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

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Thank you for your insightful comments. Below we answer all the questions one by one.

(1) Page 7, Eq. (16), what r12 expression is used? Please provide the detail. Stmax is not defined.

Zhou et al. (2001) proposed an empirical formulation for the correlation between the two concentration fields, based on their DNS results, as

$$\rho_{12} = 2.6\exp(-St_{max}) + 0.205\exp(-0.0206St_{max})\frac{1}{2}[1 + \tanh(St_{max} - 3)].$$

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The description for eq. (16) has been modified accordingly. St_{max} is defined as $St_{max} = \max(St_1, St_2)$, i.e., the larger St of two different sized droplets, at Eq.(7).

(2) Eq. (20) is missing a description for T_L.

We used the formulation of $T_L = 0.4T_e$, where T_e (=u'^2/ϵ) is the large-eddy turnover time (Kruis and Kusters, 1997; Zhou et al., 2001). This information has been added in the revised manuscript.

(3) The rationale for the St-dependence in the two limits of small and large St should be provided. At large R_λ, St_a can even be large than one. I think the St^2 dependence, derived from small St, would not apply.

Yes, St_a can be larger than 1 at some large R_λ. But it does not mean that St^2 –dependence holds for St∼1. For St∼ St_a, z_a defined by Eq. (12), and used in Eq. (11), becomes 0.5, leading to a break of the St^2 –dependence in our empirical parameterization.

(4) Eq. (21): In the limit of very large $V_{p,\infty}$, the fluid time scale seen by a sedimenting particle approach $L_f/V_{p,\infty}$, where L_f is the longitudinal spatial velocity correlation length (e.g, Wang and Stock, J. Atmos. Sci. 50:1897- 1913, 1993). Then $\theta_{i,sed}$ becomes $\tau_p V_{p,\infty}/L_f$. Eq. (21) does not seem to reduce to this result.

Eq. (21) is consistent with the correlation by Wang and Stock for the limit of very large $V_{p,\infty}$. For $V_{p,\infty} \gg 1$, i.e., for $s_v \gg 1$, $\theta_{i,sed}$ becomes

$s_v\theta_i = (V_{p,\infty}/u_{rms})(\tau_{p,i}/T_L) \sim \tau_{p,i}V_{p,\infty}/L_f$ with assuming $T_L \sim T_i$ (e.g., Gouesbet et al. Phys. Fluids, 27, 827-837: 1984), where T_i is the fluid integral scale, and $L_f \sim u_{rms}T_L$. Of course, as Wang and Stock (1993) pointed out, the assumption of $T_L \sim T_i$ is problematic. However, the problem would not be serious for this study since the particle velocity fluctuations become negligible and the turbulence effect on collisions become insignificant consequently.

(5) Page 8, the last sentence following Eq. (22) is confusing in two regards. First, clarify what the notation $< |w_r| >$ is. If it is already averaged as the angle brackets usually mean, it should not have a distribution. Second, for the case of gravity only, the distribution of $|w_r|$ can be derived (see, e.g., Wang et al. J. Atmos. Sci. 63, 881 - 900.) and it is not Gaussian.

The angle brackets denote the averaging procedure. We have removed some of the angle brackets. They were erroneous as you point out.

(original) *This simple form is exact if no clustering occurs and* $< |w_r| >_{turb,sed}$ *and* $< |w_r| >_{grav}$ *and follow Gaussian distributions.*
(after modification) *This simple form is exact if no clustering occurs and* $|w_r|_{turb,sed}$ *and* $|w_r|_{grav}$ *and follow Gaussian distributions.*

(6) Page 9, first paragraph. The meaning of $E_{c,PKS01}$ needs to be clarified. Is this the collision efficiency for gravitational collision from PKS01? Other places in the paper, Ec is used to indicate the collision efficiency for turbulent collision.

Yes, $E_{c,PKS01}$ is the collision efficiency (Ec) for gravitational collision from PKS01. We have modified the corresponding sentence accordingly. Hall (1980) also provides another set of values for Ec for gravitational collision: Ec,Hall. The notation 'E_c' is used for the collision efficiency in general in this manuscript.

(7) The dissipation ratio in Eq. (33) is more like $\left\langle (\partial u_1/\partial x_1)^4 \right\rangle / \left\langle (\partial u_1/\partial x_1)^2 \right\rangle^2$, so it is not flatness.

Yes. That's why Eq. (33) is written in an approximation form.

(8) The symbols in Fig. 2 need to be better explained. Why are there six different types of symbols and what do they represent?

As we cannot analytically calculate the integration in Eq. (38), we have to numerically calculate it to obtain g_{11} for a certain combination of St and Re_λ. The six types of symbols correspond to six values of Re_λ (Re_λ=100, 200, 400, 1000, 4000 and 10000). We have modified the corresponding explanation.

(9) Fig. 4, the large value for the monodisperse case in Ayala model is due to large collision efficiency. The reference DNS data is based on the binary based superposition method (BiSM). Wang et al. (2008) found that the turbulent collision efficiency depends on the liquid water content, implying that the long-range multiple-droplet hydrodynamic interactions are important. I wonder if BiSM will encounter systematic error when simulating turbulent collision efficiency for the monodisperse case, so the reference DNS data and LCS data can no longer be used as the benchmark.

Onishi et al. (2013) reported that BiSM is as reliable as the iterative superposition method (Ayala et al. 2007) for the typical liquid water content of 1 g/m^3, while Wang

et al. (2008) investigated the collision efficiency for liquid water content ranging from 1 to 55 g/m^3, which are larger than the typical value in clouds (0.5-1 g/m^3). Although further investigation is needed, BiSM can be as reliable as the iterative method for cloud research.
It is not yet clear the source of the large discrepancy between the Ayala-Wang data and ours for the monodisperse case in Fig.4. We leave the investigation of this discrepancy for future study.

(10) Figs. 5 to 8: When the droplet radius is above 100um, droplet deformation and coagulation efficiency must be considered. I think the discussions in this paper should be focused on $a <$ 100um, due to the large number of assumptions involved.

It is true that we cannot make robust discussion for $a >$100um, and we do not actually discuss the droplets much larger than 100um. We have added the following note for readers in the end of Subsection 2.1:
"*Droplet deformation and coalescence efficiency, which this study ignores, affect the collision growth of droplets with $r >$100um, although such effects only become significant for droplets with $r >$500um. It would, therefore, lead to some errors if extending the present results to such large droplets.*"

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