small shrubs without trees. In general, the records of instrument 2b were much more frequently disturbed by wind than those of the other two. Besides, during the day and sometimes at night, there appear to be more or less regular air-currents up or down the slope near 2b.

The following are results found from the records: The microbaroms are very small during the summer. About the beginning of September, they begin to increase, reach their maximum during the winter and die down rather rapidly during March. During the three months when all three instruments were operating, there was never a time-difference of more than a small fraction of a second between the records of instruments 1 and 3, whereas 2 always received the waves later by almost one second (see Figs. 2b-2d). Consequently, the waves came from southwest to west (calculated azimuths between 230° and 270°. The waves arrive almost horizontally, but this is to be expected, even if the source is at some distance in the lower stratosphere, due to the curvature of the rays convex to the ground.

In all instances, where the amplitudes were unusually large, a rather pronounced low-pressure area was situated off the coast of Southern California. As soon as the low-pressure area passed the coast, the microbaroms decreased rapidly. During the months January to March, 1940, the microbaroms were much smaller than in the corresponding months in 1941, when low-pressure areas were much more frequently close to Pasadena than in 1940. No correlation was found with microseisms. On the contrary, the microseisms are a phenomenon not related to local conditions. On the other hand, both show the same type of yearly period and similar relationship to low-pressure areas, one locally, the other with distant storms; consequently, a similar type of source seems to be indicated.

Microbaroms have been found, in the interim, by Baird and Banwell [2] at Christchurch. Their findings correspond in every respect with the results obtained at Pasadena. They believe that microbaroms and microseisms are independent phenomena, possibly both related to large swells. Large ocean-waves in storms are not excluded as source of the microbaroms at Pasadena, though on relatively calm days when large swells break on the nearest coast the microbaroms remain small.

Other results presented in the previous paper [1] were confirmed. Trains of short waves were found again in a few instances. On January 17, 1941 (Fig. 2b), they came from the same direction (west-southwest) as the microbaroms. On other days, the amplitudes were too small to correlate the three records. On some days, vibrations with periods of a small fraction of a second were observed (Fig. 2a, 2c), but it could not be decided whether they are pressure-waves. Finally, the convection-currents gave practically the same records as in the preceding years.

References

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California Institute of Technology,
Pasadena, California

APPARENT RATE OF PROGRESS AS AFFECTED BY CHANGING INTENSITY OF HURRICANE SAN FELIPE (II) WHILE CROSSING PUERTO RICO

Charles F. Brooks

On R. G. Stone's map [Trans. Amer. Geophys. Union 1941, p. 254, 1941] of isochrones of lowest station-pressure as the great hurricane of September 13, 1928, crossed the length of Puerto Rico there is an apparent acceleration in the advance of the storm in the east portion of the Island and a retardation in the west. In such a major storm, which must have reached great heights and been carried along, therefore, by the average of the winds through that deep portion of the atmosphere penetrated, it does not seem likely that a disturbance of its lower part by friction with a moderately mountainous island could have materially changed the general rate of progress of the storm.

If uniform progress is assumed, the times of observed minimum pressure can be compared with the times when the storm-center was nearest, and a map of the differences can be prepared. Using Stone's map, the times of lowest pressure as the storm approached the Island and after it had

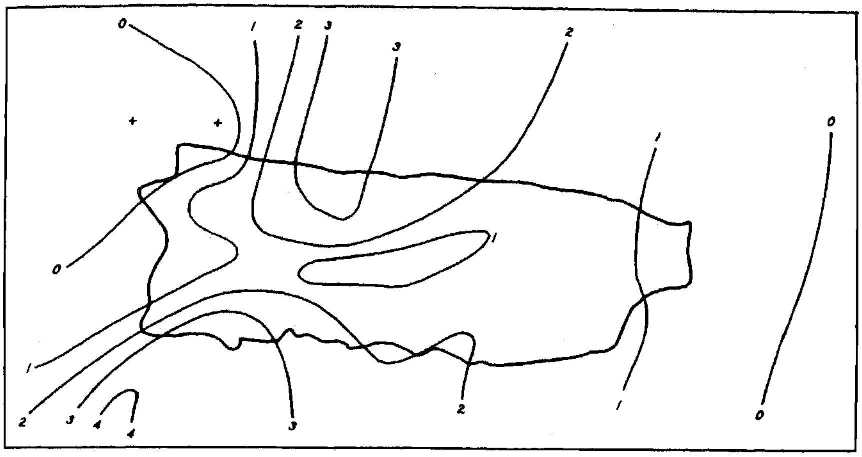

Fig. 1--Advance of time of minimum pressure ahead of time of probable passage of center of hurricane of September 13, 1928, across Puerto Rico (Units are in hours; in northwest corner minimum pressure came after passage of center and in rest of Island before)

left, namely, 1 p.m. and 11 p.m., lie on lines 135 miles apart. When the space between these lines is divided into ten hourly units of 13.5 miles each, we should have the approximate hour-by-hour advance of the storm. Subtracting the observed times of lowest pressure as shown by Stone's map over and near the Island from these assumed times of steady advance, we arrive at a map shown as Figure 1.

As the storm came ashore at the east end of the Island, the minimum pressure occurred an hour before the arrival of the center. Before the axis reached the central longitudes of Puerto Rico the advance of the minimum pressure was a matter of two hours on the northern and southern lower lands, but still only an hour on the mountains. Still farther west, the advance of the minimum pressure exceeded three hours. On the west end, however, as the center moved out to sea the time of minimum pressure quickly approached the time of storm-passage, and on the extreme northwest corner even came after the center had passed nearest.

The lowest pressure observed when the storm came ashore was 27.30 inches; the minimum, as the storm was leaving the Island, had risen to 28.46 inches. The central pressure thus rose more than one inch in the 5-1/4 hours. This rise was evidently caused by the effect of friction in reducing the velocity of the whirl and consequently the centrifugal force that helped to maintain its low pressure. After the storm left Puerto Rico and continued on toward West Palm Beach and Lake Okeechobee, Florida, it recovered its strength soon, and on the next day had a minimum pressure of 27.80 inches and on the second day of 27.43 inches, at West Palm Beach [1].

We can now see why the minimum pressure at a station in Puerto Rico should come before the storm-center was nearest--as the storm was filling up over the Island the pressure at the center was rising faster than the nearer approach of the center could bring lower pressures to the station. In other words, the isobars were moving toward the center in advance of the storm faster than the storm was moving forward.

The earliness of the minimum pressure, one to three hours, was greater where the whirl was most hindered by the general roughness of the Island, namely, the lower elevations. At the height of the tops of the mountains, however, the rotation was not obstructed so much, and the advance in the time of minimum pressure was of the order of only one hour. At the west end of the Island when the hurricane regained the sea its system of isobars began moving outward rapidly as it deepened, and so rapidly that the pressure continued to fall, though not for as much as an hour, after the center had been nearest.

Thus, if the time of lowest pressure is used as a criterion of the advance of the storm, the center will appear to advance rapidly as the land is reached, and it will seem to linger as the storm goes out to sea.

That this is a general rule has been found by a tabulation of 15 hurricanes on the Gulf and southern Atlantic coasts, the details of which will be presented in the Bulletin of the American Meteorological Society. Therefore, it appears that, except in the open sea, it is unsafe to use the time of minimum pressure for the nearest passage of the center of a cyclone.

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Blue Hill Observatory, Harvard University,
Milton, Massachusetts

FORESHADOWING MONTANA'S WINTER PRECIPITATION (VERIFICATION)

I. I. Schell

(1) It was generally but vaguely held at one time that the modest but real success of the official predictions of the summer monsoon-rainfall in India was due to the peculiar nature of the monsoon. However, it appears from Walker's studies and from the fact that seasonal foreshadowing has been adopted by the official services of several other countries that, as far as it can be shown, the principles on which the predictions of monsoons are based evolve from the apparent fact that the rainfall of India during monsoon, like the winter precipitation of northwest central North America, for example, is but one of a substantial number of elements which have the property of being components of several interconnected relationships which go by the name of Oscillations [see 1 of "References" at end of paper]. (The term "foreshadowing" as applied to predictions of the seasonal weather was introduced by Walker to denote the difference between the rather detailed daily forecast and the seasonal forecast, which is given in more general terms; the term refers to forecasting the "weather-trend," and is thus akin to the term "Witterungsvorhersage" adopted by Baur.)

The Oscillation of particular interest to this country and Canada is the Southern Oscillation of September to November since, as was shown by Walker and Bliss [2], there is an apparent relationship between its activity and the trend of the precipitation during the following winter in Montana, Idaho, Wyoming, Manitoba, Saskatchewan, and Alberta--an area of roughly a million square miles. There appears to be also a similar relationship with the winter precipitation in Florida and the Bahamas.

The Southern Oscillation of September to November represents an interconnected relationship between pressures in the area of southeast Asia to north Australia as represented by the stations Manila, Port Darwin, Batavia, and a group in northwest India, and temperatures at Auckland and Batavia, and rainfall in Java. Thus there are seven elements which comprise the Oscillation. The average number of years on which the correlations of the interconnection were based is 56, the lowest being 47. The values of the correlation-coefficients of the individual centers with the Oscillation as a whole range from 0.6 for temperature at Batavia to 0.9 for pressure at Port Darwin.

The relationship between the Southern Oscillation of September to November and the following winter precipitation in Montana was studied further [3] with the view of determining whether or not the relationship will hold reasonably also for years not included in any arbitrarily chosen period on which it may be based, and thus serve as a basis for future foreshadowing. The method used [4] consisted of breaking up the available 44-year period of data (1895/6-1938/9) into a period of 33 years, on which a formula is based, and a period of 11 years used as a test; this was performed four times, permitting the derivation of four formulas each based on a period of 33 years, and allowing a test of four successive 11-year periods not included in the formulas, and hence of the entire 44 years. The computed departures derived with the aid of the respective formulas favorably agreed with the actual departures, both with respect to sign and amount of departure [3]. A further analysis also led to a revision of the Southern Oscillation in so far as its relationship with Montana is concerned. The Java rainfall and Batavia temperatures were both dropped, and, for practical considerations, the stations in northwest India were substituted by Calcutta. For physical reasons it was further decided to treat the four pressure-elements as a unit.

In conclusion, the experiments with the relationship between the Southern Oscillation of September to November and the following winter precipitation in Montana indicated that there is a reasonably good chance that future predictions of Montana's winter precipitation based on the