AN UNUSUAL REFLECTION OF SUNLIGHT FROM ALTO-CUMULUS CLOUDS

By GEORGE M. FRENCH

[Weather Bureau Airport Station, Burbank, Calif., May 1936]

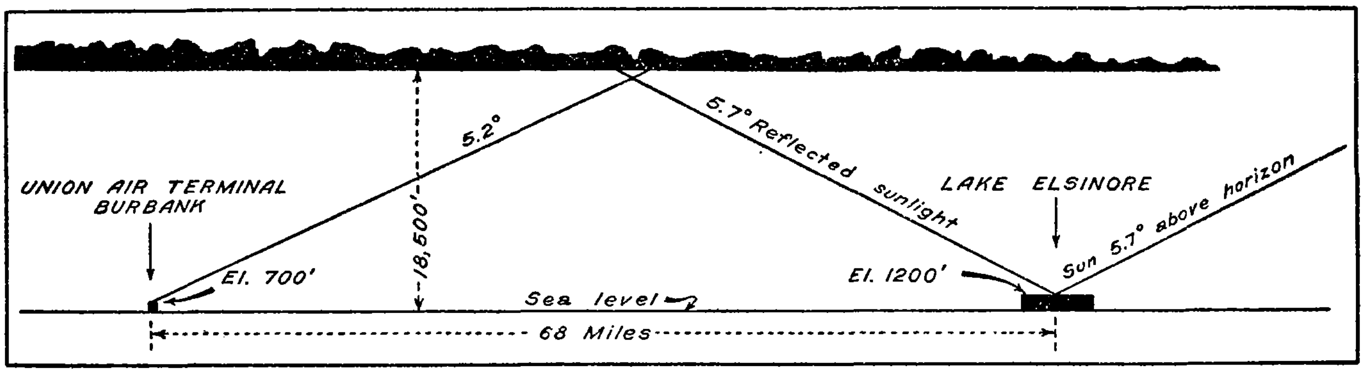
On November 30, 1935, unusually good visibility was noted at dawn at the Weather Bureau Airport Station, Burbank, Calif. Mount Santiago, which is approximately 60 miles southeast of the station and the most distant object from the station in line of vision, stood out clearly with no indication of being dimmed. The sky was overcast with alto-cumulus clouds, but with a clear opening to the east and southeast from an altitude of about 4° down to the horizon. The conditions were perfect for a colorful sunrise; and the morning was therefore not disappointing as the display started with a dark red, progressing through bright red to brilliant gold, and then disappearing soon after sunrise.

It is a familiar fact that the display of sunrise colors starts when relatively strong light from the sun strikes the under side of the clouds, and continues as long as the rays of the sun are directed at an angle away from the earth; the display disappears as soon as the rays are inclined downward toward the earth. When the light which reaches the observer passes over a long path through the earth's atmosphere, it is depleted of the shorter wave lengths by scattering, and the red predominates, slowly changing toward a white light as the sun rises and the rays pass through the atmosphere at a lesser angle with the vertical.

On the morning referred to, as the sun rose it was obscured by the alto-cumulus clouds except as faintly seen occasionally through thin spots in the clouds. However, on this particular morning, after the sun had been obscured by the clouds, the sequence of colors was repeated on one relatively large definite spot; this display was slightly golden in color, and not as brilliant as the preceding. The spot was southeast of the station and a short distance to the right of a direct line toward the sun. It was plainly evident that the phenomenon could not have been produced by light coming through the clouds, but must have been caused by reflected light.

The horizontal position of the sun was noted, and the center of the spot was found to be about 2° to the right of the direction toward the sun. The sun's elevation angle was measured, and the elevation angle of the center of the spot. By means of a pilot balloon the elevation of the base of the clouds was obtained. The cloud layer appeared to have a uniform base except for small undulations.

A map was consulted to find if any rather large bodies of water were in a position to be nearly in line with the sun. It was found that Lake Elsinore, 68 miles southeast of this station, was slightly to the right of the position of the sun. The elevation angle of the sun was then computed to be 5.7° at Lake Elsinore, taking into account the correction for difference in longitude and applying it to the measured angle at Burbank, Calif. The elevation of the clouds was 18,500 ft. above sea-level as measured by pilot balloon at Burbank, Calif.; the elevation of the ground at Burbank is 700 ft., and the elevation of the surface of Lake Elsinore is 1,200 ft. A computation of the path of a beam of light from the sun, striking the lake and being reflected back on the clouds at an angle of 5.7° showed that it should have shown on the clouds at a point 35 miles southeast of the Weather Bureau Airport Station at Burbank, Calif. Using the measured altitude of the spot from this station, 5.2°, it was computed to be 37 miles southeast of the station. As there might be some error in the exact height of the clouds at the point where the spot appeared, this was thought to be very excellent agreement and to be reasonable proof that the source of the light was reflection from Lake Elsinore.



The accompanying figure, in which the scale for elevation is much larger than the one for horizontal distance, illustrates the conditions described.

Wind velocities on the morning of November 30 were generally very light to calm; and although no record was obtainable from Lake Elsinore, it is believed reasonable to assume that it was calm or nearly so, and thus the glassy surface of the lake would give almost a perfect reflecting surface.

Further proof that the source of the light producing the spot was reflection from below is afforded by the fact that the spot receded southeastward as the sun rose, which is as would be expected, since the angle of reflection would decrease as the sun's rays became more nearly vertical.

The phenomenon had never before been noticed by the writer nor by anyone with whom he has discussed the matter; and it is therefore believed that the requisite combination of conditions for its appearance rarely occurs.

NOTE ON THE FOREGOING OBSERVATION

Reflection from clouds is diffuse, and not specular—i. e., a cloud surface illuminated by a directed beam reflects light in all directions. We should therefore expect that the area illuminated by reflection from the lake surface would have been visible from all directions, and not merely at places in the direction of specular reflection.

Near grazing incidence, however, matt surfaces exhibit an effect of regular reflection, especially for long wave lengths, to a surprising extent (*cf.* R. W. Wood, *Physical*

Optics, 3 ed., p. 40); and, although comparatively little seems to be known about reflection from clouds, the phenomenon reported above is apparently consistent with previous observations: Measurements at Mount Wilson, Calif., in 1906 and 1918, of reflection from the upper level surface of fog filling the valley below (*Annals Astrophys. Obs. Smiths. Inst.*, vol. II; *Smiths. Misc. Coll.*, vol. 69, no. 10) showed that the cloud surface departed more and more from the character of a perfect matt surface the greater the zenith distance of the sun and the greater the nadir distance of the cloud; at low sun there was a marked concentration of the reflected light in the direction of specular reflection.

It may be noted that the effect of specular reflection would be much enhanced if the cloud were composed of plate-shaped ice crystals or snow flakes. Available aerological data do not indicate with certainty the conditions at the cloud level on this occasion, but in all probability the temperature was well below 0° C.

EDGAR W. WOOLARD.

NOTE ON THE HURRICANE OF AUGUST 5 TO 8, 1936, IN MEXICAN WEST COAST WATERS

By DEAN BLAKE

[Weather Bureau, San Diego, Calif. March 1937]

There are two points in connection with the tropical hurricane of August 5–8, 1936, briefly described on pages 277–278 of the MONTHLY WEATHER REVIEW for August, 1936, which deserve emphasis: (1) the pronounced tropical properties of the attendant air mass; and (2) the movement of the storm in relation to the prevailing air motions aloft over Southwestern United States.

It is generally agreed that the unusually squally weather over southern California on August 8 was caused by the unstable air mass that attended the storm. This particular phenomenon, however, has been discussed in detail by Ward in the November 1936 *Bulletin* of the American Meteorological Society, and no further description here seems necessary.

The disturbance probably formed about 100 miles southwest of Manzanillo, or near lat. 18° N. and long. 106° W., whence it moved northward over the Gulf of California, and dissipated in southern California.

The deep tropical origin of the air is borne out by the aerographical sounding made at 6 a. m. (P. S. T.), August 8, or about the time the air mass began to overspread Southwestern United States. This sounding showed abnormally high equivalent potential temperatures (Θ_E), and specific humidities (q), especially in the lower levels. Comparisons with the average yearly values for equatorial air over Batavia, (lat. 6° S.), taken from chart V. A., page 90, of Willett's American Air Mass Properties, and with the values for summer over Pensacola, as found on page 65 of the same publication are given below.

During its short life the hurricane took a course northward along the Mexican coast, thence up the Gulf of California, and disappeared from surface maps on the 7th. That the air mass went much farther as unstable air aloft, and caused thunderstorms over the plateaux and even over the northern Rocky Mountains, for several days thereafter, is evidenced by the weather maps for the next few days.

	San Diego		Batavia		Pensacola	
	Θ_E	q	Θ_E	q	Θ_E	q
Surf	336	15.2	349	17.8	359	20.7
1 km	348	13.0	341	13.2	350	15.6
2 km	345	11.3	336	9.4	345	12.5
3 km	343	10.0	334	7.1	341	9.5
4 km	339	7.7	334	5.3	----	----
5 km	335	5.0	334	3.7	----	----

In a recent paper, West Coast Mexican Cyclones (Monthly Weather Review, December 1935), the writer ventured the opinion that to forecast the paths of these tropical disturbances is a matter of correctly anticipating directions of upper air motions over the area they are likely to traverse. The movement of this hurricane certainly justifies this conclusion.

Winds aloft over southwestern United States during the life of the disturbance were from an easterly or southerly direction—part of the vast upper-level anticyclonic whirl common to this region in the summer—and they corresponded very closely to the direction of travel of the storm. Even after the vortex was no longer discernible at the surface, the remaining unstable air mass was carried northward almost to the Canadian border by this circulation.

NOTES AND REVIEWS

Charles F. Brooks, A. J. Connor, et al. *Climatic Maps of North America*. Published by the Blue Hill Observatory at the Harvard University Press, Cambridge, Mass., 1936.

This publication comprises the maps which are included (on a smaller scale) in the Köppen-Geiger *Handbuch der Klimatologie*, vol. II, part J, The Climates of North America, by R. DeC. Ward, C. F. Brooks, and A. J. Connor. The base maps are of size 43 by 56 cm, the same size as those on which the data were originally plotted. Detailed climatic data for the entire continent of North America, as well as Greenland and the Caribbean region, are presented in this manner for the first time.

The original data for the United States, Mexico, Alaska, and the West Indies were adjusted to 30.44 day (one-twelfth year) "months"; expressed in terms of degrees centigrade and millimeters; and, for six temperature and two pressure maps, reduced to sea level.

Seven elements are represented: temperature, pressure, rainfall, snowfall, humidity, cloudiness, and thunderstorms. Temperature and precipitation maps make up 19 of the 26 maps.

The temperature maps comprise the following: (1) Six sea-level monthly mean temperature maps for alternate months beginning with January; the values were obtained by adding 0.5° C. for every 100 m of altitude above sea-level to the actual normal temperature; by this device distinctive features of temperature distribution are brought out (such as the chinook warmth of Montana as compared to the continental coldness of North Dakota) which are usually masked in ordinary temperature maps. (2) *Actual* mean temperature distributions for January and July. (3) The mean annual range of temperature; this element brings the regions of equable temperature into contrast with those of temperature extremes. (4) The mean values of the annual maximum and the annual

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