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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Radiative forcing estimates in coupled climate-chemistry models with emphasis on the role of the temporal variability" *by* C. Déandreis et al.

Anonymous Referee #1

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General comments:

In this paper, the authors examined the effects of temporal variations of sulfate aerosol concentrations on the estimate of sulfate aerosol radiative forcing. Not surprisingly, they showed that, sulfate temporal variability can cause slightly different shortwave flux at the top of the atmosphere (for example, from 240.48 W/m2 to 240.72 W/m2. This is not a large modification, which is in contrast to their claim in the abstract). They further examined several different ways to estimate the radiative forcing of sulfate aerosols in their coupled chemistry/climate model. The paper is written in reasonable well, and the methods and results are documented in detail. However, there are several issues with

this study:

1. The treatments of aerosols and aerosol-cloud interactions in this model are not as sophisticate as it should be, which may affect some conclusions of the current study. For example, only sulfate aerosols are included in the INCA model, while in most next generation of global aerosol-climate models, sulfate aerosols are treated as internally mixed with other primary aerosol species. It is also not clear whether sulfate aerosol size distributions are predicted in the INCA model, but aerosol size distribution are predicted in most next generation aerosol-climate models. The activation parameterization used in this model is an empirical formula, and activated droplet number concentrations depend only on sulfate aerosol mass, but not on sulfate size distributions and on subgrid vertical motion from turbulence. The simple treatment in this study may affect some of their conclusions. For example, if sulfate aerosol mass and number concentrations in both the Aitken and accumulation modes are predicted in the model and used in the activation parameterization, the difference in the shortwave fluxes at the top of the atmosphere between the "MONTH" and "VAR" simulations (section 3.3.3) can be smaller, as the non-linear dependence of activated droplet number concentrations on the accumulation mode sulfate number concentrations should be smaller than that on total sulfate mass.

2. As the aerosol-cloud interaction in this model is treated in a simple way (no cloud life time effects, and droplet number concentrations are directly diagnosed from sulfate aerosol mass), the approach explored in this study is only useful to their particular model and is not applicable to most next generation aerosol-cloud models that solve a prognostic equation for cloud droplet number concentrations, and accounts for other aerosol effects on climate, such as cloud lifetime effects and aerosol effects on ice clouds. Even if you can get the instantaneous PI aerosol field in a PD simulation, it is still not clear how you can calculate the needed PI droplet number concentrations online in a PD simulation for those next generation aerosol-cloud models. As aerosols and clouds are closely coupled in those next generation aerosol-climate models, it is

not practical to estimate the first indirect effects online in my opinion.

Specific comments:

Title: I would suggest to add “of sulfate aerosol’ after “Radiative forcing estimates’, as the paper only focus on the estimate of radiative forcing of sulfate aerosols.

p. 24314, line 10-11: these modifications are not large, as it is 0.20 W m-2 out of 240 W m-2. It is not fair to compare this value to the radiative forcing of sulfate aerosols, as the radiative forcing is the difference between PD and PI simulations. The estimates of the radiative forcing are quite similar for both approaches (see Section 3.1 and 3.2).

p. 24314, lines 16-19: I think the reason is not because of the meteorological trajectories used, but is because of the monthly mean PI aerosol fields are used in the second radiation call (section 4.1). The difference between the ‘extended off-line’ method and the offline method is 0.22 W/m2, which is the close to the difference in the shortwave fluxes at the top of atmosphere between the “MONHT” and “VAR” examined in section 3.3.2. This suggests that the use of monthly vs. instantaneous aerosol fields is the reason.

p. 24318, line 28: the formula of re. As the relationship between effective radius and volume-mean radius are different over ocean and over land, it will be better to use different formulas over land and over ocean (Martin et al., 1994).

p. 24320, section 2.2.2: how is the size distribution of sulfate calculated? Does this model include any new particle formation from aerosol nucleation? How about other aerosol species, such as dust, sea salt? These primary aerosols can affect size distributions, and can affect droplet number concentration and further affect the estimate of the indirect effect of sulfate aerosol.

p. 24324, section 3.3.1: It is not clear to me how the authors keep the meteorological fields exactly the same in the four runs (two MONTH simulations, and two VAR simulations). Does this mean the model run in an offline model, without aerosol effects on

meteorological fields?

p. 24325, lines 24-28, and p. 24326, lines 1-2: As I mentioned above, this results can be model-dependent. If aerosol number concentrations in both the Aiten and accumulation modes are simulated, the non-linear dependence between droplet number concentrations and aerosol fields can be smaller.

p. 24326-24327, section 3.3.3: Again, many discussions in this section regarding the role of sulfate concentrations are likely to be model-dependent too.

p. 24329, lines 14-22: I think the reason is not because of the meterological trajectories used, but is because of the monthly mean PI aerosol fields are used in the second radiation call .The difference between the ‘extended off-line’ method and the offline method is 0.22 W/m2, which is the close to the difference in the shortwave fluxes at the top of atmosphere between the “MONHT” and “VAR” examined in section 3.3.2. This suggests that the use of monthly vs. instantaneous aerosol fields is the main reason.

p. 24330, Section 4.2: Is this reference method the same as the off-line approach in Section 3.2, but it reads aerosol fields every half hour instead of using the monthly data?

p. 24332, lines 1-2: here the authors provide the correct explanation why the ‘extended off-line mehod’ gives a quite different estimate compared to the offline method. The explanation in the abstract (p. 24313, lines 16-17) and in section 4.1 (p. 24329, line 14-22) are not accurate.

p. 24333, section 4.4: in this approach, you will have to finish PD and PI simulations first to calculate “preindustrial aerosol fraction”, and then rerun the PD simulations.

Fig. 1: In the new approach (solid), cloud droplet number concentrations are quite low even at very high sulfate concentration. Is simulated droplet number concentrations compared with observations?

Fig. 4: Why is the 1st indirect forcing positive over some regions?

Technical corrections:

p. 24321, line 4: ‘conentrations’ → ‘concentration’?

p. 24326, line 7: ‘the same pattern than” → “ the same pattern as”?

p. 24332, line 20: ‘higher that’ →’higher than’?

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 24313, 2011.