Case I. When the probability of frost after date C is less than half the total probability of frost; that is, when $1/Y$ is less than half of R/Y. The value of A in this case is found from the proportion

$$1/Y : 1/A :: R : L,$$

from which $A = RY/L$. Since R and L are known, either A or Y can be found when the other is known, and one of them is always known in problems of the kind here under consideration.

Case II. When the probability of frost after date C is just half the total probability of frost; that is, when $1/Y = R/2L$. Substituting this value of $1/Y$ in the proportion of Case I, and reducing, we have $A = 2$. In this case the date C coincides with the average date of last frost.

Case III. When the probability of frost after date C is greater than half of R/L and less than R/L. In this case the value of A is less than 2, and is hence not on the curve; but if we deal with the probability of last frost occurring before date C, instead of after C, we shall then find a value of A that does lie on the curve. The date C will then come before the mean date of last frost.

Since the total probability of frost is R/L, the probability of last frost occurring before date C is $R/L - 1/Y$, or $(RY - L)/LY$. Hence we have

$$(RY - L)/LY : 1/A :: R : L,$$

from which $A = RY/(RY - L)$.

Case IV. When the probability of frost after date C is equal to the total probability of frost, or $1/Y = R/L$. Here A is infinite, and there is no solution.

Case V. When the probability of frost after date C is greater than the total probability of frost, or when $1/Y$ is greater than R/L. In this case A is negative and there is no solution.

A CORRELATION BETWEEN THE RAINFALL OF NORTH AND SOUTH AMERICA.

By H. HELM CLAYTON.

[Dated: Oficina Meteorológica Argentina, Buenos Aires, Mar. 20, 1916.]

Pursuing a line of research outlined in the Popular Science Monthly (New York) of December, 1901, the writer obtained the average rainfall in the United States between the longitudes of 80° W. and 110° W., which includes all the States except the north Atlantic, the Plateau, and the Pacific coast. This average was compiled from the data published in the bulletin of the Weather Bureau entitled "The Annual Precipitation of the United States for the Years 1872 to 1907," in which the rainfall is given for selected stations nearly equally distributed. Mr. P. C. Day has kindly extended this data to the end of 1914.

The object of the research was to compare the total rainfall with the total crop production, and between the two there is an interesting correlation. There has also been discovered a correlation between this rainfall of central North America and that of central South America as indicated by the outflow in the River Paraná. There appears to be an inverse correlation between these two and the rainfall of Australia. The data are given in Table 1.

TABLE 1.—*Comparison of annual rainfall over the central United States with that over Australia and the mean annual heights of the Paraná at Rosario, Argentina.*

Year.	Mean general rainfall in the United States between meridians 80° and 110° W.		Paraná at Rosario.		Australia.
	Annual fall.	Departure from mean.	Mean annual height.*	Departure from mean.	Percentage of area with rainfall above the average.
	Inches.	*Inches.*	*Meters.*	*Meters.*	*Per cent.*
1900	31.97	+2.11	4.527	+0.792	....
1901	26.75	−3.11	2.998	−0.737	....
1902	30.44	+0.58	3.536	−2.001	....
1903	30.14	+0.28	3.268	−0.467	....
1904	28.08	−1.78	3.807	+0.072	....
1905	34.18	+4.32	5.611	+1.876	....
1906	32.71	+2.85	3.621	−0.114	....
1907	28.77	−1.09	3.634	−0.101	....
1908	30.93	+1.07	4.249	+0.514	33
1909	30.09	+0.23	2.924	−0.811	40
1910	23.63	−6.23	2.837	−0.898	75
1911	28.37	−1.49	3.128	−0.607	25
1912	31.67	+1.81	4.382	+0.647	12
1913	30.80	+0.94	3.664	−0.071	27
1914	29.34	−0.53	3.836	+0.101	11
Mean	29.86.	....	3.735	....	....

* From data kindly furnished me by the Chief of the Hydrometric Section of the Oficina Meteorológica Argentina.

In this table column 1 gives the year; column 2 gives the mean annual rainfall per station in the United States; column 3 gives the departures from the average values; column 4 gives the mean annual river stages at Rosario; column 5 the departures of these from the average; column 6 gives the percentage of the area of Australia over which the rainfall was above the normal. These percentages were taken from a meteorological chart published by Mr. H. A. Hunt, Commonwealth Meteorologist. Unfortunately the data do not go back of 1908.

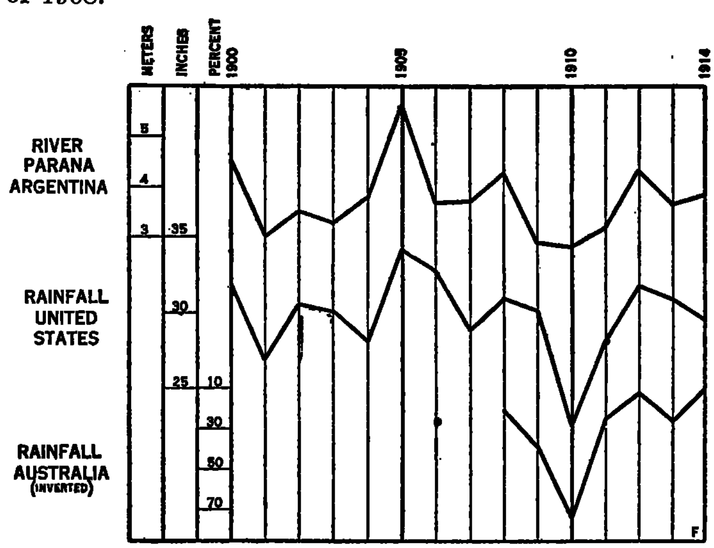

FIG. 1.—Argentine rainfall, as represented by mean annual stages of the Paraná, compared with central United States and Australian rainfalls.

Computing the correlation factor between the departures of annual rainfall in the United States and the departures of the mean river heights at Rosario by the formulas given by Yule in his Theory of Statistics, the correlation is found to be 0.71. The data are plotted in figure 1 and show to the eye the closeness of the correlation. This correlation of rainfall is probably associated with correlations of temperature found by Mossman and Arctowski in the Southern Hemisphere.

In an article on Australian and South American correlations in Symon's Meteorological Magazine, 1913, 48, Mr. R. C. Mossman gives the data in Table 2, comparing the mean temperature for the months from January to March at Cordoba in central Argentina (lat. 31° 25′ S., 64° 12′ W., height = 1,437 feet) with those of Alice Springs in central Australia (lat. 23° 38′ S., long. 133° 37′ E., height = 1,926 feet), both stations being located in a strictly continental situation.

TABLE 2.—*Comparison of mean temperatures at Cordoba, Argentina, and at Alice Springs, central Australia.*

Year.	Mean temperatures, January-March.		Departures from average.	
	Alice Springs.	Cordoba.	Alice Springs.	Cordoba.
	°F.	°F.		
1897	81.0	72.7	+0.4	+0.9
1898	80.2	71.9	−0.4	−0.7
1899	79.7	71.1	−0.9	+3.2
1900	83.0	75.0	+2.4	+3.2
1901	80.3	71.2	−0.3	−0.6
1902	83.3	74.2	+2.7	+2.4
1903	83.0	72.7	+2.4	+0.9
1904	75.7	67.6	−4.9	−5.2
1905	80.5	69.7	−0.1	−2.1
1906	82.8	72.9	+2.2	+1.1
1907	79.7	72.1	−0.9	+0.3
1908	79.2	70.9	−1.4	−0.9
1909	80.5	72.5	−0.1	+0.7
1910 (?)	79.8	71.4	−0.8	−0.4
Mean	80.6	71.8		

From these figures Mossman deduces a correlation coefficient of 0.89. The temperatures at Alice Springs are the means of maxima and minima, while at Cordoba they are the means of 24 hourly values. The values of temperature are plotted in figure 2, and comparing these with the rainfall variations in figure 1 there is seen to be a similarity between the rainfall and temperature curves in the number of fluctuations and in the times of maxima and minima.

This similarity is even better shown by H. Arctowski's means of consecutive 12 months at Arequipa[1] shown in figure 3.

From these curves one sees that there were maxima of temperature and rainfall about the years 1900, 1902, 1905–6, 1908, and 1912, and minima about the years 1901, 1904, 1907, and 1910. However, the absolute maxima and minima of rainfall and temperature do not coincide very well, except in the case of Arequipa, where the deep minima of 1909–10 coincide with the equally marked minima of rainfall in North and South America and a maximum in Australia.

My earlier researches, published in the American Meteorological Journal,[2] as well as the recent ones of Arctowski, show that maxima and minima of temperature and pressure, as shown by consecutive means of 12 months, do not occur simultaneously everywhere, but oscillate irregularly back and forth over these continents. Yet when the averages over large continental areas are taken, as in the present study of rainfall, there certainly

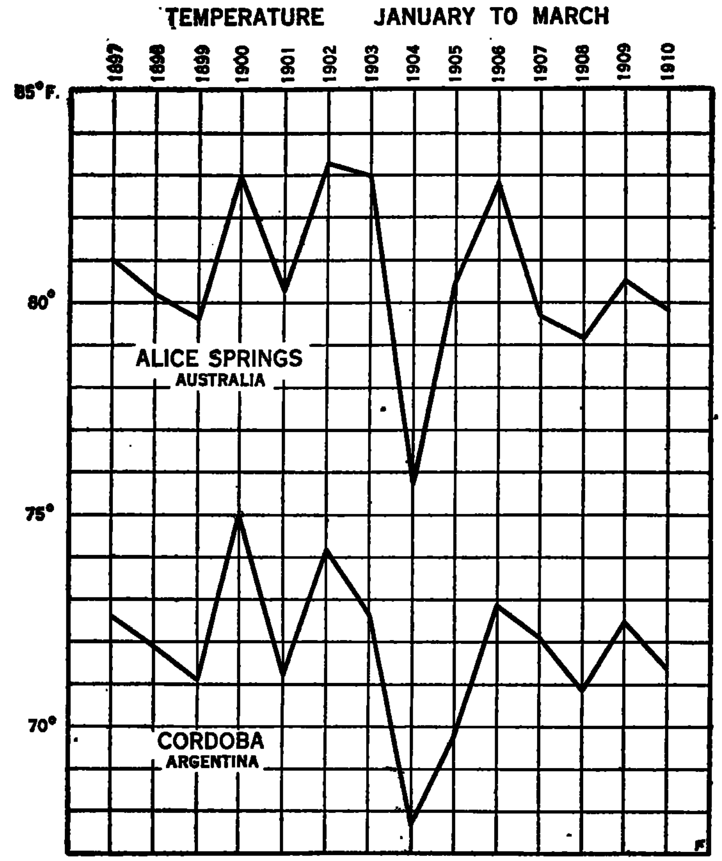

FIG. 2.—Temperatures (Jan.-Mar.) at Alice Springs, Australia, and Cordoba compared.

does appear a similarity on widely separated continents. So striking is this similarity that there can scarcely be a doubt of a common cause of these changes which may

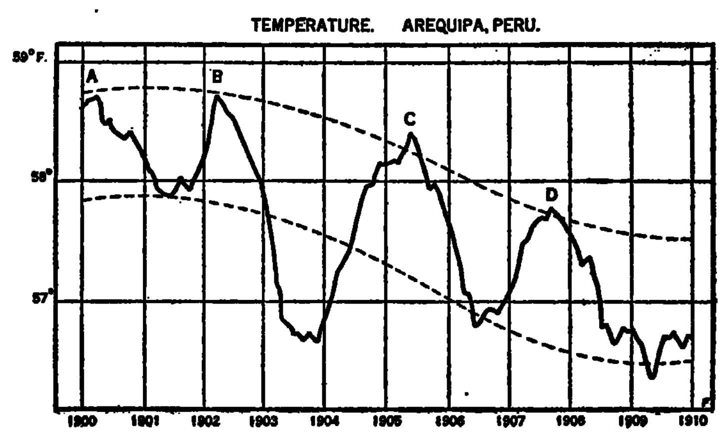

FIG. 3.—Curve of consecutive annual means of temperature at Arequipa, Peru. *A, B, C, D*, pleionian crests alternating with antipleionian depressions. Macrochronic variation shown by the dotted lines. (After Arctowski.)

well be changes in the solar heat, indicated by variations in the number of solar faculæ such as is claimed by Lockyer, Bigelow, and Arctowski.

[1] *See* Annals, New York acad. sci., June, 1914, 24: 43.
[2] *See* Amer. meteorol. jour., Detroit, 1885, 2: 126.