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(11) Onweders, optische verschijn., enz., 1899, p. 57.
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(13) Onweders, enz., 1899, p. 62.
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HALOS AND THEIR RELATION TO THE WEATHER.

By ANDREW H. PALMER, Assistant Observer.

[Dated Weather Bureau, San Francisco, Cal., July 15, 1914.]

When rays of light from the sun or the moon pass through a cloud sheet, various subjective phenomena are caused by the moisture particles which make up the cloud mass. When the sun is observed through haze or attenuated fog it appears as a disk with sharply defined edges. When a moderately dense cloud sheet occurs at a low or intermediate level, the sun's disk, when visible, is irregularly defined, is sometimes too bright to be observed directly with the naked eye, and is frequently surrounded by concentric rings of light called coronas. These rings, which vary in number from time to time, are ordinarily 1° to 5° in radius, and show the various colors of the spectrum, always with the red on the *outside*. They are produced through diffraction and interference of the light rays by the water spherules and ice crystals encountered. Because of the brightness of the sun many solar coronas pass unobserved, as they usually may be seen only by reflected light. Incomplete coronal arcs are often seen in the thin margins of broken clouds like strato-cumulus and alto-cumulus. With the highest cloud sheet, the cirro-stratus, refraction and reflection of the rays by the ice crystals produce rings in which the colors, when visible, are always arranged with the red on the *inside*. These are halos proper or greater halos, and may be defined as somewhat complicated arrangements of arcs and circles of light surrounding the sun or the moon, accompanied by others tangent to or intersecting them, with spots of special brightness called parhelia appearing at the points of tangency and intersection. Parhelia are most often observed about sunrise or sunset, frequently when the intersecting arcs are themselves invisible, except at the points where the two causes combine to reflect a double portion of the sun's rays. In the order of their frequency, halos average about 22°, 46°, or 90° in radius, but on rare occasions various other sizes have been observed. In the following discussion halos proper are alone considered.

There is a very intimate relation between halos and cirro-stratus clouds, a halo usually being formed whenever this kind of cloud is penetrated by the rays of the sun or the moon. Based upon the observations made at Blue Hill Observatory during 1896–97, the mean height of cirro-stratus clouds is 10,099 meters during April to September, inclusive, and is 8,893 meters during October to March, inclusive (1). The mean for the year is 9,496 meters, an average higher than that of any other form of cloud. The maximum height at which they have been observed is 13,601 meters, while an instance of cirro-stratus cloud at 4,036 meters is also on record. However, it is sufficient to say that they are high clouds, so high in

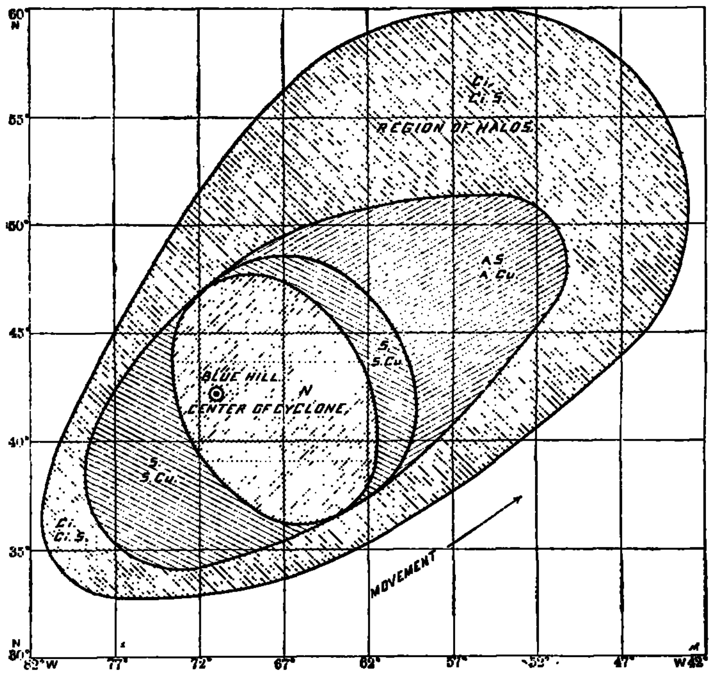

FIG. 1.—Cloud regions and cloud classes about a typical Northern Hemisphere cyclone central over Blue Hill Observatory. (International cloud notation.)

fact that the water particles making up the cloud are known always to be in the form of hexagonal prisms of ice. Though it is unnecessary to consider the physics of halo formation here, it should be stated that the form and the arrangement of these ice spicules or needles are important considerations in the refraction and the reflection of the light rays (2). The size of the halo, whether it be approximately at 22°, 46°, 90°, or one of the rarer types, is determined by the amount of reflection and refraction suffered by the rays, and is therefore closely dependent upon the density, the thickness, and the height of the cirro-stratus sheet. While most halos are approximately circular, a few are elliptical, the latter form being explained sometimes by inequalities in distance between the observer and the moisture particles, and sometimes by the distortion resulting from heterogeneous conditions of temperature, and hence of density in the lower atmosphere. The light of some arcs is polarized, while that of others is not (3). From a study of halos observed in Russia, Dr. Ernst Leyst concluded that there was no relation between halos and sunspots (4).

At Blue Hill Observatory, which is located upon the summit of a high hill 10 miles south of Boston, Mass., record is kept of the occurrence of halos among the other miscellaneous phenomena. The kind of halo, whether solar or lunar, and the duration of its existence, is recorded. Though no record as to size is kept, the 22°-halo is by far the most common, and the 46°-halo the next most common. As pointed out by M. E. T. Gheury (5), who made a study of halos and coronas observed in England, one does not realize how common halos are until he keeps a systematic record of their occurrence. Table 1 shows the monthly occurrence of halos, both solar and lunar, as recorded at Blue Hill Observatory during the 20 years, 1891 to 1910, inclusive. Doubtless practically all of the solar halos which have been visible there during that time have been recorded, but many lunar halos have probably been unnoticed, since no observer is on duty between midnight and 7 a. m. It is apparent from the table that solar halos are most frequent in the spring, the mean number for March being 5.9, and are least common in the autumn, October and November each having a mean of 2.3. Lunar halos are most frequent in winter, the mean for January being 2.7 and are least frequent in summer, the mean for June, August, and September being but 0.6.

TABLE 1.—*The numbers of halos observed at Blue Hill Observatory, Great Blue Hill, Mass., 1891–1910, inclusive.*

SOLAR HALOS.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891....	4	5	5	3	7	5	7	0	1	0	3	2	42
1892....	5	2	6	6	3	3	3	2	3	1	1	4	39
1893....	1	3	2	2	3	4	5	3	2	4	4	3	36
1894....	5	6	9	5	4	3	2	1	2	2	4	4	47
1895....	10	5	10	4	5	4	4	7	0	4	1	8	62
1896....	4	3	6	3	4	2	0	0	5	2	3	5	37
1897....	4	5	2	5	2	5	2	0	2	2	1	4	34
1898....	7	4	9	7	4	1	0	2	2	1	0	7	44
1899....	3	5	3	0	5	0	1	2	2	3	1	5	30
1900....	0	4	3	2	2	8	3	0	4	4	1	3	34
1901....	6	3	3	1	1	1	0	4	6	2	1	3	31
1902....	5	7	6	5	4	7	4	2	0	3	6	1	50
1903....	3	4	2	2	1	2	2	5	5	3	2	2	33
1904....	4	4	7	4	6	1	2	4	4	1	3	4	44
1905....	6	6	9	10	3	7	4	4	3	2	4	2	60
1906....	5	6	7	6	5	4	4	4	2	4	1	1	49
1907....	3	7	5	5	4	4	1	4	0	0	1	1	35
1908....	5	7	12	4	6	3	2	5	6	2	3	5	60
1909....	5	3	6	6	7	8	5	8	4	2	2	6	62
1910....	4	8	5	6	5	3	2	3	2	3	3	5	49
Mean ..	4.5	4.9	5.9	4.3	4.1	3.8	2.7	3.0	2.8	2.3	2.3	3.8	

LUNAR HALOS.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891....	3	2	3	1	1	0	0	1	1	0	0	1	13
1892....	5	1	1	3	1	1	2	0	1	0	1	2	18
1893....	1	1	3	1	1	0	0	0	1	2	0	1	11
1894....	1	4	2	3	1	0	0	0	0	2	0	2	15
1895....	2	3	2	2	2	0	0	0	0	3	2	1	17
1896....	3	3	0	2	1	0	0	0	0	1	6	3	19
1897....	5	1	4	2	1	0	0	0	1	1	1	2	18
1898....	5	2	3	0	2	0	0	1	0	1	2	7	23
1899....	3	2	1	0	0	0	0	1	2	0	3	4	16
1900....	1	2	2	0	1	1	1	0	0	1	2	1	12
1901....	1	3	0	1	0	0	0	1	1	1	1	1	10
1902....	2	1	1	3	0	0	0	0	0	0	2	0	9
1903....	2	1	1	1	0	0	0	0	1	1	2	2	11
1904....	2	0	1	2	1	0	0	1	0	0	4	1	12
1905....	2	3	1	1	2	0	0	0	0	1	1	0	11
1906....	3	1	3	1	3	1	2	2	1	3	0	0	20
1907....	6	0	3	3	3	0	0	3	0	2	1	3	24
1908....	4	5	1	1	1	2	1	0	2	0	3	4	24
1909....	2	1	4	1	0	3	0	0	1	0	2	2	16
1910....	1	4	4	1	1	3	2	1	0	2	1	2	22
Mean ..	2.7	2.0	2.0	1.5	1.1	0.6	0.4	0.6	0.6	1.1	1.7	2.0	

Certain other facts must be considered in this connection, however. In the latitude of the observatory (lat. 42° 13′ N., long. 71° 7′ W. of Greenwich) the sun is above the horizon about 6 hours longer in June than it is in December, thus increasing by about 67 per cent the time when solar halos may occur. Cyclones are more frequent and hence cirro-stratus clouds are more common in winter than in summer. The relatively small number of solar halos in summer as compared with the number in winter seems to indicate, when these facts are kept in mind, that the conditions favoring their formation are very much less frequent then. On the other hand, since the nights are longer in winter than in summer more lunar halos are theoretically possible during that half-year. Moreover, lunar halos are also related to the age of the moon, since the latter must usually be in a phase between first and last quarter in order to give sufficient light to produce a halo. Partly for this reason, the total number of solar halos in a year is more than twice that of lunar halos. As may be learned from the table, few months occur in which no solar halos are observed while sometimes as many as 12 are seen, as was the case in March, 1908. During the 20 years the total number of solar halos per year ranged from 30 in 1899 to 62 in 1895 and 1909. Lunar halos are not observed every month, though as many as 7 were seen in one month, December, 1898. During the period considered the number per year varied from 9 in 1902 to 24 in 1907 and 1908. Halos vary greatly in the duration of their existence, some lasting but a few minutes, while others continue for many hours. A solar halo was observed to persist for 10 hours, while on several occasions a lunar halo observed in the evening was still visible early the next morning, doubtless having continued all night. Based upon the records for the 10 years 1901 to 1910, inclusive, the average duration of halos in hours for each month of the year at Blue Hill is as follows:

TABLE 2.—*Average duration (in hours) of halos for each month.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Solar halos...	1.6	2.2	2.2	2.3	1.9	1.9	1.9	2.2	2.4	1.9	1.1	1.7	1.9
Lunar halos..	1.3	1.8	1.8	1.9	1.3	1.3	.....	1.7	2.3	1.6	1.8	1.5	1.7

In the popular mind considerable attention is given to halos as forerunners of precipitation, frequent references to them occurring in poetry and proverb. Various European studies have been made in this connection, but with the exception of a paper by Mr. George Reeder (6), Section Director of the United States Weather Bureau at Columbia, Mo., no extensive study based upon American data has been made. After examining the record of halos observed at Columbia, Mo., during 1905 and 1906, Mr. Reeder concluded that (*a*) "halos are a very good guide in predicting weather changes, especially the 22-degree circles;" (*b*) the 22-degree circle is followed by precipitation usually within 12 to 18 hours, the storm center crossing the meridian near the point of observation; and (*c*) "when the 45-degree circle is observed the storm center is usually from 800 to 1,000 miles or more away, and precedes precipitation, if any, by 24 to 36 hours." He has also observed well-defined 45-degree solar halos on occasions when a West Indian hurricane was immediately off or near the east Gulf or South Atlantic States.

The relation of halos to precipitation as shown by the data obtained at Blue Hill Observatory during the 10 years 1901 to 1910, inclusive, is summarized in Table 3. Considering solar halos first, it is apparent that with the exception of one month, July, more than half are followed by precipitation within 36 hours. During the winter months, December to April, inclusive, more than 70 per cent of the solar halos are followed by precipitation, the highest proportion being that of January, with 76 per cent. Some halos are preceded but not followed by precipitation within 36 hours. The largest number of these occur during the summer half-year, 24 per cent of those occurring in October falling within this class. Moreover, some halos are neither preceded nor followed by precipitation within 36 hours, the greater number of these again occurring during the summer half-year, one-third of the July halos being of this type. The average interval between the appearance of a solar halo and precipitation, when it follows, is longer in summer than in winter. Generalizations regarding lunar halos, on the basis of the data studied, are not so well established, since a relatively small number were available. Only those lunar halos were considered which occurred upon days when no solar halos were seen. Generally speaking, however, lunar halos show conditions not greatly unlike those associated with solar halos.

The apparent close relationship existing between halos and precipitation can be easily explained from a study of cloud distribution in cyclones. Long-continued observations have established the fact that when no low clouds are present a halo is formed (*a*) whenever a thin stratum of cirro-stratus cloud exists in that part of the sky where the sun or the moon is visible, or (*b*) occasionally with high cirrus clouds in which the streamers are sufficiently dense or are matted to produce the stratus effect, the halo in this case being broken or incomplete. The study of halos, therefore, resolves itself largely into a study of cirrus and cirro-stratus clouds. Because of their infrequent occurrence, cirro-stratus clouds in anticyclones are not considered here. For the same reason cirro-stratus clouds associated with thunderstorms are not referred to. Figure 1 shows the distribution of clouds in a cyclone central at Blue Hill, based upon the observations made

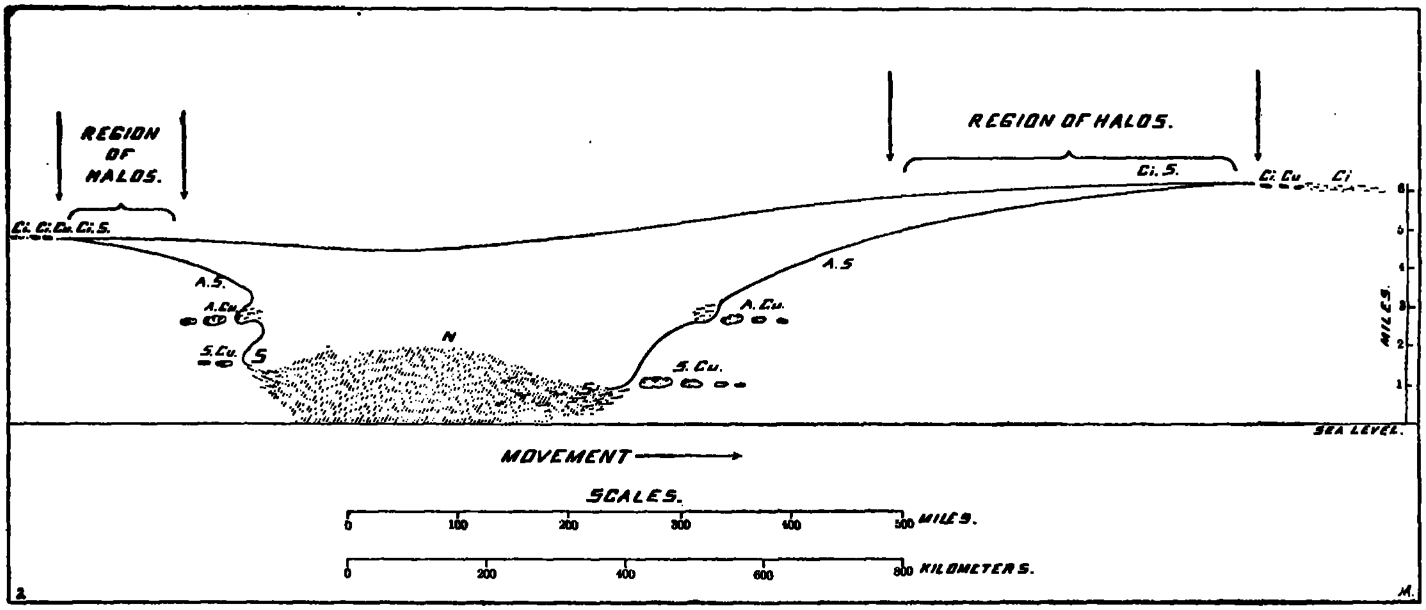

FIG. 2.—Longitudinal section of a typical Northern Hemisphere cyclone, showing regions of halos. (International cloud notation.)

TABLE 3.—*Relations of occurrence of halos to occurrence of precipitation at Blue Hill Observatory for the 10 years 1901–1910.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total and means.
SOLAR HALOS.													
Total number considered....	45	53	59	50	43	41	27	41	32	21	26	29	467
Proportion followed by precipitation within 36 hours (per cent)................	76	74	71	74	63	68	48	68	59	62	69	72	69
Proportion preceded but not followed by precipitation within 36 hours (per cent).	6	7	17	8	21	17	19	10	16	24	10	11	12
Proportion neither preceded nor followed by precipitation within 36 hours (per cent).....................	18	19	12	18	16	15	33	22	25	14	21	17	19
Average number of hours between halo and precipitation....	15.4	13.8	14.1	16.0	16.8	16.8	*12.8*	18.9	16.4	17.0	14.6	13.5	15.6
LUNAR HALOS.													
Total number considered....	20	9	13	6	6	3	4	5	3	9	11	13	102
Proportion followed by precipitation within 36 hours (per cent)................	60	44	62	100	83	0	75	40	67	33	64	62	60
Proportion preceded but not followed by precipitation within 36 hours (per cent).	30	56	23	0	17	33	0	20	33	22	27	23	26
Proportion neither preceded nor followed by precipitation within 36 hours (per cent).....................	10	0	15	0	0	67	25	40	0	45	9	15	16
Average number of hours between halo and precipitation....	14.2	16.0	18.2	14.8	19.6	....	....	....	....	....	14.1	*11.1*	15.4

at the observatory in 1890–1891 (7). The large ring of cirrus and cirro-stratus cloud covers an area about as large as the remainder of the cyclone. In this large territory, where a halo is everywhere visible when the sun or the moon is above the horizon, the cloud and the halo are the only visible evidences of the cyclone. If the observer is in the forward part of this ring he will find that as the hours pass the cirrus cloud first seen changes to cirro-stratus, the halo disappears when the latter in turn is obscured by the lower alto-cumulus and alto-stratus. The latter stratum is subsequently obscured by still lower stratus and strato-cumulus cloud, and precipitation begins soon afterwards. The transition is faster in winter than in summer, since storms, the upper winds, and the clouds are accelerated in movement then. This explains the shorter interval between halos and precipitation in winter than in summer. If the observer is in a position of the ring to the right or to the left of the path of the moving cyclone the halo persists longer than usual, and it is neither preceded nor followed by precipitation. This explains the cases of this kind included in the summary. Moreover, the summary also shows a few halos in which precipitation precedes but does not follow within the time limits designated. This condition would be represented by that part of the ring at the rear of the cyclone center, the precipitation having gone before the halo, and the fair weather of the anticyclone following. It should be borne in mind that the cloud distribution shown in the diagram is that of a typical cyclone, and though based upon a great number of observations it does not necessarily represent the conditions accompanying every individual cyclone.

Based upon the cloud observations made at Blue Hill Observatory during 1890–1891, the percentage frequency of precipitation following cirro-stratus cloud is as follows(7):

TABLE 4.—*Frequency of precipitation following cirro-stratus, at Blue Hill Observatory.*

Cirro-stratus moving from	S.	SW.	W.	NW.
Precipitation frequency (per cent)	60	42	55	62
Departure from normal (per cent)	+24	+6	+19	+26

The departure from the normal shows how much more frequently precipitation follows cirro-stratus cloud than is indicated by the average probability of rain regardless of cloud. Cirro-stratus cloud moving from an easterly point is a rare phenomenon at Blue Hill, only 8 out of 239 observations during that year showing such movement.

While Figure 1 may be regarded as a projection upon the ground of the cloud areas in a cyclone, Figure 2 may be considered as a longitudinal section along a major axis through the center of a typical storm, and hence parallel to the direction of movement (7). In this diagram the vertical dimension is not directly comparable with the horizontal dimension, since the typical storm represented is, in round numbers, 10 to 13 kilometers (6 to 8 miles) in depth, 2,400 to 4,800 kilometers (1,500 to 3,000 miles) in length, and 1,600 to 2,400 kilometers (1,000 to 1,500 miles) in breadth. The storm as shown in the diagram is supposed to move from left to right. The sequence of conditions often noted at Blue Hill Observatory is as follows: Cirrus streamers accompanied by scattered cirro-cumulus clouds give the first warning of the approach of a storm, and often appear before the barometer begins to fall. Soon the cirrus becomes denser and cirro-stratus cloud is formed, a halo appearing if the sun or the moon is favorably located. The barometer begins to fall about this time, the wind goes around to a southerly point and the temperature rises.

The cloud stratum becomes thicker and lower, and the halo disappears when the clouds change to alto-stratus and alto-cumulus. The clouds become denser and darker, the wind veers to an easterly point and increases in velocity, the humidity rises, and the barometer continues to fall sharply. Low fracto-stratus and fracto-nimbus clouds appear and precipitation begins after a short time. The duration of the rain varies greatly for the various storms, often being but a few hours in winter, while it may last for several days in summer when the storms move slowly. After precipitation ceases the sequence of events which preceded it is repeated, but in the reverse order and at an accelerated rate. The dark nimbus cloud gives way to the lighter stratus and strato-cumulus, the wind shifts to northwest and increases in velocity, the barometer rises, and the temperature and humidity fall. Later the clouds become the higher alto-stratus and alto-cumulus, which are soon replaced by cirro-stratus, which again shows a short-lived halo if the sun or the moon is above the horizon. As the storm passes out to sea in a northeastward

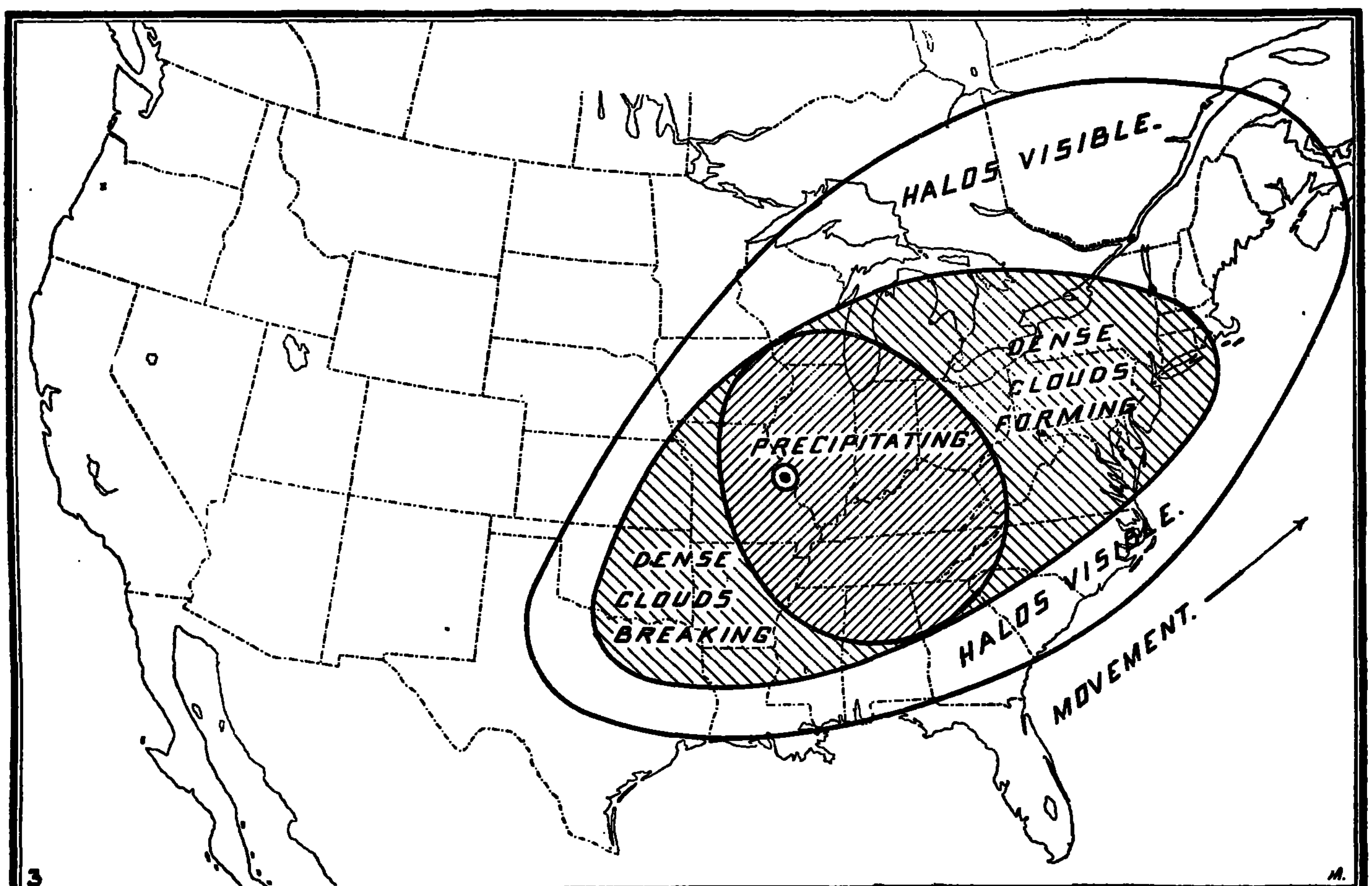

FIG. 3.—Sky conditions surrounding a typical cyclone, showing regions where halos may form. O center of cyclone.

direction cirrus and cirro-cumulus clouds linger for a time as a last reminder. Usually an anticyclone follows with clearing skies, light variable winds, clear cool air, low humidity, and accelerated radiation accompanying the relatively high pressure.

The mean horizontal velocity of the cirro-stratus cloud in which the halos are usually formed is 35.8 meters per second. The mean for April to September, inclusive, is 30.0 meters per second, while that for October to March, inclusive, is 41.7 meters per second. A maximum velocity of 94 meters per second was observed, while the minimum was but 0.5 meter per second, both of these, strange to say, occurring in the month of February. In the front of a cyclone the wind at the cirro-stratus level is apparently blowing at a considerably higher rate than it does at the same level in an anticyclone when cloud is not present. While the mean velocity of the cirro-stratus cloud during the summer half-year is 30 meters per second, that for the wind at the same level in the clear air of an anticyclone is but 18 meters per second, as indicated by observations of pilot balloons made at the observatory. The mean velocity of progression of cyclones for the United States in meters per second, as determined by Loomis (8), is as follows:

January	15.1	May	11.4	September	11.0
February	15.3	June	10.9	October	12.3
March	14.1	July	11.0	November	13.3
April	12.3	August	10.1	December	14.9
				Mean	12.7

However, cyclones have sometimes traveled from western Kansas to the vicinity of Blue Hill in a single night, while others have required four days to travel over the same distance. The point to be emphasized here is the fact that the great irregularity in the rate of cirro-stratus movement, together with the equally marked range in the rate of progress of cyclones, accounts for the extreme variability in the duration of halos.

The general conditions which prevail in the eastern part of the United States when a halo is visible at Blue Hill are shown in figure 3. This diagram shows the typical distribution of weather conditions in a cyclone the center of which is at St. Louis. Precipitation is then in progress in the central part of the Mississippi Valley, while dense alto-stratus and stratus clouds are forming in the Middle Atlantic States, and the same kinds are breaking up and disappearing at the immediate rear of the area of precipitation. Surrounding this whole area and including the greater part of New England is a ring of territory, broad at the front and narrow at the rear, in which cirrus and cirro-strata are the prevailing clouds. Everywhere within this belt halos are visible when the sun or the moon is favorably located. The halo visible at Blue Hill under these conditions disappears when the denser and lower alto-stratus cloud arrives. Precipitation soon occurs and the center of the cyclone passes close to this vicinity. The sequence of events is slow or rapid depending on the time of the year.

THE HALO IN WEATHER LORE.

Numerous weather proverbs are based upon the fact that halos are usually followed by precipitation. While many of these are of European origin they are equally applicable to American conditions, since the weather is dominated by cyclonic control in the greater part of Europe, as well as over most of the United States. Like most weather proverbs which have survived the test of time, they are expressions of scientific principles, but their origin is probably explained by the similar observations of many people, rather than by deductive scientific reasoning. The following proverbs have been gleaned from various books of weather lore, and are given in the forms in which they have appeared in print:

(1) The moon with a circle brings water in her beak.

(2) When the sun is in his house it will rain soon.—(Zuñi Indians.)

(3) When round the moon there is a "brugh,"
The weather will be cold and rough.—(Scotland.)

(4) For I fear a hurricane;
Last night the moon had a golden rim,
And to-night no moon I see.—(Longfellow, "The Wreck of the Hesperus.")

(5) The moon in halos hid her head,
The boding shepherd heaves a sigh.

(6) If two parhelia occur, one towards the south, the other towards the north, with a halo round the sun, they indicate rain within a short time.—(Theophrastus.)

(7) When the fourth day around her orb is spread
A circling ring of deep and murky red,
Soon from his cave the God of Storms will rise,
Dashing with foamy waves the lowering skies.—Aratus (J. Lamb).

(8) No weather fair expect, when Iris throws
Around the azure vault two painted bows;
When a bright star in night's blue vault is found
Like a small sun by circling halo bound.—Aratus (J. Lamb).

These first eight proverbs are generalizations embodying the principle that halos are usually followed by precipitation within a short time.

(9) When the wheel is far, the storm is n'ar;
When the wheel is near, the storm is far.

(10) Circle near, water far;
Circle far, water near.—(Italy.)

The next two proverbs refer to the size of the halo and state, in other words, that rain follows a 46°-halo sooner than a 22°-halo. Since the halos recorded at Blue Hill are not classified as to radius, the truth or falsity of these sayings can not be tested. However, it is interesting to note in this connection that Mr. George Reeder found (6) that rains followed 22°-halos within 12 to 18 hours, and 46°-halos within 24 to 36 hours. This would indicate that, for Missouri at least, the opposite of the idea expressed in the two proverbs is true.

(11) A lunar halo indicates rain, and the number of stars inclosed the number of days of rain.

No relation is apparent between the number of stars visible inside of a halo and the number of days of rain. The number of stars visible inside of a halo depends upon many facts, such as the part of the sky, the density of the cirro-stratus cloud, and the transparency of the lower air.

(12) The circle of the moon never filled a pond,
The circle of the sun wets a shepherd.

While no data are available showing a difference in the amounts of rain following solar and lunar halos, Table 3 shows that on the average for the year as a whole, solar halos are followed by precipitation 9 per cent more frequently than are lunar halos. As far as the earth's atmosphere is concerned, the physical explanations of the two kinds of halos are similar.

(13) A halo around the sun indicates the approach of a storm, within three days, from the side which is the most brilliant.

(14) Halos predict a storm at no great distance, and the open side of the halo tells the quarter from which it may be expected.—(Scotland.)

While these two proverbs at first appear to express a paradox, both are probably true statements, and may be explained as follows: As the cirrus and cirro-stratus fronds push across the sky in the region of the sun the halo first appears and subsequently becomes brighest in that part of the arc from which the cyclone is approaching. Later the halo becomes complete and the light is homogeneous throughout. As the storm advances, altostratus cloud arrives and obliterates the original and for a time the brighest part of the halo, that is, the side nearest the oncoming storm. Both proverbs are true generalizations but refer to different times in the life history of the halo.

(15) Double or treble circles round the moon foreshadows rough and severe storms, and much more so if these circles are not pure and entire, but are spotted and broken.—(Bacon.)

When halos are double or treble it signifies that the cirro-stratus cloud is relatively thick, such as is likely to be the case in a deep and hence well-developed storm. Broken halos indicate a much disturbed state in the upper air, with precipitation near at hand.

(16) If there be a ring or halo around the sun in bad weather, expect fine weather soon.

(17) If the rising sun be encompassed with an iris or circle of white clouds and they equally fly away, this is a sign of fair weather.—(Pliny.)

(18) If the sun or moon outshines the "brugh," bad weather will not come.

These three proverbs may refer to the halo often observed at the rear of a cyclone, and belong to the type referred to in Table 2, as halos preceded but not followed by precipitation. Or they may refer to a halo on either side of the path of the precipitation area, this type of halo being neither preceded nor followed by precipitation.

(19) A halo round the moon is a sign of wind.—(China.)

(20) A circle or halo round the moon signifies rain rather than wind, unless the moon stand erect within the ring, when both are portended.—(Bacon.)

(21) A white ring round the sun towards sunset portends a slight gale the same night; but if the ring be dark or tawny, there will be a high wind the next day.—(Bacon.)

(22) If there be a circle round the sun at rising, expect wind from the quarter where the circle first begins to break; but if the whole circle disperses evenly there will be fine weather.—(Bacon.)

In the present study the relation between halos and wind was not investigated. However, the four proverbs referring to wind seem to be applicable to the wind at the rear of a cyclone which usually accompanies the clearing conditions following precipitation.

(23) A halo oft fair Cynthia's face surrounds,
With single, double, or with triple bounds:
If with one ring, and broken it appear,
Sailors, beware! the driving gale is near.
Unbroken if it vanisheth away—
Serene the air, and smooth the tranquil sea.
The double halo boisterous weather brings,
And furious tempests follow triple rings.
These signs from Cynthia's varying orb arise—
Forewarn the prudent, and direct the wise.
—Aratus (J. Lamb).

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