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# Comment on egusphere-2022-348

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Referee comment on "Lightning assimilation in the WRF model (Version 4.1.1): technique updates and assessment of the applications from regional to hemispheric scales" by Daiwen Kang et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-348-RC1, 2022

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** General comments

The submitted manuscript describes how a method for convection in the WRF model to observed lightning changes its sensitivity to various namelist parameters, at both local and regional spatial scales. The paper is informative and very well organized, but heavy on details that may not serve the overall message (more on this below). I recommend it for publication following minor revisions, which are outlined below.

** Specific comments

1. I am concerned about the use of the term "data assimilation" to describe the approach used here, which essentially uses the presence of observed lightning to trigger convection in the model, whereas the term "data assimilation" typically refers to complex systems that use some sort of variational or Kalman-filter type method to periodically update prognostic model variables with observations. "Lightning-triggered convection" might be a more apt descriptor, but I leave this up to the authors and editor to decide.
2. The main thrust of the paper outlines how LTA changes the sensitivity of the convection to various namelist parameters in WRF. It's unclear, however, to what extent this result is interesting to users of other models. It looks like there are two major conclusions about the parameters (reading from lines 579-584 here): (1) that regional simulations are sensitive to both a parameters but hemispheric simulations only to the trigger parameter, and (2) that sensitivity to both of these parameters really goes down once LTA is turned on. I can see how the second of these is interesting beyond WRF (more constraint to data means less sensitivity to parameters) but the first is less intuitive. Can you zoom out and draw a more general, non-WRF-specific, conclusion?
3. Lines 95-117: The introduction explains previous successes with LTA and the plan for the current paper, but without explaining what LTA actually is. As stated above, calling it "Lightning Data Assimilation" might imply something different than what is actually done (i.e. the assimilation of lightning data as part of the existing WRF 4D data assimilation), which makes it difficult to see why LTA should be tested in conjunction with two namelist

parameters for convection. Paragraph 1 of section 2 has a great, concise summary of what LTA does -- I suggest moving this statement to the introduction.
4. Line 257: How many minutes is the model timestep? (Is cudt=10 more or less frequent?)
5. The abbreviations for the experiment matrix (Table 1) are confusing! For example, since the names of individual WRF namelist parameters are pretty meaningless to people who don't use WRF, there's nothing intuitive about abbreviating which convective trigger is used as "K" or abbreviating the timing of the convective scheme as "C". I can't say what a more effective naming scheme would look like, but I found the abbreviations hard to remember, which made all the subsequent figures hard to understand. For example, the discussion of Figure 1 talks about the effects of trig 1 vs trig2, but in order to understand what is being talked about, the reader needs to connect the xaxis labels in 5 panels to entries in table 1 and figure out what all that means, and all that work is going to muddle the main results of the figure.
6. Line 294: the "ShallowOnly" option is mentioned but not explained. It would be helpful, in Section 3 where the parameters of the convective scheme are described, to briefly explain how the trigger options change then LTA is on/off.
7. Figure 3: I advise against the use of a line plot here, because connecting the dots with lines implies to the reader that they are have a temporal ordering, when really you are showing independent experiments. How about bar graphs? This would clearly show one of the major results of this figure, which is that the experiments with LTA off are much more sensitive to the choice of convection parameters. Also, it really necessary to show 5 different statistical measures? They seem to mostly reflect the same things (correlation goes down, while bias and errors go up, when agreement with obs is poor) so it seems like there is a lot of redundant information in this figure.
8. Figure 3: It's unclear from the text _why_ LTA has the strongest effect on the Ohio Valley -- I assume it would be because there is a lot of lightning in this region in the summer, but the same is true for the Southeast and the Upper Midwest, and those regions have a much smaller effect on LTA. Is there a simple explanation?
9. Figs. 4-5: These figures show a lot of the same things as Fig 3, with the most noticeable difference being (I think?) that the different namelist parameters can really affect the bias in surface variables. However, it's hard to discern a real memorable message from this part -- Section 4.2 lists a lot of detailed results but doesn't really put them into a greater context. It would be great if these figures could be distilled down to the most salient results (perhaps by only showing one type of bias?) and then given more physical explanation rather than listing out the various details of each figure.
10. Fig. 7: Column and row headings would be great here; without them, it's really hard to know which panel shows what (again, the experiment abbreviations aren't really intuitive). For the panels showing differences in rainfall, a divergent colormap (where zero is white) would be helpful (I realize that this can be pain to implement in a small-multiples plots so this is just a tip). More impportantly, the only result discussed for Figure 7 is that LTA brings the simulated precipitation closer to the observations. If that's all this figure shows, are 9 panels really necessary? Again, it's a lot of information to confront the reader with, when the actual take home message of the figure is probably more simple.
11. I'm not sure how Figure 8 fits into the larger premise of the paper. The main result seems to be that the different parameters produce subtle differences in the daily precipitation. Since you don't go into detail about these differences, it's maybe not necessary to include this figure. (Figure 9 seems far more informative and maybe covers your bases sufficiently?)
12. Line 450: FDDA is mentioned for the first time here; are all the simulations described here run with data assimilation? If yes, that should be made clear much earlier, i.e. when the experiments are described. Also, since most of the runs have significant biases in precipitation, it would be good to know roughly what types of data were assimilated in the FDDA framework.
13. Figure 11: If I understood correctly, the authors are arguing that mean bias changes more drastically with different parameters settings for regions that are less constrained by

observations and/or to which the model is less well tuned than the United States. But does this really bear out? Looking at the figure, I see MB for the USA vacillate wildly between the different experiments, even flipping sign. Also, why does MB change so drastically between experiments but RMSE doesn't? Since you show both, it would be good tp explain what each of these measures reflects.

14. Line 468: On the hemispheric scale, LTA means triggering convection over a huge area by something as local and small scale as lightning -- it actually seems quite surprising that you have any success at all with LTA at these scales. It would be helpful to mention much earlier on what a stretch it is to try to apply LTA at these scales, and then emphasize what about it works (if I understand correctly, it's that LTA improves the correlation to rain gauge data, i.e. Fig. 9?).

** Technical corrections

1. Line 103: Does the lower cost of WWLLN data mean a lower cost to users (i.e. it costs less to obtain the data) or a lower cost of the actual measurements? Is there a simple reason why this is the case?

2. Line 133: If lightning is present the Updraft Source Layer changes relative to the default value of what? Also you don't really need to abbreviate updraft source layer since it doesn't come up again. There are already a lot of acronyms in this paper!

3. Lines 138-151: This paragraph explains why Heath et al changed the criteria for deep convection. The previous paragraph explains that the scheme adds moisture and heat to meet the criteria, but it's a bit confusing since at that point we don't get know what the criteria are and what they have to do with lightning. I suggest switching the paragraph that starts at line 138 with the one that starts at 126 (with other edits to make it flow).