

## General comments

The authors have conducted CCN measurements in China, nearby Beijing, during three consecutive weeks in 2009 and 2010. The authors have used a CCN counter with two columns to measure total CCN concentrations, total CCN activation efficiency and size-resolved CCN efficiency. A closure study comparing the results derived from the two columns was performed along with sensitivity studies showing that the size distribution is more important in predicting the CCN concentrations compared to the size-resolved activation efficiency (which reflects the chemistry and mixing state of the aerosol). The study provides new information on CCN characteristics in a relative polluted region, and meets the criteria required for publication in Atmospheric Chemistry and Physics. Before publication, the following relatively minor comments need to be considered.

## Major issues

1. Presenting some additional results would shed more light into the activation behaviour of the sampled aerosol. First, please provide time series for the bulk (absolute) CCN and CN concentrations for the measurement period. Second, it would be interesting to see a comparison between  $D_m$  and the so-called  $D_{50}$  diameter, i.e. the diameter at which the activation efficiency is 50%. Finally, using the inferred  $D_{50}$  diameters and modeling the activation behaviour with a step function, the CCN concentrations could be recalculated and compared to calculations based on Eq. 2.
2. The usage of English in the manuscript. The manuscript contains several grammatically incorrect and unclear expressions. Some of the language issues are pointed out below but, if possible, a native English speaker should proof-read the manuscript to improve the language and overall flow of the text.
3. The description of methodology for calculation CCN concentrations in Section 2 needs some revisions. Related to this, the usage of the symbol  $N_{CCN}$  is not consistent in the manuscript: please use e.g. different subscripts to differentiate between  $N_{CCN}$  calculated under different assumptions. See specific comments below.

## Specific comments

1. Page 1, lines 26-28. Please report representative values (median or mean, for example) for the inferred cut-off diameters instead of making a qualitative statement only.
2. Page 2, lines 6-8. The last sentence of the paragraph should be removed because it refers solely to the results of another study that has not been yet published.
3. Page 2, lines 14-15. Please clarify the last sentence of the paragraph, for example as follows: “The  $N_{CCN}$  can be reliably estimated using time-averaged, size-resolved activation efficiencies without accounting for the temporal variations.”
4. Page 2, lines 21-23. The sentence starting with “Comparison of the...” needs rewording, for example as follows: “Closure studies where measured and predicted CCN concentrations are compared provide a test for quantitative understanding of CCN activation properties, and to parameterization schemes used in large-scale models in particular.”
5. Page 2, lines 27-29, second and third sentences of the paragraph. These sentences need also rewording. If I understood right, the authors want to express the fact that measurements of aerosol size distribution and chemical composition can be used to predict CCN concentrations reliably. There is no need to use vague and too general expression “...are the two most important aerosol properties that can be measured...”. Please re-word the sentences so that the underlying thought becomes clear.
6. Page 2, lines 30-31. Please explain the concepts PM1 and PM10. Also, please do not use expression “such” here because it is not clear to which word it refers to in this sentence.
7. Page 3, lines 5-6, first sentence of the paragraph. I disagree with the notion that measurements of chemical composition would be necessarily time-consuming (take AMS studies, for example) but detailed chemical analysis of compounds present in the aerosol phase certainly is. Please explain in more detailed fashion why direct measurements of CCN activation properties are needed. Also, in its

- current form, the sentence structure should be changed so that the sentence starts with the clause "Direct and detailed measurement techniques...".
8. Page 3, lines 14-21. The contents of this paragraph overlap partially with those of the second paragraph of Introduction. Please check and correct this.
  9. Page 3, lines 20-21. Please explain the concept of mixing state.
  10. Pages 3-4, lines 30-32 and 1-4, respectively. The authors should consider of omitting this paragraph because, in my opinion, it does not contain any useful information that is relevant for this study. After all, the authors investigate CCN activation properties of ambient aerosol, not cloud formation or cloud microphysics.
  11. Section 2, pages 4 and 5. I recommend slight re-organization and some re-writing to make the section more accessible. First, the second paragraph is not needed as equations (1) and (2) can be used without the Koehler theory. Also, the critical supersaturation is not (necessarily) determined by Koehler theory and not even by size and composition alone, because e.g. particle morphology may play a role as well. Second, I'd split the section into two sub-sections so that the cases with internal (fourth paragraph) and external (fifth and sixth paragraphs) are in separate sections. Third, using the critical dry diameter of NaCl particles to illustrate the minimum diameter needed for activation is problematic because, in principle, it is possible that the atmosphere contain substances which are even more hygroscopic than NaCl and/or depress the droplet surface tension so that the corresponding particles are even more CCN active than NaCl particles. Instead, the authors could introduce, for example, an operationally defined diameter  $D_{\min}$  which is the minimum diameter needed for activation (within the experimental uncertainties).
  12. Section 2, pages 4 and 5. Please use the  $N_{\text{CCN,Cal}}$  consistently when presenting the calculations based on equation (2) in the manuscript. Also,  $N_{\text{CCN}}$  is now defined twice: through equation (1) and eq. (5). Please correct this.
  13. Page 5, lines 29-30. Would "has been undergoing" be the right expression instead of "underwent"? Also, "has been causing", not "caused"?
  14. Page 5, line 30. "Pollution episodes", not "pollutions"? Are there any studies or documents to support the statement? Please refer, if available.

15. Page 6, lines 4 and 5. Should be: “The field study... WAS carried out...”. Also, “...focusing on aerosol CCN and optical properties...”, for example.
16. Section 3.1, pages 5 and 6. Please provide a more detailed description of the immediate surroundings of the measurement site and on the local meteorological conditions.
17. Section 3.2, page 7, lines 11-12. Please provide a reference for the applied form of the Koehler equation.
18. Section 4.1, page 8. Please insert a figure showing the time series of CN and bulk CCN concentrations.
19. Section 4.1, page 8, lines 12-13. The authors claim that the  $N_{CCN}$  depended on the meteorology during the measurement without giving any evidence. Do the authors have any evidence to substantiate this claim? I’d recommend that the authors elaborate further the connection between  $N_{CCN}$  and meteorology.
20. Section 4.1, page 8, lines 28-30. Please provide explicit calculations for the error introduced in  $N_{CCN}$  when using a fixed  $D_m$  at various supersaturations.
21. Section 4.2, page 9, line 3. “shows” instead of “is”.
22. Section 4.2, page 9, lines 4-9. The two sentences are irrelevant in this context and the topic is also covered in Section 2. Please remove the overlap.
23. Section 4.2, page 9, lines 13 and 14. In this sentence, three diameters are given but only two supersaturations are mentioned. Please correct.
24. Section 4.2, page 9, third and fourth paragraphs. The discussion regarding the results presented in Figure 6 could be extended by reporting the diameter at which the activation efficiency is 50%,  $D_{50}$ , for different supersaturations. Also, it would be interesting to see how well  $D_{50}$  compares with  $D_m$ .
25. Section 4.2, page 9, line 17. “shows” instead of “is”.
26. Section 4.2, page 9, line 22. “...activate at all measured supersaturations.”, instead of “...are activated at all of the measured...”
27. Section 4.2, page 9, lines 24-26. Please insert “, respectively” to the end of the sentence.
28. Section 4.3, I’d split the section into two subsections so that the last five paragraphs would form a subsection that deals with the sensitivity studies.

29. Section 4.3, page 10, line 18. “showed”, not “shows”.
30. Section 4.3, page 10, third and fourth paragraphs. Please describe the fitting it in a more detailed fashion. The sentence starting with “If an activation curve is measured...” is vague, please clarify.
31. Page 10. Only two equations are presented before Eq. 5 so it should be Eq. 3.
32. Page 11, line 2. “measurements”, not “measurement”.
33. Page 11, lines 22-28. The description of the sensitivity cases needs to be clarified. At least, provide explicit equations showing how the CCN concentrations are calculated in the three sensitivity studies described in this paragraph.
34. Page 12, lines 7 and 8. Please clarify the sentence starting with “The calculated  $N_{CCN}$  for each supersaturation,...”.
35. Page 12, line 12. Please insert “...,respectively” to the end of the sentence.
36. Page 12, line 28. “Provide”, not “gain”.
37. Page 13, lines 8-23. This paragraph does not summarize the results of the study but could be classified under the title “Discussion”. Therefore, re-organize the section and add a separate section for discussion.
38. Page 13, lines 9 and 10. The sentence “The cloud property...” contains vague expressions such as “The cloud property”, “thermodynamic processes”, and “microphysical processes”. Please clarify.
39. Page 13, lines 29-30. How the soluble fraction was calculated? Please describe the method briefly.
40. Page 13, lines 31-32. Please provide evidence for this claim.
41. Page 13, lines 13-21. Please express the finding that the variation in the size-resolved activation ratio did not have large impact on  $N_{CCN}$  in a more condensed manner. In particular, the sentence starting with “The activation ability of aerosol...” is not relevant in this context.
42. Page 14, lines 18-19. The sentence starting with “This average activation property...” contains vague expressions (“average activation property” and “well predicted aerosol size distribution”). Please revise.
43. Table 1, text. Add word “particles” to the end of the sentence.