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Interactive comment on "CLABAUTAIR: a new algorithm for retrieving three-dimensional cloud structure from airborne microphysical measurements" *by* R. Scheirer and S. Schmidt

Anonymous Referee #3

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GENERAL COMMENTS

This paper presents a relatively simple technique to "fill the gaps" between adjacent aircraft runs in cloud, thus simulating a plausible 3D cloud field based on 1D measurements. In a number of places the paper is vague or has insufficient investigation into the possible shortcomings of the method. The method is also likely to be inferior to stochastic methods that are constrained to produce the correct power spectrum and cloud overlap behaviour. However, it is probably rather simpler to implement, so I recommend it to be published subject to revision.

SPECIFIC COMMENTS

1) Title: I'm not sure that the word "retrieving" is appropriate here as in many respects this method is more a "simulation", aiming to provide a realistic cloud field but not necessarily aiming to exactly reproduce the structure of the actual cloud.

2) Motivation of study in first sentence of introduction: this is written as if performing 3D radiative transfer is an end in itself. Surely the point is that we want to know the radiative effects of clouds because of their role in climate; 3D radiative transfer is a means to finding this out, but we need to know the detailed 3D structure of clouds and that is where methods such as yours can play a role.

3) A striking omission from the introduction is mention of active instruments, specifically cloud radar and lidar. These instruments can retrieve time-height cross-sections of microphysical parameters and have been used both to derive statistics on cloud inhomogeneity as well as providing the basis for stochastic cloud-generation algorithms. The authors should reference work such as Evans and Wiscombe (2004, Atmos. Res. 72, 263-289), Hogan and Illingworth (2003, J. Atmos. Sci., 60, 756-767) and Eloranta's Volume Scanning Lidar.

4) The description of the self-similar nature of clouds (lines 9-22 of 8611) is far too vague: by "rather a patchy structure" you really mean "structure on a range of scales", "several length scales" is really "a spectrum of length scales", and "similar behaviour" I think means "self-similar behaviour". "The turbulent spectrum is determined by the state of the atmosphere" is not very meaningful: "state" can mean anything.

5) The weighting expressed by equations 1 and 2 will provide the "most likely" estimate of the value at a particular point, given the measurements at the other points and the known autocorrelation. However, the "most likely" estimate at every point will not produce a very "likely" cloud field in the sense that when there are no observations in the vicinity of a region of the cloud, the simulated cloud field there will be too smooth. A more realistic cloud field would be obtained by introducing structure at small scales

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using some kind of stochastic method. This explains why the simulated fields in Figure 2 are smoother than the input fields. This point needs to be acknowledged in the discussion, since the structure at small scales may be important for radiative transfer.

6) Equations 1 and 2 will mean that the range of values in the simulated cloud field will always be "bracketted" by the maximum and minimum value in the aircraft data, even though the aircraft data constitute only a small number of the initial pixels and so are unlikely to have contain the maximum and minimum of the whole field. The result is that the variance of the simulated field is likely to be somewhat less than that of the actual field, and indeed there is evidence of this comparing the width of the green PDF in Fig 3 with the red and blue PDFs. This point needs to be discussed, as the variance is crucial for determining the albedo and emissivity biases of clouds in GCMs.

7) What is the colour scale used in Figure 2? What is the horizontal size of the domain being shown? What, indeed, is the parameter being plotted?

8) In section 3, is the cloud allowed to evolve in the time taken for an aircraft to sample it, or is a single snapshot used? The overturning (and hence decorrelation) time of stratocumulus is of order 15 minutes, shorter than the time taken for an aircraft to perform the necessary number of runs. While you might be right that this has no meaningful impact on the structure at a particular level, it is crucial to obtaining the right overlap characteristics when the aircraft proceeds to sample the structures at different levels. The overlap is important radiative transfer, and neglecting cloud evolution means that your method will tend to predict the overlap to be much closer to "random" than actually the case; see Hogan and Illingworth (2000, Quart. J. Roy. Meteorol. Soc., 126, 2903-2909) and the 2003 paper mentioned above. The brief discussion at the end of section 5 is not really adequate.

9) The tests of the retrieved cloud structure against the original structure in section 3 are unrevealing: getting cloud fraction or volume tells you very little about the skill of your method. At least a power spectrum comparison should be performed, as in

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Figure 6. My expectation is that the structure at small scales will be noticeably underestimated, for the reasons given in item 5 above. Also there is no mention of vertical structure. Ideally you should estimate the correlation coefficient of the LWC in one layer with that in another, for the original and retrieved fields. This should also be done taking into account the evolution of the cloud while the aircraft is performing its various runs.

10) Section 4: The plots shown of this case are insufficient to demonstrate the skill of the technique with real data. You need to show a retreived LWC field, or perhaps a typical trace of LWC measured during an aircraft compared with an LWC trace extraced from your simulation in a region not close to any aircraft data. Also, why not show a visible satellite image from the same time? The visible AVHRR image from this date shows the stratus field nicely. You should also comment on the fact that stable stratus will tend to be much more homogeneous (and hence easier to model) than unstable stratocumulus.

TECHNICAL COMMENTS

While the paper is generally clear, there are some gramatical slips; the authors might consider asking a native English speaker to proof-read the revised document.

Interactive comment on Atmos. Chem. Phys. Discuss., 4, 8609, 2004.