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Some characteristics of recurving cyclones of the Indian seas

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सार - प्रस्तुत शोध-पत्र में भारतीय समुद्रों में प्रतिवर्तित होने वाले चक्रवातों के प्रतिवर्तन के समय उसकी गति, तीव्रता और अक्षांश जैसी कुछ विशेषताओं का अध्ययन किया गया है। जिन सिनाप्टिक विशिष्टताओं के कारण इन चक्रवातों का प्रतिवर्तन होता है उनका भी अध्ययन किया गया है। 200 हैक्टापास्कल के पवन सम्मिश्रों के विश्लेषण से यह पता चलता है कि चक्रवातों के प्रतिवर्तन से कम से कम 24 घंटे (IST) पूर्व कुछ प्रागुक्तीय संकेत मिलते हैं।

ABSTRACT. The present study deals with some of the characteristics of recurving cyclones of the Indian seas like speed, intensity and latitude of recurvature etc. The synoptic features, which are responsible for recurvature, are also studied. Analysis of 200 hPa wind composites indicates some predictive signature atleast 24 hours (IST) prior to recurvature.

Key words – Recurvature, Tropical cyclones, Steering, Wind composites.

1. Introduction

Normally cyclones are steered by the basic flow in which they are embedded and the basic flow is often represented by the wind field above 500 hPa and as far as the Indian seas are concerned the upper level anticyclones in the oceans steer the cyclone around their periphery in a westerly to west-northwesterly direction. But the most difficult aspect is that the environmental steering flow itself becomes often unidentifiable or gets distorted or modified due to the presence of the cyclone, resulting in atypical tracks like abrupt recurvatures, looping, etc. Prediction of these atypical tracks pose great challenge to forecasters.

One of the most important aspects of cyclone track forecasting is recurvature. A cyclone track is said to recurve when it changes its path from the predominant zonal flow (normally westwards) to predominant meridional flow (normally northwards) and often again back to zonal flow in the opposite direction (normally eastwards). The recurvature is said to be abrupt if the meridional flow is short-lived and there is sudden change in the direction of more than 60°. The position and time of the recurvature depend upon the environmental flow prevailing at that time. Since the presence of the cyclone itself often modifies the environmental flow, the maximum errors in the forecasting positions are associated with abrupt recurvature and due to the acceleration after the recurvature. The present study aims to make a detailed climatological study of such recurving tropical cyclones over the Indian seas which has hitherto not been attempted and to identify certain specific characteristics and synoptic features which may give us useful hints for prediction of such recurving tracks.

2. Data used

As far as the climatological details of recurving *vis-à-vis* non-recurving storms are concerned, all the available cyclone tracks from the cyclone stage onwards for the period 1891 to 1995 were considered. The data on storm tracks for the period upto 1990 were collected from the storm atlas of the India Meteorological Department (IMD), published in Vols. I and II while the details of subsequent tracks were collected from the Annual cyclone review reports of IMD and also from the reports published in Mausam.

For preparation of the wind composites, the upper air data is obtained from the available 6 /12 hourly RS/RW and PB ascents and additional ascents if any during the actual cyclone situations. Further, if any satellite derived winds were reported at the cyclone time, they were also utilized at the appropriate wind composites to the nearest 12 / 24 / 48 hrs (IST) period prior to cyclone recurvature and also the aircraft reports (in-flight and post-flight) as obtained from AIREP bulletins reported at the mandatory Met. reporting points over the Bay of Bengal and neighbourhood during the cyclone period. Based on the time of reports and flight level, they were

TABLE 1

Frequencies of recurving tropical cyclones over Bay of Bengal and Arabian Sea during 1891 - 1995

Details	Bay of Bengal	Arabian Sea
Total number of cyclones	458	124
Total number of storms recurved	65	27
Total number of storms with abrupt recurvature (direction change > 60°)	13	4
Percentage of recurvature	14	24
Percentage of abrupt recurvature	3	3

TABLE 2

Speed of movement with respect to recurving point of time (cyclone tracks of 1891 - 1995)

Time period in hrs with respect to recurvature	Speed (knots)
Before	
48 hrs	4.1
36 hrs	4.0
24 hrs	4.8
12 hrs	1.8
After	
12 hrs	1.5
24 hrs	4.2
36 hrs and more	7.0

TABLE 3

Monthwise mean latitude position of recurvature

Month	Mean latitude position of recurvature °N	
	Bay of Bengal	Arabian Sea
Jan	N.R.	N.R.
Feb	N.R.	N.R.
Mar	N.R.	N.R.
Apr	N.R.	17.5
May	18.1	18.5
Jun	18.1	21.3
Jul	N.R.	N.R.
Aug	18.1	N.R.
Sep	18.1	N.R.
Oct	19.2	19.8
Nov	15.2	16.5
Dec	14.2	15.3

N.R. - No recurvature

TABLE 4

Synoptic conditions present 24 hours (IST) prior to recurvature in cyclone tracks (1951-95)

Synoptic features	Frequency (%)
Deep amplitude westerly trough between 300 and 200 hPa level	76
Entrapment in the upper air Col region	18
Presence of another strong vortex in the surface in the vicinity of cyclone (Fuji Whara type)	6

used appropriately. However, such reports were few and far between.

3. Analysis and discussion of results

3.1. *Frequency and speed of recurving storms*

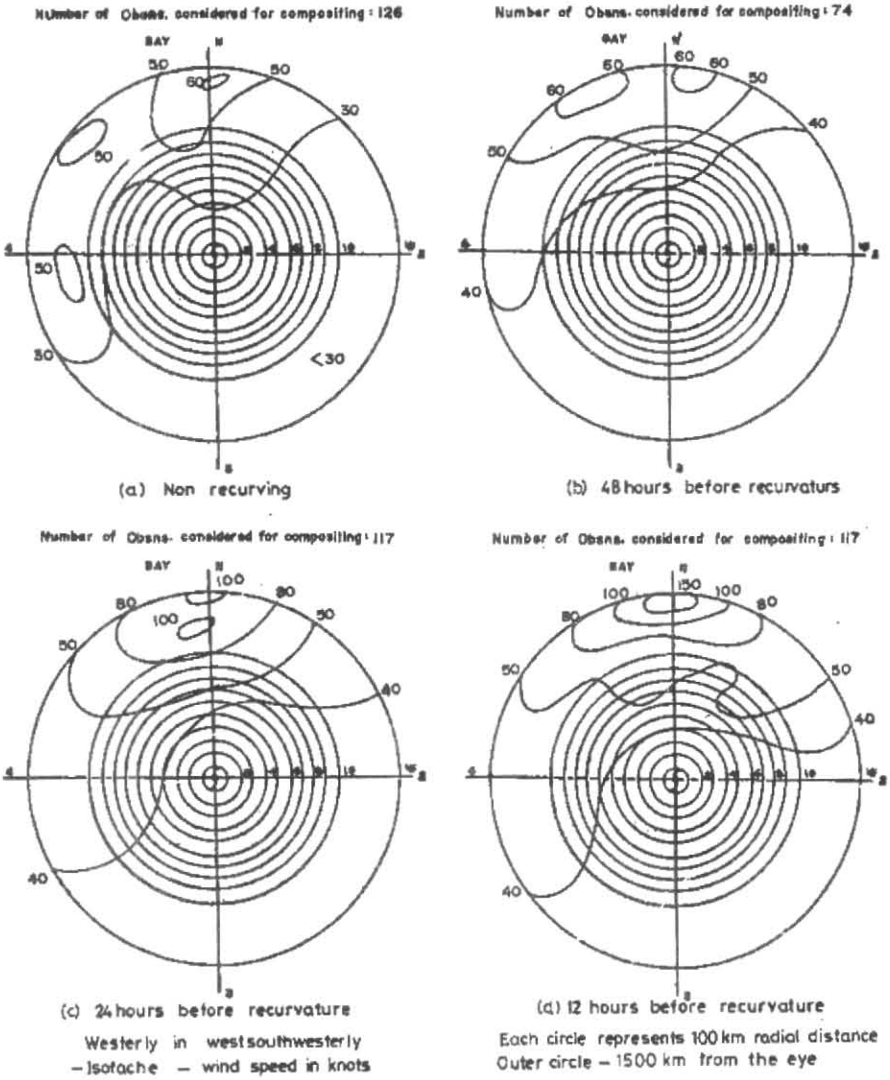
Table 1 gives the frequency of such recurving storms against the total formed over the Bay of Bengal and the Arabian Sea.

Recurvature is seen to have occurred only in 14% of cases in the Bay of Bengal, and it occurs more frequently in the Arabian Sea when compare to the Bay of Bengal. Incidence of abrupt recurvature is not at all common (Table 1).

Changes in speed are noted in such recurving storms during 48 hours before and 48 hours after recurvature. More than 90% of the recurving storms moved slower while 8% accelerated and 2% showed no change within the interval of ± 12 hrs (IST). In general, about 95% of the cyclones were associated with acceleration after 12 hrs of recurvature. Table 2 gives the mean value of translation speed with respect to time of recurvature.

3.2. *Latitude of recurvature*

Table 3 gives the month-wise mean latitude position at the time of recurvature. Examination of the past storm tracks indicates that during January, February and March, either there were on cyclones or no recurvature is indicated. As far as the monsoon season is concerned, generally no recurvature is seen in the Arabian Sea side. In other seasons, it is seen that the mean latitude position shifts southwards with the advance of the cyclone season. The recurvature of storms in both the Arabian Sea and the Bay of Bengal generally occurs only above the latitude of 14°N. But generally recurvature over the Arabian Sea occurs slightly at higher latitudes when compared to the



Figs. 1 (a-d). Isotach analysis of upper air 200 hPa wind composites for the period 1951-95 around the eye of the cyclone

Bay of Bengal side. It is further seen that on more than 60% of the occasions the recurvature occurs above 19.0°N latitude. As far as the longitudes are concerned, no such preferred locations are seen.

4. Intensity changes with respect to recurvature

Cyclones due to their sea travel, normally pick up their ocean thermal energy and intensify as they move poleward, provided no external negative influence like advection of cold air from north, lack of moisture supply, frictional drag due to land influence etc. are present. Normally, slow moving cyclones pick up more energy and intensify faster. In a statistical study of the intensity of recurving typhoons, Riehl (1979) showed that 65% of the hurricanes in Atlantic attained peak intensity within ± 12 hrs of recurvature while 30% reached a day prior to recurvature; and only 5% reached maximum intensity before recurvature. Lan and Sadler (1983) have indicated that 40% of typhoons reached within ± 12 hrs and 20% reached + 18 hrs or more after recurvature. Almost all reached high typhoon intensity only after recurvature.

A similar analysis is carried out in the present study for the Bay of Bengal and the Arabian Sea cyclones. The intensity changes are obtained again from the IMD cyclone reports, which are normally based either on actual maximum wind (V_{max}) or as estimated from the T.No. classification based on the empirical formula suggested by Mishra and Gupta (1976). The analysis indicates that nearly 50% of the cyclones reached peak intensity within ± 12 hrs of recurvature, while 35% reached the maximum intensity after 12 hrs and only 10% were 12 hrs before recurvature and 5% weakened after recurvature over sea itself. Generally, it is seen that irrespective of the oceanic area, the storm generally attained peak intensity within 1 to 18 hrs after the recurvature.

5. Synoptic features associated with recurvature

Table 4 shows the percentage frequency distribution of the identifiable synoptic features, which are responsible for recurvature with a lead-time less than 24 hrs prior to recurvature. The study is based on the 45 years data during the period 1951-95 due to easy accessibility of daily weather charts of this period. It is noted that the deep amplitude westerly trough present in the upper level are mainly responsible for recurvature within 12 to 24 hrs, contributing more than 75% of the total synoptic conditions.

6. 200 hPa upper wind as a predictor for steering

By studying the wind composites over Atlantic hurricanes, Gray (1981) has indicated that there existed some significant difference in large-scale flow patterns at 200 hPa between recurving and non-recurving cyclones, on the poleward side of the cyclones. A similar attempt has been made here utilizing the observed wind data from RS/RW ascents, satellite derived winds and aircraft reports wherever and whenever available. Figs. 1 (a-d) indicate the isotach analysis of the wind composites for non-recurving and recurving storms 48/ 24/ 12 hours prior to recurvature at 200 hPa level based on the wind data for the 45 years period from 1951-95. The total number of wind data available for the compositing is also indicated in the above figures. The compositing is done upto a radial extent of 2000 km from the centre of the storms. The analysis of the wind composites at 24 hrs and 12 hrs prior to recurvature distinctly indicate the strengthening of westerlies beyond 800 km peaking around 1700 km from the centre of the storm at 200 hPa level to the north of the cyclone even 24 hrs prior to recurvature. While no such feature is seen in case of non-recurving storms, this strengthening of upper air westerly flow in the northward sector of the storm could be considered as an indication of recurving within 24 to 12 hrs. Similar such peaking has been reported by Gray (1981) for Atlantic hurricanes.

However the main drawback in the day-to-day operational forecasting is the non-availability of upper level wind data over oceanic area on real time basis. Since the upper air data required for the recurvature prediction is not necessarily confined to the storm field but even beyond 1700 km poleward, there may be some land-based stations to give the forecaster an effective clue. This method is no doubt a very useful tool, but it needs to be tested more vigorously with more satellite derived winds and aircraft reports over data sparse oceanic areas.

7. Summary and conclusion

The present study indicates that the recurving cyclones over the Indian seas contribute only 14% of the total over the Bay of Bengal and 24% over the Arabian Sea and generally they occur only above the latitude of 14° N, attaining their peak intensity within 12-18 hrs after recurvature. In more than 75% of the recurving cyclones, the main synoptic feature associated is the deep amplitude troughs in the upper level westerlies, which are seen even 24 hrs prior to recurvature.

Also 200 hPa upper wind composite around the storm field could be used as a predictor for recurvature even 24 hrs early. There is a distinct poleward strengthening of westerlies from the centre beyond 800 km peaking around 1700 km. However, the success of this simplistic forecasting tool will depend on the availability of upper wind data from various sources like satellites and aircraft reports apart from the conventional RS/RW and PB data.

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