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## 1. INTRODUCTION

In order to analyze the 2007-2008 cool season, a comparison was made between this season and past cool seasons. A 50 cool season time-span from 1958 to 2008 is the baseline for this study and is used to compute averages for the number of tornadoes, number of outbreaks and number of fatalities.

In addition to exploring the relationships between the 2007-2008 cool season and the last 50 cool seasons, trends in tornadoes, tornado outbreaks, and fatalities over these years are also reviewed.

It must be noted that significant non-meteorological factors have affected tornado reporting over the last 50 years. Better observations and recent trends in aggressive National Weather Service (NWS) verification have likely resulted in more tornadoes being documented than ever before. These factors will more than likely skew some of our results, especially the number of weak tornadoes in recent cool seasons. However, the 50 seasons will be analyzed without making any alterations to account for these changes.

## 2. METHODOLOGY

The Storm Prediction Center (SPC) database used for this study attains its data from the NWS Performance Management website. The NWS maintains its tornado data in county by county segments. The SPC joins the segments of continuous track tornadoes to form individual tornado records. The SPC database allows queries for specific numbers of tornadoes, fatalities, and other information.

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Before data collection and analysis could begin, the authors had to define certain terms for this study. The subjective definition for tornado outbreak was chosen to be 6 or more tornadoes on any calendar day anywhere in the United States, or 5 or more F2 or stronger tornadoes on any calendar day anywhere in the United States (*Cook and Schaefer 2007*). Furthermore, the 6-month period from October to March was designated the "cool season" for the purposes of this study.

After developing the necessary definitions, the SPC database was queried for each cool season month from October 1958 through March 2008. The number of tornadoes, tornado outbreaks, and fatalities in each month were compiled. Tornado numbers were also broken down into weak tornadoes (F0, F1) and strong to violent tornadoes ( $\geq$  F2).

Once all of the cool season information was gathered, it was further categorized into individual cool season months, and also separated by first and second 25-year periods in the 50 season time period for trend analysis.

## 3. RESULTS

The difference in the 2007-2008 cool season tornado numbers from the 50 year average was dramatic in almost all categories studied. This helped to better portray how active this particular season was in comparison to past seasons.

### 3.1 2007-2008 vs. 50 season average

#### 3.1a Outbreaks

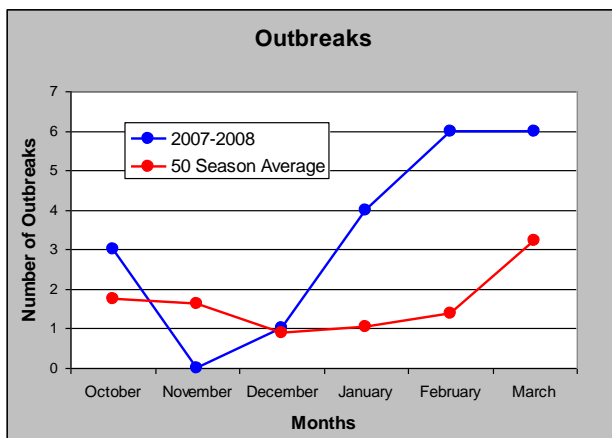
The 2007-2008 cool season had a total of 20 outbreaks according to the

definition used for this study. This tied the 1997-1998 cool season for the most outbreaks in a season (Table 1). The average number of outbreaks per cool season over the 50 season period is only 10.

Rank	Season	Number of Outbreaks
1	2007-2008	20
1	1997-1998	20
3	1998-1999	19
4	2006-2007	17
5	2004-2005	16
5	2002-2003	16
5	1996-1997	16
5	1975-1976	16

**Table 1**

All 2007-2008 cool season months except for November 2007 had more tornadoes than the 50 season monthly averages. February 2008 stood out with the most striking deviation from average with 6 tornado outbreaks compared to a normal February outbreak value of 1.38 (Fig. 1). October 2007, January 2008, and March 2008 were all well above the average while December 2007 had one outbreak, marginally surpassing a 50 year average of 0.88. November 2007 had none, making it the only month to have fewer than average tornado outbreaks.



**Figure 1**

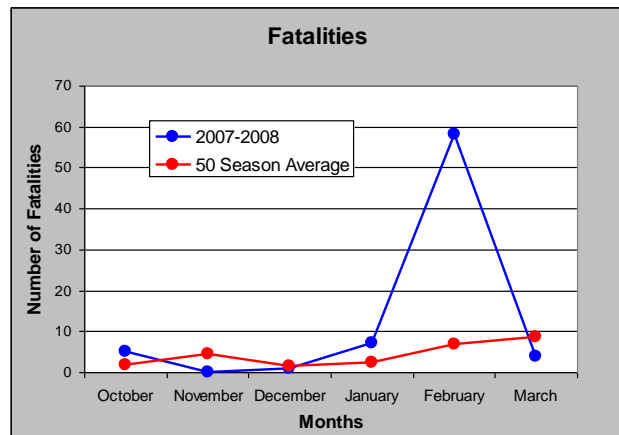
### 3.1b Fatalities

The number of tornado fatalities of the 2007-2008 cool season ranked high against the last 50 seasons. This season had a total of 75 fatalities. The only cool season with more fatalities occurred in the 1970-1971 season with 143 (Table 2).

Rank	Season	Number of Fatalities
1	1970-1971	143
2	2007-2008	75
3	1983-1984	69
4	1965-1966	64
5	2006-2007	63
6	1997-1998	58
7	2002-2003	54
8	1993-1994	44

**Table 2**

Every decade used for this study except for the 1950s had a stand-out year in terms of fatality numbers showing that although this past season experienced a large number of fatalities, there have been seasons with a large number of fatalities at least once every decade. Compared to the average of only 25 fatalities per cool season studied, 2007-2008 stands out with three times the normal number of fatalities.



**Figure 2**

Unlike outbreaks, tornado fatality numbers were very near average for all of the cool season months studied except for February 2008. Radically surpassing the average February value of 6.84 fatalities, February 2008 had a total of 58 fatalities. Most of these fatalities occurred during the February 5-6, 2008 tornado outbreak. All the other months were within 5 fatalities of their respective averages (Fig. 2).

### 3.1c Tornadoes

After such dramatic above average numbers for the previously mentioned months, it made sense that this season would rank highly in terms of the number of tornadoes in a cool season. This season totaled at 471 tornadoes (Table 3). This is 63 more tornadoes than the previous most active season (1998-1999), and 266 more than the average of 205 tornadoes per cool season.

Rank	Season	Number of Tornadoes
1	2007-2008	471
2	1998-1999	408
3	2005-2006	402
4	2006-2007	400
5	2004-2005	360
6	1997-1998	328
7	1996-1997	313
8	2002-2003	311

Table 3

The results for the number of tornadoes were similar to those for outbreaks. October 2007, January, February, and March of 2008 were all well above average. November 2007 was well below the average. With 19 tornadoes, December 2007 was close to the 50 year average of 19.66 tornadoes. February 2008 once again had the most dramatic difference from the average. The 148 tornadoes during February 2008 far exceeded the average February value of 24.78 tornadoes (Fig. 3).

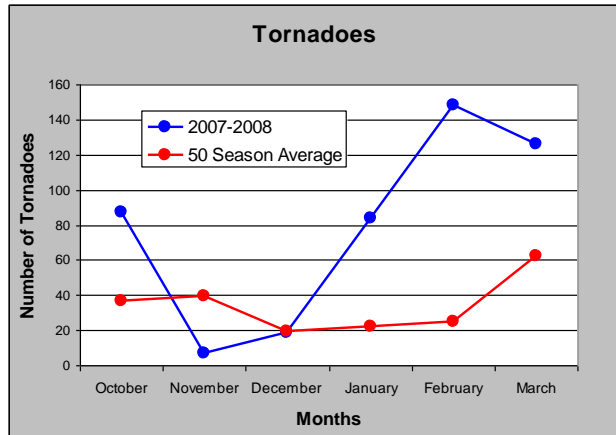


Figure 3

### 3.1c-i Weak Tornadoes

The typical cool season has only 150 weak tornadoes while this past season was well above average with 378 (Table 4).

Rank	Season	Weak Tornadoes
1	2007-2008	378
2	2006-2007	334
3	1998-1999	325
4	2005-2006	324
5	2004-2005	323
6	1997-1998	291
7	2002-2003	268
8	1995-1996	253

Table 4

The graph of cool season weak tornadoes (Fig. 4) looks nearly identical to the graph for all tornadoes (Fig. 3). The same months that stand out in the all tornadoes category – October 2007, January, February and March of 2008 – also stand out for having many more weak tornadoes than average. February 2008 had nearly 100 more weak tornadoes than average. All the cool season months were above average with the exception of November 2007 which had only six weak tornadoes compared to an average of nearly 28.

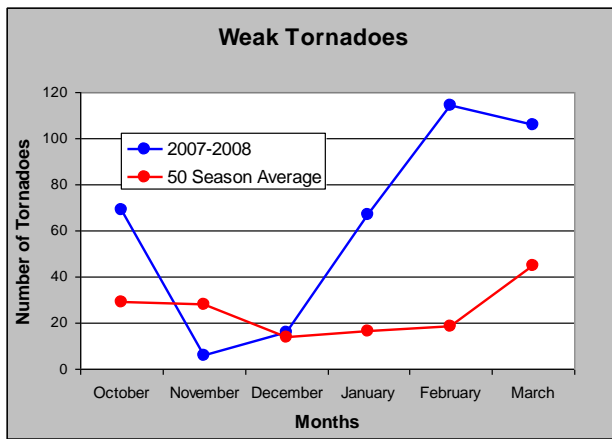


Figure 4

### 3.1c-ii Strong to Violent Tornadoes

The 2007-2008 cool season recorded 93 strong to violent tornadoes (EF2-EF5) (Table 5). This is 48 strong to violent tornadoes more than the average of 55.

Rank	Season	Strong to Violent Tornadoes
1	1975-1976	123
2	1974-1975	107
3	1960-1961	103
4	1970-1971	99
5	1973-1974	95
6	2007-2008	93
7	1966-1967	91
8	1971-1972	89

Table 5

The graph of strong to violent tornadoes throughout the 2007-2008 cool season (Fig. 5) looks very similar to the graph for weak tornadoes (Fig. 4) with a few exceptions. Unlike with weak tornadoes, March 2008 was very standard in terms of the number of strong to violent tornadoes, having only two more than the average. February 2008 still stands out as the most above-average month with 27 more strong to violent tornadoes than average. October 2007 and January 2008 also had greater

than normal strong to violent tornado activity.

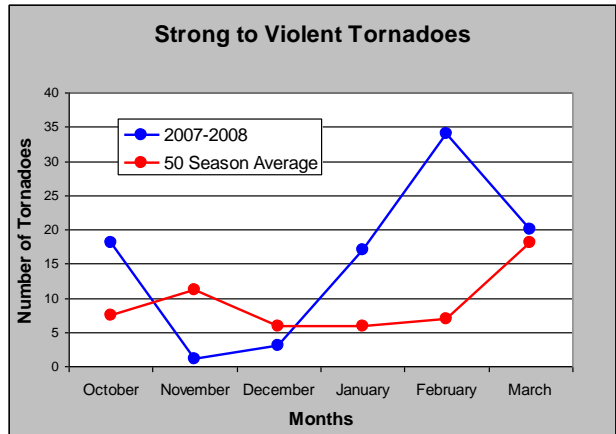


Figure 5

### 3.2 1958-2008 Trends

#### 3.2a Outbreaks

As with all of the categories examined for trends, the number of outbreaks through the 50 season period varies greatly from season to season. The long-term outbreak trend in Fig. 6 indicates an upward tendency which would make sense given the nearly parallel increase in tornadoes shown in Fig. 11.

After breaking down outbreak trends into individual months it becomes evident that none of the months are trending downwards and that some – October, November, January and March – have definitive upward trends.

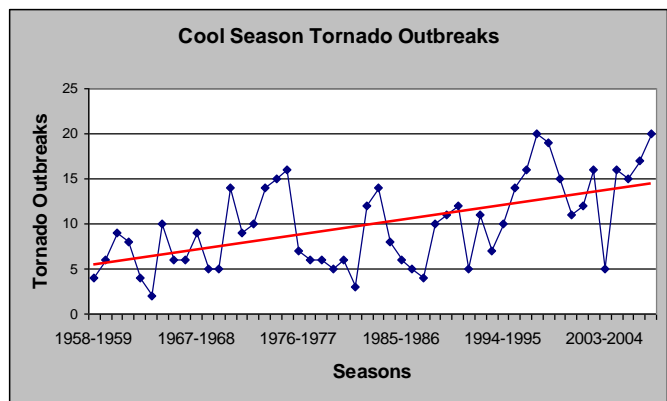


Figure 6

After breaking the last 50 seasons into two 25-year periods, it becomes

apparent that both the period from 1958-1983 and 1983-2008 exhibit upward trends as seen in Fig. 7 and Fig. 8. The more recent of the two time periods has a more prominent upward trend, however.

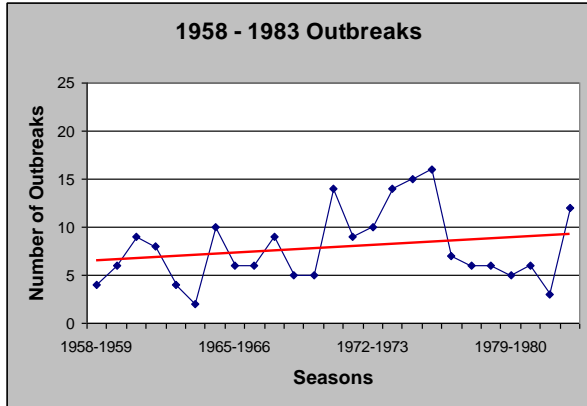


Figure 7

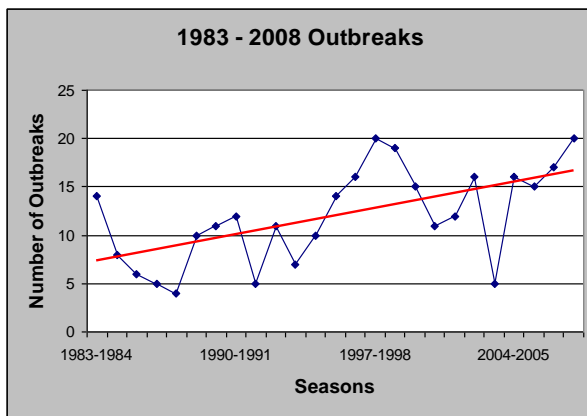


Figure 8

### 3.2b Fatalities

Looking at long-term trends in fatalities, it is evident that there is definite year to year variability and that a season

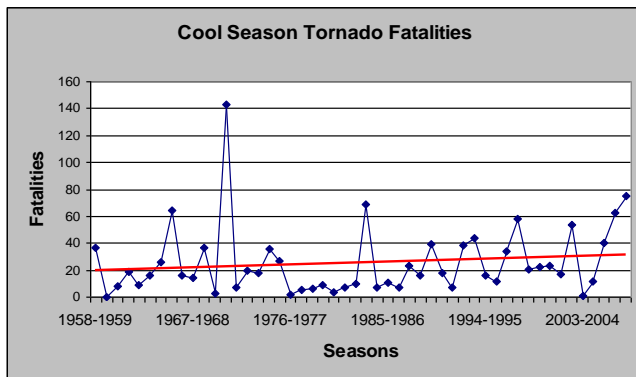


Figure 7

well above the average of 25 fatalities occurs at least once every decade (Fig. 9).

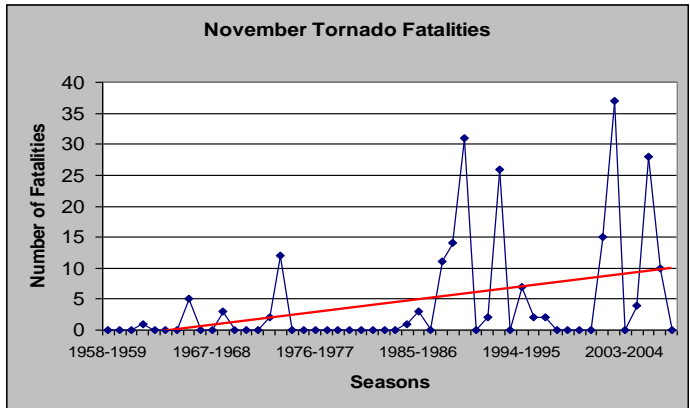


Figure 10

Month by month analysis reveals that all months except November exhibit no obvious trend. November shows an upward trend in the number of tornado fatalities. As shown by the spikes in Fig. 10, some November months in the early 1990s and 2000s had twice number of fatalities experienced in any previous November during the 50 season time period.

### 3.2c Tornadoes

As previously mentioned in the *Outbreaks* section, tornadoes per cool season appear to be on a definite incline. The last five cool seasons are a good indicator of this. The 2003-2004 cool season had 142 tornadoes, well below the average of 205 per season (Fig. 11). Since then, the number of tornadoes per season has increased to the past season's total of 471.

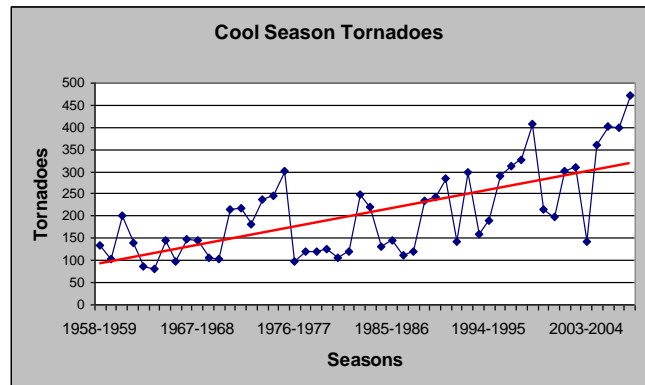


Figure 11

Every cool season month appears to be on some degree of upward trend. October, November and March are definitely on the most dramatic inclines in the long-term.

Both time periods examined in Fig. 12 and Fig. 13 show upward trends, but Fig. 13 has a more dramatic upward slope.

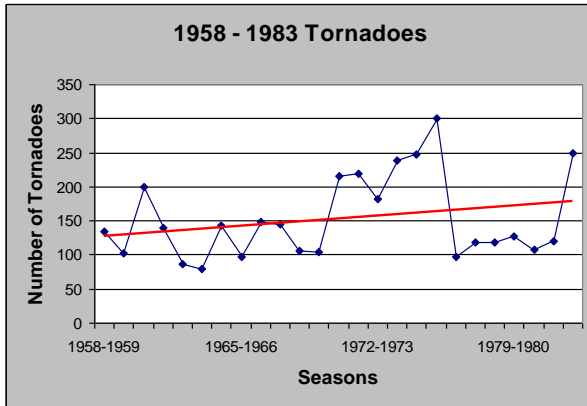


Figure 12

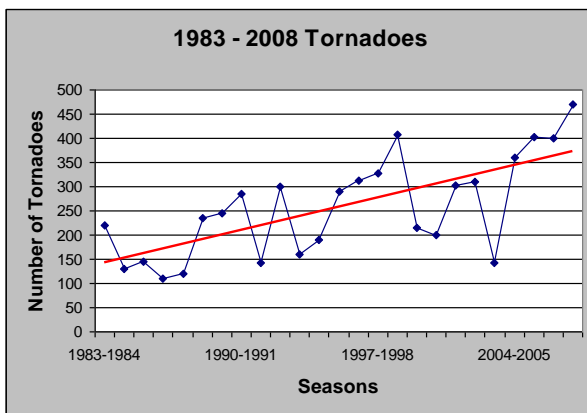


Figure 13

### 3.2ci Weak Tornadoes

Very similar to Fig. 9, the long term trend for weak tornadoes is on a fairly steep incline (Fig. 14). The same months that were greatly contributing to this upward trend in the *Tornadoes* category – October, November and March – are also greatly contributing to the overall upward trend in weak tornadoes.

In much the same way that 50 year tornado trends and weak tornado trends were similar, the two 25-year periods are also very much the same in terms of trends. As shown in Fig. 15, 1958-1983 had a slight upward trend in weak tornadoes per season

and 1983-2008 had a more defined upward slope.

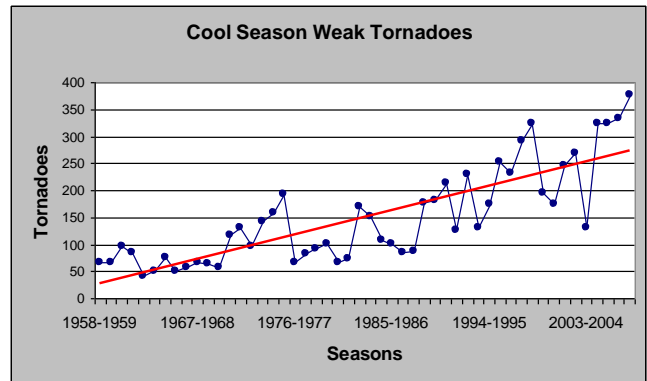


Figure 14

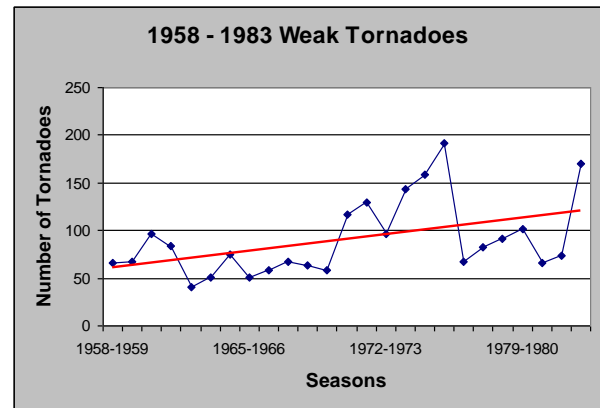


Figure 15

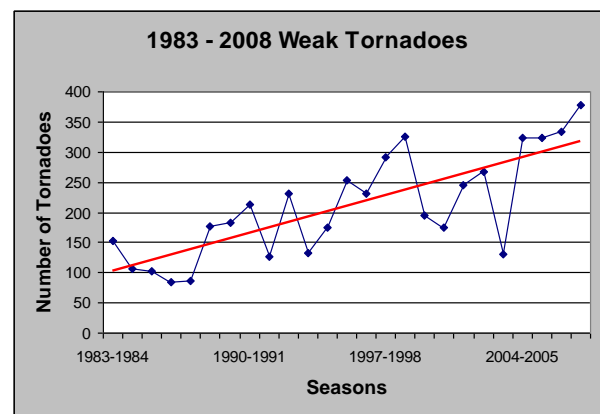


Figure 16

### 3.2cii Strong to Violent Tornadoes

The trend in strong to violent tornadoes appears to be the opposite of the trend in weak tornadoes (Fig. 17).

Throughout the last 50 seasons, strong to violent tornadoes have experienced a very slight downward trend. A large amount of variability is noted from season to season.

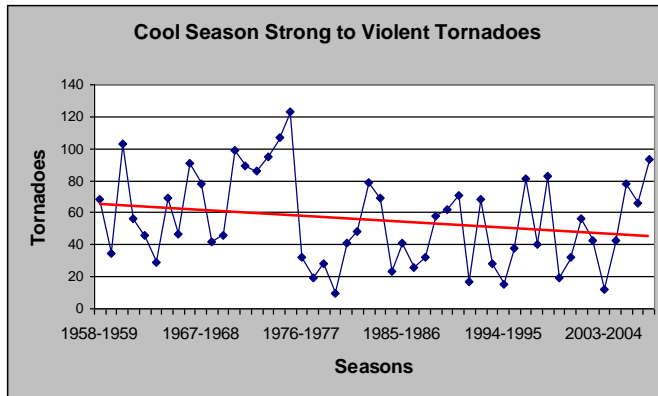


Figure 17

There appears no overwhelming trend in most months with the possible exceptions being December and March. These months show a slight downward trend over time.

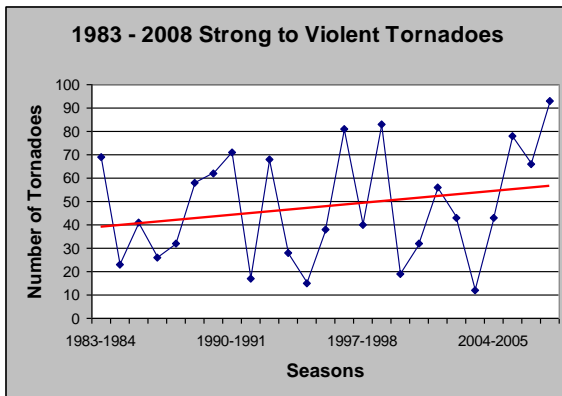


Figure 18

Breaking the timeline into two periods reveals a slight downward trend for the first 25 years and an upward trend during the 1983-2008 time frame (Fig. 18). However, the high variability exhibited in the tornado numbers suggests that a simple linear trend analysis may be insufficient in revealing any actual signal in these data.

#### 4. CONCLUSION

Although this study did quantify the 2007-2008 cool season as one of the top cool seasons in the last 50 seasons with respect to tornado activity, the quantification depends largely on the definitions used for “cool season” and “outbreak”.

Any changes to these definitions would alter the categorical rankings to some degree. With such outstanding rankings given our definitions, however, the 2007-2008 cool season can be considered a very active season. Data over the past 50 years also indicate a dramatic upswing in overall tornado numbers but there is unchanging to slightly downward trend in strong to violent tornadoes during the cool season. Our analysis also revealed that large fatality cool seasons have appeared in the data about once each decade over the past 50 years.

When the data are split into two 25-year periods, the upward trends persist in all categories with the possible exceptions in cool season fatalities which show a slight downward trend through the early 1980s, and a gradual increase (amidst high variability) in the years since. Also, as previously mentioned, strong to violent tornadoes display a slight downward trend if not nearly static behavior.

#### 5. ACKNOWLEDGEMENTS

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#### 6. REFERENCES

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