Finally, our results may be compared to those of similar experiments carried out by Falckenberg (**12**) which extend over a more limited range of moisture. Falckenberg's values for the emissivity are much higher than ours, for instance for 0.0005 gr/cm^2 of water he finds 6.7 percent emission, for 0.0015 gr/cm^2 he has 13.4 percent, and for 0.0075 gr/cm^2 he has 17.5 percent, the figures referring to the same temperature of 20° for water vapor as ours. On the other hand, we might derive some information from the results obtained by Hottel and Mangelsdorf (**9**) on steam. The values of the latter work are intermediate between those of Falckenberg and ours. Now general spectroscopic evidence indicates (and this will also be seen from the numerical values in the radiation chart) that between 0° C. and 100° C. the percent emissivity increases with increasing temperature for the thicknesses of moisture considered here. The values for steam ought therefore to lie above our values, as is observed, while an experimental error in Falckenberg's values seems indicated. For the same interval of moisture, Schnaidt (**13**) has calculated the emissivity on the basis of spectroscopic data partly independent of those used in the construction of our radiation chart and his results are in close agreement (within ±1–2 percent of the black body intensity) with our measured curve.

Conclusion.—The experiments carried out by us seem to indicate that there are a number of advantages in using for the measurement of atmospheric radiation the closed type radiation instrument with a concave mirror. Two ways seem to be open to increase the sensitivity of the instrument. While our mirror covers a solid angle which is about 8 percent of the maximum solid angle of 2π, it should be possible without much difficulty to grind a short focus mirror covering about one-half of the hemisphere. Furthermore multiple junction thermopiles might be used, although it is perhaps difficult to compensate them as well against temperature changes due to adiabatic compression of the air as one can compensate the one-junction type, and the use of the latter might remain more advantageous.

During a clear autumn night an hour-to-hour record was made of the radiative temperature of the foliage of several trees, one of them an orange tree. Simultaneously the radiative temperature of a piece of bare ground and the sky radiation were recorded. While the radiative temperature of the ground was consistently below the air temperature by about 0.8° C. from early evening until sunrise, the temperature of the tree foliage showed an irregular deviation from the air temperature of only a few tenths of a degree, which is within the observational errors. The dew point was however very close to the air temperature during the whole night, so that it is hardly possible to apply this result to the dry polar outbreaks during which the freezing of orchards occurs.

BIBLIOGRAPHY

(1) Kleinschmidt, *Handbuch der meteorologischen Instrumente*, Berlin, 1935.
(2) L. B. Aldrich, *Smithsonian Misc. Coll.*, vol. **72**, No. 13, 1922.
(3) W. H. Dines and L. H. G. Dines, *Mem. Roy. Meteor. Soc.*, **2**, No. 11, 1927.
(4) P. Dubois, *Gerl. Beitr. z. Geophys.*, **22**, 41, 1929.
F. Linke, *Met. Zeits.*, **48**, 25, 1931.
E. Süssenberger, *Met. Zeits.*, **52**, 129, 1935; *Gerl. Beitr. Geophys.*, **45**, 384, 1935.
(5) F. A. Brooks, *Bull. Am. Met. Soc.*, **20**, 433, 1939.
(6) P. Dubois, *Met. Zeits.*, **49**, 432, 1932.
(7) J. Strong, *Proceedings in Experimental Physics*, 1938.
(8) A. H. Pfund, *Jour. Opt. Soc. Amer.*, **23**, 375, 1933.
(9) Hottel and Mangelsdorf, *Trans. Amer. Inst. Chem. Eng.*, **31**, 517, 1935.
(10) W. M. Elsasser, *Quar. Jour. Roy. Mete. Soc.*, **66**, suppl. p. 41, 1940.
(11) W. M. Elsasser, Mo. WEA. REV., **68**, 185, 1940.
(12) G. Falckenberg, *Met. Zeits.*, **53**, 172, 1936; **55**, 174, 1938; **56**, 72, 1939; **56**, 415, 1939.
(13) F. Schnaidt, *Met. Zeits.*, **54**, 234, 1936; *Gerl. Beitr. z. Geophys.*, **54**, 203, 1939.

THE VARIABILITY OF PRECIPITATION

By V. CONRAD

[Pennsylvania State College, State College, Pa., October 1939]*

In some years on Malden Island, precipitation amounts to 100 millimeters (3.94 inches), and in others to 2,000 millimeters (78.8 inches) and more. The mean of many years amounts to 727 millimeters (28.6 inches). The relative variability is 71 percent.[1] This is the most extreme case on the earth, as far as known. From the geophysical, meteorological, and climatological standpoint, such variations of precipitation are of great interest. The possibility of years with floods, with abundant crops, and of years with famines at the same place indicates great variability, the explanation of which is a problem for the above sciences.

In the present paper the variability of precipitation is discussed, from a statistical point of view.

If the mean yearly sum is called $\bar{p}$ and the individual yearly sum p_i, then

$$p_i - \bar{p} = \epsilon_i.$$

The expression

$$\frac{\Sigma \epsilon_i}{n} = v_a$$

is called *absolute average variability*. It is clear that v_a must increase with $\bar{p}$. The geographical distribution of v_a would therefore give the same picture as the precipitation map itself. Hence v_a should be expressed in percent of $\bar{p}$. The quantity

$$v_r = \frac{100 v_a}{\bar{p}}$$

is called the *relative variability*; it appears to be the best measure of variability.

The geographic distribution of v_r is so remarkable that a detailed investigation is desirable.

1. THE ABSOLUTE VARIABILITY

The places with yearly precipitation 0–200, 201–400, 401–600 millimeters, etc. (0–7.9, 7.91–15.7 inches, etc.), were grouped. For each group both the mean yearly sums ($\bar{p}$) and the absolute variabilities (v_a) were averaged. If the average variabilities are plotted against the mean precipitation (table 1), a linear connection is clearly indicated. The data may be closely represented by the equation:

$$v_a = 36 + 0.13\bar{p}$$

The differences "observed–calculated" (o–c) appear in the last column of table 1. As the values of v_a and $\bar{p}$ are derived from observations over the whole earth, the above equation may be regarded as the normal relation.

---

*[Now Robert De Courcy Ward Research Associate, Harvard University, Cambridge, Mass.]

[1] E. Biel, Die Veränderlichkeit der Jahressumme des Niederschlags auf der Erde. *Geogr. Jb. aus Oesterreich*, XIV & XV, Leipzig, 1929, 151–80.

TABLE 1.—*Absolute variability of precipitation as function of the yearly sum*

Number of stations	Interval	Mean yearly sum	Average variability		o–c
			Obs.	Calc.	
	mm.	*mm.*	*mm.*	*mm.*	
28	0–200	127	48	53	−5
39	201–400	317	75	77	−2
60	401–600	547	95	107	−12
61	601–800	698	130	127	+3
35	801–1, 000	901	156	153	+3
43	1, 001–1, 200	1, 093	178	178	0
29	1, 201–1, 400	1, 301	213	205	+26
27	1, 401–1, 600	1, 505	240	230	+10
7	1, 601–1, 800	1, 678	248	254	−6
7	1, 801–2, 000	1, 898	276	283	−7
15	2, 001–2, 400	2, 167	308	318	−10
13	2, 401–3, 000	2, 663	356	382	−26
11	3, 001–4, 000	3, 363	498	473	+25
6	>4, 000	6, 598	892	894	−2

2.—THE RELATIVE VARIABILITY

Now, since $v_r=100v_a\bar{p}$, we have

$$v_r=\frac{3600}{\bar{p}}+13.$$

Therefore, v_r is a function of $\bar{p}$ which has the form of a hyperbola. For $\bar{p}=0$, v_r becomes infinite: For the present purpose it is important to follow the trend of the curve on the basis of the figures in table 2.

The v_r curve is extremely sensitive to small variations of the yearly precipitation in the range of little precipitation. The sensitivity is so great that it is out of proportion to the accuracy of observation. The other branch of the hyperbola is practically parallel to the axis from 1,500 millimeters (59.1 inches) precipitation to the greatest known extremes; i. e., *starting from 1,500 millimeters (59.1 inches), the variability of the yearly precipitation v_r is independent of the yearly sum.*

TABLE 2.—*Numerical Values from the Equation* $v_r=\frac{3600}{\bar{p}}+13$

$\bar{p}$	v_r	$\bar{p}$	v_r	$\bar{p}$	v_r
mm.	*Percent*	*mm.*	*Percent*	*mm.*	*Percent*
0	∞	110	46	300	25
10	373	120	43	350	23
20	193	130	41	400	22
30	133	140	39	500	20
40	103	150	37	600	19
50	85	160	34	800	17
60	73	180	33	1, 000	17
70	65	200	31	1, 500	15
80	58	220	29	2, 000	15
90	53	240	28	4, 000	14
100	49	250	27	8, 000	13
				12, 000	13

In the case of investigations of less accuracy the limit of dependence can perhaps be moved back to 1,000 millimeters (39.4 inches). The theorem can also be expressed as follows: *the deviation of the variability from their nearly constant average value (15–13 percent) must be explained geophysically, not statistically.* But in the case of *yearly sums below 1,000 millimeters (39.4 inches) a very strong mathematical dependence of the value v_r on the yearly sum occurs:* v_r increases to infinity if the yearly sum becomes zero. In that range the expression v_r is therefore not suitable for the representation of the variability of the precipitation.[2] *In Nature* the relative variability does not increase as rapidly as would be expected from its mathematical derivation. An evidently *finite* increase of v_r results when $\bar{p}$ decreases to zero.

Therefore, I tried to find a function which changes the character of the theoretical curve as little as possible but fits the observations at the same time. The new function must have the form $\frac{A}{\bar{p}+B}+C$ instead of $\frac{A}{\bar{p}}+C$, the theoretical form, A, B, C being constants. The best value of B was found most quickly by an empirical trial method which I developed for a seismic problem many years ago.[3] It gives the average yearly sums and their v_r values in table 3.

TABLE 3.—*Mean Yearly Sums of Precipitation* ($\bar{p}$) *and the Corresponding Mean Relative Variabilities* (v_r)

$\bar{p}$	$\bar{p}$	v_r
Inches	*Millimeters*	*Percent*
5. 0	127	37
12. 5	317	24
21. 5	547	17
27. 5	698	19
35. 5	901	17
42. 9	1, 093	16
51. 2	1, 301	18
59. 4	1, 505	16
66. 1	1, 678	15
74. 8	1, 898	15
85. 4	2, 167	14
104. 7	2, 663	13
132. 3	3, 363	15
259. 8	6, 598	14

The following constants have been used in the formula: $B=20$, 50, 60, 70, 100, $A=3{,}600$, and $C=13$. There was no reason of course to change the values of A and C. The v_r have been calculated with each of the five formulas, and the differences (obs.-calc.) computed for the interval of $\bar{p}$ from 0 to 200 millimeters (0–7.9 inches). This is the critical interval which makes the introduction of the constant B necessary. Then the deviations (o–c) have been summed up for the various constants B, disregarding the signs. These sums were plotted against the accepted values of B in a diagram, figure 1.

The curve shows a conspicuous minimum between $B=50$ and 60, nearer to 60. In the first approximation. The $B=60$ may be considered as the best constant. The equation is therefore

$$v_r=\frac{3600}{\bar{p}+60}+13.$$

It follows that $v_r=73$ percent for $\bar{p}=0$, instead of $v_r=\infty$.

From table 4 we get the definitive normal values of v_r for the corresponding values of $\bar{p}$, based on the above formula.

TABLE 4.—*Definitive values v_r for increasing $\bar{p}$*

$\bar{p}$	v_r	$\bar{p}$	v_r	$\bar{p}$	v_r
mm.	*Percent*	*mm.*	*Percent*	*mm.*	*Percent*
0	13	140	30	700	18
10	64	150	30	800	17
20	58	160	29	900	17
30	53	180	28	1, 000	16
40	49	200	26	1, 500	15
50	46	220	25	2, 000	15
60	43	240	25	3, 000	14
70	41	260	24	7, 000	14
80	39	280	23	8, 000	13
90	37	300	22	12, 000	13
100	35	350	21		
110	34	400	19		
120	32	500	18		
130	31	600	18		

---

[2] It is to be emphasized that according to W. Meinardus (Die Areale der Niederschlagsstufen auf der Erde, *Petermann's Geogr. Mitt.* 1934, 141) 53.7 percent of the earth's surface receives less than 1,000 millimeters precipitation. This fact puts the above conclusion in a new light.

[3] V. Conrad, Einsätze in Fernbebendiagrammen. *Gerlands Beiträge Geophysik.* 24, 1929–30, 358.

The formula adapted to the observations yields a curve which is practically identical with the "theoretical curve" (table 2) starting from 400 millimeters (15.7 inches) precipitation. Starting from 700 millimeters (27.6 inches) both curves are really identical.

THE ANOMALIES OF VARIABILITY

The aforesaid conditions lead, as in the case of other phenomena,[4] by necessity to the use of the method of anomalies. The anomalies should presumably be independent of the yearly precipitation and therefore adapted to show new and individual features. If two elements are as closely correlated as precipitation sum (up to about 1,000 millimeters annually) and variability, one cannot expect more information from both elements than from just one. E. Biel has (*l. c.*) published an extensive table which contains the geographic ordinates, the yearly precipitation, and the absolute and the relative variabilities for a number of places. If we use the values of table 4 as normal ones, the differences "obs.-calc." can be computed. These are the *anomalies* which appear in the last column of table 5; *these values* have been calculated here and *are new.* To facilitate the use of the table $\bar{p}$ and v_a are here also given in inches, the heights also in feet. The other numbers are taken from Biel's table.

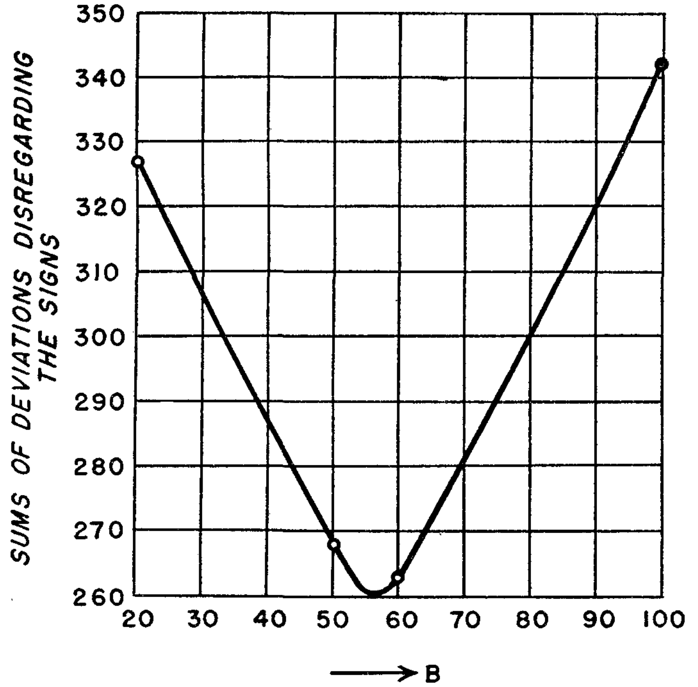

FIGURE 1.—Diagram for finding the best-fitting constant B in the formula $v_r = \frac{A}{\bar{p}+B} + C$.

4. SOME STATISTICAL CHARACTERISTICS OF THE ANOMALIES

The anomalies are characterized like many other climatological elements by a certain asymmetry. Among 360 anomalies, 167 have a positive sign and 193 a negative sign —46 and —54 percent, respectively. In the dry regions the relation seems to be inverted. In the interval 0–200 millimeters (0–8 inches), we find 63 percent *positive,* and 37 *negative;* but the total number in the interval is only 27. A similar inversion appears also in the interval 1,201–1,400 millimeters (472–551 inches). In the first case it is possible to find a general and rational explanation; in the other case regional conditions may be the cause.

The arithmetical sum of the anomalies must be about zero. The asymmetry relative to the signs results in a compensation: the positive anomalies must be of greater amount than the negative ones.

This conclusion is also confirmed by statistics. The highest observed anomaly reaches the positive value of 53 percent (Malden Island). The positive maxima of the various intervals are on the average 2.3 times larger than the negative ones. Among the positive anomalies $\frac{1}{6}$ is greater than, or equal to 10 percent; among the negative ones, only $\frac{1}{50}$. The greatest negative anomaly is only 14 percent. Generally, *positive anomalies are on the average less frequent but more intense than negative ones.*

Finally, it is important that *the anomalies are still correlated to the precipitation sums.* Even if the material is not sufficient to determine a function which connects both elements, the fact itself is remarkable. It seems that high anomalies are very frequent in dry regions. Between 1,800 and 2,200 millimeters (709–866 inches) the curve (anomaly-precipitation sum) probably reaches a minimum and increases again with further increasing sums. Similar conditions may also exist if positive and negative anomalies are segregated, and the resulting series correlated with the precipitations; but the dispersion is so great that this relation cannot be regarded as settled.

Now arises the question: Should we prefer the representation given by the anomalies to that by the relative variability in spite of the fact that *both* show a connection with the precipitation sum *at least* in *dry regions.*

In the case of the relation "*sum-relative variability*" there is a mathematical *statistical connection* so that the relative variability can be calculated from its definition in good accordance with the observations. The relation "*anomaly-precipitation sum*" deals with a *physical relation* which cannot be calculated in advance, particularly not the sign. These facts indicate the necessity of the transition from the representation of the variability itself to that of the anomalies.

5. THE ZERO-ISANOMALS OF THE RELATIVE VARIABILITY IN CARTOGRAPHIC REPRESENTATION.

A few remarks on the anomaly map are desirable:

(1) The material is not yet sufficient; therefore detailed isanomals could not be drawn.

(2) Variability values are, of course, not available for the oceans.[5]

There are no less than 384 stations on the continents: this would be enough, were they not distributed in such an heterogeneous manner. The great majority is concentrated in Europe, the United States, Canada, Argentina, and British India. Hence detailed isanomals have not been drawn. Only the lines appear on the map which separate the positive from the negative anomalies; in addition, some regions with especially high anomalies have been specifically marked.

The principal features of the cartographic picture may be summarized as follows:

(1) Huge connected regions of the earth's surface show anomalies of the same sign. The distribution of positive and negative anomalies is therefore not to be ascribed to chance or accidental local conditions, but represents a significant climatological element.

---

[4] V. Conrad, M. Winkler, Beiträge zur Kenntnis der Schneedeckenverhältnisse in den oesterreichischen Alpenländern. *Gerlands Beitrage Geoph. 34,* 1931, 473–511.
V. Conrad, Anomalien und Isanomalen der Sonnenscheindauer in den oesterreichischen Alpen. Beihefte (Supplements) *Jahrb. Zentr. Anst. Meteor.,* Wien, 1938.

[5] If it were possible to make estimates of the yearly precipitation, e.g., for 5° squares, based on intensity of rain and the number of days with rain, the transition to the relative variability and its anomaly would be possible. E. Biel was so cautious and judicious as not to draw the isolines across the oceans.

(2) The greatest and most impressive accumulation of negative signs will be found in the immense areas of the temperate and high latitudes of Eurasia and North America. *The continental climate and its effects are regulators of the precipitation. The variability is less than normal. The variations of the general circulation are dampened by the influence of the continents.*

(3) A conspicuous exception is formed by the "semiarid region"[6] to the East of the Rocky Mountains. The remarkable conditions caused by the frequent chinook winds of this region overcompensate the continental influence on the anomaly of variability. This strip has *positive* anomalies. In the remaining vast region, which is at least partly covered with a dense net of stations, only negative signs are found, with the exception of the extreme coastal strips in eastern Asia and from California to Alaska.

(4) Extremely high positive anomalies exist on some continental coasts, especially those deficient in rain, where the weather is affected by ocean currents. This occurs, it seems, in California (California current) and in Chile-Peru (Peru-Humboldt current). The normal behavior of these cold currents causes the small yearly sums on the coast of South America, and the remarkable temperature conditions in California. The smallest deviation of these currents and an invasion by warm water between the stream and the coast involves relative abundant rains (El Niño problem). The high positive anomalies of North-east Brazil (Ceara) are not easy to explain. Here catastrophic droughts occur. These remarkable phenomena may also be caused by displacements of ocean currents. It would be a problem of oceanography to decide whether advances of the Benguela current or recessions of the Brazil current would be possible. The highest anomaly (+53 percent for Malden Island) has already been tentatively explained by displacements of ocean currents.

Exceedingly high positive anomalies over a very large region occur in Beluchistan, the Persian Gulf and the southern part of Arabia. This region also reaches into Africa to the sources of the Nile. On the one side we have the border regions of the monsoon; on the other, expecially rainless territories. Variations of the general circulation which are not dampened by continental influence are the cause of an abnormally high variability.

(5) Another characteristic feature may be emphasized: the influence of the tropic belt which lowers the variability in South America, Africa, and South Asia. The tropical climate is conservative—an *independent climate.* This postulate may be expressed in the more general form: *A climate shows the higher variability the more dependent it is.* This theorem holds perhaps for most *other* climatological elements. The anomalies of the variability are in this way perhaps a *measure* of the *independence* of a *climate.*

FIGURE 2.

The anomalies of precipitation variability therefore appear to reveal features which cast new light on the regime of precipitation and the regime of wind connected with it. The hydrologist who is interested in agricultural problems could apply this method of anomalies to smaller regions. In those of negative anomalies, for instance, it will be useful to cultivate plants of less adaptability. Water power economy may also make use of the knowledge which results from the representation of the anomalies of precipitation variability. The dimensions of a dam should depend on the anomaly of variability of rain.

The principal importance of the anomaly of variability is in dynamic climatology.

---

[6] See Goode's *School Atlas,* Number 42 (N. Y. 1923).

TABLE 5.—*Anomalies of the variability of yearly precipitation for 384 places*

$\bar{p}$=mean yearly sum of precipitation in millimeters and inches
v_a=absolute variability in millimeters and inches
v_r=relative variability in percent
Δ =anomaly deviation from the normal value in percent given by the equation,

$$v_r=\frac{3{,}600}{\bar{p}+60}+13^{1}$$

80°–70° N.

Station	Latitude	Longitude	Elevation		$\bar{p}$		v_a		v_r (percent)	Δ (percent)
			Meters	Feet	Millimeters	Inches	Millimeters	Inches		
1	2	3	4		5		6		7	8
	°	°								
Upernivik	72.8	56.1 W.	19	62	226	8.9	80	3.15	35	+10
Gjesvar	71.1	25.4 E.	7	23	740	29.1	135	5.32	18	0
70°–60° N.										
Nome	64.5	165.4 W.	7	23	442	17.4	97	3.82	22	+2
Tanana	65.2	152.1 W.	67	220	319	12.6	50	1.97	16	−7
Valdez	61.1	146.3 W.	3	10	1,327	52.3	207	8.15	16	+1
Eagle	64.8	141.2 W.	255	837	273	10.7	45	1.77	16	−7
Dawson	64.0	139.4 W.	321	1,053	383	15.1	62	2.40	16	−5
Godthaab	64.2	51.7 W.	9	30	578	22.8	158	6.72	27	+9
Jacobshavn	69.2	51.0 W.	13	43	235	9.3	55	2.17	23	−2
Ivigtut	61.2	48.2 W.	5	16	1,101	43.3	200	7.87	18	+2
Angmagsalik	65.6	37.6 W.	32	104	906	35.7	221	8.70	24	+7
Stykkisholm	65.1	22.8 W.	25	82	634	25.0	76	2.99	12	−7
Vestmanno	63.4	20.3 W.	13	43	1,365	53.7	147	5.79	11	−4
Grimsey	66.6	18.0 W.	22	72	218	8.6	113	4.45	52	+27
Berufjord	64.7	14.4 W.	18	59	1,195	47.0	194	7.64	16	0
Thorshavn	62.0	6.85 W.	26	85	1,432	56.4	200	7.87	14	−1
Bodö	67.3	12.4 E.	21	69	928	36.5	173	6.81	19	+2
Ostersund	63.2	14.6 E.	310	1,017	478	18.8	63	2.48	13	−6
Karesuanda	68.4	22.5 E.	333	1,093	309	12.2	49	1.93	16	−7
Haparanda	65.8	24.2 E.	9	30	507	20.0	60	2.36	12	−7
Helsinki	60.2	24.9 E.	12	39	661	26.0	80	3.15	12	−6
Archangelsk	64.6	40.6 E.	7	23	437	17.2	95	3.74	22	+2
Ust-Zylma	65.4	52.2 E.	25	82	421	16.6	52	2.05	12	−9
Obdorsk	66.5	66.6 E.	26	85	266	10.5	56	2.20	21	−3
Jakutsk	62.0	129.7 E.	98	322	190	7.5	32	1.26	17	−10
60°–50° N.										
St. Paul Island	57.2	170.2 W.	6	20	1,796	31.3	186	7.32	23	+6
Dutch Harbor	53.9	166.5 W.	4	13	1,592	62.7	185	7.28	12	−3
Kodiak	57.8	152.4 W.	5	16	1,550	61.0	227	8.94	15	0
Sitka	57.1	135.3 W.	27	89	2,258	88.9	278	10.95	12	−3
Juneau	58.3	134.4 W.	24	79	2,046	80.5	276	10.87	13	−2
Massett	54.0	132.2 W.	3	10	1,308	51.5	274	10.79	21	+6
Bella Coola	52.7	126.9 W.	46	151	1,153	45.4	216	8.50	19	+3
Barkerville	53.0	121.6 W.	1,275	4,183	947	37.3	133	5.24	14	−3
Kamloops	50.7	120.5 W.	364	1,194	253	10.0	39	1.53	15	−9
Calgary	51.0	114.0 W.	1,034	3,392	402	15.8	98	3.86	24	+3
Edmonton	53.6	113.5 W.	658	2,158	443	17.4	86	2.39	19	+7
Prince Albert	53.2	105.6 W.	437	1,434	398	15.7	95	3.74	24	+3
Qu'Appelle	50.5	103.8 W.	645	2,116	472	18.6	85	3.35	18	−2
Fort Hope	51.6	87.8 W.	336	1,102	405	15.9	75	2.95	19	−2
Valencia	51.9	10.2 W.	14	46	1,427	56.2	147	5.79	10	−5
Aberdeen	57.2	2.1 W.	14	46	753	29.6	61	2.40	8	−9
Greenwich	51.5	0 W.	46	151	604	23.8	66	2.60	11	−7
Utrecht-De Bilt	52.1	5.2 E.	3	10	751	29.6	87	3.42	12	−5
Gütersloh	51.9	8.4 E.	76	240	722	28.4	74	2.91	10	−8
Frankfurt a. M	50.1	8.7 E.	102	335	582	22.9	63	2.48	11	−7
Oslo	59.9	10.7 E.	25	82	567	22.3	76	2.99	13	−5
Copenhagen	55.7	12.6 E.	5	16	579	22.8	59	2.32	10	−8
Berlin	52.6	13.4 E.	35	115	561	22.1	66	2.60	12	−6
Breslau	51.1	17.0 E.	147	482	583	23.0	67	2.64	11	−7
Upsala	59.8	17.6 E.	24	79	535	21.2	67	2.64	13	−6
Königsberg	54.7	20.5 E.	3	10	687	27.0	81	3.19	12	−6
Warschau	52.2	21.0 E.	133	436	475	18.7	92	3.62	19	0
Wilna	54.7	25.3 E.	148	486	546	21.5	105	4.13	19	0
Leningrad	59.9	30.3 E.	5	16	519	20.4	60	2.36	12	−7
Kiew	50.4	30.5 E.	183	600	591	23.3	90	3.90	15	−3
Moskau	55.8	37.6 E.	164	538	600	23.6	85	3.35	14	−4
Nikolaewskoe	51.4	45.4 E.	193	633	363	14.3	62	2.44	17	−5
Kasan	55.8	49.1 E.	81	266	429	16.9	71	2.80	17	−4
Orenburg	51.8	55.1 E.	114	374	366	14.4	66	2.60	18	−4
Perm	58.0	56.3 E.	163	531	589	23.2	67	2.64	11	−7
Swerdlowsk	56.8	60.6 E.	281	922	426	16.8	53	2.09	12	−9
Barnaul	53.3	83.8 E.	158	518	485	19.1	73	2.87	15	−4
Tomsk	56.5	84.9 E.	122	400	534	21.0	77	3.03	15	−4
Irkutsk	52.3	104.3 E.	467	1,532	376	14.8	63	2.48	17	−4
Nertschinskij Sawod	51.3	119.6 E.	620	2,034	385	15.2	75	2.95	19	−2
Nikolajewsk on Amur	53.1	140.8 E.	33	108	471	18.5	83	3.27	18	−1

---

[1] If p is given in inches the equation is to be read $v_r=\frac{141.7}{\bar{p}+2.36}+13$.

TABLE 5.—*Anomalies of the variability of yearly precipitation for 384 places*—Continued

50°–40° N.

Station	Latitude	Longitude	Elevation		$\bar{p}$		v_a		v_r (percent)	Δ (percent)
			Meters	Feet	Millimeters	Inches	Millimeters	Inches		
1	2	3	4		5		6		7	8
	°	°								
Victoria	48.4	123.3 W.	70	230	786	30.9	153	6.02	20	+3
Portland	45.5	122.7 W.	47	154	1,051	41.4	135	5.32	13	−3
Red Bluff	40.2	122.2 W.	101	331	621	24.4	131	5.16	21	+2
Spokane	47.7	117.4 W.	588	1,929	420	16.5	67	2.64	16	−5
Helena	46.6	112.1 W.	1,254	4,114	340	13.4	70	2.76	21	−1
Salt Lake City	40.8	111.9 W.	1,330	4,364	407	16.0	57	2.24	14	−7
Cheyenne	41.1	104.8 W.	1,857	6,092	385	15.2	65	2.56	17	−4
North Platte	41.1	100.8 W.	860	2,822	479	18.9	104	4.09	22	+3
Bismarck	46.8	100.6 W.	511	1,676	410	16.1	61	2.40	15	−6
Winnipeg	49.9	97.1 W.	232	761	513	20.2	74	2.91	14	−5
Omaha	41.3	95.9 W.	337	1,106	713	28.1	151	5.94	21	+3
Oregon, Mo	40.0	95.2 W.	320	1,050	888	35.0	168	6.61	19	+2
St. Paul	45.0	93.0 W.	255	837	701	27.6	118	4.65	17	−1
Duluth	46.8	92.1 W.	346	1,135	701	27.6	104	4.09	15	−3
Peoria	40.7	89.6 W.	186	610	888	35.0	117	4.61	13	−4
Chicago	41.9	87.6 W.	251	823	822	32.4	121	4.76	15	−2
Marquette	46.6	87.4 W.	224	735	828	32.6	92	3.62	11	−6
Detroit	42.3	83.0 W.	223	732	795	31.3	87	3.43	11	−6
Toronto	43.7	79.4 W.	116	381	791	31.1	62	2.44	8	−9
Abitibi	48.7	79.4 W.	259	850	666	26.2	121	4.76	18	0
New York	40.7	74.0 W.	96	315	1,105	43.5	118	4.65	11	−5
Albany	42.6	73.8 W.	30	98	875	34.4	104	4.09	12	−5
Montreal	45.5	73.6 W.	57	187	1,033	40.7	90	3.54	9	−7
Burlington	44.5	73.2 W.	123	404	808	31.8	116	4.57	14	−3
New Haven	41.3	72.9 W.	32	105	1,149	45.2	129	5.08	11	−5
Chicoutimi	48.4	71.1 W.	46	151	664	26.1	117	4.61	18	0
Boston	42.4	71.1 W.	38	125	1,006	39.6	106	4.17	11	−5
Father Point	48.5	68.2 W.	6	20	852	33.5	104	4.09	12	−5
Eastport	44.9	67.0 W.	23	75	1,010	39.8	158	6.26	16	0
Cape Magdalene	49.3	65.3 W.	28	92	783	30.8	115	4.53	15	−2
SW Point, Anticosti	49.4	63.7 W.	9	30	788	31.0	133	5.24	17	0
Charlottetown	46.2	63.2 W.	14	46	1,030	40.6	108	4.25	10	−6
Sable Island	44.0	60.1 W.	8	26	1,317	51.9	129	5.08	10	−5
St. Johns	47.6	52.7 W.	38	125	1,399	55.1	154	6.06	11	−4
Madrid	40.4	3.7 W.	655	2,148	436	17.2	78	3.07	18	−3
Bilbao	43.3	2.9 W.	17	56	1,125	44.3	182	7.17	16	0
Nantes	47.2	1.6 W.	37	121	786	30.9	123	4.84	16	−1
Toulouse	43.6	1.4 E.	194	636	679	26.7	88	3.46	13	−5
Paris (Parc S. Maur)	48.8	2.5 E.	50	164	571	22.5	60	2.36	11	−7
Lyon	45.7	4.8 E.	299	981	756	29.8	105	4.13	14	−3
Marseille	43.3	5.4 E.	75	246	579	22.8	124	4.88	21	+3
Trier	49.8	6.6 E.	(?)	(?)	687	27.0	66	2.60	10	−8
Zurich	47.4	8.6 E.	477	1,565	1,077	42.4	130	5.12	12	−4
Sassari	40.7	8.6 E.	224	735	599	23.6	92	3.62	15	−3
Milan	45.5	9.2 E.	147	482	1,053	41.4	151	5.94	14	−2
Säntis	47.2	9.3 E.	2,500	8,202	2,715	106.9	413	16.26	15	+1
Rome	41.9	12.5 E.	63	207	908	35.7	130	5.12	14	−3
Sonnblick	47.0	13.0 E.	3,107	10,194	1,650	65.0	178	7.01	11	−4
Obir	46.5	14.5 E.	2,044	6,706	1,527	60.1	186	7.32	12	−3
Vienna	48.2	16.4 E.	203	666	679	26.7	82	3.23	12	−6
Hvar (Lesina)	43.2	16.4 E.	20	66	800	31.5	139	5.47	17	0
Belgrade	44.8	20.4 E.	138	453	619	24.4	110	4.33	18	−1
Krynica	49.4	21.0 E.	586	1,923	834	32.8	94	3.70	11	−6
Debreczin	47.5	21.8 E.	130	427	619	24.4	98	3.86	16	−3
Sofia	42.7	23.3 E.	(?)	(?)	637	25.1	115	4.53	18	0
Lwow	49.8	24.0 E.	298	978	684	26.9	95	3.74	14	−4
Hermannstadt	45.8	24.3 E.	419	1,375	694	27.3	89	3.50	13	−5
Bucharest	44.4	26.1 E.	82	269	599	23.6	89	3.50	15	−3
Böjükdere	41.2	29.0 E.	(?)	(?)	843	33.2	209	8.23	25	+8
Sulina	45.2	29.7 E.	2	(?)	373	14.7	76	2.99	20	−1
Odessa	46.5	30.7 E.	65	213	392	15.4	86	2.39	22	+1
Noworossijsk	44.7	37.8 E.	37	121	644	25.4	141	5.55	22	+3
Tiflis	41.7	44.8 E.	404	1,325	502	19.8	73	2.87	15	−4
Astrachan	46.4	48.0 E.	14	46	168	6.6	47	1.85	28	−1
Kasalinsk	45.3	62.1 E.	(?)	(?)	125	4.9	25	.98	20	−11
Taschkent	41.3	69.3 E.	478	1,568	359	14.1	61	2.40	17	−5
Wjernyi (Alma ata)	43.3	76.9 E.	775	2,542	570	22.4	107	4.21	19	+1
Mukden	41.8	123.4 E.	44	144	631	24.8	125	4.92	20	+2
Joshin	40.7	129.2 E.	4	------	706	27.8	85	3.35	12	−6
Ochiai	47.3	142.7 E.	7	------	888	35.0	102	4.02	12	−5
Nemuro	43.3	145.6 E.	27	------	960	37.8	158	6.22	16	0
40°–30° N.										
S. Francisco	37.8	122.4 W.	47	154	544	21.4	123	4.84	23	+4
Sacramento	38.6	121.4 W.	21	69	461	18.2	104	4.09	23	+4
S. Luis Obispo	35.3	120.6 W.	61	200	551	21.7	166	6.54	30	+1
S. Diego	32.7	117.2 W.	27	89	252	9.9	77	3.03	31	+7
Yuma	32.8	114.6 W.	43	141	86	2.4	38	1.50	44	+6
Modena	37.8	113.9 W.	1,671	5,482	289	11.4	61	2.40	21	−2
Phoenix	33.5	112.0 W.	388	1,273	202	8.0	63	2.48	31	+5
El Paso	31.8	106.5 W.	1,147	3,763	238	9.4	75	2.95	32	+7
Santa Fe	35.7	106.0 W.	2,139	7,018	366	14.4	72	2.83	20	−4
Denver	39.8	105.0 W.	1,614	5,295	361	14.2	76	2.99	21	−1
Abilene	32.4	99.7 W.	530	1,739	612	24.1	140	5.51	23	+5
Little Rock	34.8	92.3 W.	109	358	1,232	48.5	198	7.80	16	0
St. Louis	38.6	90.2 W.	173	568	955	37.6	117	4.61	12	−4
Mobile	30.7	88.0 W.	17	------	1,589	62.6	251	9.88	16	+1

TABLE 5.—*Anomalies of the variability of yearly precipitation for 384 places*—Continued

TABLE 5.—*Anomalies of the variability of yearly precipitation for 384 places*—Continued

Station	Latitude	Longitude	Elevation		$\bar{p}$		v_a		v_r (percent)	Δ (percent)
			Meters	Feet	Millimeters	Inches	Millimeters	Inches		
1	2	3	4		5		6		7	8
40°-30° N.										
	°	°								
Nashville	36.2	86.8 W.	167	548	1,182	46.6	132	5.20	11	−5
Cincinnati	39.1	84.5 W.	192	630	947	37.3	137	5.39	14	−3
Portsmouth, Ohio	38.7	82.9 W.	161	528	1,086	42.7	109	4.29	10	−6
Charleston	32.8	79.9 W.	15	49	1,140	44.9	189	7.44	17	+1
Washington	38.9	77.0 W.	34	112	1,078	42.4	124	4.88	12	−4
Hatteras	35.2	75.7 W.	3	10	1,295	51.0	251	9.88	19	+4
Philadelphia	40.0	75.2 W.	36	118	1,048	41.2	122	4.80	12	−4
Bermudas	32.3	64.8 W.	45	148	1,481	58.3	172	6.77	12	−3
Horta	38.5	28.6 W.	64	210	1,091	43.0	169	6.65	15	−1
Ponta Delgada	37.7	25.7 W.	38	125	720	28.3	111	4.37	15	−3
Funchal	32.6	16.9 W.	25	82	697	27.4	165	6.50	24	+6
Lissabon	38.7	9.1 W.	95	312	749	29.5	120	4.72	16	−2
Cap Spartel	35.8	5.9 W.	56	184	771	30.3	126	4.96	16	−1
Gibraltar	36.1	5.3 W.	16	52	919	36.2	185	7.28	20	+3
Cartagena	37.6	0.9 W.	13	43	359	14.1	99	3.90	28	+6
Alicante	38.4	0.4 W.	26	85	394	15.5	121	4.76	31	+10
Palma	39.6	2.7 E.	(?)	(?)	500	19.7	83	3.27	17	−2
Bouzareah	36.8	3.0 E.	344	1,129	697	27.4	149	5.87	21	+3
Tunis	36.8	10.2 E.	21	69	419	16.5	58	2.28	14	−7
Catania	37.5	15.0 E.	65	213	625	24.6	173	6.81	28	+10
Corfu	39.5	19.8 E.	26	85	1,216	47.8	223	8.78	18	+2
Athens	38.0	23.7 E.	107	351	394	15.5	61	2.40	15	−6
Alexandria	31.2	29.9 E.	32	105	203	8.0	43	1.69	21	−5
Abbassia	30.1	31.3 E.	33	108	34	1.3	17	.67	50	−1
Jerusalem	31.8	35.2 E.	746	2,448	645	25.4	151	5.94	23	+5
Adana	36.9	35.3 E.	(?)	(?)	640	25.2	114	4.49	18	0
Beirut	33.9	35.5 E.	34	112	915	36.0	135	5.28	15	−2
Bagdad	33.3	44.4 E.	38	125	180	7.1	85	3.35	47	+19
Basra	30.5	47.8 E.	7	23	163	6.4	63	2.48	39	+10
Teheran	35.7	51.4 E.	1,221	4,006	242	9.5	52	2.05	21	−4
Isfahan	32.7	51.7 E.	1,774	5,820	114	4.5	41	1.61	36	+7
Meschhed	36.3	59.6 E.	947	3,117	237	9.3	65	2.56	27	+2
Quetta	30.2	67.0 E.	1,678	5,505	243	9.6	68	2.68	28	+3
Peschawar	34.0	71.6 E.	339	1,125	346	13.6	91	3.58	26	+4
Lahore	31.6	74.4 E.	214	702	503	19.8	149	5.87	30	+11
Simla	31.1	77.2 E.	2,206	7,238	1,617	63.7	259	10.20	16	+1
Leh	34.2	77.7 E.	3,508	11,509	83	3.3	27	1.06	33	−6
I-tch'ang	30.7	111.3 E.	518	1,699	1,095	43.1	157	6.18	14	−2
Han-k'eou	30.6	114.3 E.	36	118	1,259	49.6	243	9.57	19	+4
Tien-tsin	39.2	117.2 E.	5	16	509	20.0	121	4.76	24	+5
Ou-hou	31.3	118.4 E.	15	49	1,219	48.0	245	9.61	20	+4
Tchen-kiang	32.2	119.4 E.	12	39	1,040	40.9	223	8.78	21	+5
Heou-k'i	38.1	120.6 E.	90	295	463	18.2	116	4.57	25	+5
Tche-fou	37.6	121.4 E.	3	10	620	24.4	126	4.96	20	+2
Zi-ka-wei	31.2	121.4 E.	7	23	1,152	45.4	137	5.39	12	−4
Chemulpo	37.3	126.5 E.	68	223	950	37.4	175	6.89	18	+2
Nagasaki	32.7	129.9 E.	133	436	1,954	77.0	274	10.79	14	−1
Kioto	35.0	135.7 E.	49	161	1,573	61.9	209	8.23	13	−2
Tokyo	35.7	139.8 E.	21	69	1,540	60.6	206	8.11	13	−2
Miyako	39.6	141.9 E.	30	98	,4131	55.6	215	8.46	15	0
30°-20° N.										
Honolulu	21.3	157.9 W.	12	39	798	31.4	230	9.06	29	+12
Mazatlan	23.2	106.4 W.	4	13	723	28.5	215	8.45	30	+12
Chihuahua	28.6	106.1 W.	1,423	4,669	381	15.0	70	2.76	18	−3
Leon	21.1	101.7 W.	1,809	5,936	641	25.2	131	5.16	20	+2
Monterrey	25.7	100.3 W.	528	1,732	496	19.5	190	7.48	38	+19
Corpus Christi	27.8	97.4 W.	6	20	638	25.1	151	5.94	24	+6
Galveston	29.3	94.8 W.	16	52	1,135	44.7	247	9.72	22	+6
New Orleans	30.0	90.1 W.	16	52	1,444	56.9	242	9.53	17	+2
Progreso	21.3	89.7 W.	14	46	429	16.9	60	2.36	14	−7
Merida	21.0	89.6 W.	22	72	892	35.1	173	6.81	19	+2
Habana	23.1	82.4 W.	24	79	1,211	47.7	171	6.73	14	−2
Key West	24.6	81.8 W.	7	23	966	38.0	186	7.32	19	+3
Nassau	25.1	77.4 W.	15	49	1,231	48.5	214	8.43	17	+1
La Laguna	28.5	16.3 W.	2	7	594	23.4	176	6.93	30	+12
Heluan	29.9	31.3 E.	116	381	34	1.3	17	.67	50	−1
Bushire	29.0	49.8 E.	4	13	272	10.7	103	4.06	38	+15
Jask	25.8	57.8 E.	4	13	115	4.5	43	1.69	37	+4
Maskat	23.6	58.6 E.	6	20	106	4.2	56	2.20	53	+19
Kelat	29.0	66.5 E.	2,022	6,634	188	7.4	49	1.93	26	−1
Karachi	24.8	67.1 E.	4	13	188	7.4	109	4.29	58	+31
Haiderabad	25.4	68.4 E.	29	95	191	7.5	106	4.17	55	+28
Ahmadabad	23.0	72.6 E.	50	164	729	28.7	228	8.98	31	+13
Jaipur	26.9	75.9 E.	436	1,430	612	24.1	184	7.24	30	+12
Nagpur	21.2	79.2 E.	310	1,017	1,243	48.9	207	8.15	17	+1
Allahabad	25.5	81.9 E.	94	308	1,011	39.8	214	8.43	21	+5
Patna	20.7	83.2 E.	56	184	1,236	48.6	279	10.98	23	+7
Calcutta (Alipore)	22.5	88.4 E.	6	20	1,598	62.9	225	8.86	14	−1
Cherrapunji	25.2	91.8 E.	1,314	4,311	10,914	429.2	1,677	66.02	15	+2
Gauhati	26.2	91.8 E.	60	197	1,628	64.1	181	7.13	11	−4
Shillong	25.6	91.9 E.	1,501	4,924	2,057	81.0	277	10.91	13	−2
Akyab	20.1	93.0 E.	6	20	5,266	207.3	594	23.24	11	−3
Mandalay	22.0	96.1 E.	76	249	891	35.1	167	6.57	19	+2
Teng-yue	24.8	98.2 E.	1,633	5,358	1,479	58.2	230	9.06	16	+1
Yun-nan-fou	25.0	102.7 E.	1,893	6,211	1,040	40.9	164	6.46	16	0
Mong-tse	23.4	103.4 E.	1,305	4,281	925	36.4	134	5.28	14	−3
Laokay	22.5	103.9 E.	93	305	1,807	71.0	259	10.20	14	−1
30°-20° N.										
	°	°								
Tch'ong-k'ing	29.6	106.5 E.	230	755	1,103	43.4	166	6.54	15	−1
Phu-lien	20.8	106.6 E.	116	381	1,641	64.6	201	7.91	12	−3
Moncay	21.5	107.8 E.	9	30	2,686	105.8	181	7.13	7	−8
Kweilin	25.3	110.4 E.	(?)	(?)	1,986	78.2	273	10.75	14	−1
Ou-tcheou	23.5	111.3 E.	2	7	1,299	51.1	165	6.50	13	−2
Tch'ang-cha	28.2	112.8 E.	60	197	1,412	55.6	304	11.97	22	+7
Hongkong	22.3	114.2 E.	33	108	2,141	84.3	376	14.80	18	+3
Amoy	24.4	118.1 E.	4	13	1,183	46.6	224	8.82	19	+3
Fou-tcheou	26.0	119.4 E.	20	66	1,435	56.5	364	14.33	25	+10
Taihoku	25.0	121.5 E.	9	30	2,114	83.2	247	9.72	12	−3
Naha	26.2	127.7 E.	11	36	2,134	84.0	306	12.05	14	−1
20°-10° N.										
Mexico City	19.4	99.1 W.	2,259	7,084	577	22.7	82	3.23	14	−4
Puebla	19.0	98.2 W.	2,150	7,054	845	33.3	127	5.00	15	−2
Oaxaca	16.1	96.7 W.	1,563	5,128	684	26.9	150	5.91	22	+4
Salina Cruz	16.2	95.2 W.	56	184	932	36.7	243	9.57	26	+9
Chimax near Coban	15.6	90.4 W.	(?)	(?)	2,438	96.0	245	9.65	10	−5
Port-au-Prince	18.6	72.4 W.	37	121	1,380	54.3	192	7.56	14	−1
Caracas	10.5	67.0 W.	1,042	3,419	806	31.7	102	4.02	13	−4
S. Juan	18.5	66.1 W.	25	82	1,536	60.5	177	6.97	12	−3
Christiansted	17.8	64.7 W.	7	23	1,187	46.7	244	9.61	21	+5
Richmond Hill	12.1	61.8 W.	155	509	1,932	76.1	235	9.25	12	−3
Trinidad	10.7	61.5 W.	20	66	1,584	62.4	246	9.69	16	+1
Barbados	13.1	59.6 W.	55	180	1,343	52.9	264	10.39	20	+5
Bathurst	13.4	16.6 W.	2	7	1,209	47.6	274	10.79	23	+8
St. Louis	16.0	16.5 W.	5	16	360	14.2	106	4.17	29	+7
Gambaga	10.5	0.4 W.	107	351	1,157	45.6	198	7.80	17	+1
Chartum	15.6	32.6 E.	390	1,280	145	5.7	62	2.44	43	+13
Aden	12.8	45.0 E.	29	95	47	1.9	31	1.22	66	+19
Bombay	18.9	72.9 E.	11	36	1,774	69.8	345	13.58	19	+4
Belgaum	15.9	74.6 E.	781	2,562	1,300	51.2	202	7.95	16	+1
Mangalore	12.9	74.9 E.	22	72	3,188	125.5	388	15.28	12	−2
Kodaikanal	10.2	77.5 E.	2,345	7,693	1,579	62.2	171	6.73	11	−4
Bangalore	13.0	77.6 E.	921	3,021	881	34.7	151	5.94	17	0
Madras	13.1	80.2 E.	7	23	1,293	50.9	269	10.59	21	+6
Masulipatam	16.2	81.2 E.	5	16	1,044	41.1	269	10.59	26	+10
Waltair (Vizagapatam)	17.7	83.3 E.	12	39	1,000	39.4	239	9.41	24	+8
Port Blair	11.7	92.8 E.	18	59	2,931	115.4	308	12.13	11	−3
Rangun	16.8	96.2 E.	5	16	2,528	99.5	176	6.93	7	−7
Moulmein	16.5	96.6 E.	23	75	4,857	191.2	432	16.94	9	−5
Mergui	12.4	98.6 E.	18	59	4,232	166.6	397	15.63	9	−5
Pnom Penh	11.5	105.0 E.	13	43	1,417	55.8	235	9.25	17	+2
Saigon	10.8	106.7 E.	11	36	1,966	77.4	293	11.54	15	0
Quangtri	16.7	107.2 E.	8	26	2,514	99.0	454	17.73	18	+4
Nhatrang	12.2	109.2 E.	4	13	1,372	54.0	406	15.77	30	+15
Manila	14.6	120.9 E.	16	52	2,022	79.6	354	13.94	18	+3
Aparri	18.4	121.6 E.	5	16	2,227	87.7	484	18.91	22	+7
Iloilo	10.7	122.6 E.	7	23	2,214	87.2	210	8.27	9	−6
Legaspi	13.2	123.8 E.	6	20	3,225	127.0	698	27.20	22	+8
10° N.-0°										
S. José	9.9	84.1 W.	1,135	3,723	1,799	70.8	366	14.41	20	+5
Colon	9.4	79.4 W.	11	36	3,282	129.2	371	14.61	11	−3
Bogotá	4.6	74.1 W.	2,651	8,697	1,024	40.3	136	5.35	13	−3
Georgetown	6.8	58.2 W.	2	7	2,252	88.7	259	10.20	12	−3
Freetown	8.5	13.2 W.	57	187	3,925	154.5	603	23.63	15	+1
Accra	5.2	0.2 W.	18	59	692	27.2	172	6.77	25	+7
Lagos	6.4	3.4 E.	2	7	1,819	71.6	316	12.44	17	+2
Calabar	5.0	8.3 E.	12	39	3,130	123.2	461	18.15	15	+1
Debundscha	4.1	9.0 E.	5	16	9,877	388.9	1,912	75.28	19	+6
Duala	4.0	9.7 E.	12	39	3,974	156.5	475	18.70	12	−2
Entebbe	0.1	32.5 E.	1,173	3,849	1,474	58.0	134	5.28	9	−6
Cochin	9.9	76.3 E.	3	10	2,886	113.6	367	14.45	13	−1
Colombo	6.9	79.8 E.	12	39	2,033	80.0	326	12.83	16	+1
Nuwara Eliha	7.0	80.8 E.	1,887	6,191	2,337	92.0	258	10.16	11	−4
Trincomalee	8.6	81.2 E.	30	98	1,565	61.6	267	10.51	17	+2
Kuta-Raja	5.5	95.3 E.	7	23	1,639	64.5	203	7.99	12	−3
Medan	3.6	98.7 E.	20	66	2,044	80.5	246	9.68	12	−3
Sandakan	5.8	118.2 E.	32	105	3,041	119.7	549	21.61	18	+4
Menado	1.5	124.8 E.	4	13	2,635	103.7	452	17.80	17	+3
0°-10° S.										
Malden Island	4.0	155.0 W.	6	20	727	28.6	514	20.24	71	+53
Quixeramobim	5.3	39.2 W.	207	679	637	25.1	267	10.51	42	+24
Fortaleza	3.7	38.5 W.	20	66	1,423	55.1	484	19.06	34	+19
Recife	8.1	34.9 W.	30	98	1,388	54.6	452	17.80	33	+18
Sansibar	6.2	39.2 E.	17	56	1,529	60.2	300	11.81	20	+5
Dar-es-Salaam	6.5	39.3 E.	76	249	1,075	42.3	233	9.17	22	+6
Port Victoria	4.6	55.4 E.	(?)	(?)	2,400	94.5	336	13.23	14	−1
Padang	0.9	100.4 E.	1	3	4,442	174.9	339	13.35	8	−6
Batavia	6.2	106.8 E.	7	23	1,824	71.8	284	11.18	16	+1

TABLE 5.—*Anomalies of the variability of yearly precipitation for 384 places*—Continued

Station	Latitude	Longitude	Elevation		$\bar{p}$		v_a		v_r (percent)	Δ (percent)
			Meters	Feet	Millimeters	Inches	Millimeters	Inches		
1	2	3	4		5		6		7	8
0°-10° S.										
	°	°								
Pontianak	0.0	109.3 E.	3	10	3,202	126.1	379	14.92	12	−2
Pasuruan	7.6	112.9 E.	5	16	1,299	51.1	271	10.67	21	+5
Kajoemas	7.9	114.2 E.	930	3,051	2,524	99.4	354	13.94	14	0
Amboina	3.7	128.2 E.	1	3	3,375	132.9	867	34.13	26	+12
Monokwari	0.9	134.3 E.	20	66	2,478	97.5	513	20.20	21	+6
Port Moresby	9.5	147.2 E.	38	125	1,037	40.8	211	8.31	20	+4
10°-20° S.										
Apia	13.8	171.8 W.	2	7	2,728	107.4	526	20.71	19	+5
Arequipa	16.4	71.6 W.	2,453	8,048	106	4.2	57	2.24	54	+20
Cuyaba	15.6	56.1 W.	165	541	1,388	54.6	178	7.01	13	−2
St. Helena	16.0	5.7 W.	604	1,971	1,019	40.1	114	4.49	11	−5
Salisbury	17.8	31.1 E.	1,481	1,578	811	31.9	127	5.00	16	−1
Antananarivo	18.9	47.5 E.	1,402	4,600	1,369	53.9	196	7.72	14	−1
Kupang	10.2	123.6 E.	15	49	1,486	58.5	294	11.57	20	+5
Darwin	12.5	130.8 E.	30	98	1,554	61.2	220	8.66	14	−1
20°-30° S.										
La Serena	29.9	71.3 W.	35	115	140	5.5	82	3.23	59	+29
Catamarca	28.4	65.8 W.	510	1,673	350	13.8	71	2.80	20	−2
Salta	24.8	65.5 W.	1,178	3,865	722	28.4	133	5.24	18	0
Tucuman	26.8	65.2 W.	447	1,467	975	38.4	169	6.65	17	+1
Goya	29.2	59.2 W.	26	85	1,036	40.8	274	10.79	26	+10
Corrientes	27.4	58.8 W.	54	177	1,197	47.1	224	8.82	19	+3
Mision Inglesa	23.4	58.4 W.	(?)	(?)	1,205	47.4	266	10.47	22	+6
Villa Rica	25.1	58.1 W.	(?)	(?)	1,490	58.7	280	11.02	19	+4
Asuncion	25.3	57.7W.	93	305	1,315	51.8	238	9.37	18	+3
Posadas	27.4	55.8 W.	138	453	1,507	59.3	315	12.40	21	+6
Curityba	25.4	49.3 W.	908	2,979	1,397	55.0	197	7.76	14	−1
Alto da Serra	23.8	46.6 W.	800	2,625	3,575	140.8	398	15.67	11	−3
Rio de Janeiro	22.9	43.2 W.	61	200	1,101	43.3	202	7.95	18	+2
Swakopmund	22.7	14.5 E.	8	26	16	0.6	9	0.35	54	−6
Windhuk	22.6	17.1 E.	1,665	5,462	389	15.3	121	4.76	31	+10
Bethanien	26.5	17.2 E.	935	3,067	105	4.1	42	1.65	40	+5
O'Okiep	29.6	17.9 E.	926	3,038	169	6.7	43	1.69	25	−4
Kimberley	28.7	24.8 E.	1,203	3,947	412	16.2	97	3.82	24	+3
Johannesburg	26.2	28.1 E.	1,807	5,928	844	33.2	146	5.75	17	0
Bulawayo	20.2	28.7 E.	1,354	4,442	600	23.6	137	5.39	23	+5
Durban	29.8	31.0 E.	15	49	1,082	42.6	195	7.68	18	+2
Alice Springs	23.6	133.6 E.	587	1,926	267	10.5	91	3.58	34	+10
Brisbane	27.5	153.0 E.	38	725	1,088	42.8	273	10.75	25	+9
30°-40° S.										
Valdivia	38.8	73.2 W.	15	49	2,664	104.9	364	14.33	14	0
Junin de los Andes	39.2	71.0 W.	(?)	(?)	532	20.9	210	8.27	39	+20

TABLE 5.—*Anomalies of the variability of yearly precipitation for 384 places*—Continued

Station	Latitude	Longitude	Elevation		$\bar{p}$		v_a		v_r (percent)	Δ (percent)
			Meters	Feet	Millimeters	Inches	Millimeters	Inches		
1	2	3	4		5		6		7	8
30°-40° S.										
	°	°								
Santiago	33.4	70.7 W.	519	1,703	373	14.7	156	6.14	42	+20
Mendoza	32.9	68.8 W.	755	2,477	198	7.8	63	2.48	32	+6
S. Juan	31.5	68.7 W.	664	2,178	75	3.0	36	1.42	48	+8
Neuqueen	39.0	68.0 W.	271	889	131	5.2	46	1.81	35	+4
Cordoba	31.4	64.2 W.	423	1,388	697	27.4	119	4.68	17	−1
General Acha	37.1	64.1 W.	218	715	472	18.6	128	5.04	27	+8
Bahia Blanca	38.7	62.2 W.	25	82	550	21.7	160	6.30	29	+10
Buenos Aires	34.6	58.4 W.	25	82	988	38.9	225	8.86	23	+7
Concordia	31.4	58.0 W.	24	79	1,017	39.8	205	8.07	20	+4
Mar del Plata	38.0	57.1 W.	4	13	723	28.5	147	5.79	20	+2
Ajo-General Lavalle	36.5	56.8 W.	15	49	925	36.4	205	8.07	22	+5
Montevideo	34.9	56.2 W.	29	95	986	38.8	262	10.31	27	+11
Kapstadt	33.9	18.5 E.	12	39	663	26.1	96	3.78	14	−4
Port Elizabeth	34.0	25.6 E.	55	180	562	22.1	87	3.43	15	−3
Aliwal (N)	30.7	26.7 E.	1,327	4,354	518	20.4	113	4.45	22	+3
Adelaide	34.9	138.6 E.	43	141	523	20.6	102	4.02	20	+1
Sydney	33.9	151.2 E.	42	138	1,175	46.3	219	8.62	19	+3
Auckland	36.8	174.8 E.	38	125	1,099	43.3	181	7.13	16	0
40°-50° S.										
Punta Galera	40.0	73.7 W.	40	131	2,220	87.4	380	14.96	17	+2
Diez-y-seis de Octubre	42.2	71.1 W.	557	1,827	431	17.0	114	4.49	26	+5
Sarmiento	45.5	69.0 W.	274	899	135	5.3	49	1.93	36	+5
Puerto Madryn	42.8	64.9 W.	14	46	163	6.4	47	1.85	29	0
Hokitika	42.7	170.8 E.	3	10	2,896	114.0	277	10.91	10	−4
Christchurch	43.5	172.6 E.	8	26	653	25.7	105	4.13	16	−2
Wellington	41.3	174.8 E.	3	10	1,186	46.7	202	7.95	17	+1
50°-60° S.										
Islote de los Evangelistad	52.4	75.1 W.	55	180	3,075	121.1	287	11.30	9	−6
Punta Arenas	53.2	70.9 W.	28	92	388	15.3	68	2.68	17	−4
Santa Cruz	50.2	68.4 W.	12	39	150	5.9	31	1.22	21	−9
Año Nuevo	54.6	64.2 W.	53	174	610	24.0	47	1.85	8	−10
Stanley	51.7	57.8 W.	2	7	685	27.0	68	2.68	10	−8
South-Georgia (Grytviken)	54.2	36.6 W.	4	103	1,301	51.6	176	6.93	14	−1
60°-70° S.										
South-Orkneys (Laurie-Isld.)	60.7	44.6 W.	7	23	403	15.9	57	2.24	14	−7

METEOROLOGICAL AND CLIMATOLOGICAL DATA FOR JANUARY 1941

[Climate and Crop Weather Division, J. B. KINCER in charge]

AEROLOGICAL OBSERVATIONS

By EARL C. THOM

Mean surface temperatures for January were above normal over most of the country (chart I). Temperatures were slightly below normal, however, over New England, over the extreme eastern Great Lakes States, and over small areas along the Atlantic coast, and the eastern Gulf coast. The area having the largest positive departure for the month was in eastern Montana where mean temperatures slightly more than 8° F. above normal were recorded. This is the second successive month when temperatures were generally above normal.

At the 1,500 m.-level the directions of the 5 a. m. resultant winds for the month were to the north of directions of the corresponding 5 a. m. normals at most stations over the eastern half of the country, while the direction of these winds were generally south of normal to the westward. There were many stations in January at which less than 10 of the 5 a. m. pilot-balloon observations reached the 3,000 m.-level. With only one exception the 5 a. m. resultant winds for the month at 3,000 meters were from directions to the north of normal at all stations for which this comparison could be made over the eastern two-thirds of the country while these winds were from directions to the south of normal at the corresponding stations to the westward. At only seven of the pilot-balloon stations for which 5 a. m. normals are available did 10 or more of the 5 p. m. observations reach 5,000 meters. For this reason no comparison can be made between the directions of 5 p. m. resultant winds and the corresponding 5 a. m. normals for this level.

The 5 a. m. resultant veolcities for the month were below normal at the 1,500-meter level over about three-fourths of the country. Over Brownsville at this level and over the north-western and west-central States, however, the resultant velocities were above normal. The largest negative departure at this level, —3.2 m. p. s.,