Review of “Impact of Ice Microphysical Assumptions on RTTOV simulations of MSG/SEVIRI Visible and Infrared Observations using W-band Radar Retrieved IWC”

By R. Joseph et al., for AMT

Summary

The manuscript of Joseph et al. presents a sensitivity study to assess radiative transfer (RT) simulations for ice clouds using a case study involving radar measurements of ice water content (IWC) in a convective system. The measured cloud was simulated with two standard RTTOV parametrizations as well as three new methods that determine the particle size distribution and crystal habit from IWC and temperature. The results of these simulations were compared with SEVIRI satellite measurements. Initially, it was observed that the radar data did not capture the cloud tops, resulting in simulated infrared channel values that were too high. To address this, ice was added at the cloud top to align with SEVIRI brightness temperatures (BTs), and a second set of simulations was performed. In these revised simulations, the infrared channels showed good consistency with SEVIRI measurements across all parametrizations. However, for the visible and near-infrared channels, the SEVIRI observations could not be reproduced, particularly when using the new methods.

The topic and the results of this study are interesting. However, the paper ends somewhat unsatisfactory without providing a good explanation for the differences between simulations and satellite measurements. Finding a good explanation for the differences might require a lot of work and may be out of scope for this study, but the study would benefit from discussing the differences and possible reasons in more detail (see below). The presented methods are in general fine, and I appreciate the testing of new parametrisation schemes. However, there are some concerns in terms of methods and especially the presentation of the study that need to be addressed, and the manuscript requires major revision. These concerns are outlined in the comments below.

General Comments

1. The manuscript needs careful language editing. There are many typos, and the phrasing should be revised in large parts of the manuscript. For instance, carefully revise the use of fill-words like “hence”, “therefore”, “indeed” or “then”, which are often used in a confusing way. In parts, things are repeated several times over different paragraphs or sections, and the structure/ order of arguments is sometimes confusing. Overall, the manuscript would benefit from making it more concise.
2. I share the concerns of Reviewer 1 about the study being based only on one flight
3. The results showing the differences between different parametrization schemes are interesting. It could benefit from a bit more discussion/interpretation where differences come from. What can we learn in the end from this comparison? Can we understand better why some parametrizations work better than others? Any ideas why the visible and NIR channels could not be reproduced?

4. It is mentioned that the size distribution is found to be an important parameter. It would be worth expanding a bit more on your findings which parameters are most important (size distribution vs habit vs …).

Specific Comments

1. I stumbled across the last sentence of the abstract: 'Hence, the necessary knowledge on condition to perform simulations with these two channels stay an open question.' Please phrase differently to explain what you mean here. Also, you could think about adding an additional sentence to the abstract, summarizing e.g. the impact of this research.
2. Line 115 and following: You write that a 7.5-minute time difference might lead to significant discrepancies between in-situ and satellite measurements. Couldn't you use only the aircraft measurements in a smaller time window around the satellite measurement to avoid this uncertainty? An alternative idea would be to show somewhere how well the RTTOV simulations vs satellite measurements match as a function of time difference, to check whether this is an important factor
3. Line 123 and following: 'Figure 3 shows IWC profiles interpolated on the model levels of ERA5, where a linear interpolation is applied. Hence, IWC profiles are re-gridded onto the MSG grid using a nearest-neighbor approach in latitude–longitude space'. I am confused – isn't the measured resolution of IWC profiles higher than ERA5? Why does it need to be interpolated? Also, instead of 'Hence', maybe use something like 'In addition', since the second sentence does not follow from the first.
4. In Fig. 3., is the IWC and std(IWC) taken separately for each altitude level of the profiles? Also, you can consider plotting std(IWC) / IWC as y-axis to directly show the percentage-variation of IWC for each MSG pixel. It is stated that 10% of subpixel heterogeneity is negligible compared to the measurement uncertainties – how large are these uncertainties?
5. Does Fig. 4 show the average IWC over all profiles/time steps? Would it make sense to show a couple of different average profiles, e.g. the ones corresponding to the different SEVIRI times (a-f in Fig. 2), since at certain times the aircraft was sampling the clouds closer to the center of the convective system and at other times the anvil?
6. Line 180 and following: Add a reference here so that the reader knows that it is later specified which particle size distribution is chosen in case of Method 1-bis
7. Fig. 5a: why are there (sometimes relatively large) white gaps between the different choices of particle habits?
8. Line 201 and following: I suggest specifying a bit more how this integration is done, I am not sure if I understood it. Are the bulk optical properties computed for each altitude layer separately, and integrated within the bounds of each SEVIRI pixel? However, was not the average IWC computed for each SEVIRI pixel before (Section 2.1.2)? So which IWC is used to estimate particle habit and PSD – the one in original resolution or the averaged one?
9. In Fig. 8, it might be beneficial to add a 2d histogram in the Temperature-IWC space, to know which temperature-IWC combinations were frequently measured
10. It would be nice to show the mass-size relationship for all parametrizations that are compared

11. Line 268 and following: I stumbled over the description of the phase function for thermal wavelengths – it does not seem to fit the figure. Isn't the reason why the radiance is more angularly uniform in the thermal that absorption dominates, and re-emission does not have a large angular dependence (in contrast to the phase function being responsible)?
12. As several parts of the manuscript, the conclusions sometimes repeats itself. It should be structured in a clearer way.

Technical Corrections

1. Line 29: missing year in citation Geer et al.
2. Line 63: 'last section present and discuss' → 'last section presents and discusses'
3. Line 77: 'impact of shape and concentration': What is meant by concentration? The sentence before talks about particle size distribution. Also, this is not a full sentence, and should be merged e.g. with the sentence before.
4. Line 79: 'Whether it be the new optical properties developed for this paper or those offered with parametrization in 80 RTTOV' is not a full sentence
5. I suggest revising the whole opening paragraph of the Methods Section to enhance clarity and brevity. The current version is a bit confusing and contains several grammatical errors.
6. Line 89: 'large ice cloud' → 'large ice clouds'
7. Line 92: 'performed the' → 'performed on'
8. Line 97: no parenthesis for the citations needed
9. Line 104: What do you mean by 'delimit'?
10. Line 105: 'Figure 2' → 'The lower panel of Fig. 2'; also, either change 'Figure 2a' and '2b' to 'upper panel' and 'lower panel', or add labels (a) and (b) to the Figure
11. Line 107: '[10−2 gm−3 : 5 gm−3]' → '10−2 gm−3 to 5 gm−3'
12. Line 108: specify panel for 'Fig. 2'
13. Line 110: 'These parts highlight radar attenuation at the top of the cloud': I suggest rephrasing this explanation to make it clearer
14. Line 115 and 123: 'figure 3' → do you mean 'Fig. 4'?
15. Line 128: 'one pixel' → 'each pixel'
16. Fig. 4: 'mediane' → 'median'
17. Line 196: 'Ice crystals habit' → 'Ice crystal habits'
18. Line 198: is it 'Plate 10' or '10 Plates', 'Column 8' or '8 Columns'? (see also Fig. 5 and 6)
19. Line 199: 'particle shapes distributions' → 'particle shape distributions'
20. Line 204: 'as followed' → 'following'
21. Line 220 and 221: twice almost the same sentence
22. Line 238: 'It's' → 'It is' or 'The extinction coefficient'
23. Line 242 and throughout the script: Isn't it four new methods?
24. Line 262 and 268: specify panel of Fig. 9
25. Line 279: 'compare' → 'compared'
26. Line 297: Why 'Then'? Not a full sentence
27. Line 306: 'On the other side' → 'on the other hand'

28. Line 318: specify the parametrization
29. Line 318: what is meant by ‘where an upper bound appears’?
30. Line 323 and 324: use ice crystal ‘habit’ or ‘shape’ consistently throughout the paper
31. Line 382: ‘parametrization’ → ’parametrizations’
32. Line 385: ‘radar-derived IWC—particularly’: What does the ‘—particularly’ mean here? Maybe delete?
33. Line 389: ‘observation could’ → ‘observations might’
34. Line 395: ‘almost no big influence’ → ‘almost no influence’ or ‘only little influence’
35. Line 399: ‘these findings carry information’: strange phrasing
36. In the whole manuscript: Please make sure to be consistent in your use of ‘habit’ and ‘shape’. Are these two equivalent? Then use one of these consistently throughout the text. If you mean different things, please explain somewhere.