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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Parametric studies of contrail ice particle formation in jet regime using one-dimensional microphysical modeling" *by* H.-W. Wong and R. C. Miake-Lye

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We again thank the referee for providing insightful and constructive comments in improving our manuscript. We have listed our responses to the comments and how the manuscript is revised accordingly point by point below.

1. In agreement with referee # 1, I also feel that the present manuscript is lack of substantial originality and new findings/advances.

Response: Please see our response to referee # 1 for this comment.

2. While the authors stated generally in a number of locations that their simulated

results are consistent with previous publications, the paper would be stronger if the model performance can be validated directly with some kind of measurements (for example, the evolution of volatile particle number concentrations reported in a number of previous publications).

Response: As mentioned in our response to referee # 1, we have performed additional microphysical calculations to study two of the cases reported in the Schröder et al. paper for model validation. We have included the results from this exercise in the revised manuscript.

3. I don't think that the proposed possible approach for contrail mitigation by emitting extremely high number concentration but small size of soot particles is practical. (1) The assumed soot emission index of 4.6E18/kg-fuel is much higher than the chemi-ion emission index (~1E17/kg-fuel) and it is unclear if it is physically possible to achieve such high soot emission index (note that coagulation may limit the maximum number concentrations). (2) Even if it is technically achievable, I don't think we want to inject such high concentrations of soot cores into the atmosphere. (3) This study didn't consider the entrainment of ambient particles and the condensation of organics species. If soot cores do not activate, entrained particles and volatile plume particles (having larger size if the organic condensation is considered) may activate and form ice particles. (4) This study appears to focus on only one ambient temperature (218 K). The authors' conclusion (about contrail suppression) may change at lower ambient temperatures (say 213 K).

Response: We agree with the referee that we do not know if the proposed approach for contrail mitigation is practical at this moment. The point we would like to make is that injecting a large number of small vapor scavenging agents may suppress contrail ice particle formation. If this idea is achievable, environmentally benign particles will certainly be a better choice than soot particles. As far as entrainment of ambient or volatile plume particles and lower ambient temperature are concerned, a different number concentration and/or different size of these scavenging particles may be needed to

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achieve the same effects. We have emphasized in our revised manuscript that further modeling and/or measurement studies are necessary before concluding our proposed approach to be practical.

4. Do you consider the coagulation of volatile acid particles with soot particles?

Response: We do consider the coagulation of $H2SO4-H2O$ embryos and liquid droplets with coated soot particles. We have added a sentence in the revised manuscript to make this clear.

5. Page 22343, last sentence. Please give some details on how are the freezing points determined by sulfate mass fraction.

Response: In our work, the freezing temperatures of $H2SO4-H2O$ embryos, liquid droplets and soot coatings are determined by the composition of the solution. The relationship between the freezing temperatures and the compositions of $H2SO4-H2O$ solution reported by Gable et al. (1950) is used in the model. To make this clear, we have added a reference to their paper in this sentence in the revised manuscript.

6. When plume reaches water supersaturation (RH water >100%) at distance of $\sim$30m (Fig. 1a), some of soot particles will be activated and become liquid water droplets which will then freeze homogeneously. Do you consider liquid water droplet formation and subsequent freezing in your simulations? Or you only consider the heterogeneous freezing of soot particles?

Response: We only consider heterogeneous freezing of soot coatings in this work. The reasons we did not consider homogeneous freezing of soot coatings are 1) heterogeneous freezing takes place in a much faster rate than homogeneous freezing, as discussed in the manuscript; 2) the final surface coverage of the soot particles is less than 40% for the cases we modeled (Fig. 5b in the discussion paper), and we believe that heterogeneous freezing should be the main driving force of freezing before the surface is totally covered.

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7. In Fig.7b, It would be useful if the concentrations of ice particles (and liquid water droplets if simulated) as a function of distances are also provided.

Response: We have included a figure in the revised manuscript to show the concentration of ice coated and liquid coated soot particles, as requested by the referee.

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