

# NOAA CoastWatch/PacIOOS Satellite and Ocean Data Training Course

## Sea Surface Temperature Satellite Data and Applications in Coastal Regions

**Kisei R. Tanaka, Ph.D.**

Research Marine Biologist

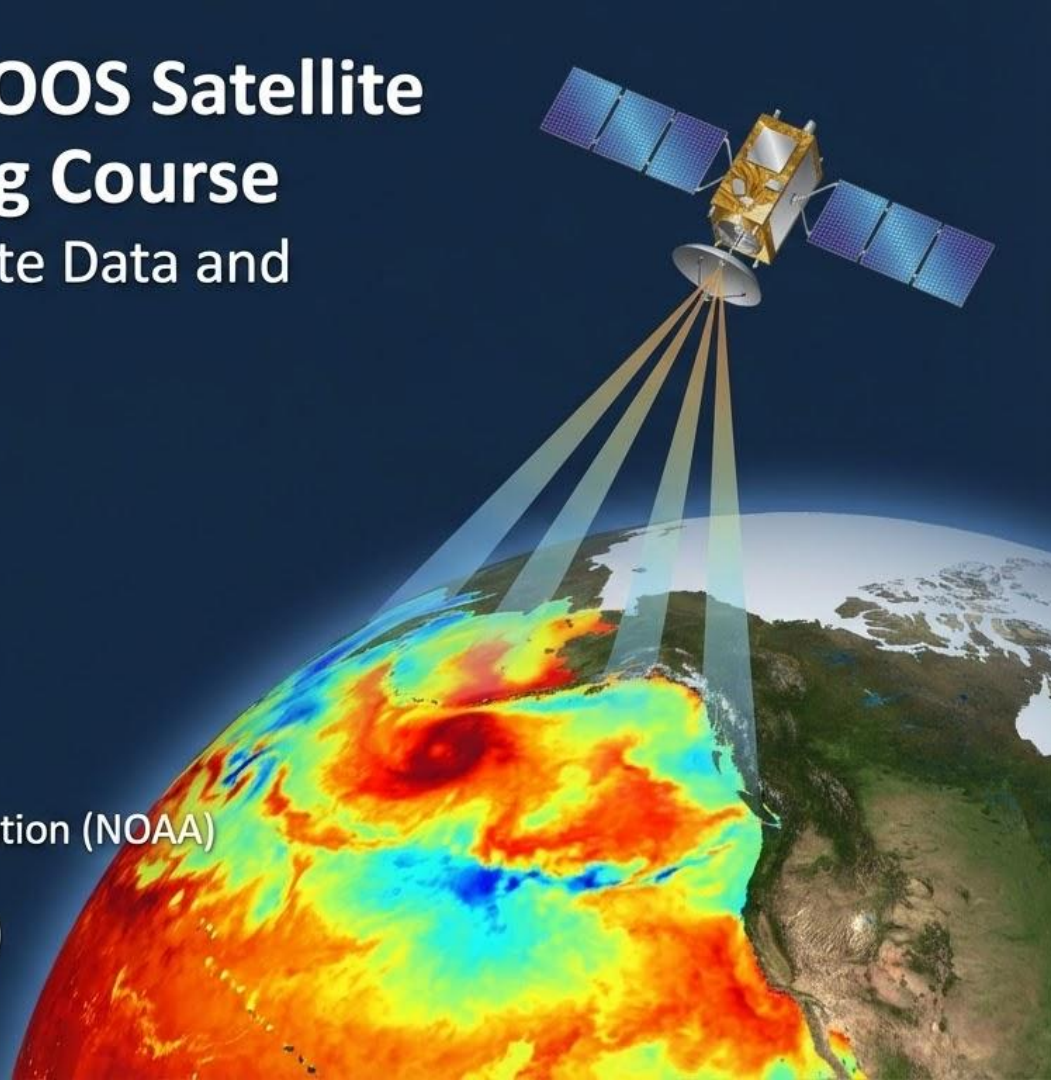
National Oceanic and Atmospheric Administration (NOAA)

National Marine Fisheries Service (NMFS)

Pacific Islands Fisheries Science Center (PIFSC)

Ecosystems Sciences Division (ESD)

Archipelagic Research Program (ARP)



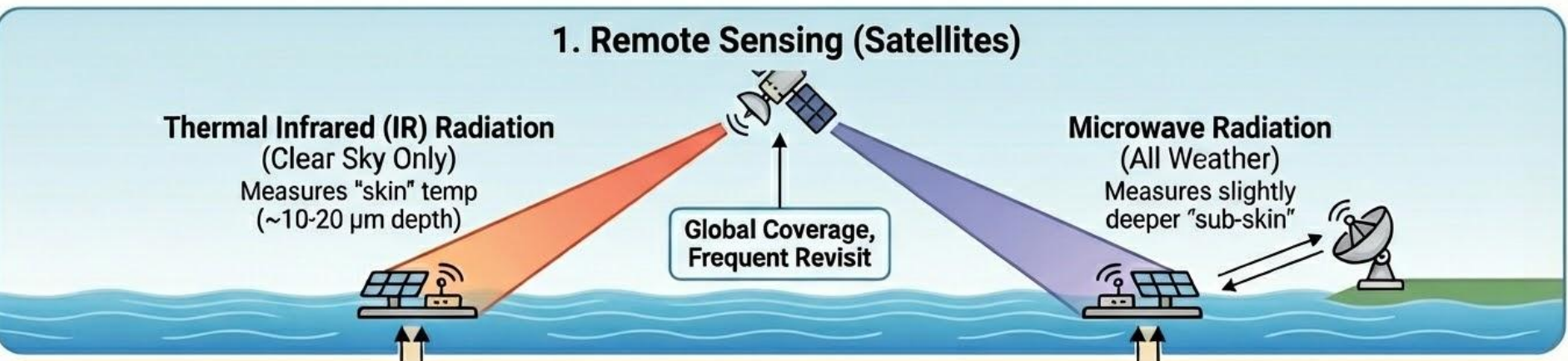
# How Sea Surface Temperature (SST) is Measured

## 1. Remote Sensing (Satellites)

**Thermal Infrared (IR) Radiation**  
(Clear Sky Only)  
Measures "skin" temp  
(~10-20  $\mu\text{m}$  depth)

Global Coverage,  
Frequent Revisit

**Microwave Radiation**  
(All Weather)  
Measures slightly  
deeper "sub-skin"



## 2. In-Situ (Direct) Measurements

**Drifting Buoys**  
(Surface)

**Ship Intake**  
(Bulk Temp ~5m)

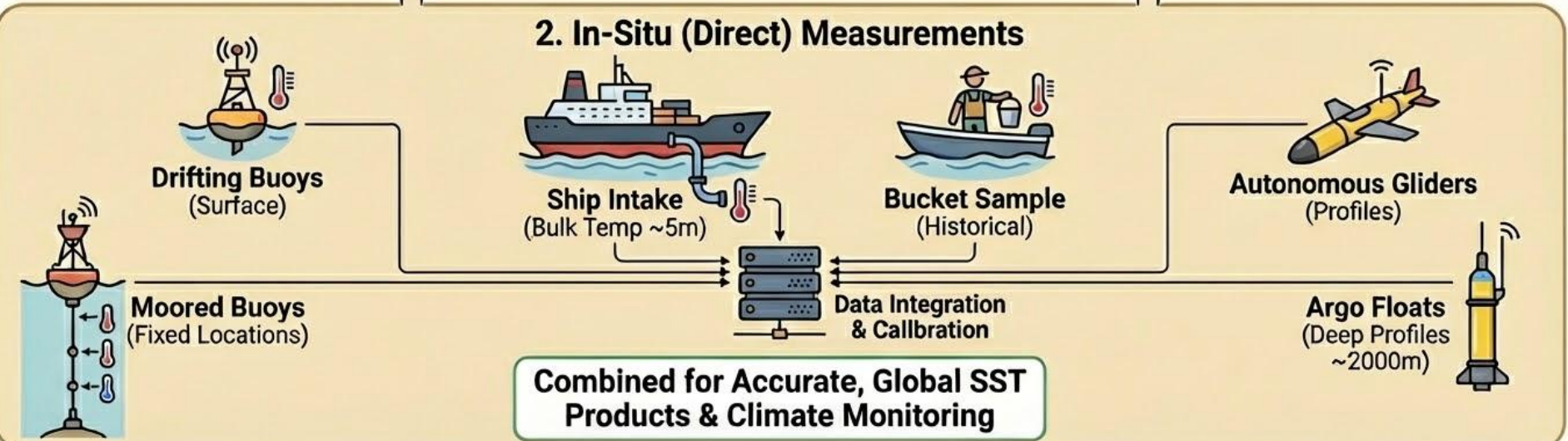
**Bucket Sample**  
(Historical)

**Autonomous Gliders**  
(Profiles)

**Moored Buoys**  
(Fixed Locations)

**Data Integration  
& Calibration**

**Argo Floats**  
(Deep Profiles  
~2000m)



**Combined for Accurate, Global SST  
Products & Climate Monitoring**

# High-Resolution Satellite SST Data: Seeing the Ocean in Detail

Precise Sea Surface Temperature Monitoring from Space

Low Resolution (e.g., 0.25 deg)



High Resolution (e.g., ~0.05 deg)



Captures small-scale features, coastal gradients, and localized events.



# Applications to NOAA's Mission

## Marine Heatwave Monitoring



Early warning for extreme heat events, like the Local Extreme Heat Index (LEHI).

## Coral Bleaching Alerts



Assesses thermal stress to predict coral bleaching risks.

## Ecosystem & Fisheries Management



Supports sustainable fisheries and ecosystem health assessments.

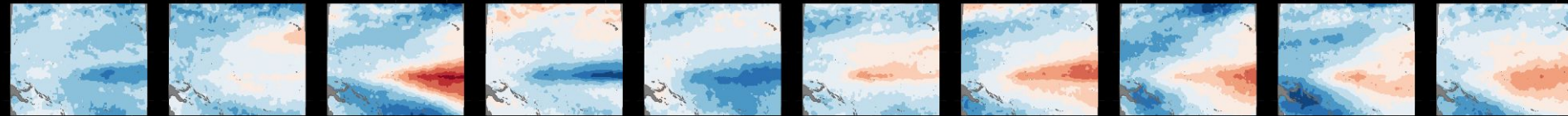


# Regional divergence of extreme marine heat in Pacific Island coastal waters a novel high-resolution heat index as an earlier statistical signal

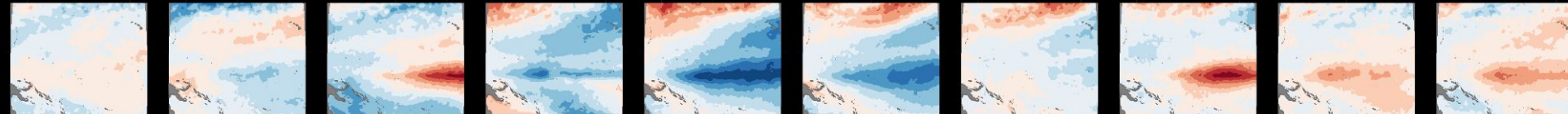
Kisei Tanaka\*, Hannah Barkley, Hui Shi, Jennifer Samson, Derek Manzello, and Kyle Van Houtan

Pacific Ocean: 40 Years of Temperature Change (1985-2024) Data: NOAA OISST v2.1

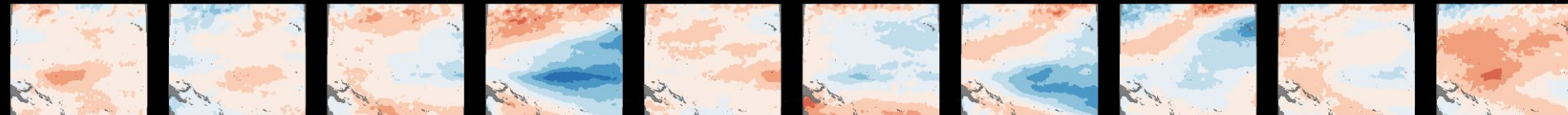
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994



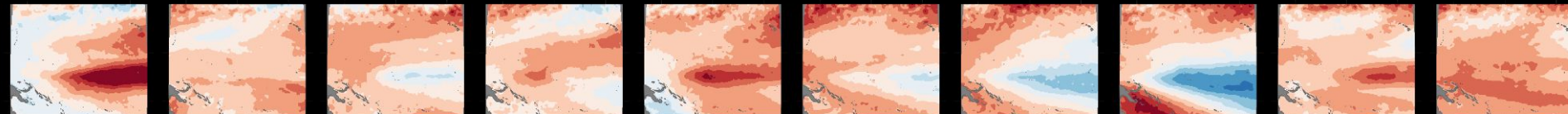
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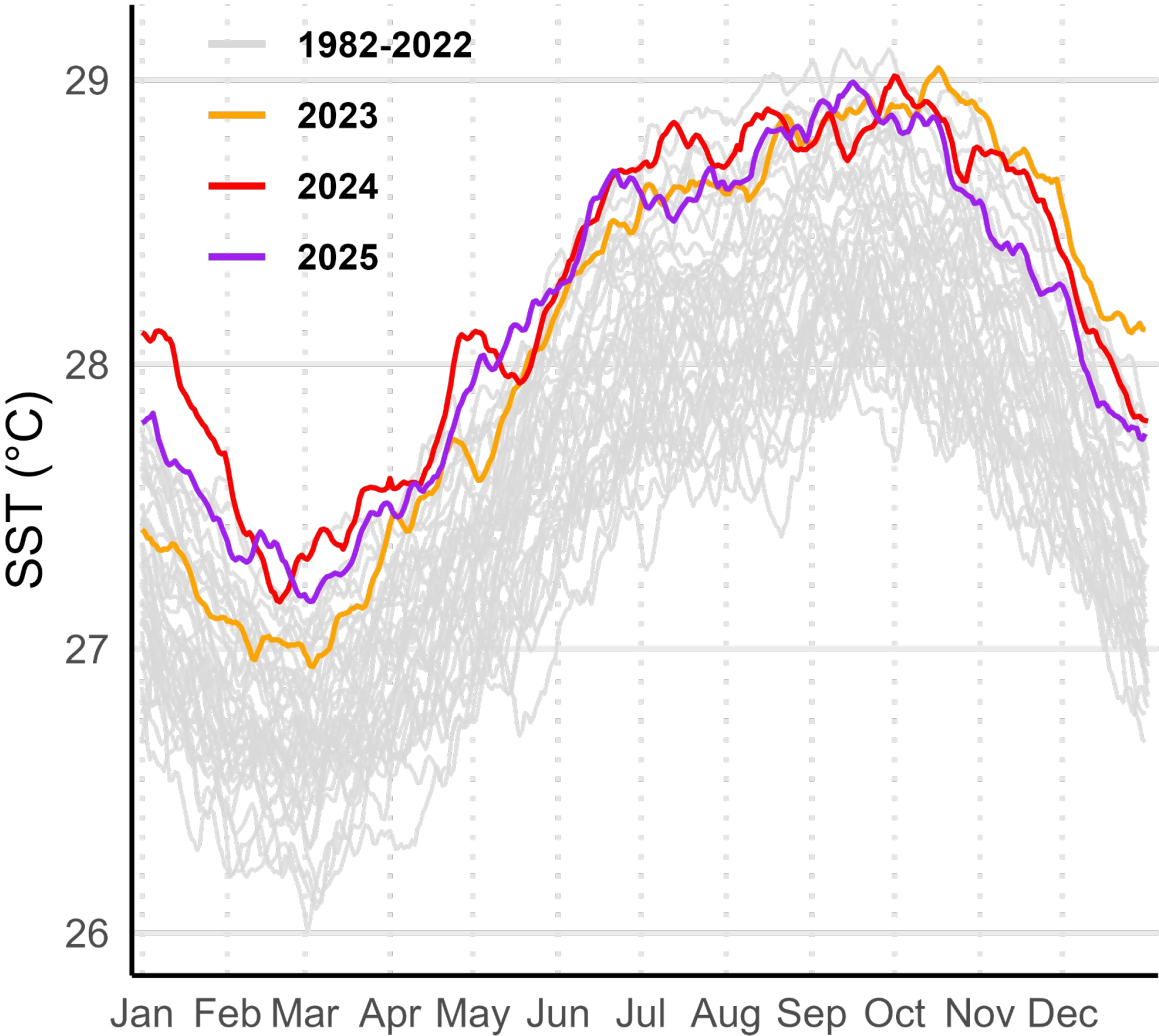
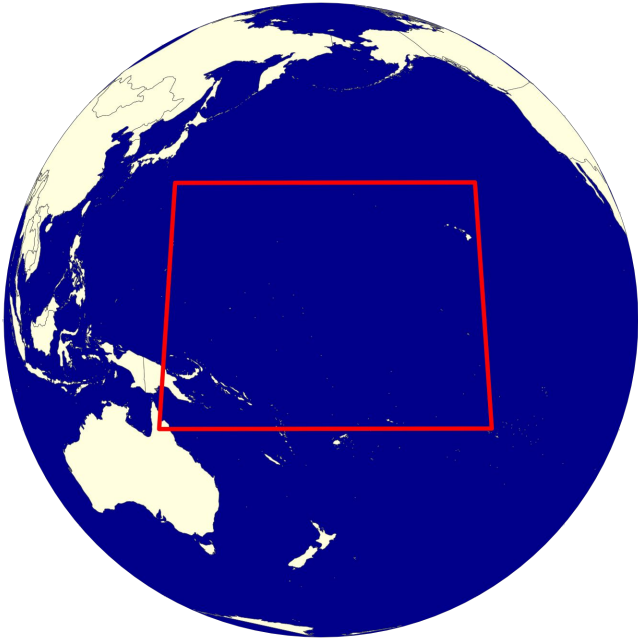
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014



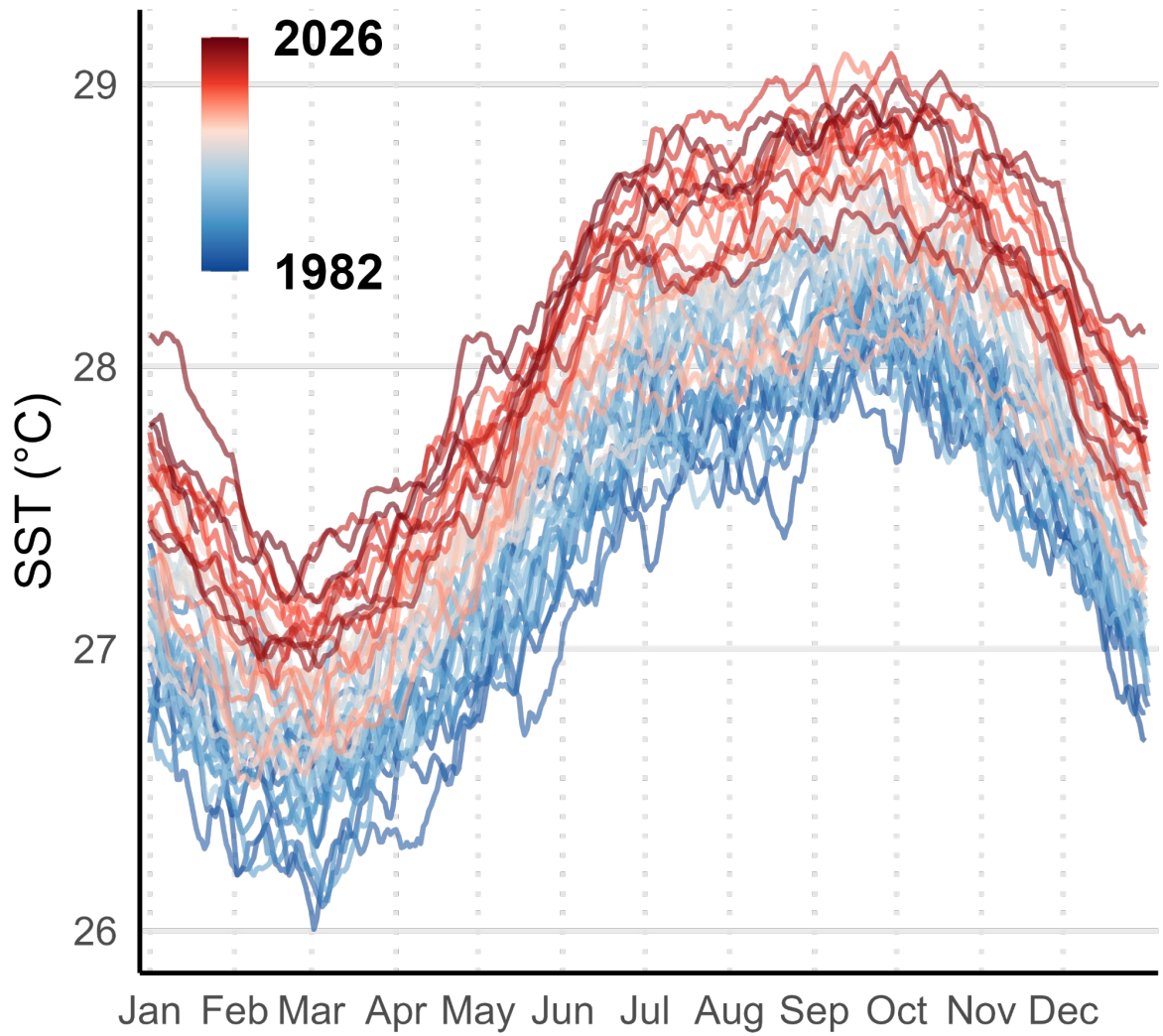
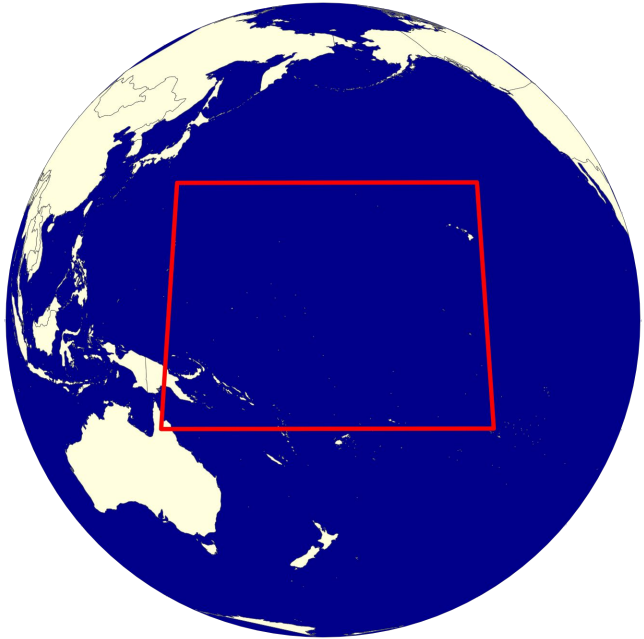
2015 2016 2017 2018 2019 2020 2021 2022 2023 2024



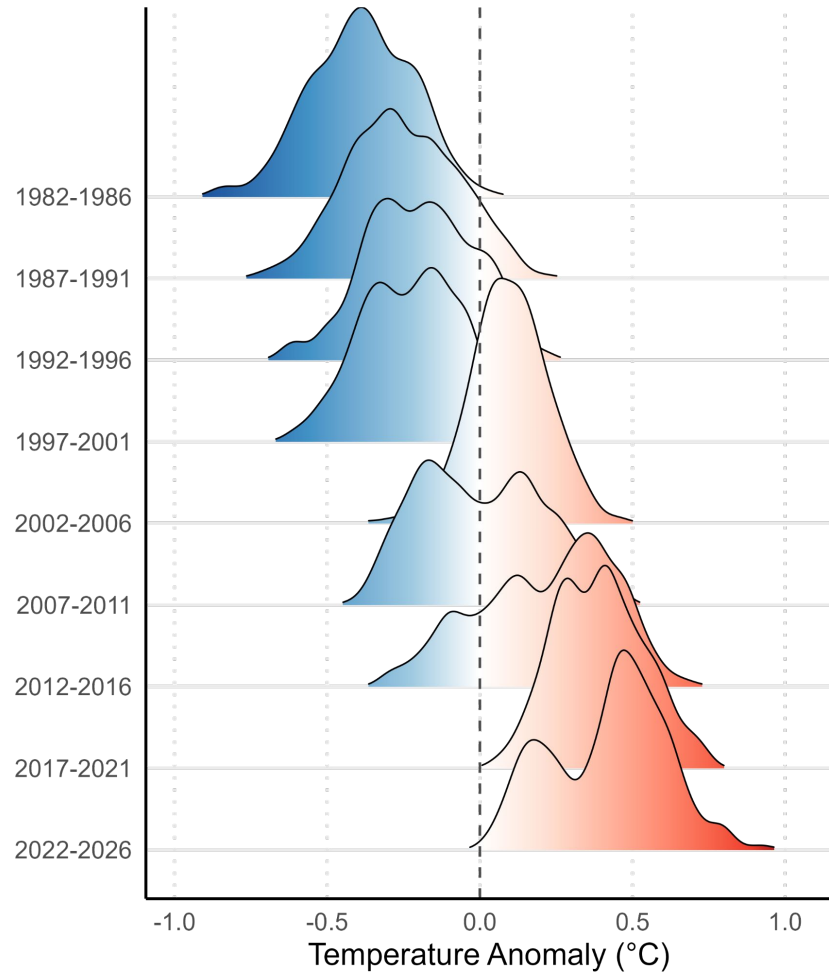
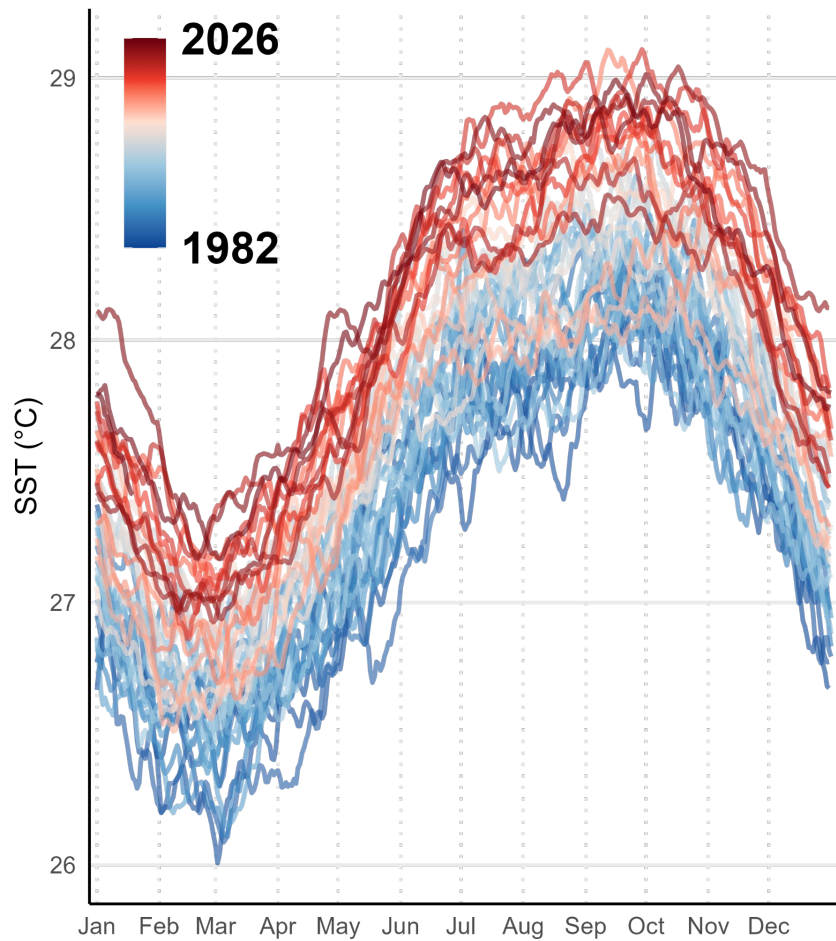
# Recent shift ?



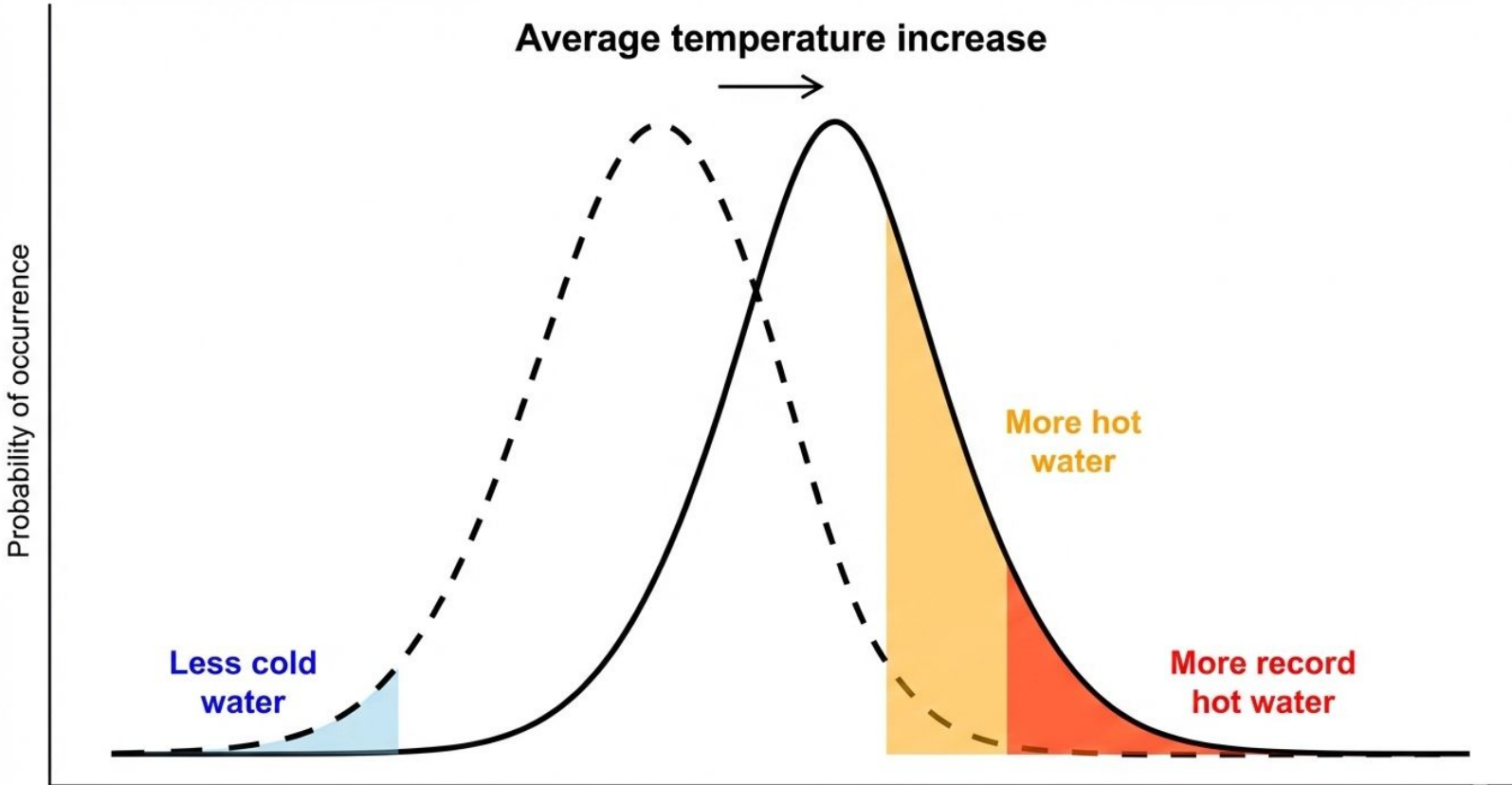
# Recent shift ? No.



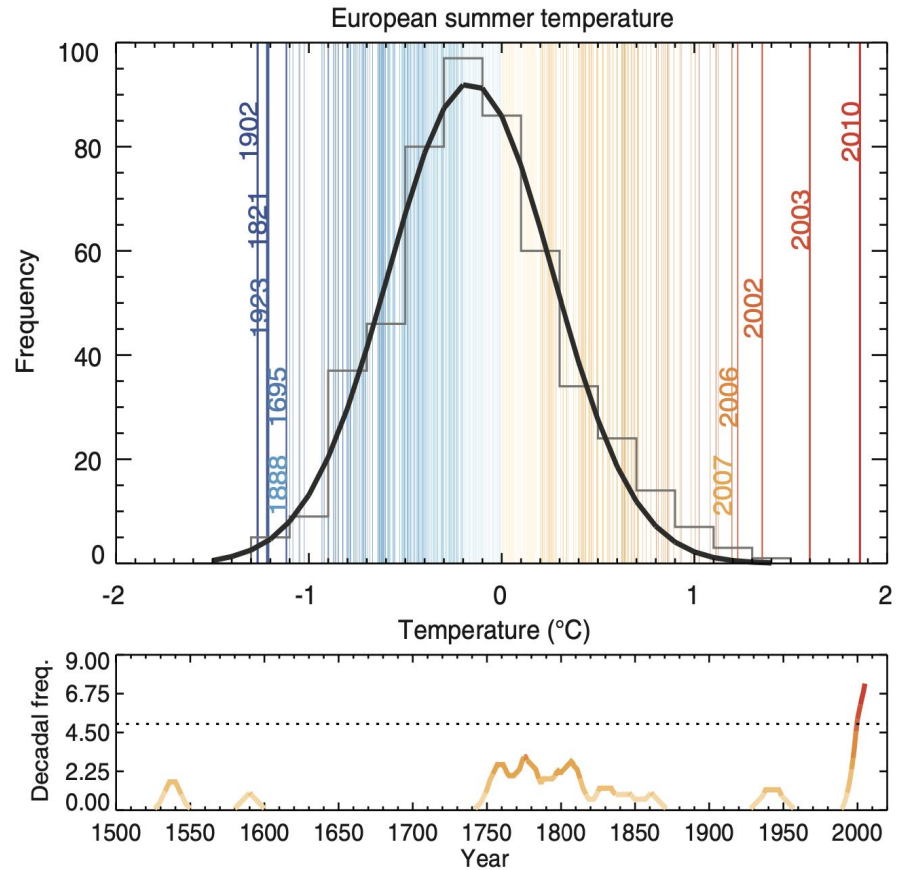
# SST Baseline Shift over time?



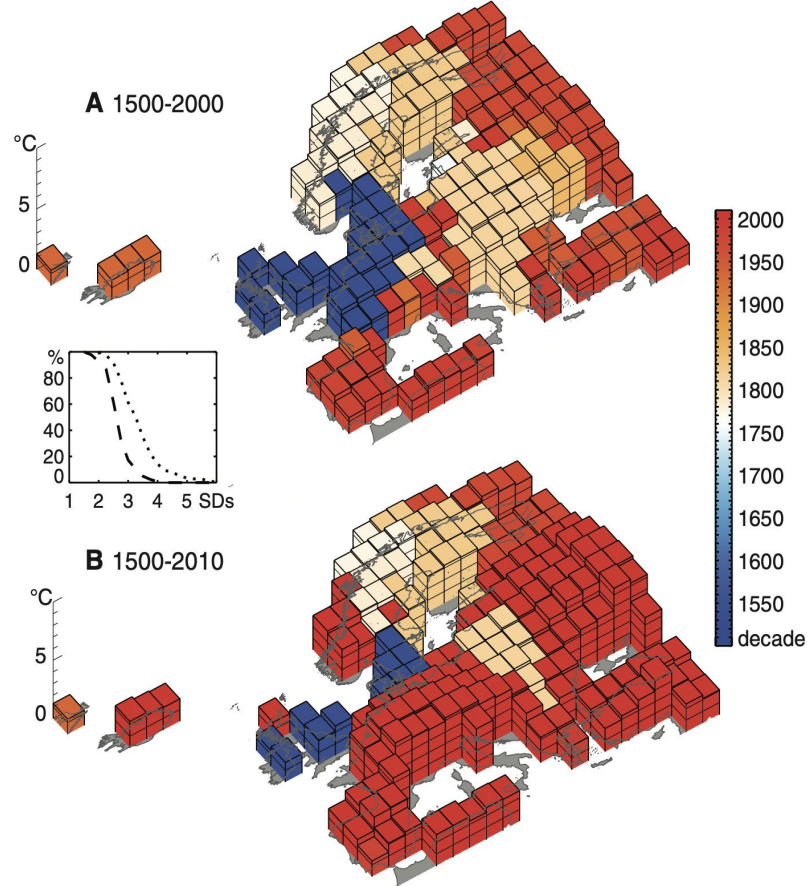
# Baseline Shift: Fewer Cold, More Hot Extremes

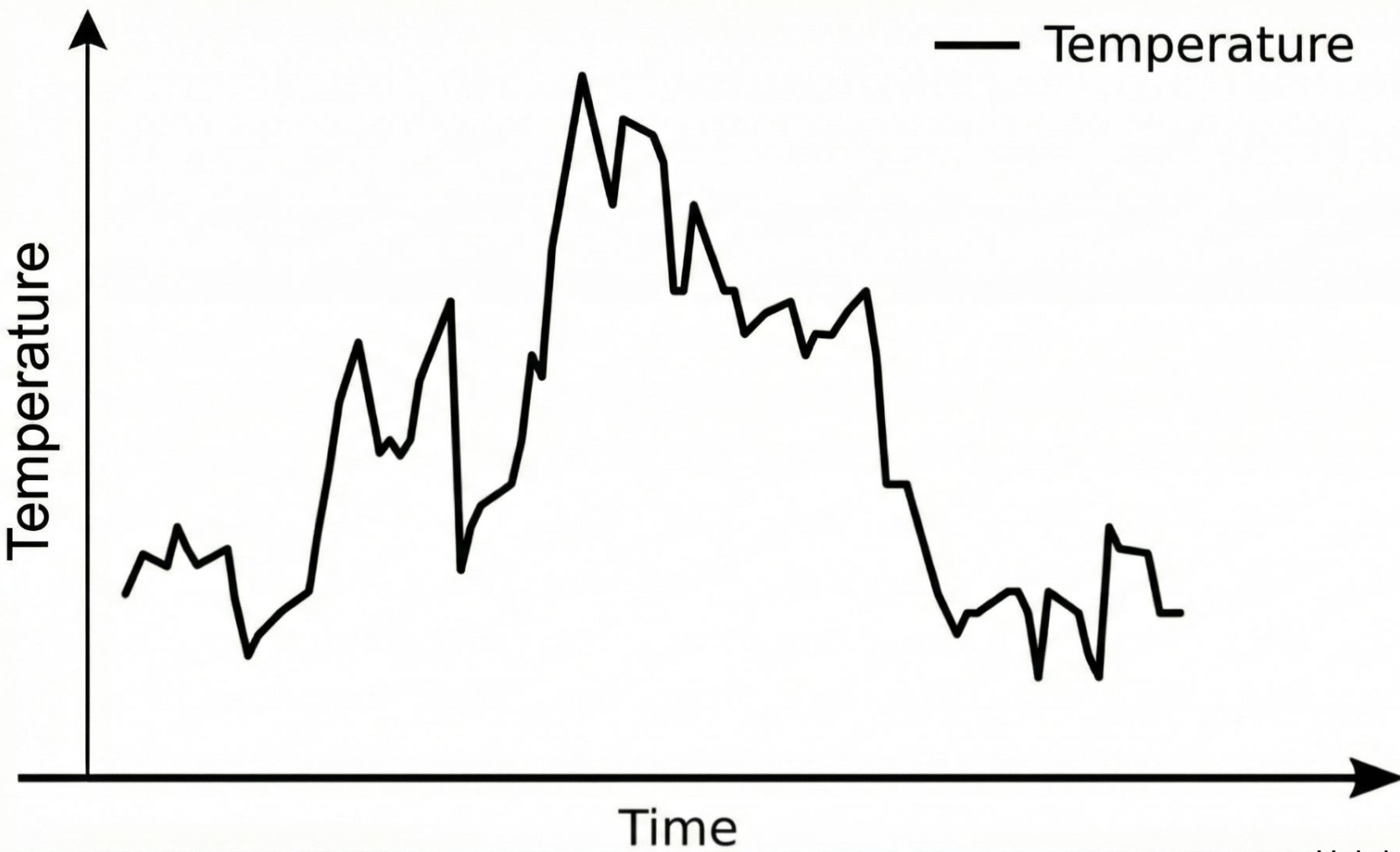


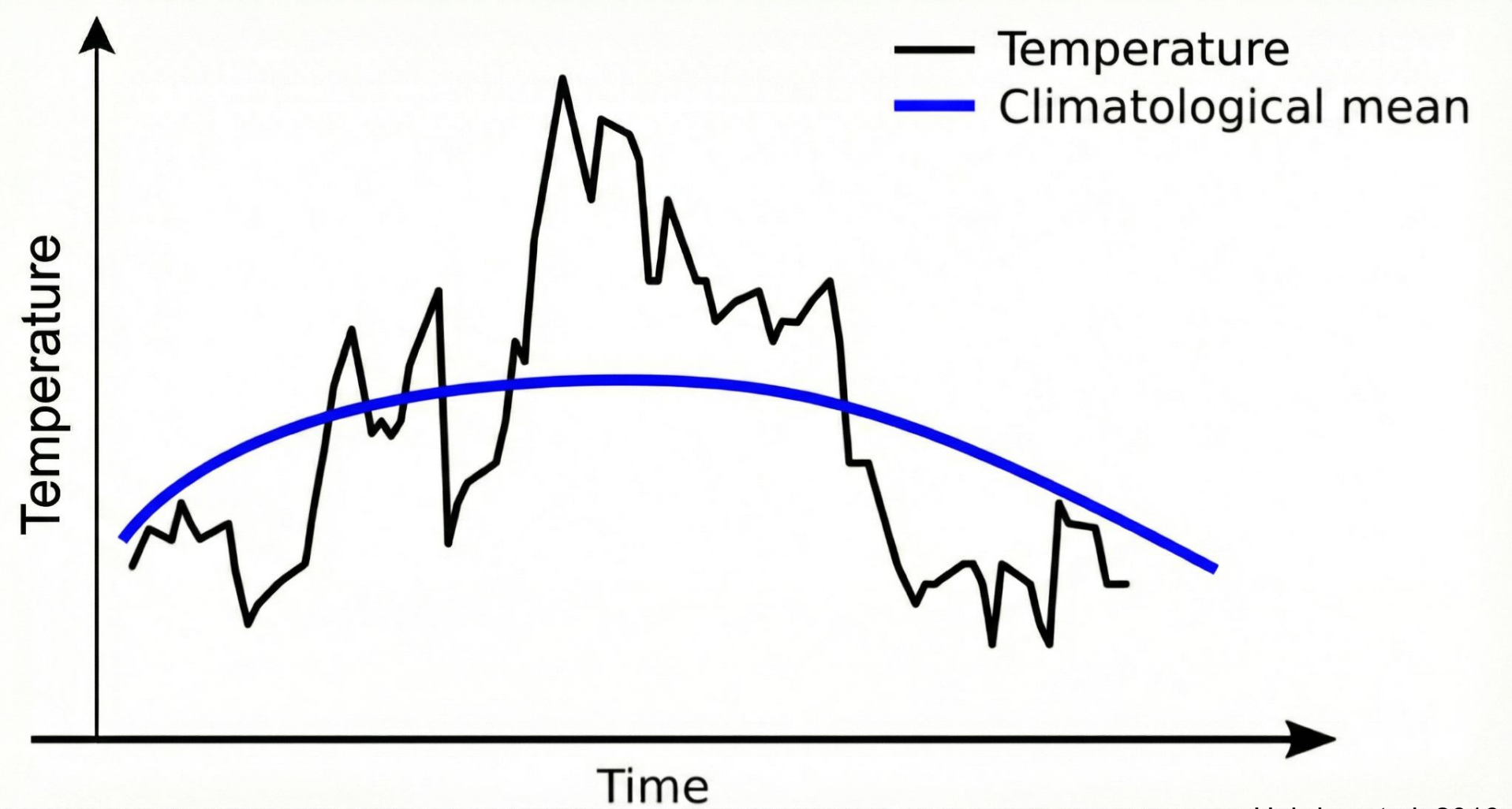
# Extreme Heat Events Becoming More Frequent?

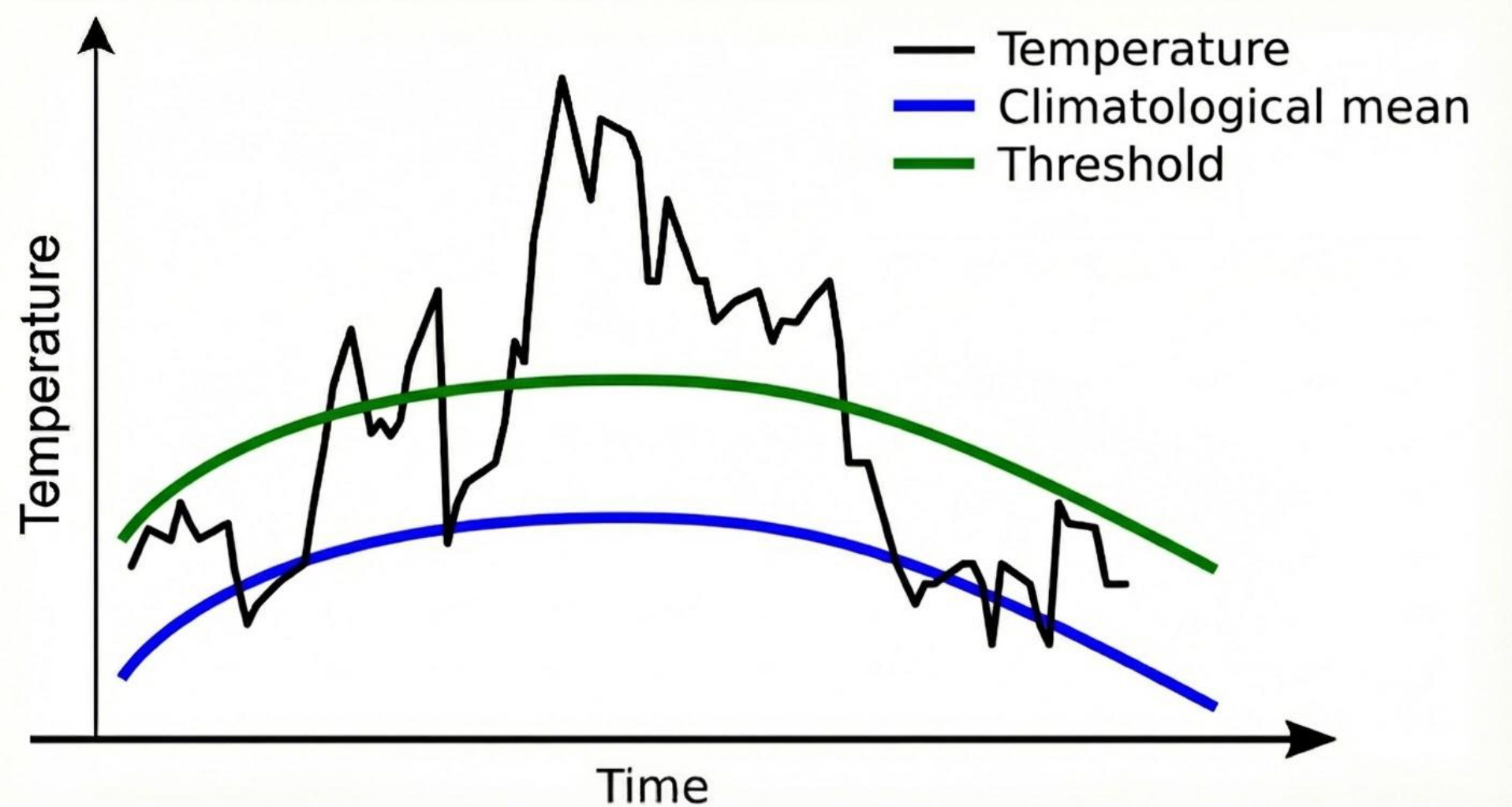


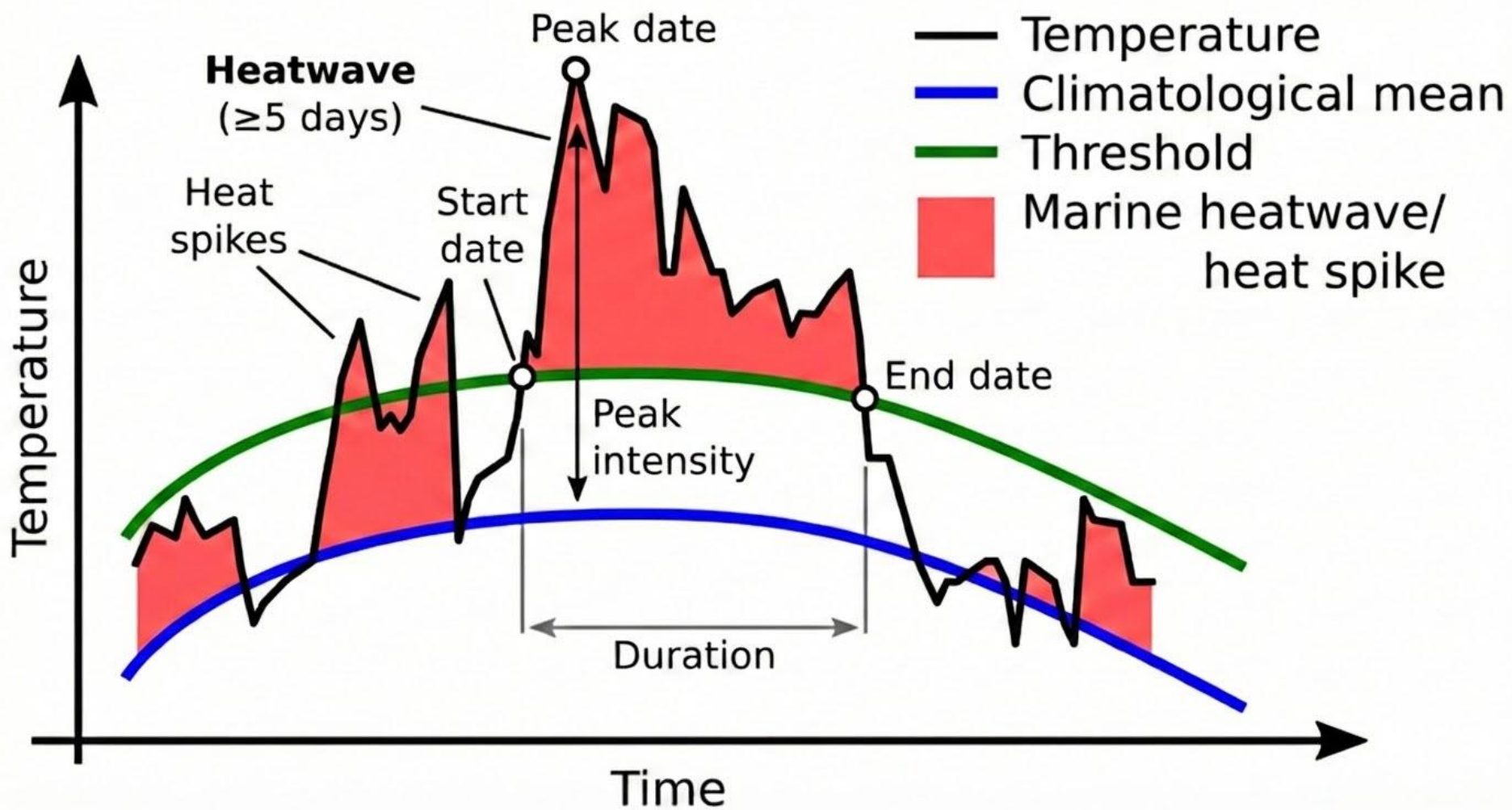
Record-breaking summers







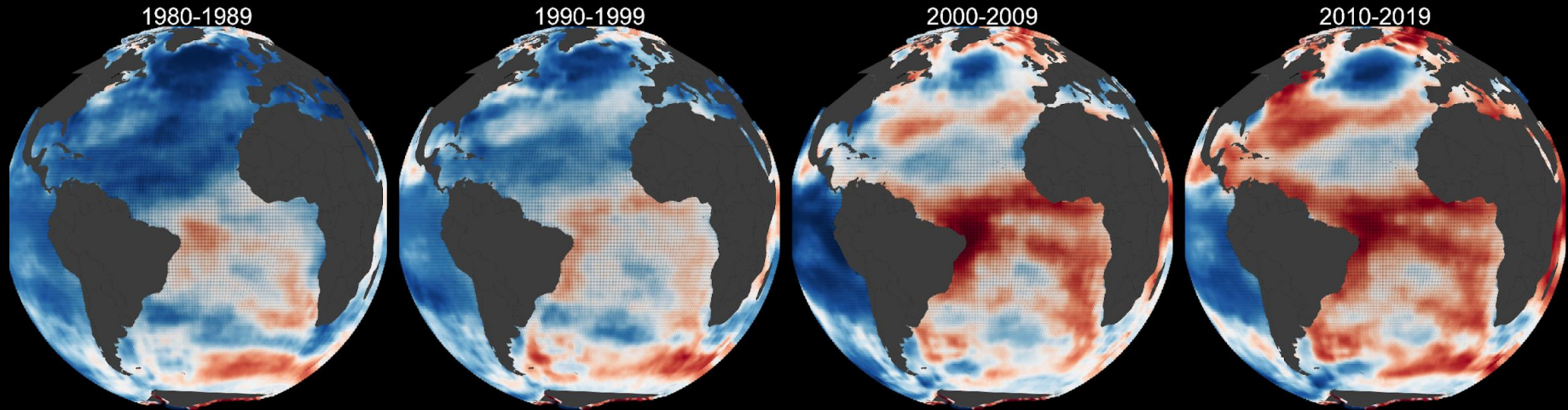




# The recent normalization of historical marine heat extremes

Kisei R. Tanaka , Kyle S. Van Houtan 

Published: February 1, 2022 • <https://doi.org/10.1371/journal.pclm.0000007>





PAPER • OPEN ACCESS

# Regional divergence of extreme marine heat in Pacific Island coastal waters: a **high-resolution extreme heat index** as an earlier statistical signal

Kisei R Tanaka<sup>\*</sup>, Hannah C Barkley, Hui Shi, Jennifer C Samson, Derek P Manzello and Kyle S Van Houtan

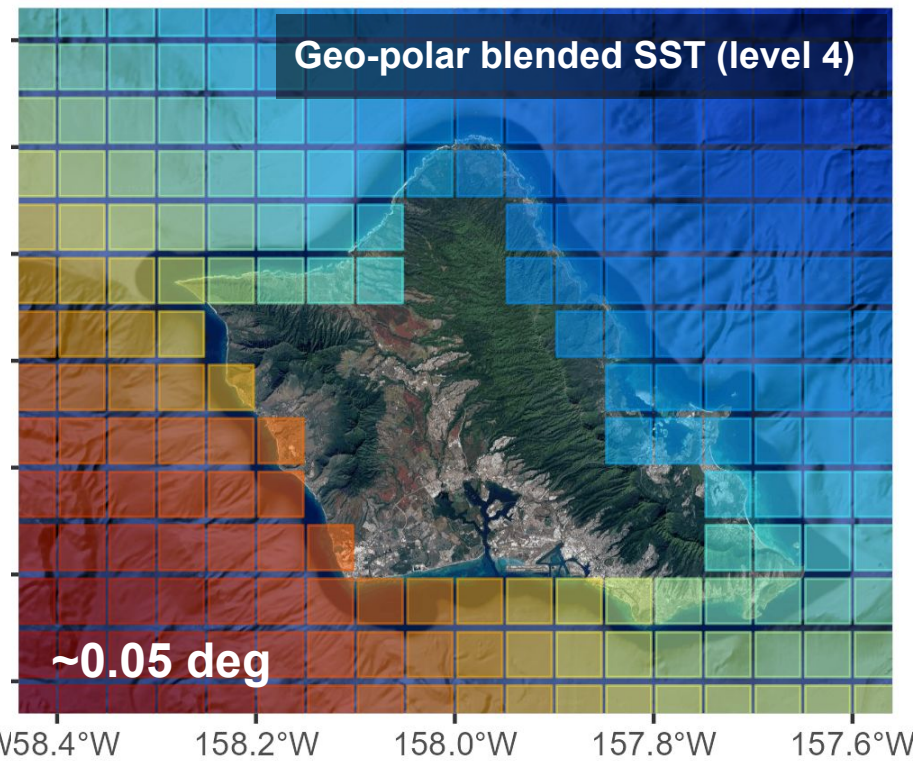
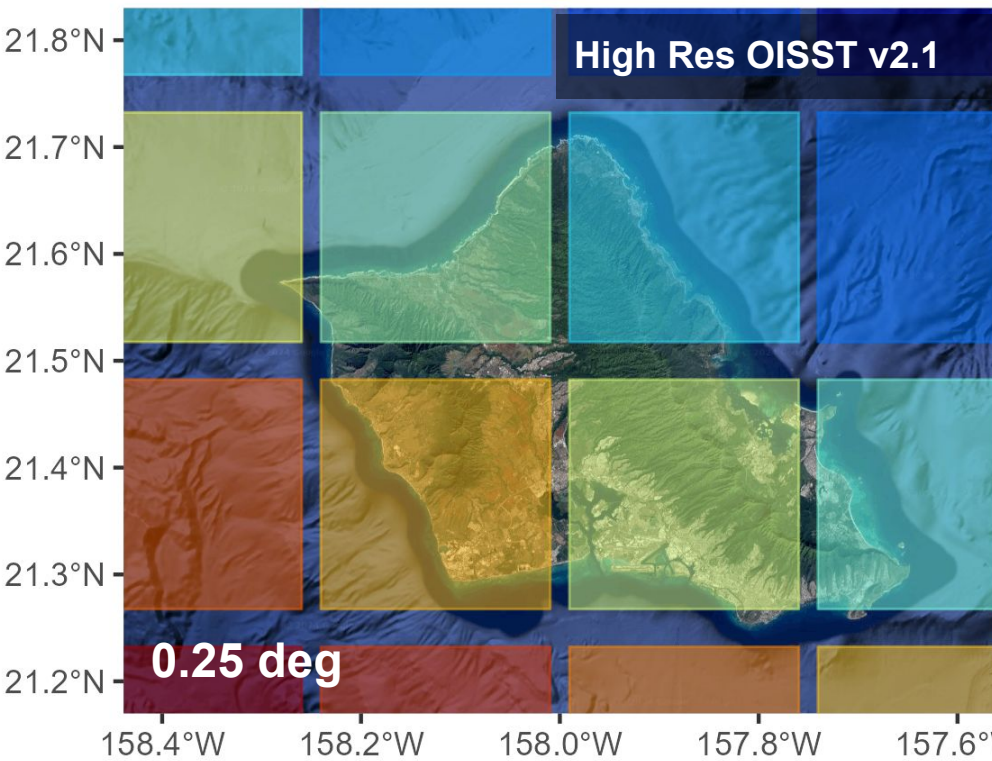
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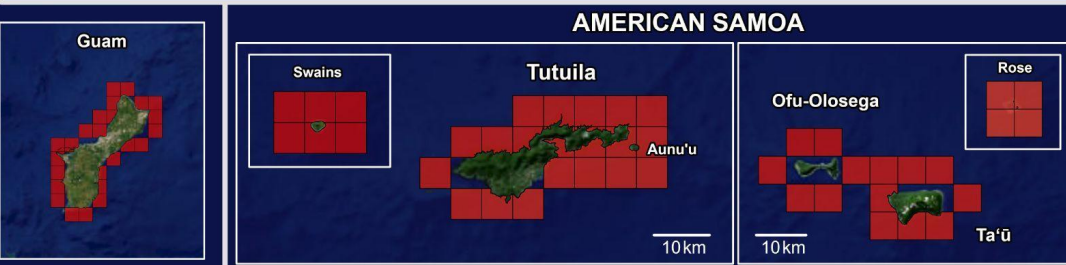
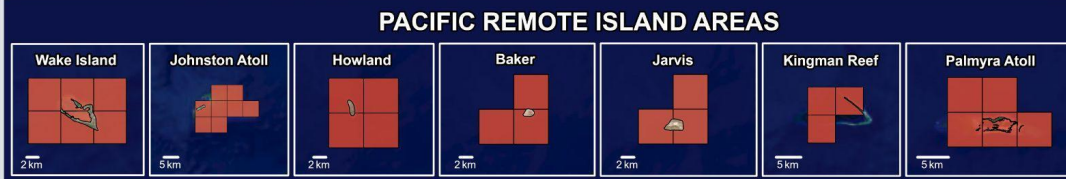
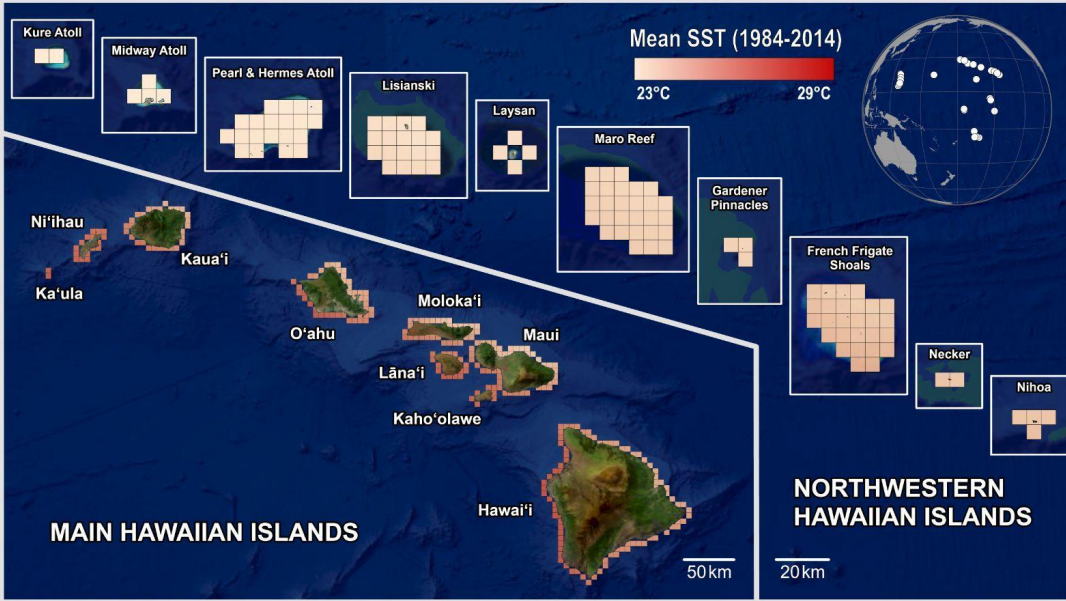
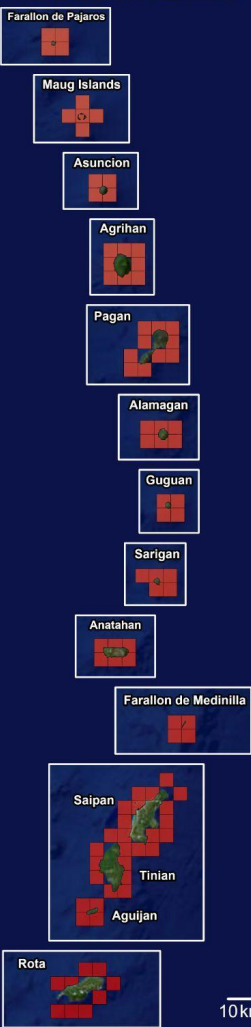
**Citation** Kisei R Tanaka *et al* 2026 *Environ. Res.: Climate* 5 015014

DOI 10.1088/2752-5295/ae2c13

# Need for High-Resolution SST Data in Coastal Analysis



# MARIANA ISLANDS



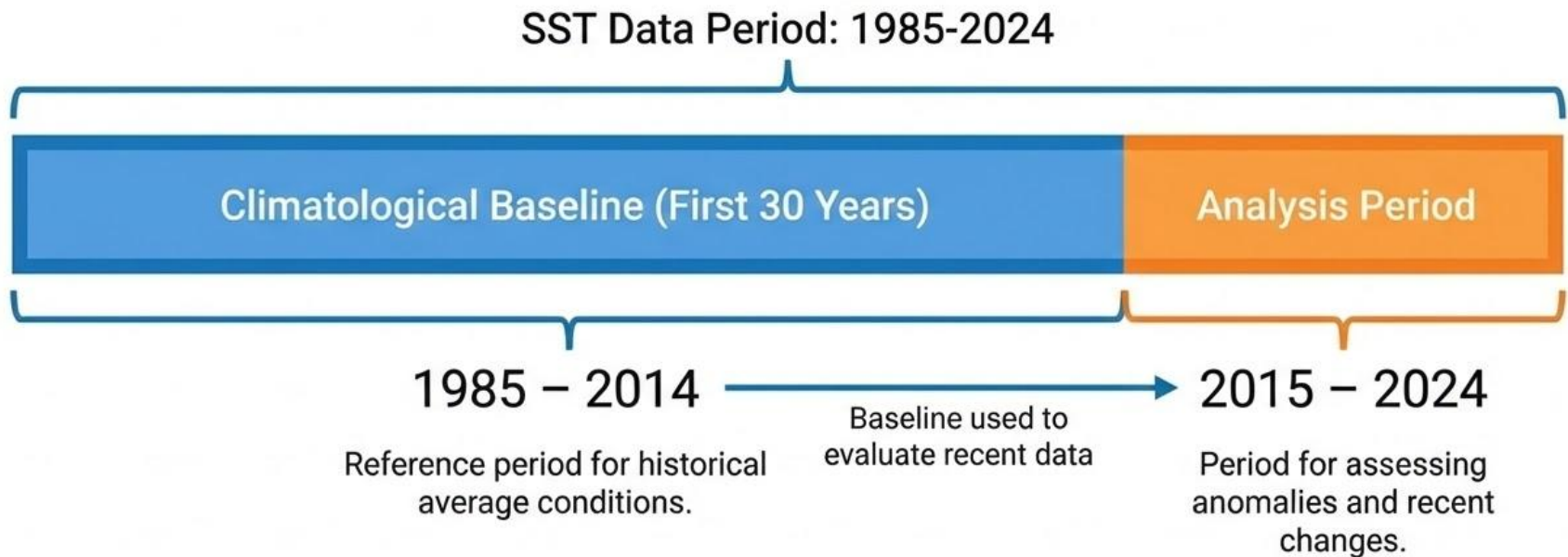
**Analysis:**

**533 coastal pixels.**

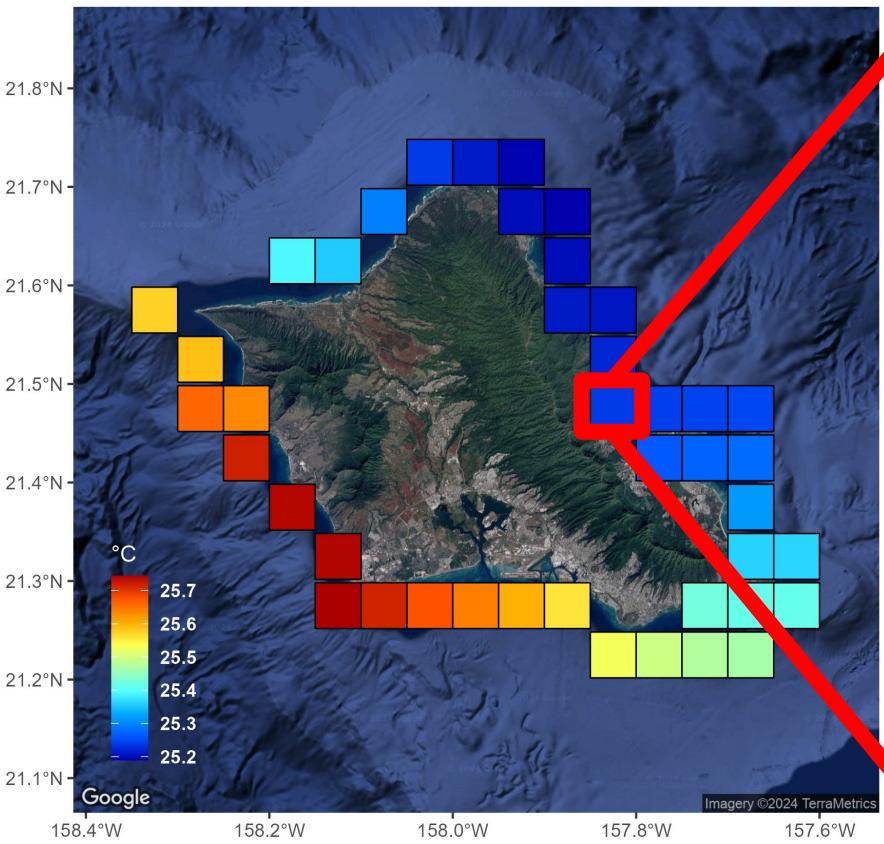
**45 islands.**

**40 years.**

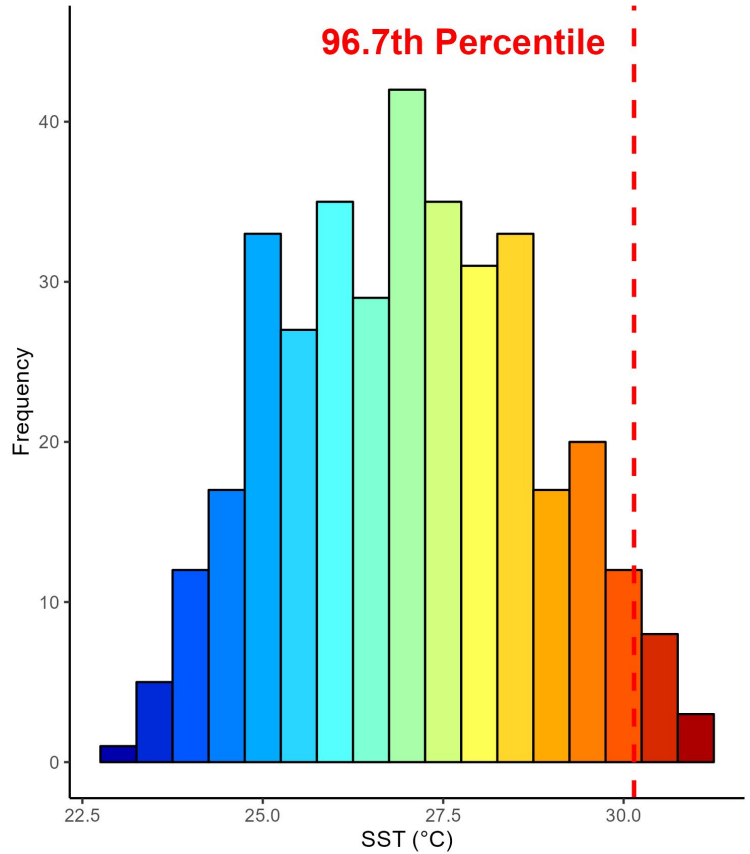
# Defining the Climatological Baseline



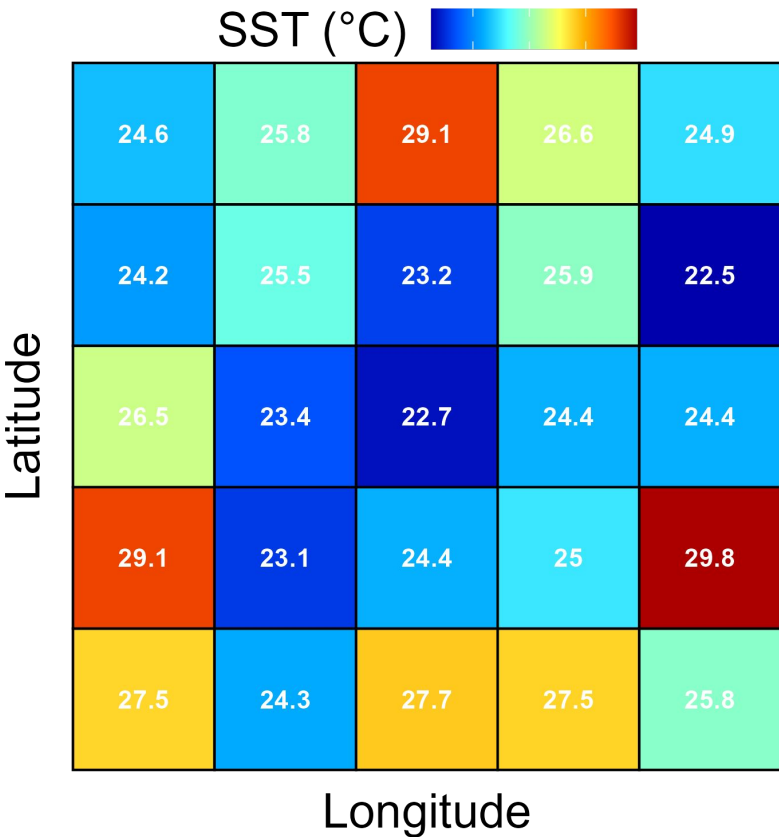
# Calculating changes in frequency of extreme marine heat event



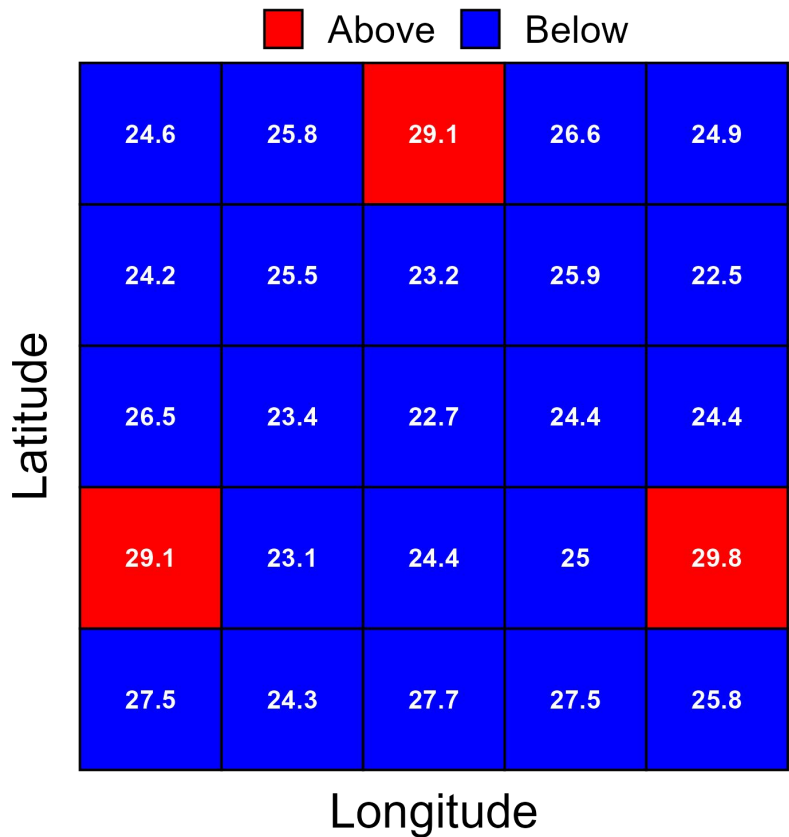
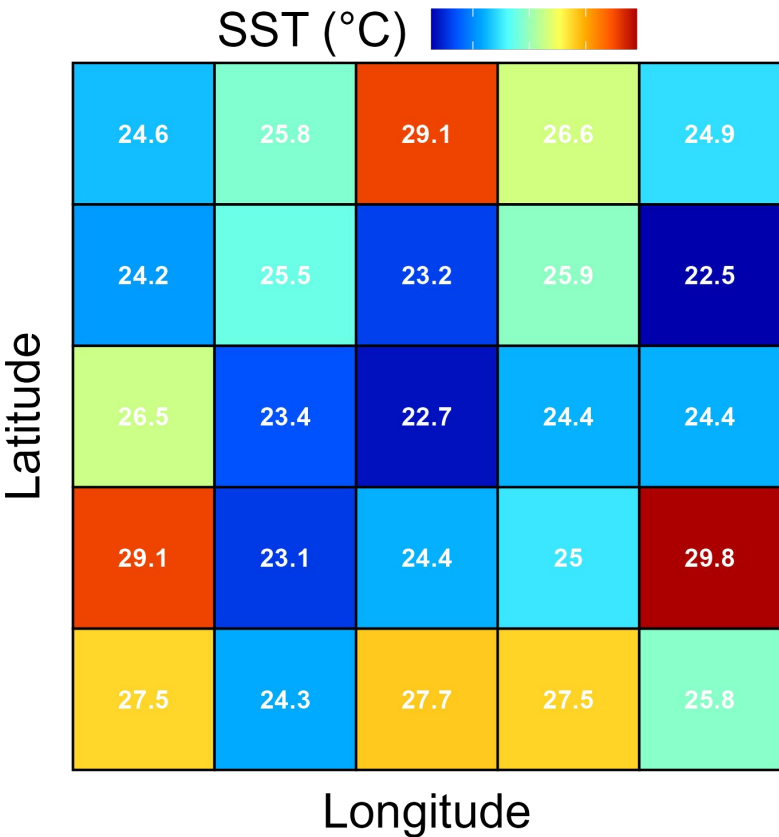
30-Year Distribution of SST



# Calculating changes in frequency of extreme marine heat event



# Calculating changes in frequency of extreme marine heat event



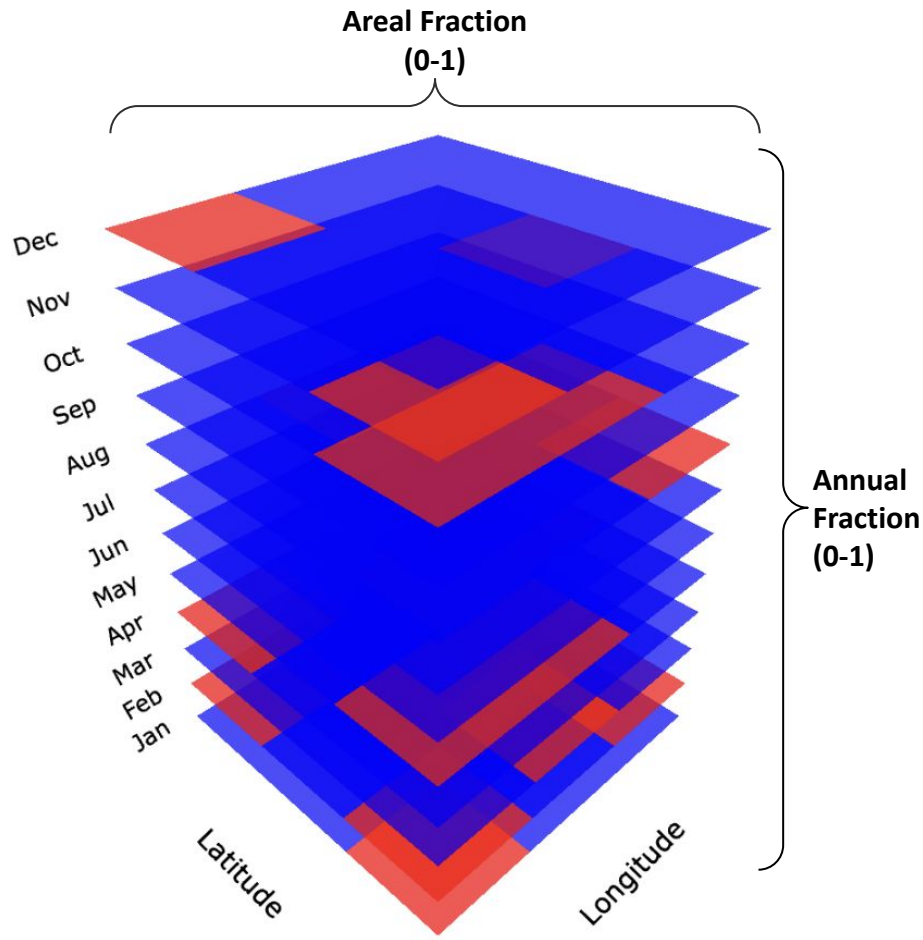
# Calculating changes in frequency of extreme marine heat event

■ Above 
 ■ Below

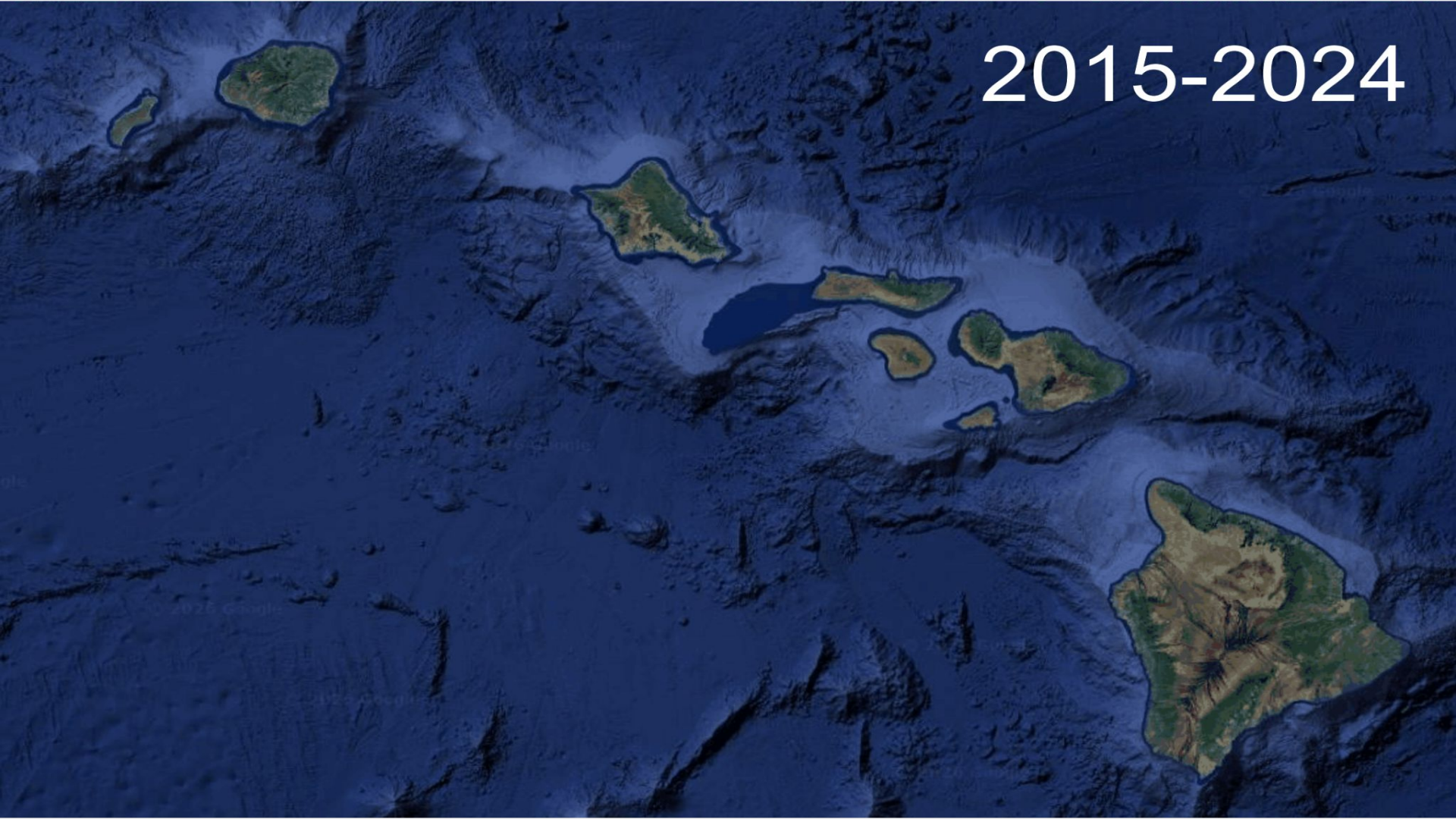
24.6	25.8	29.1	26.6	24.9
24.2	25.5	23.2	25.9	22.5
26.5	23.4	22.7	24.4	24.4
29.1	23.1	24.4	25	29.8
27.5	24.3	27.7	27.5	25.8

Latitude

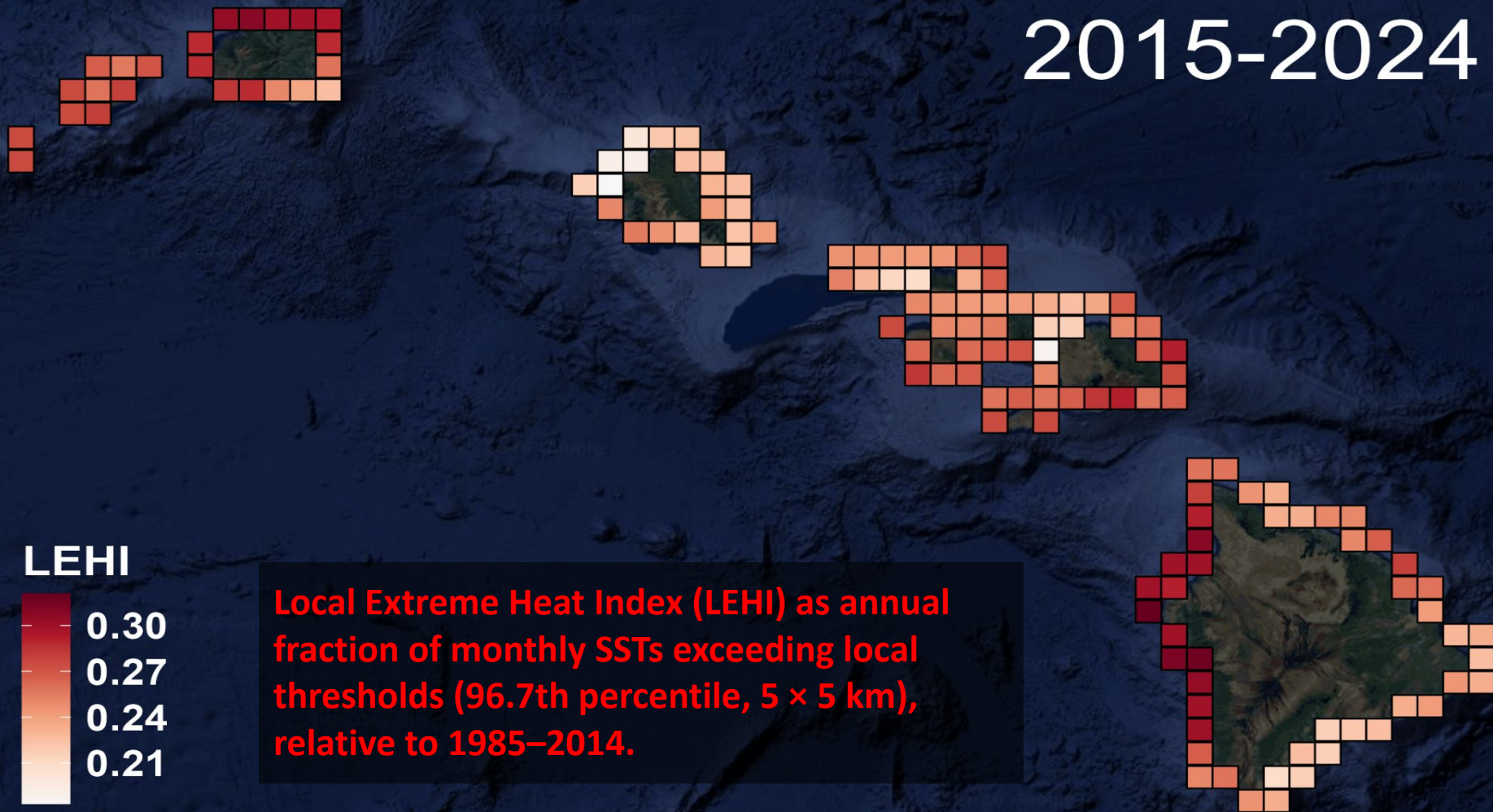
Longitude



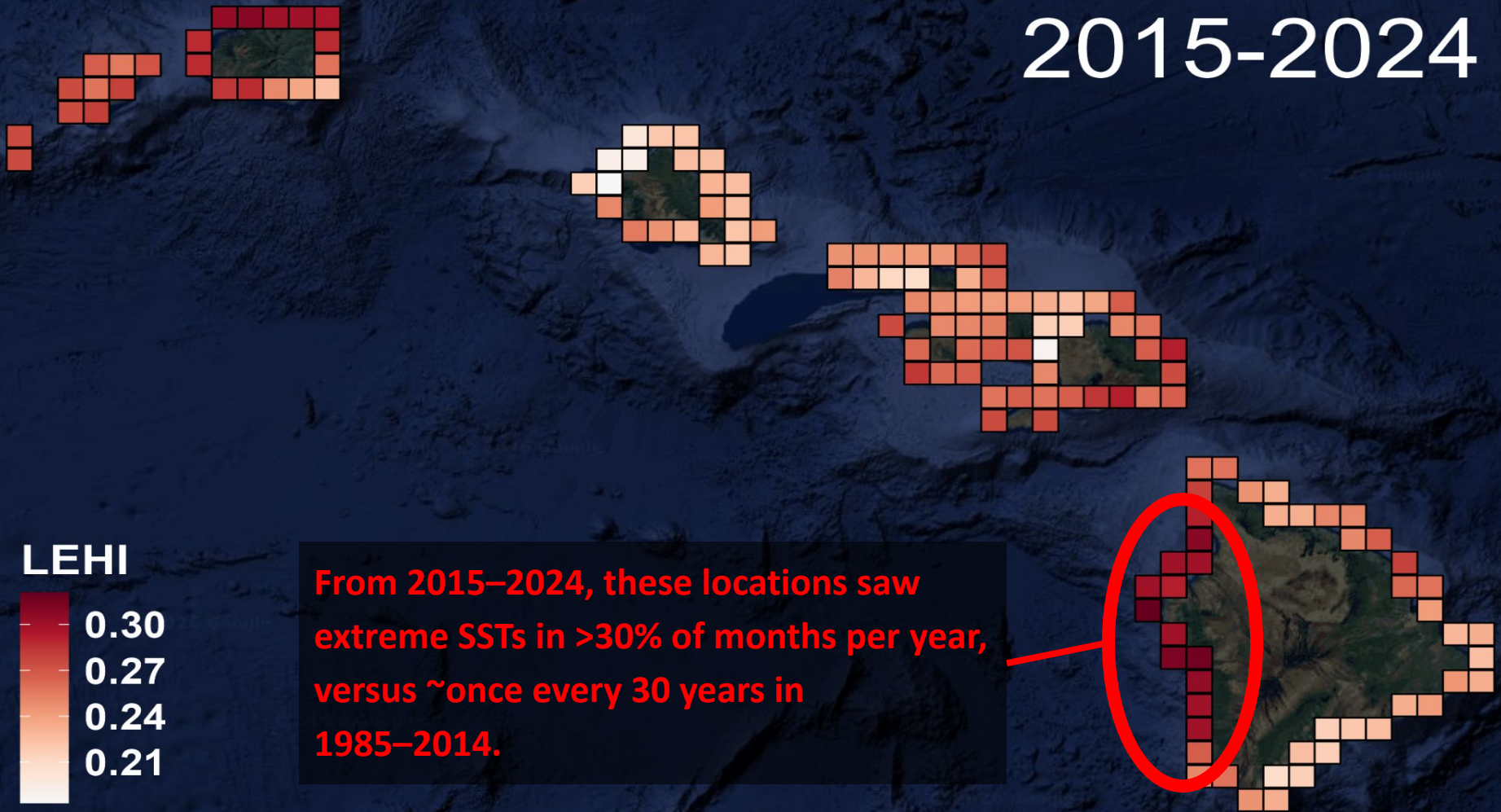
2015-2024



2015-2024

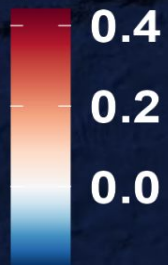


# 2015-2024

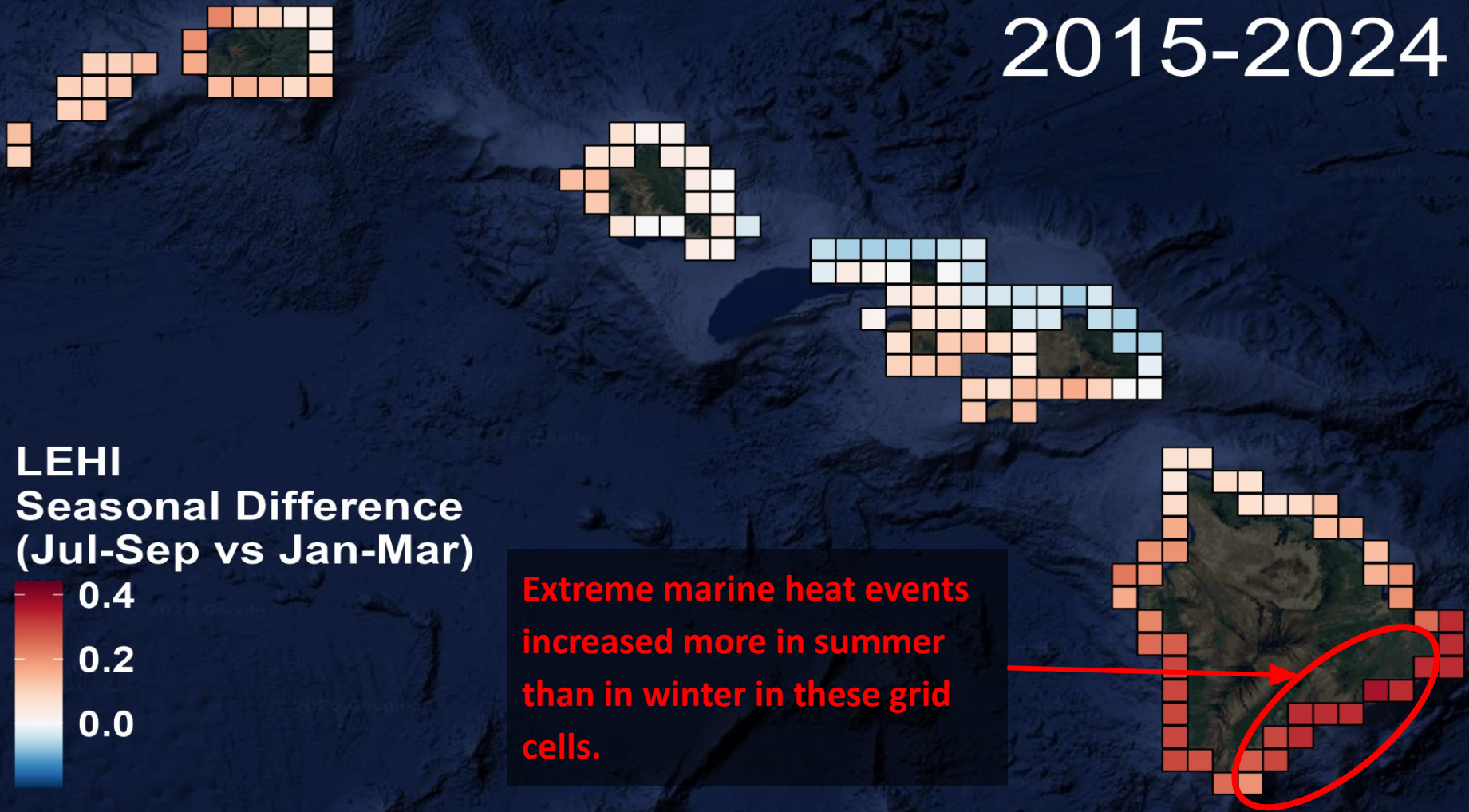


2015-2024

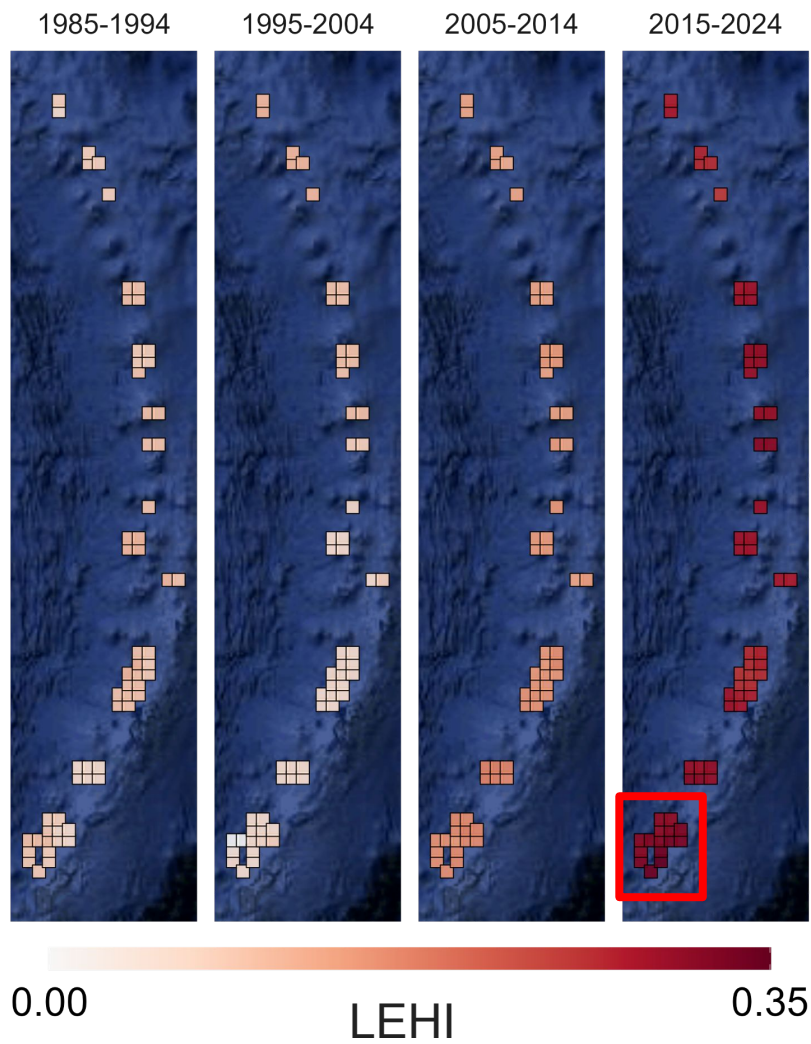
LEHI  
Seasonal Difference  
(Jul-Sep vs Jan-Mar)



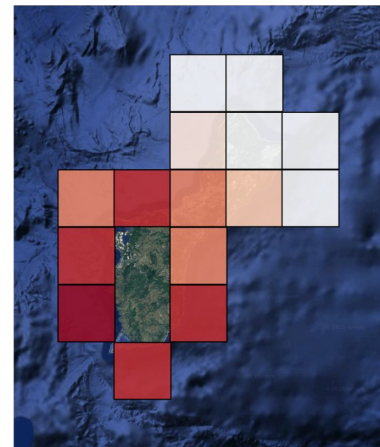
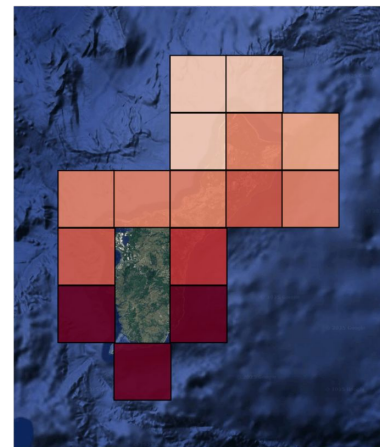
Extreme marine heat events  
increased more in summer  
than in winter in these grid  
cells.



# Decadal evolution of extreme SST frequency and local seasonality

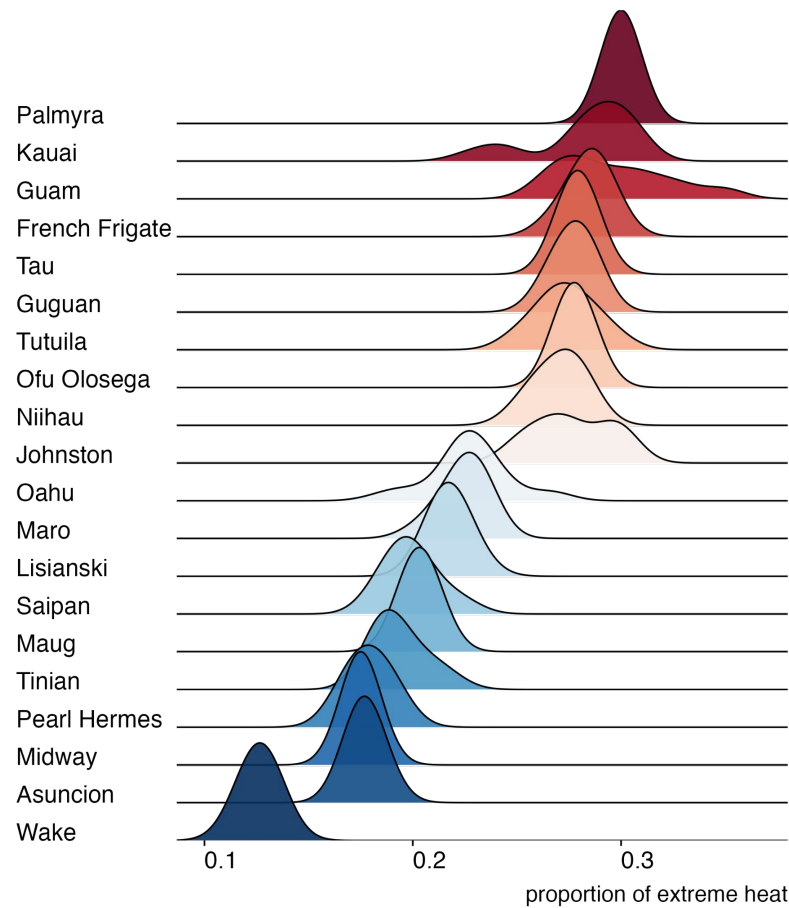


Annual

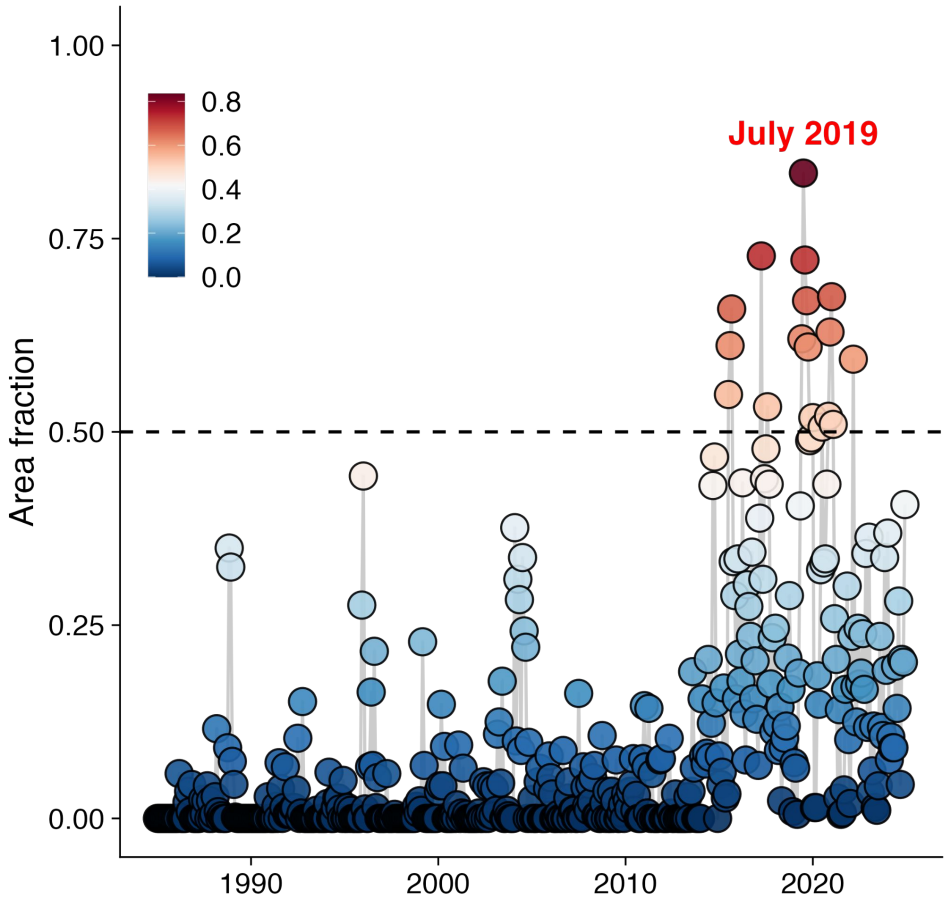


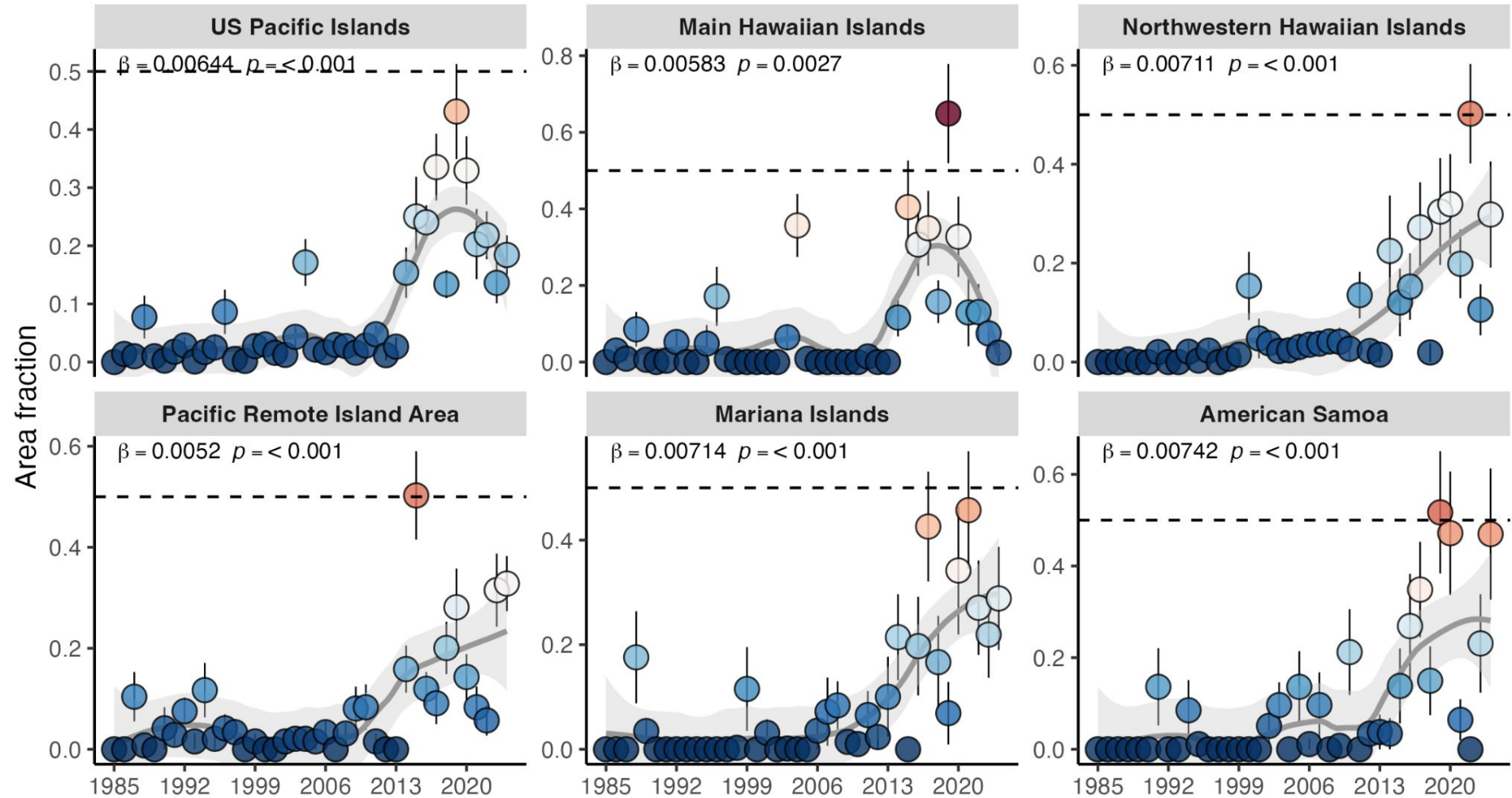
0.20    0.33

**Regional variability in the frequency of extreme marine heat events (2015–2024): Top and bottom 10 islands.**

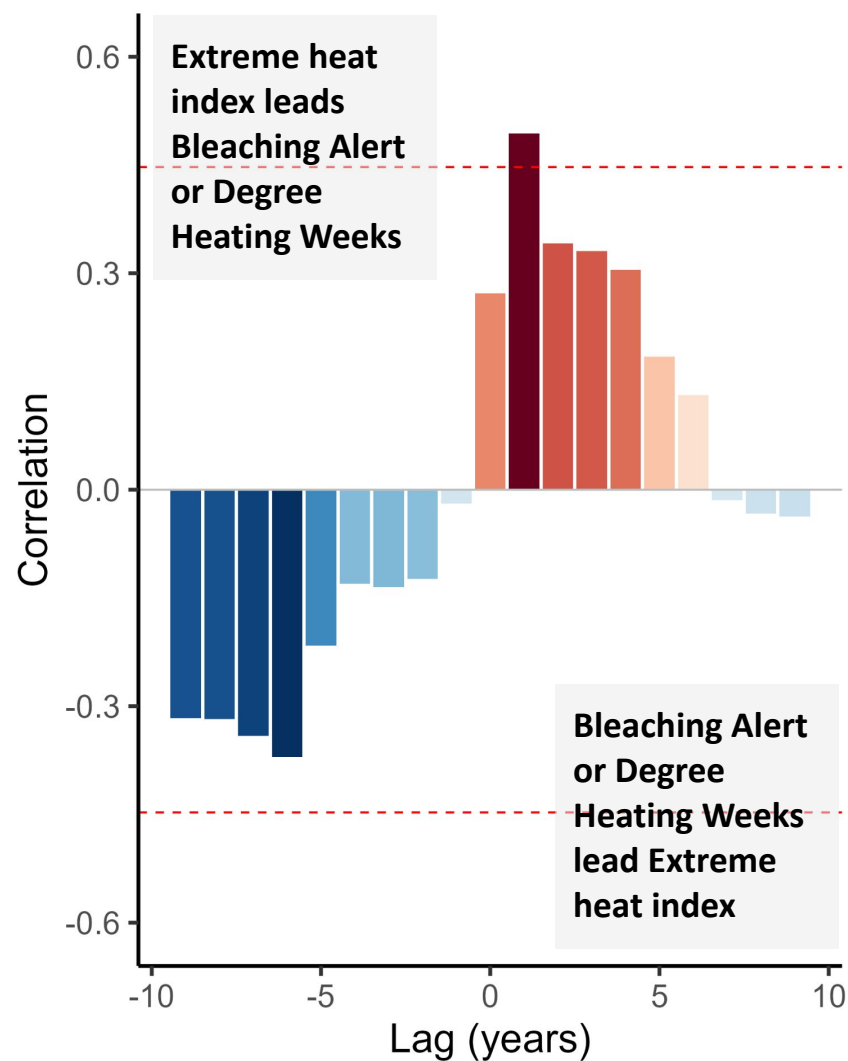
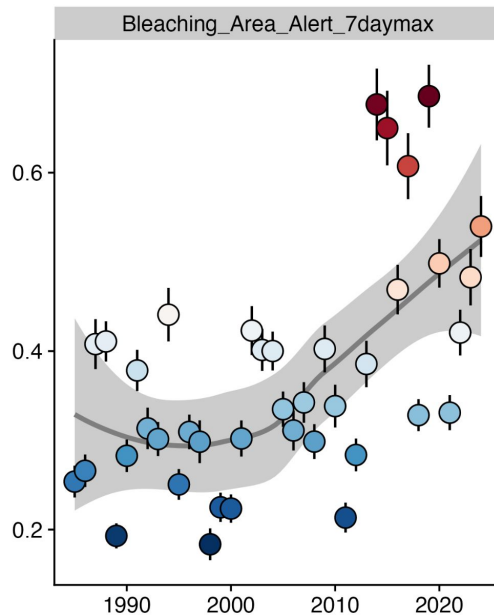
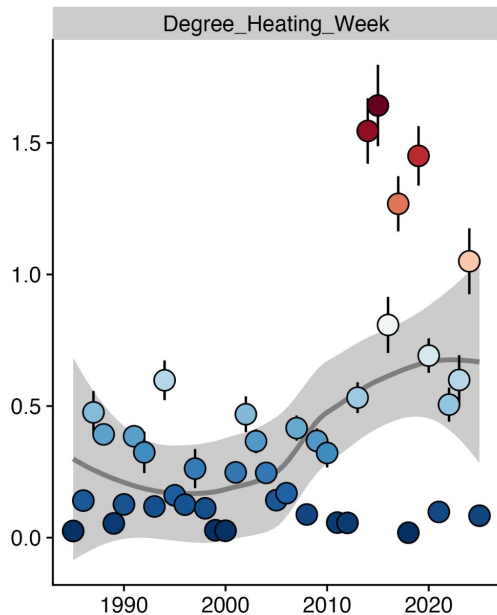


**Synoptic frequency of extreme marine heat events across U.S. Pacific Islands (n = 47) and regions, 1985–2024.**

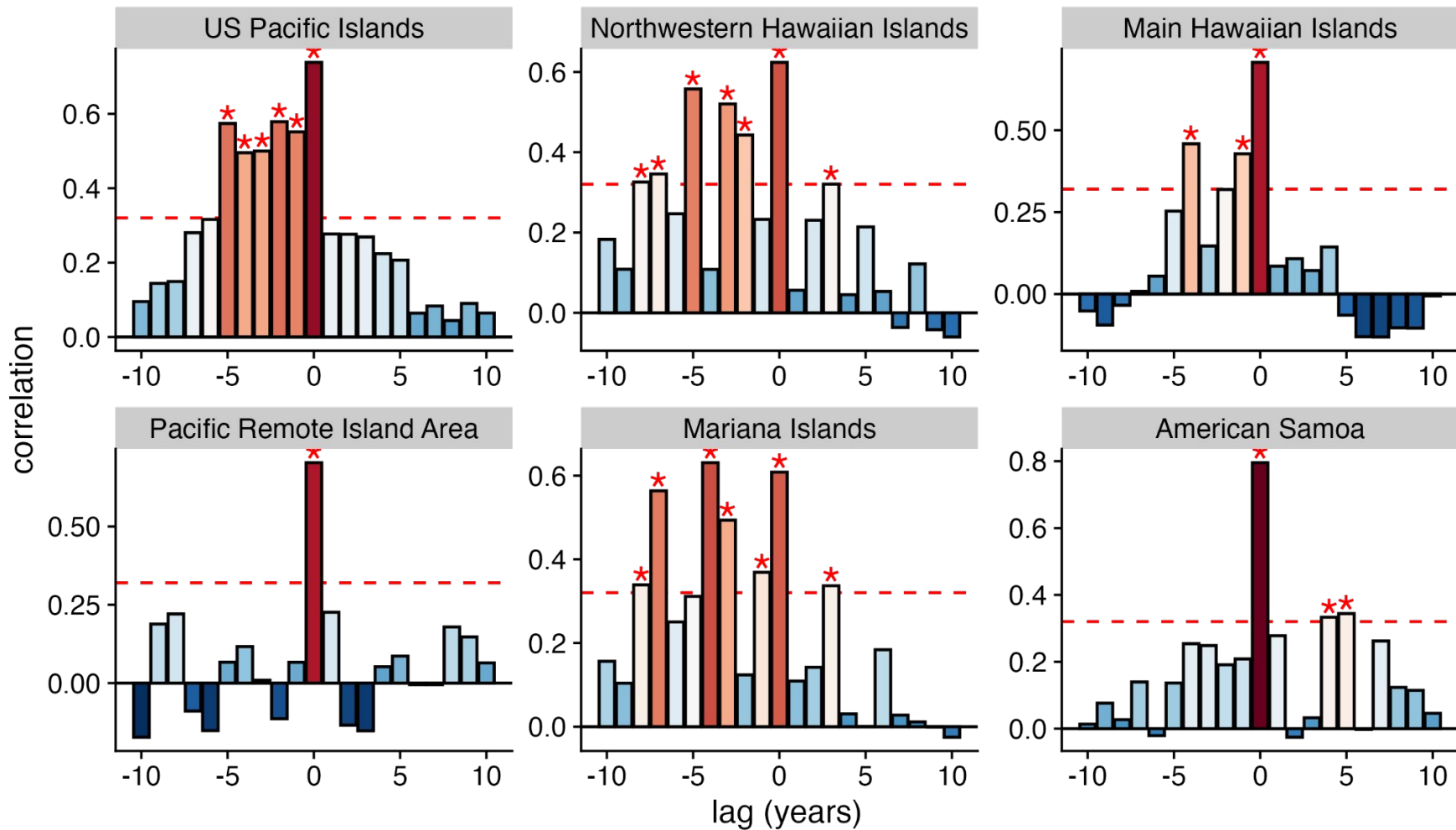




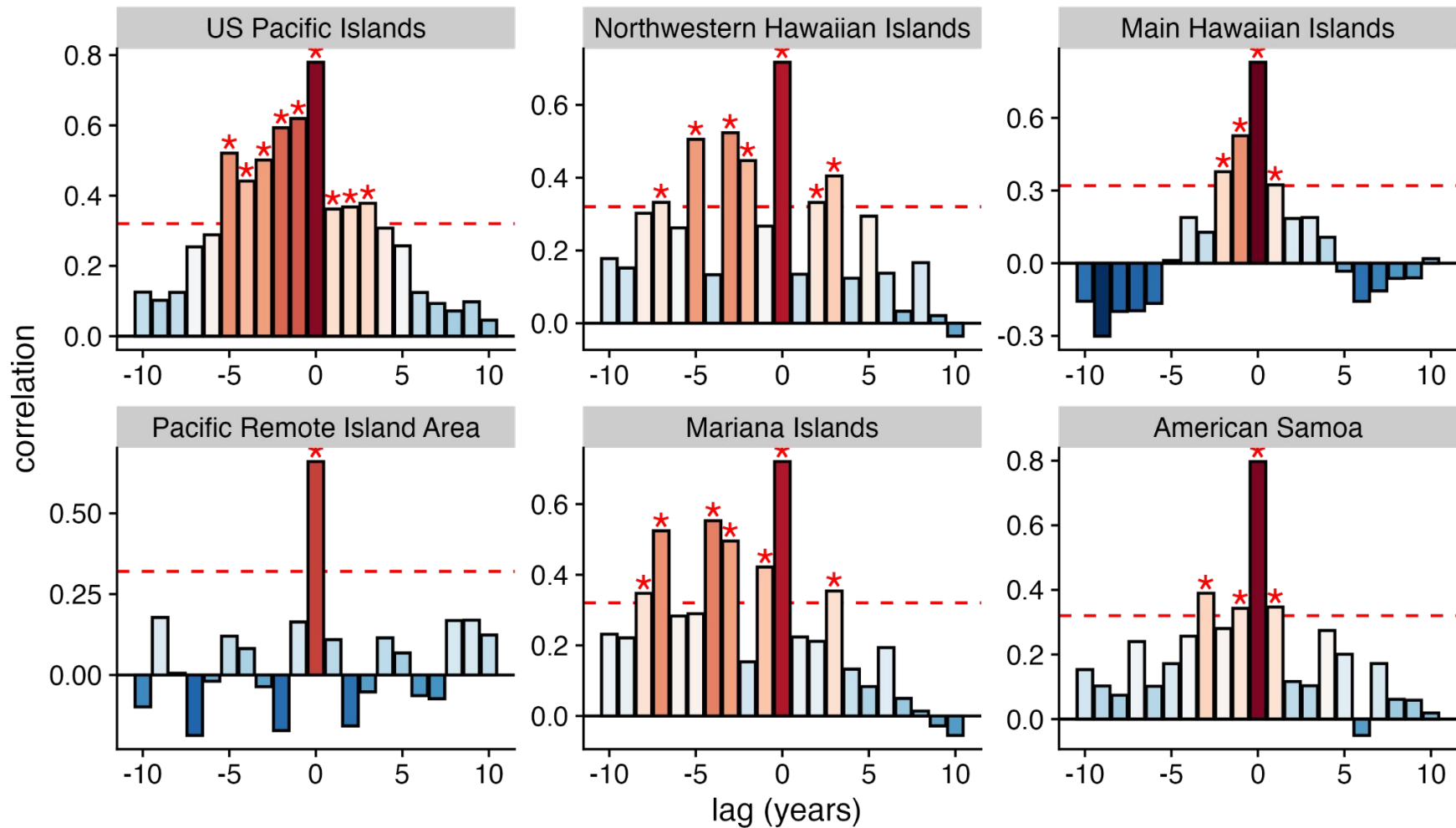
# Are there any “correlations” and “lags” when comparing the Local Extreme Heat Index to other marine heat indices?



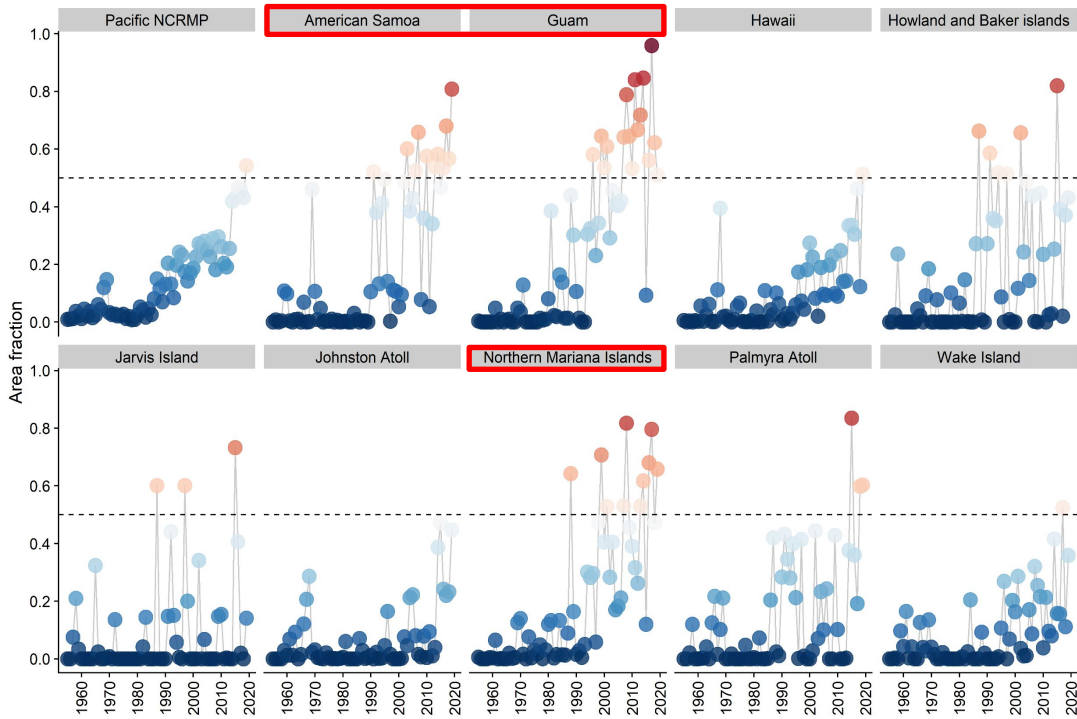
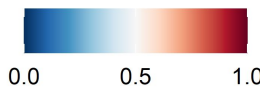
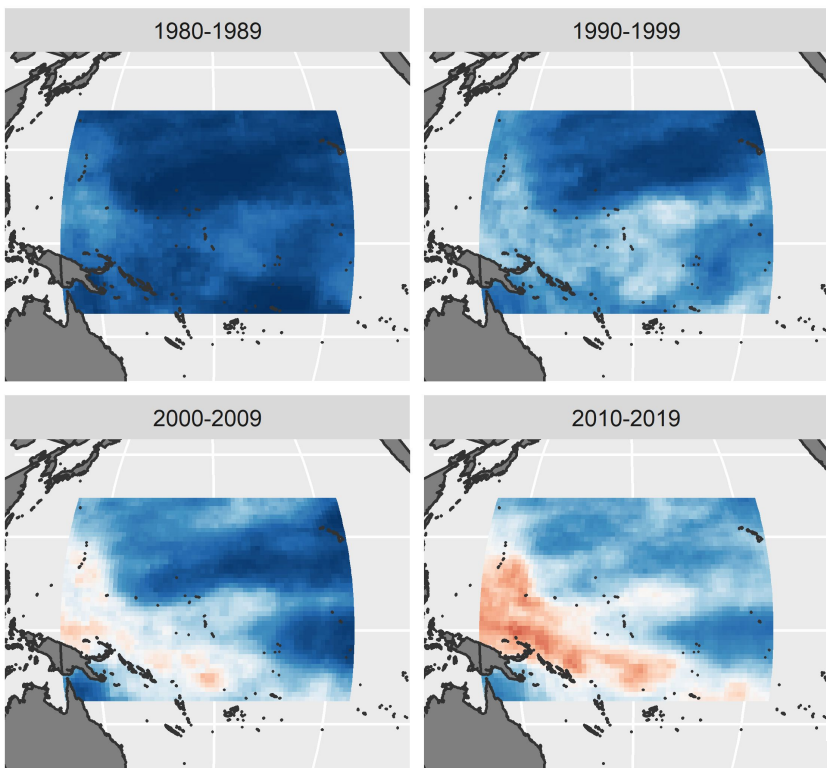
# Degree\_Heating\_Week



# Bleaching\_Area\_Alert\_7daymax

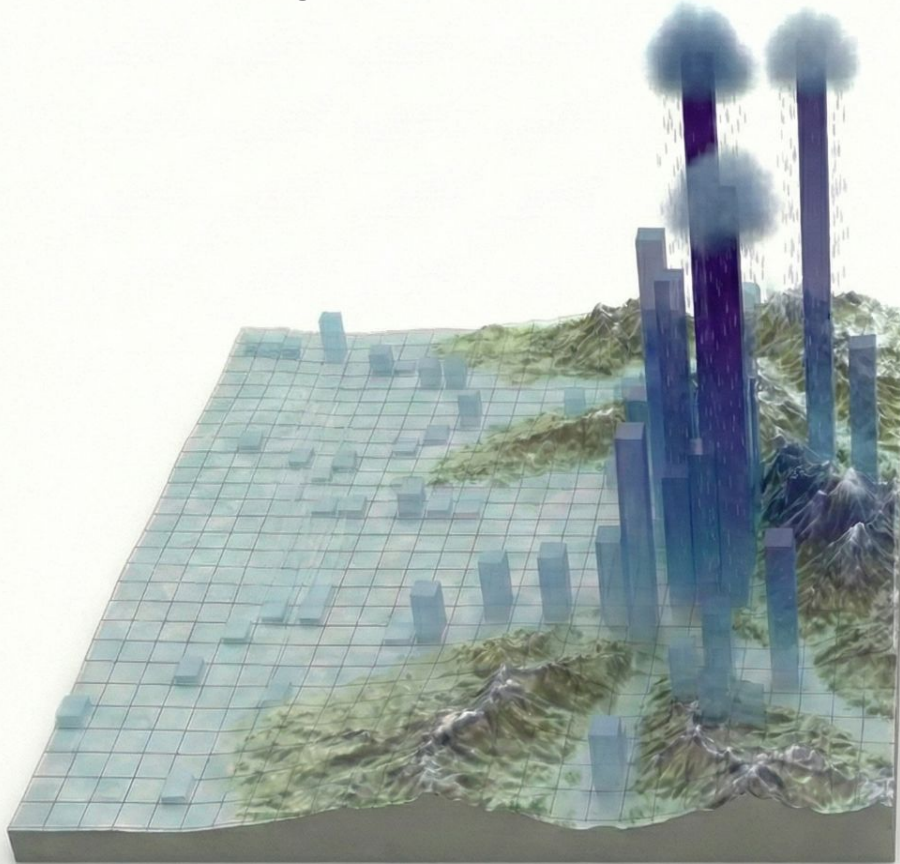


# Can Local Extreme Heat Index applied at different spatial scales & ecosystems?

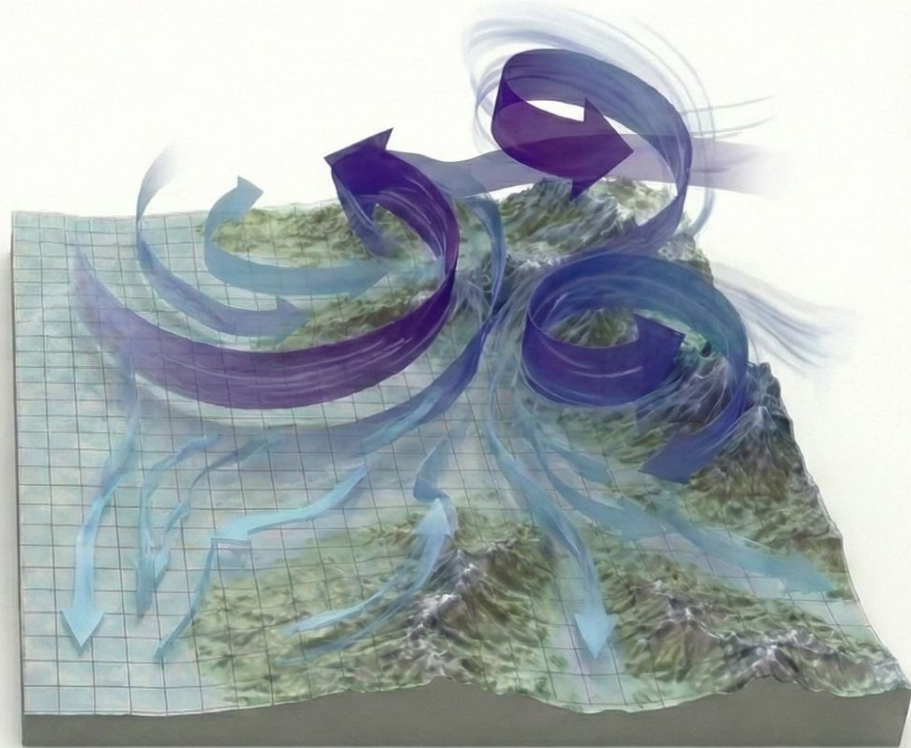


Decadal changes in frequency of extreme marine heat events from 1980–2019. The color bar (0-1) represents the annual proportion of extreme heat events (localized extreme heat index; LEHI). Extreme heat event is defined as monthly SST exceeding the localized ( $1^\circ \times 1^\circ$ ), monthly, 96.67th percentile of SST observed during 1955-1984 (CMIP6), averaged from HadISSTv1.1 and COBESSTv2.

Can this analysis be done with different variables?



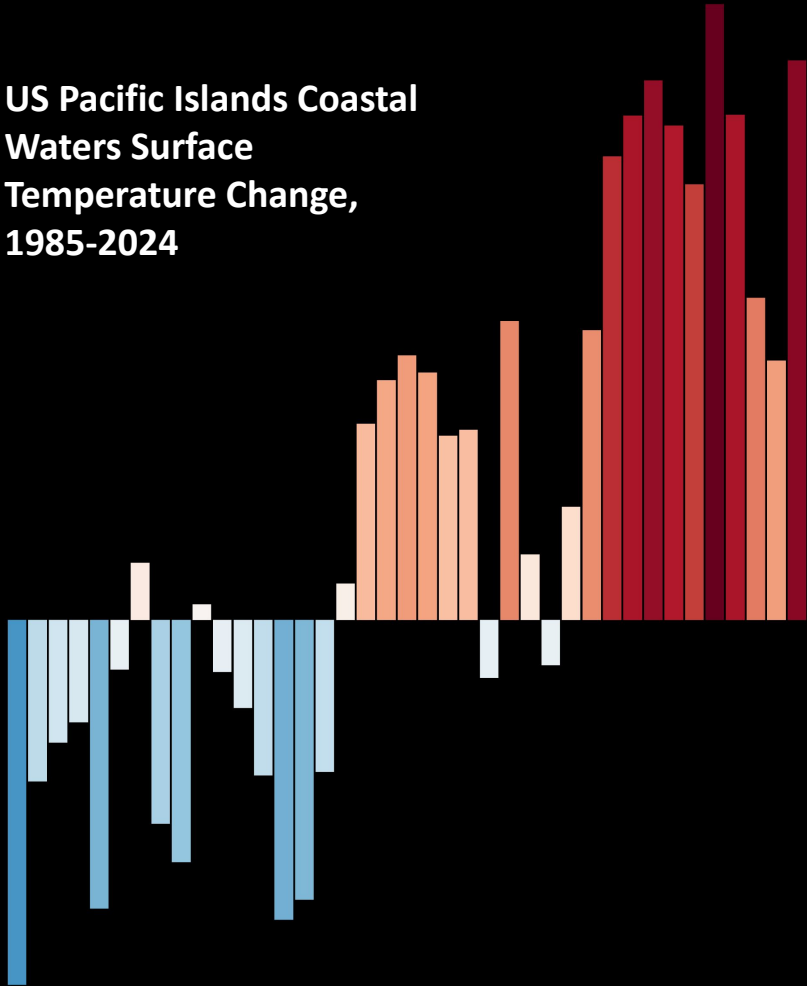
Local Extreme Precipitation Index?



Local Extreme Wind Index? ✨

From 2015–2024, **24.3%** of U.S. Pacific Islands coastal waters experienced extreme heat—conditions that historically occurred only about **once every 30 years**.

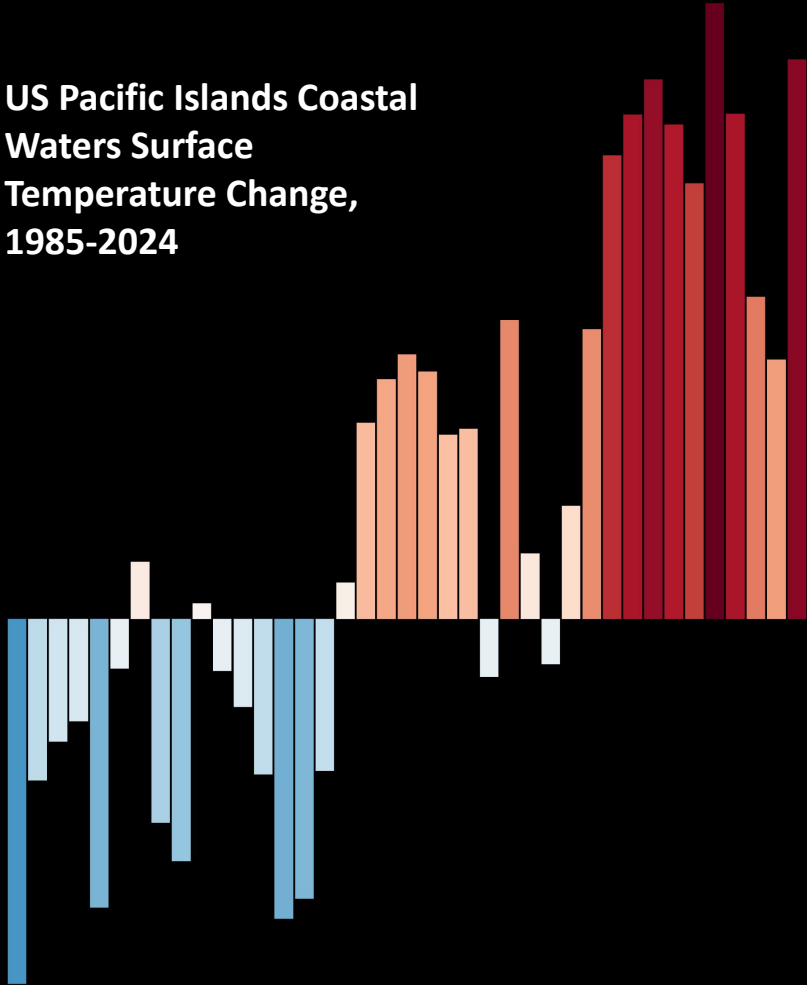
US Pacific Islands Coastal Waters Surface Temperature Change, 1985-2024



From 2015–2024, **24.3%** of U.S. Pacific Islands coastal waters experienced extreme heat—conditions that historically occurred only about **once every 30 years**.

The frequency of these events across Pacific regions has **surged in the last decade**.

US Pacific Islands Coastal Waters Surface Temperature Change, 1985-2024

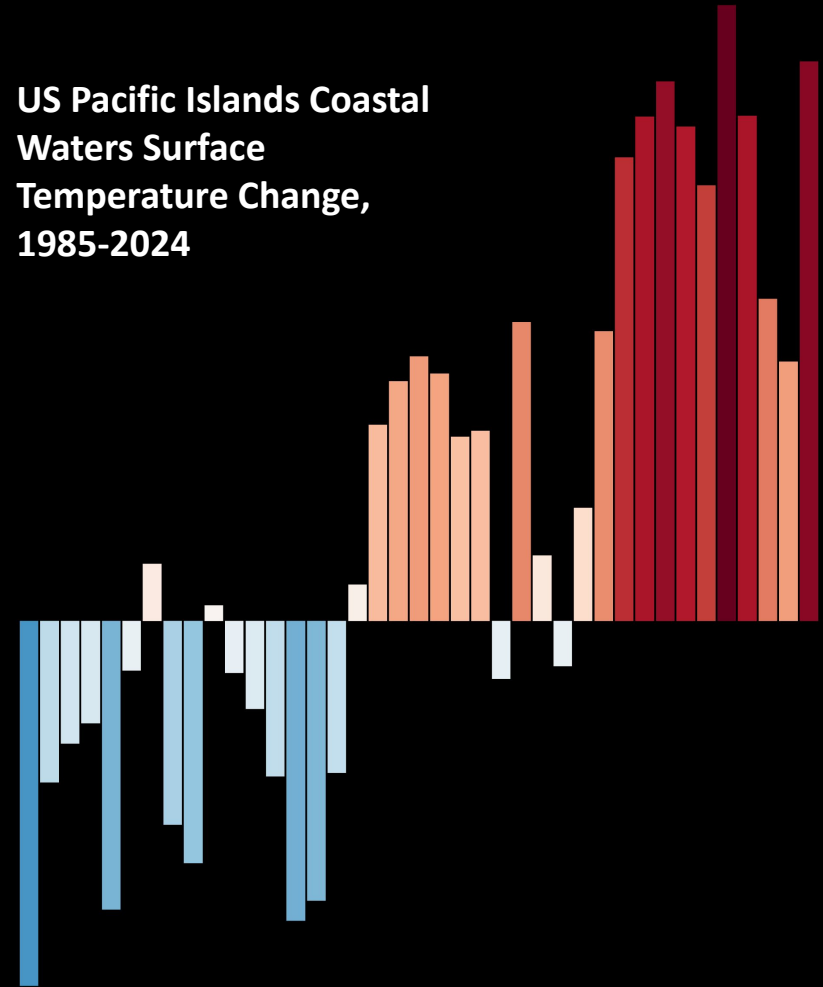


From 2015–2024, **24.3%** of U.S. Pacific Islands coastal waters experienced extreme heat—conditions that historically occurred only about **once every 30 years**.

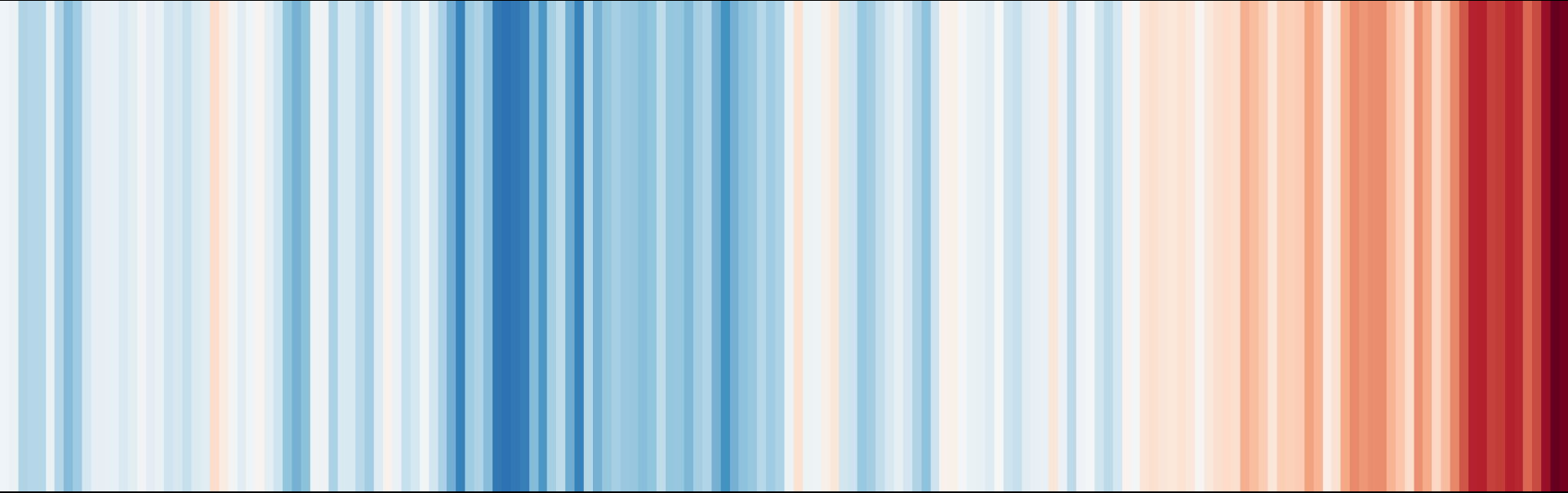
The frequency of these events across Pacific regions has **surged in the last decade**.

Extreme heat frequency often precedes other heat indices (e.g., Bleaching Alerts, Degree Heating Weeks), serving as an **potential early warning signal**.

US Pacific Islands Coastal Waters Surface Temperature Change, 1985-2024



# 172 Years of Pacific SST Anomalies (ERSSTv5, 1854–2025)



*questions?*