

Interactive comment on “Indirect radiative forcing by ion-mediated nucleation of aerosol” by F. Yu et al.

Anonymous Referee #1

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This manuscript evaluates the model-predicted aerosol, cloud and radiative-forcing changes between a binary homogeneous nucleation (BHN) scheme and a “binary” ion-mediated nucleation (IMN) scheme. The model used is the CAM5 global climate model with online modal aerosol microphysics. The authors find a large change in the properties, particularly the cloud radiative forcings. The authors claim this to be the sensitivity of the model to ionization vs. no ionization.

The manuscript has major issues that must be addressed before it is publishable. I cannot recommend that it be published in its current state.

Major comments

- While the CLOUD results in Kirkby et al. (2011) show a strong response of nucle-

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ation rates to ion formation rates in the absence of ternary species and the presence of ammonia, new CLOUD results show that the importance of ions on nucleation diminishes in the presence of many organics, and that continental BL nucleation rates cannot be reproduced without these organics. Since in previous studies, this IMN nucleation scheme used in this paper has been shown to generally predict the right order-of-magnitude for nucleation rates, and this IMN nucleation does not account for ammonia and organics, it must be getting the nucleations rates approximately right but for the wrong reasons. Furthermore, since the importance of ions is diminished in the presence of ammonia and organics, the BHN baseline for the ion-free atmosphere will strongly underpredict nucleation. While there is a mention of the importance of these ternary species in the conclusions section and a mention that the results might change, the bulk of the paper frames the results as “the effect of ions on nucleation, CCN and clouds”, while the results here are a clear overestimate of this effect.

- Why is the a solar modulation in ion formation rates not included here? It says that it is being saved for future work, but the current paper is extremely thin (1 table, 2 figures and only 2 simulations in an ACPD paper). There is really no good reason why ion-formation perturbation runs shouldn't be included here. I'd feel this comparison may be somewhat better represented by the model than the present comparison since the BHN lower limit is unrealistically low for simulations without ions (see above), and the IMN scheme generally predicts ok nucleation rates (at least when its in the GEOS-Chem model). This paper would be far more complete and informative if it included these simulations.

- As far as I know, this is the first time that the IMN scheme has been tested in the CAM model with the MAM3 microphysics scheme. This is a very different scheme than the IMN scheme in GEOS-Chem with APM (which includes a large number of size bins for the growing nucleated particles). Please add evaluation of CN and CCN concentrations.

- I am very concerned that there is no nucleation mode in MAM3 and that Kerminen

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and Kulmala is used for growth all the way until the Aitken mode. What upper diameter is used in Kerminen and Kulmala in this work? This may lead to large errors since Kerminen and Kulmala assumes that the current growth and coagulation conditions are constant and instantly grows the particles to the upper size. Nucleation rates positively correlate with high growth rates and lower coagulation sinks, and growth rates are likely to decrease and coagulation rates are likely to increase while growing to larger sizes. Thus, instant growth to sizes larger than a few nm will lead to an overprediction in the number of nucleated particles that survive growth to these larger sizes. Please add some evaluation of this bias or add a nucleation mode.

Specific comments

page 17351 line 2: "coagulation (Aitken and accumulation modes)". Do these modes not coagulate with the coarse mode? Ignoring coarse-mode self coagulation is probably fine, but ignoring coagulation losses of the smaller particles with the coarse mode will lead to an overprediction in the probability of a nucleated particles growing to a CCN size.

Page 17351 line 6: You describe cloud-droplet activation, but what about cloud microphysics? One of your outputs in the paper is precipitation, so the treatment of cloud microphysics is extremely important. Is this 1- or 2-moment microphysics? How is autoconversion treated? How are the treatments of warm and cold clouds different. Do CCN directly affect cold cloud microphysics?

Page 17352 line 1: I agree that there are uncertainties in primary sulfate and in how ions might affect the number particles from sub-grid nucleation. However, omitting primary sulfate reduces the number of CN, which makes your CCN more sensitive to regional nucleation. This needs to be discussed.

Page 17354 line 3: why is there a supplement with 1 figure and 1 paragraph? The paper is currently very short, just put this figure and text in the paper.

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Page 17355 line 13: What does "~116%" represent here? This doesn't seem to be smaller than 45%. Also, I think you meant to say "is expected to BE relatively smaller".

Page 17355 line 17: "which dominate precipitations." Total precipitation volume amount? Precipitation rates? Precipitation frequency?

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 17347, 2012.

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