

Review of WCD-2020-34

Authors: Lesetja E. Lekoloane et al.

Title: “A dynamic and thermodynamic analysis of the 11 December 2017 tornadic supercell in the Highveld of South Africa”

Recommendation: Potentially acceptable pending major revisions

Overview

Lekoloane et al. provide an interesting case study and a pair of model simulations associated with the 11 December 2017 tornadic supercell in the Highveld of South Africa. While this case would be of interest to the community, I have some serious reservations about the manuscript in its current form. In particular, there appear to be some fundamental misunderstandings—or at least omissions—related to the current knowledge base of supercell tornadogenesis.

Additionally, I am concerned that the analyses of high-resolution simulations are too limited in scope in their current state and also reveal some misunderstandings. These issues could be alleviated with considerable revision and reanalysis, but I do not think the manuscript is suitable for publication at this time.

Major Comments

1. Lines 57-59: Your discussion about near-surface vertical vorticity is short and potentially contains some misunderstandings. Tilting of environmental horizontal vorticity is the primary contributor to updraft rotation within a supercell, but it is not typically thought to contribute significantly to near-surface vertical vorticity. The other process that you mention could achieve near-surface vertical vorticity (“advection of vorticity from aloft”) is vague, and I cannot be certain that what you mean here is actually consistent with current thinking. Please revise this section for clarity, and if necessary, review recent literature on the topic to ensure your introduction is consistent.

2a. Your method of evaluating model simulations is potentially flawed. SA1.5 very clearly lacks a supercell, as there was no precipitation present in the specific time frame. Thus, the use of midlevel vorticity was a strange choice to determine the presence of a supercell (or lack thereof). Additionally, you look at one hour here; could the higher-resolution simulation simply be delayed in time? What happened beyond 16z? This analysis seems to be somewhat cursory, and perhaps too superficial for a peer-reviewed manuscript.

2b. Your comment on lines 342-343, “...as a result of the mid-level vorticity being greatly underestimated, which led to the storm not being initialized” shows a fundamental misunderstanding of the source of modeled midlevel vorticity, or at least inconsistency with your analysis of SA4.4. The midlevel vorticity maxima/minima couplets in these simulations appear to be a *consequence* of the development of convection, not a cause. Please re-evaluate this statement.

2c. Likewise, I have some concerns about your analysis and interpretations of SA4.4. As you noted, this simulation likely did not resolve the mesocyclone adequately, which is expected given the fairly coarse resolution (for a CAM). There are also some claims not entirely supported by the data provided, discussed below.

“...it follows that the stronger the low-level MFC, the stronger the mid-level vorticity would be.” While this is likely just consequence of convergence below an updraft and the corresponding

updraft, I'm not sure that the data support this claim in a more general sense. Do you have more evidence?

Lines 317-318: Given that SA4.4 doesn't adequately resolve the mesocyclone, I don't think you can expect it to accurately represent downdraft processes. RFDs tend to be considered dynamic features associated with low-level rotation within the storms. If the rotation isn't being resolved, I don't think the RFD is being (accurately) represented, either. You may be getting a similar solution for different reasons.

How did you assess the causation of the claim in lines 346-347 ("...found to be a result of...")?

3. A hook echo does not *necessarily* confirm that a storm is a supercell, as is suggested in the paragraph beginning on line 236. Instead, focus on the rotation observed from radar velocity fields; the mesocyclone is the key defining feature of the supercell.

4. You seem to provide some details about storm initiation, evolution, and key ingredients in the summary and conclusion section that are not addressed earlier in the manuscript. Please discuss the evolution from a multicell cluster into a supercell and the importance of the "three ingredients" noted beginning at line 330 earlier in the manuscript, if you'd like to keep this section.

5. In several locations throughout the manuscript, there were brief, almost random mentions of climate change and the potential increase of extreme events in the future as a result. However, this line of thinking is never appreciably explored or elaborated upon; because of this, I think these mentions should be omitted.

6. In my opinion, the two paragraphs beginning at line 288 provide no additional insight. These appear to just be confirming the presence of an updraft through show-and-tell. If there is nothing more substantive to include, I would omit these paragraphs.

Less Substantive Comments

1. Why did you analyze such a small number of the available fields from ERA5? There are 137 vertical levels, and you only use three here. Could any insight be gained by interrogating additional fields/levels?

2. What was your reasoning for using the convergence of moisture flux at 800 mb rather than the lifted condensation level (LCL) as an assessment of low-level moisture?

3. For the paragraph beginning at line 206, it would be helpful to refer back to Fig. 1 to help illustrate the storm track.

4. A hodograph corresponding to the Irene sounding would be very helpful.

5. The 35 kt "lower mid-level jet" appears to be a bit stronger than analyzed in Fig. 2. Did this play a role?

6. Line 230: Why 573 hPa? Is there some specific importance of this level, or is it arbitrary?

7. How many observation sites are used to generate the plot in Fig. 8a? Are these sites reliable? The plot appears fairly noisy.

8. Likewise, how representative and reliable are the three sites used to create Fig. 8c?

Minor/Grammatical Comments

1. Line 18: “dependent” is misspelled

2. Line 29: Commas need before “such as” and after “fishing”

3. Line 46: “spectacular” is an odd word choice

4. Line 51: “results” should be singular (“result”)

5. Lines 114-115: Suggest reworking, beginning with “Hourly data from a fifth generation European Centre...”

6. Line 120: Instead of “high”, I suggested using “fine” to describe the grid spacing.

7. Line 128: Suggest omitting “spectacularly”

8. Lines 128-129: Rather than “an even stronger”, I would say “a strong”. The defining characteristic of a supercell is a strong, persistent rotating updraft.

9. Lines 156 and 166: Rather than “which”, use “that” here.

10. Line 157: Omit comma after “damage”.

11. Lines 160-162: I suggest reworking the sentence about storm damage. Rather than starting with “Visual impacts of the...”, just note that “Damage from the storm included...”, or something to that effect.

12. Line 173: I believe that “northward-extended” should read “northward-extending”.

13. Line 174: “deepened” should maybe be “deepening”, but it is difficult to determine given a lack of temporal context.

14. Line 180: “patterns” should be singular (“pattern”)

15. Line 182: “advects” should be “advected”

16. Line 200: Add comma between “winds” and “which”

17. Line 212: Does the 1.5 km refer to the track length? This is unclear.

18. Line 249: I’m not sure what the word “near” is doing here.

19. Line 261, and others: Replace the comma before “however” with a semicolon, and place a comma after “however”.

20. Line 348: Add a comma between “incorrect” and “possibly”

21. Generally, directions such as “southwestern” should not include a hyphen.
22. Fig. 4: This figure is a bit difficult to interpret/read because of poor image resolution.