

Distribution of cyclone heat potential in the Bay of Bengal

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Southeast Bay of Bengal possesses higher cyclone heat potential (CHP) during July-September (monsoon) and October-December (fall). During monsoon, CHP varies from $25 \text{ k cal. cm}^{-2}$ in the southeastern Bay of Bengal to $10 \text{ k cal. cm}^{-2}$ in the central Bay of Bengal and then increases up to $15 \text{ k cal. cm}^{-2}$ at the head of the Bay of Bengal. Though there is a decrease of CHP over the entire Bay of Bengal during the subsequent period, it remains relatively higher in the southeast Bay of Bengal ($> 15 \text{ k cal. cm}^{-2}$). Regions of high or low CHP do not show any marked seasonality though the magnitude of it varies with season. Dynamic topography of the sea surface relative to 1000 db for these 2 periods shows that the circulation plays an important role in the distribution and maintenance of higher CHP at a few locations in the Bay of Bengal.

Depressions and cyclones either originate or intensify in the Bay of Bengal during June-September (monsoon) and October-December (fall) period respectively. The cyclones in the tropical belt form in the regions¹ where the sea surface temperature (SST) is above 26°C . The absence of tropical cyclone development when the sea surface water temperature is $< 26^\circ\text{C}$ is related to the shallow depth of the conditionally neutral or the unstable layer². These weather disturbances extract a fraction of energy that is stored in the form of heat in the upper layers of the sea during their travel over the seas. Whitaker³ has defined the cyclone heat potential (CHP) as the heat content of the water column above 26°C isothermal surface. This heat is available for the atmospheric disturbances to form and grow into cyclonic storms. The correlation of CHP with the intensity of the cyclone and the quantum of rainfall is somewhat misleading since the same amount of heat potential can be realised⁴ with different distributions of temperature and of different thicknesses of water column above 26°C . Nevertheless, the concept of CHP is useful to quantify the available heat energy for extraction by the weather disturbances in the form of latent and sensible heats. Hence, CHP is a useful parameter in identifying the energetically active zones. In the present paper, distribution of CHP during monsoon and fall periods in the Bay of Bengal is presented.

Materials and Methods

R V Gaveshani, occupied stations at 1° longitudinal and 2° latitudinal interval from 4° to 18°N

between east coast of India and 92°E as well as sections normal to the east coast of India during October-December (fall) 1983 in the Bay of Bengal. The station interval along the sections normal to the coast, varied between 10 and 30 nautical miles. *R V Sagar Kanya* re-occupied the stations during July-September (monsoon) 1984 (Fig. 1). The XBT, hydrocast and CTD data collected during these cruises were analysed and presented.

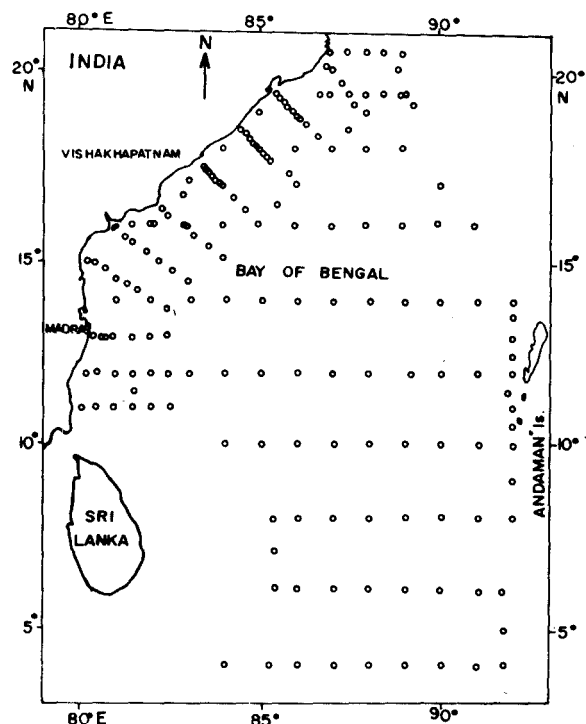


Fig. 1 - Area of study and station locations

CHP (k cal.cm^{-2}) has been computed³ for each station by;

$$\text{CHP} = \rho C_p \int_0^{D_{26}} T dz \quad \dots (1)$$

where ρ is the density of water column above 26°C ; C_p , specific heat of seawater at constant pressure; T , temperature difference between mean temperature of 2 consecutive layers and 26°C ; dz , depth increment; and D_{26} , depth of 26°C isotherm.

Distribution maps of CHP, topography of 26°C isotherm and dynamic topography of sea surface relative to 1000 db for the monsoon and fall periods are presented.

Results and Discussion

The climatological monthly SST maps⁵ for the Bay of Bengal (Fig. 2) show that during January and February the SST is well below 25°C in the north Bay of Bengal while in the south, it is more than 27°C . During the rest of the year, SST over the Bay of Bengal is well above 27°C and exceeds 29°C in May. These variations in SST are primarily due to march of the sun.

The zones of genesis of the cyclones shift markedly from month to month in the Bay of Bengal⁶. The zones of genesis of weather disturbances shift from 8°N during April to north of 20°N , during August. From September, these zones shift southwards and reach 8°N by December. Thus,

the zones of the genesis of the cyclones undergo an annual cycle in the Bay of Bengal.

From Eq. 1, it can be noted that CHP is directly proportional to the product of mean temperature of the water column above 26°C isothermal surface and the depth of 26°C isotherm. Higher CHP values can occur with high (low) mean water temperature and lower (higher) depths of occurrence of the 26°C isothermal surface.

Shallowing and deepening of 26°C isothermal surface in the Bay of Bengal during monsoon and fall periods (Fig. 3 a and b) clearly follow the surface circulation patterns (Fig. 4 a and b) in the region. The 26°C isothermal surface shoals in the region of anticlockwise circulation and deepens in the region of clockwise circulation. Consequently, low (high) CHP regions coincide with the regions of anticlockwise (clockwise) circulation. Deepening of 26°C isothermal surface towards east in the southern Bay of Bengal, south of 13°N , during fall indicates the sinking of warm surface waters and the consequent increase in the heat content. Analysis of the distribution of CHP (Fig. 5) shows that during monsoon, CHP is in general, $>10 \text{ k cal.cm}^2$ except in the west central Bay of Bengal. Southwestern Bay of Bengal has higher heat potential because during monsoon obviously because no weather system originates or passes over this area. Another interesting feature is that, the CHP is relatively higher near west of Nicobar islands than near main Andaman Island. This is the region from where the weather systems either originate or propagate during the subsequent period

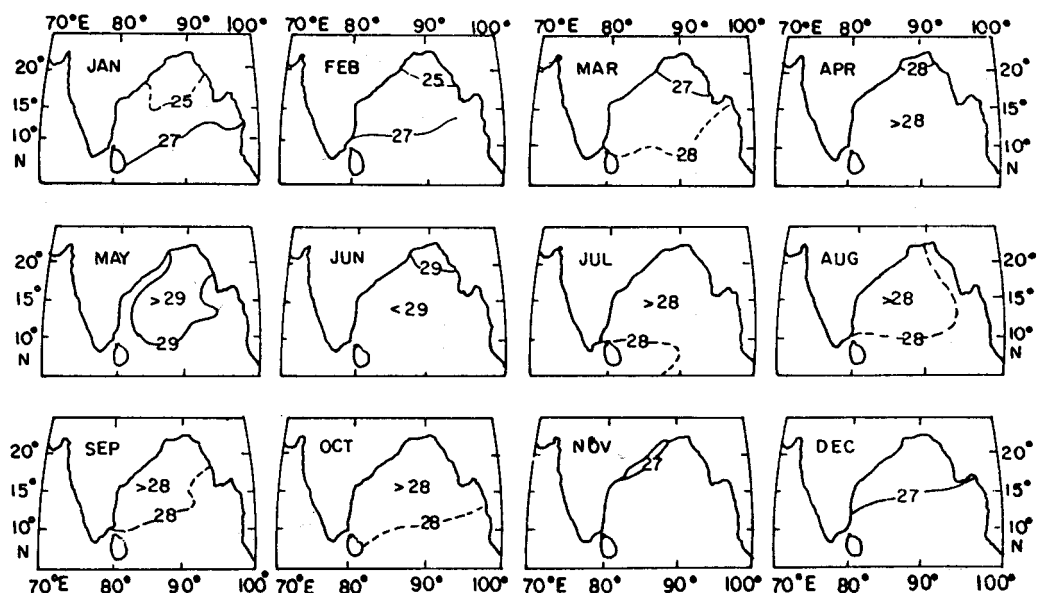


Fig. 2 – Climatological sea surface temperature distribution in Bay of Bengal

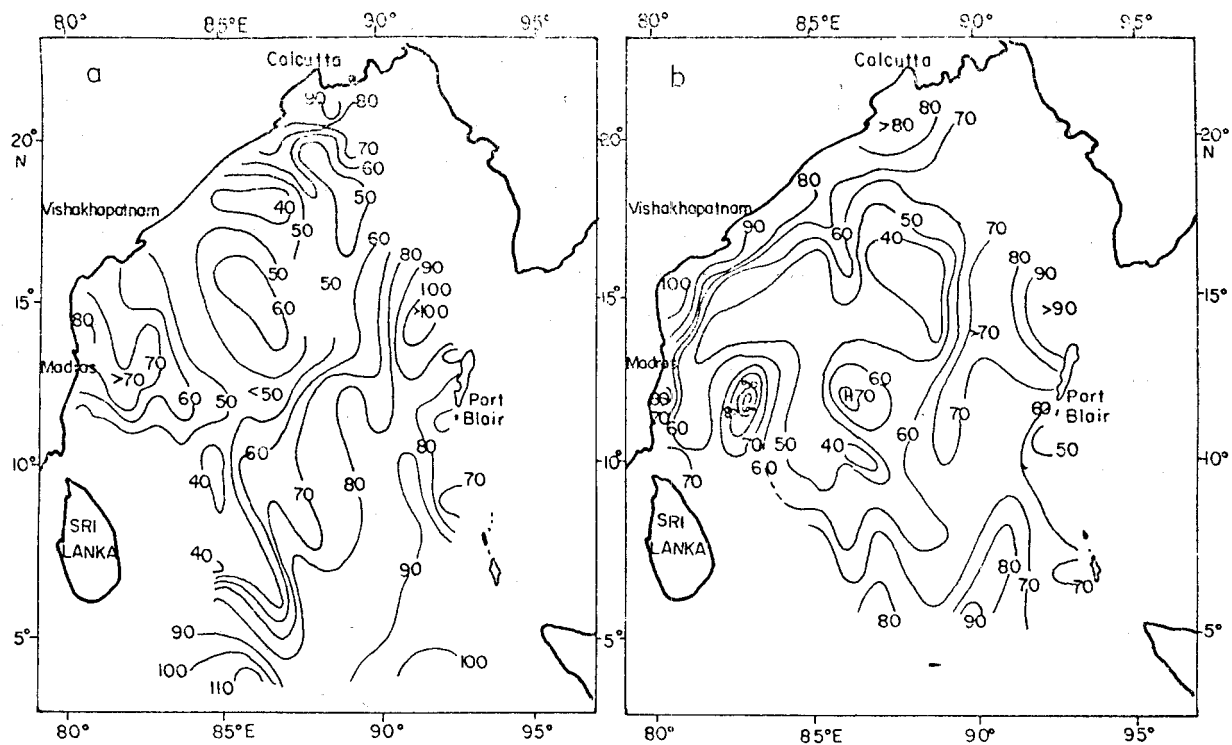


Fig. 3 – Topography of 26°C isotherm [(a) monsoon and (b) fall]

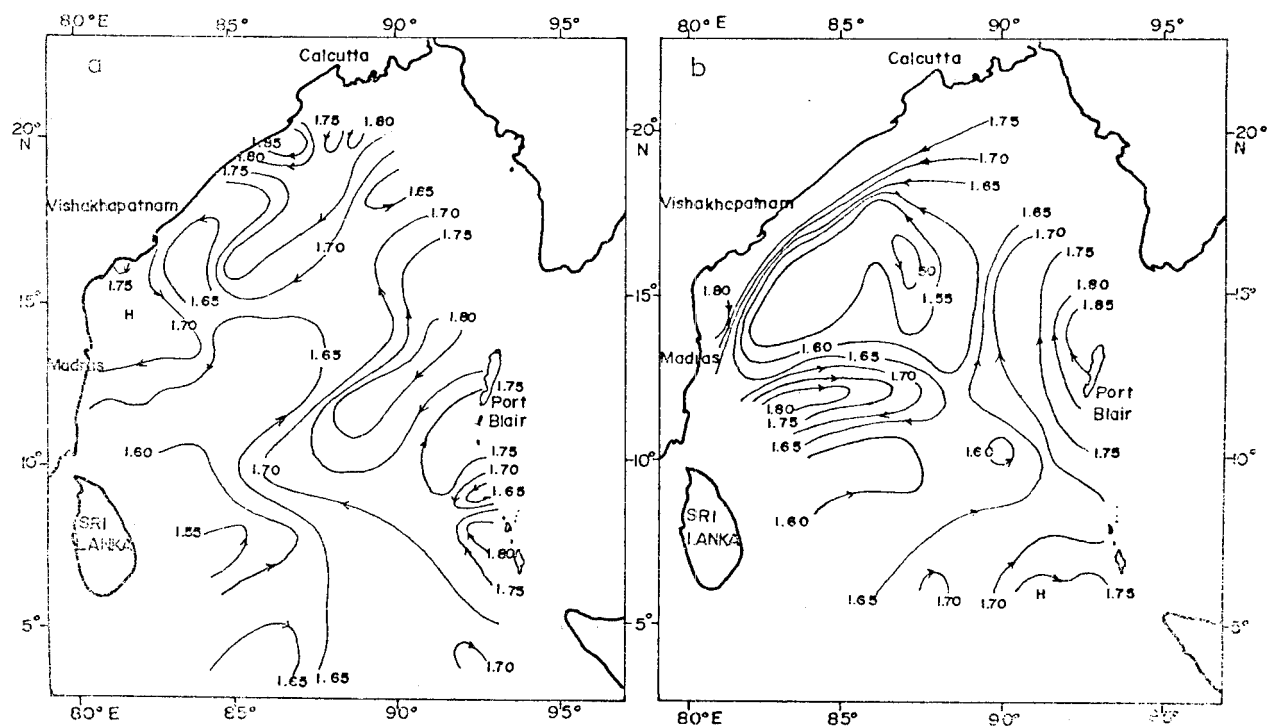


Fig. 4 – Dynamic topography of the sea surface relative to 1000 db [units; dyn.m), (a) monsoon and (b) fall]

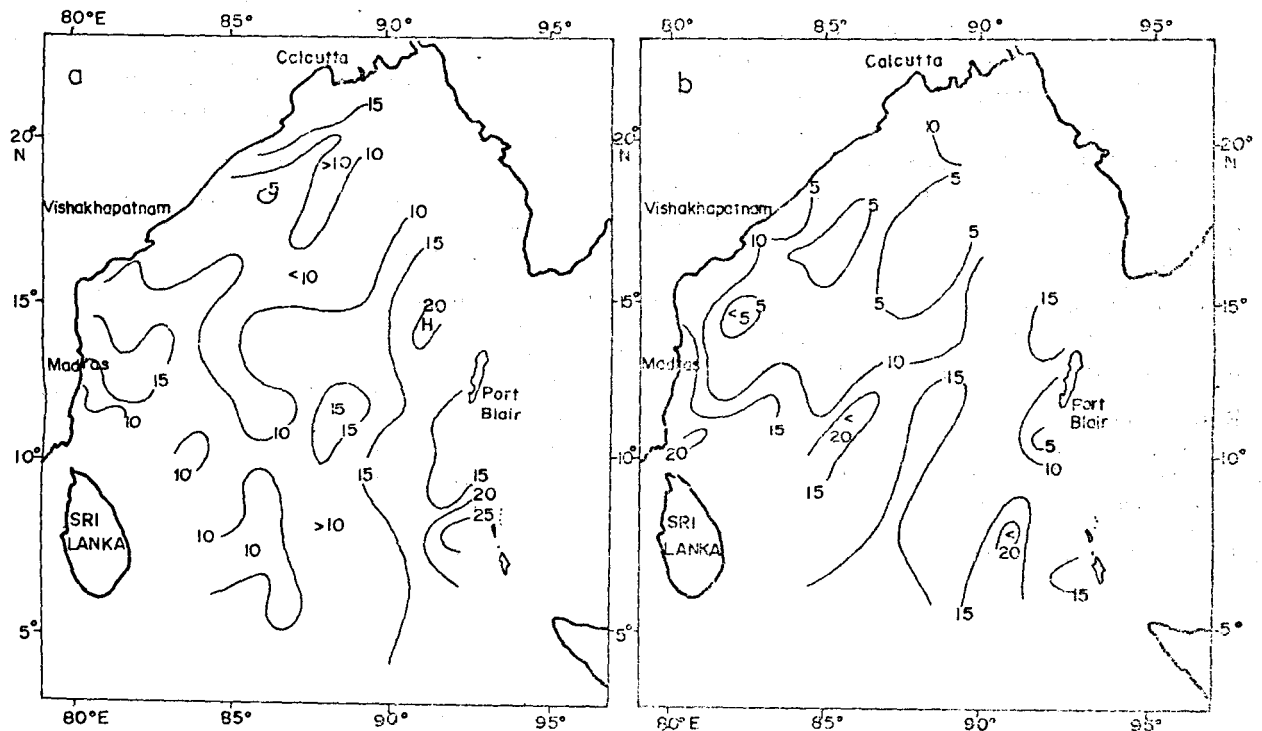


Fig. 5 – Distribution of cyclone heat potential in Bay of Bengal [(a) monsoon and (b) fall]

(during fall)⁵. This emphasises the importance of studying CHP distribution and its variability in the Bay of Bengal. In the southwestern Bay of Bengal (south of 13°N) higher CHP ($>15 \text{ k cal.cm}^{-2}$) is observed during fall than in monsoon, which may be primarily due to the increase in incoming solar radiation during fall. North of 13°N, cyclonic circulation reduces the CHP markedly in the western Bay of Bengal. In contrast to southeast and northern regions, southwest Bay of Bengal accumulates heat throughout these 2 periods. This may be because of the fact that no weather disturbances generate or pass over this region⁵. In the northern Bay, during winter months, strong subsurface temperature inversions are common^{6,7} and during this period, SST is generally $<26^\circ\text{C}$. But due to subsurface inversions in the upper layers, 26°C isothermal surface appears at deeper depths and therefore, CHP remains relatively higher in the region. However, as mentioned earlier, no depressions or cyclones develop over the head of the Bay of Bengal during winter. This underlines one important fact that the regions with $\text{SST} < 26^\circ\text{C}$, though they possess considerable CHP by virtue of subsurface inversions, are not conducive to the formation of depressions and cyclones. While studying the heat storage, estimated from heat budget parameters in the Bay of Bengal, Rao and Devi⁸ showed that during peak of the southwest monsoon only northern

Bay of Bengal gains heat. They further showed that the heat storage increases with the weakening of the southwest monsoon. Present results do agree with this observation. According to Rao⁹ an average heat potential of around 8 k cal.cm^{-2} over 28°C can sustain an intense tropical synoptic disturbance for about a week with an assumed evaporation of 2 cm.day^{-1} . In the northern Bay of Bengal, region of high CHP during monsoon coincides with the region where monsoon depressions form during southwest monsoon. Region of high CHP as noticed in the southern Bay of Bengal during monsoon provides ground for the genesis of tropical disturbances or for their further intensification during the subsequent period. Lowering of CHP to 5 k cal.cm^{-2} in the region south of Andaman Island during fall indicates that the weather disturbances have extracted the heat energy from the sea and lowered the CHP. The stored heat energy in southeastern region is higher during fall and maintained by the eastward flowing monsoon drift current. Cyclonic circulation in the northern Bay of Bengal, which brings in cold waters discharged from rivers, decreases CHP to a minimum ($<5 \text{ k cal.cm}^{-2}$) in the western Bay of Bengal during fall. The north and south Bay of Bengal are energetically active zones i.e., regions of high CHP during monsoon and fall respectively. Present study suggests that there is a certain linkage exists between CHP dis-

tribution and the formation and intensification of weather disturbances. However, further studies are required to delineate the high energy regions in the Bay of Bengal and to understand (i) nature of linkage between CHP distribution and origin of weather disturbance and (ii) quantitative contribution of CHP to the genesis and intensification of these disturbances.

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