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Atmospheric Measurement Techniques
Discussions

Interactive comment on "A simple insect removal algorithm for 35-GHz cloud radar measurements" *by* Madhu Chandra R. Kalapureddy et al.

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We are thankful to the Anonymous Referee 1, for the hearty services in rendering his/her experience and knowledge based comments, those are valuable to us for improving the quality and the focus of the paper. The point-to-point AR1 responses of the authors are as below:

AR1-Comment: The study presented a technique which uses high temporal and spatially resolved reflectivity profiles to extract the cloud echoes from the clutter (mainly from the biota). The proposed technique suggested as a simple and efficient solution for clutter removal, compared to earlier sophisticated techniques based on dual polarization and spectral techniques. I think manuscript has several shortcomings, related to

technique and assumptions, poor job of literature review, references and lack of solid conclusions. In its entirety, I would recommend rejection of this paper in its present form.

Response: Thank you! We request AR1 now to review the latest modified version of the paper where we re-written the whole introduction part the manuscript (MS) and cited all possible concern references that come under the scope of the paper and responded also to other valuable referee points. Furthermore, clarity on the technique/algorithm and its main application region has now been clearly come through the revision process in the current modified version of the MS at first Para of section 2 (pg 3) and added basis for TEST (Line 292-295, pg 4-5), including new figures (fig 13 to fig 15) show the potential of TEST in screening out clouds by filtering out biota. Further weakness of TEST under challenging conditions like within cloud and high density biota has been overcome using extra measurements like LDR and SW. This can be seen at the last two paragraphs of Results and Discussion. Thus, the main conclusion of the paper is how simplest way one can remove the biota contribution and preserve true cloud hydrometeor echo and its need for the study of important shallow cumulus/ABL clouds before the actual cloud radar echo weighted measurements consider for any research application purpose. The above revision asked necessary modification to the last section (Summary and Conclusions) from page 11 onward.

AR1-Major comments: The screening technique authors have implemented using simple measures of reflectivity (or SNR) thresholds and its variability to filter out the clutter has been a usual practice in the cloud radar community as a part of post-processing exercise. The challenge of separating insects from the cloud clutter is difficult due to the lack of clear demarcation between their properties as seen by cloud radar. More often than otherwise, the screening process requires more than one variable, which captures the texture, distribution width, and physical properties of these echoes. With this motivation, some of the earlier studies have devoted their efforts to address this problem using different techniques (fuzzy-logic, spectral technique or polarization properties).

Response: Separating biota from cloud is difficult and challenging but not impossible by the cloud radar if one effectively makes use of advancing radar and signal processing technique (e.g., chirping and DSP) that enables to have the provision of high spatial and temporal resolution radar measurements (1st paragraph of System, Data and Methodology) that can demarcate the cloud echo from insects for example through reflectivity texture (e.g., TEST). With our knowledge, TEST, it is first of its kind effort to consider both reflectivity variance (i.e., dBZ texture) and its rate of change through running average for every 4 seconds. The above point pragmatically working as to identify the time coherence or de-correlation periods associated with clouds and biota echo signature (see newly added figure 15 and its description at pg 11). Moreover, the de-correlation can be evidenced through direct third Doppler power spectral moment; spectral width measurements that clearly show biota exhibits less velocity variance thus the relatively quicker time de-correlation at the pulse scale. In Fig. 2, the zoomed portion of Fig 1, the rounded echo confirms the presence of non-hydrometeor information by their duration of maximum 10 sec which is too small for a cloud to form and then suddenly disappear. So the vertical extension and the time duration of the echoes are the two key factors to discriminate cloud from non-meteorological information. Merits and de-merits of TEST has been brought out exclusively with Figure 13 and 14 that are making use of LDR and Spectral width measurements besides to Z to enhance the proposed TEST algorithm capability under tough conditions like cloud under heavily dense insects clutter.

AR1-Comment: The authors haven't clearly appreciated and addressed the insect removal to the detail that it was needed. They have demonstrated the algorithm with several minutes of data, which doesn't warrant the techniques robustness to apply for other conditions. Authors have made several assumptions about the insect layer depth, their decorrelation timescale without presenting any evidence about the location of the shallow boundary layer clouds, where the insect clutter is very critical. Previous studies (e.g., Geerts and Miao 2005; Chandra et al., 2010) have utilized the long-term observations of insect echoes to study the convective boundary layer, where they have shown

that the insect decorrelation times may vary from few seconds to few minutes depends on boundary layer organization. The authors would have shown the distribution of the cloud base locations (from the closest ceilometer data) to justify their presumed insect layers below âĹij2km. I suggest authors to utilize the supplemental observations (such as ceilometer, microwave radiometer) to present the cloud properties and refine their insect-cloud algorithm based on the locations of cloud layer depth.

Response: Unfortunately the suggested useful complemented data was not available at and around the radar site. However using some available GPS RS observations from the radar site, the presence of weaker clouds have been proved with auxiliary Figure A2 (please also see the response to the comment 2 of AR#3). Further, we consider the reviewer's well suggested point on the inclusion of shallow boundary layer cloud case with insects clutter when both have near same reflectivity values (added Figures 13-14). In fact, thanks to the reviewer that now it is clearly illustrating the potential of TEST that lies mostly to the ABL, where shallow cloud evolves, where the affinity of biota are predominant. Below are two examples of such low level/ shallow cumulus clouds with biota clutter where the fine performance of TEST is evident.

Note: Referee figure quoted as 'Figure ARX' and MS figure as 'Figure X' Please also see pdf responses attached

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2017-254/amt-2017-254-AC2-supplement.pdf

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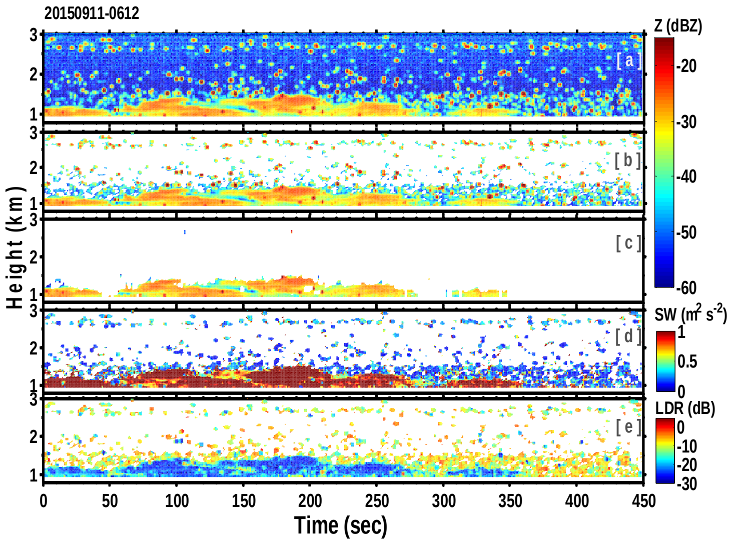

Fig. 1. Figure AR1: HTI plot of cloud radar measured (a) Reflectivity (Z), (b) noise removed Z, (c) TEST filtered Z, (d) Spectral Width (SW), and (e) LDR at 0612 UT on 11 Sep 2015.

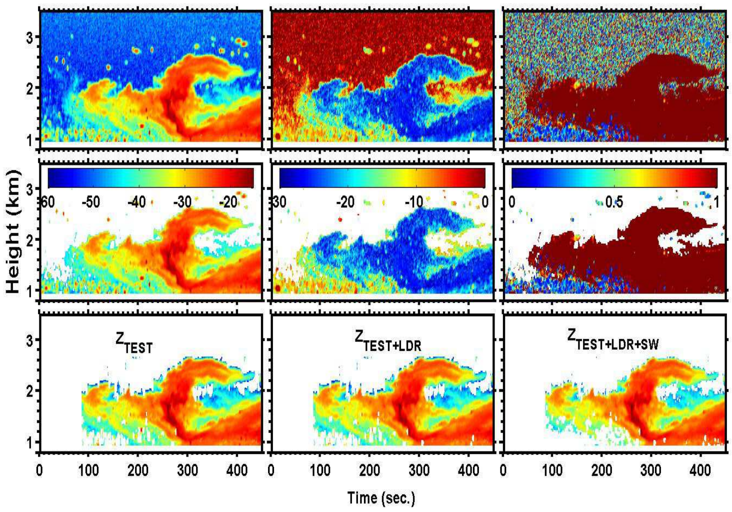

Fig. 2. Figure AR2: TEST performance in filtering biota echoes that are co-present with low clouds.