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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A variational approach for retrieving ice cloud properties from infrared measurements: application in the context of two IIR validation campaigns" *by* O. Sourdeval et al.

Anonymous Referee #1

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General comments

The paper presents a novel approach to retrieval of ice cloud properties in the presence of multi-layer cloud, using measurements from two independent infrared radiometers. Lower level cloud is taken into account in the retrieval of cirrus properties using the co-incident MODIS data at solar wavelengths. Furthermore, the paper presents comparisons between retrievals of De and absorption optical thickness using the two radiometers as well as comparisons against in situ estimates of De. They find that the retrieval uncertainties are within the in situ estimated uncertainties of De. The major advantage of using the optimal estimation method is the assignment of errors to each

retrieved parameter. The authors present a detailed analysis as to how information content can be used to quality control the data. The paper is an important contribution to the field of remote sensing. As it demonstrates the feasibility of retrieving cirrus properties in the presence of multi-layered cloud systems (two layers below the cirrus) using physically-based retrieval methods. It is rare to see such a general methodology being applied to cloudy retrievals, and even rarer to retrievals of multi-level cloud properties.

Recommendation

The paper should certainly be published. The methodology is rigorous and is technically sound, there are no major reasons as to why this paper should not be published. However, there are many minor errors and details missing. Furthermore, also missing are a number of papers that have in addition applied optimal estimation to cloudy retrievals. The Figures 2 and 3 do not appear to be discussed in the main body of the text. The figure numberings for each caption do not relate to the figure number contained in the text. The authors should use the copying proofing service now offered by this journal. However, such minor errors can be easily remedied. Minor suggestions are listed below. However, these have been quickly spotted but there are many others not noted below. I hope the authors find this a useful exercise as it is meant to be helpful.

Minor corrections

1. Abstract – Sentence beginning line 6, please re-write as the flow of the sentence is difficult to read.

2. The word "algorithm" is used; you are not presenting computational logic but rather a methodology so why not just say "a novel methodology. . .." Then go onto to say "the novel methodology is based on optimal estimation. . .."

3. The use of the words "the effective size of their ice crystals. . ." The effective size is

computed over a PSD so it is the effective size of the cirrus case rather than single ice crystals, which the former implies.

4. In the abstract you need to say that shattering could be the reason as to why the retrieved De is larger than the in situ estimated De.

5. The uses of the word “comfort” please replace this word as it conveys the wrong impression, in my opinion. Perhaps “consistent” would be better as the results you are presenting are consistent with your previous findings.

6. Introduction- Liou (1986) is cited, this is quite old there are now a number of other references present more updated reviews. These other reviews should also be cited.

7. Page 3 typo, “early” -> remove.

8. Can you put numbers to the statement “. . .but their albedo-versus-greenhouse effect balance..” (do you mean effect or balance?), what is the uncertainty?

9. Page 3 line 8, the word “new” is misplaced since FIRE took place in 1990.

10. Reduce words line 14, “These campaigns. . .. to fully represent global-scale cirrus. . .”

11. Page 3. A number of instruments are mentioned - line 17 onwards, it would be useful to also include the wavelength range of each instrument.

12. Page 4 line 6, approach-> approach,. . .

13. Page 4 line 10 replace “have been” -> are. . .

14. Page 4 line 16 exposed->discussed. . .

15. Page 4 line 22 space borne -> space-borne and throughout the paper.

16. Page 4, please define FWHM.

17. Page 5, the 2nd sentence is very long, please re-write.

18. Page 5, line 14 Please re-write sentence “For the. . .

19. Page 5, line 18, Biscay Bay -> Bay of Biscay. . 20. Page 5, line 19 remove “in the studies by”

21. Page 6, line 1, at->out

22. Subsection 3.1 title on->of

23. The discussion of various variation schemes. There are missing references here, for instance Watts et al. (1998) [P. D. Watts, C. T. Mutlow, A. J. Baran, A. M. Zavody Study on Cloud properties derived from Meteosat Second Generation Observations EUMETSAT, Final Report ITT no. 97/181, 08.11.1998 http://www.eumetsat.int/en/area2/publications/rep_cloud.pdf] were the first to apply OE to cloudy retrievals, using simultaneously solar and infrared wavelengths on ATSR-2. Moreover, Baran et al. (2003) [Baran AJ, Havemann S, Francis PN, Watts PD. 2003. A consistent set of singlescattering properties for cirrus cloud: tests using radiance measurements from a dual-viewing multi-wavelength satellite-based instrument. J. Quant. Spectrosc. Radiat. Transfer 79–80: 549–567] also applied OE to discriminate between ice crystal models (based on Watts et al. 1998) using measurement residual analysis. Please include these references in this section. Of course ATSR-2 is not part of the A-train but the idea of OE was applied to cloudy retrievals significantly before the advent of the A-train. These contributions should be recognized.

24. Subsection 3.2 page 7 line 12 bought -> provided

25. page 7 ‘measurement (x) and state (y)’ should be measurement (y) and state (x), and is the distribution of errors assumed to be Gaussian?.

26. Please give a reference for definition of De, suggest Mitchell (2002).

27. Page 8, line 2 in->by and check throughout the paper.

28. Subsection 3.3.1 page 11, please include in this sub-section all assumptions such

as plane-parallel and homogeneous layers, each of x thickness.

29. sub-section3.3.2 page 11, plan -> plane and until ->to on line 13.

30. Page 1 line 22 reanalysis -> re-analysis

31. Subsection 3.3.3 page 12 line 4 can the thickness of the layer be quantified?

32. page 13 line 6 spheroid->spheroids

33. Page 13 Dubuisson et al. (2008) is cited but Baran (2005) demonstrated the same results.

34. Page 13 line 28 Mie-Lorentz -> Lorenz-Mie

35. Page 14 no need for the word 'prospect' on page 14 line 14.

36. Page 14 line 16, exposed->discussed

37. Remove word "perfectly" on page 14 line 18.

38. Hereinafter, as noted above, Figure numbers do not match captions please change accordingly. Figure 4.1 appears to be Figure 1 in the caption since that caption is dated 16 May 2007.

39. Note also that where f is high retrieved De diverge the most. Also, Figure 1d please expand y-axis for points below noise as these are difficult to see as they appear to be close to zero.

40. Another useful quality control is the number of iterations required to minimise the cost function, does this number increase when the cost is high?

41. How do the PDFs look between the instruments, for retrieved De and tau, if data is quality controlled using H and f?

42. Page 15 line 19 lesser->less

43. Page 17 line 6 led->performed

44. The asymptotic behaviour of total optical properties for large ice crystal size was also shown by Baran and Havemann (2000) [Appl. Opt. 39, 5560–5568].

45. Page 17 line 26 When discussing relative channels on channel. . ..please chane "on"-> in and throughout paper.

46. As noted Figures 2 and 3 do not seem to be discussed in the main body of the text.

47. Page 20, line 6 onwards Baran et al. (2003) show how it is possible to discriminate between ice crystal models using optimal estimation theory. Furthermore, Baran and Francis (2004) demonstrate the necessity of combining solar and infrared measurements to discriminate between ice crystal scattering models.

48. Please re-write "it should be reminded.." page 21 line 2.

49. Page 21 line 5 "effectuated"->considered?

50. Page 21 line26 exposed->shown and check use of word throughout the paper.

51. Subsection 4.2 page 22 line 10 on->along

52. Page 24 line 4 missing "the"

53. Page 25 line 3 satisfying->satisfactory please be quantitative are consistent with respect to what uncertainty?

54. Page 28, line 4, evaluated->estimate to be. . .

55. Page 29, please supply a reference for definition of De (equation 11). Moreover, this definition is not the same as used for the space-based retrievals

of De? If so please supply a correction so that comparisons are more meaningful.

56. On page 29 there is some discussion about shattering, is there any evidence in the CPI images of shattered artefacts? you will see small ice crystals in the presence of big ice crystals.

57. Page 30, “measured effective diameters”-> estimated. . .. Since a measurement is absolute and this can never be true for in situ measurements, and throughout the paper. 4 58. Page 30 line 11 “perfectly” all you can say is that they are within the uncertainties but with the in situ estimates being biased to lower values, possibly due to ice crystal shattering. This needs to be re-phrased to be more correct.

59. Page 31, las word “good” you mean again within uncertainties that is all that can be said.

60. Summary, page 32, please re-write first sentence as you state “effective diameter of their ice crystals.”

61. Page 32, line 10 retrievals-> the retrievals

62. line 15, lesser->less

63. line 17 get-> become

64. Line 19 on-> in

65. Line 23 please remove “have also allowed to comfort” and replace with ? are consistent with the results of a previous study. . ..

66. Line 25 please insert comma after in this study,. . .

67. Page 33 line 15 an “or” is used this could be an “and/or” as it could be both.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 5553, 2013.