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

Response to referee report #1

Major Comments

Reviewer: 1. The strengthening and maintenance of the supercell is not clearly attributed to the three ingredients mentioned (vertical shear, low-level warm/moist flux, and dry midlevels). These all play a role in producing a suitable environment for a supercell to develop and thrive, but it is not clear how they specifically strengthened and maintained the supercell here. The easiest way to alleviate this issue is to adjust your wording somewhat, unless you can justify your statement with more rigorous cause-and-effect testing.

Response: Thank you for pointing this out. We have adjusted our wording by including prevailing conditions in the eastern parts of the country (new figures showing low-level moisture, midlevel environmental lapse rates, and winds), and therefore indicated that they most likely played a role in ensuring that the supercell storm is strengthened and maintained throughout its lifetime.

Reviewer: 2. Beginning of section 2.2.4: It is not clear to me why vorticity would be suitable here when it is derived from the components that you note cannot be reliably used. You should provide some reasoning for why you think vorticity is not subject to the same resolution concerns.

Response: To resolve this, we reference Stevens and Crum (2003) and indicate that an added advantage is that it includes most of the flow and is also much easier to use for rotation analysis compared to only using wind vectors.

Less Substantive Comments

Reviewer: 1. Line 35: What “development scale” are you referring to? More detail would be useful here, as I assume many readers will be unfamiliar with this scale.

Response: Thank you for this suggestion. We now reference a short paper by Carley and Bustelo (1986) which briefly explains the concept of social indicators for the reader unfamiliar with them.

Reviewer: 2. Line 48: I would argue that any thunderstorm that produces a tornado is a “severe” storm. I recommend rewording this sentence as, “It should be noted that some multicell thunderstorms can also produce tornadoes (including non-mesocyclonic tornadoes), and…”

Response: This has been noted in the revised manuscript.

Reviewer: 3. Line 68: Omit or separate “including several animals”, as these should not be included in the human injuries.

Response: This has been omitted.

Reviewer: 4. Line 228: “through energy supply” is vague and speculative. I would omit this.

Response: This has been omitted as suggested.

Reviewer: 5. Lines 240-241: What is the significance of the convergence noted here? Explain why it is worth mentioning.

Response: This is resolved by indicating that It is important to note this because, studies conducted by Seko et al. (2015) and Yokota et al. (2016), revealed that low-level water vapour and convergence near the storm are important factors for low-level mesocyclogenesis, which is a process important in supercell tornadogenesis.

Reviewer: 6. Line 260: Specifically, the advection of dry air atop warm, moist air builds “potential” instability.

Response: This is noted thanks.

Reviewer: 7. Line 316: “…which is an indicator that SA4.4 did not capture the mesocyclone of the VAM storm.” While this is likely true, I wonder if the magnitude is low because of the chosen pressure level (500 mb). How do 700-mb and 850-mb vertical vorticity compare? These levels may more accurately depict the midlevel or low-level mesocyclone.

Response: Although we do realise that the suggested levels may be true generally speaking, during our exploratory stage we did analyse these levels and found that they are well represented by the 500hPa in our case study.

Reviewer: 8. Lines 319-321: This claim is speculative. Though it may be true, do you have any support for it?

Response: Thank you for pointing this out. The co-editor also noted this, and therefore we have dropped this claim.

Reviewer: 9. Lines 385-386: Rather than referring to each component as an “underestimation”, I suggest noting the “poor resolution” of the given features due to 4.4-km grid spacing.

Response: The poor resolution of the 4.4-km grid spacing model has now been noted in the revised manuscript.

Reviewer: 10. Fig. 3: The resolution of this figure is poor, making it difficult to read the surface observations and identify the noted features. If you cannot achieve higher resolution of the hand analysis, I recommend including a figure of the surface observations and trying to digitally recreate the hand analysis, or at least annotate the key features.

Response: This figure has now been replaced with a much clearer one.

Reviewer: 11. Fig. 5: These are nice plots, but I think they would be more readable in two rows and four columns.

Response: Thank you for this suggestions. We have now changed them to two rows and four columns.

Reviewer: 12. Fig. 6: The surface point is clearly erroneous in the FAIR sounding. Can you remove it when plotting?

Response: Although we could not change this, the "hypothetical" parcel trajectory indicated by the black line is based on data masking this surface erroneous data as can be seen on the figure.

Reviewer: 13. Fig. 7: Higher resolution images would be very helpful here.

Response: Unfortunately this is caused by the radar resolution. When we apply smoothing schemes it affects some of the important features, hence this is probably the best possible plot without affecting the "true state" of the observation.

Reviewer: 14. Fig. 8: This is a great addition and succinctly addresses some of my prior comments. Thanks for including it!

Response: Thank you for suggesting that we add it!

Reviewer: 15. Fig. 9: The surface winds here seem quite high and seem to be at odds with the prior surface map, though it is a little difficult to tell based on the resolution of Fig. 3. For example, in Fig. 3, I do not see any observations of 30 kt or higher. This could be a difference in timing (12z vs. 15z), but I also want to ensure that the data in Fig. 9 are accurate.

Response: This seems to be due to the difference in timing. As can be seen in the figure indicating wind roses, Kroonstad, Klerksdorp and Ermelo do records winds of over 30kts and at times over 40kts.

Reviewer: 17. Fig. 12: It may also be helpful to show some measure of surface temperature, theta, or theta-E to delineate cold pools..

Response: Surface temperature is now included to capture this suggestion.

Reference

Stevens, D.E., and Crum, F.X.: Meteorology, Dynamic (Troposphere). Encyclopedia of Physical Science and Technology [Meyers, R.A. (ed)], 3rd Ed., Academic Press, San Diego, 629–659. doi: https://doi.org/10.1016/B0-12-227410-5/00436-1, 2003.

Carley, M, and Bustelo, E.: Social indicators and development, Project Appraisal, 1, 266–268. doi: https://doi.org/10.1080/02688867.1986.9726580, 1986.

Seko, H., Kunii, M., Yokota, S., Tsuyuki, T., and Miyoshi, T.: Ensemble experiments using a nested LETKF system to reproduce intense vortices associated with tornadoes of 6 May 2012 in Japan, Prog. Earth Planet. Sci., 2, 42. doi: https://doi.org/10.1186/s40645-015-0072-3, 2015.

Yokota, S., Seko, H., Kunii, M., Yamauchi, H., and Niino, H.: The tornadic supercell on the Kanto Plain on 6 May 2012: Polarimetric radar and surface data assimilation with EnKF and ensemble-based sensitivity analysis, Mon. Wea. Rev., 144, 3133–3157. doi: https://doi.org/10.1175/MWR-D-15-0365.1, 2016.

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

Response to referee report #2

Reviewer: The new version of the publication “A dynamic and thermodynamic analysis of the 11 December 2017 tornadic supercell in the Highveld of South Africa” has improved. The authors included additional material as suggested and addressed some of the comments raised during the review.

Authors: We would like to thank the reviewer for making time to review this manuscript. The review helped improve our manuscript. We provide a point-by-point response to all the major comments below.

Reviewer: Lines 375 to 389 contain essentially the same passages of text as the original submission, although the authors have inserted some relativizing statements in the current manuscript

Authors: Thank you for pointing this out. To fix this we have written this section in such a way that is much more clearer and have added more supporting references.

Reviewer: Here, an analysis of 2m temperature, dew point, and wind would improve the publication. The analysis provided in the recent resubmission does not help to analyse the situation with respect to the mesoscale situation. A deeper discussion on the distribution of environmental lapse rates would help to understand how necessary ingredients of convective storms came together is this situation. The comment on the importance of dry air at mid levels has not yet been addressed by the authors yet.

Authors: This is addressed this by including surface temperature, dewpoint and wind analysis plots, from the surface chart and reanalysis. We have also included a detailed discussion of the environment lapse rate (ELR) analysis alongside other convective storms ingredients already noted. ELR analysis also helps resolves the question surrounding the importance of dry mid-level air.