ning, rain, hail, or wind. This symbol will be used to indicate all cases when the storm is supposed to have passed near the station.

T *Thunder.*—Distant thunder.

⩹ *Lightning.*[11]—Distant lightning, usually called sheet or heat lightning. ⩹° faint lightning; ⩹² brilliant lightning. When distant lightning appears at a definite direction in the horizon the observer should enter in the record the point of the compass, e. g., ⩹° NW. 10 p. for "distant heat lightning in the northwest at 10 p. m."

⟶ *Strong wind, or gale.*[12]—The feathering of the arrow may be varied to indicate the force of the wind according to the Beaufort scale, or the symbol, an arrow with 4 feathers, may be used to indicate a wind whose strength is 8, 9, or 10 on the Beaufort scale, or any velocity in excess of 50 miles per hour or 20 meters per second in absolute measures; ⟶² a remarkably strong wind or one exceeding 11 on the Beaufort scale or 80 miles per hour, or 35 meters per second.

⦶ *Solar aureole, corona, or glory.*[13]—Used for small circles of prismatic color surrounding the sun. The radii of these circles are usually less than 6°, but in the extreme case of Bishop's ring the radius is 15°. Several concentric circles are sometimes visible; each circular band of prismatic colors has its red on the outside and its blue, violet, or purple on the inside, with respect to the sun. Such rings are generally formed when the sun shines through a thin cloud, and may be seen if viewed through a neutral tinted glass or by reflection in water. A smaller circle surrounding the shadow of the observer's head is called an anthelion, aureole, glory, or fog shadow.

⩌ *Lunar aureole or corona.*[13]—A small circle surrounding the moon similar to the solar corona.

⊕ *Solar halo.*[13]—Used for larger circles surrounding the sun, whose sizes are quite definite, namely, about 22° and 45° radius from the sun. They are easily distinguishable from the coronas by the fact that the colors are feebler and are so arranged that the red color is inside or nearest the sun and the blue color is outside. The greater part of the breadth of the halo is white. Complex combinations of halos, parhelia, horizontal circles, and vertical columns sometimes occur. In the symbol ⊕² the exponent indicates that the display is more brilliant than usual. A detailed statement of the radii or diameters of the rings and columns and of their arrangement should be given in the station journal.

⩌ *Lunar halo.*[13]—A circle surrounding the moon similar to the solar halo.

⌒ *Rainbow.*[13]—Brilliant rainbows may be indicated by ⌒². When there are adjacent or supernumerary bows it should be indicated in the journal.

⌓ *Aurora.*—Any display of the aurora borealis or aurora australis.

⋔ *Zodiacal light.*—The International Conference at Innsbruck, September, 1905, recommended that observations of this phenomenon be made wherever practicable. It is seen as a triangular beam of light rising from the horizon in the west after the end of evening twilight in the winter and spring, or in the east before daybreak from September to January.

DEPOSIT OF ICE COLUMNS.

By E. R. MILLER.

On December 25, 1905, the ground in the vicinity of Cabin John Bridge, eight miles west of Washington, D. C., was observed to be covered, especially where bare of vegetation, with a heavy deposit of ice columns. Where exposed to the sun the deposit had the appearance of rough shaggy fur; in shaded places the tops of the crystals were evenly covered with a thin crust of ice to which the crystals remained attached when lifted from the ground. The accompanying reproduction of a photograph shows such a fragment. The crystals photographed were about three inches long, and were of a fibrous appearance. The individual crystals were irregular in section and were from $\frac{1}{16}$ to $\frac{3}{16}$-inch in thickness. Most of the columns noticed had formed above the ground, but in some places they had formed in the soil.

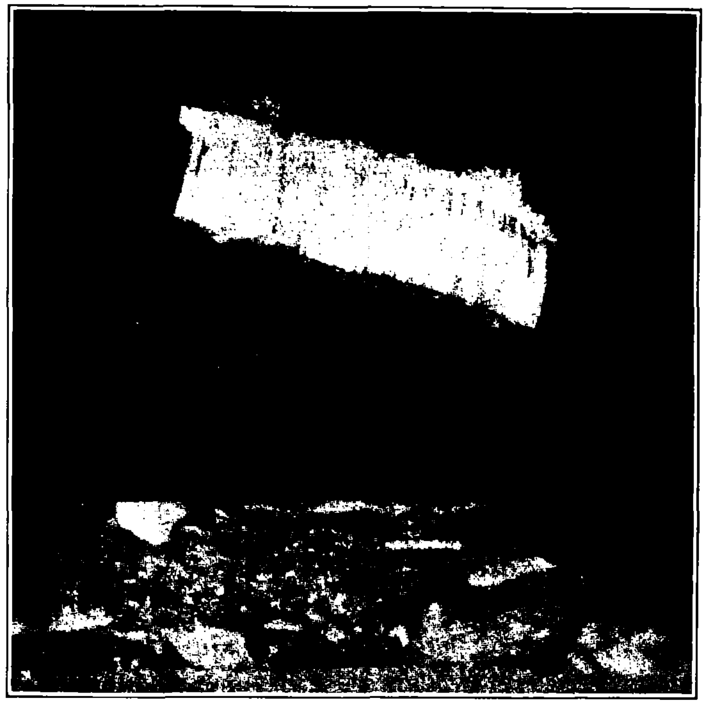

Fig. 1.—Deposit of ice columns.

The soil where the phenomenon occurred is loose and sandy. Rain to the amount of 2.03 inches (at Washington) fell during the night of the 20th and 21st followed by temperatures below freezing on the 24th and 25th, a minimum of 22° F. being recorded at Washington on the morning of the 25th.[1]

THE CLIMATE OF MADISON, WIS.

By JAMES L. BARTLETT, B. S., Observer, U. S. Weather Bureau. Dated November 27, 1905.

TOPOGRAPHY.

Madison, Wis., latitude, 43° 05′ north; longitude, 89° 23′ west, is situated in the southern portion of the State, about 75 miles west of Lake Michigan and the same distance from the nearest point of the Mississippi River. Locally, the city occupies a strip of land one-half to three-quarters of a mile wide, lying directly between Lakes Mendota and Monona, the former of which has an area of fifteen, and the latter an area of five square miles. The main portion of the city extends along the south shore of the larger lake. The site as well as the surrounding country is slightly rolling, some of the hills rising 100 feet, or more, above the level of the lakes. The elevation of the surface of Lake Mendota above mean sea level is 849 feet (see fig. 4).

HISTORICAL.

Meteorological observations were begun in Madison at the north dormitory of the University of Wisconsin, by Prof. S. H.

[11] The exponent when employed with this symbol should indicate degree of brightness or intensity, not relative frequency.—*S. P. F.*

[12] The definition of a gale varies with every locality. At some places, notably Mount Washington, and Ben Nevis, winds of 10 to 15 meters per second, 22 to 33 miles per hour, are too numerous to be noteworthy, while at less exposed places they would be quite rare, hence the symbol should indicate the occurence of an unusually strong wind or gale.—*S. P. F.*

[13] The exponent should indicate brightness, not size or complexity of structure.—*S. P. F.*

[1] See Monthly Weather Review, vol. 26, p. 217, and vol. 33, pp. 157-8.

Carpenter in January, 1853, and were continued with short lapses, by Prof. J. W. Sterling and Prof. W. W. Daniels, either there or in the neighboring main hall of the university, until October, 1878, except for a short period from March, 1856, to January, 1857, when the readings were taken by Dr. A. Schue at his office on Main street. From October, 1878, to April, 1883, the office of the United States Signal Corps was located in Madison, in Brown's Block, under the charge of the Sergeants F. M. M. Beall and C. A. Shaw. The station being discontinued at the latter date, the instrumental equipment was transferred to the north dormitory, and in August, 1883, to the Washburn Observatory (astronomical) at the university. At the last-named point observations were taken continuously under the supervision of Profs. Edward S. Holden and George C. Comstock, directors of the observatory, until December 31, 1904, when they were discontinued. The present station of the Weather Bureau was established on September 15, 1904, in the north hall, formerly north dormitory.

Most of the original records made during the earlier years have been preserved in the library of Washburn Observatory, although some are not to be found there. The observations made from 1869 to 1878[1] have been published in the Regents' Reports of the University of Wisconsin for those years, the report for the latter years also containing an interesting account by Prof. W. W. Daniels of some destructive tornadoes which occurred in extreme southern Wisconsin during that year. The observations taken from 1882 to 1893 have been printed in Publications of the Washburn Observatory.

INSTRUMENTAL EQUIPMENT AND EXPOSURE.

Beginning with October, 1878, the standard instruments furnished by the Signal Corps were used. These included maximum, minimum, dry and wet-bulb thermometers, an eight inch rain and snow gage, wind vane, anemometer, single register, and barometer.

The exposure at Washburn Observatory, where by far the greater portion of the observations was taken, was as follows: The thermometers were exposed in a wooden shelter of double louvre work, placed in the north window of the meridian circle room, eight feet above the ground. The anemometer and wind vane were placed upon supports on the roof and were about 35 feet above the ground. For the rain and snow gage a ground exposure near the observatory was used.

Washburn Observatory, main hall, and north hall are all situated on a slight ridge bordering the south shore of Lake Mendota, about 100 feet above the level of the lake and 600 feet distant from it.

GENERAL CLIMATIC SITUATION.

Southern Wisconsin enjoys a type of climate peculiar to continental interiors, characterized by great extremes of temperature. As it lies on the windward side of Lake Michigan, its atmospheric conditions are but slightly influenced by the Great Lakes. In general this is a region of warm summers, with occasional periods of extreme heat which may be interrupted by destructive local storms. The winters are somewhat cold and stormy, with frequent cold waves. The rainfall is sufficient for raising excellent crops, and is heaviest during the spring and early summer and least in the winter. About 50 per cent. of the possible duration of sunshine is recorded at the surface of the earth.

CYCLONIC STORMS.

Wisconsin lies almost in the main track of the transcontinental storms. Those coming from our north Pacific coast and western Canada pass across the northern border of the State, while many of the storms moving from the southwest toward the Great Lakes, pass near the southern boundary of the State. The storm centers, however, only infrequently touch the vicinity of Madison. Perhaps ten of these centers each year, or one-tenth of the whole, cross southern Wisconsin.

The paths of the centers of the anticyclones or high pressure areas also generally lie either north or south of this section. In the summer they pass on our north side over Lake Superior, in the winter on our south side over the middle Mississippi Valley to the south Atlantic coast. Each year, however, about half a dozen of these centers pass over this portion of the State.

Waterspouts have been observed on the Lakes. Thunderstorms are of frequent occurrence during the warmer months, and are sometimes accompanied by severe squalls. Destructive tornadoes have ravaged southern Wisconsin, but the nearest that one of any importance has ever come to Madison was ten miles farther south on May 23, 1878.

LOCAL WEATHER INDICATIONS.

Precipitation is usually preceded at Madison by southerly or southeasterly winds, and in winter and spring by winds from the east or northeast also. These winds also prevail during the occurrence of the greater portion of the precipitation, though rain or snow may fall with wind from any point of the compass. During summer thunderstorms the wind usually shifts to a westerly direction before rain begins to fall, but these storms are as a rule preceded by southerly winds. Heavy falls of rain and snow are generally received from storms which come from the southwest and whose centers pass near this locality, but during the warmer months heavy rains may occur from thunderstorms in the southeast quadrant of a "low." The warm winds during the spring and autumn come from the south, in summer from southerly to westerly points, and in winter from the southeast. The cold winds come from north or west quadrants except during the summer when the colder winds blow from northerly to easterly directions.

TABULATED DATA.

The climatic data are summarized in Tables 1, 2 and 3. Records of temperature and precipitation were kept almost continuously from 1869 to the present time, but many of them are for shorter periods. Maximum and minimum temperatures have been observed only since October, 1878, at which time the record of wind movement also began, thus limiting this record to a 26-year period. The number of years and the dates for which the various data have been computed are noted at the foot of each table.

TEMPERATURES.

The large amount of water surface within a radius of five miles of Madison (about one-third of the total surface) naturally has some influence on the overlying and surrounding air. Lakes Mendota and Menona are open in general from April 8 to December 21 each year, although the exact dates of opening and closing vary much for different years. The exact amount of the influence of these lakes upon the local air temperature is, of course, very difficult to determine. To learn, if possible, the approximate value of this influence a comparison for identical periods of time was made between the temperature data for Madison and those for four cooperative observation stations of the Weather Bureau, located at Harvey, Portage, Beloit, and Dodgeville, which four cities are in southern Wisconsin within a radius of 45 miles from Madison and have no lakes in their vicinities.[2] Slight corrections were first made to the various mean values obtained to equalize the mean annual temperatures of the different places. It was then found that the temperature conditions at Madison differed from those of the other points by amounts quite similar for the four places. The averages of these differences have been plotted. (See fig. 1.)

From the above difference curves it may readily be seen that the tendency of the lakes is to lower the mean maximum

[1] All periods mentioned in this article include the dates by which they are limited.

[2] See Monthly Weather Review for April, 1905, p. 147.

TABLE 1.—*Climatic data for Madison, Wis.—Temperature.*

Months.	Mean of the max. and min.	Highest monthly and annual mean.	Lowest monthly and annual mean.	Mean maximum.	Mean minimum.	Mean daily range.	Means for three observation hours, on local time.				Means of absolute monthly and annual extremes.		Mean monthly and annual range.	Absolute extremes for the whole period.			
							7 a.m.	2 p.m.	9 p.m.	Mean.*	Max.	Min.		Max.	Date.	Min.	Date.
	°	°	°	°	°	°	°	°	°	°	°	°	°	°		°	
January	16.4	33.5	6.3	24.1	8.6	15.5	14.0	21.3	17.6	17.6	43	—15	58	58	6, 1880	—29	{ 7, 1887 21, 1888
February	18.3	34.0	7.5	26.3	10.3	16.0	14.8	24.4	19.9	19.8	45	—13	58	63	12, 1882	—28	9, 1899
March	30.4	38.4	21.9	38.3	22.4	15.9	25.0	34.5	30.0	29.9	58	2	56	73	28, 1905	—12	5, 1890
April	46.0	51.8	40.2	54.8	37.1	17.7	40.3	51.7	45.5	45.8	76	21	55	86	12, 1887	8	3, 1886
May	58.2	66.6	51.8	67.4	48.7	18.7	53.4	64.2	57.7	58.2	82	36	46	88	29, 1881	27	7, 1885
June	67.6	71.4	63.2	76.9	58.3	18.5	63.4	73.7	66.7	67.6	88	45	43	94	26, 1901	38	1, 1897
July	72.4	79.8	66.7	81.4	63.0	18.5	67.5	78.4	71.4	72.2	91	53	38	104	21, 1901	48	{ 30, 1891 9, 1895
August	69.8	75.2	65.0	78.4	61.1	17.3	64.3	76.2	68.9	69.6	89	50	39	96	8, 1894	46	24, 1896
September	62.0	67.8	57.4	70.6	53.5	16.9	56.3	68.2	60.8	61.5	85	39	46	92	5. 1881	29	30, 1899
October	50.4	59.2	44.4	58.4	42.4	16.0	44.2	55.4	48.8	49.3	77	27	50	84	4, 1897	12	25, 1887
November	34.6	41.8	26.8	41.5	27.7	13.8	29.9	37.8	33.2	33.5	60	8	52	68	3, 1904	—14	28, 1887
December	22.7	34.9	12.4	29.2	16.2	13.0	18.9	25.4	21.8	22.0	47	—7	54	60	24, 1889	—26	27, 1886
Year	45.8	49.7[a]	42.2[b]	54.0	37.5	16.5	41.0	50.9	45.2	45.6	92	—20	112	104	{ July 21, 1901	—29	{ Jan. 21, 1888
Length and dates of data	27 years, from October, 1878, to September, 1905, inclusive.						32 years, from 1869 to 1874, 1876 to 1880, 1884 to 1904, inclusive.				27 years, from October, 1878, to September, 1905, inclusive.						

[a] 1878. [b] 1885 *By Mannheim formula $\frac{7\text{ a.m.} + 2\text{ p.m.} + 2 \times 9\text{ p.m. temperature}}{4}$

TABLE 2.—*Climatic data for Madison, Wis.—Precipitation.*

Months.	Average total precipitation.	Monthly and annual extremes.				Greatest in 24 hours.		Average number rainy days.	Snowfall.			Droughts and rainy periods.				
									Average total.	Greatest in 24 hours.		Successive days without rain.			Successive rainy days.	
		Greatest.	Year.	Least.	Year.	Amount.	Date.			Amount.	Date.	Average number.	Greatest number.	Year.	Average number.	Greatest number.
	Inches.	*Inches.*		*Inches.*		*Inches.*			*Inches.*	*Inches.*						
January	1.66	3.59	1898	0.10	1903	1.80	1, 1892	8	8.5	9.4	20, 1898	3.8	26	1891	1.6	7
February	1.56	5.42	1881	0.26	1895	1.30	17, 1887	7	9.3	7.3	19. 1898	3.6	21	1899	1.6	5
March	2.18	4.73	1882	0.27	1895	1.95	3, 1881	9	7.6	11.0	21, 1886	3.5	18	1895	1.7	5
April	2.38	5.48	1880	T.	1877	2.15	18, 1880	9	1.0	4.8	13, 14, 1892	3.6	22	1895	1.8	7
May	3.49	6.98	{ 1883 1892 }	0.51	1897	2.19	26, 1903	11	T.	T.	31, 1889	3.2	15	1881	2.0	6
June	4.19	9.31	1880	0.59	1895	3.47	14, 1880	11	0	....	....	3.0	15	1894	1.8	6
July	4.13	9.47	1881	0.79	1886	4.32	21, 1881	10	0	....	....	3.4	16	1879	1.7	5
August	3.10	6.83	1882	0.54	1894	3.25	16, 1886	9	0	....	....	3.9	17	1894	1.7	9
September	3.24	8.17	1881	0.38	1891	2.60	8, 1885	9	0	....	....	3.6	25	1891	1.7	6
October	2.48	9.12	1881	T.	1889	2.05	8, 1881	8	0.1	1.0	25, 1898	4.2	31	1889	1.6	5
November	1.76	6.02	1879	0.03	1904	2.61	6, 1885	8	3.0	4.5	6, 1900	4.1	20	1888	1.6	6
December	1.74	5.73	1884	0.21	1898	2.59	26–27, 1904	10	8.1	7.0	27, 1904	3.8	15	{ 1890 1894 }	1.9	5
Year	31.91	52.93	1881	13.12	1895	4.32	July 21, 1881	108	37.6	11.0	Mar. 21, 1886	3.6	34	1888	1.7	10
Length and dates of data	36 years, from 1869 to 1904, inclusive.							26 years, 1879 to 1904.	21 years, 1884 to 1904, inclusive.			26 years, 1879 to 1904, inclusive.				

TABLE 3.—*Climatic data for Madison, Wis.*

Months.	Humidity.					Cloudiness.							Wind.				
	Relative humidity.				Vapor pressure.	Scale, 0—10.				Average number of days.			Prevailing direction.	Average hourly velocity.	Maximum in 5 minutes.		
	7 a.m.	2 p.m.	9 p.m.	Mean.		7 a.m.	2 p.m.	9 p.m.	Mean.	Clear.	Partly cloudy.	Cloudy.			Velocity.	Direction.	Date.
	%	%	%	%	*Inch.*									*m.p.h.*	*m.p.h.*		
January	90	80	88	86	.077	6.3	5.9	5.1	5.8	8	11	12	nw.	10.1	40	n.	2, 1905
February	90	78	86	85	.089	5.8	5.8	4.7	5.4	7	11	10	nw.	11.0	40	....	11, 1881
March	86	70	81	79	.130	6.1	6.1	5.2	5.8	8	11	12	nw.	11.4	45	....	19, 1881
April	77	59	70	69	.211	5.6	6.0	4.7	5.4	8	12	10	s.	11.6	48	....	10, 1879
May	76	59	72	69	.334	5.2	6.3	4.7	5.4	8	12	11	s.	10.3	36	....	24, 1879
June	80	62	76	73	.482	5.1	5.7	4.4	5.1	8	12	10	s.	9.8	50	....	5, 1880
July	80	60	74	71	.555	4.4	5.3	3.4	4.4	10	15	6	sw.	8.3	39	ne.	17, 1905
August	82	61	74	72	.536	4.8	5.6	3.2	4.5	10	15	6	s.	8.2	40	....	—, 1879
September	84	65	76	75	.402	5.0	5.0	3.8	4.6	10	12	8	s.	9.9	45	sw.	30, 1881
October	82	63	74	73	.256	5.5	5.4	4.4	5.1	9	12	10	s.	10.8	44	sw.	16, 1880
November	85	72	80	79	.150	6.2	6.4	5.4	6.0	7	11	12	nw.	11.7	46	ne.	13, 1905
December	88	80	87	85	.098	6.4	6.3	5.4	6.0	7	10	14	nw.	11.1	40	nw.	7, 1881
Year	83	67	78	76	.277	5.5	5.8	4.5	5.3	100	144	121	nw.	10.3	50	....	{ June, 5, 1880
Length and dates of data	30 years, from 1869 to 1874; from 1876 to 1880, and from 1886 to 1904, inclusive.					26 years, from 1869 to 1904, excluding Jan., 1875, to Oct., 1876, and Nov., 1878, to Dec., 1886, not computed.							36 yrs., 1869 to 1904.	26 yrs., 1879 to 1904.	5⅔ years, Oct., 1878, to April, 1883, and Oct., 1904, to Nov., 1905.		

temperatures throughout the year, to raise the mean minimum, and thus to decrease the mean daily range. The month of the most marked difference is August, which is noticeably very oppressive at Madison. The monthly mean temperature is lowered during the first five months of the year and raised during the remaining months. From January to March, each year, the lakes are almost invariably thickly coated with ice which has only a slight influence upon the surrounding air temperatures. However, when the ice is melting in the spring a large amount of heat is undoubtedly taken from the overlying air, which may account for the lowering of the mean temperature during March.

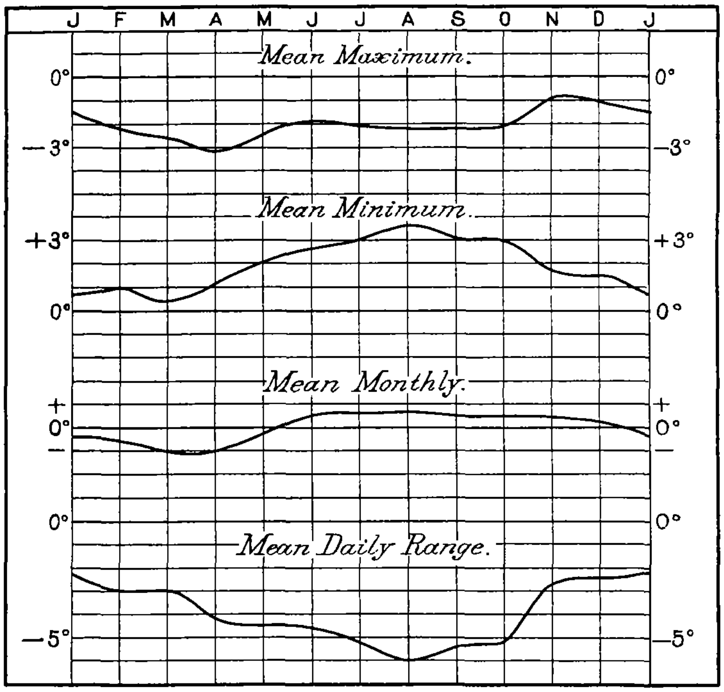

FIG. 1.—Average difference of temperatures at Madison from the combined means of Harvey, Portage, Beloit, and Dodgeville, showing the influence of neighboring lakes.

HOT PERIODS.

During the past 27 years there have been 150 days on which the temperature has risen to 90°, or over, or an average of about five and one-half days for each year. Frequently these high temperatures are recorded for a period of several successive days. The lengths of these periods and total number in 27 years have been as follows: fifteen successive days, one period; six successive days, one period; five successive days, two periods; four successive days, four periods; three successive days, eight periods; two successive days, sixteen periods; single days, forty-six times.

More than half of these hot days have occurred during the month of July, while August follows with about 20 per cent. The longest and most severe hot period occurred during July, 1901, when from the 13th to the 27th, the temperature rose above 90° every day, reaching 104°, the highest on record for Madison, on the 21st. During the same July there were six other days when a maximum of 90°, or over, was recorded, so that the whole month was abnormally hot; its mean temperature[3] was 80°, or a departure of 8° above the normal, and the highest monthly mean temperature on record for Madison. Most of the nights during this month were also very warm.

During July, 1887, a shorter but noteworthy hot period occurred. From the 11th to the 16th, temperatures of 90°, or over, were recorded each day. In July, 1894, from the 15th to the 19th, a period of five days, the thermometer rose above 90° daily. In July, 1886, a similar four-day period occurred, from the 25th to the 28th; this month contained another three-day period, from the 4th to the 6th, on the last day of which a maximum of 100° was recorded.

The longest hot period during June occurred in 1901, when there were five days, beginning with the 24th, on which maxima over 90° were registered. Another June hot spell extended from the 25th to the 28th, 1890.

In August, the longest hot periods have lasted only four days, namely: in 1881, from the 2d to the 5th, and in 1887, from the 1st to the 4th. September has had few hot days, but among these were three in succession, from the 4th to the 6th, 1881.

The highest summer average on record at Madison was that of 1901, with a mean temperature of 74°, or 4° above the normal, and the warmest winter that of 1889–90, with a mean temperature of 28°, or 9° above the average. The warmest year was 1878, with a mean of 50°, or 4° higher than the normal.

COLD SPELLS.

In calculating the length of cold periods in the winter, only those days have been considered on which the temperature did not rise above zero Fahrenheit. There have been nearly 80 of these days during the past 27 years, or an average of three each year. The lengths and number of cold spells during this time have been as follows: Five consecutive days, one period; four consecutive days, three periods; three consecutive days, three periods; two consecutive days, eleven periods; single days, thirty-one.

While the greater part of these cold days have occurred during January, which is as a rule the coldest month of the year, it is a notable fact that the longest and most intense cold spell occurred during February, of 1899, when the temperature did not rise above zero Fahrenheit, from the 8th to the 12th, and a minimum of 28° below zero was reached on the 9th. The average temperature for these five cold days was 15° below zero.

January, however, has had numerous cold spells, the most important of which were in 1883, 1884, and 1897, in all of which the mercury failed to rise above the zero point for four consecutive days. The coldest of these four-day periods lasted from the 4th to the 7th of January, 1884, with a mean temperature of 15° below zero and a minimum of 27° below; that of 1883 extended from the 20th to the 23d, with an average of 14° below zero; that of 1897 lasted from the 24th to the 27th, with an average of 12° below zero.

December being the warmest of the winter months, its cold spells are naturally shorter. Only twice in December since 1878 has the temperature failed to rise above zero for two consecutive days. These two-day cold spells occurred on the 18th and 19th, 1884, and on the 28th and 29th, 1880; the latter was the colder period, with an average temperature of 14° below zero.

It is somewhat noteworthy that the lowest temperature ever recorded at Madison, 29° below zero, did not occur during any of these long, cold periods. On January 7, 1887, this extreme was reached, but the temperature was above zero on both the 5th and 8th. Likewise on January 21, 1888, the temperature fell to 29° below zero, but the following day was again above zero.

COLD SEASONS.

The coldest month of which we have record was January, 1875, with an average temperature of 4°. The coldest summer was that of 1869, with an average temperature of 67°; the coldest winter, that of 1884–85, with a mean temperature of 10°; and the coldest year, 1885, when the temperature averaged 42°.

[3] All mean temperatures have been obtained from the sum of the daily maximum and minimum divided by two.

TABLE 4.—*Daily normal temperatures.*

[Means of 26 years, November, 1878, to October, 1904.]

Date.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
1	18	13	25	38	54	61	72	72	67	57	44	27
2	16	16	26	37	53	62	73	71	69	58	42	25
3	14	15	26	38	54	64	73	70	68	57	42	25
4	16	13	24	38	54	64	72	71	68	55	42	26
5	18	16	24	39	55	64	72	72	67	54	42	26
6	19	19	25	42	57	64	72	71	67	53	41	25
7	18	19	25	42	56	64	72	71	65	54	40	23
8	18	18	28	41	58	65	72	72	64	55	40	24
9	17	16	31	42	59	64	72	72	64	54	39	26
10	16	19	31	41	59	65	72	70	64	56	39	28
11	17	18	30	43	58	67	73	70	63	55	39	25
12	16	17	30	45	58	70	74	69	62	55	36	25
13	17	18	28	45	57	71	73	69	61	52	35	23
14	16	20	25	45	56	71	72	70	62	51	35	23
15	18	19	25	45	55	70	73	69	63	53	35	21
16	19	18	26	46	57	70	73	69	60	52	34	22
17	17	20	30	48	59	69	72	70	60	49	34	20
18	16	19	32	49	60	69	71	71	60	48	33	21
19	16	18	31	47	59	70	72	70	60	48	31	21
20	20	18	29	47	59	69	70	70	59	46	32	23
21	17	20	31	50	59	68	72	70	61	47	33	25
22	17	20	33	50	59	68	72	69	61	47	32	24
23	14	21	34	51	61	69	73	68	60	46	29	23
24	14	22	35	50	62	70	73	68	60	47	26	22
25	16	21	35	51	61	71	73	68	60	46	28	20
26	15	21	36	53	61	69	73	68	58	46	27	18
27	14	23	33	55	60	70	74	69	57	44	27	18
28	15	24	33	55	60	70	73	67	58	45	25	18
29	17	24	35	54	62	70	72	69	57	45	25	20
30	16	......	36	53	60	71	71	68	57	44	25	18
31	15	......	37	......	60	......	72	67	......	44	......	19

NORMAL TEMPERATURES.

The normal temperatures for each day of the year, as given in Table 4, have been computed from data for 26 years, from November, 1878, to October, 1904. The highest daily normal is 74°, which occurs on both the 12th and 27th of July; the lowest, 13°, occurs on the 1st and 4th of February. There are 43 days with a normal over 70°, 175 days with a normal over 50°, and 53 days with a normal below 20°.

TERDAILY TEMPERATURES ON LOCAL TIME.

As continuous self registration of the temperature has been kept only since September, 1904, the means of the observations, which were taken at 7 a. m., 2 p. m., and 9 p. m., local time, for many years, are of some interest as showing the relative temperatures at these three hours. These means are given in Table 1; fig. 2 shows the annual curve of variation for each of these terdaily means and also for the monthly means of the maxima and minima.

DIURNAL VARIATION OF TEMPERATURE.

For the year from October, 1904, to September, 1905, the mean hourly temperatures for each hour of the day have been computed, and are shown in fig. 3. As the mean temperatures for this year at 7 a.m., 2 p. m., and 9 p. m., differed but little from the 32 years' means for these hours, it may reasonably be believed that the curve represents, with an error of less than one degree at any point, the normal diurnal curve of temperature for this locality.

COMPARISON OF METHODS OF COMPUTING MEAN TEMPERATURES.

As mean daily temperatures are quite accurately computed from terdaily observations on local mean time by the use of the formula first recommended by the Mannheim Academy in 1780,

$$\frac{1}{2}\left[9 \text{ p.m.} + \frac{1}{2}(7 \text{ a.m.} + 2 \text{ p.m.})\right] = \frac{7 \text{ a.m.} + 2 \text{ p.m.} + 2 \times 9 \text{ p.m.}}{4}$$

therefore a comparison has been made, for the past year, between the means obtained by this method and those obtained from the maximum and minimum and the mean of 24 hours. A table of these comparisons follows. As is usually well known, the means obtained by the Mannheim formula appear to be slightly closer to the true mean than are the means of the maximum and minimum. Though of course the formula does not apply strictly to observations at 7 a. m., 2 p. m., and 9 p. m., standard mean time, yet the difference between standard ninetieth meridian time and local mean time at Madison is only two minutes, while a range of twenty minutes is allowed in making observations, therefore the two series can safely be combined together.

Month.	Mean of hourly observations.	Mean of maximum and minimum.	Mean by Mannheim formula.
1904.	°	°	°
October	50.3	50.7	50.3
November	39.7	40.2	39.7
December	21.5	21.4	21.8
1905.			
January	10.8	10.4	11.0
February	12.4	11.4	12.7
March	34.4	34.4	34.4
April	44.5	44.8	44.6
May	55.4	55.4	55.6
June	66.3	66.4	66.3
July	68.8	69.2	68.8
August	70.5	70.6	70.4
September	64.4	64.8	64.2

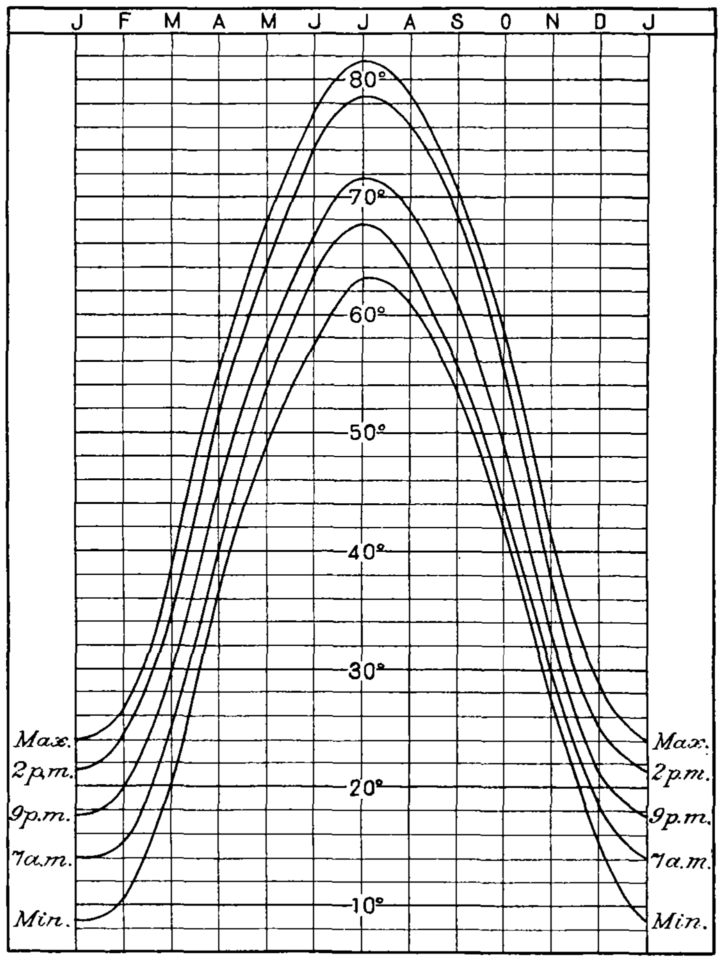

FIG. 2.—Annual curves of maximum, minimum, 7 a. m., 2 p. m., and 9 p. m. temperatures. (Average of many years.)

KILLING FROSTS.

Considering the dates of killing frosts as those on which a temperature of 32°, or lower, was recorded, it has been found that in the past 27 years the latest such frost in spring occurred on May 13, 1888, the earliest in the fall on September 30, 1883 and 1899. The average date of last killing spring frosts is April 21, and the earliest in the fall October 17. Comparing these dates for a number of years with the dates of similar phenomena at Harvey, Wis., which is directly east of Madison, away from any small lakes, but nearer Lake Michigan, it is

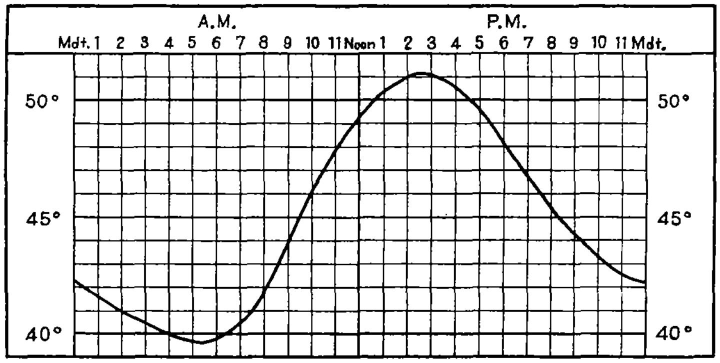

FIG. 3.—Curve showing mean hourly temperatures for one year, from October, 1904, to September, 1905, inclusive.

found that at Harvey killing frosts occur, as a rule, two weeks later in the spring and two weeks earlier in the fall. Thus the growing season is lengthened about one month at Madison, apparently by the influence of the presence of Lakes Mendota and Monona.

It is of course impossible to state exactly to what distance from these lakes their moderating influence upon the air temperature extends. With regard to the similar influence of the small lakes in the central part of the State of New York, Prof. L. H. Bailey, in The Principles of Fruit Growing, makes the following interesting statement:

> The distance to which the ameliorating influence of the water may extend is determined very largely by the conformation of the shore lands. As a rule, there are distinct slopes toward the water, and it is rare that the effect of the water upon the temperature extends beyond the crest of the elevation. As a matter of fact, when the elevation is 300 feet, or more, the region of immunity from frost ordinarily does not extend more than two-thirds of the distance to the summit. * * * The particular influence which the water exerts over injury by frost in the spring is often more due to the retardation of the period of bloom than to the actual prevention of frost, although its influence in the latter direction is important.

PRECIPITATION.

The precipitation means and extremes have been determined from data covering 36 years, 1869–1904. The average annual rainfall is a little less than 32 inches. In 1881 nearly 52 inches fell, while in 1895 only slightly more than 13 inches was collected. The greatest monthly rainfall was 9.47 inches, in July, 1881. In April, 1877, and in October, 1889, no measurable rainfall occurred. In all months except the first three falls of over 2 inches in 24 hours have been recorded, the greatest having been 4.32 inches, on July 21, 1881.

DROUGHTS.

Dry spells are of almost annual occurrence at Madison, and occasionally pronounced droughts occur. The average number of successive days without rainfall varies from 3.0 in June to 4.2 in October, the average for the year being 3.6. During 26 consecutive years, 1879 to 1904, the longest period without measurable rainfall was 34 days, from November 11 to December 14, 1888. Only a trace of precipitation occurred during the following periods: from September 30 to October 31, 1889, 32 days; January 2 to 27, 1891, 26 days; September 3 to 27, 1891, 25 days; January 29 to February 21, 1899, 24 days; April 9 to May 1, 1895, 23 days. Besides the foregoing droughts, there have been, during these 26 years, 21 periods of from 15 to 20 days without appreciable precipition. A drought of marked intensity occurred from October 11 to December 10, 1904, a period of 60 days, during which only 0.24 inch of precipitation occurred. Fortunately this was at a season of the year when it did no particular damage except through dust and the drying of the wells. A similar, though somewhat shorter, period extended from September 3 to October 16, 1905, 44 days, during which only 0.23 inch of rain fell.

RAINY PERIODS.

A rainy day, or a day with rain, is considered as one on which at least 0.01 inch of precipitation occurs during the 24 hours, 9 p. m. to 9 p. m., local time. It has been found that the average number of successive rainy days at Madison is quite constant for the various months, varying only 0.4 of one day through the year, and being greatest in May (2.0 days). The longest rainy period on record lasted ten days, from August 23 to September 1, 1880, during which rain fell every day in amounts varying from 0.01 inch to 1.42 inches. The total rainfall for this period was 4.29 inches, not a large amount, in view of the fact that 4.32 inches have fallen in a single day. By far the greater amount of precipitation occurs in single day periods. There have been, from November, 1878, to October, 1905, one period of ten successive rainy days, one of eight days, two of seven, six of six, 24 of five, and 76 of four days.

Besides the foregoing heavy rainfalls mentioned, there have been various periods extending over several days when large amounts of rain have fallen. The most important of these are as follows: May 21–27, 1903, 3.62 inches in seven days; May 6–13, 1904, 3.85 inches in eight days; May 9–16, 1905, 4.34 inches in eight days; June 2–15, 1880, 8.62 inches in fourteen days; June 2–9, 1883, 5.03 inches in eight days; June 2–5, 1890, 3.19 inches in four days; May 29–June 4, 1892, 3.47 inches in eight days; July 6–7, 1879, 4.34 inches in two days; July 20–24, 1881, 5.74 inches in five days; July 20–24, 1883, 4.37 inches in five days; July 23–24, 1884, 3.72 inches in two days; June 30–July 4, 1887, 3.92 inches in five days; July 13–20, 1900, 3.86 inches in eight days; July 16–23, 1902, 3.92 inches in eight days; August 23–September 1, 1880, 4.29 inches in ten days; August 13–15, 1882, 3.51 inches in three days; August 15–16, 1886, 3.27 inches in two days; August 22–29, 1903, 3.32 inches in eight days; September 1–6, 1887, 3.82 inches in six days; September 7–11, 1892, 3.21 inches in five days; September 8–12, 1901, 3.09 inches in five days; October 8–17, 1881, 5.88 inches in 10 days; November 8–12, 1879, 3.50 inches in five days.

The wettest spring on record at Madison appears to have been that of 1858, with a total precipitation of over 15 inches, twice the usual amount; the wettest summer, 1880, with 21.21 inches, nearly twice the average; the wettest fall, 1881, with 19.85 inches, over two and one-half times the usual amount.

SNOWFALL.

Data of snowfall, separate from its equivalent in water, have been tabulated, beginning with the year 1884. No record of snow falling in the months June to September has been found. The latest spring date of snowfall was May 31, 1889; the earliest in the fall, October 11, 1905. Months with heavy snowfall are as follows: January, 1898, 29 inches; February, 1887, 20 inches; February, 1898, 22, inches; March, 1886, 27 inches; March, 1891, 23 inches; December, 1887, 24 inches. The winter of 1885–86 witnessed the remarkably heavy fall of 76 inches; that of 1886–87, 60 inches; 1897–98, 71 inches. The winter with least snowfall was that of 1901–2, with only 4 inches.

HUMIDITY.

The readings of the wet-bulb thermometer, upon which the humidity data are based, were taken in window shelters during the years 1869–1874, 1876–1880 and 1886–1904, the thermometer being stationary. Usually the ventilation was good, but during the prevalence of light south or east winds the shelter at Washburn Observatory was in the lee of the building, in which case the readings might be appreciably affected. Steps are being taken to make such comparative readings as will give the corrections necessary to reduce the record by the still thermometer to the whirled thermometer. During the colder months, and especially with temperatures much below freezing, on frequent occasions no depression of the

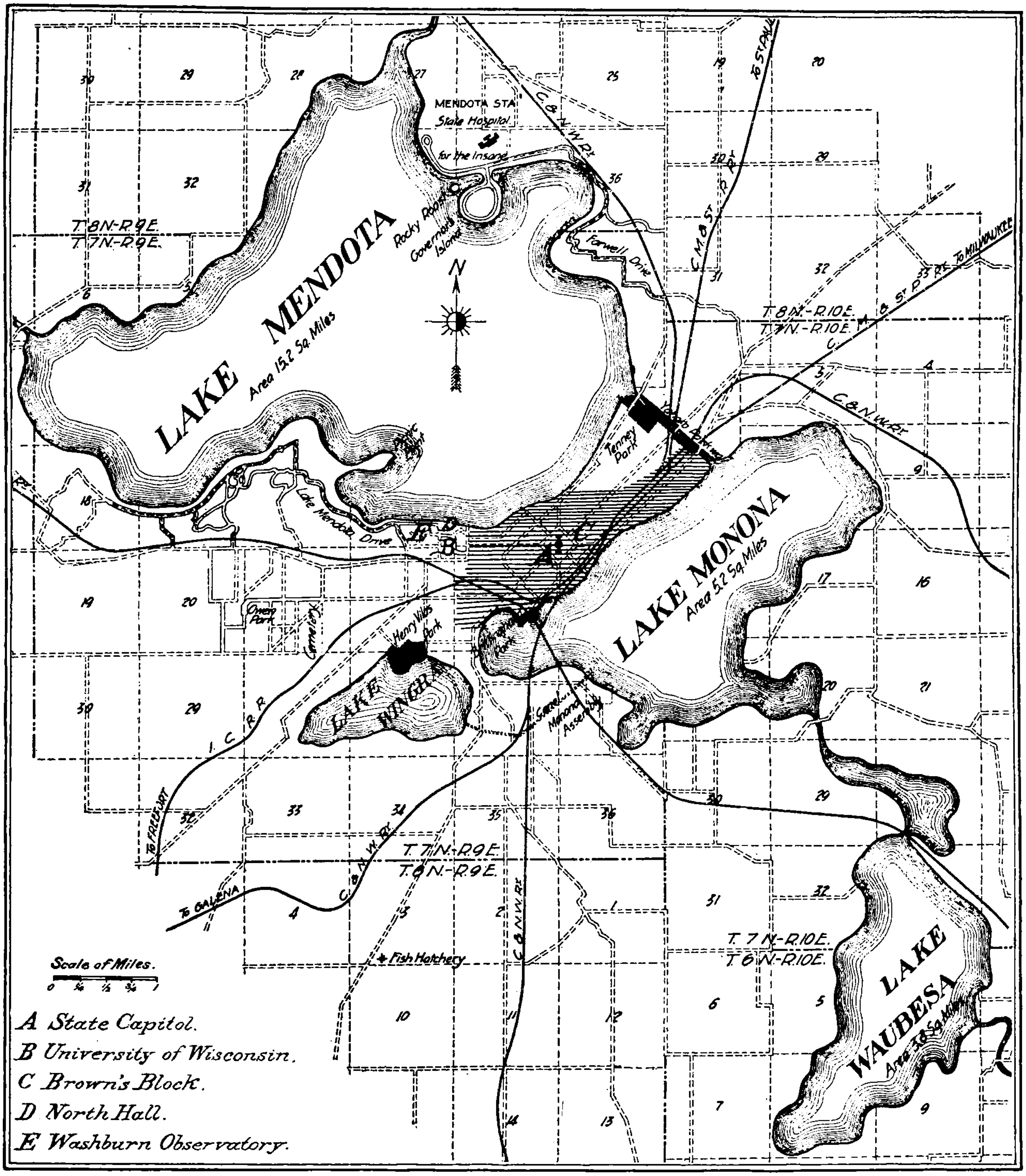

FIG. 4.—Map of Madison, Wis., showing the lakes in the vicinity and points where meteorological observations were taken. Shaded area shows main portion of city.

wet-bulb below the dry-bulb reading was obtained. It seems clear, therefore, that the humidity means computed for the winter months are somewhat too high. Curves showing the monthly means at 7 a. m., 2 p. m., and 9 p. m., respectively, derived from 30 years of data are shown in fig. 5. An apparently abnormal increase in humidity occurs in September, which may possibly be due to the peculiar moisture conditions produced by the lakes in the vicinity of Madison at that time as previously explained.

CLOUDINESS.

The mean cloudiness for each month has also been computed for 7 a. m., 2 p. m., and 9 p. m., respectively, and the annual curves for these hours have been plotted. (See fig. 6.) The cloudiness is greatest as a rule at 2 p. m. and least at 9 p. m. November and December are the cloudiest months of the year, the average cloudiness being then 60 per cent, while in July it is least—only 44 per cent. At 9 p. m. in August the mean cloudiness drops to 32 per cent, while at 2 p. m. in November and 7 a. m. in December it rises to 64 per cent. An abnormal increase in the cloudiness appears to occur in March.

WINDS.

The prevailing winds vary from northwest during November–March, to south during the remainder of the year. These

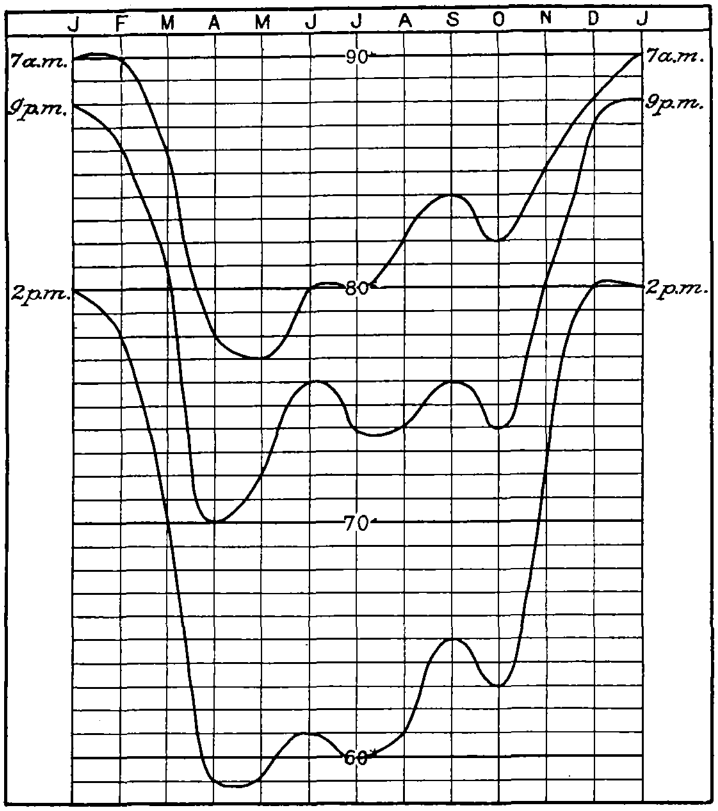

FIG. 5.—Annual curves of relative humidity at 7 a. m., 2 p. m., and 9 p. m., in percentages. (Average of 30 years.)

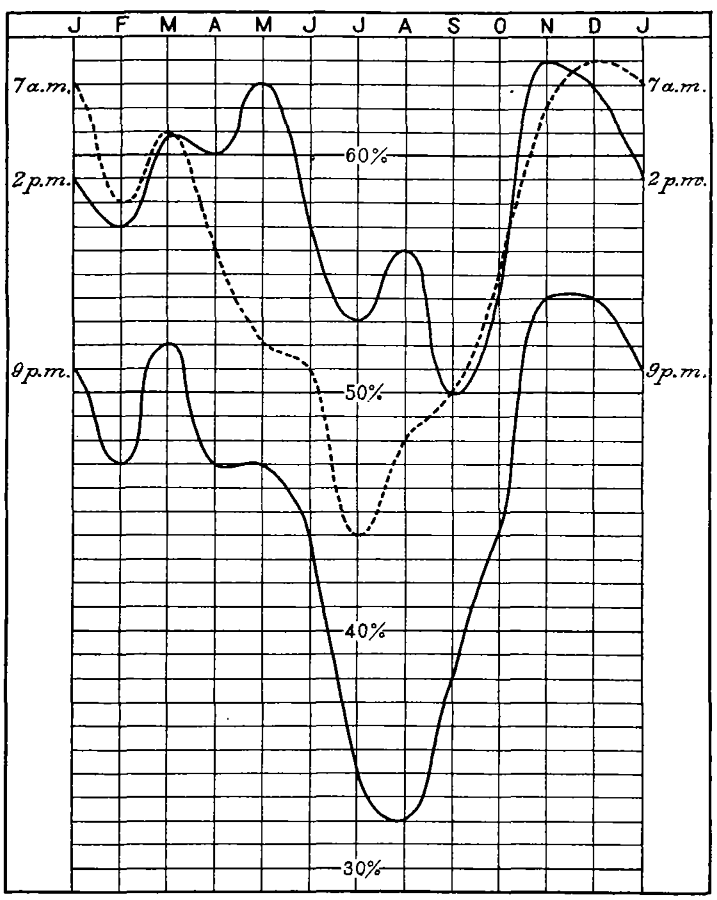

FIG. 6.—Annual curves of cloudiness at 7 a. m., 2 p. m., and 9 p. m. (Average of 26 years.)

two directions prevail nearly equally. The following table shows the number of times during the past 36 years that each direction has prevailed during the various months:

	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Variable.
January	2	1	0	0	4	8	7	14	0
February	3	0	0	0	5	4	8	16	0
March	5	1	0	0	3	1	7	17	2
April	3	3	1	3	7	6	6	5	1
May	3	5	2	3	8	7	0	5	2
June	4	0	3	2	11	10	3	2	1
July	4	0	0	3	8	11	2	8	0
August	2	1	0	0	18	5	1	8	1
September	0	1	2	0	21	7	0	5	0
October	1	0	0	3	14	8	4	6	0
November	3	1	0	1	7	4	4	15	1
December	2	0	0	1	6	5	9	12	1

TORNADO INSURANCE.[1]

By HOWARD E. SIMPSON, Instructor in Geology, Colby College. Dated Waterville, Me., December 30, 1905.

INTRODUCTION.

Much attention has been given by those interested in meteorology to the study of tornadoes, and an agreement has practically been reached as to their origin. The United States Weather Bureau goes as far as is deemed advisable in predicting from time to time "that conditions are favorable for severe local storms." All realize that the prevention of such storms is beyond human control. The little attention that is now being given to the subject is in the direction of the preservation of human life and security of property.

It is not intended that the present paper shall enter into a discussion of the relation of tornadoes to human life and safety, for the dangers have already been grossly exaggerated and the few practical means of avoiding them frequently pointed out. It is intended to show something of what has been done in the United States to afford protection by means of insurance against loss of property through tornadoes and lesser windstorms. Some conclusions will also be drawn regarding the tornado insurance business from the view point of one interested in its meteorological side.

While tornado insurance is almost unknown in some parts of the United States, or is heard of only after some particularly violent windstorm, in other portions of the country it is considered an important branch of the insurance business.

EARLY HISTORY.[2]

Little is known concerning the origin of tornado insurance, but as early as 1865 there were as many as seventeen companies organized under the laws of a single State writing this kind of insurance in connection with that of fire and lightning. In this period, however, the business was without a proper basis and has been aptly described as "The betting of stockholders' money on opinions." Another authority, as late as February, 1883, says, "It is at present only on a basis of guesswork, the business is limited, and the statistics few." Speaking further of the extent of the business and of the rates charged, the same authority gives several glimpses of its unstable character:

> Just how many companies have made a business of writing tornado risks in the West we have not ascertained, but that the business has been much more extensively prosecuted than eastern underwriters suspect is quite probable. Not less than 30 companies, and probably not more than 50, have made more or less of a specialty of tornado insurance, and with a tolerably even average of experience, leading in the same direction—that of disaster. * * * There being no guides to the business, each company ran according to its own mode of guessing, one charged one per cent for five years, another two, another six, and none could tell why this or that rate was charged.

[1] Written as a portion of the work done in the course in general climatology given by Prof. R. DeC Ward, of Harvard University, during the year 1904-5.

[2] The author is indebted to the Insurance Monitor, February to September, 1883, for many data regarding the early history of tornado insurance.