Indian J. Met. Hydrol. Geophys. (1975), **26**, 1, 65-66

551.515.11(267)

Estimation of central pressure of cyclonic storms in the Indian Seas

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(*Received 6 April 1974*)

ABSTRACT. To obtain a relationship between the minimum central pressure P_0 and maximum surface wind (V_m) when cyclonic storms are in the open seas, the data of 42 hurricanes and typhoons in the Atlantic and Pacific Oceans were considered. This provided a linear regression equation $V_m=13.6\sqrt{P_n-P_0}$ which was found to be better than Fletcher's formula for calculation of minimum central pressure for case of cyclonic storms over the Indian Seas far away from the coast.

1. Introduction

When a cyclonic disburbance in the Bay of Bengal or the Arabian Sea attains the intensity of a cyclonic storm or above that category with a wind speed 33 knots or more, the estimated central pressure of the storm is indicated in the storm warning bulletins issued by the Area Cyclone Warning Centres. The estimation of central pressure for cyclonic storms becomes difficult in the absence of aircraft reconnaissance flight data of the storm centre and its environment. Then the procedure generally followed is first to obtain an estimate of the maximum wind speed using a categorisation of the satellite picture of the storm, diameter of the overcast area and a nomogram (Hubert and Timchalk 1969) for the determination of the maximum wind speed. Studies conducted over India suggest that the nomogram can be relied upon with some degree of confidence over the Indian Seas. Using the maximum wind speed thus obtained, the central pressure of the storm is derived by the application of Fletcher's formula (Flectcher 1955) $V_m=16\sqrt{P_n-P_0}$ where V_m is the maximum surface wind in knots and P_0 and P_n are respectively the central and peripheral pressures measured in millibars. It was found that Fletcher's formula for cyclonic storms in the Indian Seas yield values of central pressures which were higher than observed values. In this study an attempt was made to obtain an empirical relationship connecting the maximum surface wind V_m with central pressure P_0 which gave closer agreement to the observed value.

2. Data

Data of maximum surface wind and minimum central pressure from reconnaissance flights into hurricanes in the Eastern Pacific and Atlantic Oceans, for the years 1970 to 1973 were obtained from the *U.S. Monthly Weather Reviews*. For the data for Typhoon Nancy, Papers in Meteorology and Geophysics (1970) were consulted. All the hurricanes were south of Lat. 25°N, except hurricanes Celia (1970) and Agnes (1972) which were near latitude 28°N at the time when their observations were considered. This was to make sure that the tropical characteristics were maintained. Only those cases, where the minimum central pressure P_0 and maximum surface wind (V_m) or maximum 700-mb level wind were clearly indicated, were considered. Moreover, only those cases in the Atlantic and Pacific Oceans, whose maximum winds exceeded 50 kt were taken for this study, as the data available over the Indian Seas for this test were above 50 kt. This yielded data on 42 tropical storms, hurricanes and typhoons for this study. For application of the results to cyclones in Indian Seas, only such of those cyclones which were quite away from the coast, were considered. This ensured that the observations were not affected by nearby land masses for which data on central pressure and maximum surface wind were available, either from ships' reports or from reconnaissance aircraft flights. Ships' observations yielded data for two Bay of Bengal cyclones on 26 November 1952 (1910 GMT) and 5 November 1973 (0600 GMT) and for one Arabian Sea storm on 11 June 1964 (1030 GMT). Reconnaissance aircraft observations provided data on three days for two cyclones in the Bay of Bengal (*i*) 9 September 1972 at 1227 GMT (*ii*) 20 September 1972 at 0730 GMT and (*iii*) 21 September 1972 at 1104 GMT and one Arabian Sea storm on two days, namely, on 22 May 1963 at 0630 GMT and on 24 May 1963 at 0813 GMT. Thus data for V_m and P_0 were available for eight occasions. For the Bay cyclone on 21 September 1972, reconnaissance data gave a very high value of 100 kt for V_m, which appeared to be doubtful. A nomogram using the diameter of the central overcast

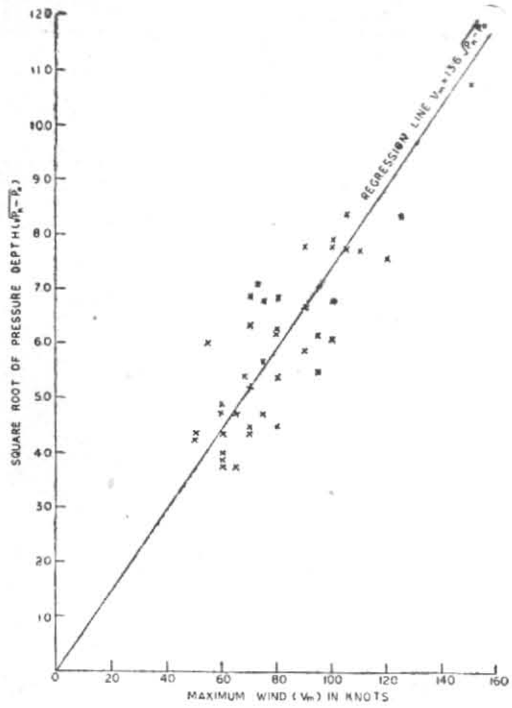

Fig. 1 Square root of pressure depth $(\sqrt{P_n\text{-}P_0})$ and maximum wind

area from APT pictures, and the categorization of the system, indicated the maximum surface wind was 63 kt which was taken as V_m for this case.

3. Discussion

Fletcher (1955) used the cyclostrophic wind equation $V^2/r=(1/\rho)\,(\partial P/\partial r)$ where r is the radius of the trajectory and V is the speed of the air particle. Using the data for the Florida Hurricane of August 1949 which passed over Lake Okeechobee, Fletcher arrived at the equation $V_m=16\sqrt{(P_n-P_0)}$ where V_m represents the maximum spot wind at the surface in knots and P_0 and P_n represent the pressure at the storm centre and at its outer edge in millibars. Considering the maximum cyclostrophic wind speed (V_{cm}) for 63 hurricanes, he obtained the relation $V_{cm}=10\cdot 7\,\sqrt{(P_n-P_0)}$. V_{cm} represents an average value along a curve passing through the point. In the equation for V_{cm} the Coriolis parameter and friction were not considered. When the actual values of V at various points for the Florida hurricane were applied in the equation $V=K\sqrt{(P_n-P_0)}$, frictional effects were included, even though this was not directly indicated. So in the equation $V_m=16\sqrt{(P_n-P_0)}$, frictional effects were indirectly considered. When this equation was applied to calculate the minimum central pressure P_0', for the storms in the Indian Seas on eight occasions, the difference $(P_0'-P_0)$ between the calculated value P_0' and the observed pressure P_0 was always found to be positive.

The data for V_m and P_0 for fortyone hurricanes and one typhoon in the open Atlantic and Pacific Oceans, not affected by land masses, yielded a linear regression equation $V_m=13\cdot 6\sqrt{(P_n-P_0)}$, passing through the origin. This is represented in Fig. 1. In all these cases P_n was taken as 1010 mb. The correlation coefficient between V_m and $\sqrt{(P_n-P_0)}$ was $0\cdot 80$. When this equation was utilised to calculate the minimum central pressure P_0'' of the Indian Sea storms the differences $(P_0''-P_0)$ in seven cases were within tolerable limits, having both positive and negative values, except in one case when the value of $(P_0''-P_0)$ was $+8$ mb. Thus, this Eqn. seemed to fit better for severe cyclonic storms, when they were in the open seas. A smaller value of $13\cdot 6$ for the constant K was probably due to the fact that the friction over a water surface was smaller than that over the land.

Fletcher and Johannessen (1965) provided another equation using the gradient wind. This equation was not considered for this study, because the correction factor due to Coriolis force was small in the region of low latitudes, where our study was conducted.

4. Conclusion

The estimation of the central pressure of cyclonic storms over the Indian Seas, when they were away from the coast, an application of the equation $V_{max}=13\cdot 6\sqrt{(P_n-P_0)}$ was found to yield better results than Fletcher's (1955) equation.

Acknowledgements

The authors wish to express their sincere thanks to Dr. A.A. Rama Sastry, Director, Regional Meteorological Centre, Madras for useful suggestions and for the facilities provided. They also thank Shri V. Balasubramanian, Meteorologist, Cyclone Warning Research Centre, Madras, for helpful discussions.

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