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***Research Article***

# INFLUENCE OF TELECONNECTION FACTORS ON NORTHEAST MONSOON RAINFALL OF TAMIL NADU

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## ABSTRACT

In the present study 110 years (1900-2010) data is used for studying correlative effects between North-East Monsoon Rainfall (NEMR) (October –December) rainfall over Tamil Nadu with Indian Ocean Dipole Mode (IODM), Southern oscillation index (SOI), Sea surface temperature(SST) and Outgoing Long wave radiation(OLR). We compute the correlation coefficients using Spearman Rank technique. Correlation between July month IODM of Nino-3 region and NEMR over a period of 110 years is 0.238. i.e., for a positive phase IODM the NEMR is enhanced and for a negative phase IODM the NEMR is depressed. The correlation between SOI and NEMR is found to be -0.35, i.e. for a positive phase SOI the NEMR is depressed and for a negative phase IODM the NEMR is enhanced. NEMR is higher during negative SOI. These statistics show that in El Nino (La Nina) condition of boreal summer season is related to the wet (dry) NEMR over Tamil Nadu. Correlation between OLR and NEMR is found to be -0.275 indicating a negative correlation.

***Key Words:*** *Correlation – Indian Ocean Dipole Mode - Southern oscillation index - Sea surface temperature - Outgoing Long wave radiation –northeast monsoon –Spearman's.*

## INTRODUCTION

Over major parts of the Indian subcontinent, the southwest summer monsoon period (June to September) is the principal rainy season. However, during the autumn, the zone of maximum rainfall migrates to southern most India. Hence, the main season of rainfall over the southern parts of India is the northeast monsoon (October to December). This season is also termed as the retreating (southwest) monsoon season or the post-monsoon season. The rainfall in this season determines the agricultural production in this area. A considerable decrease in agricultural production over this region has been noted during seasons of below-normal northeast monsoon rainfall (Rao Krishna and Jagannathan, 1953). Tamil Nadu, located in southeast peninsular India, receives the major part of its annual rainfall during the northeast monsoon season. Coastal Tamil Nadu receives about 60% of its annual rainfall and interior Tamil Nadu receives about 40-50% of annual rainfall during northeast monsoon (India Metrological department, 1973). In comparison with Indian summer monsoon, the Northeast monsoon is characterized by limited aerial extent and average lesser rainfall amount. The northeast monsoon, which is a part of the northeast trades is dry, stable and of lesser vertical extent, about 1 to 2 Km. During northeast monsoon season, Tamil Nadu generally receives rainfall due to the formation of tough of low, cyclonic circulation, easterly waves, low pressure area, depression and cyclonic storm over Bay of Bengal, because, the northeast monsoon season is the major rainy season.

The Indian Ocean (IO) surrounds the southern part of India. Since a considerable amount of moisture comes from the oceans, it is reasonable to assume that the sea-surface temperature (SST) anomalies and wind over the oceanic area would have a marked influence over the weather and climate of India and Sri Lanka (Suppiah 1988). The relationship between the October–November rainfall over Sri Lanka and the SST anomalies over the IO is positive and significant. Recent studies (Saji et al 1999,Webster et al 1999) have pointed out that a unique ocean–atmosphere mode exists in the IO, with anomalous warm SSTs over the western IO and anomalous cold SSTs in the eastern IO. This mode induces an unusual rainfall distribution in the surrounding areas, and is termed the IO Dipole Mode (IODM). This dipole mode modulates the *Maha* (September–October) rainfall over Sri Lanka (Saji and Yamagata 2003 a, Zubair et al 2003), which lies at the middle of the dipole. Since the southern part of India is also situated approximately near the centre of this mode, and since the mode peaks in the September–November period and the rainfall peaks in the October–December period, i.e. both peak during boreal autumn with a lag of 1 month, it is logical to expect the influence of this dipole mode on NEMR variability. Hence, the influence of the IODM on extreme NEMR is examined by correlation and composite analysis.

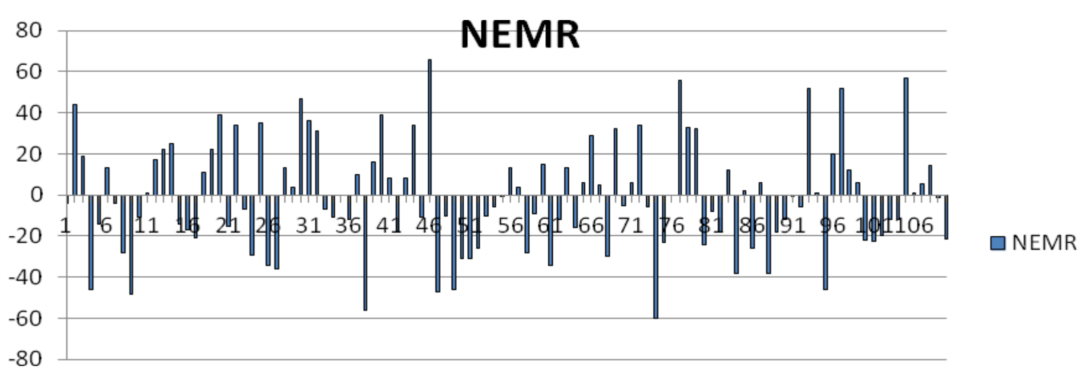


Fig1: North East monsoon rainfall of Tamil Nadu

The circulation and SST features associated with the active dipole phases and the extreme monsoon phases are determined. A comparison is made to ascertain whether a particular dipole phase has any bearing on the extreme monsoon phase. Cold SST anomalies near the Sumatra coast and in the eastern IO, and warm SST anomalies in the region of central and western IO, are associated with the positive phase of the dipole. The contrast between the SST anomalies over the western and eastern IO is obvious. Thus, the anomalous westward low-level winds in response to the anomalous zonal gradient of SST will increase the moisture transport towards Tamil Nadu and enhance atmospheric convection. For the negative IOD phase, warm SST anomalies over the southeast IO and cold anomalies over the western IO are seen. These composites also show significant differences over the western and southeast IO. However, the contrast between the SST anomalies over the two poles is less steep compared with the positive phase. Put together, clearly reveal that the east–west SST anomalies in the IO are coupled to the atmospheric circulation (Saji et al 1999,Webster et al 1999, Saji and Yamagata 2003 b).

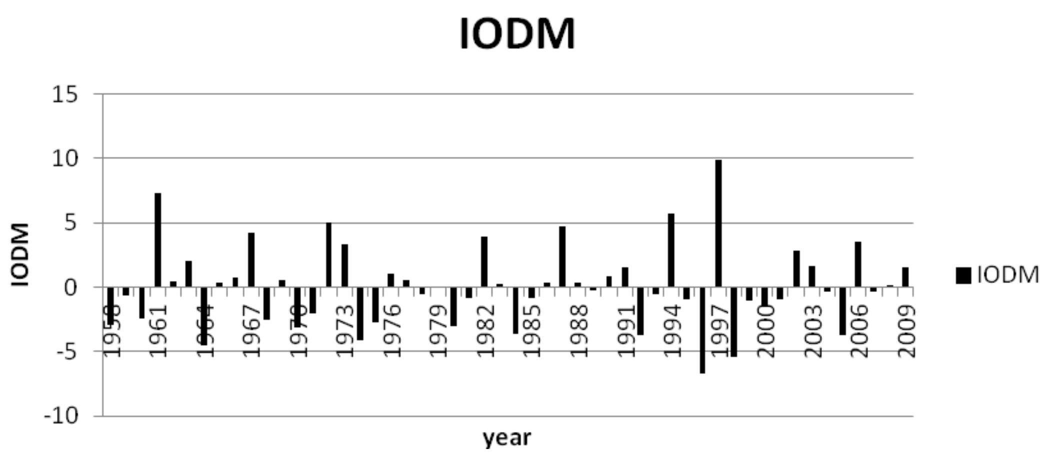


Fig2: IODM pattern for the NEMR

These changes in the SST cause local air–sea interactions in the region. Thus, this anomalous coupled ocean–atmosphere phenomenon generated over the tropical IO could produce atmospheric and oceanic changes and influence the regional climate conditions. The results exhibited that NEMR of Tamil Nadu had the positive correlation with Nino-3 SST for the month of July indicating that whenever there is raise in sea surface temperature in Nino-3 region, there is an increase in NEMR and vice-versa.

Distribution and the amount of NEMR is influenced by various parameters including El-Nino- Southern Oscillation (ENSO). There are several studies, which have examined the relation between Southern

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Oscillation Index (SOI) and Indian summer monsoon rainfall that occur between June and September months (Sikka 1980, Rasmusson and Carpenter 1987,Shukla and Paolino 1983, Parthasarathy and Panth 1985,Ropelesuski and Halpert 1987, Mooley 1997). According to the previous studies which investigated the relationship between ENSO and global precipitation signals (Ropeleswski and Halpert 1987 and 1989, Curtis et al 2001), most part of India has less (more) rainfall during ENSO (La Nina) years. In contrast to this, the southernmost part of India shows opposite signals which tend to have wet anomalies during the ENSO (SOI negative) years.

Recent investigations on the relationship with SOI and Nino-3 SST on NEMR of Tamil Nadu concludes that the SOI is negatively correlated with NEMR in Tamil Nadu and Nino-3 SST is positively correlated (Geethalakshmi et al 2003) which imply that autumn-winter precipitation over Tamil Nadu is influenced by the global climatological signals. Recently, Zubair and Ropelewski (2006) pointed out the relationship between ENSO and NEMR is strengthening. Since length of growing period and distribution of rainfall during Northeast monsoon season is important for agricultural production over Tamil Nadu (Geethalakshmi et al 2002), detailed analysis between global signals to the local precipitation is necessary for crop planning activities. The SOI pattern is shown in fig 3.

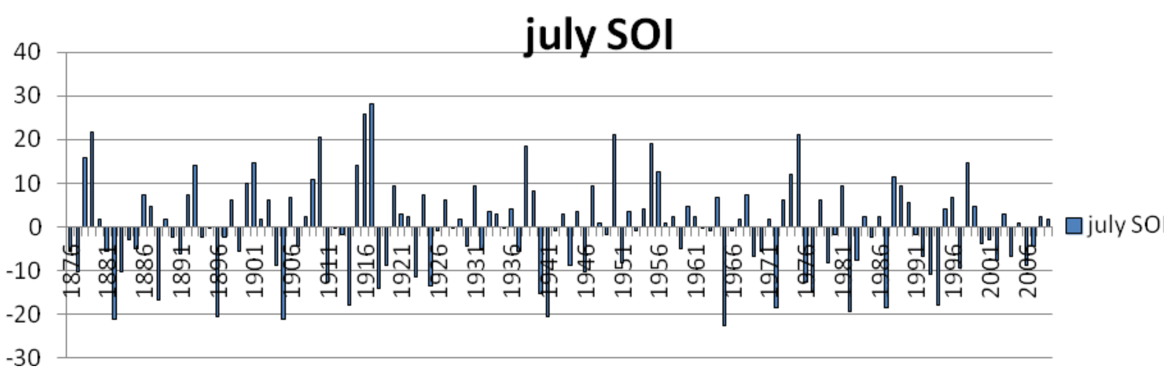


Fig 3: SOI pattern

July month SOI values above +10 and below -10 were assumed as extreme SOI conditions, and their impact on corresponding year NEMR was studied. In the 110 year study period, there were 16 extreme negative and 14 extreme positive SOI conditions prevailed in the month of July. Normal NEMR averaged over the study period is 481 mm. Average rainfalls received during the extreme negative July SOI condition is 566 mm which is 17.7 % more than the normal NEMR and that of the extreme positive condition is 395 mm which is 17.9 % less than the normal NEMR. Under negative extreme condition, only in 2 out of 17 events recorded lesser than average NEMR. This indicates a shift towards wetter (drought) conditions in relation to the extreme negative (positive) SOI in July over Tamil Nadu region.

OLR estimates have been made since June 1974 from the window channel measurements of the operational National Oceanographic and Atmospheric Administration (NOAA) polar-orbiting satellites (Gruber and Winston 1978, Gruber and Krueger 1984). These estimates have been used extensively in meteorological studies, both as one component of the radiation balance of the atmosphere (Ohring and Gruber 1982) and to infer changes in the amount and height of clouds. In particular, the dominant role of clouds in determining OLR over the Tropics has led to extensive use as an indicator of convective activity, and its broad spatial coverage and long period of record have made it invaluable in investigating atmospheric phenomena with a variety of temporal and spatial scales. Morrissey (1986) analyzed the relationships among the OLR, precipitation, and moisture budget over the tropical Pacific and found that daily OLR correlates negatively and significantly with precipitation over tropical areas where deep convection dominates. Motell and Weare (1987) related the total OLR flux to precipitation as observed by gauges at carefully selected islands over the tropical Pacific and developed a linear statistical model to estimate monthly precipitation from total OLR flux. Weare (1987) applied this model to produce gridded fields of monthly precipitation over the tropical Pacific for the 10-yr period from June 1974 to February 1984 and used them to investigate the relationship between precipitation and SST. Yoo and Carton (1988) estimated total precipitation over the tropical Atlantic Ocean from OLR for the period 1983–84. Arkin (1984) investigated the relationship between seasonal mean OLR and gauge-observed precipitation for 2.58 lat–long grid areas over the tropical Pacific and found that 57% of the variance in the total seasonal precipitation could be explained by a linear function of the mean OLR.

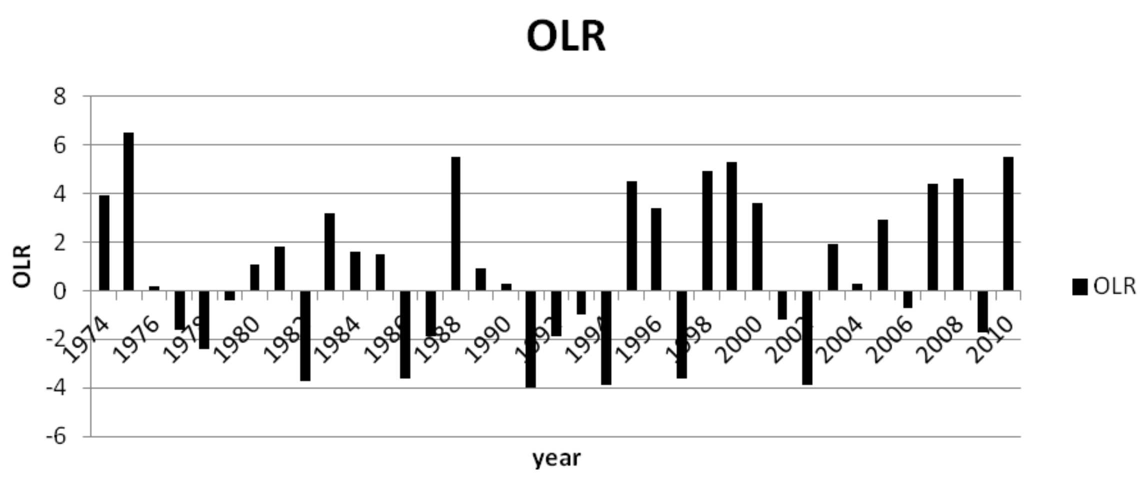


Fig 4: OLR pattern for standardized data

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**RESEARCH METHODOLOGY**

The spearman rank correlation coefficient is a Pearson correlation calculated from ranks replacing scores. We present the Spearman Rank-order correlation coefficients computed between the southwest and the northeast monsoon rainfall. This method (Press et al. 1992) of finding the correlation between two variabilities is more robust than the usual method (i.e., by linear correlation). The spearman method first determines the rank order of the sample values of each of the two variables X and Y separately. Then, it transforms the original N ordered pairs of scores to N ordered pairs of ranks. The ranks of the X scores comprise all integers from 1 to N, and similarly for the Y scores. This procedure makes it possible to derive a simple computational formula based on a sum of squared differences between ranks

$$\rho = 1 - 6\Sigma D^2 / N(N^2-1)$$

Where $D = R_x . R_y$ , the difference between ranks corresponding to X and Y.

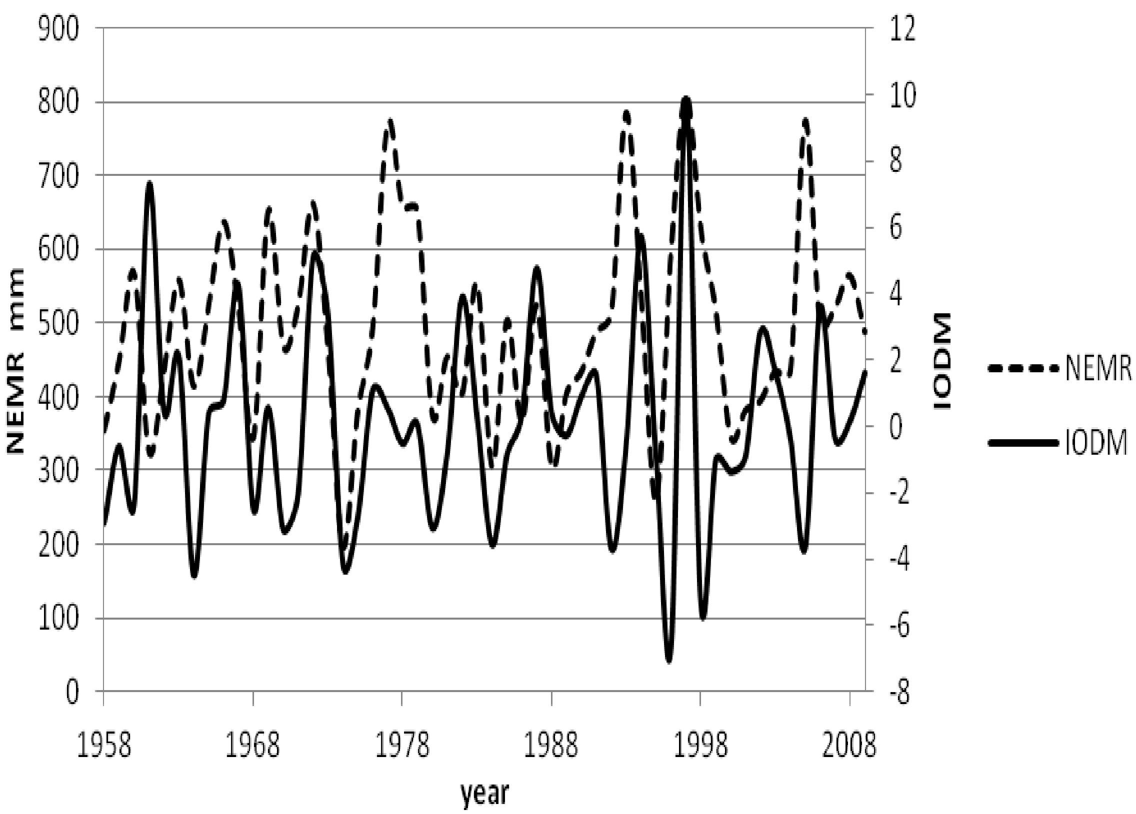


Fig 5: Relation between IODM and NEMR of Tamil Nadu.

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**DATA**

We consider 110 years (1901-2010) data of the southwest and northeast monsoon rainfall over Tamil Nadu. The above data is obtained from the Regional Meteorological Centre, Chennai. The Southern Oscillation Index (SOI) and Indian Ocean Dipole Mode (IODM) indices were compiled by the Bureau of Meteorology, Australia. The period of the data sets of rainfall, IODM and SOI used for this study are 100 years (1901 - 2010). Sea Surface Temperature (SST) Nino3 (150W-90W, 5N-5S were used in this study. The OLR data used here are derived from window channel measurements of the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA operational sun-synchronous polar-orbiting satellites.

**RESULTS**

Correlation between July month IODM of Nino-3 region and NEMR over a period of 110 years is 0.238, i.e., for a positive phase IODM the NEMR is enhanced and for a negative phase IODM the NEMR is depressed shown in fig 5

The correlation between SOI and NEMR is found to be -0.35, i.e. for a positive phase SOI the NEMR is depressed and for a negative phase IOD the NEMR is enhanced as shown in fig 6. NEMR is higher during negative SOI. These statistics show that in El Nino (La Nina) condition of boreal summer season is related to the wet (dry) NEMR over Tamil Nadu. The correlation between OLR and NEMR is found to be -0.275 shown in fig 7.

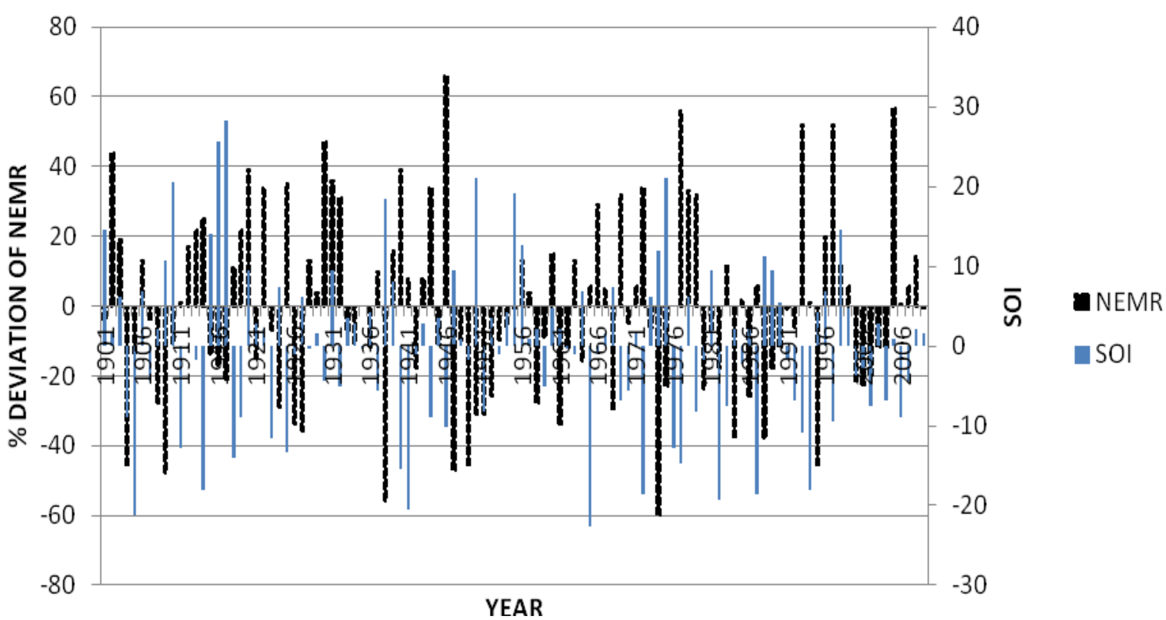


Fig 6: Relation between percent of deviation of NEMR with SOI

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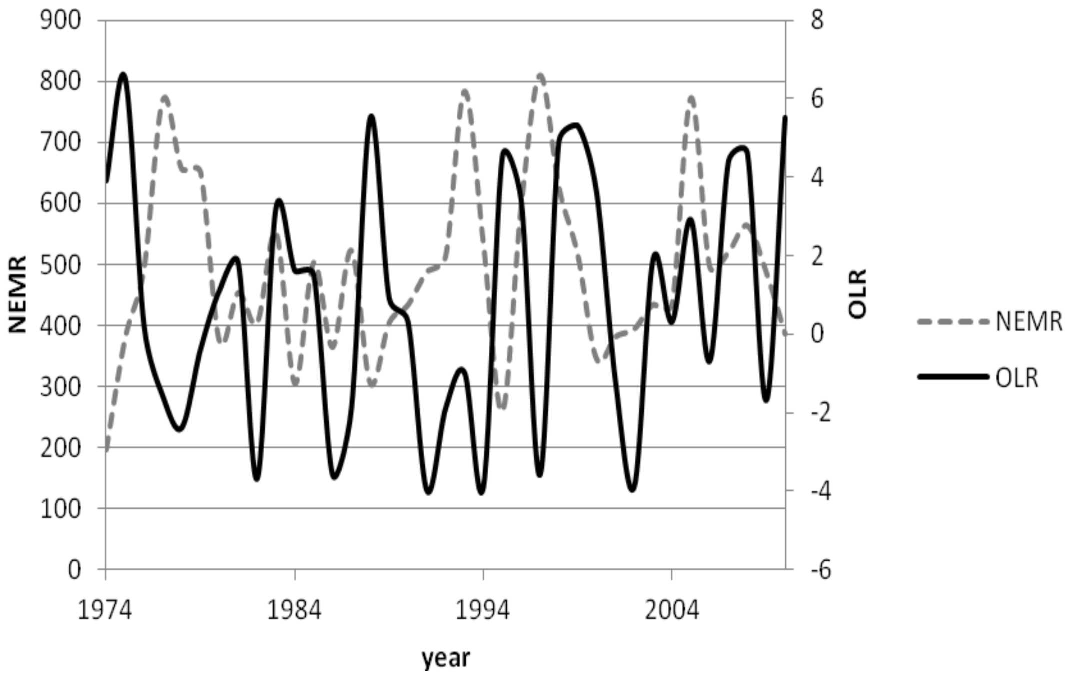


Fig 7: Relation between OLR and NEMR of Tamil Nadu

**Conclusion**

The inter-annual variability of NEMR shows random fluctuations, the decadal variability shows alternate epochs of above- and below-normal rainfall. The epochs tend to last for a decade or two. No long-term trends are detected. The decadal variability of the dipole mode clearly reveals an increasing trend. From the above study it could be concluded that IOD, SOI, Nino-3 SST and OLR are having significant influence on NEMR. The NEMR rainfall variability appears to be enhanced during the decades when the dipole is active and suppressed during the decades when the dipole is inactive. Among different months, July month SOI and Nino-3 SST has significant relationship with NEMR. July SOI is negatively correlated with the NEMR and the extreme negative SOI (El Nino years) resulted in wetter than average conditions during NEMR. The strengthened NE monsoon brings much moisture and precipitation to the Tamil Nadu region in the El Nino years. The opposite case is also true. A strong negative anomaly is observed in the Bay of Bengal during the La Nina years (SOI > 10), which resulted in weak NE monsoon.

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