Mausam, (1991), **42**, 3, 257-260

551.526.6:551.513.7(267)

El-Nino and tropical storm tracks over Bay of Bengal during post monsoon season

AKHILESH GUPTA and A. MUTHUCHAMI

Regional Meteorological Centre, Madras

(*Received 2 May 1990*)

सार—मानसून काल के पश्चात् के मौसम (अक्तूबर से दिसम्बर) में बंगाल की खाड़ी में उत्पन्न चक्रवातों की गति पर अल-नीनो के प्रभाव की जांच इस शोधपत्र में की गई है। 1901-1987 वर्षों के मध्य उत्पन्न बंगाल की खाड़ी के सभी चक्रवातों को दो श्रेणियों में बांटा गया है। ये श्रेणियां हैं 17° उत्तर अक्षांश के उत्तर में भारत के पूर्वी तट को पार करने वाले चक्रवात तथा 17° उत्तर अंक्षाश के दक्षिण में पूर्वी तट को पार करने वाले चक्रवात।

यह देखा गया कि अल-नीनों वर्षों में बंगाल की खाड़ी में उत्पन्न चक्रवातों में से अधिकतर (87%) 17° उत्तर अक्षांश अर्थात् दक्षिण आन्ध्र प्रदेश—तमिलनाडु तट के दक्षिण में पार करते है जबकि अल-नीनों वर्षों से एक वर्ष पहले के वर्षों में उत्पन्न चक्रवातों में से अधिकतर (79%) या तो 17° उत्तर अंक्षाश के उत्तर में पार करते हैं अथवा मुड़कर उत्तर-पूर्व दिशा में चल जाते हैं। अन्य वर्षों में चक्रवात इस प्रकार का कोई भी विशेष व्यवहार प्रदर्शित नहीं करते हैं। दक्षिणी प्रदोलन सूचांक तथा 1901 व 1987 (n=87) के मध्य उत्पन्न चक्रवातों के 17° उत्तर अंक्षाश के दक्षिण में पार करने की भिन्नात्मक संख्या के बीच —0.63 का सहसम्बन्ध गुणांक पाया गया जो कि जांच 1% स्तर पर सार्थक है।

ABSTRACT. The role of *El-Nino* in modulating tropical cyclone motion over Bay of Bengal during post monsoon season has been examined. Storms which formed during the years 1901-1987 have been classified into recurving or those of which crossing north of 17° N and non-recurving or those of which crossing south of 17° N on the east coast of India.

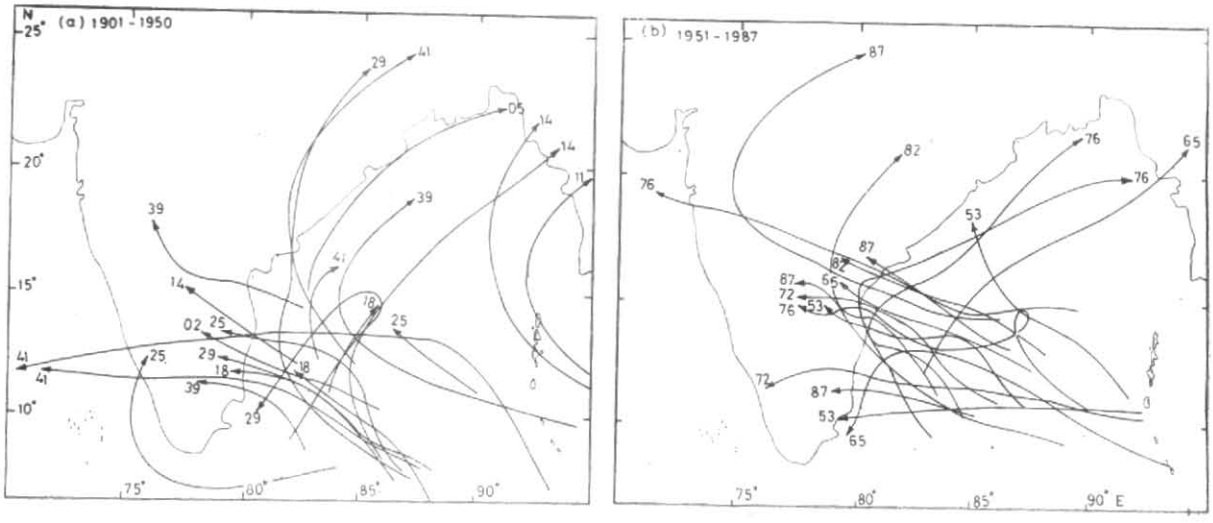
It has been found that in most of the cases (87%) during *El-Nino* years, the tropical cyclones which formed over Bay of Bengal crossed south of 17° N, *i.e.*, south Andhra Pradesh-Tamil Nadu coast, whereas tropical cyclones formed during the year prior to the *El-Nino* years [*El-Nino* (—1) year] are seen crossing mostly (in 79% of cases) either north of 17° N or recurving in northeastward direction. In other years this kind of behaviour is not generally observed. The correlation between southern oscillation indices and the fractional values of storms crossing south of 17° N for the period 1901-1987 (n=87) is found to be —0.63 which is significant at 1 per cent level.

Key words — Tropical cyclones, tracks, *El-Nino*, southern oscillation, southern oscillation index, North Indian Ocean, Bay of Bengal.

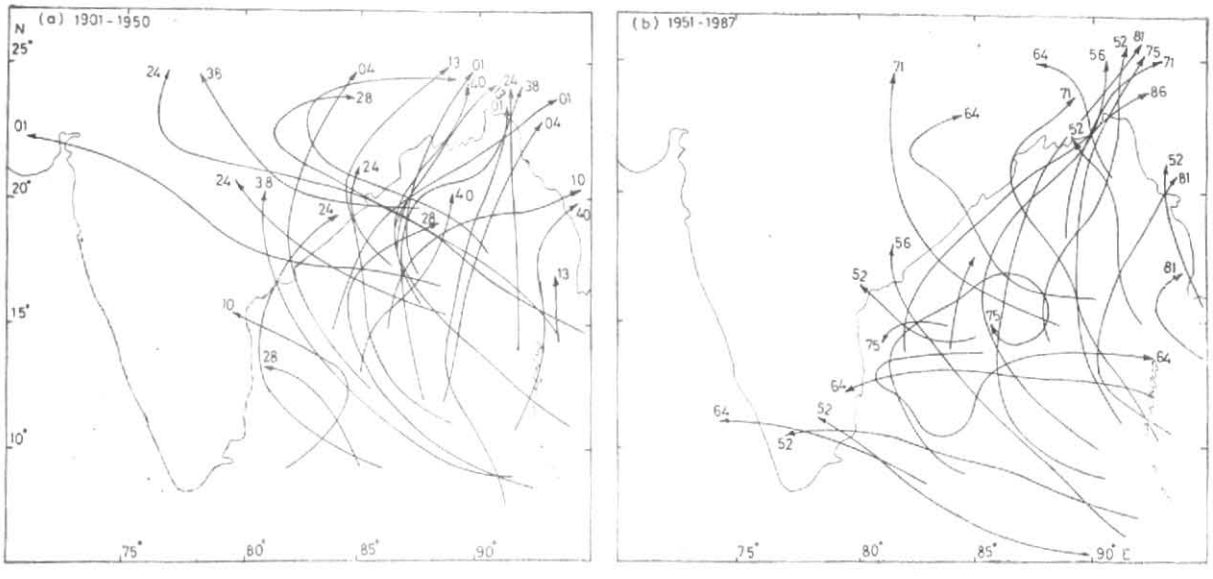
1. Introduction

The role of environment or external forcing processes on tropical cyclone formation, structure, structural change and motion has been known and accepted in varying degrees by meteorologists for many years. *El-Nino*/Southern Oscillation (ENSO) is the most important short-term climatic fluctuations of tropical circulation. In recent years its possible role in modulating tropical cyclone activities in different parts of the world has been emphasized (Gray 1984). It has been observed that *El-Nino* events reduce hurricane activities significantly in north Atlantic during the season following the onset of *El-Nino* and hurricane activity usually resumes to normal in the second summer following the events (Gray 1984, 1988). Atkinson (1977) and Chan (1985) reported similar results for northwest Pacific but Dong (1988) modified the idea and suggested that the typhoon activity is suppressed by the *El-Nino* events in the basin west of 160°E but enhanced east of this longitude. Another study for northwest Pacific by Aoki (1985) shows the minimum frequency in typhoon formation during *El-Nino* events and maximum frequency two years later. Studies for Australian region [Nicholls (1985), Revell and Gaulter (1986), Gray (1984, 1988), Dong (1988)] also suggest the negative influence of *El-Nino* event on tropical cyclone activity. Results for southwest Pacific (Ramakrishna 1989) appear to be interesting, as an enhancement in tropical cyclone activity has been observed in both the high and low phases of southern oscillation index. The relationship between tropical cyclone behaviour and ENSO for north Indian Ocean has been examined by Mandal (1985), Singh *et al.* (1987) and Rajeevan (1989), but unlike the Atlantic and the Pacific, the relationship is found very weak.

Gray (1984, 1988) has shown that to some extent, *El-Nino* events also affect the intensity and track of the tropical storms in the Atlantic. In *El-Nino* years the storms are less intense and more recurving over the Carribbean sea. The study made by Mandal (1989) for North Indian Ocean (NIO) does not support the idea, as number of recurving and non-recurving tropical cyclones were



Figs. 1 (a & b). Tracks of depressions and cyclones over Bay of Bengal during post monsoon season in *El-Nino* years (a) 1901-1950 and (b) 1951-1987 (Numbers written ahead of tracks indicate years of storm formation)



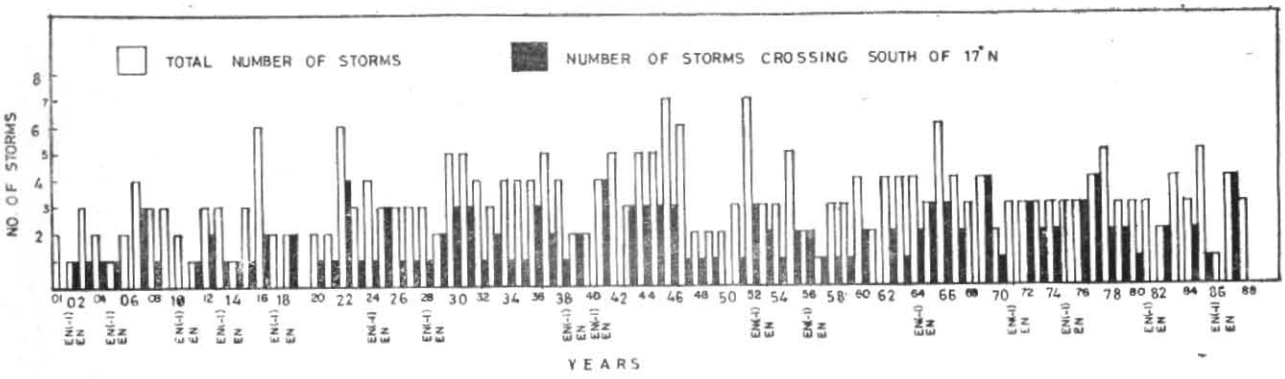
Figs. 2(a & b). Tracks of depressions and cyclones over Bay of Bengal during post monsoon season in *El-Nino* (—1) years : (a) 1901-1950 (b) 1951-1987 (Numbers written ahead of tracks indicate years of storm formation)

seen in almost equal proportion in *El-Nino* years. However, the study by Singh *et al.* (1987) shows some influence of southern oscillation on the latitude of the tracks of cyclone during post monsoon season (October-December) crossing east coast of India. The above study also shows the increase in frequency of cyclones in low latitude (AP coast) and the decrease in the higher latitude (Orissa and West Bengal coast) during low phases of southern oscillation (*El-Nino* years). Such studies for other basins are yet to be made available.

The above mentioned study by Mandal (1989) on recurving and non-recurving storms over north Indian Ocean takes account of all the storms which formed over Bay of Bengal and Arabian Sea during a year (including monsoon season). This did not show any significant relationship between *El-Nino* and storm motion. However, in the present paper, storms which formed during post monsoon season (October-December) over Bay of Bengal only are taken for study. Results have shown a significant relationship between *El-Nino* and the tropical storm motion over the Bay of Bengal.

2. Data utilised

Tropical cyclones tracks over Bay of Bengal for the period 1901 to 1987 are taken from '*Tracks of depressions and tropical cyclones over India*' published by India Meteorological Department and tracks published in *Mausam*. The data on *El-Nino* years and southern oscillation indices (Tahiti-Darwin pressures) are taken from Gray (1984) and Ropelewski & Jones (1987).



Figs. 3. Total number of storms which formed in the Bay of Bengal in post-monsoon season during the years 1901-1988 and the storms crossing south of 17° N

TABLE 1

Recurving and non-recurving cyclonic storms during *El-Nino* and *El-Nino* (—1) years

El-Nino years	No. of C.S.	No. of C.S. recurving/ crossing north of 17° N	No. of C.S. crossed south of 17° N	*El-Nino* (—1) years	No. of C.S.	No. of C.S. recurving/ crossing north of 17°N	No. of C.S. crossed south of 17°N
1902 (M)	1	0	1	1901	2	2	0
1905(M)	1	1	0	1904	1	1	0
1911(S)	1	1	0	1910	2	1	1
1914(M)	1	1	0	1913	4	3	1
1918(S)	3	0	3	1917	2	2	0
1925(S)	3	0	3	1924	5	4	1
1929(M)	3	0	3	1928	4	3	1
1939(M)	3	1	2	1938	3	2	1
1941(S)	4	0	4	1940	2	2	0
1953(M)	3	1	2	1952	7	4	3
1957(S)	0	0	0	1956	2	2	0
1965(M)	3	0	3	1964	4	2	2
1972(S)	3	0	3	1971	3	3	0
1976(M)	3	0	3	1975	3	3	0
1982(S)	2	0	2	1981	3	3	0
1987(M)	4	0	4	1986	1	1	0
Total	38	5	33		48	38	10
Mean	2.38	0.31	2.07		3.0	2.38	0.62
In %		13.1	86.9			79.16	20.84

C.S. — Cyclonic storm, S — Strong *El-Nino* year,
M — Moderate *El-Nino* year

3. Discussion

In order to examine relationship of *El-Nino* event with the tropical cyclone motion over Bay of Bengal during post monsoon period (October-December), the tracks of storms formed during the period 1901-1987 were taken for study. Tracks of the storms during the above period were plotted separately for *El-Nino* and other years such as *El-Nino* (—1) years, *El-Nino* (+1) and so on. After a careful analysis of the characteristics of the storm tracks in these years, tracks for *El-Nino* and *El-Nino* (—1) years were selected for the study, as they exhibited some important characteristics discussed in the subsequent paragraphs.

Figs. 1 (a & b) show the storm tracks during *El-Nino* years. Similarly Figs. 2(a & b) depict the tracks of the storms during *El-Nino* (—1) years. These figures clearly show that the storm tracks are mostly straight and less recurving during *El-Nino* years whereas they are more recurving during *El Nino* (—1) years. These results are opposite to those of Gray (1984, 1988) for Atlantic where the storms are found more recurving during *El-Nino* years. It is also evident from these figures that *El-Nino* years have more number of storms crossing at lower latitudes on the Indian east coast compared to *El-Nino* (—1) years. To establish a quantitative approach to this behaviour, the storms were classified into two categories, *viz.*, (1) recurving or those of which crossing north of 17°N and (2) non-recurving or those of which crossing south of 17°N on the east coast of India. Table 1 gives the details of the number of storms crossing Indian east coast under these two categories during *El-Nino* and *El-Nino* (—1) years. It may be seen from this table that 33 out of total 38 tropical cyclones (about 87%) during *El-Nino* years are non-recurving or crossing south of 17°N whereas 38 out of the total 48 tropical cyclones (about 79%) during *El-Nino* (—1) years are either recurving or crossing north of 17°N. It may also be inferred from this table that during severe *El-Nino* years 15 out of total 16 storms (about 94%) have crossed south of 17° N whereas during the years previous to severe *El-Nino* years, 17 out of total 19 storms (about 89%) were either recurving or crossing north of 17°N.

To establish a correlation between the number of storms crossing south of 17°N during *El-Nino* years and the number of storms recurving/crossing north of 17°N during *El-Nino* (—1) years, fractional values of these numbers (n=16) were statistically correlated and test of significance (t-test) was applied. The correlation coefficient of +0.84 was found between these two parameters which is significant at 1 per cent level.

Although, considering past 87 years period (1901-1987) the total number of storms during 16 *El-Nino* years (38), as shown in Table 1, is less compared to the number in 16 *El-Nino* (—1) years (48), no preferred behaviour in terms of reduction or increase in the frequency of the storms is noticed in any kinds of years [*El-Nino*, *El-Nino* (—1) etc]. Also, though characteristics of the storm tracks are distinctly different during *El-Nino* years compared to *El-Nino* (—1) years, but the prediction of onset of *El-Nino* based on the characteristics of the storm tracks in a particular year may not be possible as the storm frequency over north Indian Ocean is very low. It is seen that on an average about 2 to 3 storms form over Bay of Bengal during post monsoon season.

In Fig. 3, total number of storms which formed during a year and storms crossing south of 17°N are plotted against years for the period 1901-1987. It is evident from this figure also that storms during *El-Nino* years generally cross south of 17° N. The fractional values of storms crossing south of 17°N and southern oscillation indices (Tahiti-Darwin pressures) for the period 1901-1987 (n=87) were statistically correlated and test of significance (t-test) was applied. The correlation coefficient of —0.63 is found between southern oscillations and storms crossing south of 17°N, which is significant at 1 per cent level. These results are in agreement with those of Singh *et al.* (1987).

4. Conclusions

(*i*) Storm tracks over Bay of Bengal during post monsoon season are mostly straight and less recurving in *El-Nino* years compared to the storm tracks during *El-Nino* (—1) years.

(*ii*) Storms during *El-Nino* years over Bay of Bengal during post monsoon season mostly cross south of 17°N.

(*iii*) Storms during *El-Nino* (—1) years mostly cross either north of 17°N or recurve north eastwards.

(*iv*) Such kind of behaviour is not observed for years other than *El-Nino* and *El-Nino* (—1) years.

Acknowledgements

Authors wish to express gratitude to the Deputy Director General of Meteorology, Regional Meteorological Centre, Madras for encouragements. They are also thankful to Shri V. Manoharan for preparing diagrams and Smt. R. Radhika for typing the manuscript.

References

Aoki, Takashi, 1985, A climatological study of Typhoon Formation and typhoon visit to Japan, *Paper Meteorology and Geophysics*, **36**, 61-118.

Atkinson, G.D., 1977, Proposed system of near real time monitoring of global tropical circulation and weather patterns, Preprints 11th Tech. Conf. on Hurricanes and tropical meteorology, Miami, *Amer. met. Soc.*, 645-652.

Chan, J.C.L., 1985, Tropical cyclone activity in Northern Pacific in relation to the El-Nino/Southern Oscillation Phenomena, *Mon. Weath. Rev.*, **113**, 599-656.

Dong, K., 1988, El-Nino and Tropical cyclone frequency in the Australian Region and the North West Pacific, *Aust. met. Mag.*, **36**, 219-225.

Gray, W.M., 1984, Atlantic Seasonal Hurricane Frequency Part I, El-Nino and QBO influences, *Mon. Weath. Rev.*, **112**, 1949-1968.

Gray, W.M., 1988, Environmental influences on Tropical Cyclone, *Aust. Met. Mag.*, **36**, 127-129.

Mandal, G.S., 1985, Tropical Cyclone from Regional perspective-North Indian Ocean (*Personal Communication*).

Mandal, G.S., 1989, Low frequency oscillations and seasonal variability of Tropical Cyclones—North Indian Ocean (*Personal Communication*).

Nicholls, N., 1985, Predictability of Interannual variations of Australian Seasonal tropical cyclone activity, *Mon. Weath. Rev.*, **113**, 144-149.

Rajeevan, M., 1989, Post monsoon tropical cyclone activity in the North Indian Ocean in relation to the El-Nino Southern oscillation phenomenon, *Mausam*, **40**, 1, 43-46.

Ramakrishna, 1989, Low frequency and seasonal variability within Ocean basins : Southwest Pacific Ocean (*Personal Communication*).

Revell, C.S. and Gaulter, S.W., 1986, South Pacific Tropical Cyclones and the Southern Oscillation, *Mon. Weath. Rev.*, **114**, 1138-1144.

Ropelewski, C. I. and Jones, P.D., 1987, An extension of the Tahiti-Darwin southern oscillation index, *Mon. Weath. Rev.*, **115**, 2161-2165.

Singh, S.V. Mohile, C.M. and Inamdar, S.R., 1987, Relationships of Southern Oscillation and other large scale features with Bay of Bengal Cyclones during the post monsoon season, *Advance in Atmospheric Science*, **4**, 169-174.