
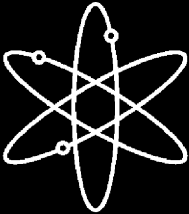




Tornado Climatology of the Contiguous United States

United States Nuclear Regulatory Commission Official Hearing Exhibit	
In the Matter of:	CROW BUTTE RESOURCES, INC. (License Renewal for the In Situ Leach Facility, Crawford, Nebraska)
	ASLBP #: 08-867-02-OLA-BD01 Docket #: 04008943 Exhibit #: BRD-016-00-BD01 Admitted: 9/4/2015 Rejected: Other:
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Pacific Northwest National Laboratory



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inconsistent with distance between the beginning and end points of the segment, the latitude and longitude of the beginning point, and the length were assumed to be correct. Overall, the database is in reasonably good condition and acceptable for use in this climatology.

2.1 Tornado Intensities

Most of the statistics in the database related to tornadoes are self-explanatory. The exception is the tornado intensity. The tornado database does not include estimates of the maximum wind speeds in tornadoes. However, it does include an estimate of tornado intensity in the form of an intensity scale that is based on the damage caused by the tornado. The most common tornado intensity scale developed by Fujita (1971, 1978) classifies tornado intensity in six F Scale classes, F0 to F5. Wind speeds are rarely measured by meteorological instruments. Instead, they are estimated from damage associated with the tornado. The range of wind speeds assigned to classes by Fujita is listed in Table 2-1. This range been extended from F5 through F12, which has the speed of sound as its upper limit (NCDC 2004). However, no tornado has been assigned an intensity of F6 or greater, and, because of the imprecision in estimating F-scale and wind speeds in tornadoes, there is some question whether an F6 or greater tornado would be identified if it did occur. According to NCDC (2004), the strongest tornadoes are in the F5 range.

Table 2-1. Fujita Tornado F Scale Intensity Wind Speed Relationships

Intensity	Description	Original Fujita Scale (Fastest quarter mile, mph)	Fujita Scale (3-s gust, mph)	Operational Enhanced Fujita Scale (3-s gust, mph)
F0	Light damage	40 to 72	45 to 78	65 to 85
F1	Moderate damage	73 to 112	79 to 117	86 to 110
F2	Considerable damage	113 to 157	118 to 161	111 to 135
F3	Severe damage	158 to 206	162 to 209	136 to 165
F4	Devastating damage	207 to 260	210 to 261	166 to 200
F5	Incredible damage	261 to 318	262 to 317	>200

It should be noted that the maximum wind speed associated with a tornado occurs for only a small fraction of the footprint and at any location for only a short period of time. Depending on the translational velocity of the tornado, a location might experience wind speeds near the maximum for 5 to 10 seconds.

The problems of tornado intensity from damage are well known. It is a subjective process. For example, damage estimates are limited by the nature of the area where the tornado strikes. If there is nothing to damage, there is no way to assign an F Scale. Similarly, where there are structures, the damage will depend on the nature of the construction.

In 2001, Texas Tech University Wind Science and Engineering Research Center organized a forum of scientists and engineers to consider alternatives to the Fujita Scale (TTU 2006). The Enhanced Fujita

In addition, treating $(u + v/2)$ as a random variable, w , the variance of w , $V[w]$ is approximately

$$V[w] \approx v / n + \frac{v^2}{2(n-1)} \quad (2-8)$$

where n is the number of tornado events used to estimate u and v . For sufficiently large n , perhaps as small as 20, the 90 percent confidence interval for the expected value is approximately

$$\exp\{w - 1.645(V[w])^{1/2}\} < E[w] < \exp\{w + 1.645(V[w])^{1/2}\} \quad (2-9)$$

Equations (2-2) through (2-9) provide the bases for estimation of strike probabilities and the 5th and 95th percentile limits on the 90 percent confidence interval for the expected values.

Table 2-2 lists the characteristics of tornado segments in the contiguous United States, derived from the NCDC tornado data. The table shows that the 90 percent confidence interval in the expected values increases as the intensity increases. This increase is associated with the decrease in the number of segments as the intensity increases. Tables 2-3 through 2-5 list the distributions of tornado dimensions for all tornadoes and for tornadoes by reported tornado intensity.

The geographical distribution of tornado events in the United States between the beginning of 1950 and the end of August 2003 is shown in Figure 2-1. A tornado event is defined as a tornado occurrence within a defined area. A tornado segment in the NCDC database may be counted as an event in more than one area. However, for the boxes shown in Figure 2-1, fewer than 5 percent of the tornadoes contribute to events in more than one box. For larger boxes, this percentage decreases. For the 2° and 4° boxes that form the basis for the analysis in Chapter 5, the percentages of segments contributing to events in more than one box decrease to about 2.3 percent and 1.1 percent, respectively.

Each number in Figure 2-1 represents the number of tornado events occurring in a box that covers 1° of latitude by 1° of longitude. The latitude and longitude labels shown in the figure represent the latitude and longitude of the southeast corners of the boxes. The area covered by each box is a function of latitude. Along the southern border of the country, the area is approximately 4,000 mi^2 ; in the middle of the country, it is about 3,600 mi^2 ; and along the northern border, it is about 3,200 mi^2 . Figures 2-2 and 2-3 show the geographical distributions of more intense tornadoes, with Figure 2-3 showing only the most intense tornadoes, i.e., those having F Scales of F4 and F5.

