A STUDY OF THE VARIATION IN ANNUAL RAINFALL OF OAHU ISLAND (HAWAIIAN ISLANDS) BASED ON THE LAW OF PROBABILITIES

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SYNOPSIS

By a method explained in detail the probabilities of the occurrences of extreme rainfalls were computed for a number of stations on Oahu. These values are given in table 3. The coefficients of variation were determined for 42 stations and plotted in figure 10. The significance of this map is discussed in the latter part of the paper.

Since the Hawaiian Islands are very mountainous and in a trade-wind region it follows, for reasons well known, that the annual amount of precipitation over them varies greatly from place to place. This is well shown by a study of the average annual rainfall of Oahu made by J. F. Voorhees (1). Figure 1 is an average annual rainfall map of Oahu Island, taken from that study, which shows the wide divergences that obtain in the average rainfall over short distances, the relative importance of elevation and distance from crest in determining isohyetal lines, and, in general, a good, broad view of the quantitative rainfall of the island. However, it does not show the variations that are known to occur at many places from year to year, and which for problems of water supply and flooding of streams, extreme conditions and fluctuations are perhaps of greater importance than average conditions. This study was undertaken to supplement Voorhees' paper with that additional useful information.

The variation in annual rainfall at Honolulu (U.S. Weather Bureau Office) is shown graphically in figure 2. It gives an idea of the variation from the average, but no general law can be given for this variation.

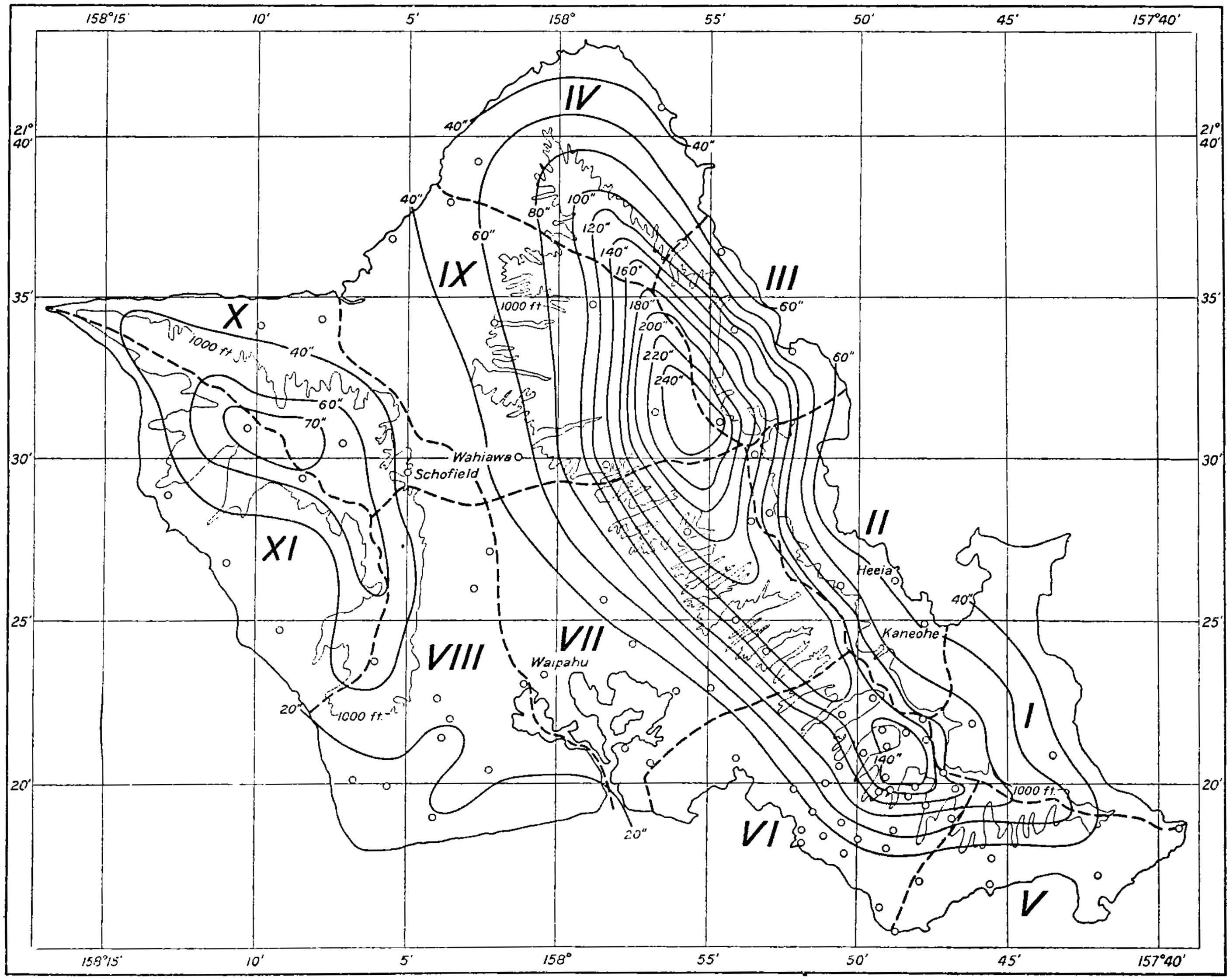

FIGURE 1.—Average annual rainfall map of Oahu Island. (W. T. Nakamura.)

To study cyclical and progressive trends in annual rainfall the method of progressive means may be resorted to. The heavy line in figure 3 is drawn through the departures of progressive means of Honolulu (WBO) data which were calculated from the forumla:

$$c' = \frac{a + 4b + 6c + 4d + e}{16}$$

where a, b, c, d, and e are the annual rainfalls of consecutive years and c' is the progressive mean for the year in which the rainfall was c. The dotted line joins points of departures of the actual rainfall from the average. While conclusive evidence is not shown, from this figure it is seen that maximum and minimum rainfalls tend to occur approximately every 14 years. However, this cycle is at best too indefinite to be of any value for forecasting rainfall in the future, as is apparent when the actual departures and departures of progressive means are compared in the figure. The time covered is too short for this kind of analysis.

Another and more detailed method of analyzing rainfall data which has been utilized by Allen Hazen (2) and Thorndike Saville (3) is based on the law of probabilities. While this method is by no means absolutely dependable much beyond the limits of experience, it has its value in interpreting the relation of rainfall to water engineering problems. A brief theoretical discussion is here presented, using the rainfall data for Honolulu (WBO) as an example.

Taking the frequency as ordinate and observed annual rainfall as abscissa where the class interval is 4 inches, we obtain the frequency polygons or histogram of figure 4. The lower of the 2 rows of figures along the abscissa axis designates the midpoints (class marks) of the class intervals.

Now it is shown in works of statistics (4) that if the true average of a series of N observations is Z, and a near

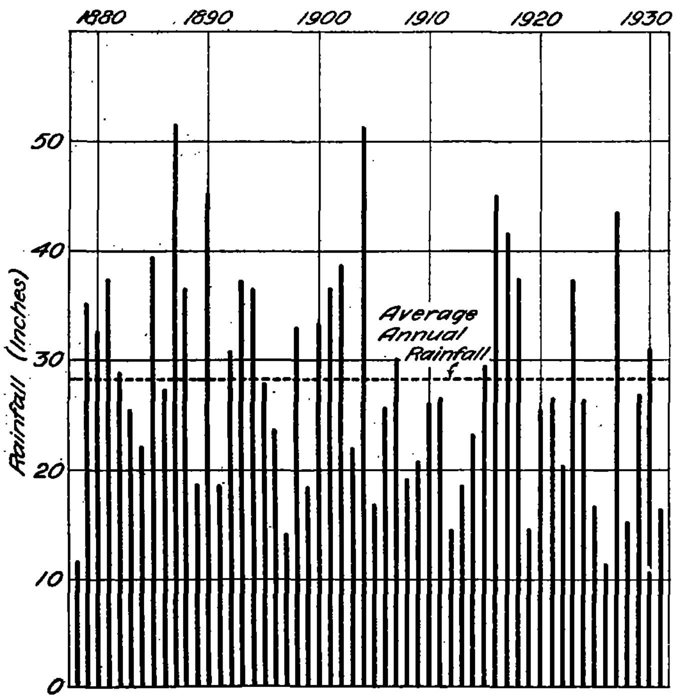

FIGURE 2.—Variation in annual rainfall at Honolulu (Weather Bureau Office).

average, or base value, taken arbitrarily is A; f, the class frequency, and c the departures of the class marks from A, then

$$Z = A + \frac{1}{N}\Sigma(fc) \qquad (1)$$

in class intervals. It is also shown that the index of variability of a distribution, σ called the standard deviation or standard variation is given by

$$\sigma = \sqrt{\frac{\Sigma(fc^2) - \Sigma(fc)}{N}} \qquad (2)$$

in class intervals.

The figures in column 1 of table 1 are the annual rainfalls at Honolulu (WBO) arranged in ascending order of magnitude. The limits of the class intervals into which these data were arranged are given under column 1 in table 2. Under column 2 (f) is given the frequency or number of times the annual rainfall fell in the different classes. Under column 3 (c) are given in class intervals the departures of the class marks from the arbitrary base value, A. Values for fc and fc^2 are products of f and c,

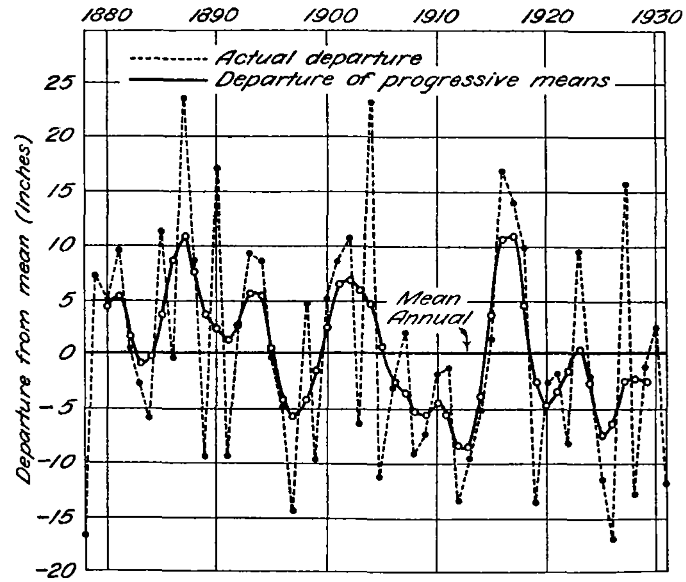

FIGURE 3.—Annual rainfall and progressive means for Honolulu (Weather Bureau Office).

and of f and c^2, respectively. The numerical computations for Z and σ are given below the data in table 2.

TABLE 1

Annual rainfall	Departure from base 28.21	Departure squared	Percentage of total years (cumulative)	Annual rainfall	Departure from base 28.21	Departure squared	Percentage of total years (cumulative)
In.	*In.*			*In.*	*In.*		
11.27	−16.94	286.96	0.926	27.63	−0.58	0.34	52.782
11.46	−16.75	280.56	2.778	27.97	−.24	.06	54.634
13.94	−14.27	203.63	4.630	28.99	+.78	.61	56.486
14.59	−13.62	185.50	6.482	29.64	+1.43	2.04	58.338
14.71	−13.50	182.25	8.334	30.13	+1.92	3.69	60.190
15.34	−12.87	165.64	10.186	30.78	+2.57	6.60	62.042
16.35	−11.86	140.66	12.038	31.04	+2.83	8.01	63.894
16.82	−11.39	129.73	13.890	32.87	+4.66	21.72	65.746
16.99	−11.22	125.89	15.742	32.88	+4.67	21.81	67.598
18.42	−9.79	95.84	17.594	33.21	+5.00	25.00	69.450
18.53	−9.68	93.70	19.446	35.26	+7.05	49.70	71.302
18.70	−9.51	90.44	21.298	36.49	+8.28	68.56	73.154
18.79	−9.42	88.74	23.150	36.70	+8.49	72.08	75.006
19.17	−9.04	81.72	25.002	36.77	+8.56	73.27	76.858
20.11	−8.10	65.61	26.854	37.23	+9.02	81.36	78.710
20.81	−7.40	54.76	28.706	37.34	+9.13	83.36	80.562
22.00	−6.21	38.56	30.558	37.46	+9.25	85.56	82.414
22.22	−5.99	35.88	32.410	37.57	+9.36	87.61	84.266
23.07	−5.14	26.42	34.262	38.71	+10.50	110.25	86.118
23.85	−4.36	19.01	36.114	39.55	+11.34	128.60	87.970
25.49	−2.72	7.40	37.966	41.64	+13.43	180.36	89.822
25.67	−2.54	6.45	39.818	43.52	+15.31	234.40	91.674
25.77	−2.44	5.95	41.670	44.96	+16.75	280.56	93.526
26.31	−1.90	3.61	43.522	45.12	+16.91	285.95	95.378
26.34	−1.87	3.50	45.374	51.34	+23.13	535.00	97.230
26.58	−1.63	2.66	47.226	51.62	+23.41	548.03	99.082
26.71	−1.50	2.25	49.078				
26.97	−1.24	1.54	50.930	Σ=1,523.40		Σ=5,419.39	

TABLE 2

Class interval	f	c	fc	fc^2
10–14	3	−4	−12	48
14–18	6	−3	−18	54
18–22	7	−2	−14	28
22–26	7	−1	−7	7
26–30	9	0	−51	
30–34	6	+1	+6	6
34–38	8	+2	+16	32
38–42	3	+3	+9	27
42–46	3	+4	+12	48
46–50		+5		
50–54	2	+6	+12	72
	Σ=54		+55	Σ=322

$$A=28.00$$
$$\Sigma fc=55-51=4$$
$$Z-A=\frac{4}{54}\text{class intervals}=0.2964 \text{ inches}$$
$$Z=28.00+0.2964=28.2964 \text{ inches}$$
$$\frac{\Sigma fc^2}{N}=5.9630$$
$$\sigma^2=5.9630-(0.0741)^2$$
$$=5.9575$$
$$\sigma=2.44 \text{ class intervals}$$
$$=9.76 \text{ inches}$$

Assuming that the distribution of rainfall as shown by the histogram of figure 4 is normal, it is an easy matter

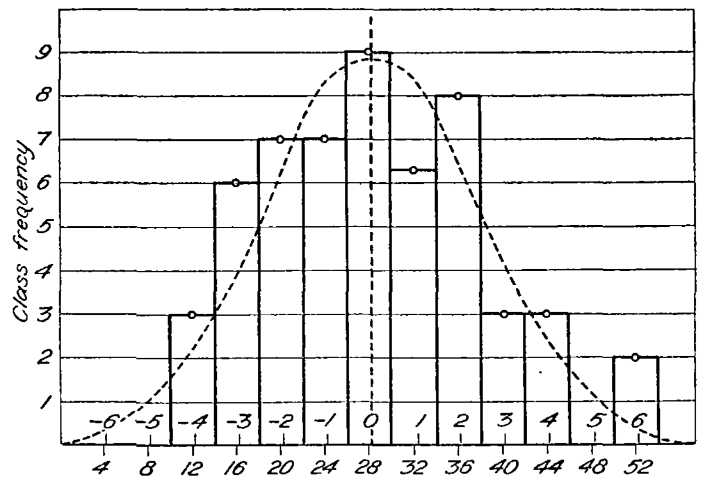

FIGURE 4.—Frequency of annual rainfall at Honolulu (Weather Bureau Office).

to obtain the curve of best fit. The equation of such a curve called the normal frequency curve is

$$y=\frac{N}{\sigma\sqrt{2\pi}}e^{-\frac{x^2}{2\sigma^2}} \tag{3}$$

where y designates the frequency, e is the familiar base of the Napierian system of logarithms, x denotes in unit of class intervals the departure from the arithmetic mean, π is the constant 3.1416, and N and σ have the same meaning as designated above.

Substituting the values of the constants as found in the computations of table 2, in the above equation, we have

$$y=8.824e^{-0.0831x^2} \tag{3'}$$

Or putting it in logarithmic form for easy computation, we have

$$\log y=0.945665-0.036086x^2$$

The dotted curve of figure 4 is the curve of equation (3′). Values of x are the upper of the 2 rows of figures along the X axis.

This normal curve may be put into cumulative form. Such a curve would show the frequency of observations

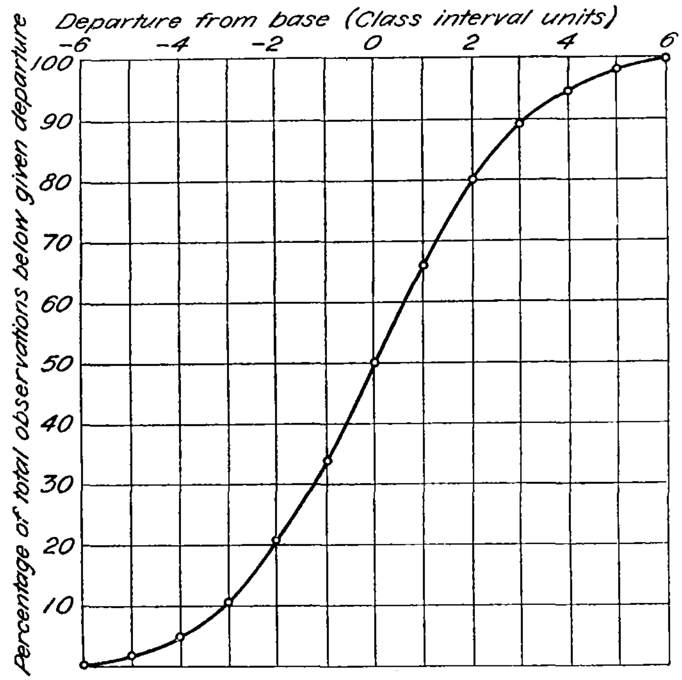

FIGURE 5.—Ogive or cumulative curve.

below any given class limit. Graphically it is obtained by reading on the normal frequency curve the departures and then adding the corresponding class frequency values progressively, starting with the smallest departures (**5**).

A more exact method would be to obtain the percentage of the total area under the curve to the X axis and from $x=-\infty$ to some finite value of x. When values of x and the corresponding values of the percentage of total area are plotted the cumulative or ogive curve of figure 5 is the result. The percentages of the total area are readily obtained from tables of the probability integral (**6**). Take, for example, the abscissa, −2, and required to find the percentage of the total area under the curve from $x=-\infty$ to $x=-2$. Davenport's table IV gives for the entry $\frac{x}{\sigma}=\frac{2}{2.44}=0.82$ the value 0.2939, which is the area under the probability curve from $x=0$ to $x=-2$. Since the area of one half the curve is 0.5000 the area from $x=-2$ to $x=-\infty$ is $0.5000-0.2939=0.2061$, or 20.61 percent (**7**).

In figure 5 if the abscissae had been expressed in units of σ, that is by $\frac{x}{\sigma}=t$, the ordinate could have been expressed by $\int_{-\infty}^{t}\frac{1}{\sqrt{2\pi}}e^{\frac{-t^2}{2}}dt$. To anamorphose the scale of the ordinate axis certain values of the above probability integral are taken between the limits $-\infty$ to t and placed opposite the corresponding values of t on the abscissa axis. The result is an anamorphosed ordinate scale and is called the probability scale. Or else, in general, by assigning definite values to the probability integral and finding the limits of the integral, i.e., $t=\frac{x}{\sigma}$, we obtain the relative distances of the lines on the

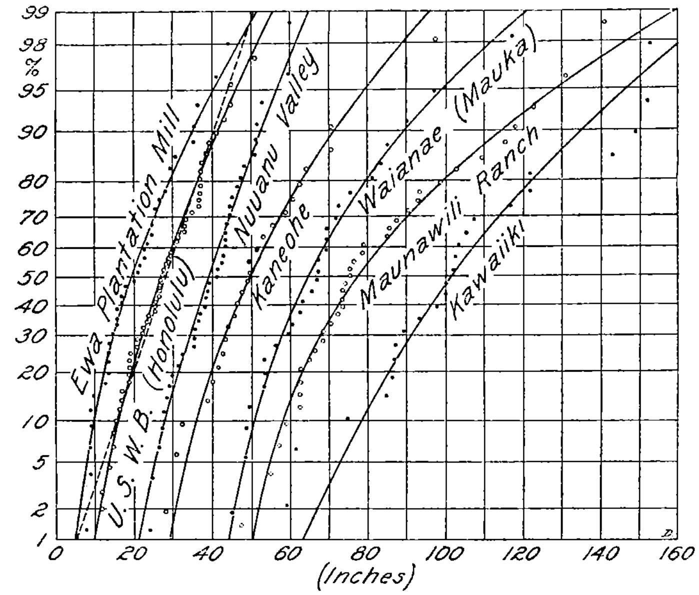

FIGURE 6.—Probabilities of annual rainfall. Probability percentage of observations below given rainfall

anamorphosed scale from the 50-percent line on the same scale. The cumulative curve of figure 5 becomes a straight line when drawn on such a scale. In figure 6 the dotted line marked "Honolulu" is the result of

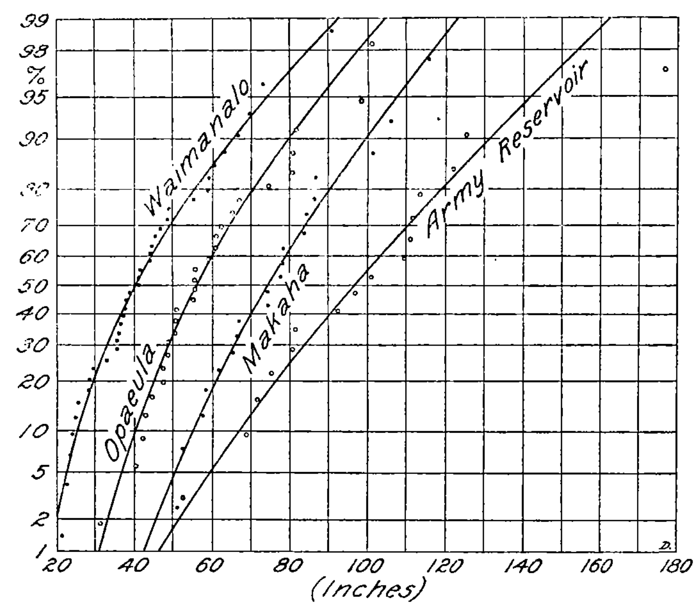

FIGURE 7.—Probabilities of annual rainfall. Probability percentage of observations below given rainfall.

drawing the curve of figure 5 on such a scale. The departures are not shown, however. They are easily gotten by adding or subtracting class interval units (4 inches for Honolulu [WBO] data) from the average.

In the above discussion it was shown that the ogive curve of a normal distribution of annual rainfall can be represented by a straight line by the use of probability paper; that is, coordinate paper with an anamorphosed scale as described above. At this point it is clear that instead of placing the rainfall into classes the actual rainfall arranged in ascending order may be used for the abscissa of the cumulative curve of figure 5. The corresponding ordinates would then be obtained as follows: since there are 54 observations, to each rainfall abscissa there corresponds an ordinate whose value is $\frac{100}{54}=1.852$ percent added cumulatively. In other words for the lowest rainfall abscissa the ordinate would be 1.852 percent; for the next lowest 2×1.852 or 3.704 percent; etc. The points were placed at the center of these percentage strips, that is, the first point at 0.926 percent; the second at 2.778 percent; etc.

These same data if plotted on probability paper would lie nearly on a straight line if the data conform essentially to a normal distribution. The points along the dotted line marked "Honolulu" of figure 6 represent Honolulu (WBO) rainfall data while the curved continuous line is

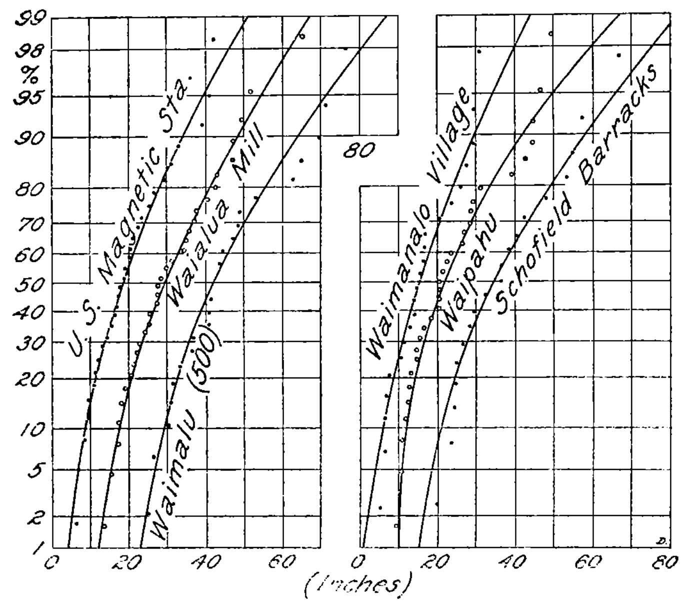

FIGURE 8.—Probabilities of annual rainfall. Probability percentage of observations below given rainfall.

an attempt to fit the data by inspection. The continuous curve departs slightly from the straight line and it means, therefore, that the rainfall distribution at Honolulu (WBO) departs somewhat from the normal; that is, the distribution is skewed.

In this study as mentioned above the curve was drawn by inspection, and no attempt was made to obtain a computed curve. Figures 6 to 9 show similar curves for 26 stations on Oahu Island. No doubt some of these would be closer fitted by skew curves, but the data are not sufficiently skewed to justify this refinement (8).

From these curves the probable frequency of occurrence of any given amount of rainfall can be obtained. The probable frequency of occurrence is equal to $\frac{100}{\text{percentage of years}}$. Table 3 gives the limiting rainfalls for 6 values of this frequency for 8 stations. It was comparatively easy to project lines to the data for these stations because of the greater number of observations, and the curves, therefore, may be considered as best-fit curves for practical purposes.

In the discussion thus far an attempt has been made to show how the dotted line of figure 6 is obtained by putting the annual rainfall into 4-inch classes. Because of the

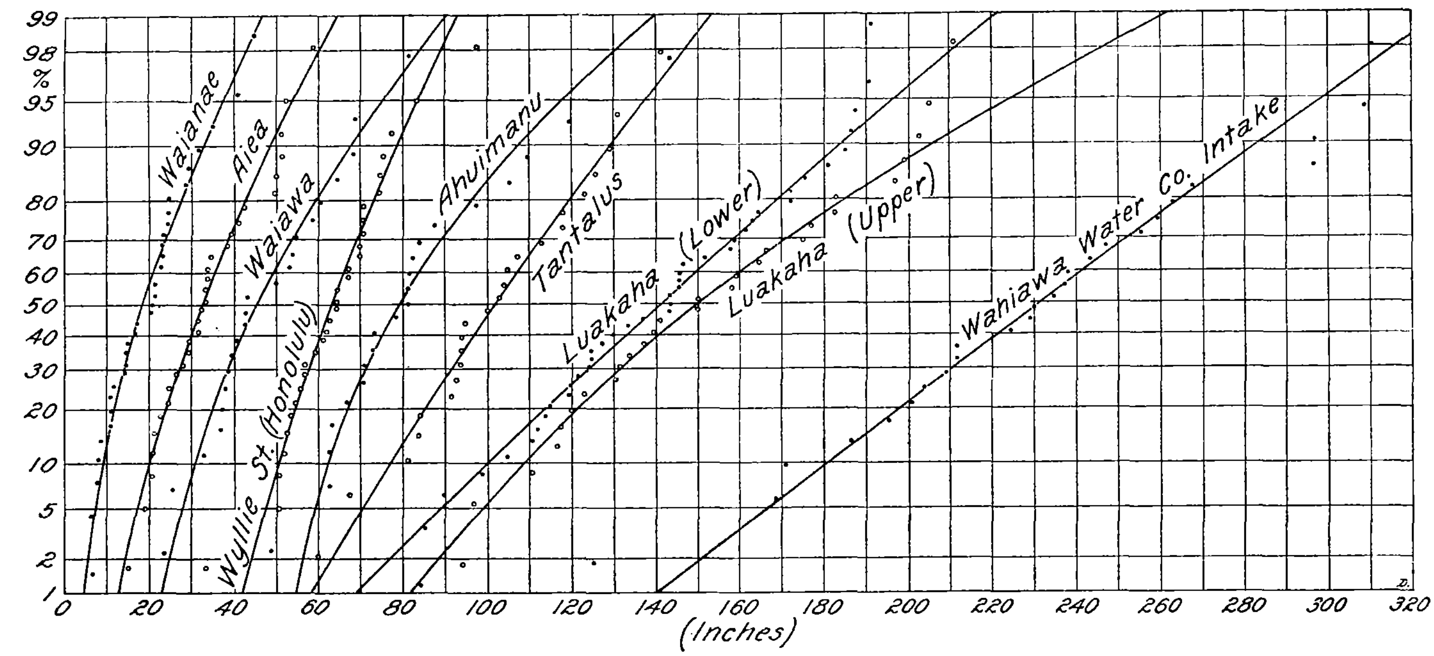

FIGURE 9.—Probabilities of annual rainfall. Probability percentage of observations below given rainfall.

small number of observations, however, the standard variation, σ, as well as other constants like r = probable variation of a single observation,[1] and R = probable variation of the average were obtained from the formulas given below. If K = any observation, v = variation of a single observation from the true mean, Z, and N = number of observations, it is shown in works of statistics **(9)** that:

$$Z=\frac{\Sigma K}{N}$$

$$r=0.6745\sqrt{\frac{\Sigma\ v^2}{N-1}}$$

$$R=\frac{r}{\sqrt{N}}=0.6745\sqrt{\frac{\Sigma\ v^2}{N(N-1)}}$$

$$\sigma=\sqrt{\frac{\Sigma\ v^2}{N-1}}$$

TABLE 3.—*Limiting rainfalls for 6 values of the probability of occurrence at 8 stations on Oahu Island*

Percentage of years Probable frequency, once in	25 4 years	15 6.7 years	10 10 years
Honolulu (W.B.O.)	20– or 34+	18– or 39+	16– or 41+
Ewa Plantation Mill	14– or 27+	11– or 32+	10– or 35+
Wahiawa Water Co. intake	205– or 258+	192– or 274+	182– or 284+
Waianae	13– or 26+	10– or 30+	9– or 33+
Waialua Mill	22– or 39+	19– or 44+	18– or 48+
Waimanalo	31– or 53+	27– or 60+	25– or 65+
Nuuanu Valley	33– or 46+	30– or 50+	28– or 53+
Luakaha (lower)	119– or 163+	108– or 175+	100– or 184+

Probable frequency, once in	5 20 years	2 50 years	1 100 years
Honolulu (W.B.O.)	13– or 46+	11– or 52+	10– or 56+
Ewa Plantation Mill	8– or 40+	6– or 47+	5– or 52+
Wahiawa Water Co. intake	168– or 298+	151– or 314+	140– or —*
Waianae	7– or 37+	6– or 43+	5– or 46+
Waialua Mill	15– or 55+	14– or 62+	12– or 67+
Waimanalo	22– or 74+	—* or 85+	—* or 92+
Nuuanu Valley	25– or 57+	22– or 62+	20– or 65+
Luakaha (lower)	89– or 196+	77– or 210+	70– or 220+

* Undetermined.

[1] Books on statistics usually give $r=0.6745\sqrt{\frac{\Sigma v^2}{n}}$. This formula is applicable with a large number of observations, n. When n is small as it is in this work, the formula retaining the term $(n-1)$ is more accurate.

TABLE 4

Station name	Station no.	Number of observations	Average annual rainfall	Probable variation of single observation	Probable variation of average	Standard variation (σ)	Coefficient of variation
			Inches	*Inches*	*Inches*	*Inches*	*Inches*
Honolulu (U.S.W.B.)	1	54	28.21	6.821	0.928	10.11	0.358
Wyllie Street (Honolulu)	2	30	64.07	8.150	1.488	12.08	.189
Insane Asylum	3	34	37.97	7.929	1.360	11.76	.310
Punahou (C. J. Lyons)	4	21	38.14	7.404	1.616	10.98	.288
Tantalus (W. F. Frear)	5	24	102.16	13.550	2.767	20.10	.197
United States Naval Station	6	27	24.40	6.041	1.163	8.96	.367
Nuuanu Valley (Hall)	7	39	40.04	6.209	.994	9.21	.230
Luakaha (upper)	8	28	152.56	22.830	4.314	33.85	.222
Luakaha (lower)	9	41	140.88	20.280	3.168	30.07	.214
Waimanalo	10	37	43.25	10.790	1.774	16.00	.370
Kaneohe	11	26	52.80	11.560	2.267	17.14	.324
Moanalua	12	26	33.72	7.926	1.554	11.75	.349
Puuloa	13	29	20.63	7.308	1.357	10.84	.525
Pearl Harbor	14	17	21.76	6.813	1.652	10.10	.464
United States Magnetic Station	15	30	19.99	6.681	1.220	9.90	.496
Waimanalo Village	16	22	16.48	5.529	1.179	8.20	.497
No. 6 Reservoir	17	22	17.80	5.936	1.266	8.80	.494
Ewa Plantation Mill	18	38	20.92	6.487	1.052	9.62	.460
Apokaa	19	22	20.01	6.450	1.375	9.56	.478
Aiea	20	30	34.13	7.647	1.396	11.34	.332
Waimalu	21	29	35.49	9.298	1.727	13.79	.388
Waiawa	22	22	47.98	9.999	2.132	14.82	.309
Hoaeae (upper)	23	24	35.21	8.648	1.765	12.82	.364
Waianae	24	33	19.93	6.460	1.125	9.58	.481
Makaha	25	20	76.31	11.800	2.639	17.50	.229
Waialua Mill	26	32	31.39	8.279	1.464	12.27	.391
Schofield Barracks	27	19	37.22	9.079	2.083	13.46	.362
Wahiawa	28	18	46.30	10.360	2.441	15.36	.332
Opaeula	29	28	59.31	11.410	2.156	16.91	.285
Army Reservoir	30	16	99.35	19.810	4.953	29.37	.296
Wahiawa Water Co. intake	31	26	231.76	30.150	5.913	44.70	.193
Kahana (800)	32	15	243.60	32.060	8.278	47.53	.195
Waimalu (500)	33	24	45.42	9.683	1.977	14.36	.316
Maunawili Ranch	34	37	82.00	15.010	2.468	22.26	.272
Ahuimanu	35	21	83.00	14.720	3.211	21.81	.263
Waianae (Mauka)	36	28	68.17	10.940	2.067	16.21	.238
Pupukea	37	16	52.49	10.160	2.540	15.06	.287
Makapuu Point	38	17	24.40	9.909	2.403	14.69	.602
Kawaiiki	39	24	104.12	17.480	3.568	25.91	.249
Kahuku	40	39	37.40	8.646	1.385	12.82	.343
Aiea (500)	41	23	41.59	9.424	1.965	13.97	.336
Waipahu	42	31	24.06	7.961	1.430	11.80	.490

In table 1 under column 1 are shown in the order of magnitude the annual rainfall at Honolulu. The departure from the mean (v), the square of the departure (v^2), and the percentage of the whole observations or total years which had rainfall below the corresponding annual rainfall are given in the other (3) column.

From this table and from the formulas above, it was found that for Honolulu $Z=28.21$, $\sigma=10.11$, $r=6{,}821$, and $R=0.928$.

The standard variation, σ, gives a good idea of how the annual rainfalls are distributed about the mean for a single station or for stations with nearly the same average. The main purpose of this study has been, however, to find how the variations at different stations differed from one another. Since it is known that the average annual rainfalls at the different stations vary greatly some measure of variability other than σ was, therefore, needed which would take into account the average from which the deviations are calculated. The desired measure or coefficient of variation is the ratio of the standard variation to the average or expressed in symbols $\frac{\sigma}{M}$. This coefficient as well as σ, R, and r have been calculated for 42 stations on Oahu Island, and they are given in table 4.

In figure 10 lines were drawn through places of equal coefficients. The smaller numbers are station numbers as given in table 4, while the larger numbers are the coefficients.

The coefficient of variation is strictly speaking a measure of variability for normal distributions. No meaning is attached to it if it is used for comparing distributions of varying degrees of skewness except that it is the coefficient of variation for a normal frequency curve of best fit to the data. However, for distributions of about the same degree of skewness it may still be used as a comparative measure of variation. In figures 6 to 9 an idea of the extent of the departure of the distribution from the normal distribution may be gained from the extent to which the continuous curves depart from the straight lines drawn through the points, x = arithmetic average, $y=50$ percent and $x=\sigma$, $y=34$ percent since in a normal distribution 34 percent of the observations are enclosed by the ordinates at x = average and at $x=\sigma$. It can be shown, moreover, that the distance along the average ordinate (on the percentage of time scale) from the 50 percent line to the point where the curve crosses the average ordinate is a measure of the coefficient of skewness of the distribution. The straight lines mentioned above are not shown in figures 6 to 9 except for Honolulu.

H. Alden Foster (**10**) states that the coefficient of variation can be computed with considerable accuracy

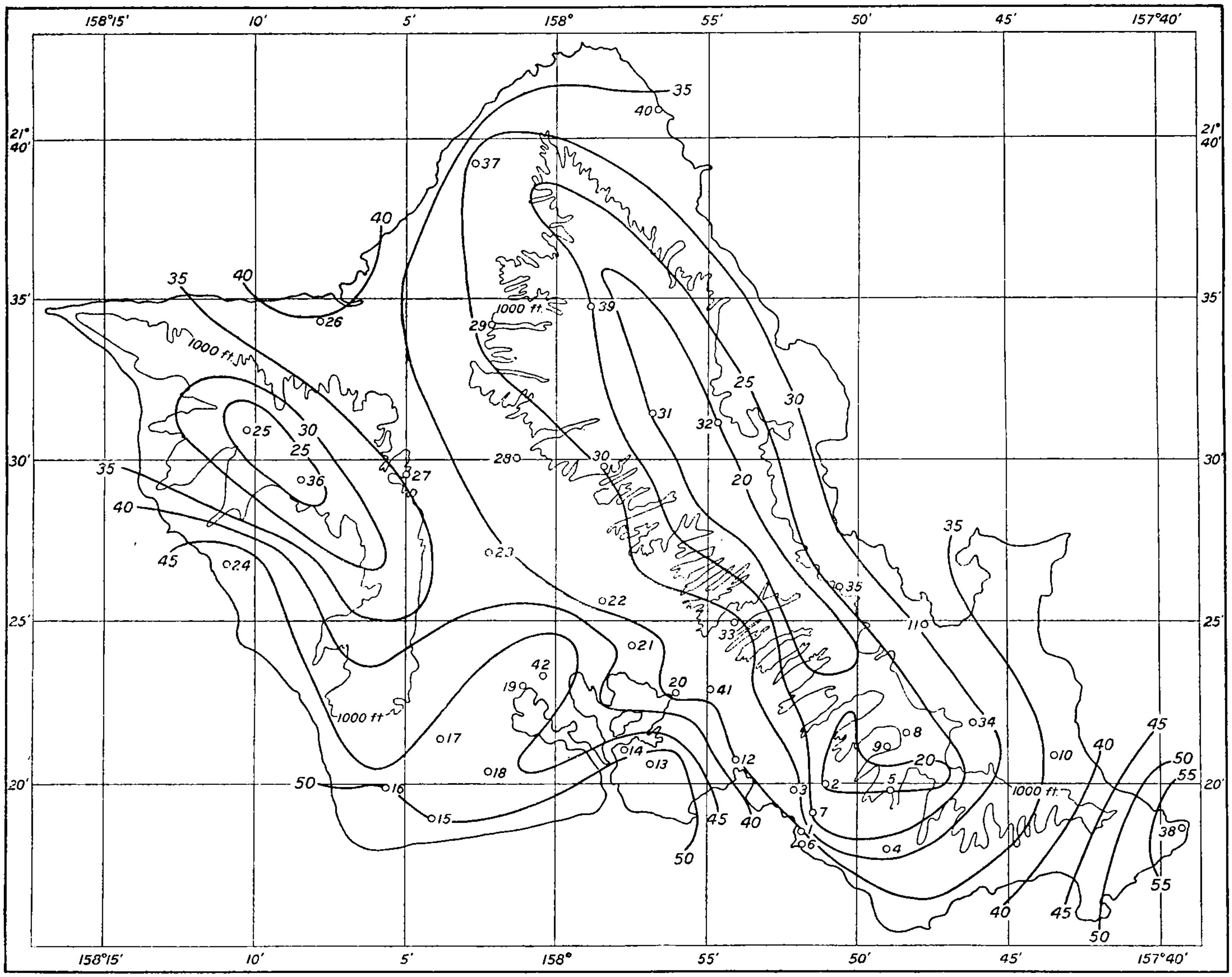

FIGURE 10.—Rainfall coefficient of variation (Oahu Island).

from a record of moderate length but that the coefficient of skewness cannot be computed with any degree of precision except from a very long record. However, he shows that for practical work an average coefficient of skew may be assumed as applicable to data of all the stations. This average coefficient was not determined in this study. Whatever it may be, with the same coefficient of skewness for all stations, the coefficient of variation can be used as a measure of variability.

Any locality with a low coefficient of variation will get more nearly the average amount of rainfall each year than will a locality with a higher coefficient. For instance from table 4 this coefficient is 0.358 or nearly 0.36 for Honolulu (station no. 1) and 0.46 for Ewa Plantation Mill (station no. 18). This means that a variation of 36 percent from the average at Honolulu comes as often as one of 46 percent from the average at Ewa Plantation Mill and with a frequency of once in about 6 or 7 years. In other words, the variations at different localities are directly proportional to the coefficient of variation at those localities.

In table 3 the percentage of years of 15 or a probable frequency of once in 6.7 years corresponds closely to a variation in annual rainfall equal to the coefficient of variation. More exactly it is 16 percent instead of 15 since as previously mentioned 34 percent of the total observations fall between the ordinates at x = average and at $x = \sigma$.

In figure 10 the lines of equal coefficients closely follow the lines of equal average annual rainfall (isohyets). Isohyetal lines are shown in the map of figure 1. It is evident that, in general, the wetter regions are regions of smaller variations. Three regions of low coefficients are distinguishable: (*a*) around the north central crest of the Koolau Range, (*b*) around the crest of the Waianae Mountains, and (*c*) the regions somewhat to leeward of the crest of the southern portion of the Koolau Range. The first region incloses the wettest area of Oahu Island, the average annual rainfall being 240 inches. In the third region coefficients are equally low although the average annual rainfall is about 140 inches. The region to the south and southwest of Pearl Harbor has the highest variability, and it is also the driest region of the island.

Like the maps of isohyetal lines the map of figure 10 should be regarded as an approximation in view of the character of the topography. Great differences in annual rainfall are noticeable over short distances; likewise, in the coefficients of variation, so that more complete data are likely to change the position of the lines of figure 10.

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PRELIMINARY STATEMENT OF TORNADOES IN THE UNITED STATES DURING 1933

By R. J. MARTIN

[Weather Bureau, Washington, D.C., January 1934]

In keeping with the custom of recent years, a preliminary statement of loss of life and property damage by windstorms is included in the December issue of the REVIEW. A final and more detailed study will be made during next summer, and will appear in the Report of the Chief of the Weather Bureau for the year 1933–34. Practically all of the information given in this summary is abstracted from the monthly REVIEW tables of "Severe Local Storms" which are compiled from the reports of many observers and the various section directors of the Bureau. While it is thought the figures given are substantially correct it must be remembered that all are subject to change after the final study mentioned above.

May, with 73 (possibly 80) tornadoes and 205 fatalities, was the month with the greatest number of storms and greatest loss of life. The second highest figures occurred in March, with 33 tornadoes and 95 deaths. Both these months were exceeded in property damage by April; during which month there were 26 storms and a property loss of nearly $10,000,000.

The total number of tornadoes during the year, 197, was considerably greater than in 1932. This figure has been exceeded only twice (1928 and 1929) during the last 18 years. The total number of deaths resulting from the 1933 storms was 343, which is considerably less than the 1932 number (394) and far less than the 1925 and 1927 figures (794 and 540, respectively).

The property damage caused by such storms in 1933 is roughly estimated at $22,180,000—nearly three times that of the preceding year. This total has been exceeded only three times during the last 18 years, in 1927 ($43,445,650), 1924 ($26,120,850), and 1925 ($24,023,900).

If further study shows the storms listed in the table of tornadic winds to be true tornadoes, the 1933 sums will be 220 tornadoes (greater than either the 1928 or 1929 figure), 344 deaths, and property losses exceeding $23,908,000.

TORNADOES AND PROBABLE TORNADOES

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Number	10	4	33	26	73	14	11	10	5	5	1	5	197
Deaths	4	0	95	20	205	2	7	1	0	3	0	6	343
Damage [1]	1,136	37	3,362	9,645	7,046	181	613	110	6	8	2	[2] 34	22,180

TORNADIC WINDS AND POSSIBLE TORNADOES [3]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Number	0	0	1	1	7	5	7	1	1	0	0	0	23
Deaths	------	----	0	0	0	1	0	0	0	----	----	----	1
Damage [1]	------	----	1	1	1,215	365	[2] 106	40	[4] 0	----	----	----	1,728

[1] In thousands of dollars.
[2] Damage occurred in addition to amount stated.
[3] Some of these may not be classed as tornadoes in the final study.
[4] Damage occurred; no estimate secured.