Review

Title: Nontrivial Relations Among Particle Collision, Relative Motion and Clustering in Turbulent Clouds: Computational Observation and Theory

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Summary

The authors presented relationship among particle collision radial distribution function (RDF) and mean relative velocity (MRV). They compared the results from Direct Numerical simulation (DNS) and theory proposed by them. The results show that collision is affects the RDF and MRV and imposes strong coupling between them.

The work done in the manuscript is novel. However, authors have to provide more details of the numerical simulations before it can be considered for publication in the journal. The major comments are provided below.

Major Comments

1. More information about the DNS has to be provided in the introduction section. In particular, the reference should be given for DNS done by others using similar condition of turbulence and numerical schemes. See the references Kumar et al. (2012,2014) and Thomas et al. (2020).
2. Section 2:
   (i) Some references are required for the DNS set up.
   (ii) More details about particle characteristics such as initial size distribution. The number density, temperature and humidity used for the simulation.
3. Section 4 (or 2): Simulation details:
   (i) Is there and phase change considered for the particles?

4. The article starts with "considering turbulent clouds containing small heavy particles", however, gravitational acceleration is not considered in particles velocity equation (Page-3, line 72, equation number is not given). Justification for this, given by the authors, is not strong enough. The entire study was done to investigate the effect of particle collision on particle relative motion. Hence in this scenario, effect of gravity should be considered in droplets velocity equation.
5. Definition of τ_p (page 3, line 73) is not mentioned in the article.
6. Detail information about particles number concentration at the time of injection, surrounding temperature and relative humidity of particles is also missing in the article.
7. Justification behind the consideration of certain values of Stokes number (St = 0.22, 0.54, 0.054, 0.001) (page-5 line113) is missing in the article. While presenting an accuracy of a theory, a large number of simulations are needed at all possible complex scenarios. I found it missing in authors' present work.

8. As per my understanding, authors considered particles of size 94.9 micrometre (0.000949 dm) or bigger. If so then mention the DNS domain size and each grid box length. Also, at what stage, the reverse effect of particle collision was considered is missing in this article.
9. The statement made by authors in section 4.3 (page 10, line 211) is not justified. The numerical simulation is done at a very basic scenario, which may lead to an insignificant impact of Stokes numbers on W_r , calculated using DNS.
10. In my opinion, authors need to work more to justify their work and give a more clear explanation about the results.

At this stage, the article is not ready for the publication and requires major changes.

References:

Kumar, B., Schumacher, J., and Shaw, R. A.: Lagrangian Mixing Dynamics at the Cloudy-Clear Air Interface, J. Atmos. Sci., 71, 2564–2580, https://doi.org/10.1175/JAS-D-13-0294.1, 2014.

Kumar, B., Janetzko, F., Schumacher, J., and Shaw, R. A.: Extreme responses of a coupled scalar–particle system during turbulent mixing, New J. Phys., 14, 115020, https://doi.org/10.1088/1367-2630/14/11/115020, 2012.

Thomas, L., Grabowski, W. W., and Kumar, B.: Diffusional growth of cloud droplets in homogeneous isotropic turbulence: DNS, scaled-up DNS, and stochastic model, Atmos. Chem. Phys., 20, 9087–9100, https://doi.org/10.5194/acp-20-9087-2020, 2020.