

Atmos. Chem. Phys. Discuss., referee comment RC2
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Comment on acp-2021-147

Anonymous Referee #2

Referee comment on "Roles of the Inner Eyewall Structure in the Secondary Eyewall Formation of Simulated Tropical Cyclones" by Nannan Qin et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-147-RC2>, 2021

General Comments:

This study examined the influences of the inner eyewall structure on the moat development, spiral rainband and subsequent secondary eyewall using a pair of model simulations with only differing horizontal grid spacing. While I believe the manuscript provides a nice discussion on the role of the strength of the inner eyewall in modifying the diabatic cooling and upper-level inflow radially outward of the primary eyewall and beneath the anvil, I believe the analysis fails to connect this cooling to the boundary layer processes which are likely forcing the secondary eyewall formation. I also have specific concerns on the choice of comparing only two simulations with differing horizontal grid spacing, specifically the fact that the CTL simulation questionably uses a PBL parameterization in the 'gray zone' (0.3 km) and NSEF uses horizontal grid spacing of 1 km and a PBL parameterization.

Specific Comments:

1) The choice of comparing two simulations with different innermost grid spacing (0.3 km vs 1 km) is odd to me. For one, grid spacing of 0.3 km is within the turbulent 'gray zone' so the choice of using a PBL parameterization is questionable (e.g., Green and Zhang 2015 and Honert et al. 2020). In addition, the finest resolved eddies will be different between the two simulations, and it is not clear to me how to interpret these differences in terms of the results presented. This is especially true in comparing with the results of Green and Zhang (2015). Green and Zhang showed that the development of the secondary eyewall in their simulations (ranging in horizontal grid spacing from 111 m – 3 km) was sensitive to how the turbulence was parameterized. More specifically, they noted that none of the simulations without a planetary boundary layer parametrization simulated

the development of a secondary eyewall, suggesting strong sensitivity of secondary eyewall formation to the parameterization of turbulence in the 'gray zone'. I think it is important that the authors reconsider their choice in comparing two simulations with different horizontal grid spacing in order to more easily interpret their results.

Honnert, R., Efstathiou, G., Beare, R., Ito, J., Lock, A., Neggers, R., et al. (2020). The atmospheric boundary layer and the "gray zone" of turbulence: A critical review. *Journal of Geophysical Research: Atmospheres*, 125, e2019JD030317. <https://doi.org/10.1029/2019JD030317>

Green, B. W., and F. Zhang (2015), Numerical simulations of Hurricane Katrina (2005) in the turbulent gray zone, *J. Adv. Model. Earth Syst.*, 07, doi:10.1002/2014MS000399.

2) Partially related to my first comment, I am not convinced that the differences in secondary eyewall formation can be completely attributed to the differences in the inner eyewall structure and not other differences related to the varying horizontal grid spacing between the two simulations and small-scale boundary layer perturbations, potentially related to differences in the model representation of turbulence. As one example, Zhang et al. (2014) demonstrated that secondary eyewall formation is sensitive to very small differences in initial conditions. As a result, I recommend the authors consider revisiting the role of the inner eyewall structure in secondary eyewall formation using a small ensemble with the same model set up.

Zhang, F., D. Tao, Y. Q. Sun, and J. D. Kepert (2017), Dynamics and predictability of secondary eyewall formation in sheared tropical cyclones, *J. Adv. Model. Earth Syst.*, 9, 89–112, doi:10.1002/2016MS000729.

3) One additional aspect lacking in the current analysis is a connection between the increased cooling radially outward of the inner eyewall and the mechanisms forcing the secondary eyewall formation. As an example, the authors should try and link this cooling to the boundary layer processes commonly discussed in secondary eyewall formation (e.g., Chen and Wu 2018, Fischer et al. 2020, Wang and Tang 2020) or describe some other relevant process (e.g., Trabing and Bell 2021). It was difficult for me to discern how, or if, the boundary layer forcing changed between these two simulations leading up to secondary eyewall formation and, if so, how that is related to the increased cooling radially outward of the primary eyewall. I suggest the authors take a closer look at any changes in the boundary layer forcing, such as convergence in the vicinity of the secondary eyewall and/or differences in the surface fluxes, and relate these differences back to inner eyewall structure and the cooling already discussed in the manuscript.

Cheng, C.-J., and C.-C. Wu (2018), The role of WISHE in Secondary Eyewall Formation, *J. Atmos. Sci.*, 11, 3823–3841, doi:10.1175/JAS-D-17-0236.1

Fischer, M. S., R. F. Rogers, and P. D. Reasor (2020), The rapid intensification and Eyewall Replacement Cycles of Hurricane Irma, *Mon. Wea. Rev.*, 3, 981–1004, doi:10.1175/MWR-D-19-0185.1

Wang, Y.-F., and Z.-M. Tan (2020), Outer Rainbands-Driven Secondary Eyewall Formation of Tropical Cyclones, *J. Atmos. Sci.*, 6, 2217–2236, doi:10.1175/JAS-D-19-0304.1

Trabing, B. C., & Bell, M. M. (2021). The sensitivity of eyewall replacement cycles to shortwave radiation. *Journal of Geophysical Research: Atmospheres*, 126, e2020JD034016. <https://doi.org/10.1029/2020JD034016>

4) I recommend adding column labels for 'CTL' and 'NSEF' on Figures 2–4, similar to that in Figure 8.

5) (L137–140) Are these fluctuations in V_{max} in CTL associated with the azimuthal mean structure (wavenumber-0) or predominantly higher wavenumbers? My speculation is these gusts are likely related to higher wavenumber structures simulated in CTL but please clarify in the manuscript if possible.

6) I am confused by the buoyancy perturbation analysis discusses (e.g., L209–214 and Eq. 1). How are the wavenumber 0 and 1 components of the perturbation field calculated? Are these related to the full wind field or only the right of shear quadrant? Also, it appears that A_0 is simply a 2d average. I would recommend refining this term as so as not be confused with the wavenumber 0 component.

7) Why was only the upshear-right quadrant chosen to discuss/show in the manuscript? Please clarify in the manuscript or consider also adding some discussion on other shear-relative quadrants.

8) I strongly recommend changing Figures 11 and 14 to clearly depict/highlight the quadrants in a shear relative coordinate system, as opposed to the cardinal directions currently used.

9) It is not clear how Eq. (2) is being solved. Please clarify in the manuscript.

Technical Corrections:

L22: change "is to further examine" to "further examines"

L23: The sentence appears incomplete I suggest adding "in the secondary eyewall formation" after "the role of the inner eyewall structure"

L46-48: Please be more descriptive here on what you mean by "a consensus has not been reached", in terms of what?

L85-87: This sentence appears incomplete, please revise.

L203: Suggest changing "encircle" to "axisymmetrize"

L207-209: This sentence is unclear, please revise.

L262–263: Change “much diabatic warming” to “more diabatic warming”.

L346–347: This sentence is unclear, please revise or remove it.