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AN EXAMINATION OF SEVERE THUNDERSTORM WIND REPORT CLIMATOLOGY: 1970-1999

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1. INTRODUCTION

Climatological information, synoptic pattern recognition and meteorological parameter assessment (or "ingredients-based approach), provide a basis for operational forecasting. Improvements in operational forecasts and warnings are often a result of improved forecasting/analysis techniques and new scientific understanding which evolve from basic and applied research. A comprehensive climatology of weather information often provides the foundation for such work, emphasizing the need for quality observations and climatological records. For hazardous weather events such as severe local storms, understanding of climatological information is necessary to assess potential risks to life and property, not only by forecasters but a wide range of users. These include local, state, and national emergency managers who are responsible for developing and coordinating plans to deal with weather related hazards, architects and structural engineers concerned with building codes and construction standards, insurance industry analysts interested in risk assessment, sociologists studying public response to hazardous weather, and government policy makers concerned with possible climate changes. Thus, accurate and reliable severe weather information is important not only to meteorologists, but to many segments of modern society.

2. SEVERE STORM CLIMATOLOGY ISSUES

The development of an accurate severe storm climatology is subject to a number of constraints. In particular, it is necessary in most instances for a person to observe the event, correctly identify and classify the event, and report the event to the proper authorities so it can be placed into the historical record (Doswell and Burgess 1988). Errors in this procedure will affect the quality and completeness of the data base, and are affected by a number of factors, including: 1) population biases, which are related to the likelihood an event will be observed, 2) diurnal influences, with night time events being more difficult to observe, 3) procedural guidelines used to determine the occurrence of a severe storm (e.g., what constitutes wind damage?), 4) the scientific understanding and training of the observer (e.g., differentiating between a downburst and a tornado from the damage pattern), and 5) the ability to conduct accurate storm surveys (e.g., identification of long-track versus multiple tornadoes). It has been recognized that the severe storm data base has historically contained biases and errors; however, the nature of the events in question and their large societal impact requires the development of the best severe storm data base possible. If users of the data base are to use the information in a meaningful and proper manner they must be aware of the strengths, weaknesses, and biases inherent in the data base, and incorporate this understanding into their analysis and interpretation of the results.

3. SEVERE STORM REPORT TRENDS

The number of severe local storm events recorded in Storm Data has increased by nearly an order of magnitude during the last 30 years. Reports of tornadoes, hail $\geq$ 3/4 inch diameter, and convective wind gusts $\geq$ 50 kt and/or wind damage exceeded 21,000 in 1999, compared to 2500-3000 per year in the early 1970s. This increase has been influenced by a number of factors, including: 1) implementation of the national warning verification program, which has resulted in increased accountability of NWS warning products, 2) the development of trained storm spotter networks, which has increased the likelihood of observing severe storms, 3) the deployment of the national NEXRAD radar network, which has resulted in substantial improvements in the remote identification of severe storms, 4) a population increase in many areas of the country and resultant growth of urban structures into previously rural areas, and 5) an overall increase in weather awareness by many segments of the population through the combined efforts of the media and many government agencies. However, these effects have not been uniform across the U.S. resulting in regional biases and inconsistencies in the data base. Weiss and Vescio (1998) documented aspects of the severe weather

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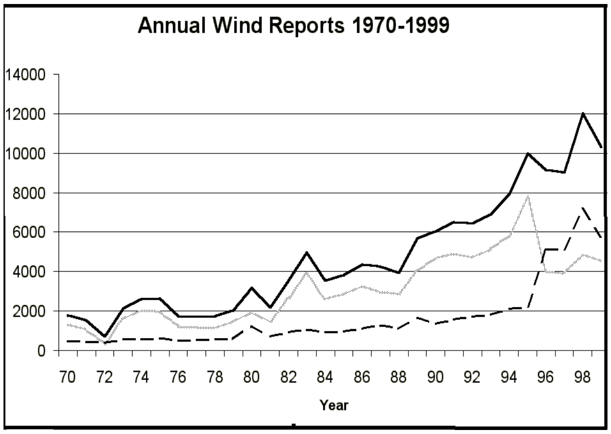

Figure 1. Annual number of severe convective wind reports from 1970-1999, with total reports (heavy solid line) stratified into gust reports (dashed line) and damage reports (light solid line).

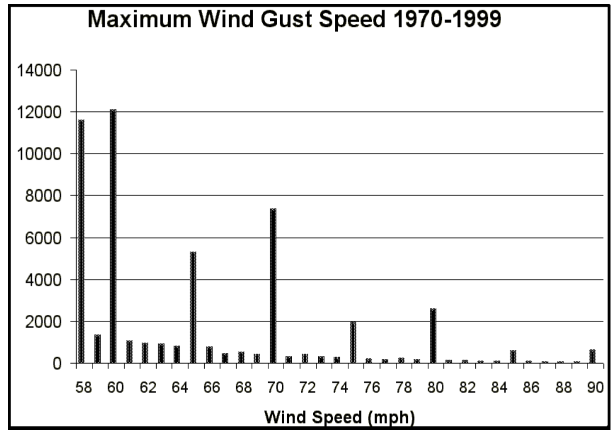

Figure 2. Number of severe wind gusts of 58-90 mph from 1970-1999.

reporting trends from 1955-1996, noting that the primary increase in severe hail, wind, and tornado reports during that period occurred at the low end of the report spectrum (especially marginally severe hail and F0 tornadoes). They also found that severe wind reports were most difficult to classify and evaluate, because most reports during their period of record consisted of various subjective degrees of "wind damage", or were listed simply as "peak wind gusts" without distinguishing between measured gusts or estimated gusts. They concluded that the wind event data base lacked sufficient precision for an in-depth analysis of the character and quality of damaging winds from a historical perspective. We have chosen to re-examine aspects of the severe wind event data base, largely because of changes in the character of these events since the middle 1990s.

3.1. Annual Wind Reports

The number of severe wind reports have increased dramatically (by more than 400%) during the past 30 years, with 10,000-12,000 wind events reported each year in the late 1990s (Fig. 1). The number of annual reports was relatively constant in the 1970s, with a gradual increase during the 1980s. The largest increase has occurred during the last decade with wind reports increasing at the rate of ~400 per year. According to Weiss and Vescio (1998), the number of severe storm reports and warnings became closely correlated starting in the middle 1980s, with a linear correlation coefficient of +0.98 since that time. This suggests that the severe storm warning program has become a major controlling factor in the gathering of severe reports by NWS offices, and that the resultant climatology is strongly influenced by effects of the warning verification system.

Figure 1 also shows that number of wind reports that contain a maximum wind gust speed increased from less than 30% of all wind reports to more than 50% since the middle 1990s, with wind gust events exceeding wind damage events in recent years. A noticeable discontinuity in the number of "wind damage" versus "wind gust" events occurred between 1995 and 1996, when the proportion of these specific events changed dramatically. Part of this is caused by the classification system used in archiving the wind event data, such that any wind event that contains a gust speed is classified as a gust event, even if it was also associated with damage. However, this also reflects a policy change that was enacted at some WFOs who arbitrarily assigned specific threshold wind speed values such as 58 or 60 mph to all wind damage events in their area of responsibility (e.g, Schaefer and Brooks 2000). In addition, there has also been a noticeable increase in the number of wind gust events (e.g., winds estimated at 60 mph) that are obtained without a coincident report of damage.

Although there has been an increase in surface mesonetworks and automated surface observing stations over the last decade, examination of Storm Data indicates that most "maximum wind gust" speeds are *estimated values* and not obtained from calibrated anemometers. This becomes apparent when looking at the distribution of maximum gust values (Fig. 2). There are pronounced peaks in the wind speed values at 58 mph (the threshold wind gust value for a severe

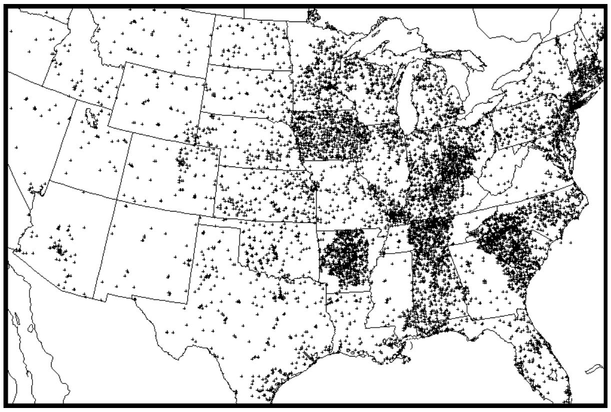

Figure 3. Plot of 58 mph wind gust reports 1970-1999.

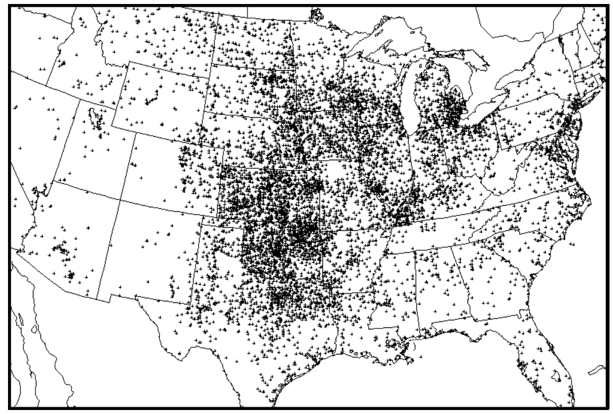

Figure 4. As in Fig. 3 except for 60 mph wind gusts.

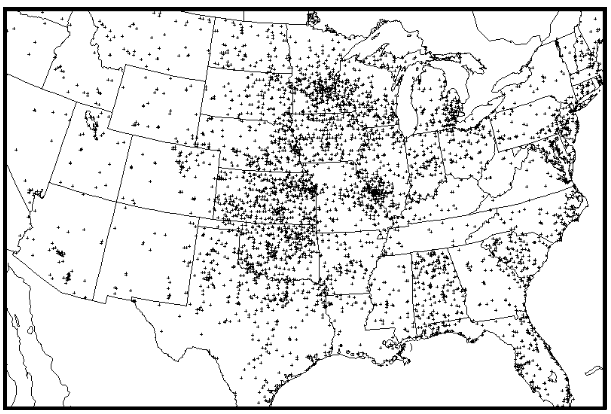

Figure 5. As in Fig. 3 except for 65 mph wind gusts.

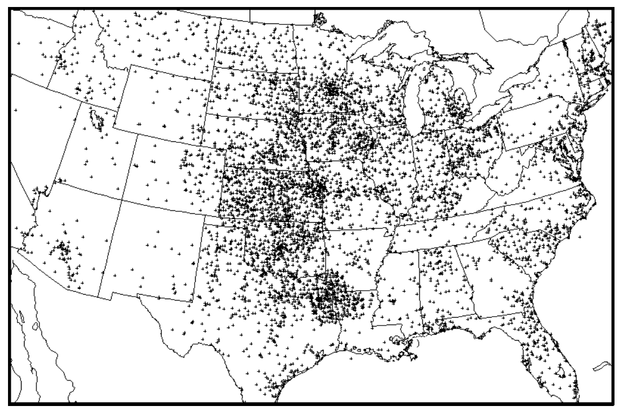

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Figure 6. As in Fig. 3 except for 70 mph wind gusts.

thunderstorm), 60 mph, 65 mph, and 70 mph, with lesser peaks apparent at 5 mph intervals through 90 mph. This preferential clustering is similar to the distribution of hail diameters found most frequently at the size of commonly used reference objects (such as various coins and balls used in sporting events - see Sammler 1993), and typically occurs when quantitative values are estimated rather than measured. It also suggests that a range of wind speed values is likely to be more meaningful compared to focusing on specific gust values. Owing to the inherent difficulty that human observers have in accurately estimating specific maximum gust speeds, it raises many questions about the reliability of most of these reports.

3.2 Geographic Distributions of Maximum Wind Gust Values

The geographic distribution of the high frequency maximum wind gust values of 58, 60, 65, and 70 mph is shown in Figures 3-6. These plots show pronounced regional biases and discontinuities along various geographic borders and between areas under different NWS warning and forecast responsibility. In addition, it becomes readily evident that specific wind speed assignments are favored in particular geographic regions, further contributing to sharp spatial discontinuities in the wind report data base. When wind gusts of 58 mph only are considered (Fig. 3), high concentrations of reports are located across parts of the upper Midwest, Arkansas, the Ohio Valley, coastal sections of the mid Atlantic region, and around the Carolinas. In particular, there are noticeable discontinuities in the frequency of 58 mph wind gust reports, which appear to be coincident with NWS WFO areas of responsibility.

Looking at wind gusts of 60 mph (Fig. 4), a very different picture emerges with higher concentrations widespread across the Great Lakes

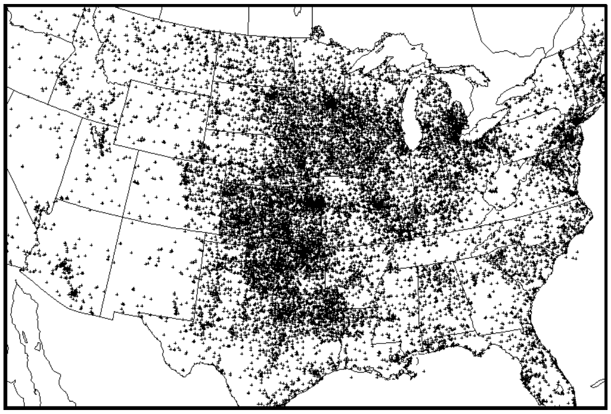

Figure 7. As in Fig. 3 except for 60-70 mph wind gusts.

and Plains states, and many fewer reports from Arkansas eastward into the Carolinas. At the higher wind gust values of 65 and 70 mph (Figs. 5 and 6), preferred regions of higher concentrations of reports still exist. These charts suggest the existence of a bias in some urban areas (such as around St. Louis, Kansas City and Minneapolis), while other concentrations of reports cover larger areas (such as a more widespread region of 70 mph reports over northeast Texas, southwest Arkansas, and northwest Louisiana). Although examining a range of maximum wind speed values will help filter some of the geographic discontinuities that exist at individual wind speeds, it does not completely remove all artifacts of local gathering and procedural biases (Fig. 7).

4. SUMMARY AND DISCUSSION

An examination of severe local storm wind events from 1970 through 1999 indicate that severe wind reports have increased substantially over the last decade, with a major change in report character evident beginning in 1996. Starting that year, the number of severe wind events that contained a maximum gust value increased dramatically from 22% of all wind events in 1995 to 56% in 1996. The vast majority of these reports on a nationwide basis are estimates provided by human observers, and given the difficulty that exists in accurately estimating wind speed (including by trained storm spotters), the change in character of the wind reports raises new questions about the quality of the data base. This is especially important for researchers interested in obtaining climatological information about the frequency of occurrence of specific convective wind gust values. Concerns about the quality of the severe wind dataset have been discussed previously by Weiss and Vescio (1998), who recommended that it is essential that the precision of the wind event data base be increased. They said: "First, it is necessary to distinguish between measured and estimated wind gusts. In addition, the reliability of an estimated wind gust value can be qualitatively determined to some extent if a binary "yes/no" wind damage category is assigned to all wind gust events (measured or estimated)." Based on the recent changes in the data base, these recommendations take on increased importance.

We believe that it is important to raise the level of awareness about the strengths and limitations of the severe wind event data base, especially in lieu of dramatic changes that have occurred since the middle 1990s. Clearly, operational challenges exist which have impacted the compilation of the data base, but it is important to stress the need for reliable and accurate reports that will serve the needs of many users, including those who strive to conduct meaningful scientific research. Otherwise, the chances of drawing misleading or even inaccurate conclusions is increased when the wind data base is analyzed in a purely statistical manner.

5. ACKNOWLEDGMENTS

We would like to thank the many SPC forecasters who have developed considerable insights into the character and reliability of the severe weather report data base through their real time observations of severe thunderstorm systems, and their efforts to bring the geographic discontinuity issue to our attention.

6. REFERENCES

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