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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Analysis of feedbacks between nucleation rate, survival probability and cloud condensation nuclei formation" *by* D. M. Westervelt et al.

Anonymous Referee #1

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The manuscript by Westervelt et al. studies the relations of particle nucleation, growth and survival probability. They present microphysical feedbacks, where increased nucleation rates decrease particle survival and CCN production. The low sensitivity of CCN to nucleation rate change has been observed in several global modeling studies, which are rather sufficiently cited in the manuscript. The manuscript is generally well written, but figures need some fine-tuning before publication. The presented results are extremely important in guiding future work with global aerosol models, and highlight the importance of particle growth over nucleation rate. I recommend the manuscript to be accepted after minor changes listed below.

The results from earlier global simulations are given in introduction (p. 32180) with only one range (5-60% sensitivity of CCN to nucleation). These are explained in some more detail in Westervelt et al. (2013). However, would it be possible to build a table from the existing results (nucleation scheme and coefficients, sensitivity of CCN, etc.)? I think this would benefit the reader to get a clear picture of current understanding and to put the presented results into context. I think for this paper, citing 2-3 percentage numbers from earlier literature might be too vague. Also, Makkonen et al. 2012 studied the sensitivity of global CCN concentrations to 5 different nucleation mechanisms, and could be included in the reference list.

The survival of nucleated particles is dependent on further growth and surrounding particle sink. In the global scale, it is therefore important if nucleation is occurring rather in locations of high sink or of high growth. The manuscript includes simulations with ion-mediated, binary homogeneous, activation-type and ternary nucleation. These mechanisms have a somewhat distinct spatial pattern (seen e.g. in Fig. 2), and the spatial variability in nucleation is discussed in p. 32195. However, it would be useful to have additional simulation with organic-influenced nucleation. Depending on selected parameterization, this could provide an additional spatial pattern of nucleated particles. In a rather extreme case, nucleation only by organic vapours would lead to a situation where nucleated particles are co-located with growing vapours, enhancing their survival probabilities.

Related to above comment: why is ION experiment not included in e.g. Fig. 2-3?

p. 32195, l. 23: Fix sentence: "It is also appears that mechanisms"

Section 2.2.1: Is one-month spin-up enough for the upper troposphere and lower stratosphere?

Section 2.2.1: Why such a small perturbation to the activation nucleation coefficient? Usually, the coefficient is varied from 10^{-7} to 10^{-5} (see e.g. Spracklen et al., 2010)

Section 3.1: "especially over the oceans where increases from nucleation may not be expected". Why would it not be expected, and why would activation-type nucleation be too active above oceans? Due to too low simulated sink?

Section 3.2.1: Hyytiälä is selected for closer comparison. As seen in Fig. 2, ternary nucleation is relatively inefficient in Hyytiälä. I would suggest to add a location where ternary nucleation has a relatively stronger effect, e.g. from North America. Indicate why only ternary nucleation is presented in Hyytiälä analysis.

p. 32205, l.13: "We also find that CCN1.0 are" –> "We also find that CCN(1.0%) concentrations are"

Section 4. The global results are rather clear in terms of global CCN. However, it should be mentioned that the spatial pattern of nucleation-CCN enhancement is rather important for the actual climate effect: which of the CCN changes e.g. in Fig.3 are modifying actual clouds and radiative fluxes. It could be that your global CCN results are indicative of modifications in cloud forcing, but this can not be simulated with the current model setup.

Figures, general: Make font types and sizes consistent in figures. Include boxes around each panel (7b, 10a-d). Check notations carefully.

Fig. 4: Mention that these are global average values (since later figures have also single station-values). Include meaning of colors (red, green, blue) in figure caption. Maybe combine panels with careful choice of colors/symbols? As the manuscript claims that CCN is rather insensitive to nucleation rate, it would be useful to easily compare the effect of particle growth (100 Tg additional SOA).

Fig. 9a,c (and a few other places): Since "SP" is not extremely common nomenclature, help the reader by including "SP_{3-50}" and SP_{3-100} in x-axis label (also missing from some other figures, e.g. 6).

Fig. 10d: include fit-formula as in 10c. Perhaps write as SP=exp(-a*CS^2) ?

Write CCN(0.2%) instead of CCN0.2 and CCN(1.0%) instead of CCN1.0.

Correct references to "Vehkamaki" to "Vehkamäki"

References

Makkonen, R. Atmos. Chem. Phys., 12, 10077-10096, doi:10.5194/acp-12-10077-2012, 2012.Spracklen, D. V. et al. Atmos. Chem. Phys., 10, 4775-4793, doi:10.5194/acp-10-4775-2010, 2010. Westervelt, D. M. Atmos. Chem. Phys., 13, 7645-7663, doi:10.5194/acp-13-7645-2013, 2013.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 32175, 2013.