Marine Heatwaves in the Tropical and South Atlantic

PIRATA 24 – TAV Meeting
10-14/05/2021

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Marine Heatwaves

Motivation

Land heatwaves are periods of extreme temperatures

Short-term extreme events - catastrophic effects on ecosystems

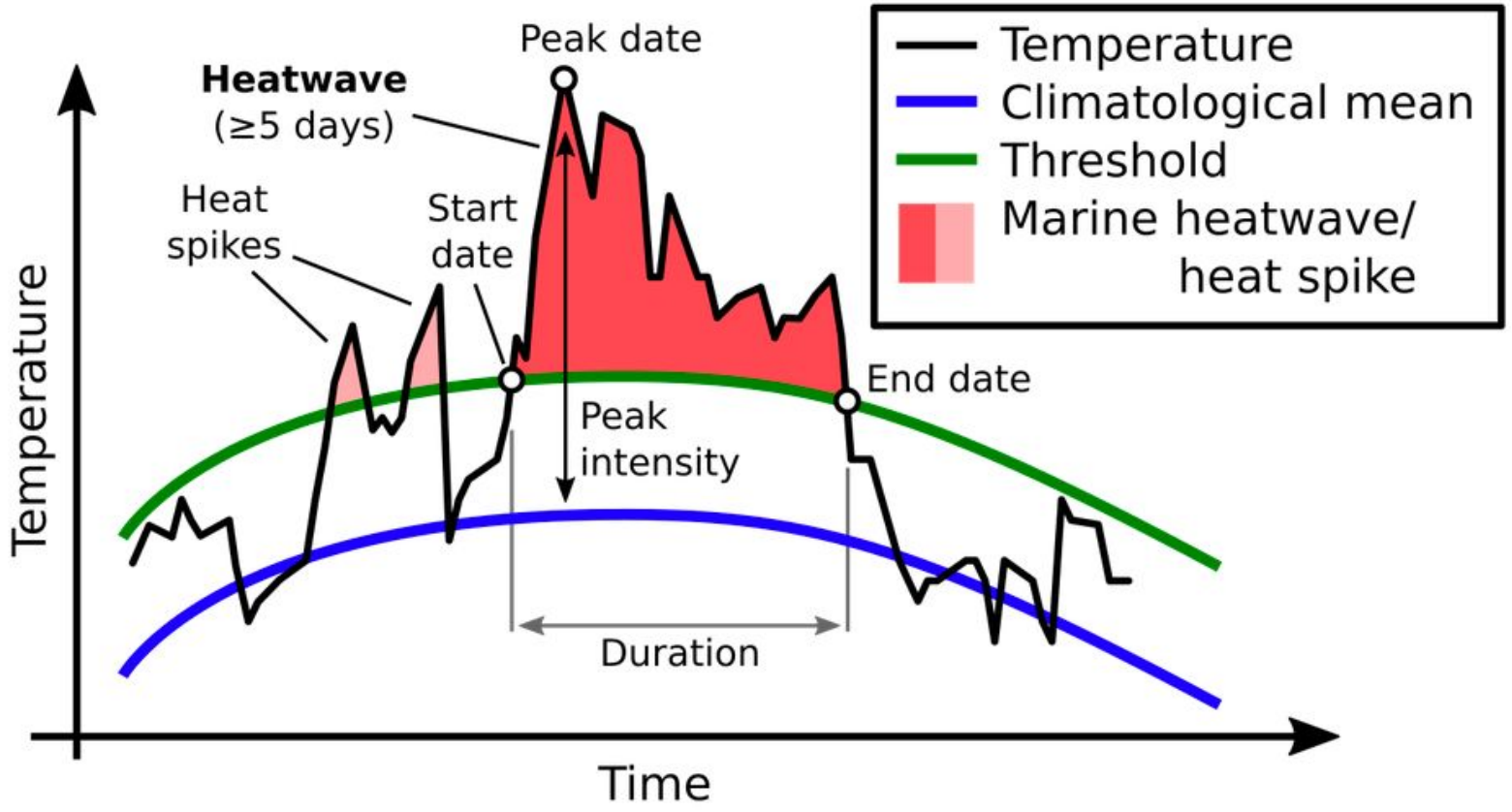
Majority of the studies - terrestrial ecosystems

Marine ecosystems are also strongly influenced by extreme climatic events

Event-based research for the ocean still lags behind trend-based work

Marine Heatwaves

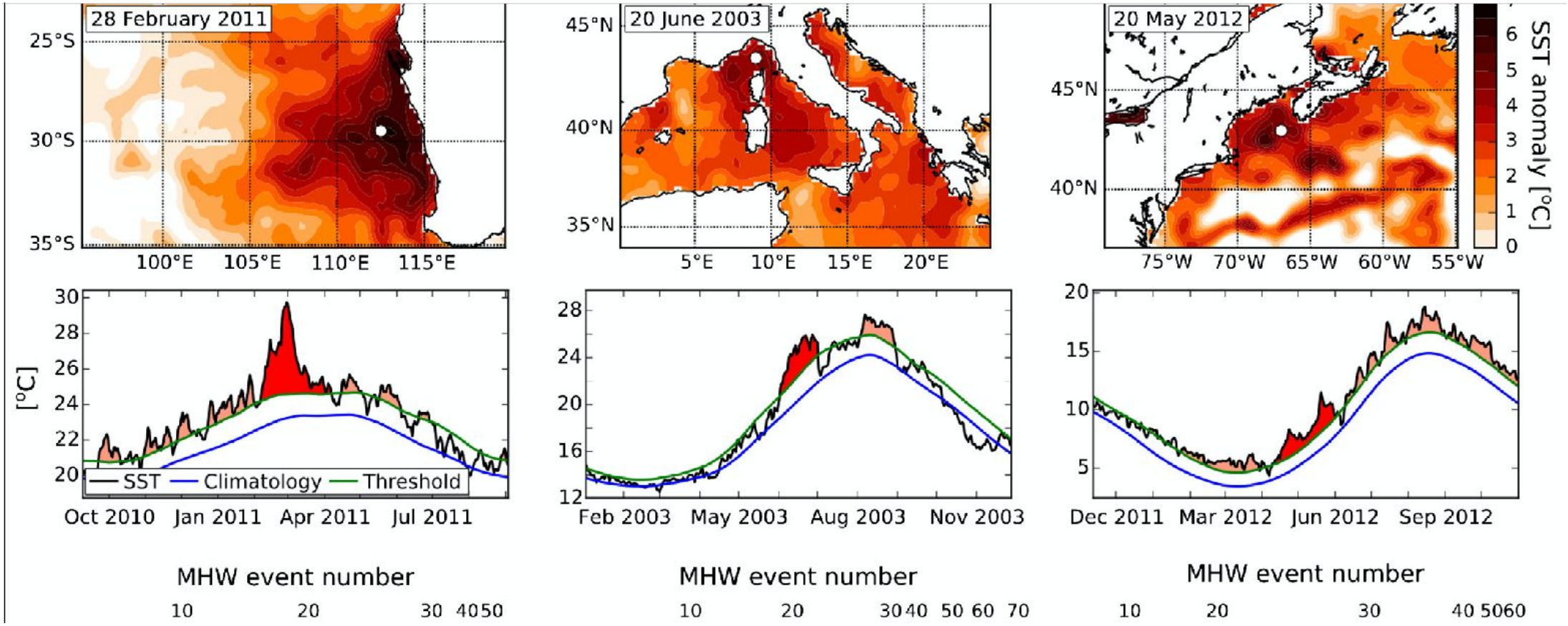
Definition



Hobday et al. (2016, Prog. Oceanogr.)

Marine Heatwaves

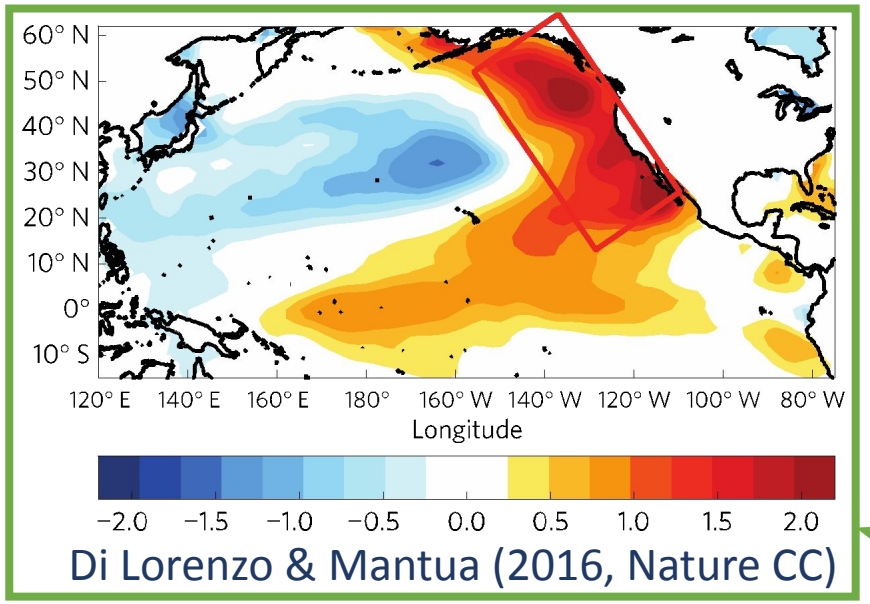
Major Events



Hobday et al. (2016, Prog. Oceanogr.)

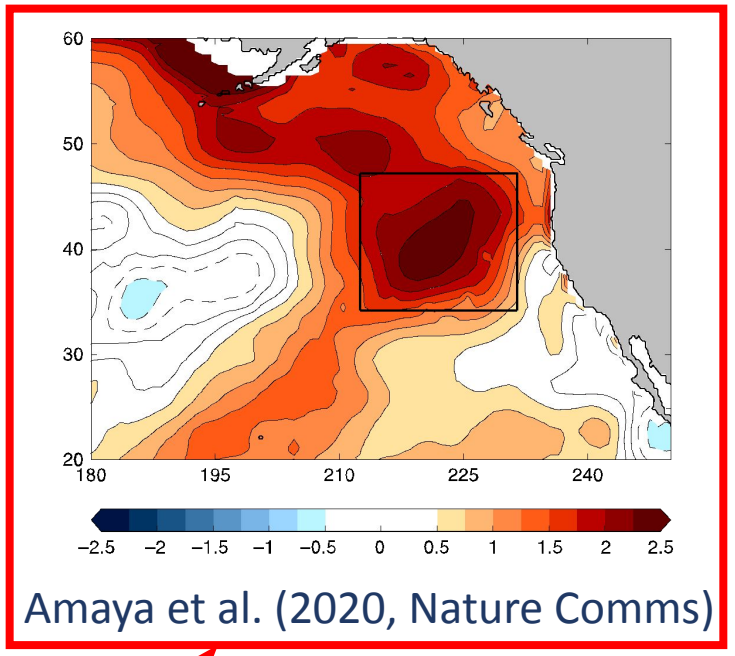
Marine Heatwaves

Major Events



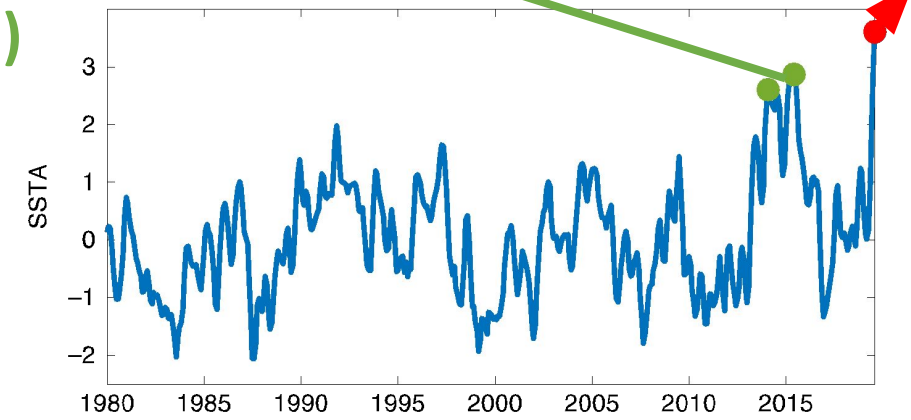
Di Lorenzo & Mantua (2016, Nature CC)

The Blob (2014-15)



Amaya et al. (2020, Nature Comms)

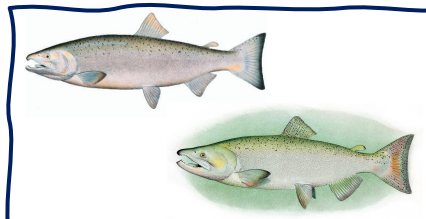
The Blob 2.0 (2019)



Marine Heatwaves

Impacts (The Blob)

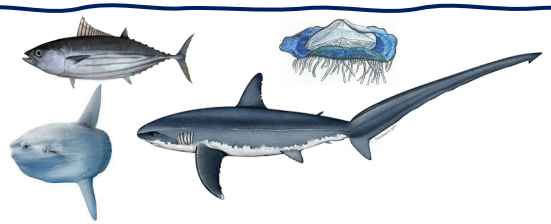
Reduced phytoplankton productivity & reduced zooplankton



Reduced catch of Coho and Chinook Salmon in Washington

Thousands of Cassin's auklets starved in Oregon

Sea lion pups starved, forcing mass beaching in California

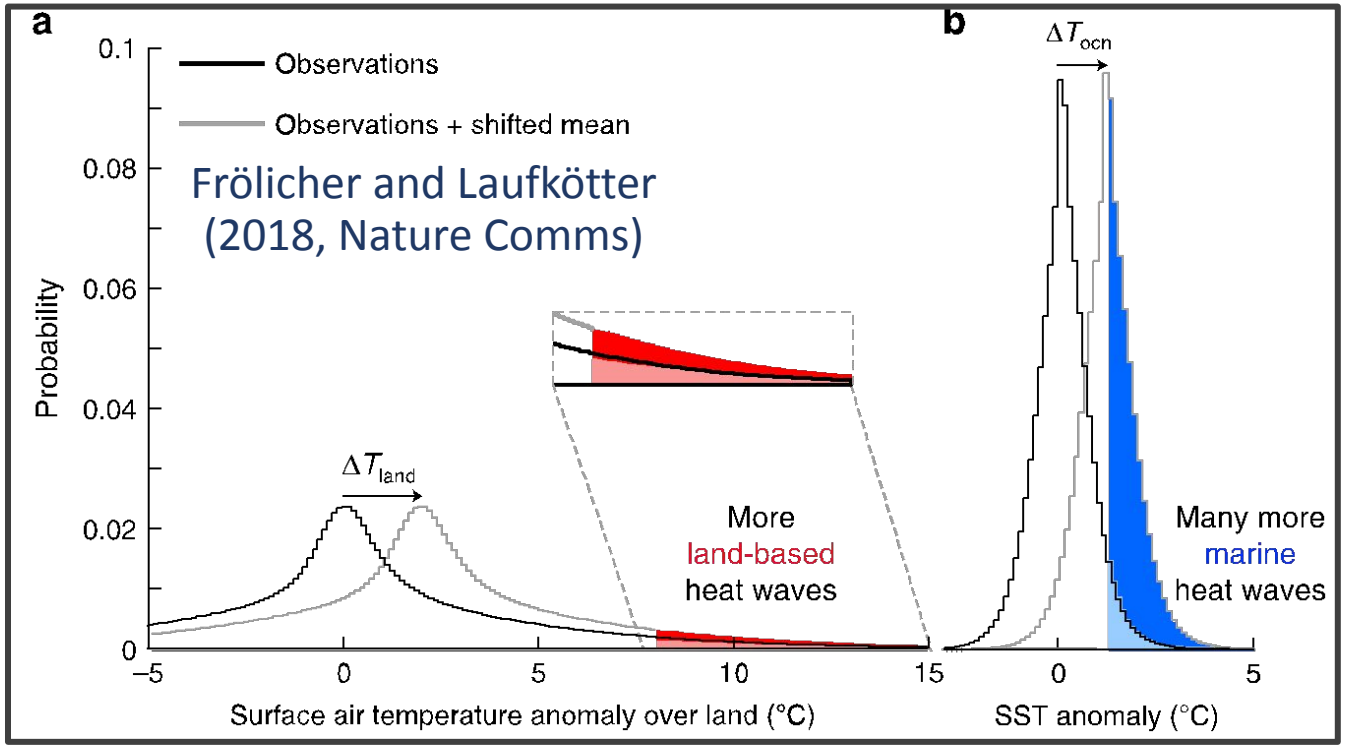


Thresher sharks, ocean sunfish, skipjack tuna, Velella velella off Alaska

Mass bleaching of coral reefs along the coast of Hawaii

Marine Heatwaves

Future Changes



LETTER

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Greater vulnerability to warming of marine versus terrestrial ectotherms

Malin L. Pinsky[1]*, Anne Maria Eikeset[2], Douglas J. McCauley[3,4], Jonathan L. Payne[5] & Jennifer M. Sunday[6]

Marine Heatwaves

Future Changes

RESEARCH

OCEAN TEMPERATURE

High-impact marine heatwaves attributable to human-induced global warming

Charlotte Laufkötter[1,2]*, Jakob Zscheischler[1,2], Thomas L. Frölicher[1,2]

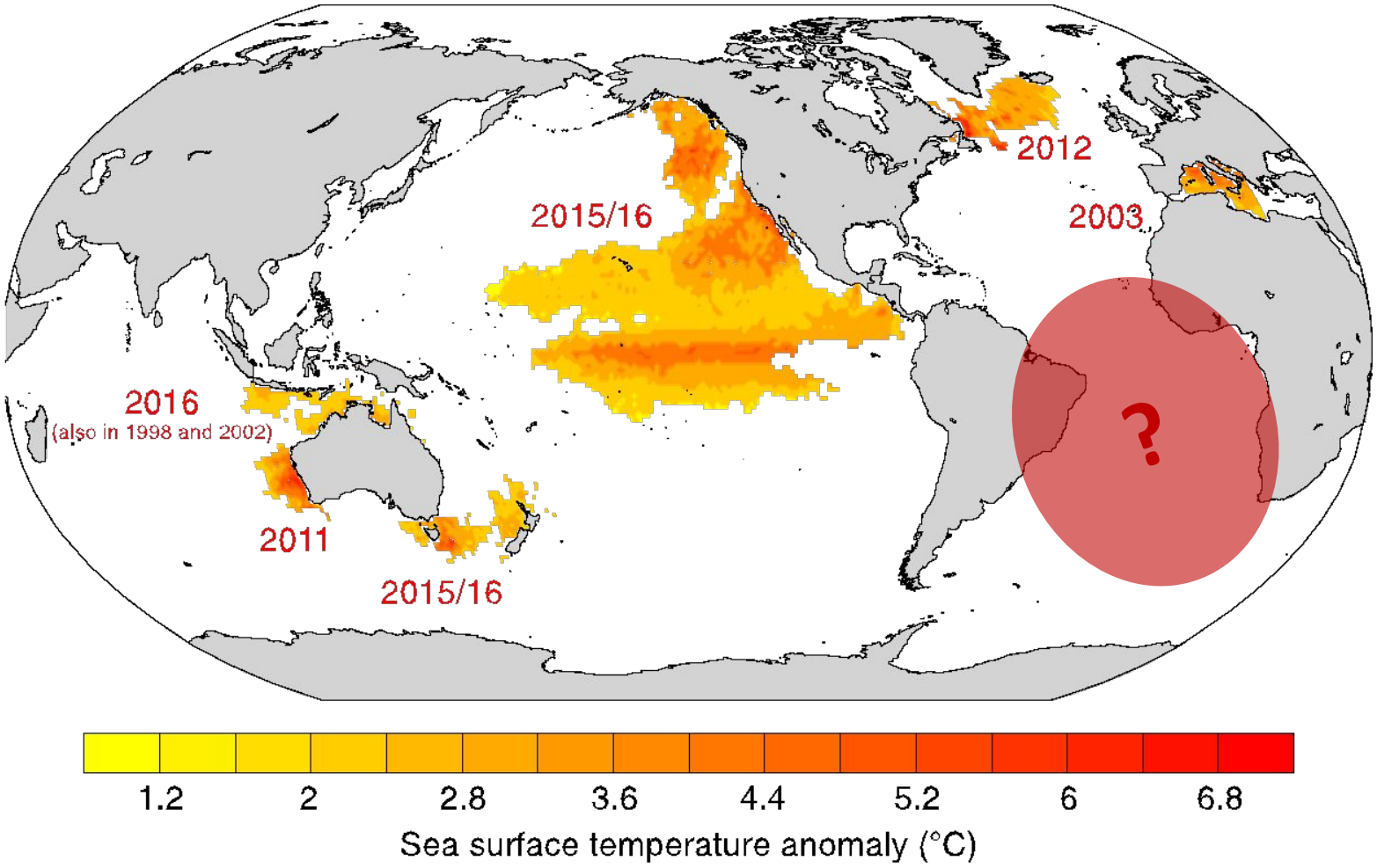
Marine heatwaves (MHWs)—periods of extremely high ocean temperatures in specific regions—have occurred in all of Earth's ocean basins over the past two decades, with severe negative impacts on marine organisms and ecosystems. However, for most individual MHWs, it is unclear to what extent they have been altered by human-induced climate change. We show that the occurrence probabilities of the duration, intensity, and cumulative intensity of most documented, large, and impactful MHWs have increased more than 20-fold as a result of anthropogenic climate change. MHWs that occurred only once every hundreds to thousands of years in the preindustrial climate are projected to become decadal to centennial events under 1.5°C warming conditions and annual to decadal events under 3°C warming conditions. Thus, ambitious climate targets are indispensable to reduce the risks of substantial MHW impacts.

that equals or exceeds the duration, intensity, and cumulative intensity of the observed MHW in preindustrial and present-day model simulations. These probabilities are denoted by $P^{duration}_{present-day}$, $P^{intensity}_{present-day}$, $P^{cumulativeintensity}_{present-day}$, $P^{duration}_{preindustrial}$, $P^{intensity}_{preindustrial}$, and $P^{cumulativeintensity}_{preindustrial}$, respectively.

Here, we explicitly take changes in the frequency of heatwaves as well as changes in the duration, intensity, or cumulative intensity of heatwaves into account (see materials and methods). Our approach builds on the work of Stott et al. (28) and Oliver et al. (6) but with several modifications. In contrast to most previous attribution studies, we specifically calculate the occurrence probabilities of heatwaves as opposed to the probabilities of ex-

Marine Heatwaves

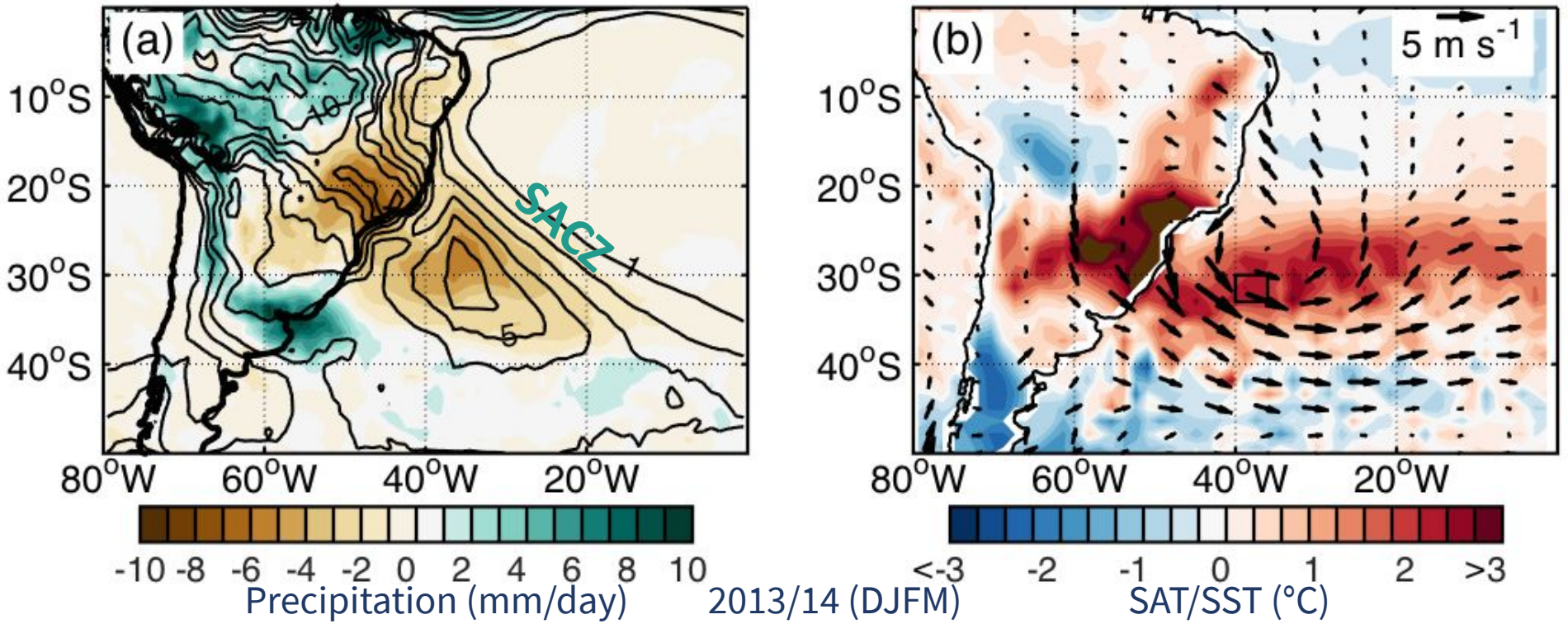
Tropical and South Atlantic



Frölicher and Laufkötter (2018, Nature Comms)

Marine Heatwaves

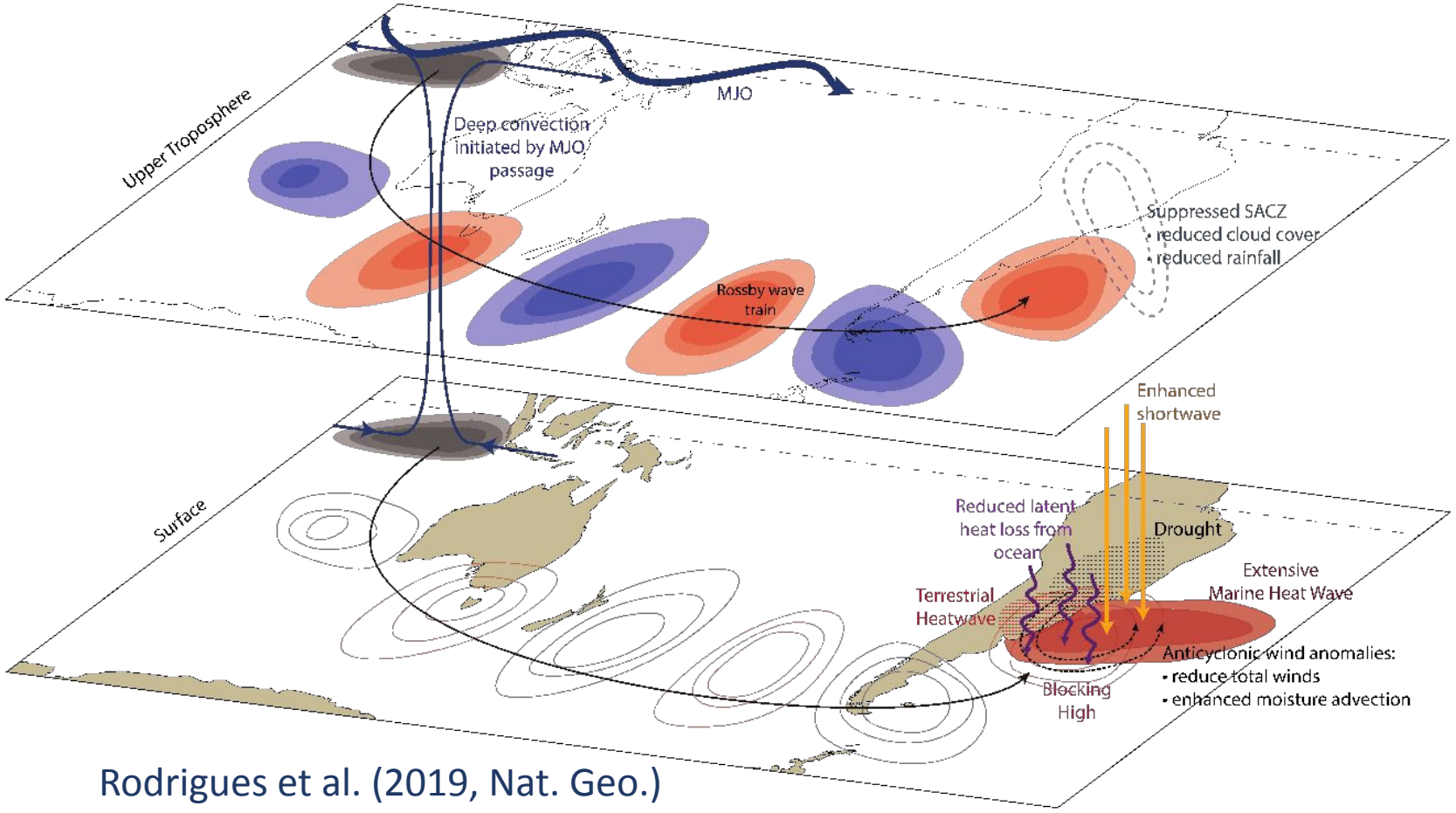
Western South Atlantic



✔ Marine heatwaves are associated with droughts and land heatwaves ⇨ Compound extreme events

Marine Heatwaves

Western South Atlantic

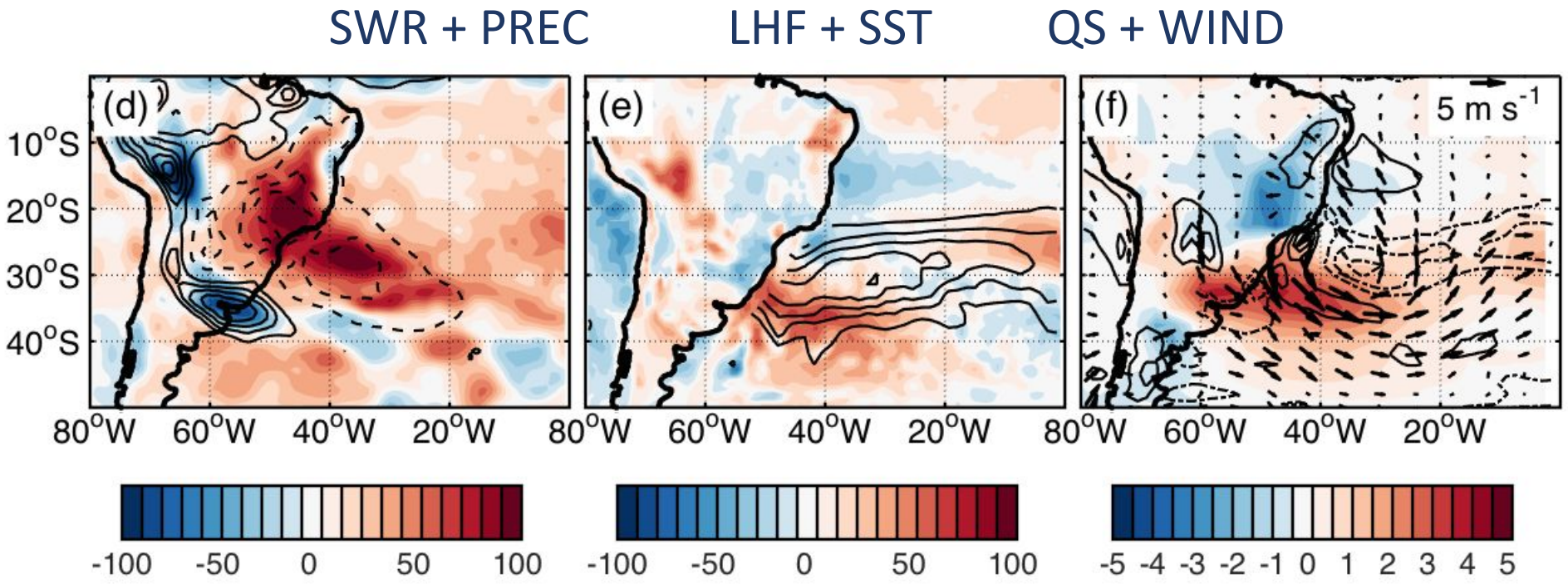


Rodrigues et al. (2019, Nat. Geo.)

- ✔ Droughts, marine and land heatwaves have the same cause
- ✔ Persistent high-pressure system (anticyclonic circulation)
- ✔ They can be remotely triggered (convection Indian Ocean – MJO)

Marine Heatwaves

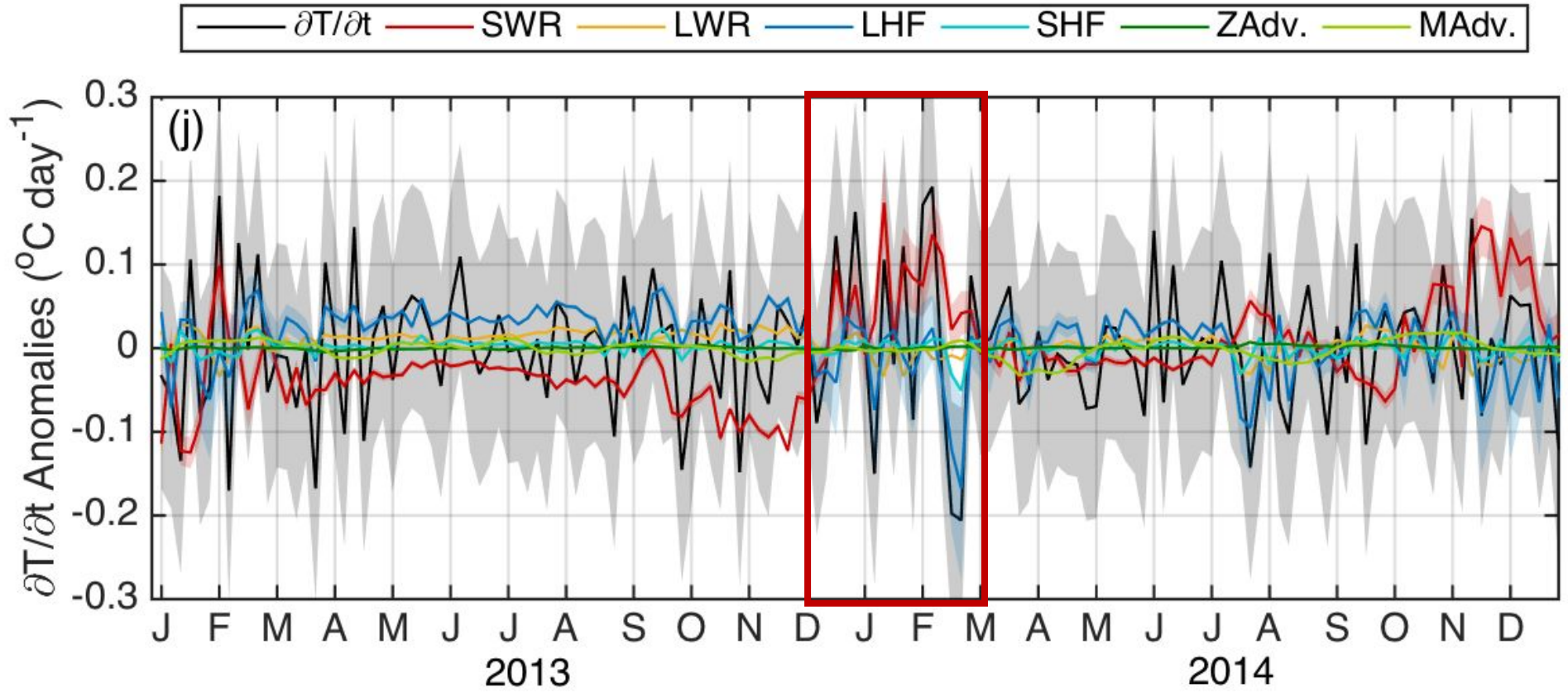
Western South Atlantic



Surface heat fluxes during the 2013/14 Event

Marine Heatwaves

Western South Atlantic

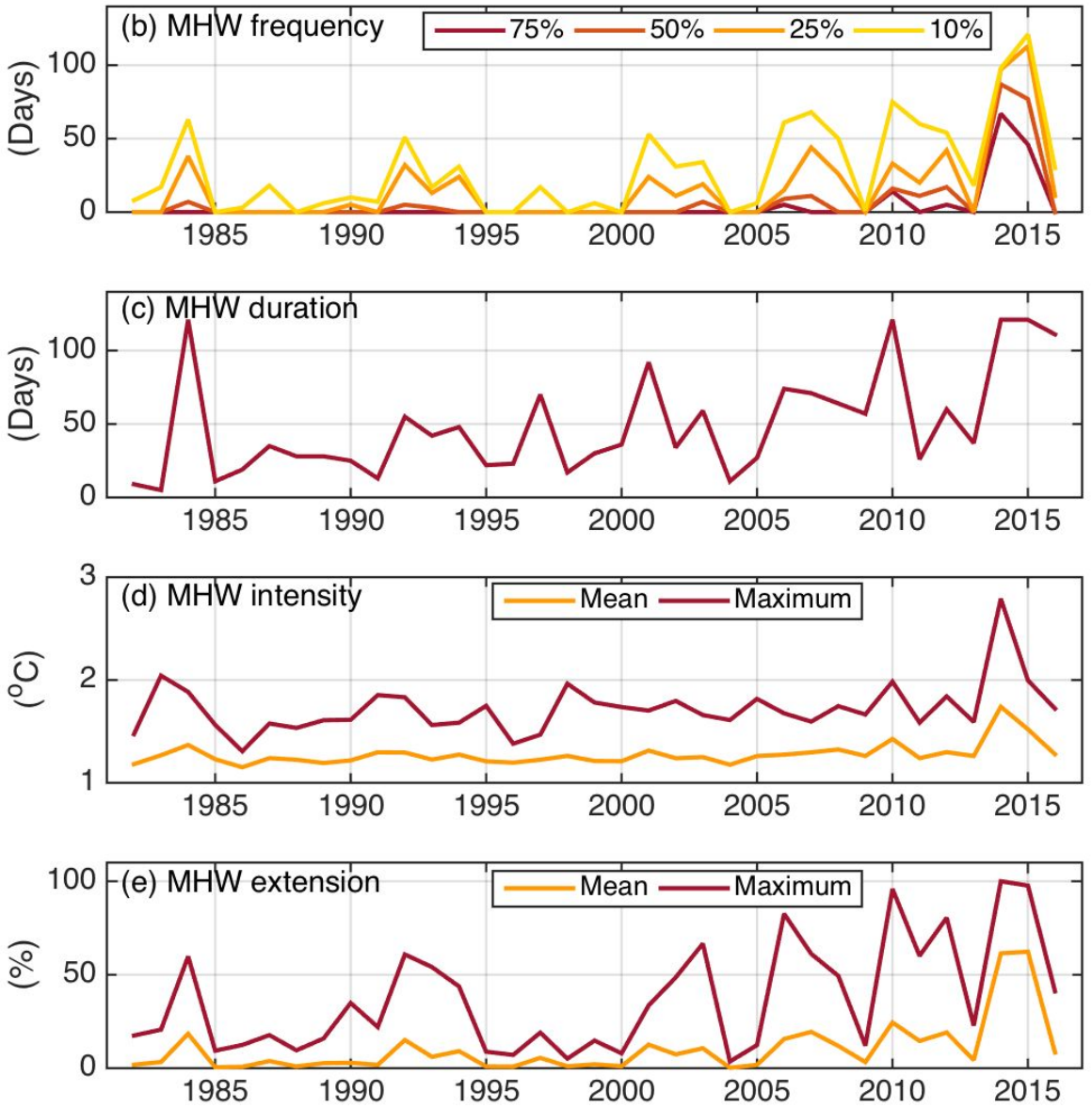


Mixed-Layer Temperature Budget (30°S-33°S, 36°W-40°W)

$$\partial T/\partial t = -v \cdot \nabla T + Q_0/\varrho\, C_p h + \epsilon$$

Marine Heatwaves

✔ Trends per decade



+8.4 days per year (50%)

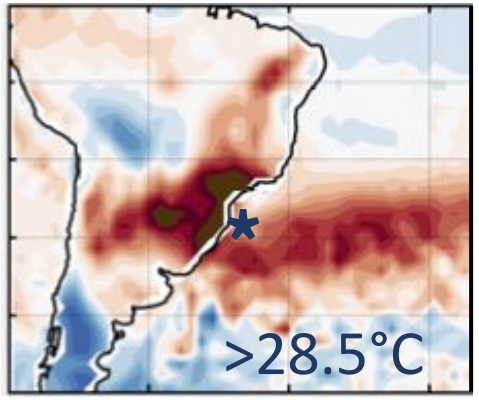
+18 days

+0.05°C

+7%

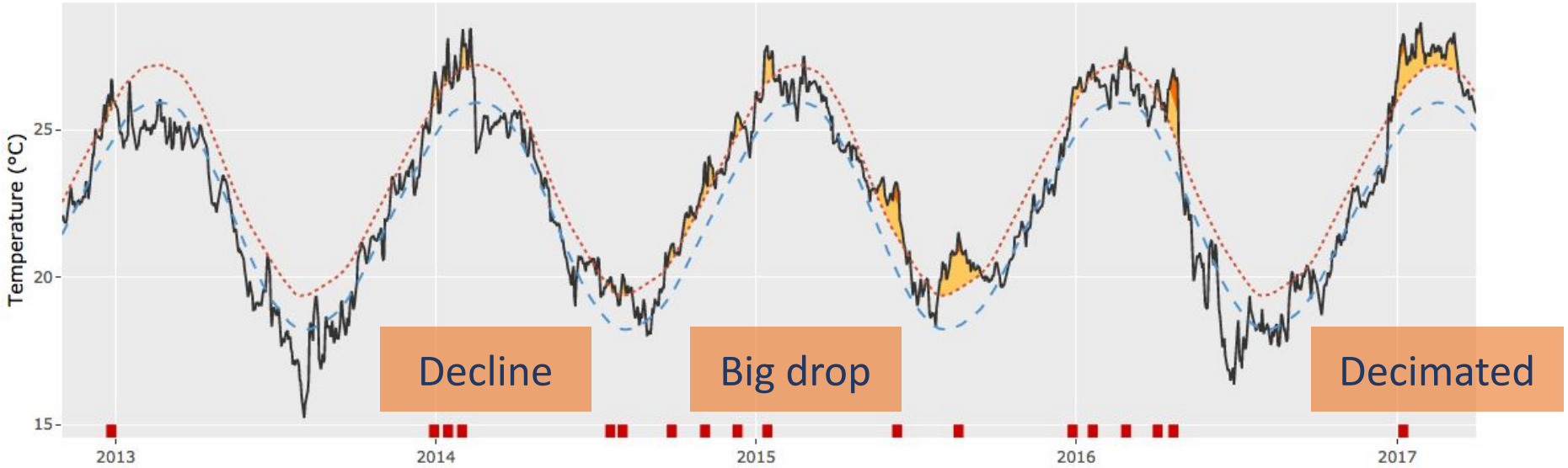
Marine Heatwaves

Western South Atlantic



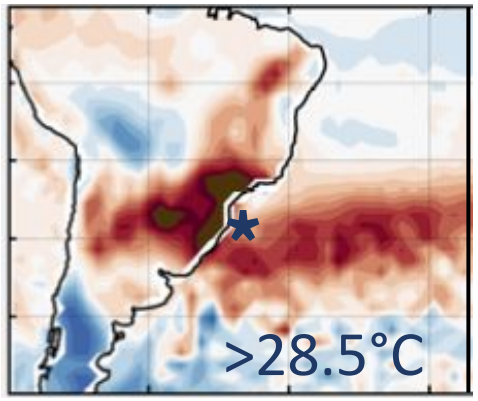
Clam - Vongole
(Anomalocardia flexuosa)

UD$ 2.5 □ UD$ 10



Marine Heatwaves

Western South Atlantic



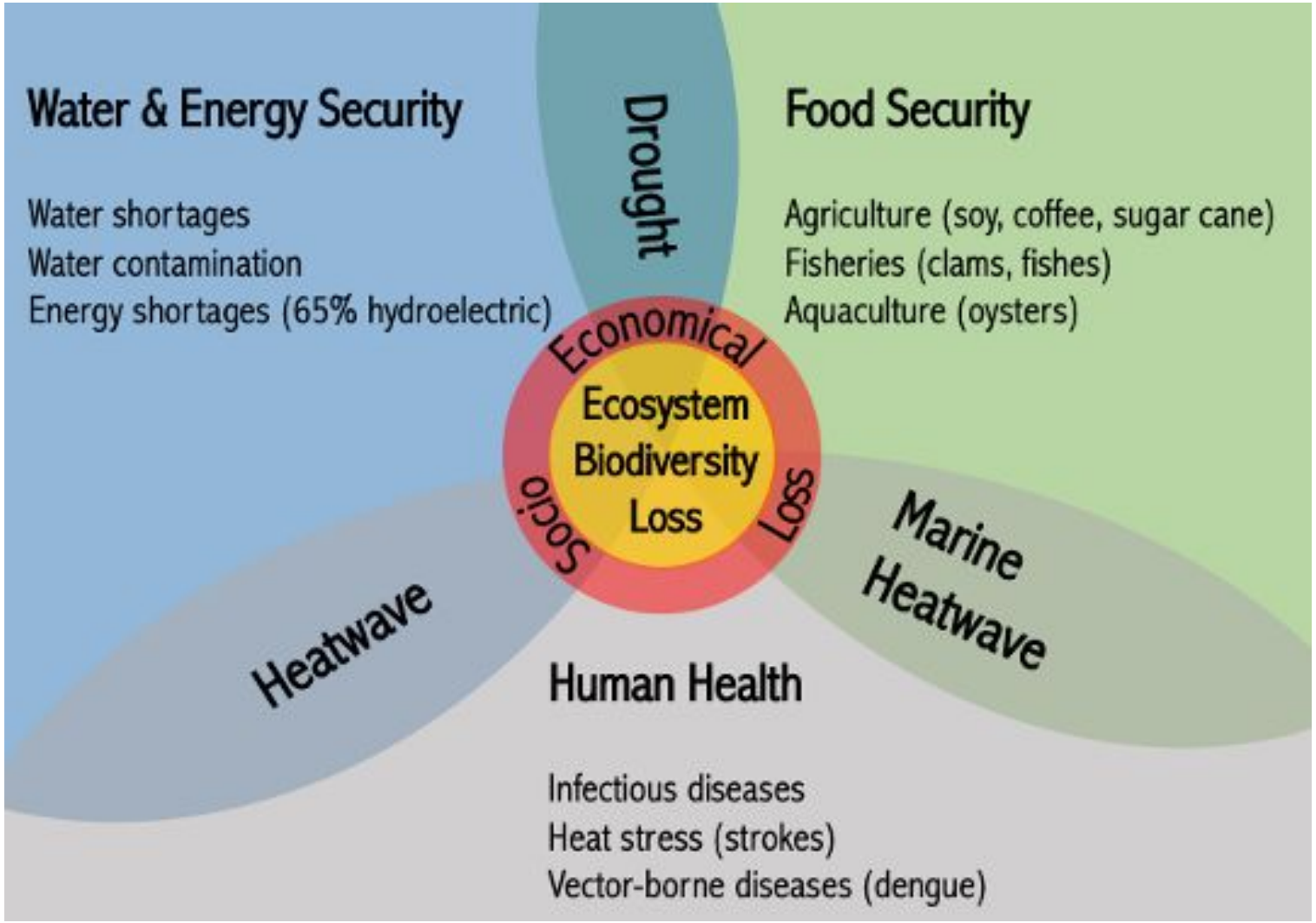
Oyster
(Crassostrea giga)

90% of the national production

Marine Heatwaves

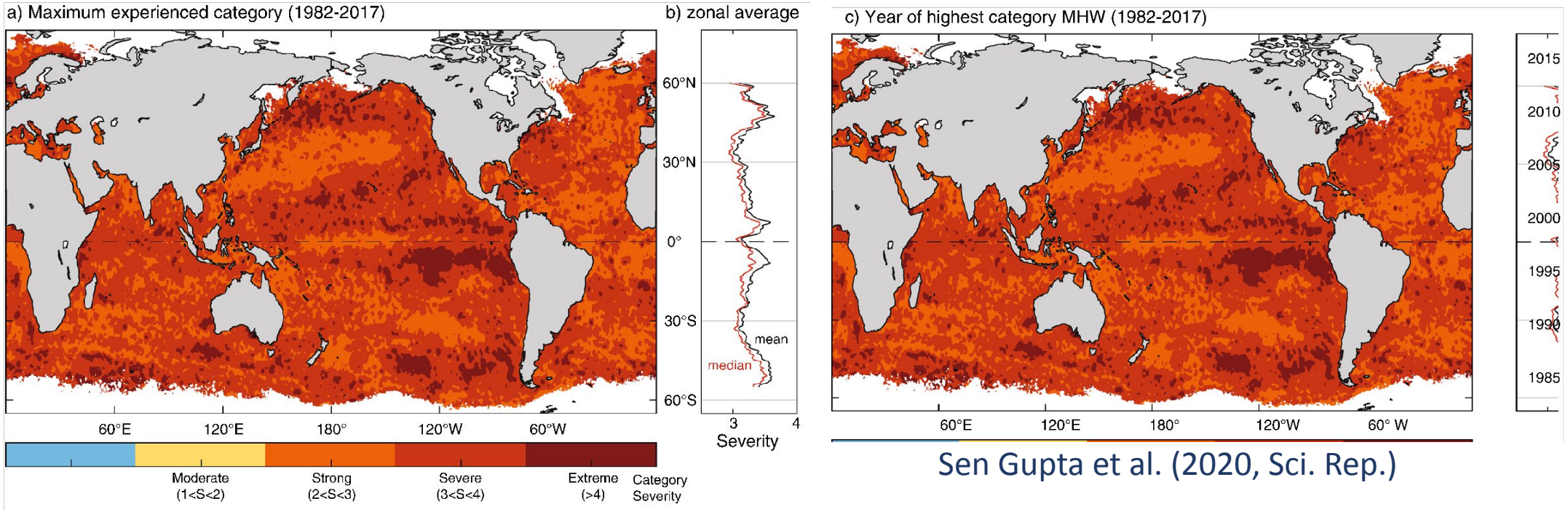
✔ Impacts – Compound Events

Western South Atlantic



Marine Heatwaves

Most extreme marine heatwaves



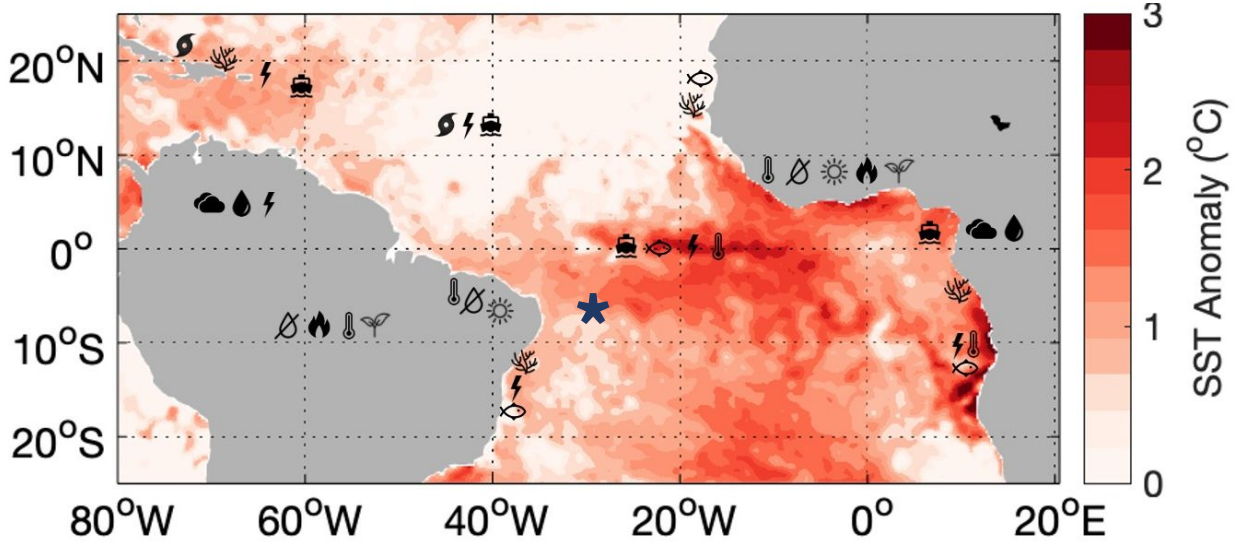
Sen Gupta et al. (2020, Sci. Rep.)

✔ Similar causes, linked to large, persistent, high-pressure systems

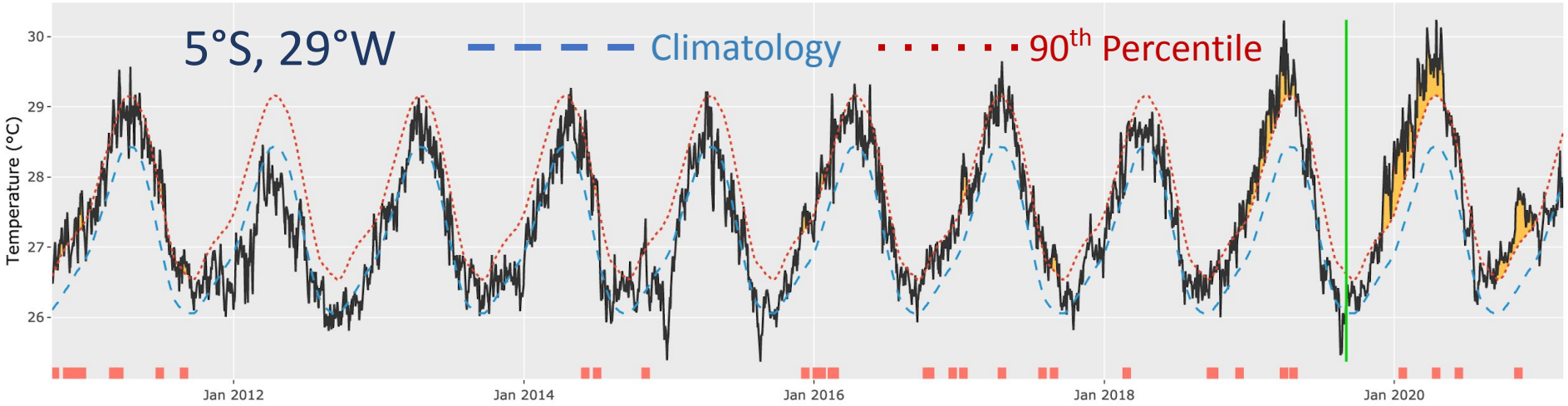
✔ Similar impacts, low levels of nutrients and chlorophyll

Marine Heatwaves

Tropical Atlantic



Massive Coral Bleaching



Marine Heatwaves

Marine Heatwaves

Next Steps

Impacts
marine heatwaves
Tropical Cyclones
Atlantic

Afonso Gonçalves Neto
Next talk!

Future changes
marine heatwaves
western South Atlantic

Natasha V. Costa
Poster!

Marine Heatwaves in the Tropical and South Atlantic

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