A Detailed Analysis of Storm Prediction Center Convective Outlook Patterns

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Introduction

The Storm Prediction Center (SPC) is an elite team of National Weather Service (NWS) forecasters that specialize in predicting severe thunderstorms (namely tornadoes, 58+ mph straight-line winds, and 1.00”+ diameter hail) and fire weather conditions. Severe thunderstorm forecasts are conveyed via the “convective outlook”, which is designed to communicate the expected severe weather threat on a 6-tier scale (from lowest to highest): no severe (or no thunder), marginal risk, slight risk, enhanced risk, moderate risk, and high risk (SPC). These convective outlooks cover the contiguous United States (CONUS), and the risks are determined by the expected probability of a tornado, 58+ mph wind gust, or 1.00”+ hailstone occurring within 25 miles (40 kilometers) of any given location. The risk category is also partially determined by the expected magnitude of the three hazards, and a special highlight is used if strong tornadoes (EF2+), hurricane force (74+ mph) wind gusts, and/or 2.00”+ hail is expected.

Convective outlooks are issued at 8 different lead times, ranging from the day of an expected severe weather event (Day 1) to 7 days in advance (Day 8). These outlooks are often presented to a wide variety of end users, including NWS Weather Forecast Offices (WFOs), other meteorologists, emergency management agencies (EMAs), elected officials, first responders, storm spotters, storm chasers, and the general public. These end users will often adjust or make plans around the expected risk magnitude and location, and this planning is often more extensive for the high-end risk days.

At longer lead times, forecast uncertainty tends to be higher since numerical weather prediction (NWP) model error tends to increase as lead time increases (Stratman et. al. 2013, Schellander-Gorgas et. al. 2016, Guan et. al. 2019, Haiden et. al. 2017, Mass 2023). This uncertainty often prompts SPC forecasters to issue lower risks at longer lead times. Consequently, the highest risk for a given severe weather event is often issued at the shortest possible lead times. As of yet, no analysis has been conducted on the day-to-day patterns of SPC outlooks. This information could be used to probabilistically predict what the maximum risk will end up being based on the risks issued at longer lead times.

Furthermore, no analyses have been conducted on the national climatological patterns of SPC outlooks, so there is currently no information regarding what risk(s) are historically most likely to be issued during specific forecast cycles or during specific months. This information would give end users a general idea of what time of year to expect high-end risk days and what hazards are most likely to occur on said high-end risk days.

Methodology

A script was used to access an archive of SPC convective outlooks for each day from 2015 to 2024 (both bounds inclusive). This script included a text parsing algorithm that would identify the highest categorical risk, tornado probability, wind probability, hail probability, and the names of the forecasters credited for each outlook. The current method used for converting probabilities to the categorical risk is detailed in Table 1. Note the overall categorical risk is determined by the greatest risk posed by any one hazard. For example, if a 10% tornado probability was issued along with a 5% wind probability and a 5% hail probability, the overall

Table 1. This table shows how neighborhood probabilities for tornadoes, wind, and hail are converted to a categorical risk (marginal, slight, enhanced, moderate, high). If magnitude is irrelevant or inconsequential, the corresponding cell in the table is blank. Currently, there is no way for hail to prompt a high risk

Categorical Risk	Tornado Probability	EF2+ Tornadoes Expected?	Wind Probability	74+ mph Wind Expected?	Hail Probability	2.00"+ Hail Expected?
Marginal (MRGL)	2%		5%		5%	
Slight (SLGT)	5%		15%		15%	
Enhanced (ENH)	10%		30%		30%	
Enhanced (ENH)	15%	No	45%	No	45%	No
Moderate (MDT)	15%	Yes	45%	Yes	45%	Yes
Moderate (MDT)	30%	No	60%	No	60%	
High	30%	Yes	60%	Yes		
High	45%					
High	60%					

categorical risk would still be "enhanced" even though the hail and wind probabilities qualify as "marginal". Currently, hazard intensity is only considered for enhanced risks, moderate risks, and high risks. For example, a 30% hail probability would be "enhanced" whether or not 2.00"+ hail is expected, but a 45% hail probability would be "moderate" if 2.00"+ hail is also expected.

For each particular date from 2015 to 2024, there were 13 totals outlooks retrieved: the Day 8 outlook (issued 7 days in advance), the Day 7 outlook, the Day 6 outlook, the Day 5 outlook, the Day 4 outlook, the Day 3 outlook, the Day 2 0700Z outlook, the Day 2 1730Z outlook, the Day 1 0600Z outlook (issued the day of the severe weather event), the Day 1 1300Z outlook, the Day 1 1630Z outlook, the Day 1 2000Z outlook, and the Day 1 0100Z outlook. Note that the tornado, wind, and hail probabilities are only consistently publicly provided on the Day 1 outlooks for the specified timeframe of 2015 to 2024.

Once these data were obtained, the analysis of day-to-day patterns and climatological averages was conducted. Each probability estimate utilized a simple experimental probability calculation, which is the number of observed cases matching a specified set of criteria divided by the total number of cases.

Results and Discussion

To provide some perspective on how common/rare each particular risk level is on SPC outlooks, please refer to Table 2. The "high risk" is by far the rarest, appearing on average approximately once every 500-1000 outlooks (less than once per year). The "moderate risk" is also respectably rare, especially at longer lead times (averaging about 10 moderate risk days per

Table 2. This table shows the fraction of risks that were issued on each SPC outlook in the 2015-2024 timeframe. This provides some perspective about how rare/common some risks are at some lead times. This information is also plotted in Figure A16.

Outlook	No Thunder	No Severe	Marginal Risk	Slight Risk	Enhanced Risk	Moderate Risk	High Risk
Day 1 0100Z	0.085	0.280	0.221	0.292	0.104	0.018	0.001
Day 1 2000Z	0.057	0.234	0.214	0.312	0.151	0.029	0.002
Day 1 1630Z	0.054	0.228	0.223	0.314	0.151	0.027	0.002
Day 1 1300Z	0.052	0.234	0.238	0.315	0.135	0.019	0.002
Day 1 0600Z	0.055	0.255	0.250	0.307	0.116	0.015	0.001
Day 2 1730Z	0.061	0.283	0.275	0.284	0.086	0.011	0.000
Day 2 0700Z	0.070	0.307	0.302	0.255	0.059	0.007	0.000
Day 3 0730Z	0.092	0.367	0.316	0.194	0.029	0.001	
Day 4				0.124	0.014		
Day 5				0.070	0.006		
Day 6				0.032	0.002		
Day 7				0.011	0.000		
Day 8				0.001	0.000		

year). Note that some cells in the table are blank, because the SPC currently does not issue some risks levels at some lead times.

Seasonal Patterns

Figure A1 shows a bar plot of the experimental probability of each risk level for each month in the calendar year using the 2015 to 2024 sample. Most high risks are issued during the spring months (March, April, and May); most moderate risks are issued in April, May, and June; and most enhanced risks are issued toward the early part of summer (peaking in June). Most slight risks are issued in July and August while most marginal risks are issued in September and October. The majority of days with no severe weather risk occur during the cool season (November through February). Overall, this is a pattern that would be expected; the highest risks occur during the peak severe storm season in and around springtime while the lowest risks are typically issued when conditions are generally cold and stable. Although, it should be noted that there is a secondary peak of moderate risks that occurs in December when vertical wind shear begins to ramp up while there is still a relatively high chance that warm and humid conditions can still occur in some parts of the CONUS (usually the Deep South).

Clearly, there is some sort of correlation between SPC risk and time of year. Since SPC risk is determined by three different severe weather hazards, it is worth examining the same graph, but looking at each hazard in isolation.

Figure A2 shows the same graph as Figure A1, but specifically looking at the tornado probabilities issued by the SPC. Most of the high tornado probabilities (15% or greater) occur during meteorological spring (March, April, and May). The low tornado probabilities (2% and 5%) peak during the summer when vertical wind shear weakens but atmospheric instability maximizes. Very similar to Figure A1, there is a high proportion of 0% tornado risk days during the cool season (November - February), but there are a handful of high tornado probability days mixed into that timeframe. This would imply that tornadoes are unlikely to occur during this timeframe, but any tornado event that does occur is relatively likely to be high-end. See also Figure A11 for a breakdown of tornado probability forecasts by individual Day 1 outlook instead of month.

Figure A3 shows the same graph as Figure A2, but for the straight-line wind probabilities issued by the SPC. Compared to the tornado probabilities, the high-end wind probabilities (45% or greater) tend peak slightly later in the calendar year, specifically during April, May, and June. The slight risk-caliber wind probabilities (15%) peak later in the summer (mostly July and August) when vertical wind shear begins to approach its weakest point in the calendar year. During that transition, there is an optimal combination of high to extreme instability and strong vertical wind shear that would theoretically favor high-impact wind events like derechos. The cold season is nearly identical to that of Figures A1 (categorical outlooks) and A2 (tornado probabilities), suggesting that straight-line wind probabilities are a key driver of the categorical risks during the November - February timeframe. Since vertical wind shear tends to be strongest and instability tends to be weakest during this timeframe, fast convective storm motions and downward momentum transport would seemingly be responsible for high-end straight-line wind events during this secondary peak. See also Figure A10 for a breakdown of wind probability forecasts by individual Day 1 outlook instead of month.

Figure A4 shows the same graph as Figure A3, but for large hail probabilities issued by the SPC. Compared to Figures A1, A2, A3; the peak for high-end hail probabilities (45% or greater) is much more confined (in the month of May). Although the peak for slight risk-caliber hail probabilities (15%) is much broader than the high-end hail probability peak, it is still narrow compared to the straight-line wind probabilities. The depicted forecast pattern would imply that extreme hail events require a very specific combination of shear and instability that almost exclusively occurs in May and is less likely to occur in other months. This is in contrast to relatively common and low-impact hail events, which most frequently occur during the summer when vertical wind shear noticeably weakens. During the cold season (November - February) hail events of any magnitude are relatively rare, presumably because instability is too weak and vertical wind shear is too strong to support much in the way of hail. See also Figure A11 for a breakdown of hail probability forecasts by individual Day 1 outlook instead of month.

Figure A18 shows the number of times a “significant (hatched) area” was issued for each of the three severe thunderstorm hazards (tornadoes, red; wind, blue; hail; green) in each month of the calendar year. Significant (EF2+) tornado forecasts are most likely to be issued in March, April, and May; significant (74+ mph) wind forecasts are most likely to be issued in May, June, and July; and significant (2.00”+) hail forecasts are most likely to be issued in May and June. This graph also suggests that predictions for significant hail are more common than predictions for significant wind and significant tornadoes.

Since a seasonal dependency has been established for each of the three severe thunderstorm hazards, and each hazard shows a different month-to-month pattern, it stands to reason the “big risk days” will be “driven” by different hazards at different times in the year. As an example based on the results presented thus far, we would expect most moderate risks in May to be driven by hail. That is to say, if we examine all moderate risks issued in May, we would expect to find more 45% hail probabilities than 45% wind probabilities and more 45% hail probabilities than 15% tornado probabilities.

Figure A5 shows the breakdown of what hazard drives each moderate risk day for each month in the calendar year. As expected, most of the moderate risk days in May are driven by hail, and most of the moderate risk days in the summer (June, July, and August) are driven by straight-line winds. However, the arguably most interesting result is the one that concerns tornadoes; for any given moderate risk day from October through April, chances are that will be a moderate risk day because of the tornado threat. Note that it is impossible to analyze high risk days the same way, because it is currently impossible for the SPC to issue a “hail-driven” high risk, and no wind-driven high risks were issued in the 2015-2024 timeframe. See Figures A6-A8 for a breakdown of what hazards drive enhanced risk, slight risk, and marginal risk days, respectively. See also Figures A12-A15 for a breakdown of what hazards drive the individual Day 1 outlooks on moderate risk, enhanced risk, slight risk, and marginal risk days, respectively.

Day-to-day Patterns

As mentioned in the introduction, model error increases as lead-time increases, so it is conceivable that there are discernible day-to-day patterns in the SPC’s forecasts. Table 3 shows the likelihood of any particular Day 1 risk given the maximum risk issued on the Day 2 outlook

Table 3. This table shows the estimated likelihood of the maximum Day 1 risk based on the maximum Day 2 risk. As an example, if the SPC issues a marginal risk on Day 2, there is 50.1% chance the outlook will still be marginal on Day 1 and there is a 46.1% chance the outlook will be upgraded to slight on a Day 1 outlook.

	Day 2 No Severe	Day 2 Marginal	Day 2 Slight	Day 2 Enhanced	Day 2 Moderate
Day 1 No Severe	0.757	0.020	0.000	0.000	0.000
Day 1 Marginal	0.227	0.501	0.010	0.000	0.000
Day 1 Slight	0.015	0.461	0.665	0.009	0.000
Day 1 Enhanced	0.001	0.017	0.313	0.755	0.103
Day 1 Moderate	0.000	0.001	0.013	0.233	0.692
Day 1 High	0.000	0.000	0.000	0.003	0.205

(the day before a severe weather event). This table can be a bit confusing to read, so here is an explanation of how to read the table: on the top row, find the risk that the SPC currently has on their Day 2 outlook. Within that column, the likelihood of seeing each of the 6 outlook levels on the Day 1 outlook is given. As an example, let's say the current Day 2 risk is "slight". Using Table 3, this would imply that there is a 1.0% chance the slight risk gets downgraded to "marginal" on the day of the severe weather event, and there is a 66.5% chance the risk levels remains "slight" on the day of the severe weather event, and there is a 31.3% chance the risk level gets upgraded to "enhanced" on the day of the severe weather event, and there is a 1.3% chance the risk level gets upgraded two levels to "moderate" on the day of the severe weather event.

The results from Table 3 indicate that a given Day 2 risk level is most likely going to be the same risk level that is present on Day 1. However, the results also indicate a significant chance that a given Day 2 risk level will be upgraded to the next level at some point during the day of the severe weather event, and that upgrade probability is highest for a Day 2 marginal risk and lowest for a Day 2 moderate risk. See also Table B1 (Appendix B) for the same analysis, but only looking at Day 2 outlooks that also included a "significant severe area" (a prediction for significant tornadoes, significant wind, and/or significant hail).

Table 4 shows the same analysis as Table 3, except it examines the Day 3 risk (issued two days in advance) instead of the Day 2 risk. Unlike the Day 2 risk, the probability of a Day 3 risk being upgraded to a higher level risk is higher than the probability of the Day 3 risk remaining unchanged (with the exception of the "no severe" risk). In fact, a Day 3 marginal is the least likely risk to remain unchanged (with 22.3% probability). Therefore, as a practical matter, it would make sense to treat a Day 3 marginal risk as an "effective slight risk" since a Day 1 slight risk is the most likely outcome if presented with a Day 3 marginal risk. See also Table B2 (Appendix B) for the same analysis, but only looking at Day 3 outlooks that also included a "significant severe area" (a prediction for significant tornadoes, significant wind, and/or significant hail).

Any risk areas in the Day 4-8 timeframe (3-7 days in advance) are currently considered optional, meaning a forecaster is not required to issue a risk area 3+ days in advance. However, if a forecaster notices a consistent pattern on model solutions that would indicate a potential severe

Table 4. Same as Table 3, except for the Day 3 risk instead of the Day 2 risk.

	Day 3 No Severe	Day 3 Marginal	Day 3 Slight	Day 3 Enhanced	Day 3 Moderate
Day 1 No Severe	0.561	0.016	0.000	0.000	0.000
Day 1 Marginal	0.316	0.223	0.014	0.000	0.000
Day 1 Slight	0.113	0.605	0.411	0.009	0.000
Day 1 Enhanced	0.009	0.147	0.500	0.467	0.000
Day 1 Moderate	0.000	0.010	0.074	0.458	0.750
Day 1 High	0.000	0.000	0.001	0.065	0.250

Table 5. Same as Table 3, except for the possible nonzero Day 4-8 risks. Note that no 30% areas were issued on Day 7 or Day 8 in the 2015-2024 timeframe.

	Day 4 15%	Day 4 30%	Day 5 15%	Day 5 30%	Day 6 15%	Day 6 30%	Day 7 15%	Day 8 15%
Day 1 No Severe	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000
Day 1 Marginal	0.031	0.000	0.035	0.000	0.035	0.000	0.077	0.200
Day 1 Slight	0.344	0.019	0.259	0.000	0.191	0.000	0.154	0.600
Day 1 Enhanced	0.503	0.308	0.502	0.348	0.452	0.571	0.436	0.200
Day 1 Moderate	0.113	0.577	0.180	0.565	0.270	0.429	0.308	0.000
Day 1 High	0.009	0.096	0.020	0.087	0.052	0.000	0.026	0.000

weather threat, the forecaster can issue an optional 15% (slight risk) or 30% (enhanced risk) area on a Day 4-8 outlook depending on perceived likelihood and potential impact. Since a marginal risk, moderate risk, and high risk cannot be issued at this lead time, there are only three possible risk categories at this lead time (no risk area, slight risk, and enhanced risk).

Table 5 shows the resulting Day 1 risk levels when given a 15% probability or 30% probability at the Day 4-8 lead times. Note that no 30% probabilities were issued on Day 7 or Day 8 in the 2015-2024 timeframe, and only five 15% probabilities were issued on Day 8. Overall, the results suggest that a 15% probability in the Day 4-8 timeframe is most likely to become at least an enhanced risk on the day of the anticipated severe weather event. Similarly, a 30% probability in the Day 4-8 timeframe is most likely to become at least a moderate risk on the day of the anticipated severe weather event. As a practical matter, these results imply that a 15% area on a Day 4-8 outlook can be treated as an “effective enhanced risk” and a 30% area on a Day 4-8 outlook can be treated as an “effective moderate risk”.

Since it is evident that a significant proportion (and in some cases a majority) of outlooks eventually get upgraded, another key item of interest might be which outlook is most likely to see the upgrade. And, in the unlikely event that a downgrade occurs, it may also be useful to known when that downgrade is most likely occur.

Table 6 shows the estimated probability that an upgrade or downgrade will occur on any given SPC outlook (except Day 8, which is the longest possible lead time and therefore cannot itself be an upgrade or downgrade of a previous outlook). One thing that is immediately and importantly evident is that downgrades are considerably rarer than upgrades. In other words, chances are that any given outlook will be upgraded instead of downgraded when it comes time for the SPC to issue a new outlook.

If an upgrade were to be issued, it is most likely to be issued on the first Day 2 outlook that follows the Day 3 outlook (with a 25.1% probability of this occurring for any given severe weather event). Thereafter, the next most likely outlook to be upgraded is the initial Day 1 outlook issued on the day of the event (with a 16.1% probability). This pattern likely indicates that upgrades are driven by increases in forecast certainty and forecaster confidence. Upgrades at 2000Z and 0100Z are comparatively rare, and this is likely because the severe weather event in

Table 6. This table shows the probability that any given SPC outlook will be upgraded to a higher risk from the previous outlook and the probability that any given SPC outlook will be downgraded to a lower risk from the previous outlook.

Outlook	Upgrade Probability	Downgrade Probability
Day 1 0100Z	0.013	0.247
Day 1 2000Z	0.025	0.033
Day 1 1630Z	0.095	0.027
Day 1 1300Z	0.095	0.014
Day 1 0600Z	0.161	0.020
Day 2 1730Z	0.148	0.012
Day 2 0700Z	0.251	0.011
Day 3 0730Z	0.016	0.009
Day 4	0.072	0.003
Day 5	0.048	0.001
Day 6	0.024	0.000
Day 7	0.010	0.001

question has either already unfolded or is already unfolding by the time these outlooks are issued.

If a downgrade were to be issued, it is most likely to be issued on the final Day 1 outlook for a given severe weather event (with a 24.7% probability). This relatively high probability of a downgrade is likely due to the fact that most severe weather events peak between 2000Z and 0000Z, so the severe weather threat after 0100Z is often lower, which justifies lowering the risk level. Otherwise, the probability of a downgrade is less than 3.5% on any given outlook.

It should be noted that a filter was applied to the Day 3 upgrade/downgrade calculations. The vast majority of Day 4-8 outlooks include no risk area, so any inclusion of any risk area on a Day 3 outlook could be considered an "upgrade" if the previous Day 4 outlook had no risk at all. The values provided for Day 3 in Table 6 only consider cases where there was either a 15% or 30% area on the previous Day 4 outlook. Otherwise, the perceived probability of an upgrade on Day 3 would be extremely high (approximately 88%).

An outlook upgrade could entail increasing an outlook by a single risk level (e.g. from "enhanced" to "moderate") or by two risk levels (e.g. from "marginal" to "enhanced"). Table 7 provides an idea of how much a risk level is likely to change from one outlook to the next. Note that Day 3 and beyond were excluded from this analysis since only 3 risk levels (none, slight, and enhanced) are possible on Day 4-8 outlooks.

In Table 7, the column denoted by "0" indicates the probability that any given outlook's risk level will be unchanged from the previous outlook, and these results are consistent with the

Table 7. This table shows the probability that an outlook risk will changed by a given increment. For example, the "+1" column gives the probability that any given outlook will upgraded by 1 risk level, and the "-2" column gives the probability that any given outlook will downgraded by 2 risk levels.

Outlook	-3	-2	-1	0	+1	+2	+3
Day 1 0100Z	0.002	0.018	0.226	0.740	0.012	0.001	0.001
Day 1 2000Z	0.001	0.001	0.030	0.943	0.023	0.000	0.001
Day 1 1630Z	0.002	0.001	0.025	0.877	0.094	0.000	0.001
Day 1 1300Z	0.001	0.001	0.013	0.890	0.094	0.001	0.001
Day 1 0600Z	0.001	0.001	0.019	0.819	0.158	0.002	0.001
Day 2 1730Z	0.001	0.001	0.011	0.841	0.147	0.001	0.001
Day 2 0700Z	0.001	0.001	0.010	0.737	0.249	0.002	0.000

numbers presented in Table 6 (with some minor discrepancies caused by rounding errors). Based on Table 7, the 2000Z outlook is most likely (94.3% probability) to have a risk level that is identical to the previous outlook. Conversely, the Day 1 0100Z and Day 2 0700Z outlooks are the least likely (about a 74% probability for both) to keep the same risk level as their respective previous outlooks.

The column denoted by "+1" indicates the probability that any given outlook's risk was increased by a single risk level (see Figure 1 for a visual representation). Out of all instances where an outlook was upgraded, the vast majority of outlooks were only increased by a single risk level. It is rare for the SPC to increase an outlook by two or more risk levels (the "+2" and "+3" columns) as these imply a sudden and unexpected change in atmospheric conditions that was also readily respected by and acted upon by a forecaster.

The column denoted by "-1" indicates the probability that any given outlook's risk was decreased by a single risk level. Similar to upgrades, downgrades by more than one risk level are relatively uncommon with a potential exception being the downgrading of two risk levels when the Day 1 0100Z outlook is issued. This particular pattern in the Day 1 0100Z outlook is likely caused by severe weather events whose peak rapidly drops after 0100Z (e.g. a major tornado outbreak warranting a "high risk" prior to 0100Z that attains a significantly lower magnitude after 0100Z).

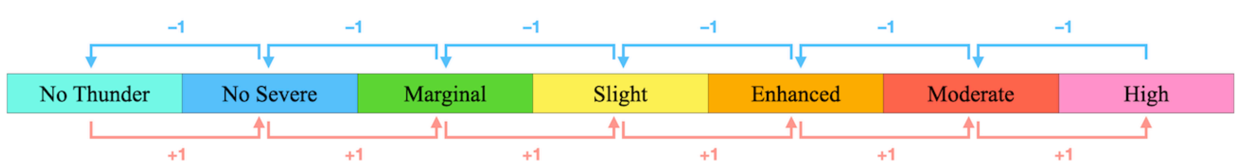

Figure 1. This figure is a visual representation of what would be considered a "single (±1) risk upgrade/downgrade", a "double (±2) risk upgrade/downgrade", or a "triple (±3) risk upgrade/downgrade".

Conclusions

The main objective of this analysis was to provide potential end users of SPC convective outlooks an idea of what they can probabilistically expect from the SPC based on (1) what the SPC has already issued at a lead time greater than 1 day and (2) the time of year. If presented with a Day 2 outlook, the probability of that Day 2 outlook being upgraded to a higher level risk on Day 1 is approximately 20% to 50%. Similarly, if presented with a Day 3 outlook, the probability of that Day 3 outlook being upgraded to a higher level risk at some point is between 25% and 70%, and that upgrade is most likely to occur on one of the Day 2 outlooks. Furthermore, generally speaking, the SPC rarely upgrades or downgrades by more than 1 risk level at a time, so the most likely upgrade or downgrade will be by 1 risk level.

Additionally, the results obtained indicate that the SPC is most likely to issue a high risk in March, April, or May; a moderate risk in April, May, or June; an enhanced risk in April, May, June, or July; a slight risk in July or August; and a marginal risk in September or October. This information can be combined with the day-to-day outlook pattern results to subjectively estimate the likelihood that a risk will be upgraded. For example, suppose an EMA activates for an enhanced risk day, but not a slight risk day. If the SPC issues a Day 2 slight risk in April, the chance of that being upgraded to a Day 1 enhanced risk (triggering the EMA's activation) would be greater than 31% since enhanced risks are relatively common in April. Conversely, if presented with a Day 2 slight risk in September, the likelihood of an enhanced risk being issued on Day 1 would be lower than 31% since enhanced risks are relatively uncommon in September.

It has also been established that each of the three severe thunderstorm hazards (tornadoes, straight-line winds, and large hail) have a discernible seasonal cycle based on SPC convective outlooks. The highest tornado probabilities are most likely to be issued in March, April, and May; the highest wind probabilities are most likely to be issued in April, May, and June; and the highest hail probabilities are most likely to be issued in May.

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Acknowledgements

Dr. Harold Brooks for providing the idea that became this research project.

Melissa Freeman for her insights into how emergency management agencies use SPC outlooks.

Appendix A: Figures

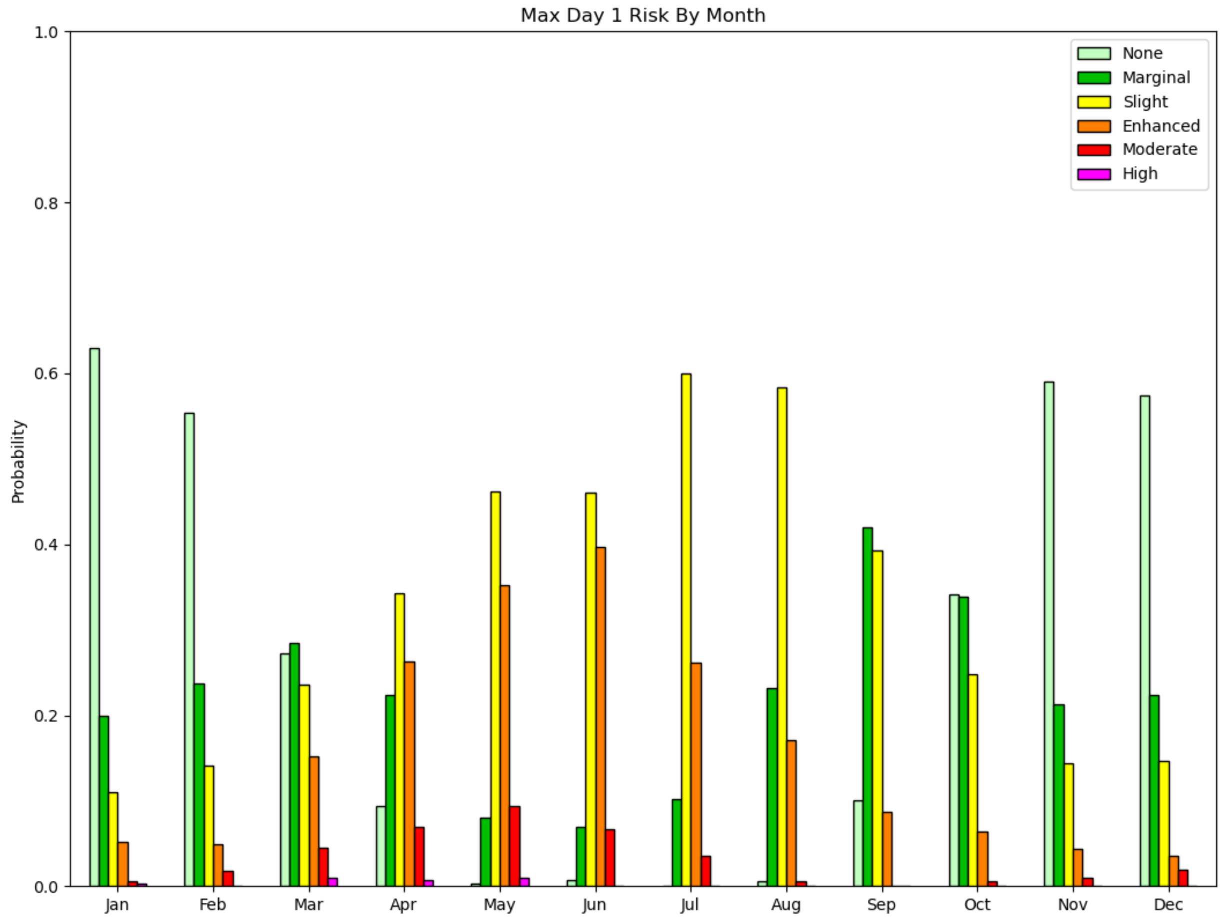

Figure A1. This bar plot shows the relative likelihood that a given risk will be issued in a particular month. Note that the vertical axis is the experimental probability calculated within each month and not for the entire year.

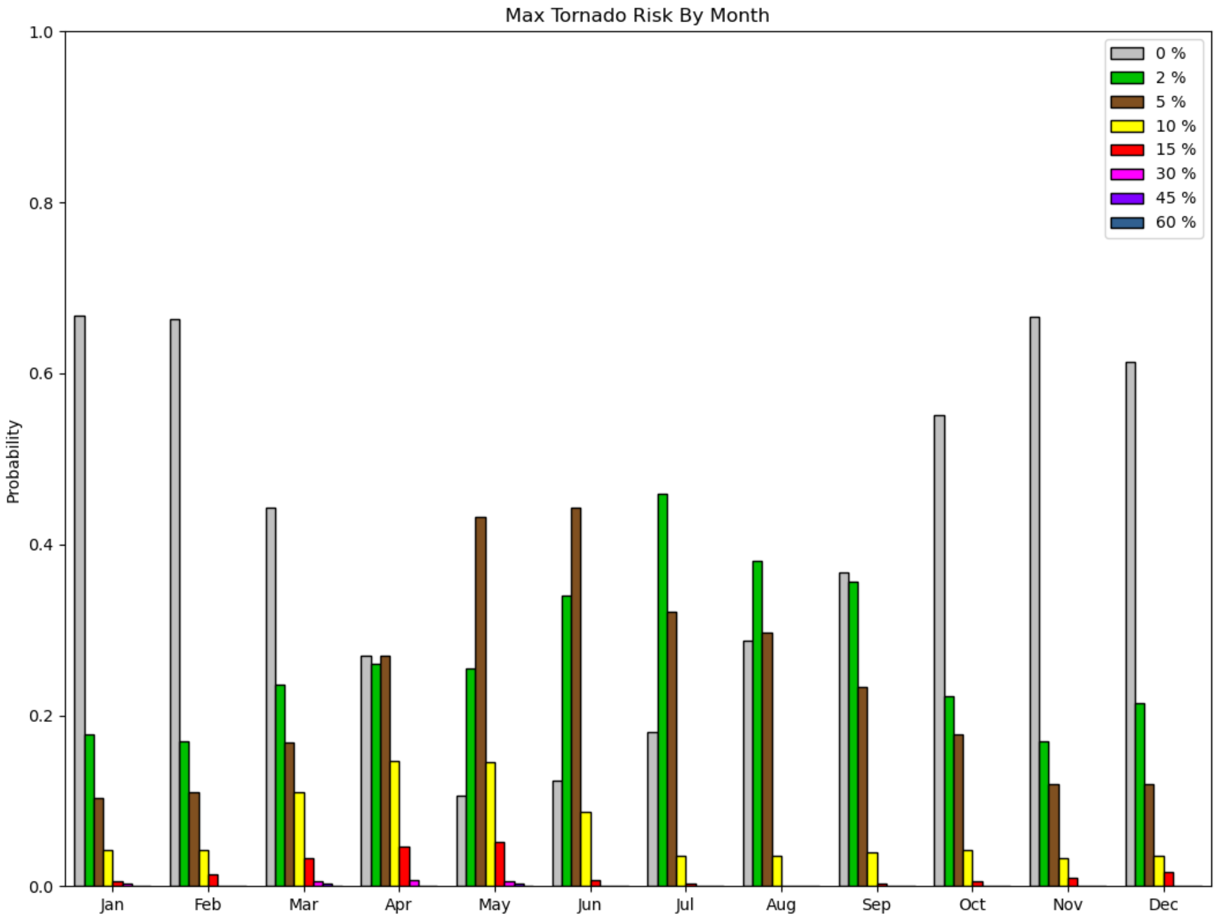

Figure A2. Same as Figure A1, but looking at the relative likelihood of tornado probabilities.

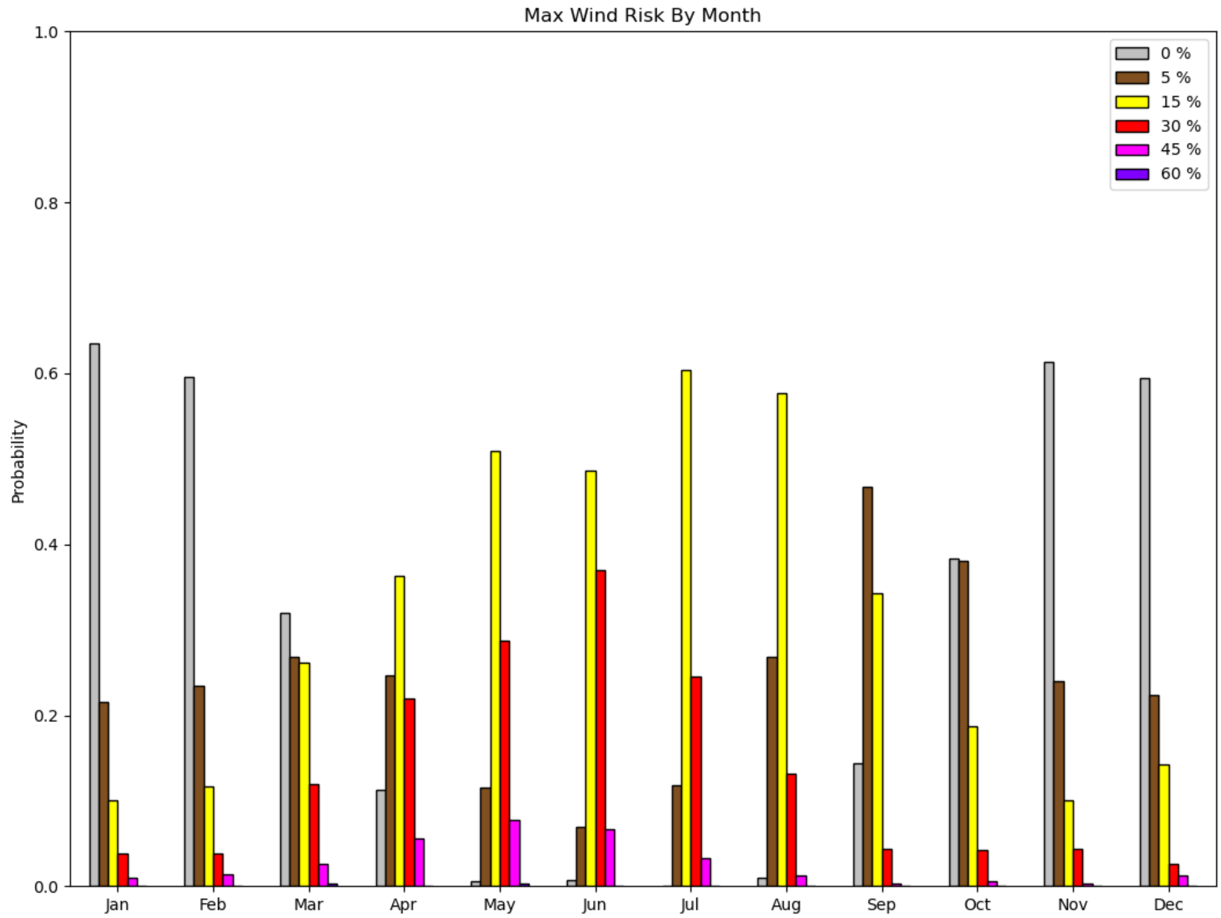

Figure A3. Same as Figure A2, but looking at the relative likelihood of straight-line wind probabilities.

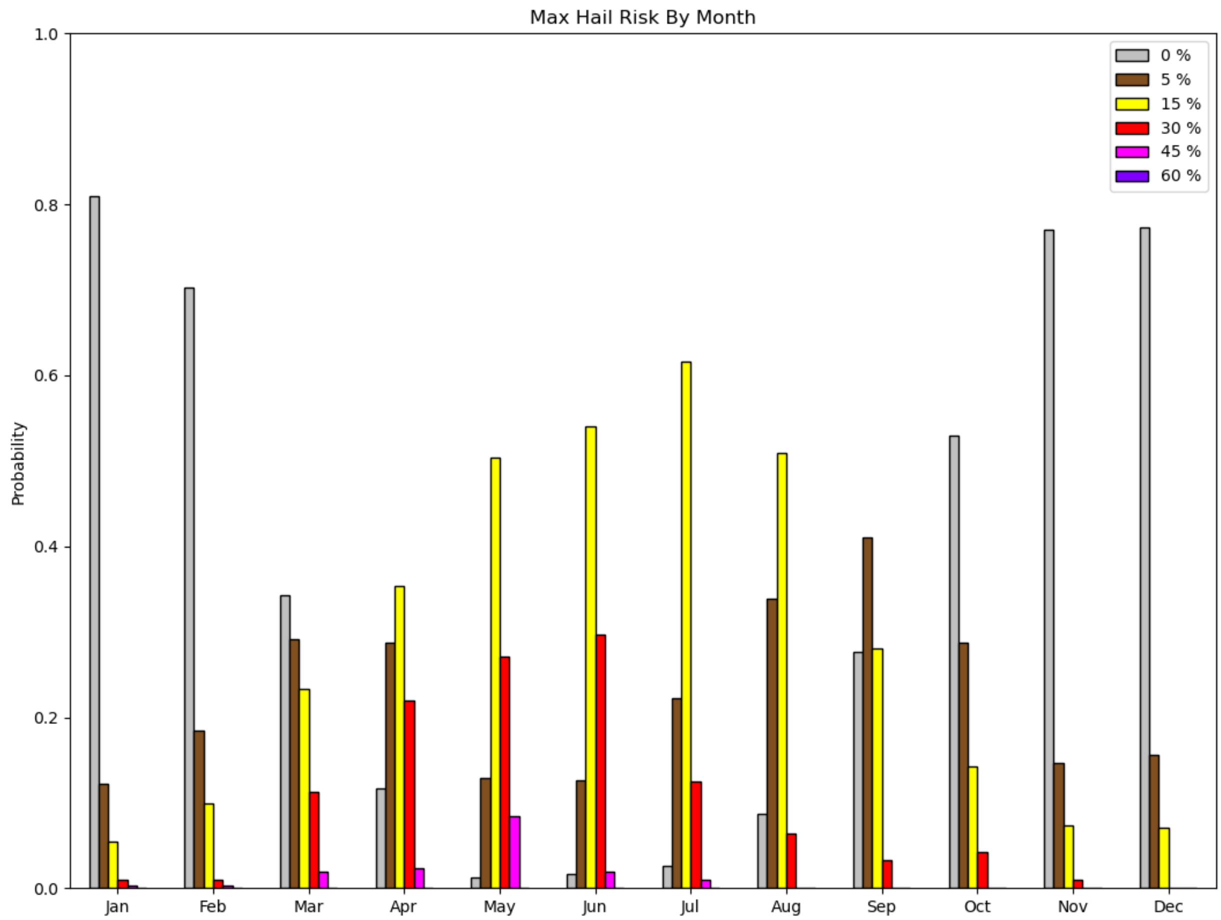

Figure A4. Same as Figure A3, but looking at the relative likelihood of hail probabilities.

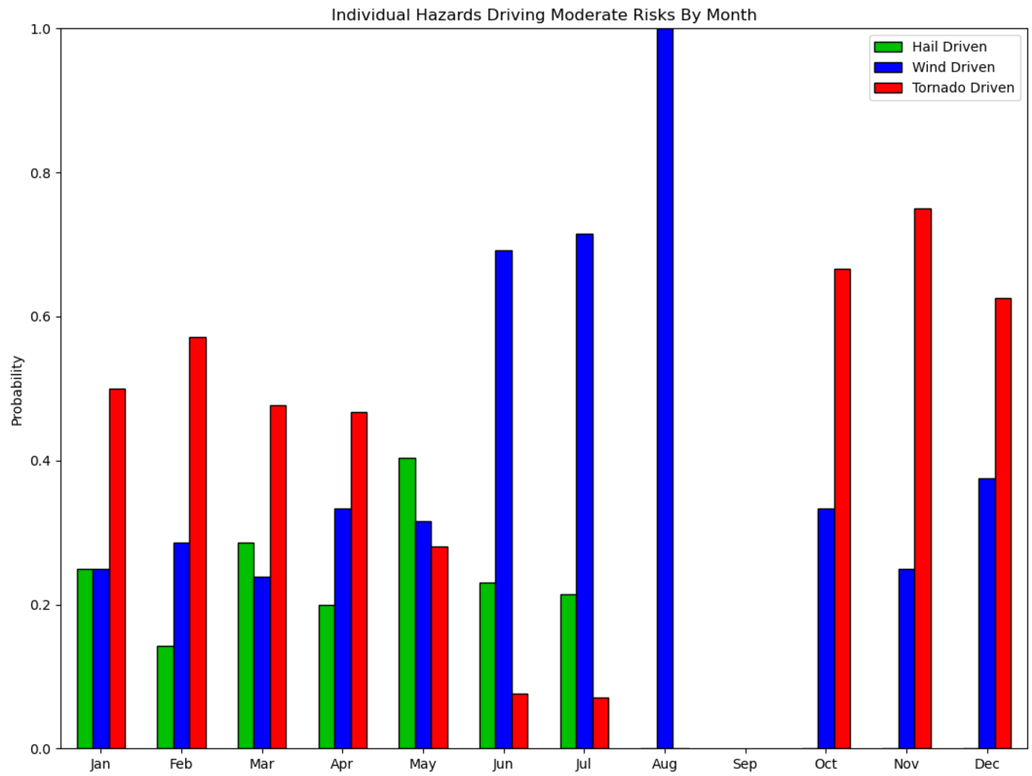

Figure A5. For each moderate risk that was issued by SPC, this figure shows what hazard was responsible for making that a moderate risk day. Note that 0 moderate risks were issued in September from 2015 to 2024, and only 1 moderate risk was issued in August (August 10, 2020).

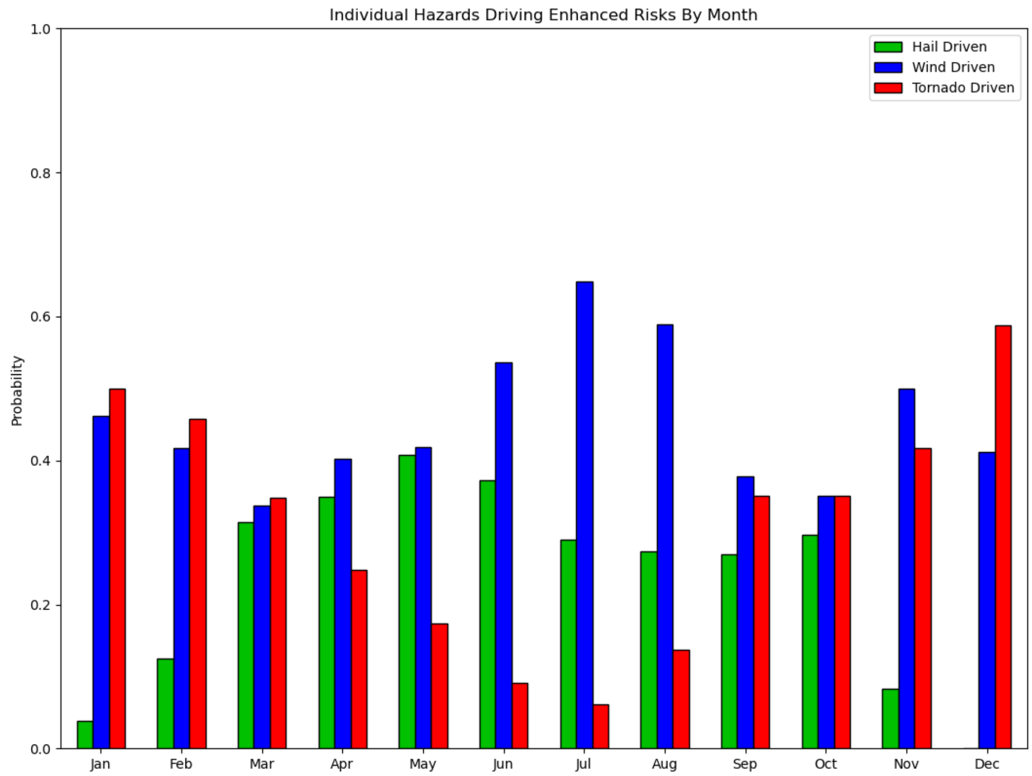

Figure A6. Same as Figure A5, but for enhanced risk days.

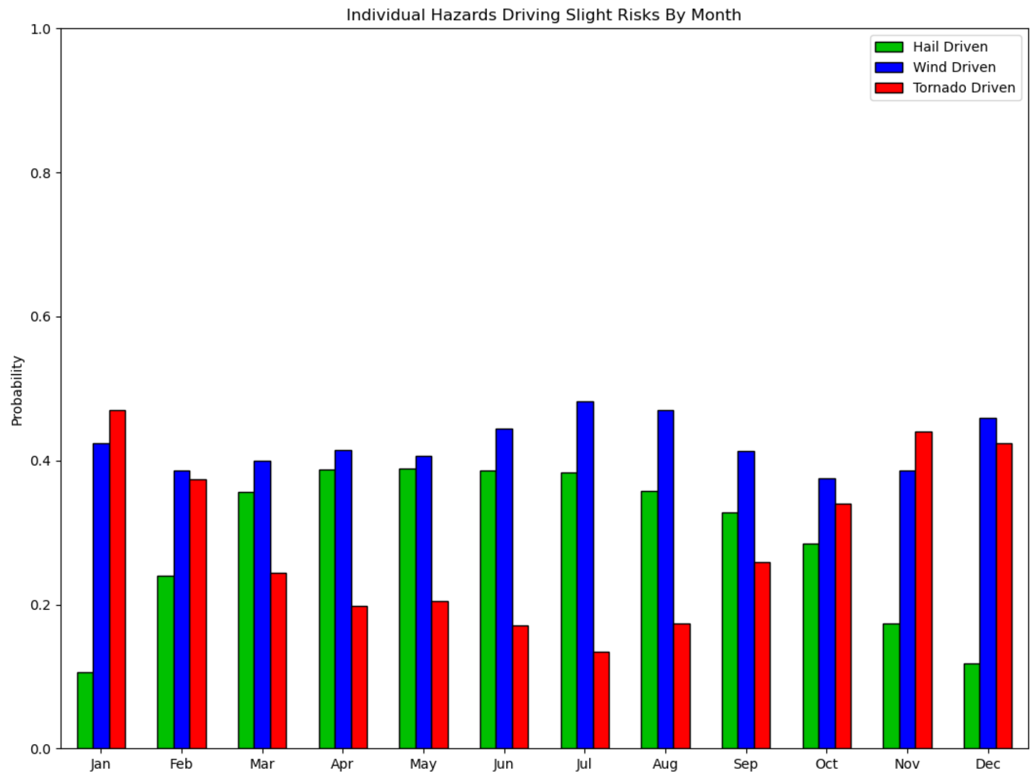

Figure A7. Same as Figure A5, but for slight risk days.

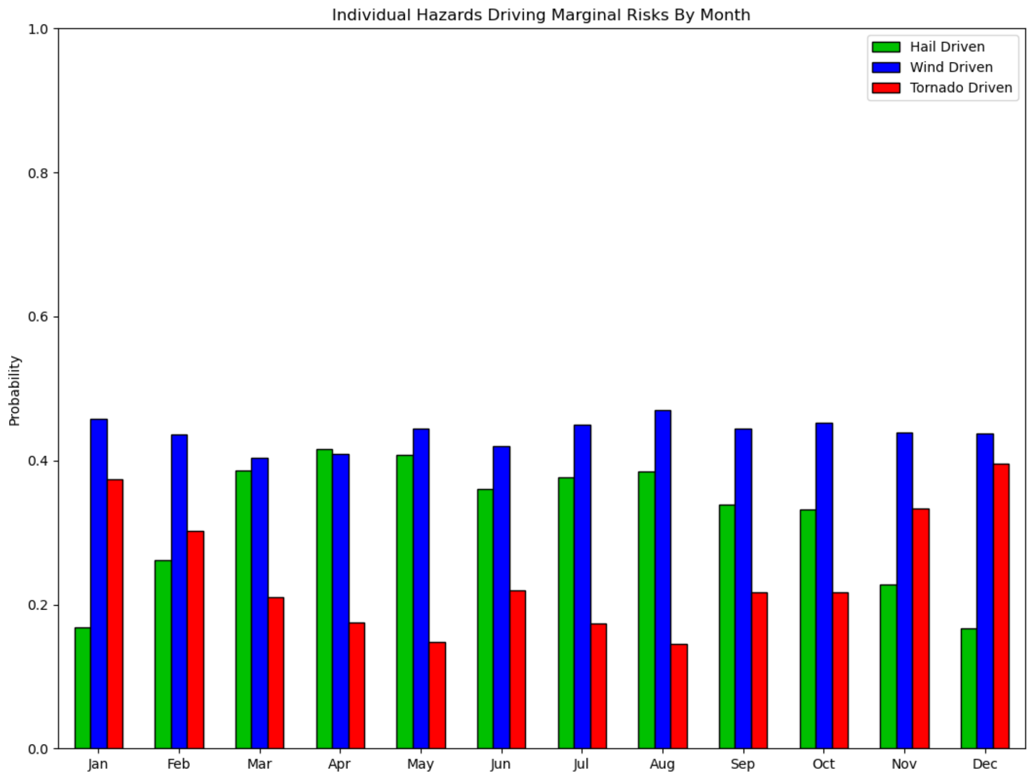

Figure A8. Same as Figure A5, but for marginal risk days.

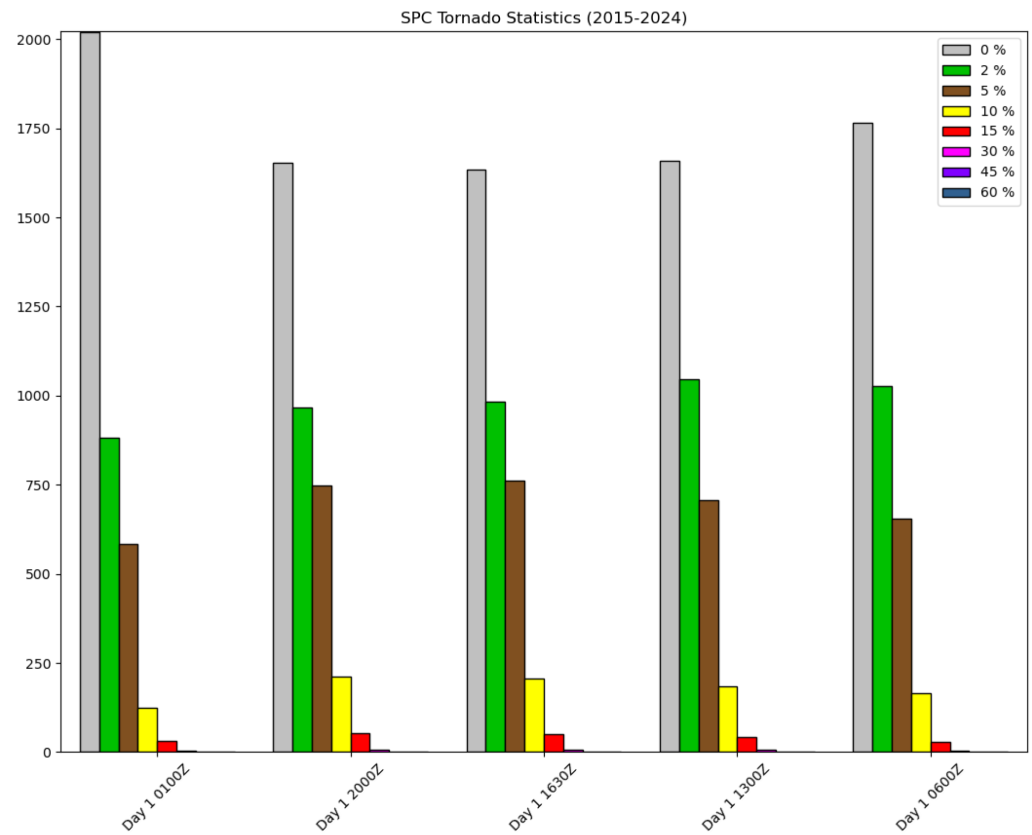

Figure A9. This figure shows the tornado probabilities that the SPC issued on each of the five Day 1 outlooks. The vertical axis represents the number of cases from 2015 to 2024. Note that tornado probabilities are slightly higher on the 1630Z and 2000Z outlooks.

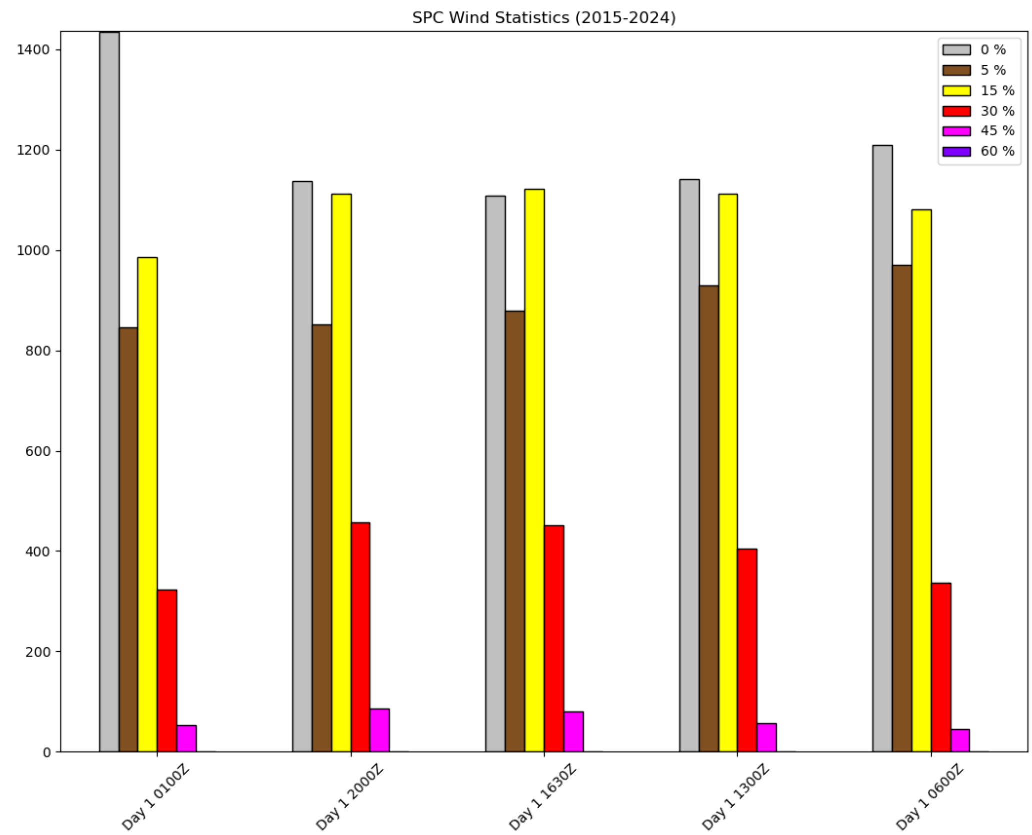

Figure A10. Same as Figure A9, but for the SPC's wind probability forecasts.

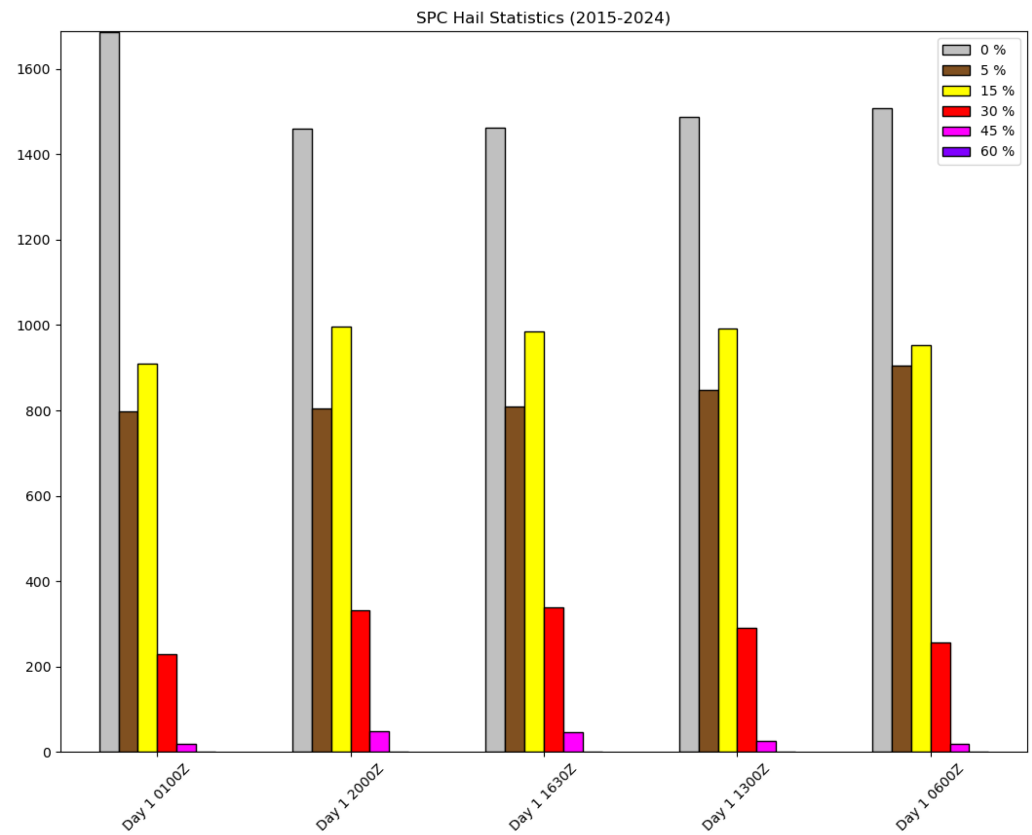

Figure A11. Same as Figure A9, but for the SPC's hail probability forecasts.

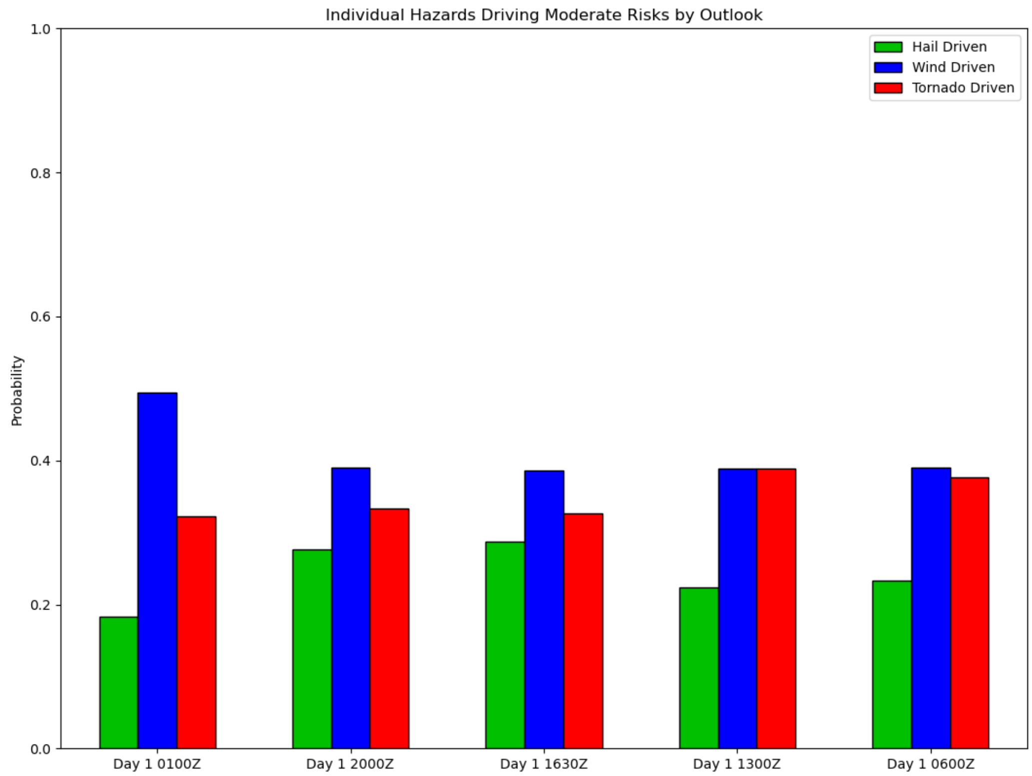

Figure A12. Same as Figure A5, but categorized by each of the five Day 1 outlooks instead of month.

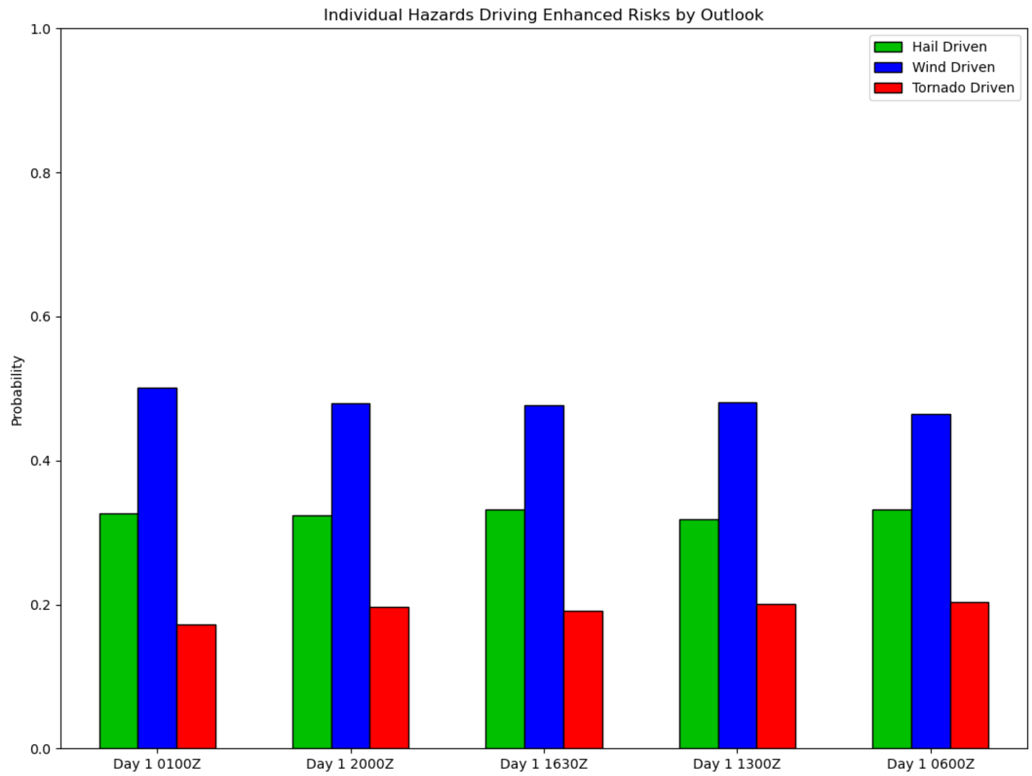

Figure A13. Same as Figure A6, but categorized by each of the five Day 1 outlooks instead of month.

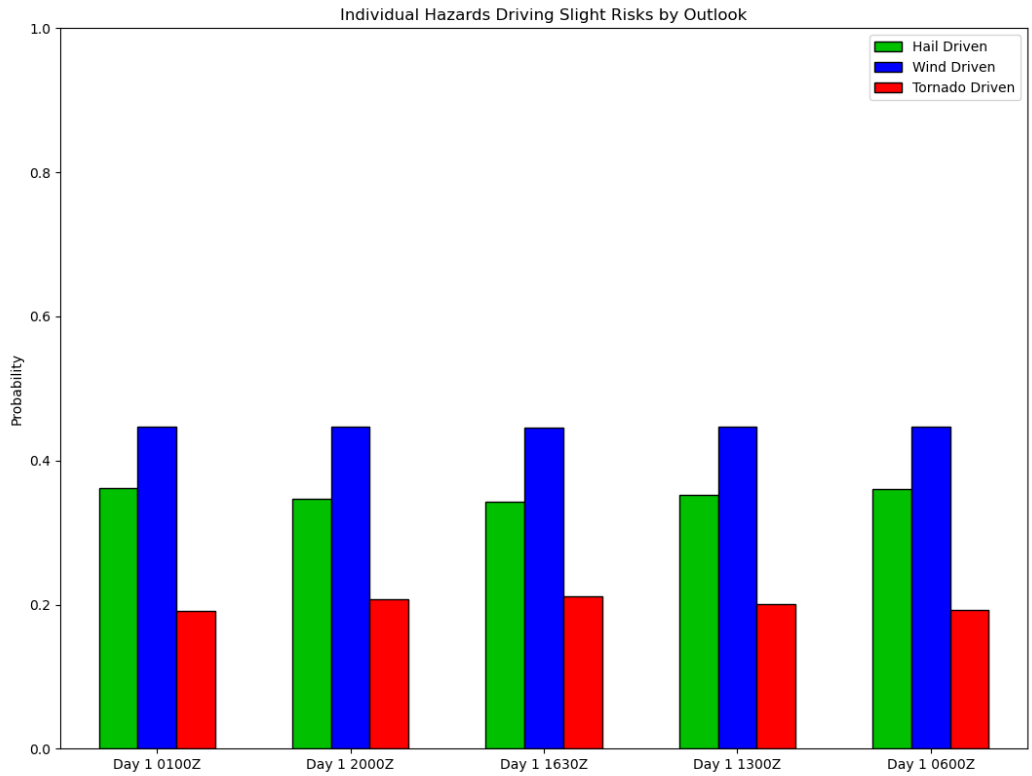

Figure A14. Same as Figure A7, but categorized by each of the five Day 1 outlooks instead of month.

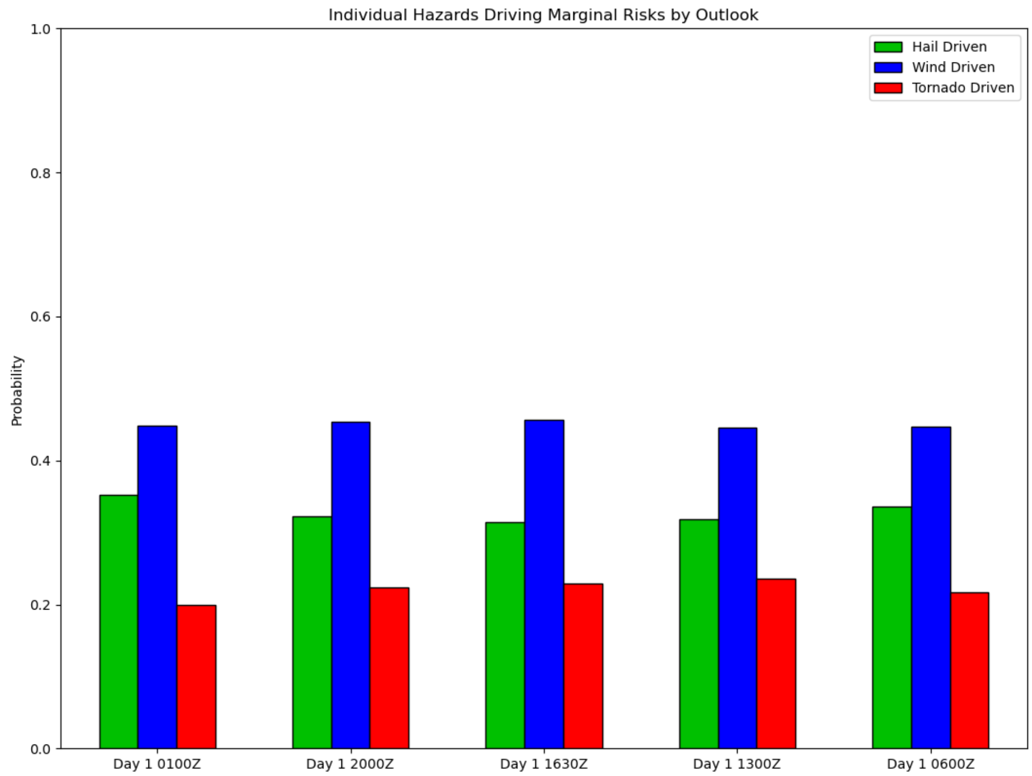

Figure A15. Same as Figure A8, but categorized by each of the five Day 1 outlooks instead of month.

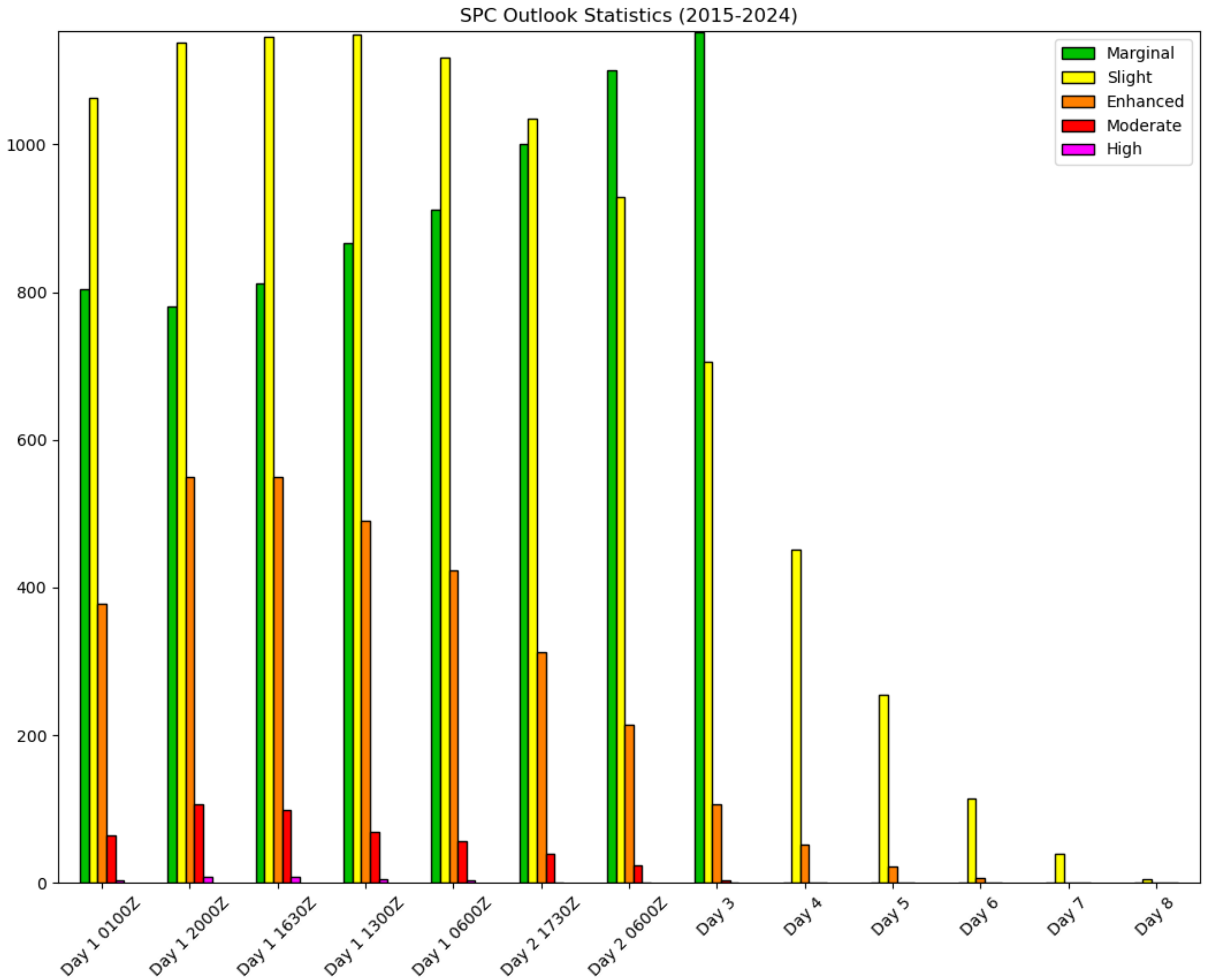

Figure A16. This is a visualization of the data presented in Table 2. Note that the vertical axis is number of cases from 2015 to 2024 and not estimated probability.

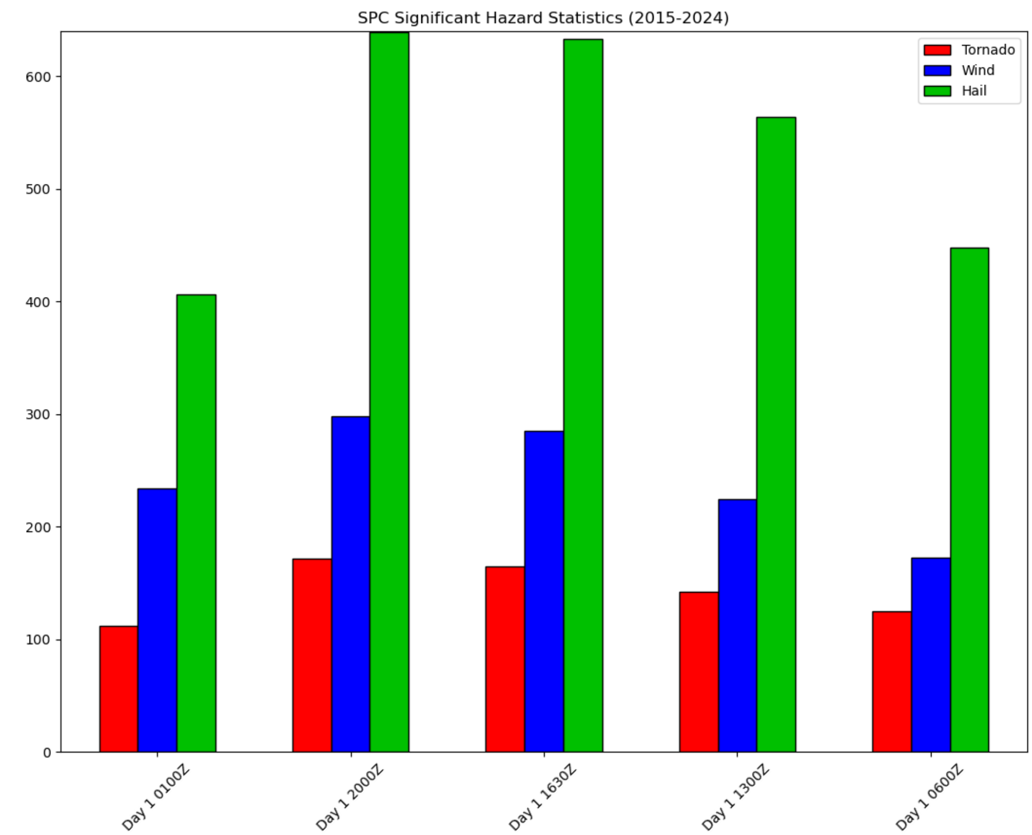

Figure A17. This bar plot provides an idea of how likely a forecast for significant tornadoes (EF2+, in red), significant wind (74+ mph, in blue), and significant hail (2.00"+, in green) is on each of the standard Day 1 outlooks. Note that the vertical axis is number of cases from 2015 to 2024 and not estimated probability.

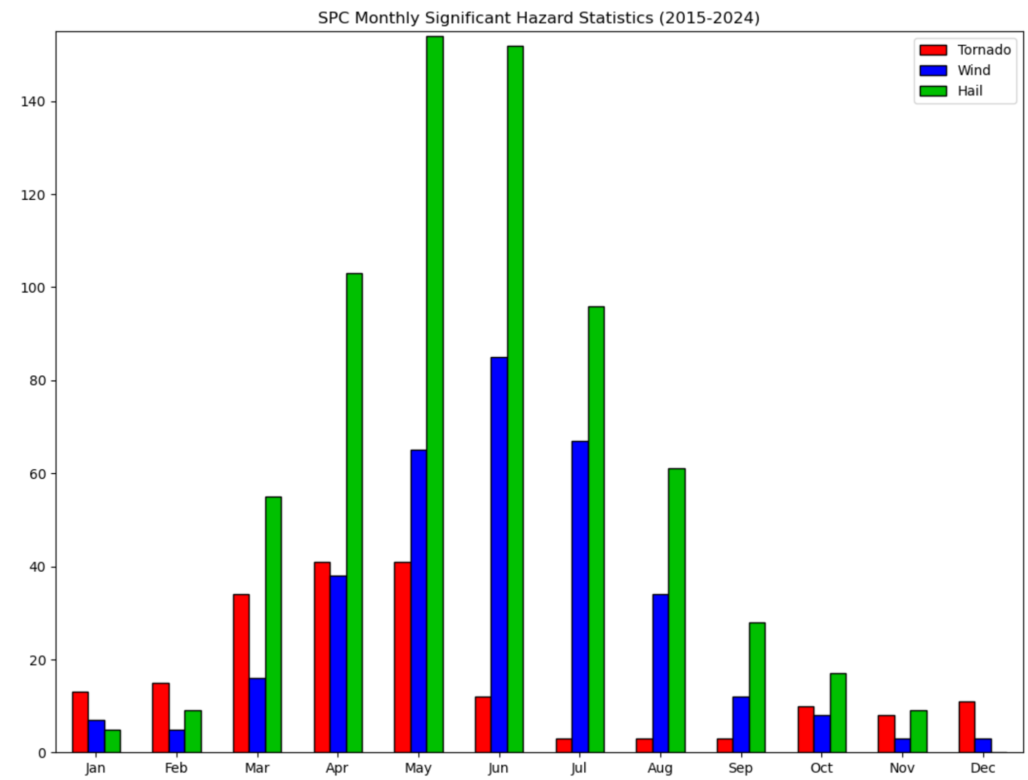

Figure A18. Same as Figure A17, but showing a breakdown by month instead Day 1 outlook.

Appendix B: Supplementary Tables

Table B1. This is the same as Table 3, but only looking at Day 2 outlooks that also included a forecast for "significant severe" (either EF2+ tornadoes, 74+ mph wind, and/or 2.00"+ hail). The only major difference is that slight risks with significant severe are much more likely to be upgraded on a subsequent Day 1 outlook.

	Day 2 No Severe	Day 2 Marginal	Day 2 Slight	Day 2 Enhanced	Day 2 Moderate
Day 1 No Severe			0.000	0.000	0.000
Day 1 Marginal			0.000	0.000	0.000
Day 1 Slight			0.359	0.009	0.000
Day 1 Enhanced			0.593	0.702	0.103
Day 1 Moderate			0.048	0.284	0.692
Day 1 High			0.000	0.004	0.205

Table B2. This is the same as Table B1, but for the Day 3 outlooks.

	Day 3 No Severe	Day 3 Marginal	Day 3 Slight	Day 3 Enhanced	Day 3 Moderate
Day 1 No Severe			0.000	0.000	0.000
Day 1 Marginal			0.000	0.000	0.000
Day 1 Slight			0.203	0.000	0.000
Day 1 Enhanced			0.641	0.417	0.000
Day 1 Moderate			0.141	0.514	0.750
Day 1 High			0.016	0.069	0.250