**MWR-D-16-0263 | Bentley et al., Response to Reviewer 2**

The authors thank Reviewer 2 for their thoughtful and thorough review. We have incorporated your recommendations as described below. We have also listed (where appropriate) the sections(s)/line(s) where each change is located in the revised manuscript.

**Overview:**  
This manuscript presents additional climatological analysis on a dataset of tropical cyclones that developed from subtropical cyclones. They show four distinct upper-tropospheric precursor features that occur prior to subtropical cyclone formation, with a 5th category of "unclassifiable". They also link three of the four categories to anticyclonic wave breaking, which was previously identified as a potential pathway for subtropical cyclone formation. This manuscript is appropriate for Monthly Weather Review. It analyzes a fairly common phenomenon in the North Atlantic basin in the context of atmospheric dynamics.   
  
The manuscript is very well written and contains substantive analysis and results that expand on their prior study. Their figures are quite good and generally easy to interpret. However, I have some minor concerns about a few aspects of the manuscript:  
- Presence of the unclassifiable category in Figs 2-6 when it is explicitly excluded from the text.   
- Minimal discussion of the meridional trough category in the context of lack of AWB  
I have detailed these concerns, plus some other minor comments, in the text below. I think this manuscript would benefit from some revisions by the authors. If the authors address these concerns, I think the manuscript is a good contribution to MWR.

The authors thank the reviewer for their kind comments! The authors feel it is important to mention that, based on recommendations by two other anonymous reviewers, the subtropical disturbance category has been removed from the present study. STCs included in that category have been reclassified, primarily as zonal troughs. The remaining categories (e.g., cutoff lows and meridional troughs) have been essentially unchanged and the results of the present study are nearly identical to the previous version. Please keep this change is mind as you read the authors responses below.

Recommendation: Minor Revisions  
   
**Major Comments**  
1) Unclassifiable STCs omitted from text (lines 146-7) but included in Figs 2-6  
The authors identify 4 categories of STC upper-tropospheric precursors, plus a fifth "unclassifiable" category. Given the focus of the article, I have no issue with removing these systems from the discussion, although I am intrigued to know their pathway(s) to formation. However, Figures 2-6 still contain the Unclassifiable category, which is inconsistent with the statement in the article. I see two options:   
1) remove the Unclassifiable category from those figures, or 2) alter the discussion to include relevant comparisons to the Unclassifiable category. Given the title of the article, #1 seems more appropriate, but the category does represent ~15% of TT STCs in the study. Perhaps the authors have another idea to resolve this discrepancy. It's just a bit disconcerting to expect only 4 categories, and then see 5 in the figures.

The reviewer brings up an important and interesting point. Based on the reviewer’s comments, the statement pertaining to the unclassifiable category on L148–150 has been expanded. In addition to stating that the unclassifiable category will not be discussed further, this statement also emphasizes that the unclassifiable category will be included in figures in the present study so that these figures can be directly compared to figures in the previous climatological study of Bentley et al. (2016). In addition, the color of unclassifiable STCs in Figs. 4–8 has been changed to white in order to be less distracting to readers.

Minor addendum to this comment: Lines 104-106 are also a bit odd after reading the rest of the article. I am led to expect that all 62 STCs in the study will be included, but then there is this 10-STC catchall category. Perhaps rewriting this line as, "For this study, NATL STCs that undergo TT are required….".

The reviewer’s comment is well taken. However, the sentence in question pertains to the 62 NATL STCs included in the previous work of Bentley et al. (2016), in which all 62 NATL STCs are required to undergo TT and form in the presence of a cold-core upper-tropospheric disturbance. For this reason, the sentence will continue to refer to all 62 NATL STCs from Bentley et al. (2016) for consistency.  
   
2) AWB and the meridional trough category (lines 495-510, 533-538).   
It's very interesting to me that the authors identify anticyclonic wave breaking in three of the four categories (meridional trough is the exception). Given the results of Galarneau et al. 2015 and McTaggart-Cowan et al. 2013, in which they suggest that AWB is an important feature of TC formation in the vicinity of upper tropospheric disturbances, I'm wondering about the implications of the lack of AWB. I'm interested in learning what is different about the meridional trough category. What do the authors think permits STC formation without AWB?

The authors believe that STC formation in the meridional trough category, which occurs in the absence of AWB, is facilitated by QG forcing for ascent downstream of the upper-tropospheric trough axis that enables the development of midtropospheric ascent and deep convection. This point is emphasized in the text on L337–341, L436–443, and L505–508. In addition, vertical motion and QG forcing for ascent associated with the meridional trough category are shown in Figs. 12,13, which depict zoomed-in views of the meridional trough composites between *t*0 − 48 h and *t*0.   
  
**Minor Comments**  
1) Lines 148-211: Principle component analysis is a common technique in the field, but it still might be good to include a brief descriptive comparison of EOF and PC to assist in interpreting Figure 1. Lines 154-155 somewhat address the interpretation, but some additional information would have been helpful for me in knowing what the physical interpretation is here. Since the manuscript is focused on a physical/dynamical understanding of STC formation, and this section supports the 4-category division, it seems important to provide additional explanation here.

Good suggestion. The authors have added new text in section 2 designed to facilitate the interpretation of the EOF analysis. Text on L158–160 indicates that similar PCs are associated with similar patterns of upper-tropospheric PV, and that STCs with similar PCs would ideally be included in the same subjective constructed category. In addition, the physical interpretation of positive/negative values of PC1 and PC2 are now discussed on L173–178 and L187–192, respectively. Characteristics of the upper-tropospheric features associated with STCs included in the cutoff low, meridional trough, and zonal trough categories are discussed on L193–214. Caveats of the EOF analysis are discussed more explicitly on L215–228.  
  
2) Figure 2 / lines 159-211: There appear to be two groupings of the unclassifiable category in this figure. On the left, there is a spray of gray dots among the yellow/meridional trough category, and on the right there is a cluster of gray dots near the subtropical disturbance/zonal trough area. If the authors decide to leave in the unclassifiable category in this figure, they should address the structure in this figure, because it really looks like they have additional meridional trough cases and a few additional ST disturbance/zonal trough cases based on the principle components. These "unclassifiable" systems are certainly worthy of further investigation, though.

Unclassifiable STCs included in Fig. 4a do not form in association with an upper-tropospheric feature whose evolution is characteristic of cutoff lows, meridional troughs, or zonal troughs during the five days prior to STC formation (L146–148). Therefore, the unclassifiable cases mentioned by the reviewer in the PC1–PC2 phase space may have similar structures to STCs included in the meridional trough and zonal trough categories at *t*0, do not exhibit the characteristic evolutions required of these categories during the five days prior to STC formation. This idea, though not explicitly used in reference to unclassifiable STCs, is included in the EOF caveats section on L215–228. Based on the reviewer’s comments, unclassifiable STCs are now colored white in Fig. 4a in order for them to be less distracting to readers.

3) Lines 309, 314: I am really interested in the large range of values for the CI. Could the authors comment on the time patterns of CI values around the time of STC formation? For example, are they relatively steady from t-12 h to t0 to t+12 h? NHC has often commented on the relatively subjective nature of determining the time of subtropical cyclone formation in their discussions, and I wonder how the means would change by adjusting formation times by +/- 12 h.

Great question. The authors have calculated the means and standard deviation of CI values calculated in a 3° × 3° box centered over the location of STC formation at *t*0 – 12 h, *t*0, and *t*0 + 12 h. Results indicate that mean CI values decrease by several degrees over the location of STC formation between *t*0 – 12 h and *t*0 in the cutoff low category, staying relatively low between *t*0 and *t*0 + 12 h. CI values decrease slightly in the meridional trough category between *t*0 – 12 h and *t*0 + 12 h, likely as the meridional trough slowly progresses eastward toward the location of STC formation. CI values increase slightly in the zonal trough category between *t*0 – 12 h and *t*0 + 12 h as the zonal trough progresses from east to west, away from the location of STC formation.

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| --- | --- | --- | --- | --- |
|  | | CI (*t*0 – 12 h) | CI (*t*0) | CI (*t*0 + 12 h) |
| Cutoff low  (*N* = 15) | Mean | 15.0 | 9.6 | 10.7 |
| Std dev | 9.5 | 5.6 | 3.8 |
| Meridional trough  (*N* = 17) | Mean | 18.7 | 17.7 | 16.9 |
| Std dev | 9.6 | 13.3 | 11.8 |
| Zonal trough  (*N* = 18) | Mean | 17.4 | 17.6 | 19.0 |
| Std dev | 7.5 | 9.1 | 7.3 |

4) Figures 7, 9, 11, 12: These figures are a bit difficult to read because of the small size of the 12 panels. If the authors wish to make them slightly smaller, I think either t0 - 120 h (a and b) or t0 - 96 h (panels c and d in all figures) could be removed since they are quite similar. By t0 - 72 h, we start to see the distinctive patterns taking shape. I understand the authors analyzed the 5 d prior to formation, but I think one of the rows could be removed without losing critical information for the analysis. I'm not going to insist on it, but if the panels get much smaller, they'll be really difficult to interpret in the print journal (I've zoomed in considerably on my screen to view them). Also, perhaps the authors could annotate the color bars to indicate (L) and (R)? The lack of yellow for the right column makes distinguishing them fairly easy upon examining the two columns, but an annotation would make it completely clear.

The authors have attempted to increase the size and readability of the 12-panel composite images as much as possible while still including images every 24 h between *t*0 – 120 h and *t*0 (Figs. 9,11,14). In addition, the color bars have been annotated to indicate (Left) and (Right) at the reviewer’s request.