

Interactive comment on “Overview: Precipitation Characteristics and Sensitivities to the Environmental Conditions during GoAmazon2014/5 and ACRIDICON-CHUVA” by Luiz A. T. Machado et al.

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Response to Referee #1 – Dr. Y. Zhuang.

We would like to thank Dr. Y. Zhuang for the valuable comments (*italic*). We will improve the manuscript based on your suggestions. Please find a point-by-point response (**bold**) and proposed changes to the manuscript below.

This study utilized field campaign data collected during GoAmazon 2014/5 and CHUVA-ACRIDICON, as well as satellite and S-band radar data, to give an overview of

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precipitation characteristic and corresponding thermodynamic conditions, and analyze the relationship between precipitation and several environmental conditions, including aerosol loading, land surface, etc. Contrast between the wet and dry season for these characteristics and relationship were emphatically discussed. Although there are numerous previous studies about the convection and precipitation in the Amazon, this is the first paper which summarizes such complex features about the precipitation and its seasonality in the Central Amazon using multiple comprehensive datasets. Overall, I found this work to be well-written and scientifically sound, and results in this work will aid to further understanding of cloud and precipitation systems in Amazon and potentially provide implications for modeling groups to improve GCM parameterization. I recommend this manuscript to be published after some minor revisions.

Thank you for your comments. The manuscript was improved based on your recommendations.

Specific Comments:

1. Page 3, Line 10: Could the authors provide reference for this statement? Additionally, I think it would be also helpful to add monthly rainfall in Figure 2 since SIPAM product is available in 2014 and 2015 whole year. In ECMWF reanalysis data and S band radar rain rate derived by (Zhuang et al. 2017, JGRA), Sep is even drier than July and August.

The reference is Machado et. al. (2004) DOI 10.1007/s00704-004-0044-9. In this case, we are referring to Manaus (data were obtained from rain gauges). You are correct that September is drier than July and that August is the driest month. September was added to the text. We added an additional Figure (Fig. 2F) to show the 2014 monthly mean rainfall and rainfall rates. We believe that it is more appropriate to use the rain gauge data in this instance. The SIPAM S-band radar data are discussed in item 3, and 2014 was chosen to reflect the same period shown in the other panels of Figure 2.

2. Page 3, Line 15: It would be helpful to describe how CAPE was calculated either

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here or in the method section. Specifically, what is the initial condition of the parcel (surface based, mixed layer average, . . .)? The choice of initial parcel could affect the CAPE value very significantly, possibly the seasonality as well.

We added the thermodynamic calculation procedures to the methodology based on your suggestion. This procedure relied on surface calculations. The Williams et al. paper also relied on surface data to compute CAPE (this information was also included in the text).

3. Page 7, Line 12: Is there a reason for only using 2014 wet-season disdrometer data to determine the Z-R relationship? Can the authors further speculate how much this approximation that the wet and dry seasons have same DSD could affect results? Such as Figure 1 and Figure 4, does the approximation make the difference between wet and dry season smaller or larger?

There was a mistake in the legends for Figures 4 and 7; the rainfall data were collected using a disdrometer, as explained in the text. The effect of the radar S-band rainfall estimation is only considered in Figures 8 and 12. As these figures are presented by vegetation and topography class for each season, the Z-R relationship has little effect on the conclusions. Therefore, the variation between the classes rather than the absolute values should be considered. We used the Joss disdrometer and the period with the best data (i.e., the wet season with the J-W) to create the Z-R relationship. A sentence was added to the text discussing the possible implications of this method on the total rainfall measurements. The Z-R relationship is more sensitive to the way one filters out disdrometer data than to the intrinsic difference between the wet and dry Z-R relationship. Thus, this relationship was considered by ARM-DOE as more appropriate (Courtney Schumacher, data mentor). The Joss disdrometer was only used during the wet season by the researchers because they were considering a more continuous and larger sample than previously collected. The researchers filtered out all points with less than 100 droplets per minute. This method resulted in a more conservative relationship that is closer to Marshall Palmer. However, if a filter of 10 drops per minute

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is considered, the Z-R relationship differs more substantially than can be explained by the wet-dry seasonal differences. Figure 1 shows some of the Z-R relationships used to test the ARM Z-R relationship. IOP2-JW is the Joss adjusted relationship during the dry season (filter 10 drops/minute); IOP1-JW is the Joss-adjusted relationship during the wet season (filter 10 drops/minute); and Aaron is the relationship used in the manuscript and in the ARM database (for wet Joss but filtered using 100 drops per minute). The Marshall Palmer (MP) and NEXRAD were also considered. Note that differences between how the disdrometer data are filtered are larger than the differences between dry and wet seasons when using the same filter. We added a discussion within the text explaining why the S-band data were not considered as an absolute value of rainfall.

4. Page 9, Line 21-22: I feel that usage of “rain rate” and “rainfall” could be a little confusing here. By “This is the reason why the wet season has a maximum rain rate”, I think the authors actually mean the average daily rain rate but not the rain rate used in Line 15-16 for rain event. I feel it’s better to explicitly specify the average period and use something like “rain rate for precipitation event”, or just use symbol RR and R to discriminate them. Also check Line 34 in abstract and description in Figure 1.

We were trying to explain the exception (the largest RR occurred during the wet season – only one case) and in doing so created confusion, as you noted. We rewrote this part to clarify our meaning and have taken your other suggestions into consideration.

5. Page 9, Line 30-33: Similar conclusions about atmospheric instability and cloud fraction variations between wet and dry season were also discussed in some previous studies such as Zhuang et al. 2017.

The reference was added to the text.

6. Page 9, Line 31: Definition of bulk shear is not given. Is it surface to 6km bulk shear? The definitions of all the thermodynamic-dynamic parameters were added to the

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methodology. The bulk shear is the difference between the surface-500 m and surface-6000 m average wind speed.

7. Page 12, Line 24-26: Is the comparison “clearer distinction” made between the dry and wet season or between 8km and above 8km in the dry season? Also, in conclusion section at Page 17, Line 28-29, “. . . more homogenous clouds above 8-km . . .”, does this contradict with “. . . higher correlation at approximately 8km” here? It seems to me the frequency of $Rho_{HV} < 0.97$ is higher above 8km, and that of $Rho_{HV} > 0.97$ is lower above 8km. Doesn't this mean the average Rho_{HV} is smaller and the cloud becomes less homogenous above 8km?

The clearest distinction appears below and above 8 km. This was clarified in the text. You are correct that the sentence was not well written, which resulted in an incorrect interpretation. The text was changed to “During the dry season, there appears to be a clearer distinction between the mixed phase and the glaciation phase above 8 km. The wet season correlation coefficient is more homogenous with height inside the cloud.”

8. Comparison between Figure 6c and 6f shows dry season has larger frequency in high Rho_{HV} range (larger purple area) above melting layer and below 8 km, which means Rho_{HV} is smaller and the cloud becomes less homogenous above 8km.

We agree and have addressed this item as discussed in item 7. The paragraph has been rewritten. We hope the new text is clearer and more accurate.

9. Page 14, Line 19-22: Discussions here are not very clear. What does “the variation . . . is 25%” mean? What “difference” is “very consistent”?

Yes; this sentence requires clarification. We intended to refer to the difference between the RR median values of each surface type. In addition, the data are not consistent but are significant. This was changed in the text.

10. Page 16, Line 2: “difference . . . increase with the altitude . . .”. I don't find this statement to be true for Figure 11b.

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You are correct that the results are only clear for leg 1. This correction was made in the text. The time of leg 1 compared with leg 2 (later, when the convective boundary layer was fully developed) resulted in this difference, which has been clarified in the text.

11. Page 16, Line 20: Please provide statistical test for the linear relationship in Figure 10, especially 10c. In addition, solid rectangles and circles look very similar in Figure 10bc. Maybe use another marker such as “x” in Figure 10a.

The statistical information (correlation) was revised in the text. As the correlation is only around 0.6, we changed the sentence from nearly linearly related to more linearly related than the vertical velocity.

12. Page 16, Line 30-31: Firstly, although dry season seems to have a stronger linear dependency between rainfall and elevation than the wet season, they still look very similar. Is this difference significance tested between all adjacent elevation groups? Similarly, it would be helpful to indicate if the difference passes the significance test between different surface types for a single season in Figure 8. Secondly, the conclusions here about the dependency of dry season rain rate on topography seem to valid at first. However, is this result independent from those in section 3.2.2 about surface type? If so, the authors need to indicate there is no specific relationship between surface type and topography. I also suggest adding a figure to show surface type and contoured elevation of the studied area. We agree that it is more appropriate to test significant differences among the classes than between the seasons. We have tested the differences among the classes, and all differences during the dry season were significant. However, we continued our analysis of this difference using the T-student parametric test. We were curious why all classes passed the test and identified important discussion points related to parametric significance tests in very large sample sizes. These comparisons were done for several days at the pixel level, so the sample set is very large. All tests generally pass under this condition, and there is no statistical way to use the test with such a large sample set. By using box plots, all basic statistics are shown. Therefore, we decided to eliminate the T-student test for vegetation and topog-

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raphy. This test was only valid when we tested T3 site-specific data, which resulted in a much smaller sample set. We eliminated the arrows in Figure 9 (new, formerly 8) and 13 (new, formerly 12).

13. Page 18, Line 21: Could the authors provide reference to the related studies?

A reference was added to the text.

14. Quality of some figures need to be improved. Specifically, e.g., sub-figures were not properly labelled, such as Figure 3-6 & 9; black lines around the figure should be removed, such as Figure 3&6; Figure 2, Maybe more details about the box plot can be given either in text, figure caption, or both. e.g. how is “outlier” defined and how to determine the length of whiskers?; text “wet” and “dry” are not all visible inside the Figure 6; Figure 10a is in different size with 10bc; some texts were not shown as subscripts, such as Nccn and Dm; etc. The sub-figures are now labeled The frame was a placeholder in the manuscript. The figures will be provided individually, and the Journal will organize according to their standards. Details about the box plots were added to the text. The “Wet” and “Dry” labels in Figure 6 are now visible. The size of Figure 10 was changed.

15. I’m not sure how to interpret the unit (%) of occurrence frequency in Figure 5&6. If the CFAD was constructed the same way as (Yuter and Houze, 1995, Part II, MWR), shouldn’t the unit be, for example, “% km-1 dBZ-1” for Figure 6ac. The CFAD was constructed as follows: each CFAD consists of a PDF of reflectivity at each height multiplied by 100 so that the values are presented as percentages. The CFAD calculation used 2 dBZ-bin and 0.4 km-bin intervals. After the first paper (Yuter and Houze, 1995), the others papers that use CFAD rely on this explanation. We added this sentence to the legend and the intervals.

Typos and Grammar Issues includes, but is not limited to:

Page 1, Line 28: “This is study” → “This study” Changed as recommended. Line

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30: “instruments systems” → “instrument systems” Changed as recommended. Line 32: “have carefully been” → “have been carefully” Changed as recommended. Line 35: “While” cannot be used to start the sentence here Changed as recommended. Page 2, Line 1: “as well” → “as well as”, “among” → “between” Changed as recommended. Line 2: “analyse” → “analyzed” Changed as recommended. Line 3: “is” → “was” Changed as recommended. Line 7: “observe” → “observed”, “dependence on” → “dependence of” Changed as recommended. Line 10: “cloud droplets number” → “cloud droplet number” Changed as recommended. Line 10-11: “revealed”, “exhibit” check tense consistency Changed as recommended. Line 20: “sea -level” → “sea level” Changed as recommended. Page 3, Line 10: “Amazonas, For” → “Amazonas. For” Changed as recommended. Page 4, Line 20: “During” → “during” Changed as recommended. Page 6, Line 20: “present” → “presents” Giangrande et al., so present is correct. Line 25: “Section two” → “Section 2” Changed as recommended. Page 9, Line 16: “differences, the” → “differences. The” Changed as recommended. Page 10, Line 6: “Cloud Clusters and Rain Cells-Size Distribution” → “Size Distribution of Cloud Clusters and Rain Cells” Changed as recommended. Line 27: “diameter” → “Diameter” Changed as recommended. Page 11, Line 4: “present” → “presented” Changed as recommended. Line 17: “function” → “ functions” Changed as recommended. Page 14, Line 21: “few differences” → “smaller differences”? Changed to smaller differences. Page 15, Line 34: “difference” → “different” Changed as recommended. Page 17, Line 25: remove “Conversely, ” Changed as recommended. Page 30, Figure 1: Label for x-axis should be “mm i’CdÂrh-1” not “mm.h-1”. Also check other figures. Use “Sep” instead of “Sept”. Changed as recommended Page 32, Figure 3: “distributions between wet and dry seasons and the difference between dry . . .” → “distributions during the wet and dry seasons and the difference between the dry . . .” Changed as recommended. Page 33, Figure 4: “t-statistic” → “t-test” Changed as recommended. Page 36, Figure 7: “radar S-band” → “S-band radar” This part was eliminated as explained in item 3. Page 37, Figure 8: “t-student” → “Student’s t-test” Changed as recommended.

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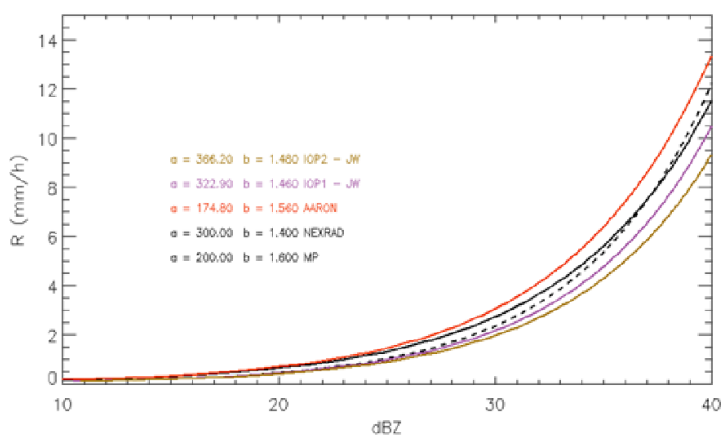


Fig. 1.

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