

Interactive comment on “Ice hydrometeor profile retrieval algorithm for high frequency microwave radiometers: application to the CoSSIR instrument during TC4” by K. F. Evans et al.

Anonymous Referee #1

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In this paper the authors describe a method for retrieving ice cloud properties from high frequency microwave radiometers. They also present an application of their method to the CoSSIR instrument operated during TC4 campaign in 2007.

The paper is well written and the work deserves to be published with modifications. I have been very impressed by the performance of the algorithm. I just regret the length of the paper, which could be probably shortened in a few places (the generation of the a priori CDF/EOF files and the very long appendixes). It is very easy to get lost in details if you are not a specialist of the methodology. I wish I could give a way to split

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the paper in two. . . I feel that the paper really is indigestible and it is very frustrating as the content of the paper is very interesting. I would strongly recommend that the authors make the paper shorter and also make extra effort to explain the method in a more didactic way for publication.

I suspect that my level of understanding is too limited to fully review this paper; this is a long paper which requires an expert in the field to understand this specific retrieval approach. The description of the method is complicated and most of the time we lose the point. I'm wondering why fig 1 is not mentioned more in the text as I am sure that would help the reader to understand.

I'm curious about the choice of the database used for building the a priori information. What is the reason for not using cloud properties retrieved by CloudSat-CALIPSO? Regarding the final evaluation using CRS radar, I think that the lidar was also available and therefore the combined radar-lidar retrievals would be more accurate for evaluating the performance of the algorithm. Note that the integrated radar backscatter is mainly dominated by large reflectivity so it might be inadequate to characterise the particle assumption; only the largest particles might be represented. I really wonder how these retrievals compare to radar-lidar retrieval in general.

Here are specifics comments. I have tried to be as constructive as possible.

L99 : “A Bayesian pdf is not about how frequently a parameter has a particular value, but instead a pdf specifies how likely the parameter is to have particular values.”, I am not sure I understand what you mean here. Maybe the use of “frequently” is misleading me. L145 “Since optimal . . . substantially underestimated.” I have probably misunderstood but need to use it to estimate errors in your retrieval, is that correct? L 195: “AMSU-B channels”, it would be useful to add a reference.

L 202: “Odin-SMR limb-sounder”, any reference?

L235: “A priori profile information is obtained from CloudSat (Stephens et al. , 2008)

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project files of radar reflectivity, CALIPSO lidar cloud fraction". Don't you think it is a pity not to use the radar-lidar product instead? Furthermore you have at least 3 products with different assumptions and approaches that you could use to build your CDF/EOF. I agree with the fact that IWP will be strongly dominated by the radar measurement but in the radar-lidar common region you should have a better retrieval. L 285 : I know that you give all the details in App B but you could specify the ice particles used in your method in this paragraph.

Section 2:

Please see my global remark concerning the use of radar-lidar data.

L341-342: You could give some references for these products.

L348-349: What do you mean by "interpolated to the layer interfaces"?

L352: I guess you are referring to the clutter contamination? Am I correct?

L358: You mention supercooled droplets - where does this information come from? Could it be detected by the radar? Or does it come from the in-situ data?

L367: You should mention that you use DDA calculation... Once again, I know it is in the appendix.

L377: I don't understand why you don't use the radar mask available in the 2B-GEOPROF product. Actually CloudSat is more sensitive than what you suggest, see publication from Tanelli et al.

L345: Not sure I understand the purpose of Fig 2 (also could you put the x and y axes on the figure, is x axis the latitude, time?), you want to show that you can simulate the clouds not detected by CloudSat? It is difficult to tell whether it works or not as there are no reference values. Maybe you should use the extinction retrieved from the lidar and converted to reflectivity to check if there is a good agreement or not. I know there might be errors in the extinction-reflectivity conversion but it would be a good indicator

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as you are in the Rayleigh regime (low Z).

L444: Which attenuation are you referring to? Attenuation due to ice, liquid, gas? To me Ice attenuation at 94GHz is very small.

L487-488: Are you sure this is mainly a problem in the rain layer? I thought that Battaglia et al. showed that it also happens in convective ice cloud, with a kind of phantom effect in the reflectivity (ie, what you see after a few kilometres below the cloud top is only due multiple scattering).

L516 to 543: I found this paragraph quite difficult to understand.

L576: Fig 6 is quite difficult to interpret. What are the axes for each block?

L579: I think that Dme and IWC are by construction highly correlated (Dme is weighted by IWC).

L582 : " Although there seems to be a lot of information in the covariance matrix, and hence the EOFs, it should be noted that there is only one number to represent the relationship between any two variables, which is a tiny fraction of the information contained in a joint probability distribution." Could you explain the nature of the rest of this information and how you can use it, please? Section 3:

In this section you should refer more to the Fig 1, that could help. I found it very difficult to understand.

L769-782: Why don't you go for an adjoint method instead, then you would need to compute the Jacobian?

L783: Sorry I am a bit confused here., Is it consistent with what you claimed in the introduction regarding the advantage of not using the optimal estimation?

L809: What is the purpose of the Markov Chain Monte Carlo solution Method? What is the link with the previous subsection? Sorry to ask this but it is not very clear to me and I actually needed to reach the conclusion to understand their roles.

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Section 4:

To me this is probably the most interesting part of the paper but unfortunately the least developed.

L898: "When CRS radar reflectivity is input to the retrieval it is averaged to 20 layers from 5 to 15 km and has a multiplicative uncertainty of 0.4 (about 1.5 dB)." Could you explain the multiplicative uncertainty? What is the original vertical sampling of the CRS radar? L932: Do you assimilate radar reflectivity here?

L939: Is there any reason for choosing this value?

L946: It might be due to the fact you are looking at fractional error. If I am correct: $\Delta \ln IWC = (\Delta IWC)/IWC$, so if you increase IWC the relative error decreases.

In fig 7 and 8, maybe you could over plot values retrieved from radar or radar-lidar retrievals. Radar+lidar would give cloud fraction and IWP. Difficult to distinguish the dots from bars. . .

L 996: "a burn in fraction of 0.5" what does it mean?

L1025-1030: Are these values computed in dB or linear scales?

L1046-1048: To me these are very large errors.

Regarding Fig 17, would it be possible to add a panel with the difference between CRS and CoSSIR? A scatter plot of the difference as a function of Z could be interesting to illustrate the comments in the text.

Fig 19 and 20, why do you retrieve IWC where the radar can't detect any cloud above ~13km(see fig 17)? It is not surprising if you only use the microwave but with the radar, this is weird. . . Maybe the vertical scale is wrong. Could you add the y axis please?

L1080: How different is retrieved IWC-Dme relationship from the in-situ (a priori)? You could add a plot to illustrate this.

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Conclusion:

The conclusion is very long and maybe it would be worth reducing the summary.

L1134: I guess it should be "updrafts"

L1199: Maybe a reference here? Are you thinking about TRMM or GPM?

I agree with the authors: liquid is a very challenging task, and I am not sure CloudSat would help if you need profiles, however there are a few techniques which retrieve integrated liquid cloud properties.

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