General Comments:

Please find here my review of 'A variational approach for retrieving ice cloud properties from infrared measurements: application in the context of two IIR validation campaigns' by O. Sourdeval, L. C.- Labonnote, G. Brogniez, O. Jourdan, J. Pelon, and A. Garnier. The authors present an optimal-estimation retrieval scheme for ice cloud properties based upon infrared measurements from the Infrared Imaging Radiometer (IIR) and the airborne CLIMAT-AV radiometer. A key component of this work is a rigorous characterization of expected inversion uncertainties based upon forward model assumptions such as ice crystal shape or atmospheric profile. They find general good agreement in retrieved cloud properties form their algorithm when applied to IIR and CLIMAT-AV observations. And they find reasonable agreement between their algorithm and the operational IIR cloud product. As expected, retrievals of cloud optical depth seem better behaved than retrievals of particle size. Comparison of retrieval results with in-situ data finds general agreement, although uncertainties in retrieved particle size for both techniques are very large.

Overall, I think the paper is a nice, technical example of the application of the optimal-estimation retrieval technique to estimate cloud properties. I very much appreciated the concerted attempt to quantify the impact of forward model uncertainties on estimated cloud properties and their uncertainties. On the slightly negative side, none of their major conclusions are really unexpected for those familiar with infrared radiative transfer and retrieval techniques. And although generally well-written, there were a few issues that certainly need to be addressed, e.g. figure labels/ references and some minor wording problems. Overall, I would happily recommend that the paper be accepted with only minor revisions. Please find my specific and technical comments below. These should be considered as suggestions and not so much as required changes.

Specific Comments:

1: Sensitivities: The finding that retrievals of optical depth are more accurate than those for effective diameter is well known. This fact can be understood simply by examining the sensitivities of the infrared measurements to retrieval parameters (optical depth and effective diameter) such as those presented in a classic split-window arch plot. Optical depth is determined through comparison of observed infrared brightness temperature relative to that of the clear-sky atmosphere. These differences (can be 50K or so dependent upon exact conditions) are much greater than the uncertainties in brightness temperature as found in your uncertainty analysis. In contrast, effective diameter is determined in part through differences in observed infrared brightness temperature values between the infrared wavelengths. These values, of course, depend upon exact atmospheric conditions (but values near 1K-2K are common) and are very much on the order of those suggested from your uncertainty analysis.

I think it might be useful for reader comprehension to spend more time explaining the sensitivities of the infrared channels to your desired cloud parameters. Perhaps include a split-window arch or even two arches generated with different assumptions such as crystal habit. In that way, for example, the reader easily could understand why it is impossible to distinguish between large particles given inherent uncertainties in the retrieval problem. Otherwise, the physical aspect of the problem gets lost in the fog of the variational description and approach of the paper.

2: Motivation: In the introduction, it might help to explain why you think you might get differences in retrieval results from IIR and CLIMAT-AV. You mention that they have nearly identical radiometric signatures and then you invert these signatures using essentially the same retrieval assumptions. Why would we expect to get a different retrieval answer from the two approaches? Likewise, perhaps explain why your retrievals and those from the operational IIR product might differ and why this motivates your work. It just seems the retrieval approaches and assumptions are all highly inter-related and that must have consequences on the significance of your work.

3: Figures: Normally, I suppose this would go in the technical comment section, but my version pretty much had every figure mis-labeled in the text, perhaps a remnant from dissertation form. This should be fixed.

4: Uncertainties Section 3.3: Again, I very much like the discussion of these potential sources of error. It might be useful to discuss the quantitative impact of these uncertainties on forward model simulated brightness temperatures. These could then be compared with expected calibration uncertainties of the instruments. I realize that these uncertainties in Tb depend heavily upon the specific cloud and atmospheric state and that you quantify these uncertainties (in terms of radiance) for one thin cloud test case. But it would be interesting, for example, to see how changes in ice crystal habit impact simulated brightness temperature for thin (tau =0.3) vs. thicker (tau= 3.0) cirrus conditions while keeping all other variables fixed. Likewise, examine other parameters such as atmospheric profile and surface properties. Again, just a suggestion to give the reader a better physical understanding of the problem.

5: Page 3, First full paragraph. You may want to acknowledge here that in-situ estimates of cloud properties have their own large sources of uncertainty (as you discuss in Section 5).

6: Page 20, Line 4. You might want to clarify that to put more retrieval parameters in the vector, you need more independent measurements. Although your work ignored correlations in uncertainties between measurements (fair enough for your application), it is also important to realize that such correlations do exist and they may limit the number of the pieces of information that can be retrieved from a given set of measurements.

Technical Comments:

I have a few technical comments. These generally refer to choices of words that do not seem quite appropriate given my own working understanding of English (I'm an American raised in the upper Midwest). I would make alternate suggestions but I am not 100% sure what the authors are trying to say.

Page 2, Line 16: 'comforts'

Page 12, Line 22: 'short'

Page 17, Line 5: 'led'

Page 17, Line 9: 'sensibility'

Page 25, Line 18: 'a' should be 'A''

Page 32, Line 23: 'comfort'