any part of the experiments, or of the volume which describes them, in which I have not been helped by Mr. C. G. Abbot of this observatory, whose aid I have had pleasure in elsewhere acknowledging.

HAWAIIAN CLIMATOLOGICAL DATA.

By CURTIS J. LYONS, Territorial Meteorologist.

GENERAL SUMMARY FOR MAY, 1902.

Honolulu.—The level of water in artesian wells fell during the month from 34.10 to 33.05 feet above mean sea level. May 31, 1901, it stood at 33.20. The average daily mean sea level for the month was 9.76 feet, 10.00 representing the assumed annual mean. Trade wind days, 31 (5 of north-northeast); normal, 24; average force of wind (during daylight), Beaufort scale, 3.2; cloudiness, tenths of sky, 4.7; normal, tenths of sky, 4.4.

Rainfall data for May, 1902.

Stations.	Elevation.	Amount.	Stations.	Elevation.	Amount.
HAWAII.			OAHU—*Continued.*		
HILO, e. and ne.	*Feet.*	*Inches.*	Makiki Reservoir	120	1.35
Waiakea	50	13.35	U. S. Naval Station, sw.	6	0.24
Kaumana	1,250	21.74	Kapiolani Park, sw.	10	0.00
Pepeekeo	100	12.55	Manoa (Woodlawn Dairy), e.	285	7.63
Hakalau	200	18.63	Manoa (Rhodes)	300	11.33
Honohina	300	19.02	School street (Bishop), sw.	50	1.05
Laupahoehoe	500	29.99	Insane Asylum, sw.	80	1.09
HAMAKUA, ne.			Kalihi-Uka, sw.	260	7.02
Kukaiau	250	17.51	Nuuanu (W. W. Hall), sw.	50	0.95
Paauhau (Mill)	300	11.90	Nuuanu (Wyllie street), sw.	250	2.50
Kukuihaele	700	16.24	Nuuanu (Luakaha), c.	850	12.14
KOHALA, n.			Waimanalo, ne.	25	0.68
Niulii	200	11.48	Maunawili, ne.	300	4.91
Kohala (Mission)	521	10.84	Ahuimanu, ne.	350	12.96
Kohala (Sugar Co.)	235	11.36	Kahuku, n.	25	1.11
Waimea,	2,720	4.45	Ewa Plantation, s.	60	0.24
Puuhue	1,847	4.48	Waipahu, s.	200	0.00
KONA, w.			Moanalua, sw.	15	0.45
Holualoa	1,350	4.40	KAUAI.		
Kealakekua	1,580	5.33	Lihue (Grove Farm), e.	200	2.03
Napoopoo	25	4.43	Lihue (Molokoa), e.	300	1.71
KAU, se.			Lihue (Kukaua), e.	1,000	5.27
Honuapo	15	0.53	Kealia, e.	15	1.00
Naalehu	650	0.71	Kilauea, ne.	325	5.75
Hilea	310	0.50	Hanalei, n.	10	14.92
Pahala	850	1.66	Haena	15	14.05
Moaula	1,700	1.05	Eleele, s.	200	0.12
PUNA, e.			Wahiawa Mountain, s.	2,100	12.26
Volcano House	4,000	4.22	McBryde (Residence)	850	1.95
Olaa, Mountain View	1,690	15.81	Lawai	450	3.21
MAUI.			East Lawai	10	2.81
Waiopae Ranch, s	700	0.00	West Lawai	200	1.86
Kaupo (Mokulau), s.	285	2.88			
Haiku	700	8.14			
Kula (Waiakoa)	2,700	1.93	*Delayed April reports.*		
Puuomalei	1,400	10.33	Kailua	.....	1.20
Haleakala Ranch	2,000	3.29	Moaula	.....	1.50
Wailuku	200	1.84	Wahiawa Mount, c	.....	18.25
OAHU.			Eleele	.....	0.95
Punahou (W. B.), sw.	47	1.34	Kula	.....	0.54

NOTE.—The letters n, s, e, w, and c show the exposure of the station relative to the winds.

Approximate percentages of district rainfall as compared with normal: Hilo, 180; Hamakua, 400; Kohala, 280; Waimea, 160; Kona, 85; South Kau, 45; North Kau, 120; Puna, 110; Maui, varying from 100 to 200; Oahu, 50, except Ahuimanu, 200; South Kauai, 66; North Kauai, 150.

Mean temperatures: Pepeekeo, Hilo district, 100 feet elevation, average maximum, 76.0°; average minimum, 68.5°; Waimea, 2,730 elevation, 73.4°, and 62.4°; Kohala, 521 elevation, 75.4° and 65.9°; Waiakoa, Kula, Maui, 2,700 elevation, 81.7° and 58.5°; United States Magnetic Observatory, 50 elevation, 85.5° and 65.7°; Ewa Mill, 50 elevation, 81.4° and 66.7°.

Mr. Fleming, at the Magnetic Observatory, reports 9 a. m. dew-point, 62.5°; relative humidity, 57.5; 9 p. m., 62.3° and 73.5; Ewa, mean dew-point, 64.4°; humidity, 70.5; Kohala, 65.6° dew-point; 80 humidity.

Heavy surf 3d, 18th, and 30th. Earthquakes reported, none. Snow fell on Mauna Kea 3d and 4th. Thunder and lightning, Oahu, 12th. Marked haze 10th. "After-glow" (with solar haze), probably from the smoke of the Martinique eruption, reported from Hawaii 21st; first seen on Oahu 22d, and continued thereafter, red for first two or three evenings, then more gray-green and yellow-green effects. Solar haze by day tinged with violet ray, afterwards white.

OBSERVATIONS AT HONOLULU.

The station is at 21° 18′ N., 157° 50′ W.

Hawaiian standard time is 10h 30m slow of Greenwich time. Honolulu local mean time is 10h 31m slow of Greenwich.

Pressure is corrected for temperature and reduced to sea level, and the gravity correction, —0.06, has been applied.

The average direction and force of the wind and the average cloudiness for the whole day are given unless they have varied more than usual, in which case the extremes are given. The scale of wind force is 0 to 12, or Beaufort scale. Two directions of wind, or values of wind force, or amounts of cloudiness, connected by a dash, indicate change from one to the other.

The rainfall for twenty-four hours is measured at 9 a. m. local, or 7.31 p. m., Greenwich time, on the respective dates.

The rain gage, 8 inches in diameter, is 1 foot above ground. Thermometer, 9 feet above ground. Ground is 43 feet, and the barometer 50 feet above sea level.

Meteorological Observations at Honolulu, May, 1902.

Date.	Pressure at sea level.	Temperature.		During twenty-four hours preceding 1 p. m. Greenwich time, or 1:30 a. m. Honolulu time.								
				Temperature.		Means.		Wind.		Average cloudiness.	Sea-level pressures.		Total rainfall at 9 a. m., local time.
		Dry bulb.	Wet bulb.	Maximum.	Minimum.	Dew-point.	Relative humidity.	Prevailing direction.	Force.		Maximum.	Minimum.	
	*	†	†			‡	‡		§				
1	29.99	70	65.5	79	68	61.3	67	ne.	2–4	5	30.01	29.95	0.00
2	30.00	69	67	78	68	62.5	70	ne.	3–5	5	30.04	29.98	0.20
3	29.95	70	65	74	68	66.3	86	ne.	2–3	10–6	30.04	29.95	0.15
4	29.94	67	61.5	75	68	62.0	73	ne.	3–5	10	30.00	29.94	0.00
5	29.94	64	61	76	67	56.0	62	nne.	4	2	29.99	29.90	0.00
6	29.89	62	59.7	76	60	58.7	70	ne.	3–4	7	29.98	29.87	0.00
7	29.94	68	63.7	76	59.5	58.7	70	nne.	1–3	8–5	29.96	29.88	0.00
8	29.95	63	61	77	64	61.3	72	ne.	3–0	10	29.99	29.91	0.00
9	29.96	70	63.5	78	62	59.0	66	nne.	3	1	30.01	29.89	0.01
10	30.00	70	63.5	78	66	62.5	70	ne.	3–5	2–8	30.05	29.95	0.00
11	30.06	70	65	76	69	60.5	69	nne.	5–3	3	30.10	29.99	0.00
12	30.05	72	67	78	69	61.3	69	ne.	3	3	30.11	30.03	0.00
13	30.04	70	69.3	79	71	66.3	77	ne.	3	8	30.10	30.03	0.33
14	30.07	72	69	80	69	67.7	81	ene.	3–1	6	30.12	30.04	0.07
15	30.10	72	65	80	71	64.7	72	ne.	3–5	4	30.14	30.06	0.00
16	30.09	72	65.5	79	70	61.3	66	ne.	4	3–6	30.13	30.03	0.02
17	30.07	72	68	79	68	61.3	66	ne.	4	5	30.14	30.07	0.01
18	30.05	68	67.3	81	72	66.5	75	ne.	3	5	30.10	30.01	0.04
19	30.02	66	64.7	82	67	65.7	74	nne.	3–0	3	30.09	29.99	0.00
20	29.98	73	67.5	82	65	65.5	77	ne.	2–0	1	30.04	29.96	0.01
21	30.01	74	69	82	72	65.3	71	ne.	3–1	3	30.06	29.96	0.01
22	30.05	74	68	82	72	66.7	73	ne.	3	5	30.08	29.99	0.00
23	30.06	74	67.5	81	72	66.0	72	ne.	4	5	30.09	30.01	0.04
24	30.06	74	68	81	71	65.3	70	ne.	4	6	30.10	30.02	0.03
25	30.05	73	67	81	72	64.0	68	ne.	3–2	7	30.14	30.06	0.04
26	30.08	72	66.5	78	71	63.7	71	ne.	3–1	8	30.10	30.02	0.12
27	30.09	73	67	80	68	63.3	70	ne.	4–2	6	30.12	30.03	0.01
28	30.08	71	63.5	80	71	63.3	69	ne.	4–5	4	30.14	30.08	0.02
29	30.04	72	65.5	79	69	61.3	66	ne.	3–4	3	30.11	30.02	0.18
30	30.04	73	66	81	69	62.7	67	ne.	4	3–1	30.08	29.98	0.04
31	30.02	72	65.5	80	71	62.7	67	ne.	4	3	30.08	30.01	0.01
Sums													
Means	30.022	70.4	65.6	79.0	68.4	63.0	70.7		3.2	4.7	30.072	29.987	1.34
Departure	+.004					—1.0	+0.4			+0.3			—1.34

Mean temperature for May, 1902, (6+2+9)÷3=73.4; normal is 74.2. Mean pressure for May, 1902, (9+3)÷2=30.033; normal is 30.029.

*This pressure is as recorded at 1 p. m., Greenwich time. †These temperatures are observed at 6 a. m., local, or 4.31 p. m., Greenwich time. ‡These values are the means of (6+9+2+9)÷4. §Beaufort scale.

CLIMATOLOGY OF COSTA RICA.

Communicated by H. PITTIER, Director, Physical Geographic Institute.

[For tables see page 292.]

Notes on the weather.—In San Jose the pressure was slightly below the normal, the daily means being very low on the 11th (662.87), 23d (662.54), 24th (662.36), 25th (662.86), and 31st (662.57). The highest means occurred on the 1st (664.39) and 16th (664.17). The temperature was slightly above normal and very uniform throughout the month, the relative humidity rather low, and the sunshine normal. On the Atlantic slope the rainfall was generally excessive and was almost uninterrupted at a few stations. At Port Limon the heat and dampness were at a maximum and numerous cases of yellow fever were reported from the Santa Clara district. On the Pacific slope the precipitation during the rainy season just ended has been in marked excess over that of previous years.

Notes on earthquakes.—May 15, 4:27 p. m., very slight shock; May 22, 9:19 p. m., tremors. In connection with the Martinique disaster, it may be noted that on the 11th and 12th especially, and on many other days afterwards, sunrise was accompanied by unusual red and purplish tints, which were noticed not only at San Jose, but also at several other places on the Atlantic slope.

THE WINDS AND RAINFALL OF NEW HAVEN.

By T. H. DAVIS, New Haven, Conn.

THE FREQUENCY OF WIND DIRECTION AS OBSERVED AT THE LOCAL WEATHER BUREAU OFFICE SINCE ITS INSTALLATION IN 1873.

The general circulatory system of the atmosphere is subject to laws that must be discovered by the discussion of continuous observations. This is particularly true of the great equatorial currents which flow away from the equator in the higher strata of the atmosphere, and the corresponding great polar currents flowing from the poles toward the equator in the lower atmosphere. These currents do not travel in direct paths parallel to the lines of longitude, as might at first be supposed, but being perfectly free, the masses of air in motion are subject to the effect of the rotation of the earth on its axis, which causes a deflection of their direction to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

These fundamental currents do not follow continuous courses, but the joint result is the production of what are known as the "prevailing westerlies" near the parallels of forty degrees north and south at the earth's surface.

At southern stations in the United States and about the Gulf of Mexico the prevalent winds have easterly components because of their close proximity to the northeasterly trades.

Cyclonic storms which cross this continent in an easterly or northeasterly direction cause occasional winds of greater or less intensity over districts through which they pass, and these may blow from any point of the compass, depending upon whether the storm center passes through, or north or south of the place of observation. These are factors of more or less importance in determining the prevailing wind direction at any point. Each is more marked in some seasons and in some years than in others, and helps to account for the irregular oscillations of the winds.

If we would embrace all influences liable either individually or collectively to interfere with the general circulation over New Haven, it would be proper to note that its location is as follows:

(1) About 400 miles from the northern edge of the calms of the Tropic of Cancer; (2) in the region of prevailing westerlies; (3) about 300 miles northwest from the average path of the centers of West Indian hurricanes; (4) about 150 miles from the landward margin of the Gulf stream; (5) open to Long Island Sound from southeast to south-southwest; (6) subject to the effects of the Arctic current which is said to flow between the landward margin of the Gulf stream and Long Island Sound.

Any or all of these circumstances may exert a more or less marked interference with the winds that would normally prevail at this point.

The topography of the surrounding country is also a factor in disturbing the wind direction. Winds that blow toward New Haven from the west, north, or northeast meet the Allegheny Mountains of Pennsylvania, the Green Mountains of Vermont, or the White Mountains of New Hampshire, respectively, besides other minor elevations. These rugged eminences, together with their extensive valleys, in considerable measure become deflecting influences on the wind's direction. Insolation and terrestrial radiation also exert influences by producing vertical currents, and these in their turn will materially affect the direction.

Since New Haven is on the coast, winds coming to it from the east, south, or southwest meet with scarcely any obstruction, the only interference being such as is experienced in their passage over the open ocean and the comparatively low-lying land.

The deflecting effects of the topographical character of the country in this vicinity are necessarily very small, but they may possibly be helpful in the explanation of the oscillations of frequency of direction.

One of the important factors to be considered in the investigation of the resultant wind direction for New Haven is its close proximity to the open ocean, by reason of which marked land and sea breezes are developed. These are particularly noticeable during the summer months. On summer mornings and evenings when the general atmosphere is free from observable motion there are distinct movements of large masses of air near the earth, from the land to the sea and from the sea to the land, respectively.

Taking all these points into consideration it will be readily perceived that we do not receive the true winds of the general circulation of the atmosphere, but are favored with resultants due to modifying influences. The directions of wind as observed by Weather Bureau officials at New Haven from 1873 to 1900, inclusive, are shown in Table 1, which gives for each year the percentages of wind frequency for each of the eight points of the compass, the percentage of calms, and finally the resultant directions for each year.[1]

TABLE 1.—*Wind directions in percentages, and annual resultants.*

Year.	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm.	Resultant direction.
										°
1873	16.7	11.2	2.2	5.5	10.4	14.5	9.0	20.0	10.4	w. 36 n.
1874	16.4	11.2	2.5	3.8	13.4	16.7	10.7	14.8	10.4	w. 18 n.
1875	20.0	15.0	3.6	4.1	13.4	14.8	10.7	14.8	3.6	w. 43 n.
1876	15.9	12.9	2.5	5.2	13.1	17.0	9.3	19.2	5.2	w. 26 n.
1877	17.8	15.1	3.6	3.8	10.4	20.0	6.3	15.6	7.4	w. 40 n.
1878	14.8	13.4	3.3	4.7	13.4	15.3	12.9	16.7	5.5	w. 24 n.
1879	16.4	12.6	2.7	4.1	12.9	18.1	8.5	19.7	4.9	w. 28 n.
1880	17.5	11.0	2.5	5.7	17.3	14.8	12.3	15.9	3.3	w. 14 n.
1881	18.9	15.6	1.9	6.0	13.7	15.1	9.3	12.9	6.6	w. 42 n.
1882	18.4	14.2	1.9	6.3	12.9	16.2	10.1	15.1	4.9	w. 33 n.
1883	18.4	13.4	3.0	6.3	13.1	17.3	9.0	15.6	3.8	w. 31 n.
1884	18.1	12.0	2.7	5.5	12.9	18.1	11.0	14.5	5.5	w. 20 n.
1885	19.7	10.7	3.3	3.8	14.8	14.2	14.0	12.6	6.8	w. 9 n.
1886	12.3	17.0	3.3	6.3	14.5	12.9	13.4	14.0	6.3	w. 26 n.
1887	16.2	12.6	3.8	6.3	14.8	14.2	13.1	15.1	3.8	w. 21 n.
1888	17.5	12.3	3.0	5.7	11.5	15.6	11.8	18.9	3.3	w. 32 n.
1889	11.8	17.0	4.4	5.7	13.4	15.3	13.0	17.3	2.2	w. 27 n.
1890	12.0	15.1	4.1	4.7	13.0	14.0	11.8	19.7	5.7	w. 31 n.
1891	14.2	14.8	3.8	6.6	12.9	18.9	12.0	15.9	1.0	w. 27 n.
1892	15.1	14.5	1.9	6.8	9.9	14.8	18.1	17.0	1.9	w. 28 n.
1893	21.0	17.8	3.6	6.8	7.9	17.3	12.0	13.4	.3	w. 55 n.
1894	21.0	15.1	4.7	5.2	9.6	19.7	12.3	11.8	1.0	w. 38 n.
1895	24.0	7.1	4.1	8.2	14.5	15.1	13.4	13.7	.0	w. 22 n.
1896	24.4	8.5	5.2	4.4	12.6	18.1	12.3	14.5	.3	w. 30 n.
1897	21.6	12.9	2.5	6.8	10.1	17.5	14.2	14.0	.3	w. 33 n.
1898	22.0	15.3	5.5	6.3	13.4	14.5	12.3	10.4	.3	w. 53 n.
1899	18.4	15.9	3.5	5.2	9.9	19.2	9.9	17.2	.8	w. 50 n.
1900	20.0	14.8	4.4	4.1	8.2	19.5	12.6	16.4	.0	w. 41 n.
Mean	17.9	13.6	3.4	5.5	12.4	16.4	11.6	15.4	3.8	w. 31 n.

Table 2 shows the mean percentage of winds from each of the eight points of the compass and the resultant directions for each month of the year.

The components of direction are exhibited graphically in figs. 1 to 4, and the resultant directions in figs. 5 and 6. In fig. 7 are shown resultant directions for the four seasons.

These curves show very clearly the march of the various winds during the year. From fig. 1 we see that the south winds have a maximum frequency in July and a minimum in

[1] From August 25, 1872, to October 31, 1879, observations were made at 7:35 a. m., 4:35 and 11:35 p. m., Washington time; from November 1, 1879, to December 31, 1884, at 7 a. m., 3 and 11 p. m., Washington time; January 1, 1885, to December 31, 1886, at 7 a. m., 3 and 11 p. m., seventy-fifth meridian time; January 1, 1887 to June 30, 1888, at 7 a. m., 3 and 10 p. m., seventy-fifth meridian time; July 1, 1888, to date, at 8 a. m. and 8 p. m. seventy-fifth meridian time. The resultant directions in Tables 1 and 2 are based on observations of wind direction only, and do not take into account variations in the average velocity for different directions.—ED.