551.515.2 : 551.513.3 (54)

CHARACTERISTICS OF CALM CENTRES OF SOME CYCLONIC STORMS WHICH FORMED IN THE BAY OF BENGAL AND PASSED OVER CALCUTTA AND SAUGOR ISLAND.

From an examination of the storm tracks of the Bay of Bengal for the period January 1934 to August 1941 and the corresponding records of the self-recording instruments at Alipore (Calcutta) (Lat. 22° 32′ N., Long. 88° 20′ E.) and Saugor Island (Lat. 21° 39′ N., Long. 88° 03′ E.), it was found that out of 4 storms and 2 depressions passing directly across or very near Alipore during the period, 2 storms and 1 depression had their calm centres over the station and out of 4 storms and 2 depressions making their way directly over or very near Saugor Island, 2 revealed calm centres over this Island. The meteorological elements recorded at Alipore and Saugor Island during the passage of the storms and depressions across the stations are shown in Figs. 1 to 5. In the majority of the cases under review the storms were severe while out at sea, but owing to lack of data it is not possible to say whether the calm centre characteristics were present throughout their life history or not. What is revealed by the present study is that even on entering mainland and after considerable weakening, some of the storms exhibited the characteristics of calm centre observed in tropical cyclones. It is interesting to note in this connection that Depperman as a result of his study of typhoons in the China Seas found that calm centres are not peculiar to severe typhoons only and that while many amongst the relatively moderate typhoons reveal this characteristic, there are a number of severe typhoons which are apparently not associated with this feature.

Wind and Pressure.

It will be seen from the wind and presaure data represented graphically in Figs. 1 to 5 that in each case wind direction, wind velocity and barometric pressure corrected for diurnal variation showed the following characteristic variations :—

1. Wind direction changed by about 180°.
2. Wind velocity at first increased to a maximum and then decreased to 'calm.' After the 'calm' had prevailed for some time the velocity again rose to a second maximum.
3. Barometric pressure corrected for diurnal variation decreased gradually to a minimum value when the calm centre passed through the station and increased thereafter.

As the wind direction before and after the epoch of calm were almost diametrically opposite and as this epoch prevailed only when the barometric pressure was minimum, it is obvious that on each of the occasions the cyclonic storm or depression did actually pass across the station and its vortex swept over it or very nearly over it during the period of calm (shown by thick curves in Figs. 1 to 5). In each case the storm or the depression was found to have a straight track across the observing station. Hence the pressure curve for the calm period over the observing station indicates the actual pressure distribution along the chord of the storm vortex passing through the station. It will be seen from the nature of the pressure curves that the chords mentioned above had more or less the characteristic V-shaped distribution of pressure along them. Table I below gives the lengths of these chords calculated from the average velocity of movement of the storms and depressions in question and the corresponding periods of calm over the observing stations. Only the average velocity of the storms in the neighbourhood of the stations has been taken into consideration and not that along the whole track.

TABLE I.

Station.	Date.	Period of calm.	Average Velocity of storm.	Length of chord of vortex.
Alipore ..	1-7-40	01 h 30 m.	5 m p h.	7 miles
Alipore ..	8-7-40	02 h. 37 m.	5 m.p.h	13 miles
Alipore ..	17-8-41	02 h. 00 m	8 m.p h	16 miles
S. Island ..	27-5-36	02 h. 00 m	7 m p.h.	14 miles
S. Island ..	10-7-41	02 h. 30 m.	6 m.p.h.	15 miles

The diameters of the calm cores of the storms and depressions cannot be less than the corresponding chords. Therefore, the diameters of the cores considered in the present note were not less than 7-16 miles as shown in the above Table. The following striking features are shown by the pressure and velocity curves (Figs. 1 to 5) associated with the calm vortices :—

1. The wind shift corresponded more or less to the passage of the barometric minimum and the calm centre.
2. The centre of the calm vortex was *very near* but not exactly coinciding with the region of the barometric minimum.
3. The calm vortex was surrounded by a ring of strong winds, but the strength of these winds was not found to be symmetrical on either side of the vortex.

It may be mentioned in this connection that Desai and Basu have found that the inner structure of tropical cyclones is not symmetrical.[1]

Temperature and Humidity.

It will be seen from the temperature and humidity data represented graphically in Figs. 1, 2, 3, and 5 that as the calm centre passed over the observing station, there was in each case a rise in Dry Bulb temperature, however slight it was, but the Wet Bulb temperature remained practically constant and humidity mixing ratio decreased at the same time when compared with values obtained at immediately preceding and succeeding intervals. These observations are in substantial agreement with those shown by Normand in the case of Manila Typhoon of 20-10-1822.[2] The rise of temperature in the calm centre of a tropical cyclone is explained by assuming a gentle descending current in the eye of the cyclone. As this central descending air current has its origin in the whirl of violent winds in the region surrounding the central calm, both these samples of air are expected to have the same entropy under an adiabatic process. In accordance with Normand's theorem[3] these two samples of air should have the same Wet Bulb potential temperature. Consequently the Wet Bulb temperature of a station should not change at all as the ring of violent winds and the calm centre pass successively across the station. The constancy of the Wet Bulb temperature with an associated decrease in the humidity mixing ratio indicates, as explained by Normand, that the rise in Dry Bulb temperature is not due to a decrease in cloud amount or absence of precipitation during calm epochs—

a conclusion which is corroborated by the fact that in some of the cases under discussion even with completely overcast skies and drizzle at the calm centre, Dry Bulb temperature was found to rise.

As for the storm passing over Saugor Island on 27-5-36 there was a slight fall of 1.2°F. in Dry Bulb temperature just at the onset of the calm epoch, but the Dry bulb rose afterwards and this rise was also during the passage of the calm over the station as shown in Fig. 4. This time lag in the increase of Dry Bulb temperature may perhaps be due to the fact that unlike the other cases under discussion there was a rapid fall of Dry bulb temperature before the approach of the calm centre over the station probably due to rain cooling, (Wet Bulb temperature data for this storm were not available) and this fall in Dry Bulb took some time to be counterbalanced by the rise in temperature due to dynamical heating at the calm centre.

Cloudiness and Precipitation.

It will be seen from the weather remarks given at the bottom of the Figs. 1 to 5 that during the interval when the centre was passing over a station, there was generally a slight improvement in weather condition—often a decrease in cloud amount, an increase in cloud height and a decrease in the intensity of precipitation. There were cases when precipitation was altogether absent during the calm. But the epoch of the calm was preceded and followed by a general bad weather condition—skies overcast with very low clouds and moderate to heavy precipitation. It is significant that the nature of precipitation as well as its intensity were not, in any way, symmetrical on either side of the calm vortex.

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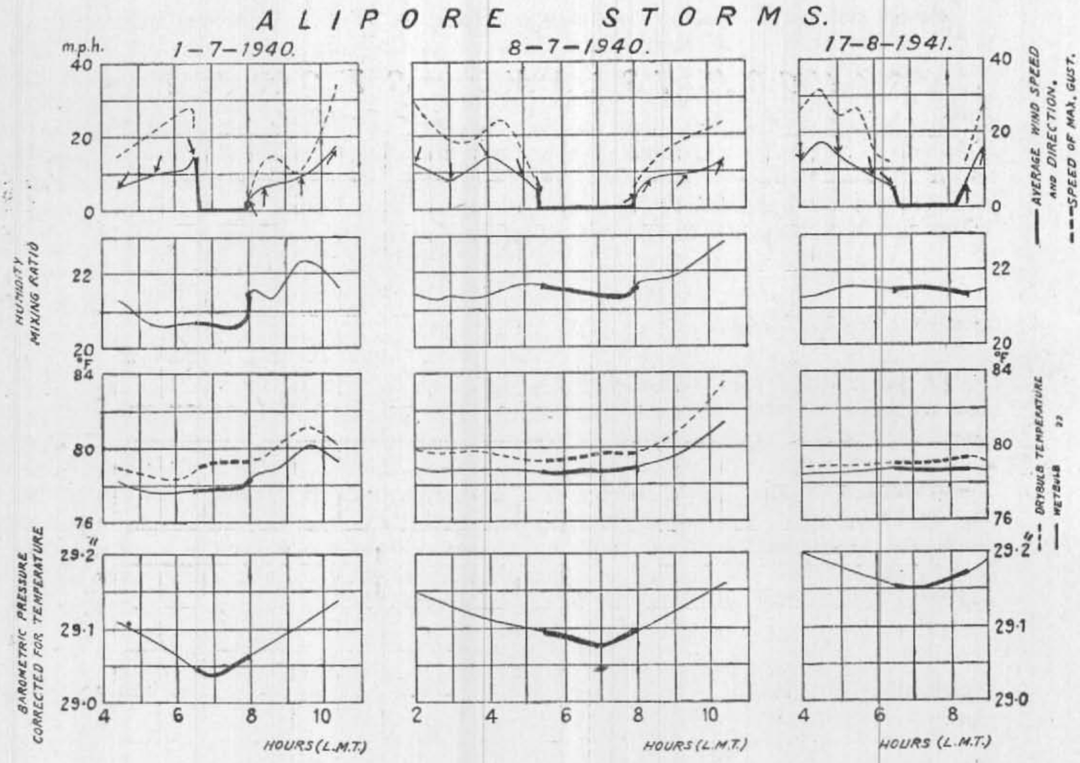

Fig. 1.

Fig. 2.

Fig. 3.

0423-0630 hrs. Low clouds 10/10. 0700-0730 hrs. Low clouds 7/10, medium clouds 3/10. 0800-1030 hrs. Low clouds 10/10. 0340-0600 hrs. Intermittent drizzle 0630-0805 hrs. Continuous drizzle. 0805-0950 hrs. Intermittent drizzle. 0950-1030 hrs. Continuous rain.

2123-1023 hrs. Low clouds 8/10 to 10/10, medium clouds 1/10 to 2/10. 1023-1723 hrs. Low clouds 6/10 to 8/10, medium clouds 2/10 to 4/10. 2123-0423 hrs. Intermittent drizzle. 0423-0523 hrs. Continuous drizzle and rain. 0523-0723 hrs. Intermittent slight drizzle. 0723-0830 hrs. Continuous drizzle. 0926-1430 hrs. Intermittent drizzle. 1550-1658 hrs. Continuous drizzle and rain.

1723-0600 hrs. very low clouds 10/10. 0600-0830 hrs. Low clouds 6/10 to 9/10, medium clouds 1/10 to 4/10. 0830-1000 hrs. Low clouds 10/10. 1000-1253 hrs. Low clouds 5/10-to 6/10 Medium clouds 4/10 to 5/10. 1723-2158 hrs. Intermittent rain or drizzle. 2158-2223 hrs. Heavy rain. 2223-0150 hrs. Light or moderate rain. 0150-0600 hrs. Moderate to heavy rain. 0600-0700 hrs. Continuous slight drizzle. 0730-0800 hrs. Intermittent drizzle. 0800-1512 hrs. Drizzle or rain.

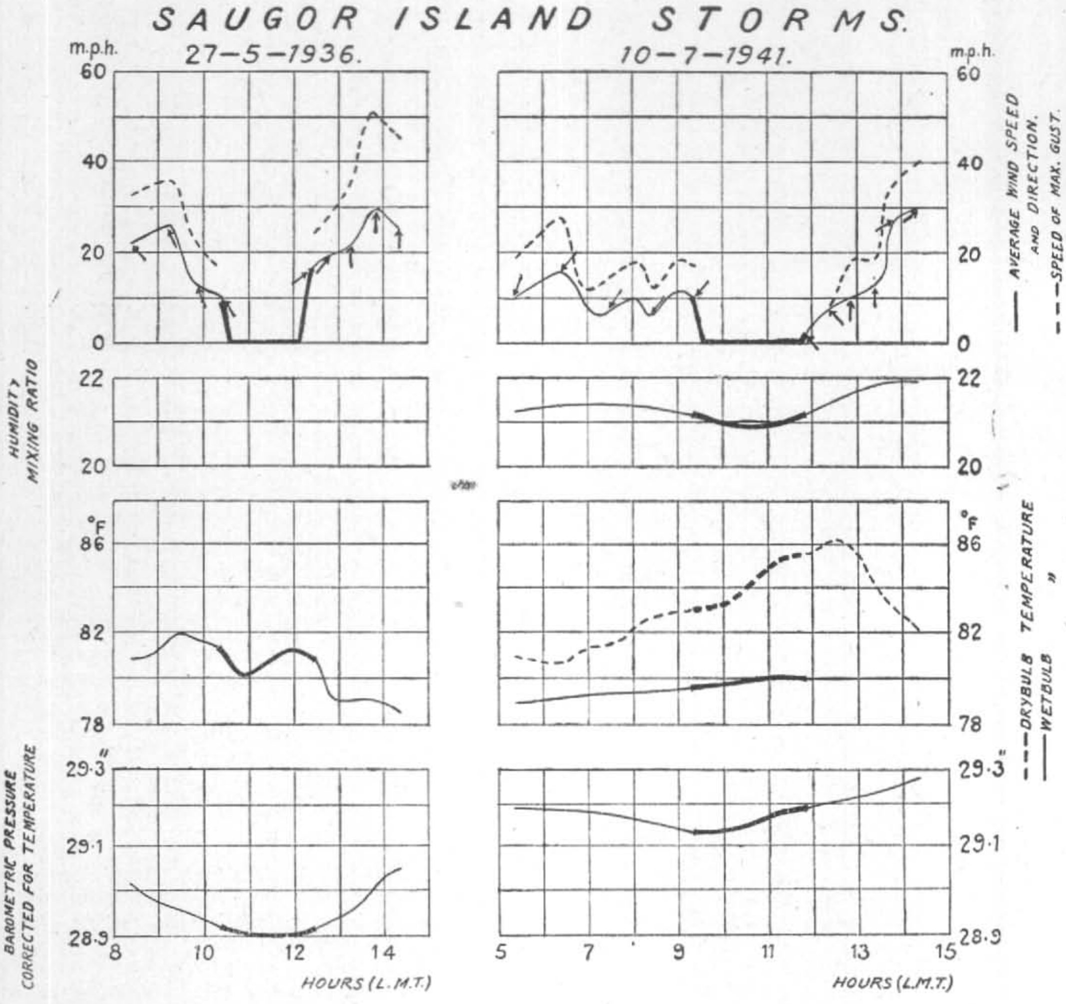

Fig. 4.

Fig. 5.

0022-0717 hrs. Moderate to heavy rain. 0800-0947 hrs. Drizzle and slight rain. 1052-1102 hrs. Slight rain. 1123-1207 hrs. Drizzle or slight rain. 1255-1442 hrs. Moderate to heavy rain. 1442-1722 hrs. Intermittent rain.

0520-0607 hrs. Slight rain or drizzle. 1325-1407 hrs. Slight to moderate rain. 1512-2400 hrs. Squall with slight to moderate rain.