

Interactive comment on “A simplified treatment of surfactant effects on cloud drop activation” by T. Raatikainen and A. Laaksonen

Anonymous Referee #2

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This manuscript addresses an important problem in cloud microphysics, namely how surface active molecules affect the cloud droplet activation of atmospheric particles.

It is known that partitioning of the surface active molecules between the surface and the interior of activating cloud droplets depend on droplet size and must be accounted for when predicting critical supersaturation and droplet size at activation. Until now this problem has involved numerical solution of a set of non-linear equations. This is computationally demanding and has only been done for relatively simple systems. This manuscript aims at presenting analytical equations for surfactant partitioning which are more practical for large scale applications.

The authors are experts on this topic and the manuscript presents interesting results and is timely and relevant.

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My main concern with this manuscript is that it is somewhat difficult to follow and unclear in many places. It relies on the reader being highly familiar with the topic. This is unfortunate since the topic and the results presented merit to be understood by a wider audience. I recommend that the manuscript is published when the text has been revised and the issues below addressed. In particular, the authors should be much more careful in keeping indices throughout the text, deriving the equations in more detail and explaining carefully the meaning of all symbols used and the units of the physical quantities. I hope the comments below will be helpful in improving the manuscript.

Page 1131, lines 10-17. “...However even if the models agree on this aspect” – this is difficult to follow – I assume it means that even if the same critical supersaturation is obtained by accounting for surface tension lowering and surfactant partitioning or ignoring surface tension lowering and using the surface tension of water these two approaches can result in different critical droplet sizes. It should be written what is meant with droplet solution concentration (bulk concentration at activation?)

It is mentioned both in the abstract and in the introduction that it is a problem to solve “a set of non-linear equations” with numerical methods – this set of equations should be written early in the text so that it is clear to the reader which equations are referred to and what the assumptions involved are.

Page 1142 line: “Both conditions” it is not clear from the text what the conditions are and what they are conditions for.

It is slightly confusing that n_{Tw} is called “molar concentration” when it has the unit [moles]. Normally, the unit for a concentration includes volume-1. At least it should be written that n_{Tw} is the total number of moles of water in the droplet.

Page 1142 line 18: I suggest to write: “The total number of moles of solute in the droplet can be calculated ...” instead of “Total molar concentrations of solutes ...”.

Page 1142 line 19: Why is the dry volume fraction of solutes introduced here and never

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used again?

Page 1142: the term “droplet total concentrations” may sound like the number of droplets per volume of air. I suggest rephrasing this sentence - it means the number of moles of solute per volume of water in the droplet I think.

Page 1143: line 12: I suggest to write “critical droplet diameter” not to confuse with the dry particle diameter which activates at a given supersaturation.

Page 1143: line 14: The sentence: “As described above, the total number concentrations of the droplet species can be calculated from input parameters” should be rewritten: define what is meant by total number concentration of the droplet species, also write specifically which input parameters are referred to.

Page 1144, it should be written what the unit for c_{Bi}

Page 1144: write in words what VS is.

Page 1144: In the equation on line 23 – it is unclear if the sum includes water (compare the equation in line 19).

Page 1145: line 12: To help the reader it should be explained why the condition (Laaksonen et al. 1999) does not hold here. On the previous page this equation was written as an assumption. The text is somewhat confusing and should be made clearer.

Page 1145 line 21: explain what is c_0 ? Should the equation have the indices S ? Equation 4: B superscript is missing?

Why is the word “concentration” used for the volume of the droplet (c_0)?

Page 1147 The use (or lack) of the indices can cause confusion. It was said before that i is reserved for the surfactant and j for the non-surfactant. It should be explained better what the common ions are. Why is the index removed – there could still be more than one type of surfactant in the system?

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Explain what v_+ and v_- is even if it might seem obvious.

Equation 9: Explain why only the positive solution is acceptable.

Page 1147, line 13-14: The sentence “one of the common ion concentrations represented by $n_+(\text{mol})$ and $n_-(\text{mol})$ is zero” should be explained better.

Equation 11: I might be wrong, but is there not a cross term including $1/n_B$ missing in the denominator?

The first sentence in the Model comparison section is a bit confusing – “we use iterative methods to test our analytical partitioning equations” – is it not a comparison?. The authors should write explicitly the equations to be solved in the analytical approach and in the numerical approach for multicomponent systems and what the assumptions are - maybe it could even be put in a table.

Page 1150: surfactant concentration is directly proportional to number concentration: the units should be given here.

It should be explained what “all hybrids” mean in more detail.

Page 1151 line 10, Explain what is meant with “critical droplet surface tension” – I assume it is the surface tension at activation?

Page 1151 line 19: please give a short summary of the conditions needed here.

Page 1151 line 23-35: explain why the finding of similar model results is not generally valid. The statement “it seems that in this case NaCl has quite small effect” should also be explained.

In the conclusion it is stated that the computer time needed for the calculation of droplet concentrations are reduced by an order of magnitude using the equations presented in this work compared to what has been used previously. This has not been addressed in the main text and no examples of computer times for specific calculations have been given, I suggest this is done.

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Minor

Abstract Lines10-12: I suggest to reformulate: "can be solved" -> "have so far been solved numerically from a group of equations"

Page 1142, line 12: "the" missing after "Here,"

Last line page 1145: delete "by": We apply the well known . . ."

Interactive comment on Geosci. Model Dev. Discuss., 3, 1139, 2010.