Response to Reviewer Comments

Dear Reviewer and Editors:

We are sincerely grateful to the editor and reviewer for their valuable time for reviewing our manuscript. The comments are very helpful and valuable, and we have addressed the issues raised by the reviewer in the revised manuscript. Please find our point-by-point response (in blue text) to the comments (in black text) raised by the reviewer. We have revised the paper according to your comments (highlighted in blue text of the revised manuscript).

Sincerely yours,

Dr. Yuanjian Yang, representing all co-authors

#Review 1#

The manuscript presents a comprehensive analysis of how different aerosol types affect the microphysical properties and precipitation patterns of shallow precipitation systems in South China. Utilizing a comprehensive dataset that includes GPM DPR data, MERRA-2, and ERA5, the study finds that coarse aerosols generally enhance rainfall by promoting collision-coalescence processes, leading to larger raindrop sizes and higher rainfall rates. In contrast, fine aerosols tend to suppress rainfall through increased raindrop breakup and reduced coalescence efficiency. The study's findings are particularly relevant for understanding regional precipitation patterns and aerosol-cloud-precipitation interactions. Overall, this manuscript is well-organized and of clear scientific significance. I want to offer the following minor suggestions:

1. The MERRA-2 aerosol data product may have certain uncertainties in its representation of aerosol species and concentrations. It would be beneficial to

include a brief introduction to the known limitations of the MERRA-2 product, as well as acknowledging the potential impacts of these uncertainties.

Response: Thank you.

(1) In Section '2.1 Data', a detailed analysis of the accuracy of the MERRA-2 AOD has been added (Lines 127-139): **'Previous studies have shown a relatively good consistency of the AOD of MERRA-2 and ground-based observations, ie AERONET, Sun sky radiometer observation network (SONET) (Ou et al., 2022; Buchard et al., 2015; Sun et al., 2019a). The correlation coefficient between MERRA-2 AOD and AERONET could reach 0.92 in summer China (Sun et al., 2019a). However, there is a slight underestimation of MERRA-2 AOD compared to in situ observations. Ou et al. (2022) revealed that the MERRA-2 AOD is underestimated by approximately 0.1 compared to a SONET station over South China. This is mainly because MERRA-2 lacks nitrate aerosols, leading to underestimations in the estimation of total AOD and fine aerosols (Sun et al., 2019b; Ou et al., 2022). The fine and coarse aerosol environment is defined by not only the AOD thresholds but also the AOD fractions to the total AOD, which can reduce uncertainties caused by underestimating AOD to some extent. '**

(2) In the section of 'Conclusion and Discussion', the uncertainties introduced by MERRA-2 are discussed (lines 674-681): **'Furthermore, MERRA-2 shows a slight underestimation of approximately 0.1 compared to in-situ observations in South China (Ou et al., 2022), probably due to the absence of nitrate aerosols in the MERRA-2 dataset. Consequently, the fine aerosol-polluted environments examined in this study may not fully capture conditions with high nitrate loading. There is an urgent need for long-term observational data on aerosol concentrations with high spatiotemporal resolution and accuracy to fully capture the samples of high aerosol loading and more effectively capture fine-scale processes in aerosol-cloud interactions. '**

References:

Buchard, V., da Silva, A. M., Colarco, P. R., Darmenov, A., Randles, C. A., Govindaraju, R., Torres, O., Campbell, J., and Spurr, R.: Using the OMI aerosol index and absorption aerosol optical depth to evaluate the NASA MERRA Aerosol Reanalysis, Atmos. Chem. Phys., 15, 5743-5760, 10.5194/acp-15-5743-2015, 2015.

Fan, J., Rosenfeld, D., Zhang, Y., Giangrande, S. E., Li, Z., Machado, L. A. T., Martin, S. T., Yang, Y., Wang, J., Artaxo, P., Barbosa, H. M. J., Braga, R. C., Comstock, J. M., Feng, Z., Gao, W., Gomes, H. B., Mei, F., Pöhlker, C., Pöhlker, M. L., Pöschl, U., and de Souza, R. A. F.: Substantial convection and precipitation enhancements by ultrafine aerosol particles, Science, 359, 411-418, 10.1126/science.aan8461, 2018.

Ou, Y., Li, Z., Chen, C., Zhang, Y., Li, K., Shi, Z., Dong, J., Xu, H., Peng, Z., Xie, Y., and Luo, J.: Evaluation of MERRA-2 Aerosol Optical and Component Properties over China Using SONET and PARASOL/GRASP Data, Remote Sensing, 14, 821, 2022.

Pan, Z., Mao, F., Rosenfeld, D., Zhu, Y., Zang, L., Lu, X., Thornton, J. A., Holzworth, R. H., Yin, J., Efraim, A., and Gong, W.: Coarse sea spray inhibits lightning, Nat Commun, 13, 4289, 10.1038/s41467-022-31714-5, 2022.

Sun, E., Xu, X., Che, H., Tang, Z., Gui, K., An, L., Lu, C., and Shi, G.: Variation in MERRA-2 aerosol optical depth and absorption aerosol optical depth over China from 1980 to 2017, Journal of Atmospheric and Solar-Terrestrial Physics, 186, 8-19, https://doi.org/10.1016/j.jastp.2019.01.019, 2019a.

Sun, E., Che, H., Xu, X., Wang, Z., Lu, C., Gui, K., Zhao, H., Zheng, Y., Wang, Y., Wang, H., Sun, T., Liang, Y., Li, X., Sheng, Z., An, L., Zhang, X., and Shi, G.: Variation in MERRA-2 aerosol optical depth over the Yangtze River Delta from 1980 to 2016, Theoretical and Applied Climatology, 136, 363-375, 2019b.

2. The different datasets, including GPM DPR data, MERRA-2, and ERA5, have different spatial resolutions, which might not fully capture the fine-scale processes in aerosol-cloud interactions. The authors may discuss the consistency of different products to strengthen the conclusions.

   Response: Thank you. We agree that the coarser resolutions of MERRA-2 (0.5° × 0.625°, approximately 50 km) and ERA5 (0.25°, approximately 27 km) make it challenging to capture fine-scale processes in aerosol-cloud interactions directly. To ensure consistency among the DPR, MERRA-2, and ERA5 datasets, we applied linear interpolation to adjust them to a resolution of 0.05 degrees in the manuscript. The interpolation process may introduce errors and not fully reflect the true conditions. Following your nice suggestions, we have added some discussions in the 'Discussion and Conclusion': ' **However, it is important to note that the spatial resolution of MERRA-2 and ERA5 is much coarser than that of DPR. The interpolation methods employed in the present study may introduce errors and may not fully capture the true conditions, making it challenging to accurately assess fine-scale processes in aerosol-cloud interactions …. There is an urgent need for long-term observational data on aerosol concentrations with high spatiotemporal resolution and accuracy to fully capture the samples of high aerosol loading and more effectively capture fine-scale processes in aerosol-cloud interactions.'** (Lines 670-681) in the revised manuscript.

3. The study focuses primarily on the microphysical processes within shallow precipitation systems. The authors may discuss whether it is possible to extend the approach from shallow to deep convection or mixed-phase cloud regime.

Response: Thank you. Your suggestion is promising for fully understanding aerosol-cloud-precipitation interactions across different cloud types. The methods introduced in this study, along with the merged data set (which includes shallow and deep convection clouds), may be valuable to further analyze these interactions in deep convection scenarios. In the revised manuscript, we have added these comments to suggest future work: **'This study primarily elucidates the microphysical processes within shallow precipitation systems under varying aerosol conditions. However, the methods and data utilized have broad application potential. Future research could extend these approaches to explore the relationship between deep convection or mixed-phase clouds and aerosols. Such investigations could reveal the complex effects of aerosols on the precipitation process and further enhance our scientific understanding of the physical connections between aerosols and precipitation microphysics.'** (Lines 664-670).

For your reference, we conducted a preliminary study on deep convective clouds (storm top height > 10 km). Unfortunately, there are only about 660 deep convective samples under coarse aerosol-polluted environments, which is a small sample size. In the future, longer-term observations are needed to accumulate more deep convection samples to further advance research in this area.

4. The authors may clarify the methodology for aerosol classification, particularly the choice of thresholds for defining polluted and clean environments. Is it possible to have some sensitive test for the threshold to ensure the representation of the conclusions?

Response: Thank you for the good suggestions.

(1) The thresholds are primarily based on the PDFs of the AOD for total aerosols, fine aerosols, and coarse aerosols, as illustrated in Figure 1b in the manuscript. For example, a clean environment is classified when the total AOD is below 0.225 (the lowest 30%). A fine (or coarse) aerosol-polluted environment must not only exceed 60% quantiles across all sampled data but also have the AOD of fine (or coarse) particles exceeding 50% of the total aerosol AOD. This approach ensures that in fine (or coarse) aerosol-polluted environments, fine (or coarse) particles are the primary influencing factor.

In the revised manuscript, we have provided a further explanation of the classification methods in the manuscript: **' There are three types of aerosol conditions discussed in the present study: clean environment, fine aerosol-polluted environment, and coarse aerosol-polluted environment.'** (lines 201-203). **' A fine (or coarse) aerosol-polluted environment must not only exceed 60% quantiles across all sampled data but also have the AOD of fine (or coarse) particles exceeding 50% of the total aerosol AOD. This approach ensures that in fine (or coarse) aerosol-polluted environments, fine (or coarse) particles are the primary influencing factor. '** (Lines 211-215)

(2) Sensitivity Test:

Following your nice suggestions, we have conducted a sensitivity test by changing the PDF thresholds. In the sensitivity test, a clean environment is classified when the total AOD is below 0.235 (the lowest 33% quantiles). A fine (or coarse) aerosol-polluted environment must not only fall within the top 67% quantiles across all sampled data, but also have the AOD of fine (or coarse) particles exceeding 50% of the total aerosol AOD. The new thresholds and sample sizes are shown in Table R1.

Similarly, the box plots of RR, N_w, D_m, and Z_e near the surface at 2.5 km altitude, as well as LWP and STH for shallow precipitation under different aerosol conditions in South China are shown in Figure R1. DSDs at 2.5 km altitude for shallow precipitation clouds over southern China under three aerosol conditions are illustrated in Figure R2. Sensitivity tests show conclusions similar to those of the previous thresholds (results in Figure 2 and Figure 3 in the manuscript). For example, compared to clean environments, RR, N_w, D_m, LWP, and Z_e decrease slightly in fine aerosol-polluted environments but increase in coarse aerosol-polluted environments.

Sensitivity tests indicate that different thresholds do not significantly affect the conclusions of our paper. Therefore, the previously set threshold design to classify different environmental conditions is reasonable. In Data and Methods (Lines 219-222): **'A sensitivity test was conducted with different thresholds to ensure the robustness of the present study. The results indicate that varying the thresholds does not significantly affect the conclusions of the work.'** Thank you again.

Table R1 Sensitivity test: Definitions of clean conditions, fine and coarse aerosol-polluted environments in southern China during the summers of 2014-2021.

Environment	Definition	Samples
Clean	Total AOD < 0.235	10090
Polluted_Fine	Fine AOD > 0.355 & Fine AOD ratio>50%	8330
Polluted_Coarse	Coarse AOD > 0.0495 & Coarse AOD ratio>50%	2557

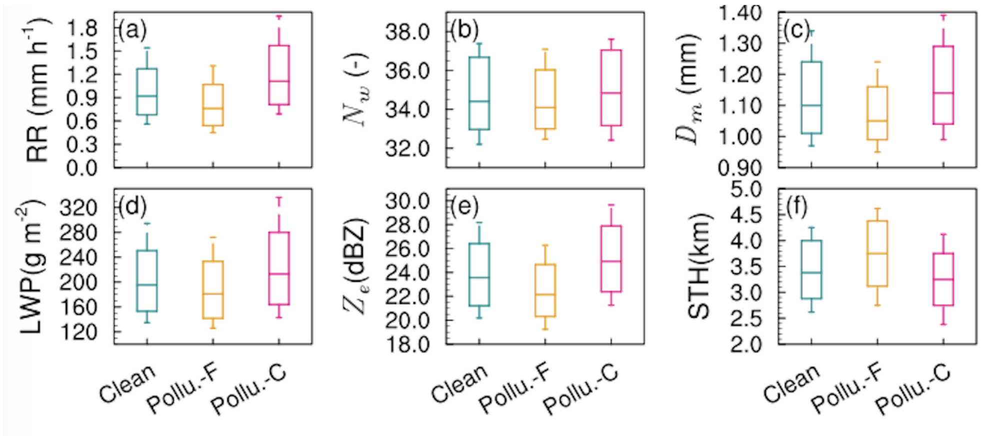

Figure R1 Similar to Figure 2 in the manuscript, but for new AOD thresholds presented in Table R1.

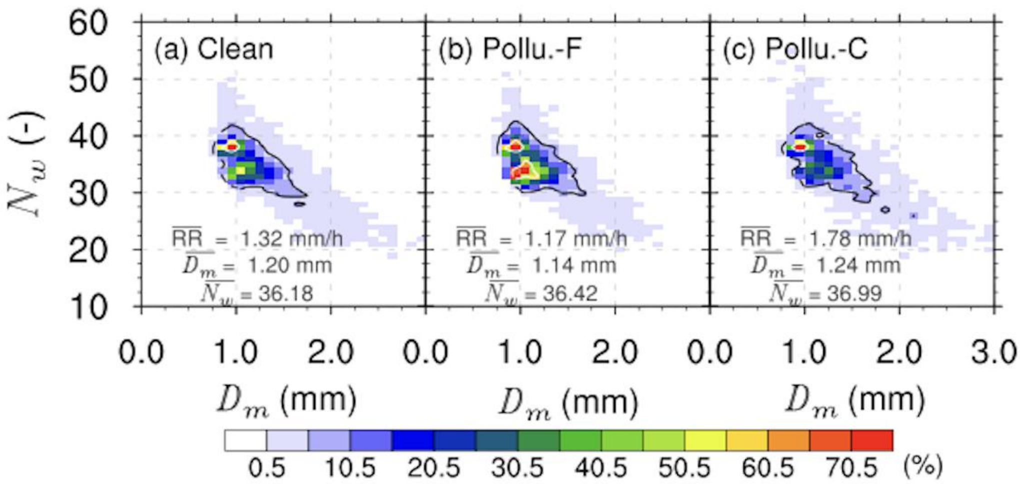

Figure R2 Similar to Figure 3 in the manuscript, but for new AOD thresholds presented in Table R1.

5. In addition to the CAPE, the authors may acknowledge the contribution of other meteorological factors, as well as their potential role in affecting aerosol-precipitation relationships.

Response: Thank you. Precipitation is a complex process influenced by multiple meteorological factors, such as instability, moisture, temperature, and wind vectors. In the manuscript, only CAPE and relative humidity are used due to the limitations of the length of the article. We also analyzed the near-surface RR, N_w, D_m, LWP, Z_e, and STH under different aerosol and surface air temperature (TM) conditions, as illustrated in Figure R3. Based on the terciles of the TM values during precipitation events in southern China, the samples are grouped into three groups: TM1 < 299 K, TM2: 299~301 K, and TM3: > 301K. The result shows that the suppression of RR in fine aerosol-polluted environments and the invigoration of RR in coarse aerosol-polluted environments are independent of the temperature conditions. Similarly to the conclusion for various CAPE and RH conditions at 850hPa (Figure 6 and Figure 7), the amplitudes of invigoration and suppression are related to the conditions of surface air temperature. Invigoration and suppression effects are more significant under low surface air temperature conditions (TM1). These comments have been added in lines (637-642): **'The effects of fine and coarse aerosols on the suppression and enhancement of RR are independent of CAPE and humidity, consistent with the findings by Liu et al. (2022). However, our results show that the extent of suppression or enhancement varies with CAPE and humidity. Additionally, the analysis of aerosol-precipitation interactions under different surface air temperatures yields results similar to those observed for CAPE and RH at 850 hPa (figures not shown).'**

Furthermore, following your nice suggestions, we have stated more about the role of meteorological factors in aerosol-precipitation relationships in the "Conclusion and Discussion" (Lines 659-663): **'It is important to note that precipitation is a complex process influenced by multiple meteorological factors, including instability, moisture, and temperature. Other factors such as wind vectors and pressure may also affect the impact of aerosols on precipitation, which is worthy of further study.'**

Reference:

Liu, F., Mao, F., Rosenfeld, D., Pan, Z., Zang, L., Zhu, Y., Yin, J., and Gong, W.: Opposing comparable large effects of fine aerosols and coarse sea spray on marine warm clouds, Communications Earth & Environment, 3, 232, 10.1038/s43247-022-00562-y, 2022.

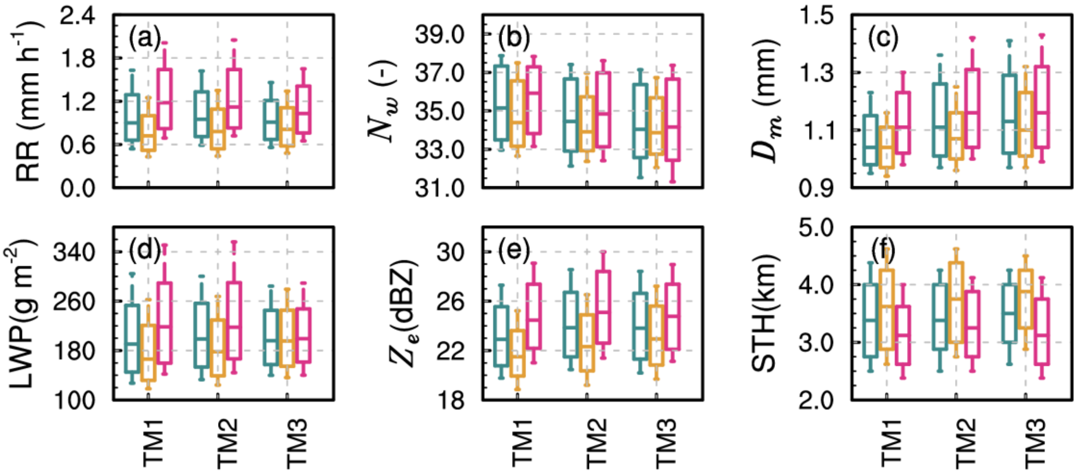

Figure R3 Box plot of the near-surface rain rate (a), N_w (b), D_m (c), LWP (d), Z_e (e), and STH (f) under different aerosol and surface air temperature conditions for shallow precipitation over southern China during the summers of 2014-2021.

#Reviewer 2#

This present study the potential effects of different types of aerosols on precipitation microphysics. Many previous studies have revealed the potential effect of aerosols on precipitation, while little attention has been paid on the aerosols on precipitation microphysical structures and processes, considering the different aerosol species. This topic is interesting and meaningful. The paper is composed logically, well-written, and the figures are clear. How I have some concerns of the manuscript, therefore a major revision is suggested.

Major suggestions

(1) Why choose specific criteria for defining aerosols and identifying polluted environments? Are there any references to support this choice? Could different criteria lead to varying conclusions about the results?

Response: In the manuscript, three types of environments are classified, including clean, fine aerosol-polluted, and coarse aerosol-polluted environments. In nature, both fine and coarse particles coexist in the environment, making it difficult to distinguish fine and coarse particle pollution. To ensure the integrity of the coarse and fine particle pollution environments, we have imposed restrictions on the proportions of these two particle types to the total aerosol concentration. On the one hand, we need to ensure that the AOD of coarse particles is relatively high (exceeding 60% quantiles), while also ensuring that their proportion exceeds that of fine particles (i.e., more than 50%). This approach ensures that in a coarse-particle pollution environment, coarse particles are the dominant contributor. The same rationale applies to the classification of fine aerosol-polluted environments.

In addition, to ensure the robustness of the results, we have performed a sensitivity test by changing the PDF thresholds. In the sensitivity test, a clean environment is classified when the total AOD is below 0.235 (the lowest 33%). A fine (or coarse) aerosol-polluted environment must not only fall within the top 67% quantiles across all sampled data, but also have the AOD of fine (or coarse) particles exceeding 50% of the total aerosol AOD. The new thresholds and sample sizes are shown in Table R_1. Similarly, the boxplots of RR, N_w, D_m, and Z_e near-surface at 2.5 km altitude, as well as LWP and STH for shallow precipitation under different aerosol conditions in South China, are shown in Figure R_1. Sensitivity tests show conclusions similar to those of the previous thresholds. For example, compared to clean environments, RR, N_w, D_m, LWP, and Z_e decrease slightly in the fine aerosol-polluted environments, but increase in coarse aerosol-polluted environments.

In the revised manuscript, we have made more clear about the methods of environment classification (lines 211-215), as well as the sensitivity to the AOD thresholds to the results (lines 219-222).

Table R_1 Sensitivity test: Definitions of clean conditions, fine and coarse aerosol-polluted environments in southern China during the summers of 2014-2021.

Environment	Definition	Samples
Clean	Total AOD < 0.235	10090
Polluted_Fine	Fine AOD > 0.355 & Fine AOD ratio>50%	8330
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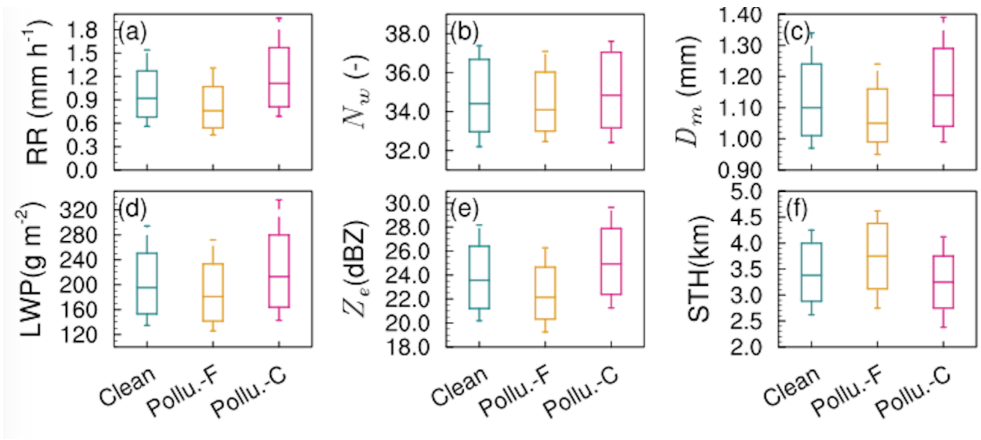

Figure R_1 Similar to Figure 2 in the manuscript, but for new AOD thresholds presented in Table R1.

(2) This study primarily outlines the main observational findings and potential underlying mechanisms of aerosols on precipitation. How do these findings compare with previous studies? Please include more comparisons with past research, highlighting both differences and similarities.

Response: Thank you for the nice suggestions. The main focus of this study is to elucidate the differences in the microphysical processes of precipitation under varying aerosol backgrounds, which is a relatively new scope in the meteorological field. Frankly, the topic of the effects of different aerosol types on shallow precipitation is not new (Pan et al., 2022; Liu et al., 2022; Fan et al., 2018). For example, Liu et al. (2022) found that coarse particles promote rainfall while fine particles suppress it, and these impacts are independent of meteorological conditions. However, their focus was mainly on shallow precipitation over the ocean, with limited attention given to shallow precipitation over land, and they did not analyze the associated microphysical processes. Moreover, we found that the extent of suppression or enhancement by fine and coarse aerosols varies with environmental conditions. These conclusions contribute new insights to the field.

In the revised manuscript, more comparisons with previous studies have been added in "Conclusion and Discussion". Please see lines 611-612, lines 617-619, and lines 637-638.

References:

Liu, F., Mao, F., Rosenfeld, D., Pan, Z., Zang, L., Zhu, Y., Yin, J., and Gong, W.: Opposing comparable large effects of fine aerosols and coarse sea spray on marine warm clouds, Communications Earth & Environment, 3, 232, 10.1038/s43247-022-00562-y, 2022.

Fan, J., Rosenfeld, D., Zhang, Y., Giangrande, S. E., Li, Z., Machado, L. A. T., Martin, S. T., Yang, Y., Wang, J., Artaxo, P., Barbosa, H. M. J., Braga, R. C., Comstock, J. M., Feng, Z., Gao, W., Gomes, H. B., Mei, F., Pöhlker, C., Pöhlker, M. L., Pöschl, U., and de Souza, R. A. F.: Substantial convection and precipitation enhancements by ultrafine aerosol particles, Science, 359, 411-418, 10.1126/science.aan8461, 2018.

Pan, Z., Mao, F., Rosenfeld, D., Zhu, Y., Zang, L., Lu, X., Thornton, J. A., Holzworth, R. H., Yin, J., Efraim, A., and Gong, W.: Coarse sea spray inhibits lightning, Nat Commun, 13, 4289, 10.1038/s41467-022-31714-5, 2022.

Minor suggestions

1. Line 30, radar and radar reflectivity … -> radar reflectivity

   Response: Done (Line 31). Thank you.

2. Line 34-35, where does the "22.2% " come from?

Response: It comes from the results in Figure 10. **'with an enhancement of 22.2%'** has been added (Lines 582-583).

3. Line 73, Other studies suggest -> Another study suggests

   Response: Done (Line 75). Thank you.

4. Line 138, This sentence is missing a period.

   Response: Done (Line 146). Thank you.

5. Line 91, efficiency of coalescence of rain droplets-> coalescence efficiency of rain droplets

   Response: Done (Line 93). Thank you.

6. Lines 96 – 97, for the study on the effect of the effect of aerosols on shallow precipitation -> the study of aerosols effect on shallow precipitation.

   Response: Done (Lines 98-99). Thank you.

7. Lines 173-176, Is there any reference for the definitions for the fine and coarse aerosols?

   Response: A reference by (Gelaro et al., 2017) has been added to the manuscript (Line 186). Thank you.

Reference:

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., da Silva, A. M., 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), Journal of Climate, 30, 5419-5454, https://doi.org/10.1175/JCLI-D-16-0758.1, 2017.

8. Line 204, it should be 8967.

Response: Sorry for the careless error in the previous manuscript. It has been corrected in the manuscript (Line 222).

9. Line 226, how about the ratios of dust and sea salt aerosols to the coarse aerosol? Similar, how about the black carbon, organic carbon and sulfate to the fine aerosols?

Response: Thank you. The average AODs for five different aerosol species across various environmental settings are computed to determine the contributions of each aerosol type (Table R_2). It can be seen that the mean AOD of sulfate (0.481) is the largest for fine aerosol-polluted environments, while it is the sea salt (0.164) for coarse aerosol-polluted environments. In determining the average AODs across five species relative to the overall mean AOD (Table R_3), sulfate aerosols represent 54.8% in clean environments and 80.4% in fine-polluted environments, while sea salt accounts for 63.1% in coarse-aerosol polluted environments..

In the revised manuscript, ' **The mean AODs of five aerosol species under various environmental conditions are calculated to understand the contributions of different aerosol types (not shown). In South China, the primary contributors to aerosol species are sulfate aerosol, sulfate aerosol, and sea salt aerosols in clean, fine, and coarse aerosol-polluted environments, respectively.'** has been added in lines 224-228.

Table R_2 The mean AODs of five aerosol species in different environmental conditions

	Sulfate	Organic carbon	Black carbon	Dust	Sea salt
Clean	0.092	0.017	0.009	0.006	0.044
Fine-polluted	0.481	0.052	0.029	0.014	0.022
Coarse-polluted	0.072	0.013	0.006	0.005	0.164

Table R_3 The mean ratio of five aerosol species (units: %) to the total AODs in different environment conditions

	Sulfate	Organic carbon	Black carbon	Dust	Sea salt
Clean	54.8	10.12	5.35	3.57	26.19
Fine-polluted	80.4	8.70	4.85	2.34	3.68
Coarse-polluted	27.7	5.0	2.3	1.92	63.1

10. Line 227, "Coarse AOD > 0.0425" is duplicated.

Response: Sorry for the careless. Done (Line 253). Thank you.

11. Line 240, "promoting" -> benifical for the

Response: Done (Lines 265-266). This sentence has been modified to **'Nevertheless, the presence of coarse aerosol-polluted conditions appears to inhibit the vertical development…'**

12. Line 245, "mode" - > environments

Response: Done (Lines 268-272). This sentence has been modified to **'Examining the situation from a microphysical standpoint, it is observed that in comparison to a clean environment…'**

13. Line 251, provide some reference to support this statement.

Response: Done. As responded to question 9, sea salt contributes to 63.1% of the total aerosols in the coarse-polluted environment. This has been added in Data and Methods (Lines 226-228).

14. Line 281, not in italics.

Response: Done (Line 304). Thank you.

15. Line 359, fine mode -> fine; similarly in Line 367

Response: Done (Line 382). This has been modified to **'In presence of fine aerosol-mode'.**

16. In section 3.3, since precipitation can be affected by many other effects, please explain more about the reasons of choosing these two factors (CAPE and RH at 850hPa).

Response: Thank you. We totally agree with you that the precipitation can be influenced by numerous factors. In the manuscript, **'However, precipitation itself is a complex process influenced by multiple thermal and dynamic environmental factors, such as instability, humidity, temperature, and wind vectors. Among these, dynamic conditions and moisture levels are particularly important indicators.'** has been added in Lines 400-403. Additionally, a further analysis of the sensitivity of surface air temperature to aerosol's impact on precipitation has been discussed.

Based on the tercile values of the TM values during precipitation events in southern China, the samples are grouped into three groups. TM1 < 299 K, TM2: 299~301 K, and TM3: >301K. The result in Figure R_2 shows that the suppression of RR in fine aerosol-polluted environments and the invigoration of RR in coarse aerosol-polluted environments are independent of the temperature conditions. Similarly to the conclusion of different CAPE and RH at 850hPa conditions (Figure 6 and Figure 7), the amplitude of the invigoration and suppression are related to the meteorological conditions. The invigoration and suppression effects are more significant under low surface air temperature conditions (TM1).

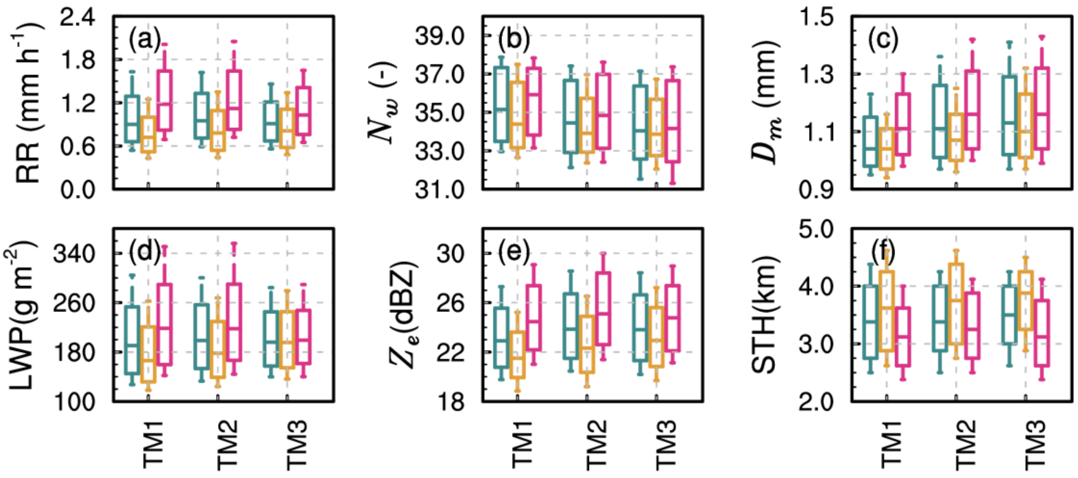

Figure R_2 Box plot of the near-surface rain rate (a), N_w (b), D_m (c), LWP (d), Z_e (e), and STH (f) under different aerosol and surface air temperature conditions for shallow precipitation over southern China during the summers of 2014-2021.

17. Line 502, where the -> the

Response: Done (Line 524). Thank you.

18. Line 550, modify the phrase "the presence of CAPE and RH"

Response: Done (Line 573). Thank you. ' the presence of CAPE and RH ' has been changed to ' **the value of CAPE and RH** '.

19. Line 554, notify the previous findings specifically.

Response: Done (Lines 576-577). We mean that **'These conclusions are consistent with the results in Figure 5.'**

20. Line 639: available on May 2023 -> accessed in May 2023

Response: Done (Line 691). Thank you.

#Response to Professor Hu

The sample selection method for aerosol-type-dominated pollution seems to be incorrect, which will produce overlapping samples. For example, the number of samples that meet both FA and CSA greater than the threshold is small but still exists. The AOD value of FA is generally greater than that of CSA. How can this mean that CSA is the main influence in the Polluted_Coarse type defined in the article? It is not ruled out that the AOD value of FA is also large at the same time.

Response: Thank you. We have noted that the classification of aerosol conditions was not clearly addressed in the previous version. We agree that the AOD value for fine aerosols (FA) is generally greater than that for coarse aerosols (CSA). To avoid overlapping samples between fine and coarse aerosol-polluted conditions, it is important to establish an additional criterion beyond the AOD thresholds (PDF of higher 60%). Specifically, for a coarse (or fine) aerosol-polluted environment, the AOD of coarse (or fine) particles must exceed 50% of the total aerosol AOD, as well as exceeding a specific AOD threshold. For example, for a case of a coarse aerosol-polluted environment, the coarse AOD must be greater than 0.0425, and the ratio of the coarse AOD to the total AOD must be greater than 50%. Therefore, there is no overlap between the coarse aerosol-polluted and fine aerosol-polluted samples.

In the revised manuscript, we have addressed more clearly the classification method of aerosol conditions in lines 211-215.

Additionally, when describing the samples, there are multiple values in the text that are inconsistent with the description in Table 1; for example, lines 196 and 204.

Response: Sorry for the carelessness in the previous version. The correct values should be 0.225 and 9785. These corrections have been made in the revised manuscript (Lines 211 and 222). Thank you.