fall than in the early, and we may add that the records of the two stations are in close agreement in percentages throughout the 50-year period under discussion.

It is accordingly evident that pressure conditions conducive to rainfall in Southern California are more reliable factors in the autumn than in the spring. The tracks followed by disturbances moving eastward over the coast have in general a more southerly tendency in the autumn, and especially in November. Besides, "lows" which make their way into the Pacific Southwest from Mexico are more frequent in the fall months. Another occasional rainfall factor is the summer "low" over the lower Colorado River valley. This often persists, albeit somewhat weakened, throughout October, and the cooling of the air in the near-by coastal region occasionally operates with this "low" to produce considerable October rains.

On the other hand, the development of secondary "lows" over Nevada occurs more frequently in the spring than in the fall. Nevertheless, these depressions are uncertain causative factors in Southern California's late seasonal rainfall. If the barometric gradient between their centers and the coast is fairly large, it often happens that brisk to strong westerly or northwesterly winds are the only appreciable results of their development. Still, the coastal region sometimes receives a good rainfall from them, and we note that the greater relative frequency of thunderstorms in the Los Angeles area in the spring months is due to the barometric "lag" which remains for a day or two over the Tehachapi Mountains after their centers have moved eastward. In the long run, however, the tables show that rain producing conditions are decidedly more effective in the autumn months.

The direct movement of energetic depressions from the Pacific over or just north of Southern California is infrequent before December or after March. Occasionally, however, this occurs, and the results are seen in the excessive rainfalls of October, 1889, November, 1900, April, 1926, May, 1921, and June, 1884. These exceptional storms are, of course, included in the tabular values given above, but their amounts balance in the fall and spring totals so well that they do not sensibly affect the order of the several absolute and relative values.

Some interest may be taken in a comparison of the 50-year results for Southern California with those of two stations farther north: San Francisco and Sacramento. The following data are for the same period, and the columnar values have the same significance, as the corresponding ones in the southern tables:

San Francisco

	(a)	(b)	(c)	(d)	(e)	(f)
	Inches	*Inches*	*Per cent*	*Inches*	*Per cent*	*Per cent*
1877-87	254.97	41.60	16.3	46.74	18.3	65.4
1887-97	233.16	41.66	17.9	25.72	11.0	71.1
1897-07	193.78	43.29	22.3	20.27	11.5	66.2
1907-17	213.87	25.97	12.1	13.30	6.2	81.7
1917-27	201.37	42.10	20.9	23.42	11.6	67.4
Sums	1,097.15	194.62		129.45		
Means	219.43	38.92	17.9	25.89	11.7	70.4

Sacramento

	(a)	(b)	(c)	(d)	(e)	(f)
1877-87	209.71	32.70	15.7	31.50	15.2	69.1
1887-97	201.26	36.84	18.3	26.65	13.2	68.5
1897-07	186.71	39.82	21.3	23.04	12.3	66.4
1907-17	154.60	17.55	11.4	11.92	7.7	80.9
1917-27	142.85	33.99	23.8	18.65	13.1	63.3
Sums	903.33	160.90		111.76		
Means	180.66	32.18	18.1	24.37	12.3	69.6

It will be remarked that the early rainfall in these tables is remarkably uniform, in actual quantity, in four of the five 10-year periods, and that, in the decade in which it is deficient, an even larger proportional deficiency is found in the season of late rains also. In this particular decade—1907–1917—there is, therefore, an abnormally high relative value for the mid-seasonal rains. But, leaving this decade out of consideration, the others fail to show in the quantity of their late rains the uniformity which is characteristic of their earlier rains. On the whole, however, the irregularities from decade to decade are not so striking as they are in the southern tables, and this because the influence of northern "lows" is much more pronounced, and that of secondary "lows" over southern Nevada much less pronounced, than in the south.

On the other hand, in autumn the centers of nearly all important depressions move over the coast north of the central California stations. The prevailing winds during their passage are from southerly quadrants, and the rainfall in consequence is quite uniform from decade to decade. We find, therefore, that at all four stations the autumnal rainfall régime is similar, whilst in the vernal one considerable differences are introduced between north and south by the occasional development of depressions east or northeast of southern California. The presence or absence of these means a larger proportional element of variability in the southern spring.

While this method of statistical treatment does not afford good indications of the probability of early or late rains in any given year, it is nevertheless a fair indicator of the distribution of these rains in a group of years. In other words, it is a generalized analysis, useful in a broad sense.

SEVERE SAND STORM IN EASTERN WYOMING, JANUARY 18, 1933

By F. L. Disterdick

[Weather Bureau office, Cheyenne, Wyo.]

Strong winds are of frequent occurrence over the plains section of Wyoming, but owing to the scarcity there of populous areas their occurrence seldom is noticed. On January 18, 1933, however, a wind and dust storm occurred that was so exceptionally severe that it attracted much attention.

On the morning of this date a cyclone was centered at Lander where the barometer (reduced) read 29.24 inches. The State forecast warned of strong shifting gales. The State highway commission was notified and the usual precaution was taken of stationing sentinels on all highways leaving Cheyenne to warn travelers. The winds of the forenoon ranged from 26 to 30 miles per hour and the storm center apparently moved directly eastward with increasing intensity, and passed out of the State near noon, close to the South Dakota-Nebraska boundary. At Cheyenne the true wind velocity was 65 miles per hour, 2 miles greater than the highest velocity previously recorded. Shortly before noon there was a sudden drop in the barometer soon followed by a decided increase in the wind velocity which for the next five hours was 52, 55, 54, 52, and 46 miles per hour, respectively. For three hours thereafter the wind was comparatively light, but from 8 o'clock till midnight the hourly movement exceeded 40 miles.

The greatest damage occurred in the vicinity of Cheyenne, principally to roofs, chimneys, spouting, window glass, small garages, street signs and wires. At Fort Frances E. Warren the damage exceeded $12,000 and in Cheyenne more than $10,000. In the immediate vicinity of Cheyenne the damage to buildings amounted to about $3,000. In the rest of the State the damage is placed at $20,000 to $40,000.

For more than a month prior to this storm there had been very little precipitation and the wind, being abnormally high, had removed moisture from the soil to a considerable depth. Hence, in addition to the wind damage, there occurred also the most severe dust storm ever known to this part of the country. The small particles of the soil, consisting largely of decomposed granite, were caught up and some of it carried to great heights. The air near the surface was so completely filled with the sand that at times objects were invisible beyond 50 feet and headlights were used on automobiles. The larger particles, up to the size of walnuts, sent bouncing along the ground, caused large stock, some of which was injured, to stampede to shelter. Sheep could not stand up in the gale. The surfacing was removed from gravel roads and streets to the foundation. The soil in many plowed fields, in cases a foot deep, was removed to the gravel. Large windrows of sand were formed and many ditches filled. Great damage occurred to winter grain; much was blown out or covered with sand. Alfalfa also suffered in a similar manner. It is stated that the per cent of abandoned winter grain will be the greatest ever known in the State.

In some cases the sand blast stripped every particle of paint from the exposed parts of automobiles and so pitted the glass that not a piece could be seen through. All insulated objects became amazingly charged electrically. The ignition systems of automobiles were completely disrupted and hundreds of cars were stranded. The city engineer of Cheyenne states that the induced current was sufficient to start small electric motors. The anemometer pole at the city office became so charged that the triple register could not be touched without receiving a severe shock and it was necessary to ground the instrument.

UNUSUAL LUNAR HALOS

M. R. Hovde, assistant meteorologist, and Mac A. Emerson, senior observer, St. Paul, Minn., noted at 11:30 p. m., Februray 7, 1933, the halo of 22°, complete; the halo of 46°, large arc; and the paraselenic circle, complete.

Harry V. Myers, observer, Moline, Ill., noted at 5 a. m., February 8, 1933, both paraselenae of 22°; the 22° halo, a portion of the 46° halo, the circumzenithal halo, a portion of the paraselenic circle, the moon pillar, and a cross through the moon.

C. G. Andrus, meteorologist, Cleveland, Ohio, recorded at 6:45 p. m., February 8, 1933, both paraselenae of 22°; the halo of 22°; the upper tangent arc of the halo of 22°; the upper portion of the halo of 46°; the circumzenithal circle; half of the paraselenic circle; a lunar pillar, vertical through the moon, and a cross, produced by the lunar pillar and the adjacent portions of the paraselenic circle.

J. H. Spencer, senior meteorologist, and A. P. Keller, junior meteorologist, Buffalo, N. Y., observed from 8 p. m., February 8, 1933, to after midnight (brightest from 9:30 p. m. to 10:30 p. m.) the halo of 22°; the paraselenic circle, complete; and a portion of the halo of 46°.

NOTE.—On these dates the moon was nearly full, that is, at about its brightest, and the halo-producing cirrus so thin that the brighter stars were clearly visible through it. In short, both the moon and the cirrus haze were in their optiumum states for producing visible halos. Similar solar halos were observed on this date, February 8, by Joseph J. Eigenmann, assistant observer, at Springfield, Ill., by Berlin Pugh, at Royal Center, Ind., and, doubtless, by many others. Evidently, therefore, the thin cloud that produced these solar and lunar halos was both extensive and persistent.—EDITOR.

THE DUST STORM OF JANUARY 22, 1933, OVER SECTIONS OF ILLINOIS, INDIANA, AND MICHIGAN

By C. G. ANDRUS

[Weather Bureau Airport Station, Cleveland, Ohio]

On January 22, 1933, a rather well-defined dust storm that began and ended abruptly was reported by aviators and observers in sections of Illinois, Indiana, and Michigan. At some stations the visibility was reduced to less than 1 mile, causing a real hazard to flight. An aviator on passing through sudden dashes of rain about 3 p. m. on this date, in the northwestern corner of Ohio, found his windshield streaked with reddish-yellow "mud." The rain he encountered farther east was clear. On the next day, according to the Canadian press, about an inch of grayish-yellow snow fell at Chicoutimi, in Quebec.

This dust presumably was caught up in the dry southeastern sector of a low centered, at 8 p. m., January 21, in middle Kansas.

SOLAR HALO, DECEMBER 14, 1932, AT MOORHEAD, MINN.

Mr. C. A. Olsen, junior observer at Moorhead, Minn., reports an interesting solar halo complex observed at that station on December 14, 1932. This consisted of (1) both the parhelia of 22°, (2) both the parehlia of 46°, (3) both the parhelia of 120°, (4) a short section of the parehlic arc through each parhelion of 120°, (5) the anthelion, (6) a short section of one or more of the anthelic arcs, (7) the parhelic circle, complete, (8) a sun pillar, vertical through the sun, (9) a cross (combination of pillar and adjacent portions of the parhelic circle, (10) the halo of 22°, (11) the upper tangent arc of the halo of 22°, (12) the halo of 46°, (13) the circumzenithal arc very brilliant over 20° to 30° on side nearest the sun; faint over the rest of the circle, but complete all the way around.

NOTE.—It is unusual, but not unknown, for the circumzenithal arc and Kern's arc (the arc farthest from the sun on the same circle as the circumzenithal arc) to blend into a complete circle.—EDITOR.