Atmos. Chem. Phys. Discuss., 12, C10088–C10091, 2012
www.atmos-chem-phys-discuss.net/12/C10088/2012/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Cloud condensation nuclei production associated with atmospheric nucleation: a synthesis based on existing literature and new results" *by* V.-M. Kerminen et al.

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Received and published: 4 December 2012

We would like to thank the reviewer for the positive and constructive comments. Below we have added our response separately after each detailed referee comment.

This paper reviews current understanding of the role of atmospheric new particle formation (nucleation) in the creation of cloud condensation nuclei. The paper is a fairly comprehensive review of relevant work and will be a useful resource for the community. The paper is clearly written. I recommend publication after the following minor details are dealt with.

Minor Comments

P22143, L16-L18. It is maybe worth being more careful with definitions of primary and secondary particles here. Some of the "primary particles" discussed in Adams and Seinfeld (2003) are largely the result of nucleation at small spatial scales (e.g. within anthropogenic pollution plumes). You refer to this issue of definition later in the manuscript (P22161, L2 and P22168, L2-5). But I think it might be worth clarifying here.

Our response: We fully agree with the reviewer. We have modified the end of section 1 essentially by adding the following paragraph into there:

"Before starting our analysis, it is worth keeping in mind that, in a broad sense, atmospheric CCN production can be thought to originate from three different sources: i) those resulting from "regional nucleation" taking place in the atmosphere, ii) those resulting from nucleation taking place in the immediate vicinity of localized sources like power plants or cloud outflow regions, and iii) those resulting from the atmospheric processing of primary aerosol particles that are originally too small to act as CCN. Current large-scale models have major problems in capturing the second of these source categories, usually counting those particles as primary CCN. Partly because of this, we will constrain our analysis to the first of the above source categories, but discuss also briefly the second source category in sections 3.1 and 5.2. CCN resulting from the atmospheric processing of small primary aerosol particles, while extremely important as well (e.g. Adams and Seinfeld, 2003; Luo and Yu, 2011a), will not be considered here."

P22162. Is there a reason that you only review regional model simulations, and do not review global model simulations? I think such a review would be useful here. However, the manuscript is already extensive and I leave it up to the authors as to whether they would like to include.

Our response: We do actually review both global and regional model simulations, but in slightly different ways. In case of regional simulations, we present a very short review

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and supplement that we some new results (section 4.2). In case of global simulations (which are more numerous than regional ones), we summarize the general findings without discussing individual studies separately (paragraphs 3-5 in section 4.1). The radiative forcing associated with nucleation and resulting CCN production based on global model simulations is reviewed in section 4.3, and this is done separately for each study available.

P22165, L6-L16. Please clarify whether these are all aerosol radiative forcings (present day compared to pre-industrial).

Our response: All the estimates mentioned in these lines are indeed radiative forcings. To clarify this, we have changed the text "radiative forcing" on page 22165 (line 4) into "radiative forcing (present day compared to pre-industrial)".

P22617. It might be worth noting studies such as Reddington et al. (2011) who used non-volatile aerosol number as an indication of primary particles.

Our response: We agree. We modified the paragraph discussing this issue into the following form:

"The field studies published so far have had limited capabilities in differentiating between primary and secondary CCN, which prevents us from making any quantitative estimates on the contribution of atmospheric nucleation to regional CCN budgets. In order to improve the situation, more versatile measurements of atmospheric CCN production are clearly needed. The simplest way to do this is to measure aerosol volatility and use the non-volatile aerosol number as an indication of primary particles (e.g. Reddington et al., 2011). A more ideal approach is to measure simultaneously the particle number size distribution down to a few nm and preferably below 3 nm diameter, CCN spectrum, aerosol chemical composition and mixing state, concentrations of the main aerosol pre-cursor vapors, and main meteorological variables. Vertically-resolved information on these quantities would be highly beneficial as well. In addition to this, we should develop further the methods by which atmospheric CCN production is being

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analyzed based on field measurements."

P22169, L9-L11. I missed your review of the literature on nucleation and direct aerosol effect? Please add a short summary of these studies.

Our response: We are not aware of studies that have given a quantitative estimate of direct forcing resulting from atmospheric nucleation. However, a recent model study by Yu et al. (2012, ACP, 12, 5719) suggests that secondary particles originating from nucleation may be a major contributor to AOD and thus this topic clearly merits further research. We modified the text in the first paragraph of section 5.4 as follows. "... The available studies agree in general that the direct radiative perturbation resulting from atmospheric nucleation is minor, both locally and in the global atmosphere. This topic may, however, merit some further research in light of the recent results (Yu et al., 2012). The indirect radiative perturbation caused by atmospheric nucleation may be quite significant, especially under clean or moderately-polluted conditions, but the associated uncertainties are too large for drawing any definite conclusions at the moment."

P22141, L20. Change "the future" to "future"

Our response: Corrected.

P22153, L25. Change "forests" to "forest"

Our response: Corrected.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 22139, 2012.