Marine Heatwave

Visualizing Ocean Temperature Extremes

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What is a Marine Heatwave?

Marine heatwaves are extreme and often prolonged warming events in sea surface temperature (SST) that have been observed around the world. A well-known event occurred in the northeast Pacific in late 2013 and persisted through 2015. This Pacific marine heatwave (MHW) had devasting impacts on coastal ecosystems, fisheries and the economy.
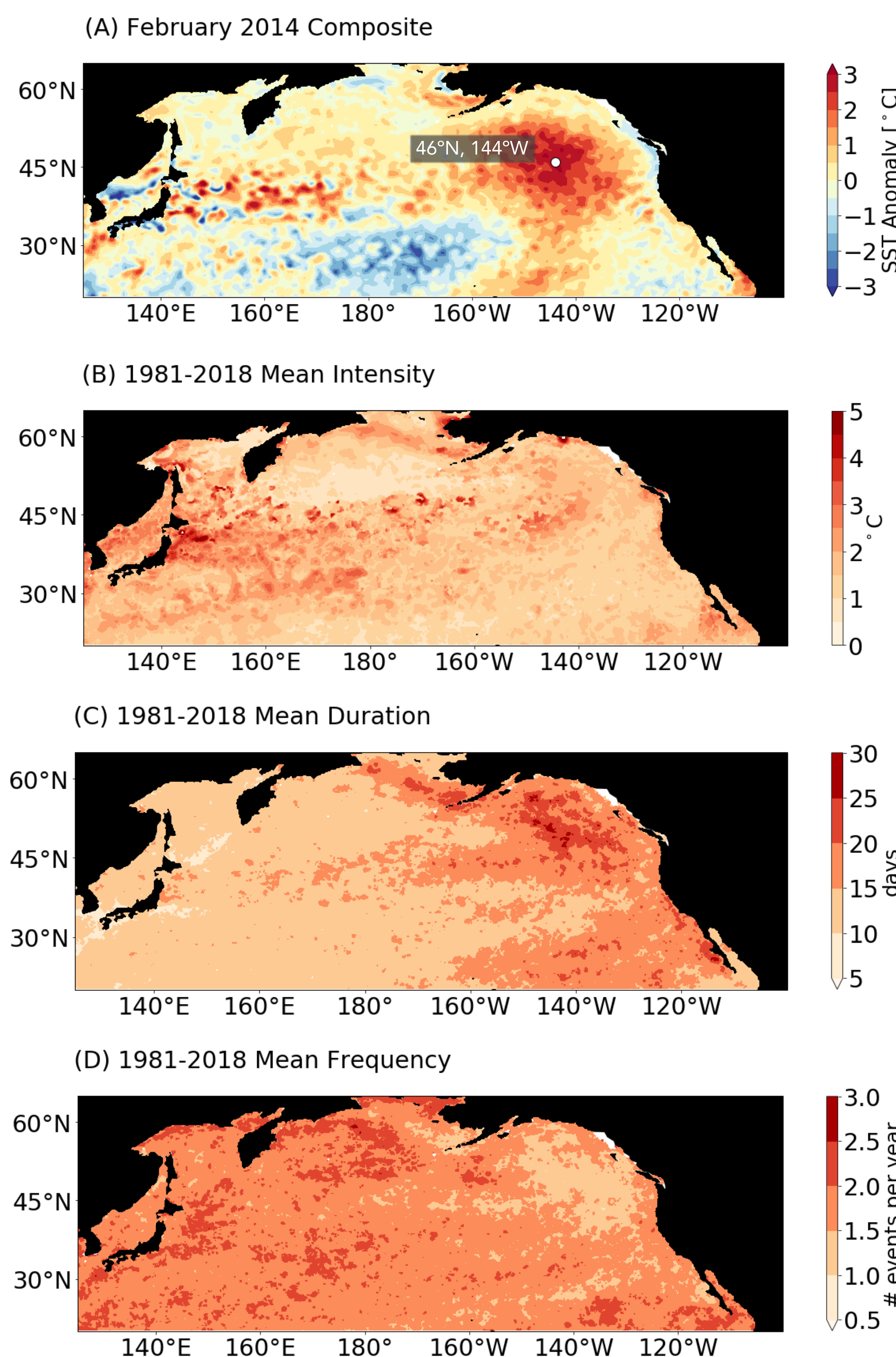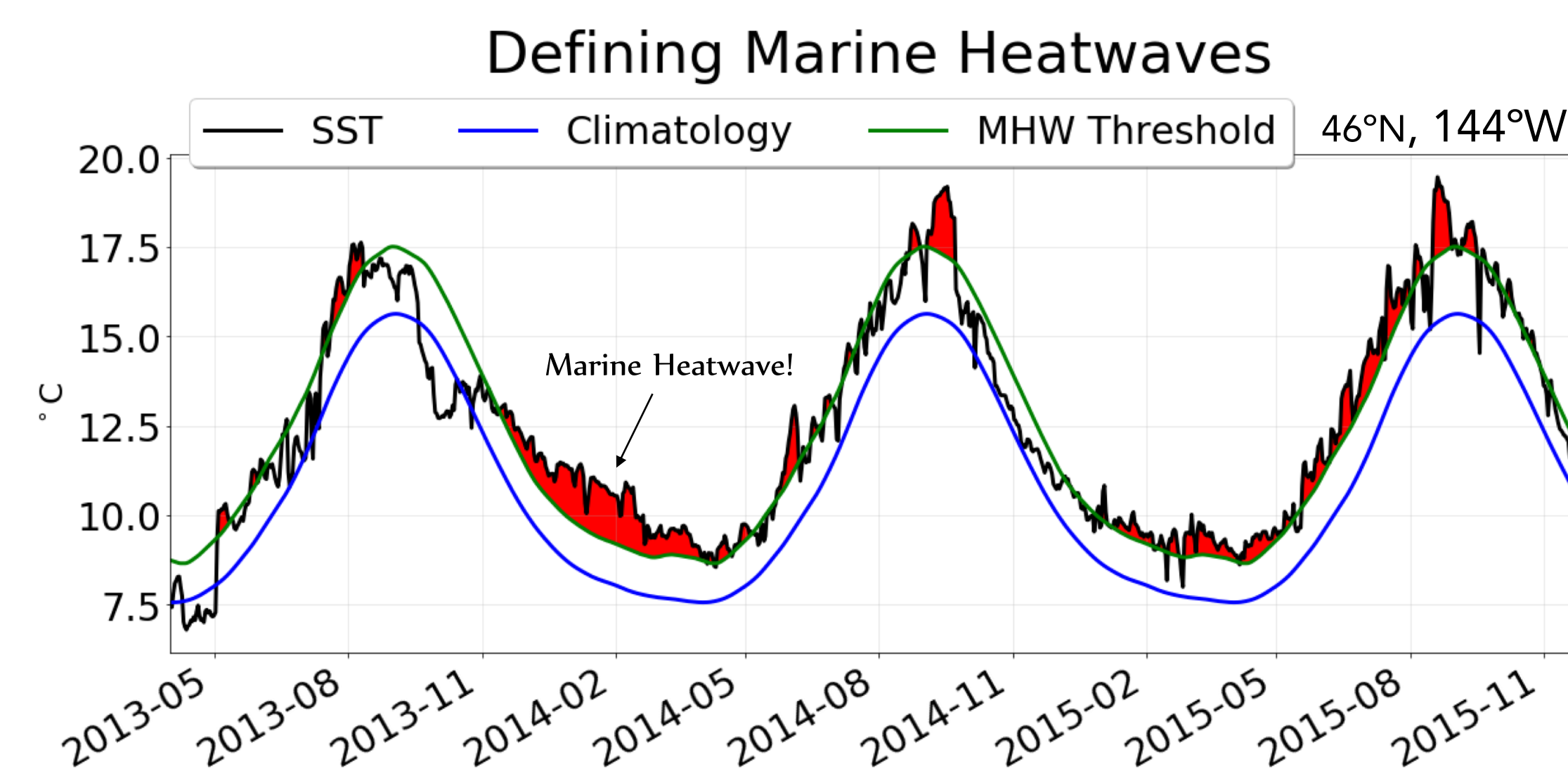
To study the impacts of these extreme events, marine heatwaves are defined relative to their temperature intensity using a 90th percentile threshold calculated over on a 30-year climatology (1988-2017). An event is considered a marine heatwave when at least 5 continuous days are above this threshold with no more than a 2-day gap in between.

Visualization Design & Implementation

Traditional event-based research often portrays MHWs as static composites of abnormal temperatures over some period of time (Figure A). The problem with this view is that it does not convey the growth, evolution, nor decay of marine heatwaves over time. This motivates the development of MHW visualizations to better understand their evolution and movement through animation.
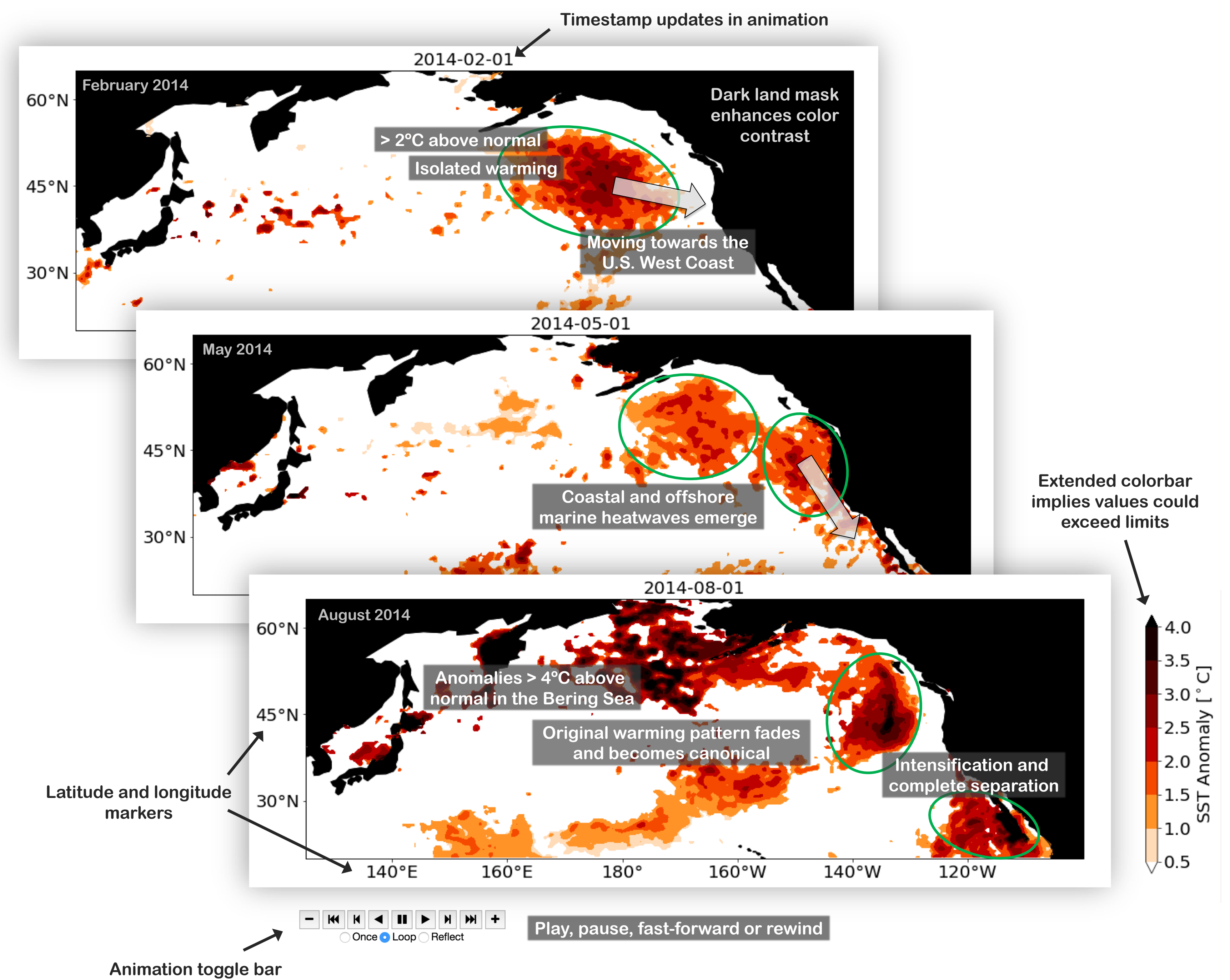
The goals of this design are to (1) develop/modify a classification algorithm that extracts marine heatwave event information from daily SST observations, (2) compute summary metrics over the entire data record (Figures B-D), and (3) create an animation of marine heatwave SST anomalies during the northeast Pacific event.

These visualizations are implemented in Jupyter Notebooks that are hosted in a GitHub repository.
https://cse512-18s.github.io/marine-heatwave/

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Project Website: https://cse512-18s.github.io/marine-heatwave/

Defining Marine Heatwaves
— SST — Climatology — MHW Threshold 46°N, 144°W
Marine Heatwave!

(A) February 2014 Composite
46°N, 144°W
SST Anomaly [°C]

(B) 1981-2018 Mean Intensity
°C

(C) 1981-2018 Mean Duration
days

(D) 1981-2018 Mean Frequency
events per year

Tracking the Pacific Marine Heatwave

Marine heatwaves are mapped to a Plate Carrée projection centered in the North Pacific Ocean and are color encoded according to the intensity of SST anomalies [°C] above the 1988-2017 climatology. Frames are animated using Matplotlib and rendered as an interactive JavaScript widget directly inside a Jupyter Notebook using iPython's HTML display mode. This widget play inline with an HTML5 slider element that advances frames forwards and backwards.

Timestamp updates in animation
2014-02-01
February 2014
Dark land mask enhances color contrast
> 2°C above normal
Isolated warming
Moving towards the U.S. West Coast

2014-05-01
May 2014
Coastal and offshore marine heatwaves emerge

Extended colorbar implies values could exceed limits

2014-08-01
August 2014
Anomalies > 4°C above normal in the Bering Sea
Original warming pattern fades and becomes canonical
Intensification and complete separation
SST Anomaly [°C]

Latitude and longitude markers

Animation toggle bar
Once Loop Reflect
Play, pause, fast-forward or rewind

Using animation to track the Pacific marine heatwave in 2014 helps tell a story about this event. Anomalies >2°C were confined offshore early in the year and spread to the U.S. West Coast by late spring where the intensity was less severe. Anomalies were likely brought to the coast by seasonal spring storms and cooled via coastal upwelling. By late summer, the pattern becomes canonical extending westward and reaching further north and south with the most extreme temperatures occurring near the Bering Sea and surrounding Baja California.

Data: NOAA daily Optimum Interpolation Sea Surface Temperature is a product of merged satellite, ship and buoy observations. Daily data is globally gridded with a ¼° resolution beginning since 1981.

— SST Anomaly ■ MHWs above threshold 46°N, 144°W
SST Anomaly [°C]