



ANIL AGARWAL DIALOGUE 2022

Marine Heatwaves and Cyclones Cascading in a Changing Climate

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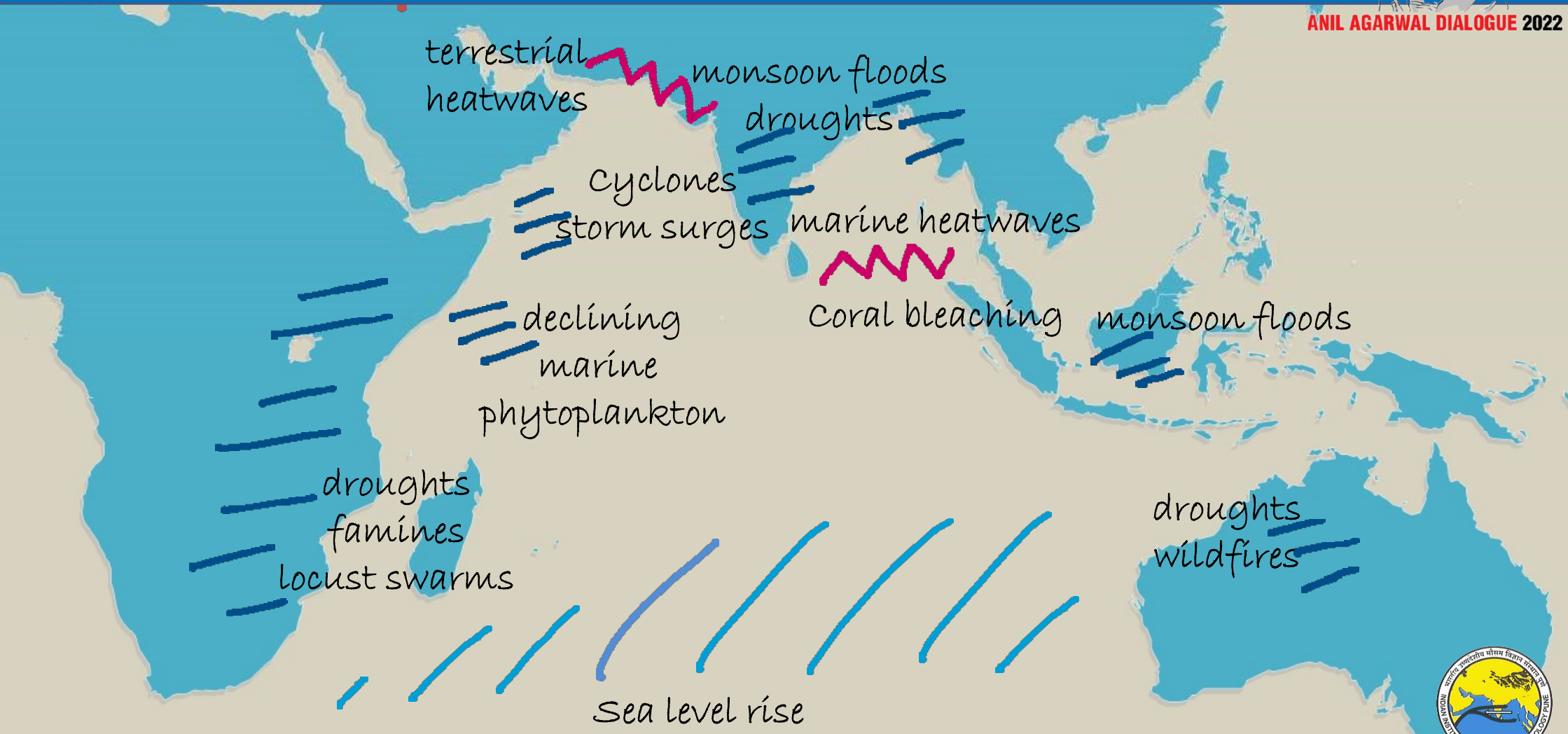


Marine Heatwaves and Cyclones

Cascading in a Changing Climate

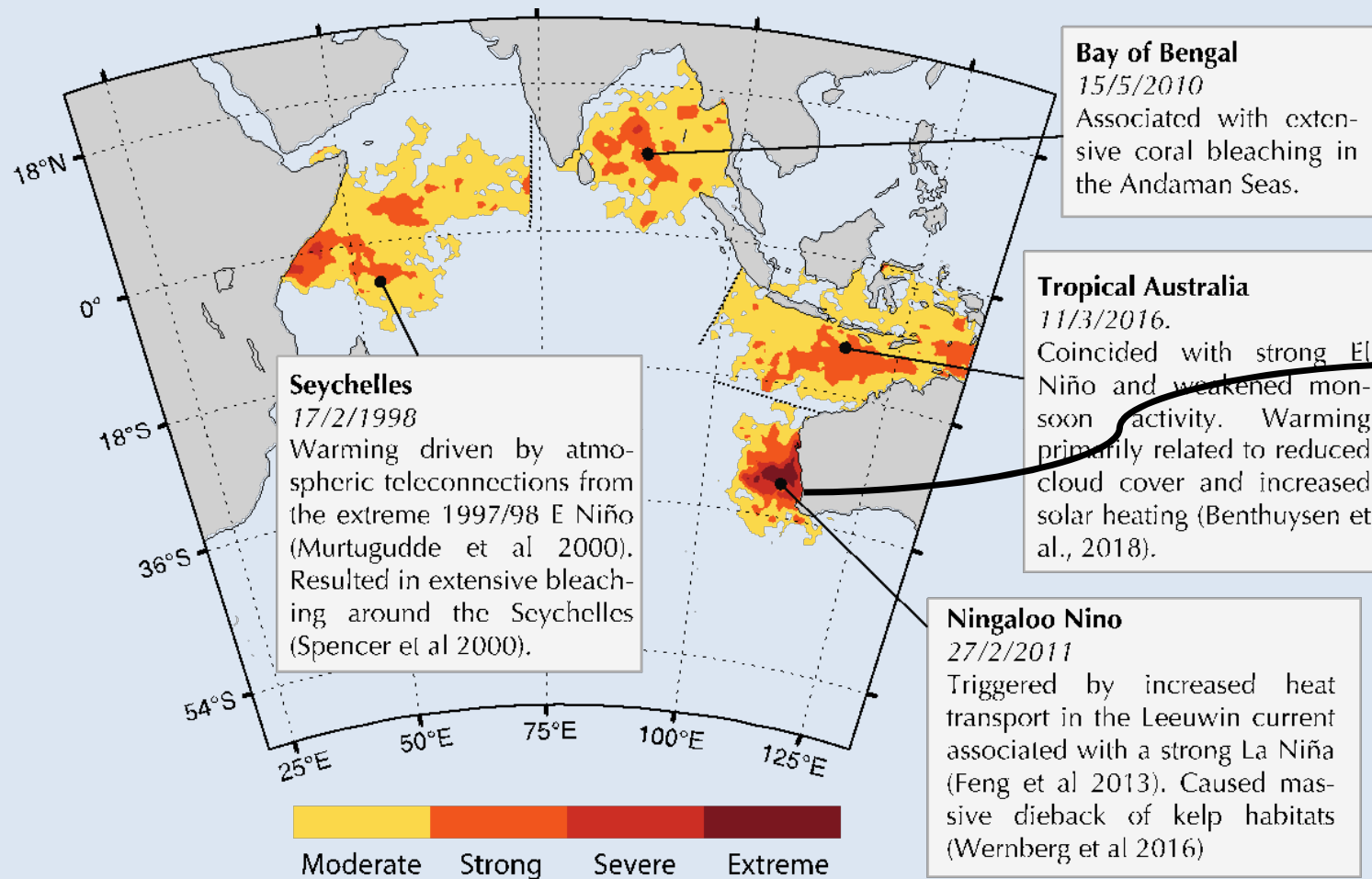


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Roxy Mathew Koll, Indian Institute of Tropical Meteorology, Pune

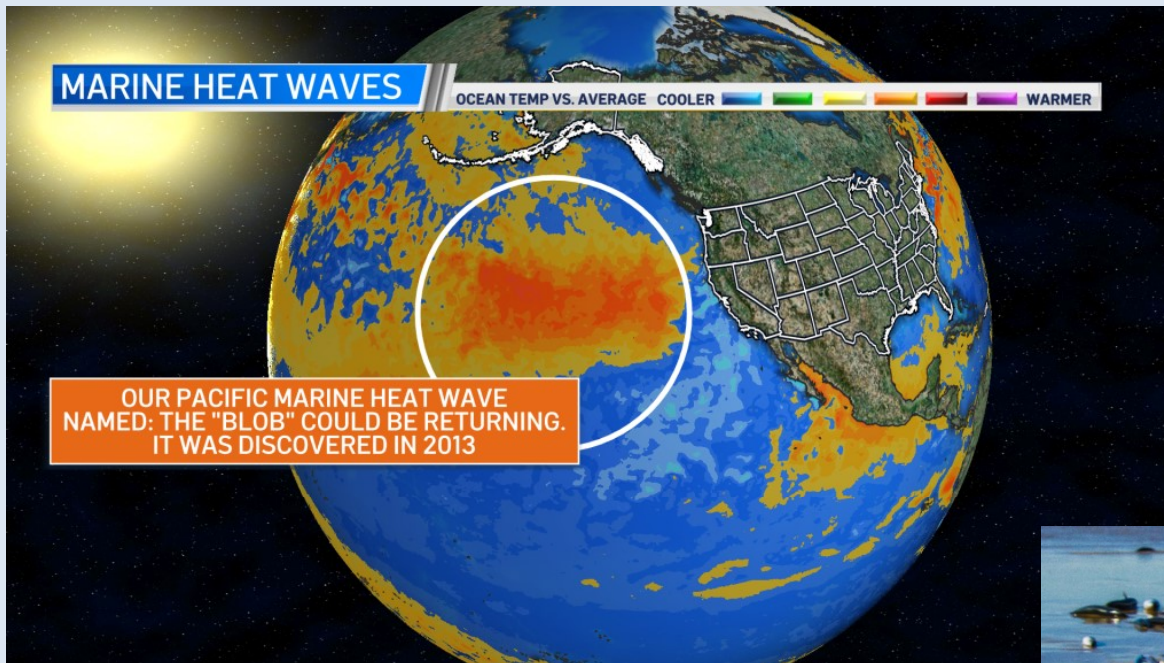
Marine Heatwaves — described only a decade ago



First described in 2011

The term “marine heatwave” was initially used to describe an extreme surface warming event off the west coast of Australia during 2010-11 austral summer

Marine Heatwaves — The Blob



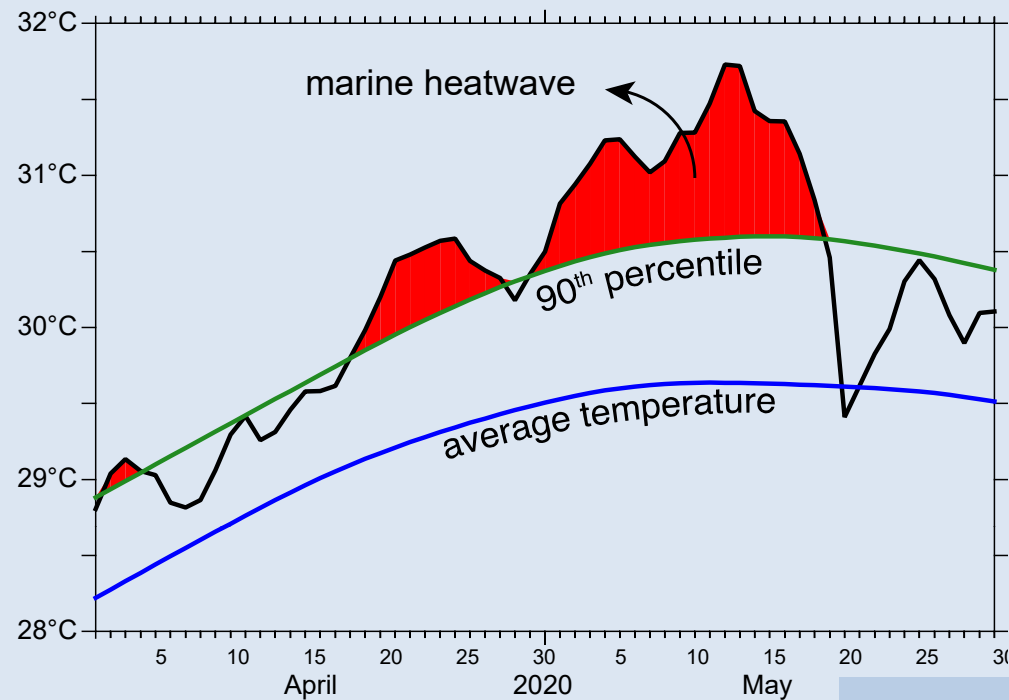
First identified in 2013

Marine heatwaves like The Blob has resulted in mass mortalities in marine mammals and birds, and collapse of fisheries and aquaculture in the US, Korea, etc.

We don't know how it has impacted India/South Asia.



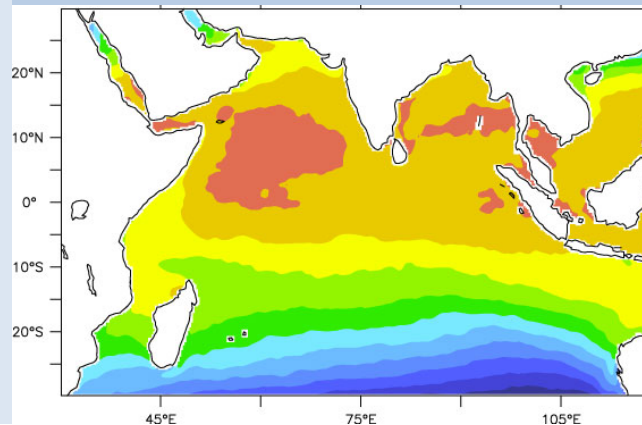
Marine Heatwaves — by definition



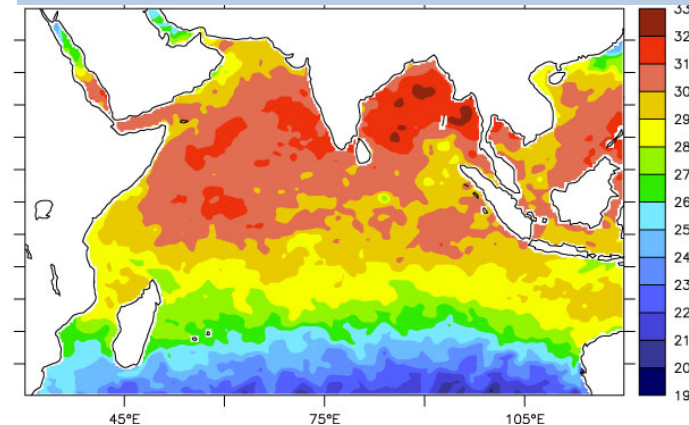
Marine heatwaves are periods of extremely high temperatures in the ocean (above the 90th percentile).

These events cause marine habitat destruction due to coral bleaching, seagrass destruction, and loss of kelp forests, affecting the fisheries sector adversely.

SSTs — mean conditions

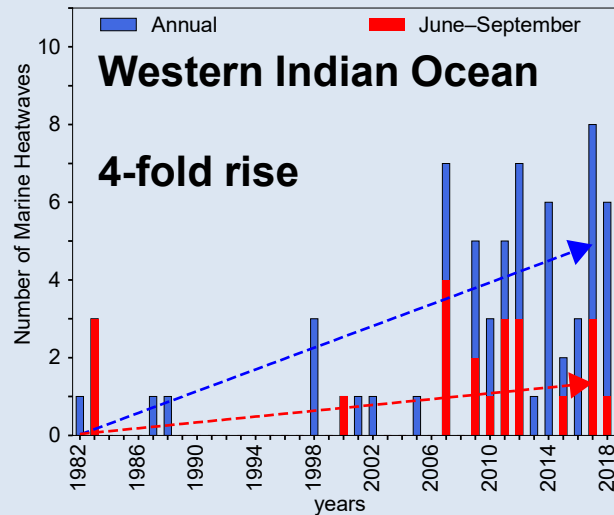


SSTs during marine heatwaves

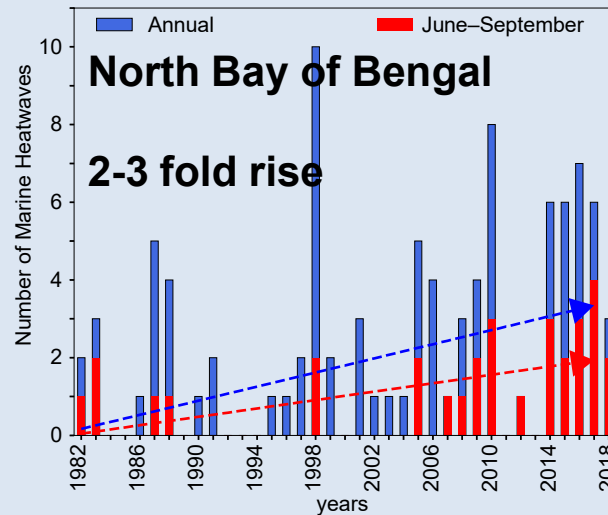


Marine Heatwaves — trends, impact on the monsoon

a Marine Heatwaves in the western Indian Ocean



b Marine Heatwaves in the north Bay of Bengal



During 1982–2018,
the **western Indian Ocean**
experienced a four-fold rise in
marine heatwaves.

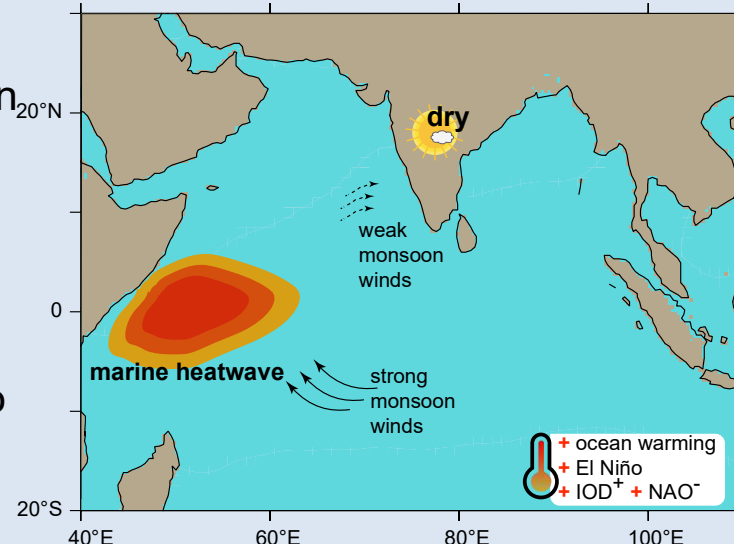
the **north Bay of Bengal** saw a
two-to-three fold rise in the
number of marine heatwaves.

Impact on the Monsoon

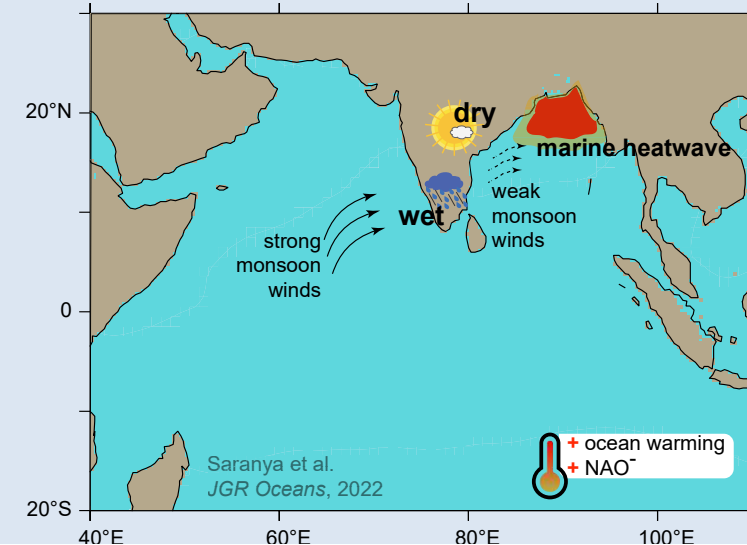
The marine heatwaves in the western Indian Ocean and the Bay of Bengal are found to result in dry conditions over the central Indian subcontinent.

There is an increase in rainfall over south peninsular India in response to the heatwaves in the Bay.

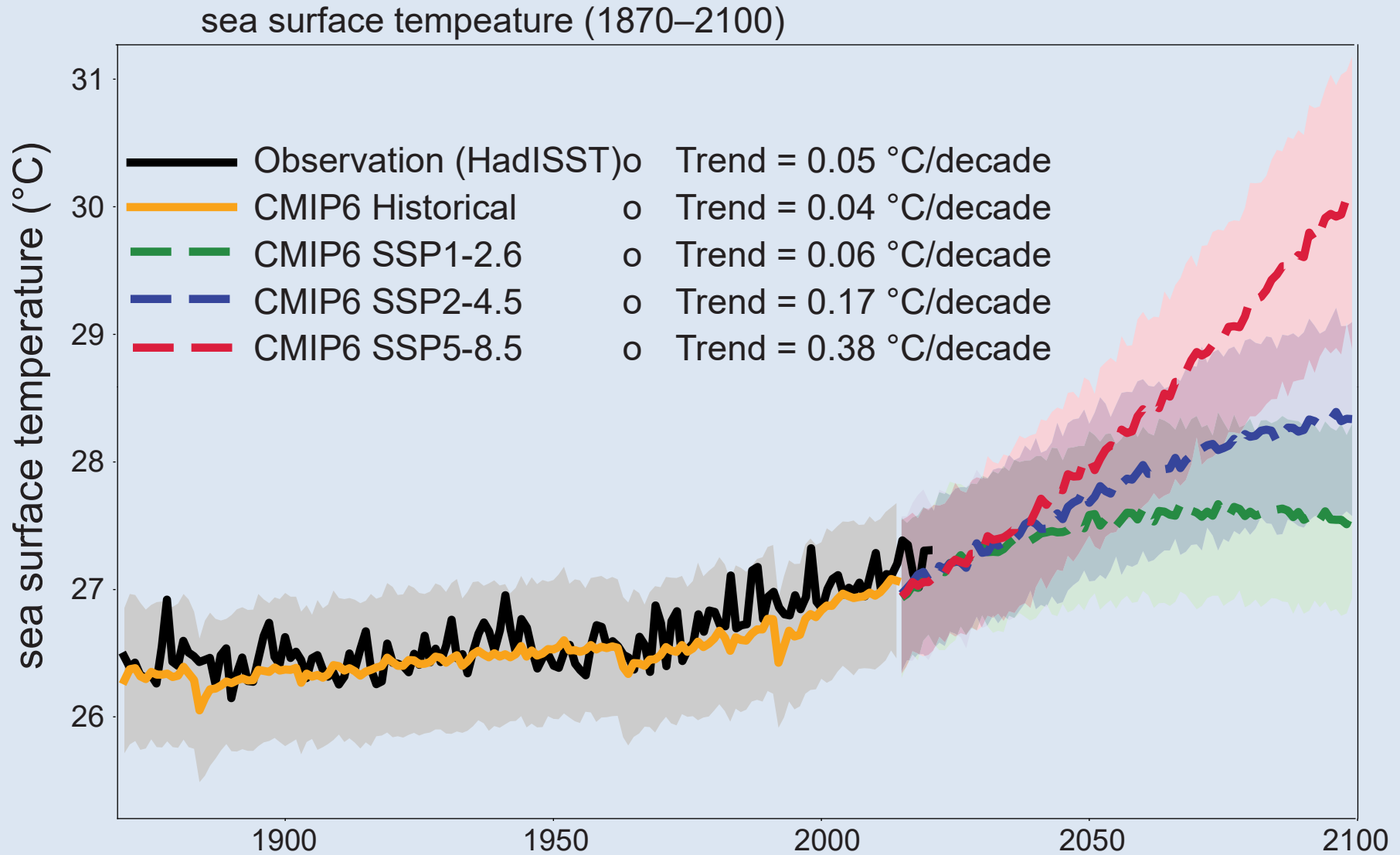
Marine heatwaves in the western Indian Ocean



Marine heatwaves in the north Bay of Bengal

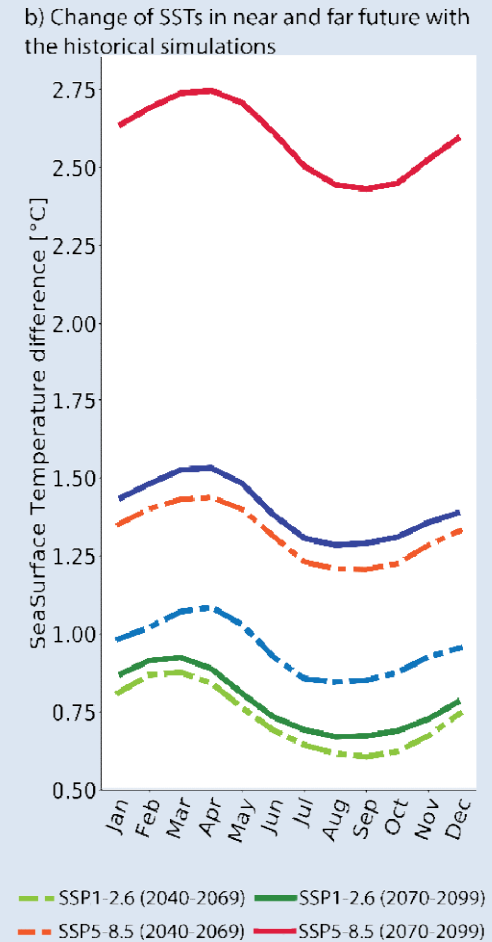
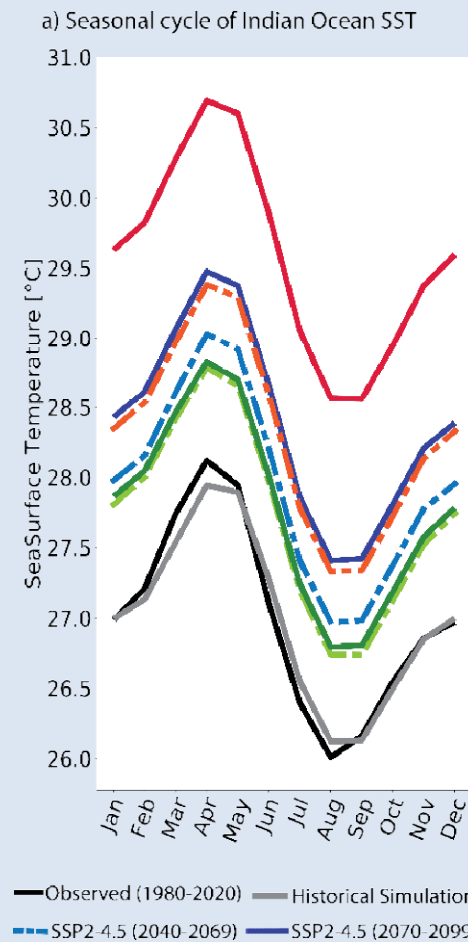
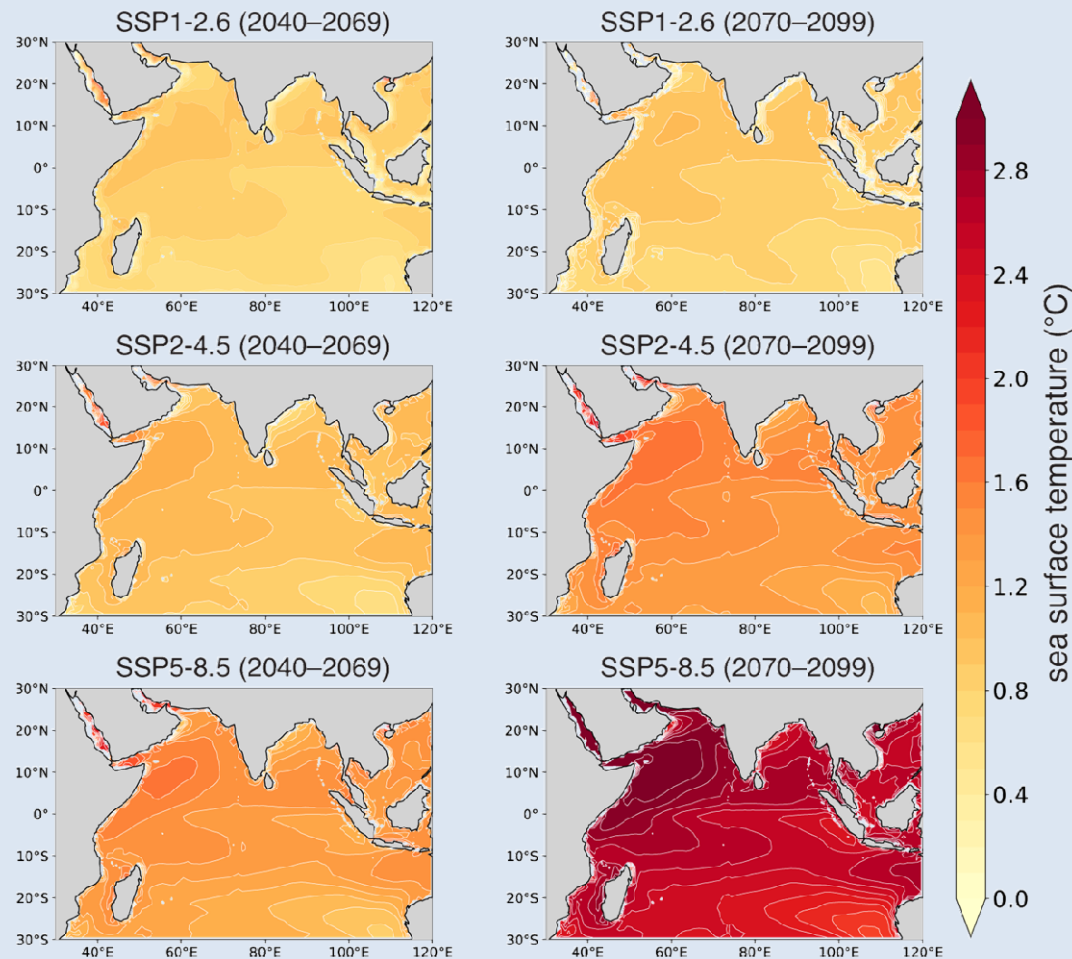


Indian Ocean in the Future — the warming

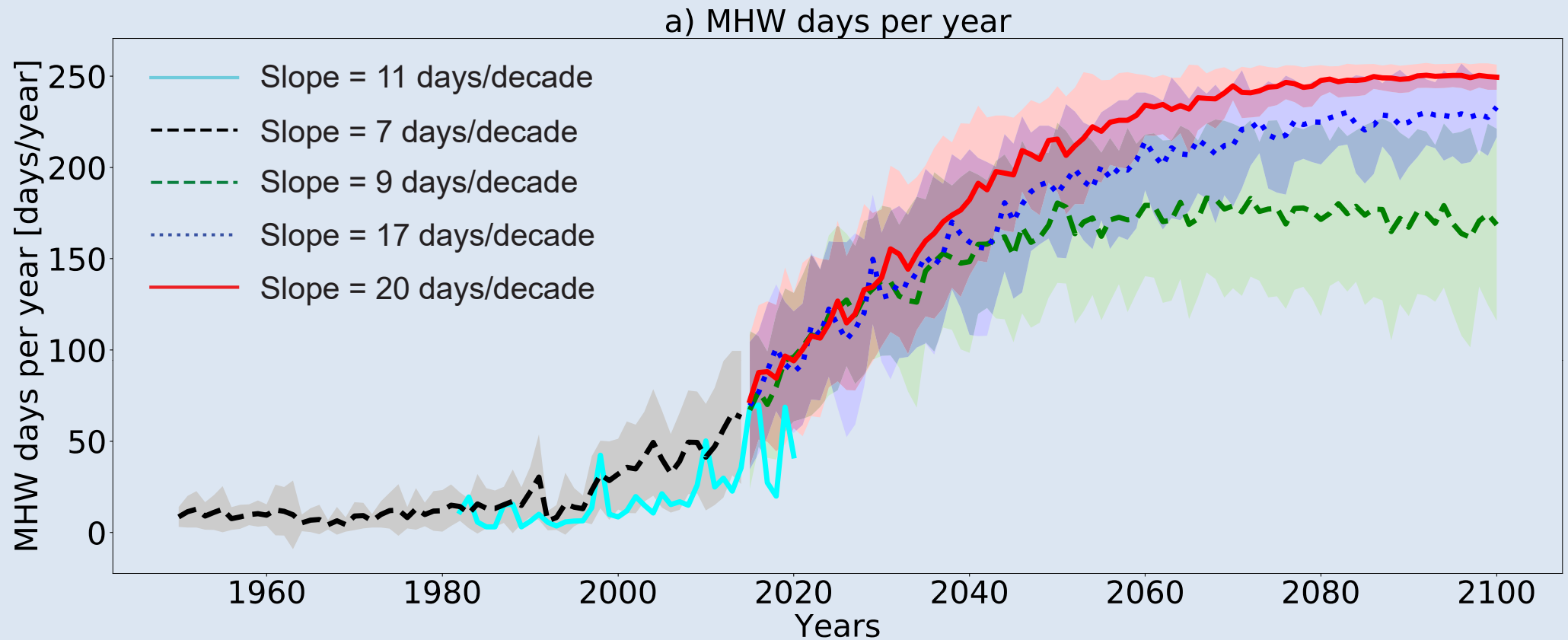


Indian Ocean in the Future — pattern and cycle

While the average temperatures during 1980–2020 remained below 28°C (26°C – 28°C)
the minimum temperatures (SSP5-8.5) by the end of 21st century is above 28°C (28.5°C – 30.7°C)

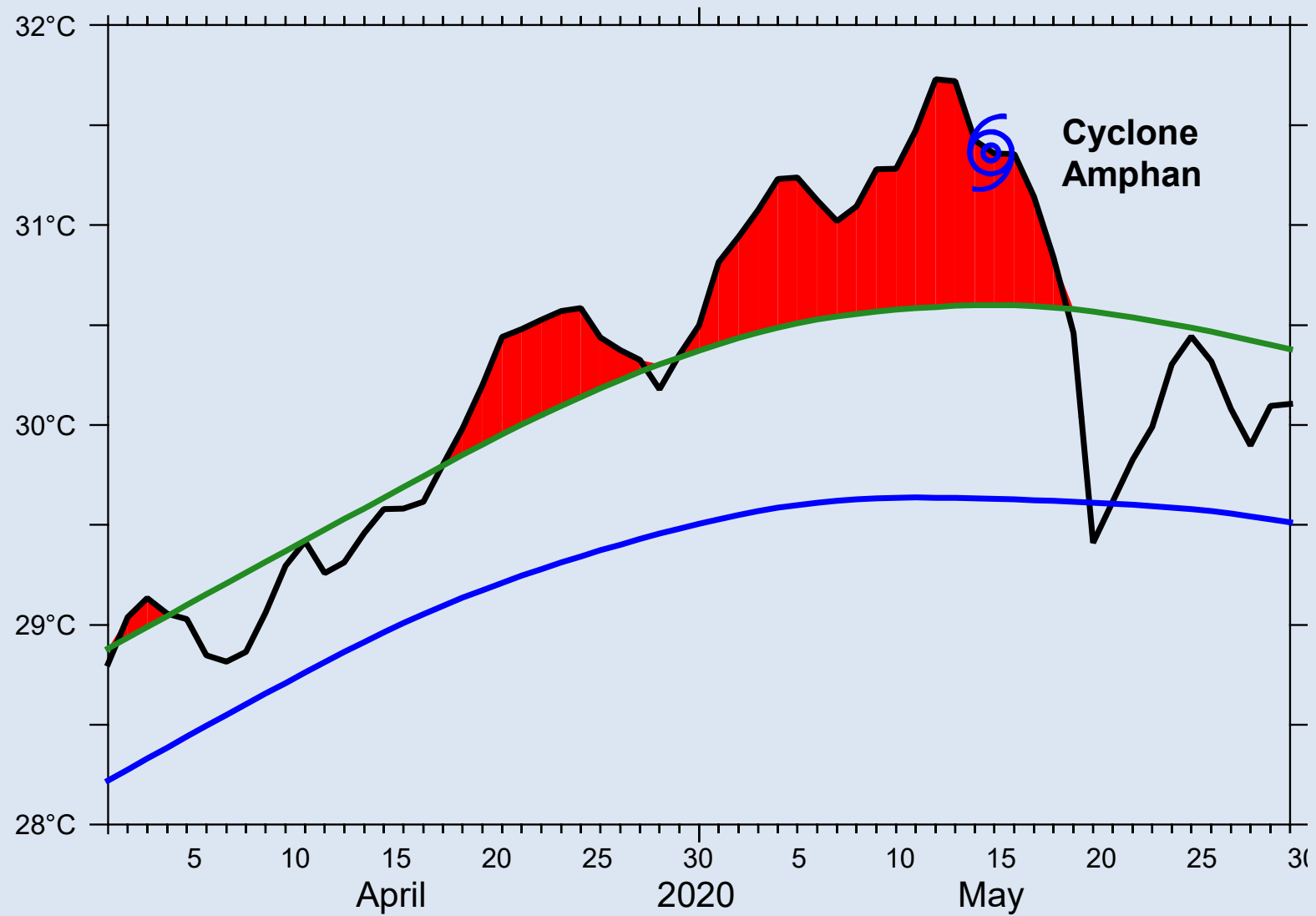


Marine Heatwaves in the Future — permanent marine heatwave state



Indian Ocean is reaching a permanent marine heatwave state

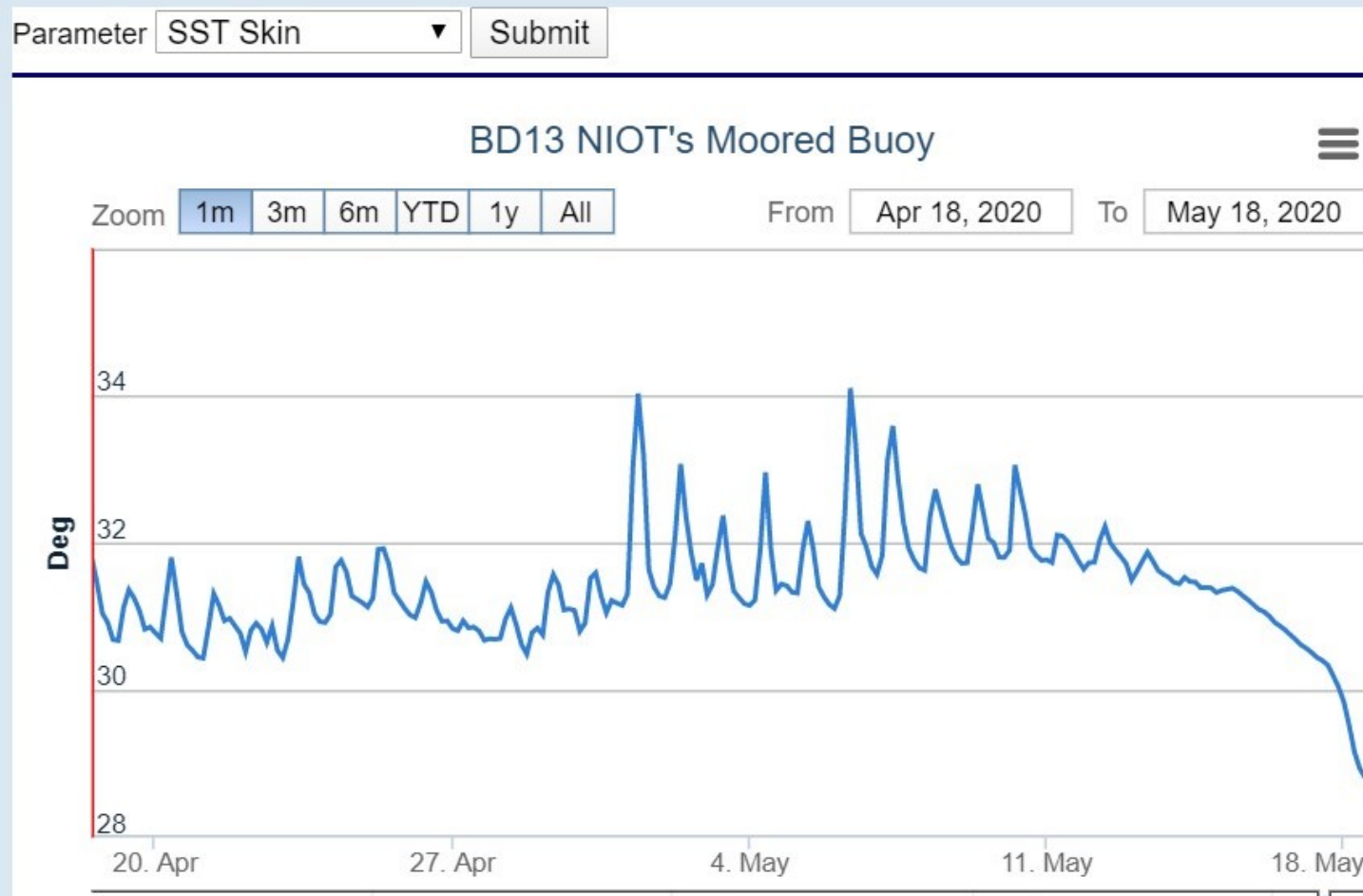
Marine Heatwaves and Cyclones



Marine Heatwaves and Cyclones

In-situ observations show much higher temperatures.

Moored Buoys Data

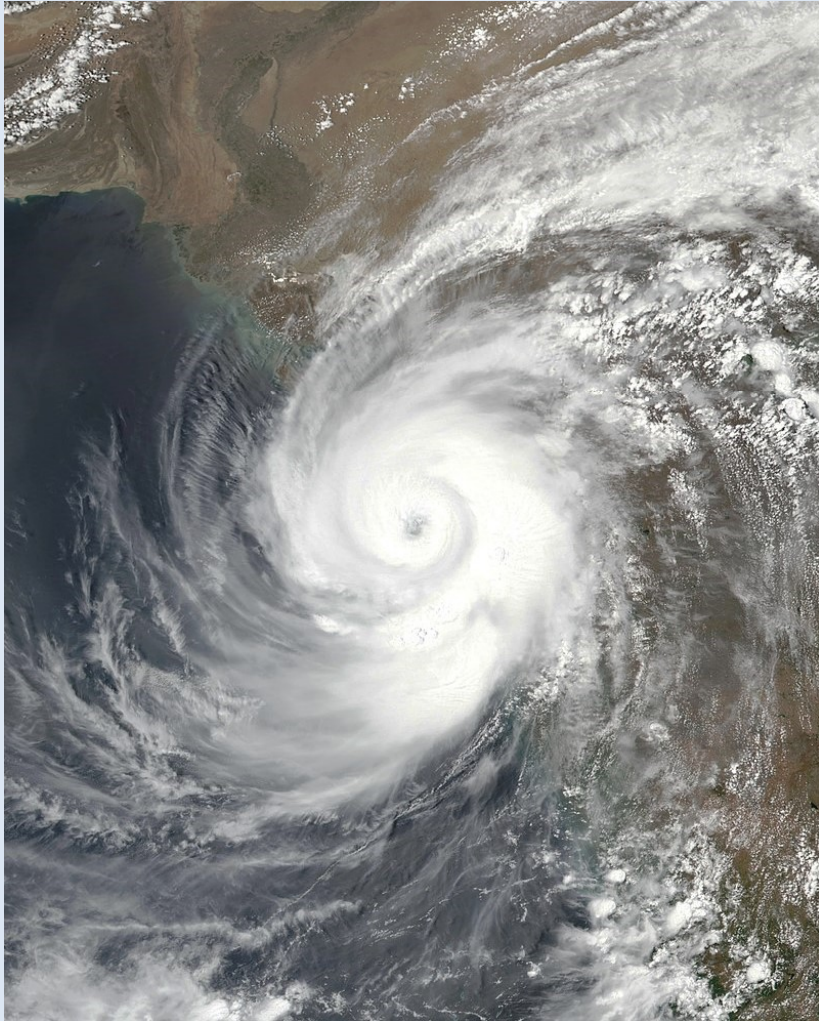


Bay of Bengal recorded surface temperatures of 32-34°C, before Cyclone Amphan.

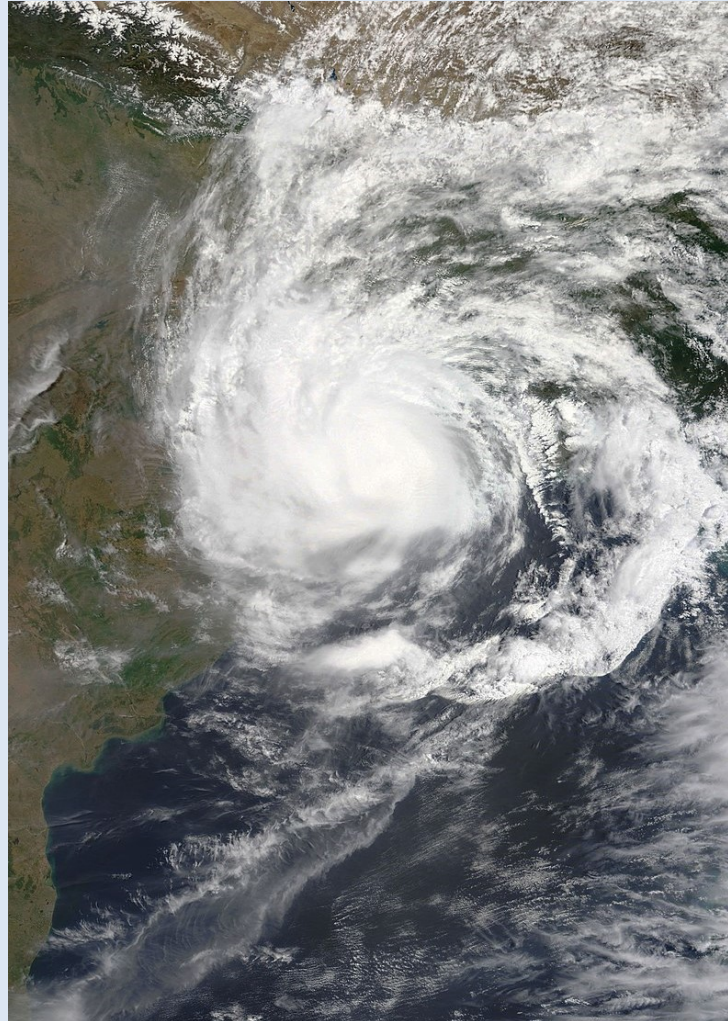
We have never seen such high values until now.

Increasing cyclones

Tauktae Cyclone
220 km/hr

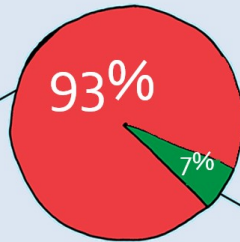


Yaas Cyclone
110 km/hr



93% of the heat from global warming goes into the oceans

Ocean



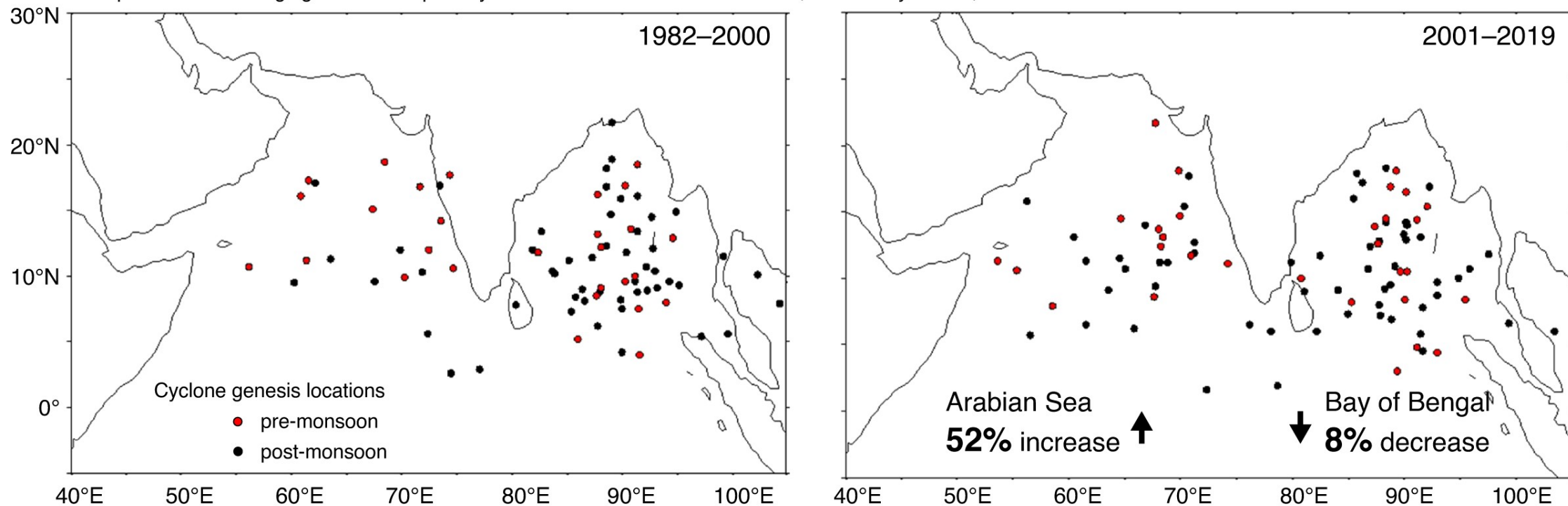
Warm waters are an energy source for cyclones

— heat & moisture —

As the Arabian Sea warms, the number and intensity of cyclones and heavy rains increase

52% increase in the number of cyclones in Arabian Sea

Deshpande et al. Changing status of tropical cyclones over the north Indian Ocean, *Climate Dynamics*, 2021



Over the Arabian Sea

150% in the number of very severe cyclones

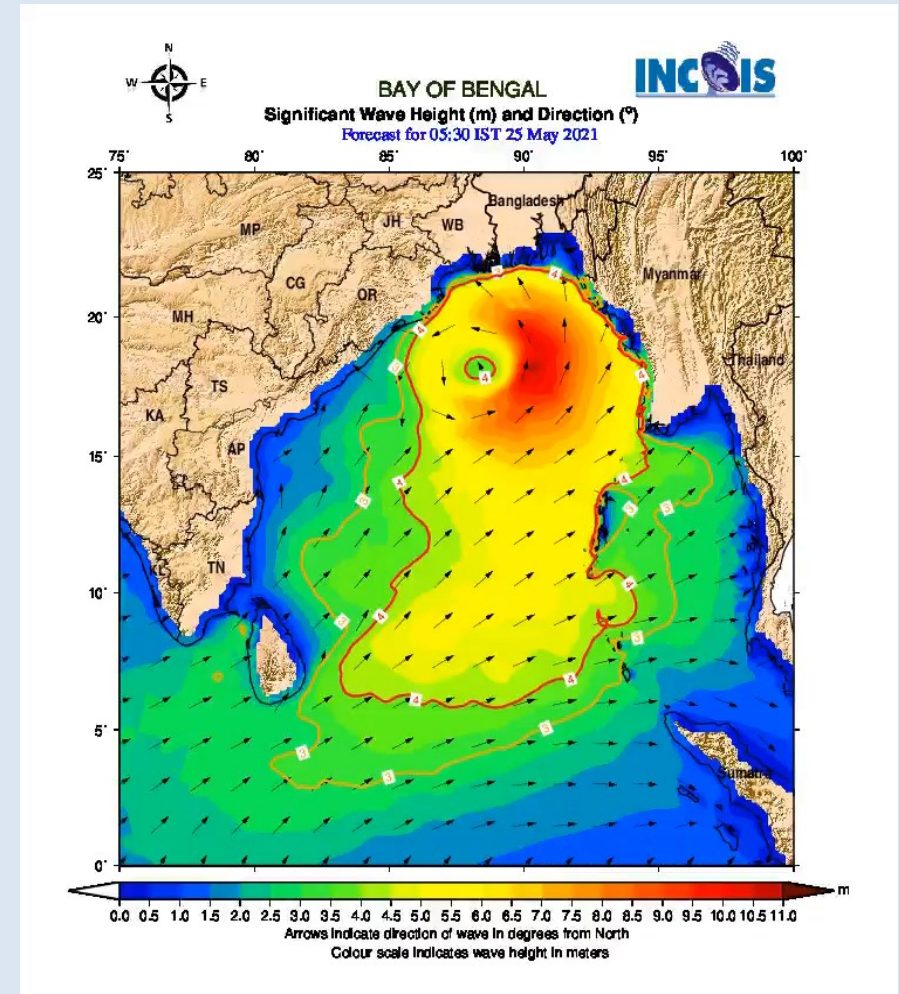
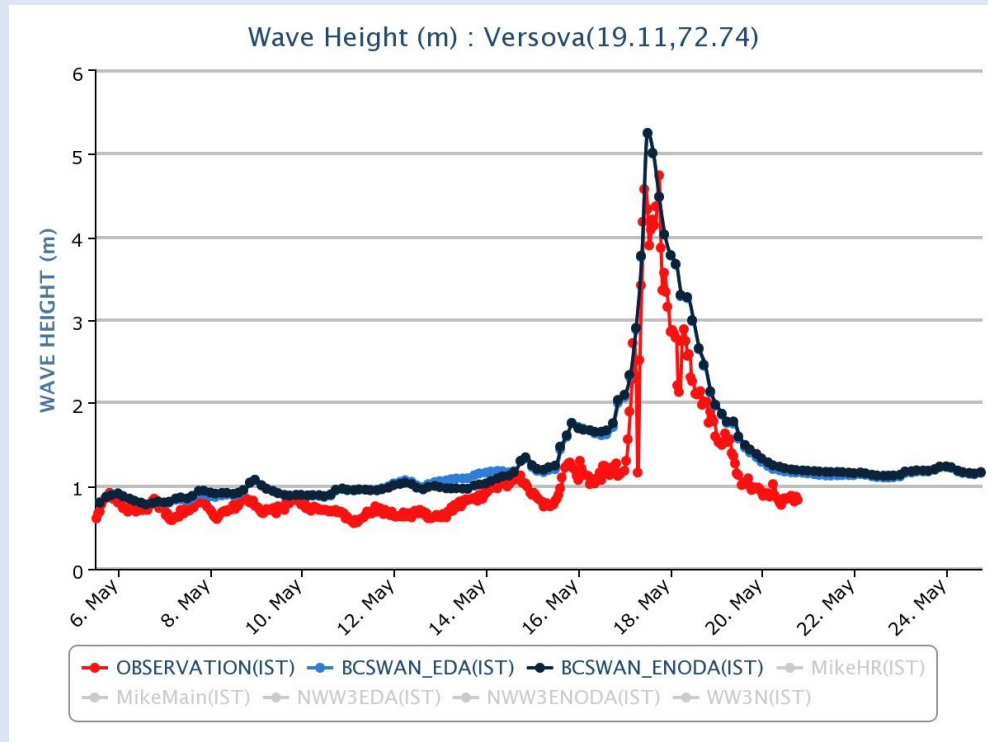
80% rise in the total duration of cyclones

20%-40% rise in the intensity of cyclones

Over the Bay of Bengal, rapid intensification may be occurring more. Trends not clear

Compound events during a Cyclone — Waves and Storm Surges

Mumbai



Compound events during a Cyclone



Cyclone
Tauktae

Compound Flood

= storm surge + rain water + sea level rise + high tide



Cyclone
Yaas

Compound events during heavy rains



Climate change is not the only culprit

The floodplain gives room for the river to fill, sink in, and move



Once this space is encroached, largescale floods occur

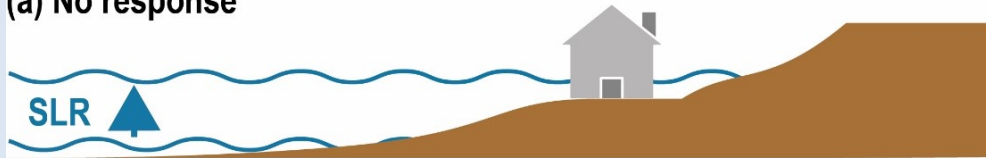


Climate change is not the only culprit



Ecosystem based adaptation should be explored

(a) No response



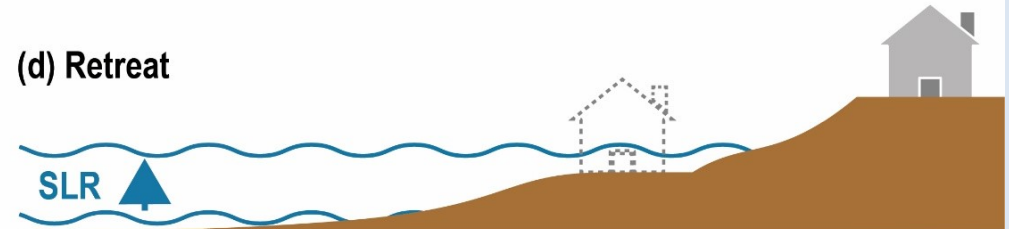
(b) Advance



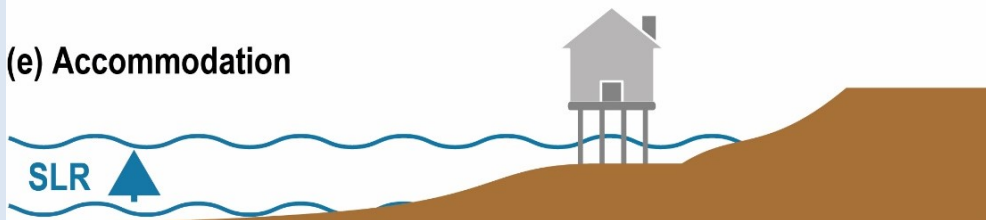
(c) Protection



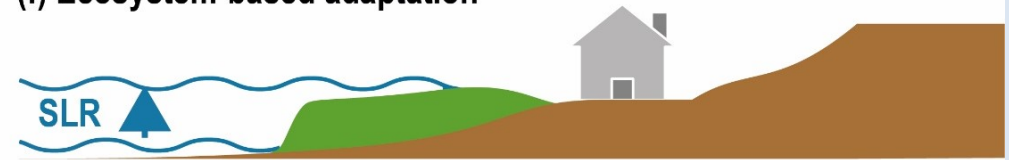
(d) Retreat



(e) Accommodation



(f) Ecosystem-based adaptation



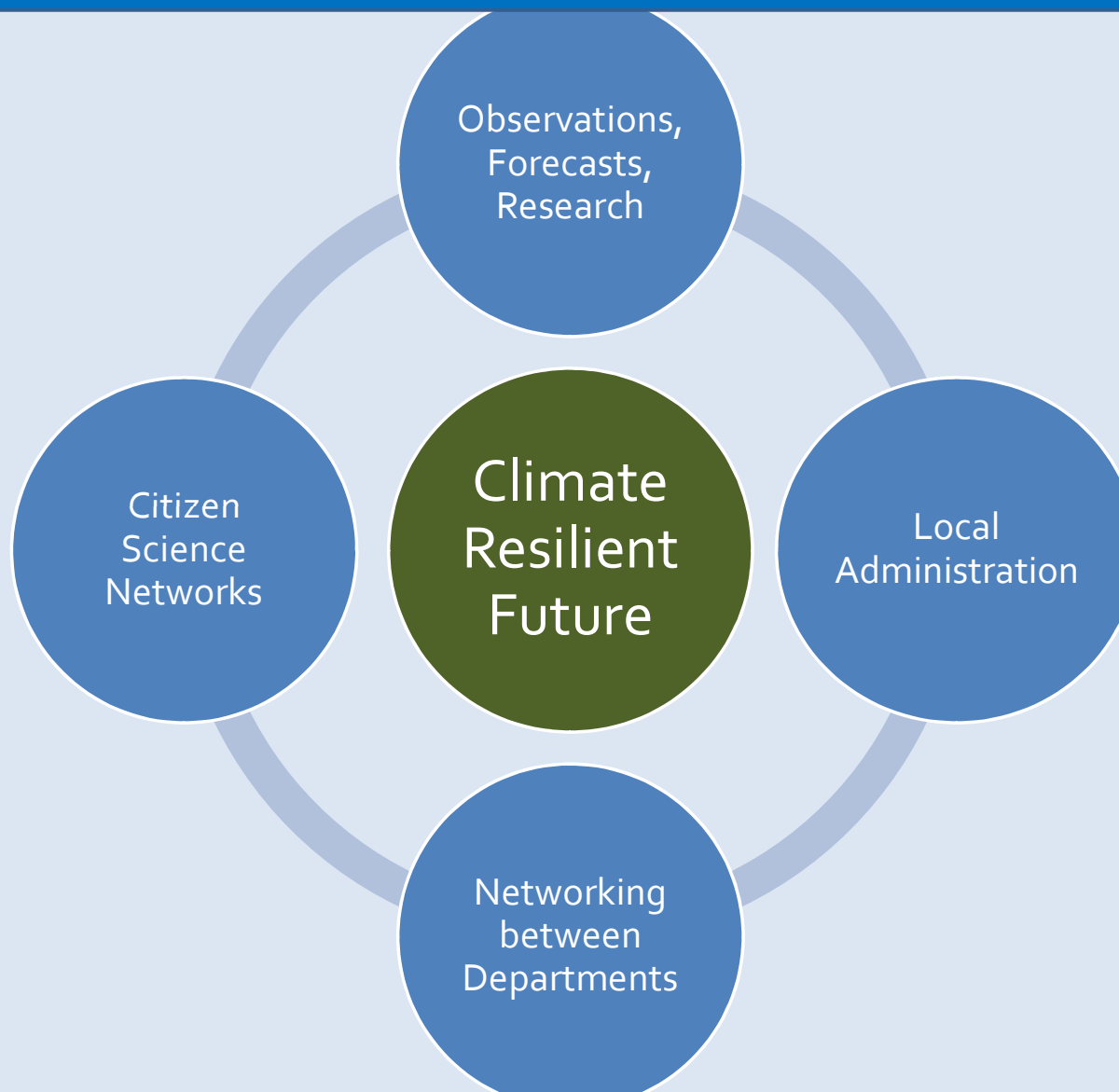
Need better observations for better forecast



Collective Effort for a Climate Resilient Future



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Thank You

