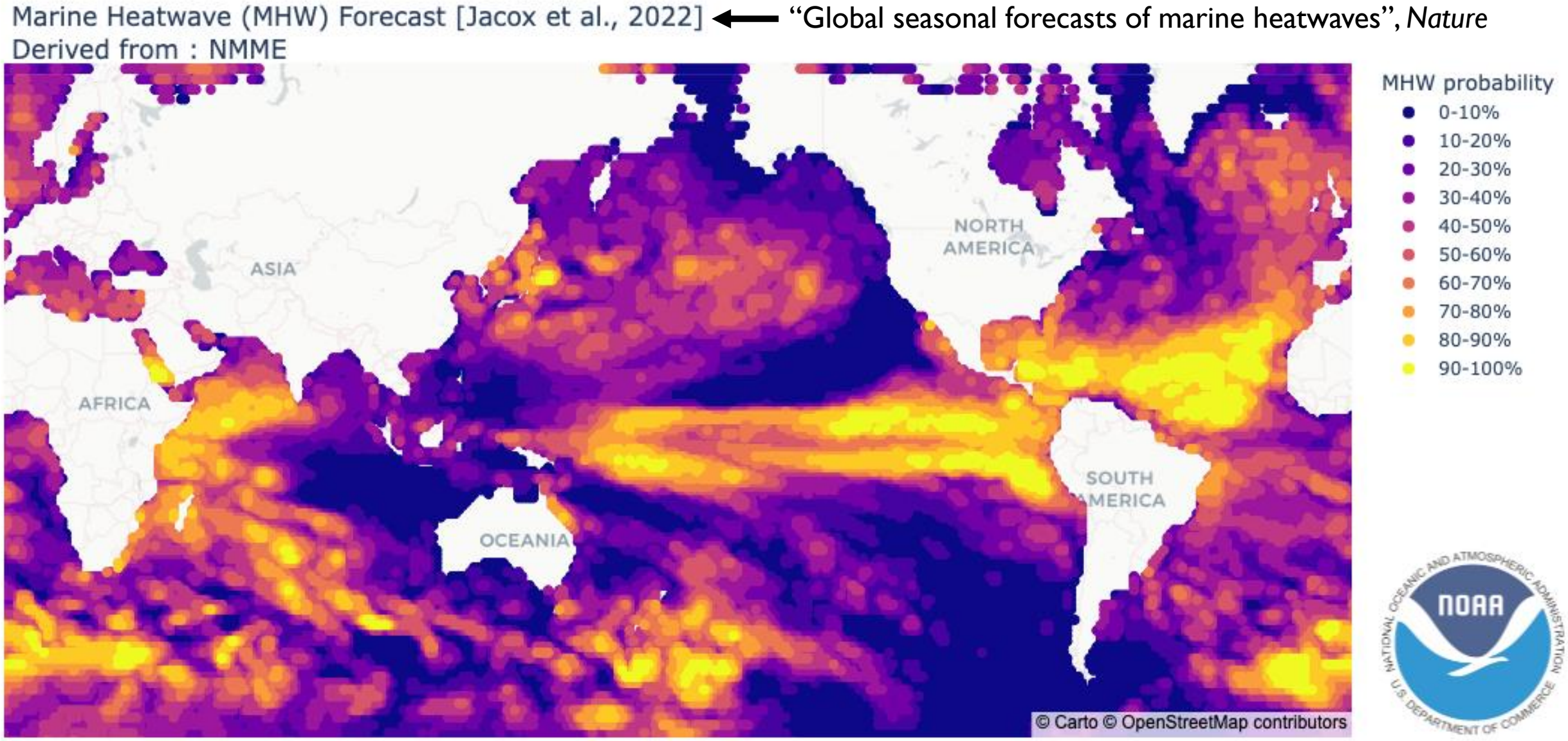
Detecting marine heatwaves in forecasting systems – Dillon Amaya



Initialized July 2023

Forecast at 3.5 months lead, valid for October 2023

Seasonal forecasting system

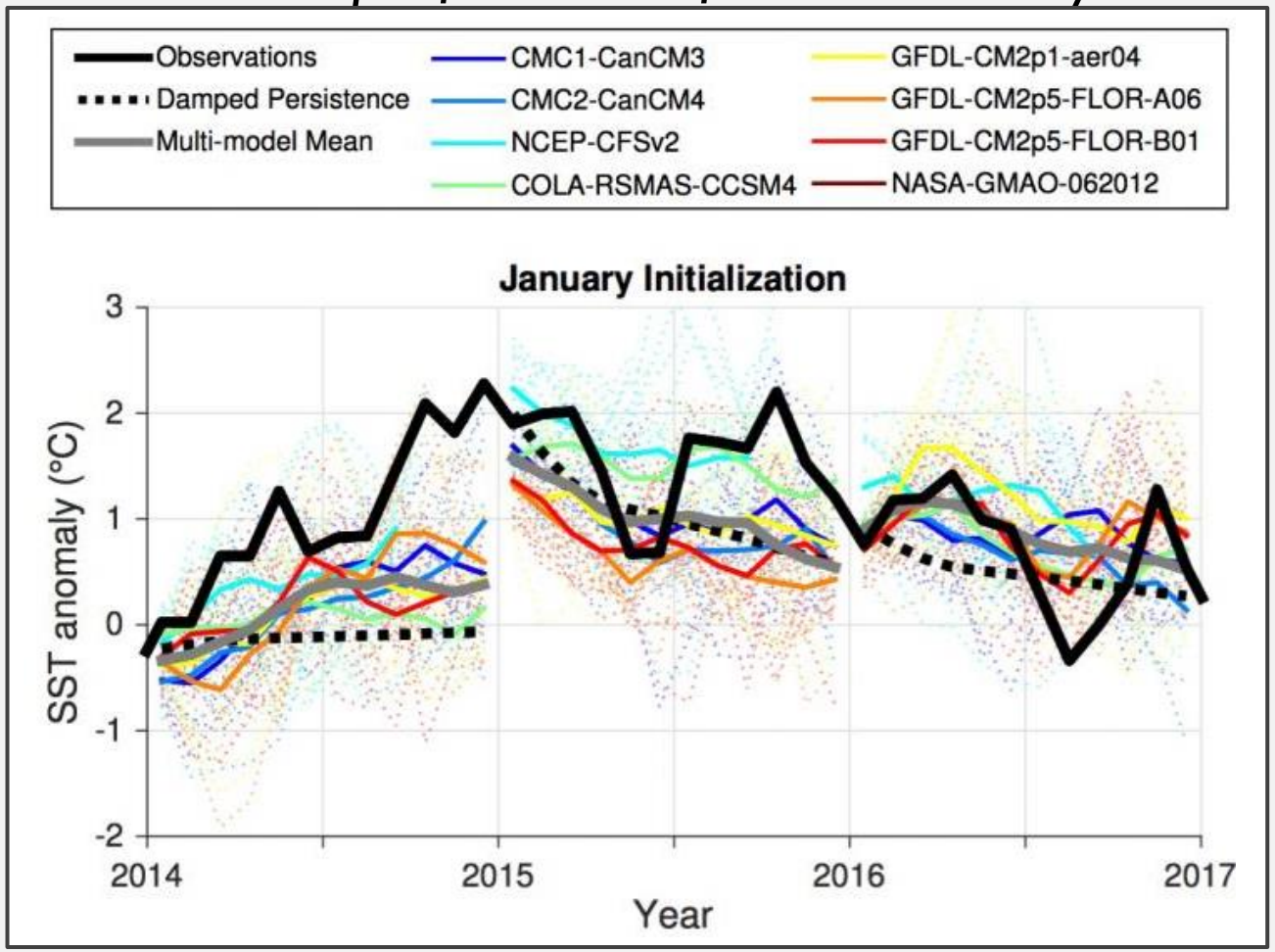
Operational or real-time forecast – Based on the latest observations and produces forecasts 6-12 months into the future.

Hindcast or reforecast – Multidecadal set of retrospective forecasts that are initialized with historical observations (e.g., 1980-2020).

- Answers the question: how well can we predict what's already happened?
- Used to understand the underlying skill of the forecast system so we know how confident we can be in real-time forecasts.

Seasonal forecasting system

Hindcast example for the California Current System



Jacox et al. (2019), *Frontiers in Marine Science*

Global coupled seasonal forecasts:

- Ocean/atmo initialized with reanalyses on the 1st of each month. Freely evolve afterwards.
- Each forecast consists of an ensemble (usually ~10 members).
- Typical resolution is ~1˚x1˚.
- Usually only have monthly means publicly available.
- Ocean forecasts often compared to damped persistence.

Detecting MHWs in a forecast system

Seasonal SST reforecasts from 1991-2020 taken from North American Multimodel Ensemble (NMME).

<u>For a given model:</u>

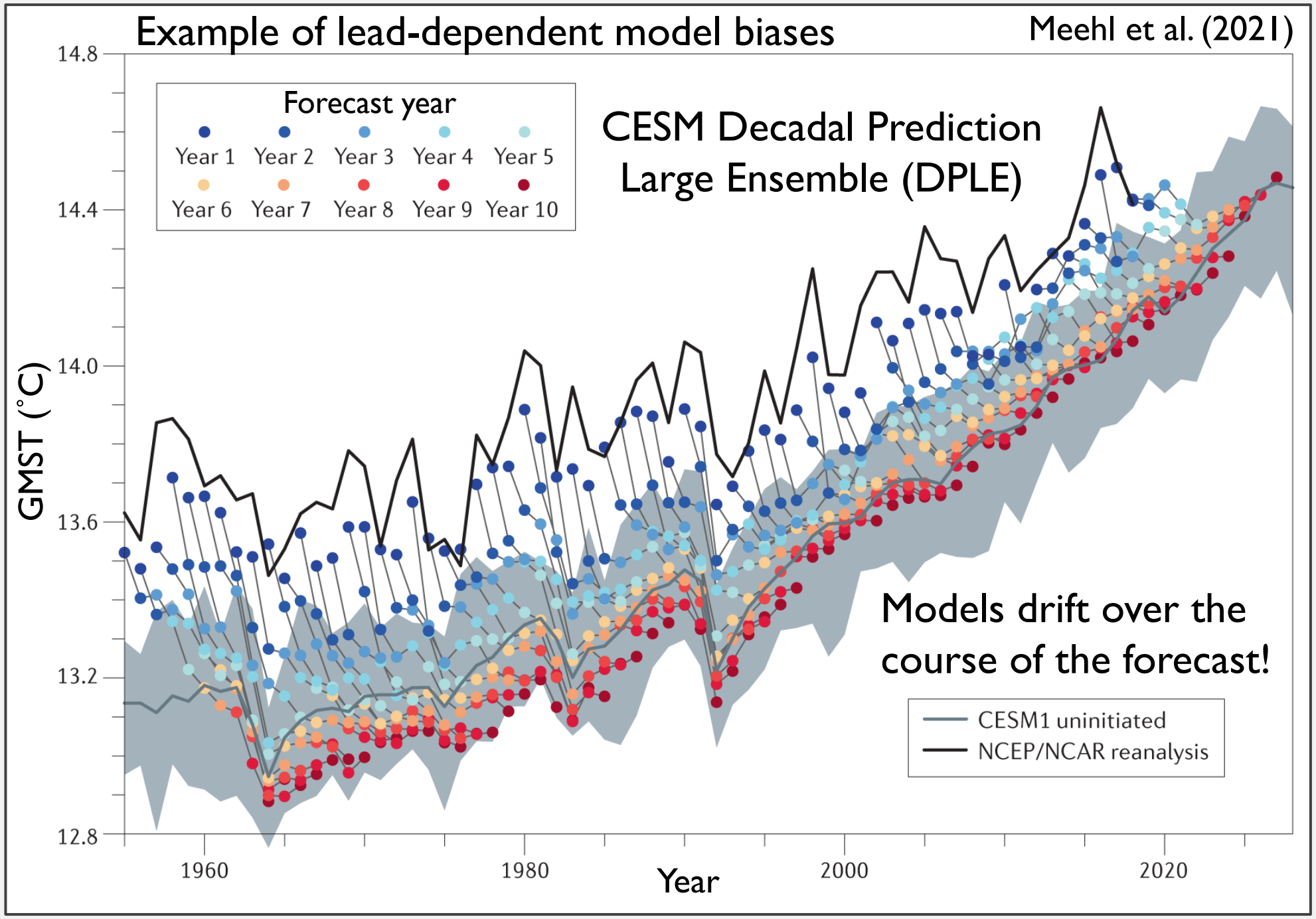
1. Remove lead-dependent model mean climatology from each ensemble member to get SSTA.

Six total models, ~70 total ensemble members

Typical data structure for a single model:

Initialization x Lead x Ensemble x Lat x Lon

Jacox et al. (2022), *Nature*


Example of lead-dependent model biases
Meehl et al. (2021)
Forecast year
Year 1
Year 2
Year 3
Year 4
Year 5
Year 6
Year 7
Year 8
Year 9
Year 10
CESM Decadal Prediction Large Ensemble (DPLE)
Models drift over the course of the forecast!
CESM1 uninitiated
NCEP/NCAR reanalysis
GMST (°C)
14.8
14.4
14.0
13.6
13.2
12.8
1960
1980
2000
2020
Year

Detecting MHWs in a forecast system

Seasonal SST reforecasts from 1991-2020 taken from North American Multimodel Ensemble (NMME).

<u>For a given model:</u>

1. Remove lead-dependent model mean climatology from each ensemble member to get SSTA.

   (Detrend)

2. Calculate lead-dependent MHW threshold (i.e., the 90th percentile of forecast SSTA from pooled ens. members).

3. Identify forecast MHWs (0 or 1).

→ Six total models, ~70 total ensemble members

Typical data structure for a single model:

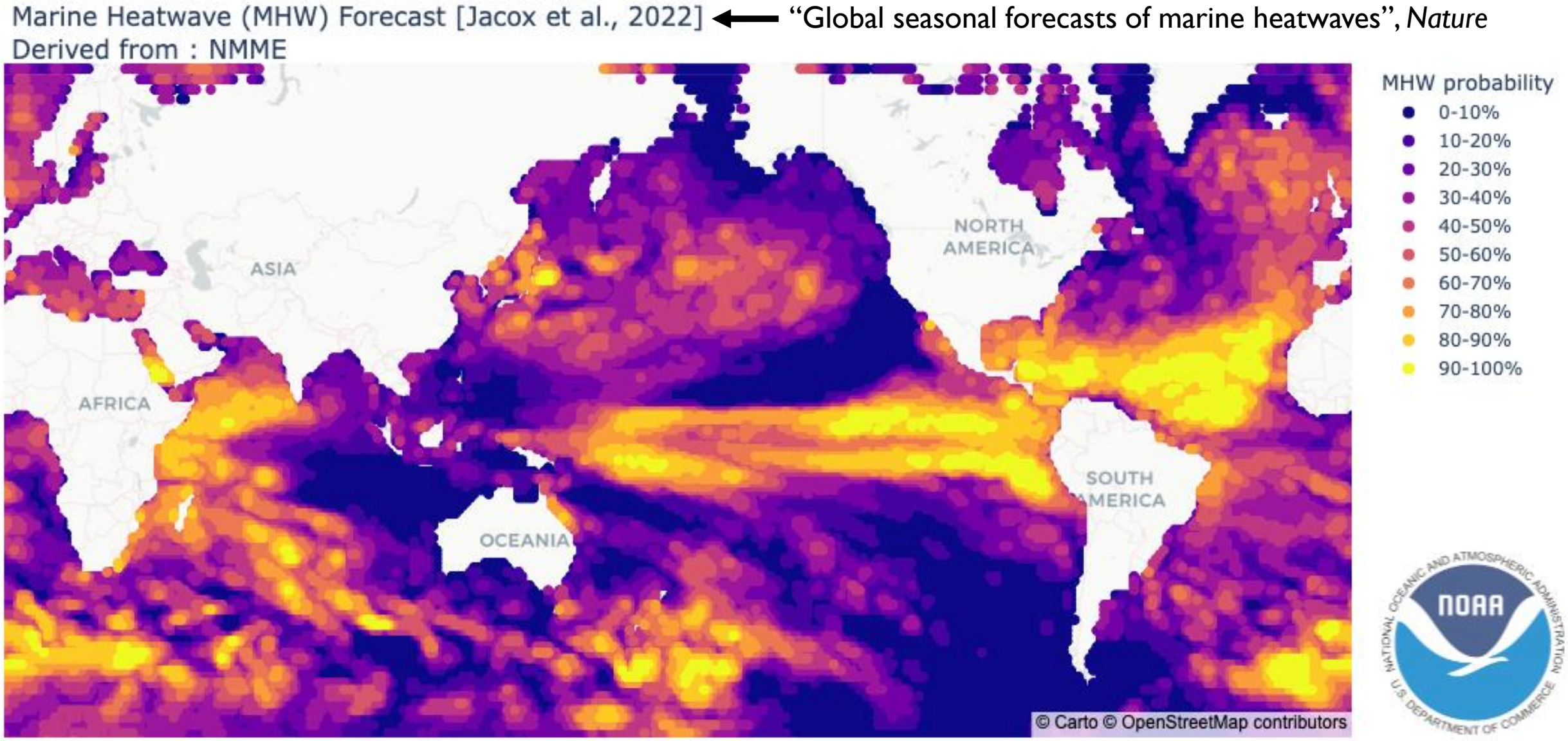
Initialization x Lead x Ensemble x Lat x Lon

Calculate MHW forecast probability as fraction of ens. members with events

Repeat for each of six models → ~70 member monthly MHW forecast

Jacox et al. (2022), *Nature*

https://psl.noaa.gov/marine-heatwaves



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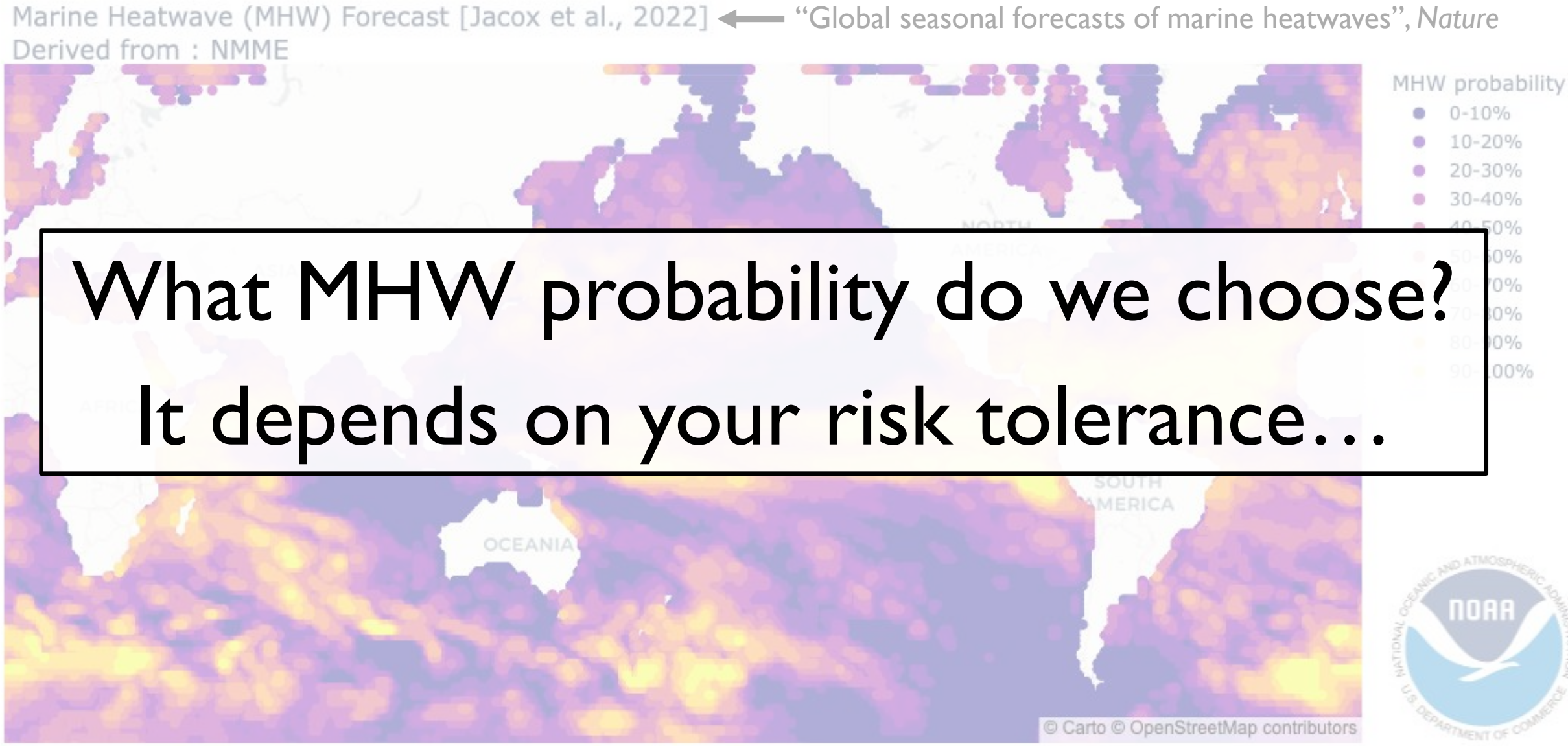

"Global seasonal forecasts of marine heatwaves", *Nature*

What MHW probability do we choose?

It depends on your risk tolerance…

Initialized July 2023

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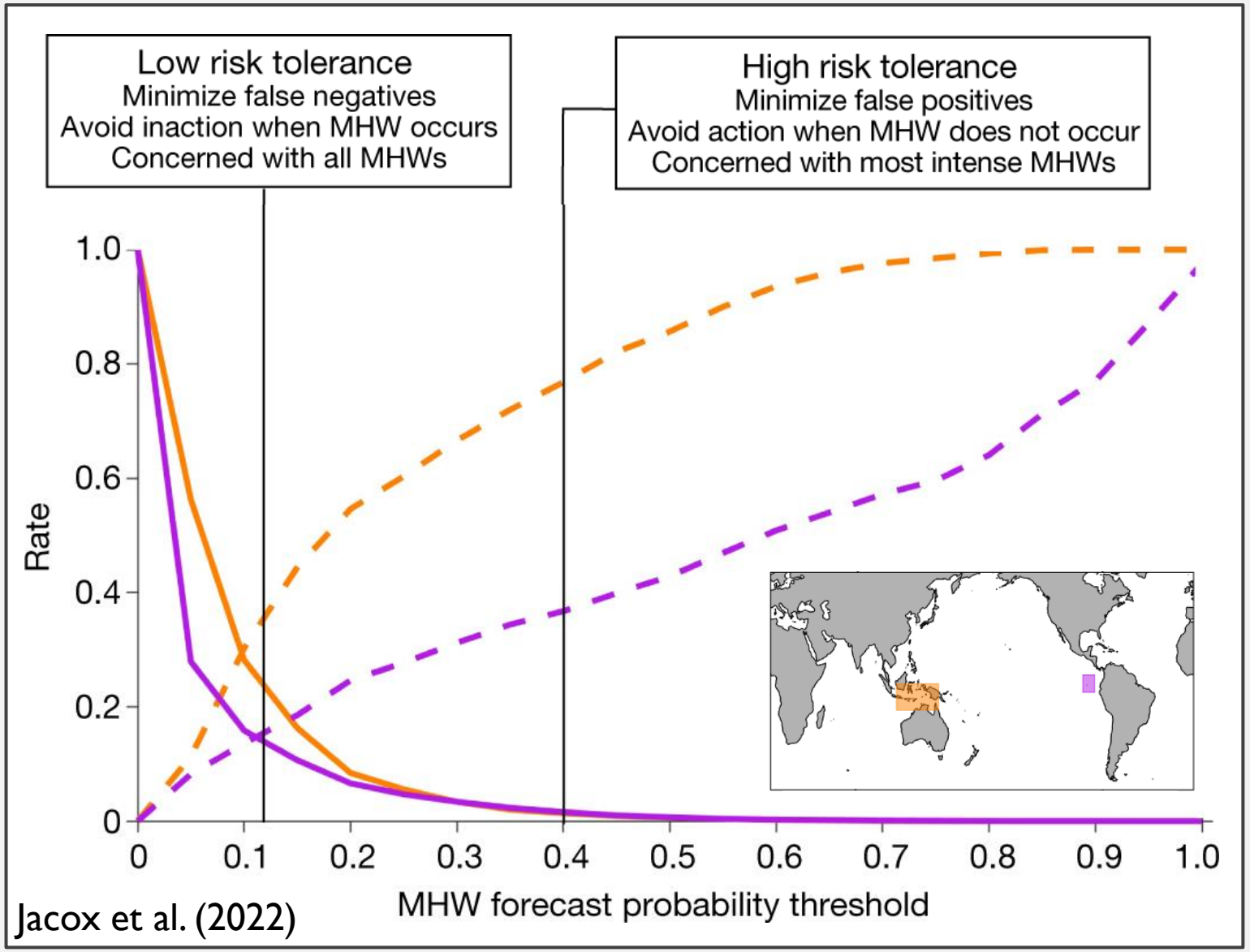
Detecting MHWs in a forecast system



False Positive – A forecasted event that does not occur.

False Negative - A forecasted non-event that does occur.

False Positive

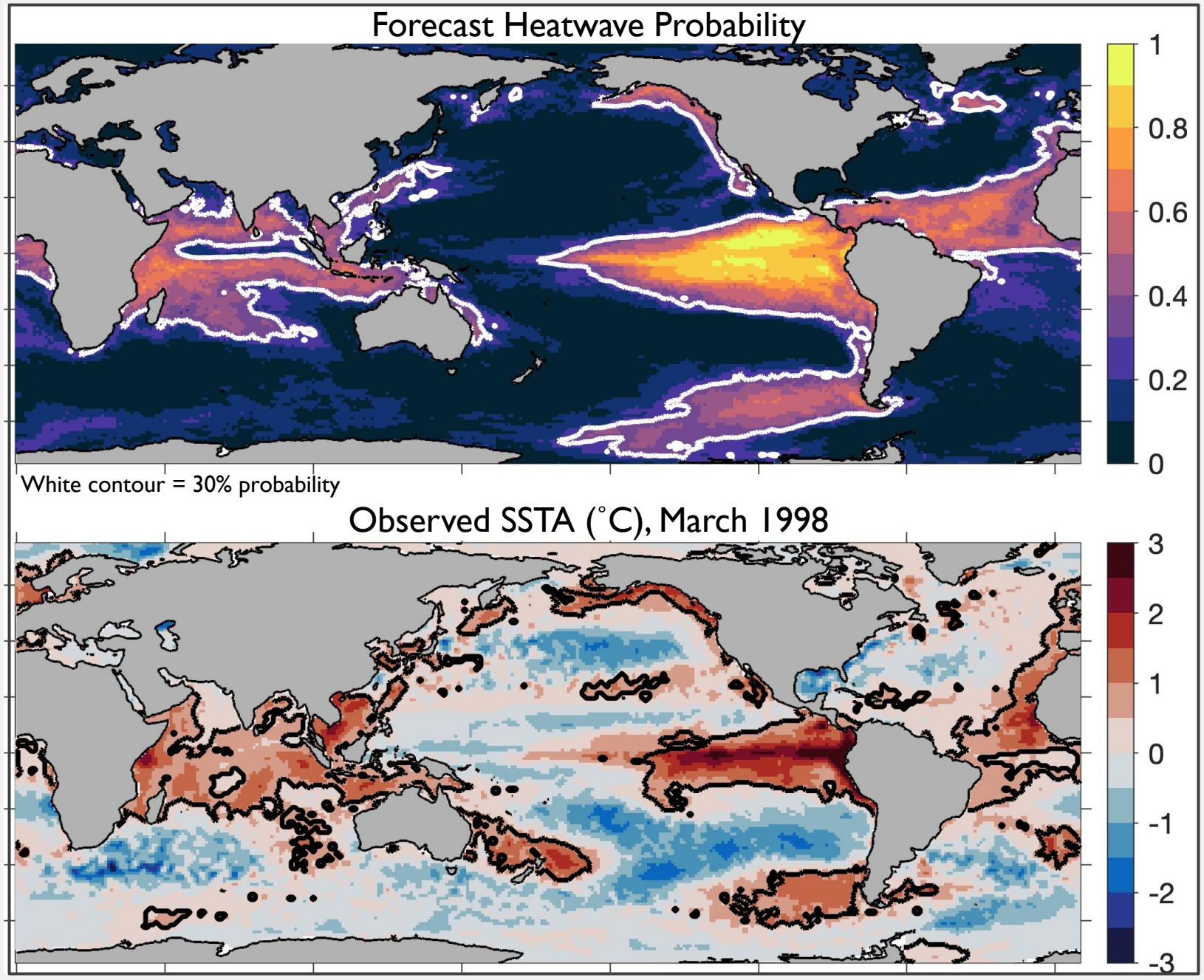
False Negative

Example MHW forecast

July 1997 forecast

8.5 month lead time

March 1998 heatwaves



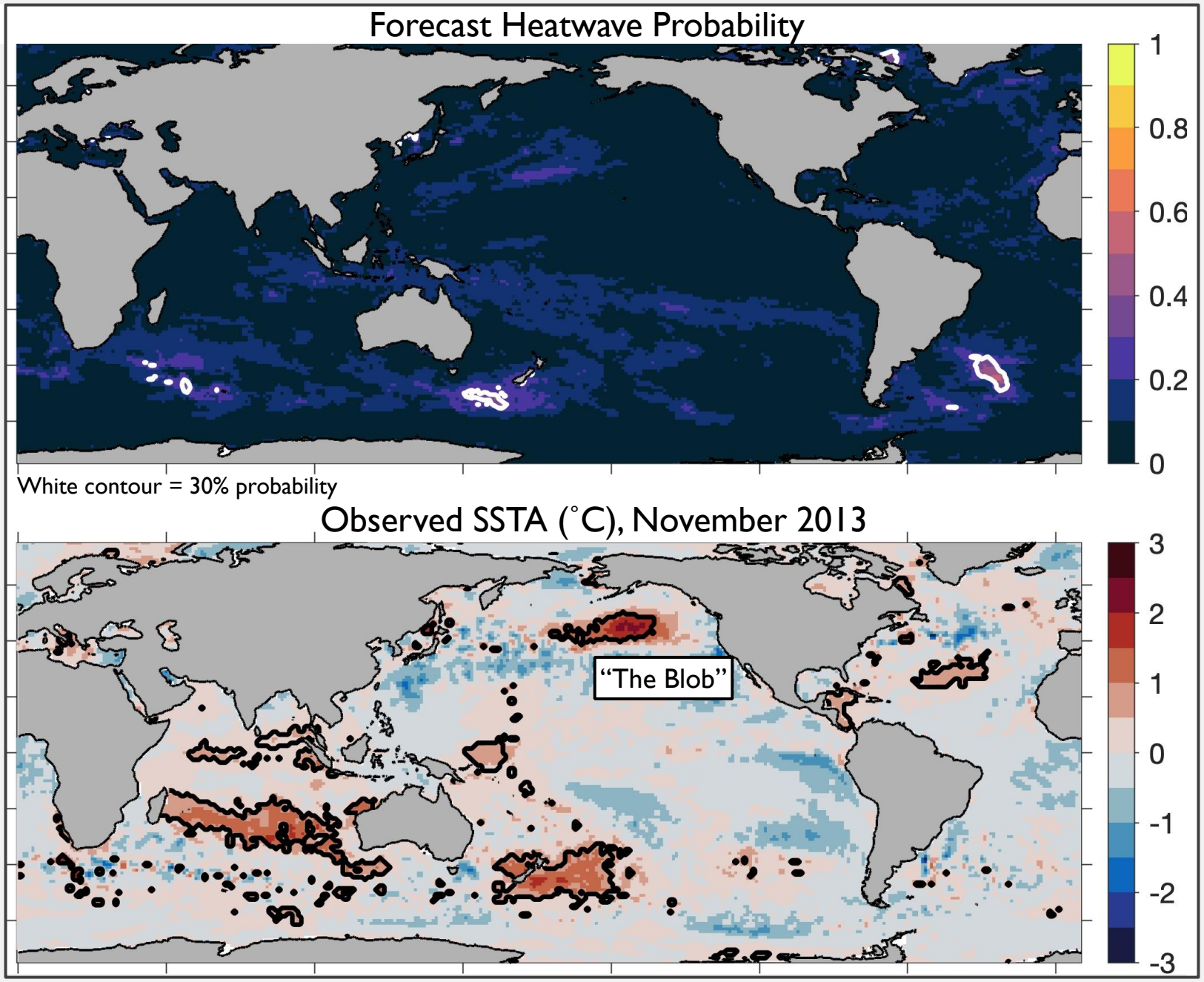
Figures courtesy of Mike Jacox

Example MHW forecast

March 2013 forecast

8.5 month lead time

November 2013 heatwaves



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Example MHW forecast

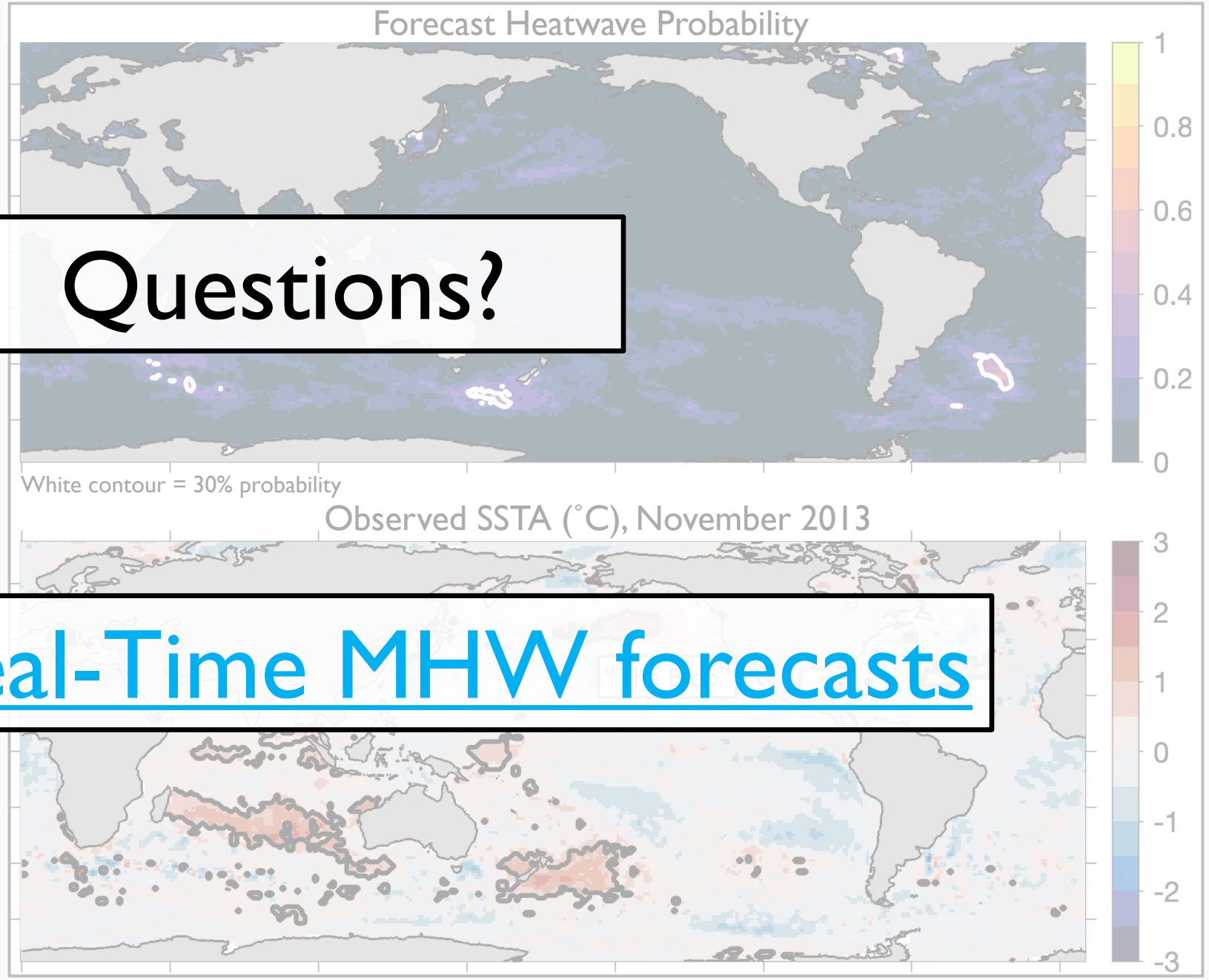
March 2013 forecast

8.5 month lead time

November 2013 heatwaves

Questions?

NOAA Real-Time MHW forecasts

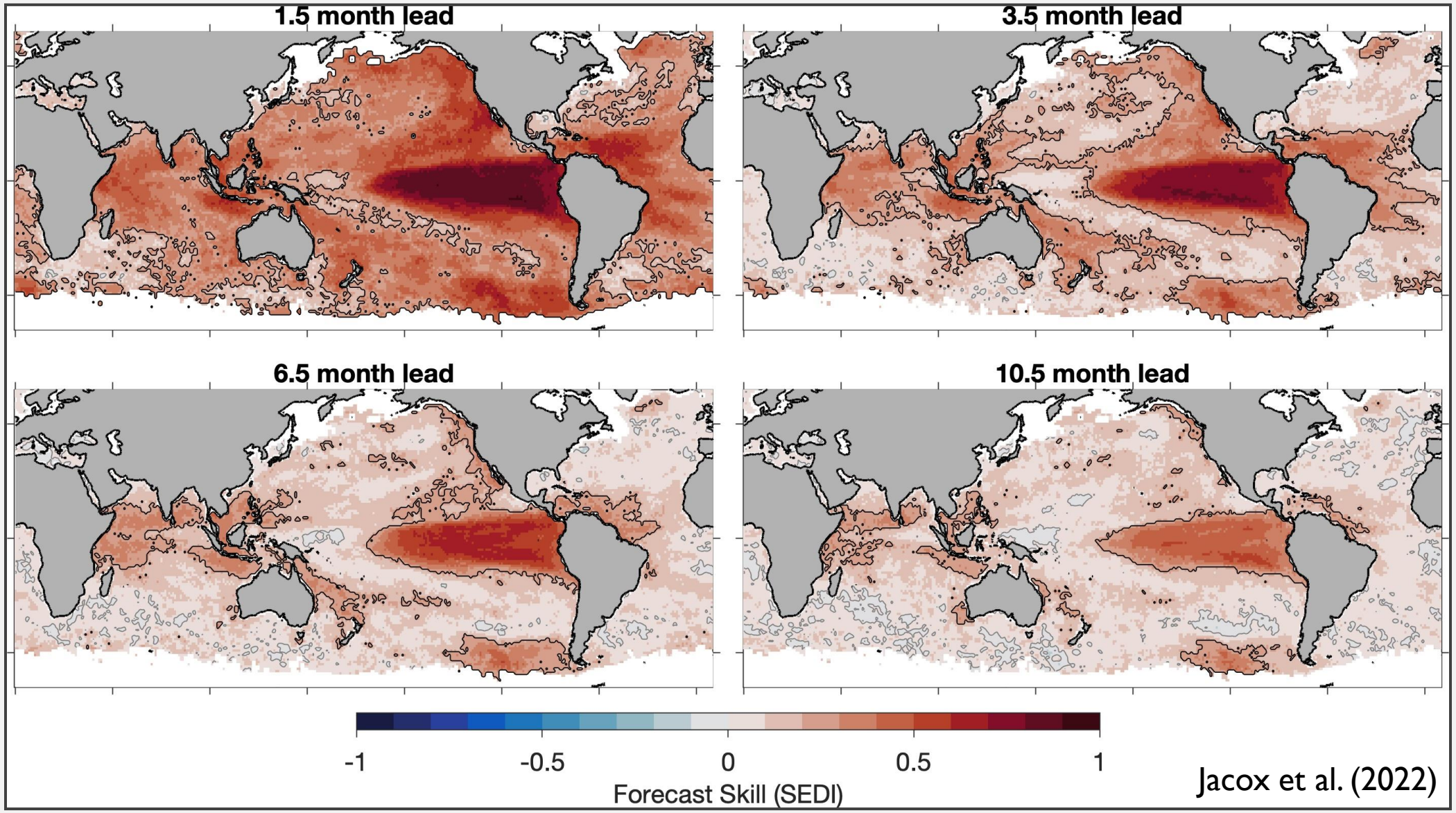


Figures courtesy of Mike Jacox

EXTRA SLIDES

MHW historical forecast skill

SEDI = Symmetrical Extremal Dependence Index



Jacox et al. (2022)

MHW historical forecast skill

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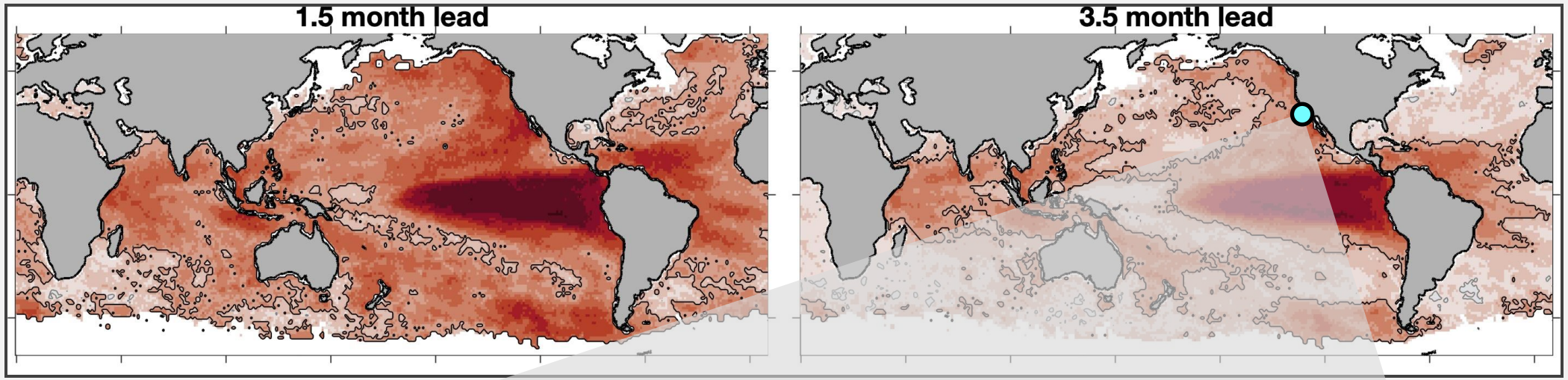
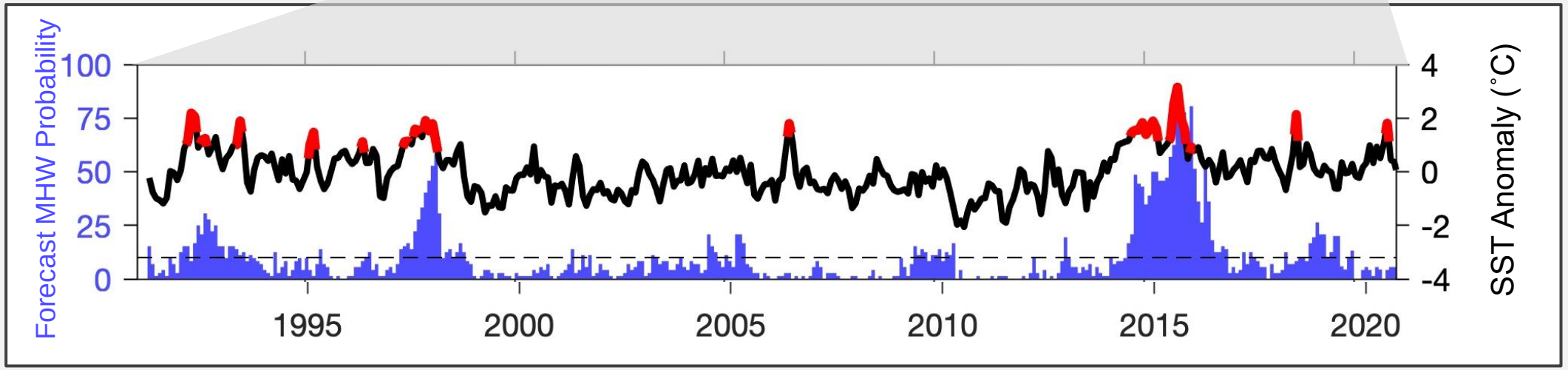


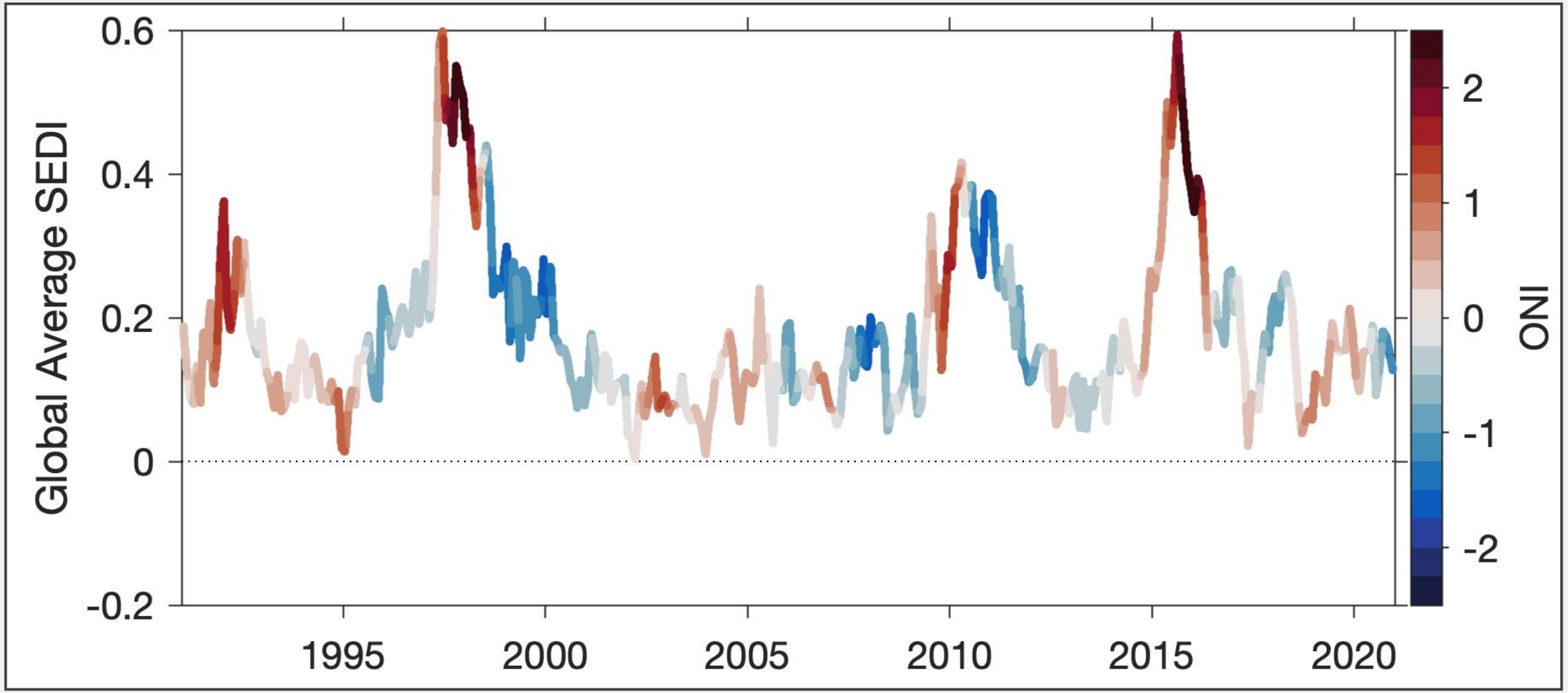


Jacox et al. (2022), *Nature*

MHW historical forecast skill

ENSO is dominant driver of forecast skill (on seasonal timescales)

3.5 forecast lead time



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