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Statistical Method of Predicting the Northeast Rainfall of Tamil Nadu

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Abstract:
Over the last few decades, several models have been developed, attempting the successful forecasting of rainfall in India. Before going into robust methods, it is always healthy to analyze the recorded data. This paper presents the use of statistical techniques: multiple linear regression method in modeling the rainfall prediction over Tamil Nadu. The rainfall data for a period of 110 years was obtained from Indian Meteorological department, Chennai. The other parameters used to predict the rainfall was Outgoing long wave radiation, global temperature and sunspot numbers. The percentage error estimated was 15%. Thus the Outgoing long wave radiation, global temperature and sunspot numbers can be used as firm predictors of rainfall in other techniques like artificial neural network, GCM, etc. Thus this paper aims at determining the best predictors for forecasting the Tamil Nadu rainfall using statistical method.

Keywords: Monsoon Rainfall, Multiple Linear Regression, Outgoing Long Wave Radiation, Global Temperature, Sunspot Number

1.0 Introduction:
Tamil Nadu, located in southeast peninsular India, receives the major part of its annual rainfall during the northeast monsoon season (the three-month period from October to December). 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. 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 vicissitudes of the rainfall of Tamil Nadu state has led to considerable and widespread interest among the public, farmers as well as in government circles in recent years, in view of the frequent failure of northeast monsoon rainfall over Tamil Nadu.

There are several papers and documents to explain the relation between OLR and Northeast monsoon rainfall. The inter-annual variation of the outgoing long-wave radiation for the summer monsoon period showing a close association with the large-scale monsoon rainfall over India has been mentioned by Prasad and Verma (Prasad and Verma, 1985). They have concluded that the satellite-derived outgoing long-wave radiation can be used to monitor more comprehensively, the large-scale monsoon circulation and its year-to-year variability, in view of its spatial coverage over oceanic areas. Prasad and Bansod have found the relationship between averaged OLR for west central India and the Indian summer monsoon rainfall to be stable (Prasad and Bansod, 1964).

The inter-annual variability of Indian summer monsoon rainfall and Northeast monsoon rainfall is determined by external forcings and nonlinear internal dynamics. Surface air temperature is one of the factors that influence monsoon variability. The distribution of surface air temperature over land and sea determines the locations of heat source and sink which in turn affect circulation patterns through thermal and latent heat energy exchange between atmospheres and the surface beneath. A number of studies addressed the relationship between Indian summer monsoon and land and sea surface temperatures (Sikka, 1980; Verma. Et al, 1985). Many studies (Rajeevan.et al, 1998; Pai, 2003) examined the global land surface air temperature anomaly patterns in association with inter annual variability of Indian summer monsoon rainfall. Balachandran et al (2006) suggested that, in the correlation coefficient patterns, the positive correlation coefficient regions indicate that when the surface air temperature over these areas are warmer (cooler) than normal when the northeast monsoon is above (below) normal (Balachandran et al,2006). Similarly, the negative correlation coefficient regions indicate that the surface air temperatures over these areas are cooler (warmer) than normal when the northeast monsoon rainfall is above (below) normal.

Sun is the primary source for all activities of earth atmospheric system. If there is any variation in solar output, it affects the generation of cloud condensation nuclei or wind pattern or droplet growth size. Samuel Selvaraj et al found that the linear correlation between sunspot activity and Tamil Nadu annual rainfall is -0.21, which is significant at 1% level, but it is able to explain the 5% of variations in rainfall. Regression estimation, which is made for Tamil Nadu annual rainfall, using sunspot activity by a quadratic regression equation, is able to explain about 75% of the variations in annual rainfall of Tamil Nadu (Samuel Selvaraj et al, 2009).

2.0 Methodology:

Multiple linear regression (MLR) is a method used to model the linear relationship between a Predictand (dependent variable) and predictors (one or more independent variables). This model is based on least squares and it is widely used in dendroclimatology for developing models to reconstruct climate variables from tree-ring series. The regression model is applied to generate estimates of the predictand variable outside the period used to fit the data. The uncertainty in the reconstruction is summarized by confidence intervals, which can be computed by various alternative ways.

Regression has long been used in dendroclimatology. Some examples of dendroclimatic studies using linear regression are:

- Reconstruction of annual precipitation in the Pacific Northwest (Graumlich, 1987);
- Reconstruction of runoff of the White River, Arkansas (Cleaveland and Stahle, 1989);
- Reconstruction of an index of the El Nino Southern Oscillation (Michaelsen, 1989) and
- Reconstruction of a drought index for Iowa (Cleaveland and Duvick, 1992).

The predictors in any regression problem might be inter-correlated. This so-called multi-co-linearity does not preclude the use of regression, but can make it impossible or difficult to assess the relative importance of individual predictors from the estimated coefficients of the regression equation. The MLR model is reviewed below, with emphasis on topics of particular interest for time series. More detailed information can be found in many standard references – for example, a statistical text on regression (Weisberg 1985), a chapter on regression as applied to the atmospheric sciences (Wilks 1995) and a monograph on regression in a time series context (Ostrom, 1990).

$$\mathbf{Y = a + b_1X_1 + b_2X_2 + \ldots + b_kX_k} \pm \varepsilon$$

$$\mathbf{Y = a} + \sum_{i=1}^{k} \boldsymbol{b_i X_i} \pm \boldsymbol{\varepsilon}$$

Where

Y= Northeast rainfall of Tamil Nadu
a= regression intercept
b1, b2 = regression coefficients
X_1, X_2, X_3 = Predictors considered

2.1 Data:

The OLR for the period of 1974-2009 and sunspot activity data is collected from the National Geophysical Data centre, Colorado, USA at ngdc.noaa.gov.in. The Global temperature and Rainfall data of Tamil Nadu is collected from Indian Meteorological Department.

3.0 Results:

A multiple linear regression method was adopted to predict the northeast rainfall for Tamil Nadu. Figure 1 shows the actual and predicted rainfall graph of northeast Tamil Nadu. Using multiple linear regression, the results were verified for the 2007, 2008 and 2009 years and are shown in table 1 below. Hence, it is concluded that the above model can be used for predicting Northeast monsoon of Tamil Nadu.

Table 1: Actual and predicted rainfall value for 2007, 2008 and 2009

Year	2007	2008	2009
Observed	521	564	488
Calculated	443	484	418
Percentage Error	14.97%	14.18%	14.34%

4.0 Conclusion:

The atmosphere is very much chaotic by nature and no prior assumptions can be made while developing any models for chaotic atmospheric processes. In this paper we have illustrated the Multiple Linear Regression method to predict Tamil Nadu northeast rainfall. We have used the Outgoing long wave radiation, global temperature and sunspot numbers as the predictors for the rainfall.

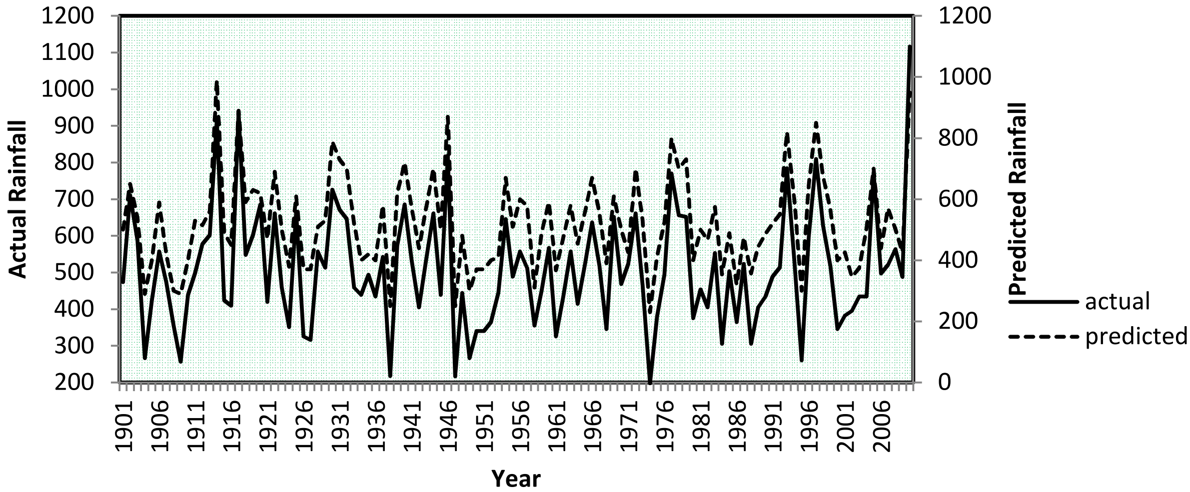

Figure 1: Graph for Actual Rainfall Value and Predicted Rainfall Value of Tamil Nadu

The percentage error was calculated to be 15 %. Thus we can use the statistical method to choose the right predictor for the predictant for use in various rainfall models. The percentage errors of prediction from the three inputs multiple linear regression models are computed for Tamil Nadu rainfall.

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