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Tropical cyclone frequency in the north Indian Ocean in relation to southern oscillation phenomenon

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सार – इस शोध-पत्र में हिंद महासागर के उत्तर में उष्णकटिबंधीय चक्रवातों की आवृति पर दक्षिणी दोलन के पड़ने वाले प्रभाव के विषय में बताया गया है। अध्ययन से प्राप्त हुए परिणामों से यह पता चलता है कि दक्षिणी दोलन की निष्क्रिय अवस्था के दौरान मई के महीने में बंगाल की खाड़ी तथा अरब सागर में उष्णकटिबंधीय चक्रवातों और अवदाबों की आवृति कम हो जाती है, जो कि मानसून पूर्व ऋतु का चक्रवातों के दृष्टिकोण से अत्याधिक महत्वपूर्ण महीना होता है। चक्रवातों और अवदाबों की आवृति और दक्षिणी दोलन इंडेक्स (एस.ओ.आई.) के बीच सहसंबंध गुणांक +0.3 है जो 99 प्रतिशत के स्तर पर महत्वपूर्ण होता है। नवंबर के महीने के दौरान बंगाल की खाड़ी में मानसून ऋतु के बाद बंगाल की खाड़ी में आने वाले चक्रवात की आवृति के साथ दक्षिणी दोलन के विशेष सकारात्मक सहसंबंध होने का पता चलता है जबकि यह दक्षिणी दोलन की निष्क्रिय अवस्था के दौरान कम भी हो जाती है। अतः एलनिनों/दक्षिणी दोलन (एनसो) की अवधियों में तीव्र चक्रवात वाले मई और नवंबर दोनों ही महीनों में उष्णकटिबंधीय चक्रवातों की आवृति में कमी पाई गई है। इसलिए यह कहना उचित नही होगा कि हिंद महासागर के उत्तर में चक्रवातों के बनने पर एनसो का कोई प्रभाव नही पड़ता है। जबकि यह सही है कि अरब सागर में चक्रवातों की आवृति पर एनसो का कोई उल्लेखनीय प्रभाव नही पड़ता है।

अवदाबों के चक्रवात की अवस्था तक तीव्र होने की गति को भी एनसो प्रभावित करता प्रतीत होता है। एनसो की अवधि में हिंद महासगार के उत्तर में अवदाबों के तीव्र होने की गति मई के महीने में बढ़ जाती है और नवंबर के महीनें मे कम हो जाती है। 1891 से 1990 तक की 100 वर्षों की अवधि के उष्णकटिबंधीय चक्रवातों और अवदाबों की मासिक आवृति तथा दक्षिणी दोलन इंडेक्स के विश्लेषण के आधार पर ये परिणाम प्राप्त किए गए है।

ABSTRACT. The present paper deals with the influence of Southern Oscillation (SO) on the frequency of tropical cyclones in the north Indian Ocean. The results show that during the negative phase of SO the frequency of tropical cyclones and depressions over the Bay of Bengal and the Arabian Sea diminishes in May which is most important pre-monsoon cyclone month. The correlation coefficient between the frequency of cyclones and depressions and the Southern Oscillation Index (SOI) is +0.3 which is significant at 99% level. Post-monsoon cyclone frequency in the Bay of Bengal during November shows a significant positive correlation with SOI implying that it also decreases during the negative phase of SO. Thus there is a reduction in the tropical cyclone frequency over the Bay of Bengal during both intense cyclone months May and November in El-Nino/Southern Oscillation (ENSO) epochs. Therefore it would not be correct to say that ENSO has no impact on the cyclogenesis in the north Indian Ocean. It is true that ENSO has no significant impact on the frequency of cyclones in the Arabian Sea.

ENSO also seems to affect the rate of intensification of depressions to cyclone stage. The rate of intensification increases in May and diminishes in November in the north Indian Ocean during ENSO. The results are based on the analysis of monthly frequencies of tropical cyclones and depressions and SOI for the 100 year period from 1891-1990.

Key words – Southern oscillation, ENSO, Tropical cyclone, Rate of intensification, Correlation coefficient, SOI.

1. Introduction

The Southern Oscillation phenomenon is known to cause worldwide climate anomalies (Gray and Sheaffer, 1991). Recent studies have brought out the relationships between SO and tropical cyclone frequency in different ocean basins which vary from basin to basin. There is a substantial reduction in the cyclone frequency over the North Atlantic Ocean during negative phase of SO (Gray, 1992). It is well known that during the negative phase of SO, central Pacific is dominated by the negative surface pressure anomalies and the Australian areas are dominated

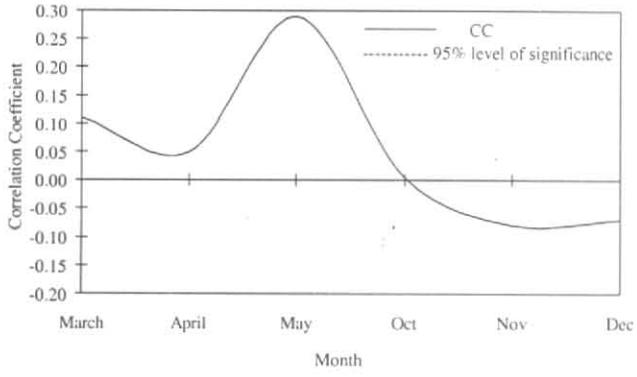

Fig. 1. Correlation between SOI and the frequency of total cyclonic disturbances over the Bay of Bengal and the Arabian Sea

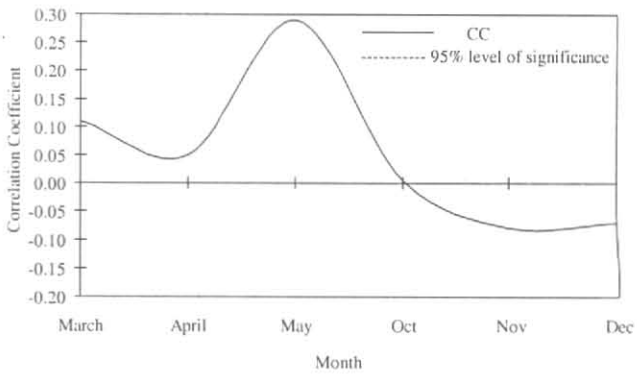

Fig. 2. Correlation between SOI and the frequencies of tropical cyclones

by the positive anomalies. The difference of surface pressure at Tahiti and Darwin is a measure of Southern Oscillation Index (SOI).

According to Chan (1985) the frequency of cyclones in the north Pacific between 140°-160°E increases during SO years (*i.e.* negative phases of SO). The frequency over the south China Sea, however, decreases during negative phase of SO. Sadler (1984) reported increased cyclone frequency over the central and eastern South Pacific during El-Nino/Southern Oscillation (ENSO) episode of 1982-83. Rao (1997) has summarized the relationships between the cyclone activity and ENSO in a general way. There have been some qualitative studies on the relationship between the cyclone activity in the north Indian Ocean and ENSO (Rajeevan, 1989 and Mandal, 1991) but none of them have looked into these relationships on a monthly scale and in a quantitative way. As the impact of SO on the average annual frequency of cyclones in the north Indian Ocean was not very significant more detailed analysis was needed to reveal the influence on seasonal and monthly scales.

2. Data and methodology

The frequencies of tropical cyclones and depressions in the north Indian Ocean for the period 1891-1979 have been obtained from the storm atlas published by the India Meteorological Department (IMD, 1979). The data for recent period 1980-1990 has been obtained from IMD records and quarterly journal Mausam.

The data pertaining to Southern Oscillation Index have been obtained from Climate Prediction Centre, USA, NOAA-CIRES Climate Diagnostic Center, University of Colorado, Boulder, USA and Bureau of Meteorology, Australia.

The correlations between monthly SOI and corresponding frequencies of cyclones and depressions have been computed for each month of pre-monsoon and post-monsoon season. The values of CCs have been presented in Figs. 1 and 2.

3. Results and discussion

3.1. *Relationship between SOI and tropical cyclone frequency*

Fig. 1 shows that highest CC of + 0.3 has been found between the SOI and the frequency of total cyclonic disturbances (cyclones and depressions) in the Bay of Bengal and the Arabian Sea during May. Positive SOI indicates that during negative SOI epochs the cyclogenesis in the Bay of Bengal and the Arabian Sea reduces. Other CCs for pre-monsoon season (*i.e.* for March and April) are not significant. Similarly, the CCs for post-monsoon season from October to December is also not significant.

When the frequencies of tropical cyclones in relation to SO were analyzed separately for the Bay of Bengal and the Arabian Sea it was found that during the negative phase of SO the cyclone frequency over the Bay of Bengal diminished in November also. The results for important cyclone months May, October and November have been presented separately for the Bay of Bengal and the Arabian Sea in Fig. 2. The highest CC of +0.3 was found between the cyclone frequency in the Bay of Bengal during May and the corresponding SOI. During November similar CC is +0.2. The interesting aspect is that both the CCs are positive showing the reduction in the cyclone frequency in the Bay of Bengal during May and November of ENSO years. The CC for November is significant at 95% level.

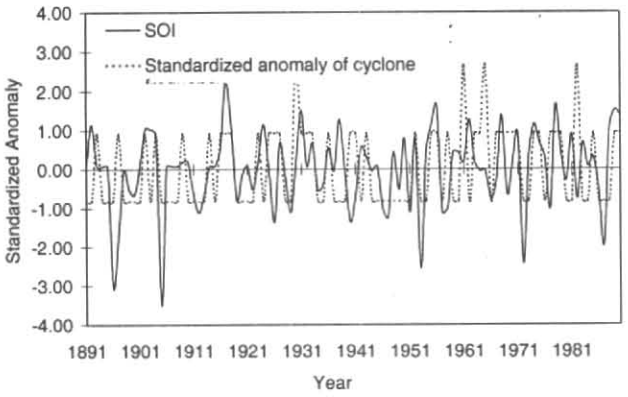

Fig. 3. Standardized anomaly of tropical cyclone frequency in the Bay of Bengal and SOI for May (1891-1990)

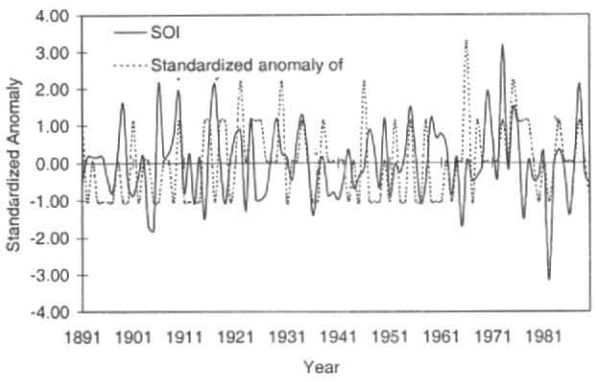

Fig. 4. Standardized anomaly of tropical cyclone frequency in the Bay of Bengal and SOI for November (1891-1990)

None of the CCs pertaining to the Arabian Sea are significant implying that SO does not have any significant influence on the cyclogenesis over the Arabian Sea.

The standardized anomalies of the topical cyclone frequencies over the Bay of Bengal alongwith the SOI for May and November have been presented in Figs. 3 & 4. During the 100 years period under consideration highest negative value of SOI in May was observed during 1905. No cyclone formed in May during that year. Similarly, other 4 significant negative peaks in SOI in Fig. 1 correspond to the years 1896, 1953, 1972 and 1987 (all El-Nino/Southern Oscillation years). It is noteworthy that during none of these years any cyclone formed over the Bay of Bengal in the month of May. Negative peaks in the standardized anomaly of cyclone frequency during all these years in Fig. 1 signify this aspect.

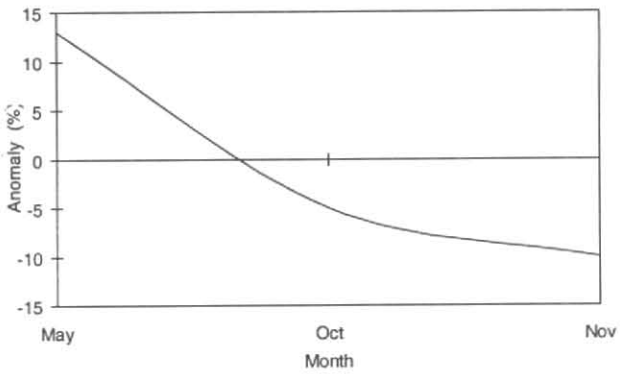

Fig. 5. Anomalies of intensification rates during May, October and November of ENSO years

When we consider the anomalies for November we find that highest negative SOI occurred during 1982. Again no cyclone formed over the Bay of Bengal in that month. Thus the inverse relationship between the Southern Oscillation and the tropical cyclone frequency in the Bay of Bengal is apparent from the examination of Figs. 1 & 2.

It may be remarked that any qualitative examination of the relationship of cyclone frequency with ENSO on annual or seasonal scale may not reveal the actual relation. For instance, when we categorise ENSO years we should remember that ENSO phenomenon may not be present in all the months of that year. Thus quantitative relationship on monthly scale is necessary. It is perhaps due to this reason that many investigators have not been able to obtain any significant difference in the cyclone frequencies during ENSO and La-Nina years (Rajeevan, 1989, Mandal, 1991).

3.2. *The rate of intensification*

The rate of intensification of cyclonic disturbances in the north Indian Ocean to cyclone stage is maximum during November and May. About 60% of the disturbances concentrate into tropical cyclones during these two months. It was observed that ENSO influenced the intensification rate also. There were 17 ENSO years during the period under consideration. Average intensification rate in May of ENSO years was about 75% and in November it was only 50%. Thus ENSO inhibited the intensification during post-monsoon season. The anomalies of intensification rates during May, October and November have been presented in Fig. 5.

The results of the present study have shown that the common impression about non-influence of ENSO on the cyclone activity in the north Indian Ocean is not fully correct. When we consider annual or seasonal frequencies over the entire north Indian Ocean, the impact of ENSO is smoothed out and the net influence becomes insignificant. While analyzing the marine data one finds that the responses of Bay of Bengal and the Arabian Sea to different phenomena are not the same. Similarly, north Indian Ocean being totally different from other ocean basins, it is characterised by large seasonal and intraseasonal fluctuations. The dampening influence of ENSO on the tropical cyclone activity over the Bay of Bengal in intense cyclone months May and November can be understood as the entire Bay area is dominated by the positive surface pressure anomalies during negative phases of SO. But it would be perhaps a very simplistic explanation. It has been observed that monsoon depression activity over the Bay increases in July-August during ENSO epochs. Therefore, same argument does not hold good in case of cyclogenesis during monsoon. It is true that the characteristics of monsoon systems are significantly different from those of pre-monsoon and post-monsoon cyclones. But the reasons for selective impact of ENSO on the cyclogensies in the Bay of Bengal needs to be further investigated.

4. Conclusions

The study has brought out the following results.

(*i*) The tropical cyclone frequency over the Bay of Bengal diminishes in May and November during the negative phase of Southern Oscillation.

(*ii*) Southern Oscillation has no significant impact on the cyclone activity over the Arabian Sea.

(*iii*) The rate of intensification of cyclonic disturbances in the north India Ocean to cyclone stage increases during May and decreases during November of ENSO years.

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