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CAN WE PREDICT THE FREQUENCY OF CYCLONES OVER BAY OF BENGAL DURING OCTOBER-DECEMBER?

1. Forecasting cyclone activity in Australian (Nicholls, 1984; 1992) and southern Pacific (Revell and Goulter, 1986) regions with SO (Southern Oscillation) and the influence of El-Nino-Southern Oscillation (ENSO) on Bay of Bengal cyclones (Felton *et al*., 2013) were reported earlier. Balachandran and Geetha (2012) reported the statistical method to predict the cyclone days over north Indian ocean during the post-monsoon (October-December) season using the data from 1971-2000 and tested for the period, 2001-09. Singh (2008) studied the relationship between Indian Ocean dipole Mode Index (IODMI) and the frequency of cyclones over Bay of Bengal. He found that IODMI during September-October is negatively correlated (r = -0.4; significant at 99% level) with the frequency of cyclones during November. In this study an attempt has been made to examine the relationship between Sea surface Temperature (SST) and Total Number of Cyclones (TNC) (depressions + cyclones + severe cyclones) during post-monsoon (October-December) season over Bay of Bengal.

2. In this study, the relationship between TNC and the SST in the northern Australia-Indonesia region (5° S - 15° S : 120° E - 160° E : (Box A) and Bay of Bengal (5° N - 15° N : 85° E - 100° E; (Box B) (Fig. 1), has been examined using the long term data of 123 years (1891-2013). The SST in Box A was used earlier to examine the relationship with the SO (Nicholls, 1984). Data on TNC during post-monsoon season have been taken from IMD (India Meteorological Department) web site, www.imd.gov.in., for the above period. Extended Reconstructed (ER) SST (version3b) data at 2° × 2° grid (Smith *et al*., 2008) in September are downloaded from the website, www.iridl.ldeo.columbia.edu and the average values in both the Boxes (A&B) are used in the computations. High resolution (0.25° × 0.25°) daily OI (Optimum Interpolation) SST (Reynolds *et al*., 2007) during September month in Box A are also used to compute the correlations (daily).

3. Using the above data sets, 18 year sliding correlations of TNC with the SST during September in Boxes A&B (Fig. 1) are computed for the period, 1891-2013. Daily correlations between averages SST in Box A on each day of September month and TNC are computed using OISST for the recent period, 1996-2013. For example, SST on 1st September of the all years is correlated with the TNC. This has been repeated for all the 30 days in September month. To remove the trends in the time series, the first differences are normally used to compute the correlations (Nicholls, 1984). Following this methodology, the correlations with the first differences (current year minus previous year) in SST (average during 18-25 September in Box A and TNC differences (current season minus previous season) are computed. The results are presented in Figs. 2 to 4.

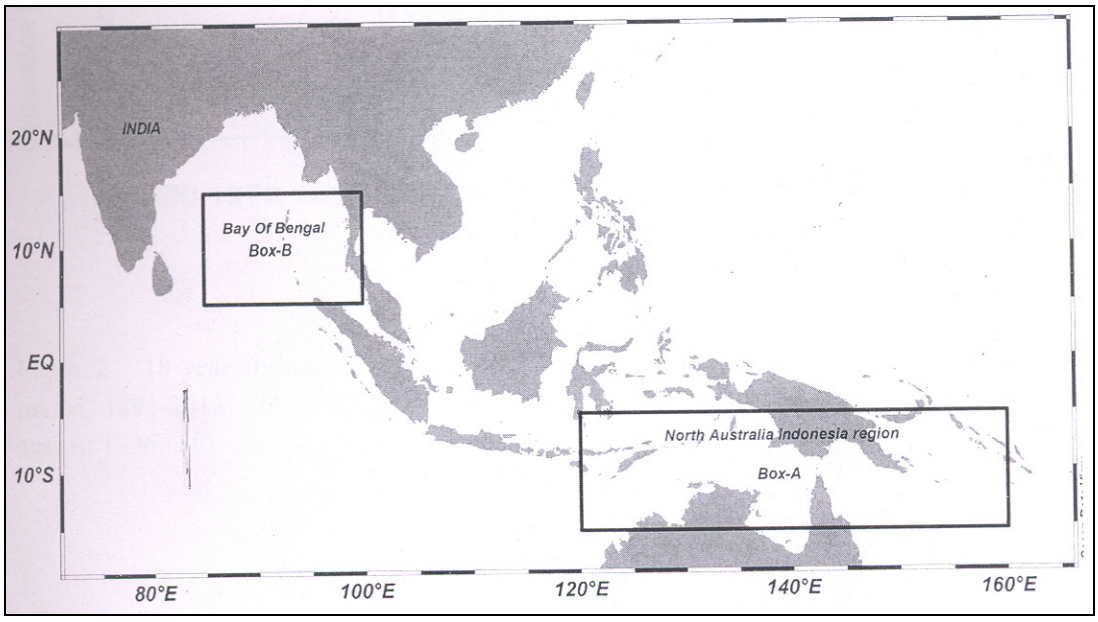


Fig. 1. Study area (Box A : 5° S - 15° S; 120° E - 160° E) (north Australia Indonesia region) and Box B (5° N - 15° N; 85° E - 100 °E) (Bay of Bengal)

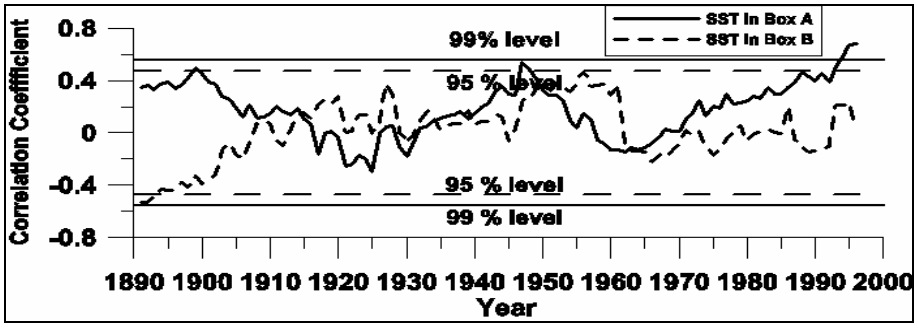


Fig. 2. 18 year sliding correlations of TNC with September SST in Box A & Box B during the period, 1891-2013. The value shown against 1891 represents the period, 1891-1908 and the last value against 1996 is for the recent period, 1996-2013. Significance levels (95% & 99%) are shown as dashed lines. (Box A: average SST during September in the region ,0-5° S; 120° E-160° E; Box B:average SST during September in the region , 5° N-15° N: 85° E-100° E)

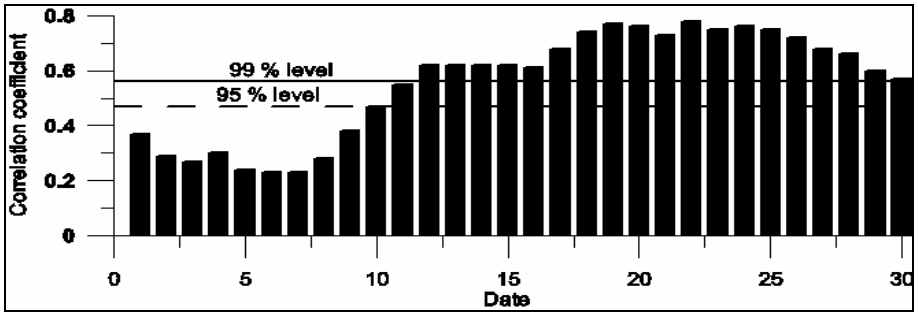
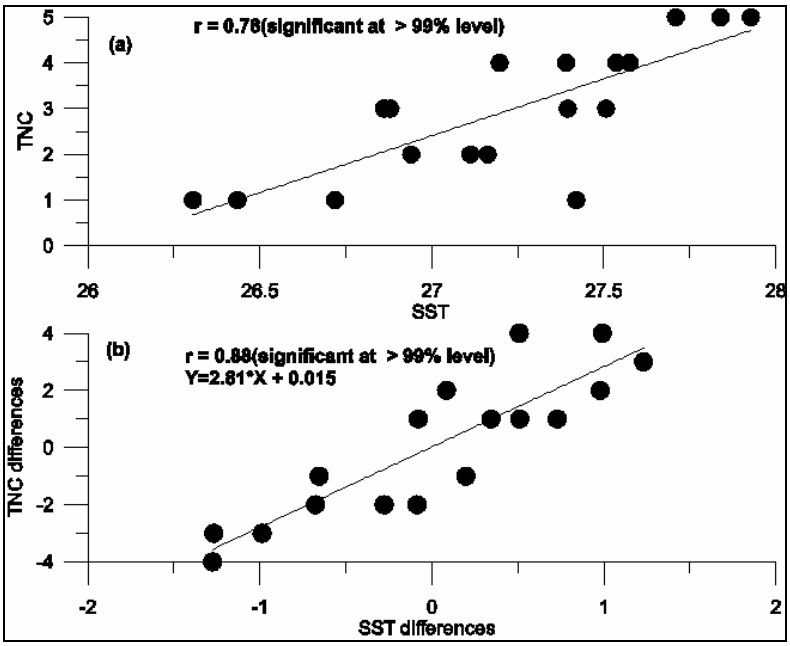


Fig. 3. Correlations of TNC with the daily OISST during September in Box A. Significance levels (95% & 99%) are shown as dashed lines



Figs. 4(a&b). Scatter plots between (a) TNC *vs* average SST during 18-25 September in Box A (actual values) and (b) with the first differences (current year minus previous year)

4. The correlations between September SST in Box A and TNC are positive and significant at 95% level during 1899-1916, 1947-65 and 1988-2005. They are high from 1993 onwards and the maximum correlation of 0.68 (significant at > 99% level) is observed during the recent period, 1996-2013. Surprisingly, the correlations between September SST in Box B (Bay of Bengal) and TNC are weak throughout the period except during 1891-1910, 1956-73 in which negative and significant correlations are observed (Fig. 2). The relationship has been tested with. the daily OISST in Box A during September. An increasing trend in the correlations is observed from 10th September onwards and the peak value of 0.78 is observed on 22 September. During 18-25 September, the correlations varied from 0.74 to 0.78 (Fig. 3). Hence, the average SST during 18-25 September in Box A (actual) and the first differences are used to correlate with TNC (actual & differences) and the results are shown in Figs. 4(a&b). The correlation with the actual values is 0.78 [Fig. 4(a)] while a remarkably high correlation of 0.88 (explains 77% variability) was noticed with the differences [Fig. 4(b)]. The regression equation from Fig. 4(b), is $Y = 2.81^* X + 0.015$, where X is the differences (present year minus previous year) in average OISST during 18-25, September in Box A (north Australia Indonesia region) (Fig .1) and Y is the TNC differences (present year minus previous year) over Bay of Bengal during post-monsoon (October-December) season., for the period, 1996-2013. During the year 2014, the estimated TNC from this method is 3 while the actual was 2. (www.imd.gov.in). The above SST is strongly correlated (r = 0.95) with the SST during October-December in Box A which has a very close relationship (r = 0.84) with the SOI. It appears that the SST during 18-25 September in the north Australia- Indonesia region (Box A) influencing the genesis of cyclones over Bay of Bengal and found to be useful to predict TNC prior to the season. Further improvement with additional predictors and the physical mechanism behind this relationship will be reported in a separate study.

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