Chapter-7

NE monsoon over Sri Lanka

Sri Lanka lies within the tropics between 5° 55' to 9° 51' North latitude and between 79° 42' to 81° 53' East longitude, with a tropical climate. The central part of the southern half of the island is mountainous with heights more than 2.5 Km. The remainder of the island is practically flat except for several small hills that rise abruptly in the lowlands. These topographical features strongly affect the spatial patterns of winds, seasonal rainfall, temperature, relative humidity and other climatic elements, particularly during the monsoon season.

7.1. **Mean Rainfall**

Sri Lanka received rainfall due to southwest and northeast monsoons, local convective storms (thunderstorms) and low-pressure systems like lows/depressions moving across the region. The mean annual rainfall varies from 900 mm in the driest parts (southeastern and northwestern) to over 5000 mm in the wettest parts (western slopes of the central highlands). Fig. 7.1 shows the spatial distribution of annual rainfall over Sri Lanka taken from the Sri Lanka Met Department.

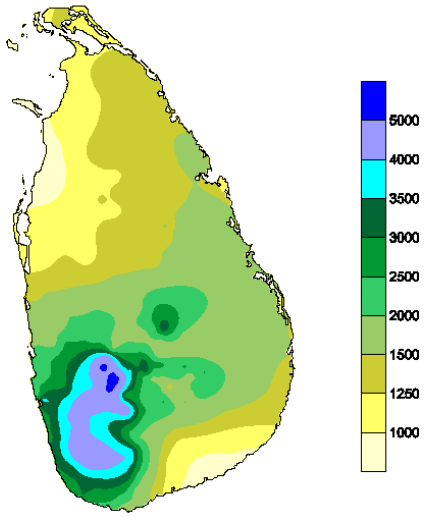

Fig. 7.1. Annual rainfall over Sri Lanka in mm. (Source: Sri Lanka Met Department).

As per the Sri Lanka Met Department, the seasons in Sri Lanka are classified into 1) First inter-monsoon season (March-April) 2) Southwest monsoon (May- September) 3) Second Inter-monsoon season (October-November) and 4) Northeast monsoon (December-February). The spatial distribution of mean rainfall during these four seasons are shown in Fig. 7.2.

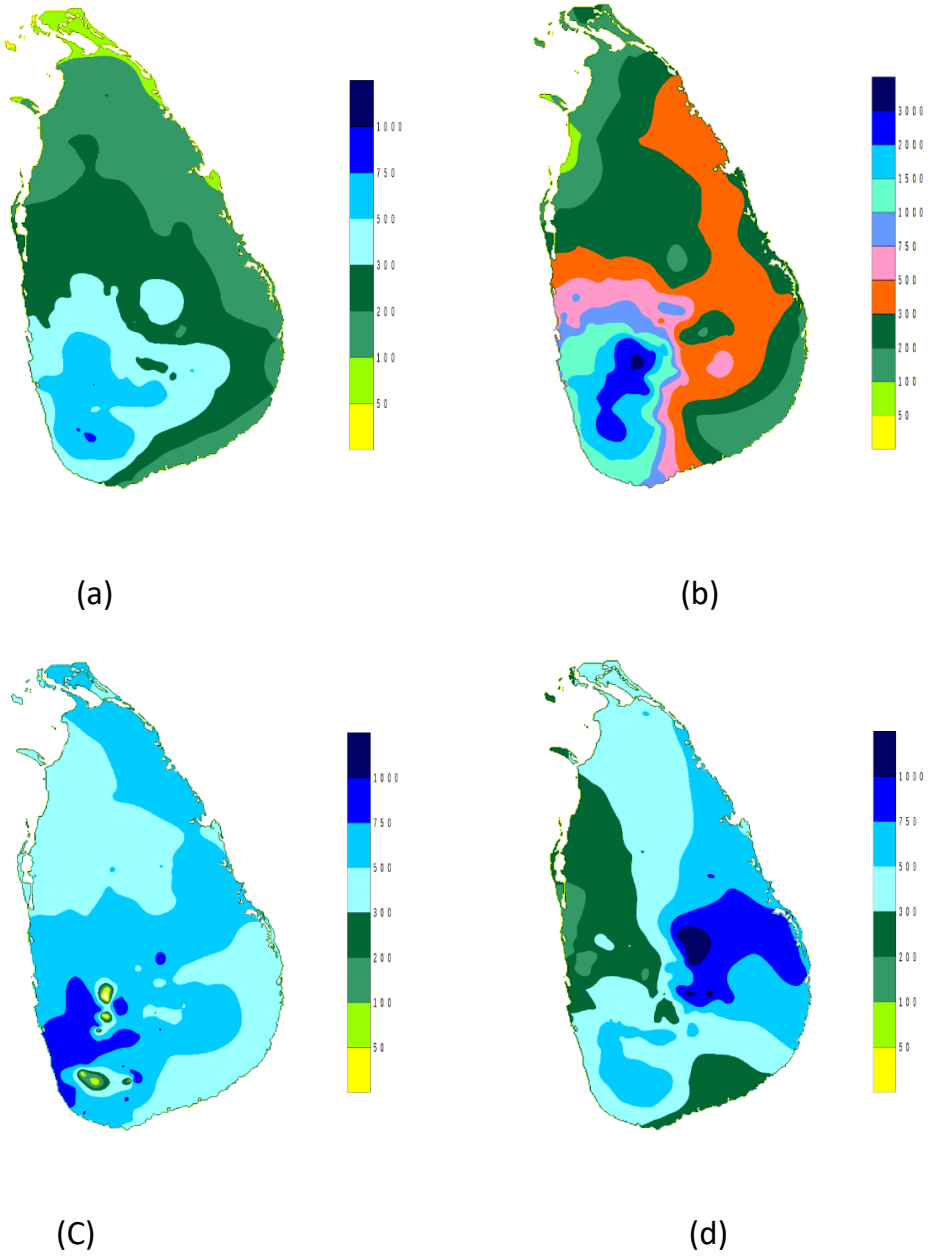

Fig. 7.2. Mean rainfall in mm during a) March-April b) May-September c) October-November and d) December-February. Source: Sri Lanka Meteorological Department.

The months October-November contributes maximum rainfall with the whole country experiencing rainfall more than 300 mm. Except during December-February, maximum rainfall is observed over the western coast, especially the southwest coast. During the December-February season, maximum rainfall is observed over the east coast.

The monthly mean rainfall averaged over the whole Sri Lanka is shown in Fig. 7.3. This time series was prepared using the merged rainfall data of CHIRPS (https://www.chc.ucsb.edu/data/chirps). The Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS) is a 35+ year quasi-global rainfall data set ranging from 1981 to near present. This data set incorporates $o.05^0$ resolution satellite imagery and in-situ station data.

This plot of monthly rainfall clearly suggests that October-December months contribute to maximum rainfall over Sri Lanka. Another smaller peak is observed in April and May. This peak could be associated with the northward movement of ITCZ from the equator and associated convective activity, before the southwest monsoon sets in. During the month of April and May, the ITCZ starts moving northwards and there could be large scale convective activity associated with this movement due to low-level convergence and abundant moisture content.

For the rest of this chapter, we refer to October to December as the northeast monsoon (NEM) season, consistent with the designation of the India Meteorological Department (IMD).

Domroes and Ranatunge (1992) have identified three types of orthogonal structure of the monsoon regime in Sri Lanka using long-term mean monthly rainfall data. Their analysis revealed that a large amount of rainfall occurs from March to October in the southwestern parts of Sri Lanka, from December to February in the eastern parts, and in November in the northern and mid-western parts. Orthogonal factor scores for the first three factors account for 93.6% of the total variance of mean

monthly rainfall. Seasonal changes in the monsoon wind system, ITCZ weather phenomena, and topography are the main factors which influence the spatial structure of monsoon rainfall over Sri Lanka.

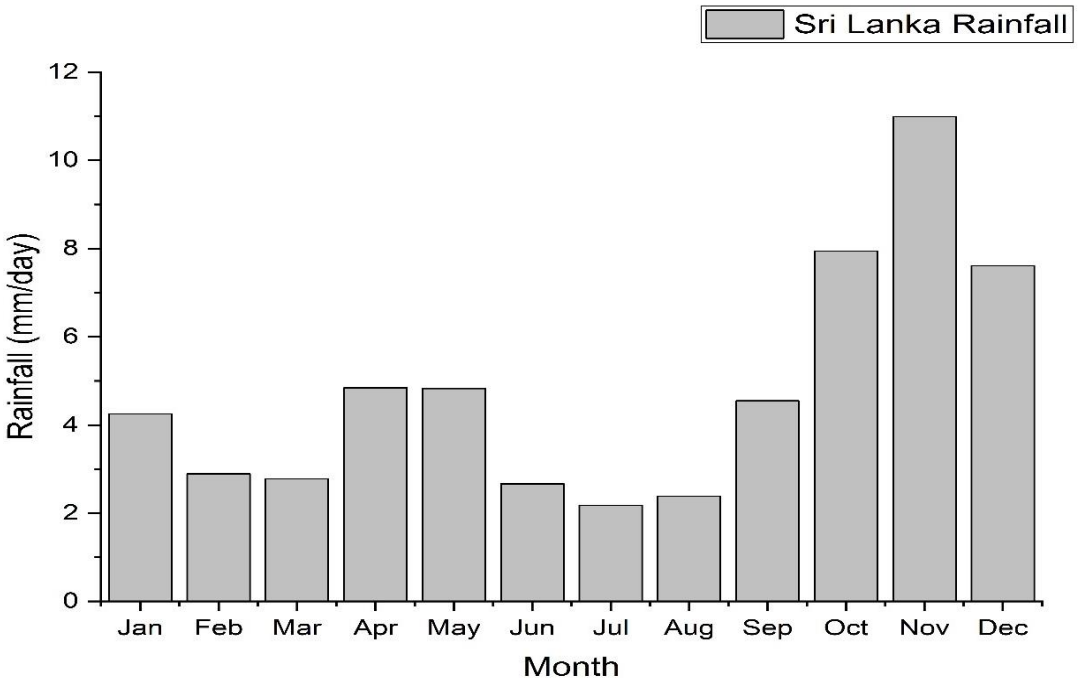

Fig. 7.3. Mean Monthly rainfall (mm/day) averaged over Sri Lanka using CHIRPS data.

Nisansala et al. (2019) analyzed Sri Lanka rainfall using the data during the period 1987-2017. They found increasing trends in annual rainfall at 24 stations with five stations showing significant increasing trend. Annual rainfall at 13 locations (35%) showed decreasing trend, but these trends were not significant ($p < .05$). There is an increasing trend at 76, 51, 32, and 86% of stations during the First Inter-Monsoon (FIM), Second Inter-Monsoon (SIM), South West Monsoon (SWM), and North East Monsoon (NEM) seasons, respectively. In general, the eastern, south eastern, north and north central regions of the country showed increasing rainfall trend over the last 31 years (1987–2017) while western, part of north western and central part of the country indicated a decreasing rainfall trend during the same period. The annual trend in rainfall is shown in Fig. 7.4 below.

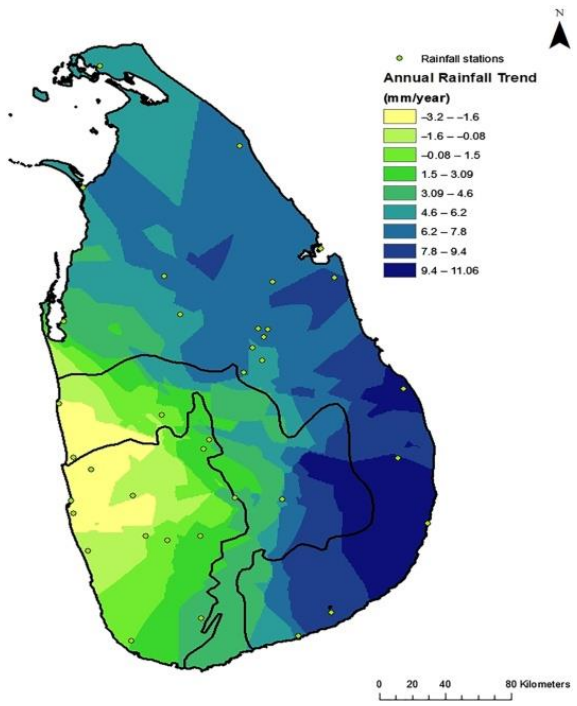

Fig. 7.4. Spatial distribution of linear trends of annual rainfall for the period 1987-2017. This plot is taken from Nisansala et al. (2020).

In Sri Lanka, convective activity with lightning contributes abundant quantity of rainfall. Jayawardhana et al. (2014) studied the lightning activities over Sri Lanka using data Lightning Imaging Sensor of TRMM Satellite. The period 1998-2012 was used for the analysis. The highest occurrence of lighting activities is confined to the highly populated western part of the island while the south eastern and mountain areas have low occurrences. There is a clear spatial polarization of lightning activities during the south-west and north-east monsoon seasons. There is an increasing trend in lightning activities, they appear to be increasing by 50 flashes per year. It has a seasonal dependency with the south-west and first inter-monsoon seasons having the higher increase. The percentage of lightning per month is highest (46%) during the Inter-monsoon-1 period and the lowest (7%) during the Northeast monsoon season. Second highest percentage of lightning per month (25%) can be observed during the inter-monsoon-2 period followed by the Southwest monsoon (22%) period.

During the Oct-Dec season, Sri Lanka receives rainfall, often heavy rainfall due to westward moving depressions and tropical cyclones over the south Bay of Bengal. Fig 7.5 shows the tracks of depressions and tropical cyclones which crossed the coasts of Sri Lanka during the October-December season for the period, 1971-2021.

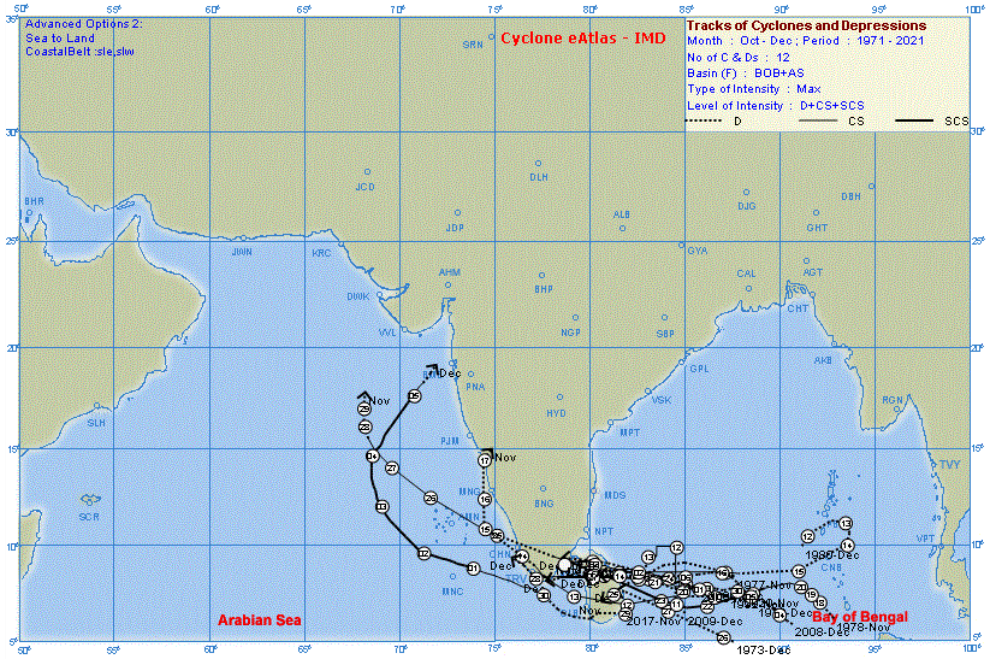

Fig. 7.5. Tracks of Depressions and tropical cyclones crossing the coasts of Sri Lanka during the period Oct-Dec, 1971-2021.

7.1. **Diurnal Variations.**

An analysis of diurnal variations over Sri Lanka was made using sub-daily TRMM data set for the period 1998-2019. Similar results for the NE monsoon season over the south peninsula are discussed in Chapter-6 (section 6.1). The same methodology was followed for this analysis also.

Fig. 7. 6 shows the three hourly mean rainfall over Sri Lanka and adjoining region, averaged during the period 1998-2019. The plot clearly shows that there is significant diurnal variation of rainfall over Sri Lanka and neighborhood during the NE monsoon season. The changes are more evident over the western parts of Sri Lanka, where

rainfall peaks during the evening time (09-12 UTC). Over the eastern parts and adjoining oceanic area, there is hardly any diurnal variation, but a major peak during the early hours (00-03 UTC).

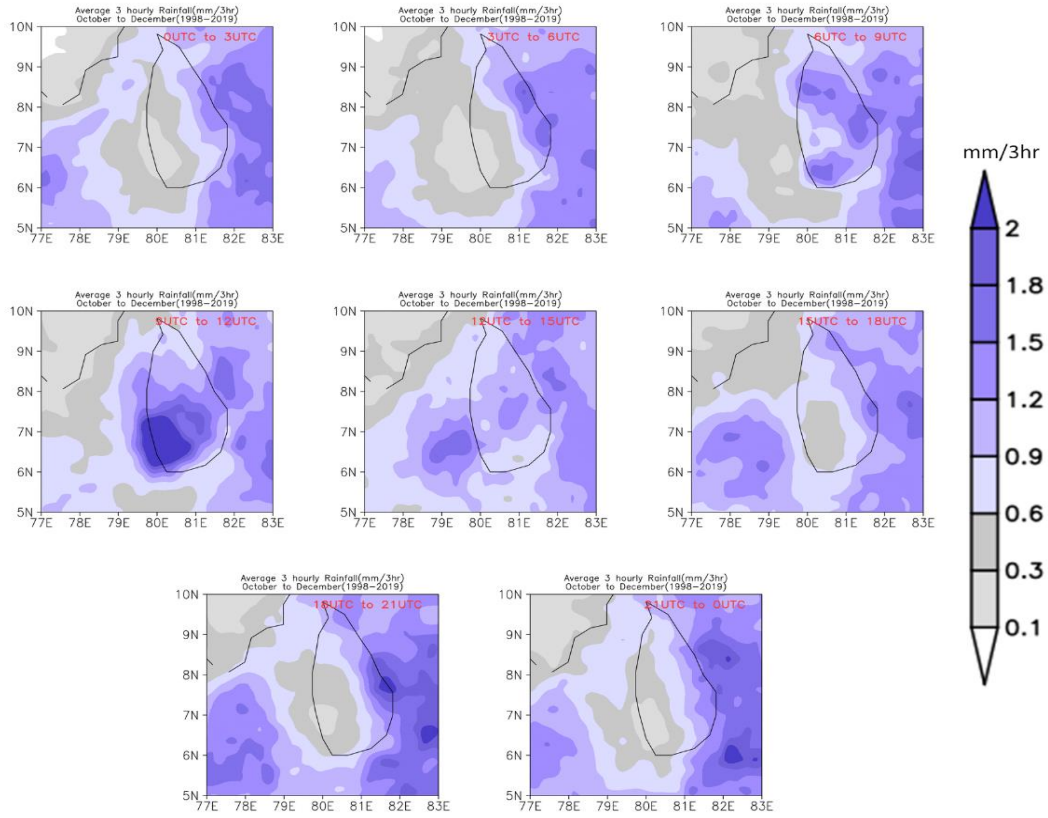

Fig. 7.6. Three hourly mean rainfall over Sri Lanka and neighborhood, averaged using the TRMM satellite data of 1998-2019.

The similar results are revealed in the Phase diagram obtained from the Harmonic analysis as shown in Fig 7.7. The phase diagram shows clear peaking of rainfall during evening and early night hours, which is consistent with Fig 7.6. This peaking could be associated with the solar heating during day time and initiation of convection. More studies are required to establish the physical mechanisms for this observed diurnal pattern. Also, it is important to understand whether the NWP model is capable of predicting this observed diurnal pattern over Sri Lanka.

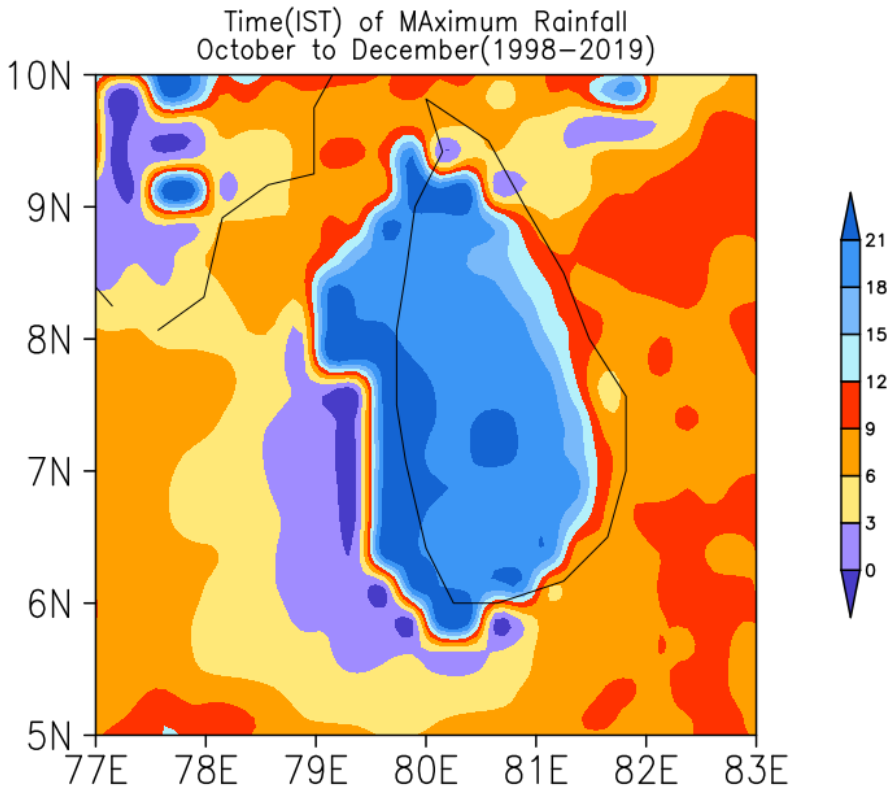

Fig. 7.7. The phase diagram of the harmonic analysis of hourly rainfall using the satellite data of 1998-2019. The phase diagram shows the time (IST) of maximum rainfall.

7.2. **Intra-seasonal variations**

There are not many studies addressing the intra-seasonal variability of the NE monsoon rainfall over Sri Lanka, which is an important component of rainfall variability. Therefore, a preliminary analysis on the intra-seasonal variability of rainfall over Sri Lanka is done and the results are discussed below.

Fig. 7.8 shows the daily rainfall averaged over Sri Lanka during the period 1 Oct 2018- 31 Jan 2019 (above) and 1 Oct 2019- 31 Jan 2020 (below). These two years are selected just as examples to show the rainfall variations within the season. The plot suggests that there is significant rainfall variability within the season, with specific periods of more rainfall, interspaced with little or no rains.