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Comment on acp-2021-147

Anonymous Referee #1

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-RC1, 2021

This study examined the role of inner eyewall structure in the formation of a secondary eyewall by performing two WRF simulations of (realistic or idealized unknown) tropical cyclones (TCs) with different horizontal grid spacings. The simulation with secondary eyewall formation (SEF) has stronger and deeper eyewall updrafts that produce more hydrometers falling out of anvil clouds outside the eyewall. The associated diabatic cooling helps induce a descending inflow beneath the outflow layer that is argued to contribute to the formation of a moat. In contrast, the simulation without SEF does not show the descending inflow and moat. The authors then emphasized the importance of accurately simulating the structure of the eyewall in the SEF.

I would like to appreciate the substantial efforts the authors made to diagnose the mechanism responsible for the formation of descending inflows outside the primary eyewall. However, after going through the paper, I fail to locate any solid evidence that can support the statement that the descending inflow outside the eyewall contributes to the SEF. The literature review is insufficient, and thus key findings from this study are mostly facts we have learned from previous studies. The model design is not clear and the experiment design with different horizontal grid spacings needs to be justified. The writing suffers from numerous grammatical errors. In some instances the grammatical issues were so severe that I could not discern the meaning of the authors. If the revised manuscript is not substantially improved to address these issues, then I will recommend rejection.

General comments:

- The take-home message of this study is compared to non-SEF TCs SEF TCs have stronger intensity, and stronger upper-level inflows that descend into the boundary layer and contribute to a formation of moat. Is this a novel finding? A statistical analysis of Western North Pacific typhoons (Kuo et al. 2009) has shown that major typhoons are more likely to undergo SEF than weaker typhoons (see their Fig. 4). Additionally, a existed debate is the relative importance between strong strain flows that shear apart or suppress convection (Kossin et al. 2000; Rozoff et al. 2006) and subsidence, a component of the secondary circulation; the latter is argued to be the dominant factor by Wang et al. (2008). The related discussion is missing in the literature review. The inflow layer beneath the outflow layer for SEF TCs can be a response to momentum forcing, radiation, and many other factors, while authors only diagnosed the contribution of diabatic heating. Differences in TC structure and inflow strength between the two experiments are largely attributable to differences in TC intensity. I don't understand the motive of revisiting these processes. Most importantly, please provide solid evidence to prove the descending inflow contributes to the SEF.
- The description for experiment design and model setup is not clear. Please inform readers whether these simulations use a realistic or an idealized TC. Reasons for performing simulations with different horizontal grid spacing are missing. Comparison of inner-core structure with different model grid spacing is not fair. The usage of a traditional PBL scheme at gray-zone resolutions (e.g., 333 m) is problematic. Given these issues, I would encourage the authors to perform ensemble simulations with 1-km horizontal grid spacing and compare the simulations with and without SEF.
- Different types of descending inflows have been documented in literature, including the one mentioned in this study, the one coming from the stratiform region outward of the outer rainband (Didlake et al. 2018), and the one coming from the upper levels and outward of the outer rainband (Dai et al. 2019). I would encourage the authors to discuss whether these processes are intrinsic to the SEF or they are the results of SEF based on their numerical simulations. The inflow layer beneath the outflow layer has been discussed in modeling studies (e.g., Wang et al. 2020, https://doi.org/10.1002/qj.3856). Under which situation would the inflow layer descend into the boundary layer and contribute to the moat and SEF formation? These descending inflows typically locate within a confined region around the TC center, and how do they contribute to the symmetrization of outer rainband during the SEF? These open questions need to be addressed to some extent to advance our understanding of SEF.
- There are numerous grammar mistakes in the text. I only list a few. Please carefully edit the text before resubmission.

Minor comments:

- Line 25: "The SEF was simulated in the experiment …" ->"The experiment with … shows a SEF"
- Line 30: "Compared to the simulated …, diagnostic analysis". Rewrite this sentence.
- Line 32: Could the outflow layer itself induce an inflow layer beneath it? A complete Sawyer-Eliassen equation diagnosis is needed.
- Line 58: What is "stretching time"? Probably you mean filamentation time but that needs to be defined too.

- Line 63: Did Kepert (2013) use an axisymmetric boundary layer model? You may be aware SEF is typically associated with an axisymmetrization of outer rainband. What insights would you think the axisymmetric framework can provide into this phenomenon?
- Lines 81-82: I agree, and why not focus on this key scientific issue in this study?
- Line 86: “since” -> due to
- Lines 358-359: I may miss something. Did this study discuss under which situation would upper-level inflows descend into the boundary layer?