

## 5.4 PDS WATCHES: HOW DANGEROUS ARE THESE “PARTICULARLY DANGEROUS SITUATIONS?”

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### 1. INTRODUCTION

When the threat for damage caused by severe convection is unusually high, the Storm Prediction Center (SPC) enhances the wording of its convective watch product with the following statement:

THIS IS A PARTICULARLY DANGEROUS SITUATION

Such watches are known as “PDS” watches. PDS tornado (TOR) watches are issued when the forecaster has high confidence that multiple strong (F2-F3 on the Fujita Scale) or violent tornadoes (F4-F5 on the Fujita Scale) will occur in the watch area, while PDS severe thunderstorm (SEV) watches are issued when there is a threat of a high end “derecho” (e.g. Johns and Hirt 1987, Coniglio et al. 2004) with widespread wind damage.

In this study, we investigate verification measures for PDS watches for the period 1996-2005 designed to evaluate whether the PDS wording was appropriate in these forecast products. Hales (1998) discussed verification of PDS TOR watches for earlier time periods. Our main focus will also be on PDS TOR watches, since strong tornadoes pose a significant threat to life and property. We will also briefly discuss PDS SEV watches, which are rarely issued (only 22 during the period 1996-2005). All report data in this study is drawn from the National Climatic Data Center’s *Storm Data* publication.

### 2. DESTRUCTIVE POTENTIAL OF STRONG AND VIOLENT TORNADOES

Most tornado-related casualties and damage are produced by F2-F5 tornadoes. Figure 1 shows the fraction of tornado reports, fatalities, injuries, and property damage broken down by F-scale for the period 1996-2005. F2-F5 tornadoes represented less than 10% of all tornado reports for the period, but produced over 90% of the fatalities, over 80% of the injuries, and around 80% of the damage. It is clear that an outbreak of multiple strong or violent tornadoes is a major threat to life and property. This is the motivation for using enhanced wording in a PDS TOR watch when there is a particular threat of multiple strong or violent tornadoes occurring in the watch area, in order to highlight the unusually high threat level to the media, emergency managers, and general public.

### 3. PDS TORNADO WATCH COVERAGE

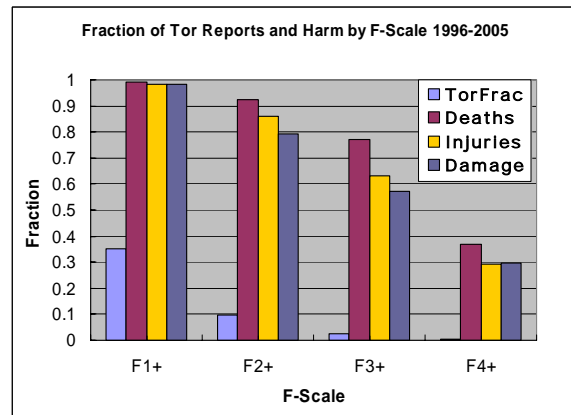


Figure 1: Fraction of tornado reports (light blue), deaths (red), injuries (gold), and damage (dark blue) by F-scale for the period 1996-2005.

PDS TOR watches are rare; of 3058 TOR watches issued during the period 1996-2005, only 7% (216) were PDS watches. The greatest concentration of PDS TOR watches was in the lower Mississippi Valley, with a secondary maximum over the traditional “Tornado Alley” area of the Plains states (Figure 2). No area averaged more than 2.5 PDS TOR watches per year for the period. The distribution of PDS TOR forecasts featured a maximum along an axis from Arkansas across northern Louisiana and Mississippi. This pattern is fairly similar to, but displaced slightly southward of, the pattern of observed F2-F5 tornadoes, which featured a maximum along an axis from Arkansas eastward into middle Tennessee and south-central Kentucky (Figure 3). Interestingly, the highest frequency of PDS TOR watches and F2-F5 tornadoes are east of the traditional “Tornado Alley” (Concannon et al. 2000).

### 4. PDS TORNADO WATCH EVALUATION

When compared with regular TOR watches, PDS TOR watches should ideally be associated with a greater risk of strong or violent tornadoes. We examined the last 10 years of reports and watches to see if this was the case. Three different verification measures were used: the areal coverage of tornadoes in watches, the probability of detection (POD) of tornado reports, and the fraction of watches which contained tornadoes, with all three measures stratified by F-scale and watch type. While verification measures will also be presented for SEV watches, the main focus will be on comparing PDS and non-PDS TOR watches, since, when deciding if a PDS TOR watch should be issued, the decision to issue a TOR watch instead of a SEV watch has already been made.

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### PDSTOR Watch Frequency (month: ALL) 1996-2005

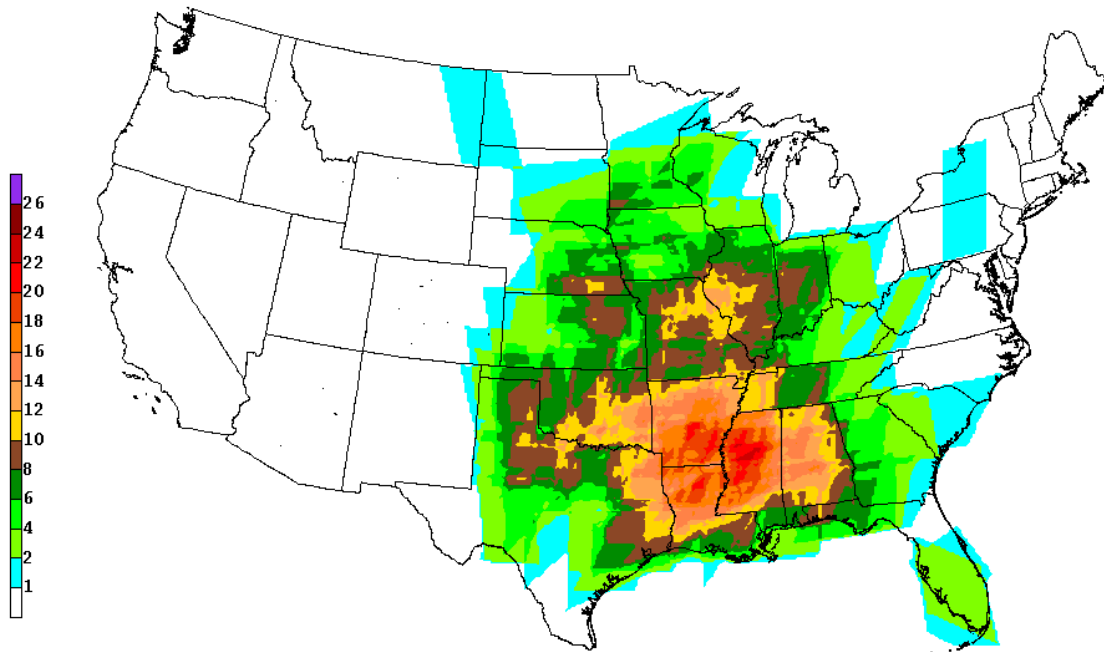


Figure 2: Coverage of PDSTOR watches for the period 1996-2005. Values represent the total number of watches at a given location for the entire 10 year period.

### Strong (F2+) Tornado Frequency (month: ALL) 1996-2005

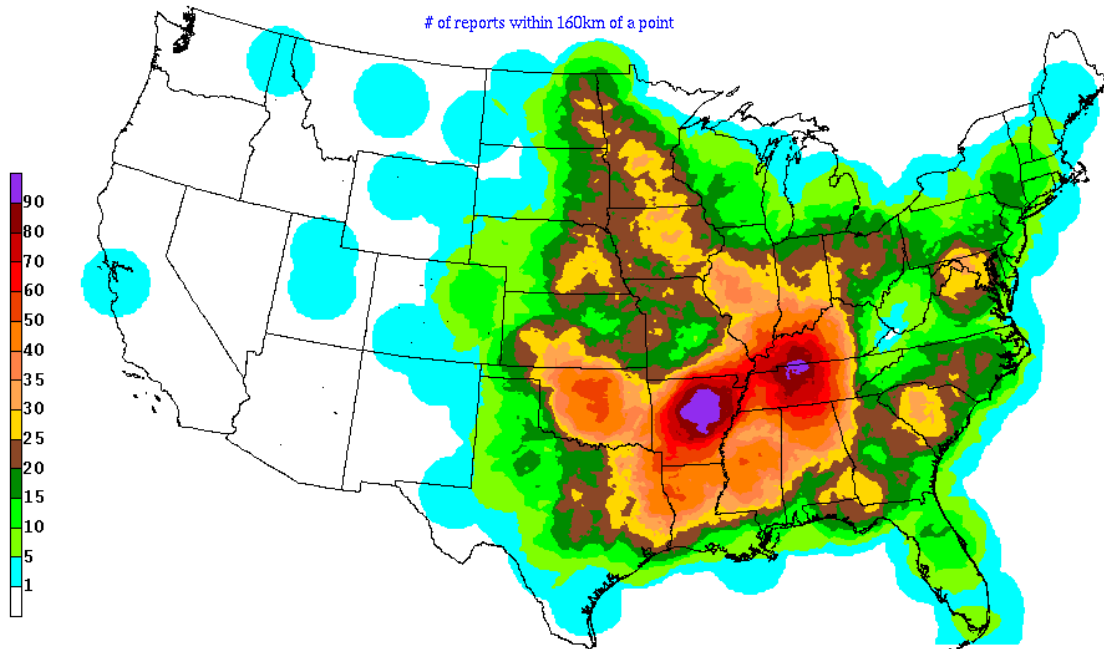


Figure 3: Coverage of strong tornadoes for the period 1996-2005. Values represent the total number of F2-F5 tornado reports that occurred within 100 miles (~160km) of a point on a 10 km grid.

TYPE	PDS?	#	RepCov	TorCov	F2+Cov	F4+Cov	WndCov	ExtWndCov
SEV	N	5805	0.343	0.020	0.002	0.0001	0.224	0.026
SEV	Y	22	0.605	0.032	0	0	0.548	0.091
SEV	ALL	5827	0.344	0.020	0.002	0.0001	0.226	0.026
TOR	N	2842	0.366	0.084	0.016	0.0012	0.216	0.030
TOR	Y	216	0.520	0.170	0.059	0.0056	0.312	0.054
TOR	ALL	3058	0.380	0.092	0.020	0.0016	0.225	0.032

Table 1: Coverage of all severe reports (RepCov), all tornado reports (TorCov), F2-F5 tornado reports (F2+Cov), F4-F5 tornado reports (F4+Cov), severe wind reports (WndCov), and extreme wind ( $\geq 65$  knots) reports (ExtWndCov). Coverage is calculated as the fraction of 10 km grid points inside of a watch that had a report pass within 40 km. PDS TOR values are shaded in red, while PDS SEV values are shaded in blue.

#### 4.1 Areal Coverage of Tornado Reports in Watches

Areal coverage was computed by placing the watches and reports onto a 10 km grid and then determining the fraction of grid points in a watch which had a report pass within 40 km (~ 25 statute miles). A neighborhood of radius of 40 km around each grid point was used so that the resulting values would not be extremely small; such a radius is also used in SPC's probabilistic outlook products. A 10 km grid is considered to provide sufficient resolution given the mesoscale character of watches.

The coverage of both F2-F5 and the subset F4-F5 (violent) tornadoes was much higher in PDS TOR watches compared with regular TOR watches, as shown in table 1. Areal coverage of F2-F5 tornadoes was over 3.5 times higher, and areal coverage of F4-F5 tornadoes, while quite small in all cases, was over 5 times higher. Table 1 also shows areal coverage values for SEV watches. Tornado coverage in TOR watches was much higher on average than in SEV watches, indicating that, given an environment capable of supporting severe convection, SPC forecasters are capable of distinguishing environments supportive of tornadoes from those that are not. Overall severe coverage increased from SEV to TOR to PDS TOR watches, indicating a greater severe threat on average when TOR or PDS TOR watches were issued.

Meanwhile, PDS SEV watches had the greatest severe coverage of any type of watch. Coverage of extreme wind reports (straight line wind gusts of 33 m/s [65 knots] or greater) was almost 1.7 times higher in PDS SEV watches than in the next highest category. Although only 22 PDS SVR watches were issued, these results suggest that the threat of extreme wind events is much higher when a PDS SEV watch is in effect.

#### 4.2 Probability of Detection

As F-scale increases, the probability of a tornado being in any watch, being in a TOR watch, and being in a PDS TOR watch all increase (Figure 4). TOR watches contained over 70% of F2-F5 tornadoes and nearly 90% of F4-F5 tornadoes during the period 1996-2005. Meanwhile, PDS TOR watches contained around 18% of F2-F5 tornadoes and 21% of F4-F5 tornadoes during the same period. Thus, while a strong or violent tornado is more likely to occur in a PDS TOR watch compared to a weak tornado, the majority of such tornadoes occur in

a regular TOR watch. This is not an unexpected result since only 7% of TOR watches during the period were PDS watches. This reflects the inherent uncertainty in identifying storm-scale physical processes and environments associated with strong or violent tornadoes.

#### 4.3 Report Occurrence in Watches

When compared to other types of watches, PDS TOR watches are much more likely to contain tornadoes (Figure 5). When only F2-F5 tornadoes are considered, the difference is quite marked. When compared with regular TOR watches, PDS TOR watches were nearly three times more likely to contain at least one F2-F5 tornado (44% compared to 15%) and over four times as likely to contain at least two F2-F5 tornadoes (27.3% compared to 6.7%). These results correspond well with the areal coverage results presented earlier and strongly suggest that when a PDS TOR watch is issued, the threat to life and property will be substantially greater than if a regular TOR watch is issued. Given the rare nature of strong and violent tornadoes, these results suggest that SPC forecasters can often recognize situations when there is an enhanced threat of strong or violent tornadoes.

## 5. CONCLUSION

These results indicate that a forecast of a "Particularly Dangerous Situation" tornado watch did indeed represent an increased risk to life and property from strong and violent tornadoes for the period 1996-2005. There is an opportunity to further refine these forecasts, since less than half of PDS TOR watches contained at least one F2-F5 tornado, but improvements will be dependant on improved specification of storm-scale environments and processes.

Since all tornadoes are potentially dangerous and most F2-F5 tornado events still occur in regular TOR watches, the lack of PDS wording in a watch should not be interpreted as downplaying the threat to life and property. However, when the PDS wording is included the threat is to be considered as substantially higher.

Even though watches are classified as SEV, PDS SEV, TOR, and PDS TOR, it must be stressed that there is a continuum of risk associated with watches. The tornado risk in a SEV watch is not zero, while the threat for non-tornadic severe events in TOR watches is

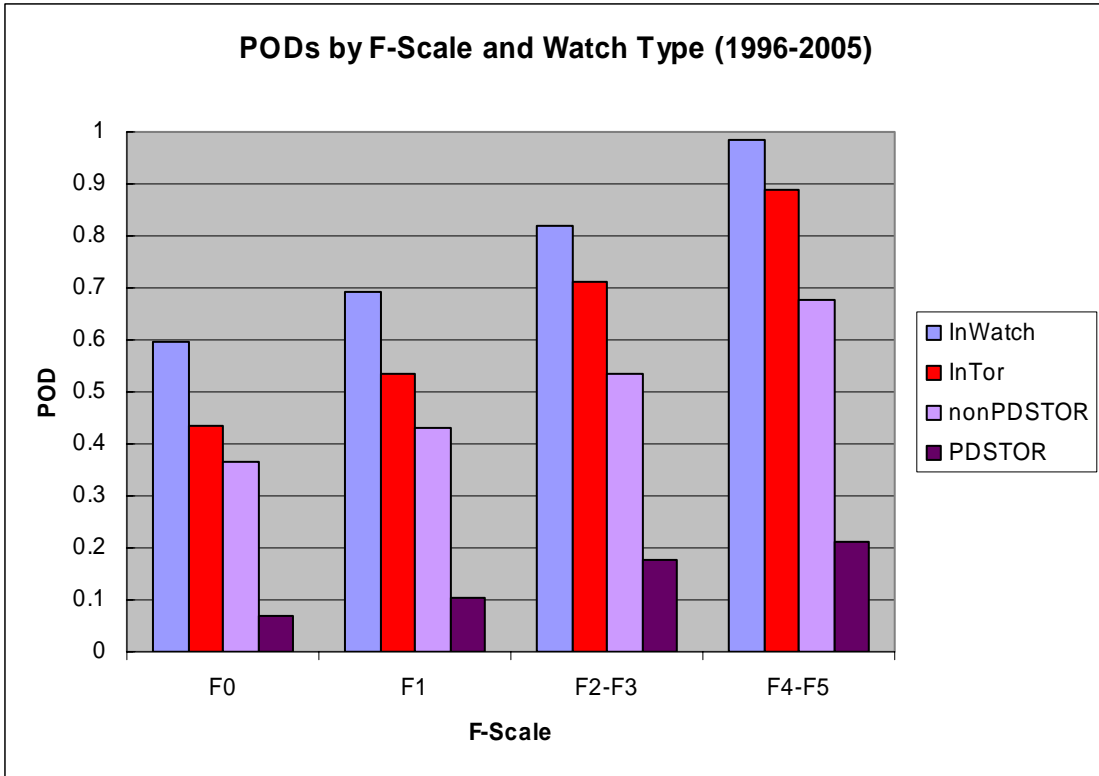


Figure 4: POD by F-scale and watch type for the period 1996-2005.

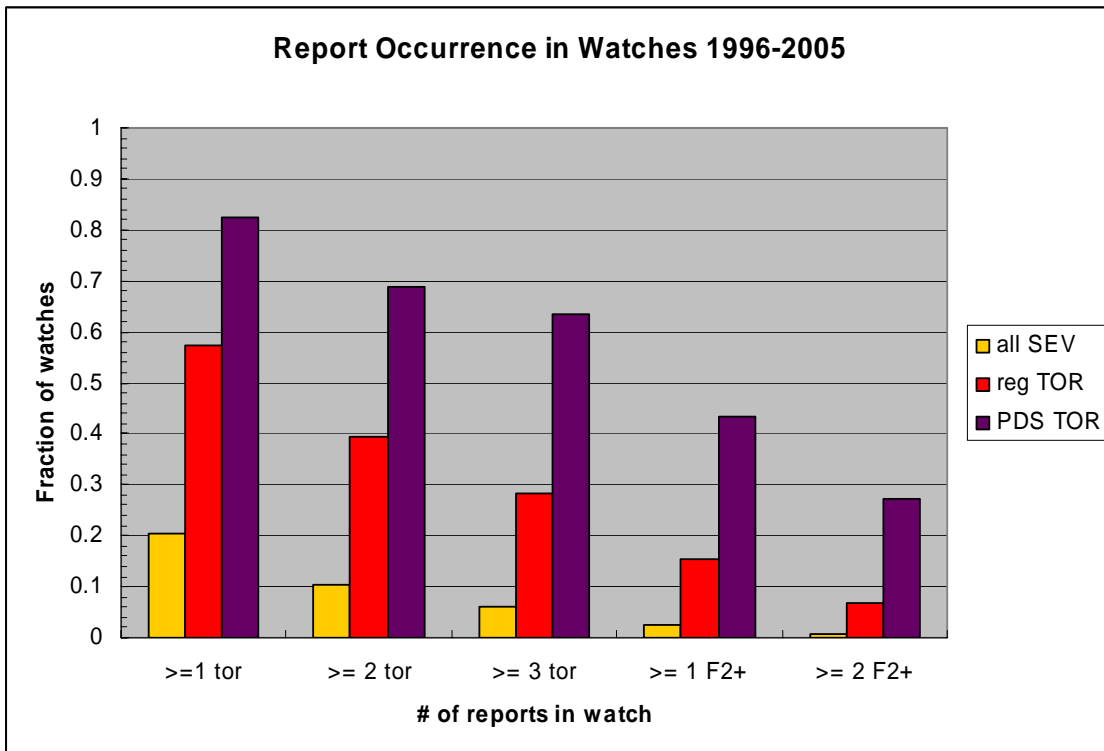


Figure 5: Fraction of watches with a given number of reports, broken down by watch type, for the period 1996-2005.

often quite high. This calls into question the practice of only deploying storm spotters when a tornado watch is in effect, since watch type alone does not fully describe the threat associated with a given watch. The recent addition of hazard probabilities (such as the probability of two or more tornadoes in the watch or of at least one F2-F5 tornado in the watch) to the SPC watch product is a more specific way to indicate the forecaster's assessment of risk in each individual case. The SPC watch probability table (WWP) complements the SEV/TOR and PDS classifications in more thoroughly communicating the threat associated with a given watch to the user community.

*Acknowledgements:* We would like to thank Steve Weiss for his thoughtful review of this paper. Numerous discussions with SPC staff helped to clarify the ideas presented. Andrew R. Dean was funded under NOAA-University of Oklahoma Cooperative Agreement #NA17RJ1227, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of NOAA or the Department of Commerce.

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