

Dear authors, thank you for taking the time to address my comments. After reading your responses, I have only a few outstanding questions.

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*New reviewers' comment:*

One of the main conclusions of this article is “Whereas CF from merged MPL-ceilometer data provides the largest estimates of the multi-year mean cloud cover: about 0.12 (35%) and 0.08 (24%) greater than FSC for the first and second sub-periods, respectively. CF from merged ceilometer-MPL-radar data has the strongest sub-period dependence with a bias of 0.08 (24%) compared to FSC for the first sub-period and shows no bias for the second sub-period. The strong period dependence of CF obtained from the combined ceilometer-MPL-radar data is likely due to increased reliance on the radar for cloud top height returns.”

This statement leaves me with the following thoughts:

- 1) If the largest factor affect the ceilometer-MPL-radar CF estimate is whether or not the radar detects a cloud top then I think the authors should reconsider their answer to my original comment about the role of insects.

*Reviewers original comment:* “Clarifications regarding the impact of insects on ShCu top detections - Multiple studies have reported that the presence of insect hinders the radars ability to accurately detect cloud top. I think more information is needed here about how insect contamination is handled in ARSCL both pre and post 2011 where the authors hint that the MPL stopped being applied in the boundary layer. This could offer an alternative explanation to the changes in radar-lidar CF post 2011 where the increase in radar detected cloud top could be due both to the KAZR being more sensitive than the MMCR and to the KAZR insect filtering having changed such that more insect returns are misclassified as cloud tops. If both effects are in play, then I would like to see their relative importance quantified.”

Let me be clearer about this statement; By “accurately” I meant that sometimes the radar cannot detect the “real” cloud at all but can detect an insect layer which happens to fly above a lidar-detected cloud base. This would lead, for the same “real” cloud, to CF only being estimated by the ceilometer-MPL-radar algorithm if insects are detected and interpreted as being cloud; thus generating biases if the insect filter is altered.

*Authors original response:* “We agree that insects can contaminate accurate determination of cloud boundaries by radar. However, accurate cloud top height retrievals by radar is not required in our analysis because a simple threshold is used to determine the presence of ShCu. Moreover, cloud base height estimation involves lidar observations (both ceilometer and MPL) which are not impacted by the presence of insects, Text has been added to clarify this point: (Section 3.1, lines 141-144) “Insect contamination may contribute to significant uncertainty of the radar-based retrievals of cloud boundaries. Therefore, our analysis employs a semi-quantitative threshold approach when using the cloud top heights. This approach is less sensitive to the insect contamination.”

I agree with the authors that “cloud base height estimation involves lidar observations (both ceilometer and MPL) which are not impacted by the presence of insects”. But the importance of detecting “true” cloud tops should not be undermined since it is a fundamental criterion in the ceilometer-MPL-radar CF estimate. Given this, I think the authors should specify how insect filtering is performed both pre and post 2011. I understand that this may have been the topic of

previous studies but it would make this manuscript much more thorough to statement the main points of these algorithms; For instance, are they relying on polarimetric variables, are they threshold based, do they have continuity arguments? I would think something has changed after the much improved KAZR was installed post-2011. I also think the potential bias insects could generate should be specifically stated in the conclusions perhaps at the end of point 1).

- 2) What does “increased reliance” mean. Going to the conclusion section I get a sense that “increased reliance” means only relying on the radar for cloud top detection below 3km. I would suggest taking the following statement out of the parenthesis in the conclusions “(MPL is not used below 3km in the second sub-period)” since it is a very important part of the sentence. Also, I would suggest making a small change to the abstract to improve clarity: “The strong period dependence of CF obtained from the combined ceilometer-MPL-radar data likely results from a change in what sensors are relied on the detect clouds below 3km; Post 2011, the MPL stopped being used for cloud detection below 3km leaving the radar as the sole sensor for cloud detection in that region.”

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*Authors revised text:* “Insect contamination may contribute to significant uncertainty of the radar-based retrievals of cloud boundaries. Therefore, our analysis employs a semi-quantitative threshold approach when using the cloud top heights. This approach is less sensitive to the insect contamination.”

*New reviewers’ comment:* Can you clarify what you mean by “semi-quantitative threshold”.

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*New reviewer’s comment:* Line 463, please consider changing “see” for “detects” without quotation marks.

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*Reviewer’s original comment* 7) The idea of compensating bias introduced on Page 8 “introduction of compensating errors using the cloud top height criteria in the updated merged lidar-radar product.” needs clarification. - If I understand correctly the hypothesis is that in the 2000-2010 period the MPL was overly sensitive to aerosols leading to a CF overestimation while the MMCR was underly sensitive to cloud leading to a CF underestimation hence the compensating bias

*Authors original response:* Thank you for pointing this out. For the later sub-period (2010-2017), the merged cloud radar-lidar product relies on the “shallow” (< 3 km) radar data instead of the combined MPL-radar observations for determining the cloud top. The radar misses a substantial fraction (about 30%) of ShCu, therefore the cloud top height (below 3 km) is very likely to be missed. Meanwhile, the merged lidars (ceilometer and MPL) data are used to detect the cloud base height and exhibit higher CF than that from the ceilometer alone. A compensating error could potentially arise from the over-detection of clouds in the merged lidar data with the under-detection of cloud from the radar observations. The RMSD for the CF including cloud top heights for the later sub-period (2010-2017) is higher than those for the CF obtained from ceilometer alone (even for near-zero bias). This indicates that the instrument detection differences in the merged lidar-radar product contribute mostly to the CF uncertainty.

*Reviewer's new comment:* Thank for you for the clarification. How has it been incorporated in the revised manuscript?