**Atmospheric
Chemistry
and Physics
Discussions**

Interactive comment on "The relevance of aerosol optical depth to cumulus fraction changes: a five-year climatology at the ACRF SGP site" *by* E. I. Kassianov et al.

Anonymous Referee #3

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This manuscript utilizes the independent datasets of aerosol optical depth and cloud fraction of the fair-weather cumulus (FWC) clouds from the ARM surface observations and cloud optical depth and effective radius from MODIS Aqual and Terra. The paper concludes that the relationships between cloud properties (cloud fraction, optical depth, and effective radius) and aerosol optical depth (τ_a) are time- (i.e., morning and afternoon) and size-dependent.

The conclusions are misinterpreted by the poor statistics/discussions of the data. The article lacks detailed physical explanation, and in many places, the results are explained by casually/incorrectly citing one or two references. Because of the major and

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minor issues described below, the current form is not satisfactory for publication in ACP.

Major issues:

1) One of the major conclusions is based on the regression results shown in Table 1a and Figure 9, which are obtained from data shown in the histogram in Figure 8. The authors state that the first and last bins of the histogram have quite few sampling points ($\sim$10); therefore the mean values of cloud fraction of these bins are less statistically robust. (page 11807). Following this statement, the data points of τ_a = 0.05, 0.55, and 0.65 (medium value in the histogram Figure 8) should be excluded from the regression, and this would result in only four points for morning and afternoon regressions to be shown in Figure 9 and Table 1a. Therefore, with only four points, the data are insufficient for statistically robust regression; the discussions for Table 1a and Figure 9 would not be meaningful. It is unclear why the authors do try to remove the first point (τ_a = 0.05) from the regression results (Table 1b) but not the other two points at the end of histogram (Figure 8).

2) Figure 8 shows that the 5-year climatology of available cloud fraction samples are 226 hours and 246 hours for morning and afternoon clouds, respectively. Using the number of 240, which is equivalent to 48 hours per year, and 8 days per year if using 6 hours observational time per day. 8 days of clouds per year during the summer time do not sound remarkably sufficient cloud samples for climatological sense.

3) The authors state that the observed positive correlation in the morning (Table 1a) is spurious, because by removing one statistically less robust point from the regression, the regression becomes negative (Table 1b). But the authors keep using this spurious positive correlation throughout the text (e.g., page 11811 and the conclusion). From the above conflicting regression results, it's unclear why the authors also reach the following statement "The obtained results suggest that thermodynamical and dynamical effects primarily control the FWC development in the morning."

4) As mentioned in 1), the regression of small and large clouds is questionable if those

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statically less robust points (< 10 samples) are not removed from the regression process.

Also, if the small and large clouds are separated into "morning" and "afternoon" groups, does the conclusion still hold?

5) Section 5.1 incorrectly cites the results of the modeling study by Jiang and Feingold [2006] and performs erroneous comparison. In that paper, two sets of simulations are performed, where one set (S1) is with no aerosol radiative effects and the other set (S2) studies the semi-indirect effect of absorbing aerosols. The current work considers FWC under mostly non-absorbing aerosols, and therefore should cite the simulation results S1 not S2. The S1 results in Jiang and Feingld [2006, Figure 6] show nearly no change in cloud fraction and surface fluxes by aerosols loadings, while S2 results show reductions in cloud fraction and surface fluxes. Because of the incorrect comparison, the conclusion drawn in this section is not valid.

6) In Section 5.2, it is stated that the observed r_e-τ_a relationship by the Aqua in the afternoon is contrary to the modeling results by Xue and Feingold [2006], but none of the possible physical explanation is given.

Xue and Feingold [2006] proposed the polluted clouds have more smaller and readily evaporated cloud droplets and that results in smaller cloud fraction. If the observed r_e-τ_a relationship from the afternoon Aqua is opposite to Xue and Feingold [2006], how do the authors reach the conclusion that the the positive relationship of cloud fraction with τ_a for small clouds (< 1 km $\sim$ 1-km MODIS) supports the model by Xue and Feingold [2006]. This goes back to point 4) that the small clouds need to be separated into morning and afternoon groups.

Why there are region-related variations in the LWP in the morning Terra but no variations in the afternoon Aqua?

Minor issues:

These are relatively minor points but they still serve important roles for the science of the paper.

- Strictly speaking, referring time before 14:00 LST (20:00 UTC) as "morning" is not so technically correct.

- Line 17-20, Page 11806: The two representative cases in Figure 7 do not support the claimed climatology that cloud fraction reaches its maximum at 20:00 UTC.

- What are the number of samples for large and small clouds in Figure 10, respectively?

- "the net SW flux contributes most of the total flux" of line 27 and "trends" of line 28 on page 11810 – based on what? intercept, slope, or correlation? Please clarify.

- Line 16-19, Page 11812: "trend" refers to slope or correlation? morning or afternoon? Also miscellaneous places. Please be clear.

- Line 26-27, Page 11813: Why is τ_a = 0.2 selected for polluted and clean criteria?

- Line 11, Page 11814: It is mentioned that Aqua makes observations in the "afternoon" (20:00 UTC), which is right at the cutoff time (20:00 UTC) of previously defined morning and afternoon in Table 1.

- Line 15-18, Page 11814: "Different process are responsible.." and "..these processes.." What are the different processes here? Please clarify. Xu et al. [2005] is a modeling inter-comparison paper of frontal clouds. It is less relevant to the FWC in this study.

- Line 27, Page 11814 - Line 7, Page 11815: It was mentioned that the results agree with the model predictions by Xue and Feingold [2006], but later this model suggested aerosol-droplet evaporation rate feedback is not included in the discussion of combined effects. Also, what is purpose to state the lifetime of small and large clouds?

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