

Comments on “Mitigating Hail Overforecasting in the 2-Moment Milbrandt-Yau Microphysics Scheme (v2.25.2_beta_04) in WRF (v4.5.1) by Incorporating the Graupel Spongy Wet Growth Process (MY2_GSWG v1.0)” by Shaofeng Hua, Gang Chen, Baojun Chen, Mingshan Li, and Xin Xu.

Overall, this manuscript is well organized. The authors implemented the spongy wet growth process into a two-moment bulk cloud microphysics scheme in the WRF model to mitigate the overprediction of hail particles. Their approach is based on a thorough consideration of the physical mechanisms of hail formation and successfully reduces hail overprediction in heavy rainfall cases. In addition, the new setting was tested for hail events and was shown to reasonably reproduce hail distributions compared with ground-based radar observations. I have identified several that need clarification, but none of them are serious issues. Some revisions to the organization of the text are also needed to improve readability. Therefore, I recommend minor revision. Please see the detailed comments and suggestions below.

Main points on organization of text.

1. To improve readability, I suggest describing the results for the old and new settings in separate subsections.

For example, subsection 3.1 could start at line 224 and subsection 3.2 at line# 374. Some content may need to be slightly revised accordingly.

2. The Discussion and Summary sections should be clearly separated.

The Discussion section may include interpretations, speculations, or opinions, whereas the Summary section should concisely present only what authors did and the key findings derived from the study. After separating these sections, the outcomes will stand out more clearly. In addition, the current Summary section includes too much detailed explanation for a summary. For instance, it may not necessary to rely on the specific case of Maiyu – the overprediction appears to be a more general tendency.

I believe the study's value will still be evident to readers even with a more concise Summary. For example, the last two paragraphs (lines 533-555) are not essential. If the authors consider them necessary, I recommend moving them to the newly separated Discussion section.

Specific comments.

1. Please spell out all abbreviations at their first occurrence.

Line#105 MYJ, line#106 ACM2, and line#114 NTU, SBM.

2. Line#140-142. The sentence is overly long, which makes the logical flow unclear. I recommend dividing it into shorter sentences to improve readability.

3. Eqs.(1-10)

Please clarify units and dimensions of Q_{cg} , Q_{rg} , Q_{gwet} , and Q_{fill} . In Eq. (9), $Q_{gwet} dt$ is added to Q_{fill} . This indicates that Q_{gwet} and Q_{fill} have different dimensions, despite both using the same capital letter “Q”. This could be quite confusing for readers.

4. Eq.(5)

$N(D)$ is necessary in the integral. In addition, please clarify the assumptions made to derive this formulation (e.g., particle shape and capacitance). Subsequently, check whether these assumptions are consistent with those used for graupel in the MY scheme.

In addition, it should be \geq instead of $=$, in my opinion.

5. Line#148. Is E_{cg} constant?

Please specify its value. In general, E_{cg} depends on particle sizes and shapes (cf. Böhm, 1999). Some models explicitly consider the dependence using look-up-table or an approximated formulation.

Böhm, J. P., 1999: Revision and clarification of “A general hydrodynamic theory for mixed-phase microphysics.” *Atmospheric Research*, 52, 167–176, [https://doi.org/10.1016/S0169-8095\(99\)00033-2](https://doi.org/10.1016/S0169-8095(99)00033-2).

6. In Eq. (4), I don’t find the terms related to “ $|vg(Dg) - vr(Dr)| \approx \sqrt{(VQg - VQr)^2 + 0.04V_{Qg}V_{Qr}}$ ”

7. Eq. (9)

I think it should be as follows (in fortran coding):

If ($\{(Qrg + Qcg)dt \geq Q_{gwet}dt\}$.and. $\{(Qrg + Qcg)dt \geq Q_{fill}\}$) then

Wet growth occurs

Else

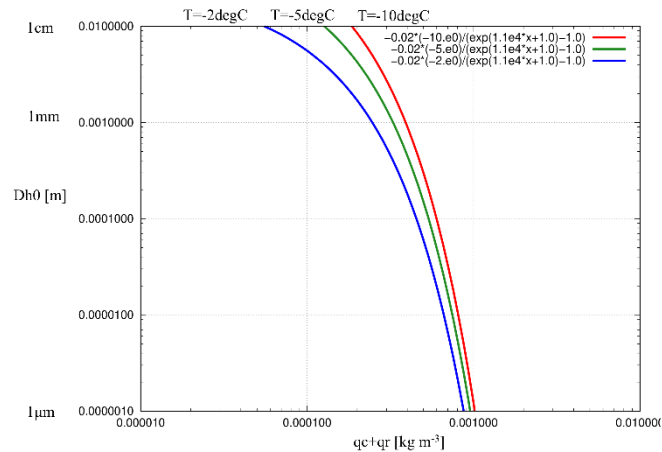
Dry growth occurs

End if

Why do authors add $(Q_{rg}+Q_{cg})dt$ to Q_{fill} ?

8. Line#183-185. This is a very good approach.
9. Figure 1. Please label “Rainstorm1” in the figures as (a) Rainstorm1 (2022-06-23_12:00) to improve readability, as readers may not be particularly interested in the specific date and time of the event here.
10. Line#253-255. The reason provided for not using the radar simulator is not entirely justified. Radar simulators are designed to enable consistent comparisons between observations and models, thereby reducing uncertainties. However, if the authors argue that the numerical model does not incorporate representations of ice particle nonsphericity—an essential factor for sensitivity to polarization—then the benefits of using a simulator would indeed be limited. In that case, citing previous studies (e.g., Matsui et al., 2020) would help clarify and support this point.

Matsui, T., B. Dolan, T. Iguchi, S. A. Rutledge, W. Tao, and S. Lang, 2020: Polarimetric Radar Characteristics of Simulated and Observed Intense Convective Cores for a Midlatitude Continental and Tropical Maritime Environment. *J. Hydrometeor.*, 21, 501–517, <https://doi.org/10.1175/JHM-D-19-0185.1>
11. Line#293. Please move the location of only as “0.1 g kg⁻¹ is ~~only~~ observed only above 3000 m”
12. Figure 5c, 5g, 5k. It is very difficult to distinguish the gray lines and color shades. Please change the visualization of the figures.
13. Line#354-359. I don’t reach the same conclusion from Eq. (11). Please refer to the following figure, which is based on Eq. (11). In addition, this figure does not resemble the one presented in Khain et al. (2010). According to Khain et al., their Figure 14 was derived using a look-up table. Therefore, I conclude that Eq. (11) in this manuscript may not be valid for certain (q_c+q_r) or T_c ranges. Please clarify specific form of the SLL used in the MY scheme implemented in the WRF model.



14. Line #369-371 (For instance, $\sim -2\text{degC}$). This sentence is difficult to follow due to the dense listing of conditions. Please consider rephrasing it using semi colons and clearer parallel structure to improve readability.
15. Line # 379. “a noticeable decrease” is overemphasized.
16. Line#424. “conditions” is better than “locations”.
17. Figure 11b. The boxes are too thin to distinguish colors. Please use wider boxes as in Figure 11a.
18. Line#452-454. This sentence is about heavy rainfall cases. So, the terms “in hail events” is very confusing.
19. Line#466. Fig. 9 is a typo.
20. Line# 473-475. This phenomenon is well described by the cold-pool-shear interaction (e.g., Weisman and Rottuno, 2004).
Weisman, M. L., and R. Rotunno, 2004: “A Theory for Strong Long-Lived Squall Lines” Revisited. J. Atmos. Sci., 61, 361–382, [https://doi.org/10.1175/1520-0469\(2004\)061<0361:ATFSLS>2.0.CO;2](https://doi.org/10.1175/1520-0469(2004)061<0361:ATFSLS>2.0.CO;2).