**Atmospheric
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Discussions**

Interactive
Comment

# *Interactive comment on* "Remote sensing of cloud sides of deep convection: towards a three-dimensional retrieval of cloud particle size profiles" *by* T. Zinner et al.
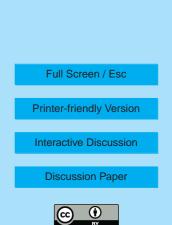
**T. Zinner et al.**

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You had some minor questions on technical issues which we tried to clarify. In addition, you have been critical of some "over-statements" in wording and demanded some more discussion on the limits of our simulations. We tried to consider your legitimate criticisms and added an additional pragraph into the discussions. Thanks a lot for your efforts.

Please find our reply ($->$) following each of your specific remarks:

Specific remarks

1) General: In addition to the vertical cloud size variability, which is mostly driven by

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cloud particle growth processes, there is also some horizontal variability due to local up- and downdrafts as well as due to turbulence. Aircraft measurements of drop size distributions (e.g. Fast FSSP) nicely demonstrate this variability. In order to establish and conclude about a robust relation between cloud and radiance properties, this kind of noisy behavior should be addressed in such a study. The situation is further complicated by the fact that the formulas to derive particle size from water or ice mixing ratios presented in sections 2.2.1 and 2.2.2 are certainly not absolutely perfect. This implies an additional noise that needs to be added to the cloud realizations. I understand that handling 100s of cloud scenarios is not feasible even with modern computer capacities. However, a discussion of the role of noisy cloud microphysical variability on the Bayesian retrieval should be added.

$->$ This is why we added Gaussian noise to each horizontal layer of particle size. Described in Sec. 2.2.1 last paragraph on page 4277. We added a short discussion of possible stronger natural variability into the section "Conclusions".

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2) page 4268, line 25: "controlled" is too strong a word: The major drivers in cloud particle growth are supersaturation and particle number concentration, both in turn driven by updraft velocity. I would say that the aerosol plays a minor role here, and that there is always sufficient background aerosol

$->$ Changed the wording to "strongly influenced".

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3) page 4269, lines 1-4: Again, I think this cloud-aerosol relation is overstated. There are other processes that effect cloud particle size more than the aerosol characteristics. 4) page 4269, line 8: see 2), 3)

$->$ Here we only do cite recent work on this topic (a few of a multitude of papers on the aerosol/cloud interaction). There are certainly other local influences on the particle size

characteristics for specific clouds. Nonetheless many hints have been found recently that on top of all these local impacts there are systematic impacts of aerosol load and type. This is why we propose CLAIM3D to observe and investigate such relations.

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5) page 4269, lines 14-15: Well, the recent IPCC report states that substantial progress has been made in understanding the inter-model differences in equilibrium climate sensitivity. Cloud feedbacks have been confirmed as a primary source of these differences, with low clouds making the largest contribution. So, I would give aerosol-cloud interactions a high uncertainty, but not the highest. There are other more important processes, which trouble the climate change community.

$-$> The IPCC 2007 technical summary lists "... modification of cloud properties by aerosols is not well understood and the magnitudes of associated indirect radiative effects are poorly determined..." first among others in the section "Robust findings and key uncertainties - Changes in Human and Natural Drivers of Climate". Yes, there are others ... so we softened the wording to "one of the fields with highest uncertainty".

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6) page 4270, lines 24-26: Is the Nakajima & King scheme applicable to situations for large optical thickness where even large changes in optical thickness have little effect on the reflected (non-absorbed) radiance. If I remember correctly, the NIR radiance requires a correct estimate of the optical thickness form the VIS measurement to obtain effective radius. Given the high convective clouds and the slant viewing geometry (which imply large effective optical thickness) this may pose a problem in the retrieval.

$-$> Nakajima & King schemes are even more robust once the optical thickness is large, because - as you mentioned correctly - the reflectance in the non-absorbing as in the absorbing channel doesn't change due to optical thickness anymore. That leaves you with the particle size as the only reason for changes in the reflectance in the near-

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infrared, i.e., less ambiguities.

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7) next sentence: "Due to the strong slanted viewing geometry...": Sorry, I don't understand this statement...

$-$ The second result of a Nakajima/King retrieval would be the optical thickness. In our case it is the optical depth of a tilted column, which is not the usual vertically integrated quantity "optical thickness", but a quantity hard to interpret. We tried to clarify that.

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8) chapter 2: Is there no en/de-trainment parameterization in the CRM?

$-$ Yes, there is. Therefore, we do have a lower LWC and IWC close to the cloud edges.

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9) page 4277, lines 9-10: From my understanding of this section you need liquid water content AND particle number concentration to get effective drop radius?

$-$ Yes, correct. As stated in line 15 on page 4276 we do need one "fixed number concentration of cloud condensation nuclei N" to derive the adiabatic droplet size.

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10) Conclusions: In my eyes 13 (x4) clouds is not a "large number of cloud cases"

$-$ From a 3D radiative transport point of view, this is a tremendous number of cases. Sure enough, this is not covering the natural variability. But also compared to the ususal number of forward combinations on which standard 1D radiative transfer retrievals are based, 48 cases providing more than 10ˆ6 possible pixel values of radiance (depending on various combinations of optical thickness, effective radius, and 3D structure) are a large number of realistic combinations.

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11) "Conclusions" -> "Summary & Conclusions"

−> Sorry, this is an issue of ACP style rules. One section with the title "Conclusions" is required.

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12) Appendices: I suggest to replace Appendix A1 with a reference to Emde & Mayer. Hasn't the "solar delta-scaling" (Appendix A2) been described elsewhere, already?

−> It has been described once in Iwabuchi (2006) in widely read English literature, but our implementation is slightly different and for users of our model it is important to document this added feature.

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Interactive comment on Atmos. Chem. Phys. Discuss., 8, 4267, 2008.