The unusual excess year of the 2021 NE monsoon season is discussed below.

6.4. **The unusual NE monsoon during the year 2021**

During the year 2021, the southwest monsoon withdrew from the Indian region on 25th October. Simultaneously, the Northeast monsoon (NEM) of 2021 commenced over the southeastern parts of peninsular India on 25th October against the normal date of 20th October. Excepting Coastal Andhra Pradesh (CAP), which received normal rainfall during the season, the other four sub-divisions [Tamil Nadu (TN (including Puducherry & Karaikal), Kerala (KER), Rayalaseema (RYS) and South Interior Karnataka (SIK)] benefitted from the NE monsoon. These sub-divisions received excess to large excess rainfall during the NEM season (October-December) with KER, SIK, RYS recording more than 100% excess (large excess) rainfall. During the season, there were 30 days of active to vigorous monsoon conditions over Tamil Nadu and Kerala. There were 65 days of isolated heavy rainfall activity with 33 days of isolated very heavy rain, including 09 days of isolated extremely heavy rainfall activity over Tamil Nadu. Two Depressions formed over the North Indian Ocean during November contributed significantly to NEM rainfall over the peninsular India. Cyclonic Storm (CS) Jawad over the Bay of Bengal (BOB) during 02-06 December tracked northwards towards West Bengal- Bangladesh coasts and did not contribute towards NEM seasonal rainfall. However, two days of extremely heavy rainfall occurred over Chennai (i) 06th November night & (ii) 30th December 2021. Recurrent heavy rainfall over the coastal and adjoining districts from the last week of October to November led to the filling up of water bodies, and inland and riverine flooding occurred over several areas of Tamil Nadu and Rayalaseema. As a result, NE monsoon 2021 was extended into January 2022 and cessation of NEM 2021 rainfall over peninsular India was declared on 22nd January 2022 (Geetha et al., 2022). A more detailed report on 2021 NE monsoon is available for reference (Geetha et al., 2022).

The Table 6.3 presents the frequency of active and vigorous monsoon days and heavy rainfall days during the 2021 NE monsoon season (after Geetha et al., 2022).

Table 6.3

Subdivision	Number of Days				
	Activity		Heavy Rainfall		
	Vigorous	Active	Extremely Heavy	Very Heavy	Heavy
Tamil Nadu	8	22	9	33	65
Coastal Andhra Pradesh	2	7	0	8	28
Rayalaseema	8	12	1	4	22
Kerala	11	19	2	18	40
South Interior Karnataka	5	10	0	9	28

Note: Heavy Rainfall > 6.5 cm/day Very Heavy rainfall> 12 cm/day and Extremely Heavy rainfall >21 cm/day

Active: Failrly widespread to widespread sub-divisional rainfall with rainfall more than 1.5 to 4 times the normal with at least two stations reporting more than or equal 5 cm in coastal Tamil Nadu and south coastal Andhra Pradesh and 3 cm elsewhere in the NEM region.

Vigourous: Fairly widespread to widespread sub-divisional rainfall with rainfall more than 4 times the normal with at least two stations reporting more than or equal to 5 cm in the coastal Tamil Nadu and the south coastal Andhra Pradesh and 3 cm elsewhere in the NEM region.

Fig. 6.16 a shows the seasonal (Oct-Dec) rainfall over the south peninsula and neighborhood (in mm/day) during the 2021 monsoon season. It shows widespread abundant rains over the south Peninsula and the adjoining southwest Bay, suggesting an excess monsoon year (73% above its long period average).

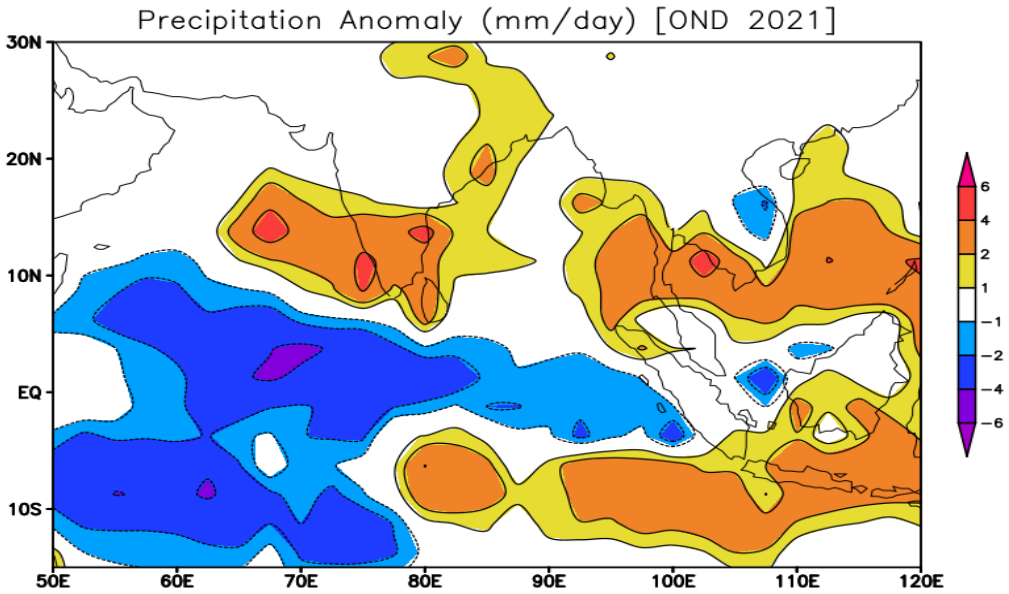

Fig. 6.16 a. Precipitation anomaly (mm/day) during OND 2021. Source: ERA5 reanalysis.

The 850 hPa wind pattern (Fig. 6.16 b) shows an extended east-west trough extending from the east central Arabian sea to the west equatorial Pacific Ocean across the south peninsula and south Bay of Bengal. This suggests the presence of active ITCZ over the region during the NE monsoon season. This convergence zone must be the cause of the genesis of several weather systems over the south Bay of Bengal and their westward movement towards the south Peninsula. The SST anomaly during Oct-Dec 2021 (Fig. 6.16 c) shows the presence of cold SST anomalies over the equatorial Pacific, suggesting La Nina conditions. It may be interesting to note the presence of above normal SSTs over the Bay of Bengal. Some recent studies like Singh et al. (2017) suggested that local air-sea interaction plays a crucial role in modulating or driving extremes over South Peninsula associated with ENSO. More studies are required to understand the physical mechanisms of relationship of Bay of Bengal SSTs and the NE monsoon rainfall.

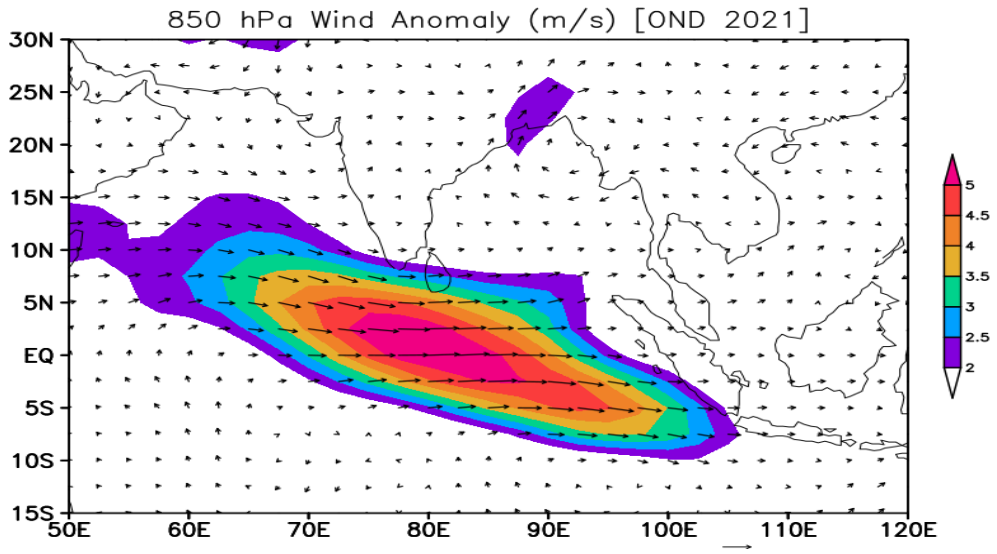

Fig. 6.16 b. 850 hPa wind anomalies during OND 2021. Source: ERA5 reanalysis.

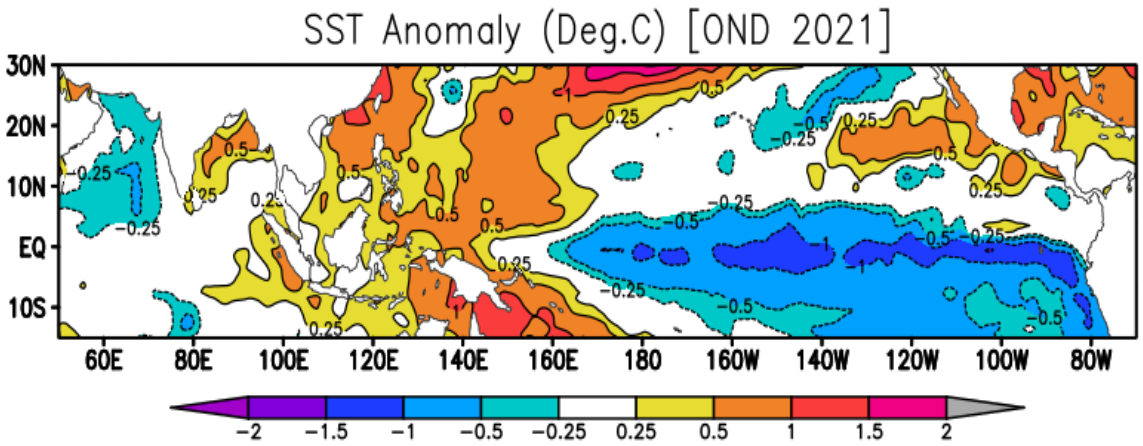

Fig. 6.16 c. SST anomalies during OND 2021. Source: NOAA OI SST data.

6.5. **Seasonal Forecasting of NE Monsoon**

India Meteorological Department (IMD) has been attempting to prepare long-range forecasting of NE Monsoon rainfall (Oct-Dec) using indigenously developed statistical models based on principal component analysis (PCA). The parameters used for the statistical models are shown in Fig. 6.17. Overall, five predictors are used for long range prediction of NE monsoon rainfall. Out of these five predictors, four predictors are