5.1. **Composite meteorological features associated with the monsoon onset**

To understand the changes in dynamical and thermodynamical parameters occurring associated with the NE monsoon onset, a composite analysis was made with Mean Sea Level Pressure (MSLP), winds at 1000, 850 and 700 hPa level, Outgoing Longwave Radiation (OLR), and precipitable water content. The analysis was made as a pentad (5 days) composite with the onset date as the central date. The other dates in the pentad are two days before the onset and two days after the onset date. Such composites will provide useful information on the dynamical and thermodynamical changes occurring in the region associated with the monsoon onset. Also, they will provide clues for some important parameters to be considered for developing criteria to declare the monsoon onset.

Fig. 5.3 shows the composite MSLP pattern associated with the NE monsoon onset. It clearly shows the presence of a low-pressure area over the southwest Bay of Bengal, off the Tamil Nadu coast, suggesting an area of convergence and associated rainfall activity. However, the surface pressure gradient over the South Bay of Bengal is not strongly associated with the monsoon onset. Instead, a trough of low pressure at the surface extends from the northwest Arabian sea across the southern part of the peninsula to the southeast Bay of Bengal.

Fig. 5.4, 5.5 and 5.6 show the composite mean wind flow at 1000, 850 and 700 hPa levels associated with the monsoon onset. These maps clearly show the presence of east-west trough (ITCZ), from south-west Arabian sea to south-east Bay of Bengal across south Peninsula right from 1000 hPa to 700 hPa. At 1000 hPa, there is a cyclonic circulation over southwest Bay of Bengal associated with the low-pressure area observed at the mean sea level (Fig. 5.3). At 850 hPa and 700 hPa levels, the east-west trough across south peninsula is very prominent. At 850 hPa and 700 hPa levels, the east-west trough passes across south peninsula around 9^0N. It may be also noted that the strong easterlies north of the trough line, between 12^0N and 20^0N and strong

westerlies south of the trough line, between the equator and 5^0N. Therefore, the east-west trough zone is an area of strong horizontal wind shear and associated convergence.

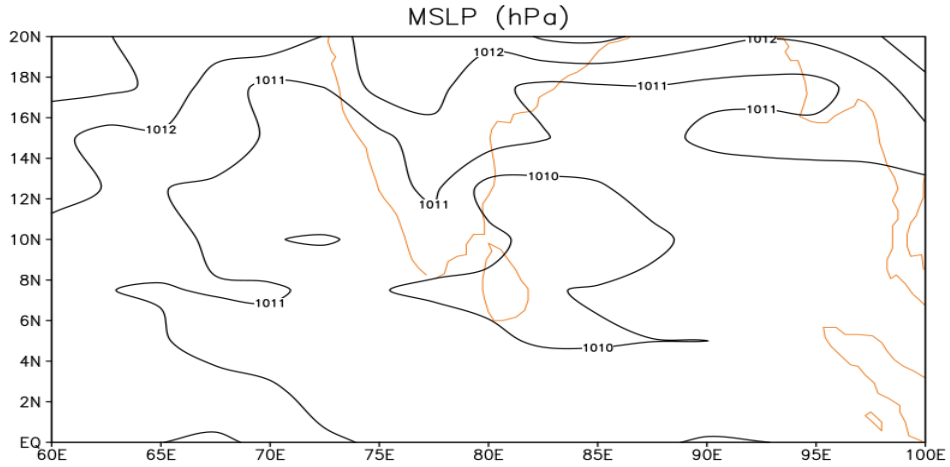

Fig. 5.3. Composite Mean Sea Level Pressure (MSLP) during the pentad of monsoon onset date. The onset date is the central date of the pentad. Onset dates of 1977-2020 were considered for the analysis. Data source: NCEP/NCAR reanalysis.

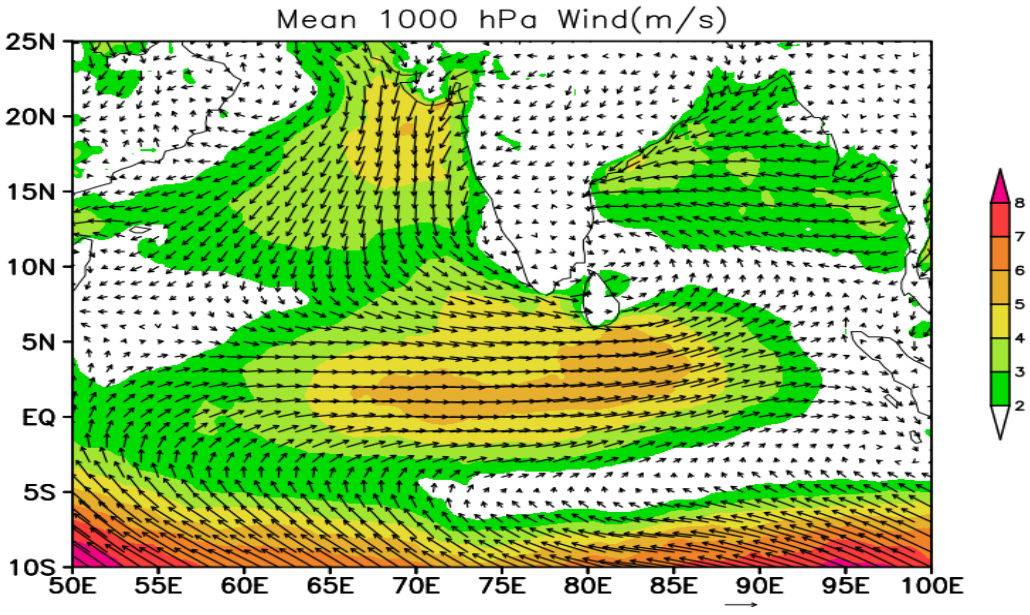

Fig. 5.4. Composite wind flow at 1000 hPa during the pentad of monsoon onset date. The onset date is the central date of the pentad. Onset dates of 1977-2020 were considered for the analysis. Data source: NCEP/NCAR reanalysis.

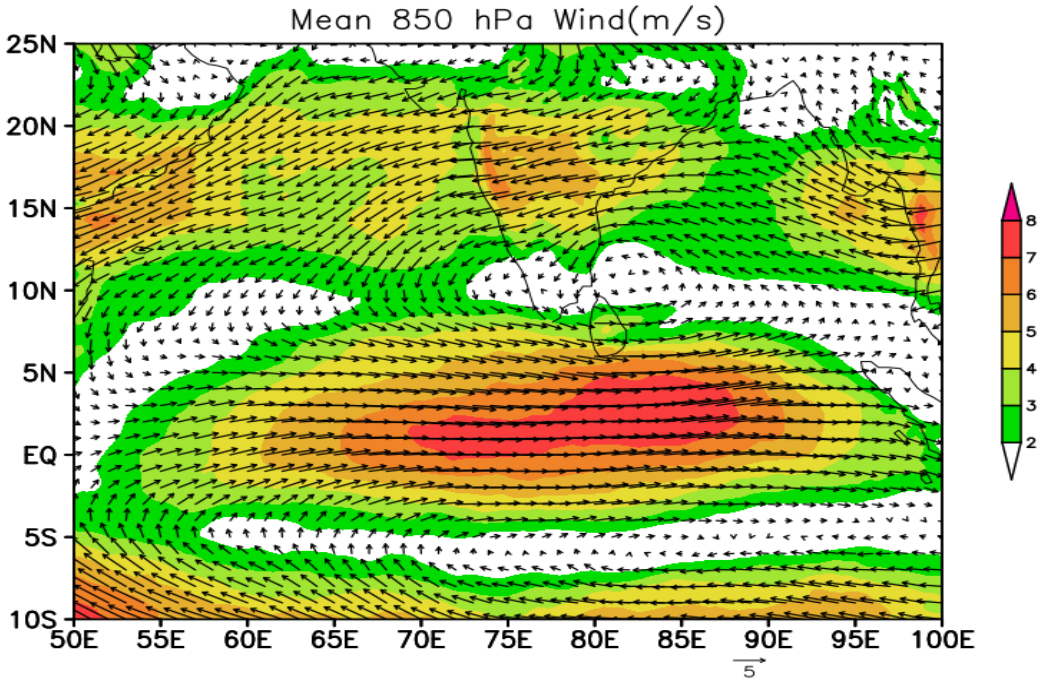

Fig. 5.5. Same as Fig 5.4, but for 850 hPa winds.

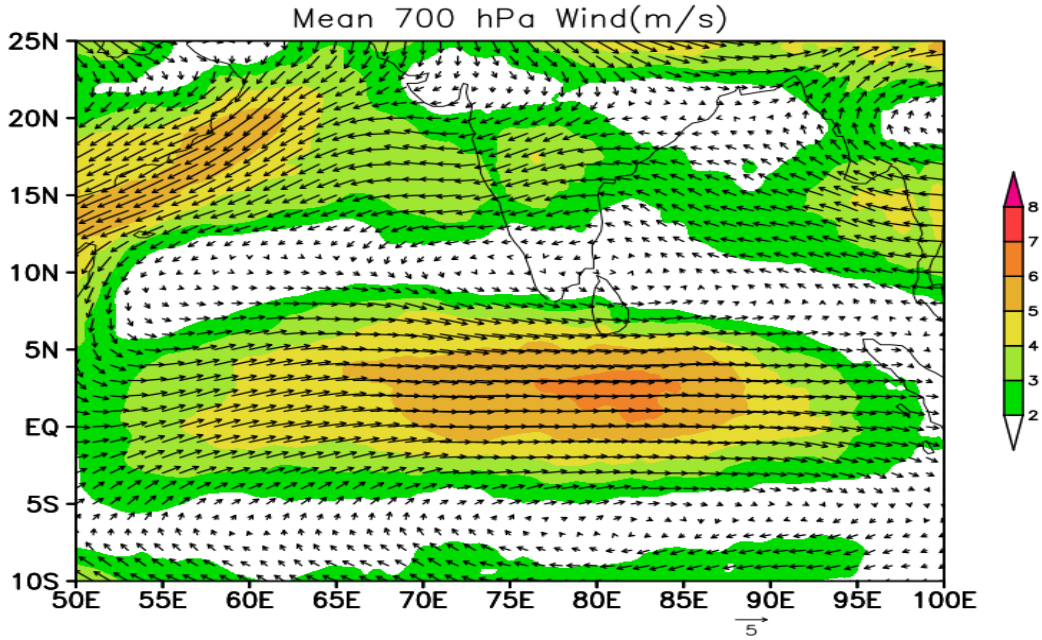

Fig. 5.6. Same as Fig 5.4, but for 700 hPa winds.

Fig. 5.7 shows composite latitude-height distribution of zonal winds averaged between 80^0E-90^0E. There is an easterly wind maximum from 975 hPa to 700 hPa between 13^0-17^0E. At the surface the zero zonal wind line is close to 10^0N, which suggests the presence of the east-west trough line. Between the equator and 5^0N, there is a maximum of westerly zonal winds. The zonal wind pattern clearly shows a small southward tilt with height.

Fig. 5.8 shows the pentad composite OLR pattern associated with the NE monsoon onset. This plot was made using observed OLR data derived from National Oceanographic and Atmospheric Administration (NOAA) satellites (http://psl.noaa.gov). The plot shows the southern part of Peninsula, especially the eastern coast is covered with large scale convection with OLR values less than 220 Wm^{-2}.

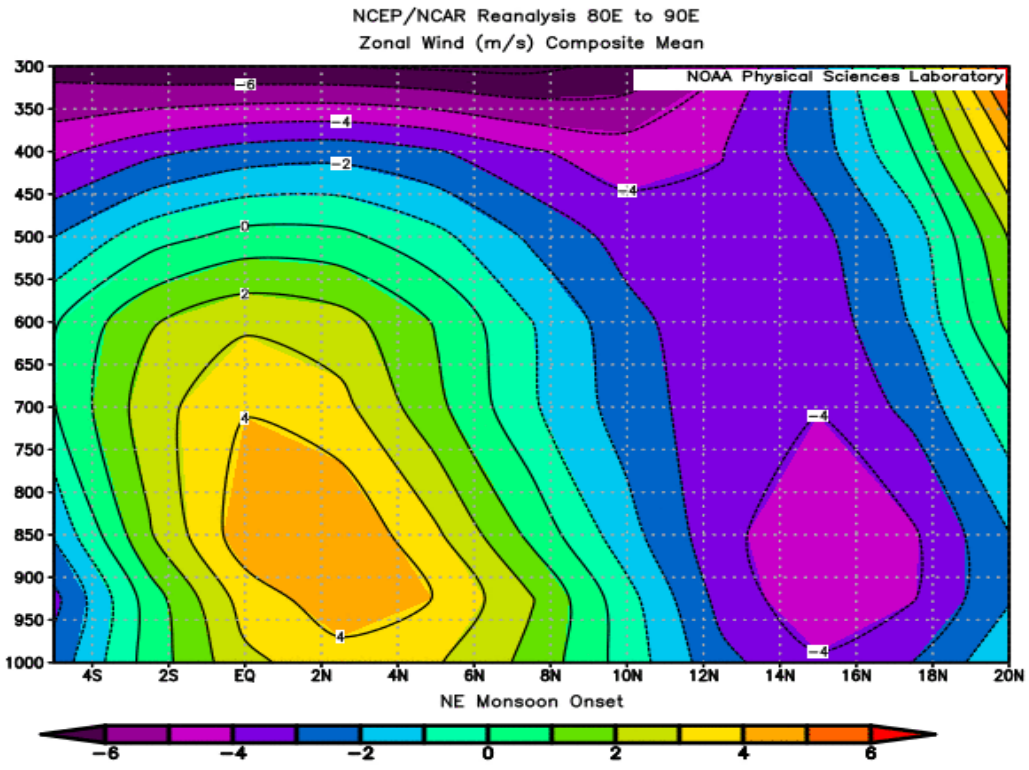

Fig. 5.7. Composite Latitude-Height distribution of zonal winds averaged between 80-90E during the pentad of monsoon onset date. The onset date is the central date of the pentad. Data source: NCEP/NCAR reanalysis.

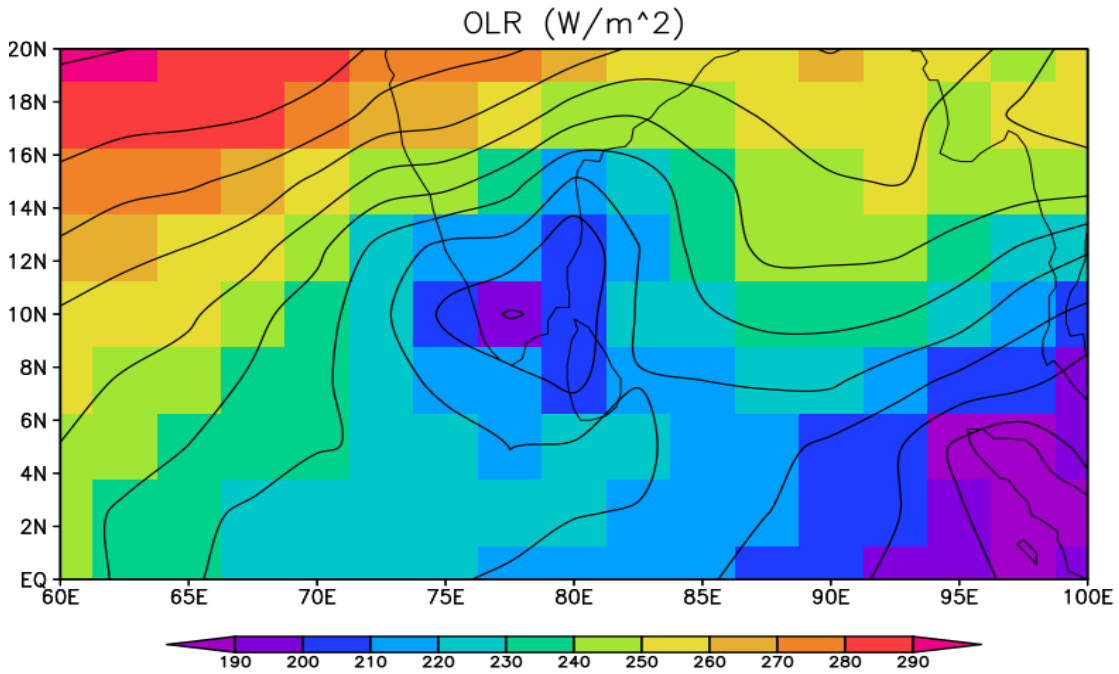

Fig. 5.8. Composite Outgoing Long Wave Radiation (OLR) during the pentad of monsoon onset date. The onset date is the central date of the pentad. Onset dates of 1977-2020 were considered for the analysis. Data source: NOAA OLR Data.

Over the eastern coast of Tamil Nadu (up to 14^0N) the composite OLR value is less than 210 Wm^{-2} suggesting severe convection over the region. Therefore, the NE monsoon onset is associated with large scale convection (with low OLR) over southern part of peninsula covering up to 16^0N or so. The monsoon onset is also associated with the presence of large amount of precipitable water content (moisture content) over the region (Fig. 5.9). Over the extreme southern parts of peninsula and east coast of Tamil Nadu, high amount of PWC values (exceeding 42 kg/m^2) is observed. Fig. 5.10 shows the spatial distribution of vertically integrated moisture convergence over the region associated with the NE monsoon onset. This plot also shows abundance of moisture flux off- east coast of south peninsula. Therefore, the monsoon onset is associated with the presence of large amount of moisture flux and large-scale convection over the region.

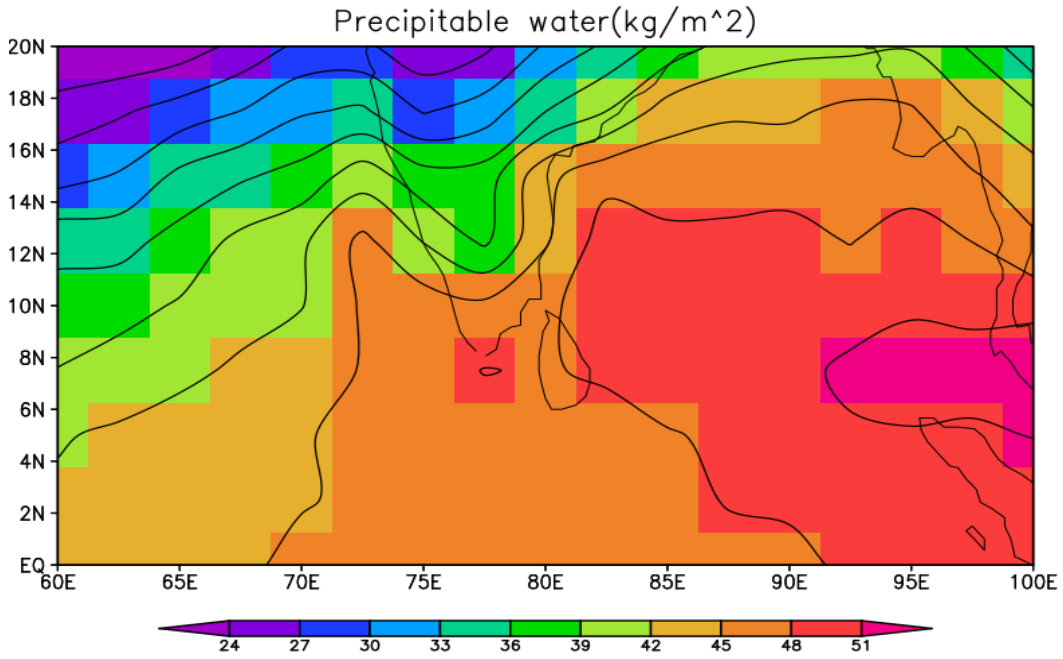

Fig. 5.9. Composite precipitable water content (PWC) (in Kg/m^2) during the pentad of monsoon onset date. The onset date is the central date of the pentad. Onset dates of 1977-2020 were considered for the analysis. Data source: NCEP/NCAR reanalysis.

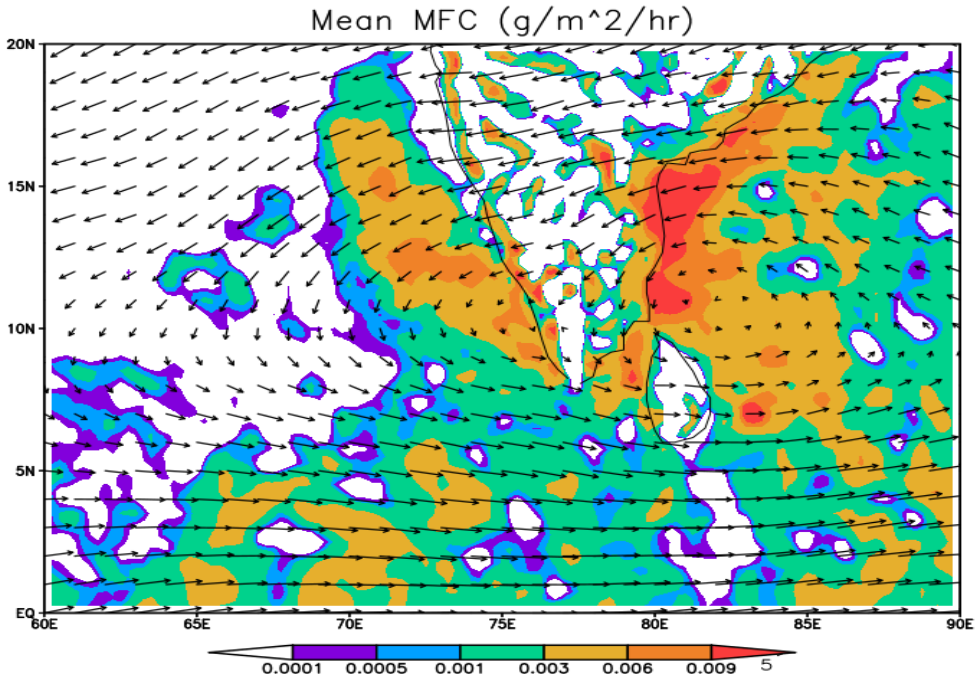

Fig. 5.10. Mean moisture flux convergence (shaded) along with 850 hPa vector winds associated with NE Monsoon Onset.