

Atmos. Meas. Tech. Discuss., referee comment RC1  
<https://doi.org/10.5194/amt-2020-448-RC1>, 2021  
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## Comment on amt-2020-448

Anonymous Referee #1

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Referee comment on "Why we need radar, lidar, and solar radiance observations to constrain ice cloud microphysics" by Florian Ewald et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2020-448-RC1>, 2021

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Review of "Why we need radar, lidar, and solar radiance observations to constrain ice cloud microphysics" by F. Ewald et al.

This is a very interesting paper focusing on achieving short-wave radiative closure using multi-instrument cloud observations. The ability of such studies to constrain ice cloud particle habits is particularly noteworthy. The results are especially relevant to upcoming active remote sensing satellite missions (e.g. the ESA/JAXA Earth Clouds and Radiation Explorer mission).

The paper is, on the whole, well written and structured. There are, however, some areas where the text must be improved.

### Specific Issues

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P-1, L-19: Bad sentence: I suggest: "In this case, collocated in-situ measurements indicate that the lack of closure may be linked to unexpectedly high values of the ice crystal number density."

P-2: L-30: "...distribution contribute to..."

P-3: L-70 to 75: This paragraph is confusing (e.g. it is not clear to me at all when you are referring to lidar+radar, passive, or lidar+radar+IR radiometer measurements).

I think the points you are trying to make here are:

1. Combined lidar-radar measurements can provide high-resolution (on the scale of 10s of meters) vertical profiles of cloud

properties. This capability can not be matched by passive sensor only based cloud retrievals.

However,

2. Lidar measurements are most sensitive to the particle extinction while radar reflectivity is mostly dependent on the squared-mass distribution.

3. Using lidar derived extinction together with radar reflectivity is not enough to constrain e.g. the effective size or IWC unambiguously. The mapping between the lidar and radar measurements and e.g. IWC and Reff depends significantly on the assumed particle habit and size distribution.

4. Using IR emissivity measurements can help constrain the problem. However, even then ambiguity can remain as IR measurements can saturate with optical depth quite quickly.

Please rewrite the first half of this paragraph (with appropriate references).

P-4: L 101: Concluding "..the paper concludes with the presentation of a case..."

P-77: L-177: "...online.." ? Do you mean to say that the lidar forward model you use is being run through a remote web interface ? I think you want to say that the model is available for download. If the later is true, then please give a url, or just delete "online".

P-7: L-185: "..and the beam..."

P-8, First paragraph. Bad first two sentences. I suggest something like

The ice microphysical and scattering models employed in this study are of central importance. Both the lidar+radar (+radiometer) results as well as the simulated SW radiances used in the closure assessment depend on the ice microphysical and scattering models assumed. In this section, we describe the microphysical and scattering models employed in this study. We cover both the models/assumptions used in the retrievals and in the simulation of of the short-wave radiances used to assess the closure."

P-8, L 193: "A commonly used framework which simplifies the... is the concept of an effective ice particle density..."

P-9: L-200: Delete the coma after "Analogous"

P-10, L-243: Very unclear sentence (e.g. what do you mean by "At first..?". I recommend deleting this sentence.

P-13: L-291: "..scientific objective.." is not the proper phrase here, I recommend simply "target".

P-13, L-295: Define WCB ?

P-14: L-328 "Overall, the lidar signal is extinguished much more rapidly ..."

P-17: L-348: "..for all the microphysical models considered..."

P-18: L-365: "Comparison of in-situ and remote-sensing observations"

P-18: Last line "..and its processing are..."

P-19: L-393: Define "ICNC"

P-19: End of page: A small bit of foreshadowing here would help guide the reader, e.g. end the section by stating "The implications of the occurrence of the regions of unexpectedly high ICNCs are discussed in the next section".

P-20: Last sentence of page: Awkward sentence. I suggest "The resulting oversmoothing across this discontinuity could lead to the undesired perturbation of ....."

P-21: L-445: "...water vapor absorption which insures that mainly light...."