acp-2020-159 (revised)

Title: Diffusional growth of cloud droplets in homogeneous isotropic turbulence: DNS, scaled-up DNS, and stochastic model

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General Comments

I accept most of the authors' responses. However, I do not agree with their responses to the following three comments. I also included two additional comments which are motivated by the authors' responses to some of my other comments.

The original comments are in black, the authors' comments are in blue, and my responses to their responses are in red.

Specific Comments

1. line 65: It is possible to do simulations with larger domains with the EMPM. It would appropriate to mention here that the EMPM simulations reported in Su et al. (1998) used a 20-m domain size, and EMPM domains up to 100-m domains were used in Tölle and Krueger (2014).

   Tölle, M. H., and S. K. Krueger, 2014: Effects of entrainment and mixing on the droplet size distributions in warm cumulus clouds. *J. Adv. Model. Earth Syst.,* **6,** 281–299, `doi:10.1002/2012MS000209`

   As stated in our response to 1 and 2, we do not want to bring entrainment/mixing in this manuscript except in a brief comment in the final paragraph in the conclusion section. No changes to the text.

   lines 62-65 (revised): The authors write "From the point of view of realistic cloud modelling, developing and validating robust subgrid-scale schemes for contemporary large eddy simulation (LES) models (i.e., featuring grid lengths of a few tens of meters) requires performing DNS-like simulations in computational domains comparable to the size of the LES grid box." The EMPM does exactly this, as noted in my original comment. This capability is not limited to entraining parcels. It seems that it would be appropriate to mention the EMPM approach as well. It is clearly relevant to the authors' text.

2. line 100, Eq. (1): In general, this equation should include a term $w' d\bar{T}/dz$. I suspect that this term is missing because $\bar{T}/dz = 0$ is enforced due to the cyclic b.c. at the top and bottom boundaries. It this is the case, it should be mentioned. It should also be mentioned that forcing $\bar{T}/dz = 0$ is equivalent to forcing a non-zero gradient of potential temperature, which acts as the source of temperature and supersaturation fluctuations.

   The reviewer is correct. DNS by design cannot feature mean temperature gradients because of the triply-periodic boundary conditions. This is why Eq. (1) does not have the w dT/dz term. Eq. (1) is standard for the DNS of homogeneous isotropic turbulence (e.g., see Eq. 9 in Vaillancourt et al. JAS 2001). We prefer not to bring this aspect in the model description. No changes to the text.

   The source of the supersaturation fluctuations is vertical velocity fluctuations and condensation. Air parcels ascend or descend along saturated adiabats to a good approximation, so that $dT/dz = \Gamma_s$, which produces temperature fluctuations $\Delta T \approx -\Gamma_s \Delta z$ when $d\bar{T}/dz = 0$. Therefore, the specification of $d\bar{T}/dz = 0$ is important and should be mentioned.

   It also is not true that "DNS by design cannot feature mean temperature gradients". If the thermodynamic variable used in the DNS is potential temperature, for example, then $d\bar{\theta}/dz = 0$ would be required but $d\bar{T}/dz = g/c_p$.

3. lines 365-6: This might be too general of a statement. The large eddies dominate for this mode of supersaturation fluctuation because they span a larger potential temperature difference for the same mean vertical gradient. For other modes of supersaturation fluctuation generation such as entrainment, large eddies also dominate, but for a different reason (their greater mixing time scale).

   This comment is incorrect. Larger eddies feature larger and longer-lasting vertical velocity fluctuations because of the way TKE scales with L for the same eddy dissipation rate. As explained above, spectral DNS has no mean vertical gradients. No changes to the text

   As noted in the previous comment, it is incorrect to state the "spectral DNS has no mean vertical gradients". When $d\bar{T}/dz = 0$, $d\bar{\theta}/dz = \Gamma_d$, for example.

Addtional Specific Comments

4. lines 376-383 (revised version): The authors "consider supersaturation fluctuations in a simple stochastic model of a droplet ensemble" and note that "The key advantage of the stochastic model is that its computational cost is just a tiny fraction of a DNS simulation." Furthermore, they write that "the stochastic model provides a simple and physically appealing approach to multiscale large-eddy simulation of a cloud applying Lagrangian particle-based microphysics."

   The same could be said about the EMPM (Su et al. 1998; Tölle, M. H., and S. K. Krueger, 2014) and the L3 model (Hoffmann and Feingold, 2019; Hoffmann et al., 2019). It may benefit the readers to mention these relevant studies.

   > Hoffmann, F. and G. Feingold, 2019: Entrainment and Mixing in Stratocumulus: Effects of a New Explicit Subgrid-Scale Scheme for Large-Eddy Simulations with Particle-Based Microphysics. J. Atmos. Sci., 76, 1955-1973, https://doi.org/10.1175/JAS-D-18-0318.1
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   > Hoffmann, F., T. Yamaguchi, and G. Feingold, 2019: Inhomogeneous Mixing in Lagrangian Cloud Models: Effects on the Production of Precipitation Embryos. J. Atmos. Sci., 76, 113-133, https://doi.org/10.1175/JAS-D-18-0087.1

5. lines 384-6 (revised version): The authors write that "The next step can be to apply this approach in a rising parcel simulations..." This statement should be qualified because in the approach described, the supersaturation fluctuations are generated by turbulent vertical motions acting on a specified and unrealistic mean gradient of temperature (isothermal rather than saturated adiabatic). See comment 2.