Reviewer 1

Recommendation: Major Revisions

The authors have made numerous changes and improvements to the manuscript. However, there are still questions surrounding their analysis of the convective allowing simulations, particularly the sources of errors. At minimum, their chosen updraft helicity threshold needs better justification, analysis of updraft helicity needs to extend later in their simulations, and the conclusions regarding model error need to be softened or removed. Specific comments are bellow.

We thank the reviewer for their feedback and additional suggestions. We have made an effort to take all of their comments into account and believe that the overall quality of the article has been improved as a result:

- The changes to the UH threshold have filtered regions with non-supercellular convection and provided a better discrimination in the forecast skill for the set of three WRF simulations.
- The analysis of the model errors has been modified to better reflect the evolution of the simulated supercell. Note that we have also slightly alternated our idealized example in Figure 20 to better reflect these changes.

Further discussion on some of the points raised by the reviewer is provided below.

Comments:

1. The updraft helicity threshold for much of the analysis has been increased from 10 m$^2$s$^{-2}$ to 50 m$^2$s$^{-2}$, however this value still needs more justification. Your UH threshold value is based on Kain et al. 2008, but the grid spacing in that study was much coarser than your current study. The operational CAM models in the U.S. now use 75 m$^2$s$^{-2}$. Clark et al. (2012) used a 100 m$^2$s$^{-2}$ value for their 1 km simulation.

The UH threshold has been increased from 50 m$^2$s$^{-2}$ to 100 m$^2$s$^{-2}$ to be consistent with the Clark et al. (2012) study. Although UH thresholds do not have any physical meaning and are traditionally tuned in accordance to some verifying observations, we found out that an increase in the UH threshold filters regions of non-supercellular convection (e.g., compare Figure 14 in the old and revised versions of the manuscript). Furthermore, the higher UH threshold provides a better discrimination regarding the skill of the three CAM ensembles, especially in terms of convection initiation at 11:00 UTC (c.f., Figures 11 and 12). While similar changes were observed for the 75 m$^2$s$^{-2}$ threshold, their magnitude was not as pronounced. This ultimately justified our decision to employ the higher UH threshold for the presentation of our results.

2. The times shown in Fig. 15 and 16 don’t match. In Fig. 16, you analyse the supercell all the way to 16Z, but the updraft helicity information shown in Fig. 15 only extends to 12:30 Z. How do you know that the storm in your simulations after 12:30 Z is even a supercell? Other than a plot of simulated radar reflectivity, there is no supporting information (plots of UH, overlays of vorticity and vertical velocity to show updraft rotation). Related to the previous comment, you state that the supercell motion is impacted by the “spurious convection” around 15 Z, but are you sure the simulated storm is even a supercell at that time? From your UH plot in Fig. 15, it looks like the WRF model is producing a supercell between 11 and 1230 Z, but you don’t show what comes after that.

The reason why the times in Figures 15 and 16 (Figures 16 and 17 in the revised manuscript) do not match is because they serve different purpose. Namely, the goal of Figure 15 (Figure 16 in the revised manuscript) is to highlight the presence of two ensemble clusters in which convection initiation takes place at different times. Figure 16 (Figure 17 in the revised manuscript), on the other hand, is intended...
to overview the convection evolution in member 30 and confirm the good correspondence between the simulated and observed supercells.

The supercellular nature of the convection in our simulations is highlighted in several places within the revised version of the manuscript:

- As explained in comment 1, the UH threshold has been increased from 50 m$^2$s$^{-2}$ to 100 m$^2$s$^{-2}$.
- The experiment comparison in the newly added Figure 15, which displays the locations where the UH values exceed 180 m$^2$s$^{-2}$, Naylor et al. [1] shows that this value is optimal for discriminating supercells in 1-km model simulations. The UH swaths in Figure 15 show that there are numerous storms in the three CAM ensembles which can be classified as supercells if we adopt the aforementioned criterion.
- In terms of member 30 from WRF.15may00utc, the newly added Figure 18 displays the UH swaths for the time period 10:00-14:30 UTC. During its peak intensity, the simulated storm exhibits UH values exceeding 350 m$^2$s$^{-2}$, which are more than sufficient to classify it as a supercell. Moreover, the track of simulated storm shows a considerable right deviation, consistent with the hail reports collected from NIMH and ESWD (Figure 18b).

3. Lines 477-479 in revised manuscript:

"Note that while the maximum NEP UH values during this time appear to be associated with WRF.14may12utc, they result from the spurious convective activity to the east of the observed supercell and, hence, do not indicate a better forecast skill."

This statement perfectly illustrates the need for choosing the proper UH threshold. If the UH threshold were appropriate for your grid configuration, then you shouldn’t be getting false alarms based on non-supercell convection.

We would like to thank the reviewer to their comment. Their suggestion ultimately helped us choose a more appropriate UH threshold to successfully addresses the problem outlined by them.

4. Lines 509-510, revised manuscript: unless you plan on showing a trajectory analysis to back up this claim, then it’s not appropriate to present this as a fact. Several studies have investigated the result of storm interaction and “cutting off the inflow” is only one possible outcome. I refer you to Hastings and Richardson (2016) for more details on the outcome of supercell-ordinary cell interactions.

We are greatly appreciative of the reviewer’s reference to the Hastings and Richardson (2016) study (HS16 hereafter). A thorough analysis of the convective evolution in member 30 revealed that the simulated supercell interacts with the surrounding spurious convection 4 times prior to its dissipation. According to the conceptual model of HS16, the first three interactions resemble (i) a multi-core supercell system (Figure R1), (ii) an HP supercell (Figure R2) and (iii) a forward-flank merger leading to the dissipation of the original supercell (Figure R3). Note that the third interaction also shows up as a temporary termination of the original UH swath in the newly introduced Figure 16a. During the last interaction, the updraft of the simulated supercell propagates towards to the cold pool of a newly convective cell that develops ahead of the supercell, causing a weakening of the simulated mesocyclone (refer to the shrinking radius of the UH180 contour) and a deviation of the supercell’s trajectory to the left of the observed one. While we agree with the reviewer that interactions between the supercell and the surrounding ordinary convection can be constructive (as was the case for the first three interactions), the large amounts of spurious convection that surround the supercell in the later forecast hours eventually weaken the supercell and lead to its upscale growth. The latter is to be contrasted with the idealized simulations of HR16 which focus primarily focus on two-cell interactions that are more likely to intensify the strength of the original supercell. The relatively strong cold pools of the
interacting cells in member 30 are another important difference with HR16, wherein the simulated supercells are not allowed to interact with mature ordinary cells.

Despite the evidence provided above, we understand the reviewer’s concern about the determination of the precise mechanism leading to the weakening of the simulated supercell in the absence of a comprehensive parcel trajectory analysis. Therefore, we have changed L530-L532 to exclude the wording “cutting off the inflow” and substitute it with the following sentence: Nevertheless, the spurious convection that develops in the model domain and the accompanying storm-scale interactions (e.g., Figures 17b and 17d) have an adverse impact on the predicted supercell trajectory in the later forecast hours.

5. Lines 570-576, revised manuscript: As previously mentioned, there’s no supporting evidence that the storm in your simulations is even a supercell at the times when the track deviates from the observed storm.

Evidence for the supercellular character of the simulated storms can be found in point 2.

Lines 640-644, revised manuscript: I’m not convinced these are separate items. It’s possible that interaction with the widespread convection causes the mode to change from supercell to something else, and that’s why you see a deviation in storm motion. You would need to present UH fields later in the simulations.

We agree with the reviewer’s comment that the interaction of the simulated supercell with the surrounding convection ultimately leads to its deviations from the observed track. Strong evidence for this hypothesis is shown in Figure R4. Note that changes in the forecasted UH swaths in Figure 18 are coincident with the time period shown in Figure R4. In the updated version of the manuscript, the statement on L601-L604 as well as the bullet points on L684-L685 only describe 2 sources of model errors – (i) CI timing and (ii) spurious convection. On L694-L695, we clarify that the spurious convective activity leads to deviations in the track of the simulated supercell and proceed with the description of the idealized example.
Figures

**Figure R1.** First supercell interaction in member 30 from WRF.15may00utc similar to the multi-core conceptual model from Hastings and Richardson [2] (top panel is adopted from their Figure 27b). *Left column:* Simulated composite radar reflectivity overlaid with contours of hourly-maximum 2-5 km UH=180 m\(\text{s}^{-2}\). *Right column:* 2-m temperature (color shading), 10-m wind (arrows), simulated 30-dBZ composite reflectivity (white contour) and hourly-maximum 2-5 km UH=180 m\(\text{s}^{-2}\).
Figure R2. Second supercell interaction in member 30 from WRF.15may00utc similar to the high-precipitation (HP) supercell conceptual model from Hastings and Richardson [2] (top panel is adopted from their Figure 28b). The rest of the symbols have the same meaning as in Figure R1.
Figure R3. Third supercell interaction in member 30 from WRF.15may00utc similar to the forward-flank merger conceptual model from Hastings and Richardson [2] (top panel is adopted from their Figure 27a). The rest of the symbols have the same meaning as in Figure R1.
Figure R4. Supercell weakening resulting from the ingestion of negatively buoyant from the surrounding ordinary cell convection. The rest of the symbols have the same meaning as in Figure R1.
References
