P5.1

TORNADO OUTBREAK DAYS: AN UPDATED AND EXPANDED CLIMATOLOGY (1875-2003)

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1. INTRODUCTION

Tornado outbreaks are a key focus of the severe weather forecast community. Even outbreaks that are relatively small from a national perspective scale can be defining events for the few forecast offices and communities directly affected. Similarly, intermediate sized outbreaks, such as the Red River Outbreak of 10 April 1979, can dominate events on a regional scale, and the largest outbreaks, such as the Superoutbreak of 3 April 1974, can dominate events within much of the United States. Understanding the historic character of these defining events can help us realistically prepare for the future and place current events in their proper perspective. This study will seek to illuminate the character of tornado outbreaks and to document their influence on society.

This paper describes the foundation of this re-examination of the spectrum of tornado outbreaks. The study employs data from Grazulis (1993), NOAA (Kelly et al. 1978; Schaefer and Edwards 1999), and, to the extent possible, Fujita (1987) to update the outbreak climatology of Galway (1977). After this introduction, Section 2 describes data content and preparation. Section 3 outlines basic definitions and criteria employed to define and categorize tornado outbreaks. This section also discusses some of the nuances of the data. A few preliminary results are provided in Section 4, and Section 5 offers a summary of the research to date and its future directions.

2. DATA SET PREPARATION

Although the notion of a tornado outbreak is common, specific criteria defining these events vary from manuscript to manuscript. Galway (1977) provides the most widely-used definition with a focus on approximately 6–10 tornadoes as an initial threshold for an outbreak, and with progressively higher thresholds used to define major outbreaks. Since his work focused primarily on the record prior to 1975, it did not fully benefit from the introduction of the Fujita damage scale (Fujita 1971) and the reanalysis of the climatological record that ensued (Grazulis et al. 1993). With the availability of intensity estimates for historic storms, Galway's threshold can be modified to include information on the widely varying character of tornadoes.

A daily tornado and severe weather summary database was constructed for the period from 1875 through 2003. The Grazulis (1993) database, which only contains information on tornadoes thought to be F2 or greater in intensity (significant tornadoes), is generally used for the early portions, 1875–1950. The NOAA database (Kelly et al. 1978, Schaefer and Edwards 1999) also contains records on reported weak tornadoes (F0 and F1) and was used for storms during the past decade. During the period 1950–1995, the two databases generally agree on significant tornado occurrence (Grazulis et al. 1993). Differences are handled on a case-to-case basis. The tornado data was augmented by the NOAA databases of severe thunderstorm reports (Schaefer et al. 2003) and hail reports (Schaefer et al. 2004) that are available for the period 1955 through 2003. Daily summaries (midnight to midnight) of a variety of measures of tornado and severe thunderstorm activity were constructed to aid the classification of each day in the 128-year record.

"Tornado Outbreak Days," essentially a count of calendar days on which a tornado outbreak occurred, are used in this study. This is in contrast to Galway (1977), who used a count of actual tornado reports that considered both time and space continuity of the reports. While Galway's approach attempted to assure continuity with synoptic scale weather systems, the boundaries of weather systems associated with a specific event are somewhat arbitrary and require the detailed plotting of each of the individual tornado reports. Also, with the individual tornado approach, some events become very difficult to categorize. For instance, the 21–22 November 1992 tornado outbreak was characterized by almost two days of near-continuous tornado

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activity over the southeast third of the United States, but it also featured a distinctly separate area of tornadic activity over the upper Ohio Valley. Was this one event, two events or three events? Should this two-day event be considered an equal to the one-day 3 April 1974 Superoutbreak?

One advantage of the calendar day approach is that the uniformity of time period for each event window precludes such questions. Tabulation of tornado days is simple, and normally a cursory glance at the event locations will tell if activity on one day is related to that on adjacent days. A companion paper on Tornado Outbreak Day Sequences (Schneider et al. 2004) illustrates this point with a discussion of an outbreak that occurred in May 1949. However, the use of a calendar day partition does have a disadvantage in the lack of continuity in events that cross midnight. If the "day" had been broken at 1200 UTC (the approximate time of the diurnal minimum of tornado occurrence) rather than midnight CST, slightly lower counts would have been found.

The Tornado Outbreak Day database includes traditional measures such as counts of tornadoes as a function of estimated intensity (F-scale) as well as alternative measures such as total path length or integrated Destructive Potential Index (Thompson and Vescio 1998, Schaefer et al. 2002). Particular care was taken to track the nuances of each dataset that influence the interpretation of the daily summary statistics. Examples include reports of a "skipping path" within long-track significant tornadoes or the combination of a family of tornadoes into a single event.

3. DEFINITIONS AND CRITERIA

The summary database was used to determine whether a day qualified as a Tornado Outbreak Day and to further categorize outbreak days according to their severity. Initial (objective) criteria for each Outbreak Day severity category (1–6) were established. Each day was then subjectively analyzed, both individually and within its severity category, in an effort to reduce biases arising from differences in the collection era (Fig. 1) and to resolve any disagreements between the Grazulis and NOAA datasets. As a result of the subjective analysis, it became apparent that changes in the number of significant tornadoes (F2 – F5) required to categorize an event needed to be modified. The initial and modified categorization criteria are given in Table 1. Much of the variability in tornado counts between the proposed outbreak categories can be attributed to the collection era and to the availability of less-commonly reported event characteristics. Although an initial subjective pass has been completed, considerable work remains to fully resolve conflicting views of specific events and to better define the proposed categories.

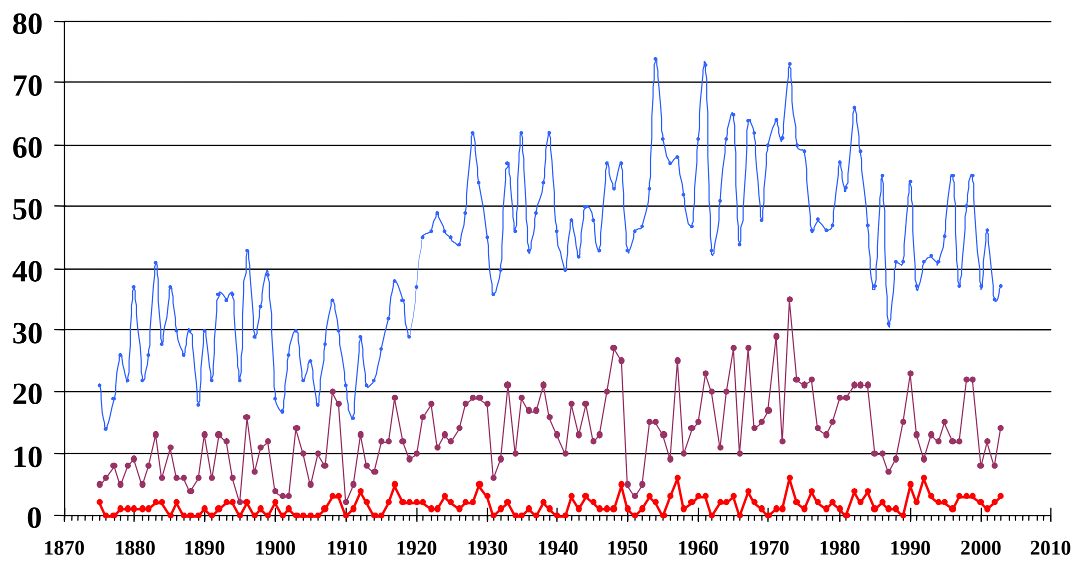

Figure 1: Plot of annual number of significant tornado days (solid blue); Tornado Outbreak Days (cat. 1 – 6, solid maroon); and Major Outbreak Days (cat. 3 – 6, solid red) for the period from 1875 – 2003.

	Range of Tornado Counts by Outbreak Category					
	Cat. 1	**Cat. 2**	**Cat. 3**	**Cat. 4**	**Cat. 5**	**Cat. 6**
F2–F5 (initial)	**2 – 5**	**6 – 11**	**12 – 17**	**18 – 23**	**24 – 29**	**30+**
F2–F5 (modified)	1 – 7	2 – 9	6 – 21	9 – 28	14 – 31	31 – 88
F3–F5	0 – 2	0 – 6	1 – 10	2 – 14	8 – 18	16 – 62
F4–F5	0 – 1	0 – 3	0 – 6	0 – 6	1 – 8	8 – 30

Table 1: Proposed Tornado Outbreak Day categories based on the range of tornado counts within select F-scale ranges. The ranges of significant tornado counts that served as a starting point for event classification are also indicated.

4. PRELIMINARY RESULTS

The preliminary Tornado Outbreak Day database was analyzed to provide insight into key characteristics of the events. The initial results document that the primary climatological Tornado Outbreak Day maximum occurs in April, May, and June, with a shift of the maximum forward to March, April, and May for outbreaks of historic severity (Fig. 2). A secondary, late fall maximum in the number of Tornado Outbreak Days is also evident in the dataset. This agrees with the semiannual peak in the number of reported tornadoes found by McNulty et al. (1979) and validates the existence of a "second tornado season" that is often cited in the press.

These data can also be used to gauge the rarity and importance of outbreak days within the overall context of tornado climatology, forecasting, and preparedness. The preliminary data suggest that while only about 3.5 percent of all days can be classified as Tornado Outbreak Days (Cat. 1–6), they account for over 80 percent of all tornado fatalities. Further, Major Tornado Outbreaks (Cat. 3–6) are observed on an average of 1.6 days per year (less than 0.5 percent of days), but account for nearly 50 percent of all fatalities.

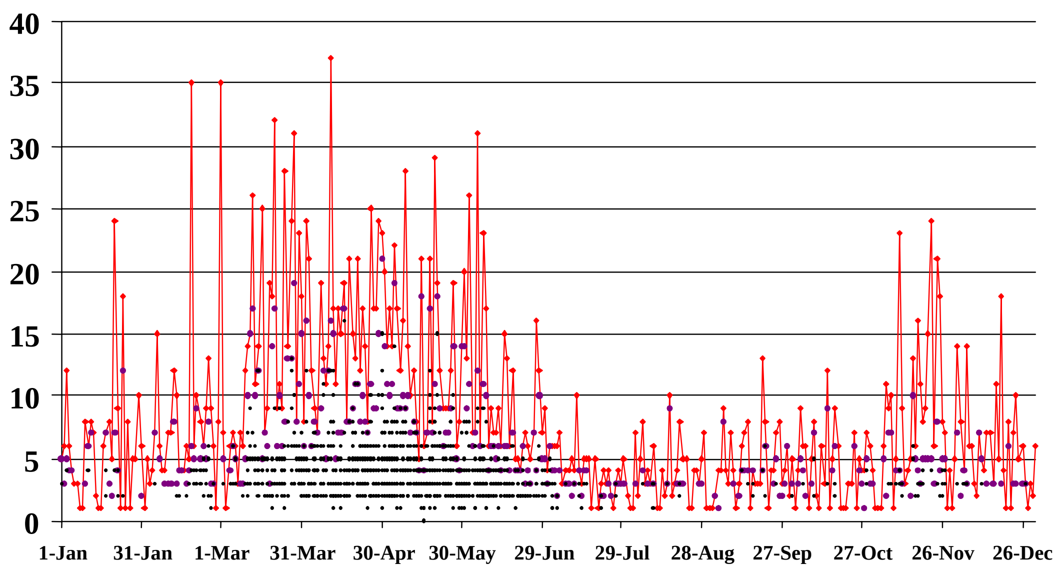

Figure 2: Count of significant tornadoes for each calendar day from 1875 – 2003 with occurrences plotted at all observed values. The maximum value for each day (solid red line and markers), penultimate value (purple markers), and other observed values (black markers) are specifically plotted. Note: the data for 3 April 1974 (88 significant tornadoes) is not plotted on graphic to aid in identification of smaller events!

5. SUMMARY

A daily tornado and severe weather summary database has been constructed for the period from 1875 through 2003 using both the NOAA and the Grazulis databases. The databases included both traditional measures such as counts of tornadoes as a function of estimated intensity (F-scale) and alternative measures such as total path length or integrated Destructive Potential Index. Particular care has been taken to track the nuances of each dataset that influences the daily summary statistics. This project is still in its developmental phase with only preliminary results available. Enhanced results will be available at the conference, but the work will continue thereafter in an effort to illuminate the character of both small and large tornado outbreaks and document their influence on society.

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