

New York State Agricultural Experiment Station
Geneva, New York

TRENDS IN AIR TEMPERATURE AT GENEVA, NEW YORK

by

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Computer Centre

Technical Report 34

TRENDS IN AIR TEMPERATURE AT GENEVA, NEW YORK

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Methods

Weather records at Geneva, New York¹ for the years 1893...2009 were examined for the presence of trends in air temperature. Records include daily maximum and minimum temperatures, and for each year in the series, mean, mean maximum, and mean minimum air temperatures were compiled. All temperatures are recorded in Fahrenheit degrees (°F).

In addition, subsets of each year were examined to determine patterns of winter and summer temperatures.

Winter trends were examined by looking at each January and February of the series (*i.e.* the 59 or 60 mid-winter days). These two months were the coldest months for 71 of the 117 years. The process was repeated to include December of the appropriate winter year²: these three months being the coldest in 113 of the 117 years.

The same approach was used for summer. July and August were the warmest months for 96 of the 117 years. When June was included, the warmest months for 116 of the 117 years were covered.

Second-degree polynomial locally-weighted regressions (Cleveland, 1979), using the R (Ihaka, 1996) function `loess`, were fitted to characterise trends. Spans of the local regressions were selected such that *AIC* (Akaike, 1974) was minimised for each graph.

Missing data

Of the 42,795 days in the study (117 years plus December of 1892), 58 were missing a maximum, a minimum, or both. 55 instances of the missing data occurred in years 1895 and 1898.

Number of days with missing data are as follows:

	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>May</i>	<i>Jun</i>	<i>Jul</i>	<i>Aug</i>	<i>Sep</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>
1893					1							
1894				1								
1895						18	12		2			
1898			20	3								
1903												1

¹ The New York State Agricultural Station Vegetable Crops Farm weather station (NOAA benchmark weather station, #3031840) is presently located at 42°52.6' N, 77°01.9' W. Altitude is 718 ft above sea level. Data before 1963 was collected at various other sites at the Experiment Station, all within a half mile radius. Data is available at www.nysaes.cornell.edu/weather/history.

² For example, December of 2008 is grouped with January and February of 2009. December of 1892 was included in the data.

Results

Values for the 15 statistics are given in Table 1. Figures 1...5 display the data overlaid with trend lines. The figures are:

Fig. 1 Mean, mean maximum, and mean minimum annual temperatures

Fig. 2 Mean, mean maximum, and mean minimum winter (January and February) temperatures

Fig. 3 Mean, mean maximum, and mean minimum winter (December, January and February) temperatures

Fig. 4 Mean, mean maximum, and mean minimum summer (July and August) temperatures

Fig. 5 Mean, mean maximum, and mean minimum summer (June, July and August) temperatures

Observed ranges in the statistics were as follows:

		<i>Lowest</i>	<i>Highest</i>
Annual	Mean	45.1	52.1
	Mean maximum	53.7	62.6
	Mean minimum	35.2	41.8
Winter (<i>Jan, Feb</i>)	Mean	15.8	34.0
	Mean maximum	24.3	42.6
	Mean minimum	6.7	26.4
Winter (<i>Dec, Jan, Feb</i>)	Mean	19.1	34.3
	Mean maximum	27.3	43.0
	Mean minimum	10.4	26.8
Summer (<i>Jul, Aug</i>)	Mean	65.4	75.1
	Mean maximum	73.8	86.9
	Mean minimum	54.5	63.4
Summer (<i>Jun, Jul, Aug</i>)	Mean	64.6	73.1
	Mean maximum	73.2	85.5
	Mean minimum	54.4	62.2

Observed ranges in the overall daily data, and years of occurrence, were

	<i>Lowest</i>	<i>Highest</i>
Mean	-16 (1934)	92 (1936)
Maximum	-4 (1918)	106 (1936)
Minimum	-31 (1934)	86 (1910)

The extreme monthly averages, and years of occurrence, were

	<i>Lowest</i>	<i>Highest</i>
Mean	13.1 (1994)	78.1 (1921)
Maximum	20.5 (1979)	90.1 (1921)
Minimum	1.0 (1934)	66.1 (1921)

The figures suggest a cyclical pattern of temperature over the 117 years. Starting with lower temperatures at the beginning of the series (1893), there was an increase to the 1930s, a decline to about 1980, and a rise thereafter.

For the summer series, cycles were more pronounced for the maximum temperatures and essentially 'flat' for the minimum temperatures. Year to year fluctuations in the summer temperatures were markedly less than those for the winter.

The results presented are simply a description of temperature patterns observed at Geneva, New York. No backward or forward extrapolation is implied, and no wider inferences on national or worldwide trends are made.

References

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- Cleveland, W. (1979) Robust locally weighted regression and smoothing scatterplots. *Journal of the American Statistical Association*, **74**, 829-836.
- Ihaka, R. & Gentleman, R. (1996) R: A language for data analysis and graphics. *Journal of Computational and Graphical Statistics*, **5**, 299-314.

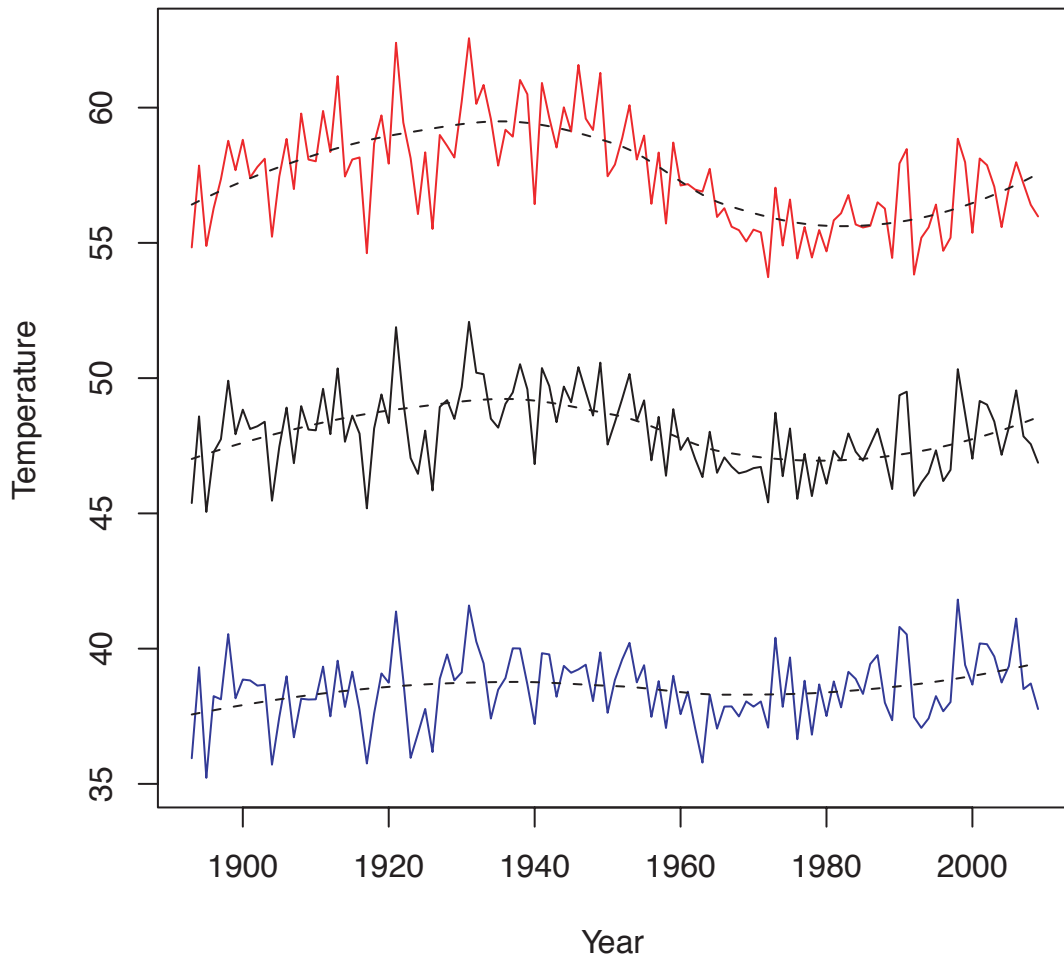
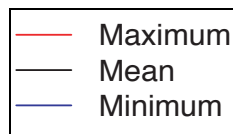


Fig 1. Annual temperatures for the years 1893...2009



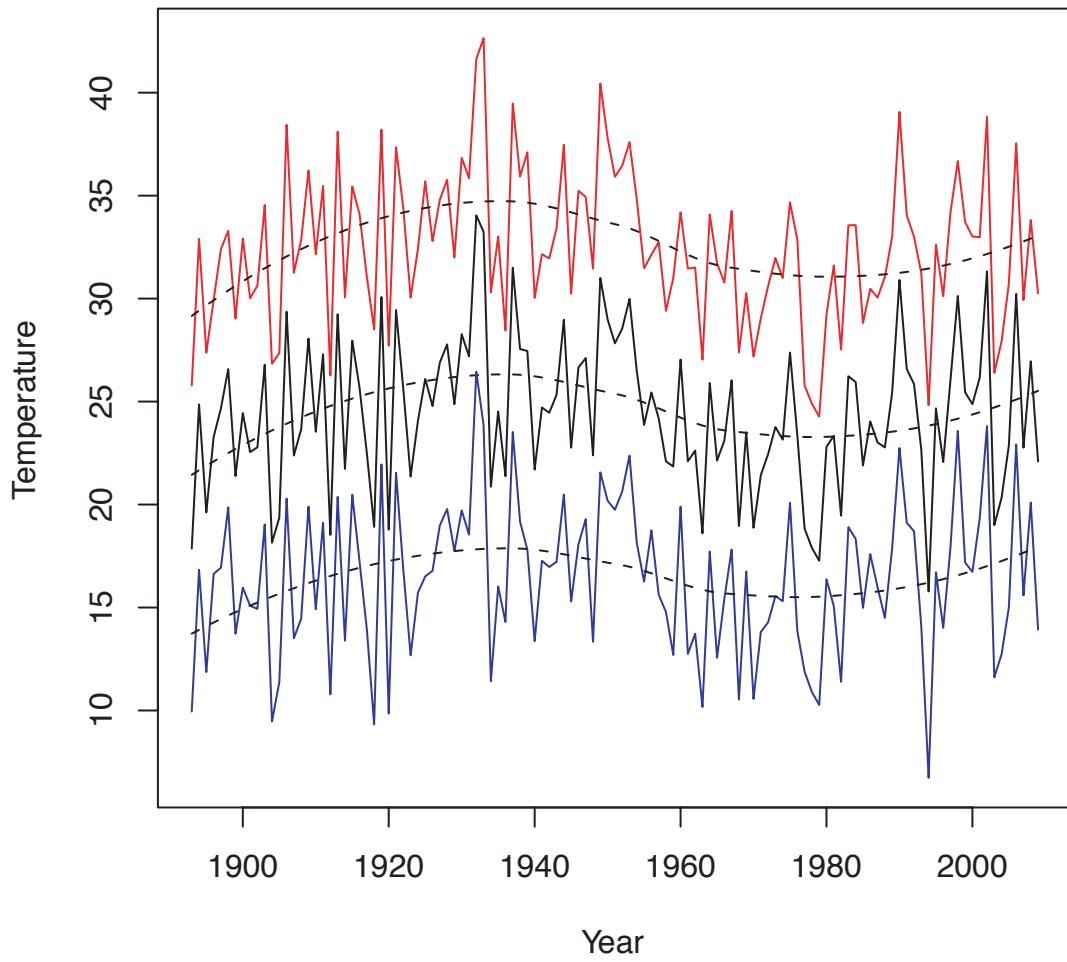
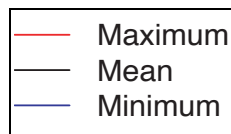


Fig 2. Winter temperatures (January, February) of 1893...2009



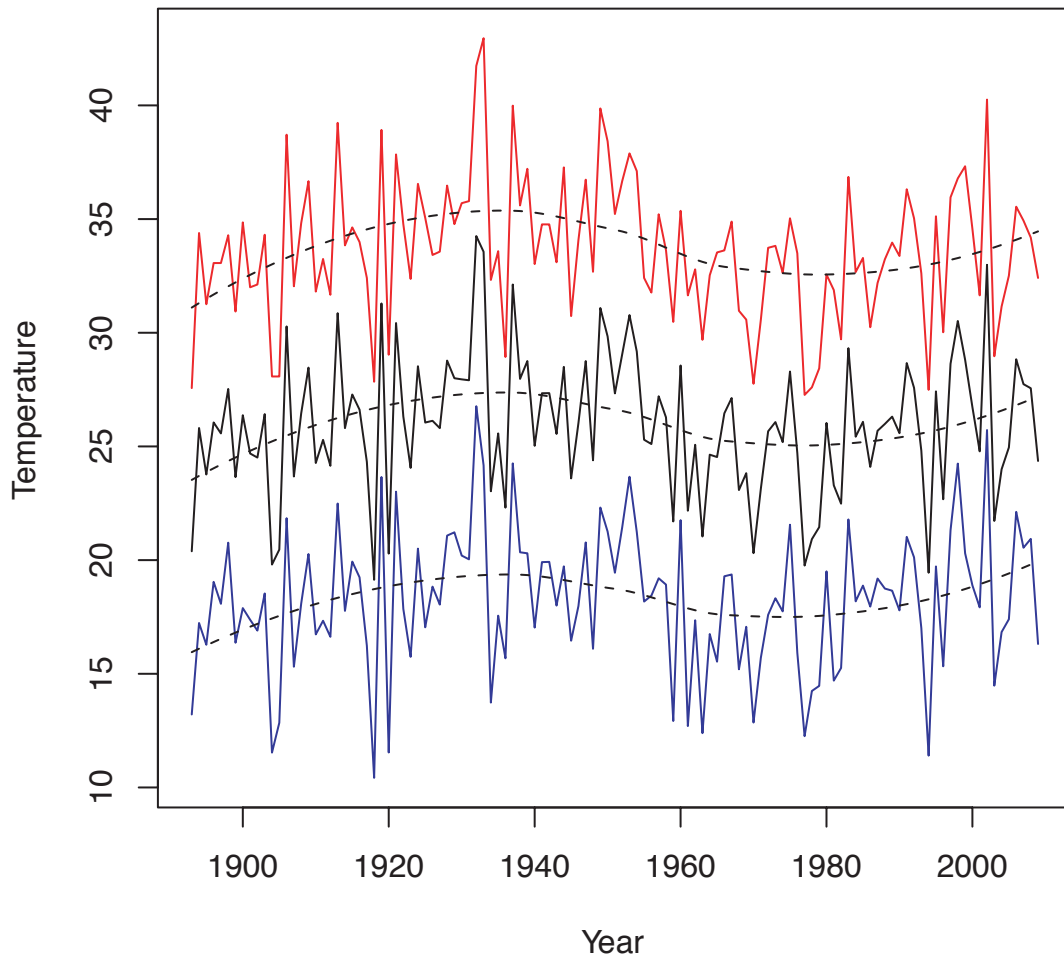
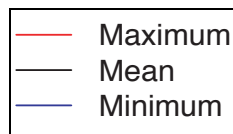


Fig 3. Winter temperatures (December, January, February) of 1893...2009



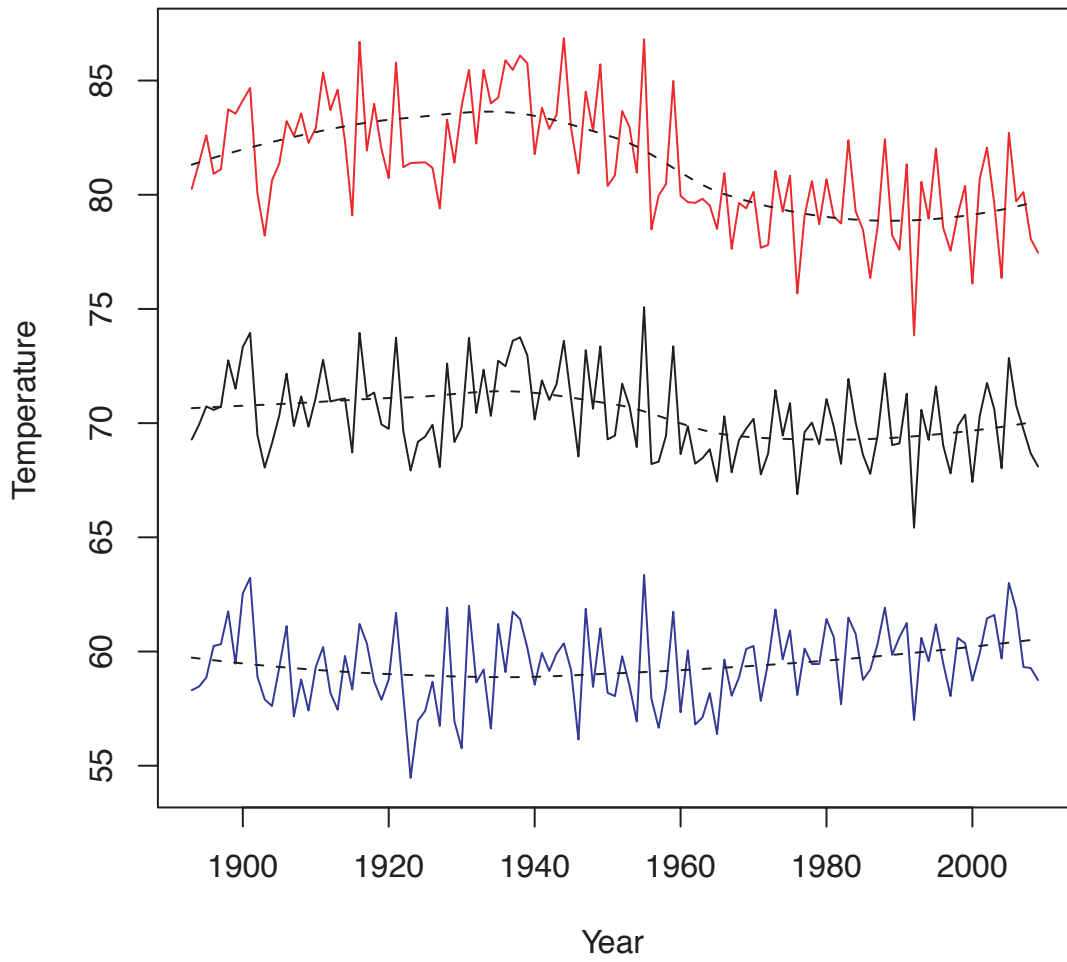
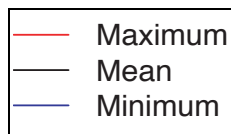


Fig 4. Summer temperatures (July, August) of 1893...2009



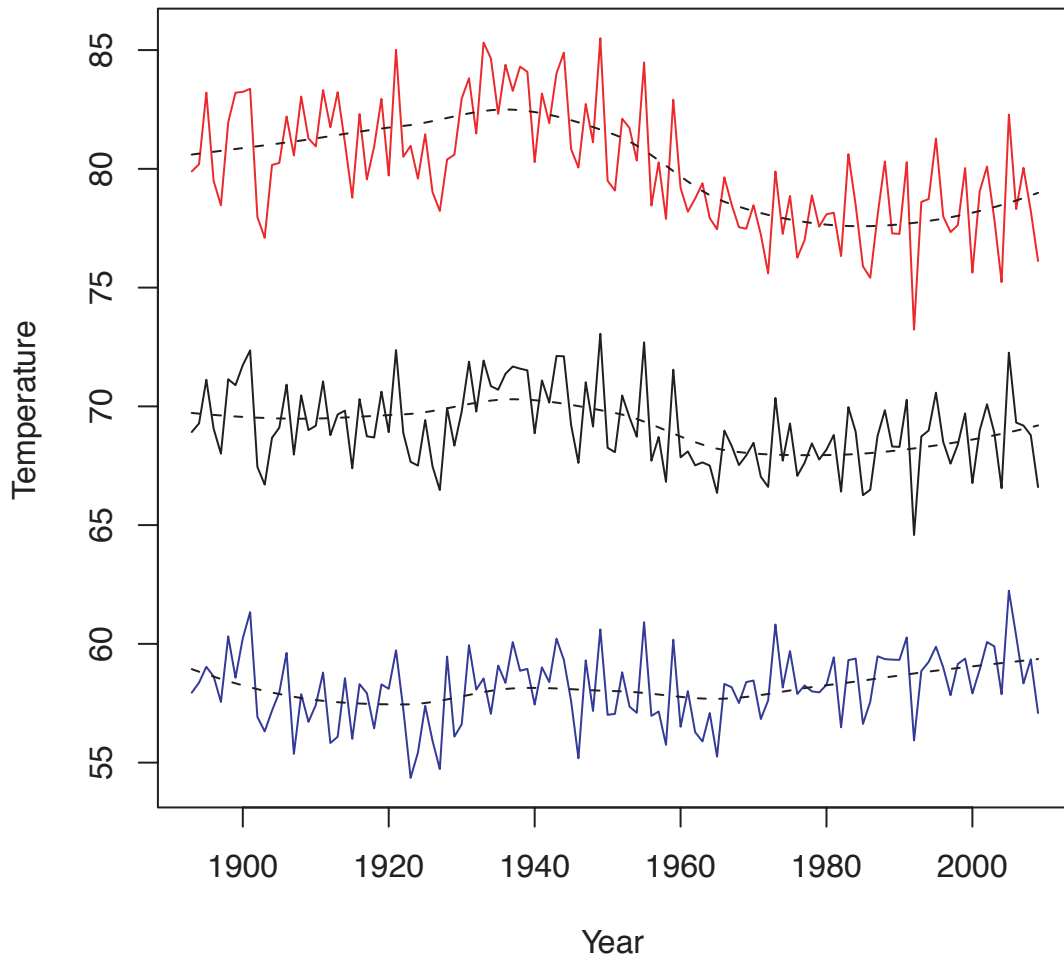


Fig 5. Summer temperatures (June, July, August) of 1893...2009

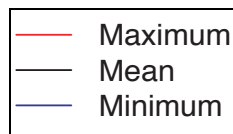


Table 1. Annual and seasonal means for air temperature, 1893...2009

	<i>Annual</i>			<i>Winter (Jan, Feb)</i>			<i>Winter (Dec, Jan, Feb)</i>			<i>Summer (Jul, Aug)</i>			<i>Summer (Jun, Jul, Aug)</i>		
	<i>Mean</i>	<i>Mean max</i>	<i>Mean min</i>	<i>Mean</i>	<i>Mean max</i>	<i>Mean min</i>	<i>Mean</i>	<i>Mean max</i>	<i>Mean min</i>	<i>Mean</i>	<i>Mean max</i>	<i>Mean min</i>	<i>Mean</i>	<i>Mean max</i>	<i>Mean min</i>
1893	45.4	54.8	35.9	17.9	25.8	9.9	20.4	27.6	13.2	69.3	80.3	58.3	68.9	79.9	57.9
1894	48.6	57.9	39.3	24.9	32.9	16.8	25.8	34.4	17.2	69.9	81.4	58.5	69.3	80.2	58.4
1895	45.1	54.9	35.2	19.6	27.4	11.9	23.8	31.3	16.3	70.7	82.6	58.9	71.1	83.2	59.0
1896	47.3	56.3	38.2	23.3	29.9	16.6	26.1	33.1	19.0	70.6	80.9	60.2	69.1	79.5	58.6
1897	47.7	57.4	38.1	24.7	32.4	16.9	25.6	33.1	18.1	70.7	81.1	60.3	68.0	78.5	57.6
1898	49.9	58.8	40.5	26.6	33.3	19.9	27.5	34.3	20.8	72.8	83.7	61.8	71.1	82.0	60.3
1899	47.9	57.7	38.2	21.4	29.0	13.7	23.6	30.9	16.4	71.5	83.5	59.5	70.9	83.2	58.6
1900	48.8	58.8	38.9	24.4	32.9	16.0	26.4	34.9	17.9	73.3	84.1	62.5	71.7	83.2	60.2
1901	48.1	57.4	38.8	22.6	30.0	15.1	24.7	32.0	17.4	74.0	84.7	63.2	72.4	83.4	61.3
1902	48.2	57.8	38.6	22.8	30.6	14.9	24.5	32.1	16.9	69.5	80.1	58.9	67.4	78.0	56.9
1903	48.4	58.1	38.7	26.8	34.5	19.0	26.4	34.3	18.5	68.1	78.2	57.9	66.7	77.1	56.3
1904	45.5	55.2	35.7	18.1	26.8	9.5	19.8	28.1	11.5	69.1	80.6	57.6	68.7	80.2	57.2
1905	47.5	57.5	37.5	19.4	27.4	11.4	20.5	28.1	12.8	70.3	81.4	59.3	69.1	80.2	58.0
1906	48.9	58.8	39.0	29.4	38.4	20.3	30.3	38.7	21.8	72.2	83.2	61.1	70.9	82.2	59.6
1907	46.9	57.0	36.7	22.4	31.3	13.5	23.7	32.0	15.3	69.9	82.6	57.2	68.0	80.6	55.4
1908	49.0	59.8	38.1	23.7	32.9	14.5	26.5	34.8	18.1	71.2	83.6	58.8	70.5	83.0	57.9
1909	48.1	58.1	38.1	28.1	36.2	19.9	28.5	36.7	20.3	69.8	82.3	57.4	69.0	81.3	56.7
1910	48.1	58.0	38.1	23.5	32.2	14.9	24.3	31.8	16.7	71.1	82.9	59.3	69.2	80.9	57.4
1911	49.6	59.9	39.3	27.3	35.5	19.1	25.3	33.2	17.3	72.8	85.4	60.2	71.1	83.3	58.8
1912	47.9	58.4	37.5	18.5	26.3	10.8	24.1	31.7	16.6	71.0	83.7	58.2	68.8	81.8	55.8
1913	50.4	61.2	39.6	29.2	38.1	20.4	30.9	39.2	22.5	71.0	84.6	57.5	69.7	83.2	56.1
1914	47.6	57.5	37.8	21.7	30.1	13.4	25.8	33.8	17.8	71.1	82.4	59.8	69.8	81.1	58.6
1915	48.6	58.1	39.1	28.0	35.4	20.5	27.3	34.6	19.9	68.7	79.1	58.3	67.4	78.8	56.0
1916	47.9	58.2	37.7	25.7	34.1	17.2	26.6	34.0	19.2	74.0	86.7	61.2	70.3	82.3	58.3
1917	45.2	54.6	35.8	22.5	31.1	13.9	24.3	32.4	16.2	71.1	81.9	60.4	68.7	79.6	57.9
1918	48.1	58.7	37.6	18.9	28.5	9.3	19.1	27.8	10.4	71.3	84.0	58.7	68.7	80.9	56.4
1919	49.4	59.7	39.1	30.1	38.2	21.9	31.3	38.9	23.7	69.9	82.0	57.9	70.6	82.9	58.3
1920	48.3	57.9	38.7	18.8	27.7	9.8	20.3	29.0	11.5	69.8	80.7	58.8	68.9	79.7	58.1
1921	51.9	62.4	41.4	29.4	37.4	21.5	30.4	37.8	23.0	73.7	85.8	61.7	72.4	85.0	59.7
1922	49.1	59.4	38.8	25.6	34.4	16.8	26.3	34.8	17.9	69.7	81.2	58.1	68.9	80.5	57.2
1923	47.0	58.1	36.0	21.4	30.1	12.7	24.1	32.4	15.7	67.9	81.4	54.5	67.7	81.0	54.4
1924	46.5	56.1	36.9	24.1	32.4	15.7	28.5	36.5	20.5	69.2	81.4	57.0	67.5	79.6	55.4
1925	48.1	58.3	37.8	26.1	35.7	16.5	26.1	35.1	17.0	69.4	81.4	57.4	69.4	81.5	57.4
1926	45.8	55.5	36.2	24.8	32.8	16.8	26.1	33.4	18.8	69.9	81.2	58.7	67.5	79.0	55.9
1927	48.9	59.0	38.9	26.9	34.8	19.0	25.8	33.6	18.0	68.1	79.4	56.7	66.5	78.2	54.7
1928	49.2	58.6	39.8	27.8	35.8	19.8	28.8	36.5	21.1	72.6	83.3	61.9	69.9	80.4	59.5
1929	48.5	58.2	38.8	24.9	32.0	17.7	28.0	34.8	21.2	69.2	81.4	57.0	68.3	80.6	56.1
1930	49.7	60.2	39.1	28.3	36.8	19.7	27.9	35.7	20.2	69.8	83.9	55.8	69.8	83.0	56.6
1931	52.1	62.6	41.6	27.2	35.8	18.5	27.9	35.8	20.0	73.7	85.5	62.0	71.9	83.8	59.9
1932	50.2	60.1	40.3	34.0	41.6	26.4	34.3	41.7	26.8	70.4	82.2	58.6	69.8	81.5	58.1
1933	50.1	60.8	39.5	33.2	42.6	23.8	33.6	43.0	24.2	72.3	85.5	59.2	71.9	85.3	58.5
1934	48.5	59.6	37.4	20.9	30.3	11.4	23.0	32.3	13.7	70.3	84.0	56.6	70.9	84.7	57.1
1935	48.2	57.9	38.5	24.5	33.0	16.0	25.6	33.6	17.6	72.7	84.3	61.2	70.7	82.3	59.1
1936	49.0	59.2	38.9	21.4	28.4	14.3	22.3	28.9	15.7	72.5	85.9	59.1	71.4	84.4	58.4
1937	49.5	58.9	40.0	31.5	39.5	23.5	32.1	40.0	24.3	73.6	85.5	61.7	71.7	83.3	60.1
1938	50.5	61.0	40.0	27.6	35.9	19.2	28.0	35.6	20.3	73.8	86.1	61.4	71.6	84.3	58.9
1939	49.6	60.5	38.7	27.5	37.1	17.8	28.8	37.2	20.3	73.0	85.8	60.2	71.5	84.1	58.9
1940	46.8	56.4	37.2	21.7	30.0	13.4	25.0	33.0	17.0	70.2	81.8	58.5	68.9	80.3	57.4
1941	50.4	60.9	39.8	24.7	32.2	17.3	27.3	34.8	19.9	71.9	83.8	59.9	71.1	83.2	59.0
1942	49.7	59.6	39.8	24.5	31.9	17.0	27.3	34.8	19.9	71.0	82.9	59.1	70.2	81.9	58.4
1943	48.4	58.5	38.2	25.3	33.4	17.2	25.6	33.1	18.0	71.7	83.5	59.9	72.1	84.0	60.2
1944	49.7	60.0	39.4	29.0	37.5	20.5	28.5	37.3	19.7	73.6	86.9	60.4	72.1	84.9	59.3
1945	49.1	59.1	39.1	22.8	30.2	15.3	23.6	30.7	16.5	71.0	82.9	59.2	69.2	80.8	57.6
1946	50.4	61.6	39.2	26.7	35.2	18.1	26.0	34.1	18.0	68.5	80.9	56.1	67.6	80.1	55.2
1947	49.5	59.6	39.4	27.1	34.9	19.3	28.8	36.7	20.8	73.2	84.5	61.9	71.0	82.7	59.3
1948	48.6	59.2	38.1	22.4	31.4	13.3	24.4	32.7	16.1	70.6	82.8	58.5	69.1	81.1	57.2
1949	50.6	61.3	39.9	31.0	40.4	21.6	31.1	39.9	22.3	73.4	85.7	61.0	73.1	85.5	60.6

	<u>Annual</u>			<u>Winter (Jan, Feb)</u>			<u>Winter (Dec, Jan, Feb)</u>			<u>Summer (Jul, Aug)</u>			<u>Summer (Jun, Jul, Aug)</u>		
	Mean	Mean max	Mean min	Mean	Mean max	Mean min	Mean	Mean max	Mean min	Mean	Mean max	Mean min	Mean	Mean max	Mean min
1950	47.5	57.5	37.6	29.0	37.8	20.2	29.8	38.4	21.3	69.3	80.4	58.2	68.3	79.5	57.0
1951	48.4	57.9	38.8	27.8	35.9	19.7	27.3	35.2	19.4	69.5	80.9	58.0	68.1	79.1	57.1
1952	49.2	58.9	39.6	28.5	36.5	20.6	29.1	36.7	21.4	71.7	83.7	59.8	70.5	82.1	58.8
1953	50.2	60.1	40.2	30.0	37.6	22.4	30.8	37.9	23.7	70.7	83.0	58.5	69.5	81.7	57.4
1954	48.4	58.1	38.8	26.5	34.8	18.1	29.2	37.1	21.2	69.0	81.0	56.9	68.7	80.3	57.1
1955	49.2	59.0	39.4	23.9	31.5	16.3	25.3	32.4	18.2	75.1	86.8	63.4	72.7	84.5	60.9
1956	47.0	56.4	37.5	25.4	32.1	18.8	25.1	31.8	18.4	68.2	78.5	57.9	67.7	78.5	57.0
1957	48.6	58.3	38.8	24.2	32.7	15.6	27.2	35.2	19.2	68.3	80.0	56.7	68.7	80.3	57.2
1958	46.4	55.7	37.1	22.1	29.4	14.8	26.3	33.6	18.9	69.4	80.5	58.4	66.8	77.9	55.8
1959	48.9	58.7	39.0	21.8	31.0	12.7	21.7	30.5	12.9	73.4	85.0	61.7	71.5	82.9	60.2
1960	47.3	57.1	37.6	27.0	34.2	19.9	28.6	35.4	21.8	68.6	80.0	57.3	67.9	79.2	56.5
1961	47.8	57.2	38.4	22.1	31.5	12.7	22.2	31.6	12.7	69.9	79.7	60.0	68.1	78.2	58.0
1962	47.0	57.0	37.1	22.6	31.5	13.7	25.1	32.8	17.4	68.2	79.6	56.8	67.5	78.8	56.3
1963	46.3	56.9	35.8	18.6	27.0	10.2	21.0	29.7	12.4	68.5	79.8	57.1	67.6	79.4	55.9
1964	48.0	57.7	38.3	25.9	34.1	17.7	24.6	32.5	16.7	68.9	79.5	58.2	67.5	77.9	57.1
1965	46.5	56.0	37.0	22.1	31.7	12.6	24.5	33.5	15.5	67.4	78.5	56.4	66.4	77.5	55.2
1966	47.1	56.3	37.9	23.1	30.8	15.4	26.5	33.6	19.3	70.3	81.0	59.6	69.0	79.6	58.3
1967	46.7	55.6	37.9	26.0	34.3	17.8	27.1	34.9	19.4	67.8	77.6	58.1	68.3	78.5	58.2
1968	46.5	55.5	37.5	19.0	27.4	10.5	23.1	31.0	15.2	69.2	79.6	58.9	67.5	77.5	57.5
1969	46.6	55.1	38.0	23.5	30.3	16.7	23.8	30.6	17.1	69.8	79.4	60.1	67.9	77.5	58.4
1970	46.7	55.5	37.9	18.9	27.2	10.6	20.3	27.8	12.9	70.2	80.1	60.2	68.5	78.5	58.5
1971	46.7	55.4	38.0	21.4	29.1	13.8	23.1	30.6	15.7	67.8	77.7	57.8	67.0	77.2	56.8
1972	45.4	53.7	37.1	22.4	30.6	14.3	25.7	33.7	17.6	68.7	77.8	59.5	66.6	75.6	57.6
1973	48.7	57.0	40.4	23.8	32.0	15.6	26.1	33.8	18.3	71.4	81.0	61.8	70.4	79.9	60.8
1974	46.4	54.9	37.8	23.2	31.0	15.3	25.2	32.6	17.7	69.5	79.3	59.7	67.7	77.3	58.2
1975	48.1	56.6	39.7	27.4	34.7	20.1	28.3	35.0	21.6	70.9	80.8	60.9	69.3	78.9	59.7
1976	45.5	54.4	36.7	23.4	32.9	13.9	24.7	33.5	15.9	66.9	75.7	58.1	67.1	76.3	57.9
1977	47.2	55.6	38.8	18.8	25.8	11.9	19.8	27.3	12.3	69.6	79.1	60.1	67.6	77.0	58.2
1978	45.6	54.5	36.8	17.9	24.9	10.9	20.9	27.6	14.2	70.0	80.6	59.5	68.4	78.9	58.0
1979	47.1	55.5	38.7	17.3	24.3	10.3	21.4	28.4	14.5	69.1	78.7	59.5	67.8	77.6	58.0
1980	46.1	54.7	37.5	22.8	29.2	16.4	26.0	32.6	19.5	71.0	80.7	61.4	68.2	78.1	58.3
1981	47.3	55.8	38.8	23.3	31.6	15.1	23.3	31.9	14.7	69.8	79.0	60.6	68.8	78.2	59.4
1982	47.0	56.1	37.8	19.5	27.5	11.4	22.5	29.7	15.3	68.2	78.7	57.7	66.4	76.3	56.5
1983	48.0	56.8	39.1	26.2	33.6	18.9	29.3	36.9	21.8	71.9	82.4	61.5	70.0	80.6	59.3
1984	47.3	55.7	38.9	25.9	33.6	18.3	25.4	32.7	18.2	70.0	79.3	60.8	68.9	78.5	59.4
1985	46.9	55.6	38.3	21.9	28.8	15.0	26.1	33.3	18.9	68.6	78.5	58.8	66.3	75.9	56.6
1986	47.5	55.6	39.4	24.0	30.5	17.6	24.1	30.2	18.0	67.8	76.4	59.2	66.5	75.4	57.6
1987	48.1	56.5	39.8	23.0	30.1	16.0	25.7	32.2	19.2	69.5	78.6	60.3	68.8	78.0	59.5
1988	47.1	56.3	38.0	22.8	31.1	14.5	26.0	33.2	18.7	72.2	82.4	61.9	69.8	80.3	59.4
1989	45.9	54.4	37.4	25.4	33.0	17.9	26.3	34.0	18.7	69.0	78.2	59.9	68.3	77.3	59.3
1990	49.4	57.9	40.8	30.9	39.1	22.7	25.6	33.4	17.8	69.1	77.6	60.6	68.3	77.3	59.3
1991	49.5	58.5	40.5	26.6	34.1	19.1	28.7	36.3	21.0	71.3	81.3	61.2	70.3	80.3	60.3
1992	45.6	53.8	37.5	25.9	33.0	18.7	27.6	35.0	20.1	65.4	73.8	57.0	64.6	73.2	55.9
1993	46.1	55.2	37.1	22.6	31.2	14.1	24.8	32.6	17.0	70.6	80.6	60.6	68.7	78.6	58.9
1994	46.5	55.6	37.4	15.8	24.8	6.7	19.4	27.5	11.4	69.3	79.0	59.6	69.0	78.7	59.2
1995	47.3	56.4	38.2	24.7	32.6	16.7	27.4	35.1	19.7	71.6	82.0	61.2	70.6	81.3	59.9
1996	46.2	54.7	37.7	22.1	30.1	14.0	22.7	30.0	15.3	69.0	78.5	59.5	68.5	78.0	59.0
1997	46.6	55.2	38.0	26.1	34.2	17.9	28.6	36.0	21.3	67.8	77.5	58.0	67.6	77.3	57.8
1998	50.3	58.8	41.8	30.1	36.7	23.6	30.5	36.8	24.2	69.9	79.1	60.6	68.4	77.6	59.2
1999	48.7	58.0	39.4	25.4	33.7	17.2	28.8	37.3	20.3	70.4	80.4	60.4	69.7	80.0	59.4
2000	47.0	55.4	38.7	24.9	33.0	16.7	26.7	34.6	18.9	67.4	76.1	58.7	66.8	75.6	57.9
2001	49.2	58.1	40.2	26.2	33.0	19.3	24.8	31.6	17.9	70.3	80.7	59.9	69.0	79.1	58.9
2002	49.0	57.9	40.2	31.3	38.8	23.8	33.0	40.3	25.7	71.8	82.1	61.5	70.1	80.1	60.1
2003	48.4	57.1	39.7	19.0	26.4	11.6	21.7	29.0	14.5	70.6	79.6	61.6	68.9	77.9	59.9
2004	47.2	55.6	38.7	20.3	27.9	12.7	24.0	31.2	16.8	68.0	76.4	59.7	66.6	75.2	57.9
2005	48.2	57.0	39.4	22.9	30.7	15.0	25.0	32.5	17.4	72.9	82.7	63.0	72.3	82.3	62.2
2006	49.5	58.0	41.1	30.2	37.5	22.9	28.8	35.5	22.1	70.8	79.7	61.8	69.3	78.3	60.3
2007	47.8	57.2	38.5	22.8	29.9	15.6	27.7	34.9	20.5	69.7	80.1	59.3	69.2	80.0	58.3
2008	47.6	56.4	38.7	27.0	33.8	20.1	27.6	34.2	20.9	68.7	78.1	59.3	68.8	78.2	59.3
2009	46.9	56.0	37.8	22.1	30.3	13.9	24.4	32.4	16.3	68.1	77.5	58.7	66.6	76.1	57.1