

## ***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 #2**

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This study considers how simplifying a state-of-the art GCM indirect effect parameterization affects aerosol amount, direct and indirect forcings. It finds that the simplifications considered here have relatively small effect on radiative forcing, an interesting result. I recommend the following improvements prior to publication. Most importantly, the manuscript lacks physical explanation for the experiments and their effects on results, making evaluation and application difficult.

1. The experiments need better definition and physical explanation. Do all experiments include both 1st and 2nd indirect effects?
2. How much are clouds (cloud cover, distribution, cloud height) affected by the experiments?

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3. The explanations for the biases of DIAG and RESUSP are not clear. Why is RESUSP removal larger than FULL? Why are the aerosols that have been re-suspended scavenged more readily than those that remain within a cloud over successive time-steps? Is this because the clouds and/or precipitation are affected: RESUSP encourages increased cloud and precipitation? And I am really lacking a physical sense of what DIAG does.

4. Nothing is said about effects on aqueous chemistry. Firstly, is gaseous oxidant uptake into cloud limited to new cloud growth, as AP uptake is? Secondly, one might expect in the RESUSP case that more oxidant would be consumed, are such effects present?

5. Some of the plots tell the same story. Instead of showing some of the similar plots:  
a) A zonal mean similar to Figure 3 could be shown. B) It would be very interesting to bring in some observations. One possibility would be to compare the various model versions with observed sulfate as a function of month at some sites (e.g. IMPROVE or EMEP). Differences at higher latitude sites may be significant. Does the FULL result look best?

6. Section 4. In contrast with the statement in the text, the indirect effect in DIAG differs significantly from FULL, why?

7. Note that since other models have a larger indirect effect than this model, the absolute value of indirect effect variation of such experiments in other models would also be larger.

8. The changes (for RESUSP, DIAG) to indirect forcing are opposite sign to direct forcing. Is this because of cloud changes such as in item 3 above?

9. Conclusion: This study demonstrates relatively small impacts on indirect forcing of some simplifications to the indirect effect treatment. Yet models have a very large range in indirect effect estimates. Can we conclude from this study that the cause of

the large diversity among models is primarily because of differences in model clouds and other model climate components, rather than due to treatment of aerosols and aerosol indirect effect parameterization differences? If so then this seems an important conclusion that should be highlighted.

10. Abstract: State the direction of the biases, within which regions and for which variables?

11. Summary, 2nd sentence. This study spans the range of models used to look at indirect effects, but not direct effects. Many models consider direct effects only and I don't think this study applies to them.

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

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