4.2 THE CLUSTERING OF SEVERE STORMS ACROSS THE UNITED STATES

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1. INTRODUCTION

Severe thunderstorms are defined as those associated with hail three-quarters of an inch in diameter or larger, convective wind gusts greater than 58 mph (50 knots) or damage compatible with such winds, and/or tornadoes. Severe weather is considered significant if the hail is two inches in diameter or greater, convective winds are 75 mph or greater, or if a tornado creates F2 or greater damage. The Storm Prediction Center (SPC) maintains a database of tornado reports that goes back through 1950, and severe thunderstorm wind and hail reports back through 1955 (Fig 1). [Note: because of a change in computer systems, the data for 1972 is incomplete.] Reports of severe storms have been increasing greatly since 1988 with a current average of 26,000 reports per year. When the events are sorted by severity, some definite trends emerge. They reflect on the way severe thunderstorms events are reported.

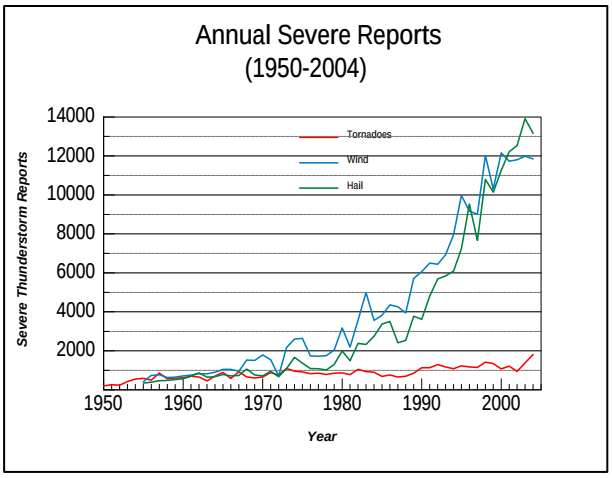

Figure 1: The number and type of severe thunderstorm reports by year (Note: 1972 wind and hail data are incomplete.)

Tornadoes can be sorted into three categories depending on the Fujita scale associated with them (Fujita, 1971). Weak tornadoes are those that have produced F0 or F1 damage, strong tornadoes produced F2 or F3 damage, and violent tornadoes produced F4 and F5 damage (Fig. 2). All of the increase in reported tornadoes over the past half century comes from weak tornadoes. This increase is due to such things as improved communications (e.g., cellular telephones), education, storm chasing, weather broadcasters with their emphasis on watches and warnings, and the warning verification efforts. The number of strong and violent tornadoes has actually decreased since the mid-1970s as a result of changes in the methodology used to rate tornados by the NWS.

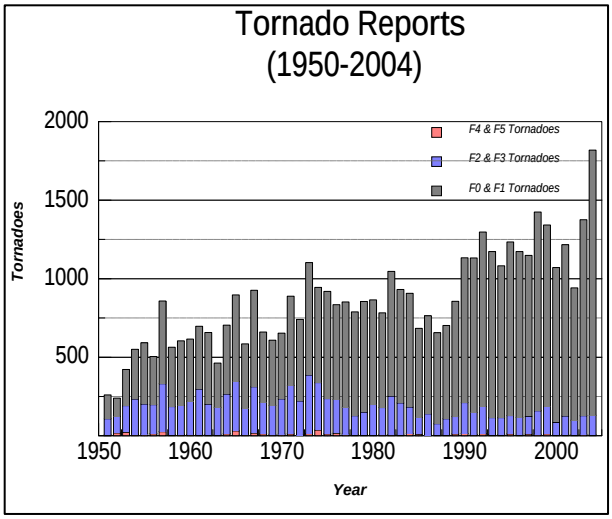

Figure 2: The annual number of reported tornadoes by Fujita Scale category.

Reports of severe thunderstorm wind gusts can be sorted according to their reported speed (Fig. 3). About 6% of severe thunderstorm wind reports are of gusts 65 knots or faster (75 mph). At the other end of the spectrum, a large number of past severe thunderstorm wind reports were simply listed as “damage” with no accompanying speed estimation. Beginning in 1996, estimated or measured wind speed values were supposed to be associated with all wind reports. (Starting in 2003, Storm Data reports were created using a computer interface that enforced this new rule.) Surprisingly, this rule had little impact on the number of wind reports.

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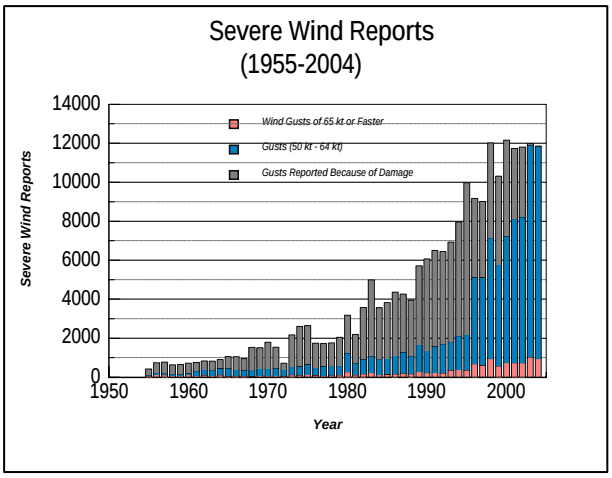

Figure 3: The annual number of severe thunderstorm wind reports sorted by speed. (Note: 1972 data are incomplete.)

The trend over the past half century of severe thunderstorm hail reports sorted by size is quite illustrative (Fig. 4). The ability to operationally "observe" vertically integrated liquid water (VIL) (Greene and Clark, 1972) in the mid-1980s resulted in a jump in the number of reports of penny- and nickel-sized hail (¾" to less than an inch in diameter). Similarly, the advent of operational Doppler radar (the WSR-88D) in the mid-1990s is reflected in a jump of severe hail reports of all sizes.

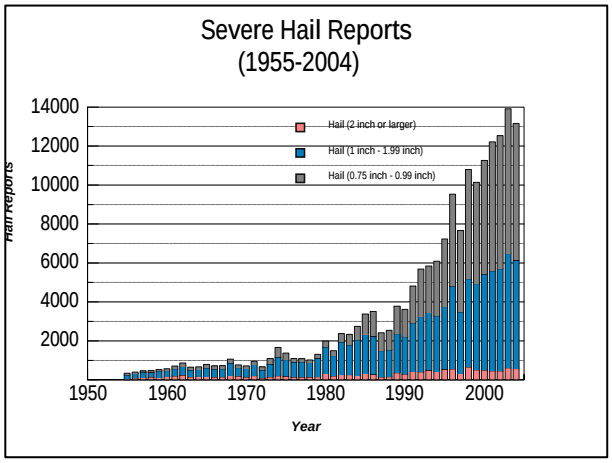

Figure 4: The annual number of severe thunderstorm hail reports sorted by diameter. (Note: 1972 data are incomplete.)

Currently, in an operational experiment, selected NWS offices in eastern Kansas and western Missouri are only issuing warnings for 1" (quarter-sized) and larger hail. However, reports of ¾" to 1" hail are still to be included in their *Storm Data* entries. It will be interesting to see what effect, if any, this change has on distribution of hail reports.

2. REDUNDANT HAIL REPORTS IN *STORM DATA*

The SPC severe thunderstorm event databases were originally compiled as part of the NWS tornado and severe thunderstorm verification program (Pearson and David, 1979). In an attempt to automatically account for multiple reports from the same storm, a 10 mile/15 minute rule was used on reports included in the database. Under this rule, multiple reports of severe thunderstorm wind or hail events occurring less than ten statute miles and less than fifteen minutes from each other and in the same county were generally recorded as one event. The exceptions to this rule were:

- All distinct tornadoes were retained as separate events.
- All wind events of 65 knots or greater were retained.
- All hail reports with a diameter of two inches or greater were retained.
- All reports including injuries or fatalities were retained.
- Any event that verified a warning that would otherwise not be verified was retained.

Beginning with the 1996 data, the responsibility for warning verification was transferred from the SPC to NWS Headquarters. After this transfer, the 10 mile/15 minute rule was no longer applied to the SPC datasets so that they would reflect the content of *Storm Data*.

Unfortunately, this assumed *prima facie* decision had the unanticipated consequence of inflating the database with "redundant" reports. To show this, the databases were filtered by using a slightly modified version of the 10 mile/15 minute rule. The modification is that only the largest hail size or fastest gust of apparently-multiple reports of a single storm is considered. This filtering revealed numerous storms that apparently generated multiple reports (Fig. 5). As anticipated, most of the redundant reports occurred after 1996.

When only unique wind reports are considered (Fig. 6), the magnitude of the explosive growth in the number of reports in the late 1990s is decreased. As would be expected from the rule used to eliminate multiple reports, most of the redundant reports are in the lowest category present (damage before 2002, and 50 kt to 64 kt in 2003 and 2004).

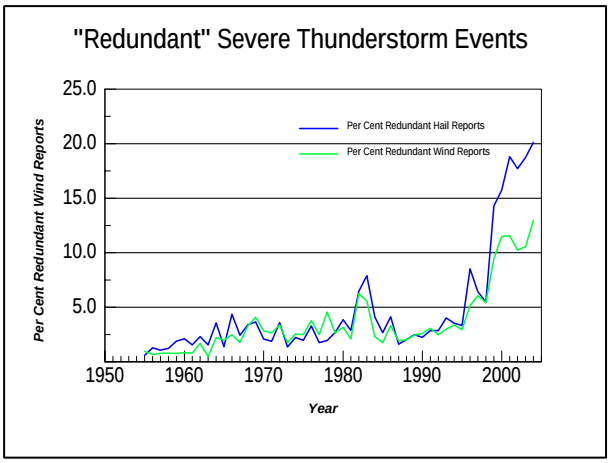

Figure 5: Percent of Severe Thunderstorm Reports that are "redundant." (Note: 1972 wind and hail data are incomplete.)

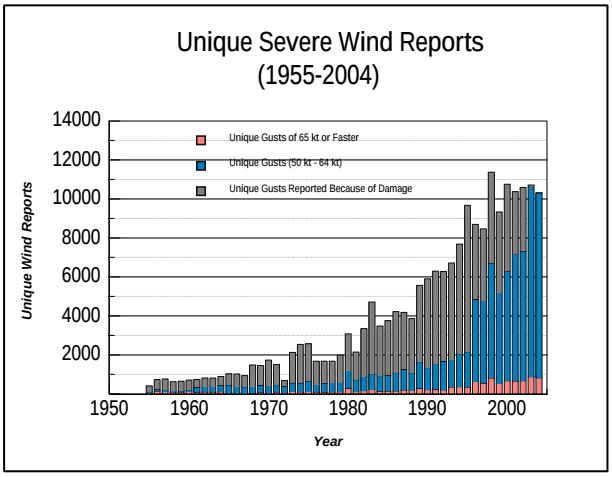

Figure 6: Unique severe thunderstorm wind reports sorted by gust speed. (Note: 1972 data are incomplete.)

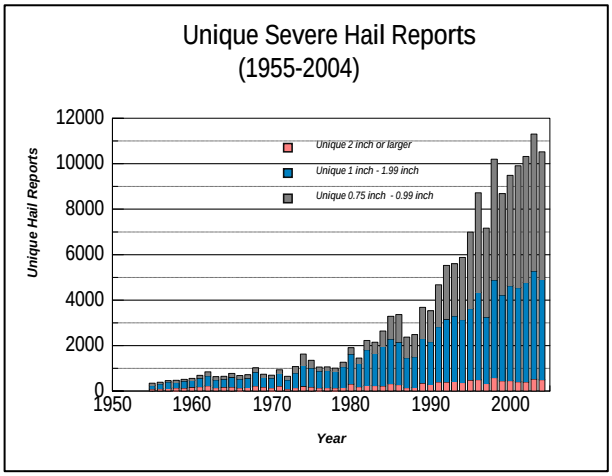

Figure 7: The annual number of unique severe hail reports sorted by diameter. (Note: 1972 hail data are incomplete.)

In general, the annual trends in the distributions of unique hail reports (Fig. 7) are very similar to those of the unfiltered data. The reduction in the number of reports is largest for the smallest category, while very little difference is seen in the 2" and larger category. In recent years the number of unique hail storms reported has leveled off at about 10,000 reports per year, of which about 5,000 were 1" (quarter-sized) or larger hail.

3. CLUSTERED SEVERE THUNDERSTORM EVENTS

To estimate the frequency of isolated severe thunderstorms, the unique events in the database were "clustered". A cluster is defined as a group of events which occurred within 90 nautical miles (103 statute miles) and six hours of each other. (Ninety nautical miles was chosen because it results in a circle with an area roughly equivalent to the average size of a watch.)

Clustering is accomplished by using a 10 km grid that covers the United States. First, the reports that are within 90 n. mi. of each grid point and six hours of each other are identified. Then for each report, the largest grid point group that it belongs to is identified. Since this number is also the size of the largest cluster that the report is associated with, the number of clusters of each size within the database can then be tabulated.

During the period 2000 through 2004 (Fig. 8), slightly over 13% of tornadoes have a cluster size of "1", i.e., they are isolated. In contrast, the number of clusters in the severe wind and hail events is practically uniform. There is no preference for any particular cluster size. Less than 3% of severe hail and wind reports are isolated. As extreme events are considered (F2 and greater tornadoes, 2" diameter and larger hail, and wind gusts reported at least at 65 kt (75 mph)), isolated reports are more frequent.

The number of clustered reports per decade indicates that the frequency at which groups of events are reported has increased markedly. For instance, 28% of the hail events reported during the early 1960s were "isolated" (Fig. 9). This percentage has constantly decreased until only 2% of severe hail events were isolated during the first 5 years of the 21st century. A similar trend is observed in an analysis of reported severe thunderstorm wind reports. This implies that much of the increase in frequency of severe thunderstorms is due to improved reporting efficiency.

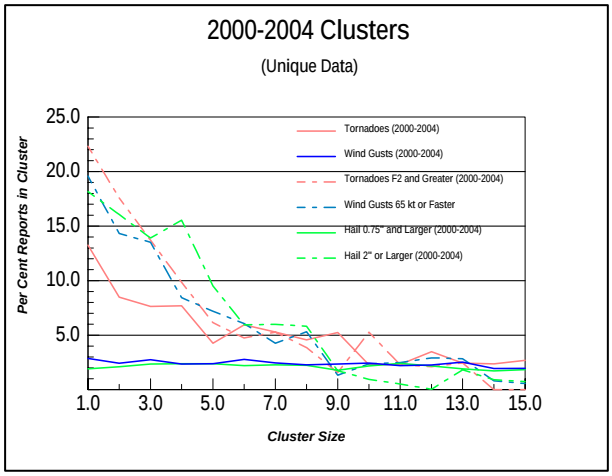

Figure 8: The annual number of unique severe hail reports sorted by diameter. (Note: 1972 data are incomplete.)

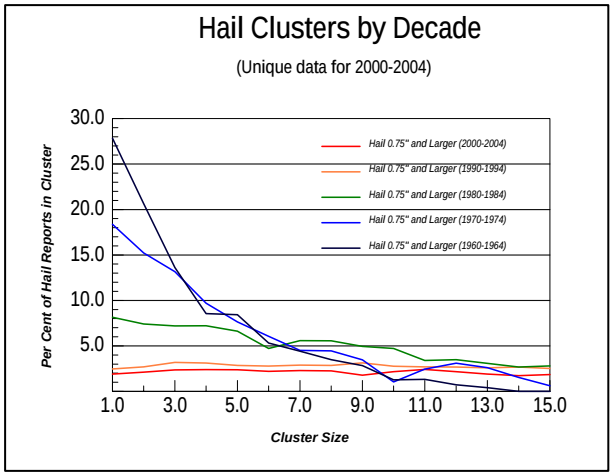

Figure 9: The clustering of "unique severe hail storms during the first 5 years of each decade.

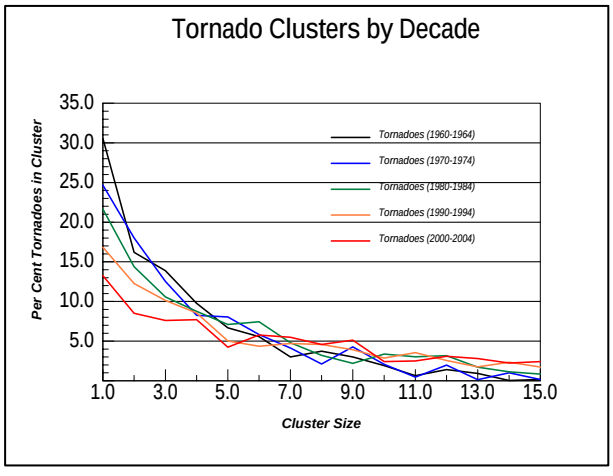

Figure 10: The clustering of reported tornadic storms during the first 5 years of each decade.

For tornadoes, the trend towards groups of reports is much less pronounced (Fig. 10), but it is still present. In the early 1960s, 30% of tornadoes were isolated. Forty years later, this has decreased so that only 13% are isolated. The observation that the decrease in the reported occurrence of isolated hail events is much greater than the decrease in the reported number of isolated tornadic events is compatible with the markedly higher inflation in the annual number of hail reports as compared to the annual number of tornado reports.

4. CONCLUSIONS

The increase in the annual number of severe thunderstorm reports increases as the intensity increases. However, the increase in severe hail reports and winds reports is much less than the increase of tornadoes.

About one-fifth of severe hail reports and one-tenth of severe gust reports come from the same storm. This is very important to remember when interpreting *Storm Data* entries or when broadcasting information about ongoing severe thunderstorms.

Recent observations indicate that only about 3% of non-tornadic severe thunderstorm events are truly isolated. Thus, if you have one severe non-tornadic thunderstorm report, you will likely receive more.

A higher percentage of tornadoes are isolated events, but this is still only about one in ten tornadoes.

The increase in the number of severe thunderstorms over the past few decades is in large part due to the increased reporting efficiency. Even though the total number of tornadoes has grown over the past 50 years, the number of strong and violent tornadoes (F2 and greater) has decreased over the same period.

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5. REFERENCES

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