

The Climatology of Indiana Tornadoes

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Abstract

Various tornado statistics for Indiana have been determined based upon climatological records from 1916 through 1968. Yearly, monthly, and diurnal variations of tornado frequencies, injuries, and deaths are examined on a state-wide and county basis. An attempt has been made to remove the problem of the population bias in tornado reporting. Also, the effect of terrain on the areal distribution of tornadoes is noted. Further study into the matter of orographic effects is suggested.

Introduction

A national summary of tornado statistics by Flora (1) has provided the scientific community with considerable information on tornado frequencies and occurrence patterns. It is recognized, however, that the scope of study in a national summary does not provide the detailed information that is often desired on a state-wide basis. Precedence for the value of state summaries of tornado statistics and related climatological inferences is evident in the work by Darkow (unpublished data) on Missouri tornadoes. In fact, the study by Darkow provided considerable incentive to do a similar study for Indiana, especially since it is well above the national average as a tornado-producing state. Indiana has been involved in some of the most dramatic tornado outbreaks of this century. Most notable are the tri-state tornadoes of 1925 and the Palm Sunday tornadoes of 1965.

The primary objectives of this investigation were to determine yearly, monthly, and diurnal variations of tornado frequencies, injuries, and deaths for Indiana. In addition to obtaining an areal distribution of tornadoes, a limited effort was made to examine the effects of population and topography. Tornado data for the United States (2) do show a tendency for decreasing tornado frequencies toward the southeast corner of Indiana, which could be attributed to population and/or terrain effects. It was one of the intentions of this study to substantiate or dismiss this observation by examining the data in greater detail on a state-wide basis. Finally, it was hoped that this work would also provide a suitable format and method for examining the climatology of tornadoes for other states. A generalized computer program has been compiled and is available to other investigators.

Methods

The period of this study dates from 1916, the beginning of official tornado records, through 1968. Data assembled from United States Weather Bureau records (3, 4, 5, 6, 7) were checked against the records maintained by Indiana's State Climatologist, Mr. Lawrence A. Schaal.

Data extraction required that certain decisions be made in making the tornado tallies. Funnel clouds aloft were not counted but waterspouts over Lake Michigan were. Also, tornadic winds were counted when accompanied by path damage with tornado characteristics. In

nearly all cases, however, the storm was logged in the records as a tornado.

The format of the data reduction was prescribed by the computer program developed simultaneously to handle the data analysis. Information recorded included the date, time of day, and place of origin of tornado by county (in some cases out of state). Also, counties affected, width and length of damage path, direction of movement, injuries and deaths, and estimated property damage were recorded. All available information was placed on one computer card per tornado. Problems in handling the data included such matters as broken storm paths, changing directions, large time intervals, varying damage paths, and different translational speeds.

Other data collected for the study include rural population figures per Indiana county (9) for 1920, 1940, and 1960. These three sets of values were averaged to yield a mean rural population per county and for the state during the period of the study. Also obtained were the number of square miles in each county and the state.

Results and Discussion

During the period from 1916 through 1968 a total of 551 different tornadoes were observed and recorded in climatological data. Of this total, 20 came from Illinois, 2 from Kentucky, and 529 originated in Indiana. Some of those tornadoes only touched down briefly in a single county while others had continuous paths on the ground through several counties and into the adjacent states of Michigan and Ohio.

Figure 1 shows the number of tornadoes affecting each Indiana county from 1916 through 1968. Twenty-four tornadoes were observed in Porter County, more than any other. Close behind are Elkhart with 22, Lake with 20, and Marion and St. Joseph with 19 each. These counties are highly populated and certainly reflect the effect of population density on tornado reporting. No tornadoes have been officially recorded for Ohio and Crawford counties. Also shown are the number of tornadoes originating in each county. A maximum of 20 tornadoes originated in Lake County. On the other hand none have originated in Crawford, Dearborn, Ohio and Union counties. Of course counties are political boundaries and do not represent equal geometrical areas. But, a county-by-county analysis has been made for the sake of convenience. Figure 1 also gives the number of tornado days per county. Porter County has the highest value with 21.

In Figure 2 the effects of population and unequal county areas have been considered. To reduce the number of tornadoes affecting each county to a more meaningful statistic a tornado index has been formed. This dimensionless quantity is defined as,

$$\text{Tornado Index} = \left\{ \frac{\text{Tornadoes/Unit Area}}{\text{Rural Population}} \right\}_{\text{county}} \cdot \left\{ \frac{\text{Rural Population}}{\text{Tornadoes/Unit Area}} \right\}_{\text{state}} \quad (1)$$

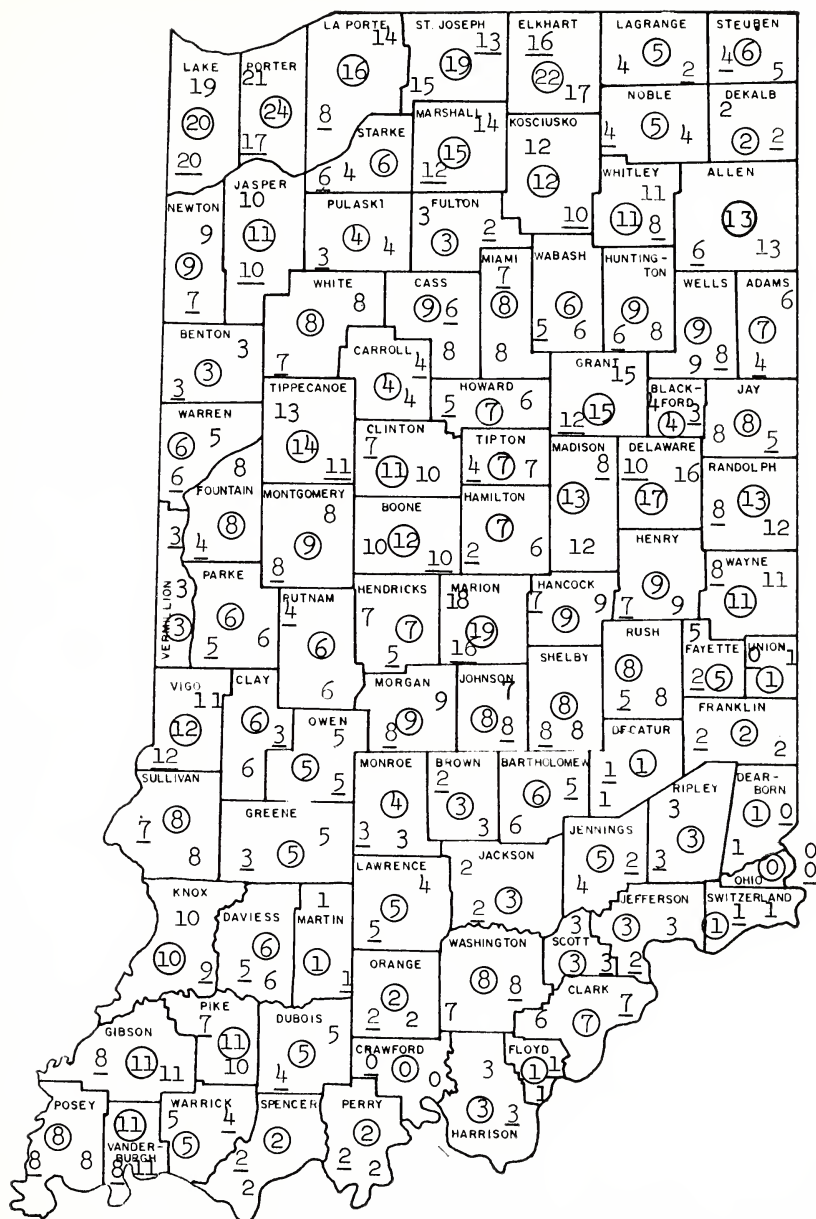


FIGURE 1. Tornadoes affecting Indiana counties (circled), tornadoes originating in county (underlined), and the number of tornado days per county from 1916 through 1968.

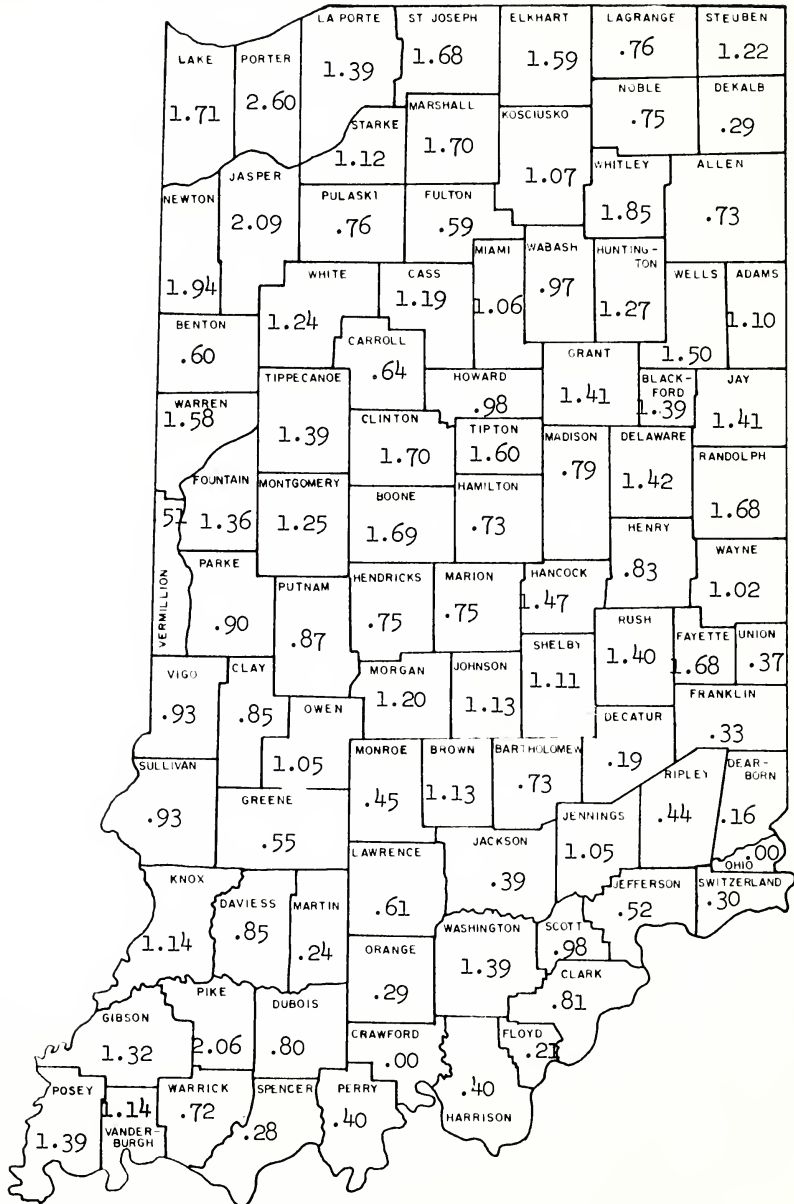


FIGURE 2. Tornado indices per Indiana county for 1916 through 1968.

The tornado index for each county is therefore based on a common denominator of 1.00, the state average. Counties with indices greater than 1.00 are above the state average and those less than 1.00 are below the state average. The use of rural population was observed to more aptly handle the problem of population bias than total population. Further, it seems logical that a given area should only be inhabited to a certain extent, beyond which additional population would not improve the chances of tornado detection. Rural population figures were also used by Darkow in his Missouri study, supporting the approach in this investigation. The largest tornado index, 2.60, was computed for Porter County. Other high values include Jasper with 2.09 and Pike with 2.06. The northwest quadrant and the southwest corner of the state are well above the state average. As was expected the southeast portion of the state is considerably below the state average. It was not the objective of this study to examine in detail the effect of topography on tornado distribution but these data are indicative of terrain effects and do suggest further study into the problem. It should be mentioned, however, that the method used to handle the population bias in tornado reporting may not be the most accurate and the tornado indices could be slightly misrepresentative.

Figure 3 shows the yearly distribution of tornadoes and tornadoes causing injury or death. Most notable is the increase in tornado occurrences since 1954. This can be partially attributed to the development of the severe local storm (SELS) forecasting and warning program by the U. S. Weather Bureau. This program also improved and updated the efforts in the tornado recording network which should account for much of this increase. Figure 3 is also indicative of more tornadoes causing injury and death in recent years. The most tornadoes for any single year was the 52 recorded in 1965. Nineteen of these caused injury or death. However, the Palm Sunday tornado outbreak in 1965 did make this an exceptionally high tornado year for Indiana. Also shown is the yearly distribution of tornado days and tornado death days for Indiana. Again, the initiation of the program by the U. S. Weather Bureau is reflected in the data.

Figure 4 shows the monthly distribution of tornadoes. More tornadoes occurred in April than any other month and 78% of all tornadoes occurred during the period March through July. The maximum number of tornado days occurred in June but tornado days in early spring produced more tornadoes. For instance, 45 tornado days produced 63 tornadoes in July, but 30 tornado days produced 71 tornadoes in March. Another interesting feature is that a larger portion of the tornadoes occurring in late winter and early spring caused injury and/or death. Notice that March had 71 tornadoes, 30 of which caused injury and/or death. But, April had 124 tornadoes and only 29 caused injury and/or death. This seems to indicate that the tornado season must be in progress for awhile before people begin to take it seriously. The data also suggest a small second maximum of tornado occurrences in early fall. This is associated with increased frontal activity which is not as violent as that associated with the storms that develop in the spring.

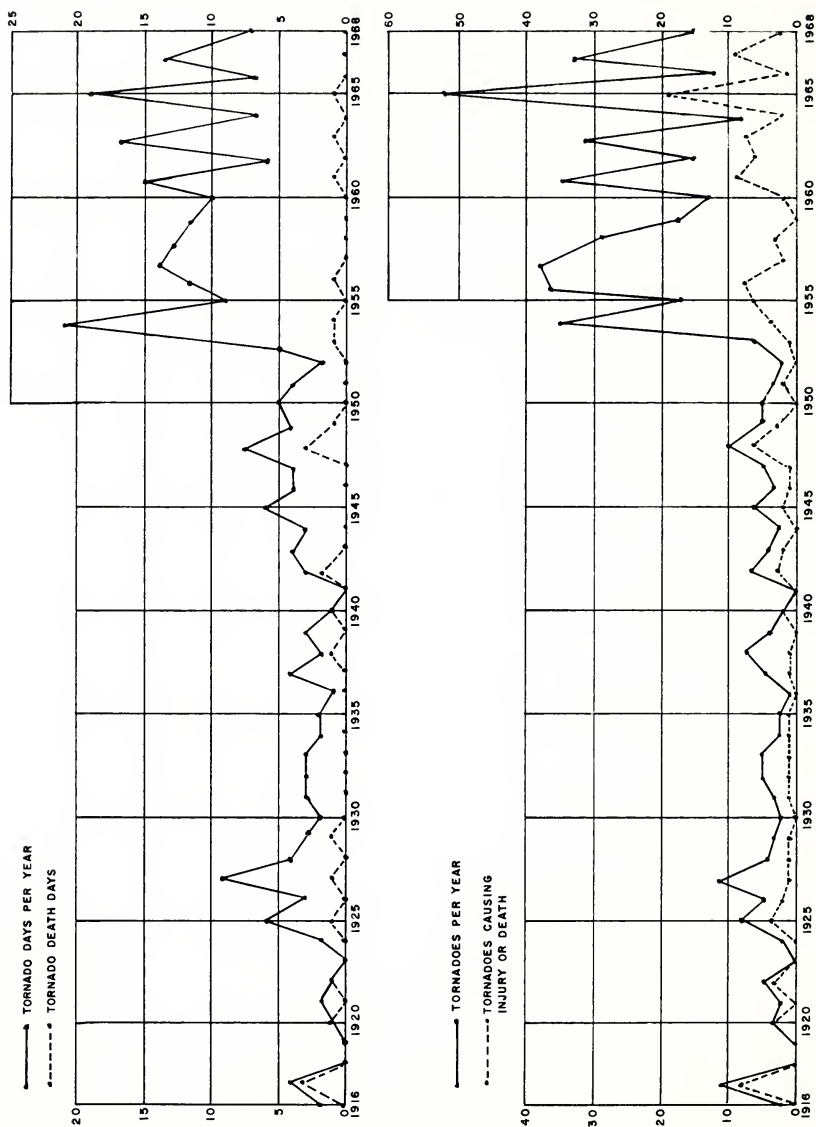


FIGURE 3. *Yearly distribution of tornadoes, tornadoes causing injury or death, tornado days, and tornado death days for Indiana (1916-1968)*

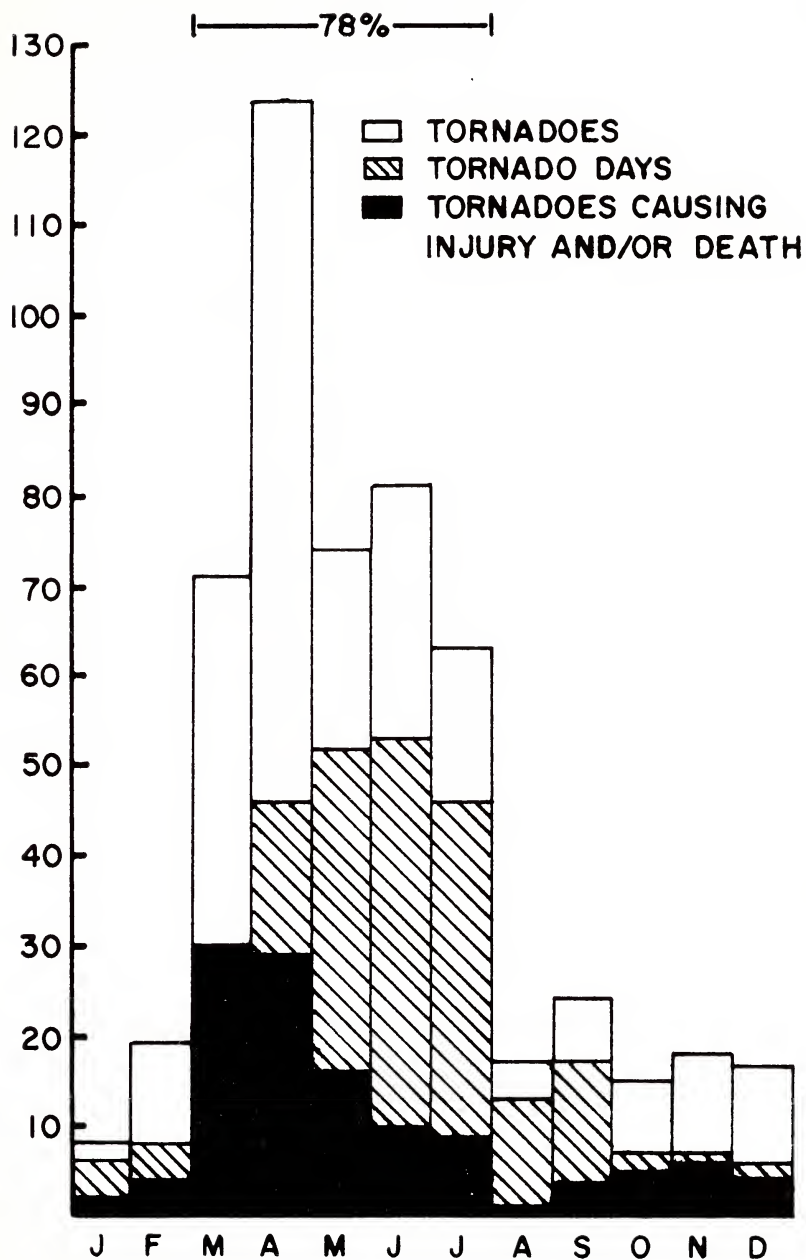
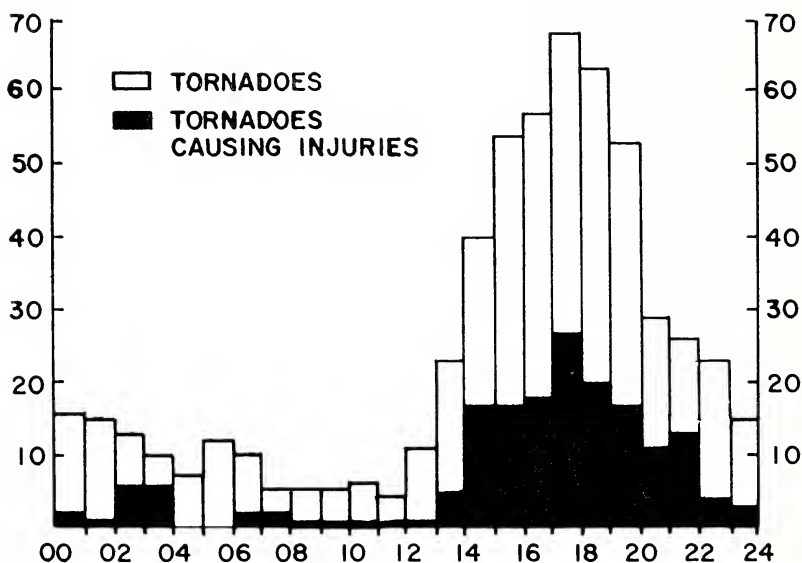


FIGURE 4. Indiana tornado occurrences by month from 1916 through 1968.

TABLE 1. *Indiana tornado deaths and tornado death days by month from 1916 through 1968.*

	J	F	M	A	M	J	J	A	S	O	N	D
Tornado Death Days	1	0	10	4	3	2	1	0	0	1	0	0
Tornado Deaths	1	0	207	157	27	5	3	0	0	2	0	0

Table 1 gives the number of Indiana tornado deaths and tornado death days by month for the period. More deaths have occurred in March which interestingly enough is not the month of maximum tornado activity.

FIGURE 5. *Diurnal variation of Indiana tornado activity from 1916 through 1968.*

The diurnal variation of tornado activity is given in Figure 5. Tornadoes can occur any hour of the day just as they could any day of the year, but late afternoon is the preferred time. More tornadoes occurred between 5:00 and 6:00 PM than any other hour of the day. A second maximum appears between midnight and 1:00 AM which is probably attributed to the midwest's nocturnal thunderstorm activity. Also, tornadoes causing injuries appear to be less in proportion to the number of tornadoes for nighttime compared to daytime. If such is true this could be related to the fact that more people are at rest or asleep in their homes and are therefore not quite as vulnerable to injury.

TABLE 2. *Diurnal variations of Indiana tornado deaths from 1916 through 1968.*

00-01	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12
0	0	3	2	0	0	1	0	0	0	0	0
12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24
0	2	24	66	118	174	40	73	30	5	0	0

Table 2 shows the diurnal variation of tornado deaths. The maximum is associated with peak tornado activity. Again it is evident that nighttime deaths are much less than for daytime in proportion to the number of tornadoes occurring. Since death producing tornadoes did occur at the beginning and end of adjacent hourly periods, the tabular data indicate more deaths than actually happened (Table 1).

The direction of movement in percentages for Indiana tornadoes has also been determined. Over 81% of the tornadoes traveled in an east through northeast direction with 47% moving toward the northeast. Tornadoes have been observed to move in all directions but from southwest to northeast is the general tendency.

Summary

Yearly, monthly, and diurnal variations of tornado frequencies, injuries, and deaths for Indiana have been presented based upon data assembled for the period 1916 through 1968. The data are summarized in Figures 1-5 and Tables 1 and 2. An attempt has been made to remove the problem of population bias in tornado reporting. Also, the effect of topography on the areal distribution of Indiana tornadoes has been touched upon and further study is intended along these lines. A generalized computer program has been developed, and is available, to do similar climatological analyses for other states.

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