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SOLAR RADIATION AND THE WEEKLY WEATHER FORECAST OF THE ARGENTINE METEOROLOGICAL SERVICE

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INTRODUCTORY NOTE

By C. G. ABBOT,

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In publishing Mr. Hoxmark's paper, the Smithsonian Institution is glad to bring to the notice of English-speaking people the results which have come from the acceptance of the evidence of solar variability as a working hypothesis by the Weather Service of Argentina. The preliminary investigations in this line by Mr. H. H. Clayton, when he was official forecaster of Argentina, were published by the Institution in Volume 68, No. 3, of the Smithsonian Miscellaneous Collections, and these studies led to the attempt to forecast temperatures and precipitation at Buenos Aires based on solar-radiation measurements made by the Smithsonian observers at Calama and Montezuma, Chile.

These forecasts, begun in December, 1918, by Mr. Clayton, and continued since June, 1922, by his successor, Mr. Hoxmark, have given rise to the present paper by the latter. The temperature forecasts are given not in general terms such as most forecasters content themselves with using, but state precisely for a narrow locality the exact temperatures to be expected, morning and evening, to the end of the eighth day after the forecast is published. Verification consists in taking differences between observed and forecasted temperatures and the normal depending on many years records, and computing correlation coefficients therefrom, according to the well known methods of Galton and Pearson.

This, it goes without saying, is a very severe test. An error of 12 hours in the time when a sharp rise or fall of temperature is predicted, even though the reality and magnitude of the change is truly forecasted, will often give large departures which ruin for the time the correlation between forecast and event. Moreover, the results of Clayton, which appear in the next preceding serially numbered paper of these Miscellaneous Collections, show that even a half per cent change in solar radiation produces notable temperature changes. The accuracy of Smithsonian solar-radiation observations is not adequate to prevent many errors as great as half of one per cent, or even twice that magnitude occasionally. Hence, on this account, also, the solar forecaster is at a disadvantage.

TABLE A.—*Hoxmark's weekly correlation coefficients segregated by months*

Numbers of cases and mean values between certain limits of time and percentage magnitudes of positive and negative correlations

Percentages		0–15		15–30		30–45		45–60		60–75		75–100		Total		Total both signs
Months		Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	Plus	Minus	
Jan.	No.	0	2	1	1	1	1	2	0	0	0	0	0	4	4	8
	Mean	—	11	15	28	37	36	53	—	—	—	—	—	+40	—28	+ 6
Feb.	No.	1	0	2	1	1	0	0	2	1	0	0	0	5	3	8
	Mean	3	—	17	20	43	—	—	46	63	—	—	—	+28	—37	+ 4
Mar.	No.	2	0	1	0	0	2	0	0	2	0	2	0	7	2	9
	Mean	8	—	23	—	—	41	—	—	65	—	93	—	+51	—42	+30
Apr.	No.	0	0	0	1	0	1	0	0	4	1	2	0	6	3	9
	Mean	—	—	—	21	—	34	—	—	67	70	85	—	+56	—42	+24
May	No.	1	1	2	0	0	0	1	0	0	2	0	1	4	4	8
	Mean	7	7	24	—	—	—	57	—	—	69	—	95	+25	—60	—17
June	No.	2	0	1	1	2	0	1	0	1	0	1	0	8	1	9
	Mean	9	—	19	23	35	—	52	—	75	—	89	—	+40	—23	+33
July	No.	2	0	3	0	1	0	0	2	1	3	1	1	8	6	14
	Mean	0	—	24	—	38	—	—	51	60	67	82	82	+32	—56	— 5
Aug.	No.	1	1	2	0	3	1	0	1	3	0	1	0	10	3	13
	Mean	0	6	29	—	39	40	—	52	69	—	96	—	+48	—33	+29
Sept.	No.	1	0	3	3	2	1	1	0	1	0	1	0	9	4	13
	Mean	8	—	23	23	36	41	48	—	61	—	97	—	+40	—27	+19
Oct.	No.	2	1	0	1	0	2	2	0	1	1	3	0	8	5	13
	Mean	7	9	—	17	—	35	51	—	72	76	87	—	+56	—34	+21
Nov.	No.	1	0	1	2	1	0	4	0	3	1	0	0	10	3	13
	Mean	0	—	21	23	42	—	49	—	67	67	—	—	+46	—38	+30
Dec.	No.	0	0	3	4	3	0	0	2	1	0	1	0	8	6	14
	Mean	—	—	19	18	37	—	—	48	67	—	75	—	+39	—28	+10
Year	No.	13	5	19	14	14	8	11	7	18	8	12	2	87	44	131
	Mean	+5	—9	+22	—21	+38	—38	+51	—49	+67	—69	+88	—88	+44	—39	+16
Dec., Jan., Feb.	No.	1	2	6	6	5	1	2	4	2	0	1	0	17	13	30
	Mean	3	11	18	20	38	36	53	47	65	—	75	—	+36	—17	+13
May, Oct.	No.	3	2	2	1	0	2	3	0	1	3	3	1	12	9	21
	Mean	7	8	24	17	—	35	53	—	72	71	87	95	+46	—46	+ 6
Mar., Apr., June, July, Aug., Sept., Nov.	No.	9	1	11	7	9	5	6	3	15	5	8	1	58	22	80
	Mean	5	6	24	23	38	39	49	51	67	67	90	82	+44	—40	+21

Furthermore, Mr. Clayton's early studies proved that the sign of correlation between solar changes and the temperature changes at Buenos Aires alternates between plus and minus from summer to winter. There are transition months, May and October, when it is sometimes indeterminate. Besides this, the months December, January, and February have always proved the most unfavorable of the year for the Smithsonian solar radiation work, not only in Chile but in Arizona, on account of disturbed sky conditions.

It occurred to me, therefore, to analyse Mr. Hoxmark's 131 weekly correlation coefficients with reference to the time of the year. Also, I noted in a cursory inspection that there were few small correlation coefficients, but nearly all were large, either positive or negative. Hence, I rated them according to magnitudes, and kept separated the weeks in which his forecasts correlated with the right sign from the

Table B.—*Summary of Table A*

Percentages	Separate signs Number of cases						Both signs Number of cases		
	0–30%		30%–60%		60%–100%		0–30%	30%–100%	Total
Month-group	+	—	+	—	+	—			
Dec., Jan., Feb....	7	8	7	5	3	0	15	15	30
May, Oct.	5	3	3	2	4	4	8	13	21
Remaining months.	20	8	15	8	23	6	28	52	80
Totals	32	19	25	15	30	10	51	80	131

weeks in which he erred as to sign. The result seems to me very illuminating, and is given in table A. Some of the outstanding features of table A are gathered in table B.

From this analysis there stand out clearly:

1. The months December, January and February are the poorest, as was to be expected, because the radiation data are then poorest.

2. The months May and October, although yielding a large percentage of high correlations, are unsatisfactory because so many of these large correlations are negative to the event.

3. All remaining months of the year yield much better results.

4. It is remarkable that over 60 per cent of the weeks forecasted yield correlation coefficients exceeding 30 per cent.

5. It is unfortunate that of the large correlation coefficients nearly one third are of the wrong sign. This, of course, brings down the average positive correlation to the low figures of 16 per cent for all months and 21 per cent for the best 7 months, as shown in table A.

6. One is impressed by these very large negative correlations, that they are not accidental, but are real correlations and full of meaning but reversed because some governing factor is neglected. If they had all been of the correct sign, and without altering the signs of coefficients less than 30 per cent, which may well be of a more accidental character, the average correlation coefficients for the entire 131 weeks would have risen to over 37 per cent.

7. Readers of the next preceding serially numbered paper of these Miscellaneous Collections, by Mr. Clayton, will have noted that he has discovered an enormous shift in latitude of cyclones and anticyclones depending on absolute values of the solar constant. May it not be that Mr. Hoxmark, by further investigation along those lines, will find such additional relations for Argentina as will enable him to obtain correct signs of correlation in the numerous cases of incorrect but high correlations, so that his future forecasts can be notably improved? It would seem that a special study of the conditions surrounding the cases of high correlations of incorrect sign, which he is here reporting, might lead him to new points of view, which would prove very helpful in future.

ACKNOWLEDGMENTS

I am indebted to the former Chief of the Argentine Weather Service, Mr. G. O. Wiggin, and the present Chief, Mr. F. Burmeister, for encouragement given, to Mr. H. H. Clayton, the founder of the weekly weather forecast, to Dr. C. G. Abbot and his assistants, Messrs. Moore, Abbot and Aldrich, to Mr. E. Wolff, Chief of the Pilar Magnetical Observatory, and to the Director of the La Plata Astronomical Observatory, and their respective staffs, all of whom have assisted the weekly weather forecast and without whose help it would have been impossible to produce it.

SOLAR RADIATION AND THE WEEKLY WEATHER FORECAST OF THE ARGENTINE METEOROLOGICAL SERVICE

By GUILLERMO HOXMARK

The Argentine Meteorological Service publishes every Wednesday a weekly weather forecast, the forecast zone being the federal capital (Buenos Aires) and the region of the River Plata.

The prediction is issued in the form of a curve diagram wherein exact values are given of temperature to be expected at 8 a. m. and 8 p. m., for each day of the coming week. The rain forecast is given in an accompanying note.

This forecast was initiated during the Directorship of Mr. G. Wiggin by Mr. H. H. Clayton, with the author as collaborator.

The basis for the predictions, which began with December 12, 1918, was the measurements of solar radiation expressed in calories per square centimeter per minute, transmitted by cable from the Solar Observatory in Calama, Chile, maintained by the Smithsonian Institution of Washington, D. C. The solar-radiation data have also been used for more extensive investigations covering the whole earth. Results of these researches have been presented in several papers.[1]

Owing to unfavorable conditions, the solar-radiation measurements were often discontinued during days and sometimes weeks, so that it became necessary to find some other method of calculating solar changes.

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[1] Effect of Short Period Variations of Solar Radiation on the Earth's Atmosphere, by H. H. Clayton. Smithsonian Misc. Coll., Vol. 68, No. 3, 18 pp., 8 charts, 2 diagrams, Washington, D. C., May, 1917; also in Spanish "Boletin Mensual," Junio, 1916. Oficina Meteorologica Argentina.

Variations in Solar Radiation and the Weather, by H. H. Clayton. Smithsonian Misc. Coll., Vol. 71, No. 3, 53 pp., 5 pls., 17 figs., Washington, D. C. Jan. 15, 1920; and "Boletin Mensual," Febrero, 1918. Oficina Meteorologica Argentina.

La Maxima De La Radiation Solar En Enero Y Febrero De 1920.

Y El Estado Del Tiempo Mundial, H. H. Clayton y Guillermo Hoxmark, "Boletin Mensual," Junio, 1919, 18 pp., 9 figs., 2 cuadros. Oficina Meteorologica Argentina (included in "World Weather" Chap. X).

World Weather, by H. H. Clayton. 393 pp., 265 figs. and illustrations, 16 pls., New York, 1923.

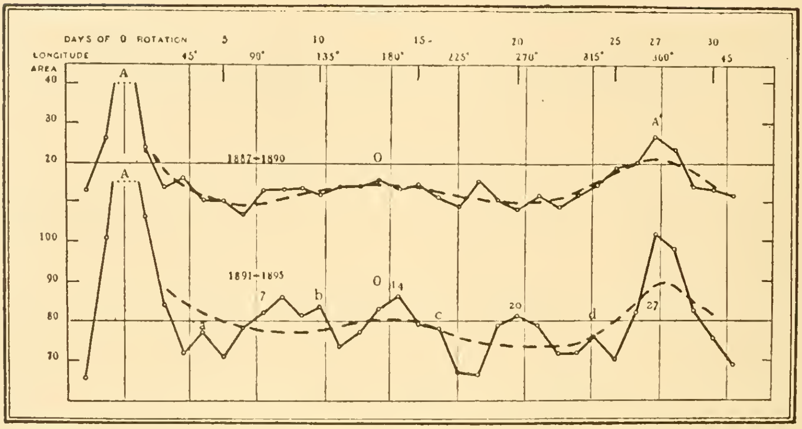

FIG. 1.—Mean distribution of faculæ in longitude on sun following marked outbreaks of faculæ.

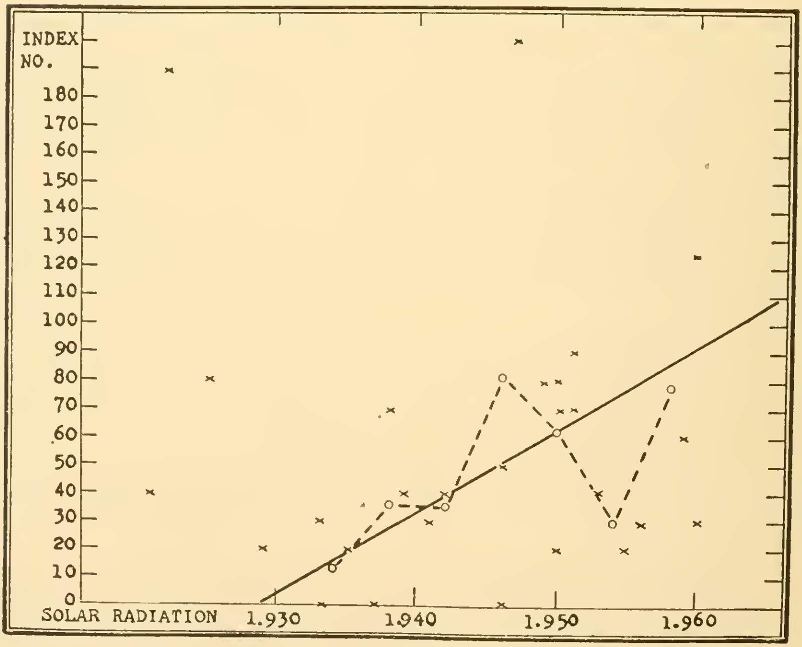

FIG. 2.—Relation of solar radiation to area and intensity of faculæ.

As Dr. C. G. Abbot had found that there is a relation between the visible phenomena of the sun and the solar radiation intensities, an arrangement was made with the Astronomical Observatory of the University of La Plata to make observations of the sun from August, 1920. Later on, the same class of observations were made by the Magnetical Observatory of Pilar, Argentina, and the Astronomical Observatory at Rio de Janeiro, Brazil. Figure 1 shows the mean distribution of faculae in longitude on the sun following marked outbreaks of faculae, and figure 2 shows the relation of solar radiation to area and intensity of faculae (after Clayton).

Some months after the departure of Mr. H. H. Clayton, until then chief of the forecast department of the Argentine Meteorological Office, when the author took charge of the weekly prediction, the scope of the investigations was widened by including the daily observations of the magnetic components, and from February, 1924, there were included the atmospheric electricity data, from the Pilar Observatory.

To calculate the weekly forecast of the weather, all the various observations previously mentioned, solar radiation, solar faculae, earth magnetism, atmospheric electricity and the meteorological observations are analysed and subjected to an exhaustive and comparative study.

VERIFICATION—TEMPERATURE

The difficulties offered by a weather prognostication for intervals longer than 24 hours, increase considerably with the length of the selected period.

For example, the prediction for the first day of the weekly forecast can be formulated with great accuracy, but as the number of days augment, the technical processes and the calculations must be multiplied to attain the exactitude of the first day, so that it can be stated that the difficulties increase in geometrical progression.

The verification of a forecast formulated in exact numbers, and for a limited territory, does not suffer from the same weakness as that of a prediction published in words, whose true sense afterwards can be made a subject of dispute. The fixed temperatures given by the weekly forecast are very convenient for a mathematical comparison, absolutely free from personal bias.

The method of finding correlation coefficients worked out by Galton and Pearson is much employed at present, and therefore the following equation was used to determine the relations between predicted and observed values.

$$r = \frac{\Sigma XY}{\sqrt{\Sigma X^2 \cdot \Sigma Y^2}}$$

Where X represents the departures from the mean value of the forecasted temperatures, Y the departures from the mean value of the observed temperatures, and r the correlation coefficient. For verification purposes there were employed only the temperature observations from the Villa Ortuzar Observatory, Chacarita, Buenos Aires, though it probably would have been better to have used a mean of several stations around the River Plata.

Table 1.—*The method for calculating the correlation coefficient*

August 14-20, 1924

Date	Temperature mean of day		X	Y	X^2	Y^2	XY		
	Predic.	Observ.					+	—	
14	7.0	5.6	—26	—44	7	19	+ 11		Log. 12 = 1.079181
									33 = 1.518514
15	8.5	8.8	—11	—12	1	1	+ 1		
									2.597695
16	10.0	10.3	4	3	0	0	+ 0		
									1.298847
17	10.1	10.2	5	2	0	0	+ 0		Log. 19 = 1.278754
18	11.6	13.4	20	34	4	12	+ 7		9.979907
									r = 0.955
19	10.0	10.9	4	9	0	1	+ 0		
20	10.0	10.5	4	5	0	0	+ 0		
Sum	67.2	69.7			12	33	+ 19	—0	
Mean	9.6	10.0							

The first step was to obtain the mean of the days for the predicted and observed values and these were then used to calculate the correlation coefficient as shown in table 1.[1]

The correlation coefficients will be found in tables 2, 3, 4, 5 and 6, representing two and a half years' forecasts from June, 1922 to

[1] Objection may be taken by some to the use of separate means by Mr. Hoxmark for predicted and observed temperatures in computing departures. Yet he merely gives himself thereby the slight advantage that he puts his forecasts on the true scale. The variations from day to day are not affected.

Table 2.—*Correlation between Predicted and Observed Temperature Departures in the Weekly Weather Forecast for the Region of the River Plata. Mean of the day*

Period July–December, 1922

Year	Month	Week	Correlation Factor
1922	July	29– 5	.25
		6–12	—.68
		13–19	.60
		20–26	—.61
		27– 2	—.82
	August	3– 9	.30
		10–16	—.06
		17–23	.40
		24–30	.68
	September	31– 6	.61
		7–13	.24
		14–20	.42
		21–27	.48
	October	28– 4	.08
		5–11	—.76
		12–18	.99
		19–25	—.39
		26– 1	.51
	November	2– 8	.48
		9–15	.67
		16–22	—.67
		23–29	.21
	December	30– 6	—.20
		7–13	—.16
		14–20	.17
		21–27	.75
		28– 3	.67

TABLE 3.—*Correlation between Predicted and Observed Temperature Departures in the Weekly Weather Forecast for the Region of the River Plata. Mean of the day*

Period January–June, 1923

Year	Month	Week	Correlation Factor
1923	January	4–10	—.26
		11–17	—.36
		18–24	—.08
		25–31	—.14
	February	1– 7	—.47
		8–14	.15
		15–21	—.46
		22–28	.43
	March	1– 7	.95
		8–14	.05
		15–21	.91
		22–28	.67
	April	29– 4	.63
		5–11	.62
		12–18	—.34
		19–25	—.21
		26– 2	.69
	May	3– 9	.07
		10–16	—.07
		17–23	.20
		24–30	.28
	June	31– 6	.38
		7–13	—.23
		14–20	.33
		21–27	.07

TABLE 4.—*Correlation between Predicted and Observed Temperature Departures in the Weekly Weather Forecast for the Region of the River Plata. Mean of the day*

Period July–December, 1923

Year	Month	Week	Correlation Factor
1923	July	28– 4	.19
		5–11	.38
		12–18	.82
		19–25	.00
		26– 1	—.54
	August	2– 8	.28
		9–15	.39
		16–22	—.52
		23–29	—.40
	September	30– 5	—.23
		6–12	.31
		13–19	.97
		20–26	.15
		27– 3	—.22
	October	4–10	.72
		11–17	.51
		18–24	.07
		25–31	—.09
	November	1– 7	.45
		8–14	.57
		15–21	—.17
		22–28	.00
	December	29– 5	.19
		6–12	.35
		13–19	—.16
		20–26	.34
		27– 2	.43

TABLE 5.—*Correlation between Predicted and Observed Temperature Departures in the Weekly Weather Forecast for the Region of the River Plata. Mean of the day*

Period January–June, 1924

Year	Month	Week	Correlation Factor
1924	January	3– 9	.57
		10–16	.37
		17–23	.49
		24–30	.15
	February	31– 6	.63
		7–13	.03
		14–20	—.20
		21–27	.20
	March	28– 5	.12
		6–12	—.44
		13–19	—.39
		20–26	.23
		27– 2	.63
	April	3– 9	—.70
		10–16	.74
		17–23	.81
		24–30	.89
	May	1– 7	—.95
		8–14	—.67
		15–21	.57
		22-28	—.72
	June	29– 4	.75
		5–11	.11
		12–18	.19
		19–25	.52
		26– 2	.89

TABLE 6.—*Correlation between Predicted and Observed Temperature Departures in the Weekly Weather Forecast for the Region of the River Plata. Mean of the day*

Period July–December, 1924

Year	Month	Week	Correlation Factor
1924	July	3– 9	.00
		10–16	—.49
		17–23	—.73
		24–30	.28
	August	31– 6	.67
		7–13	.71
		14–20	.96
		21–27	.39
		28– 3	.00
	September	4–10	.29
		11–17	—.23
		18–24	.08
		25– 1	—.41
	October	2– 8	.85
		9–15	—.17
		16–22	—.32
		23–29	.77
	November	30– 5	.70
		6–12	.42
		13–19	.45
		20–26	—.29
		27– 3	.63
	December	4–10	—.21
		11–17	—.51
		18–24	.22
		25–31	—.45

December, 1924. It is evident that by calculating the correlation for each week independently, all seasonal influences will be eliminated from the results.

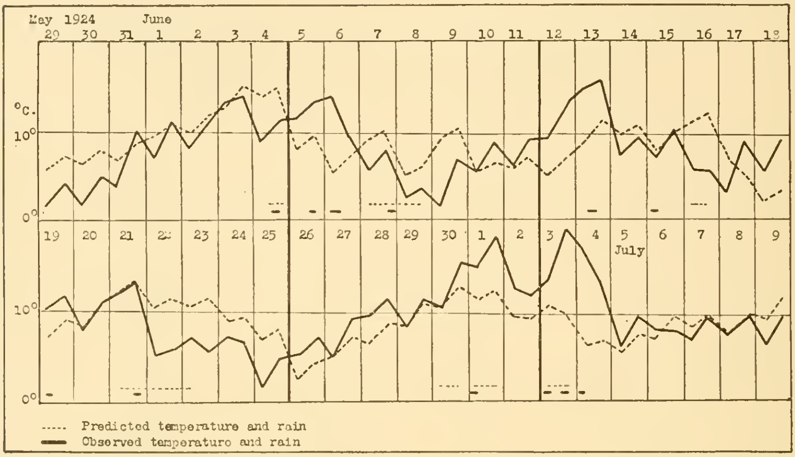

FIG. 3.—The dotted lines show predicted temperature and rain in the Weekly Weather Forecast for six weeks from May 29 to July 9, 1924, and the lines in full show the observed temperature and rain for the same period.

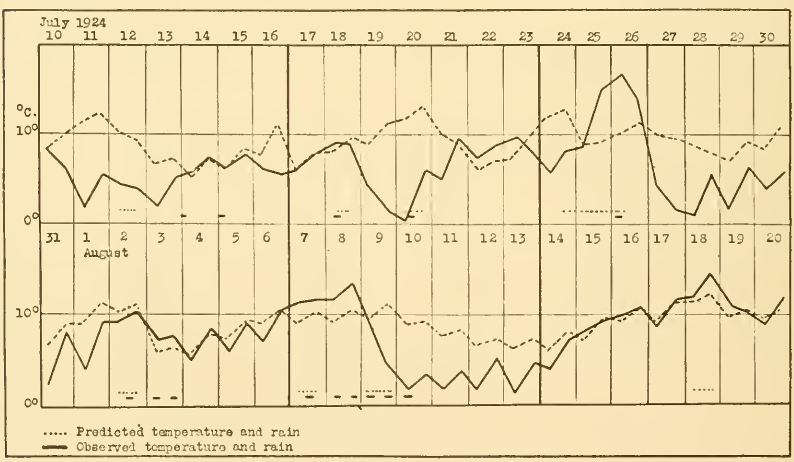

FIG 4.—The dotted lines show predicted temperature and rain in the Weekly Weather Forecast for six weeks from July 10 to August 20, 1924, and the lines in full show the observed temperature and rain for the same period.

Figures 3 and 4 each give six weekly forecasts, from May 29 to August 20, 1924. The dotted lines show predicted temperature and the full lines the observed temperature. Underneath the temperature curves, the predicted rain is indicated by small dots, and the observed precipitation by short heavy lines.

The predicted and observed temperature values at 8 a. m., and 8 p. m., for each day from May 29 to August 20, 1924, will be found in tables 7, 8, 9 and 10, with their corresponding weekly correlation coefficient. The solar-radiation data received by cable from the Montezuma Observatory, Calama, and the solar faculae observations from the Pilar Magnetical Observatory for the same period, are shown respectively in tables 11 and 12.

A negative correlation is not always indicative of absolute failure of a forecast. This is amply illustrated by the two weeks, July 10-16 and July 17-23, 1924.

Glancing at the graph, figure 4, we can see that the observed curve on the eleventh of July shows the maxima indicated by the forecast, though the temperature had fallen several degrees under.

In the second case, on only two days, namely the 19th and the 20th, were the observed values contrary to the forecasted; and yet the correlation coefficients for those weeks turn out to be −.49 and −.73.

TABLE 7.—*Predicted and Observed Temperature at 8 a. m., and 8 p. m. Predicted Temperature from the Weekly Weather Forecast for the River Plata Region, Observed Temperature from the Chacarita Observatory, Buenos Aires*

Year	Month	Day	Temperature Predicted	Temperature Observed	Correlation Factor
1924	May	29	8 a. m. 5.7	1.6	
			8 p. m. 7.2	4.3	
		30	6.7	1.8	
			7.9	5.1	
		31	6.8	3.7	
			8.4	10.2	
	June	1	9.1	7.1	
			10.4	11.2	
		2	9.8	8.2	
			11.5	10.3	
		3	12.5	12.8	
			14.8	14.0	
		4	13.9	8.8	.75
			14.5	11.5	
		5	8.0	11.6	
			9.6	13.3	
		6	5.3	13.9	
			7.3	9.3	
		7	8.9	5.8	
			9.9	8.1	
		8	4.9	2.6	
			6.1	3.5	
		9	9.0	1.7	
			10.2	6.8	
		10	5.4	5.9	
			6.3	8.6	
		11	5.9	6.3	.11
			6.8	9.0	
		12	4.8	9.4	
			6.5	13.0	
		13	8.7	14.5	
			11.2	15.7	
		14	9.7	7.4	
			10.5	9.2	
		15	7.9	7.1	
			9.6	10.1	
		16	10.6	5.7	
			11.9	5.7	
		17	6.9	2.7	
			5.3	9.0	
		18	2.1	5.6	.19
			2.7	9.0	

TABLE 8.—*Predicted and Observed Temperature at 8 a. m., and 8 p. m. Predicted Temperature from the Weekly Weather Forecast for the River Plata Region, Observed Temperature from the Chacarita Observatory, Buenos Aires*

Year	Month	Day	Temperature: Predicted	Temperature: Observed	Correlation Factor
1924	June	19	8 a. m. 7.0	10.4	
			8 p. m. 8.9	12.0	
		20	8.3	7.9	
			11.3	10.8	
		21	11.9	11.9	
			13.1	12.8	
		22	10.3	5.0	
			11.0	5.5	
		23	10.5	6.7	
			11.3	5.7	
		24	8.8	7.2	
			8.9	6.6	
		25	6.7	1.7	.52
			7.7	4.4	
		26	2.2	5.2	
			4.1	7.4	
		27	4.5	4.9	
			7.1	9.1	
		28	6.3	9.3	
			8.3	11.2	
		29	8.0	8.1	
			10.3	11.0	
		30	10.3	10.2	
			12.3	15.1	
	July	1	11.2	14.8	
			11.9	18.4	
		2	9.0	12.2	.89
			8.9	11.8	
		3	10.3	13.6	
			9.5	19.0	
		4	6.1	17.1	
			6.5	13.0	
		5	5.3	6.0	
			7.0	8.9	
		6	6.9	7.6	
			9.1	7.6	
		7	8.0	6.7	
			9.2	8.8	
		8	7.6	7.4	
			9.3	9.4	
		9	8.9	6.2	.00
			11.6	8.8	

TABLE 9.—*Predicted and Observed Temperature at 8 a. m., and 8 p. m. Predicted Temperature from the Weekly Weather Forecast for the River Plata Region, Observed Temperature from the Chacarita Observatory, Buenos Aires*

Year	Month	Day	Temperature: Predicted	Temperature: Observed	Correlation Factor
1924	July	10	8 a. m. 8.2	8.5	
			8 p. m. 9.6	6.5	
		11	11.0	1.9	
			12.2	5.6	
		12	10.4	4.6	
			9.8	4.1	
		13	6.8	2.0	
			7.2	5.3	
		14	5.4	5.8	
			7.0	7.6	
		15	6.4	6.7	
			8.4	7.8	
		16	7.8	6.3	—.49
			11.1	5.8	
		17	6.2	6.1	
			7.9	8.0	
		18	8.1	9.1	
			9.5	9.0	
		19	8.7	3.5	
			11.3	1.2	
		20	11.7	0.4	
			12.9	6.2	
		21	10.0	4.6	
			9.1	9.8	
		22	6.0	7.7	
			6.8	9.3	
		23	6.9	9.9	—.73
			9.8	8.3	
		24	12.0	5.8	
			12.8	8.0	
		25	8.6	8.6	
			9.0	15.3	
		26	10.0	16.8	
			11.2	14.0	
		27	10.0	4.0	
			9.7	1.5	
		28	8.6	1.2	
			8.1	5.9	
		29	7.3	1.5	
			9.2	6.6	
		30	8.6	4.0	.28
			10.6	6.0	

Table 10.—*Predicted and Observed Temperature at 8 a. m., and 8 p. m. Predicted Temperature from the Weekly Weather Forecast for the River Plata Region, Observed Temperature from the Chacarita Observatory, Buenos Aires*

Year			Temperature		Correlation Factor
	Month	Day	Predicted	Observed	
1924	July	31	8 a. m. 6.5	2.0	
			8 p. m. 8.7	7.9	
	August	1	8.9	3.9	
			11.1	9.1	
		2	10.4	9.2	
			10.8	10.2	
		3	5.9	7.3	
			6.0	7.7	
		4	5.5	4.7	
			7.6	8.2	
		5	7.2	6.0	
			9.0	8.7	
		6	8.8	6.9	.67
			10.2	10.3	
		7	9.1	11.3	
			10.4	11.5	
		8	9.3	12.0	
			10.3	13.6	
		9	9.9	9.2	
			11.0	4.1	
		10	8.8	1.6	
			8.9	3.2	
		11	7.7	1.7	
			8.3	4.1	
		12	6.6	1.7	
			7.3	5.4	
		13	6.4	1.3	.71
			7.4	4.6	
		14	5.9	4.0	
			8.2	7.3	
		15	7.5	8.2	
			9.5	9.4	
		16	9.4	9.8	
			10.6	10.8	
		17	9.4	8.6	
			10.9	11.8	
		18	11.1	12.1	
			12.2	14.7	
		19	9.9	11.4	
			10.2	10.4	
		20	9.5	8.8	.96
			10.5	12.3	

Table 11.—*Solar-Constant Values, Montezuma Station, Calama, Chile*

June, July, and August, 1924

June	Value	Grade	July	Value	Grade	August	Value	Grade
1	1.935	S	1	1.929	S	1	1.871	U
2	1.933	S	2	1.930	S	2	1.909	U
3	1.933	E—	3	1.926	U	3	1.928	S
4	1.927	S—	4	Clouds		4	1.935	S—
5	Clouds		5	1.917	S—	5	1.927	S—
6	1.934	S—	6	1.916	S	6	1.905	U
7	1.931	U	7	1.918	S	7	Clouds	
8	Clouds		8	1.925	S	8	Clouds	
9	1.929	S	9	1.920	S	9	1.918	S
10	1.941	S—	10	1.922	S	10	1.911	S
11	1.930	U	11	1.921	S	11	1.907	U
12	1.930	S—	12	1.912	S—	12	Clouds	
13	1.919	S	13	1.927	S—	13	1.915	S—
14	Clouds		14	1.920	E—	14	1.914	S
15	Clouds		15	1.937	S	15	1.911	E—
16	1.925	S—	16	1.927	S	16	1.922	S
17	1.931	S—	17	1.918	VG—	17	1.920	S
18	1.931	S—	18	1.923	S	18	1.913	S
19	1.927	S—	19	1.925	S	19	1.910	E—
20	Clouds		20	1.924	S	20	1.844	U
21	Clouds		21	1.919	E—	21	Clouds	
22	1.924	E—	22	1.937	S	22	1.875	U
23	1.921	S	23	1.916	S	23	1.931	U
24	1.934	S—	24	1.914	S	24	1.907	E—
25	Clouds		25	1.908	S—	25	1.908	S
26	1.913	E—	26	1.918	S—	26	1.928	S
27	1.931	U	27	1.920	S	27	1.922	VG+
28	1.925	S	28	1.921	E—	28	1.918	S
29	1.924	VG	29	Clouds		29	Clouds	
30	1.934	S	30	Clouds		30	1.914	U
			31	1.910	S	31	1.910	S—

TABLE 12.—*Pilar, Magnetical Observatory, Lat. 31° 40′ 13″ S., Long. 63° 53′ 00″ W. Results of Solar Faculae observations*

June, July, and August, 1924

June	Area	July	Area	August	Area
1	175	1	35	1	140
2	0	2	Cloudy	2	Cloudy
3	0	3	0	3	Cloudy
4	Cloudy	4	Cloudy	4	166
5	Cloudy	5	Cloudy	5	195
6	160	6	70	6	Cloudy
7	Cloudy	7	242	7	86
8	0	8	185	8	Cloudy
9	0	9	70	9	0
10	100	10	95	10	0
11	80	11	Cloudy	11	170
12	0	12	Cloudy	12	Cloudy
13	0	13	Cloudy	13	180
14	0	14	0	14	140
15	50	15	Cloudy	15	133
16	118	16	315	16	175
17	110	17	Cloudy	17	Cloudy
18	Cloudy	18	Cloudy	18	Cloudy
19	Cloudy	19	Cloudy	19	28
20	66	20	Cloudy	20	0
21	Cloudy	21	0	21	0
22	Cloudy	22	60	22	50
23	0	23	90	23	33
24	35	24	0	24	Cloudy
25	Cloudy	25	Cloudy	25	110
26	15	26	160	26	200
27	44	27	Cloudy	27	105
28	75	28	165	28	68
29	131	29	150	29	15
30	172	30	138	30	0
		31	60	31	Cloudy

The area is the combined area of all the daily solar faculae observed, multiplied by their degree of luminosity or intensity, which is expressed as I, II and III.

VERIFICATION—RAINFALL

In the following verification of precipitation predicted in the weekly weather forecast, only rain fallen within the small zone in heavy shading on the accompanying map, figure 5, has been used, and days with fog and great humidity which did not materialize into rain were not included.

Atmospheric changes over the region of the River Plata usually cover a great area, approximately indicated by dotted shading on the map of an extension of about 600,000 km.^{2}, besides the small zone 50,000 km.^{2} immediately around the River Plata.

TABLE 13.—*Villa Ortuzar Observatory, Chacarita, Buenos Aires, Lat. 34° 35′ 15″ S., Long. 58° 28′ 15″ W. H. 25 mt.*

Average rainfall in mm.

(1901–1920)

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
		79	66	100	120	72	51	55	57	73	85	100	104	962
Monthly rainfall observed, and deviations from the normal.														
1922	Obs.	123	76	74	121	48	101	161	278	53	85	56	19	1195
	Devi.	44	10	—26	1	—24	50	106	221	—20	0	—44	—85	233
1923	Obs.	32	73	135	108	17	60	88	159	53	70	80	101	976
	Devi.	—47	7	35	—12	—55	9	33	102	—20	—15	—20	—3	14
1924	Obs.	56	157	102	19	63	20	3	54	107	15	42	17	655
	Devi.	—23	91	2	—101	—9	—31	—52	—3	34	—70	—58	—87	—307

Notwithstanding that the verification results over the greater area would have improved the percentage, these were not taken into account, so as not to fall into the very common error made by long-range forecasters who claim for verification purposes, atmospheric phenomena occurring over great extensions of territories, and frequently over the whole world.

Table 13 shows the normal rainfall for Buenos Aires for a period of 20 years from 1901 to 1920, and also the monthly values observed during the years 1922, 1923, and 1924 with their corresponding departures from the normal. The year 1924 was very dry compared with the normal, the precipitation being 32 per cent under normal.

With reference to tables 14 to 18, the column headed "Day" indicates the days of the forecast week. As the prediction is issued on Wednesday, Thursday is the first day, Friday the second, etc. In

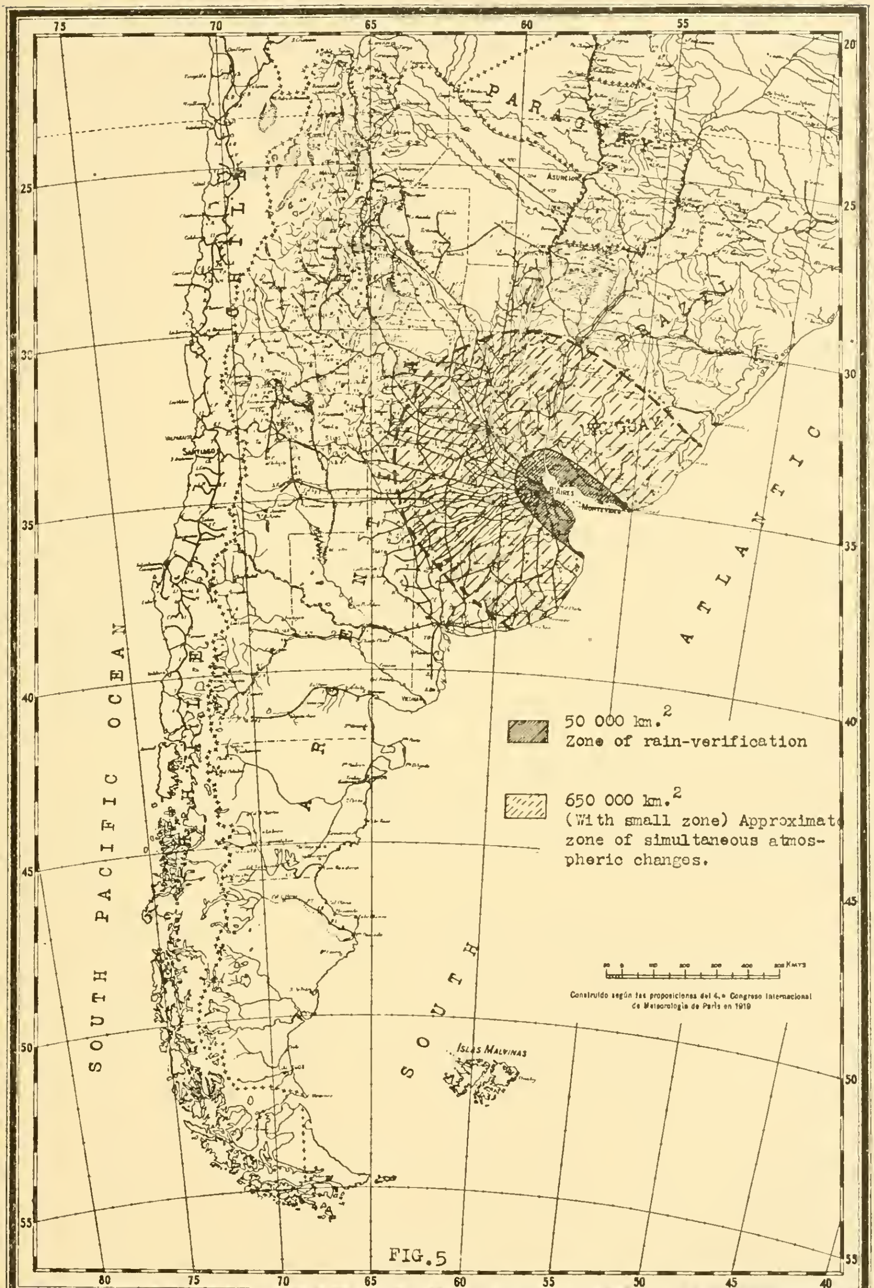

Fig. 5.—Map showing area used in rainfall verification.

the column headed "0 day" are given the cases in which the forecasted rain fell exactly on the day indicated, and in those headed "1 day," "2 days," etc., cases when rain fell one day or more before or after the forecasted day.

TABLE 14.—*Verification of forecasted rain for the River Plata Region*

Period June 29, 1922–January 3, 1923

Day		0 day	1 day	2 days	3 days	4 days	Sum
Thursday	I	1			1		2
Friday	II	1	1	2	1		5
Saturday	III	1		3		2	6
Sunday	IV	2	2	1			5
Monday	V	4	1	1			6
Tuesday	VI	3	1	1		1	6
Wednesday	VII		1				1
Cases		12	6	8	2	3	31
Per cent		39	19	26	7	10	

It must be remarked that only one case out of 26 was predicted with only one day's anticipation, of the cases within the limit 0-2 days, and the rest prognosticated with 2 to 7 days anticipation in the above period.

In the following period, January to July, 1923, of 34 cases of probable rain within the same limit, only four were forecasted for the first day of the week, and 30 cases with from 2 to 7 days anticipation.

TABLE 15.—*Verification of forecasted rain for the River Plata Region*

Period January 4–July 4, 1923

Day		0 day	1 day	2 days	3 days	4 days	Sum
Thursday	I	2	2				4
Friday	II	4	3		1	1	9
Saturday	III	4		1	1	2	8
Sunday	IV	2	1		1	1	5
Monday	V	3		1	2	1	7
Tuesday	VI	2	3	1		1	7
Wednesday	VII	3	1	1			5
Cases		20	10	4	5	6	45
Per cent		44	22	9	11	13	

TABLE 16.—*Verification of forecasted rain for the River Plata Region*

Period July 5, 1923–January 2, 1924

Day		0 day	1 day	2 days	3 days	4 days	Sum
Thursday	I	2		1			3
Friday	II	3		1	1	1	6
Saturday	III	4		2	1		7
Sunday	IV	8	3	1			12
Monday	V	8			1		9
Tuesday	VI	5		1			6
Wednesday	VII	1	1		2		4
Cases		31	4	6	5	1	47
Per cent		66	8.5	13	11	2	

Of the 47 cases of rain predicted for the last half year of 1923, only 3 were forecasted one day in advance and the rest with from 2 to 7 days' anticipation. The majority of the rains fell exactly on the day indicated.

TABLE 17.—*Verification of forecasted rain for the River Plata Region*

Period January 3–July 2, 1924

Day		0 day	1 day	2 days	3 days	4 days	Sum
Thursday	I	2					2
Friday	II	3	1	1	2	1	8
Saturday	III	5	1	1			7
Sunday	IV	4	2		2		8
Monday	V	5	3	2	1		11
Tuesday	VI		2		1	1	4
Wednesday	VII	3	2	1		1	7
Cases		22	11	5	6	3	47
Per cent		47	23	11	13	6	

Of the 47 cases of rain forecasted for the above period, only 2 were predicted one day in advance, and the rest with from 2 to 7 days anticipation.

TABLE 18.—*Verification of forecasted rain for the River Plata Region*

Period July 3–December 31, 1924

Day		0 day	1 day	2 days	3 days	4 days	Sum
Thursday	I	5	2				7
Friday	II	4	2	1			7
Saturday	III	13	2				15
Sunday	IV	5		3		1	9
Monday	V	3	2			1	6
Tuesday	VI	2				1	3
Wednesday	VII		1	2			3
Cases		32	9	6		3	50
Per cent		64	18	12		6	

Seven cases of rain in this period were forecasted 1 day in advance, and 43 with from 2 to 7 days' anticipation.

TABLE 19.—*Summary of verification of forecasted rain for the River Plata Region in Per Cent*

Period	0–1 day	0–2 days	0–3 days
June 29, 1922–January 3, 1923	58	84	91
January 4–July 4, 1923	66	75	86
July 5, 1923–January 2, 1924	75	88	98
January 3–July 2, 1924	70	81	94
July 3–December 31, 1924	82	94	94
Average per cent	70	84	93

TABLE 20.—*Summary of verification of sign of forecasted temperature*

Period	Weeks		Per Cent
	+	—	
June 29, 1922–January 3, 1923	18	9	200
January 4–July 4, 1923	15	10	150
July 5, 1923–January 2, 1924	19	8	238
January 3–July 2, 1924	19	7	271
July 3–December 31, 1924	16	10	160
Average per cent			198

The final result of the temperature verification for two and a half years weekly forecasting is, as will be seen in table 20, that the number of weeks with positive correlation as compared with the number of weeks with negative correlation is 198 per cent.

After working some time independently with the weekly weather forecast, the author found that if, as it is intended, the new method of weather prognostication by solar data is going to assist or supplant the primitive and established basis for weather prediction, namely, the daily synoptic weather maps, it is necessary not to make use of these to help the weekly forecast. Therefore the daily weather maps were only consulted a few times during the year 1922 when the difficulties were greater than usual, especially with regards to rain on the first day. Later on this was discontinued, and the weather maps not consulted.

At times it has been a very severe test, but the fact that the daily forecast is in charge of a separate department has made it possible.

As the present paper was intended to show only the verification results for the weekly weather forecast of the "Oficina Meteorologica Argentina," it was not thought advisable to go deeper here into the most interesting point, the discussion of the connection between solar radiation and the various terrestrial phenomena, especially of magnetism and precipitation.