Relating Convective Mode Information to SPC Tornado Outlook Verification

Andrew R. Dean, Richard L.Thompson, and Bryan T. Smith
NOAA/NWS/NCEP Storm Prediction Center, Norman, OK

Introduction

This analysis combines three sources of data developed at the Storm Prediction Center (SPC):

1. Convective mode classification for a filtered subset of tornado reports (Smith et al. 2012) for the period 2003-2017
2. SPC product archive for tornado hazard outlooks
3. Gridded mesoanalyses of severe-storm-environment parameters dating back to 2003.

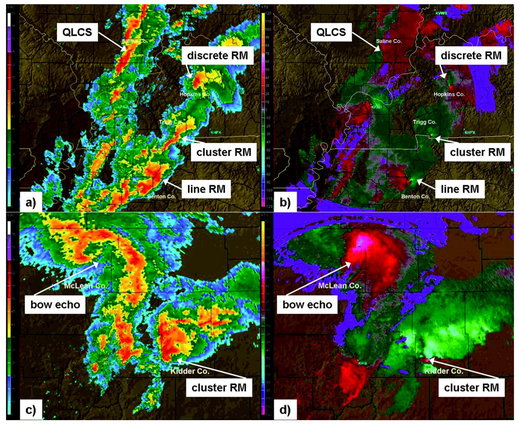

Fig. 1: Example of convective mode classification, taken from Smith et al., 2012

Convective Mode Analysis

The convective mode for a filtered subset of tornado reports was assigned according to the methodology in Smith et al. 2012 (see Fig. 1 for a graphical example). The primary focus in this analysis is a comparison between supercell and QLCS tornadoes.

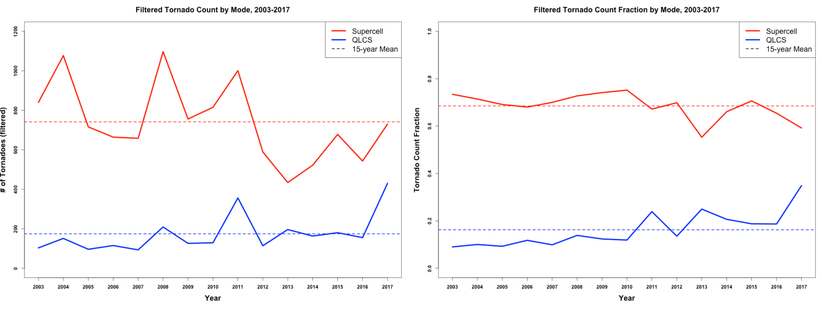

Fig. 2: Annual count and fraction of filtered tornado reports by mode, 2003-2017. Dashed lines represent 15-year mean. Supercell mode in red and QLCS mode in blue.

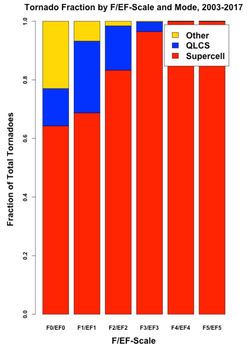

Fig. 3: Stacked barplot showing distribution of tornadoes by intensity and mode

Supercell modes represent the majority of tornadoes, as shown in Fig. 2. However, an increasing incidence of QLCS tornadoes has been noted, which is best seen by comparing the fraction of supercell and QLCS tornadoes in recent years to the 15-year mean (dashed line) above.

The stacked barplot in Fig. 3 shows that QLCS tornadoes are most likely to be rated F1/EF1, while "other" (disorganized) modes are usually F0/EF0, and supercells represent a larger fraction of the sample at higher damage intensity.

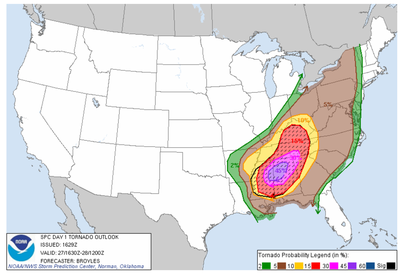

Fig 4: Example of an SPC tornado outlook, taken from 27 Apr 2011.

SPC Tornado Outlooks

SPC issues outlooks depicting the probability of a tornado within 40 km of a point (see Fig. 4). Since 2006, the set of probability thresholds for tornado outlooks has been: 2%, 5%, 10%, 15%, 30%, 45%, 60%. A hatched area defining a 10% (or greater) probability of significant (EF2+) tornadoes also may be drawn. Typical verification metrics include reliability and POD (for tornado events) within various probability thresholds.

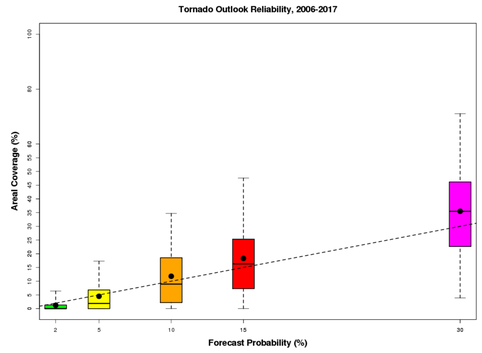

Fig. 5: Modified reliability diagram for SPC tornado outlooks for 2006-2017. Dots indicate mean areal coverage. Boxes are drawn from 25th-75th percentiles, with whiskers extending to 5th-95th percentiles of areal coverage. Dashed line indicates perfect reliability.

Tornado Outlook Verification

Fig. 5 above is a modified reliability diagram for SPC tornado outlooks from 2006-2017. The mean areal coverage (filled dots) of all tornadoes (EF0 – EF5) within each probability threshold lies relatively close to the perfect reliability (dashed) line, indicating generally good reliability. The percentile boxplots show the distribution of areal coverage for individual forecasts at each threshold.

The distributions for 2% and 5% thresholds are skewed toward values lower than the forecast probability, indicating a tendency for most forecasts to verify below the probability threshold, with a few forecasts verifying significantly above the threshold. For larger probability thresholds (10% and above), the distribution of areal coverage is more evenly distributed around the forecast value. *It should be noted these are considered true probability forecasts, not deterministic forecasts of areal coverage, so individual forecasts are not necessarily expected to verify with a coverage equal to the probability value.*

References

Smith, B.T., R.L. Thompson, J.S. Grams, C. Broyles, and H.E. Brooks, 2012: Convective modes for significant severe thunderstorms in the contiguous United States. Part I: Storm classification and climatology. Wea. Forecasting, **27**, 1114–1135.

Thompson, R.L., B. T. Smith, J. S. Grams, A. R. Dean, and C. Broyles, 2012: Convective modes for significant severe thunderstorms in the contiguous United States. Part II: Supercell and QLCS tornado environments. Wea. Forecasting, **27**, 1136–1154.

Convective Mode + Verification

SPC has begun to examine tornado outlook verification in the context of convective mode. Such an analysis is rather complicated, since forecasts are made for all tornado events, not just for a particular mode, and only preliminary results are shown here. POD and the distribution of tornadoes at various probability thresholds for different modes are shown in Fig. 6 and Fig. 7 below.

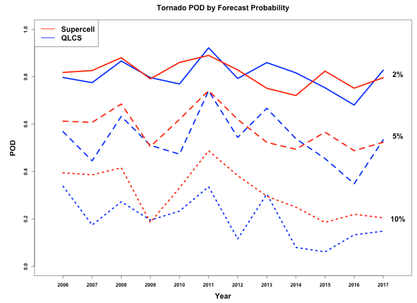

Fig. 6: POD for supercell (red) and QLCS (blue) tornadoes within various forecast probability thresholds, by year.

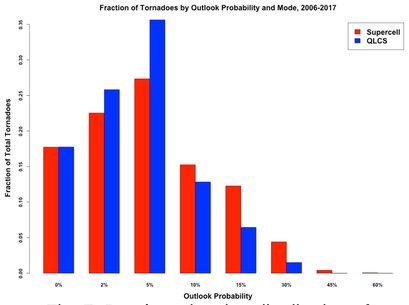

Fig. 7: Barplots showing distribution of supercell (red) and QLCS (blue) tornadoes within the various tornado probability thresholds.

PODs for supercell and QLCS events at the 2% or greater threshold are very similar, as shown in Fig. 6 above. POD for supercell events tends to be slightly higher at the 5% threshold, and POD at 10% is consistently higher for supercell events, though there has been a downward trend in recent years.

Fig. 7 shows that QLCS tornadoes are most likely to fall within 2% and 5% forecast areas, while supercell events are more common at the higher probability thresholds.

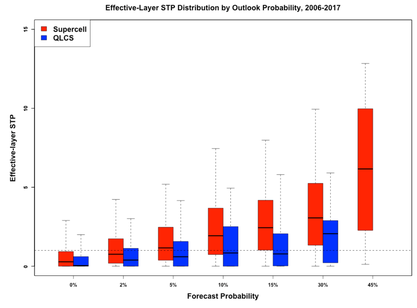

Fig. 8: Distribution of effective-layer STP values for supercell (red) and QLCS (blue) events, by forecast probability.

Fig. 8 incorporates environment information with the verification and mode data, using effective-layer STP (Thompson et al. 2012) as a proxy for the favorability of the near-storm environment. A clear increase in STP is noted for supercell events as probability increases. STP values are consistently higher for supercell events compared to QLCS, even at higher-end forecast probabilities.

Summary

- QLCS tornadoes have been increasing in number in recent years.
- SPC probabilistic tornado outlooks are generally statistically reliable.
- QLCS tornadoes are nearly as likely to be captured in low probability areas (2% and 5%) as supercell events, but less likely at higher probabilities (10% and above).
- Supercell tornadoes occur in more favorable environments (as measured by STP) than QLCS tornadoes, even at the higher probability thresholds.