Response to Anonymous Referee #2

-The paper presented a new approach to improve cloud detection from Millimeter wavelength cloud radar measurements. The method has potentials. However, this paper didn't present enough evidence to demonstrate that the approach is really better. Thus, the paper needs significant improvements before accepting for publication.

Response: We thank the reviewer for his/her constructive comments and suggestions on this manuscript, which are very helpful for us to improve our paper. This paper is mainly a description of an improved hydrometeor detection approach for cloud radar. Additional work has been done and the results do show our method can recognize more signals. Our responses to the comments are given below.

- As illustrated in Fig. 6, the new method picks up more thin clouds detected by MPL (correctly), but it also picks up significant more clouds in the lower troposphere due tonoise. If this is the best case to illustrate the approach, it is hard to convince readers that the new approach is better.

Response: The increased detections in the lower troposphere are not due to noise. They could be some large dust particles. As shown in Fig 1, the depolarization ratio around 2 km is larger than surroundings. We also analyzed our radar Liner Depolarization Ratio (LDR) in Figure 2. It is clear that those increased detections around 2 km have large LDRs compared to that of noise. Although the dust is not desired information for cloud mask, the appearance of those particles and their detection prove the capability of our method on recognizing weak signals.

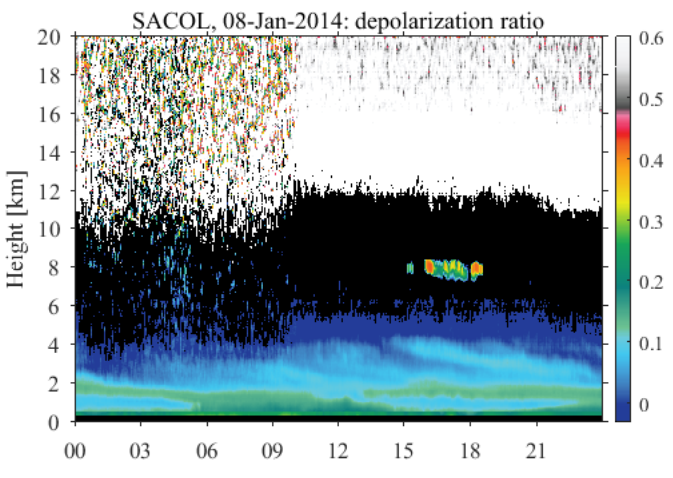

Figure 1. Depolarization ratio of MPL for January 8, 2014

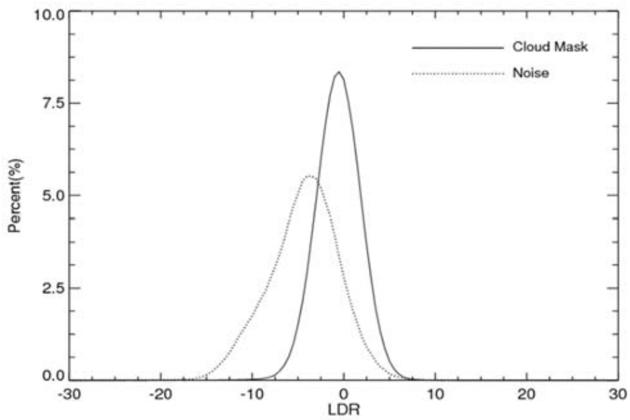

Figure 2. Radar LDR distributions for increased detections in the lower atmosphere and noise.

-Figure. 8 is a simple comparison between the two approaches; it is hard to demonstrate which one is more reliable. To show the new approach improving cloud detection for weak cloud signals, it is important to have lidar measurements as a truth for each cloud layer. Then you can provide quantitative assessments on improvements in both correct and false detections.

Response: We compare the radar cloud mask results derived from our method and ARM algorithm with the MPL detected features in January and July, 2014 when both radar and lidar observations are available. It is found that the increased detections by our method as compared with the ARM algorithm are mostly those also identified as features by MPL. Figure 3 shows an example in January 5, 2014. The features that are not observed by MPL are mainly related to a total attenuation of lidar signals by optically thick clouds below or appear at the base of clouds from where large hydrometeors may fall out which can not be observed by MPL.

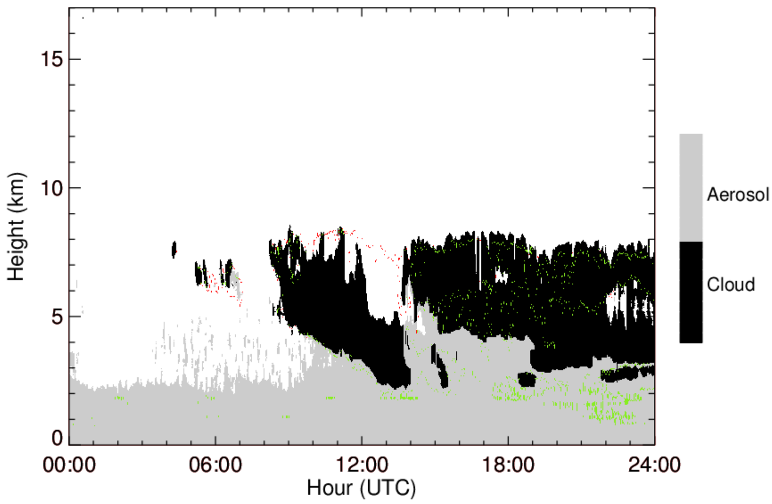

Figure 3. Increased hydrometeor detections by our algorithm versus ARM algorithm in comparison with the MPL feature mask in January 5, 2014. The black and gray regions represent the cloud and aerosol detected by MPL. The green part represents

the increased detections that are also identified as features by MPL detection. The red part represents the increased detection that are not detected by MPL.

We also calculated the percentage of the increased detections identified by both our mothed and MPL observations in the total increased detections only found by our mothed as shown in Figure 4. We can see that most part of the increased detection from our method is also detected as features by MPL. The percentage drops to a minimum of 70% at about 9 km, where the total increased cloud range bins are only about 110 and there are 35 range bins that are identified by our method are not observed by MPL. Considering all the increased detections by our method, 98.6% of them are confirmed by MPL as features.

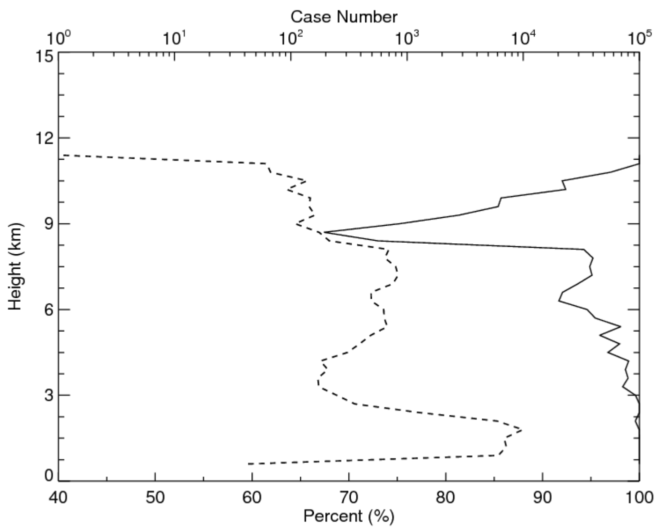

Figure 4. The solid line is the percentage of increased detections seen by both KAZR with our method and MPL as compared with the total increased detections. The dot line is the number of increased detections in each level.

-Although it is possible for cloud radar to detect dust storm when significant large dust particles were lifted in the atmosphere, such as dust storm illustrated in Auxiliary Figure1. But it is not possible to detect elevated thin dust layer because large dust particles fall out quickly after transporting certain distances. Thus, dust is not a possible explain for increased cloud detection by the new method at the low atmosphere in Fig. 6. Do you have depolarization measurements from your lidar? It will be great that you can provide depolarization measurements to further illustrate the occurrence of dust.

Response: Yes, we believe that long range transported dust particles should not be detected by millimeter radar. But as shown in Fig. 1, the large MPL depolarization ratio appear in the layer around 2 km. Figure 5 shows the MPL depolarization ratio for Januray 9, 2014. It can be seen that the increased detections in the lower atmosphere by our method in Fig. 3 correspond well with the large lidar depolarization.

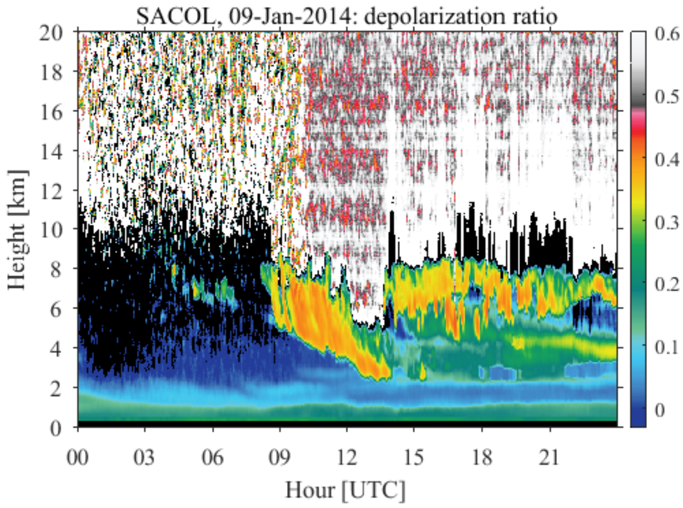

Figure 5. Depolarization ratio of MPL for January 9, 2014

-For the bottom two figures of Fig. 7: How is the percentage calculated, related to the total measurement profiles or other parameters? The high increasing region in the upper troposphere is corresponding to small case numbers. So an important question is what is the over all impacts on cloud amount. From cloud microphysics retrievals, what are potential impacts on upper troposphere cloud water content and radiative heating? Any justification for the importance of these missing clouds is helpful to justify the value of the new algorithm.

Response: The percentage is calculated by taking the ARM approach as a reference. The two lines represent the percentage of the increased detection by our method compared to ARM algorithm. Yes, it is true the high increasing region in the upper troposphere corresponds to small cloud amount. Small cloud amount should not be expected to have significant impacts on radiative heating. But these missing clouds may still be important for understanding the cloud formation and its relation to atmospheric conditions.

More importantly the optically thin cirrus clouds prevail in tropical upper troposphere. Applying our algorithm to cloud radar observations in the tropics would enhance the detection of thin cirrus there, which will be our future research.

-Many typos in the paper need to be corrected, for example, line 349, "evens" should be "events".

Response: We have corrected this error and carefully revised the manuscript again.