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# *Interactive comment on* "Reynolds-number dependence of turbulence enhancement on collision growth" *by* Ryo Onishi and Axel Seifert

**Anonymous Referee #1**

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## 1 General Comments

This article is concerned with the Reynolds-number dependence of the effect of turbulence on the collision statistics of cloud droplets. It updates a previously proposed empirical coagulation kernel proposed by Onishi et al. by using DNS data at higher Reynolds numbers, and compares the results to those of another model by Ayala and Wang. Theoretically deriving a coagulation kernel for such a problem is extremely difficult, and so one is forced to construct models for droplet collisions empirically, at least until the theoretical work matures sufficiently. Since the empirical models are not firmly grounded theoretically, one can never be really surely how they will extrapolate to larger Reynolds numbers, and so such studies such as in the present article are needed. The influence of turbulence on cloud droplet collisions and the effect that Reynolds number



has on this is certainly of interest to ACP.

The article is quite well written, and states the issues and objectives of the study clearly. However, one of the criticisms I have is that in several cases things are not explained in sufficient detail and that justification for the approximations invoked is not always given (discussed more in the next section of my review). The article does however address the questions that the study set out to consider, and provides useful results concerning how the effect of turbulence on droplet collisions might vary as one goes to higher and higher Reynolds numbers. The article also gives a helpful discussion and comparison of the two empirically based coagulation models, showing where they work well, and where they need to be improved.

There are, however, several important issues that the authors need to address before I can recommend the paper for publication in ACP, and these are explained below.

## 2 Specific Comments

- The authors do not sufficiently discuss, from a physical perspective, how/why changing the Reynolds number might change the collision behavior. The authors should include a discussion, based on modern results (e.g. see Extreme events in computational turbulence, Proc. Natl. Acad. Sci. USA, 2015, Yeung et al.), of how turbulence changes structurally/statistically when the Reynolds number increases, and how this might affect the collision behaviour.
- Two papers recently appeared on the arXiv by Ireland et al. (arXiv:1507.07026 and arXiv:1507.07022) that use DNS to consider, from a fundamental perspective, how changing the Reynolds number of the turbulence affects particle collisions in turbulence. The authors of the present article should comment on how their results and conclusions compare with those of Ireland et al. This is partic-

ularly important since Ireland et al. suggest that the effects of Reynolds number on the collisions may not be so important.

- In the DNS simulations, periodic boundary conditions are used and the particles are subject to gravity. In Ireland et al. (arXiv:1507.07022) it is shown that the simulation box needs to be quite large to avoid errors associated with the settling particles looping through the periodic box during the integral timescale of the turbulence. The results of Ireland et al. seem to show that for simulation domains of the size used in the DNS in the present article $(2\pi L_0)$ such errors could be significant. Can the authors comment on this? How might such errors influence the results and conclusions of the present article?
- In section 2, I could not see any explanation regarding what particle equations of motion these collision kernels relate to?
- Regarding equation 26, the authors make no mention of the validity of such an equation of motion. What about nonlinear drag effects, or finite particle sizes for the larger $St$ particles?
- Regarding equation 10; presumably this model was derived for the case without gravity. Recently published results show that for $St \geq \mathcal{O}(1)$, the scaling of the RDF power law exponent with $St$ differs significantly with and without gravity (with gravity it varies vary slowly with increasing $St$ for $St \geq \mathcal{O}(1)$, and definitely not like $St^{-2}$). Could the authors comment on this?
- Where does equation 21 come from? What are the assumptions behind this?
- Can the authors include error bars on some of their plots? This would help to show the statistical significance of the argued Reynolds number dependencies of the collision statistics.

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