revised manuscript.

The differences were all statistically significant ($p < 0.01$).

We have quantified the changes in peak diameter and peak value for each periods, and have revised the text to explicitly discuss these quantifications and emphasize the variations.

Comparisons of size distributions (Fig. 8b) showed that number size distributions exhibit a relatively stable value in $0.835\text{-}1.981 \mu\text{m}$ particle size range, and subtle differences emerged in this particle range. Quantitatively, peak diameter varied slightly across periods: $0.571 \mu\text{m}$ in nighttime, $0.567 \mu\text{m}$ in the NDT period, $0.569 \mu\text{m}$ in daytime, and $0.570 \mu\text{m}$ in the DNT period. More notably, the peak value was 147.05 cm^{-3} in nighttime, then rose to 155.87 cm^{-3} in NDT period, further increased to 165.60 cm^{-3} in daytime, and reached the highest value of 206.79 cm^{-3} in DNT period, registering a 0.4-fold increase relative to the nighttime baseline. The peak value showed a clear and continuous increasing trend, which may reveal variations in aerosol production. In addition, all size distributions for marine aerosols had the same shape. The consistent shape can be explained by their common marine origin and production mechanisms.

RC3.65: Lines 428: the values are "more negative" not "smaller than" -0.75.

Response: Thanks for the comment. We have changed "smaller than" to "more negative".

RC3.66: Section 3.3.2. First Paragraph (SST influence): the authors should comment on the fact that the correlation found here for aerosol concentrations and SST occur for a very small range of SST of about 1-2 deg C. This is likely much smaller than the field and laboratory studies used for comparison. Do the authors think this has any effect on the observed correlations/slopes and the claims the authors make about entrainment and density changes that influence aerosol number concentrations? Terms like "daughter bubbles" are not described and make this discussion confusing. Please clarify this discussion for readability.

Response: Thank you for your constructive comments on Section 3.3.2. We have carefully addressed your concerns about the SST range, and clarification of "daughter bubbles".

On the small SST range ($28\text{ }^{\circ}\text{C} \leq \text{SST} \leq 31\text{ }^{\circ}\text{C}$) and its influence on correlations/slopes:

We acknowledge that the SST range in our study ($28\text{ }^{\circ}\text{C} \leq \text{SST} \leq 31\text{ }^{\circ}\text{C}$) is narrower than that in most field and laboratory studies for comparison. However, this narrow range is a reflection of the actual observational conditions in pelagic regions of the SCS during this cruise, where SST exhibits low spatial variability in the study period. Despite the small SST range, the negative correlations between SST and NCs remain significant (all $R < -0.75$), indicating that even subtle SST fluctuations can drive detectable changes in aerosol number concentrations (NCs) in this region. For the regression slopes, the narrow SST range may lead to a slightly underestimated magnitude of influence of SST (compared to studies with broader ranges), but it does not alter the direction of the trend (negative dependence) or the core claim: that SST regulates NCs via modifying near-surface air entrainment and bubble-related processes. This is because the physical mechanisms are still applicable to small SST variations. Even a small increase (1-2 $^{\circ}\text{C}$) can reduce the near-surface air entrainment volume, thereby decreasing plunging jets and subsequent bubble formation. Therefore, we believe that the narrow temperature range does not affect the research conclusions of this paper.

Clarification of "daughter bubbles":

To improve readability, we have added a definition of "daughter bubbles" in the revised manuscript. These refer to small secondary bubbles generated at the edges of larger "central bubbles" when the latter rupture at the sea surface—a key process in marine aerosol formation, as daughter bubbles contribute to the production of submicron aerosols (Miguet et al., 2021; Sellegri et al., 2023).

Meanwhile, the processes of the bubble rupture changed; the larger central bubbles (the primary bubbles rising to the sea surface) ruptured at the sea surface, small daughter bubbles (secondary bubbles with smaller diameters, generated at the edges

of central bubbles) were produced. These daughter bubbles are critical for formation of submicron marine aerosols (Miguet et al., 2021; Sellegri et al., 2023).

RC3.67: Lines 432-433: Please clarify what is meant by "the influences of the SST on the NCs might be different in different seas due to the different components of the seawater."

Response: Thank you for your comment. We apologize for the ambiguity in the original manuscript. In this paragraph, we use "the different components of the seawater" to denote marine phytoplankton species.

Different phytoplankton species (e.g., diatoms vs. coccolithophores) have vastly different capacities for producing aerosol, and SST exerts distinct effects on the metabolic activity of different phytoplankton species (Lu et al., 2025; Yu et al., 2025). Therefore, the impact of SST on NC of phytoplankton-generated aerosols is different due to the regional differences in phytoplankton species and relative abundance.

However, our study does not include discussion or data on phytoplankton. Consequently, we have removed this particular phrasing to ensure the manuscript remains tightly focused on analyzing the effects of SST on marine aerosol NCs.

Reference:

Lu, Z., Qin, G., Zheng, L., et al.: The role of phytoplankton in structuring global oceanic dissolved organic carbon pools, *Nat. Commun.*, 16, 7742, <https://doi.org/10.1038/s41467-025-63105-x>, 2025.

Yu, J., Jiang, Y., Chen, R., Lai, J. G., Zhou, H. J., Chen, Y. Q., Zhang, Q., and Yang, G. P.: Distributions of DMS and DMSP and the influences of planktonic community assemblages in the Bohai Sea and Yellow Sea, *Marine Environmental Research*, 204, 106927, <https://doi.org/10.1016/j.marenvres.2024.106927>, 2025.

By comparing regression slopes across the different aerosol particle modes, the accumulation mode was likely more sensitive to SST. This observed trend was inconsistent with some laboratory studies (Keene et al., 2017; Forestieri et al., 2018) but consistent with the previous studies (Salter et al., 2014; Zábóri et al., 2012b). A recent study also reported decreasing NCs with rising SST (Christiansen et al., 2019). In pelagic region of the SCS, combined evidence from prior studies (Christiansen et al., 2019; Salter et al., 2014; Zábóri et al., 2012b) and our observational trends suggested that elevated SST may suppress near-surface air entrainment volumes, consequently decreasing plunging jets.

RC3.68: Line 433: "according to the results of the previous studies" What studies?

Response: Thank you for your comment. We have revised this sentence and clarified the prior research.

In pelagic region of the SCS, combined evidence from prior studies (Christiansen et al., 2019; Salter et al., 2014; Zábóri et al., 2012b) and our observational trends suggested that elevated SST may suppress near-surface air entrainment volumes, consequently decreasing plunging jets.

RC3.69: Section 3.3.2. Second Paragraph (SST-T2m): The authors spend quite a lot

of time making declarative statements about what's influencing the SST-T_{2m} relationship to the aerosol concentration based on previous work. For such declarative statements, similar analysis exercises need to be carried out. They declare that SST-T_{2m} was the "major determinant of atmospheric stability" which led to the "upward transport" of marine aerosol in the boundary layer. Other such declarative statements are made further in the paragraph, but no such results are shown. If the authors don't mean to declare such factors definitively describe their observations, they should be careful to instead place their findings in context with prior work rather than discuss with certainty.

Response: Thanks for your constructive comments. We fully acknowledge two key issues raised: our previous statements about SST-T_{2m} were overly declarative, and we insufficiently distinguished "visual/comparative correlations" from "substantive quantitative analyses", which aligns with earlier comment (RC3.5) on avoiding definitive claims without robust quantitative support.

To address this, we have revised the relevant content to place our findings in the context of prior work more cautiously, rather than stating the influences with excessive certainty, and replaced absolute declarative language with cautious phrasing to reflect that our inferences are based on visual and comparative correlations (not fully validated quantitative mechanisms).

Compared to the WS and SST, SST-T_{2m} can better reflect the variations of the NCs ($R > 0.90$, Fig. 12). Meanwhile, the correlations can explain that NCs had a significant negative correlation with the SST-T_{2m} ($-1\text{ }^{\circ}\text{C} \leq \text{SST} \leq 4\text{ }^{\circ}\text{C}$). Figs. 13 and 14 illustrated the NC of all aerosol particle modes versus SST-T_{2m} respectively for WS and SST intervals, and further presented this negative correlation under controlled WS and SST intervals. Prior studies (Lewis et al., 2004; Yuan et al., 2019) had suggested that SST-T_{2m} may be related to atmospheric stability and play a role in air convection, mechanical mixing over the ocean, and plume rise processes. As proposed in Song et al. (2023), SST-T_{2m} could influence marine aerosol production by affecting atmospheric stability and thus the interfacial and effective production fluxes of marine aerosols by affecting the sea state, sea wave, and the process of the whitecap formation. Combining these previous inferences with our observational negative correlation between SST-T_{2m} and NCs, it was plausible that SST-T_{2m} could influence marine aerosol transport (e.g. potential upward transport driven by plume rise) and production. For example, increased SST-T_{2m} may intensify plume rise, leading to reduced NCs near the sea surface. Additionally, increased SST-T_{2m} might indirectly decrease aerosol production by altering atmospheric stability.

RC3.70: Line 496: Did the authors use an anomaly for SST-T_{2m} or is it the difference between SST and T_{2m}. Please clarify.

Response: Thanks very much for your meticulous comments. We apologize for the misunderstanding caused by our incorrect use of "anomaly". We use the difference between SST and T_{2m}; therefore, we have revised this sentence accordingly.

Notably, the SST-T_{2m} exhibited the strongest correlation with NCs.

RC3.71: Line 501-502: The authors mention "rapid solar radiation shifts" that drive changes in the aerosol concentrations. What is meant by this? Do they mean just day night differences? Please clarify as this is not discussed prior.

Response: Thank you very much for your valuable comment.

As the core medium linking diurnal variations to meteorological variations, the rapid solar radiation shifts caused by the day night differences, and ultimately result in obvious changes in meteorological parameters (e.g., WS, SST, and SST- T_{2m}). Such meteorological parameters changes further affect aerosol transport and production, ultimately triggering NCs fluctuations.

However, since the changes in solar radiation and the impact of solar radiation on meteorological factors have not been discussed in the previous text, it is inappropriate for us to replace "diurnal variations" with "rapid changes in solar radiation". The sudden mention of "rapid changes in solar radiation" would cause confusion among readers. Therefore, based on the discussions in the manuscript, we have rewritten the conclusions in this section, and the previously inappropriate mention "solar radiation" has been deleted. In the revised manuscript, we clearly state that during the sunrise and sunset, the rapid changes in meteorological parameters directly lead to NC fluctuations.

WS, SST, and SST- T_{2m} displayed distinct diurnal cycles, which may drive a distinct diurnal variation of NCs. Compared with the daytime, the combination of lower WS and higher SST and SST- T_{2m} caused lower NCs in the nighttime. During sunrise and sunset, rapid variations in meteorological parameters triggered NC fluctuations. In the NDT transition (the transition period₁), stable WS left SST and SST- T_{2m} as dominant NC regulators. In the DNT transition (the transition period₂), all aforementioned three factors jointly influenced NCs.