Dear Editors and Reviewers,

Firstly, we would like to express our sincere gratitude for the time and effort you spent reviewing our manuscript titled "[WRF-SBM Numerical Simulation of Aerosol Effects on Stratiform Warm Clouds in Jiangxi, China]" and for providing valuable feedback. We have carefully considered all the comments from the reviewers and have made comprehensive revisions to our manuscript. We believe these revisions significantly improve the quality of our paper. In the following sections, we will respond to each of the reviewers' comments in detail, explaining how we have addressed these issues in the revised manuscript.

For ease of reference for both the reviewers and editors, we have organized our responses according to the comments of each reviewer, detailing our reply, and have indicated the locations of the changes in the corresponding sections of the paper.

Here are our point-by-point responses to the reviewers' comments:

Referee #1：

Reviewer’s comment 1: Fig 4 is the same as Fig 6 a, right? Maybe remove Fig 4.

Response: Thank you very much for your suggestion. Figure 4 originally depicted the flight path during the aircraft observation period, and this information was reiterated in Figure 6, leading to redundancy. We have removed the original Figure 4 from the data presentation and now display the flight path in Figure 6. (Due to adjustments in the figure sequence, the flight path and the variation in water content along the path are now presented in Figure 4 in our revised manuscript.)

Reviewer’s comment 2: L131 It is still unclear what is the vertical grid resolution in meters, this is relevant to understand how many grid points there are in the cloud region. If not constant you could give a range for the first kilometers. The discussion of this potential modeling issue could be valuable, and motivate future work to elucidate its importance.

Response: Thank you for your comment. We apologize for not providing sufficient details on the vertical layer configuration in the previous revision. In the WRF model setup, the nested grids for the inner and outer domains share the same vertical grid configuration, with a total of 57 vertical layers, and the top level at 50 hPa. The vertical spacing is not uniform, and within the first two kilometers, the layer heights are set as follows: 401 meters, 457 meters, 528 meters, 618 meters, 733 meters, 876 meters, 1053 meters, 1270 meters, 1533 meters, 1845 meters, and 2209 meters. This information has now been introduced in lines 130 to 132 of the manuscript.

Referee #2:

Reviewer's comment 1: The title is not clear. What is the meaning of spectral evolutions?

Response: Thank you for your comment. We acknowledge that the previous title of our paper, "Numerical Simulation of Aerosol Concentration Effects on Cloud Droplet Size Spectra Cloud Spectral Evolutions of Warm Stratiform Clouds in Jiangxi, China," was not sufficiently clear. The term "cloud spectral evolutions" actually refers to the changes in the particle size distribution of cloud droplets. We have revised the title to better reflect the study's focus and changed it to "Numerical Simulation of Aerosol Concentration Effects on Cloud Droplet Size Spectra and Cloud Spectral Evolutions of Warm Stratiform Clouds in Jiangxi, China." We hope this revised title more clearly conveys our research on the impact of different aerosol modes on cloud droplet size distribution.

Reviewer’s comment 2: The Abstract: The abstract needs to be rewritten in a more precise and accurate manner, as it contains several unclear and incomplete statements. For example, consider the first sentence: “Aerosols, as cloud condensation nuclei (CCN), may impact cloud droplet spectrum relative dispersion (ε), affecting precipitation and climate change.” This should be rewritten to provide more detail and accuracy, such as: “Changes in aerosol amount and size distribution may impact the size distribution of cloud droplets (since they serve as CCN), as well as their relative dispersion. Relative dispersion is a key factor used to parameterize cloud processes in general circulation models (GCMs) and bulk microphysical schemes, and thus influences precipitation estimates and various aspects of climate predictions.” Another example is the second sentence: “However, the influence of various aerosol modes on cloud microphysics remains controversial, and this effect varies with area and cloud type.” Again, this statement is unclear and inaccurate. It should be rewritten as: “However, the influence of changes in the concentration of various aerosol modes on cloud microphysical processes is still a subject of debate, and it depends significantly on thermodynamic conditions and cloud type.”

Response: Thank you very much for your comment. We acknowledge that the background information in the abstract was indeed not detailed enough. As you pointed out, the description of the aerosol effects on cloud droplet spectral dispersion was overly brief, and the influencing factors of aerosol effects were not clearly explained. In response to your suggestions, we have revised the wording and descriptions in the abstract. First, we elaborated on the relationship between aerosols, cloud droplet size, cloud droplet spectral dispersion, and cloud microphysical processes. Second, we clarified that the influence of aerosols on cloud microphysical processes is affected by thermodynamic conditions and cloud type. Third, we corrected the conclusion regarding how changes in accumulation mode aerosol concentration affect the correlation between cloud droplet spectral dispersion and Rv. The specific modifications have been reflected in the revised abstract.

Reviewer’s comment 3: The introduction: line 47 states: “On the one hand, ε influences the effective radius of cloud droplets and the auto-conversion process, thereby affecting cloud precipitation processes … . On the other hand, impacting climate”. This description is partial and unclear. Phrases like “ε influences the effective radius of cloud droplets” and “ε affects cloud-aerosol interactions” lack specificity. These statements need to be rewritten for clarity and accuracy.

Response: Thank you for your comment. We agree that the previous description lacked a detailed explanation of the influencing mechanisms. In the revised version, we clarified the impact of cloud droplet spectral dispersion (ε) on droplet size and microphysical processes. The specific changes are as follows: "On one hand, ε (the relative dispersion of cloud droplet spectra) influences the effective radius (Re) of cloud droplets by altering their size distribution. A higher ε typically leads to a broader droplet size distribution, which increases the effective radius, thereby enhancing the auto-conversion process that drives the formation of precipitation from cloud droplets. On the other hand, ε modulates cloud-aerosol interactions by affecting cloud microphysical properties, such as droplet concentration and liquid water content, which in turn influences cloud radiative properties and, consequently, climate." You can find these revisions in lines 43 to 48 of the manuscript.

Reviewer’s comment 4: The introduction: Throughout the entire introduction, it is crucial to specify the exact type of cloud being studied in each referenced work. While "warm shallow clouds" is a broad term encompassing various cloud types, it is important to clearly identify the specific cloud types under investigation. This distinction is necessary because different cloud types are governed by unique controlling processes, which significantly influence their formation, behavior, and interaction with aerosols. Moreover, throughout the paper, it should be clear what specific type of cloud is being simulated and studied. Simply referring to "warm shallow clouds" or warm processes is insufficient and could lead to ambiguity in interpreting the results. Precise terminology should be used consistently to describe the cloud type under investigation in this study. This will ensure that the findings are accurately interpreted and compared with previous studies on similar cloud types. Adjustments should be made to the manuscript to address this issue.

Response: Thank you for your comment. In the previous introduction, we indeed did not clearly specify the cloud type involved when referencing certain conclusions, and we lacked detailed explanations of specific cloud processes such as condensation growth and collision-coalescence. To address this, we have now provided a detailed description of the warm cloud types mentioned in the introduction and throughout the manuscript, with the relevant sections highlighted in the revised version.

Reviewer's comment 5: In the results section, it is important in my opinion to provide some information about changes in cloud fraction across the different sim ulations. Cloud fraction is a significant factor in cloud-aerosol interactions and can substantially influence the interpretation of results related to cloud properties and processes. Understanding how cloud fraction varies with different aerosol concentrations is crucial for assessing the broader implications of the study.

Response: Thank you very much for your suggestion. Cloud fraction is indeed an important indicator of aerosol effects. In response, we have added an analysis of the hourly cloud fraction variation in different aerosol mode concentration experiments in section 3.2.2 of the manuscript. The results show:

In the NM and AM experiments, increased aerosol concentrations significantly enhance cloud formation, particularly between 03:00 and 05:00 UTC, with the peak cloud fraction above 2 km increasing. In the AM experiment, the cloud fraction remains elevated above 3 km, suggesting extended cloud formation and persistence in the upper cloud layers. This result is consistent with the tendency of accumulation mode aerosols to increase cloud droplet number concentrations and extend cloud lifetime, as reported by Liu et al. (2022). In the ITM experiment, the increase in cloud fraction is most prominent between 03:00 and 05:00 UTC, especially concentrated in the middle cloud layers at 2 to 3 km.

In contrast, the DTM experiment shows a significant reduction in cloud fraction, particularly in the upper cloud layers. The maximum cloud fraction only reaches about 0.4, with most cloud formation concentrated below 3 km. This suppression of cloud formation indicates that lower aerosol concentrations limit cloud development, reducing droplet activation and cloud water content.

Reviewer's comment 6: To enhance the clarity of the study, I recommend including more comprehensive meteorological data for the event under investigation. The current version of the manuscript presents a single snapshot of the 500 mb height and 700 mb winds, which is insufficient for a thorough analysis of the conditions affecting cloud formation and development. Adding detailed meteorological context will greatly assist in interpreting the results and understanding the processes involved in cloud dynamics. Adding 850 mb and surface pressure maps will provide insights into low-level dynamics and synoptic influences affecting cloud formation. Instead of a single snapshot, present meteorological data at multiple time points to show how conditions evolve during the event, correlating with cloud development. Include radiosonde data to provide thermal and humidity profiles, helping to understand atmospheric stability and conditions relevant to cloud formation.

Response: Thank you for your suggestion. The initial analysis at the 500 hPa and 700 hPa levels was indeed insufficient to fully describe the background conditions of cloud formation. In response, we have revised this section of the analysis and expanded the weather charts. We now provide a comprehensive analysis of the pressure and height fields at 500 hPa, 850 hPa, and the surface, and we also examine the synoptic changes across multiple events. These specific revisions can be found in section 2.1 of the manuscript.

Reviewer’s comment 7: Results: Fig 5: The figure presents the validation of the simulated cloud top temperature against satellite measurements. There are significant differences between the two that should be addressed and explained. The validation is a bit questionable.

Response: Thank you for your comment. After reviewing the data validation and comparison section in detail based on your feedback, we found that the resolution of the FY-2F satellite was too low compared to the model simulation results, making it inadequate for capturing the detailed distribution of warm clouds in the Jiangxi region. As a result, we recalculated the entire validation comparison. Initially, we selected a segment of the aircraft cloud-penetration process between 04:10 and 04:20 UTC to compare with the model simulation results, validating the vertical distribution of cloud microphysical properties. Subsequently, we replaced the satellite data source with Modis (Aqua) data and compared it to the aircraft observations in a similar spatial region, finding a consistent cloud-top temperature distribution. Additionally, we supplemented the comparison with liquid water path (LWP) data obtained from the microwave radiometer at the Ganzhou Meteorological Bureau in Jiangxi Province. Overall, the results show that the model simulation successfully reproduced the warm cloud process over southern Jiangxi on December 25, 2014.

Reviewer’s comment 8: Fig. 15,16,17: What time in the simulation do these presented results represent? How general they are?

Response: Thank you for your suggestion. Figures 15, 16, and 17 reflect the combined data from all simulated cloud grid points between 00:00 and 05:00. In fact, the distribution of dispersion with Rv and number concentration with Rv represents the entire growth process of cloud droplets, from small to large droplet sizes, during the warm cloud process. It also illustrates the changes in the correlation between cloud droplet spectral dispersion and droplet number concentration with Rv throughout cloud development. Therefore, these data points are highly representative of the evolution of the warm cloud process as a whole.

Reviewer’s comment 9: Fig. 18: Very informative schematic figure that should be explained more clearly in the text.

Thank you for your suggestion. The original explanation of the physical mechanisms in Figure 18 was not sufficiently clear. To address this, we have added a more detailed explanation of the mechanisms in the discussion section and revised the figure caption to include descriptions of the physical processes represented by each component of the figure. These changes provide more clarity and detail. The specific revisions can be found in lines 430 to 440 of the manuscript.