Manuscript #: EGUSPHERE-2026-536

Referee #1 Round 3 Feedback and Author Reply

Author General Comments:

Thank you to the reviewer for their 3rd round of feedback, and we appreciate their comments and suggestions for publication in weather and climate dynamics. Our replies to their remaining minor comments are in blue.

Thank you to the authors for addressing my concerns. I especially acknowledge the new relative likelihood calculation/figures and streamlined Possible Role of SST analysis/section. The paper is greatly improved and suitable for publication. Just minor comments to address:

L171-173: By reporting terciles, I meant reporting the actual tornado index values the correspond to belonging to the lower/upper tercile. For example, what is the highest value that the tornado index can have to be considered a "lower tercile" event? I imagine the observed and model tornado index thresholds are different, and each tercile probably has a different range.

Here are the values that divide between lower, middle, and upper terciles in figure 3 (Table 1):

Event	Lower Tercile	Middle Tercile	Upper Tercile
TD observation (Figure 3a, red)	< -0.356	$-0.356 \leq N \leq 0.535$	>0.535
TD prediction (Figure 3a, blue)	< -0.067	$-0.067 \leq N \leq 0.523$	>0.523
TO observation (Figure 3b, red)	< -0.566	$-0.566 \leq N \leq 0.346$	>0.346
TO prediction (Figure 3b, blue)	< -0.162	$-0.162 \leq N \leq 0.537$	>0.537

Table 1: *Values associated with differentiating the terciles in figure 3.*

If both the TD observation and TD prediction are below the corresponding values in the lower tercile column, then it would be a correct prediction. The table above is now in the manuscript as Table S1 and lines 247-248 now state:

"We also evaluated the tercile-based predictions using the TO and TD time series in Fig. 3 (see the tercile thresholds in Table S1)."

L365-369: Some of this information might fit better in Methodology section.

This has been removed in section 3.3 and added to lines 194-200:

"In addition, SSTs were investigated as a possible source of TO predictability. SST and 500H composite years were selected as years in which the April-May TO count exceeds +1 standard deviation (active) or falls below -1 standard deviation (inactive) relative to the 1960-2023 mean. Extended Range SST (ERSST) (Huang et al. 2017) *of 2° x 2° resolution is used here, and we focus on SST anomalies in April because SST signals for TOs in April are more pronounced than in May based on a previous study* (Chu et al. 2019) *and our own analysis. In addition, the analysis is done for 1960-2023 to increase the sample size."*

Referee #2 Round 3 Feedback and Author Reply

Author General Comments:

Thank you to the reviewer for their 3rd round of feedback, please see our replies below in blue using line numbers from the version without tracked changes.

Thank you to the authors for addressing the second round of comments. See my comments below.

Introduction:

- (tracked changes version) Lines 98-111: This is overall, a nice addition to the introduction. However, the authors may be confusing distinguishing "low-frequency" climate modes with SST variability. "Climate modes" themselves are, at times, defined by variability in SSTs. The primary example is ENSO, which is driven by variability in tropical Pacific SSTs. This point is actually made by the authors in Lines 52-65 (tracked changes version). The authors should consider reframing this discussion slightly so that they aren't distinguishing between climate modes and SST variability like they are two separate things/ This might include rewriting the leading sentence of this new paragraph to something like, "There is growing evidence that SST variability outside of the tropical Pacific could provide an additional source of predictability for seasonal tornado activity."

  This is true, and another example would be the North Atlantic Tripole SST pattern reinforcing the NAO (Czaja and Frankignoul 2002)*, which we discuss in lines 94-96. It is possible for SSTs unrelated to climate modes to modulate tornado frequency (lines 96-98), such as in the Gulf of Mexico* (Molina et al. 2016)*, but if it helps to clear up that climate modes and SSTs are not completely independent of each other, we'll edit the opening sentence.*

  Lines 88-89 now state: "There is growing evidence that SST variability, which in some cases is related to climate modes, could serve as a source of predictability for seasonal tornado activity."

  "Low-frequency" climate modes: I would caution the authors on the use of this terminology. While modes of variability such as ENSO or NAO, for example, might seem relatively "low-frequency" when considering typical weather timescales, in climate, these climate modes are generally known to be relatively "high frequency." The authors might consider removing "low-frequency" when it is mentioned, and could replace it with mode-specific timescales (i.e., ENSO is "interannual") or just leave it at "climate modes."

  We appreciate this comment from the reviewer on the terminology of "low-frequency" climate modes. This came up in a previous round of reviews, and our emphasis in this study is on the low-frequency variability of these climate modes. Modes like NAO, AO, PNA have daily indices and can change phase on subseasonal to weather timescales, but our focus was on their seasonal variability which relatively speaking for these modes would be considered low-frequency variability. This is explained in section 2.4, lines 183-187:

  "The impacts of some climate modes, ENSO (via Nino3.4), PNA, NAO, and AO, on tornado activity and WR counts were investigated to provide a physical basis for TD and TO predictability. We focus on their low-frequency variability on the seasonal and longer time scales and derived their April-May seasonal indices using the data from the NOAA Climate Prediction Center (2024a,b)*."*

  Throughout the manuscript, all mentions of "low-frequency climate modes" have been edited to either say: "climate modes" or "low-frequency variability of climate modes."

Section 3.3: Possible role of SST

- The authors should be very careful with discussion of statistical significance in this section. Regardless of whether looking at the composites of Active or Inactive TO years statistical significance is quite limited. Additionally, a limited sample size leads a reader to question the reliability of the significance testing. The authors might consider removing discussion of significance in discussion of these specific results, and maybe add a statement saying something like, "The composite anomalies of SSTs during TO Active and Inactive years had limited statistical significance."
  We understand and appreciate the concern from the reviewer regarding the interpretation of statistical significance in our results. Since we show the significance in our results, it does make sense to discuss it. However, we agree that it is important to address potential limitations and to acknowledge caution in interpreting the results.
  The paragraph now ends with the following in lines 379-383: "The lack of significant SST anomalies and weak 500H anomalies in the active TO years are consistent with the reduced model skill during active TO years and during climate mode phases that are favorable for tornado activity and suggest that inactive TO years are more predictable than active TO years. Statistical significance of results for inactive years should be interpreted with caution given the limited sample size available (N=7)."
  We believe the SST and 500H anomalies having clearer signals in inactive years is still an important result for the manuscript with inactive years having higher model skill but agree that the statistical significance should still be interpreted with caution.

- (tracked changes version) Lines 479-482: This sentence should be re-word for clarity. Perhaps it should read, "The lack of significant SST anomalies and weak 500H anomalies in the active TO years are consistent with the reduced model skill during **active** TO years and during climate mode phases that are **favorable** for tornado activity and suggest that inactive TO years are more predictable than active TO years."
  Thank you to the reviewer for pointing out this typo, and this has now been amended in the manuscript.
- Figure S6 should include the number of samples in each composite. Consider removing this component of the manuscript or move the discussion to the supplement (track changes Lines 488-507). This discussion feels disjointed from the rest of this section. The caveat at the end of the section "Overall, the SSTs over the Pacific and Atlantic may help explain the predictability of WRs, though further investigation using longer observational records is needed to better understand the predictability of tornado activity" is nice and might be added to the final paragraph of this section, if this discussion is removed.

  Figure S6 already includes the number of samples in each panel title. We have further shortened the paragraph, and the limitations of the analysis and the need for more investigation have been acknowledged. However, we prefer to keep some discussion as they help to provide a more complete picture of the predictability of tornado activity via WRs,

  Lines 389-404 now state: "We also examined composite SST and 500H anomalies for active and inactive WR years, defined as the years when the springtime WR count exceeds ± 1 standard deviation from the mean (Fig. S6). WR-A shows opposite circulation patterns over the CONUS between its active and inactive years, with the inactive years resembling a -AO/-NAO pattern consistent with reduced WR-A occurrence during those phases. Active WR-B years exhibit a North Atlantic 500H pattern resembling a -AO pattern. In contrast, inactive WR-B years feature anomalously low SSTs over the North Pacific and an anomalous 500H high over Canada, *resembling a +PNA pattern. These patterns are consistent with how PNA and AO modulate WR-B frequency (Fig. 6). The SST composite for active WR-B years has the highest pattern correlation with active TO years (cc=0.45, Table S2). Active WR-C years feature enhanced southerly flow from the Gulf of Mexico and anomalously low SSTs in the Gulf of Mexico. Their offsetting effects help explain the near-climatology tornado activity. WR-D and WR-E show opposite and statistically significant SST anomalies in the subtropical Pacific, suggesting some potential predictability. Overall, the SSTs over the Pacific and Atlantic may help explain the predictability of WRs, though further investigation using longer observational records is needed to better understand the predictability of tornado activity."*

Author References:

*Chu, J.-E., A. Timmermann, and J.-Y. Lee, 2019: North American April tornado occurrences linked to global sea surface temperature anomalies. Sci. Adv., **5**, https://doi.org/https://doi.org/10.1126/sciadv.aaw9950.*

*Czaja, A., and C. Frankignoul, 2002: Observed Impact of Atlantic SST Anomalies on the North Atlantic Oscillation. J. Clim., **15**, 606–623, https://doi.org/https://doi.org/10.1175/1520-0442(2002)015<0606:OIOASA>2.0.CO;2.*

*Huang, B., and Coauthors, 2017: Extended Reconstructed Sea Surface Temperature, version 5 (ERSSTv5): Upgrades, validations, and intercomparisons. 15 Oct 2017, **30**, 8179–8205, https://doi.org/https://doi.org/10.1175/JCLI-D-16-0836.1.*

*Molina, M. J., R. P. Timmer, and J. T. Allen, 2016: Importance of the Gulf of Mexico as a climate driver for U.S. severe thunderstorm activity. Geophys. Res. Lett., **43**, 12295–12304, https://doi.org/https://doi.org/10.1002/2016GL071603.*

NOAA Climate Prediction Center, 2024a: Daily climate mode indices, accessed 1 September 2025, https://ftp.cpc.ncep.noaa.gov/cwlinks/.

——, 2024b: Oceanic Niño Index (ONI) v5 - Monthly SST anomalies in the Nino 3.4 region, accessed 1 September 2025, https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php.