Author's Response to Anonymous Referee #1

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This manuscript aims explore the TRMM PR radar characteristics of RPFs with and without lightning over the steep terrain gradient from the Himalayan Plateau east to the South/East China Sea, and examining these characteristics from the perspective of convective lifecycle.

From a composition standpoint, there are numerous construction and grammar errors, and several instances of text copied from other articles, teetering on plagiarism. Although much of the authors' scientific argument hinges on the classification of RPFs into different lifecycle stages, the authors do not use consistent nomenclature throughout the text, which becomes exceedingly confusing.

From a scientific standpoint, I have strong reservations about using the convective/total precipitation ratio to classify storms by lifecycle stage, especially when comparing storms with lightning and without, and over diverse terrain. Convective mode will vary extremely widely by geographic regime, and the 'maturity' of storms in each regime is not universal. Throughout the text there are many instances of gross understatement and over generalization of electrified convection and orographic enhancement/forcing of precipitation, and arguments made for the primitivity of the field of meteorology in these areas that is very much so not the case now. I have grave concerns about this manuscript's composition, scientific argument, and methodology, for these reasons, I find this manuscript to be substandard for this publication and suggest rejection.

The authors are grateful to the reviewer for the criticism and comments on this manuscript. This is a very rare and precious opportunity for our young researchers to learn and progress. Which can help us always maintain an objective and rigorous scientific attitude in the future research work.

We have carefully considered about your comment, and have revised the manuscript accordingly. The grammar errors and other existing problems have also been revised. For some other explanations, please refer to the responses to the comments below.

The followings are our responses to your comments and action taken in the revised manuscript.

Major/Thematic Comments:

1. The use of the convective/total precipitation ratio as a rough measure of an MCS's maturity dates back to Houze's 1997 paper, but its application requires the inherent assumption that you are comparing features of a same morphology, and perhaps even stricter, only comparing MCSs at different lifecycle stages. Bang and Zipser (2015) employ this ratio on RPFs with lightning only. To apply that methodology to very different geographical regimes and apply it to the entire convective spectrum is misleading. And, while I strongly do not believe that you should, there is not a point in the manuscript where you use the differing ratios explicitly to confine the RPFs into lifecycle stages, despite mentioning the different stages multiple times. This method of determining maturity is flawed, and even then, is not described clearly. I suggest looking at the recent works of Roca, Fiolleau, and Bouniol for an alternate approach to describing the lifecycle of convection.

Response: The authors are very sorry for the confusion that has brought you.

Yes, the use of the convective rain ratio is a rough measure, and it is because of this, the present paper use it in combination with the radar echo structures characteristics to distinguish the different stages of different thunderstorms, rather than using this ratio alone. In addition, this paper discussed four very different geographical regions, but each subregion is a relatively single terrain condition, the comparisons of different convection are performed within the same subregion.

Secondly, just as you mentioned that 'there is not a point in the manuscript where you use the differing ratios explicitly to confine the RPFs into lifecycle stages.' The purpose of this paper is not to specifically show a method to distinguish the lifecycle stages of thunderstorms, but to statistically analyze the lightning activity and radar echo structure in thunderstorms based on the long-term TRMM satellite data. Actually, the convective rainfall ratio together with the radar echo structure (both of vertical and horizontal) and lightning flash rate are combined to compare the stages of thunderstorms. Moreover, it is not used to clearly identify which lifecycle stages of a convection belongs to, but only to help us compare a certain cluster of thunderstorms are earlier or later than the other cluster of thunderstorms. For example, as the red rectangular box marked in the following table (half of the Table 4 in the paper), there are 690 non-thunderstorms with 30 dBZ echo top exceed 9 km but no lightning was observed by the LIS. Although the 30 dBZ echo top is at the same range, the statistical values shows that these non-thunderstorms are characterized by larger convective rainfall ratio (0.84) but smaller in horizontal scale(22 pixels, far less than the 120 pixels of thunderstorms) than thunderstorms, all these convective characteristics together illustrate that the non-thunderstorms are in the earlier stage than those thunderstorms.

Table. Count, average of the maximum 30 dBZ echo pixels (Area30) and convective rainfall ratio to total rainfall (Ratio) of precipitation events for different 30 dBZ echo top height over the four subregions.

Subregions	Types	7—9 km			9 km～		
		count	Area30	Ratio	count	Area30	Ratio
Plateau	Non-thunderstorm	1830	13	0.67	3176	8	0.72
	Thunderstorm	1542	19	0.60	6298	23	0.65
Foothills	Non-thunderstorm	5260	37	0.78	690	22	0.84
	Thunderstorm	3802	84	0.75	5108	120	0.81
Hilly land	Non-thunderstorm	2536	60	0.81	366	40	0.86
	Thunderstorm	2254	162	0.76	3824	149	0.83
Ocean	Non-thunderstorm	1738	165	0.71	283	196	0.72
	Thunderstorm	686	341	0.67	902	406	0.70

The recent paper of Roca et al. (2017) you mentioned using the meteorological geostationary satellite date showed a simple parametric model, which is a very reliable and useful method to document the time evolution of the cold cloud shield of MCS over the tropics. I believe this will be of great help in the future use of satellite data to study MCSs. However, this paper mainly analyzes thunderstorms based on TRMM radar echo and lightning data, so it has not been adopted this time.

Roca R , Fiolleau T , Bouniol D . A Simple Model of the Life Cycle of Mesoscale Convective Systems Cloud Shield in the Tropics[J]. Journal of Climate, 2017:JCLI-D-16-0556.1.

2. Satellites in low earth orbit, such as TRMM, only get an instantaneous 'snapshot' of the precipitation, and therefore there are likely many cases of RPFs that were electrified and did produce lightning, especially over the ocean, where flashrates are low, that were not observed by the LIS. This is likely not very rare, as the authors argue, and may cause problems with this line of argument.

Response: Yes, the case you mentioned does exist. However, the official introduction about the TRMM LIS said that: 'The imager's field of view allows the sensor to observe a point on the Earth or a cloud for 80 seconds, **a sufficient time** to estimate the flashing rate, which tells researchers whether a storm is growing or decaying.' Therefore, it must be extremely weak if the case did produce lightning but not observed by the LIS within ~80 seconds. It is believed that such weak convection can not affect the results of this paper.

Again, this study focused on statistical analysis of long-term TRMM observation data, and attempts to characterize the evolution of lightning and radar echo structures in thunderstorms. It is aiming to explore the relationship between lightning and radar echoes during different cycle stage of thunderstorms from a statistical perspective.

3. In examining the radar reflectivity heights and profiles of RPFs with and without lightning over terrain, and over land vs. ocean, this manuscript provides little new insight beyond what Zipser, Cecil, and Liu have done in years past with the TRMM PF/RPF dataset. I find little new scientific progress accomplished by this manuscript, nor do I believe the work is a good fit for the ACP journal.

Response: There are indeed many studies about lightning and convective properties of thunderstorms, but this study is different. Several highlights of this paper are summarized as follows:

Firstly, the result shows that 30 dBZ echo top height has a concise relationship with the occurrence probability of lightning in convective storms, which will be very useful for lightning nowcasting and warning services.

Secondly, the result of this paper confirmed that combining the ratio of convective rainfall to total rainfall with the radar echo structure of convection is an effective and feasible method to distinguish the stage of different convection (snapshot of convection) observed by the TRMM. This can help us further explore and maximize the usage of the observation data from non-sun-synchronous satellites, e.g., the TRMM, the GPM.

On this basis, the coupling patterns of the radar echo structure feature and lightning activity with the evolution of the extreme thunderstorms are summarized and discussed according to the statistical analysis of 16-yr TRMM data. Furthermore, this study found that convection with stronger radar echo structure but less or no lightning, are considered as thunderstorms in developing/cumulus stage. While those weak thunderstorms, with lightning but especially weak in radar echo core (maximum reflectivity less than 40 dBZ) are actually thunderstorms in the dissipating stage. It is believed that a more stable and reliable relationship between lightning and convective properties of thunderstorms will be obtained if considering these different situations in advance. This is benefit to improving the lightning data assimilation techniques and simulation results (Mansell et al., 2007; Fierro et al., 2013; Qie et al., 2014).

Composition Comments:

Throughout the manuscript, especially in the earlier introduction and methodology sections, there are large portions of text that appear from their sources (cited or otherwise) largely without or with barely minimal paraphrasing. I present a handful of examples below:

3. 24 "Thunderstorms are responsible for the development and formation of many severe weather phenomena"

"Thunderstorms are responsible for the development and formation of many severe weather phenomena."

https://en.wikipedia.org/wiki/Thunderstorm

Response: This sentence has been replaced in the revised manuscript.

4.54 ". . . mesoscale convective systems with the most robust stratiform regions occur primarily in the rainiest season and regions"

“Convective systems exhibiting broad stratiform regions occur primarily in the rainiest season and regions” (Romatschke et al., 2010; p. 419)

Response: The author believes that this is a normal literature citation.

4.62 “. . . the juxtaposition of updraft and mixed-phase microphysics (0 to −40C) provides favorable conditions where non-inductive charging can efficiently occur via collision and separation between graupel/hail and ice crystals in the presence of supercooled liquid water in thunderclouds”

“This juxtaposition of updraft and mixed phase microphysics provides a region where noninductive charging can efficiently occur via rebounding collisions between graupel/hail and ice crystals in the presence of supercooled liquid water” (Deierling and Peterson, 2008; p. 16210)

Response: Thanks for pointing out this dispute. Actually, I don't think this is a problem, this is a customary description about the non-inductive charging in atmospheric electricity, however, I still modified it to avoid unnecessary dispute.

8.154 “This study followed the logic used in previous studies (e.g., Houze, 1997; Romatschke and Houze, 2010; Zuluaga and Houze, 2015) that as a convective system evolves, the young, vigorous convective region matures into widespread convection coexisting with a stratiform region, and finally into mostly stratiform precipitation. A ratio value of 1 means that the storm is 100% convective, which is commonly typified as 'young'convection, whereas a value close to 0 means that the dominant radar precipitation feature (RPF) is stratiform precipitation, which is typified as 'mature' convection.”

“A value of 1 means that the RPF is 100% convective, which is commonly typified as “young”convection, whereas a value close to 0 means that the RPF is dominantly stratiform precipitation, which is typified as “mature.” This logic is put forth in numerous papers [e.g., Houze, 1997; Romatschke and Houze, 2010; Zuluaga and Houze,2015] in that as a mesoscale convective system (MCS) evolves, the young, vigorous convective region matures into widespread convection coexisting with a stratiform region and finally into mostly stratiform precipitation."

(Bang and Zipser, 2015; p 6845)

Several of these instances were detected using the similarity software, as below:

I do not believe that inserting the word 'vigorous' into an otherwise unchanged sentence -including the references - constitutes paraphrasing.

Response: Originally, in order to describe the method clearly, it indeed quoted too long content from Bang and Zipser (2015), this might be not correct. Now, it has been modified in the revised manuscript. Thank you.

16.325 "The convective intensity can be defined by the properties of the convective updrafts in a storm"

". . . intensity can be defined by the properties of the convective updrafts in a storm . . ."

(Zipser et al., 2006; p. 1060)

Response: The author believes that this is a normal literature citation.

Other Composition Comments:

There are massive over generalizations in the text, such as thunderstorms usually occur randomly in time and space,"which is simply not true. Also comments like "the stronger the convective intensity of a thunderstorm, the more the lightning," made without citation or context, is a gross overstatement. ". . . lightning discharge is produced when the electric field in thunderclouds break through a certain threshold"is also a massive oversimplification of the noninductive ice-ice collision mechanism and the dieletric threshold. Despite a large portion of scientific argument resting upon lifecycle classification, and it not being made explicitly clear as to how this classification is conducted using the convective/total ratio–the naming convention of the lifecycle stages is not consistent throughout this manuscript. The first stage is described as 'initiation,' 'cumulus,' and 'triggering' and at one point, 'mature' is broken up into 'pre-mature, mature, and post-mature,' which already is confusing, an add to the fact that the original term is included within the new term's subdivision. This makes it very difficult for readers to deduce the points you are trying to make about each.

Response: Yes, some sentences in the original manuscript were over generalizations in text, this has been corrected in the revised version. For the question about how the lifecycle classification is conducted please refer to the previous response to the major comment 1.

The authors use the terms ‘non-sun-synchronous’ and ‘non-geostationary’ interchangeably to describe the low earth orbit of TRMM, and while TRMM is in fact neither of those types of satellite, they also mean two very different things for spaceborne observations.

Response: Yes, this do cause some confusion, we have confirmed and unified it into ‘non-sun-synchronous’, this is consistent with the official statement.

I find the phrase ‘hilly land’ to be too colloquial for formal scientific writing.

Response: Sorry, we searched for it and found that the word ‘hilly’ was also used in some paper published in professional geographical journals. More importantly, we did not find a more appropriate phrase to describe the geographical characteristics of this area. So, this phrase ‘hilly land’ is still retained in the revised manuscript.

The figures, in general, are well-made and well-captioned. I would suggest in future to make the panels of figures such as 4 and 5 larger, as at present they are too small for readers' eyes to resolve the white count contours and the finer detail in the gradients of the probability of lightning colors.

Response: Thank you, we fully accept your suggestion and we must pay attention to it in future work.