Marine Heatwaves and Cyclones
Cascading in a Changing Climate

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Marine Heatwaves and Cyclones
Cascading in a Changing Climate

- Marine heatwaves
- Cyclones
- Storm surges
- Marine phytoplankton
- Coral bleaching
- Monsoon floods
- Droughts
- Famines
- Locust swarms
- Sea level rise
- Droughts
- Wildfires

Roxy Mathew Koll, Indian Institute of Tropical Meteorology, Pune
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.

**Seychelles**
17/2/1998
Warming driven by atmospheric teleconnections from the extreme 1997/98 E Niño (Murttugude et al 2000). Resulted in extensive bleaching around the Seychelles (Spencer et al 2000).

**Bay of Bengal**
15/5/2010
Associated with extensive coral bleaching in the Andaman Seas.

**Tropical Australia**
11/3/2016
Coincided with strong E Niño and weakened monsoon activity. Warming primarily related to reduced cloud cover and increased solar heating (Benthaysen et al., 2018).

**Ningaloo Nino**
27/2/2011
Triggered by increased heat transport in the Leeuwin current associated with a strong La Niña (Feng et al 2013). Caused massive dieback of kelp habitats (Wernberg et al 2016).
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.
### Marine Heatwaves — trends, impact on the monsoon

#### 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.

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.
Indian Ocean in the Future — the warming

Observation (HadISST)\(\text{o}\) Trend = 0.05 °C/decade
CMIP6 Historical \(\text{o}\) Trend = 0.04 °C/decade
CMIP6 SSP1-2.6 \(\text{o}\) Trend = 0.06 °C/decade
CMIP6 SSP2-4.5 \(\text{o}\) Trend = 0.17 °C/decade
CMIP6 SSP5-8.5 \(\text{o}\) Trend = 0.38 °C/decade
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)
Indian Ocean is reaching a permanent marine heatwave state.
Marine Heatwaves and Cyclones

Cyclone Amphan

Temperature changes from April to May 2020.
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

<table>
<thead>
<tr>
<th>Cyclone</th>
<th>Speed (km/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tauktae Cyclone</td>
<td>220</td>
</tr>
<tr>
<td>Yaas Cyclone</td>
<td>110</td>
</tr>
</tbody>
</table>

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

Warm waters are an energy source for cyclones.

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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

Wave Height (m) : Versova(19.11,72.74)

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NIOT/INCOIS
Compound events during a Cyclone

Cyclone Tauktae

Cyclone Yaas

Compound Flood
= storm surge + rain water + sea level rise + high tide
Compound events during heavy rains

Mahabaleshwar Rains
19/07 098 mm
20/07 110 mm
21/07 164 mm
22/07 480 mm
23/07 600 mm

1080 mm in two days

Sea Level Rise + High Tide

River Encroachment
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

NOW THEY ARE PUTTING ALL THE BLAME ON YOU...
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

Observations, Forecasts, Research

Citizen Science Networks

Local Administration

Networking between Departments

Thank You