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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cloud Characteristics, Thermodynamic Controls and Radiative Impacts During the Observations and Modeling of the Green Ocean Amazon (GoAmazon2014/5) Experiment" *by* Scott E. Giangrande et al.

Anonymous Referee #2

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Overview

This manuscript presents a nice overview of unique datasets from the central Amazon, specifically focusing on vertical profile measurements of thermodynamic conditions and cloud boundaries with collocated surface radiative flux observations. It doesn't get into much detail on any one science question, but that is okay for an overview paper, especially since these datasets are not discussed in detail in Martin et al. (2016, 2017) overview papers. The results showing differences between wet and dry seasons are expected from previous studies, and the most interesting new results are the estimated

cloud radiative effects of different cloud types as a function of season and diurnal cycle showing mean properties over a year that are similar to shortwave and longwave cloud radiative effects at a very rainy site in the Tropical Western Pacific. Another interesting finding is that cumulus clouds tend to be deeper with greater liquid water paths in the wet season than the dry season despite similar liquid water contents in the clouds and larger droplets in the wet season clouds. My primary concern is that the authors don't delve far enough into these interesting findings leaving the paper very descriptive with open questions. Being an overview paper of newly available datasets, I don't expect as much scientific investigation as in other types of papers, but I think that there are fairly simple and straightforward ways that the authors could attempt to explore some of the reasons for the aforementioned interesting results, as described further in major comments 5 and 6.

Major Comments

1. There are a lot of coauthors on this paper, and I can't help but wonder how each coauthor contributed to the paper. Does each coauthor meet ACP's guideline that "only persons who have significantly contributed to the research and paper preparation should be listed as authors"? What did each coauthor contribute?

2. The CAPE values seem extremely high. For example, they are far higher than those from Manaus in Machado et al. (2004) and in Williams et al. (2002) in Rondonia, Brazil (both papers that you cite). This could be a result of having mid-day soundings, but have you checked to make sure that these are correct? Was any comparison made with the 12 and 00Z Manaus operational soundings? And what is causing the CAPE to rise so dramatically to near 4000 most days? This is an interesting feature. Is this confined to lifted parcels within a thin PBL layer, so that mixing erases much of it and prevents extreme convection from occurring?

3. Increase the text size on Figure 3. It is currently unreadable. Also, the units in Figure 12a-b are off by 2 orders of magnitude.

4. The hour to hour noisiness of rain rate in Figure 7 seems to indicate modest sample size, perhaps not surprising for a point location, even if observed for nearly 2 years. Does this impact the robustness of conclusions that require sub-setting of the data (e.g., diurnal cycle, seasonality)? The peak in rainfall at noon is also sooner than is typically observed in most land locations, and it doesn't seem to match up with the peak congestus and deep convection cloud fractions in Figures 6, 8, and 9. Is there a reason for this?

5. The similar CRE between Manaus and Manus is interesting, and perhaps expected, especially relative to Darwin and Nauru, which are not typical of many rainy, tropical places because of the dry air aloft that often impacts them. However, breaking down the overall SW and LW CRE at each site by frequency of cloud type and conditional CREs for each cloud type like in Table 2 would be much more interesting. Are some cloud types similar while others are different between sites? How do these similarities and differences impact the overall SW and LW CRE? Are there differences in the diurnal cycle of cloud type frequencies and CREs? Ideally, it would be extremely informative to investigate potential thermodynamic relationships with cloud frequency or CRE at the different sites or to pick a key cloud type like shallow cumulus and relate its CRE with its depth and LWP at each site. I'm not suggesting that I expect you to do all of this, but it seems that it would be fairly straightforward and not very time consuming to investigate a little more, placing this new dataset into better context with other well-observed sites.

6. Given the datasets available that are highlighted in this paper, it seems like it should be straightforward to investigate the cause of deeper cumulus clouds with greater LWP in the wet season as compared to the dry season, but with similar LWC. Is the cumulus cloud depth related to the CIN, relative humidity just above the boundary layer, both? When cumulus cloud depth is controlled for, do the dry season clouds have a stronger SW CRE caused by greater numbers of smaller droplets? How much of an increase in cloud depth is required to offset the cloud droplet SW CRE? These are questions that could probably be examined without too much effort that are important

to understanding how all of these observations connect together through processes.

7. ACP requires a "Data Availability" section on how all research data can be accessed, which goes before the "Acknowledgements" section. Please insert this section.

Minor Comments

1. On page 5, lines 5-7, I have trouble seeing higher CAPE and lower CIN in the transition periods in Figure 2. It looks fairly constant and the CIN appears lowest in the wet season and highest in the dry season, consistent with Figure 3, so can you clarify this sentence or better show it in the figure? It is then stated on page 11, lines 23-24 that wet season conditions favor weaker CAPE and dry season stronger CAPE, but the figure don't seem to show that. There is very little difference in Figure 3a, with enough spread that the differences between wet and dry season CAPE is likely not statistically significant.

2. On page 5, lines 16-17, it is stated that CIN decreasing during the day with CAPE peaking at mid-day is consistent with development of convection breaking the capping inversion and consuming CAPE, but I don't understand this argument. Isn't the layer of CIN (not necessarily an inversion, by the way) simply reduced through boundary layer mixing induced by daytime heating, while the same daytime heating warms the boundary layer and increases CAPE?

3. Is the moisture advection in Figure 4 the same as moisture convergence? How is it calculated? It is difficult to interpret 3-D advection. How much of the advection in Figure 4 is a result of the vertical component? Can it be stated if vertical mixing is the dominant component?

4. On page 7, it is stated that the RWP is used to reconstruct cloud boundaries up to 13 km, but really, isn't the RWP observing precipitation boundaries due to its sensitivity limitations? And because of these same limitations, doesn't it underestimate cloud top? These seems apparent in Figure 5, for example. If so, I recommend mentioning

this limitation.

5. The CRE estimates depend on accurate estimates of the clear sky radiative fluxes. What causes the sharp decrease in clear sky longwave flux at 15Z in Figure 5f that appears coincident with the edge of the deep convective system? Is this accurate? If not, is there a bias in some situations that impacts longwave CRE?

6. It is mentioned that low level clouds impact the detection of upper level clouds by the micropulse lidar and ceilometer. Is this what caused the discontinuities in cirrus cloud fraction at 6 and 18Z in Figure 6a? If so, can this be stated? And does this mean that cirrus is significantly underestimated at the uppermost levels?

7. On page 9, there are several places where the wording doesn't seem accurate:

a) On lines 5-6, it is stated that shallow clouds dominate the early morning hours, but to me, it looks like they continue well into the afternoon.

b) On line 12, it is stated that congestus and deep convective clouds are prominent from mid-late afternoon, but it looks like they are prominent starting right at noon, and peak cloud fraction looks to be between 12 and 1 PM for congestus and 12 and 2 PM for deep convection rather than at noon, as is stated in the paper.

c) On line 21, it is stated that the convection aligns with the mid-upper level vertical motion, but there is a secondary maximum in deep convection overnight when there is descending mid-upper level motion, so these don't seem perfectly aligned to me.

d) On line 24, the pre-dawn peak in altocumulus is its primary peak, not its secondary peak.

e) Lines 25-27: The wording here is confusing. What does precipitation have to do with congestus cloud fraction peaks? Please clarify.

8. Stating that 103 wet season days produce 1600 mm of rainfall and 52 dry season days produce 600 mm of rainfall doesn't necessarily lead to a factor of 2 difference in

average rain rate. I can see that differences in Figure 7, but the argument from the number of days and precipitation perspective requires knowledge of how many total wet season and dry season days were sampled.

9. The statements on page 10, lines 5-7 and lines 23-25 seem contradictory with one saying that relative convective intensity is not much different between wet and dry seasons, while the other says that dry season convection is stronger. I personally don't see evidence in Figure 7 that dry season rain rates are more intense with conditional rain rates in both seasons that are similar.

10. On page 10, line 28, how are you defining "organized systems"? And similarly, on page 11, line 1, how is "organized cloud" defined?

11. It's not surprising that clouds and thermodynamics are not strongly correlated when viewed from a stationary vertically pointing perspective, but this shouldn't be confused with them not being correlated over a larger scale from a Langrangian perspective. When you state that weak correlations are found between cloud behaviors (isn't cloud state a better term here than behavior?) and thermodynamic parameters, what time scale is this correlation being computed on and is it a time lag correlation?

12. On page 12, line 10, I believe you can delete "Compared to SW CRE" to make the sentence read more clearly. This sentence mentions SW CRE being much larger than LW CRE, but SW CRE is 0 at night and the surface energy balance is much different at night than during the day, so a given LW CRE at night, even if small compared to the larger daytime SW CRE, could have just as significant of impacts on variables such as surface temperature, couldn't it?

13. On page 13, line 2, insert "and" between "(SW)" and "longwave" with a comma after "fluxes". And on line 29, add an "s" onto "peak".

14. On page 15, line 15, it is stated that sharper CAPE and CIN contrasts during the wet season and transitional periods enhance the likelihood for deep convection to have

organized components. First, how are organized components defined? Second, how is this known? I didn't see any evidence presented that shows this and important components of mesoscale convective system growth such as vertical wind shear were not discussed. Mid-upper level humidity and vertical motion are also potentially important factors aside from CAPE or CIN.

15. Consider rewording "supports local congestus to deeper cloud triggering" on page 15, line 19.

16. On page 16, line 1, consider rewording to "between maritime-like 'active monsoon' conditions with widespread clouds and precipitation and continental-like 'break monsoon' conditions with less clouds and precipitation, but more intense deep convection".

17. On page 16, line 10, insert "cumulus" after "thicker".

18. What is meant by "natural cloud laboratory" on page 16, line 14?

19. The last paragraph on page 16 has some confusing wording in spots. For example, the third sentence seems out of place in the paper since the Manaus plume was not discussed at all in this study. Additionally, the last two sentences don't seem worded well. Can you attempt to clarify what is meant in these sentences?

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