Spectral Signatures in Rainfall and Its Inter-Relationship with Other Meteorological Variables in North-East India

A thesis submitted in partial fulfilment of the requirements for award of the degree of

Doctor of Philosophy

Parashmoni Borah

Registration No.: TZ132875 of 2013

SCHOOL OF SCIENCES

DEPARTMENT OF ENVIRONMENTAL SCIENCE

TEZPUR UNIVERSITY

NAPAAM, TEZPUR-784028

ASSAM, INDIA

DECEMBER 2022

CHAPTER 8

Conclusion

Chapter 8

Conclusion

The present study aims at finding the characteristics features of the rainfall time series over selected regions of NER, namely Cherrapunji (CHR), Dibrugarh (DBR), Guwahati (GHY), Kailashahar (KSH) and Tulihal (TUL) mainly in the spectral domain. The association of rainfall with various meteorological parameters, viz. temperature (MaxT and MinT), RH, SLP and WS were also investigated. The inter-relational sensitivity of rainfall towards changes in different resolutions of the other meteorological time series as decomposed via wavelet technique was explored also.

The salient findings from each objective are described below.

In Chapter 3 a detailed trend analysis of all the meteorological parameters is presented. Homogeneity tests were applied prior to trend testing. It was found that the annual and seasonal rainfall in NER is homogeneous in nature. As evident from the trend analysis results, the annual rainfall was significantly decreasing at DBR (UBV), while at three locations (CHR, KSH and TUL) it had been found increasing, though the increase was insignificant. In seasonal analysis of rainfall, it came to notice that the winter rainfall at DBR, GHY and TUL was declining. The decrease in winter rainfall was significant at DBR, which may be the cause for the declining annual rainfall at this site. The pre-monsoonal rainfall at all the sites of NER was increasing, and among them the increasing trends at GHY and TUL were significant. To the opposite, monsoonal rainfall in most of the sites of NER (CHR, DBR and GHY) was found to be declining and this decline was significant at DBR and GHY. Rainfall during the post-monsoon season was also declining in NER but this decline was insignificant. The presence of significant declining trends in the seasonal homogeneous series at certain locations may point to the impact of climate change on rainfall. Other than rainfall, inhomogeneity was observed in the other meteorological parameters across majority of the selected locations. The presence of significant trends in these non-homogeneous series thus indicates to the artificially induced shifts.

In Chapter 4 the spectral features of rainfall and other meteorological parameters were detected with the aid of FFT. From the power spectral density (PSD) estimation, it was observed that the monthly rainfall across all the selected study areas exhibited a strong annual periodicity. This periodic component was evident in the other parameters also, except WS. In case of WS, the PSD plots revealed the presence of a long-term trend towards the low frequency regions across all the sites. Another 6 months periodicity was also inherent in rainfall (CHR and DBR), MaxT and MinT (all locations), RH (all locations) and SLP (CHR). In case of RH, the half yearly periodicity was stronger as compared to the other meteorological parameters. 2-4 months periodic fluctuations were also evident in RH. The coherence analyses that were performed to view the association of rainfall with the other parameters in frequency domain, revealed that the association was strong (close to 1) in the annual periodicity of 12 months with all the meteorological variables over NER. Other than that, mild association (0.4-0.6) was evident in the coherence plots for MaxT and rainfall at all the locations, MinT and rainfall at GHY, RH and rainfall at CHR and DBR (2-3 years periodicity). The association of the variables and rainfall followed a long tail feature in either increasing/decreasing pattern across different sites, as evident in the coherence plots, which may be the manifestation of the effect of low frequency noise present in the time series. However, no clear phase-coherence association could be evident from the phase plots.

In Chapter 5 the behaviour of all the meteorological variables was studied with the help of ARIMA. It was observed that the all-time series were non-stationary in nature, with the presence of inherent seasonality (6 and 12 months) as evident form the ACF-PACF plots. Henceforth, differencing was performed on these series and then ARIMA model was fitted to find the best fit model for the time series. A varied number of ARIMA models (a total of 24) were found to be the best fit for different meteorological variables per selected study areas of NER. Among them, ARIMA(2,1,4) (model 22) was fitted as the parsimonious one for the maximum number of times (7)- for MaxT at CHR, MinT at DBR and GHY, SLP at DBR, GHY, KSH and TUL. Contrary to model 22, model 12 [ARIMA(2,1,2)] was the best fitted model that appeared for only once, in case of MaxT at KSH. In all the cases, the AIC values were the determining factor governing the selection of the best fitted model than the other two criterions (HIC and SIC). Looking at the performance of ARIMA in forecasting the meteorological variables, the use of SARIMA instead was suggested. The coupling of ANN techniques which was not included in this study, could improve the prediction efficiency as suggested in the literatures.

In Chapter 6 SSA and wavelet tools were used to identify and isolate the dominant features present in the rainfall time series. This chapter thus linked the previous objectives in the identification of characteristics features in the rainfall. The study was explored in frequency scale (SSA) and both time-frequency scale (wavelet). It was found from the SSA that trend component constitutes the major percentage of contribution (about >45%), followed by the annual periodic component of 12 months over NER. Another two periodic components of 4 and 2.4 months were also evident in some of the locations. The presence of more than two trend components was a salient feature of the findings from this chapter. The wavelet analyses provided the inputs to the object 4, by decomposing the monthly time series into different resolutions (w1-w10). Also, it enabled the detection of significant periodic components of rainfall time series in the 8-16 months period band as detected in the wavelet power spectra across all the studied locations of NER. A ridge in the 12 months period of the wavelet spectra confirmed the findings from chapter 4 as well as from SSA analyses. Interestingly, significant strong association of rainfall with all the other meteorological variables was also evident in this period band. Apart from this periodicity band, the high frequency band of 2-8 months period and low frequency band of 64-128 months period displayed strong coherence between rainfall and selected variables at some locations. Intermittent strong association of rainfall with other variables were also evident in some cases. Inter-decadal associations were also detected in some period bands at certain locations. Among these explored associations, the strong significant association that was present in the 8-12 months period band was in phase (usually the second variable was leading) with almost all the variables except SLP. Anti-phase associations were mostly distinct in the low frequency bands, while in the high frequency bands most of the associations were in phase. Significant phase reversal of 180^o was also evident in some cases. Significant inter-relations could be seen in the association of rainfall with most of the variables, after 1997 or between the year 1997-2010.

The inter-relational sensitivity of rainfall was explored in Chapter 7, with the help of wavelet coupled with VAR-IRF. The wavelet decomposed meteorological series were subjected to VAR for finding the inter-associations, which afterwards analysed with IRF. In this case the sensitivity of only rainfall to shocks in the different resolutions of the other meteorological parameters were examined. From the observations the clarity in the response of rainfall was observed in each of the climatic series w5-w7 per study areas. 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. It could be seen that the initial response by rainfall in most of the cases was sharp in either negative or positive way, but the response died off soon.