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**Geoscientific
Model Development
Discussions**

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

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We would like to thank Referee #2 for constructive comments. In general, we will add more details to the text and also clarify our notations. Responses to the comments are below.

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?)

We will clarify this part of the text.

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.

Only the Gibbs adsorption equation and a surface tension model are needed, which will be mentioned in the text. The rest depends on assumptions and simplifications. Even for our simple case with three different approximations, there are 12 combinations of model assumptions. Therefore, a detailed explanation is not possible at this point. We will clarify the complex nature of the partitioning calculations in the specific parts of the text where model assumptions are mentioned.

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

The important conditions for bulk-surface partitioning are small droplet size and dilute solutions. This will be clarified.

It is slightly confusing that nTw 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 nTw is the total number of moles of water in the droplet.

We will change the term 'molar concentration' to 'total number of moles'.

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. . ."

Will be corrected.

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

The symbol ξ will be removed.

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.

It means total numbers of moles of water and solutes in the droplet. We will clarify this.

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.

Word "droplet" will be added.

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.

We will rewrite this sentence.

Page 1144, it should be written what the unit for cBi

The unit of c_i^B is not fixed. We will explain this in the text.

Page 1144: write in words what VS is.

It will be written that V^S is volume of the surface.

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

It will be mentioned that subscript i includes all species.

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.

In the simplified equations, where only the surfactant partitions (here subscript sft means surfactant), surface volume calculated as $V^S = \sum n_i^S v_i = n_{sft}^S v_{sft}$ can not go to zero unless n_{sft}^S is zero. We will clarify this part of the text.

Page 1145 line 21: explain what is c0? Should the equation have the indices S?

c^0 will be explained. The equation is needed for the bulk solution only, so superscript S is not used.

Equation 4: B superscript is missing?

Superscript B will be added.

Why is the word "concentration" used for the volume of the droplet (c0)?

We will clarify our use of the term "concentration " and the meaning of c^0.

Page 1147 The use (or lack) of the indices can course 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?

Indexes are not needed, because there is only one surfactant. The usage of indexes and the common ions will be explained in the text. As mentioned in the replies to Referee #1, extensions to mixed surfactant solutions are possible when certain approximations are made. This will be explained later in the text.

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

It will be mentioned that ν_+ and ν_- are dissociation factors of the surfactant.

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

It will be mentioned that negative bulk solution concentrations are unphysical.

Page 1147, line 13-14: The sentence "one of the common ion concentrations represented by n+(mol) and n-(mol) is zero" should be explained better.

This will be explained.

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

Eq. 11 seems to be correct. Dimensions would not match in the case of 1/nB term.

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 multicomponet systems and what the assumptions are - maybe it could even be put in a table.

We will clarify this section. The iterative model model is described in Appendix A and the assumptions needed for deriving the analytical expressions are described in Sect. 2.2.1, which will be clarified.

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

Units are not fixed. We will explain this in the text.

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

We will explain this.

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

Yes, we will explain this in the text.

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

The conditions will be summarized.

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.

We will reformulate this part of the text.

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.

An example of computing times will be presented.

Minor

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

The sentence will be reformulated.

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

Will be corrected.

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

Will be deleted.

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