2.6. **Relationship between SST and Convection during the NE monsoon**

There is a strong relationship between SST and atmospheric convection over the tropical ocean basins. Previous studies (Gadgil et al., 1984, Sabin et al., 2012) have shown that during the southwest monsoon season, convection over the Bay of Bengal is initiated when SSTs are between 27^0-28^0C. A similar analysis was made for the NE monsoon season (Oct-Dec) using long term data of SST and Outgoing Long Wave Radiation (OLR) data over the Indian Ocean. OLR is a proxy for atmospheric convection.

Fig. 2.12 d shows the scatter plot between SST and OLR over the a) the Arabian Sea (0-20^0 N, 60-75^0 E) and b) the Bay of Bengal (0-20^0 N, 80-100^0 E). The data during 1982-2021 have been used for these plots. Over the Bay of Bengal, convection starts abruptly and increases sharply once the SST threshold crosses 28.0^0 C. At 28.5^0C, the OLR in the Bay of Bengal is 20 Wm^{-2} lower than in the Arabian Sea due to much deeper clouds over the Bay of Bengal. The mode with the highest probability for SST above the threshold of 28^0C over the Bay of Bengal has low OLR (about 210 Wm^{-2}) corresponding to deep convection whereas that for the Arabian sea it is around 250 Wm^{-2}.

It is interesting to note that even above the SST threshold of 28^0C, there are points with OLR values more than 240 Wm^{-2} suggesting severe convection is not present at these locations. It may be worthwhile to note that only SST threshold will not decide whether convection will occur or not. Initiation of convection also depends on atmospheric circulation, which should be conducive for low level convergence and ascending motion (Lau et al., 1997). This aspect is not further examined here and should be taken up as a separate study.

2.7. **Spatial distribution of cloud properties**

A further analysis was made on the spatial structure of some vital cloud properties during November over the region using the International Satellite Cloud Climatology Product (ISCCP) data (Rossow et al., 1991) for the period 1998-2019. Fig. 2.13 a, b and c show the spatial pattern of Deep convective clouds (DCC) (%), Cloud

Optical Thickness and Cloud Water Path (cm) respectively. Cloud optical thickness is the vertical optical thickness between the top and bottom of a cloud. The optical thickness of a cloud is the degree to which the cloud prevents light from passing through it. It depends directly on the cloud thickness, the liquid or ice water content and the size distribution of the water droplets or ice crystals.

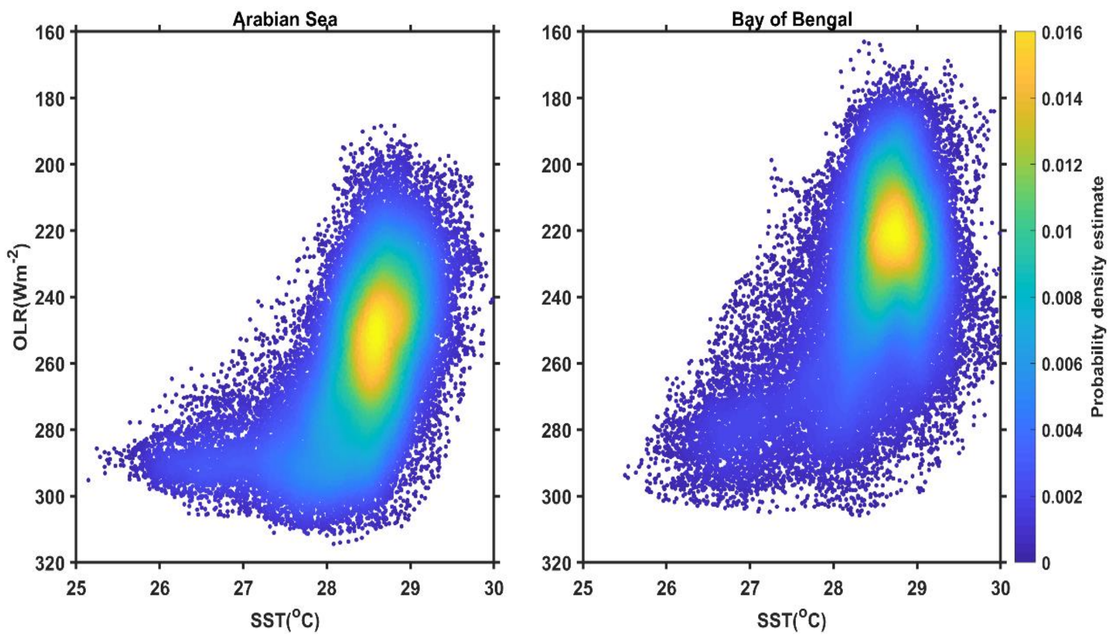

Fig. 2.12 d. The scatter plot between SST and OLR over a) Arabian Sea (0-20^0 N, 60-75^0 E) and b) Bay of Bengal (0-20^0 N, 80-100^0 E). The data during 1982-2021 have been used for these plots.

Deep convective clouds are clouds with cloud top crossing above 400 hPa. The spatial distribution of DCC suggests maximum percent DCC over the east equatorial Indian Ocean (12-14%) coinciding with warmer SSTs (Figs 2.13 a, b and c). Over the southwest Bay of Bengal and off the Tamil Nadu coast, DCC is around 8%. Comparatively, DCC distribution over the Arabian sea is much smaller, suggesting the Bay of Bengal has much deeper convective clouds.

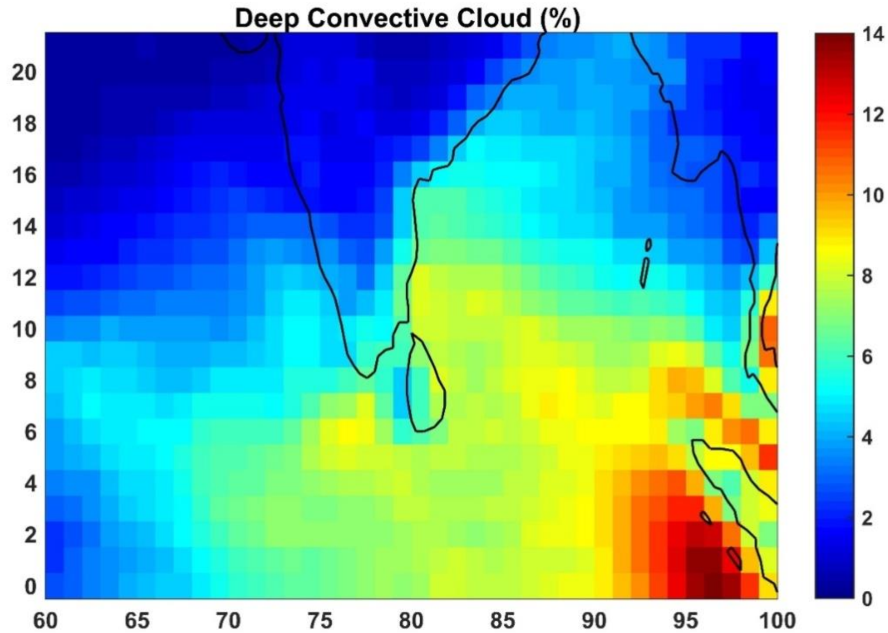

Fig. 2.13 a. Spatial distribution of Deep Convective Clouds during the NE monsoon season (October- December) based on the ISCCP data. Period: 1998-2019.

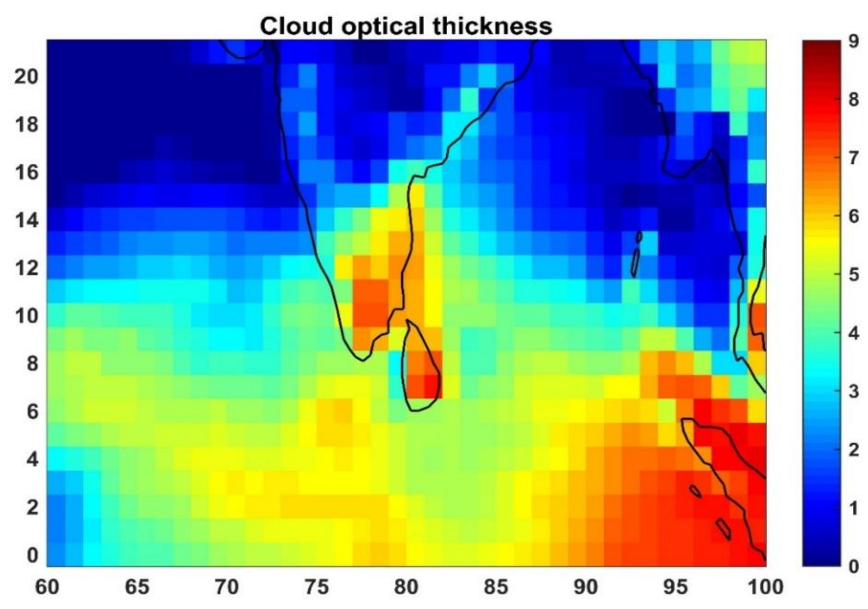

Fig. 2.13 b. Spatial distribution of Cloud Optical thickness during the NE monsoon season (October- December) based on the ISCCP data. Period: 1998-2019.

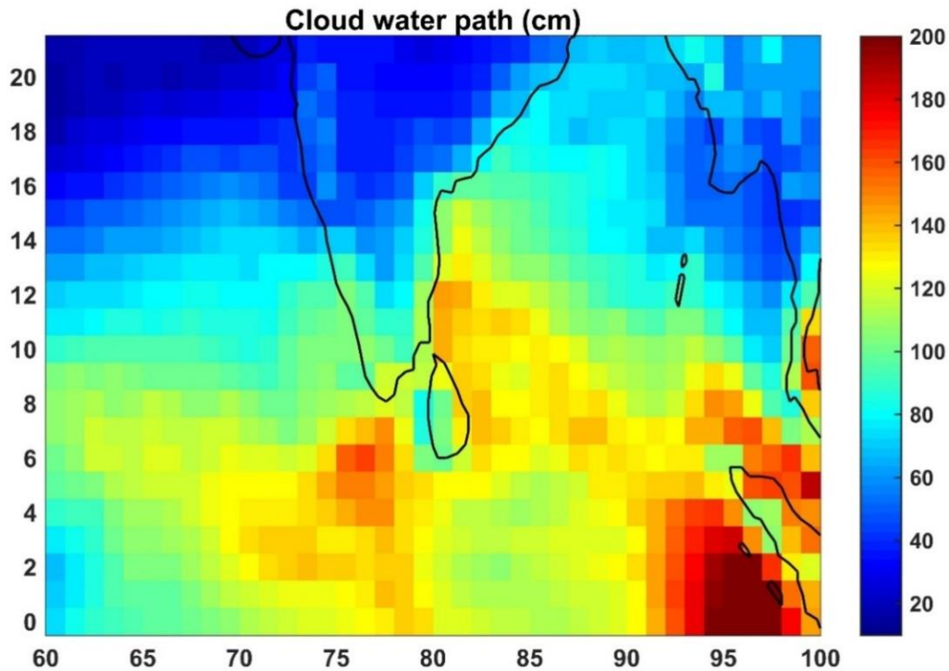

Fig. 2.13 c. Spatial distribution of Cloud water path (cm) during the NE monsoon season (October- December) based on the ISCCP data. Period: 1998-2019.

The spatial distribution of cloud optical thickness suggests maximum distribution over the east equatorial Indian Ocean coinciding with warmer SSTs and a large amount of deep convective clouds. Another maximum of cloud optical thickness is observed over the southeast Peninsula and adjoining Bay of Bengal. The spatial distribution of cloud liquid path (cm) shows that maximum is observed over the east equatorial Indian Ocean. Another maximum of cloud liquid path with values more than 120 cm is observed over the southwest Bay of Bengal off Tamil Nadu Coast. Therefore, the eastern parts of south peninsula and adjoining Bay of Bengal have deeper convective clouds with larger optical depth and cloud liquid water path. The spatial distribution shown here is based on long term climatology. On a day-to day basis, there could be significant variations in the distributions of cloud properties and they should be monitored using INSAT and similar satellite data products.

Characteristics of raindrop size distribution (DSD) are studied by Rao et al. (2009) during the southwest (SW) and northeast (NE) monsoon seasons using 4 1/2 years of Droplet Size Distribution (DSD) measurements made at Gadanki (13.5°N, 79.2°E) by an impact-type disdrometer. The observed DSD is found to be distinctly different in the NE monsoon from that of the SW monsoon. The stratified DSD (based on rain rate) shows more small drops and fewer bigger drops in the NE monsoon compared to the SW monsoon, particularly in the low rain rate regimes.

2.8. **Thunderstorms/ Lightning**

During the NE monsoon season, the south Peninsula experiences large scale thunderstorm activity. A good review of thunderstorm activity over India using station data is given in a recent paper by Omvir Singh and Bharadwaj (2017). A detailed study on lightning activity over the Indian region was published by Ranalkar and Chaudhari (2009) using the TRMM Lightning flash data. The average number of thunderstorm days during October, November and December are given in Fig. 2.14 a, b and c respectively. These plots are taken from the IMD Climate Hazards and Vulnerability Atlas of India (2022) (https://imdpune.gov.in/hazardatlas/index.html). The data from 1981-2010 have been used to prepare these spatial maps.

During October, some districts in coastal Andhra Pradesh, Tamil Nadu and Kerala experience more than 4 thunderstorm days. Over south interior Karnataka and Rayalaseema, average number of thunderstorm days is between 2 and 3. During November, thunderstorm activity is reduced in Coastal Andhra Pradesh. However, Tamil Nadu and Kerala still experience thunderstorms with average number varying between 3 and 7 days. Over the coastal Andhra Pradesh, south interior Karnataka and Rayalaseema, thunderstorm activity is slightly reduced. By December, thunderstorm activity is further reduced. During December, maximum thunderstorm days are observed over Kerala and southern parts of Tamil Nadu.