

**Review of Manuscript EGUSphere-2024-2756:**

**Measurement report: Aircraft observations of aerosol and microphysical quantities of stratocumulus in autumn over Guangxi Province, China: Diurnal variation, vertical distribution and aerosol-cloud relationship, by Liu et al.**

**General comments:**

Liu et al. presented aircraft observations on the physical properties of stratocumulus in autumn in 2020 over Guangxi Province in China, including the number concentrations of aerosol particles and cloud droplets, liquid water path, cloud droplet sizes, as well as cloud temperature and relative humidity. The authors first compared the above observations as a function of altitude to understand their vertical variabilities. In addition, the authors attempted to investigate the variabilities of the above observations at different times during the day from 10:00 to 20:00 hours (though the time zone was not provided). The authors further divided the stratocumulus, by using the so-called  $Z_n$  values (defined by the equation 4), into three layers, including lower cloud layer ( $0 \leq Z_n < 0.33$ ), middle cloud layer ( $0.33 \leq Z_n < 0.67$ ), and upper cloud layer ( $0.67 \leq Z_n \leq 1.0$ ). Then, the authors compared the above cloud properties of each layer. Finally, the authors performed two case studies on Oct 29 and Nov 2, 2020. The authors also plotted the cloud droplet sizes as a function of the number concentration of aerosol particles for different cases with varying liquid water path and attempted to investigate the Twomey effect. Overall, I think I can follow the flow of the manuscript, though many sentences and statements are poorly and carelessly organized. Unfortunately, some figures (particularly Figures 5, 7 and 8) are poorly presented and some important results are lack of in-depth analysis. In general, significant amount of improvements need to be made carefully, regarding to results visualization, data interpretation, results discussion, and writing. Therefore, I contend that it should not be published in ACP as a measurement report.

I have seven major comments and many specific comments as below:

1. The writing of this manuscript has much space to be improved. It would benefit from a clearer thesis statement in many paragraphs and a more logical progression of concepts in many discussions. Please find my specific comments below and hope they could help. Before next submission to EGUSphere or elsewhere, a thorough proofreading or the assistance of a language editing service could help to get rid of many language issues.
2. A clear definition of stratocumulus in this study should be provided in the introduction. In addition, many important definitions are missing, including  $Z_n$ , PBL (planetary boundary layer), PBL height, etc.  $Z_n$  was introduced by equation 4. However, neither a relevant reference nor a further statement about more detailed physical explanation was provided. PBL height, the concepts of inside and outside the PBL came up suddenly. How is PBL defined in this study? How did the authors determine the PBL height? All those were missing in the manuscript. Even relevant studies were hardly referenced appropriately.

3. This study only includes 9 aircraft observations during daytime between 10:00 and 20:00 hours. Nighttime observations are completely missing. Thus, the authors could not assert that the results from this study can present diurnal variabilities of stratocumulus clouds in the region.
4. In section 2.1, the number concentration of aerosol particles corresponds to particles between 0.11 and 3.0  $\mu\text{m}$ , and the number concentration of cloud droplets have sizes between 2.0 and 50  $\mu\text{m}$ . Does the size refer to optical size or aerodynamic size? If they are the same size with the same definition, there is an overlap between the two size ranges. Would the counted aerosol particles include droplets between 2.0 and 3.0  $\mu\text{m}$ ? or would the counted droplets include aerosol particles between 2.0 and 3.0  $\mu\text{m}$ ? How could this influence the results in this study? This was not evaluated/addressed in this manuscript.
5. Are the number concentrations of aerosol particles and cloud droplets in volumetric unit or are they already corrected to the standard atmospheric condition? The presented results in Figure 2 are from different days and different altitudes, they should be corrected to the standard atmospheric condition before being combined in one figure.
6. The authors stated the source apportionment of airmasses and tried to use the property difference between continental and marine aerosols to explain the differences in observed cloud properties. However, how was the source apportionment performed in this study? Or was it published in parallel studies? What are the physiochemical properties of these two kinds of airmasses? like size distribution and hygroscopicity which are important for acting as cloud condensation nuclei.
7. It is well known that aerosol particle number concentration and updraft velocity (i.e., water supersaturation conditions) are the two most important factors for the observed cloud droplet number concentrations. Although the authors presented the latitudinal profiles of vertical pressure velocity at different times (Figure 5), the discussions on the single effect of updraft velocity and the combination effects of these two factors are still lacking. The results in Figure 5a at 08:00 are irrelevant to results in Figures 2, 3 and 4, whereas the required results at 10:00, 12:00, 13:00, 15:00, 16:00 and 18:00 are missing. Also, the x-axis in Figure 5 is not labelled, it is neither indicated in the caption nor clarified in the text. The y-axis might have an unit in Pascal.

### **Specific comments:**

Title: better to have 'aerosol-cloud interactions' rather than 'aerosol-cloud relationship'

Line 24: 'boundary layer (PBL)' or 'planetary boundary layer (PBL)'?

Line 25-26: I am confused about the sentence 'The lower layer of the stratocumulus cloud in Guangxi was mainly small particle-size cloud droplet' and also the phrase 'small particle-size cloud droplet'. How could the layer be cloud droplets?

Did you intend to state that the layer mainly contain small-sized cloud droplets? Or did you intend to state that the layer mainly contain cloud droplets which are formed by small-sized aerosol particles (i.e. small-sized cloud condensation nuclei)?

Line 28: Does “cloud microphysical quantity” refer to  $N_c$  and  $E_d$ ?

Line 29: Didn't you define  $N_c$  already in Line 22?

Line 32: Did you mean the lower layer of the PBL will show increases in small-sized cloud droplets? It would be good to increase the clarity of the statement.

Line 34:  $N_a$  was defined in Line 22 already.

Line 39: What does 'FIE' mean?

Line 40: It should be 'The boundary layer' or 'The planetary boundary layer'

Line 44-45: Stratocumulus clouds cannot account for land or water surfaces but can account for clouds that are over land or water surfaces.

Line 56-57: Please correct the grammar in the statement “... an increase of aerosol number concentration ( $N_a$ ) would increase in cloud droplet number concentration ( $N_c$ ) and a decrease in cloud droplet size, ...”

Line 61: Change “ground-based remote” to “ground-based remote sensing”

Line 62: Change “between aerosol and cloud” to “between aerosols and clouds”

Line 65: What is 'AOD'?

Line 67: should be 'cloud'

Line 70-72: In the sentence “Under high aerosol loading, smaller cloud droplets with higher droplet number concentration were observed under high aerosol loading, while fewer larger cloud droplets were formed under low aerosol loading.”, how did you define low and high aerosol loadings? How do you compare higher and fewer cloud droplets? Numbers should be provided from the literature.

Line 72: Didn't you already define 'Cloud droplet number concentration' as ' $N_c$ ' in Line 57? And in Line 73, did you mean liquid water path (LWP defined in Line 65) by saying 'liquid water content'. It is not far away. The same problem was shown in the abstract. More carefulness in writing will be appreciated. No further comments will be provided on such

abbreviations, including but not limited to  $N_c$ ,  $N_d$ ,  $E_d$ , LWP, and PBL. Please check through the whole manuscript. Detailed writing tips/rules can be found in ACP guidelines (via <https://www.atmospheric-chemistry-and-physics.net/submission.html>).

Line 74: Is it between aerosol number concentrations and the effective diameter of cloud droplets ( $E_d$ )? Or is it between one of any other aerosol properties and the  $E_d$ ?

Line 77: Please refer to an exact study that directly compared aircraft observations with other methodologies and successfully demonstrated that aircraft observations are the most reliable method to investigate the vertical relationships between aerosols and clouds.

Line 81-82: Please correct the grammar in ‘This leads to cloud condensation nuclei (CCN) variations and droplet concentration near cloud tops.’

Line 87: It should be ‘they showed’.

Line 89: What is ‘LWC’?

Line 92: What are ‘hair drops’?

Line 93: The first indirect effect of what? Or it refers to Twomey effect? It is not clear and the readability should be improved.

Line 106-108: Is the statement relevant for your findings or are those findings are from Liu et al. 2024? “

Line 108-109: The statement of ‘aerosols can have microphysical properties of clouds’ sounds very wired.

Line 114-115: ‘We demonstrated that this region's correlation between aerosols and clouds conforms to the Twomey effect.’

The structure and grammar of this sentence can be much better developed.

Line 126: Is it ‘accuracy’ or ‘uncertainty’?

Line 134-137: Average values should be provided.

Line 139-140: This statement contradicts the other statements. How do you mean by saying ‘close to’? Does it mean ‘similar to’? More rigorous and clearer logic to develop statements would be appreciated.

Line 140-141: Why to have capitalized ‘Stratocumulus’?

Line 150: The observations from 08:00 to 20:00 hours do not represent diurnal observations. Also, relevant statements/conclusions on diurnal variations do not make sense based on daytime observations only.

Line 155: The  $LWC \geq 10^{-3} \text{ g m}^{-3}$  is ambiguous.

Line 158: Is the observation height above seal level or ground level?

Line 161-163: What are  $n_i$ ,  $r_i$ , and  $\rho_w$ ?

Line 166: A full stop is missing.

Line 170: 'Where is the amount of  $\alpha$  aerosol', this statement does not make sense.

Line 176-179: Sentence too long and wrong grammar. Also, how cloud the same  $N_a$  represent two parameters of two cases (interstitial aerosols and out-cloud aerosols)? How did you calculate the average values? Is it calculated at the same height of nine flights? Or is it calculated as the average of observations in the height interval (10 m) for each flight and then you present the results if nine flights together? This should be clearly introduced in the manuscript.

Line 180-181: It is very hard to read these two average values in Figure 1a.

Line 181-185: The authors contradict themselves. They first stated that 'Nc decreased first and then remained unchanged with the increase of height.' On the contrary, they stated that 'Between 1500 and 3300 m, the Nc changed little with the increase of height, and the range of Nc is 10-200 cm<sup>-3</sup> (Fig. 1a).'

Line 190: Altitude values for each stage should be specified.

Line 192-193: The reason why there exists an inversion layer for temperatures should be shortly but clearly explained. Why such a temperature inversion layer hamper cloud droplet growth should be elaborated.

Line 197: The results presented in this study cannot represent diurnal variations since the night results are missing.

Line 202-205: Sentence too long and with a poor structure.

Line 215: Is Nc less than 100 cm<sup>-3</sup> or is it lower than the detection limit of the instrument? What is the detection limit of the instrument? There are only a few data point for altitudes below 900 m.

Line 217: Figure 4a was mentioned earlier than Figure 3. So, why not switch these two figures.

Line 217: Why only temperature only is the reason? Is RH irrelevant? are the aerosol size and other physiochemical properties irrelevant?

Line 222: Which part of the results shows that water vapor is sufficient?

Line 225-228: Poor sentence structure. Is there any statistical results or results from Nc that could support this statement

stating that the temperature inversion layer and the increase in  $N_a$  are correlated? Between 1500-1600 m, there are approximately 10 data points only.

Line 229: Where is the top of PBL? How was the PBL height determined/calculated?

Line 229-232: Very poor sentence structure.

Line 240-242: Can the pressure be calculated into altitude values? This way, it will be easier to compare to the results in Figures 2, 3 and 4.

Line 246: What do 'different locations' mean? Air mass regions? Or vertical locations?

Line 247: Figure 5b is for 11:00 and Figure 5c is for 14:00. How could these two panels be used for discussions on 13:00?

Line 248: what does 'more significant' mean? Is there a difference between those two beyond the uncertainty? It is also very ambiguous too say 'many cloud droplets', how many? From where one can read the quantity of the cloud droplets mentioned by the authors?

Line 250: A strong inversion layer of what?

Line 254: What does 'the top height of PBL was the highest' mean? Can the height of the PBL be compared to  $N_c$  number concentrations? From where, it presents the results of PBL height?

Line 257: An inversion layer of what?

Line 260: more cloud droplets than what?

Line 262-263: There are no results in Figure 5 or other figures to show the updraft. This interpretation is not groundless.

Line 263-264: Based on results from which Figure could the authors draw such a statement? Please specify.

Line 268: How do authors define low temperatures and high humidities? The development of the statement should be clarified.

Line 271: How could it be known that 'At 17:00, the height of the top of PBL decreased, and part of the aerosol remained above PBL,....'?

Line 273: What does 'E<sub>d</sub> concentrated in the 10-20  $\mu\text{m}$ ' mean? given that E<sub>d</sub> is defined as a size.

Line 277: The same comment on the statement '... resulting in  $N_a$  (interstitial aerosol) being more significant than  $N_a$  (out cloud)' as the comment on Line 248.

Line 299: 'Na and Nc in the cloud lower layer were large', how large they are? And the results refer to which figure and which panel?

Line 299-300: It is very awkward to have 'Na and Nc in the cloud lower layer were large' and 'large cloud droplet was less'.

Line 301-302: 'Na and Nc the upper cloud layer are the smallest', should be in the upper cloud layer.

Line 302: How do the authors know the water vapor is sufficient?

Line 305: 'the updraft diffused aerosols in the lower atmospheric layer upward' read awkward. Better wording is needed.

Line 305-307: 'From 14:00 to 16:00, the updraft diffused aerosols in the lower atmospheric layer upward, and Na and Nc in the lower cloud layer decreased, which was conducive to the condensation growth of cloud droplets, and the number of cloud droplets with a diameter greater than 20 $\mu$ m increased.' One cannot understand what is the cause and what is the effect in the statement. This sentence is also very poorly organized.

Line 312: Which part of the results in this manuscript shows the downdraft of the PBL between 17:00 and 20:00?

Line 316-317: What is the minor reasons? Based on which kind of comparisons, can the authors be sure the major reason?

Line 318: What are stratified clouds? Are they the same as or different from the aforementioned stratocumulus? No further information can be found in the following text.

Line 319: Which previous studies? Any references? Are the air mass source apportionment in those studies relevant for the same period of observations in this study?

Line 320: What does it mean by stating that 'air masses from land will bring higher aerosols'? Higher aerosol particle number concentrations? Or aerosols in higher altitudes?

Line 319-337: Without a clear definition for y-axis in Figure 7, the corresponding discussions do not make sense.

Line 338-369: It is unbelievable to discuss the results in Figure 8 without a unit for the colormap.

Line 365-367: 'The aerosol spectral patterns were similar', similar to what? It is nonsense to do aerosol source apportionment in such a baseless way. Did the authors analyse the physiochemical properties of those aerosols samples and compare the results to those of aerosol pollution sampled in surrounding areas of Guangxi? Or did the authors conduct simulation experiments (e.g. HYSPLIT or FLEXPART) to calculate the trajectory of these air masses? Even if the source apportionment is based on previously relevant studies, at least, the relevant publications should be cited.

Line 367-368: Again how can one read the PBL height in Figure 8?

Line 383: What is the significance level of the calculated correlation coefficient?

Line 388: meteorological parameters instead of 'meteorological elements'

Line 389: The results in this study are not diurnal since night time observations are missing.

Line 394-395: 'Between 1500 m and 3300 m,  $N_a$  was low,  $N_c < 200 \text{ cm}^{-3}$ , and did not change with the height.' This is not academic writing.

Line 401-403: Again, the results are not diurnal.

### **Figures and Tables:**

Table 1: What do the values in brackets mean? Are these concentration values corrected to standard conditions?

Figure 1: The results in Figure 1d were not discussed or referred in the text. I am wondering the point of discussing the average values since more specific results as a function of altitude were provided in Figure 1. Given the large spread of the results in Figure 1, an average value of a selected range does not really make sense.

Figure 2: What is the time zone of the hours? Why the results at 19:00 is missing?

Figure 3: The same comments as those on Figure 2. The legend and axis labels can be better organized to improve its readability.

Figure 4: The same comments as those on Figure 3.

Figure 5: What is the time zone of the hours? What does the x-axis mean?

Figure 7: What does the y-axis (Counts) mean? There is no definition in the manuscript.

Figure 8: The unit for the colour map scale is missing.

Figure 10: Which kind of correlation coefficient is presented in this Figure? How was it calculated? What is the significance level ( $p$  value) of the correlation coefficient? The maximum  $n$  value is only 7. Is the equation in each panel representing the function to calculate the correlation coefficient?