AN ANALYSIS OF THE 2007-2008 TORNADO COOL SEASON

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Abstract

The fall and winter months of 2007-2008 were particularly active in terms of tornado events and the number of tornado-related fatalities in the United States. The media portrayed the severe weather during this period in time as unusual, if not record-breaking. Journalists and reporters asked questions about the causes of such an active cool season and how this season compared with other years.

Defining “cool season” as the 6 month period from October to March, this study analyzes the 2007-2008 cool season tornado outbreaks in terms of tornado frequency, number of fatalities, and tornado strength based on Enhanced Fujita scale ratings. Data from the Storm Prediction Center’s Storm Event Database was utilized to determine the uniqueness of the 2007-2008 cool season tornado outbreaks as compared to the last 50 cool seasons. Our results will more accurately define the significance of this season with respect to the past 50 seasons in order to aid the media and other interested parties in quantifying this period of time. Trends in cool season tornado outbreaks are also investigated.

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 this these changes.

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.

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 (≥ 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.

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.

1. 2007-2008 vs. 50 season average

a. 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.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Season</th>
<th>Number of Outbreaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2007-2008</td>
<td>20</td>
</tr>
<tr>
<td>1</td>
<td>1997-1998</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>1998-1999</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>2006-2007</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>2004-2005</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>2002-2003</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>1996-1997</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>1975-1976</td>
<td>16</td>
</tr>
</tbody>
</table>

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.

b. 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).

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

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.

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).

c. 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.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Season</th>
<th>Number of Tornadoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2007-2008</td>
<td>471</td>
</tr>
<tr>
<td>2</td>
<td>1998-1999</td>
<td>408</td>
</tr>
<tr>
<td>3</td>
<td>2005-2006</td>
<td>402</td>
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<tr>
<td>4</td>
<td>2006-2007</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>2004-2005</td>
<td>360</td>
</tr>
<tr>
<td>6</td>
<td>1997-1998</td>
<td>328</td>
</tr>
<tr>
<td>7</td>
<td>1996-1997</td>
<td>313</td>
</tr>
<tr>
<td>8</td>
<td>2002-2003</td>
<td>311</td>
</tr>
</tbody>
</table>

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).
\[i. \text{Weak Tornadoes}\]

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

<table>
<thead>
<tr>
<th>Rank</th>
<th>Season</th>
<th>Weak Tornadoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2007-2008</td>
<td>378</td>
</tr>
<tr>
<td>2</td>
<td>2006-2007</td>
<td>334</td>
</tr>
<tr>
<td>3</td>
<td>1998-1999</td>
<td>325</td>
</tr>
<tr>
<td>4</td>
<td>2005-2006</td>
<td>324</td>
</tr>
<tr>
<td>5</td>
<td>2004-2005</td>
<td>323</td>
</tr>
<tr>
<td>6</td>
<td>1997-1998</td>
<td>291</td>
</tr>
<tr>
<td>7</td>
<td>2002-2003</td>
<td>268</td>
</tr>
<tr>
<td>8</td>
<td>1995-1996</td>
<td>253</td>
</tr>
</tbody>
</table>

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.

\[ii. \text{Strong to Violent Tornadoes}\]

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.

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

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.

2. 1958-2008 Trends

\[a. \text{Outbreaks}\]

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.

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. The
more recent of the two time periods has
a more prominent upward trend,
however.

b. Fatalities

Looking at long-term trends in
fatalities, it is evident that there is
definite year to year variability and that a
season well above the average of 25
fatalities occurs at least once every
decade (Fig. 8).

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.
9, 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.

As seen in Fig. 10, when splitting
the timeline into the two periods, the first
25 years exhibit a slight downward trend
while the most recent 25 years have a
more prominent upward trend in the
number of fatalities per cool season.

c. 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. 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 show upward trends, but the
most recent 25-year period has a more
dramatic upward slope.

i. Weak Tornadoes

Very similar to Fig. 8, the long
term trend for weak tornadoes is on
a fairly steep incline (Fig. 13). 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. 14, 1958-1983 had a
slight upward trend in weak
tornadoes per season and 1983-
2008 had a more defined upward
slope.

ii. Strong to Violent Tornadoes

The trend in strong to violent
tornadoes appears to be the
opposite of the trend in weak
tornadoes (Fig. 15). 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.

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.
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. 16). 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.

**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 an 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.

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**References**

Cool Season Tornado Outbreaks

1958 - 1983 Outbreaks

1983 - 2008 Outbreaks

Cool Season Tornado Fatalities

November Tornado Fatalities

Figure 7

Figure 8

Figure 9
Figure 10

1958 - 1983 Fatalities

1983 - 2008 Fatalities

Figure 11

Cool Season Tornadoes

Figure 12

1958 - 1983 Tornadoes

1983 - 2008 Tornadoes