Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2018-28-RC1, 2018
© Author(s) 2018. This work is distributed under
the Creative Commons Attribution 4.0 License.

Atmospheric Chemistry and Physics Discussions

ACPD

Interactive comment

Interactive comment on "Bridging the condensation-collision size gap: a direct numerical simulation of continuous droplet growth in turbulent cloud" *by* Sisi Chen et al.

W. Grabowski (Referee)

grabow@ucar.edu

Received and published: 8 March 2018

Review of "Bridging the condensation-collision size gap: a direct numerical simulation of continuous droplet growth in turbulent cloud" by Chen et al.

This paper reports a very nice study with some surprising results that can be published after relatively minor revisions. I have a couple more serious comments and a few technical points. All these should be straightforward to address with relatively small changes to the text. Overall, the writing is clear and the subject is suitable for the ACP journal.

Printer-friendly version

Discussion paper

General comments:

1. I found it surprising that the impact of turbulent collisions between similar-sized droplets overwhelms the gravitational collisions between droplets with different sizes. I do not say I do not believe the effect, I just think this should be emphasized more in the manuscript and perhaps supported by additional arguments. Yes, I agree that turbulence dominates the enhancement for equally-sized droplets simply because gravitational collisions vanish in that limit. This is the major problem when showing the turbulent enhancement. However, it is not clear to me why turbulent collisions between equally-sized droplets should outnumber gravitational collisions between droplets of different sizes. The argument presented in the paper, that is, narrowing of the droplet spectra through condensational growth leading to more collisions when turbulence is added, hinges on this conjecture. I think this is the crux of the argument and it should be appropriately stressed in the manuscript. Moreover, one may ask why it is so? Is this because droplets of different sizes tend to cluster in different regions of the turbulent flow (as shown by Lain-Ping Wang in some of his papers), but droplets of the same size should cluster in the same region? Is this the collision efficiency effect? I think it would be appropriate to expand the analysis and maybe come-up with a hand-waving argument to provide some additional support for the key argument.

2. I am little concerned with a small size of the computational domain used in the simulations. The size limits the range of scales that the simulations can cover, but this is not what I am worried about. There are some suggestions in the literature that claim the problem also depends on the Reynolds number, that is, the size of the domain, but I feel this is of secondary importance. I am worried about the number of droplets that simulations include. Assuming the total concentration is somewhere around 100 per cc, then you carry around about 105 droplets in your 1 liter domain. To create one 100 micron droplet out of a cloud of droplets with mean size of, say 10 microns, takes of the order of 1000 collisions. Thus, the number of droplets you carry has to significantly decrease with time. Is this a problem? Of course, this also means that

Printer-friendly version

Discussion paper

CC BY

you underestimate the impact, correct? I feel one should discuss this issue in the paper (e.g., show how the number of droplet changes with time) and suggest some improvements. One is to run ensemble of simulations to provide confidence intervals on Fig. 1 (the oscillations for radius larger than about 40 microns are a result of a single realization, correct?). The other possibility is to add droplets, for instance, create a new droplet, but keep the colliding droplets in the domain (perhaps re-positioning them randomly). The support for such an approach may come from the following argument: larger droplets fall faster and they simply fall out from the volume you consider and find themselves in the environment that has the same droplet population as before the collision. Such a methodology would provide an upper bound of the impact, correct? I feel it would worthwhile to discuss this aspect in the paper.

Minor specific comments (P – page, L – line):

1. The text uses the word "observation" and "observe" in several places. I suggest to replace with different words to avoid confusion. This is a numerical not observational study.

2. P2, L26: What you mean by the "large-scale flow" here? Is that the eddy-hopping idea as suggested by Grabowski and Wang (the ARFM review) and studied in Grabowski and Abade (JAS 2017)?

3. P4, L15: The 100 micron drop is an arbitrary choice. You can argue it comes from the traditional separation between cloud droplets and drizzle drops, correct? Arguably, one should select a smaller size because the Stokes flow solution that you apply in hydrodynamic interaction calculations is only valid for droplets up to about 50 microns in radius. A comment on that would be desirable here.

4. P. 10, L15. I think there should be R2 on lhs of Eq. B1, correct?

Signed: W. Grabowski

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-28,

CC BY

2018.