12B.2 A Climatology of the Conditional Probability of Significant Severe Hazards and Its Operational Implications

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1. INTRODUCTION

The NOAA/NWS/Storm Prediction Center's (SPC) Day 1-3 Convective Outlooks depict the unconditional probability that tornadoes, severe hail, or severe convective wind will be observed within 25 miles of a location during the valid forecast period. Historically, these convective outlooks also included a black, hatched contour which represented a 10% unconditional probability of observing significant severe hazards (i.e., EF2+ tornadoes, ≥ 2 in. hail, or ≥ 65 kts convective wind) within 25 miles of a location (Fig. 1). These unconditional significant severe forecasts (herein referred to as unconditional SIG) were designed to address the question, "What is the likelihood of a significant severe event," but anecdotally were more commonly interpreted as a binary prediction of significant severe hazards. Unconditional SIG forecasts were by definition dependent on the predicted coverage of severe weather, and so could not be drawn in areas with less than a 10% probability of tornadoes, hail, or convective wind regardless of expected intensity. Furthermore, unconditional SIG forecasts only provided a contour at the 10% threshold, meaning SPC forecasters were unable to highlight higher probabilities of significant severe hazards or to graphically differentiate between more common significant events and high-end events (e.g., EF2 vs EF4 tornadoes).

To address these limitations, the SPC replaced the unconditional SIG forecast with new conditional intensity forecasts on 3 March 2026 (Bunting 2026). These new forecasts represent the expected intensity distribution of severe weather hazards conditioned on if a severe weather event occurs. Specifically, the conditional intensity forecast answers the question, "If a severe hazard occurs, how likely will it be significant?" By conditioning the intensity forecast on a hazard's occurrence, SPC forecasters are now able to predict and highlight severe hazard intensity independently from the predicted spatial coverage of severe weather. This enables Convective Outlooks to more explicitly represent forecasts of low coverage/low

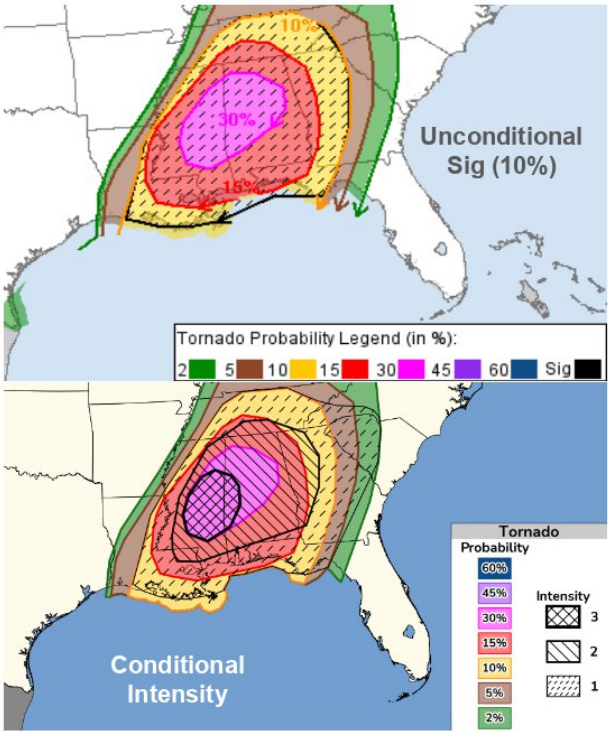


Figure 1: SPC Day 1 tornado outlook from 20250315 with (top) unconditional SIG and (bottom) conditional intensity forecasts.

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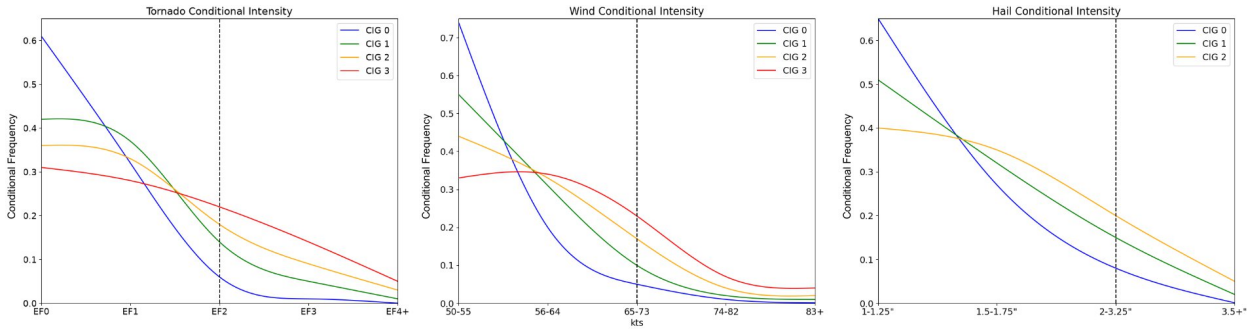


Fig. 2: CIG target distributions of conditional hazard intensity frequency for (left) tornado, (center) wind, and (right) hail.

confidence, high intensity events, such as a single isolated supercell in an environment supportive of significant tornadoes and hail.

Conditional intensity forecasts are additionally designed with multiple tiers, known as conditional intensity groups (CIGs), which SPC forecasters can use to identify areas with increasing conditional likelihood of significant severe hazards and higher intensity ceilings. Each CIG tier represents a target distribution of hazard intensities derived from a combination of environmental parameters and past SPC outlook performance (Fig. 2; Jirak et al. 2024). For example, the CIG 0 distribution for tornadoes represents the expected conditional frequency of tornado intensities in locations without an explicit conditional intensity forecast (i.e., no hatched area on the convective outlook). Approximately 93% of tornadoes in the CIG 0 target distribution are less than EF2 intensity, indicating that significant tornadoes outside of an explicit conditional intensity forecast area should be rare but not nonexistent. Conversely, the CIG 1 target distribution (equivalent to "Intensity Level 1" on the public SPC Convective Outlook) shifts to the right of the CIG 0 distribution, with about 20% of tornadoes expected to be EF2+. As such, a CIG 1 forecast represents about a 20% conditional likelihood of significant tornadoes. The CIG 2 distribution similarly represents about a 30% conditional probability of significant tornadoes, and the CIG 3 distribution represents about a 40% conditional probability of EF2+ tornadoes. Note that the frequencies of EF3 and EF4+ tornadoes also increase with increasing CIG level. As such, higher CIG levels not only indicate a higher conditional likelihood of significant severe hazards, but also a higher reasonable maximum intensity of those hazards. The target conditional probabilities of significant tornadoes, hail, and convective wind for each CIG level are provided in Table 1.

SPC forecasters have been issuing conditional intensity forecasts internally since 2021, and verification metrics have shown forecasters have considerable skill in accurately predicting the CIG target distributions. However, public discourse has raised some concern and confusion about the frequency and spatial coverage of the new conditional intensity forecasts and how they compare to the old unconditional SIG forecasts. To address these concerns, this study explores the climatology of the old unconditional SIG and how it compares to the new conditional intensity forecasts.

2. DATA AND METHODS

This study obtained quality-controlled tornado tracks, hail reports, and convective wind reports for the 30-year period of 1994–2024 from the NCEI Storm Events Database (NCEI 2026). Only wind reports with a measured or estimated wind speed and tornadoes with a rating greater than EF-U were utilized in this study. Two different methods were then applied to calculate daily CONUS-aggregated and spatial climatologies of significant severe hazards.

For the CONUS-aggregated climatology, each storm report or tornado track was first stratified by day of the year and then mapped to the 80-km NCEP 211 grid. For each day of the year, the maximum event magnitude was calculated at every grid point. The CONUS-aggregated conditional probability of significant tornadoes, hail, and

	CIG 1	CIG 2	CIG 3
Tornado	20% ≥ EF2	30% ≥ EF2	40% ≥ EF2
Wind	15% ≥ 65 kts	25% ≥ 65 kts	35% ≥ 65 kts
Hail	15% ≥ 2 in.	25% ≥ 2 in.	

Table 1: Conditional probability of a significant hazard associated with each CIG level.

convective wind was then calculated by dividing the number of grid points with a significant event by the number of grid points with any severe event for each hazard. Unconditional probabilities of significant hazards were calculated by dividing the number of years each grid point contained a significant severe event by the total number of years in the dataset, smoothing the field with a 2D gaussian filter (sigma = 120 km), and then finding the maximum smoothed unconditional probability within the CONUS on each day of the year.

Spatial climatologies were similarly calculated by mapping each report and track to the 80-km NCEP 211 grid for each day of the year and finding the maximum event magnitude in each grid point. The conditional probability of significant tornadoes, hail, and convective wind was then determined for each grid point and day of the year by dividing the number of years with a significant event by the number of years with any severe event. Unconditional probabilities were calculated for each grid point by dividing the number of years with a significant event by the total number of years in the dataset. A 2D gaussian filter with a sigma of 160 km was then applied to spatially smooth the climatology fields. A 1D gaussian filter with a sigma of 7 days was also applied to smooth the results temporally.

3. RESULTS AND DISCUSSION

The CONUS-aggregated conditional climatology of significant severe hazards answers the question, "If a severe convective hazard occurs on this day of the year, what is the historic likelihood it will be significant?" The conditional climatology of significant tornadoes was found to have two peaks during the early March and late November time periods, with each peak exceeding a conditional likelihood of 30% (Fig. 3). Conversely, the conditional climatology of significant convective wind peaked in mid June at about 22% and

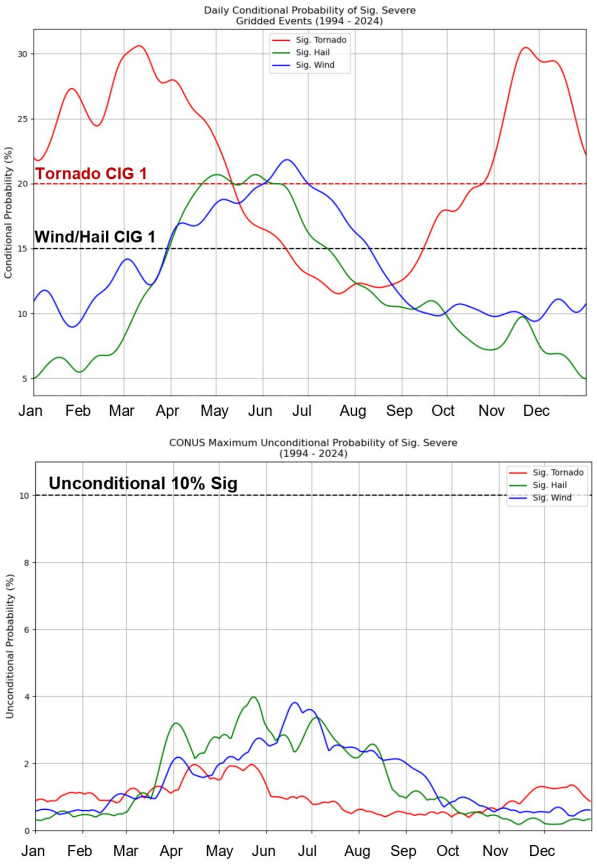


Figure 3: (Top) Daily conditional likelihood of significant tornadoes, convective wind, and hail from 1994 - 2024. The dashed red line represents the tornado CIG 1 threshold, while the black dashed line represents the wind and hail CIG 1 threshold. (Bottom) Daily unconditional likelihood of significant tornadoes, convective wind, and hail. The black dashed line represents the 10% unconditional SIG threshold.

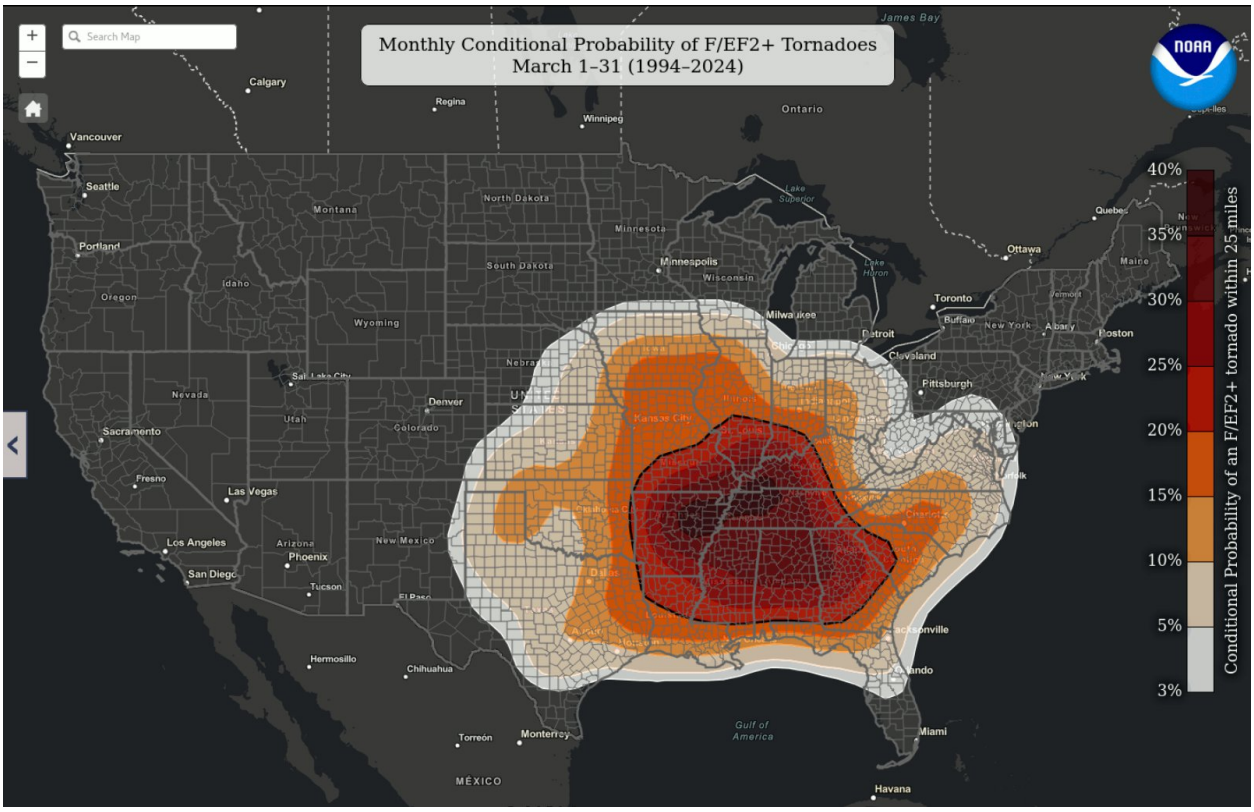


Figure 4: Conditional climatology of significant tornadoes during the month of March from 1994 - 2024. The solid black contour represents areas where climatology meets the CIG 1 tornado threshold of 20%.

significant hail demonstrated a conditional climatology maximum during May at around 20%. Significant tornadoes were generally minimized during the warm season, with a minimum of about 12% in mid-June, while significant wind and hail climatologies were minimized during the cool season. Of particular note, the unconditional climatology of significant tornadoes exceeded the CIG 1 target probability of 20% from October 23 – May 10, or for nearly the entire meteorological cool season. Similarly, the conditional climatology of convective wind exceeded the CIG 1 15% definition from March 28 – August 9, while hail exceeded the CIG 1 definition from March 29 – June 12. These results demonstrate that severe weather events are climatologically expected to reach CIG 1 thresholds for portions of the year.

In comparison, the unconditional climatology of significant severe hazards answers the question, “How often did a significant hazard historically occur on this day?” The unconditional climatologies of significant tornadoes, hail, and convective wind demonstrated peaks that were offset temporally from the conditional climatologies and with much lower maximum probabilities (Fig. 3). The unconditional likelihood of significant tornadoes peaked at 2% during April and May with a secondary peak of about 1.7% in late November and early December. Significant convective wind probabilities were maximized near 4% in mid June, while hail saw a peak of 4% in late May.

Note that no unconditional hazard climatology exceeded or came near to the unconditional 10% probability threshold that previously defined the unconditional SIG forecast. This highlights a key difference between the new conditional intensity forecasts and the old unconditional SIG. The unconditional SIG forecast represented conditions that were well above hazard climatology and thus required environments supportive of high coverage, high intensity events to justify. In comparison, severe weather environments are climatologically expected to meet the CIG 1 definition during certain times of the year. This means that at least CIG 1

conditional intensity forecasts are designed to be issued more commonly and for larger areas than the previous unconditional SIG.

Spatial representations of the conditional significant tornado climatology reveal much of Arkansas, Louisiana, Mississippi, Tennessee, and Alabama exceed the CIG 1 threshold from November through February. The area of CIG 1 probabilities then expands in March through May to include more of the southern and central Plains, central Mississippi Valley, and Ohio Valley (Fig. 4) before all areas fall below the CIG 1 threshold in June. The conditional climatology of significant convective wind primarily exceeds the CIG 1 threshold across the Plains from April to September, while the hail climatology meets the threshold in the southern Plains from April to June.

4. CONCLUSIONS

This study has shown that the definitions and resulting climatologies of the new conditional intensity forecasts are considerably different from the old unconditional SIG forecasts. Whereas the old unconditional SIG definition was only met in high coverage, high intensity scenarios, the new CIG 1 threshold is a much more common target. Tornado events are climatologically expected to meet the CIG 1 threshold across much of the Southeast during the cool season, while wind and hail events are expected to meet this threshold in the Plains during the warm season. Therefore, CIG 1 forecasts are designed to be more common during these climatologically expected times of the year and cover broader areas than the old unconditional SIG. Forecasts that do not include a conditional intensity forecast during the climatologically expected times of year are inherently predicting fewer significant events than climatology would suggest, while a CIG 2 or CIG 3 forecast would represent much higher conditional significant severe probabilities than climatology, indicating potential for a higher-end severe weather outbreak. SPC forecaster skill therefore lies in determining when to deviate from climatology, particularly during times of the year when a CIG 1 forecast is climatologically expected.

5. ACKNOWLEDGMENTS

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