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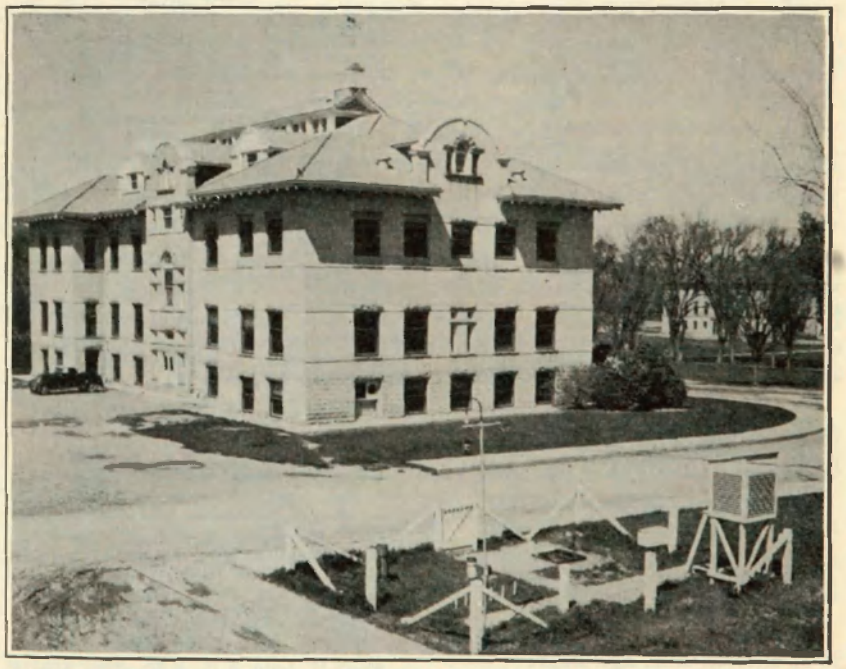
Analysis of Fifty Years' Record of METEOROLOGICAL DATA Taken at the Colorado Experiment Station, Fort Collins, Colorado

Maxwell Parshall



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Analysis of Fifty Years' Record of Meteorological Data

MAXWELL PARSHALL*

THE PURPOSE of this brief meteorological discussion is to present summaries and conclusions based on the continuous weather records taken at the Colorado Experiment Station over the past half-century. The importance of weather is recognized by both the scientist and the layman, and for this reason the data here presented are believed to be useful not only to those engaged in agricultural research but to the farmer as well.

During the late 1870's the value of meteorological data in relation to agriculture in northern Colorado was recognized, and independent observers made records, principally of precipitation, at Fort Collins. Early in 1886 there was organized the Colorado Meteorological Association with a scattered group of members who acted as volunteer observers in the interest of the public welfare. The first bulletin of this association was issued by F. H. Loud, director of observations, Colorado College Meteorological Observatory, Colorado Springs, Colo., May 25, 1886. This first issue was for the month of April 1886. An act was passed by the Colorado General Assembly, effective July 1, 1889, creating the Colorado Weather Service under the authority of the State Board of Agriculture. Monthly bulletins of the Colorado Weather Service continued to be issued at Colorado Springs in cooperation with the United States Signal Service, and later these monthly reports were compiled and distributed from the central office at Denver. The May 1891 bulletin, Colorado Weather Service, was issued in cooperation with the Weather Bureau, United States Department of Agriculture.

Special studies of meteorological phenomena, principally those of evaporation from a free water surface, were started at the Colorado Experiment Station by the late Prof. L. G. Carpenter in 1887. These data are still being recorded. This evaporation record is believed to be outstanding in point of time and continuity. In connection with these special studies, there was established in April 1890 a rather complete meteorological station where continuous daily records of the weather have been recorded to date. Over this period of years the meteorological plot has occupied three different locations on the campus of Colorado State College, the present location being shown on the cover of this bulletin. The weather data have been faithfully observed by several experienced observers. Mr. Robert E. Trimble, with few exceptions, recorded the weather data at this Station for the period April 1892 to June 1936.

*Colorado Experiment Station meteorologist.

Observations

The data collected at this Station are observed twice daily, at 7 a. m. and 7 p. m., and consist of maximum and minimum temperatures, terrestrial radiation temperature, soil temperatures, relative humidity, dew point, barometric pressure, wind direction and total wind movement, precipitation, character of the day, and unusual phenomena. The evaporation loss from a free water surface is measured from about April 1 through October, or until such time as freezing prevents further observations. Graphic records are also made of temperature, barometric pressure, hours of sunshine, wind direction, and wind movement.

The meteorological instruments used at this Station are of standard design approved by the United States Weather Bureau and are checked against accurate standards from time to time to insure accurate and dependable records. For the most part thermometers are replaced when found to be in error instead of applying instrumental corrections. All temperatures taken at this Station are measured in degrees Fahrenheit.

The maximum and minimum temperatures are measured by self-registering thermometers placed in a standard instrument shelter about 6 feet above the ground surface. The mean temperature is calculated as the average of the maximum and minimum temperatures. Terrestrial radiation temperature is measured by a self-registering minimum thermometer of special design, placed 6 inches above the ground surface and fully exposed. Soil temperatures are measured with long-stemmed mercurial thermometers at depths of 3, 6, 12, 24, 36, and 72 inches. An Assman electric-driven psychrometer of special design is used for the determination of the dew point and relative humidity. The barometric pressure is measured indoors with a mercurial barometer, and the readings are corrected to a standard temperature of 32°. A four-cup Robinson-type anemometer, mounted on a building at an elevation of 67 feet above the ground (see cover), is used to determine the wind movement in miles, and a 6-foot wind vane to indicate direction. The velocity and direction of the wind, together with the duration of sunshine, are registered electrically on the chart of a quadruple recorder. The precipitation is measured by means of a standard 8-inch rain gauge, fully exposed in the meteorological plot. In the event that the precipitation occurs as snow, an 8-inch rain gauge with the top removed is used for this measurement. The character of the day is recorded as clear, partly cloudy, or cloudy, on the basis of the cloud cover at observation time and at noon. Other features are recorded—such as time of beginning and ending of precipitation, frosts, dew, and other unusual phenomena.

The evaporation loss from a free water surface is measured by means of a micrometer hook-gauge reading to 0.001 inch. The evaporation tank, known as the Colorado sunken-pan type, is of 16-gauge galvanized iron, 3 feet square and 3 feet deep, with the top edge supported by a 1-inch angle iron around the outside. The tank is lined with 14-ounce copper sheet and is set in the ground with the top edge exposed 3 inches. The evaporation data also include maximum and minimum temperatures and temperature of the water at time of observation; also, wind movement over the water surface as indicated by a four-cup Robinson anemometer placed 1 foot from the tank with the cups 18 inches above the water surface. The water surface does not vary more than 1 inch and is maintained about 2 inches below the rim of the tank.

The maximum and minimum temperatures are recorded as the highest and lowest air temperatures in the instrument shelter during the day. The day for the purpose of recording is the 24-hour period starting at 7 p. m. of the previous date. The mean temperature for the day is taken as the average of the maximum and minimum temperatures over the 24-hour period and contains no smaller element of time; thus, this mean value, so calculated, may be in error depending upon the time of duration of either the maximum or minimum temperatures throughout the day.

Terrestrial radiation is measured as the difference between the minimum air temperature taken in the instrument shelter and the minimum air temperature observed at a point 6 inches above the ground surface under fully exposed conditions. Because of the greater density of the cooler air, the temperature near the ground surface will be lower than that observed in the shelter, which may be due in part to the lag in the air temperature within the shelter, and also to the heat capacity of the materials from which it is constructed. Unusual conditions, however, are sometimes observed, showing that at the ground surface the minimum air temperature is higher than that observed in the instrument shelter. This terrestrial radiation temperature is found useful as an indication of frost where there is no evidence of freezing within the meteorological plot or immediate vicinity at the time of observation.

If a stream of air is passed over a water-saturated muslin covering around a thermometer bulb, evaporation occurs at a rate depending upon the amount of water vapor in the air and its temperature. When water evaporates, energy is absorbed by the water vapor, some of which is taken from the mercury in the thermometer; hence, the temperature of the wet bulb thermometer is reduced. The air stream passing at the same time around a dry bulb of a thermometer is unaffected, provided its velocity is low, and the thermometer indi-

cates the temperature of the air. From the dry bulb temperature and the difference between the wet and dry bulb temperatures, the dew point and relative humidity of the air can be found by referring to psychrometric tables. The dew point is that temperature to which the air, as examined, must be cooled to cause water or ice to condense from it. Relative humidity is the ratio of water vapor in the air to the maximum amount that can be retained at any particular temperature, and is usually expressed in percent. When considering a definite air temperature, the greater the difference in the readings between the wet and dry bulb thermometers, the lower are both the dew point and relative humidity.

Barometric pressure indicates the weight of air over the station. This pressure, together with its trend, is in some cases an indication of the type of weather to be expected during the immediate future.

Evaporation measurements are made from a free water surface primarily for the purpose of establishing the relation between the loss of water and such other meteorological factors as the temperatures of the air and water, vapor pressure of the air and water, and wind movement over the water surface. The basis for calculating the evaporation losses from the surfaces of lakes and reservoirs under varying conditions of exposure is thus better established.

Records

Fifty years of weather records, based on observations taken by the several meteorologists of the Experiment Station, are available with few exceptions. The greatest use of these data, especially that of precipitation, would be the analysis indicating definite cycles other than the yearly cycle which is readily apparent. Such an analysis would be valuable to the farmer in anticipating years of sufficient precipitation to produce crops without irrigation. Unfortunately, however, cycles in the precipitation data, as collected at this Station, cannot be demonstrated to an extent of justifying a basis for long-time forecasting. Extensive study of the several meteorological elements relative to precipitation fail to show good correlation, and calculation of the statistical constant "G"* for precipitation by years shows almost exact random distribution. When the 5-year moving mean is applied, cycles are indicated which are, in all probability, false because of the great variability of the data.

The average size of storm, based on 48 years of precipitation records, together with the chance for precipitation to occur on any particular day during the year, were calculated. Trace storms, that is, where the precipitation was less than .01 inch, were used both in the "average" and the "chance" calculations. These determinations

*For explanation of constant "G", see a standard work on statistics.

are shown in graphic form only (fig. 1). As an example, on January 13, the least chance for precipitation occurs for the year, and is 0.042 or about once in 25 years, while for the greatest chance it is 0.605 or about 3 years out of 5, on May 31. Therefore, the chance of precipitation occurring on any particular day during the year will vary between the limits of once in 25 years to 3 out of 5 years. The average size of daily storms, over this period of 48 years, varies from a minimum of 0.002 inch on December 28 to a maximum of 0.746 inch on September 21. By this comparison the question arises immediately as to why the precipitation for the month of September is not greater than that for May. This is due to the fact that the average chance for rain is much greater in May than in September, in the ratio of 0.451 to 0.265, and further because the average size of storm for these 2 months in inches is 0.204 and 0.181, respectively.

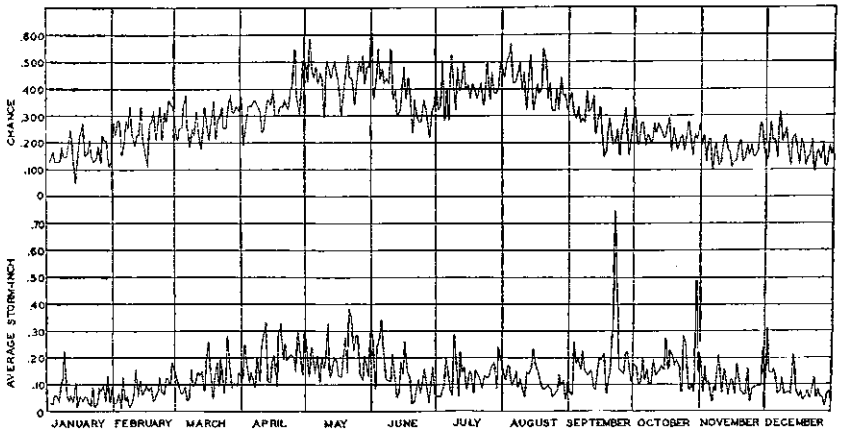

Figure 1.—Average daily chance for precipitation and storm size at the Colorado Experiment Station, Fort Collins.

The largest average monthly storm size and greatest chance for precipitation both occur in May, and the smallest average monthly storm is in January, with the least average chance for precipitation occurring in November. It is therefore apparent that the smallest and least frequent are snow storms during the colder part of the year, while the larger and more frequent are rain storms during the spring, summer, and fall months of the year.

The diagram illustrating the chance for precipitation and average storm size (fig. 1) should be helpful to the farmer in selecting the date of spring planting; also it should have application in selecting the date of outdoor exhibitions, to prevent, as far as is possible, loss in attendance due to stormy weather.

The average daily maximum and minimum temperatures, based upon daily records extending over a period of 48 years, are shown in graphic form (fig. 2). It will be noted that the highest average maximum temperature (85.9°) occurs on July 26, or 35 days after the longest day in the year, and the lowest average minimum temperature (9.6°) occurs on both January 1 and 12, or 11 and 23 days respectively after the shortest day in the year. The air temperature falls more rapidly than it rises, which is, no doubt, due chiefly to the fact that most of the year's precipitation occurs during that part of the year when the mean temperature is rising. The range of temperature is quite constant and appears to be independent of the time of year.

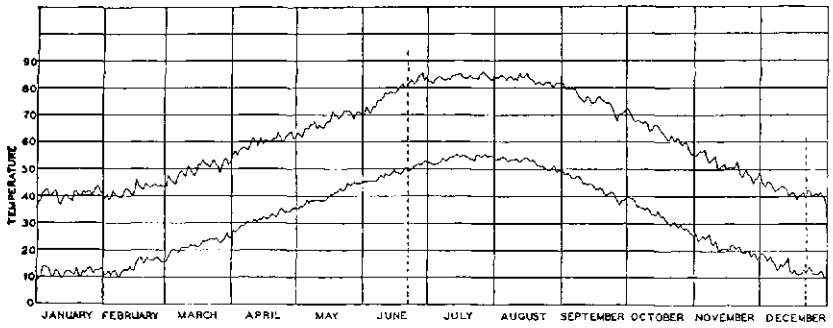

Figure 2.—Average daily maximum and minimum temperatures at the Colorado Experiment Station, Fort Collins.

The fact that the largest average storm size falls on September 21, followed 5 or 6 days later by a temperature irregularity, may indicate that the period of the autumnal equinox has some bearing or influence upon the condition of the weather. However, a similar situation does not exist, especially with regard to storm size or chance for precipitation, near March 21, the vernal equinox, and it is therefore doubtful whether the periods of the equinoxes have any effect upon the state of weather.

Table I is the monthly precipitation record at Fort Collins, Colo. The record for the period 1872-1887 was taken by several members of the college faculty in various departments, and 1 year's record was taken by the late Mr. R. Q. Tenney, a private citizen. The subsequent record was taken, as stated before, by the Colorado Experiment Station staff, chiefly by Mr. Robert E. Trimble. The monthly and yearly averages are based on the 50 years' complete record 1887-1936, inclusive.

Table II shows the daily maximum temperature extremes and table III the daily minimum temperature extremes over the period

1887-1937. The monthly record extremes in both cases are identified as to the year in which they occurred.

Table IV shows the average daily mean temperature as calculated over the 50-year period, 1887-1936.

Table V shows frost dates and growing period, 1889-1937. In many cases frost was not recorded, which for a particular day may have occurred during the night; hence, these dates of frost were taken from terrestrial temperatures. Any observed terrestrial temperature below 32° was used as an indication that frost had occurred. For this limit any crop will be reasonably safe from freezing during the growing period indicated, and for the more hardy field crops, the growing period will be much longer. In this locality very tender crops, such as tomatoes, may be damaged at a temperature of 32°, or slightly above, as indicated by the terrestrial radiation thermometer, because evaporation from leaf surfaces could under some conditions lower the temperature below the freezing point. Thus it cannot be assumed that all crops will be absolutely safe from freezing at an indicated air temperature of 32°.

The latest spring frost on record over this 49-year period, though not a killing frost, was June 20, 1895, and the earliest fall frost, also not considered destructive, was August 22, 1904. This record indicates a possible minimum growing period of only 63 days at Fort Collins, at an elevation of 5,000 feet, while the maximum growing period is found to be 161 days, May 1 to October 9. The average frost-free growing period is 120 days.

From an examination of table III, extreme minimum temperatures, it will be noted that May 24 is the earliest spring day on which the minimum temperature, as recorded in the instrument shelter, has never been below 32° during the 50-year period, and September 5 is the last day in late summer when the minimum temperature in the instrument shelter has never reached the freezing point. Based on this record, the growing period is 105 days, although frosts have occurred, as stated before, later in the spring and earlier in the fall than shown for these limiting dates of May 24 and September 5.

The growing period of a single year may vary greatly as to locality because the limiting frosts are usually restricted to small local areas. It has been observed that parts of a field have been damaged by frost, while other places in the same field have escaped injury entirely.

Table VI shows the average monthly and yearly temperature, average monthly and yearly precipitation, and the average monthly and yearly barometric pressure, together with their standard deviations. Monthly and yearly median values for precipitation are also shown. Because of the opinion that storms of less than 0.50 inch of

precipitation in 24 hours are of little value to agriculture, the number of such storms per month is given for the 50-year period.

Monthly and yearly averages of relative humidity, dew point, terrestrial radiation, and soil temperatures are also shown. No standard deviations were calculated for these data. The recorded values of the dew point and relative humidity are not representative of conditions existing over the whole day, because they are the average of the 7 a. m. and 7 p. m. observations.

Average soil temperatures are not strictly comparable because different periods are lacking in the records for the various depths. For example, the 47 years' record at 6 inches is not the same 47 years recorded for 1 foot. However, all records were used in computing the averages. The maximum variation over the year and the length of record is given for each series of data, as well as the maximum variation of temperature of the soil as related to depth.

The standard deviation simply expressed shows that for 2 out of 3 years the temperature and other data considered will vary between the limits of the average plus or minus the standard deviation, and 1 out of 3 years these same data will vary more than the average, plus or minus the standard deviation. These variations will be greater than the average, plus or minus twice the standard deviation, in only 1 out of 25 years.

Evaporation records are not fully prepared and thus are not included in this discussion.

When the barometric pressure is low in Colorado, the temperature is usually above the average. If the air is of relatively high moisture content and if the temperature of the air mass is lowered to the dew point or below, precipitation will occur as the temperature falls. The pressure usually rises while precipitation is occurring. If, however, the air mass is warm and of low moisture content, rising barometric pressure and falling temperature are accompanied by wind of abnormally high velocity and little or no precipitation. At this Station, these winds are from the northwest. A low barometric pressure must be referred to the average for the particular time of year because the average pressure varies from month to month. Summer precipitation is not closely related to barometric pressure changes because most of it occurs as local thundershowers.

Acknowledgment

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Maxwell Parshall
October 1939

TABLE I.—*Monthly Precipitation, in Inches, at Colorado Experiment Station, Fort Collins.*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1872	....	....	....	....	....	....	....	....	....	....	.02	.20	....
1873	.25	.16	.00	1.20	2.30	1.50	1.30	.85	.75	.42	.20	.17	9.10
1874	.06	.43	1.29	.77	2.95	.65	3.15	.25	.00	1.00	.02	.00	10.57
1879	....	....	....	....	....	....	....	....	....	1.75	.15	.60	....
1880	.72	1.09	.38	.94	.60	.86	1.80	.37	1.47	2.07	1.10	.10	11.50
1881	1.10	.55	1.45	....	....	....	....	....	....	....	....	....	....
1882	....	....	.17	....	4.67	3.07	1.76	.89	2.51	.82	.29	....	....
1883	1.00	1.50	.68	....	2.51	3.18	....	1.78	1.00	1.29	T	1.33	....
1884	1.10	.70	1.15	3.94	4.84	....	....	....	....	.10	1.80	.35	....
1885	1.77	....	....	....	....	....	....	....	....	....	....	....	....
1886	....	....	....	....	....	....	....	....	....	.69	1.18	.33	....
1887	.86	.23	.45	1.10	1.23	1.93	3.05	2.12	.54	.43	.15	.00	12.12
1888	.29	.36	.73	1.23	3.39	.47	.60	1.01	.29	.88	.38	.16	9.79
1889	.21	.34	.65	2.07	3.39	2.06	.79	.95	.42	3.16	.42	.02	14.48
1890	.13	.21	.22	3.92	1.19	.12	1.27	3.14	.07	.70	.32	.12	11.41
1891	2.32	.15	1.21	2.14	4.07	1.30	.17	2.06	1.02	.20	.60	.46	15.70
1892	.60	1.29	1.52	1.60	4.83	2.42	1.32	.22	.14	.93	.23	.35	15.45
1893	.02	.54	.14	1.66	1.92	.26	.64	.92	.18	.16	.55	.12	7.11
1894	.25	.60	.67	.89	3.09	.42	1.72	1.53	2.29	.00	.14	.76	12.36
1895	.24	1.52	.54	1.36	3.62	3.65	3.75	1.45	.47	1.06	.40	.01	18.07
1896	.43	.03	1.73	1.26	1.68	3.05	3.05	2.20	1.55	.49	.05	.24	15.76
1897	.18	.54	2.15	1.39	2.06	1.69	2.65	1.74	.75	.75	.67	.67	15.24
1898	.14	.08	.50	1.08	3.65	1.37	.50	.98	.50	.82	1.24	.17	11.03
1899	.66	1.04	1.50	1.10	1.01	1.03	4.95	.99	.21	3.23	.00	.47	16.19
1900	.25	1.12	1.07	10.56	1.75	.82	1.14	.16	1.92	.24	.07	.11	19.21
1901	.19	.38	1.88	3.62	7.47	2.35	.71	.72	2.10	.30	.02	1.37	21.17
1902	.32	.15	1.50	.61	2.13	2.43	1.31	.67	7.12	1.15	.27	.77	18.43
1903	.16	1.60	1.03	1.50	.63	2.23	1.06	.86	.87	1.70	.18	.07	11.89
1904	.04	.34	.51	.89	5.37	1.68	1.99	.71	1.09	.39	.00	.12	13.13
1905	.29	.35	1.75	6.32	4.13	.64	2.18	1.25	.28	2.60	.07	.00	19.86
1906	.01	.03	2.44	4.30	2.40	1.80	1.96	.80	3.08	1.59	1.35	.12	19.88
1907	.23	.36	.69	2.80	2.44	.44	2.28	1.27	.58	.08	.44	.03	11.64
1908	.11	.03	.28	.05	5.83	1.16	3.66	2.12	.54	1.78	1.06	.60	17.22
1909	.02	.90	3.35	1.34	1.06	2.59	1.98	1.45	2.10	.08	.79	.58	16.24
1910	.29	.16	.06	.42	4.75	1.04	.87	1.92	1.79	1.03	.11	.48	12.92
1911	.34	1.52	.05	1.89	.72	1.78	1.47	.59	.80	.93	.43	.37	10.89
1912	.37	1.65	1.79	.90	2.84	2.43	2.93	1.26	2.66	2.03	.59	.21	19.66
1913	.30	.94	.20	1.49	2.09	.15	2.63	.41	2.39	1.00	.17	4.08	15.85
1914	.35	.30	.87	3.23	2.73	2.01	1.68	1.27	.02	1.58	.12	.15	14.31
1915	.12	1.41	1.73	4.01	3.78	1.90	2.12	1.56	2.97	1.97	.10	.82	22.49
1916	.84	.11	.31	.86	3.85	.60	.65	.71	.70	2.92	.98	.62	13.15
1917	.40	1.04	.99	1.22	5.86	.03	1.19	1.21	.45	.62	.40	.31	13.72
1918	.41	1.05	.14	3.72	2.95	1.18	4.83	1.91	3.23	.71	.90	.76	21.79
1919	.00	.30	1.65	.93	.45	.10	.64	.61	2.61	1.93	1.22	.39	10.92
1920	.54	.64	.14	3.60	1.95	.60	.58	1.72	.60	.50	.24	.54	11.65
1921	.96	.19	.13	1.71	1.97	3.66	1.40	2.55	.68	.37	.32	.89	14.83
1922	.35	.53	.36	2.80	.87	1.03	.80	.73	.02	.74	1.44	.31	9.98
1923	.19	1.39	2.74	2.18	4.46	6.23	4.50	.62	1.36	3.55	.10	.25	27.57
1924	.51	.54	1.83	.93	3.90	.22	.21	.05	.84	.78	.09	.74	10.64
1925	.27	.09	.58	.10	1.18	1.50	1.85	1.32	1.96	3.26	.89	1.50	14.50
1926	.25	.28	1.54	2.99	1.76	1.58	.93	.86	1.03	1.15	.36	.83	13.56
1927	.04	.40	1.87	2.69	.91	2.17	2.19	2.10	1.10	1.05	1.00	.25	15.77
1928	.26	.52	1.38	.98	3.35	2.73	.83	.69	.09	1.50	1.15	.06	13.54
1929	.21	.70	1.78	2.37	1.08	.64	.46	2.35	2.13	.99	.93	.09	13.73
1930	.45	.07	.70	.56	4.08	1.50	1.00	5.45	.16	.36	.70	.14	15.17
1931	.00	1.26	.41	1.07	2.55	1.50	.10	.78	.40	1.00	.63	.18	9.88
1932	.08	.48	1.09	.88	2.14	1.11	2.15	3.68	.01	.34	.34	.49	12.79
1933	.16	.13	.60	1.91	4.56	.05	.71	4.34	2.10	.00	.06	1.03	15.65
1934	.01	1.11	.71	1.41	1.92	1.25	1.33	.28	.79	.00	.06	.00	8.87
1935	.07	.89	.21	1.24	6.71	.62	1.14	.50	3.29	.62	.66	.00	15.95
1936	.04	.39	.71	1.17	1.10	2.90	.95	1.46	1.11	1.38	.18	.38	11.77
1937	.36	.53	1.14	2.23	1.48	1.94	1.18	.63	.09	.71	.56	1.52	12.37
Average-1887-1936	.32	.61	1.02	2.00	2.86	1.53	1.66	1.40	1.27	1.10	.47	.46	14.70

TABLE II.—*Daily Maximum Temperature Extremes at Colorado Experiment Station, Fort Collins, 1887-1936.*

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	64.6	65.0	71.0	75.2	86.0	88.3	91.8	90.6 (1902)	92.6	88. (1887)	78.	67.0
2	62.7	71.9	71.0	77.	81.8	87.7	96.6	98.2	89.8	84.0	77.	62.7
3	66.3	66.6	72.6	74.0	80.0	87.2	94.4	99.2	93.8	84.2	75.7	61.0
4	67.3	67.8	70.7	78.	84.6	88.4	95.4	96.6	89.1	86.8	74.0	68.0
5	67.8	66.7	76.1	72.6	88.3	89.8	97.2	94.	94.6	85.0	74.9	63.0
6	61.3	62.2	67.	79.2	86.	92.	97.	97.	91.2	85.3	79.1 (1934)	59.9
7	60.5	64.1	72.4	83.	85.3	93.2	94.8	97.	91.9	84.4	74.1	62.0
8	66.1	68.8	68.	79.9	90.0 (1895)	86.8	95.0	97.3	90.	82.2	74.2	62.9
9	60.7	62.8	71.1	76.4	87.8	94.2	94.0	93.8	92.1	84.7	69.8	71.0 (1933)
10	67.0	67.0	76.9	80.0	86.	93.7	95.0	93.6	92.0	83.2	75.3	67.6
11	66.0	65.3	76.	79.0	82.9	95.0	99.	93.4	91.8	80.8	72.3	64.8
12	60.8	68.	74.9	80.2	82.6	92.9	95.	93.4	89.5	83.1	75.0	64.1
13	64.2	66.3	74.	84.	83.0	91.0	97.6	94.5	94.0	80.0	71.8	65.3
14	65.0	68.0	76.2	84.	86.6	94.3	97.3	95.5	93.0	81.0	74.0	70.0
15	63.2	61.	72.	83.	85.6	91.0	101.7 (1925)	96.4	89.2	80.2	75.	66.6
16	63.3	66.	75.7	82.	86.0	90.4	98.0	97.0	95.0 (1895)	80.8	70.2	57.8
17	63.2	65.	80.	83.	86.1	90.9	96.0	95.0	93.5	88.0	73.7	60.4
18	64.0	63.5	81.0 (1921)	82.	88.7	99.8 (1936)	98.1	92.6	93.7	81.9	69.4	58.3
19	69.0	66.2	79.3	79.	88.0	94.0	96.8	94.7	87.3	78.1	75.6	61.6
20	58.8	65.0	80.3	86.	90.0	93.4	96.5	93.1	90.2	78.8	70.8	64.7
21	59.4	67.0	78.8	91. (1888)	88.0	95.2	96.0	95.6	88.1	82.8	71.2	66.1
22	60.9	67.8	79.9	87.	86.6	94.2	97.4	94.0	88.3	76.6	66.2	68.9
23	62.6	65.8	71.0	83.	86.5	93.0	96.0	94.4	90.5	79.8	67.0	69.5
24	64.1	65.3	75.8	76.4	87.0	96.0	94.2	94.0	84.6	80.7	67.0	62.2
25	68.0	69.7	75.0	81.9	85.0	96.	97.0	93.5	90.0	77.3	70.0	63.7
26	71. (1888)	66.6	71.5	86.2	85.5	94.9	99.9	94.0	87.9	78.6	65.8	60.3
27	70.	74.2 (1932)	80.2	85.2	89.3	94.0	96.8	93.0	90.0	78.8	71.0	60.2
28	69.	70.	71.1	86.4	89.3	97.2	96.2	95.2	86.7	78.9	75.4	66.8
29	67.	(61.9)	76.9	82.	87.0	95.0	94.2	95.6	89.3	76.9	69.5	63.0
30	70.	....	78.3	80.	84.4	95.1	94.1	94.4	88.9	76.8	71.8	61.2
31	68.	....	79.	....	90.	....	97.	93.5	....	77.	....	65.7
Highest Temperature	71.	74.2	81.0	91.	90.0	99.8	101.7	99.6	95.0	88.0	79.1	71.0

TABLE III.—*Daily Minimum Temperature Extremes at Colorado Experiment Station, Fort Collins, 1887-1936.*

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	-21.7	-18.3	-20.1	7.2	19.2	30.8	40.7	43.0	37.1	27.5	3.4	2.6
2	-18.4	-23.0	-11.0	-3.0	24.3	30.0 (1919)	43.0	43.0	37.0	24.6	3.5	-5.1
3	-18.0	-18.0	-7.0	8.0	23.0	30.3	41.0	44.9	34.3	29.5	8.6	-6.7
4	-15.9	-31.4	-13.1	-4.0 (1920)	23.4	35.4	36.0 (1903)	46.1	37.0	24.0	8.0	-15.0
5	-20.8	-31.6	-4.9	16.8	27.8	31.3	41.7	45.0	33.5	15.7	1.0	-19.1
6	-26.0	-38.3	-3.2	9.2	12.1 (1917)	32.5	38.8	44.	31.	19.9	8.8	-5.6
7	-29.5	-32.0	-12.2	17.6	23.6	31.6	40.0	44.	29.7	23.7	5.1	-18.3
8	-25.8	-31.4	-7.2	8.8	31.0	36.2	44.0	45.0	30.1	22.	6.8	-10.8
9	-23.0	-21.4	-27.5 (1932)	11.6	24.2	34.5	43.0	46.0	28.0	16.3	-9.7	-35.2 (1919)
10	-15.2	-31.6	-19.6	16.8	25.0	35.0	44.0	45.9	31.0	17.8	-11.3	-11.4
11	-28.4	-29.7	18.7	5.1	26.6	37.0	45.6	46.1	27.5	21.3	-6.8	-23.2
12	-16.2	-38.4 (1899)	-24.4	9.1	28.7	40.1	42.0	45.2	22.0	20.5	-11.0	-29.7
13	-22.3	-26.8	-6.4	17.8	29.2	31.8	44.0	45.8	27.1	19.5	-21.1 (1916)	-19.0
14	-16.	-22.6	-8.8	7.6	22.3	39.1	47.4	45.8	26.1	19.8	-13.0	-14.0
15	-28.	-28.0	-18.0	16.0	27.7	36.3	45.4	47.2	26.0	23.8	1.1	-17.5
16	-17.	-23.4	-4.8	21.2	26.1	39.4	44.2	38.3	28.0	19.3	-3.1	-17.6
17	-38.5 (1930)	-18.0	-19.7	8.7	28.4	40.3	46.9	44.8	28.0	19.3	-6.2	-9.4
18	-23.8	-8.2	-9.2	12.5	27.4	33.8	47.3	45.3	30.0	21.0	-10.0	-13.4
19	-26.6	-13.0	-24.6	23.9	27.0	33.0	43.0	43.2	30.8	18.1	-4.0	-23.4
20	-17.0	-14.	-7.9	21.0	28.2	36.5	38.9	42.4	30.0	17.5	-9.3	-21.3
21	-32.2	-11.2	-12.1	5.7	29.2	38.8	44.8	42.	27.4	14.6	-2.0	-17.3
22	-19.0	-17.3	-2.0	14.8	29.0	38.9	43.2	36.7	25.5	16.5	-9.4	-15.1
23	-14.1	-12.2	-7.0	20.1	29.2	38.6	47.0	37.6	27.0	16.	-12.8	-9.0
24	-22.0	-11.3	2.5	21.8	34.0	38.8	46.4	39.7	28.8	11.	-7.8	-16.5
25	-10.3	-12.6	4.0	21.1	33.7	39.6	45.0	31.7 (1910)	20.1 (1926)	13.	-3.8	-10.0
26	-31.4	-10.0	-2.8	13.4	35.7	40.2	45.0	33.2	25.3	11.8	-12.	-13.2
27	-26.0	-20.0	-24.5	25.0	34.8	41.5	48.0	39.2	23.4	14.8	-13.	-16.0
28	-19.7	-19.0	-16.7	21.0	33.1	39.8	45.0	40.1	28.3	12.5	-14.4	-24.0
29	-24.2	(-14.3)	4.0	20.3	34.9	41.0	45.3	33.9	23.0	-7.4	-9.4	-8.0
30	-16.3	.... ..	-7.5	5.7	32.2	42.0	43.0	34.5	26.5	4.2	-4.9	-14.0
31	-16.8	.... ..	-8.9	.... ..	33.4	.... ..	42.5	36.0	.... ..	-8.0 (1905)	.... ..	-22.3
Lowest Temperature	-38.5	-38.4	-27.5	-4.0	12.1	30.0	36.0	31.7	20.1	-8.0	-21.1	-35.2

TABLE IV.—*Average Daily Mean Temperature for the Period 1887-1936 at Colorado Experiment Station, Fort Collins.*

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1	24.6	24.7	29.6	41.6	49.3	57.9	67.3	68.7	65.3	56.0	40.8	32.4
2	24.3	25.9	33.3	41.8	49.5	59.0	67.2	68.8	63.3	55.0	39.4	31.6
3	27.7	25.5	32.7	41.1	48.9	58.3	66.6	69.2	64.1	54.1	40.6	30.6
4	28.1	25.1	32.6	42.6	50.8	58.2	67.4	69.3	63.7	52.8	40.9	30.9
5	28.4	27.0	32.1	43.4	51.9	59.2	68.0	69.2	63.3	51.8	40.8	31.7
6	26.5	26.1	33.1	43.4	51.0	59.3	68.2	68.4	63.1	52.1	39.4	29.8
7	25.3	25.4	33.8	43.7	52.2	60.7	68.4	68.4	63.1	51.5	39.0	28.6
8	26.0	24.7	35.4	43.6	52.2	61.6	68.3	68.7	61.9	51.1	37.8	27.9
9	27.5	25.7	34.7	44.5	53.0	61.3	68.0	68.3	61.1	51.2	37.5	27.8
10	26.0	27.2	33.8	46.0	51.7	61.8	68.7	68.5	60.2	51.2	38.8	29.1
11	23.4	27.6	35.9	45.9	52.2	63.5	69.6	68.2	59.8	49.1	35.0	28.9
12	23.9	27.6	36.0	45.1	51.9	62.6	69.7	68.9	60.4	48.6	35.2	29.3
13	25.2	27.7	34.9	45.7	51.6	63.2	69.7	68.7	60.3	49.7	35.8	27.1
14	26.9	26.2	35.0	46.5	52.9	63.6	70.2	69.0	59.7	50.0	36.1	26.6
15	25.6	27.2	34.8	45.8	53.7	63.7	69.9	69.8	58.9	50.1	35.2	26.5
16	25.3	30.9	36.7	46.2	54.1	63.3	69.7	68.3	58.5	48.1	35.2	26.6
17	24.6	30.5	37.0	45.8	55.7	64.0	69.5	68.3	59.5	48.2	36.2	25.4
18	26.7	30.3	38.3	46.1	55.9	64.2	68.7	68.1	60.0	46.9	36.1	25.6
19	27.5	28.8	37.6	47.0	55.5	65.1	68.9	67.3	59.1	45.6	35.6	25.8
20	25.0	30.0	37.7	46.9	55.2	65.1	69.2	66.5	57.8	45.3	36.9	27.1
21	25.2	30.6	37.6	46.5	55.9	65.5	69.0	66.9	57.4	45.7	35.1	26.0
22	27.1	29.7	37.9	48.6	55.8	65.5	68.5	66.2	58.1	45.6	33.2	27.5
23	26.2	29.9	38.6	48.1	57.3	66.4	69.5	66.1	57.8	44.7	34.2	28.4
24	27.6	30.3	38.5	47.3	58.0	66.3	69.3	66.1	56.9	44.9	34.6	26.7
25	27.7	30.8	37.4	47.2	57.8	66.4	70.0	65.9	55.1	44.8	34.1	25.7
26	26.7	30.2	35.3	48.4	57.5	67.6	70.3	65.8	52.8	43.5	32.9	26.5
27	26.2	30.2	37.5	48.7	57.1	68.1	70.3	65.7	53.2	43.8	31.8	25.7
28	27.9	29.5	39.0	49.5	57.1	68.7	69.3	65.7	54.4	43.8	32.6	27.3
29	28.3	(30.1)	40.4	48.2	57.9	67.9	69.2	65.4	54.6	41.9	31.8	26.8
30	27.3	....	37.8	48.6	57.8	68.6	68.9	65.7	55.4	41.0	33.6	25.1
31	27.2	....	38.8	....	58.0	....	68.8	65.7	....	40.6	....	23.8

TABLE V.—*Frost Dates and Growing Period.*

Year	Spring		Fall		Growing Period (Days)
	Date	Day of Year	Date	Day of Year	
1889	May 12	132	Sept. 6	249	117
1890	May 6	126	Sept. 8	251	125
1891	May 2	122	Sept. 3	246	124
1892	May 22	142	Aug. 30	242	100
1893	June 6	157	Sept. 14	257	100
1894	May 11	131	Sept. 14	257	126
1895	June 20	171	Sept. 21	264	93
1896	May 20	140	Sept. 26	269	129
1897	June 3	154	Sept. 17	260	106
1898	May 7	127	Sept. 7	250	123
1899	June 7	158	Sept. 17	260	102
1900	May 19	139	Sept. 18	261	122
1901	May 26	146	Sept. 17	260	114
1902	June 3	154	Sept. 9	252	98
1903	May 31	151	Aug. 29	241	90
1904	May 17	137	Aug. 22	234	97
1905	May 29	149	Sept. 2	245	96
1906	May 9	129	Oct. 5	278	149
1907	June 1	152	Sept. 10	253	101
1908	May 29	149	Sept. 27	270	121
1909	May 25	145	Sept. 22	265	120
1910	May 22	142	Aug. 25	237	95
1911	May 22	142	Sept. 19	262	120
1912	May 14	134	Sept. 14	257	123
1913	May 15	135	Sept. 17	260	125
1914	May 7	127	Sept. 14	257	130
1915	June 7	158	Sept. 16	259	101
1916	June 7	158	Sept. 12	255	97
1917	June 13	164	Sept. 27	270	106
1918	May 13	133	Sept. 16	259	126
1919	June 3	154	Sept. 23	266	112
1920	May 26	146	Sept. 26	269	123
1921	May 3	123	Sept. 21	264	141
1922	June 1	152	Oct. 7	280	128
1923	May 16	136	Sept. 29	272	136
1924	May 15	135	Sept. 19	262	127
1925	May 5	125	Oct. 9	282	157
1926	May 14	134	Sept. 24	267	133
1927	May 30	150	Sept. 20	263	113
1928	May 5	125	Sept. 21	264	139
1929	May 6	126	Sept. 9	252	126
1930	May 23	143	Sept. 26	269	126
1931	May 22	142	Sept. 21	264	121
1932	May 16	136	Oct. 4	277	141
1933	May 15	135	Oct. 8	281	146
1934	May 15	135	Sept. 16	259	124
1935	May 7	127	Sept. 27	270	143
1936	May 1	121	Sept. 27	270	149
1937	June 6	157	Oct. 5	278	121
Average-	May 21	141+	Sept. 18	261+	120
Limits-	May 2-June 20		Aug. 22-Oct. 9		90-157

TABLE VI.—*Summary of Monthly Averages of Meteorological Data at Colorado Experiment Station, Fort Collins, 1887-1936.*

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Max. Var.	Period Years
Mean temperature—° F.	26.3	28.1	35.9	45.8	54.2	63.6	68.9	67.6	59.3	48.0	36.2	27.7	46.9	42.6	50
Standard deviation—° F.	4.6	6.0	5.2	3.2	2.7	2.6	2.2	1.7	2.4	2.6	3.5	5.0	1.36	....	....
Precipitation—inches	.32	.61	1.02	2.00	2.86	1.53	1.66	1.40	1.27	1.10	.47	.46	14.70	2.54	50
Standard deviation — inches	.37	.48	.76	1.73	1.65	1.15	1.18	1.04	1.26	.92	.40	.62	3.76	....	....
Median value—inches	.25	.48	.73	1.41	2.44	1.50	1.31	1.21	.80	.88	.38	.31	14.31	2.19	51
Number of storms during 50 year period of 0.50 inch or more per 24 hours	3	11	34	80	102	52	50	46	44	40	13	8	.....	.....	50
Barometric pressure—inches of mercury	24.935	24.938	24.913	24.932	24.944	24.984	25.071	25.070	25.047	25.035	25.019	24.966	24.989	.166	50
Standard deviation—inches of mercury	.066	.070	.060	.047	.047	.047	.031	.035	.043	.042	.056	.053	.018	....	....
Relative humidity—percent	70.6	71.1	65.8	59.6	62.4	62.8	65.0	66.2	67.1	67.8	69.4	72.3	66.8	12.7	48
Dew point—° F.	11.8	13.9	20.7	29.1	39.7	49.4	54.9	52.9	43.3	31.0	20.2	13.8	31.4	43.1	48
Terrestrial radiation—° F.	4.3	4.0	3.8	3.7	4.7	5.2	5.1	4.7	4.8	4.5	4.6	4.5	4.5	1.5	48
Soil temperatures—° F.															
at depth: 3 inches	27.9	30.0	36.7	46.9	56.8	67.2	72.3	70.0	61.5	48.9	35.2	30.0	48.6	44.4	48
6 inches	29.3	30.8	37.3	47.7	56.9	67.3	72.5	70.8	63.2	51.2	39.2	31.7	49.8	43.2	47
1 foot	30.5	31.3	36.9	47.0	56.2	66.0	71.8	70.8	64.2	52.9	41.2	33.5	50.2	41.3	47
2 feet	33.1	32.9	37.0	45.5	54.0	63.1	69.4	69.5	64.5	55.0	44.3	36.7	50.4	36.6	48
3 feet	35.9	35.1	37.4	44.1	51.7	59.8	66.3	67.6	64.3	56.4	46.9	39.6	50.4	32.5	41
6 feet	42.1	40.9	41.2	44.8	49.9	55.9	61.2	63.8	63.4	59.3	53.1	47.0	51.9	22.9	31
Maximum variation	14.2	10.9	4.5	3.6	7.0	11.4	11.3	7.0	3.0	10.4	17.9	17.0	3.3	14.9	....

Soil temperature record varies from 30 to 49 years. All observations were used in making averages; therefore the averages are not exactly comparable.