ABSTRACT

Rainfall is the key variable that governs the socio-economic conditions of an agrarian region like the North-East (NE) India. This region is the home to diverse biota and is known not only for the richness in biodiversity, but also for the varieties of rice germplasm. The rainfed agriculture of NE India is flourished due to its uniqueness in the physiography, with the Brahmaputra-Barak system of rivers and southeast monsoon providing the shelter to livelihood. However, in a changing climate scenario, along with the increasing development pressure, there is the possibility of this region to face vulnerability in near future. Literatures present the accounts of changing nature of precipitation in global as well as regional scale. Increase in the extreme events associated with rainfall are projected for a long run. Therefore, an understanding of the features in rainfall and the associated characteristics is imperative, so that the possibility of the severity in extreme events in near and far future could be tackled and reduced. To address these points, this thesis work is aimed to evaluate the characteristic features in rainfall and its inter-relationship with selected meteorological variables with the following objectives:

1) To characterize significant trends, present in the times series of rainfall and other meteorological parameters in NE India.
2) To characterize the significant spectral components and associated physical processes present in the time series of rainfall and other meteorological parameters.
3) To examine the behaviour of the time series of rainfall and other meteorological parameters using linear statistical processes.
4) To develop multi-resolution model to examine the inter-relational sensitivity among meteorological parameters and rainfall for NE India.

The present thesis is organized as follows:

Chapter 1 presents a brief introduction to the study pertaining to several available literatures in global as well as regional context from past. The objectives of the thesis are included in this chapter.

Chapter 2 describes the details of the study area and the data used in the present thesis. Daily time series on six meteorological variables, viz. rainfall, maximum and minimum temperature, relative humidity, sea level pressure and wind speed were acquired for five representative stations of the NE India from 1969-2017, depending on data availability and adequacy. These locations were- Cherrapunji (Meghalaya state), Dibrugarh and Guwahati (state of Assam), Kailashahar (state of Tripura) and Tulihal (Manipur state). The daily time series data were transformed into monthly, seasonal, or annual series as per the desired analyses. Necessary pre-processing techniques were also performed. A detailed account of these techniques is also described here.

Chapter 3 discusses the 1st objective of this study. The identification and characterisation of significant trends present in the rainfall as well as the other selected meteorological time series for the selected locations of NE India are elaborated with the help of Sens'slope estimator and Mann-Kendall tests. Four homogeneity tests were performed on the time series data prior to trend analysis, to separate out the artificially induced trends because of inhomogeneity. It was found that rainfall exhibited significant declining trends in the monsoon season for some of the regions, while an increase in rainfall was observed in the pre-monsoon rainfall across the study areas. Inhomogeneity was observed in the other meteorological parameters across majority of the selected locations other than rainfall. The presence of significant trends in these non-homogeneous series indicates to the artificially induced shifts.

Chapter 4 deals with the detection of the spectral components, their characterisation and the associated physical processes present in rainfall and other meteorological parameters for the selected locations of NE India. The dominant periodicities were identified from the power spectral density estimation. Annual and a half yearly periodicity were detected in all the meteorological parameters across the studied locations. High degree of association of rainfall with different meteorological parameters in terms of coherence was also noticed in these periodicities. Apart from this, 2-3 months periodicities of relatively lower power were present in some locations. Phase-coherence association of rainfall with different meteorological parameters reveal anti-phase association in the annual periodicity of strong coherence. However, no definite pattern could be revealed regarding the leading or lagging parameters.

Chapter 5 presents a study on behaviour of rainfall time series for the selected locations of NE India using statistical processes. The ACF and PACF plots reveal the presence of seasonality in the original time series. ARIMA method was then applied following a first order differencing to find out the best-fit model among 24 ARIMA built models for different meteorological variables, among which it could be seen that The model ARIMA(2,1,4) was best fit in most of the cases (7), followed by ARIMA(4,1,4). The ARIMA best fit models were used in forecasting the meteorological series, however, the results were not promising. Application of Seasonal ARIMA models instead of ARIMA models are therefore suggested in forecasting the meteorological parameters in NE India.

Chapter 6 provides the link between objective 3 and 4. Here singular spectrum analysis is performed to detect the components of rainfall time series and wavelet analysis to detect the oscillatory components constructing the rainfall time series in both time-frequency domain. It could be seen the trend component contributes the highest percentage (>45%) in construction of rainfall time series, followed by the annual periodic component in NE India. The chapter also includes the inter-association of rainfall with other meteorological variables with the help of wavelet cross-spectrum and wavelet coherence. Strong significant association of rainfall with different meteorological variables can be observed in the periodicity band of 8-12 years. Intermittent strong associations in both high and low frequency bands also exist. Wavelet decomposition provided the differentiation of the time series into different resolutions, which are further used in developing a multi-resolution model with vector autoregression and impulse response technique, which is described in the next chapter.

Chapter 7 discusses the inter-relational sensitivity of rainfall with different meteorological variables with the application of VAR-IRF approach, coupled with wavelet. In this study the sensitivity of rainfall towards changes in different resolutions of other meteorologic parameters are studied. It was evident that the response of rainfall upon changes to each of these different resolution's series per variable could last for 5-12 months of initial application of shocks. The initial response by rainfall in most of the cases are sharp in either negative or positive way, but the response dies off soon.

Finally, the conclusion of the present study is presented in chapter 8.