Seasonal Cyclogenesis Patterns in the Bay of Bengal: An Integrated Atmospheric and Oceanic Analysis

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Abstract:-

This study examines the formation and intensification of tropical cyclones in the Bay of Bengal, focusing on the Upper Ocean Heat Content (UOHC) and other atmospheric and oceanic factors. By analyzing data from 1980 to 2014, we developed a modified Genesis Potential Index (GPI) that incorporates parameters like UOHC, vertical wind shear, relative humidity, and sea surface temperatures. Our findings indicate significant seasonal variations influenced by monsoons, with distinct Cyclogenesis patterns during the pre-monsoon and post-monsoon periods. Additionally, there is an increasing trend in the frequency and intensity of cyclones in recent decades, likely linked to global warming and changing climate patterns, such as the El Niño-Southern Oscillation (ENSO). The refined GPI model shows improved predictive capability for Cyclogenesis in the Bay of Bengal, enhancing early warning systems and disaster preparedness. This research underscores the critical need to integrate atmospheric and oceanic parameters in cyclone model to better understand and predict these severe weather events, ultimately aiding in the mitigation of their impact on vulnerable coastal regions. Continued research and advancements in model techniques are essential to address the challenges posed by a changing climate.

Key Words:- Upper Ocean Heat Content, Potential Index, monsoons, Cyclogenesis, El Niño-Southern Oscillation,, and mode etc

Introduction:-

Tropical cyclones are very destructive natural calamities, and the Indian subcontinent often bears the brunt of their effects during the pre-monsoon (April-May) and post-monsoon (October-November) periods. Cyclones are propelled by the transfer of heat, momentum, and moisture in the ocean. The studies conducted by Sadhuram et al. in 2004, 2006, and 2010, as well as Maneesha in 2013, emphasize the significance of Upper Ocean Heat Content (UOHC) in the development and strengthening of cyclones in the Bay of Bengal. These studies propose that a minimum UOHC of 40 kJ/cm^2 is required for cyclone formation during these specific seasons. The UOHC, or Tropical Cyclone Heat Potential (TCHP), plays a crucial role in this particular situation.

Studies have identified multiple elements that affect the formation of cyclones, including the correlation between the Southern Oscillation and cyclone frequency (Goulter and Revell, 1986), as well as the techniques used to predict Australian cyclones (Nicholls, 1984, 1992). A study conducted by Maneesha and Manasa (2015) examined the influence of sea surface temperature (SST) on cyclones in the North Indian Ocean. Gray (1978) outlined crucial factors necessary for the development of tropical cyclones, which include warm ocean waters (with a minimum temperature of 26.5°C extending 50 meters deep), an atmosphere that is potentially unstable, a mid-troposphere that is moist, a location sufficiently far from the equator, existing disturbances near the surface, and minimal vertical wind shear.

The frequency of cyclones in the Bay of Bengal (BOB) is approximately four times higher than that in the Arabian Sea, which renders the Indian east coast particularly susceptible to cyclone-induced damages. Significant storms that have caused substantial loss of life and property include the 1999 super cyclone in Orissa, the 2014 cyclone Hudhud, and the 2020 cyclone Amphan

Meteorologists continue to face significant challenges in accurately predicting the intensity and trajectory of cyclones. The development of cyclones throughout both winter and summer seasons is affected by atmospheric circulation parameters over a period of many weeks (Wang and Moon, 2017; Moon et al., 2018). Prior research (Emanuel, 1987; Camargo et al., 2007) has created the Genesis Potential Index (GPI) by utilizing atmospheric variables to assess the likelihood of tropical cyclone formation in different marine areas. GPI models for the North Indian Ocean have been developed by Roy Bhowmik (2003) and Kotal et al. (2009), incorporating atmospheric parameters. These models have been further improved by adding vertical velocity terms (Murakami and Wang, 2010).

Inspired by these investigations, we have created a novel GPI model that integrates atmospheric and oceanic variables specifically for the Bay of Bengal. This study calculates the Global Precipitation Index (GPI) for the region between 5° and 20°N latitude and 80° and 100°E longitude. The analysis period is from 1995 to 2018, specifically focusing on the southwest and post-monsoon seasons.

An analysis has been conducted on the origins and year-to-year changes in tropical cyclones, uncovering clear patterns and variations over different seasons, particularly influenced by ENSO. The primary objective of this comprehensive method is to improve the accuracy and comprehension of cyclone formation in the Bay of Bengal.

The Indian Ocean is distinct from the Atlantic and Pacific Oceans as it is land-locked to the north and does not reach the colder climates of the Northern Hemisphere. Covering approximately 68.556 million square kilometers with a coastline of 66,526 km, its unique geographical structure leads to asymmetrical circulation patterns. The Asian landmass influences the Indian Ocean's climate by causing seasonal monsoon changes, which reverse northern circulation patterns. Upwelling areas are significantly affected during the southwest monsoon, contrasting with other major upwelling regions worldwide. Additionally, high salinity water formations occur in the Arabian Sea, Red Sea, and Persian Gulf, and the Indian Ocean's lowest oxygen concentrations are found in different locations compared to the Atlantic and Pacific Oceans.

Data and Methodology:-

Data:

For plotting the tracks of Cyclones over Bay of Bengal during the period 1948-2018, the tracks data is obtained from Joint Typhoon Warning Centre (JTWC). Different datasets have been used in this study. The zonal wind (U), meridional wind (V), Relative Humidity, Air Temperature and Sea Surface Temperature (OISST) data for the years 1981-2017 have been obtained from theNational Centre for Environmental Prediction/National Centre for Atmospheric Research (NCEP/NCAR) wentieth Century Reanalysis product version 2 . The resolution of the datasets for U-wind, V-wind, Relative Humidity, Air Temperature are 2.0° latitude x 2.0° longitude, ranging from 1981 to 2017, daily means The NCEP/ NCAR reanalysis products are downloaded from (https://www.esrl.noaa.gov/ psd/data/gridded/ data.ncep.reanalysis2.html). The OISST data, the resolution is 0.25° latitude x 0.25° longitudeisobtainedfrom (https://www.esrl.noaa.gov/psd/data/gridded/data.noaa.oisst.v2.highres.html#detail).

For Ocean heat content, the datasets of gridded temperature profile of sea has been utilized. These datasets have been taken from the Met Office Hadley Centre (http://hadobs.metoffice.com/en4/download-en4-2-1.html). Here, the resolution is 1.0° latitude x 1.0° longitude and monthly mean data is utilized. All the datasets are analysed only for the Post Monsoon season (October, November, and December) which is the study period for present study

Methodology:

The datasets taken here are of different temporal resolutions. To make them all synonymous, the monthly means have been calculated using Climate Data Operators (CDO). Now, after getting all the datasets in monthly means Genesis Potential Index-1 (GPI-1) and Genesis Potential Index-4 (GPI-4) are calculated. These indexes are modified for North Indian Ocean.

For the north Indian Ocean, Kotal et al. (2009) developed a genesis potential Parameter (GPP) which is used by India Meteorology Department (IMD), New Delhi. The GPI-1 involves only the atmospheric parameters only. For the calculation of GPI-1 the following formula is used.

$$GPI\ -1 = \begin{cases} \frac{\xi_{850} \times M \times I}{S},\ if\ \xi_{850} > 0, M > 0\ and\ \ I > 0 \\ 0,\ if\ \xi_{850} \leq 0, M \leq 0\ or\ I\ \leq 0 \end{cases}$$

Where ξ_{850} =low -level relative vorticity (at 850 hPa) in 10^{-5} s^{-1} ; S= vertical wind shear between 200hPa and 850 hPa (m s^{-1}); $M = \frac{[\mathrm{RH}-40]}{30}$middle troposphere relative humidity; Where Rh is the average relative humidity between 700 hPa and 500 hPa:; I = (T_{850}-T_{500}) °C = middle troposphere instability (Temperature difference between 850 hPa and 500 hPa)

Maneesha et al. (2015) brought out the importance of upper ocean heat content (UOHC) in the genesis and intensification of cyclones over Bay of Bengal, no ocean parameter has been included in the GPI-1. Recently, Zhang et al. (2016) developed a GPI for western north Pacific using ocean parameters. A similar index for the Bay of Bengal to include ocean parameters in addition to the above atmospheric parameters. Based on studies, (Maneesha 2013;Patnaik et al. 2014; Maneesha et al. 2015) UOHC above 40 kj/cm2 is necessary for the genesis of a cyclone over Bay of Bengal. Sadhuram et al., (2017) have developed a new Genesis Potential Index (GPI-4) taking into consideration, the upper ocean heat content, hence GPI-4 is the modified version of GPI-1 where in the Oceanic parameters are also included to measure the genesis potential.

GPI-4 is calculated by using the formula,

$$\mathrm{GPI}\ -4\ =\ \mathrm{GPI}\ \ -1\ *\left(\frac{UOHC}{40}\right)$$

UOHC (it was referred as hurricane heat potential/cyclone heat potential) which is a measure of heat content from the surface to the depth of 26°C isotherm. This value is chosen since it represents a threshold temperature suggested for the genesis of hurricane by Palmen (1948).

UOHC has been computed using the formula put forth by Leipper and Volgenau (1972).

$$\mathrm{UOHC} =\ \rho C_p \longrightarrow \int_{0}^{D26} (\bar{T} - 26)dZ$$

Where ρ is the density of water column above 26°C isotherm, Cp is the specific heat of seawater at constant pressure, T is the average of two consecutive layers with a depth increment dz and D26 is the depth of the 26°C isotherm (meters).
Pearson Correlation Coefficient are computed using the formula.

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \acute{x})(y_i - \acute{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \acute{x})^2 \sum_{i=1}^{n}(y_i - \acute{y})^2}}$$

r = Pearson’s correlation coefficient, n = number of observations and x,y are variables.

In order to know the variations over the years both Spatial trend and time-series plots have been plotted for Air Temperature, Relative Humidity, Ocean Heat Content, Wind Shear, Vortices.

Results and Discussion:-

Fluctuations in tropical cyclone activity are of obvious importance to society, especially as populations of afflicted areas increase. Tropical cyclones account for a significant fraction of damage, injury and loss of life from natural hazards and are the costliest natural catastrophes in India. The Bay of Bengal is subjected to tropical cyclones during pre-monsoon (March, April, May) and post-monsoon (October, November and December) seasons (Sreenivas et al., 2012 and references therein). The frequency of cyclones in about 4 times higher Over Bay of Bengal compared with the Arabian Sea. Most of the cyclones during peak post-monsoon season (October-November) originate in the Andaman Sea and southern Bay of Bengal. They travel in west North West direction and hit east coast of India. Some cyclones either move towards north or northeast and hit Bangladesh/ Myanmar coasts (Sadhuram et al. 2004, 2006). Earlier studies brought out the importance of upper ocean heat content (UOHC), eddies and warm ocean features in the genesis and intensification of cyclones. Our earlier studies emphasized the role of the above in the genesis of and intensification of cyclones over Bay of Bengal during pre-monsoon (April-May) and peak post monsoon (October- November) seasons. From these studies a threshold UOHC of 40 kj/cm2 is necessary for the genesis of a cyclone in Bay of Bengal during the above seasons. The post-monsoon storms are often more intensified compared to the pre-monsoon season. Figure 3 and Figure 4 shows the tracks of ‘severe-cyclonic storms’ and ‘very-severe cyclonic storms’ over Bay of Bengal for the period 1978 to 2018 for the post-monsoon period. From Figure. 3 and Figure. 4 it is clear that there is significant number of intense cyclonic storms over Bay of Bengal with varied regions of land-fall. The region where these intensified cyclones go land fall are often associated with severe property and fatalities. The damage due to tropical cyclones could be agricultural, societal and property loss; the severe cyclonic storm Nargis over Bay of Bengal has caused 1.5 lakhs of fatalities (McPhaden et al., 2009) in addition to severe property loss.

Hence the cyclones over Bay of Bengal with intensity more than cyclonic storm (please refer Table-1 for classification of cyclone intensities) or more could cause intense havoc over the countries surrounding Bay of Bengal, including India.

The recent decades (1996 to – 2019) have evidenced increased frequency and number of very severe cyclonic storms over Bay of Bengal (Table 2 and Figure. 5).

Figure. 3 Tracks of Severe cyclonic storms over Bay of Bengal during the period 1970-2018(Post Monsoon Season).

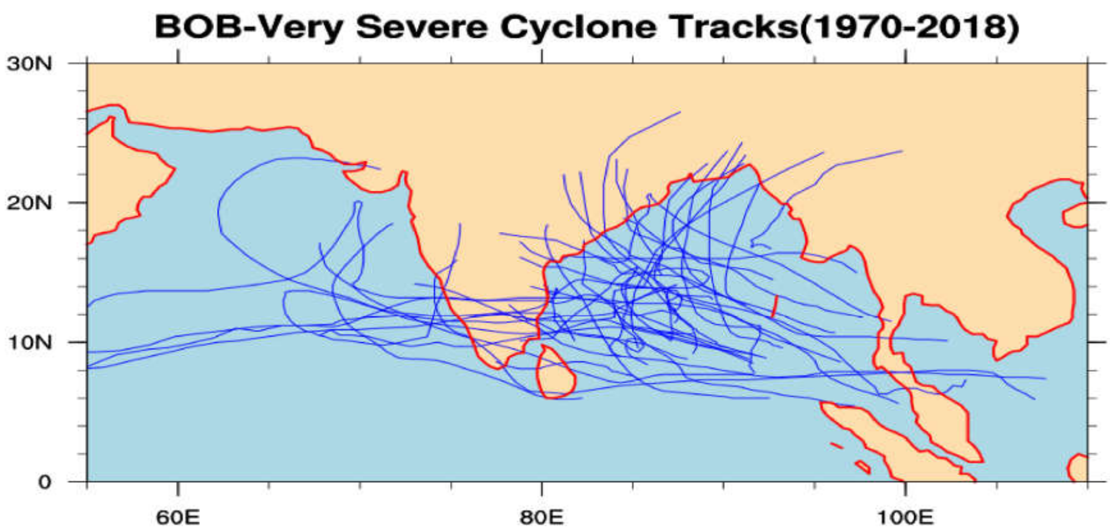

Figure. 4 Tracks of Very severe cyclones over Bay of Bengal during 1970-2018(Post Monsoon season).

YEAR	MONTH	NAME	INTENSITY	MAX WIND SPEED (mph)	LANDFALL
1972	September	Hurricane 9	Very severe	80	Andhra Pradesh
1972	September	Hurricane 10	Severe	70	Orissa
1972	November	Hurricane 14	Very severe	90	Tamil Nadu
1996	October	BOB 1	Severe	70	Andhra Pradesh
1996	November	BOB 5	Very severe	90	Andhra Pradesh
1996	November	BOB 6	Very severe	75	Andhra Pradesh
2013	October	PHAILIN	Extremely severe	140	Orissa
2013	November	HELEN	Severe	60	Andhra Pradesh
2013	November	LEHAR	Very severe	75	Andhra Pradesh
2013	December	MADI	Severe	70	Tamil Nadu
2018	October	TITLI	Very severe	95	Andhra Pradesh
2018	November	GAJA	Very severe	75	Tamil Nadu
2018	December	PHETHAI	Severe	55	Andhra Pradesh

Table. 2 1972,1996,2013,2018 are the years in the recent decades to observe three or more intensified cyclones during the post monsoon season.

Global climate models show a substantial increase in potential intensity with anthropogenic global warming, leading to the prediction that actual storm intensity should increase with time (Emanuel KA et al., 1987). A recent comprehensive study using a detailed numerical hurricane model run using climate predictions from a variety of different global climate models supports the theoretical predictions regarding changes in storm intensity (Henderson-Sellers et al., 1998). With the observed warming of the tropics of around 0.58 °C, however, the predicted changes are too small to have been observed, given limitations on tropical cyclone intensity estimation. Global climate model predictions of the influence of global warming on storm frequency are highly inconsistent, and there is no detectable trend in the global annual frequency of tropical cyclones in historical tropical cyclone data (Emanuel KA et al., 2005).

Figure. 5 Number of very severe cyclonic storms during post monsoon seasons over Bay of Bengal during the period 1970-2018(post monsoon season).

The present study addresses the causative factors responsible for the observed increase in number and intensity of severe cyclonic storms over Bay of Bengal. Tropical cyclones do not respond directly to SST, however, and the appropriate measure of their thermodynamic environment is the potential intensity, which depends not only on surface temperature but also on several other parameters like mid-tropospheric relative humidity, vertical wind shear, air temperature etc (Kotal et al., 2009). The GPI-1 and GPI-4 indices (described under methods section) includes both the oceanic and atmospheric parameters that can influence the genesis and intensity of tropical cyclones. Here under, we have examined the nature of GPI-1 and GPI-4 their trends during recent decade

The present study examines the causative factors responsible for observed increase in the number and intensity of cyclones over Bay of Bengal. Both the GPI-1 and GPI-4 indices are been examined here. The GPI-1 has most of the atmospheric parameters that can support cyclogenesis (Kotal et al., 2009) and the GPI-4 includes the oceanic parameters that could impact cyclogenesis and intensity. The method for computing GPI-1 and GPI-2 is provided in Chapter II. The region considered for this study is the North Indian Ocean (80°E-100°E,2°N-23°N). The intensity of a Cyclone can be measured by the Genesis Potential Parameter (GPP). Interannual variability of different parameters used in calculating GPI-1,4 are showed in the following figures. For this study we have excluded the days of cyclones during the study period so as to have a better view of the changes occurring in the atmospheric and oceanic parameters.

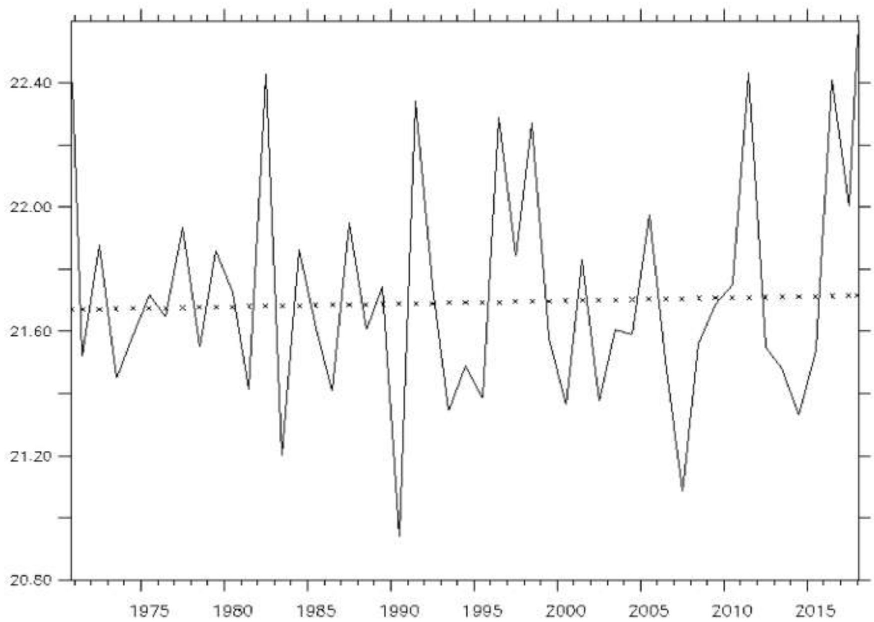

Figure. 6: Time series of temperature instability (T_{850}-T_{500}) over the years 1970-2018(excluding cyclone days) for the post-monsoon period; overlaid by trend as crossed line.

Figure. 7: Spatial trend in Air Temperature(T_{850}-T_{500}) in °C, trend is computed over the period 1970-2018(excluding cyclone days, post monsoon season).

The Figure.6 and Figure.7 represents Temperature difference (between the pressure levels 850 hPa and 500 hPa) in a time series and spatial trend plots respectively. From the time series plot it is clear that there is an increase in the Air Temperature over the years by about 0.05° C, it varied between 21.0 ° C to 22.5° C and the average value is above 21° C. From the Spatial trend plot, one can observe that the southern and central Bay of Bengal (BOB) basin has positive trend (Fig. 7). The temperature instability has been calculated only for the non-cyclonic days of the post monsoon season during the years 1970-2018. By doing so, we can see how the temperature instability varied with respect to time over the years in the post monsoon season. The greater the instability the higher the chances to get an intensified cyclone. From the spatial trend plot (Figure. 7) we can observe that the cyclones that take birth in the BOB basin has higher chances of turning into an intensified one. The upward trend in the time series plot (Figure. 6) indicates that the average temperatures of the post monsoon season are on the rise, favouring the intensification of cyclones in the recent era.

Figure. 8:Time series of Relative Humidity (average between RH_{700} and RH_{500}) over the years 1970-2018(excluding cyclone days) for the post monsoon season, overlaid by trend as crossed line.

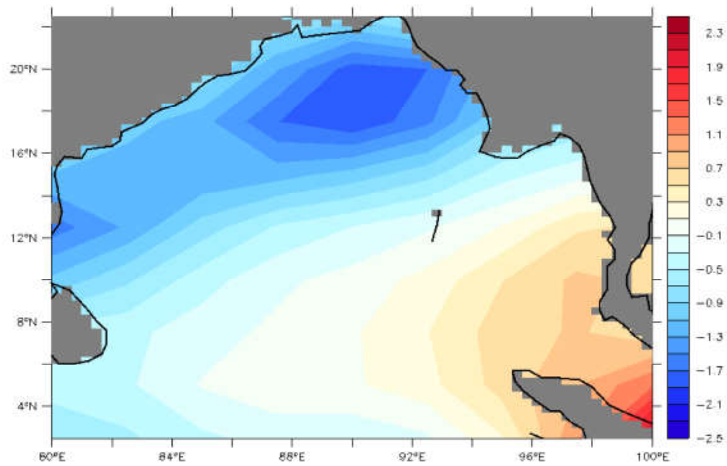

Figure. 9: Spatial trend in Relative Humidity (average between RH_{700} and RH_{500}) in %, trend is computed over the period 1970-2018(excluding cyclone days) for the post monsoon season.

The Figures. 8,9 are about Mid Tropospheric Relative Humidity (average between RH_{700} and RH_{500}) through the years 1970-2018. In the time series plot one can observe that there is a downward trend and the values varied between 40% to 58% and average value is above 40%. When considering the spatial trend plot, we can observe that there is a downward trend in the Mid Tropospheric Relative Humidity over BOB basin. The Mid tropospheric relative humidity is calculated only for the non-cyclonic days of the post monsoon season during the period 1970-2018. During the non-cyclonic days, we see a negative trend in the humidity levels at mid troposphere (RH_{850}-RH_{500}). The drop is about 2% over the span of 48 years. From the spatial plot (Figure. 9) we can say that if a cyclone takes birth in the BOB basin it has got more chances of turning into a intensified cyclone as there is a positive trend over that area. But, if a cyclone forms nearer to the coast the chances of it turning into a severe cyclone are pretty low as the moisture content is decreasing in the mid tropospheric area in the post monsoon season.

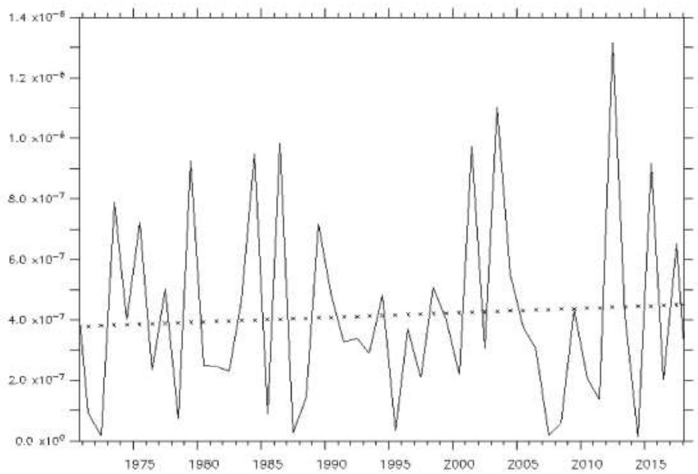

Figure. 10: Time series of Relative Vorticity (850 hPa) over the years 1970-2018(excluding cyclone days) for, post monsoon season,overlaid by trend as crossed line.

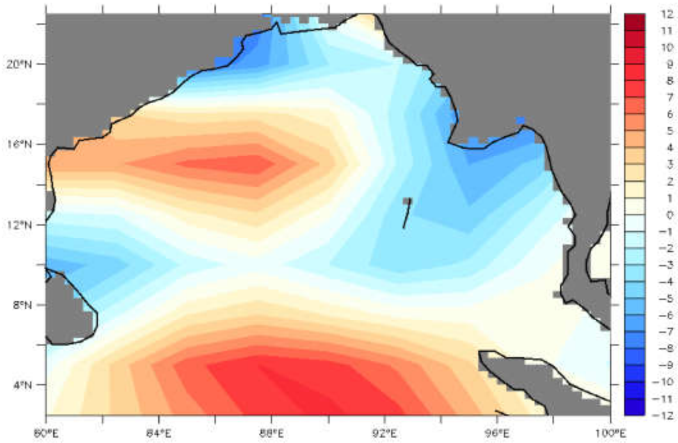

Figure. 11: Spatial trend in Relative Vorticity (850 hPa) , trend is computed over the period 1970-2018 (excluding cyclone days) for the post monsoon season.

Figure 10 represent the inter-annual oscillations and trend in Relative vorticity (850hPa), area averaged for the study region and the spatial trend is shown in Figure. 11. In the time series plot (Fig. 10) its can be observed that there is an increasing trend in relative vorticity over the years. Only magnitude of Zeta has been taken here by applying absolute function. The vales ranged between 0 to 1.4 * 10^{-6}. In the spatial plot (Figure. 11) the absolute function has not been applied, and there is an increase in the magnitude of the parameter all over BOB. Only the non-cyclonic days were considered for calculating the relative vorticity for the post mon monsoon season during the period 1970-2018. Theoretically, the higher the vorticity at 850 hPa the stronger a cyclone would be. From the time series plot (Figure. 10) it is evident that there is an increase the vorticity magnitude at the lower levels (850 hPa). Stronger vorticity suggests that the atmosphere is dynamically unstable, thus resulting in the formation or intensification of a system. From the spatial trend plot (Figure. 11) it is observed that the area between 14 °N-18 °N, 80 °E-90 °E has strong positive trend. Considering the Figure. 3,4 we can conclude that most of the cyclones traversing through this area (14 °N-18 °N, 80 °E-90 °E) have intensified into severe or very severe cyclones.

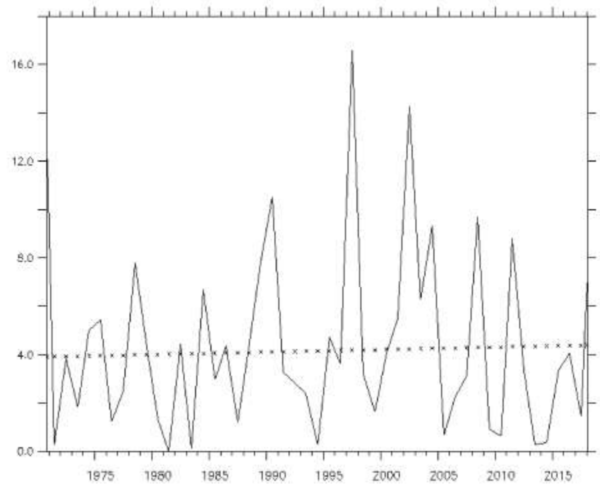

Figure. 12: Time series of Vertical Wind Shear (S_{850}-S_{200}) over the years 1970-2018(excluding cyclone days)for the post monsoon season, overlaid by trend as crossed line.

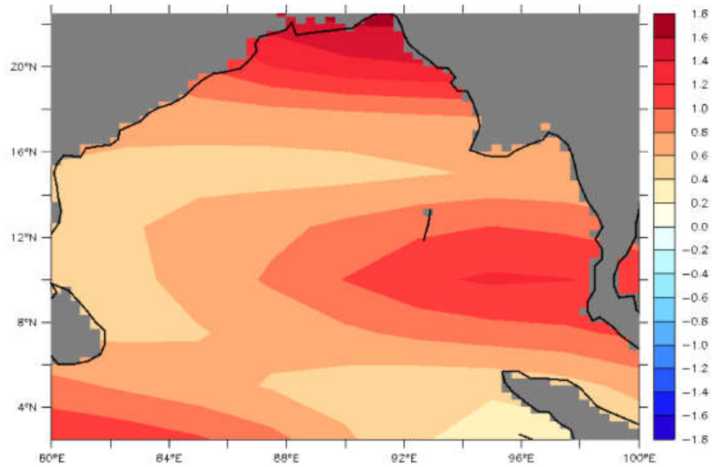

Figure. 13: Spatial trend in Vertical Wind Shear(S_{850}-S_{200}) in m/sec, trend is computed over the period 1970-2018(excluding cyclone days), for the post monsoon season.

The Figure 12 and Figure 13 are the trend in vertical Wind Shear (between the pressure levels 200 hPa and 850 hPa) calculated over the years 1970-2018. It is clear from the time series plot (Fig. 12) that there is a slight increasing trend in the Wind Shear (absolute) when we consider the whole period (1970-2018), however there is a significant downward trend that can be observed starting from the year 2003. The magnitude of the shear varied from 0 to 16 m/sec. From the spatial trend plot (Fig. 13), it can be observed that there is positive trend over the North Indian Ocean (BOB). For a cyclone to form the vertical wind shear must be less than 10 m/sec. Even after excluding the cyclone days the average vertical wind shear is less than 10 m/sec apart from couple of years. If we consider the time series plot (Figure. 12) one can observe that there is an upward trend till 2003 and after that there is significant downward trend. Also, the number of severe cyclones is on the rise in the recent decades. This observation supports the thesis that there is a rise in the number of intensified cyclones in the post monsoon season.

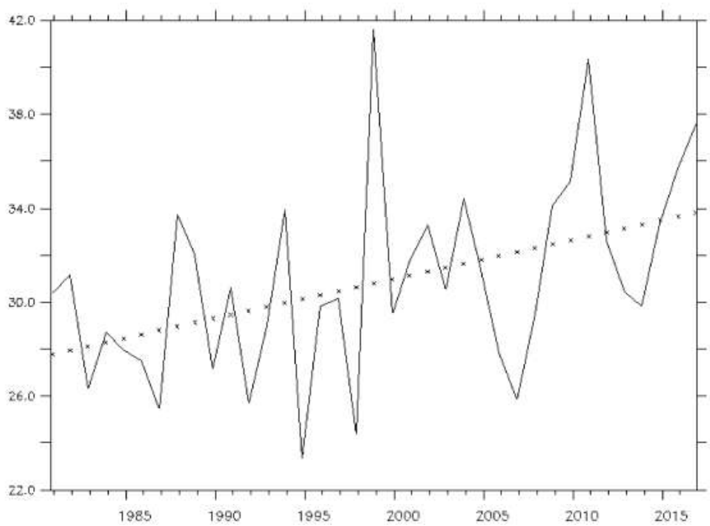

Figure. 14: Time series of Upper Oceanic Heat Content (D26 isotherm) over the years 1970-2018(excluding cyclone days) for post monsoon season, overlaid by trend as crossed line.\

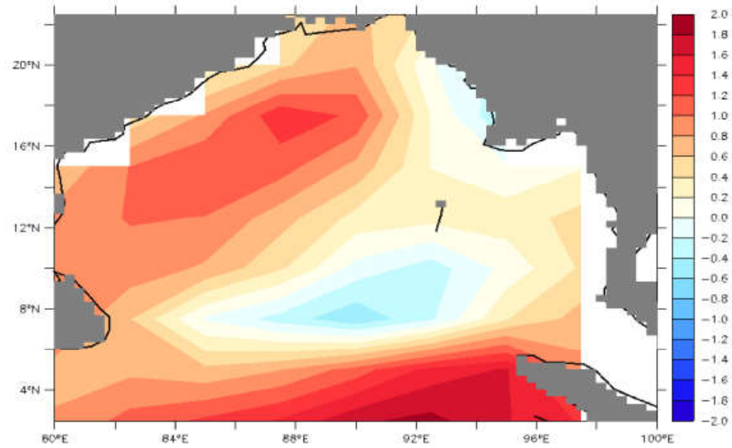

Figure. 15: Spatial trend in Upper Oceanic Heat Content (D26 isotherm) in kj/cm^2 trend is computed over the period 1970-2018(excluding cyclone days) for the post monsoon season...

The Figures. 14,15 shows the trend in Upper Oceanic Heat Content, which has been calculated for the levels above D26 (Depth of 26 °C isotherm). In the time series plot (Fig. 14) over the years 1970-2018, there is a significant increasing trend. The values vary from 24 to 42 kj/cm^2. The UOHC is used in the GPI-4 calculation. This is the only oceanic parameter used in calculating GPI. If the temperature of the upper level of the ocean is high it will help in the intensification of a cyclone, as there will be more moisture for the system to pick up and intensify.

From the Figure. 14, it is evident that that there is a significant rise in the UOHC in the Bay of Bengal region, which can increase the potential of intense tropical cyclones over Bay of Bengal. cyclones in the recent decades in the BOB region over the past decades. From the spatial plot (Figure.15) it is clear that there is a positive trend all over the BOB. So, irrespective of the place of genesis or path a cyclone takes it is bound to strengthen because of all the moisture that is available (UOHC).

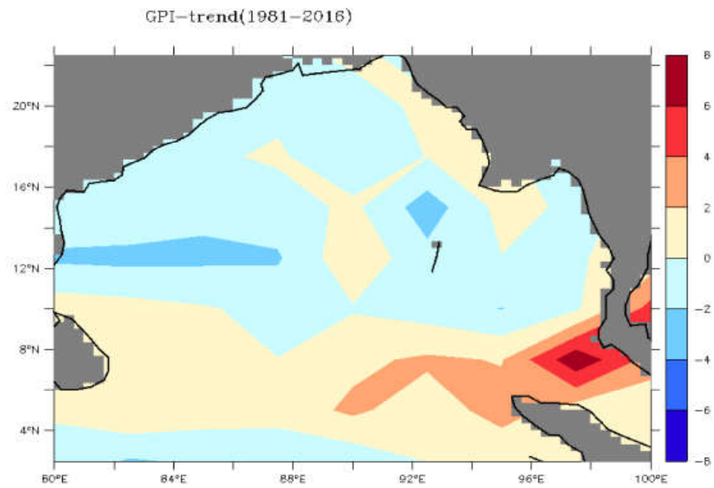

Figure. 16: Trend of GPI-1 (excluding cyclone days) over Bay of Bengal during the years 1980 to 2016 (post monsoon season) in the order of 10^{-6}

The Figure. 16 represents the trend of GPI-1 over the years (1981-2016). The days of cyclones have been discarded while calculating GPI-1 (i.e. only data of days without cyclones during the post monsoon season have been utilised). From the figure it is clear that there is a positive trend over southern and central Bay of Bengal even after discarding the cyclone days. In the region between (4N- 10N, 80E-100E) the chances of formation of a cyclone is high.

Figure. 17: Trend of GPI-4 (excluding cyclone days) over Bay of Bengal during the years 1981 to 2016 (post monsoon season) in the order of 10e-6

The Figure. 17 here represents the trend of GPI-4 over the years (1981-2016). The GPI-4 values have been computed by multiplying the GPI-1 values with UOHC. The oceanic GPI index is also inferring increased trend over southern and central parts of Bay of Bengal, as observed in GPI-1.

Figure. 18: Correlation of GPI-1 (excluding cyclone days) with GPI-4 (excluding cyclone days) over Bay of Bengal during 1980-2016(post monsoon season)

The Figure. 18 is the correlation between GPI-1 and GPI-4 through the years 1981-2016. We can see a strong positive correlation between GPI-1 and GPI-4. The correlation coefficient ranges from 0.725 to 0.995. The high positive correlation value indicates that the inclusion of oceanic heat content gives us a better approximation at the genesis potential index

Considering all the variables, it is to be observed that Upper Oceanic heat content plays the major role in the increase of Genesis Potential Parameter. The Wind shear also has a downward trend in terms of magnitude after the year 2003. The Vorticity is increasing, so is the temperature difference between 850 hPa and 500 hPa. All these factors result in increasing the intensity of a cyclone during the post monsoon season.

Other factors influencing cyclone intensification

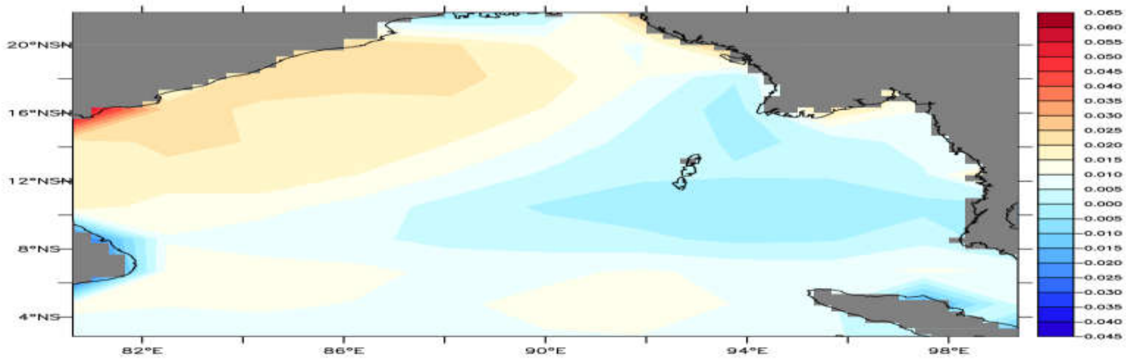

Fig 19: Sensible heat flux

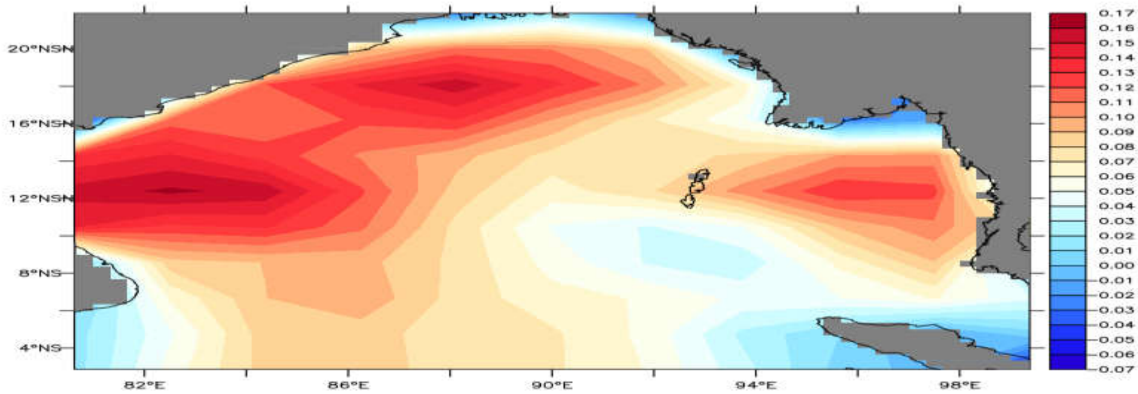

Fig 20 :Latent heat flux

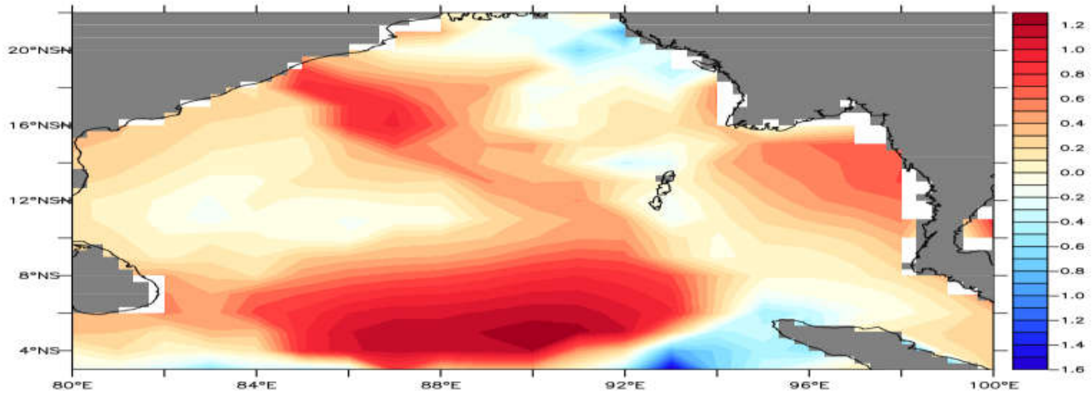

Fig 21: Mixed layer depth (Temperature)

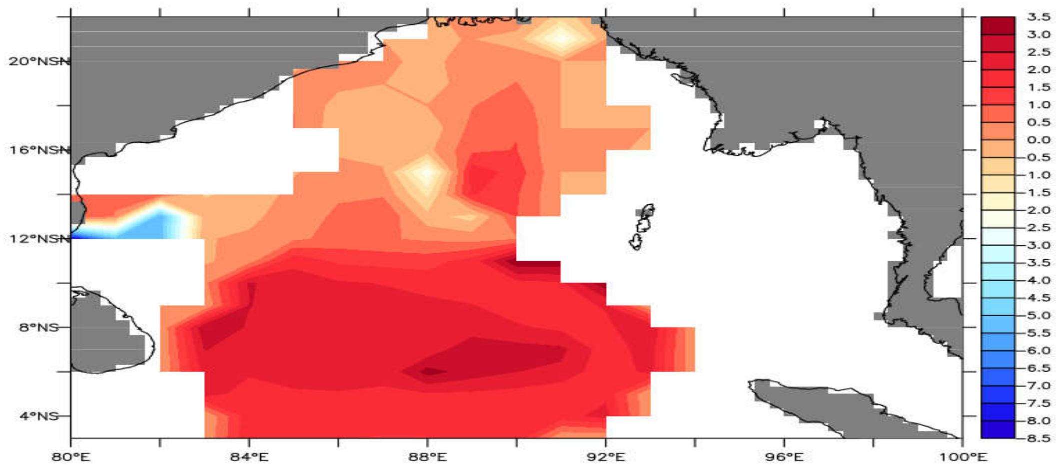

Fig 22 : Mixed layer depth (Density)

The following variables have been considered as some few factors affecting the cyclone intensification in the Bay of Bengal region during the post monsoon period. In this time period, consecutive positive and negative dipole years have been taken into consideration and studied. Those years include 1981&82, 1996&97, 2013&14. In these 6 years, the post monsoon period of the region has shown some significant results which have observable coincidence with the GPI-4 of the Andaman Sea region.

The sensible heat flux and latent heat flux have significant difference from one another as the latter shows promising significance with the GPI-4 calculations. The former one has normal results yet effective in its own nature.

Summary and Conclusions:-

This study delves into the formation and intensification of tropical cyclones in the Bay of Bengal, focusing on the role of Upper Ocean Heat Content (UOHC) and other atmospheric and oceanic variables. The Indian subcontinent is particularly vulnerable to these cyclones, especially during the pre-monsoon and post-monsoon seasons. Previous research has established the importance of UOHC, with at least 40 kJ/cm² necessary for cyclone formation. This study analyzes data from sources such as the Joint Typhoon Warning Centre and the National Centre for Environmental Prediction, covering the period from 1995 to 2018. It highlights significant seasonal variations in cyclone activity, influenced by monsoon transitions and factors like ENSO and atmospheric circulation patterns.

A new Genesis Potential Index (GPI) model was developed, integrating both atmospheric and oceanic parameters specifically for the Bay of Bengal. The refined GPI demonstrates improved predictive capability, enhancing our understanding of Cyclogenesis in this region. The analysis reveals an increasing trend in both the frequency and intensity of cyclones over recent decades, likely driven by global warming and shifting climate patterns.

The findings underscore the critical role of UOHC and related factors in cyclone formation and intensification. The improved GPI model can significantly enhance early warning systems and disaster preparedness, potentially mitigating the impact of cyclones on vulnerable coastal regions. This research advocates for ongoing investigation and the refinement of predictive models to address the challenges posed by a changing climate. Continued advancements in modeling techniques are essential for improving the accuracy of cyclone predictions and minimizing the destructive impact of these natural disasters.

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