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Interaction between the two cyclones of November 1977 over Indian seas

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सार — नवम्बर 1977 में एक साथ बंगाल की खाड़ी और अरबसागर में दो भीषण चक्रवाती तूफानों की उपस्थिति एक प्रसाधारण घटना थी । उनका गमन ऊपरी कर्णधार प्रवाह के विपरीत रहा और उनके केन्द्रों को मिलाने वाला अक्ष एक निश्चित बिन्दु के हर्द गिर्द चक्रवाती घूर्णन के जाल के नीचे तीन दिन तक उस समय रहा जब तक खाड़ी चक्रवात तट को पार नहीं कर गया । इस बिन्दु से उनके केन्द्रों तक की दूरियों का अनुपात एक जैसा बना रहा । ब्रांड के सूत्र से इस अक्ष के कोणीय घूर्णन और प्रेक्षित मानों का अनुपात तीनों दिन तक लगभग 1.5 रहा ।

ABSTRACT. The simultaneous presence of two severe cyclonic storms one over Bay of Bengal and the other over Arabian Sea in November 1977 was a rare event. Their movement was contrary to the upper steering flow and the axis connecting their centres underwent a cyclonic rotation about a fixed point for three days till the Bay cyclone crossed coast. The ratio of the distances of their centre to this point remained constant. The ratio of the angular rotation of this axis calculated by Brand's formula to the observed value was about 1.5 on all the 3 days.

1. Introduction

Study of the past storms over the Indian seas during the period 1877 to 1979 indicates that the cases of co-existing cyclonic storms are very few in number. November 1977 is one of the unique occasions when two storms of severe intensity were present simultaneously, one over Bay of Bengal and the other over the Arabian Sea and these were separated by a distance of less than *1500 km*. In all the other cases the co-existing-cyclone pairs were not of severe intensities and they were separated by more than *2000 km*.

2. Steering aspects

Mukherjee and Gupta (1979) while studying the interaction of the November 1977 cyclone pairs have already discussed in detail the synoptic features associated with these two systems. Fig. 1 gives the (best) track of these two cyclones.

From the tracks it is clearly seen that the change of course in case of both the systems occurred almost simultaneously. Normally, the recurving of an Arabian Sea cyclone usually takes place with an anti-cyclonic curvature thus

gaining latitude in the process. In this case the unusual feature lies in a cyclonic recurvature and crossing the coast at a more southerly latitude (as low as the station Honavar). Similarly, the Bay cyclone which was initially moving in a westerly direction, abruptly changed into a north-northwesterly course. We may look at this change of track from the point of upper steering currents. Figs. 2(a) & 2(b) give the 200 mb flow pattern for 14th and 15th, conventional data being supplemented by satellite derived and aircraft winds. On 14th the upper tropospheric winds over the Peninsula north of 15 deg. N were southwesterly over the west coast leading to an expectation of the normal recurvature towards Maharashtra coast. Also as seen on the NOAA satellite picture of 14th (Fig. 3a) the pronounced cirrus outflow to the NE of the Arabian Sea system corroborates this view. However, the expected motion did not take place. In fact on 15th (Fig. 3b) even the cirrus outflow disappeared and the storm moved southwards. The peculiar movement of the Arabian Sea cyclone contrary to the expectation can, therefore, be attributed to the powerful influence *viz.*, the presence of the Bay system and their mutual interaction with each other.

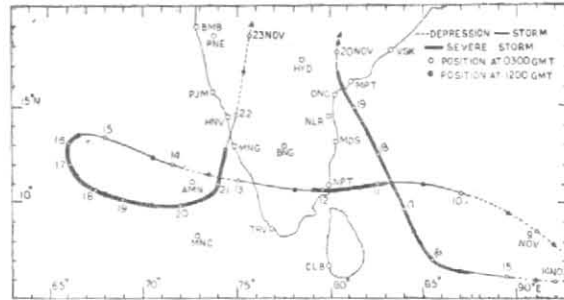# V. BALASUBRAMANIAM AND N. JAYANTHI

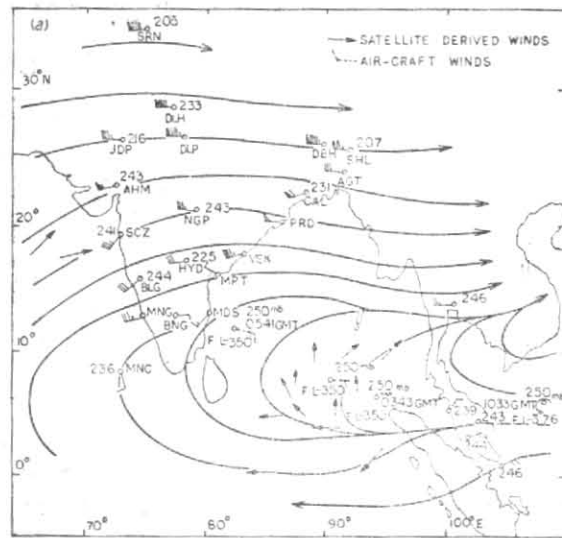Fig. 1. Tracks of storms 1977

Fig. 2 (a). 200 mb flow pattern of 14 Nov 1977 at 00 GMT
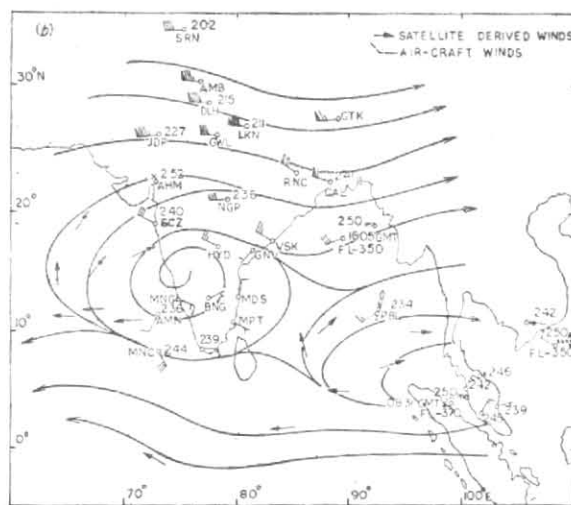
Fig. 2 (b). 200 mb flow pattern of 15 Nov 1977 at 00 GM t

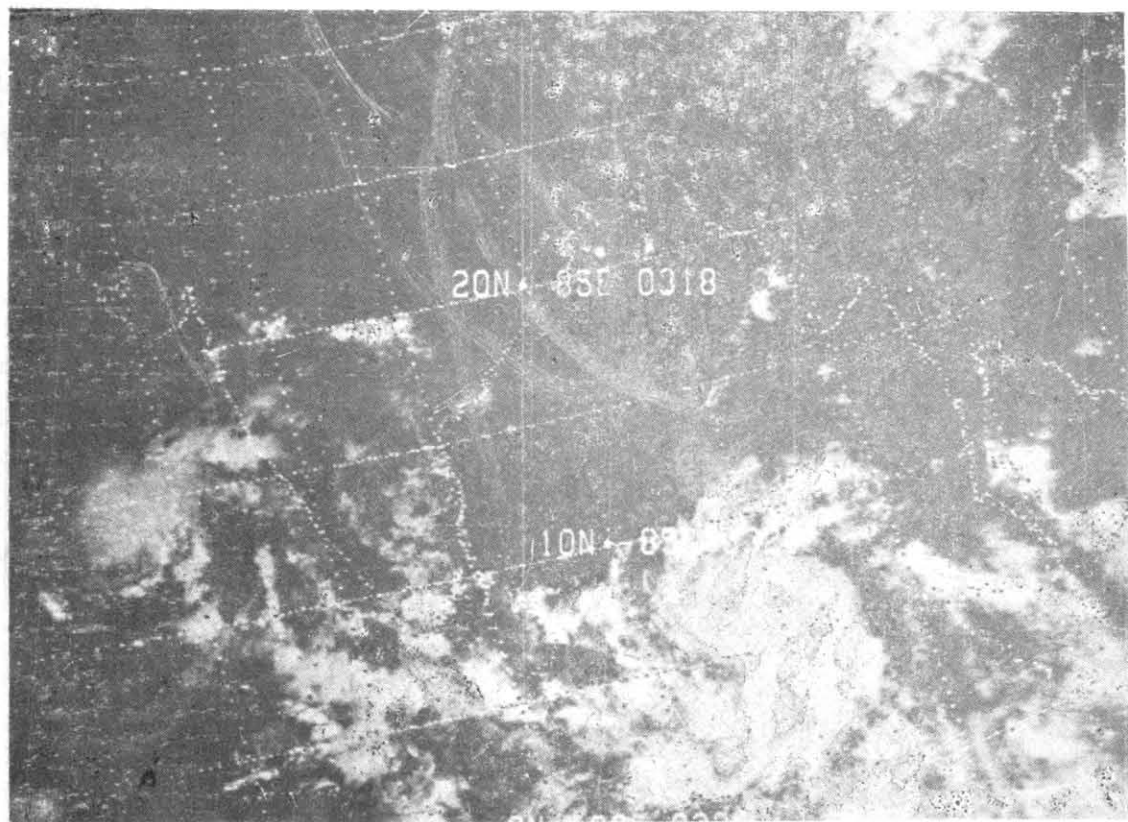Fig. 3 (a). NOAA satellite picture on 14 Nov 1977

V. BALASUBRAMANIAM AND N. JAYANTHI

Fig. 3 (a). NOAA satellite picture on 15 Nov 1977

TABLE 1

Maximum wind velocity (kmph) of the two storms

Date (Nov '77)	Arabian Sea V_m	Bay of Bengal V_m
16	90	130
17	100	170
18	110	190
19	110	190

3. Fujiwhara effect

If two tropical cyclones are less than about 2000 km apart they tend to spiral cyclonically around each other about a common point of gyration and this was pointed out by the Japanese meteorologist Fujiwhara. Mukherjee and Gupta (1979) computed the angle of rotation of November 1977 cyclone pairs using Haurwitz's (1951) method. The accuracy of the method used by them depends upon accurate isobaric analysis. The pressure gradients were also computed at arbitrary points, not necessarily within the active storm fields.

Since the mass of the two interacting cyclones is not readily determinable, Brand (1970) modified the original equations of Fujiwhara to use data which is *operationally* available.

3.1. *Comutations of angular rotation between the two storms*

The angular rotation rate of two Rankine vortices about one another is given by :

$$W = (V_1 R_{m1} + V_2 + R_{m2})/d^2$$

where, V_1, V_2 are the maximum tangential velocity components, R_{m1}, R_{m2} are the corresponding radii of maximum velocities. In the above formula the velocity distribution is given by the relation VR=Constant. This involves a too rapid decrease of wind with distance. Therefore Brand (1970) approximated the motion in the vicinity of tropical storms as $VR^{1/2}$=constant. Using this profile, Brand has given the modified formula for angular rotaion as :

$$W = (V_1 + V_2) \left(\frac{R_m/D}{d^3} \right)^{1/2}$$

The above formula has been derived on the principle that the centre of each storm is moved by the wind field due to the other storm. In the present paper this modified formula is used
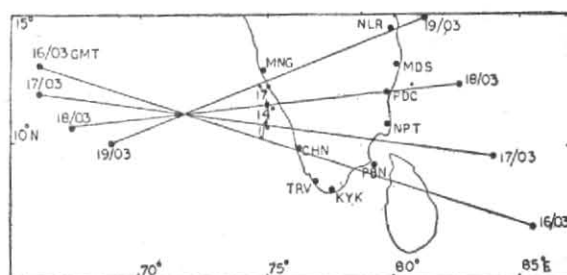

Fig. 4. Interaction between Bay & Arabian Sea cyclonic storms

to calculate the angular velocity of gyration of the two vortices of November 1977 making use of observed wind values during their co-existing period.

A mean value of 25 km was used for R_m in computation. The eyewall parameters determined by the Cyclone Warning Radar, Madras indicated this value. Table 1 gives the V maximum values for the two systems estimated from satellite information and using Dvorak's (1972) technique. One ship *Jagat Swamini* went through the eye of the storm and another ship *"Netaji Subash Chandra Bose"* also gave observations near the storm field. The actual wind profiles at the stations Gannavaram and Masulipatnam near the point of landfall were also considered. All these observations were found to be consistent with each other.

The respective morning positions (03 GMT) of the Bay and the Arabian Sea cyclones were joined by straight lines for the days 17th, 18th and 19th. Fig. 4 shows the gyration of the axis connecting the centres of the two cyclones. The very interesting feature was that the three straight lines crossed one another at precisely at one and the same point suggesting that the centres of gyration of the two systems did not undergo any motion during the period though there was a reduction in the distance between the two. This suggests that the two systems moved around one another as an integrated system which rotated about a common point throughout the period, something similar to the rotation of the dumb bell on a pivot. The distance of each cyclone from the common gyration point and the ratio of the distances of each storm from the common point of gyration are given in Table 2. It was found that the ratio of the distance of the Bay cyclone and Arabian Sea cyclone from the gyration point was found to be nearly constant, while the total distance between the two cyclones was gradually reducing from 2400 km on 15 November to 1200 km on 19th morning.

V. BALASUBRAMANIAM AND N. JAYANTHI

TABLE 2

Distances (km) of the two storms from the
point of gyration

Date	Bay (d_1)	Arabian Sea (d_2)	Ratio (d_1/d_2)
16th/03 GMT	1590	660	2.4
17th/03 GMT	1370	600	2.3
18th/03 GMT	1170	490	2.4

TABLE 3

Comparison of the computed and observed
angles of rotation

Date (Nov '77)	Angle (°) of rotation		Ratio
	Computed	Observed	
17	15	11	1.4
18	22	14	1.6
19	28	17	1.6

Table 3 gives the comparison of angle of rotation between the computed values using Brand's formula and the observed values. From this table it is seen that the computed values give a higher angle of rotation than the observed ones, the calculated rotation being uniformly about 50 per cent greater than the observed values on the 3 days. This may be due to the fact that the index assumed as 0.5 in the wind profile may not fit the actual distribution and also probably due to the presence of intervening land mass. However the day to day increase in angular rotation observed during the period 17-19th could qualitatively be explained on the basis of reduction of d during the period and also due to the increase in the maximum winds.

References

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