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Trend analysis of tropical storms during summer monsoon seasons over Indian seas

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ABSTRACT

A cyclone is an intense low pressure system, which invariably forms over warm ocean surface and in which very strong winds circulate around the center of the system. The present study includes the trend and fluctuation analysis of all the tropical storms that occurred in the monsoon season over the Indian Seas during 1971–2000. It is seen that Arabian Sea is more pronounced for the cyclones developed in June up to severe intensity rather than those originating from the Bay of Bengal. The study also indicates that an overall linear decrease in the occurrences of cyclone exists for the monsoon season over the entire period of study (1971-2000).

Key words : Monsoon season, Indian seas, tropical storms, decadal.

Disturbed weather occurs generally in association with the low pressure systems that are seen over different parts of the globe. Observations show that intense low pressure systems like depressions and cyclones originate in the equatorial trough zone over warm ocean surface under certain favorable atmospheric conditions. Tropical Cyclones are warm core low pressure systems having a large vortex in the atmosphere, which is maintained by the release of latent heat by convective clouds that form over warm oceans.

For Indian regions surrounded by north Indian Ocean, cyclonic systems cause devastation but also provide substantial rainfall to the coastal as well as inland regions along their track on land useful for agriculture and water resource management (De *et al,* 1993). Few attempts have been made to study the trends and fluctuations of cyclonic systems over the north Indian Ocean (Bhaskar Rao *et al*, 2003). Mooley and Mohile (1983, 1984) reported an increase in the frequency of storms crossing the Indian coast during 1965 and 1980. De and Joshi (1999) have discussed the interannual and inter decadal variability of tropical cyclone over Indian seas. Regarding studies related to other ocean areas, Gray (1990) reported a decrease in the Atlantic hurricane activity during 1970 – 1987 by about 50% compared to the period 1947-1969. A decrease over Australian Atlantic Ocean and South China Sea and an increase over the north and south central Pacific Ocean during El-Nino years was recorded (Gray, 1995).

Generally the tropical storms in the

Fig. 1 : Tracks of storms in different months during 1971-2000 (Source: IMD)

North Indian Ocean occur in both the pre and post-monsoon season. The occurrence of the cyclones in monsoon season is less pronounced; however, an analysis of storm track data shows that there are existences of cyclones in the monsoon season.

DATA AND METHODOLOGY

The present study primarily deals with the cyclonic storms in the monsoon season (i.e., June to September) which is a rare phenomenon because of high vertical shear of horizontal wind in the atmosphere during monsoon season. But it has been found that 32 cases of such cyclones existed during monsoon period (either developed or diffused) in last thirty years (1971-2000) and all those cyclones have been considered here month wise along with their tracks given in the Fig. 1. The data is collected from the tracks of storms and depression in the Bay of Bengal and Arabian Sea for the period 1971-1990. The data for 1991-2000 were obtained from the report on the cyclonic disturbances over north Indian Ocean prepared by India Meteorological Department, Pune.

In the present study the cyclonic systems have been classified only into two categories as "cyclonic storms" (wind speed in between 34-47 knots) and "severe cyclonic storms" (wind speed > 47 knots). Various statistical analyses of the data obtained during monsoon season for the last 30 years period (1971-2000) have been discussed. The epochs of increasing and decreasing decadal trends have also been computed.

RESULTS AND DISCUSSIONS

As tropical storms have their genesis over warm oceans, they are a seasonal phenomenon having a maximum frequency during summer to early autumn. In the North Indian Ocean, their frequency shows a bimodal character, with maximum peaks, one from mid-April to mid-June and other from October to mid-December. Over the Bay of Bengal and the Arabian sea, during monsoon season (June to September), the intense systems do not develop due to shift of the convergence zone northward over land.

The distribution as well as yearly frequency of all the cyclonic storms formed over the Indian seas during the period of study is shown in Fig. 2. A linear decrease of occurrence of tropical storms over the area is indicated by the trend line.

Monthly distribution of cyclonic storms/severe cyclonic storms that formed during 1971-2000 (Table 1) shows that out of total 32 cyclonic storms, 17 storms attained the strength of severe cyclonic storms. The number of cyclonic and severe cyclonic storms is found maximum in June and minimum in July. It also shows slight increase in August (total 5 storms). Again it becomes 10 in the month of September. The relatively higher number in June and September seems to be because of these being transition months from pre-monsoon to monsoon and monsoon to post-monsoon respectively. Less number in July and August is because during these months monsoon current is fully established over the region.

Table 1 : Monthly distribution of cyclonic storms/severe cyclonic storms

Month	Cyclonic storm(CS)	Severe cclonic storms(SCS)	Total (CS & SCS)
June	7	7	14
July	2	1	3
August	3	2	5
September	3	7	10
Total	15	17	32

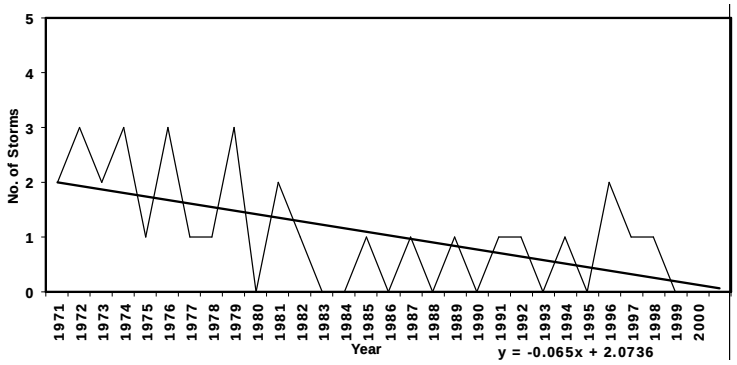

Fig. 2: Number of tropical stoms in India in monsoon period during 1971-2000

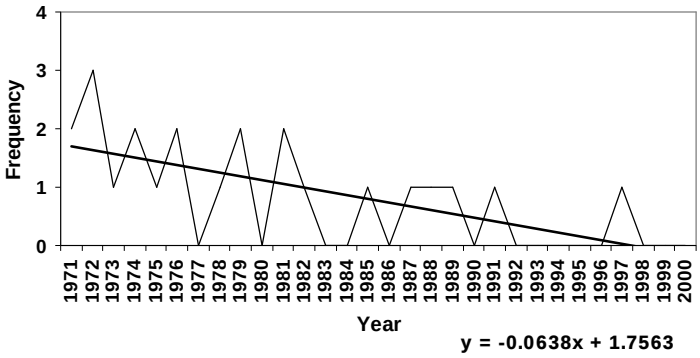

Fig. 3: Yearly frequency of storms over Bay of Bangal

About 50% of cyclonic storms that occurred in June reached up to the strength severe cyclone whereas this percentage has risen to 70% in the month of September.

The monthly and seasonal distribution of storms separately over the Bay of Bengal (BOB) and Arabian Sea (AS) (Table 2) reveals that during the period of study in

Table 2 : Frequency of cyclonic storms originating over Bay of Bengal and Arabian Sea

Region	June	July	August	September	Total
1. Bay of Bengal	6(2)	3(1)	5(2)	9(6)	23(11)
2. Arabian Sea	8(5)	0(0)	0(0)	1(1)	9(6)

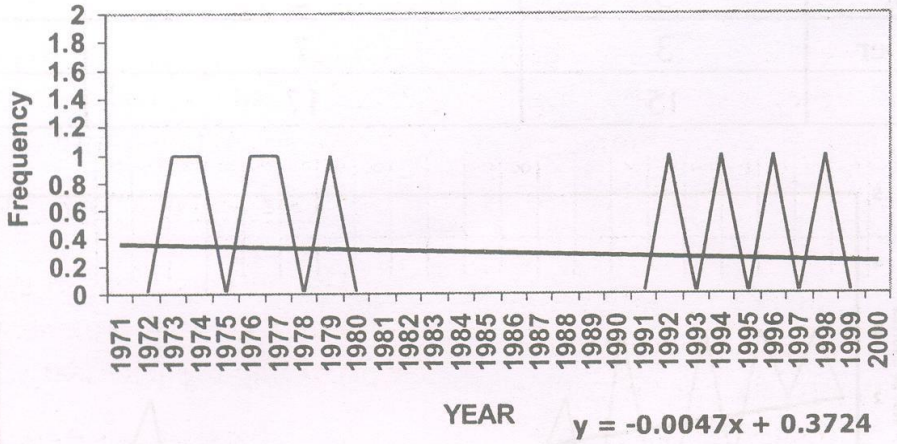

Fig. 4: Yearly frequency of storms over Arabian Sea

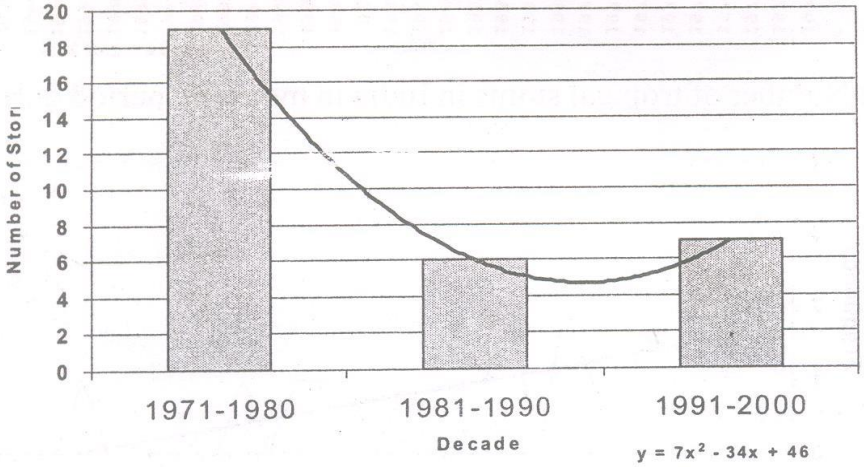

Fig. 5: Decadal Frequency of storms in monsoon season

monsoon months of the 23 storms that occurred over BOB, only 11 have reached up to the strength of severe cyclonic storms whereas over AS out of total 9, six of them have reached up to the strength of severe cyclone. Cyclone development was absent during July and August over AS. Even in the month of September only one is observed. June is found to be more prominent for the development of cyclone

in the case AS. It is seen that out of 8 cyclones formed during June over AS 3 have crossed the west coast of India and 5 moved further westward towards Saudi Arabia (Fig. 1a). So far as BOB is concerned in every month from June to September there were cases of cyclonic development. In the month of September out of 9 cyclones over BOB 6 had reached up to severe a cyclonic storm which indicates that September is more prominent for the development of cyclonic storms over BOB than in the AS.

The annual frequency of occurrence of cyclonic storms over BOB (Fig. 3) shows a linearly decreasing trend while very slight decreasing trend is found over AS (Fig. 4).

Decadal frequency analysis revealed that the number of cyclonic and severe cyclonic storms showed distinct decadal variability. The maximum number (19) occurred in the decade 1971-80 and minimum (6) during 1981-90. A polynomial trend of decrease and the slight increase can be observed (Fig. 5) during the first to second and then second to third decade respectively.

CONCLUSION

From the above discussion we infer that the percentage frequency of cyclones during monsoon is to be 1.06 per year. AS is observed to be more prominent for the development of cyclonic and severe cyclonic activity than over BOB in the month of June while reverse is true during month of September. It has also been noticed that cyclone activity in September has more chances (70%) for the development up to severe cyclonic stage in comparison to June (50%). An overall linear decrease in the cyclone occurrence exists for the monsoon season over the entire period of study (1971-2000), the decrease was found to be more for BOB than AS. A polynomial decreasing trend for first to second decade with slight increasing trend between second and third decade is found.

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