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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Droplet number prediction uncertainties from CCN: an integrated assessment using observations and a global adjoint model" *by* R. H. Moore et al.

Anonymous Referee #1

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General remarks

Moore et al. present a study on the sensitivity of cloud droplet number concentrations and albedo to aerosol number concentrations. For this, the authors loosely couple results from closure studies based on measurements and results from a global chemistry transport model. The topic is very relevant, and well suited for Atmos. Chem. Phys. The study is well written. There are, however, several points which need substantial further work before this study should be published.

(1) Literature: The authors seem not to be aware of the very large body of studies on the topic in the recent literature. They fail to discuss at all the manifold works around

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ground-based and satellite remote sensing. As a start, I suggest the authors read and discuss the recent overview studies on the term dln N_d / dln N_a by McComiskey and Feingold (Atmos. Chem. Phys. 2012; doi:10.5194/acp-12-1031-2012) and Nakajima and Schulz (What do we know about large-scale changes of aerosols, clouds, and the radiation budget? in Clouds and the Perturbed Climate System. Ernst Strüngmann Forum, edited by J. Heintzenberg and R. J. Charlson, ISBN 978-0-262-01287-4, MIT press, Cambridge, 2009.). On the albedo susceptibility, I suggest e.g., the studies by Bellouin et al. (Atmos. Chem. Phys. Discuss., 2012; http://www.atmos-chem-phys-discuss.net/12/20073/2012/acpd-12-20073-2012-discussion.html), Oreopoulos et al. (J. Geophys. Res. 2008, doi 10.1029/2007JD009655) or Quaas et al. (J. Geophys. Res. 2008; doi 10.1029/2007JD008962).

(2) The model evaluation at the sites (Table 3) is far too superficial. So far, these results are in bulk qualified "reasonably" good. Firstly, the numbers need to be made comparable, and secondly, a thorough quantitative evaluation is necessary. From the numbers provided, the usefulness of the model may be questioned at least at stations 3, 7, 12, 19, 20, 21, 29, 33.

(3) The uncertainties in their study needs discussion. So far, just one simulation is conducted with two globally constant values of the updraft for land and ocean, respectively. How sensitive are the result to this oversimplification? The model uses the simulated size distributions and chemical compositions to compute Na at each time step and grid-point. Also for this quantity, large sensitivity of the results is expected.

(4) The cloud albedo definition seems wrong, or at least the authors need to justify why they believe that Twomey's formula (their eq. 1) should apply to their unconventional definition.

Minor comments

The term "normalised sensitivity" (e.g., ∂N_d/∂N_a / (N_d/N_a)) is unusual. One would rather call this relative or logarithmic sensitivity (∂ln N_d / ∂ln N_a).

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l13: units?

l19: The qualification “reasonably well” needs quantitative corroboration. As it stands, the comparison to the in situ observations appears almost useless.

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l22: The difference between all-sky and clear-sky albedo is not the cloud albedo. The quantity the authors compute is the cloud radiative effect normalised by the incident radiation. For cloud fraction f, in a grid box, the all-sky albedo is the weighted sum of the cloud- and clear-sky-albedo:

A_all-sky = f A_cloud + (1 – f) A_clear

→ A_cloud = (A_all-sky – A_clear) / f + A_clear

As correctly stated in l26, nevertheless the quantity is useful, it is just unconventional and thus more difficult to interpret.

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l3: It is important to note that this definition of cloud albedo is different from the one discussed above.

l9: Nd to be used in Eq. 1 in this approach is from the simulation, I assume?

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l3: Why “overprediction uncertainty” and not just “overprediction”?

Tab. 2: How are the uncertainty ranges defined?

Tab. 3: This table should show the simulated CCN range for the observed s range. It should also list smax.

Caption: Albedo sensitivity should read $\partial A/\partial Na$. Means are provided only for the

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model, and standard deviations, only for the multi-station results. The data source for the satellite albedo should be stated. Why is this also only a mean value?

Fig. 1: Which level is shown?

Fig. 2: How are the data sampled? Is this one time step globally, or several timesteps for a specific region?

Fig. 3: It would be useful to show the term ∂A/∂N_d.

Fig. 4: Also the intermediate term, ∂ln N_d /∂ln N_a should be shown. Why can coloured regions in the left and right columns differ?

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