NOTES BY THE EDITOR.

OBSERVATIONS AT HONOLULU, HAWAIIAN ISLANDS.

Meteorological observations at Honolulu, Republic of Hawaii, by Curtis J. Lyons, Meteorologist to the Government Survey.

Pressure is corrected for temperature and reduced to sea level, but the gravity correction, —0.06, is still to be applied.

The absolute humidity is expressed in grains of water, per cubic foot, and is the average of four observations daily.

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 10.

The rainfall for twenty-four hours is given as measured at 6 a. m. on the respective dates.

May, 1895.	Pressure at sea level.			Temperature.					Humidity.			Wind.		Cloudiness.	Rain measured at 6 a. m.
									Relative.						
	9 a. m.	3 p. m.	9 p. m.	6 a. m.	2 p. m.	9 p. m.	Maximum.	Minimum.	9 a. m.	9 p. m.	Absolute.	Direction.	Force.		
	Ins.	Ins.	Ins.	°	°	°	°	°	%	%					Ins.
1 ..	30.22	30.15	30.20	72	78	73	80	72	62	66	5.9	ne.	3	3	0.00
2 ..	30.22	30.12	30.16	73	79	74	81	73	57	70	6.0	nne.	3	3	0.00
3 ..	30.14	30.09	30.14	73	78	71	80	72	70	90	6.9	se-n.	1	7-10	0.00
4 ..	30.15	30.11	30.19	69	79	73	82	68	69	78	6.8	ene.	2	5	0.12
5 ..	30.20	30.11	30.16	71	80	74	81	67	78	70	6.9	ne.	3	4	0.12
6 ..	30.13	30.08	30.14	72	77	70	80	71	60	84	6.4	ne.	4	4	0.00
7 ..	30.14	30.08	30.18	73	79	74	81	71	70	74	6.7	ne.	4	3	0.02
8 ..	30.20	30.09	30.18	73	78	74	81	72	63	70	6.4	ne.	4	5	0.01
9 ..	30.14	30.04	30.09	72	77	74	78	70	74	70	6.7	ne.	5	5	0.02
10 ..	30.06	29.98	30.04	70	79	72	80	68	60	79	6.2	ne.	4	4	0.08
11 ..	30.04	30.00	30.09	71	77	73	81	70	59	66	6.0	nne.	5	1	0.02
12 ..	30.13	30.06	30.14	72	80	72	82	71	56	73	6.2	nne.	3	1	0.00
13 ..	30.12	30.05	30.10	67	80	69	83	65	61	81	6.4	s-n.	1-0	2	0.00
14 ..	30.08	30.03	30.08	64	78	72	81	61	67	69	6.1	s-ne.	2	2	0.00
15 ..	30.08	30.01	30.10	64	79	73	84	62	60	65	5.8	s-nne.	2	1-3	0.00
16 ..	30.13	30.10	30.16	71	80	75	84	65	60	70	6.4	nne.	3	4-1	0.00
17 ..	30.20	30.10	30.18	73	80	75	83	71	60	70	6.4	ne.	3	4	0.00
18 ..	30.18	30.10	30.16	72	80	74	83	72	60	70	6.4	ne.	3	3	0.00
19 ..	30.14	30.08	30.13	68	79	72	81	66	67	78	6.7	ene.	2	7	0.00
20 ..	30.12	30.07	30.12	67	76	69	82	65	70	90	7.0	s-n.	2	8-10	0.00
21 ..	30.13	30.10	30.15	70	75	75	83	67	73	70	6.7	se-e	4	8	0.70
22 ..	30.15	30.08	30.13	72	79	74	83	67	67	70	6.6	ene.	3	2	0.10
23 ..	30.15	30.10	30.16	72	80	75	83	71	67	70	6.7	ne.	4	1	0.00
24 ..	30.15	30.12	30.16	73	80	76	83	71	65	69	6.6	ene.	4	3	0.04
25 ..	30.18	30.13	30.18	73	79	74	82	71	66	65	6.6	ne.	3	5	0.07
26 ..	30.17	30.12	30.17	73	81	75	81	72	67	66	6.4	ne.	4	5	0.04
27 ..	30.18	30.10	30.16	75	81	75	82	73	61	70	6.3	ne.	4	3	0.00
28 ..	30.16	30.13	30.18	74	80	75	83	73	63	67	6.4	ne.	3	4	0.00
29 ..	30.17	30.10	30.14	73	82	75	83	70	63	83	7.0	ne.	4	3-9	0.00
30 ..	30.16	30.09	30.15	76	81	76	84	73	67	70	7.0	ne.	4	8-3	0.01
31 ..	30.14	30.06	30.13	75	80	77	84	74	63	71	7.0	ne.	4	4	0.00
	30.15	30.08	30.14	71.4	79.1	73.6	....	....	64.7	72.7	6.5	.....	.....	.....	1.35

Mean temperature: 6 a. m. + 2 p. m. + 9 p. m. ÷ 3 = 7.47; the normal is 74.3; extreme temperature, 84° and 61°.

The rain period for the month was from the 18th to the 20th throughout the group of islands.

FROSTS IN MAY AT MARDELA SPRINGS, MD.

Mr. A. E. Acworth, voluntary observer at Mardela Springs, Md., states that on May 13 his minimum thermometer went down to 42°. This led him to make an examination of the weather record for May at the neighboring station of Princess Anne for twenty years, and at his own station for the past sixteen years, with the following result:

At Princess Anne there were 103 instances of decided falls in temperature occurring between the 3d and 19th of May, the mean dates being between the 8th and 13th. The average fall was 10.6° below the mean of the month (63.6°); there were two years of no marked fall; five showed a fall of 4°; nine years showed a fall of 5° only; the remaining four ranged from 6° to 11.6°.

At Mardela Springs, from 1879–'94, the mean temperature of the minimum thermometer at 7 a. m. was 63.4°. Throughout the whole period there was but a single day when the minimum thermometer was above this mean, and seventy-eight days, ranging between the 1st and 19th, on which the mean temperature was 52°. From these figures Mr. Acworth concludes that a cold snap may always be expected some time between the 8th and 13th of May.

The frosts recorded in May came before the 11th at Princess Anne in 10 cases out of 17, and before the 10th at Mardela Springs in 9 cases out of 13. He states that a frost bulletin compiled from all accessible sources is a great need.

RAINFALL AND BAROMETRIC PRESSURE.

A correspondent inquires why his barometer does not show low pressure during local storms as it does during the great cyclonic storms. This is a problem that troubled meteorologists for many years, but may now be considered as settled. It is so natural to associate together as cause and effect two phenomena that occur at the same time and place that for a long time it was supposed that the falling of the rain must relieve the atmosphere of just so much weight, thereby causing the barometric pressure to diminish. Brandes, in 1820, published the first general study of a European storm area, viz, that of 1783, and in 1826 further studies of the storms of 1821 and 1822. He found the barometer lowest at the central region and thought that the winds blew toward that. He failed to see the whirlwind character of his large storms, though recognizing it in very small disturbances. He seems to suggest that the lightness of the warm moist air in the neigborhood of a storm would cause it to rise up and overflow, thereby producing lower pressure in the central region that ought to be annulled by the inflowing winds. Similar ideas have been very widely disseminated ever since in popular text-books. Espy, in his lectures on storms between 1825 and 1840, showed that if the ascent of light air caused the barometer to fall, on the other hand the formation of rain would cause an evolution of latent heat that would warm up and expand the air more than enough to make up for the loss of the vapor, and might thus retard or annul any fall of pressure at the earth's surface. Dove, in 1828, showed that the winds and direction of rotation of a whirlwind must in some way depend on the diurnal rotation of the earth on its axis; by considering storms as whirlwinds he might have concluded that the fall of the barometer at the center is due to the whirling action, but this was first clearly expressed, not by him, but by Redfield, between 1821 and 1831. In the latter year Prof. E. Mitchell, of North Carolina, published his conclusions that *all* the phenomena of storms are the result of a vortical gyration. In 1843, Mr. Charles Tracy gave a popular exposition of the action of the rotating earth upon the movement of the wind and the rotation of storms, and enunciated the general law of deflection of winds to the right, similar to that previously deduced analytically by Poisson in his treatise on the motion of projectiles; but still nothing was said about the barometric pressure. In 1854 and 1859, Ferrel gave a full expression to the law of deflection to the right and to the resulting influence on the barometer, correcting the imperfect view known as Hadley's. It was Ferrel that first demonstrated that the diminution of pressure in a storm is directly due to the combined action of two centrifugal influences and has little or nothing to do with the rainfall, temperature, moisture, or the density of the air, except as these conspire to initiate or maintain the motion. These two centrifugal influences may be described as follows: (*a*) The whirling of the wind around a central vortex is accompanied by a tendency to fly outward, which is called centrifugal force, although this is, strictly speaking, not a special force but only an expression for the resistance that the inertia of a moving body offers when forced to move in a circle instead of a straight line. (*b*) Every particle of atmosphere revolves daily in a circle known in geography as a small circle of latitude; this motion gives rise to a centrifugal force. If the particle moves so as to change its latitude and longitude and comes into regions where the earth is moving slower or faster than on its original circle of latitude, its motions bring into play centrifugal forces that produce the so-called "deflection to the right."

Both of these manifestations of centrifugal force combine

together in cyclonic storms to produce a low pressure in the central region. The storm rotation is most important in very small whirls; the earth's rotation is most important in large whirls. *The observed fall of the barometer is the result of the motion of the air.* To be sure, the air would not move at all unless there was a slight deficiency or excess of pressure in some region to keep the air in motion; but this is a very slight matter, scarcely the thousandth part of the excess or deficiency observed in our high and low areas. The air is so mobile and light that a very minute barometric gradient produces a wind directly in the line of the gradient; this wind calls out the action of the centrifugal forces, and these produce the observed storm gradient which is almost perpendicular to the direction of the wind. The barometer falls as a vortex approaches and, therefore, shows the presence of high winds—not necessarily rain.

In our local thunderstorms there is generally very little rotation around a vertical axis and, therefore, no special fall in the barometer. If a rotation should ever take place around a horizontal axis, or one nearly so, as in rolling gusts of wind, the depression at the center of the whirl would be so far above the ground that the observer would not notice it.

With regard to high barometric pressure we note that the motions of the atmosphere give rise to high pressures on the right-hand side of the direction of movement just as truly as they give rise to low pressures on the left-hand side in storms of any extent and thus contribute to the formation of "high areas." Masses of cold or dry air descending through a lighter atmosphere to the ground raise the pressure a little as soon as the descent ceases. The almost explosive rapidity with which thunderheads are sometimes formed is a sudden expansion that may produce a temporary high pressure or waves of high and low pressure at the ground. Local storms are frequently formed in regions where the dense air of a high area is pushing under and lifting up the lighter air of the low area so that the barometric pressure is rising every moment, but in a rather irregular way, as shown by the continuous curves of the barograph. In general, the areas of high and low pressure are alike the result of a complex system of motions.

DRY NORTHER IN NEVADA.

The Monthly Review of the Nevada State Weather Service gives an account of the dry northers that prevailed in that State during May:

> The heavy wind of the 28th was very destructive to all vegetation, while whipping off the green fruit. The frosts and cold winds from the 27th to the 31st blasted the early fruits; the wild flowers disappeared entirely from the mountains and valleys. The frost of the 30th did a great deal of damage. The snow and wind storm beginning on the 26th almost destroyed the fruit at the northern end of the Washoe Valley. On the 25th and 26th we had the most severe windstorm for twenty-five years.

THE GREEN COLORED SUN OF SEPTEMBER 9–10, 1883.

The May Bulletin of the New England Weather Service gives a summary of earthquake phenomena at Manilla, and in this connection mentions the green sun that was observed on the 9th and 10th of September, 1883, a few weeks after the great irruption of the volcano at Krakatoa, in the Straits of Sunda. Similar strangely-colored suns were indeed observed at that time in other parts of the world, and have been observed on many other occasions. The Editor of this REVIEW had an excellent observation of a pale green sun in the damp atmosphere of Cape Ledo, on the west coast of Africa, through a rather thick cirrus cloud. The explanation of this phenomena has been made remarkably clear by the researches of Professor Barus, as published in Bulletin No. XI of the Weather Bureau. It appears that when the moisture begins to condense into cloud, the minute globules grow in size from microscopic invisibility up to the globules of fog. When these are all of some one uniform size the sunlight that penetrates them is analyzed into its elementary colors, as in the spectrum, and the visible color of the sun, as seen by us, depends upon the diameter of these globules, so that the color of the sun tells us of the size of the drops. These colors usually occur only when the globules are very small; that is to say, in the early stages of cloudy condensation, and the phenomenon is very closely allied to the colors shown by the soap bubble and known as the colors of thin plates.

THE TORNADOES OF MAY 3, 1895.

The accompanying chart, No. VIII, presents the general meteorological conditions prevailing at the time of occurrence of tornadoes in Iowa and neighboring States on May 3; the locations of the tornadoes and thunderstorms are shown by the short red lines. In addition to the main chart a number of others showing the changes that took place between 8 a. m. and 8 p. m. were constructed for study.

The principal local storms are numbered on this chart as follows:

1.—Between 3.45 and 4.20 p. m. in Spink County, S. Dak.
2.—Cain Creek, S. Dak.
3.—Near Tyndall, S. Dak., between 3 and 4 p. m.
4.—Near Sioux Falls, S. Dak., about 3 p. m.
5.—In Sioux and Osceola counties, Iowa, between 3 and 3.45 p. m.
6.—Baker Township, Osceola County, at 4.15 p. m.
7.—Ocheyedan, Osceola County, at 3.30 p. m.
8.—Alta, Iowa, sudden shift of wind to southeast at 3 p. m., and thunderstorms at 4 and 6.10 p. m.
9.—La Crosse, Wis., heavy hail between 3.36 and 3.45 p. m.
10.—Langdon, in the northwest corner of Missouri, and College Spring, in the southwest corner of Iowa; heavy hailstorm.
11.—Creston, Iowa, 7.30 p. m.
12.—Marshalltown, Marshall Co., Iowa; heavy thunder.
13.—Des Moines and St. Charles; tornado about 9 p. m., but may have been a straight-line blow; Steamboat Rock, 9.30 p. m., length of path, 3 miles. Madrid, Iowa, terrific wind and hail in all this part of the State, during the evening.
14.—Mound Ridge, McPherson Co., Kans.; path 25 miles long.
15.—Leavenworth, Kans., whirlwind at 6 p. m., 2 miles south of the town; path 1 mile long.
16.—St. Joseph, Mo., at 6.30 p. m., destructive straight-line blow from south-southwest.
17.—Clinton, Iowa, thunderstorm and hail during the night.
18.—Jacksonville, Ill., destructive winds, hail, and rain—almost a tornado in the afternoon.

On Friday, May 3, an area of low pressure (No. I of the series for this month) was central in the northern part of South Dakota, having moved southeastward to this point. It now turned northeastward slowly and disappeared in Manitoba on the 4th.

The central depression was accompanied as usual by a rapid extension southward of the region of falling barometer, so that the isobar of 29.7, for instance, extended from central Texas northward beyond the limits of our reports, while its east and west extension, reached from Wyoming to Wisconsin. Within this long oval the west and northwest winds on the west side were sharply divided from the south and east winds on the east side. So far as our reports show, the dividing line between these winds corresponded closely to the dividing line between the lower cloud movements. This dividing line is traced on Chart VIII for both 8 a. m. and 8 p. m. In the region immediately east of the evening position of the dividing line where all the severe tornadoes and thunderstorms occurred after 3 or 4 p. m., neither the winds nor the lower clouds give any evidence of important changes in their direction between 8 a. m. and 8 p. m., therefore it is evident that any unstable condition of the atmosphere, such as might contribute to a tornado, was not pro-

duced by the flowing of cold or dry air from the extreme west over the lower layer of air near the surface of the ground.

The study of the maps of relative humidity leads to the same conclusions, namely, that the lower air which was dry on the western side of this dividing line, although it advanced with that line eastward, yet did not in the least rise up and get ahead of it in order to descend in the region where thunderstorms and tornadoes occurred.

The proper study of the isobars requires that we should distinguish the effect of the weight of the air on the barometer from the effect of the motions of the atmosphere on its elastic pressure. An increase or diminution in the mass of the atmosphere over any point will, of course, increase or decrease its weight and, therefore, the barometric pressure. Now, the weather chart shows that between a. m. and p. m. the pressure fell over all that region within which the northwest winds supplanted the southerly winds, namely, the region over which the dividing line between northwest and southeast winds passed between a. m. and p. m. Of course the pressure also fell over a much larger region, but the fact that it fell over this region at all suffices to show that although the inflow of the northwest winds added to the mass of air above the stations of this region, yet this did not suffice to counteract the fall of pressure due to some other cause, which cause we must now recognize as the dynamic action of the wind.

In whatever direction the wind blows it is deflected to the right as a result of its rotation with the earth, and there is, therefore, an increased pressure of the moving wind against the quieter air on the right side, and a diminished pressure against the quieter air on the left-hand side, therefore, an area of low pressure forms on the left-hand side of the wind. All straight-line winds, as well as all the whirlwinds in the Northern Hemisphere, have the lowest pressures on the left-hand side. When parallel and adjacent belts of territory are covered by northerly and southerly or northwest and southeast winds, respectively, as in the present case, the dividing line between these two systems of winds becomes the axis of a trough of low pressure. An increase in the velocity of the wind produces on its left side a fall in the barometer by reason of the increased deflection to the right. An increase in the wind will arise whenever any excess of the static barometric pressure is converted into motion, hence, a falling barometer in its rear is the first result of the starting up of wind, and a falling barometer on its left-hand side is the second result. This latter is what causes the larger barometric gradients ordinarily observed. On the 3d of May there was a very general increase in the force of the wind between the a. m. and p. m. observations; for stations near the above-described dividing line the northwest winds generally rose from light winds up to 20 miles, and the west winds from 8 up to 18 and 28. On the east side of the dividing line the south winds rose from 12 and 16 to 14 and 28, and southeast winds from 10 and 12 to 28 and 52 at the maximum.

If we follow the line joining the points where the barometer fell 0.20 inch between the a. m. and p. m. observations and pick out, by interpolation, the rise in the velocity of the wind, irrespective of direction, we find an average of 24 miles per hour increase in the velocity. Similarly, the line of 0.10 fall in the barometer gives an average rise in the velocity of the wind of 11 miles per hour. The line of no fall in the barometer may be divided into an eastern and western branch. The former shows a small average increase in the velocity of the wind, while the latter branch, which skirts along the Rocky Mountain ridge, shows an average rise of 14 miles in the wind velocity. In passing to the western extreme we have, therefore, reached the region where the dynamic effect of the increase in the velocity of the wind is overcome by the direct effect of the increase in the weight of the mass of atmosphere. Every storm region may be thus divided into three regions: (*a*) the central region in which the barometer falls as a consequence of the rapid movement of the wind; (*b*) an exterior region, usually on the west side, where the barometer rises by reason of an increase in the mass of air above it; (*c*) an intermediate region where the effect of changes in the wind and changes in the mass of air approximately counterbalance each other.

As the tornadoes and thunderstorms occurred within the region of southerly winds and cloud movements long before any inflow of air had taken place from the west, even in the middle levels of the atmosphere, and as they occurred at very irregular hours as compared with the regular advance of the isobars, we are compelled to seek their origin not in any general conditions, but in combinations of favorable local circumstances.

When a mass of air that is heavier than its neighbor, by reason of greater dryness or slightly lower temperature, sinks to the ground it must slide, as it were, on an inclined plane, at the same time pushing the lower air away. In proportion as the mass descends more nearly vertically and rapidly it is liable to become a warm fœhn wind, but in proportion as it descends slowly and more nearly horizontally the warming effect of compression is less noticeable. In the latter case the descending mass rolls over on itself and spreads over the ground. The minor whirls that are formed on its south or right-hand side are soon broken up, while those that form on its north or left-hand side are far more persistent and constitute the ordinary severe local storm and tornado. The severity of these local storms depends not upon the speed of the descending current, but upon the conditions as to moisture within the cloud that is formed by the rising air in advance of it. This cloud can not be due, to any great extent, to a process of mixture of warm and cold air, nor to a process of radiation, but, so far as known, must be formed by the cooling due to the expansion of the rising air. In most cases such cooling goes on gradually, and small cumulus clouds are thus formed, that may be dissipated either by the sun's heat or by the stoppage of the supply of ascending moist air. But occasionally the air within the cloud comes into a condition of supersaturation, and when this is relieved a violent expansion upward takes place; the cloud grows very rapidly; a powerful upward suction sets in toward it; the inflowing air acquires a violent whirl; the barometer within this whirl falls rapidly, owing to the centrifugal action of the whirlwind; the inflowing air, expanding and cooling as it enters the low pressure within the whirl, forms the central tornado funnel; much of the vapor is carried up high enough to form the snow and hail that descends some distance to the right and left of the path of the tornado.

The local influences that determine the special formation of large cumulus clouds and their development into tornadoes within the general current of southerly winds can be indicated, in a general way, as follows:

1. The air must be pushed upward either by its intrinsic lightness—that is to say, the heaviness of surrounding air—or by the presence of obstacles, such as hills and forests, or by the coming together of two currents from slightly different directions, crowding and pushing each other up.

2. The air must be moist enough to easily form cloud and there must be an abundance of dust or other nuclei on which to begin the cloudy condensation. If these conditions are fulfilled at a dew-point above 60° F., there will generally be sufficient moisture to bring on that supersaturated condition that seems to be necessary for violent action, which action may be manifested as lightning or rain or hail or wind.

The straight-line winds, tornadoes, thunderstorms, and hailstorms of May 3 illustrate each successive phase of the general process above outlined.