

Assessing Escalation of Extreme Marine Heat Events in Pacific Island Regions: A High-Resolution SST Analysis from 1985-2023

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Abstract

This study examines the changes in frequency of extreme marine heat events in coastal waters of more than 40 U.S. Pacific islands using high-resolution SST data. We developed a spatially and temporally resolved index of extreme marine heat events based on a 30-year baseline (1985-2014), identifying significant increases in frequency of extreme heat across the Pacific Islands. Our index reveals that 24.3% of U.S. Pacific Islands coastal waters experienced extreme heat events in the most recent decade (2015-2023). Our findings highlight regional differences in climate impacts on economically and ecologically vital coastal habitats, providing insights for climate-informed management in the region.

Material and Method

We developed a spatially (5 km × 5 km) and temporally (annual & seasonal) resolved index of normalized historical extreme marine heat events, expressed as the fraction of a year or area exceeding a locally determined, monthly varying 96.7th percentile of SST gradients derived from the first 30 years of climatological records (1985-2014). We utilized 39 years (1985-2023) of gridded, daily historical SST data from NOAA's daily global 5km Geo-Polar Blended Night-only SST Analyses to evaluate decadal changes in meso-scale occurrences of extreme marine heat events.

For each month and each 5 km × 5 km grid, extreme marine heat was defined as a monthly average SST value exceeding the 96.7th percentile SST value observed over the 1985-2014 period (i.e., the hottest temperature observed in the earliest 30-year period of record). The normalization of historical marine heat extremes was expressed as the fraction of a year or an area exceeding a locally identified threshold relative to the 1985-2014 climatology, hereafter referred to as the "Local Extreme Heat Index (LEHI)."

For each grid cell, the LEHI represents the proportion of each year (0–1) that exceeds the monthly extreme SST values. Using these historical benchmarks of extreme heat frequency, we generated summaries of normalized LEHI for the U.S. Pacific Islands (n = 57) from 1985-2023.

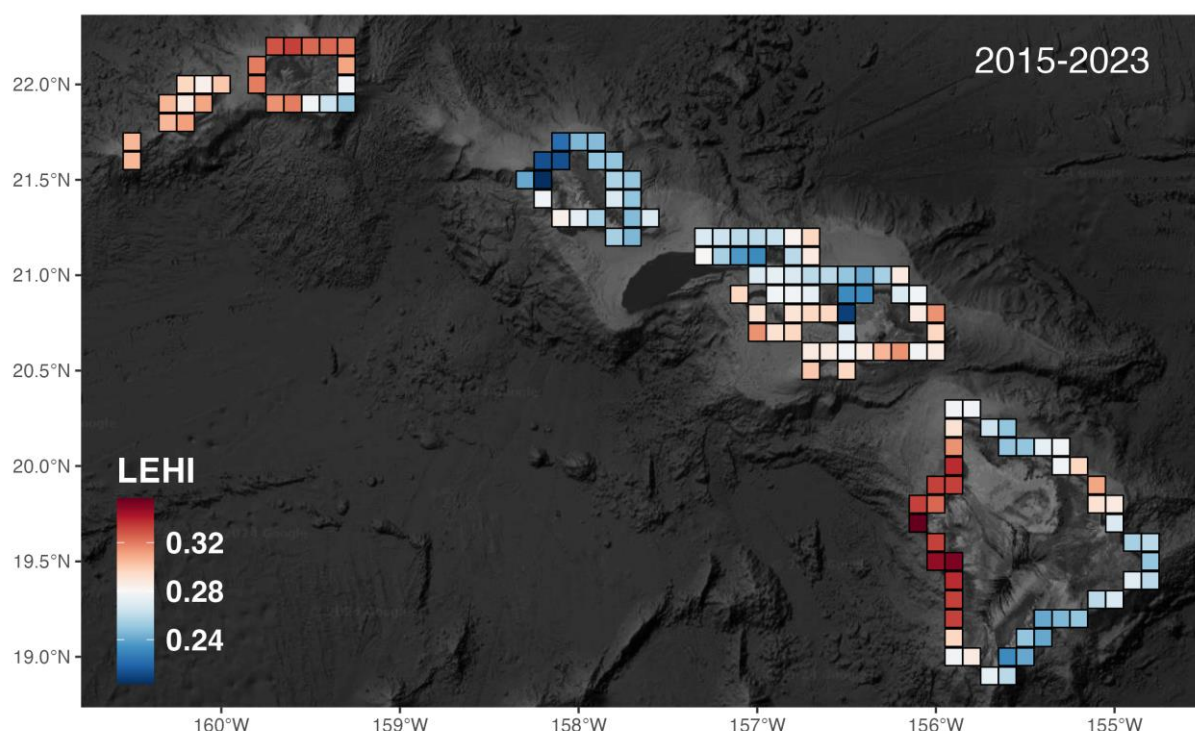


Figure 2. Mean frequency of extreme marine heat events from 2015-2023. Extreme heat is defined as sea surface temperatures (SST) exceeding the localized (5km x 5km) monthly 96.7th percentile, based on observations from 1984-2014 in NOAA's daily global 5km Geo-Polar Blended Night-only SST Analyses. LEHI is scaled from 0 to 1, with 1 indicating that all calendar months exceed local baseline SST thresholds.



Figure 1. Study areas of major island archipelagoes.

Results

We document significant increases in the extent of extreme marine heat events across the Pacific Islands coastal waters (Figs 2 & 3). Over the most recent decade (2014-2023), our index indicates that 24.3% of the U.S. Pacific Islands coastal waters have experienced extreme heat events. The results also show pronounced regional differences in the impacts of climate change among the islands during this period (Fig 4), providing a nuanced understanding of how climate shifts are diverging across economically and ecologically crucial coastal habitats.

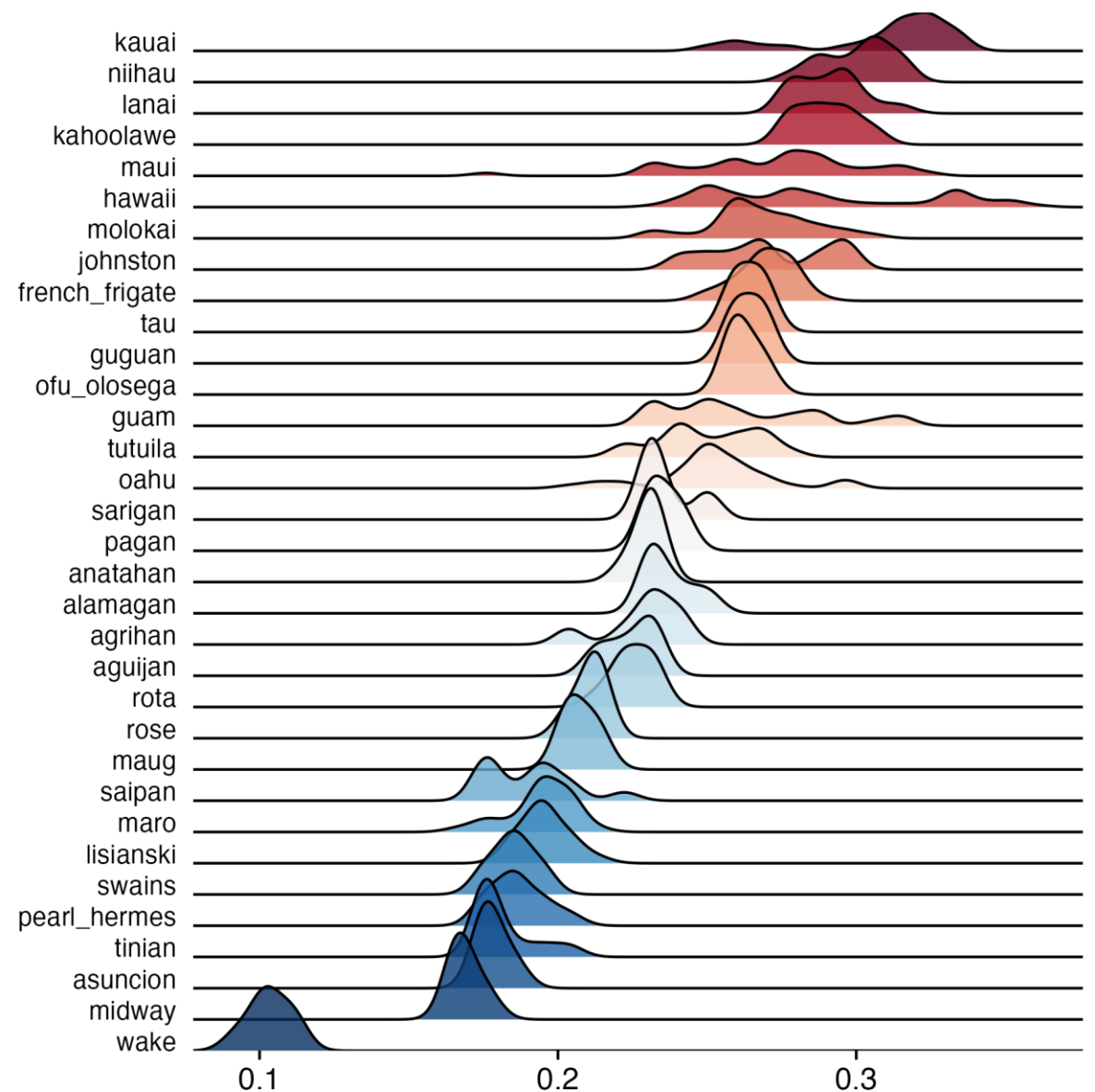


Figure 3. Inter-pacific island variability of frequency of extreme marine heat during 2015-2023. Islands are ranked and sorted by median extreme value. X-axis represents LEHI scaled from 0 to 1, with 1 indicating that all calendar months exceed local baseline SST thresholds.

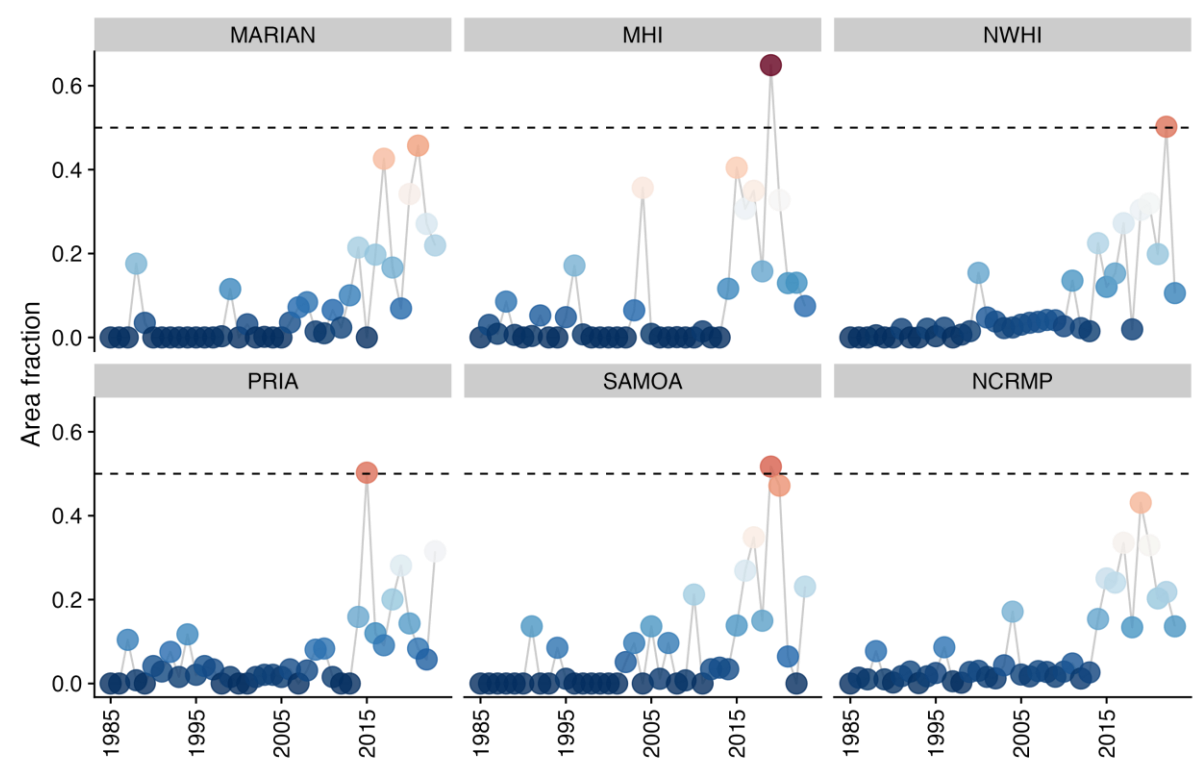


Figure 4. Synoptic frequency of extreme marine heat across Pacific Island regions from 1985-2023. The figure shows the annual fraction of ocean surface experiencing extreme heat, grouped by regions: Mariana (MARIAN), Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), Pacific Remote Islands Area (PRIA), and regions monitored under the National Coral Reef Monitoring Program (NCRMP).

Acknowledgement

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