

Indiana Data on Lightning, Hail, Squall-Wind, and Tornado Frequencies and Damage

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Lightning

Data on the frequency of lightning storms in Indiana are gathered incidentally by the regular, full-time weather bureau stations, which report on the frequency of nearby thunderstorms. Thunderstorms occur on about 50 days each year in central Indiana, on about 45 days in northeastern part of the state, and on about 55 in the southwestern corner. During the summer each locality has an average of about two thunderstorms each week. Lightning from distant storms, too far away to have local significance, may be visible on one or two additional nights a week in summer. Most thunderstorms cover only about one-third of the state and many of them cover less area than that. Moreover, sometimes two or even three thunderstorms affect a locality during a single 24-hour period. Hence, it is probable that about 200 individual thunderstorms occur in Indiana each year.

As it takes the average thunderstorm about four or five hours to cross the state and there are an average of hundreds of lightning flashes per hour, it is quite possible that millions of bolts of lightning are discharged in Indiana each year. Of these a few thousand strike trees, buildings, fences, or the ground. Most of the taller trees, especially the more isolated ones, have been struck at one time or another. Telephone, telegraph, and power lines are frequently damaged. Lightning is a major cause of fire to farm buildings. The U. S. Weather Bureau investigated the average annual fire losses to farm buildings caused by lightning as recorded in an eight-year period, 1915-1922. A recent official map shows that in Indiana nearly a half-million dollar loss a year is caused thus. The average annual totals for certain states are as follows: Indiana \$491,000, Ohio \$685,000, Illinois \$1,094,000, Michigan \$289,000, Kentucky \$266,000, Pennsylvania \$656,000, Missouri \$478,000, Iowa \$611,000, Minnesota \$305,000, Oklahoma \$784,000, and New York \$838,000.

In Indiana lightning causes most fires in summer, chiefly because lightning is much more frequent then. The higher air temperatures of summer and the fact that the combustibles are often dryer than in the cooler months also is more conducive to the rapid spread of summer fires.

Thousands of livestock are killed annually by lightning in Indiana. From the reports of those coöperative observers who have taken especial pains to gather data on these losses in Indiana (for example, Fred Baker of Rockville, Parke County), it seems probable

that on the average more than 4000 hogs are killed annually in Indiana and more than 1000 cattle.

Several hundred people annually are killed by lightning in the United States, seven a year in Indiana, on the average (according to mortality data in the Statistical Bulletin of the Metropolitan Life Insurance Company, June, 1936).

The mortality in four southeastern states (Georgia, Florida, Alabama, and Mississippi) and in three Rocky Mountain states (Colorado, New Mexico, and Arizona) is nearly four times as great as in Indiana in proportion to population. In several other states, however, the death rate is considerably less than in Indiana. This is particularly true for the states with many people living in cities, where very few people are killed in proportion to population, and in the states on the Pacific Coast and New England. In the Pacific States there are few thunderstorms in the lowlands as there is little summer rainfall. In New England thunderstorms are relatively uncommon, and likewise, the population is largely urban.

By the conventional census divisions, the death rates per million population are: Rocky Mountain states 8.3, East South-Central states 7.1, South Atlantic states 6.0, West South-Central 5.6, West North-Central states 3.4, East North-Central states, which includes Indiana 2.1, Middle Atlantic states and New England 1.3, Pacific states 0.2. In deaths per ten thousand square miles, however, the rates are different, and Indiana is in the second class, less unfortunate than Kentucky, Ohio, and West Virginia but worse off than most of the nation.

Although the chances of being killed by lightning are very small in Indiana, almost negligible in the cities, some readers may be interested to learn of ways of reducing the chances.¹

Hail

Violent thunderstorms are frequently accompanied by hail; occasionally hail falls in sufficient quantities to cause considerable damage.

Indiana had, during a 15-year period recently studied by the U. S. Weather Bureau (1916-1930), an average of 4.8 damaging hailstorms each warmer season (April 1 to September 30). Indiana had fewer hailstorms recorded officially as "damaging" than any nearby state, except Illinois and Missouri, which had about as many in proportion

¹ In this connection the following are also helpful:

U. S. Dept. Agr., Farm. Bull. 1512, 1926.

U. S. Bur. Stand., Handbk. 17, 1936.

The following extract may be justified here:

"(a) Do not go out of doors or remain out during thunderstorms unless necessary. Stay inside of a building where it is dry, preferably away from fireplaces, stoves, and metal objects.

"(b) If there is any choice of shelter, choose in the following order: 1. Large metal or metal-frame buildings. 2. Dwellings or other buildings protected against lightning. 3. Large unprotected buildings. 4. Small unprotected buildings.

(c) If remaining out of doors is unavoidable, keep away from: 1. Small sheds and shelters if in exposed location. 2. Isolated trees. 3. Wire fences. 4. Hilltops and wide open spaces.

(d) Seek shelter in a cave, a depression in the ground, a deep valley, the foot of a steep cliff, in dense woods or a grove.

to area. In contrast with Indiana's 4.8 damaging hailstorms a year are the following annual average totals: Ohio 8.3, Illinois 6.9, Kentucky 6.2, Michigan 12.6, Wisconsin 8.9, Missouri 5.2, Iowa 21.6, Montana 21.6, and Kansas 33.4.

Data on the extent of damage from hail in Indiana are not yet available. This is partly because hail seldom causes extensive damage in this state. In certain states where more damage is done, more data have been accumulated. For example, in Iowa, which has more than four times as many damaging hailstorms as Indiana (twice as many in proportion to area), the property loss averages more than ten million dollars a year. In a single county, representative of the northwestern part of the state (which has more hail damage than the state average), hail caused an average property loss of \$227,000 a year for a 15-year period. If Indiana's hail damage is proportionate to that of certain comparable areas in other nearby states, the property damage is in excess of \$1,000,000 per year on the average.

Occasionally hailstones reach the size of baseballs or even larger. Large hailstones occasionally kill even people in some parts of the world. Indeed, some scores of hail-induced-fatalities occur annually, on the average, in southeastern Europe and southwestern Asia. None in Indiana, however, are known to the present writer.

Rarely the hail is so small as to closely resemble snow. A remarkable summer snow storm in Indiana is worthy of mention here.

"The most remarkable warm season snowfall in Indiana occurred on July 2, 1924, in Wabash county. There, with the temperature at the nearest Weather Bureau Station nearly 70 degrees, during a hail storm, snow fell to a depth of eight inches on a small area."

An account of this remarkable fall was published in the Bulletin of the American Meteorological Society for August, 1924, and the report was investigated by J. H. Armington, state director of the United States Weather Bureau, Indianapolis, who was convinced of the correctness of the report. This remarkable snowfall was associated with a violent hailstorm which had a distinct tornado-like funnel. Hail covered the ground for some distance around the patch of snow.

Squall-Winds

Violent windstorms, nearly all of the thunderstorm-squall type, cause extensive loss in Indiana. Indeed, for the 20 years of a recent special study by the U. S. Weather Bureau (1916-1935) Indiana suffered a total estimated property loss of \$7,656,000 from violent winds not tornadoes. This was one-fiftieth the total loss for the nation as a whole for such storms. As there are 48 states, it might seem that Indiana has had only slightly less than its proportionate share of such loss, but Indiana is a small state. In proportion to area, Indiana (with 7.66 million loss) had more property damage from violent windstorms not tornadoes than did Ohio (5.15), Michigan (9.3), Missouri (3.3), Minnesota (5.9), Kentucky (6.3), Iowa (7.3), Illinois (9.7), or Wisconsin (10.7).

Thunder-squall damage occurs occasionally in all parts of the state. Among the seasons it is decidedly most frequent in summer. Indiana's

losses in five-year periods were as follows: 1916-1920, \$1,005,000; 1921-1925, \$2,408,000; 1926-1930, \$3,913,000; 1931-1935, \$330,000. The average annual loss is about \$383,000, but the variation from year to year is great. Indiana's greater than average recorded loss for squall winds may be due partly to the fact that the State Director of the Weather Bureau, J. H. Armington, has made especial efforts to gather information of this type. Much of Indiana has, however, more than the average number of farm buildings per square mile, more telephone and similar poles than most states, and because of the earlier settlement than true for most of these states, more old buildings.

Tornadoes

A study of tornado frequency in the United States made by the U. S. Weather Bureau disclosed that for the 20 years, 1916-1935 inclusive, Indiana had 66 tornadoes or an average of 3.3 per year. This number was larger than for Michigan (3.0 a year) or Kentucky (1.2), but smaller than for Illinois (4.0), Wisconsin (4.3), Missouri (6.6), or Tennessee (3.6). Indiana has only about one-fourth as many tornadoes as Iowa or Kansas (15 or 14.6 per year respectively). These latter states are much larger than Indiana, however. In proportion to area, Indiana has about one-half to one-third as many tornadoes as the states wherein they are most frequent, Iowa to Arkansas, inclusive.

In the approximately 2,800 tornadoes recorded in the United States during the twenty years, 1916-1935, 5,224 people were killed by tornadoes; and property losses in excess of \$230,000,000 were sustained. Losses in excess of \$100,000 were sustained in 375 tornadoes although million dollar losses were caused by each of 30 tornadoes.

Partly because tornadoes have played only a minor role in Indiana, no detailed account of Indiana's tornadoes has yet been prepared. With few exceptions, tornadoes damage only a minute fraction of the area of the state. So few occur and the damaged strip is so narrow that the chances of any one spot being hit by a tornado are very small. It has been calculated, for example, that even in the part of our country where tornadoes are most frequent (southern Iowa, Missouri, Arkansas, and eastern Kansas) the chances that any given half-mile square of land (160 acres) will be crossed by a tornado in a century is only 1 to 1600. As most tornadoes devastate a strip only a few hundred feet wide, a farm might be crossed several times without the buildings being demolished. Many buildings are damaged without the inhabitants being killed.

In Indiana tornadoes are least rare in the lower Wabash Valley of the southwestern part of the state. They are next least rare in central Indiana. They are very rare at the surface near Lake Michigan and in the more rugged parts of the state. Bloomington, for example, has not been appreciably damaged by a tornado during its history, which extends about 120 years. Presumably this is largely because a wide belt just west of the city is quite rugged. Tornadoes which cross rugged areas tend to rise above the surface where they do little or no harm.

Indianapolis, in the midst of a plain, has been affected by several

tornadoes, three in one decade. But fortunately no very severe one has plowed through the city. A moderately severe one, that of May 18, 1927, demolished many buildings in the western part of the city, then rose above the surface passing over the downtown part of the city. It caused a property damage estimated at more than \$2,000,000 but only two deaths.

The question of whether or not it may be possible to cause tornadoes to rise above the surface and thus be rendered almost harmless is of interest.

Tornadoes are violent whirls, started by opposing winds and associated with sharp contrasts in temperatures. They occur only when sharp vertical temperature gradients are present. They are formed in the clouds and extend down to the ground only where the temperature of the surface air is relatively warm (as compared with the higher air). Tornadoes rise above the surface again wherever the surface air is relatively cool. Evidence on these points is extensive. For example, tornadoes are most numerous, as to time of day, when the surface air is relatively warm in the early evening. Occasionally, to be sure, a tornado which started in the afternoon continues on its course until midnight but only if the surface air is relatively hot. Records show that the few nocturnal tornadoes occurred on nights when because of cloudiness and high relative humidity nocturnal cooling had been slight. Tornadoes after nightfall occur on "hot sultry nights," never the reverse.

In their seasonal distribution, also, tornadoes are most numerous at seasons when the vertical temperature gradient is greatest. For the mid-west this is during the spring. In the south the temperature gradient is greatest and tornadoes most numerous, earlier than here, in the early spring. Conversely, in the northern states and southern Canadian provinces temperature gradients are greatest in the summer, and hence tornadoes are most frequent then. In certain other parts of the country along the southern Atlantic coast, for example, temperature gradients are often great in the autumn; and hence tornadoes are relatively frequent then.

The influence of temperature gradients on tornadoes is illustrated in other ways. For example, although several tornadoes have entered the western outskirts of Chicago, none have closely approached Lake Michigan. When tornadoes occurred, winds from off Lake Michigan cooled the downtown part of the city. Finally, at Tokyo, Japan, on September 1, 1923, several typical tornadoes developed as a result of the conflict of air movements produced by the great fire and the cooler higher layers of air associated with the typhoon. Excellent photographs of two of these tornadoes indicated that they were closely comparable with those of the mid-west.

If the presence of a surface layer of relatively cold air causes an approaching tornado to rise above the cool air, as appears almost proved by the foregoing data, then a city on a plain, such as Indianapolis, if it could be bathed in cold air on the approach of a tornado, would be thereby protected because the tornado would rise above the buildings and people.

Tanks of rustless steel containing air compressed to say 20 atmos-

pheres (300 lbs. per square inch) could be buried at various points throughout the city, being especially numerous in the western end of the city and just west of the down-town district. Such tanks should be connected electrically with the office of the U. S. Weather Bureau in the city. When telephone reports and supplementary evidence indicated that a tornado was almost at hand approaching the city, the official should close the electrical switch which permits the covers of the tanks to fly off, allowing the compressed air to escape rapidly.

The escaping air would greatly lower the temperature of the surface air, producing a protective cold layer over which the tornado would rise. The cost of maintaining the tanks, including the interest on their installation, would be great; but at present some millions of dollars are expended annually in Indianapolis for tornado insurance premiums. And although insurance reduces the individual's loss, it does not reduce the total loss.