Manuscript #: EGUSPHERE-2026-536

Referee #1 Round 2 Feedback and Author Reply:

Author General Comments:

Thank you to the reviewer for their 2nd round of feedback. Our replies are in blue.

We would like to let the reviewer know that substantial edits were made in sections 3.2 and 3.3 in response to reviewer # 2. Mainly, these sections now focus only on tornado outbreaks. This hopefully improves the flow and readability of the manuscript. Figure 5 was changed to only show probability anomalies for outbreaks. Figure 6 now shows relative likelihood for WR frequency during specific climate modes, which hopefully makes that figure more interpretable. The SST section in the main manuscript now only includes the SSTs during active and inactive tornado outbreak years, though the WR SST figure is now in the supplementals. As such, the discussion related to this figure is substantially shortened. A paragraph on SSTs has also been added to the introduction. We invite reviewer # 1 to review these changes if they would like.

Minor Comment:
In the revised manuscript, the authors add several new paragraphs into the introduction which define the modes of climate variability that they consider in their analysis and discuss why these mode of variability may impact the predictability of spring season tornado days and tornado outbreaks in the United States. The definition of these climate modes is concise and sufficient. However, in connecting these climate modes to tornado occurrence, all indices are connected to the jet stream (i.e., Lines 55-56: "ENSO modulates the strength and position of the Pacific jet stream...", Lines 65-66: "NAO and AO are strongly correlated and modulate the strength and position of the midlatitude jet stream...", Lines 75-76: "PNA modulates the position and intensity of the East Asian jet stream which influences large-scale circulations relevant for severe weather."). For clarity, the authors might consider slightly modifying this discussion. Later in the manuscript, the authors do discuss more in-depth how individual climate modes explicitly modify the circulation over the regions where tornadoes occur (see Section 3.2). They might include some discussion closer to these lines, including when such has been discussed in previous work, rather than solely stating that each mode "modifies the jet stream".

Some discussion was added where appropriate. Much of the prior literature focuses on winter phases since that is when these climate modes are at peak intensity. This manuscript focuses on the low-frequency variability of these modes during April-May. Likewise, the results in this manuscript are not completely consistent with what previous studies have found for winter modes. As it is, we will add a sentence or two where possible with it being known that these studies used winter climate modes. Some of what is put here was already added, but additional references and statements were added.

For ENSO, a statement on tornado activity has been added in lines 59-63: "Previous studies have linked the winter ENSO phase to the variability of tornado activity with the La Niña phase being associated with increased springtime tornado activity particularly in the Southeast (Allen et al. 2015, 2018; Cook and Schaefer 2008; Knowles and Pielke 2005; Lee et al. 2016; Malloy and Tippett 2024)*."*

ENSO has been investigated far more than NAO, AO, and PNA, but a few papers are available that are important to mention.

For NAO and AO, lines 70-77 now state: "Previous work has demonstrated that NAO and AO influence tornado activity across the central and eastern CONUS. The positive AO phase is associated with enhanced winter and early-spring tornado activity in the Southeast (Childs et al. 2018; Hoogewind et al. 2025; Niloufar et al. 2021; Tippett et al. 2022)*, while the positive NAO phase corresponds to anomalously low springtime tornado activity in the Southeast and Central Plains* (Elsner et al. 2016; Niloufar et al. 2021)*. These relationships indicate that the NAO and AO may provide additional sources of predictability for springtime tornado activity."*

For PNA, most notable references were already cite but Kim et al (2024) was added as well. Not much literature exists regarding how PNA modulates tornado activity.
Lines 84-87 state: "The negative phase of PNA has been associated with enhanced springtime tornado activity and high-impact tornado outbreaks (Kim et al. 2024; Munoz and Enfield 2011)*, and previous work has linked the variability of tornado activity to SST anomalies that are connected to PNA-like patterns over the Pacific* (Chu et al. 2019)*. These relationships suggest that PNA, along with ENSO, AO, and NAO, potentially serve as sources of predictability for springtime tornado activity."*

Line 53: ENSO should be written out in words here when it is first mentioned.

ENSO is first mentioned in line 46 and is written out in full as written.

Line 94: TD should be defined here instead of in line 127 when it is first defined.

Lines 112-114 now state: "Graber et al. (2025) identified two WRs that strongly affect the warm-season tornado activity, especially TOs, and developed an empirical model using WR frequency, persistence, and probability of tornado days (TD; hereinafter, days with ≥ 1 EF/F-1+ tornadoes)."

Lines 163-164: Citation here seems to have an error.

This has been fixed

Section 3.3: Need to mention that "+-WR-X" means "active" and "-WR-X" means "inactive" weather regime years.

Please see general comments on major revisions to this section. This has been amended where necessary.

Line 355: "+WR" should be "+WR-A"

Done

Author References:

Allen, J. T., M. K. Tippett, and A. H. Sobel, 2015: Influence of the El Nino/Southern Oscillation on tornado and hail frequency in the United States. *Nat. Geosci.*, **8**, 278–283, https://doi.org/https://doi.org/10.1038/ngeo2385.

——, M. J. Molina, and V. A. Gensini, 2018: Modulation of annual cycle of tornadoes by El-Nino-Southern Oscillation. *Geophys. Res. Lett.*, **45**, 5708–5717, https://doi.org/https://doi.org/10.1029/2018GL077482.

Childs, S., R. S. Schumacher, and J. T. Allen, 2018: Cold-season tornadoes: Climatological and meteorological insights. *Weather Forecast.*, **33**, 671–691, https://doi.org/https://doi.org/10.1175/WAF-D-17-0120.1.

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.

Cook, A. R., and J. T. Schaefer, 2008: The relation of El Nino-Southern Oscillation (ENSO) to winter tornado outbreaks. *Mon. Weather Rev.*, **136**, 3121–3137, https://doi.org/https://doi.org/10.1175/2007MWR2171.1.

Elsner, J. B., T. H. Jagger, and T. Fricker, 2016: Statistical models for tornado climatology: Long and short-term views. *PLoS ONE*, **11**, https://doi.org/https://doi.org/10.1371/journal.pone.0166895.

Hoogewind, K. A., V. A. Gensini, and H. E. Brooks, 2025: On the relationship between monthly mean surface temperature and tornado days in the United States. *Npj Clim. Atmospheric Sci.*, **8**, https://doi.org/https://doi.org/10.1038/s41612-025-00993-2.

Kim, D., S.-K. Lee, H. Lopez, J.-H. Jeong, and J.-S. Hong, 2024: An unusally prolonged Pacific-North American pattern promoted the 2021 winter quad-state tornado outbreaks. *Npj Clim. Atmospheric Sci.*, **7**, https://doi.org/https://doi.org/10.1038/s41612-024-00688-0.

Knowles, J. B., and R. A. Pielke, 2005: The Southern Oscillation and its effects on tornadic activity in the United States. 15 pp.

Lee, S.-K., A. T. Wittenberg, D. B. Enfield, S. J. Weaver, C. Wang, and R. Atlas, 2016: US regional tornado outbreaks and their links to spring ENSO phases and North Atlantic SST variability. *Environ. Res. Lett.*, **11**, https://doi.org/10.1088/1748-9326/11/4/044008.

Malloy, K., and M. K. Tippett, 2024: A stochastic statistical model for U.S. outbreak-level tornado occurrence based on the large-scale environment. *Mon. Weather Rev.*, **152**, 1141–1161, https://doi.org/https://doi.org/10.1175/MWR-D-23-0219.1.

Munoz, E., and D. Enfield, 2011: The boreal spring variability of the Intra-Americas low-level jet and its relation with precipitation and tornadoes in the eastern United States. *Clim. Dyn.*, **36**, 247–259, https://doi.org/https://doi.org/10.1007/s00382-009-0688-3.

Niloufar, N., N. Devineni, V. Were, and R. Khanbilvardi, 2021: Explaining the trends and variability in the United States tornado records using climate teleconnections and shifts in observational practices. *Sci. Rep.*, **11**, https://doi.org/https://doi.org/10.1038/s41598-021-81143-5.

Tippett, M. K., C. Lepore, and M. L. L'Heureux, 2022: Predictability of a tornado environment index from El Nino Southern Oscillation (ENSO) and the Arctic Oscillation. *Weather Clim. Dyn.*, **3**, 1063–1075, https://doi.org/https://doi.org/10.5194/wcd-3-1063-2022.

egusphere-2026-536

Seasonal prediction of springtime tornado activity in the United States using a hybrid model

Graber et al.

Recommendation: major revisions

General comments:

Thank you to the authors for addressing my concerns. See remaining comments / response below.

We appreciate the reviewer's comments, and we will consider all of their suggestions in the next version of the manuscript. Our responses below are in blue.

Major comments:

1. For readability and brevity, authors should consider focusing on TO prediction results for remainder of paper's main text after figure 3. A statement near the end of section on L203-211 about why they focus on TO prediction for remainder of paper is justified by TD lower prediction skill and weaker connection to WRs.

We appreciate and agree with the reviewer on this and have made the change in the revised manuscript. Hopefully this will help with the readability and flow of the manuscript, and it should also help cut down on acronyms since TD won't be used in sections 3.2 and 3.3. We will pretty much keep the messaging of section 3.1 the same and add a statement at the very end of the section stating that the rest of the paper will focus on the TOs only.

Lines 252-253 now state: "Given the low model skill (Fig. 3) and weaker connection to WRs for TDs (Fig. 1), the remainder of this paper will focus solely on TOs."

Below is a general summary of the changes:

- *Acronyms were removed for the Southeast and Midwest, and they are now written in full.*
- *Figure 5 now only includes TO probability anomalies by region and climate mode. Any discussion on TDs has been removed.*
- *Ahead of figure 6, any comments on TDs have been removed.*
- *The discussion section has also been amended with removal of comments related to TOs.*

Related- Figures 5 and S3: The TD probability anoms are weak/noisy for some panels in Fig S3, consistent with the generally weaker relation between TD and climate modes in Fig 5 a,c,e,g (except maybe NAO?). The authors should consider plotting TO anoms in Figure S3 to accompany discussions, e.g. L252-253.

We have updated the manuscript in sections 3.2 and 3.3 to only focus on tornado outbreaks. Figures 5 and S3 have been updated to include only TO probability anomalies. Figure S3 is pasted below as Fig. 1. In general, some anomalies remain noisy such as the negative phase of AO and negative phase of PNA as two examples, but this would also be consistent with those phases having lower predictive skill than their positive phase counterparts. The discussion in this portion of section 3.2 now only includes discussion on TOs and any discussion on TDs has been removed.

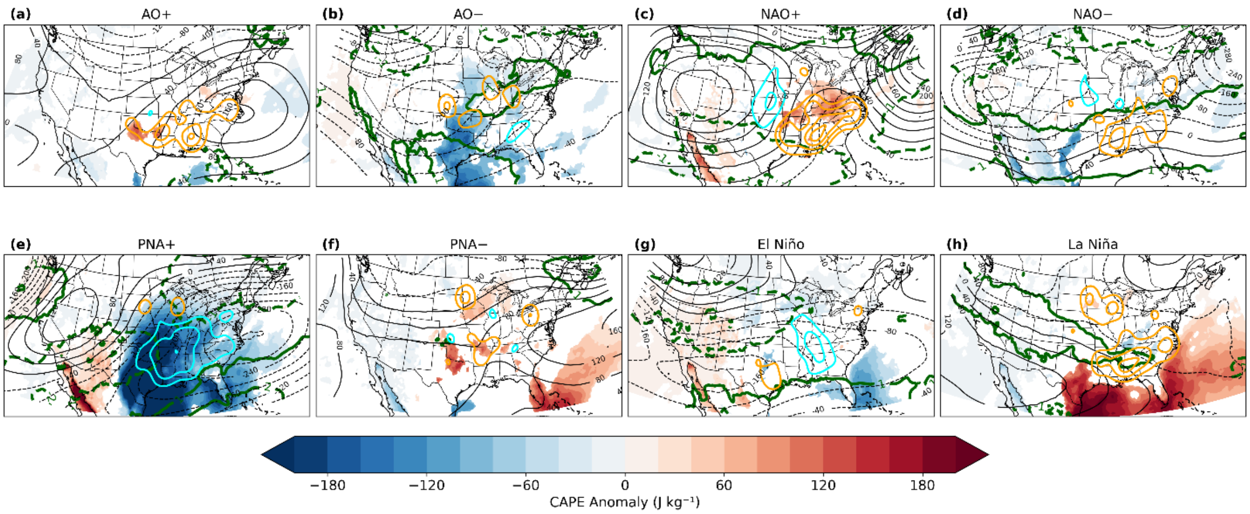


Figure 1: *500H anomalies (units: m; black contours) for positive and negative years of AO (top left), NAO (top right), PNA (bottom left), and ENSO (bottom right) overlayed with daily maximum CAPE anomalies (units: J Kg^{-1}; red/blue filled contours), 2^o x 2^o uniform-filtered daily mean vertical wind shear anomalies (units: m s^{-1}, green contours) and Gaussian smoothed tornado outbreak probability anomalies (contour intervals: ±20%; orange/cyan contours). Significance ($p \leq 0.05$) for anomalies is determined using a one-sample, two-sided t-test to mask out non-significant anomalies.*

2. Figure 6 and L327-328: "However, WR-E's occurrence during the negative phase of ENSO is still less than any other WR." The authors are asking if a climate mode (like ENSO) makes a WR more or less likely, to explain if tornado outbreaks are more or less likely, so they should be comparing these fractions/occurrences to the WR climatological frequency. WR-E only occurs 14% of the time (Fig. 1), so it makes sense that it would almost always be the lowest percentage regardless of climate mode. In the case of ENSO as example, WR-E occurring ~20% during El Nino are robust increases in WR-E's frequency. This could partially explain predictive skill for negative years since WR-E on average relates to -50% reduction in (persistent) outbreak days (cf. Figure 1).
   We agree, the redundant statements on WR-E's occurrence being less than any other WR have been removed. An additional statement on how WR occurrence during +PNA could be used to indicate the higher predictive skill of inactive TO years.

Lines 340-343 now state: "The reduced occurrence of WR-B and increased occurrence of WR-E are consistent with reduced TO activity over CONUS, Midwest, and SGP during +PNA (Fig. 5), and also help explain the high predictive skill of inactive TO years and indicate that +PNA offers a forecast of opportunity for inactive TO years (Fig. 6c)."

In fact, for this figure and section, it might make more sense for the authors to compare the frequency/fraction of each WR given climate mode to the WR climatological frequency. E.g. Relative likelihood = P(WR | climate mode) / P(WR). This ties back to Figure 1's relative TD/TO frequencies more cleanly and the raw percentages can be misinterpreted easily.
We appreciate this comment from the reviewer and have changed the figure to relative likelihood (which is pasted below as figure 2). This does in fact make it easier to interpret. Some additional statements have been added.

Lines 324-326 now state: "Figure 6 shows the relative likelihood of each WR during different phases of low-frequency climate modes, expressed as the ratio of its phase-specific frequency to its climatological frequency."

Lines 326-328 now state: "WR-A us ~36% less likely to occur during the -AO phase, while WR-B is ~35% more likely to occur (Fig. 6a)."
Lines 330-332 now state: "WR-D is ~27% less likely to occur during -AO, so the above average tornado activity in -AO (Fig. 5a) is mainly due to above average frequency of WR-B. Additionally, WR-A is 21% less likely to occur during +AO years."

Lines 333-334 now state: "During +NAO years, WR-A is ~42% more likely to occur, which is consistent with the reduced TO probability in the NGP and SGP (Fig. 6)"
Lines 336-338 now state: "WR-A's increased occurrence could help explain the high predictive skill of inactive TO years and indicate that +NAO offers a forecast of opportunity for inactive TO years (Fig. 6b). Additionally, WR-A is ~30% less likely to occur and WR-E is ~30% more likely to occur during -NAO years."

Lines 339-340 now state: "During +PNA years, WR-B is ~35% less likely to occur, whereas WR-E is ~62% more likely to occur (Fig. 6c)."
Lines 340-343 now state: "WR-E's increased occurrence could also help explain the high predictive skill of inactive TO years and indicate that +PNA offers a forecast of opportunity for inactive TO years (Fig. 6c).

Lines 346-349 now state: "ENSO is not associated with significant changes in WR frequency, except for WR-E (Fig. 6d). WR-E is ~32% more likely to occur during El Niño, which is consistent with the reduced tornado activity during El Nino years reported in previous studies (Cook et al., 2017). Additionally, WR-E is ~18% less likely to occur during the neutral phase."

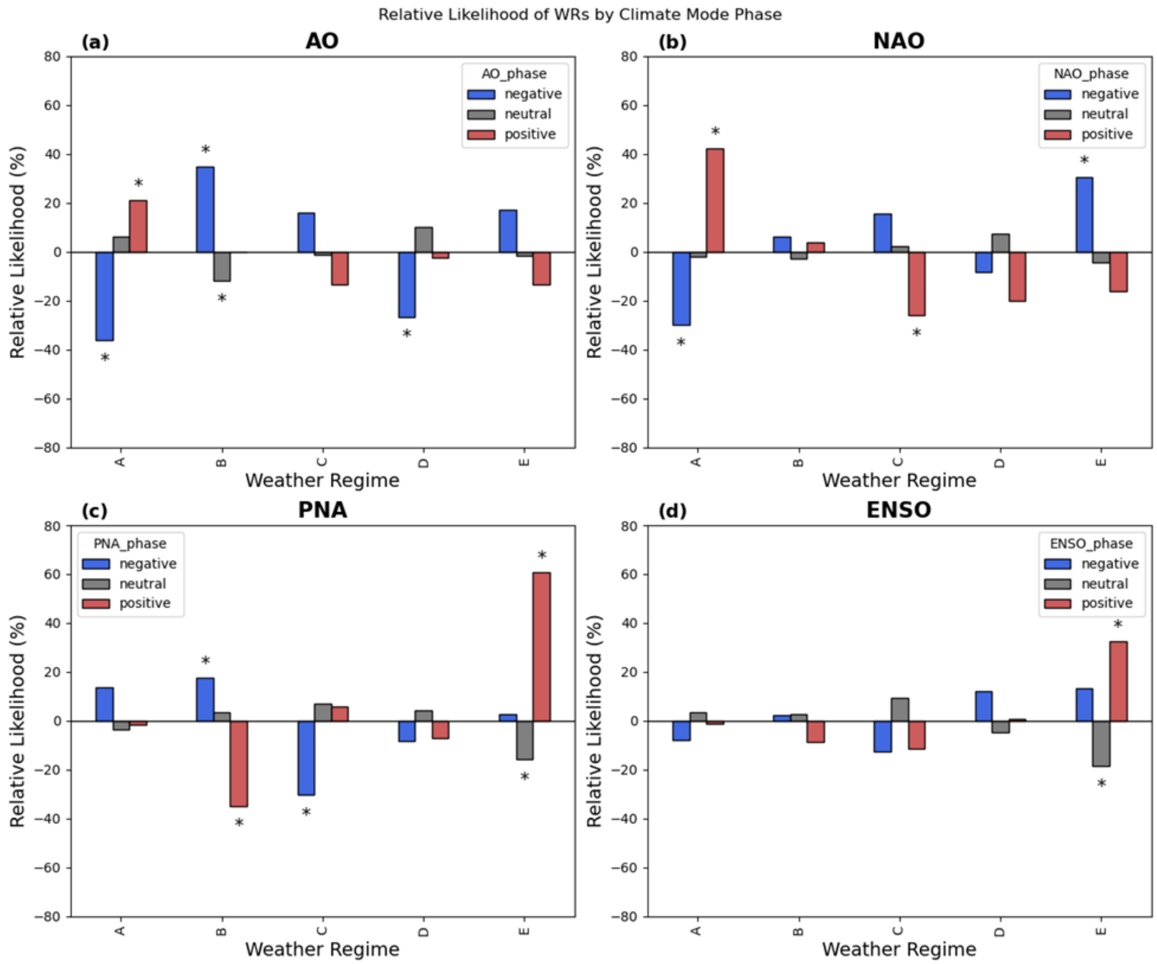
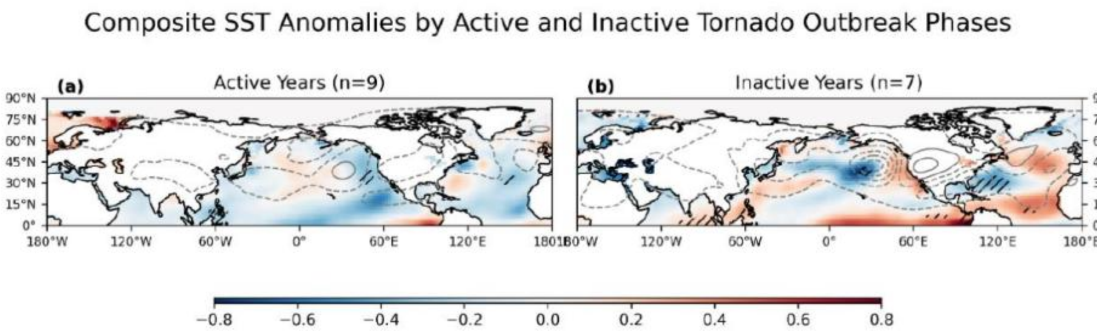


Figure 2: Relative likelihood (RL: %) of each WR in different phases of AO (a), NAO (b), PNA (c), and ENSO (d). An asterisk indicates that the frequency is significantly different (p ≤ 0.05) from climatology using a scipy binomial test. Black horizontal line representing the climatological frequency is at RL=0.0.

3. Figure 7 and Reviewer Response to Referee 2 #1d (and related Referee #1 comments): I still think there needs to be more refining of the potential role of SSTs as source of predictability. Its current presentation/discussion does not flow from previous sections, and most of the patterns discussed are not statistically significant so statements are inflated/not justified.

   I liked Referee #1's suggestion of comparing SST/H500 anomalies of active and inactive TO years (new Figure S6, pasted below), which I think is the main signal the authors are trying to extract.



We appreciate the reviewer's comments on this section, and we agree that a better connection needs to be made. The above figure is the new figure 7, and the text has been majorly updated.

Lines 370-386 now state: "During inactive TO years, significant positive SST anomalies are found over equatorial eastern Pacific and significant negative SST anomalies over the North Pacific and subtropical western Atlantic. Inactive TO years feature an anomalous 500H high over the west-central CONUS and anomalous 500H lows over the East Pacific and Southeast CONUS, resembling WR-A. A positive phase of the North Atlantic tripole SST pattern is present, consistent with (Lee et al., 2016). In contrast, significant SST anomalies are nearly absent during active TO years except a limited region of cold SST anomalies over the East Pacific just off California. The 500H anomalies are characterized by an anomalous trough over CONUS, resembling WR-B, but the anomalies are much weaker than those during the inactive TO years. The lack of significant SST anomalies and weak 500H anomalies in the active TO years are consistent with the reduced model skill during inactive TO years and during climate mode phases that are unfavorable for tornado activity and suggest that inactive TO years are more predictable than active TO years.

To quantify the link between the SST anomalies and climate modes, we calculated the pattern correlations between SST composites in Fig. 7 and those associated with various climate modes (Table S1). Stronger correlations tend to be found in inactive TO years. The highest correlation occurs for inactive TOs and +PNA (cc=0.71), thus demonstrating that +PNA can be used to identify a forecast of opportunity for inactive TO years."

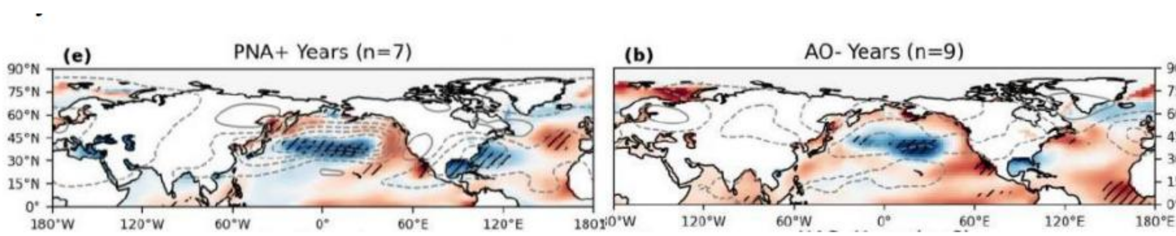
In addition, a paragraph was added into the introduction to better motivate this section. This paragraph comes after the paragraph describing the PNA pattern:

Lines 88-101 now state: "In addition to low-frequency climate modes, there is growing evidence that SST variability could provide an additional source of predictability for seasonal tornado activity. Increasing CONUS tornado activity has been previously linked to global SST increases, with anomalously warm North Pacific SSTs associated with enhanced tornado activity (Zhao et al., 2025). Additional work shows that North Pacific SST anomalies can influence the variability of tornado activity through PNA-like circulation anomalies, including an eastward shift of the Aleutian Low and enhanced moisture transport from the Gulf of Mexico (Chu et al., 2019). The North Atlantic tripole SST pattern, which reinforces the NAO through positive air-sea interactions (Czaja and Frankignoul, 2002), has been linked to CONUS tornado outbreaks (Lee et al., 2016). Gulf of Mexico SSTs also modulate spring tornado frequency with anomalously warm (cool) Gulf SSTs favoring more (fewer) CONUS tornadoes (Hoogewind et al., 2025b; Molina et al., 2016). These Gulf SSTs are also somewhat dependent on the phase of ENSO with La Niña (El Niño) *favoring warmer (cooler) SSTs. These studies motivate a closer examination of how SSTs may serve as an additional source of predictability for springtime tornado activity."*

The original figure related to WRs is now in the supplementals, and a summarized version of the original text is now included in the main manuscript:

Lines 387-406 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 have the highest pattern correlation with active TO years (cc=0.45, Table S1). Active WR-C years feature a favorable 500H pattern for tornado activity with an anomalous low over the western Atlantic and enhanced southerly flow from the Gulf of Mexico. However, anomalously low Gulf of Mexico SSTs in active WR-C years demonstrates offsetting thermodynamical and dynamical components, which helps explain the near-climatology tornado activity during WR-C. WR-D and WR-E show opposite and statistically significant SST anomalies in the subtropical Pacific, suggesting some potential predictability. Since WR-D is favorable for tornado activity and WR-E suppresses it, these relationships are noteworthy, though the robustness of the relationship requires further examination given the overall weak SST patterns. 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."*

Robust SST signals are present only for the inactive years, which resembles SST anomalies related to PNA+/AO- (Figure 2 from Reviewer Response to Referee #2, pasted below). It does not particularly resemble any of the SST patterns from the active/inactive WR composites except maybe inactive WR-A.



Another suggestion is that the authors could attempt to perform pattern correlation between the SST anomaly composites for the active/inactive TO years and the SST anomaly composites for the climate modes/WRs, which would help quantify/summarize/explain similarities.

This was a great suggestion, and a data table has been added to the supplementals showing the pattern correlations (pasted below as table 1). It further demonstrates that +PNA seems to offer a forecast of opportunity for inactive TO years.

Lines 382-386 now state: "To quantify the link between the SST anomalies and climate modes, we calculated the pattern correlations between SST composites in Fig. 7 and those associated with various climate modes (Table S1). Stronger correlations tend to be found in inactive TO years. The highest correlation occurs for inactive TOs and +PNA (cc=0.71), thus demonstrating that +PNA can be used to identify a forecast of opportunity for inactive TO years."

WR or Climate Mode SSTs	Active TOs SSTs	Inactive TOs SSTs
+WR-A	0.2	-0.02
-WR-A	-0.06	0.57
+WR-B	0.45	-0.11
-WR-B	-0.26	-0.08
+WR-C	-0.12	0.4
-WR-C	-0.02	-0.42
+WR-D	-0.05	-0.31
-WR-D	-0.29	0.29
+WR-E	-0.19	-0.22
-WR-E	0.09	0.11
+AO	0.11	-0.43
-AO	-0.15	0.44
+NAO	0.25	-0.16
-NAO	0.03	0.27
+PNA	-0.27	0.71
-PNA	-0.05	-0.46
El Nino	-0.22	0.55
La Nina	0.34	-0.45

Table 1: *Pearson pattern correlations between SST composites for active and inactive TO years and SST composites associated with active/inactive WR years, and the SST composites with the phases of AO, NAO, PNA, and ENSO.*

Minor Comments

L62: Capitalize Northern Hemisphere

Done

L89: Change "year-long" to year-round"

Done

L91: Sentence needs to reworked for clarity as it is unclear what the authors mean by "results mainly driven by years with more Pacific Ridge WR days."

Basically, the frequency of the Pacific Ridge WR in Tippett et al. (2024) is the main driver of the relationship between tornado reports and year-round WRs. This has been re-worded:

Lines 108-112 now state: "Tippett et al. (2024) explored the modulation of tornado activity using year-round WRs (Grams et al. 2017; Lee et al. 2023) and found statistically significant relationships between tornado reports and WRs during all months except June-August, with the frequency of the Pacific Ridge WR days being the main driver of the relationship with tornado reports."

L149-151: State the tercile thresholds that dictate if tornado index in upper and lower tercile.

Lines 171-173 now state: "Additionally, a three-tier categorical verification was used by classifying both observed and predicted tornado index values into lower (0^{th}-33^{rd} percentile), middle (33^{rd}-67^{th} percentile), and upper (67^{th}-100^{th} percentile) terciles."

L179-180: WR-A resembles Pacific *Trough* from Lee et al. (2023).

The mistake was not saying the ridge, but rather saying WR-B. Lines 202-203 make this fix: "Specifically, WR-B and WR-E resemble the Pacific Ridge and Alaskan Ridge regimes in Lee et al. (2023)…"

L208: The authors should elaborate on what a "weak" pattern means… Non-persistent? Weak geopotential height anomalies? Patterns that do not cleanly project onto the calculated WRs?

Transient patterns would be considered non-persistent. In this sense, the more persistent a WR is then the more likely it is to produce a tornado outbreak, and the more predictable it may be. This is grounded in the literature as well (Graber et al., 2025; Trapp, 2014)*. Patterns may also be weaker, in which case the 500H anomalies would have a weaker signal and would be less predictable. This has been added to the manuscript:*

Lines 229-233 now state: "The skill contrast between the TO and TD predictions is probably because TOs usually occur under strong and persistent synoptic-scale patterns (Mercer et al. 2012; Cwik et al. 2022; Jiang et al. 2025; Graber et al. 2025), while transient (i.e., non-persistent) and weak patterns (e.g., patterns with weaker 500H anomalies than those associated with TOs), which are not well captured by the ECMWF springtime forecasts, may have strong impacts on TDs."

L287: Threat Score should briefly be explained in Section 2.3. In addition, was the Threat Score only evaluated for NAO+ and PNA+ years? It is unclear why only one number for upper tercile and one number for lower tercile is reported though PC was reported for each climate mode phase.

This is a valid question. It is not calculated for any of the climate modes. It is simply calculated for all upper-tercile years, and then all lower-tercile years. For example, with upper-tercile years, there are 6 hits, 2 misses, and 8 false alarms. The 6 hits mean that the observation and prediction time series were both in the upper tercile (≥67th percentile), the 2 misses mean the observation curve was in the upper tercile and the prediction curve was not, and the 8 false alarms mean the prediction curve was in the upper tercile and the observation curve was not. The threat score was calculated in response to the results in figure 5 and thus explaining it in the methodology may hurt the flow of the manuscript.

The same 33rd and 67th percentiles are used separately for the full observation and prediction time series to define the three terciles. For each individual climate mode, only the relevant years are evaluated, and the PC was calculated for those years based on whether the two time series were in the same terciles.

Fig. 1: Panels g and I have the p-value in title displayed as one decimal point (0.0 instead of 0.0x). Can the authors check the string formatting, such that a p-value like 0.01, 0.02, …, isn't displaying as 0.0? It looks correct in later figures.

We took a look at this and the p-value string formatting was set to .1f, and the new version of the figure will be set to .3f. However, the p-value for the TD model is 0.0003 and 0.00008 for the TO model. Therefore, the p-value will show up in the figure as <0.001.

The authors should consider including these missed references on climate modes-tornado/outbreaks over the last few years:

Hoogewind, K. A., Galarneau Jr, T. J., & Gensini, V. A. (2025). Severe Convective Weather Outbreaks on 10 and 15 December 2021: Large-Scale Antecedent Conditions. Monthly Weather Review, 153(7), 1171-1194.

Hoogewind, K. A., Gensini, V. A., & Brooks, H. E. (2025). On the relationship between monthly mean surface temperature and tornado days in the United States. npj Climate and Atmospheric Science, 8(1), 119.

Kim, D., Lee, S. K., Lopez, H., Jeong, J. H., & Hong, J. S. (2024). An unusually prolonged Pacific-North American pattern promoted the 2021 winter quad-state tornado outbreaks. npj Climate and Atmospheric Science, 7(1), 133.

Malloy, K., & Tippett, M. K. (2024). A stochastic statistical model for US outbreak-level tornado occurrence based on the large-scale environment. Monthly Weather Review, 152(5), 1141-1161.

Malloy, K., & Tippett, M. K. (2025). Forecasting US Tornado Outbreak Activity and Associated Environments in the Global Ensemble Forecast System (GEFS). Weather and Forecasting, 40(4), 593-608.

Thank you to the reviewer for these suggestions. Four of these manuscripts are now cited in our study.

The 1st Hoogewind et al. paper listed discusses how Gulf of Mexico SSTs are additional drivers of tornado activity, with this paper referring to a specific case.

Lines 96-98 now state: "Gulf of Mexico SSTs also modulate spring tornado frequency with anomalously warm (cool) Gulf SSTs favoring more (fewer) CONUS tornadoes (Hoogewind et al., 2025b; Molina et al., 2016)."

The 2nd Hoogewind et al. paper listed is added to the introduction for its connection to the Arctic Oscillation.

Lines 71-75 now state: "The positive AO phase is associated with enhanced winter and early-spring tornado activity in the Southeast (Childs et al., 2018; Hoogewind et al., 2025a; Niloufar et al., 2021; Tippett et al., 2022), while the positive NAO phase corresponds to anomalously low springtime tornado activity in the Southeast and Central Plains (Elsner et al., 2016; Niloufar et al., 2021)."

Kim et al. 2024 is a great reference for discussing PNA's relationship to tornado activity and is needed here.

Lines 84-86 now state: "The negative phase of PNA has been associated with enhanced springtime tornado activity and high-impact tornado outbreaks (Kim et al., 2024; Munoz and Enfield, 2011)."

Malloy & Tippett (2024) is added as an additional paper relating ENSO to tornado activity.

Lines 59-63 now state: "Previous studies have linked the winter ENSO phase to the variability of tornado activity with increased springtime tornado activity during the La Niña phase, particularly in the Southeast (Allen et al., 2015, 2018; Cook and Schaefer, 2008; Knowles and Pielke, 2005; Lee et al., 2016; Malloy and Tippett, 2024)."

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