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Geoscientific Model Development Discussions

Interactive comment on "Spatial and Temporal Evolution of a Lightning Diagnostic in HWRF (V3.7a)" *by* Keren Rosado et al.

Anonymous Referee #3

Received and published: 16 September 2019

Summary: The authors implement the Lightning Parameterization Index (LPI) into the HWRF(V3.7a), and assess its performance in both idealized and real tropical cyclone case scenarios.

Recommendation: Accept, pending major revisions.

Main Comments:

The manuscript covers a topic of significance for the hurricane forecasting community. However, there are some major shortcomings in the main message. This is further stressed in the case selection, methodology, and choice of verification/validation data.

1. Not enough discussion or results aimed at the main stated purpose here: To reduce TC intensity forecast errors and bias. The results did not appear to show any additional

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useful information for forecasters and model developers on the usefulness (or not) of having LPI implemented in the operational HWRF. This is in part due to a poor case selection, and an discussion that was not focused or concise enough around this point. For example, the authors go through a range of topics and cases, that give the reader a hard time to understand what exactly are they trying to accomplish. An ideal case with eyewall replacement cycle (ERC) is used, but both real cases shown here had ERCs (see NHC preliminary storm reports), and this is somehow ignored in the text. Why?

2. The case selection is puzzling. Initially, I thought this was going to be justified by use of data from the field campaigns of 2010 (e.g. NASA GRIP, NCAR PREDICT), in which a significant amount of in situ data were collected (especially on hurricane Earl). Having such old cases hinders the authors from the use of more robust lightning data sets that are currently available thanks to satellite sensors (e.g. GLM), which would be of great value to this study. There are plenty significant hurricane cases in the Atlantic that would make for a better selection. See, for example, hurricanes Irma, Jose, and Maria of 2017, or Michael in 2018.

3. The methodology is inconsistent and lacks depth. For example, in Fig. 1 the LPI is shown for the entire storm, instead of per storm region (e.g. inner core or eyewall, rainbands, periphery, etc.). This despite the discussion of lightning evolution in different regions (e.g. rainbands) during specific periods in the lifetime of the selected cases (e.g. rapid deepening vs. steady state). Azimuthal averaging was used for the ideal case, but not on the real cases. This should be addressed in order to have a more clear picture of the findings.

4. The verification/validation work is not robust at all. This is understandably related to the case selection (discussed above). More specifically, on hurricane Earl there was no mention of the ERC that strongly modulated the storm intensity/structure on August 30-31st, effectively ending the rapid intensification process, which is of focus in this study for its implications on lightning behavior. Evidently, the occurrence of the ERC meant major structural changes in Earl as well. None of this is properly

addressed here. No use of San Juan, Puerto Rico (TJUA) Doppler radar data is done to verify the HWRF reflectivity structure, nor the WWLLN lightning locations. For Igor, no land-based radar data is available, but microwave imagery would have been of use to validate the simulated storm structure. For the latter I suggest the NRL Monterrey TC Page archives, which do not require additional plotting. The main point here is: It is hard to credibly propose a set of conclusions without a more rigorous examination of the selected cases.

Specific comments:

Suggest adding a table listing each simulation and its main specifics for easier following.

Page 3, Line 8-9: Define "long/short time scales".

Page 3, Line 28 (and beyond): The use of kts is fine, but please include m/s as well, especially when those are the units used in the figures of this manuscript.

Page 4, Line 5-11: No need to repeat the abstract. Suggest removing this entire section.

Page 4, Line 29-33: Too many unnecessary details. Suggest making it more concise. Once sentence should be enough for the reader.

Page 5, Line 12-13: "In order to obtain the center of the tropical cyclone the model is run." This sentence needs to be fixed.

Page 6, Line 3-5: Why was LPI not implemented in the Ferrier-Aligo (operational), and on Thompson instead? The purpose of this selection ought to be discussed for clarification. Also, how do these two microphysics schemes compare? Use of existing literature is suggested.

Page 7, Line 5 (and beyond): Suggest reducing the long date format use in the manuscript to mm/dd/yyyy hhhhUTC (or Z).

Section 2.5: Many details not relevant to this study are included here. A much more concise description of both storms, focused on the simulation periods, would be a nice improvement. Also, citing NHC preliminary storm reports should be enough for the more thirsty readers.

Page 8, Line 17: "lightning peak occurs hours before the intensity peak". Please briefly explain the physical process(es) responsible for such behavior.

Page 8 Line 34-36: The writing here is confusing. Are you referring to the lack of direct ERC observations (not true), or of lightning in hurricanes undergoing ERCs? Either way, more recent cases prove otherwise.

Page 9 Line 20: Suggest expanding on this statement. A series of events lead to the expansion of the tangential wind field, which shifts the focus of low-level convergence to the secondary eyewall radii. In addition to Bell et al. (2011), suggest reading Houze et al. (2006), Terwey and Montgomery (2008), and Huang et al. (2012).

Page 10 Line 2 (and rest of manuscript): "Inner core" and "outer region" need to be defined quantitatively.

Page 10 Line 15-16: Not sure I agree with this statement. LPI appears to peak in advance of maximum winds, which may not be depicted as a negative correlation, but instead as a lagged (or delayed) response in the behavior of the wind speeds.

Page 10 Line 18-21: Suggest briefly describing storm structure here, including ERC and its role on intensity changes.

Page 11 Line 1: Why are August 30 at 0400 and 0800 UTC discussed, but not shown on figure? Suggest addressing this by either modifying figures, removing discussion on these times, or clarifying that it's "not shown".

Section 3.4: The discussion on hurricane Igor results seems too brief and superficial. Suggest either removing this case altogether, or conducting a more meaningful discussion on findings for this simulation.

Page 11 Line 19: A negative correlation of just -0.29 seems to contradict your conclusion on Page 10 Line 15-16. This is a weak correlation, at best.

Page 11 Line 25-29: Again, findings strongly contradicting your own statement on LPI vs maximum wind correlations.

Page 11 Line 35-36: The incompleteness of WWLLN data strengthens the point I made before; better (and more recent) cases need to be added to this study.

Page 12 Line 20-22: This statement was never properly addressed in this study.

Page 12 Line 29-30: This is a finding that is more consistent with the results presented herein. Suggest building on it across the text of this manuscript.

Page 13 Line 4: Not intending to beat a dead horse, but this is exactly one of the main issues with the current version of this manuscript.

Page 13 Line 7-10: This is a puzzling statement. How can a diagnostic tool dependent on the model itself be a warning for the own model's forecast error?

Page 13 Line 21-22: This has not been proved here, at all. Need to include radar observations and microwave imagery in order to make such statement.

Figures:

Fig 2. Why is the storm exhibiting a Southern Hemisphere signature (i.e. clockwise rotation), while showing counter clockwise signature (N.H. cyclone) on Fig. 6?

Fig. 6: More robust if showing an azimuthal average here as well. This will ensure a more complete picture of the storm structure and behavior.

References:

Houze RA Jr et al (2006) The hurricane rainband and intensity change experiment observations and modeling of Hurricanes Katrina, Ophelia, and Rita. Bull Am Meteorol Soc 87:1503–1521

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Huang Y-H, Montgomery MT, Wu CC (2012) Concentric eyewall formation in Typhoon Sinlaku (2008). Part II: axisymmetric dynamical processes. J Atmos Sci 69:662–674

NHC Hurricane Earl tropical cyclone report: https://www.nhc.noaa.gov/data/tcr/AL072010_Earl.pdf

NHC Hurricane Igor tropical cyclone report: https://www.nhc.noaa.gov/data/tcr/AL112010_Igor.pdf

NRL Monterrey TC archives: https://www.nrlmry.navy.mil/tc_pages/tc_home.html

Terwey WD, Montgomery MT (2008) Secondary eyewall formation in two idealized, full-physics modeled hurricanes. J Geophys Res 113:D12112. doi:10.1029/2007JD008897

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