Climate Change

Two Decades of Sea Surface Temperature Trends in the Bay of Bengal (2004–2024) from Multi-Satellite Observations (NOAA, NASA, Copernicus)

Arnab Guha Neogi[1]*

To Cite:
Neogi AG. Two Decades of Sea Surface Temperature Trends in the Bay of Bengal (2004–2024) from Multi-Satellite Observations (NOAA, NASA, Copernicus). *Climate Change* 2025; 11: e12cc3137
doi: https://doi.org/10.54905/disssi.v11i30.e12cc3137

Author Affiliation:
[1]Department of Oceanography, University of Dhaka, Bangladesh

***Corresponding author:**
Arnab Guha Neogi,
Department of Oceanography, University of Dhaka, Bangladesh,
Phone: +8801957217070
Email: guhaneogiarnab@gmail.com
ORCID: 0009-0009-9035-3996

Peer-Review History
Received: 27 March 2025
Reviewed & Revised: 18/April/2025 to 05/October/2025
Accepted: 27 October 2025
Published: 05 November 2025

Peer-Review Model
External peer-review was done through double-blind method.

Climate Change
pISSN 2394-8558; eISSN 2394-8566

URL: http://www.discoveryjournals.org/climate_change

© The Author(s) 2025. Open Access. This article is licensed under a Creative Commons Attribution License 4.0 (CC BY 4.0)., which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

DISCOVERY SCIENTIFIC SOCIETY

ABSTRACT
The Sea Surface Temperature (SST) plays a major role in monsoon dynamics, ocean-atmosphere interactions, and cyclone activity in the Bay of Bengal, which is one of the most climate-sensitive regions of the Indian Ocean. This study shows two decades (2004-2024) of SST variability and long-term trends in the Bay of Bengal using multi-satellite datasets from NOAA (OISST v2.1), NASA (MODIS-Aqua), and Copernicus (CMEMS), calibrating them with in-situ observations from NOAA moored buoys and ARGO profiling floats. The results indicate a clean basin-wide warming over the study period, with the highest increases observed during the pre-monsoon and monsoon seasons. Seasonal variability is noticeable, with SSTs ranging from ~25–26 °C in winter to more than 30 ^{0}C in April-May. To enhance confidence in observed patterns, validation with in-situ data confirmed strong agreement with satellite products. The rising SSTs are correlated with increasing monsoon variability, which provides favorable conditions for the strong formation of tropical cyclones. These findings underscore the importance of SST in framing regional climate and emphasize the need for monitoring of the Bay of Bengal to build climate resilience.

Keywords: Sea Surface Temperature (SST), Bay of Bengal; Remote Sensing, Climate Variability, Monsoon, Cyclone Intensification.

1. INTRODUCTION
Sea Surface Temperature (SST) is a crucial aspect of the global ocean system that influences the heat exchange between ocean and atmosphere, monsoon circulation, as well as the development and intensity of tropical cyclones (Reynolds et al., 2007; Roxy et al., 2020). Changes in SST affect regional weather patterns, ocean stratification, marine ecosystems, and biodiversity in addition to larger phenomena like the El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) (Ashok et al., 2004; Ashok et al., 2001). Over the past few decades, the ocean has shown a significant rise in SST compared to previous decades (Hansen et al., 2010;

Kaplan et al., 1998). Human activities are the main driver of climate change, which directly changes the physical and chemical properties of the ocean's upper layer. Even small changes in SST can lead to significant consequences like sea-level rise, coral bleaching, changes in ocean circulation, coastal flooding, and intense weather events.

The Bay of Bengal is a geographically unique, semi-enclosed basin in the northeastern part of the Indian Ocean. Due to its tropical location, it is one of the most sensitive climate regions. The Bay of Bengal is bounded by India and Sri Lanka to the west, Bangladesh to the north, and Myanmar and the northern part of the Malay Peninsula to the east. The Bay's southern boundary extends from Dondra Head (the southern end of Sri Lanka) westward to the northern tip of Indonesian island of Sumatra. Several unique hydrographic and atmospheric characteristics make the Bay of Bengal vulnerable to SST variability. Major rivers from surrounding regions- including the Ganges-Brahmaputra-Meghna system, as well as the Mahanandi, Godavari, Krishna, Kaveri and Irrawaddy- all empty into this ocean basin. This huge input of freshwater creates a highly stratified upper ocean layer, which limits vertical mixing in the ocean. It allows the upper ocean to heat more rapidly than other basins. Moreover, the South Asian monsoon system influences the Bay of Bengal by controlling its seasonal cycle of SST, wind, and precipitation. Recent reviews have emphasized ocean-atmosphere feedback mechanisms during tropical cyclones (Singh & Roxy, 2022).

SST changes in the Bay of Bengal play a vital role in governing regional climate and weather. Small changes in SST can alter the strength and variability of the Indian summer monsoon, which provides water to nearly one-fifth of the global population (Casey & Cornillon, 2001). The Bay of Bengal is also a hotspot for tropical cyclones, where SST works as the fuel for cyclone intensification. Studies have shown that cyclones in the northern Indian Ocean, especially in the Bay of Bengal, have become more intense over the last few decades, which is primarily linked to warmer surface water (Hidayat et al., 2023).

Satellite remote sensing has revolutionized the SST monitoring, providing high-resolution, continuous and the spatially comprehensive datasets. But many studies have investigated SST trends as a whole comprehensively on the Indian Ocean, whereas high-resolution analyses focusing on the Bay of Bengal remain relatively scarce. Most existing works either rely on a single satellite dataset or study shorter time periods, which limit the accuracy of tangible outputs. With the advancement of satellite remote sensing, multiple global SST products are now available, including NOAA Optimum Interpolation SST (OISST v2.1), the NASA MODIS-Aqua, and GHRSST datasets and the Copernicus Marine Environment Monitoring Service (CMEMS SST), which have been widely used to investigate variables like SST, SSH, Salinity, Ocean Currents, Tides and Waves, Chlorophyll Concentrations, Surface Winds across the global oceans (Shuva et al., 2022). Though satellite-based SST data are invaluable, they may contain errors due to cloud cover, atmospheric conditions or the technical errors. Therefore, in situ observations from "NOAA moored buoys" and "ARGO profiling floats" remain necessary for calibrating and validating satellite products. ARGO floats give autonomous temperature and salinity profiles across the global ocean at the same time, NOAA buoys provide long-term fixed-point SST records, both of which are easy and important for improving the accuracy of satellite SST datasets in the Bay of Bengal region.

The systematic investigations of SST variability and long-term trends using multi-satellite observations and in-situ calibration remain scarce on the entire Bay of Bengal. Moreover, for the significant socio-economic vulnerability of the surrounding nations to climate-driven SST changes, there is an urgent need for a comprehensive analysis to cover the last two decades (2004–2024) of SST changes. This study covers this gap by conducting a detailed assessment of SST variability and trends in the Bay of Bengal using multi-satellite datasets from NOAA, NASA, and Copernicus; calibrated and validated with in-situ measurements from NOAA buoys and ARGO floats. The specific objectives of the study are as follows:

A. Analyze seasonal and interannual SST variability across the Bay of Bengal from 2004 to 2024.
B. Calibrate satellite-derived SST using in-situ data from NOAA and ARGO to improve confidence in the observed trends.
C. Discuss the implications of these SST trends for regional climate systems, monsoon variability, and cyclone activity in the Bay of Bengal.

2. METHODOLOGY

2.1. Study Area

The Bay of Bengal is located in the northeastern part of Indian Ocean, which extends from 5^0N to 25^0N and 78^0E to 100^0E. India and Sri Lanka in the west, Bangladesh in the north, and Myanmar and the Andaman-Nicobar Islands in the east, are the border of this region. The southern boundary connects with the open Indian Ocean between Sri Lanka and the island of Sumatra. This study focuses on the full extent of the Bay of Bengal region.

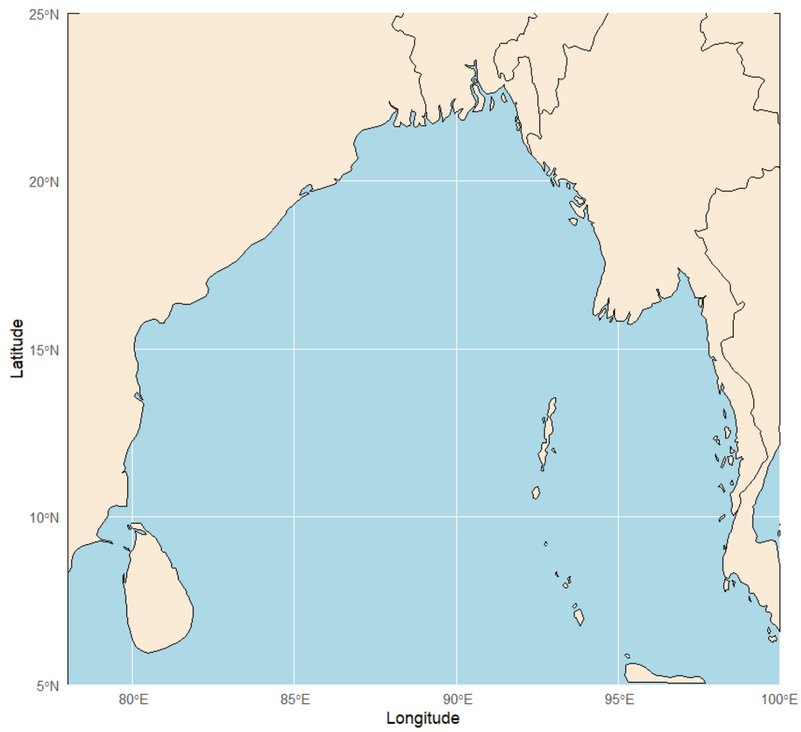

Figure 1: The Study area of the Bay of Bengal region (5^0N-25^0N and 78^0E-100^0E)

This region is one of the most complex and climate-sensitive regions in the ocean system. Massive freshwater input from large rivers from surrounding countries contributes to the formation of a highly stratified upper ocean.

2.2. Data Sources

To analyze SST trends over two decades in the Bay of Bengal region, this study utilized multi-satellite datasets calibrated with in-situ observations. This study used three primary satellite-based SST products. I collected the SST data from these sources in NETCDF format. The first dataset I used was the NOAA Optimum Interpolation Sea Surface Temperature (OISST v2.1). This product merges Advanced Very High-Resolution Radiometer (AVHRR) infrared data with in-situ buoy and ship measurements to provide spatially complete and bias-adjusted SST fields. The original dataset has a spatial resolution of 0.25° × 0.25° with a daily temporal resolution, but here I used the monthly mean form covering the period 2004–2024.

The second dataset was the NASA MODIS-Aqua SST, which aligned with the Group for High-Resolution Sea Surface Temperature (GHRSST). This dataset provides ocean color and SST information at approximately 4 km spatial resolution. Here, the data were processed as monthly averages from the 8-day composites by covering the same period, 2004–2024.

I collected the third dataset from the Copernicus Marine Environment Monitoring Service (CMEMS), which generates multi-sensor gap-free SST products using AVHRR, AMSR-E, and microwave radiometer data. This dataset has a satisfactory resolution of 0.05° × 0.05° and is also used as monthly averages from 2004 to 2024.

I also validated the satellite-based SST fields using in-situ observations, including long-term SST measurements from NOAA moored buoys located in the Bay of Bengal and temperature from ARGO floats. The profiling data from ARGO were important for cross-verification of satellite-estimated data.

2.3. Data Pre-processing

Before analysis, I interpolated satellite data to a uniform resolution of 0.25° × 0.25° using bilinear interpolation. Monthly means were analyzed from the daily and 8-day composites to reduce short-term fluctuations. To investigate seasonal variability, the data were divided into four standard monsoon-related seasons: Winter-DJF (December–February), Pre-monsoon/Summer-MAM (March–May), Monsoon/Southwest monsoon-JJA (June–August), and Post-monsoon/Northeast monsoon-SON (September–November). Besides seasonal analysis, I performed a monthly mean analysis for the 2004–2024 period. For each month, a 20-year average was calculated to produce a set of twelve mean SST maps that represent the typical spatial distribution of SST changes throughout the Bay of Bengal.

2.4. Method of Analysis

The analytical works consisted of several methods. Linear regression was applied to both basin-wide averages and individual grid points to estimate decadal warming trends expressed in °C per decade. In addition to linear regression, I applied second-order polynomial regression to find out non-linear warming patterns, primarily to assess whether the rate of SST increase accelerated after 2010.

Validation of satellite SST products against in-situ data was done by direct comparison at collocated time points. I used three statistical metrics for this evaluation: the correlation coefficient (R) to assess the strength of the relationship, the root mean square error (RMSE) to quantify the average magnitude of error, and the mean bias error (MBE) to identify any systematic over- or under-estimation.

Necessary tests were conducted using the Student's t-test at the 95% confidence level. Additionally, the non-parametric Mann–Kendall test was used to detect monotonic trends without assuming linearity.

3. RESULTS

3.1. Long-term Trends in SST (2004-2024)

Overall mean SST values across the two decades in the Bay of Bengal are shown on the time series plot (Figure 2). SST values usually oscillate between ~27 °C and ~32 °C, which indicates a clear seasonal cycle. Peak SST events, which primarily take place in summer and pre-monsoon months, are shown in red dots. The gradual upward shift to these peaks over time indicates a slowing warming trend in this region.

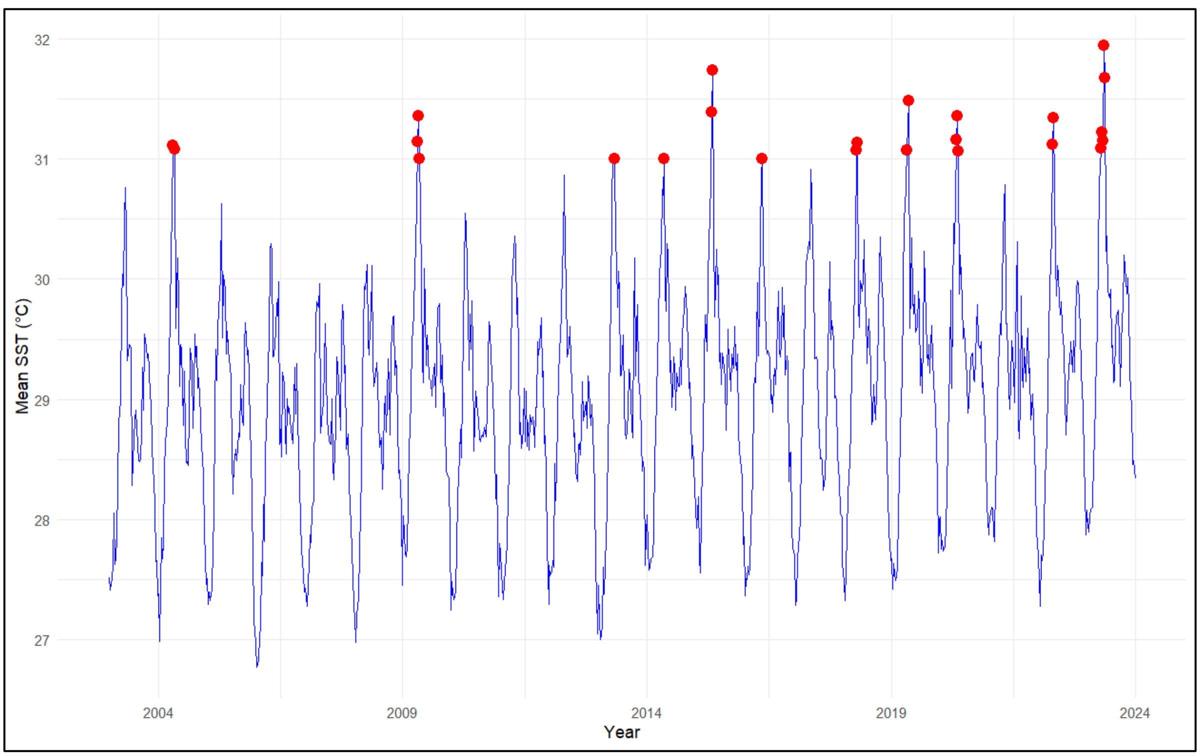

Figure 2: Basin-averaged monthly mean SST (^{0}C) time series in the Bay of Bengal (2004–2024) showing warming trend along with interannual variability. Red dots show peak SST events.

The monthly average SST (Figure 3) shows the seasonal variability more clearly. The winter months of January and February have the lowest temperatures (~28 °C) while April and May have the highest values (~30–31 °C). SST values gradually decline to the end of the year after the monsoon season (June-September). This cycle shows how ocean-atmosphere interactions vary over the two decades.

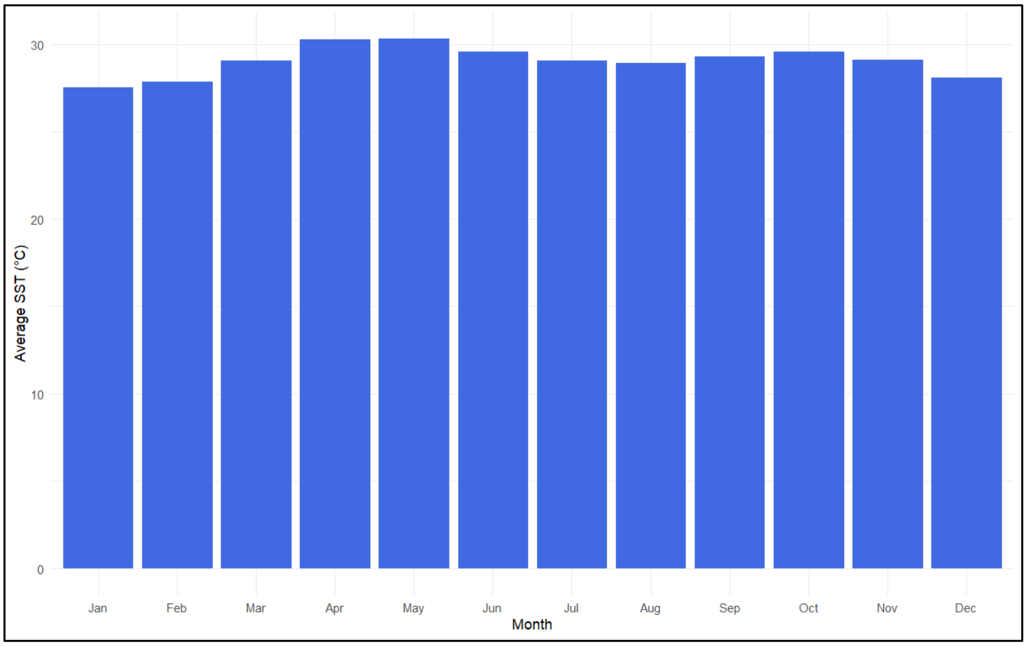

Figure 3: Monthly average SST (⁰C) in the Bay of Bengal (2004–2024). Bars show the monthly average SST over the two decades.

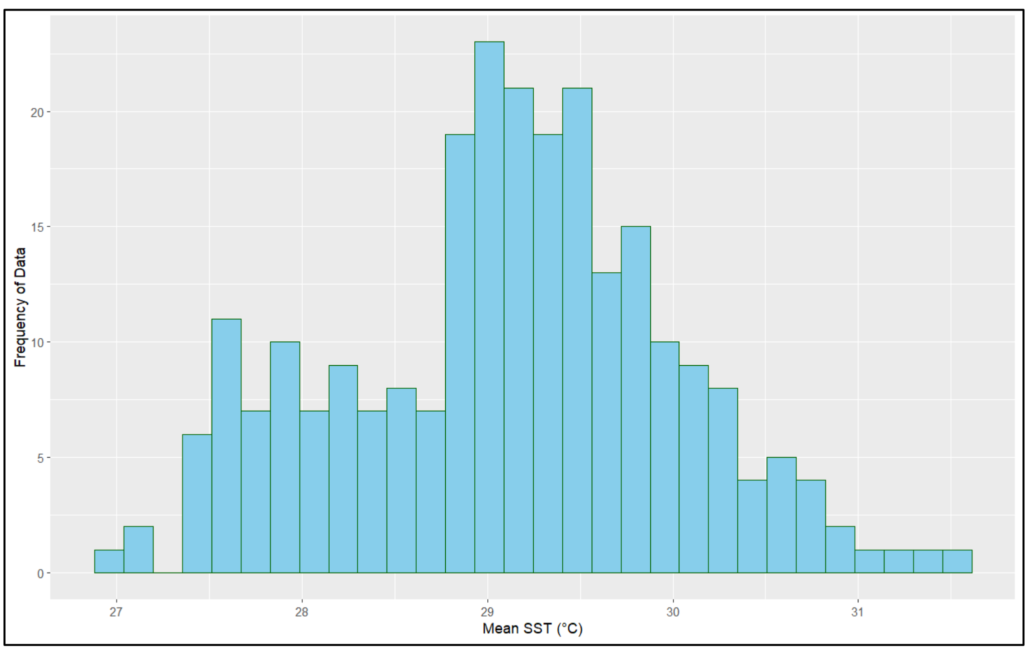

Figure 4: Frequency distribution of Mean SST (⁰C) in the Bay of Bengal (2004–2024), indicating a higher occurrence of warmer SSTs over time.

The frequency distribution of SST (Figure 4) shows that the highest frequency of data falls between 28.8 °C and 30 °C. It indicates this temperature range is the most common in this region. Extreme values are less frequent above 31 ⁰C but increasingly common in recent years.

3.2. Seasonal and Monthly Variability

Sea Surface Temperature (SST) varies both seasonally and monthly in the Bay of Bengal during the 2004-2024 study period. The distribution of SST throughout the annual cycle is shown in the monthly mean boxplot (Figure 5), where temperature rises gradually from winter (January-February) to a peak in the summer (April-May). Average SST rose continuously in April and May. The warmer months, mainly March through June, have wider interquartile ranges, which suggests more SST variability. Besides, outliers, which represent episodic warming events, are more common during this time.

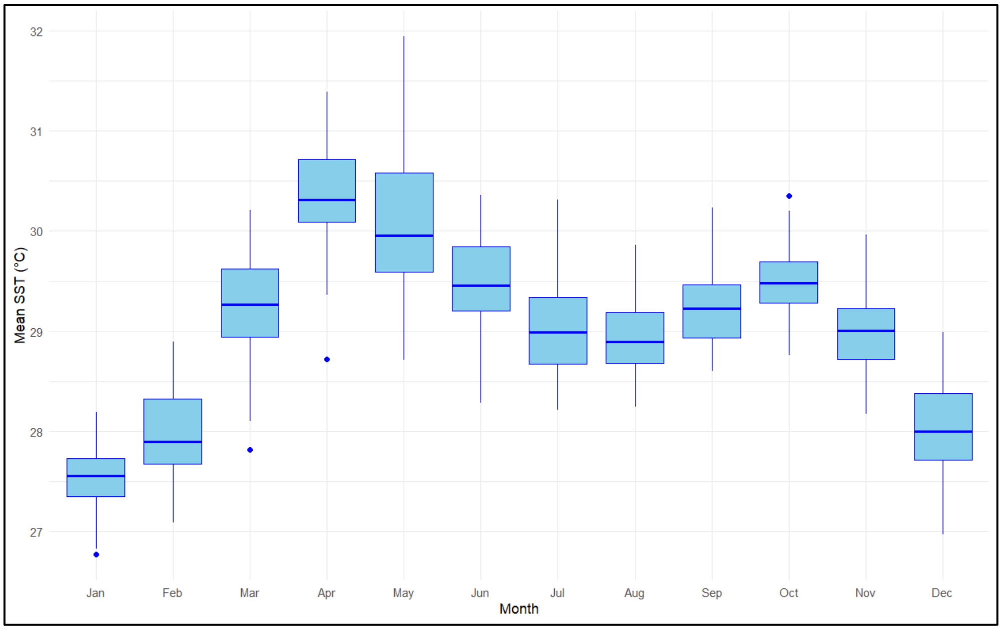

Figure 5: Monthly mean SST (^{0}C) distribution of Bay of Bengal using Boxplot from 2004 to 2024.

The monthly mean heatmap (Figure 6) also shows the temporal evolution of SST variability across two decades. The seasonal cycle is clearly visible, with colder temperatures from December to February and a sharp rising trend starting in March. Particularly in the years after 2010, persistently high SST values (>30 °C) are evident around April and May, indicating a warming trend in recent decades. While the monsoon season (July-September) shows comparatively steady but lower values, the pre-monsoon season, the post-monsoon season (October-November) also exhibits somewhat increased SST.

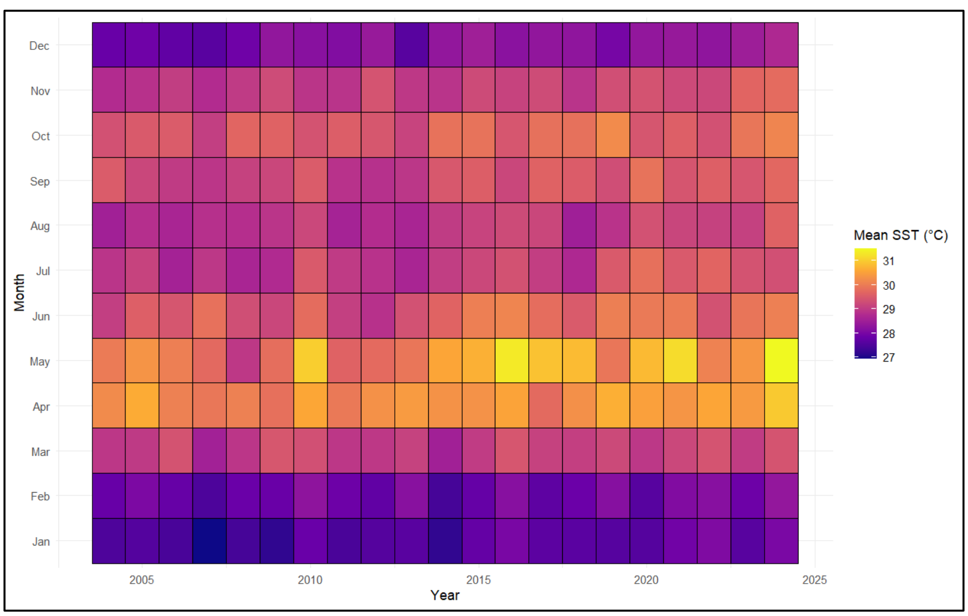

Figure 6: Heatmap of Monthly Mean SST (^{0}C) across the Bay of Bengal (2004-2024).

3.3. Spatial Distribution of SST

According to the long-term mean SST map (Figure 7), the northern Bay of Bengal usually shows lower SST values than the southern basin due to the significant freshwater input from major rivers and strong stratification that reduces surface warming. However, the SSTs in the south and central regions of the Bay remain comparatively warmer having mean values frequently exceeding 28 ⁰C.

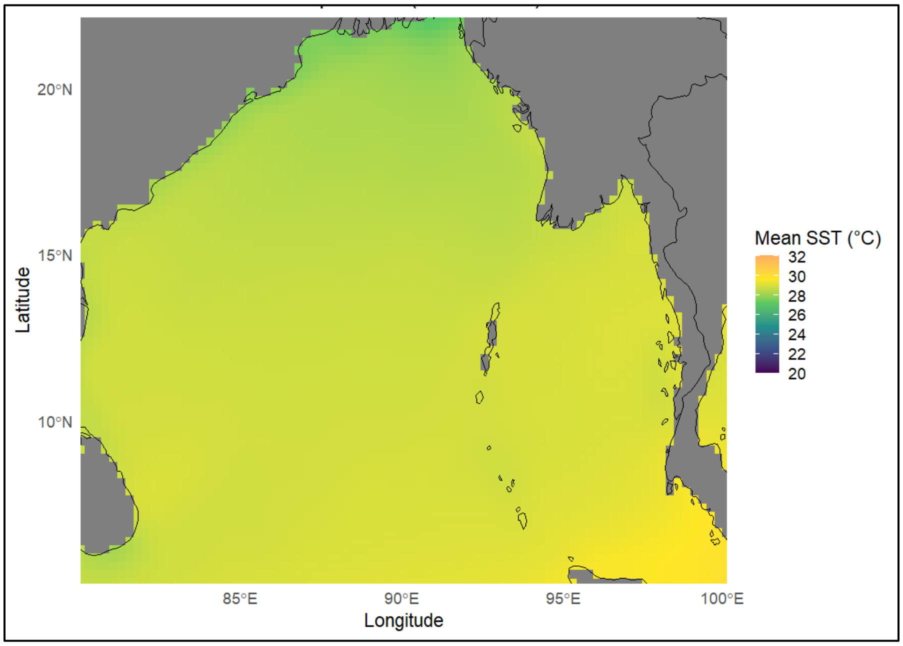

Figure 7: Mean Sea Surface Temperature across the Bay of Bengal (2004-2024)

The monthly mean SST maps (Figure 8) show noticeable seasonal variability. In January and February, SSTs are at their lowest, especially in the northern Bay, where the values drop below 24 ⁰C. From the beginning of March, temperatures increase gradually until they peak in May and June, when SSTs exceed 30 ⁰C across most of the regions in the Bay of Bengal. SST values gradually decrease after the southwest monsoon, but high temperatures are increased in October and November, which cause the intensification of post-monsoon cyclones.

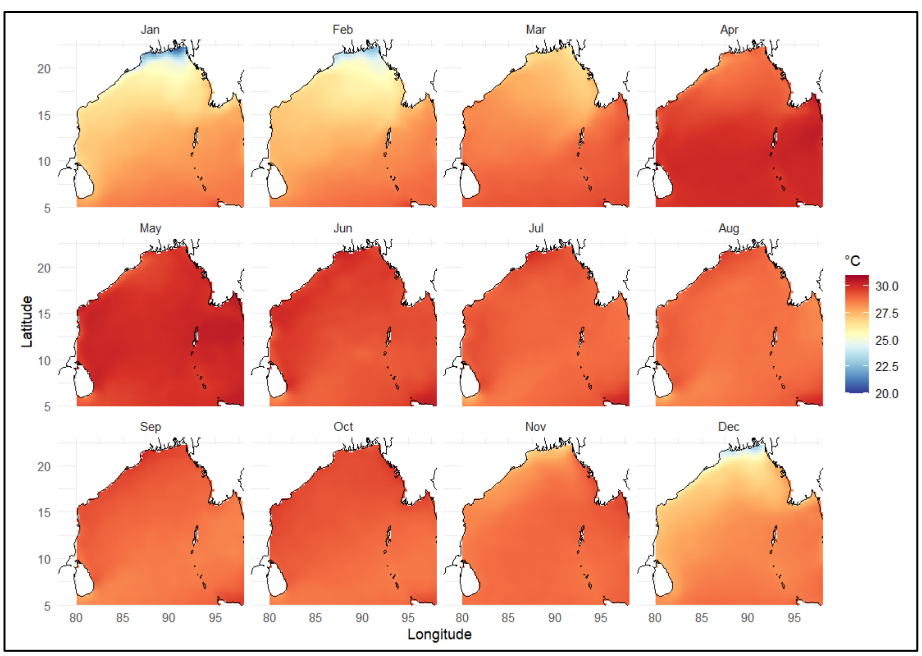

Figure 8: Monthly mean SST distribution of Bay of Bengal (2004-2024)

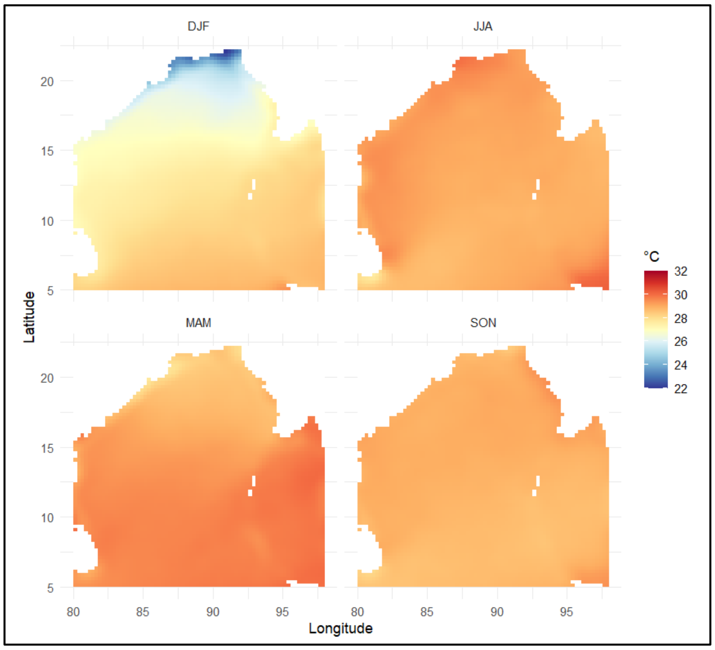

Figure 9: Bay of Bengal seasonal mean SST (^{0}C) from 2004 to 2024

Seasonal mean maps also demonstrate this variability (Figure 9). The northern Bay experiences the lowest SSTs during the winter season (DJF), while the central and southern regions experience the highest SSTs during the summer season (JJA). Moderate SST values appear in the transitional seasons (MAM and SON). Here, SON shows comparatively warmer conditions than MAM. These seasonal variations show how monsoonal winds, riverine inputs, and vertical mixing processes greatly influence the Bay of Bengal's SST distribution.

4. DISCUSSION

The analysis of two decades of SST data (2004–2024) reveals a strong seasonal cycle in the Bay of Bengal, where the winter months (December–February) show cooler conditions, while the pre-monsoon and monsoon seasons (May–August) exhibit peak warming. The heatmaps and monthly boxplots verified a warming pattern ~25–26 °C in January and >30 °C in May–June, which matches the previous results on Indian Ocean thermal dynamics (Gao et al., 2020). Solar radiation is the primary factor of this seasonal cycle. Moreover, in the northern bay, constrained vertical mixing influences it because freshwater inputs from major rivers create a shallow, stratified surface layer than warms rapidly (Chowdhury et al., 2017). Years with significant SST anomalies at the interannual scale are likely to be associated with basin-wide climate factors such as ENSO and the Indian Ocean Dipole (IOD), which both affect the atmospheric circulation, monsoon rainfall, and cyclone activity (Liu et al., 2015).

Calibrating the multi-satellite data with in-situ measurements from NOAA buoys and ARGO profiling floats improved the robustness of the observed SST variations. Slight variations were seen during cloud cover or extreme weather which cause high consistency in sensors. There challenges were noted in earlier validation studies (Banzon et al., 2016; Casey & Cornillon, 1999; Merchant et al., 2019). The involvement of ARGO profiles added confidence by capturing vertical temperature structures and ensuring that satellite-based SST accurately represented surface conditions. This calibration step improves the reliability of long-term SST trends and reduces uncertainties.

The warming trends observed in the analysis have a significant impact on regional climate systems. Monsoon variability is affected by the elevated SSTs that enhance evaporation and latent heat fluxes. Many research studies show that anomalously warm pre-monsoon SSTs in the Bay lead to intensify low-level winds, altered rainfall distribution, and greater unpredictability in the Indian summer monsoon (Roxy et al., 2015; Sandeep & Ajayamohan, 2015). These studies show that continued SST rise may boost monsoon fluctuations in the future. Warmer SSTs also provide the energy needed for rapid cyclone intensification. In recent years, extremely severe cyclone such as Amphan and Mocha aligns with the threshold SST values (>28 °C) identified in the analysis during the pre-monsoon and monsoon seasons, which prove their role as a catalyst for cyclone development (Swapna et al., 2022).

Steady surface heating is causing ocean stratification that reduces vertical mixing and limits oxygen and nutrient exchange, which may affect the marine ecosystems. Marine heatwaves in the Bay of Bengal are causing coral bleaching events directly (Krishnan et al., 2020). This shows the ecological vulnerability of the Bay of Bengal's coastal nations, where millions depend on marine foods for their livelihoods.

Overall, this study demonstrates that the Bay of Bengal is undergoing systematic warming with both seasonal and interannual effects that extend well beyond the ocean surface. By combining multi-satellite datasets with in-situ validation, the results display a reliable picture of two decades of SST change by showing how rising SSTs are reshaping climate systems, intensifying cyclones, and threatening marine ecosystems in this region.

5. CONCLUSION

This study explored two decades (2004-2024) of sea surface temperature (SST) variability in the Bay of Bengal using multi-satellite observations from NOAA, NASA, and Copernicus by calibrating the data with in-situ measurements from NOAA moored buoys and ARGO floats. The analysis showed a noticeable seasonal cycle where SSTs rising from low values in winter to peak values during pre-monsoon and summer monsoon months. There were also interannual fluctuations, where anomalies were connected to significant climate variables as ENSO and the Indian Ocean Dipole. These findings confirm that both local seasonal forcing and global climate oscillations shape the SST variability in the Bay of Bengal.

The analyzed long-term warming of the Bay of Bengal has significant regional implications. SST rising amplify evaporation and latent heat flux, which influence the variability of the South Asian monsoon. It also provides the thermal energy that is required for rapid cyclone intensification, which contributes to the increasing frequency of extremely severe cyclonic storms in the basin. Furthermore, the socio-economic vulnerability of millions of people who live along the Bay's coastline is elevated by persistent warming, which strengthens ocean stratification and harms fisheries, coral reef systems, and marine ecosystems.

Overall, this study highlights the urgent need for continued high-resolution monitoring of SST in the Bay of Bengal, supported by the integration of satellite and in-situ data. Integrating coupled ocean-atmosphere models and evaluating marine heatwaves and their biological effects should be the main goals of future research. In one of the world's most vulnerable ocean basins, these kinds of initiatives are essential for improving monsoon prediction, cyclone forecasting, and the creation of regional climate resilience plans.

Acknowledgement
I would like to thank Department of Oceanography, University of Dhaka teachers for their invaluable teaching.

Authors contributions
This work was done by author Arnab Guha Neogi who did the study, wrote the first draft of the manuscript, and managed the literature search and analysis.

Informed consent
Not applicable.

Ethical approval
Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

Conflicts of interests
The authors declare that they have no conflicts of interests, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Data and materials availability
All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Ashok K, Guan Z, Saji NH, Yamagata T. Individual and combined influences of ENSO and the Indian Ocean dipole on the Indian summer monsoon. Journal of Climate. 2004;17(16): 3141-55.
2. Ashok K, Guan Z, Yamagata T. Impact of the Indian Ocean dipole on the relationship between the Indian monsoon rainfall and ENSO. Geophysical research letters. 2001;28(23): 4499-502.
3. Banzon V, Smith TM, Chin TM, Liu C, Hankins W. A long-term record of blended satellite and in situ sea-surface temperature for climate monitoring, modeling and environmental studies. Earth System Science Data. 2016;8(1):165-76.
4. Casey KS, Cornillon P. A comparison of satellite and in situ–based sea surface temperature climatologies. Journal of Climate. 1999;12(6):1848-63.
5. Casey KS, Cornillon P. Global and regional sea surface temperature trends. Journal of Climate. 2001;14(18):3801-18.
6. Chowdhury SM, Ahmed MK, Malik MK, Masud-Ul-Alam M, Chowdhury SM. Interaction of Sea Surface Temperature and Precipitation during Indian Ocean Dipole years in the Bay of Bengal. Bangladesh Marit. Aff. 2017;1(1):2519-5972.
7. Gao J, Zhao H, Klotzbach PJ, Wang C, Raga GB, Chen S. Possible influence of tropical Indian Ocean sea surface temperature on the proportion of rapidly intensifying western North Pacific tropical cyclones during the extended boreal summer. Journal of Climate. 2020;33(21):9129-43.
8. Hansen J, Ruedy R, Sato M, Lo K. Global surface temperature change. Reviews of geophysics. 2010;48(4).
9. Hidayat MN, Wafdan R, Ikhwan M, Ramli M, Rizal S. Analysis of chlorophyll-a, sea surface temperature, and sea surface salinity in the Bay of Bengal. InIOP conference series: Earth and environmental science 2023;(Vol. 1221, No. 1, p. 012071). IOP Publishing.
10. Kaplan A, Cane MA, Kushnir Y, Clement AC, Blumenthal MB, Rajagopalan B. Analyses of global sea surface temperature 1856–1991. Journal of Geophysical Research: Oceans. 1998;103(C9):18567-89.
11. Krishnan A, Bhaskaran PK. Performance of CMIP5 wind speed from global climate models for the Bay of Bengal region. International Journal of Climatology. 2020;40(7):3398-416.
12. Liu W, Huang B, Thorne PW, Banzon VF, Zhang HM, Freeman E, Lawrimore J, Peterson TC, Smith TM, Woodruff SD. Extended reconstructed sea surface temperature version 4 (ERSST. v4): Part II. Parametric and structural uncertainty estimations. Journal of Climate. 2015;28(3):931-51.
13. Merchant CJ, Embury O, Bulgin CE, Block T, Corlett GK, Fiedler E, Good SA, Mittaz J, Rayner NA, Berry D, Eastwood S. Satellite-based time-series of sea-surface temperature since 1981 for climate applications. Scientific data. 2019;6(1):223.
14. Reynolds RW, Smith TM, Liu C, Chelton DB, Casey KS, Schlax MG. Daily high-resolution-blended analyses for sea surface temperature. Journal of climate. 2007;20(22):5473-96.
15. Roxy MK, Gnanaseelan C, Parekh A, Chowdary JS, Singh S, Modi A, Kakatkar R, Mohapatra S, Dhara C, Shenoi SC, Rajeevan M. Indian Ocean warming. InAssessment of climate change over the Indian region: a report of the Ministry of Earth Sciences (MoES), Government of India 2020(pp. 191-206). Singapore: Springer Singapore.
16. Roxy MK, Ritika K, Terray P, Murtugudde R, Ashok K, Goswami BN. Drying of Indian subcontinent by rapid Indian Ocean warming and a weakening land-sea thermal gradient. Nature communications. 2015;6(1):7423.
17. Sandeep S, Ajayamohan RS. Poleward shift in Indian summer monsoon low level jetstream under global warming. Climate Dynamics. 2015;45(1):337-51.
18. Shuva MS, Golder MR, Rouf MA, Uddin MM, Bir J. Daytime and nighttime sea surface temperature (SST) along with diurnal variability (D-SST) in the northern Bay of Bengal: a remote sensing approach. Thalassas: An international journal of marine sciences. 2022;38(1):697-708.
19. Singh VK, Roxy MK. A review of ocean-atmosphere interactions during tropical cyclones in the north Indian Ocean. Earth-Science Reviews. 2022;226:103967.
20. Swapna P, Sreeraj P, Sandeep N, Jyoti J, Krishnan R, Prajeesh AG, Ayantika DC, Manmeet S. Increasing frequency of extremely severe cyclonic storms in the North Indian Ocean by anthropogenic warming and southwest monsoon weakening. Geophysical Research Letters. 2022;49(3):e2021 GL094650.