

LITERATURE CITED

- (1) WALKER, SIR GILBERT T.
1925. ON PERIODICITY. *Quart. Jour. Roy. Met'l Soc.*, 51, no. 216, pp. 337-346.
- (2) WALKER, SIR GILBERT T.
1914. ON THE CRITERION FOR THE REALITY OF RELATIONSHIPS. *Calcutta, Indian Meteorological Memoirs*, 21, part 1.
- (3) ALTER, DINSMORE.
AN EXAMINATION BY MEANS OF SCHUSTER'S PERIODOGRAM OF RAINFALL DATA FROM LONG RECORDS IN TYPICAL SECTIONS OF THE WORLD. *Mo. Wea. Rev.*, 54: 44-56.

(4) SCHUSTER, SIR ARTHUR.

1900. THE PERIODOGRAM OF MAGNETIC DECLINATION AS OBTAINED FROM THE RECORDS OF THE GREENWICH OBSERVATORY DURING THE YEARS 1871-1895. *Cambridge Phil. Soc. Trans.*, 18, p. 107.
1905. THE PERIODOGRAM AND ITS OPTICAL ANALOGY. *Royal Soc. Proc.*, 77, 146-140.
1905. ON SUN-SPOT PERIODICITIES. PRELIMINARY NOTE. *ibid.*, 141-146.
1906. ON THE PERIODICITIES OF SUN SPOTS. *Phil. Trans. Roy. Soc., A* 206, 69-100.

SOME OUTSTANDING TORNADES

551.515 (73)

(Abstract)¹

By CLARENCE J. ROOT

[Weather Bureau Office, Springfield, Ill.]

There is no reason to believe that in prehistoric days, nor during the early history of our country, tornadic storms were any less numerous or lacked the severity of those of to-day. As has been often pointed out, the greater completeness of the record in later years is simply a result of the increase in population affected by tornadoes. Thus an early list gives four times as many in the seventies as in the preceding 76 years, and contains very little data that would enable one to classify them as to magnitude. Complete statistics seem to be very meager prior to 1875.

With a view to having in compact form a record of the outstanding tornadoes that have occurred in the United States, the writer has compiled a list and brief description² of those which fall into any of the groups given below.

- A. Storms with a death list of 50 or more,
- B. With property loss of \$500,000 or more,
- C. With path more than 50 miles long,
- D. With path 50 to 100 miles long,
- E. With paths more than 100 miles long.

TABLE 1.—Percentage distribution of the 4 groups of important tornadoes

Group	State having maximum number	Percentage in States	
		West of Mississippi	East of Mississippi
A.....	Iowa, Texas, 10 per cent each.....	53	47
B.....	Kansas, 11 per cent.....	44	56
C.....	Iowa, 10 per cent.....	47	53
D.....	Missouri, 13 per cent.....	56	44
E.....	Alabama, 10 per cent.....	31	69

The list contains 158 class one or outstanding tornadoes. In summarizing (Table 1) the results of the work, tornadoes that occurred in two States are given a weight of one-half in each and, likewise, when they occurred in three States a weight of one-third is charged to each.

According to the compilation, Iowa leads in important tornadoes with 9 per cent of the total number, the other States following in this order: Missouri, 8; Illinois, 7; Kansas, Tennessee, Alabama, Minnesota, and Wisconsin, each 6; Oklahoma and Indiana, 5 each. From the Plains States eastward, all States are represented except Maine, New Hampshire, Vermont, Rhode Island, Connecticut, New York, Virginia, and West Virginia—54 per cent occurred east of the Mississippi River.

In total number of deaths from these larger tornadoes Illinois leads by a wide margin, there being 631 deaths as a result of a single storm, a number greater than the total of all these class one tornadoes in any other State.

It was supposed that the 293-mile path of the "Mattoon" tornado of May 26, 1917, was the longest of record, but five earlier ones are now found exceeding 300 miles. Two of these had some long gaps, the information is very vague concerning two others, and it is not stated whether the fifth was continuously destructive. In our travels over the Illinois and Indiana portions of the tri-State tornado of March 18, 1925, we found absolutely no skipping in the 130 miles covered. The last-named storm exceeded all others in loss of life and value of property destroyed. The official report gave the number of deaths as 742, and the property loss at \$16,500,000. There have been 8 tornadoes with a loss of life exceeding 100, and 2 with more than 135. In 15 storms the property loss has exceeded a million dollars, and in three of them it was ten million dollars or more.

Searching through some 700 records has brought out certain facts that are, perhaps, worthy of mention. A large number of tornadoes occur nearly every year, but many are of an incipient nature or do little damage. In some cases they have a tendency to form in groups, and to move in parallel paths in a northeasterly direction. A remarkable number continue for many miles over a straight path. The great tornado of March 1925, varied scarcely more than a mile or two from a straight line in 178 miles of its course. In a list of 384 tornadoes where the direction is stated, 78 per cent moved north-east, the others in some easterly direction. Of 452 tornadoes, 80 per cent were timed between noon and 6 p. m., and 15 per cent between 6 p. m. and midnight.

Kansas leads in number but the length of path probably averages less than farther east, and the greatest number of persons killed in a single tornado in that State was but 23. Tornadoes often occur when there are opposing northerly and southerly winds, with marked thermal difference.

It is questionable whether the observance of a funnel cloud should be made a requisite in defining a storm as a tornado.¹ In connection with the one in March, 1925, very few thought they saw a funnel cloud and these persons were not very definite. None was observed at St. Louis when that city was visited by a severe tornado on May 27, 1896. All through these old reports the statement recurs that two clouds came together, one from the northwest and one from the southwest. Professor Henry² says the character of the pendant funnel-shaped cloud varies with geographic position and the average hygrometric state of the air. It seems to the writer that if there is a long and narrow path, with an easterly movement of progression, it is safe to classify the storm as a tornado, especially if light debris aloft is thrown out to the left of the path.

¹ Paper read at meeting of American Meteorological Society, Kansas City, Dec. 28-29, 1925.

² These are on file in the library of the U. S. Weather Bureau, Washington, D. C.

¹ Dr. Humphreys stated that a funnel-shaped cloud was not always an accompaniment of a tornado though there was some confusion in the definition of the term. Mr. Reed mentioned a tornado in Iowa that had three branches, also one that had made a complete circle, with a radius of about 2 miles, in its path.

² Henry, Professor A. J., *Monthly Weather Review*, April, 1925.

List of most important tornadoes with special reference to cities that suffered severe damage or loss of life

Prepared by CLARENCE J. ROOT

[Weather Bureau Office, Springfield, Ill.]

Date	Place	For entire tornado			Authority	Remarks
		Killed	Injured	Property loss (estimated)		
1804, Apr. 4	Jones County to Columbia County, Ga.				Report of C. S. O., 1875, p. 437	Considered the most destructive in Georgia prior to 1875.
1806, June 5	Missouri, Illinois, and Indiana				Jonesboro, Ill. Gazette, ca. June 5, 1925.	Unusually long path.
1852, Apr. 13 or 30	Illinois, Indiana, and Kentucky				Report of C. S. O., 1877, p. 526, and 1872, p. 193.	Known as the "Great Tornado." Said to be the most extensive of record prior to 1875.
1875, Mar. 20	Harris County, Ga., to Horry County, S. C.				Report of C. S. O., 1875, p. 398-399	Unusually long path.
1875, Mar. 20	Muscookee County, Ga., to extreme east South Carolina.				Report of C. S. O., 1875, p. 398-399	Unusually long path.
1875, July 26	Erie, Pa. (near)	134		\$500,000	Finley, J. P., 600 Tornadoes (Prof. Paper of the U. S. Signal Service, no. 7, p. 9).	
1877, Mar. 8	Southwest Mississippi to Tallapoosa County, Ala.				Report of C. S. O., 1877, p. 458	Unusually long path.
1879, Apr. 16	Alabama, Georgia, South Carolina			200,000	Mo. Wea. Rev., April, 1879, p. 10	Unusually long path.
1880, Apr. 18	Marshfield, Mo.				Mo. Wea. Rev., April, 1880, p. 12	At Marshfield: deaths, 65; injured, 200. Loss in Barry and Webster Counties, \$1,000,000.
1881, July 15	New Ulm, Minn.	18	98		Mo. Wea. Rev., July, 1881, p. 17-18	Loss at New Ulm, \$300,000 to \$500,000.
1882, June 17	Grinnell, Ia.	100			Mo. Wea. Rev., June, 1882, p. 16	At Grinnell: 60 killed; 150 injured; loss, \$600,000.
1883, Aug. 21	Rochester, Minn.				Mo. Wea. Rev., Aug., 1883, p. 187	At Rochester: deaths, 31; injured, 100; dwellings destroyed, 135; Olmstead County farm losses, \$200,000.
1884, Feb. 19	Alabama, Georgia, and adjacent States (Group of tornadoes.)	182			Report of C. S. O., 1880, p. 700. Also Mo. Wea. Rev., 12: 48. Also Finley, J. P., in U. S. Signal Service Prof. Paper, no. 16, 1885.	Said to be greatest in number and most destructive on one day since organization of Weather Service.
1885, Aug. 23	Carnden, N. J.	6	100	500,000	Mo. Wea. Rev., 13: 205	No mention of rural casualties or losses.
1885, Sept. 8	Washington Court House, Ohio	6	100	500,000	Mo. Wea. Rev., 13: 231	
1887, Apr. 21	Prescott, Kans.	20	237	1,000,000	Mo. Wea. Rev., 17: 108	
1890, Mar. 27	Louisville, Ky.	106	250	3,500,000	Mo. Wea. Rev., 18: 74	At Louisville: 76 killed; 200 injured; loss, \$2,500,000.
1893, July 3	Pomeroy, Ia.	99		213,000	Report, Chief of Wea. Bur., 1893, p. 319.	At Pomeroy: 73 killed; loss, \$175,000.
1894, Oct. 2	Little Rock, Ark.	4		500,000	Report, Chief of Wea. Bur., 1894, p. 287.	At Sherman: killed, 61; injured, 150.
1896, May 15	Sherman, Tex.				Mo. Wea. Rev., 24: 83	Most destructive in United States up to this time. At St. Louis: deaths, 137; loss, \$10,000,000. At East St. Louis: deaths, 118.
1896, May 27	St. Louis, Mo.	306		12,904,000	Mo. Wea. Rev., 24: 77	At Fort Smith: killed, 33; 19 subsequently died; 44 others seriously injured; loss, \$450,000.
1898, Jan. 12	Ft. Smith, Ark.				Mo. Wea. Rev., 26: 18	Path only 4 to 6 miles in length.
1899, Apr. 27	Kirkville, Mo.	34		250,000	Clim. Data, Missouri Sec., April, 1899.	
1899, June 12	New Richmond, Wis.				Clim. Data, Wisconsin Sec., June, 1899.	At New Richmond: deaths, 100; injured, 100.
1900, Nov. 20	Southeastern Arkansas, northern Mississippi, and western Tennessee.	73		500,000	Mo. Wea. Rev., 28: 499	Figures for series of six tornadoes. One with unusually long path.
1902, May 18	Goliad, Tex.	114	230	50,000	Clim. Data, Texas Sec., May, 1902	No mention of storm outside of Goliad.
1903, June 1	Gainesville, Ga.	98	175	1,090,000	Clim. Data, Georgia Sec., June, 1903	Path but 4 miles in length.
1904, Aug. 20	Minneapolis and St. Paul, Minn.	14		1,500,000	Clim. Data, Minnesota Sec., August, 1904.	Property loss at Minneapolis, \$500,000.
1905, May 10	Snyder, Okla.	96		270,000	Clim. Data, Oklahoma Sec., May, 1905.	At Snyder: deaths, 87; seriously injured, 49; loss, \$250,000.
1906, Apr. 24	Rapides Parish, La., to Tillman, Miss.	91	398	182,000	Mo. Wea. Rev., 36: 131	
1906, Apr. 24	Livingston Parish, La. to Wayne County, Miss.	120	190	400,000	Mo. Wea. Rev., 36: 131	
1909, Mar. 8	Brinkley, Ark.				Clim. Data, Arkansas Sec., April, 1909.	At Brinkley: Deaths, 49; injured, 600; loss, \$600,000.
1909, Apr. 29	Southwest corner Tennessee to Scott County, Tenn.				Mo. Wea. Rev., 37: 152	Unusually long path.
1913, Mar. 23	Omaha, Nebr.	94	(1)	3,500,000	Mo. Wea. Rev., 41: 396	Data are for Omaha; no mention of outside deaths or losses.
1913, Mar. 23	Terre Haute, Ind.	21	250	1,000,000	Mo. Wea. Rev., 41: 359. Also Clim. Data, Indiana Sec., 1913, p. 359.	No mention of rural casualties or losses.
1915, Nov. 10	Great Bend, Kans.	11	50 to 75	1,000,000	Clim. Data, Kansas Sec., November, 1915.	Figures for Great Bend and vicinity. Most deaths from a Kansas tornado up to this time.
1917, Mar. 23	New Albany, Ind.	45	(1)	1,000,000-1,500,000	Clim. Data, Indiana Sec., March, 1917. Also Rep't, Chief of Wea. Bur. 1917-18, p. 31.	Figures for New Albany. Considerable damage at Harrod's Creek, Ky.
1917, May 26	Illinois and Indiana	103			Clim. Data, esp. Illinois Sec., May, 1917, p. 40; Also Indiana Sec., May, 1917.	One of the longest paths of record. The figures for deaths, number injured, and property loss are as follows: State of Illinois: 101, 638, \$2,500,000; Mattoon, Ill., 53, 400, \$1,200,000. Charleston, Ill., 38, 182, \$781,000, respectively.
1917, May 27	Lake County, Tenn., to Graves County, Ky.	70	370	2,000,000	Clim. Data, Kentucky Sec., May, 1917, p. 36, and Tennessee Sec., May, 1917.	
1918, Aug. 21	Tyler, Minn.	36		1,000,000	Report, Chief of Wea. Bur., 1918-19, p. 38.	
1919, Mar. 16	Delhi, La., to Sunflower County, Miss.	35		1,000,000	Report, Chief of Wea. Bur., 1919-20, p. 37.	
1919, June 22	Fergus Falls, Minn.	59		3,500,000	Report, Chief of Wea. Bur., 1919-20, p. 37.	
1920, Mar. 23	Chicago-Melrose Park, Ill.	20	300	2,000,000	Clim. Data, Illinois Sec., March, 1920	Only second tornado to visit Chicago, the previous one being very small.
1920, Mar. 23	Kane, Cook, and Lake Counties, Ill.	8	100	1,000,000	Clim. Data, Illinois Sec., March, 1920	
1920, Mar. 23	Deatsville, Ala., to La Grange, Ga.	50		1,400,000	Report, Chief of Wea. Bur., 1920-21, p. 30-31.	
1920, Apr. 20	Mississippi and Alabama	87			Report, Chief of Wea. Bur., 1920-21, p. 30, 34.	Loss in Alabama, \$1,000,000.

¹ Several hundred.

List of most important tornadoes with special reference to cities that suffered severe damage or loss of life—Continued

Date	Place	For entire tornado			Authority	Remarks
		Killed	Injured	Property loss (estimated)		
1920, May 2.....	Peggs, Okla.....				Report, Chief of Wea. Bur., 1920-21, p. 37.	At Peggs: Killed, 60.
1921, Apr. 13.....	Melissa, Tex.....	11		\$500,000	Report, Chief of Wea. Bur., 1921-22, p. 48.	All at Melissa.
1921, Apr. 15.....	Texas and Arkansas.....	61			Report, Chief of Wea. Bur., 1921-22, p. 39, 49.	Loss in Arkansas \$1,225,000.
1922, Apr. 17.....	Illinois, Indiana, and Ohio.....	16		900,000	Report, Chief of Wea. Bur., 1922-23, p. 33, 39.	Unusually long path.
1924, Apr. 30.....	Lawrenceville, Ga., to Hickory Grove, S. C.....	10		2,200,000	Clim. Data, Georgia Sec., April, 1924; also South Carolina Sec., April, 1924.	Anderson, S. C., suffered severely.
1924, June 28.....	Lake Erie.....	85		12,000,000	Report, Chief of Wea. Bur., 1924-25; also Mo. Wea. Rev., 52: 309, 396.	At Sandusky: Deaths, 8; injured, nearly 100 loss about \$1,000,000. At Lorain: Deaths, 73; injured, 200; loss, \$11,000,000.
1924, July 13.....	Butler County, Kans.....	1		2,000,000	Clim. Data, Kansas Sec., July, 1924.....	Much damage in Augusta.
1925, Mar. 18.....	Missouri, Illinois, and Indiana.....	695	2,027	16,500,000	Clim. Data, Illinois Sec., Indiana Sec., Missouri Sec. March, 1925. See also reports of American Red Cross.	Greatest of all tornadoes. Path unusually long. Property loss: Annapolis, Mo., \$400,000; Gorham, Ill., \$150,000; Murphysboro, Ill., \$10,000,000; De Soto, Ill., \$300,000; West Frankfort, Ill., \$545,000; Griffin, Ind., \$225,000; Princeton, Ind., \$1,800,000. Missouri, \$564,000; Illinois, \$13,193,000; Indiana, \$2,775,000. Gorham, De Soto, Parrish and Griffin were wiped out.

* Barron and Root traveled over the tornado track during the period two to ten days after the storm. At that time there was much confusion as to the number of killed and injured. The American Red Cross has prepared an accurate and authentic list of the killed and injured, including those who have died since the storm. Through the courtesy of Mr. Henry M. Baker, National Director of Disaster Relief, these figures are now available.—C. J. R.

551.578.48 (792)

NOTES, ABSTRACTS, AND REVIEWS

AVALANCHE AT BINGHAM, UTAH

By J. CECIL ALTER

[Weather Bureau Office, Salt Lake City, Utah, March 5, 1926]

The snowslide which ran out of Sap Gulch into Bingham Canyon, stopping about 3 miles above Bingham town, Salt Lake County, Utah, at 9 a. m., February 17, 1926, demolished 14 miners' cottages and a 3-story frame boarding house, grouped near the mouth of the gulch, killed 36 persons and injured 13 others out of a total of about 65 who were in its path. Numerous other slides occurred about the same time in the mountains adjacent to Provo, Salt Lake City, and Ogden, though little additional damage or inconvenience resulted.

A comparatively heavy snowfall occurred during the afternoon and night of February 16, 1926, over the northern Wasatch Mountains, extending generally from eastern Juab to Cache Counties, inclusive. The depth of new snow averaged about 12 inches over the area mentioned, but averaged about 17 inches over Salt Lake County, ranging from 8 inches at Midvale (elevation 4,365) and 10 inches at Salt Lake City (elevation 4,300), to 27 inches at High Line City Creek (elevation 5,300) and 24 inches at Mountain Dell (elevation 5,500). Twelve or 15 inches fell over Sap Gulch watershed (elevation about 6,000 to 6,500).

The new snow was deposited on a general layer of crusted old snow in the mountains, and became unstable toward the end of the storm. Thus many of the better known snowslides ran, a few casting their avalanches which had not disgorged for a great many years. The Sap Gulch slide is reported to have run only twice in the past 30 years, and then with much smaller discharges. This latest slide seems to have started by the slipping of

a large area of new snow, possibly aided by blasting in a surface mine not far distant.

Once started, the moving snow skidding over the glossy old snow, was augmented by contributions within and to the sides of its path, though it was also depleted by a large amount in a depression on the way down. No important hindrance was offered by trees or other objects in any part of its 2-mile path; and it gained a little speed as indicated in its leaping off a 100-foot ledge just above the destroyed buildings, clearing 50 feet of ground at the base of the ledge. However, no testimony was given by observers as to any extraordinary wind or air pressure; and other buildings near the end of the slide were not moved or damaged.

Survivors interviewed agree that there was a brief roaring sound, then a definite jiggling of the buildings as in a sharp earthquake, and then the crash of the avalanche. The buildings in the snow path were crushed like eggshells, most of them being swept along a few rods with the rolling, mixing avalanche. Most of the fatalities were instantaneous, though several persons were rescued alive and expired later. Most of the survivors were dug out of the debris at great effort, many of them after being imprisoned several hours. Some, however, were thrown free of harm, the outstanding escape being made by a man taking a shower bath, who though naked was carried 150 feet on the crest of the slide to safety.

The mass of moving snow, came to a stop a few yards below the group of buildings destroyed, the dead avalanche being about 800 feet long, 100 feet wide, and from 10 to 20 feet deep. All of this snow was carefully moved before it could be certain that it held no more bodies. Fortunately laboring men with proper tools were available in large numbers to effect the rescues as quickly as was humanly possible. Hospital service was also available