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Comment on acp-2021-207

Anonymous Referee #3

Referee comment on "Statistical properties of a stochastic model of eddy hopping" by Izumi Saito et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-207-RC1, 2021

"Statistical properties of a stochastic model of eddy hopping" by Saito et al. 2021

This paper discussed a Lagrangian stochastic model for supersaturation fluctuations driven by vertical velocity fluctuations in clouds. This model has been used in the past for simulating the interactions of unresolved supersaturation fluctuations and Lagrangian super-particles (in the super-droplet method). The paper discussed the scaling relationship of supersaturation variance in large and small length scale limits. The authors suggest that the current "eddy hopping model" has limitations in representing the correct scaling at small scales. A correction to the model is introduced (an additional drift term representing the turbulent mixing). A further modification is introduced by multiplying the timescales with constant coefficients that adjust the magnitude of the supersaturation variance. One of the corrections was already included in earlier papers (additional drift term from turbulent mixing), although the evaluation of the supersaturation variance scaling was not presented before. The new simplified model for the super-droplet method is good. But it might not provide much computational benefit if the subgrid-scale transport of super-droplets is also needed. Overall, the content of this paper is important, and it would help model the subgrid-scale supersaturation fluctuations in a correct and consistent way. Derivation steps provided by the authors in different sections seem to be accurate, and the results are convincing. The results are also presented clearly and concisely. Apart from the above general comment, I have the following specific comments:

L120-125 and Eq. 19: I agree the drift term due to turbulent mixing is necessary for correctly representing the supersaturation fluctuations. In fact, it was included in some of the past studies. However, a corresponding complementary diffusion term (the Wiener increment term) representing small-scale fluctuations/mixing would also be required in the corrected model.

L132-136: Are the drift coefficients introduced just to scale the magnitude of the supersaturation fluctuations to a correct value, or are there any other physical reasons?

More explanation would be helpful for the readers.

A figure showing sample supersaturation trajectories from all three models (original, corrected, and simplified) could be informative (probably in the appendix section).

It would also be good to discuss the limitation of the current approach in representing the supersaturation fluctuation generation from scalar mixing (e.g., during the turbulent entrainment-mixing).