

Marine Heatwaves in the Bay of Bengal and Possible Impacts



**Annual Monsoon Workshop
and National Symposium on
“Understanding the science of
heatwaves under the warming scenario
and challenges ahead”**

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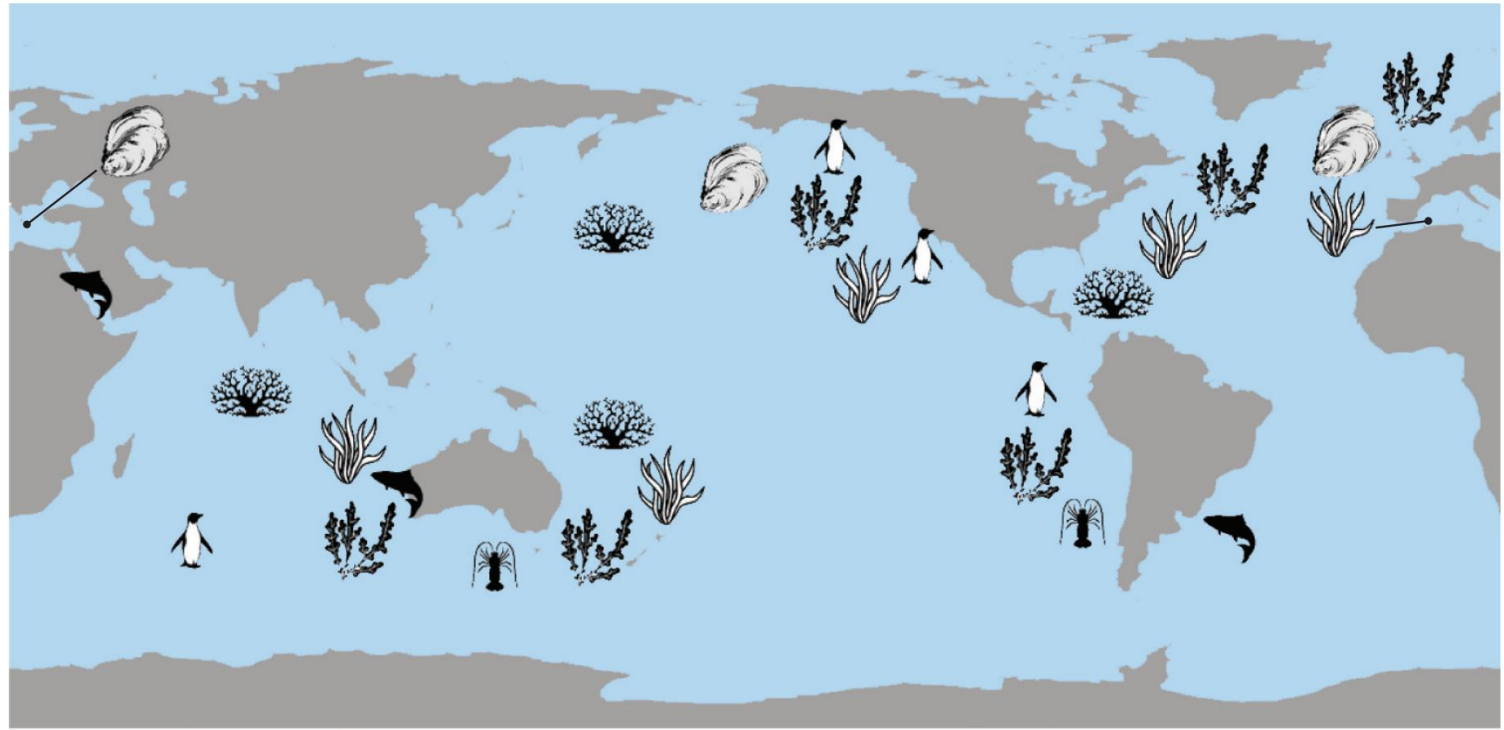
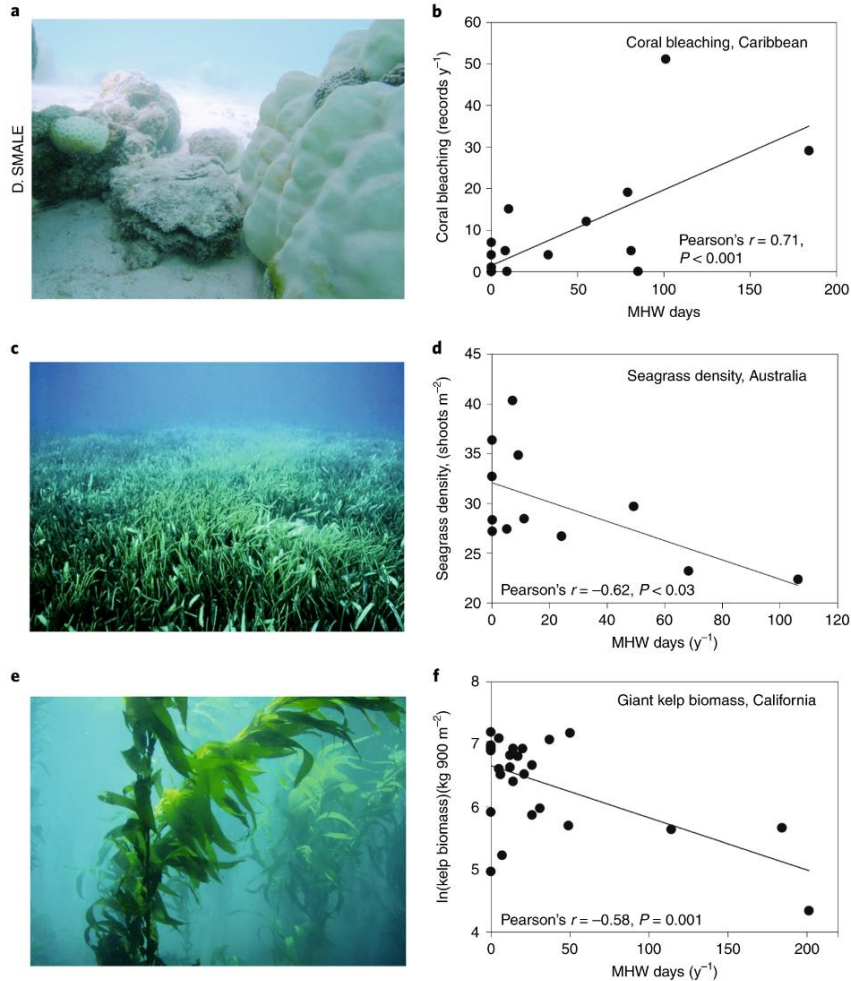
19 Mar 2024

Importance: Marine heat waves (MHWs)

MHWs are a sustained warmer (more than 90th percentile of the climatological value) ocean at least for five days

Fig. 3: Impacts of MHWs on foundation species.

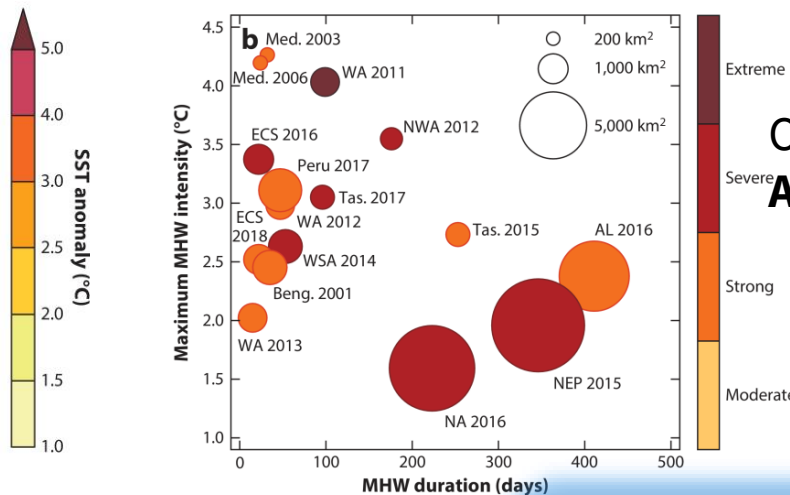
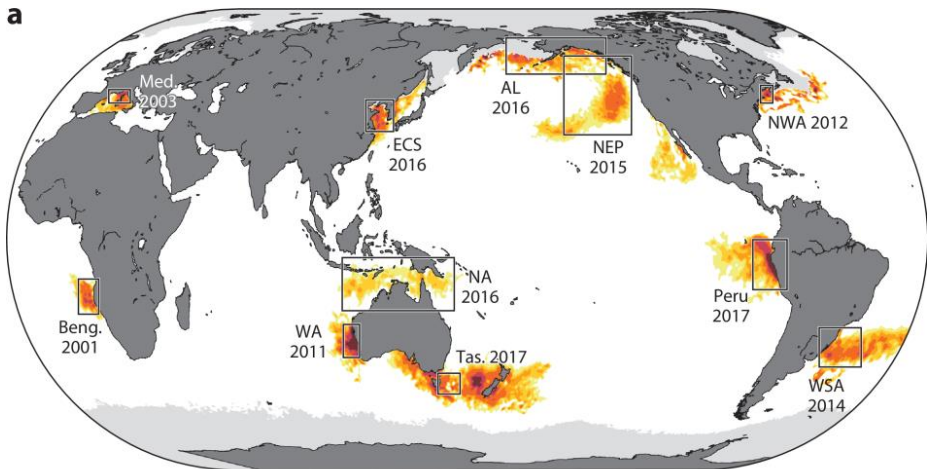
From: *Marine heatwaves threaten global biodiversity and the provision of ecosystem services*



Smith et al. (2023): *Annual Review of Marine Science*

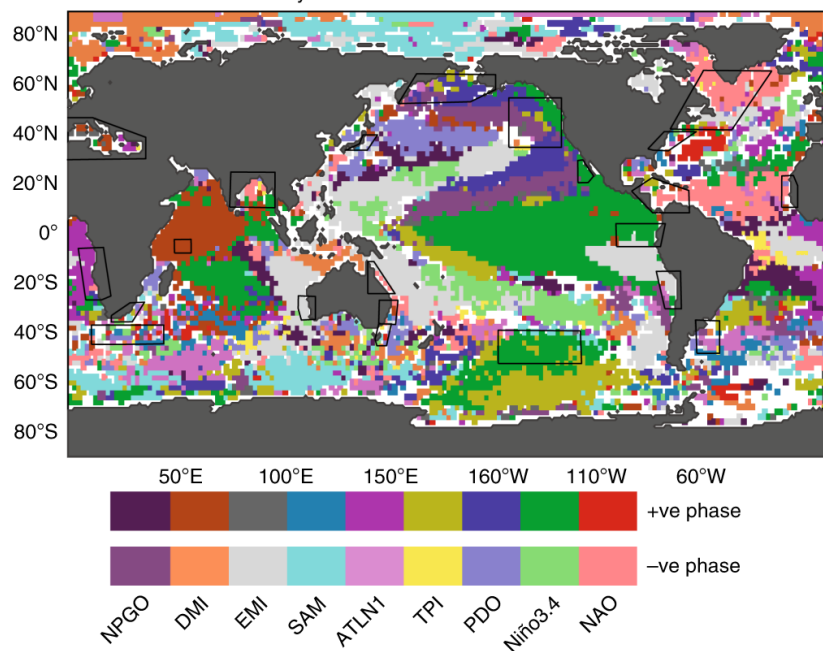
Smale et al. (2019) *Nature Climate Change*.

Marine heat waves: Events and possible Causes



Oliver et al. (2021): Marine Heatwaves, Annual Review of Marine Science

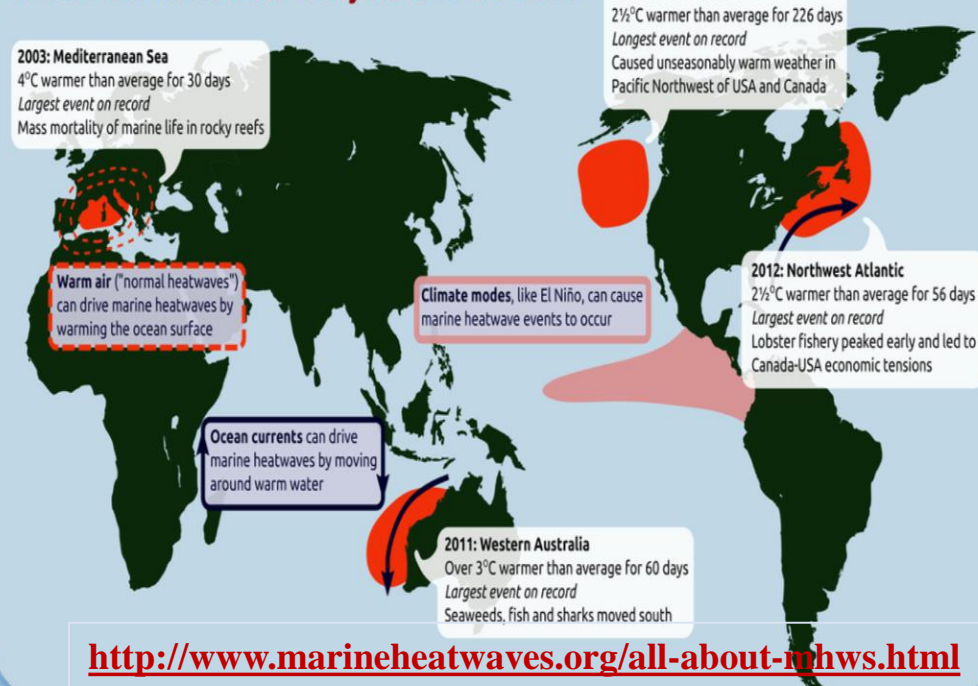
Primary drivers of increased MHW occurrence



Oliver ECJ, et al. 2021
Annu. Rev. Mar. Sci. 13:313–42

Holbrook et al., 2019

Marine Heatwaves occur everywhere in the ocean



<http://www.marineheatwaves.org/all-about-mhws.html>

MHWs in North Indian Ocean

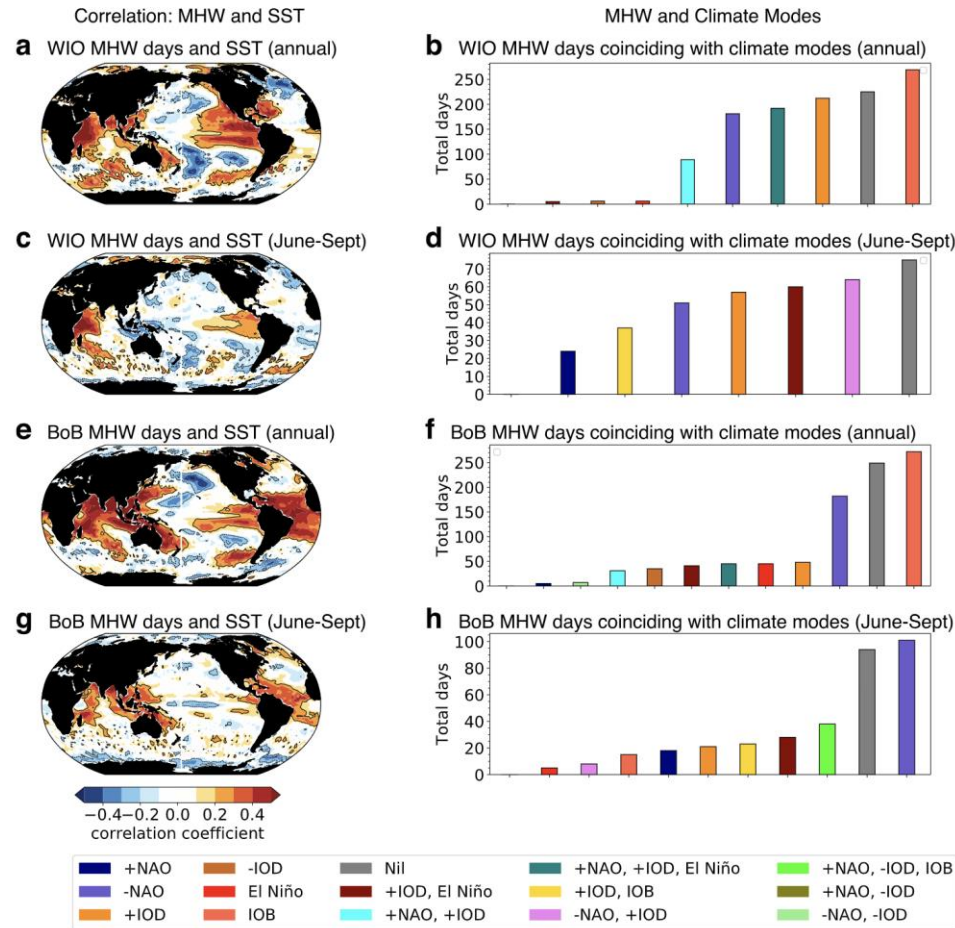


Figure 3. Correlation between the total number of MHWs and global SST for (a), (e) annual and (c), (g) June to September in the western Indian Ocean (WIO) and the north Bay of Bengal (BoB). The bar-charts (b, d, f, h) indicate the total number of MHW days coinciding with climate modes. “Nil” means the MHW days that do not coincide with any of the climate modes. MHW days during co-occurring climate modes are not counted for individual modes.

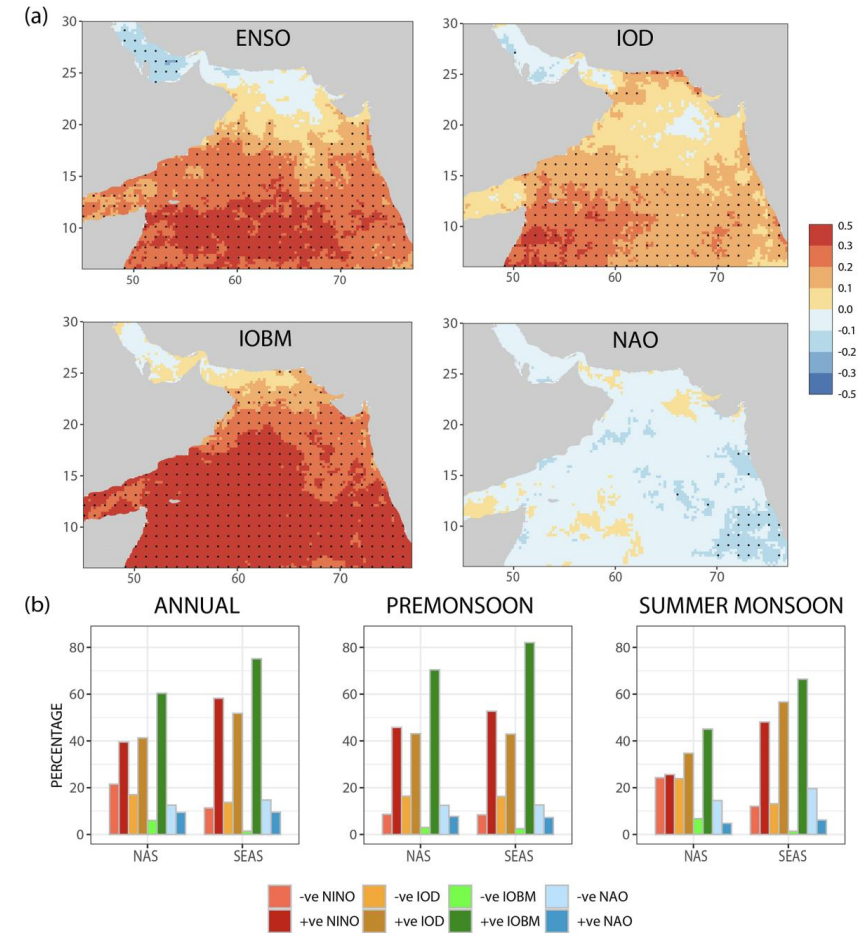
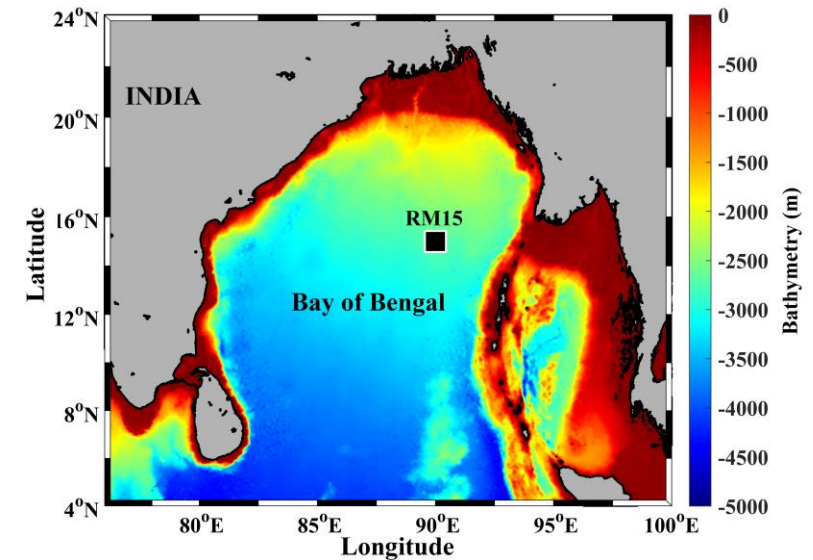


Figure 7. (a) Correlation between MHW days based on detrended SST ($^{\circ}\text{C}$) and major climate modes. Stippling represents regions where correlation is 99% significant. (b) Percentage of co-existing days between observed heatwaves and climate modes for annual, pre-monsoon, and summer monsoon periods.

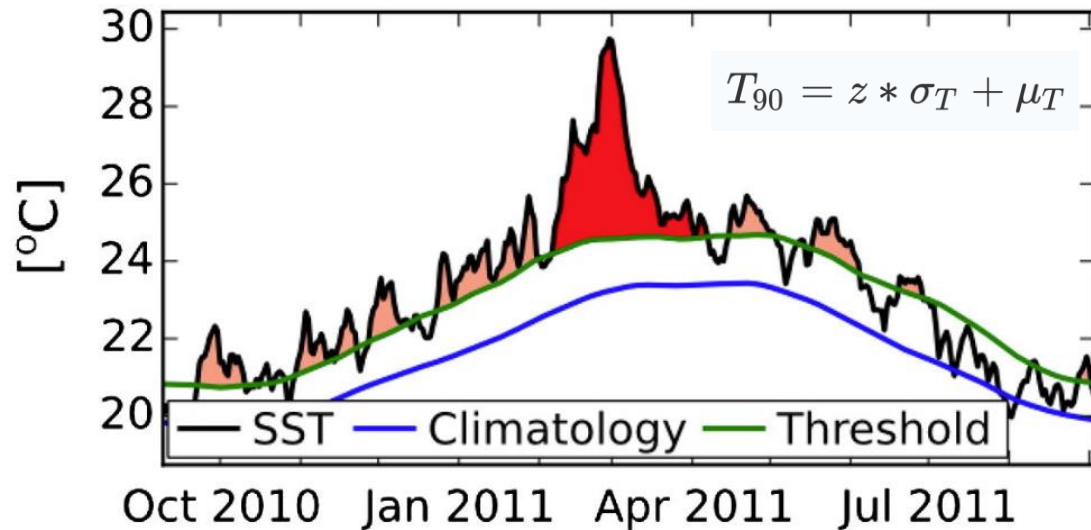
Questions?

- What are the characteristics of the MHWs in the Bay of Bengal? It is different if derived from satellite and in-situ observations?
- What are factors influencing the development and spreading of MHWs?
- Is there any subsurface MHWs?
- What are the impact of MHWs in the Bay of Bengal – Cyclones, Chlorophyll, Land Heatwaves?

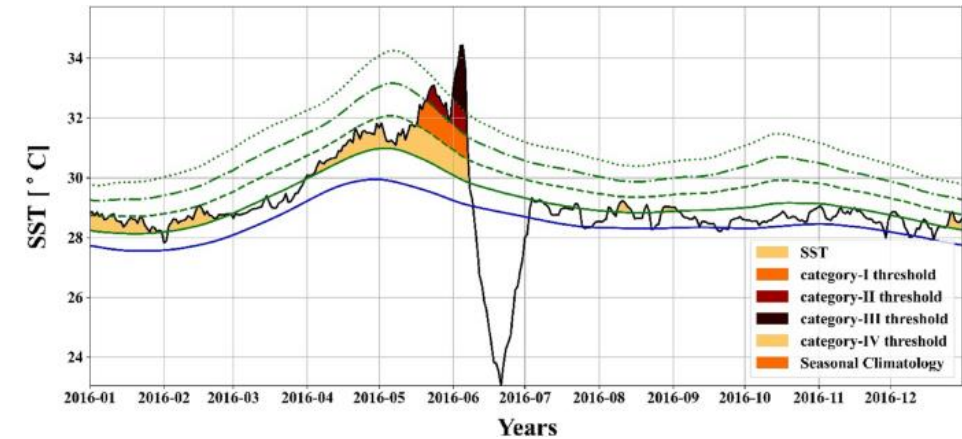


Methodology:

MWHs – Identification, Tracing and Budget Analysis



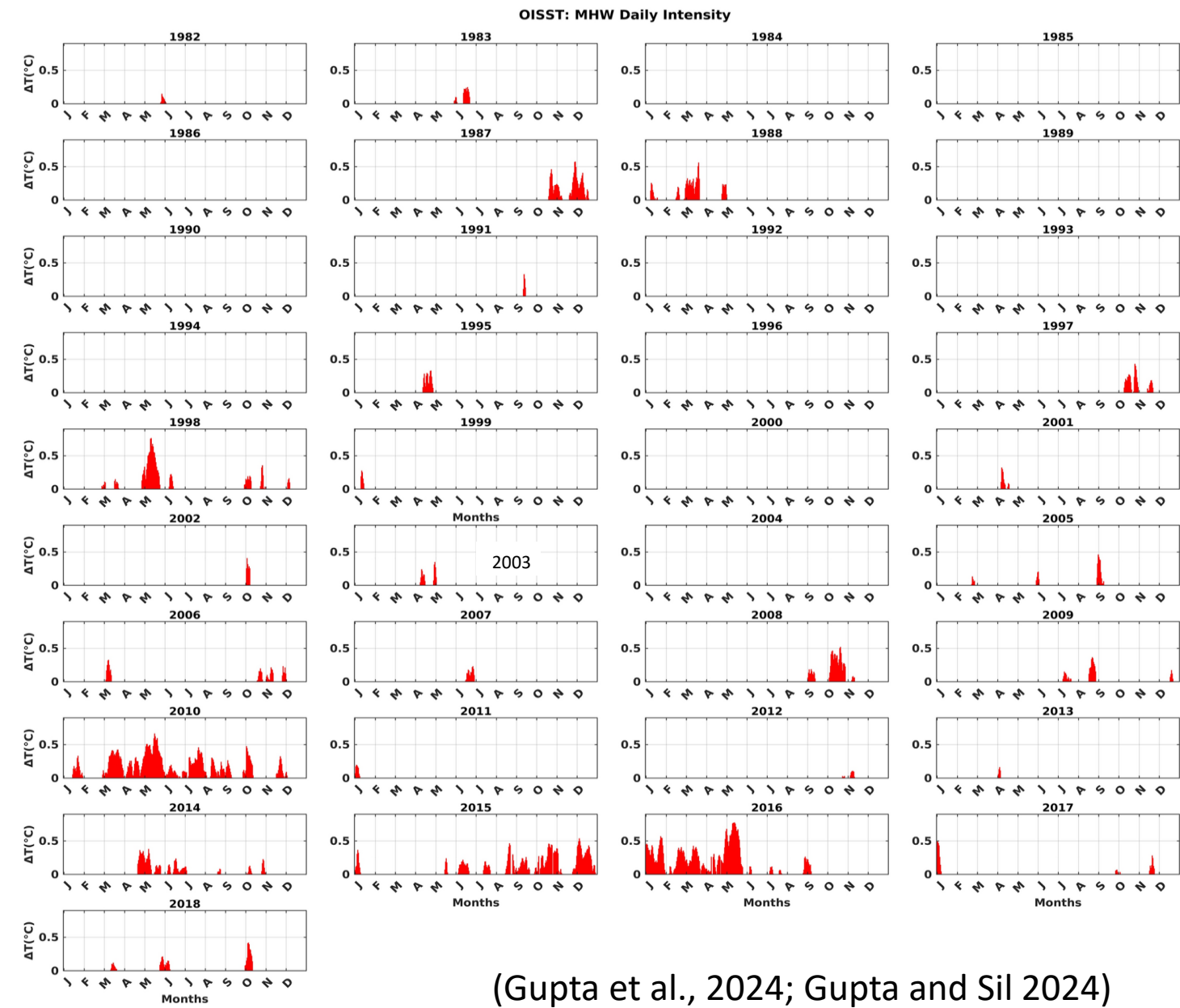
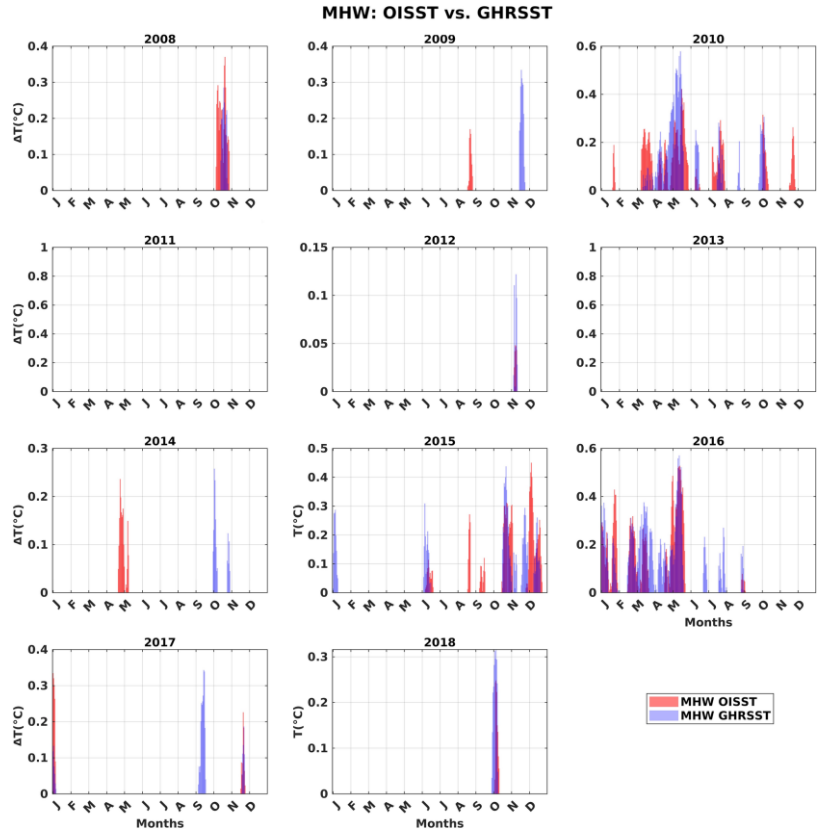
Identification of MHWs
(Source: Hobday et al. (2016))



$$\begin{aligned}
 \underbrace{\frac{\partial T}{\partial t}}_{(a) \text{ Tendency}} &= \underbrace{\frac{Q_{net} - Q_{pen}}{\rho c_p h}}_{(b) \text{ Net surface heat flux}} - \underbrace{\left(u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} \right)}_{(c) \text{ Horizontal advection}} - \underbrace{\left(\underbrace{w_{-h}}_{(d) \text{ Vertical velocity}} + \underbrace{\frac{\partial h}{\partial t}}_{(e) \text{ MLD tendency}} + \underbrace{u_{-h} \frac{\partial h}{\partial x} + v_{-h} \frac{\partial h}{\partial y}}_{(f) \text{ MLD Advection}} \right)}_{(g) \text{ Vertical entrainment}} \left(\frac{T - T_{-h}}{h} \right) + \underbrace{\frac{\partial}{\partial z} \left(\kappa_z \frac{\partial T}{\partial z} \right)}_{(g) \text{ Vertical mixing}} + \text{Residual}
 \end{aligned}$$



MHWs from OISST and GHRSSST

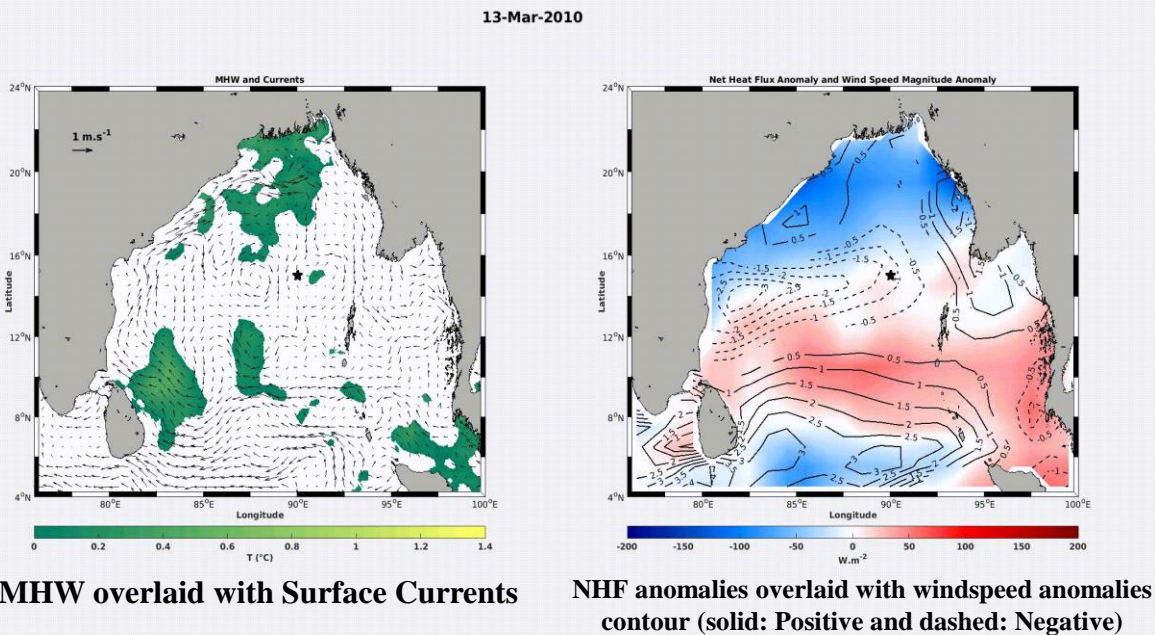


	RM15	GHRSSST	OISST
R-value with RM15	1	0.85	0.88
Mean Daily Intensity	0.87	0.82	0.90

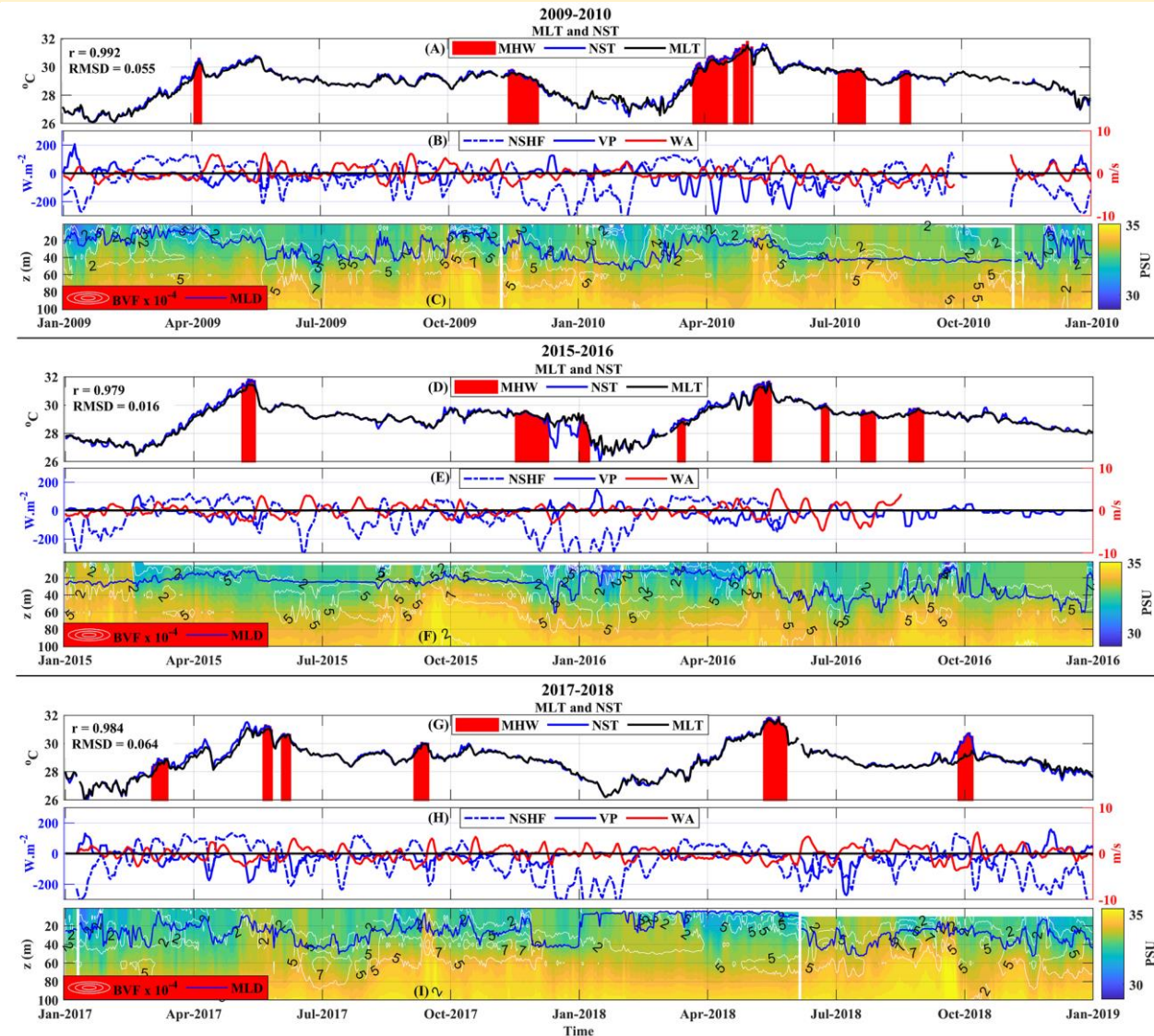
(Gupta et al., 2024; Gupta and Sil 2024)



Surface MHWs in the Bay of Bengal

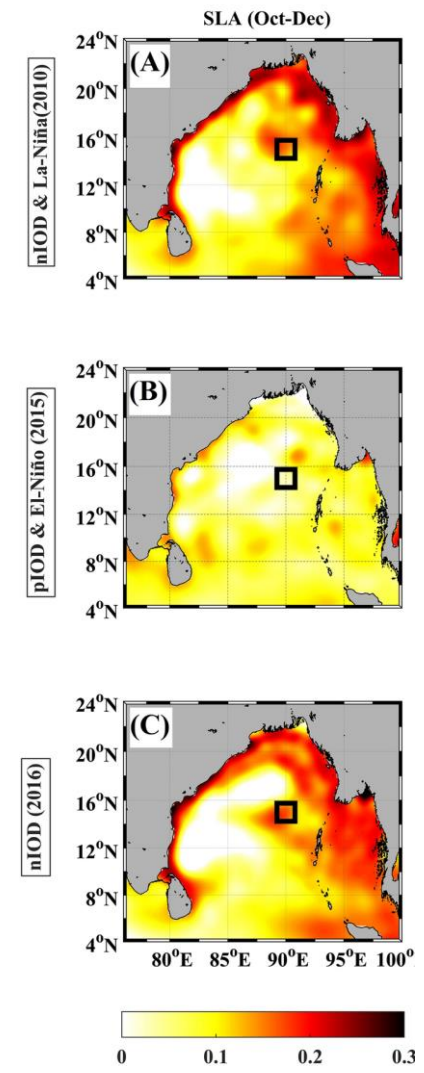
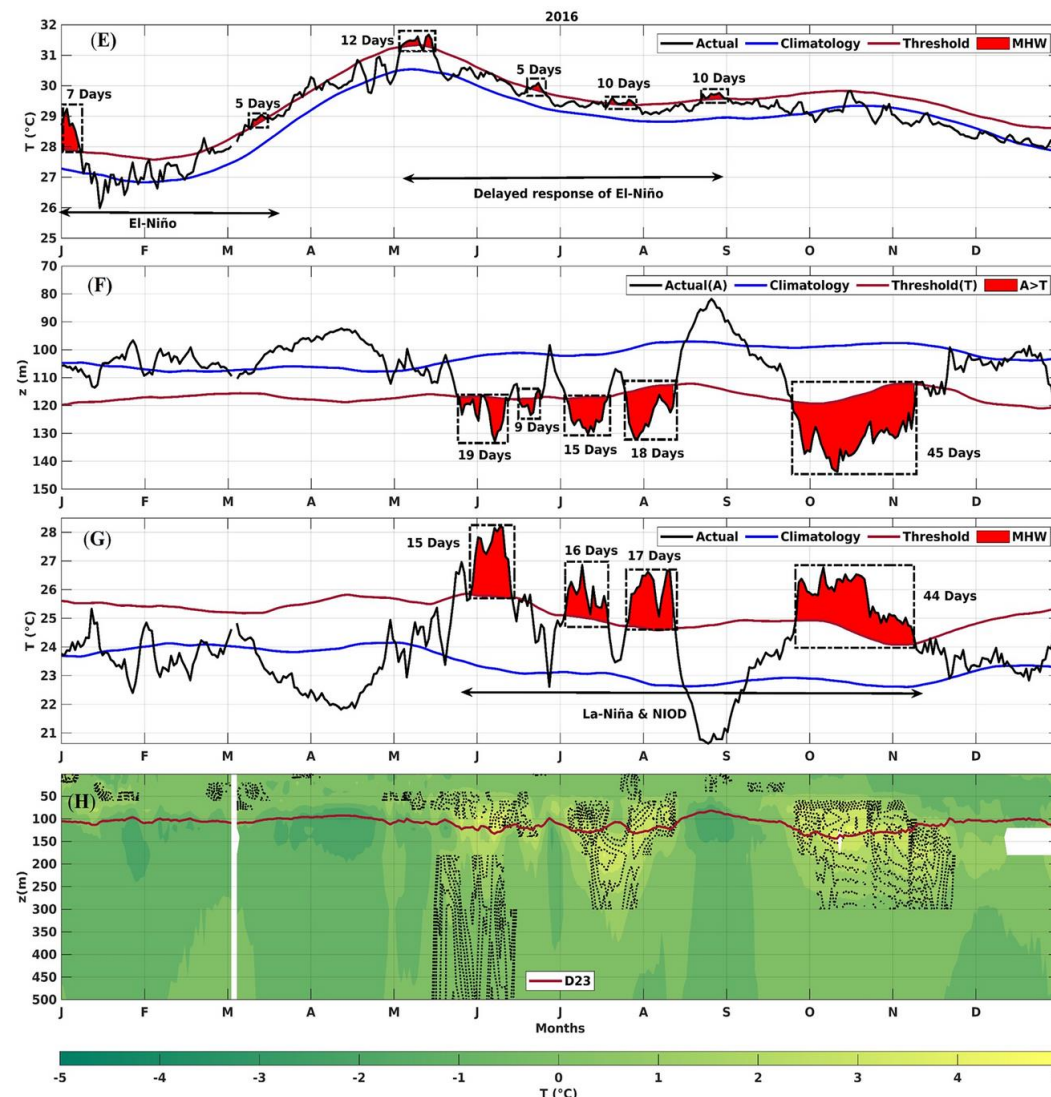
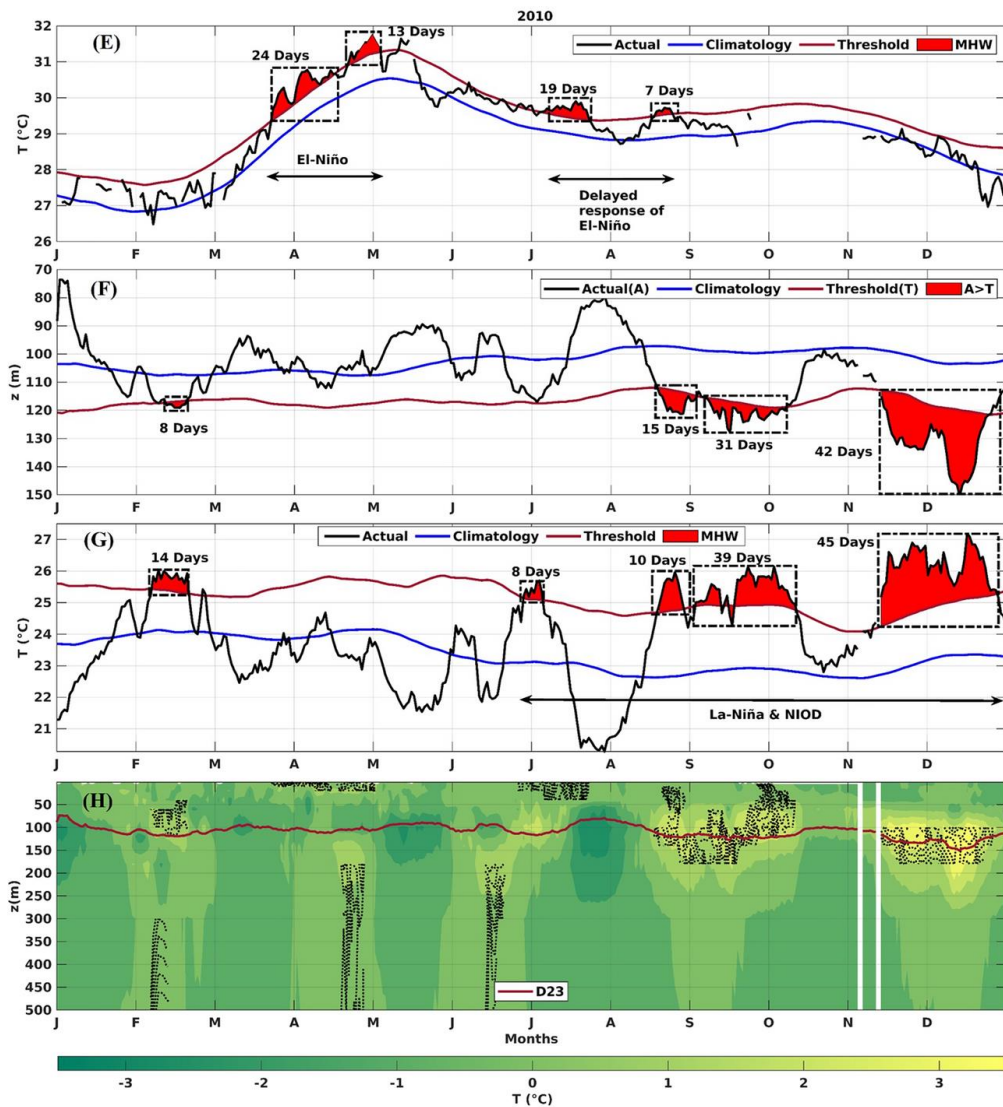


- Shallow Mixed layer Depth
- Stratification
- Eddies
- Boundary Currents



(Gupta et al., 2024, Climate Dynamics)

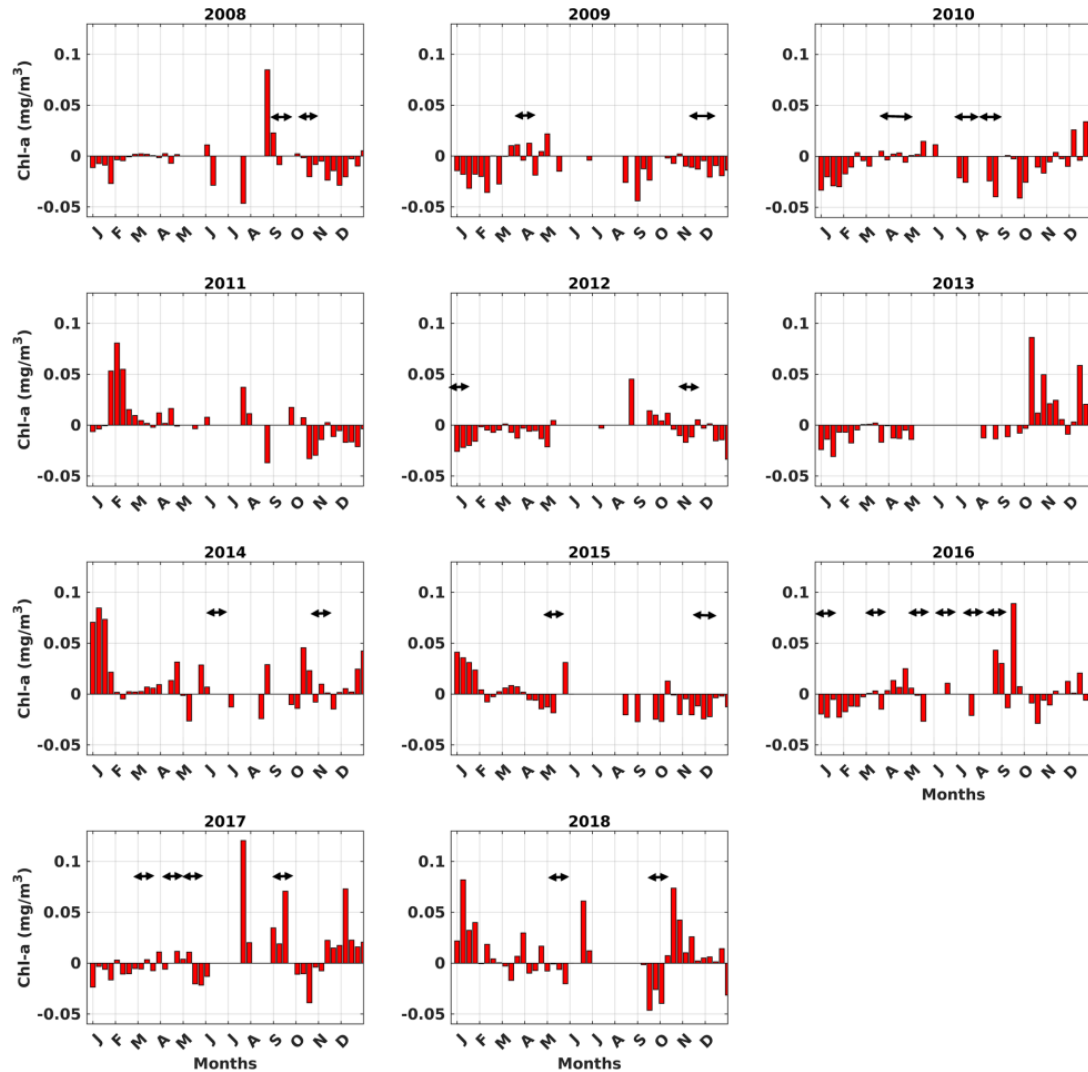
Subsurface Marine Heat Wave: Impact of NIOD and La-Niña



(Gupta et al., 2024, Climate Dynamics)

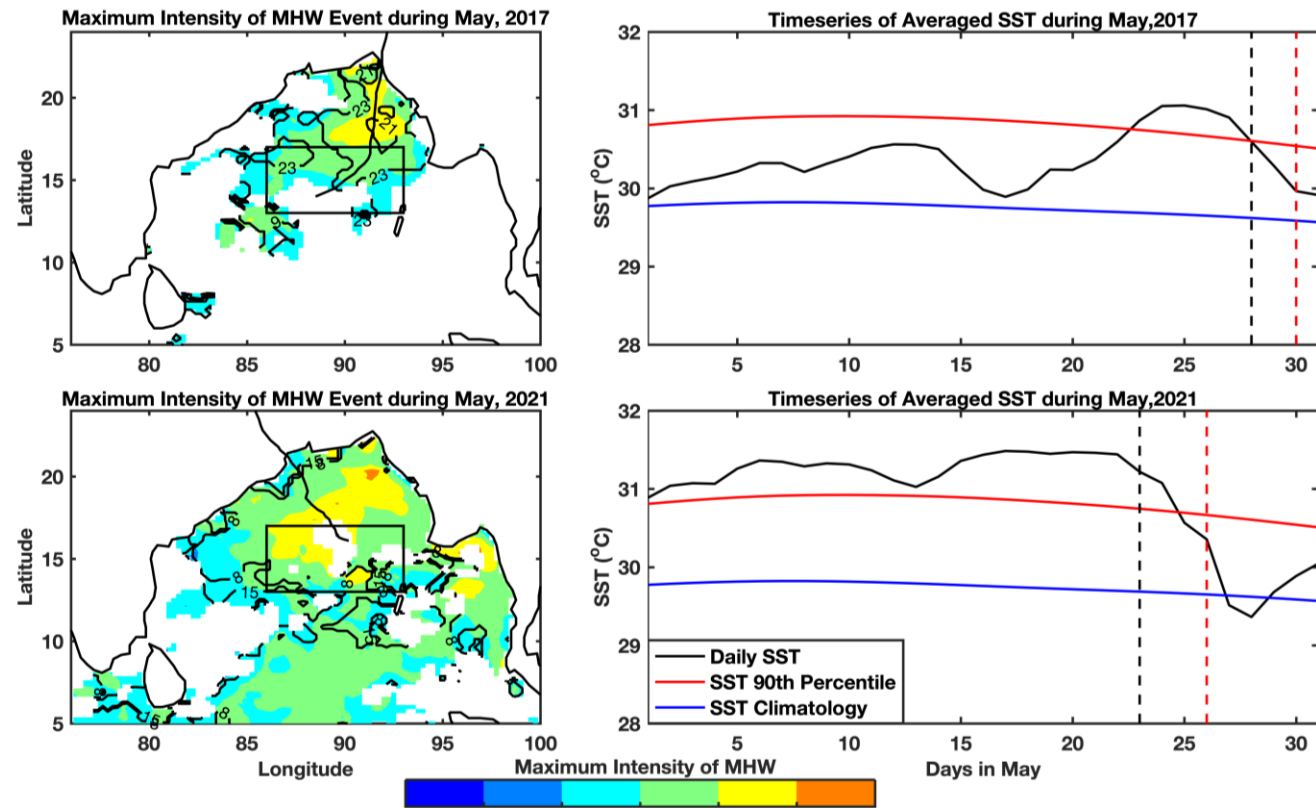
MHWs: Impacts on Chlorophyll and Intensity of Cyclones

Surface Chlorophyll-a Anomaly



(Gupta et al., 2024, Climate Dynamics)

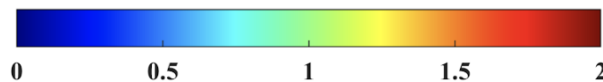
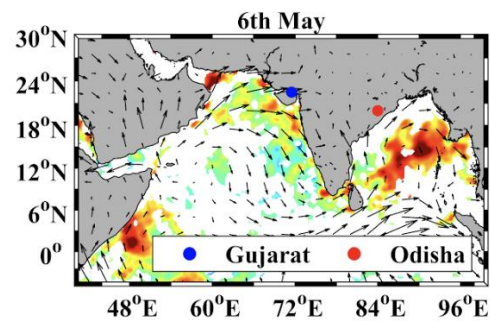
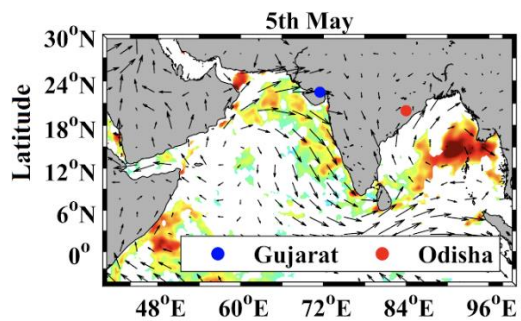
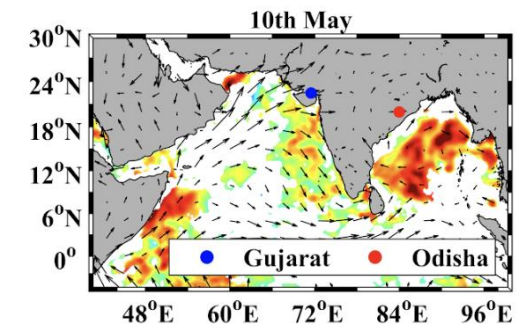
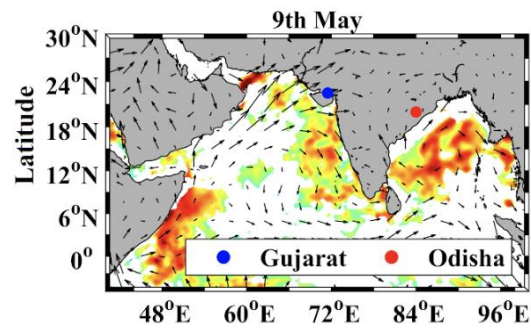
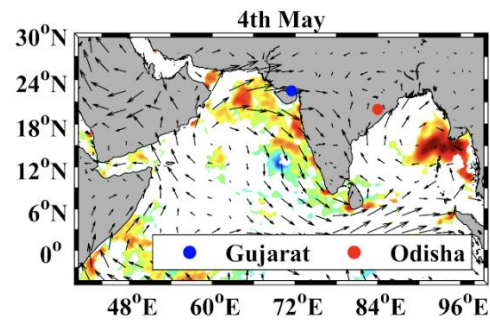
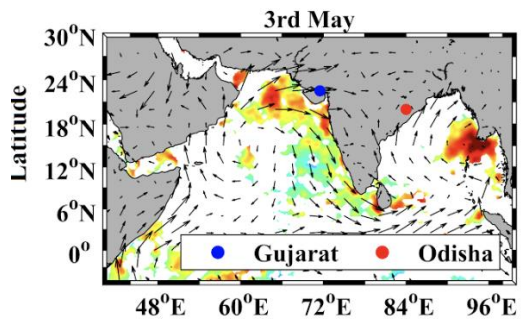
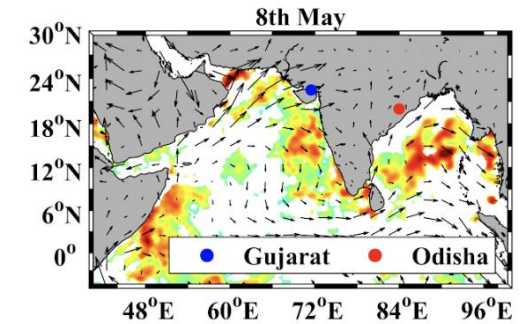
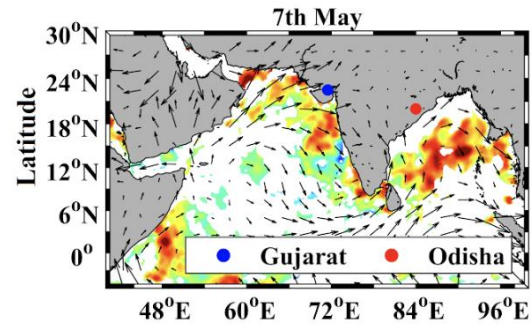
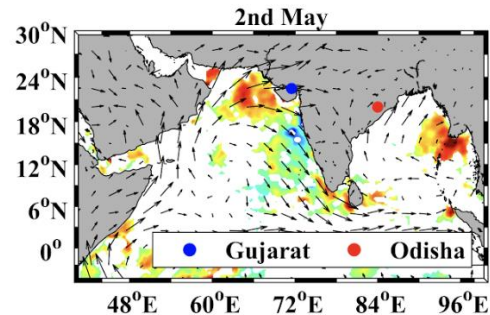
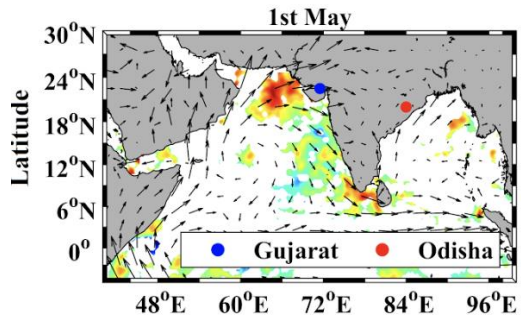
MHW duration (contour) and Max Intensity (shading) during May



(Ray et al., 2024, JGR-Ocean-Revised)

MWHs – Land Heatwaves

MHW + Winds



Government of India
 Earth System Science Organization
 Ministry of Earth Sciences
 India Meteorological Department

[Press Release](#)

Dated: 23rd May, 2020
 Time: 1600 hours IST

Sub.: a) Heat wave to severe heat wave conditions over Northwest, Central and adjoining Peninsular India during next 5 days b) Intense rainfall activity over Northeast India during 25th – 27th May, 2020.

Summary

- OISST and GHRSSST showed the similar MHWs events as compared to RAMA at 15N.
- Surface MHWs dominate during positive IOD and El-Niño, and subsurface MHWs during negative IOD and La-Niña (Larger time and space scale).
- The stratification helps to hold MHWs for longer time, and boundary currents and eddies help to distribute the warmer conditions of the MHWs (shorter time and space scale).
- Cyclone intensifications occurs in presence of the MHWs, biological productivity reduced during surface MHWs. The Land heatwaves can be influenced by the coastal MHWs.



References

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Thank You

