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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impact of cloud-borne aerosol representation on aerosol direct and indirect effects" *by* S. J. Ghan and R. C. Easter

Anonymous Referee #4

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General

Ghans and Easters (GE) paper discusses a potentially important challenge when modeling aerosol particles and their first order interactions with clouds and radiation. This challenge is the influence of particles processed by cloud water droplets. Particulate matter can be produced in cloud water droplet (e.g. sulfate) or scavenged by them, before either removed by precipitation or re-suspended after evaporation. A full physical treatment of these processes in the atmosphere requires solving continuity equations for the particulate matter in cloud water droplets, and possibly also in/on cloud ice particles. But this greatly increases the demand on computer resources, both CPU time and memory. Therefore, no climate model at present includes a treatment without considerable simplifications.

GEs global model, based on the former NCAR model CAM2, does include a full treatment. In addition, they define 4 simplifications designed to reflect different levels of sophistication in present and even yet-to-come state of the art aerosol-climate models. Their model is slightly coarser than present models, but this does not influence their conclusions. They also discuss (although without performing any tests to support their believes) the expected influence of a finer resolution.

The effects of cloud droplets on aerosols is one out of several unknowns in the chain of processes from atmospheric particle formation to climate effects. The problem is particularly relevant for the indirect aerosol effect on climate, which is still one of the most uncertain components in the understanding of human influence on climate. The paper is therefore timely, the experiments are intelligent and relevant, and it is generally clear and focused.

I recommend its publication after some minor comments for the authors to consider.

Minor comments

1. It would be helpful for the reader if the paper already from the start separates between: (1) particles presently desolved in cloud water (cloud-borne), (2) particles chemically/physically produced in cloud droplets (e.g. aqueous sulfate) and then suspended after evaporation, and (3) particles having been collected by cloud droplets or activated as CCNs and then re-suspended after evaporation. [Similar types could be defined in connection with cloud ice, which is not discussed in the paper.] This can be helpful in order to avoid confusion, e.g. when interpreting the NOADV-experiments. I believe that advection is neglected only for type (1), but I can not be sure from the text alone.

2. Second sentence in Introduction is particularly hard to read with all its slashes indicating alternatives. This also applies to several of the first paragraphs in the Introduction where sentences and words in brackets are frequently used. Is this a sign of the perfectionist who wishes to account for all strange possibilities in a few sentences,

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at the expense of readability?

3. Im not quite sure why GE uses nudging towards ECMWF analyses for the 3 year period. Frequently, this is done to enable comparison with campaign data or other date-specific observations or retrievals. This is not the case here. They mention natural variability as the reason. If the model aerosols influence physical terms in the model, I understand this. But I had the impression that the aerosol forcing is calculated off-line. If I am wrong, I think a clarifying sentence is needed.

4. On the top of page 4348, it is explained that CPU-time is decomposed into dynamics, physics and the coupling between. It is not clear to me what is included in coupling between. Physics terms influenced by aerosols define effects of aerosols on dynamics, and advection and diffusion define effects of dynamics on aerosols. Hence I am confused.

5. (Important!) Lines 7 and 8 on p. 4349 are a surprise to me. Why are cloud-borne aerosol particles re-suspended when freezing? When droplets evaporates, that's fine, but I need an explanation of the processes responsible for re-suspension when cloud glaciate. GE present this as the main reason why RESUSP has much smaller concentrations of accumulation-mode particles in the mid-troposphere. This is therefore a potentially very important point!

6. My last point concerns the choice of figures. The scatter-plots are quite numerous, yet only column burdens of particles are shown. A similar figure to Fig.3, but a zonal average in a meridional-vertical section, would be interesting to see. I am also eager to see plots analogous to Fig. 6 for different vertical portions (0-2 km; 2-5 km; above 5 km).

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 4341, 2006.

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Interactive Comment