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Atmospheric Measurement Techniques Discussions

Interactive comment on "Simultaneous retrieval of water vapour and temperature profiles and cirrus clouds properties from measurements of far infrared spectral radiance over the Antarctic Plateau" *by* Gianluca Di Natale et al.

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The article is describing an approach to retrieve water vapor, temperature and cirrus cloud properties from ground based far infrared spectra. This is achieved via a simultaneous retrieval of all parameters via an optimal estimation approach and results are shown for observation at the Antarctic plateau.

General comment: Overall, it is an interesting and ambitious article. Model and retrieval are described well and the reasoning for the approach is understandable. However, the validation part is written poorly: it doesn't explain the selection criteria or show quantitative evaluations. I think the article should be published, but needs to be improved

before. I will try to explain this point by point in the next parts.

Introduction: At first I was surprised, because I didn't consider the far IR a good area for such a retrieval approach. But I got almost convinced otherwise. The authors try it, and point out the sensitivity of the radiance with respect to the effective radius below 667 cm-1. However, they are just showing the scaled optical parameters (Figure 1). Such a sensitivity gets often "buried" in changes of other parameters, like optical thickness, water vapor or temperature can mask the impact of the effective radius. So, instead of a plot like Fig 1, I would like to see a short sensitivity study: for example, how does the radiance spectrum change if you increase the diameter from 20 to 50 mum, compared to a change of 10% in water vapor, temperature, optical thickness, ... I think this would help to convince the reader.

-I like the detailed description of the RTA approach and the retrieval algorithm in the chapters 2 and 3. However, some sentences are pretty long and sometimes difficult to read. If possible, try to split and shorten sentences, it would make everything easier to read. One thing that caught my eye in chapter 3: you speak about your "high resolution of the first layers". However, neither eigenvalue decomposition nor results show a reason to do this. Actually, your results (Figure 8) show a very coarse resolution. Perhaps I misunderstood this, so please try to explain the reasoning for choosing these many layers in the lower atmosphere.

- Chapter 3.1 is a little bit confusing to me. First you speak about a measurement every 12 minutes. That's a lot of measurements. But then you use only 15 selected spectra near to 12 UTC sonde time. Then you speak about 4 selected days. Why only 15 spectra and why these 4 days? Is the spectra selection based on a quality control? Please explain this in more detail. Why are these days so special? They look like selected to show different seasons, but why not equal time distance? I guess there is a reason for this selection, but you have to explain it.

- Chapter 3.2: I don't think it does not belong here, at least not the first part. You just explained the selection of data, so you should go to the results and not back to the theory of the optimization. Honestly, the entire chapter numbering is a little bit confusing. I would more do it this way: 1. Introduction 2. Theory : 2.1 Modelling . . ., 2.2. Retrieval algorithm, 2.3 (your 3.2) Optimization 3. Data selection and Results : 3.1. Selected data, 3.2 Eigenvector decomposition (where you describe Fig 5), 3.3 Results 4. Conclusion

- Another thing about Chapter 3.2 : It has a lot of errors with respect to grammar ("These corresponds . . ."), punctuation or citation brackets. For example: "As shown by (Rodgers, 2000) . . ." should be "As shown by Rodgers (2000) . . .". A few lines later you do it exactly the other way around. Please read this part again and eliminate these errors.

- Chapter 4: Again your 15 spectra are reduced to 4 days without much explanation. Figure 8: why do you show the water vapor on a log scale? I realize, that your "allowed range" is between 1 and 1000 ppmv, but in reality changes or errors in water vapor should be easily shown on a linear scale. Using a log scale is a little bit suspicious. Be honest and give quantitative numbers, like "compared to radio sondes, differences of 100 ppmv - or 50% - are seen at 200 m . . .". You start from a climatological profile, so errors of 50-100% in water vapor are very common and understandable, so nothing to worry about. But it has to be visible and understandable. I cannot decipher anything in these plots. You could also mention things like "it works better for water vapor in summer than winter" or "better for thin optical clouds (tau < 1) than thick clouds." I don't want to judge or condemn your retrieval approach, I want to understand the performance for the different cases and see where it performs best. As I mentioned before, the resolution of these results does not overlap with the promised high resolution of your model. Perhaps I misunderstood the reasoning, so please reiterate here or, why the high resolution in layers is not visible. Figure 9: Ok, I am guessing, that's the 15 selected spectra suddenly. So you have one per day and the 4 special days are just one spectra per day? Would be nice if you could clarify this earlier, when I asked my

question about it. But you write almost nothing about this plot. Just 3 lines about the way it looks. Why should diameter and temperature be correlated? Why are clouds usually thin? OR does your retrieval only work on thin cirrus? You don't mention z or delta-z here. As a rule: if you show something, you have to talk about it. Ok, you mention is shortly suddenly in connection with Fig.10, but that's all. Talk more about it, if you show something.

Overall: talk more in this chapter in a quantitative way. Validation is all about numbers. You are mainly defending the deviation (points 1-3 at page9, lines 20-25), without actually giving quantitative numbers of the deviation. Again, use something like "100 ppmv – or 50 percent - deviation at layer 100 m, in summer, when thick ice clouds present . . ." and THEN give reasons for the deviation. Or point out things like "the retrieval is not able to capture the fine structure at 1000 m on day XY, which is visible in the radio sondes."

- Conclusions: I just say the same again: quantitative numbers. You can give the residuals as a Chi-squared number to show the small residuals. And then you shoot out a few numbers compared to the radio sondes. Also: point out some things that do not work, try to give a reason and how you are planning to solve it. Some outlook is always a nice thing, instead if pretending you made already the perfect retrieval.

Summary of thereview: retrievals are hard to build and they do not perform well all the time. They have caveats, but also advantages – and they are usually never really finished. You are introducing a new retrieval algorithm here, so you are allowed to have a non-perfect retrieval. I know that people are often aiming on the bad cases and take them apart. And I know that's not helping. But you have to risk showing bad performance so that people can evaluate improvements in the future. As I final guideline, I would propose you follow a certain path with respect to this article: A) describe the retrieval, which is actually done very well in this article B) quantify the current performance – with numbers C) evaluate good cases and bad cases, if possible try to find reason for the good or bad cases D) give an outlook, how the certain bad cases could be improved or of you think you reached the limit of your possibilities. If you do this, I don’t see a problem to get through the final review.

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