Review of: "Roles of the Inner Eyewall Structure in the Secondary Eyewall Formation of Simulated Tropical Cyclones"

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Summary:

The authors conduct two numerical experiments using the WRF model and attempt to explain why one experiment undergoes secondary eyewall formation (SEF), while the other does not.

Evaluation:

The authors conduct two numerical simulations, one with higher horizontal resolution than the other. Based on these two solutions, the authors argue that "the structure of the eyewall can play an important role in secondary eyewall formation". The authors find that in the higher horizontal resolution simulation "the eyewall is more upright with stronger updrafts, accompanied by a wide eyewall anvil at a higher altitude." However, it is unclear to this reviewer why such eyewall features are central to SEF.

The authors claim to offer an interpretation for why the higher resolution experiment undergoes SEF. The interpretation seems to hinge on a mixed cloud-physics and balance equation explanation highlighting the "cooling outside the inner eyewall … induced by the sublimation, melting and evaporation of hydrometeors falling from the eyewall anvil." The authors claim to have shown that: "The cooling … *induces upper-level dry, cool inflow below the anvil, prompting the subsidence and moat formation between the inner eyewall and the spiral rainband"* (emphasis mine).

The authors hypothesize that the formation of a *moat* between the inner eyewall and spiral rainband is an essential precursor for the formation of SEF in their experiments. However, there is little, if any, consistent dynamical analysis offered to support this hypothesis. The only dynamical framework invoked to interpret their numerical solutions is the Eliassen equation (their Eq. (2)) in radius-height coordinates, a formulation first developed by Smith et al. 2005. Unfortunately, the authors fail to explain how the coefficients of this partial differential equation are defined in their own solutions[1]. Equally problematic is that no explanation of the Eliassen solution method is given for regions of negative *static stability*, negative *absolute vorticity* or negative *symmetric stability*. One or more of these possibilities generally occur in realistic simulations of a tropical cyclone (Wang et al. 2020,

[1] Recent work has demonstrated important differences in the solutions of the Eliassen equation using a strictly balanced basic state vortex versus an unbalanced vortex that does not satisfy thermal wind balance (Montgomery and Persing 2020).

Wang et al. 2021). An important, but subtle, discovery found in Wang et al. 2021 was that the upper-level cool inflow below the anvil is incorrectly characterized as a balanced flow feature. In the Eliassen model, this localized upper-level inflow is an artifact of regularization, a procedure that is required to solve the Eliassen equation as an elliptic partial differential equation. In contrast, in the numerical simulations, the upper-level inflow is tied fundamentally to the agradient (unbalanced) force field in the upper tropospheric outflow region.

Thus, the balanced interpretation offered in this study for “the upper level dry, cool inflow below the anvil” is problematic. In view of this problem, the underlying explanation offered to explain SEF in the one experiment and not the other collapses.

Recommendation: Do not accept. If the authors choose to revise their manuscript and resubmit to this journal, it should be required that the authors 1) cite these references given above, 2) discuss how the authors have addressed the issues raised in these references and 3) develop a physically consistent dynamical explanation for the occurrence of SEF in the one simulation and not the other.

References:

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