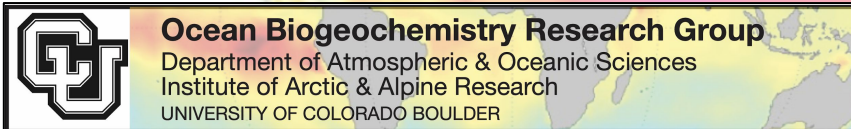


Multi-month forecasts of marine heatwaves and ocean acidification extremes

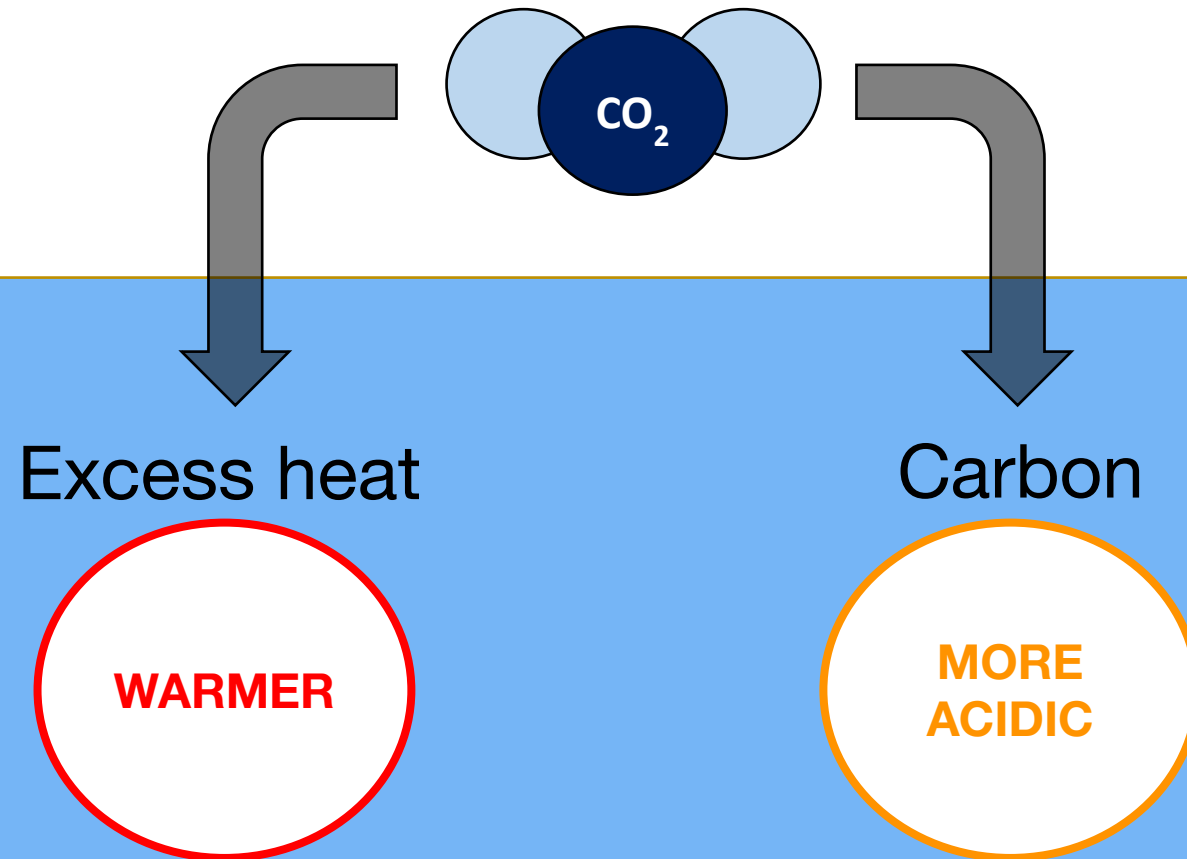
Samuel Mogen

Nikki Lovenduski, Stephen Yeager, Antonietta Capotondi, Michael G. Jacox,
Steven J. Bograd, Emanuele Di Lorenzo, Elliott L. Hazen, Mercedes Pozo Buil,
Who Kim, Nan Rosenbloom



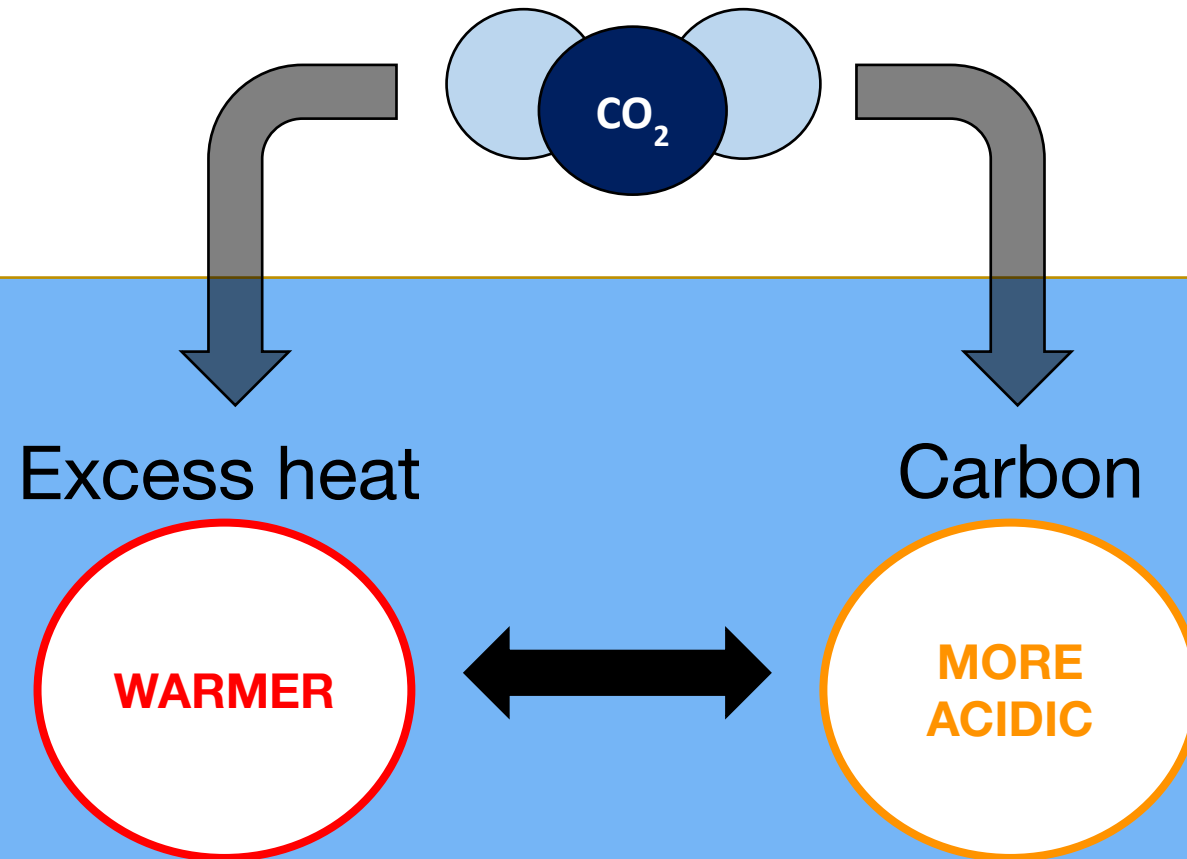
Climate Change:

long-term threats for marine ecosystems



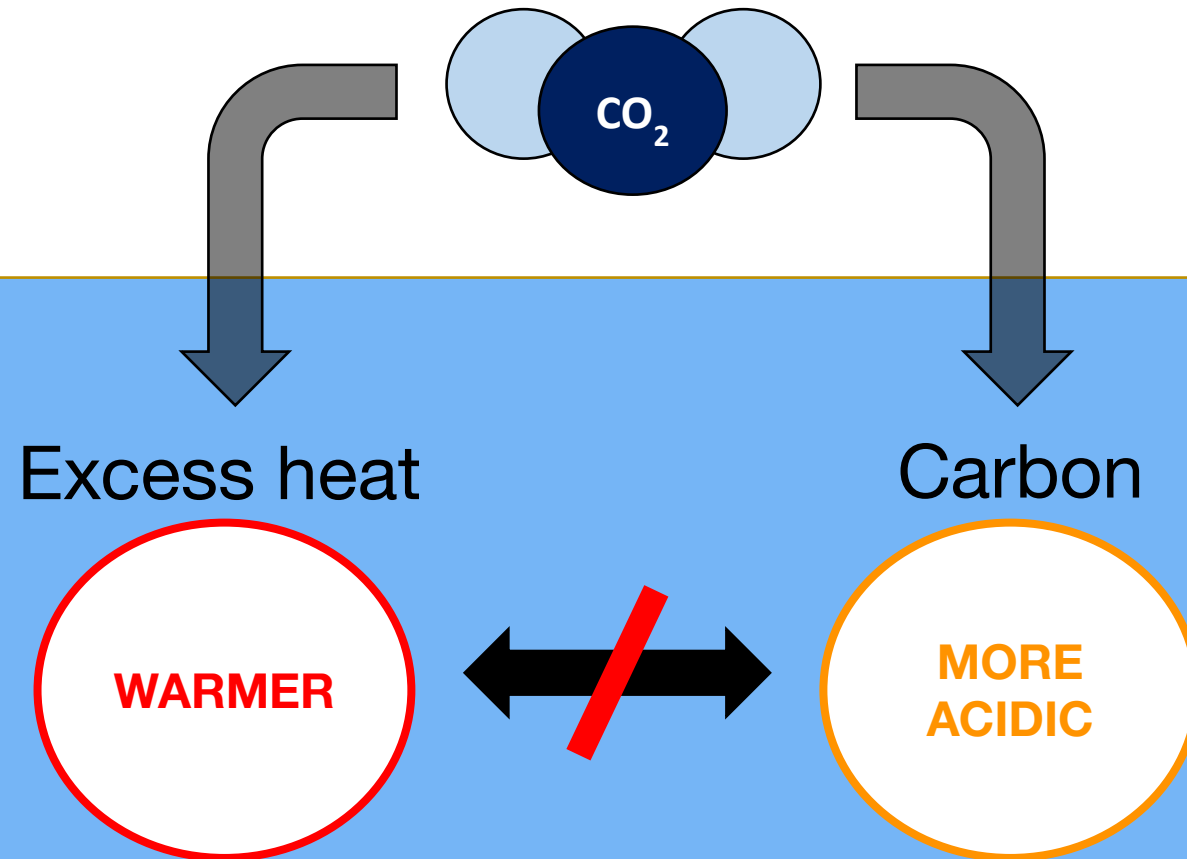
Climate Change:

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Climate Change:

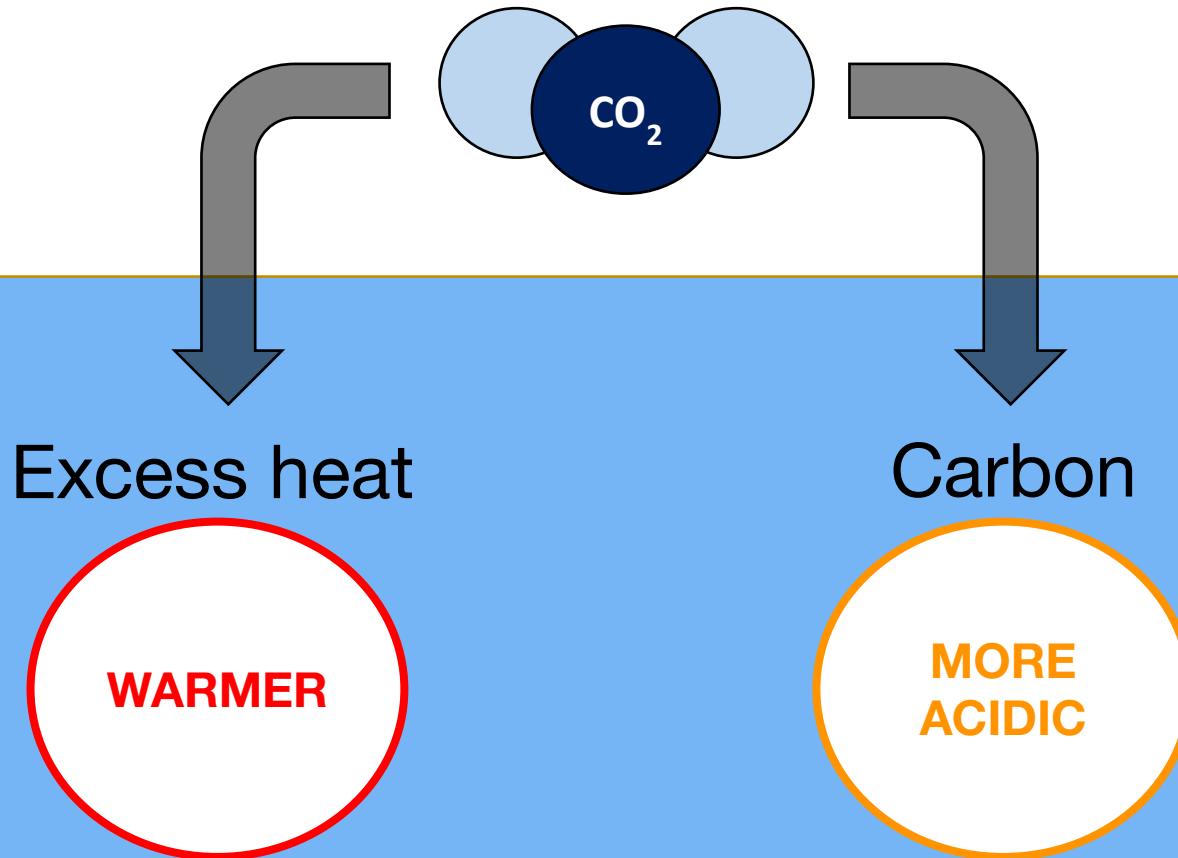
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Climate Change:

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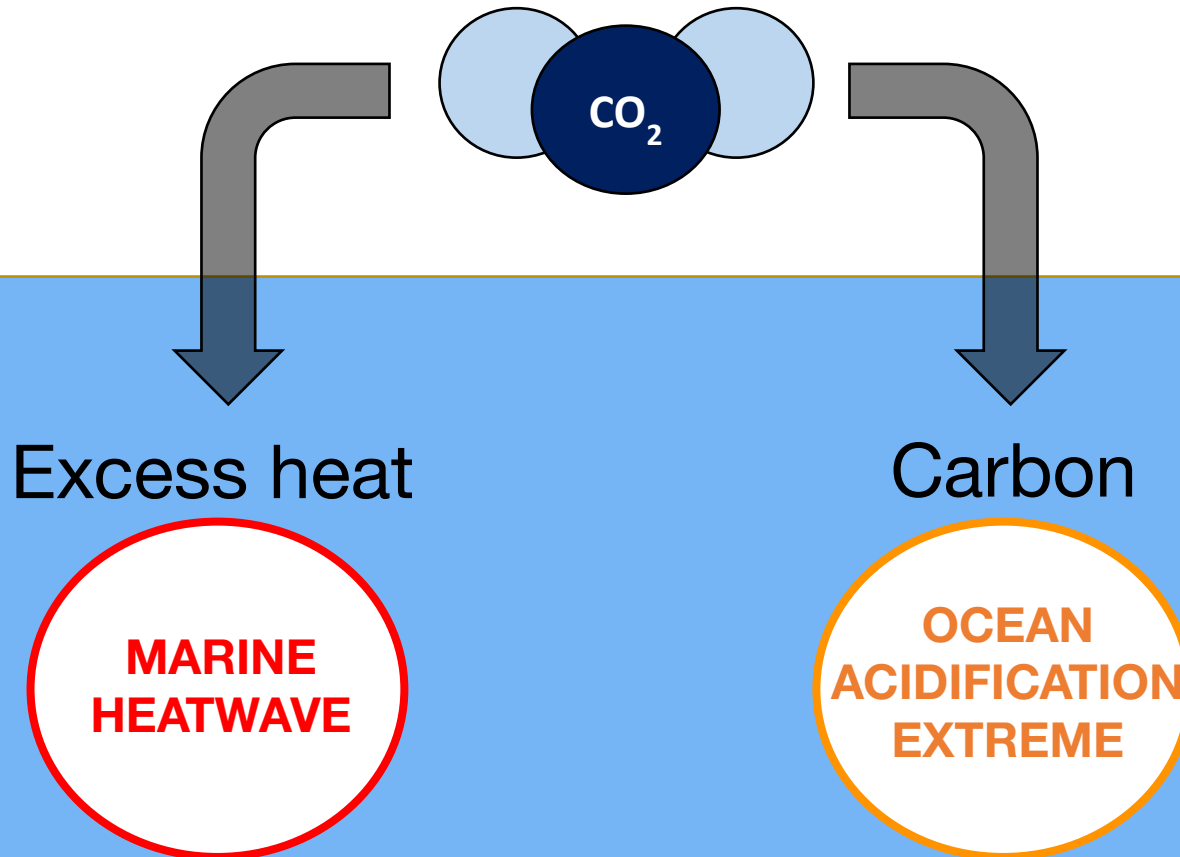
growing concern about the impacts of **short-term variability** and **extreme events**



Climate Change:

long-term threats for marine ecosystems

growing concern about the impacts of **short-term variability** and **extreme events**



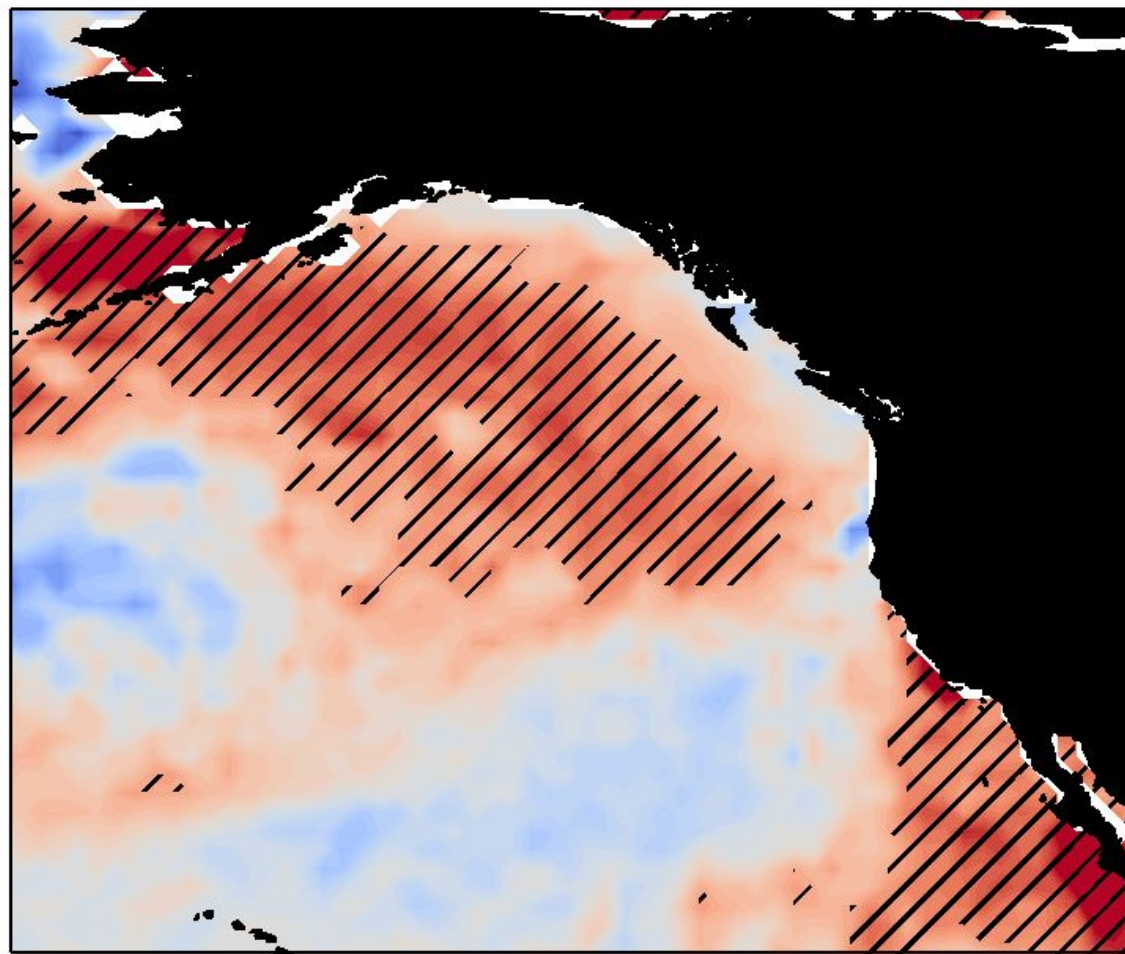
Marine Heatwaves (MHW)

SSTa > 90th percentile

The Blob (2013-16)

Forced by
persistent high
pressure ridge

Negative impacts
on marine
ecosystems, from
primary producers
to larger organisms



July,
2014

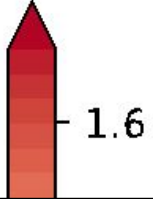
hatching indicates extreme

SSTa (°C)

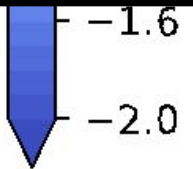
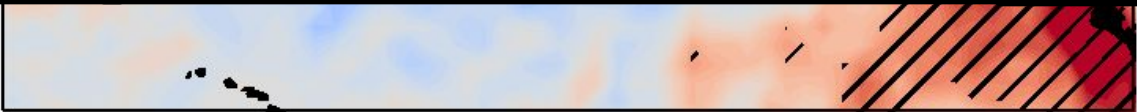
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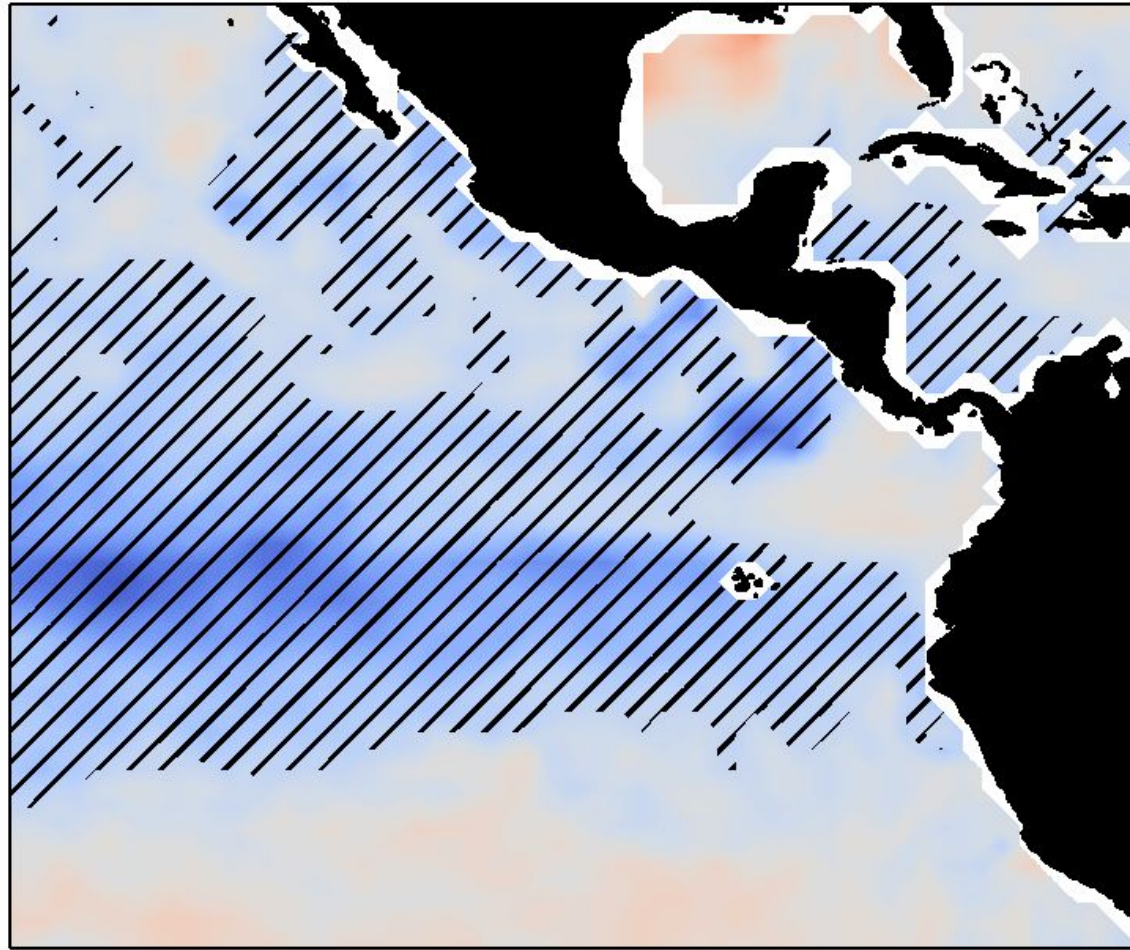
hatching indicates extreme

Ocean Acidification Extremes (OAX)

aragonite saturation state $< 10^{\text{th}}$ percentile

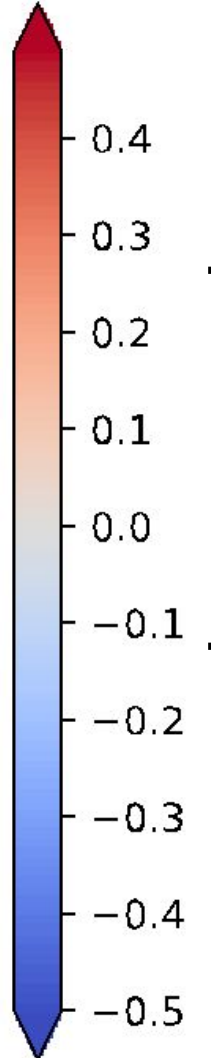
OAX are relatively understudied but also threaten marine ecosystems

Enhanced vertical mixing brings corrosive water to the surface



January, 2000

hatching indicates extreme

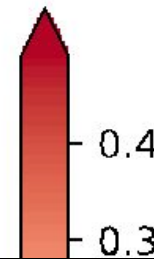


aragonite saturation
state anomaly

Ocean Acidification Extremes (OAX)

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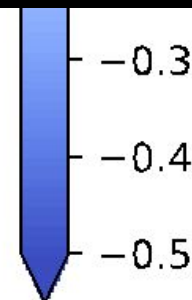


on



state anomaly

the surface

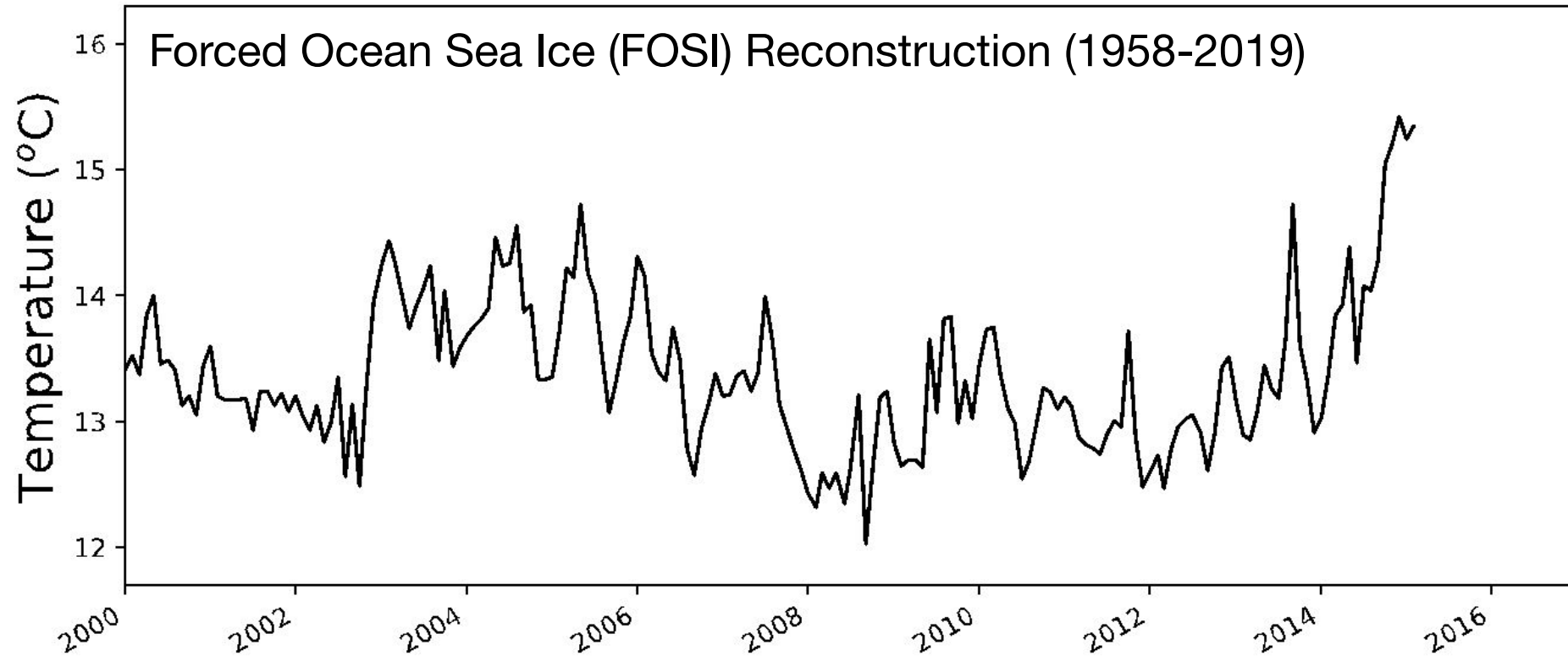


arag

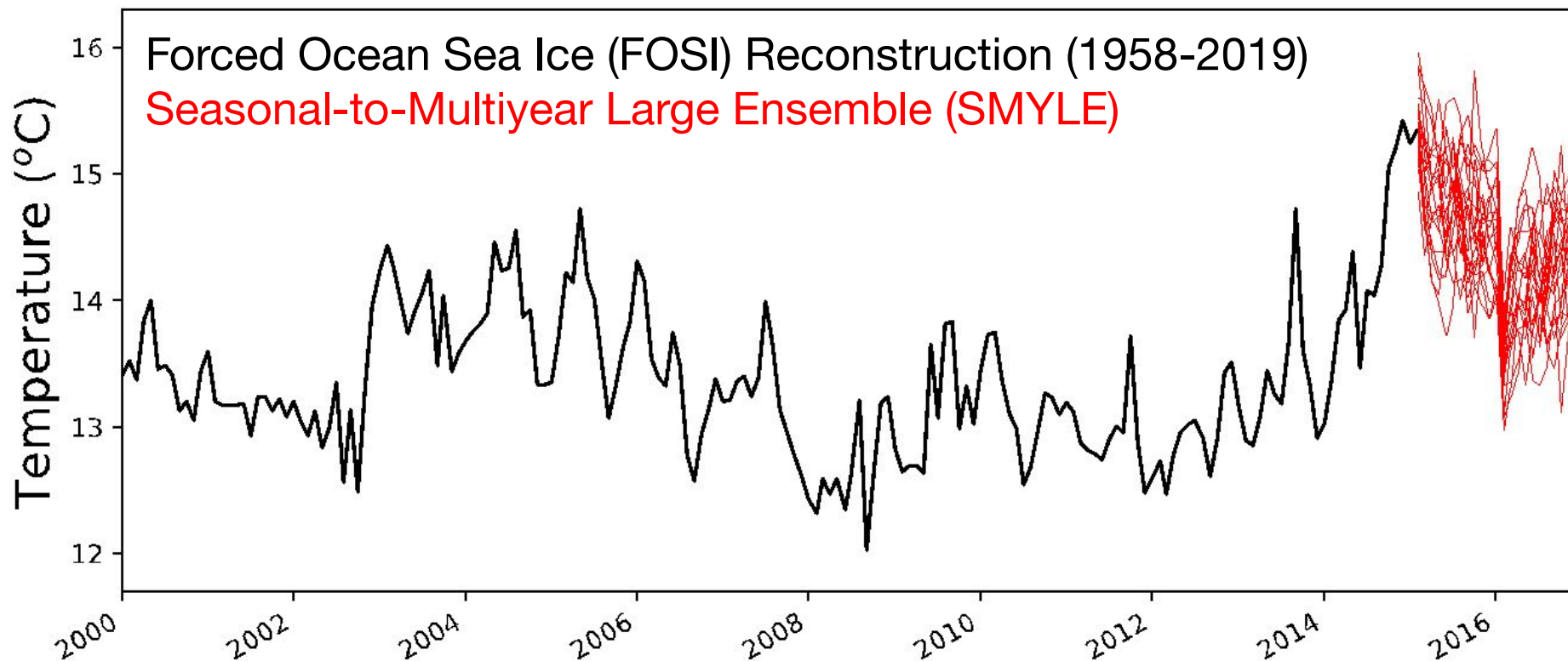
January, 2000

hatching indicates extreme

CESM2 Seasonal to Multiyear Large Ensemble (SMYLE)

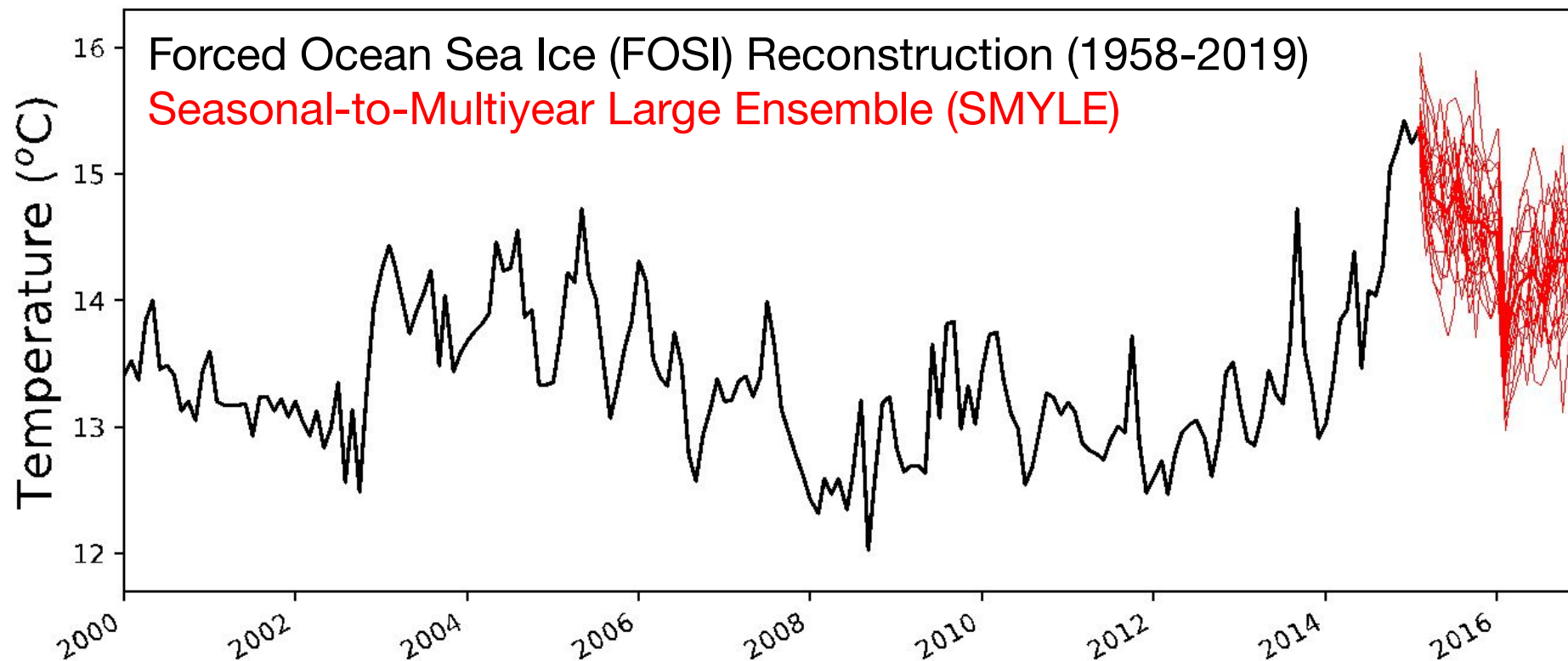


CESM2 Seasonal to Multiyear Large Ensemble (SMYLE)



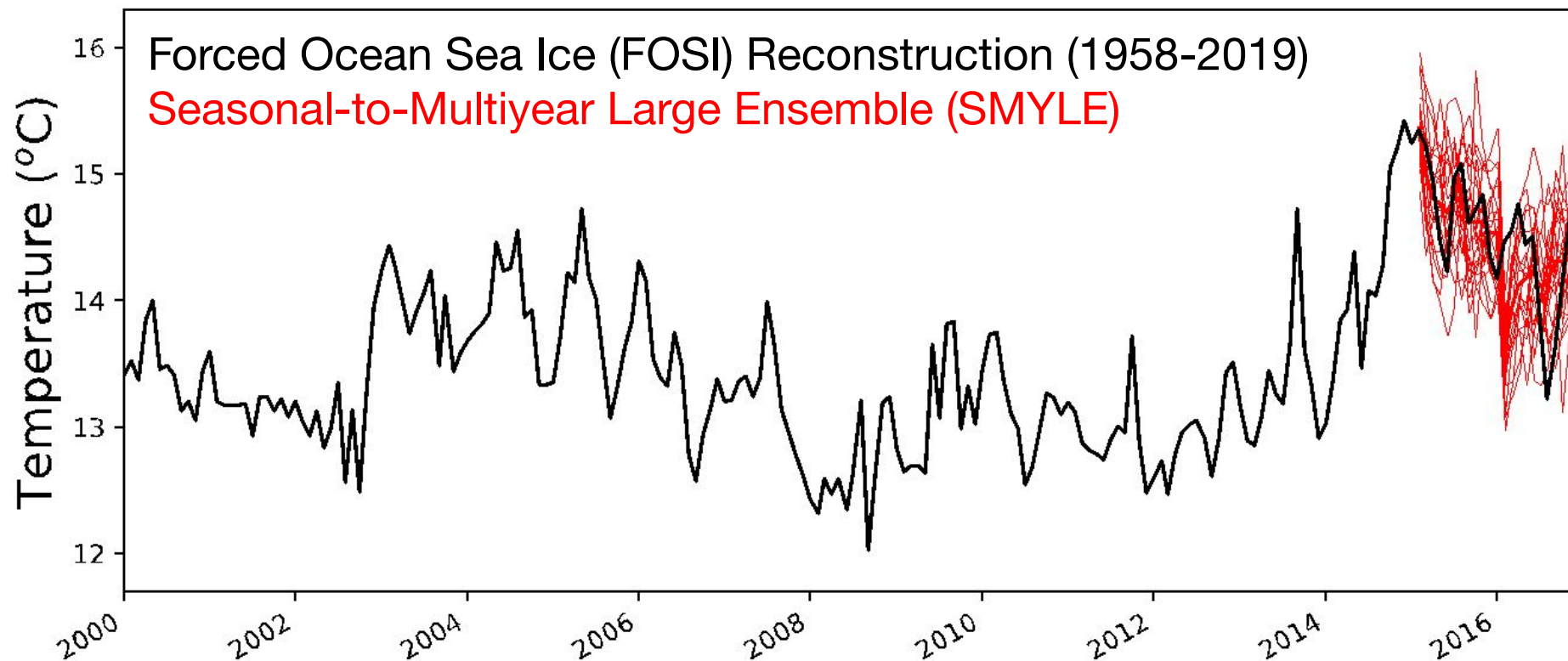
- Initialized 4 times / year (Feb. 1, May 1, Aug. 1, Nov. 1) from 1970-2019
- Each forecast integrated for 2 years

CESM2 Seasonal to Multiyear Large Ensemble (SMYLE)



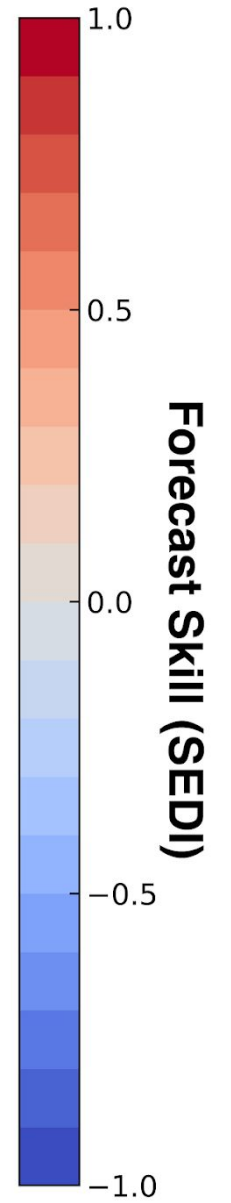
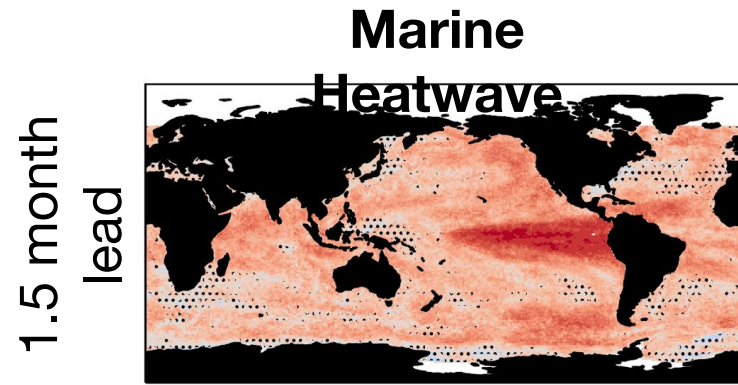
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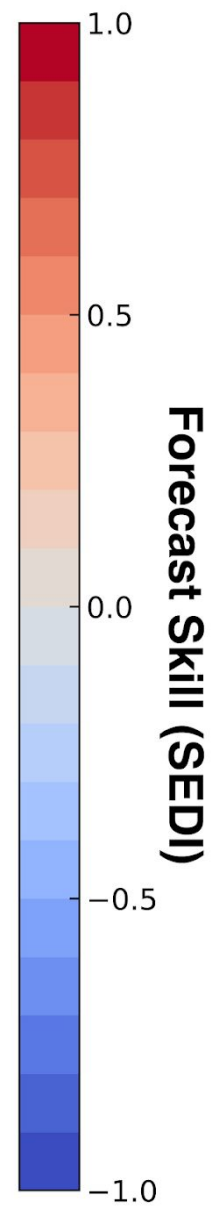
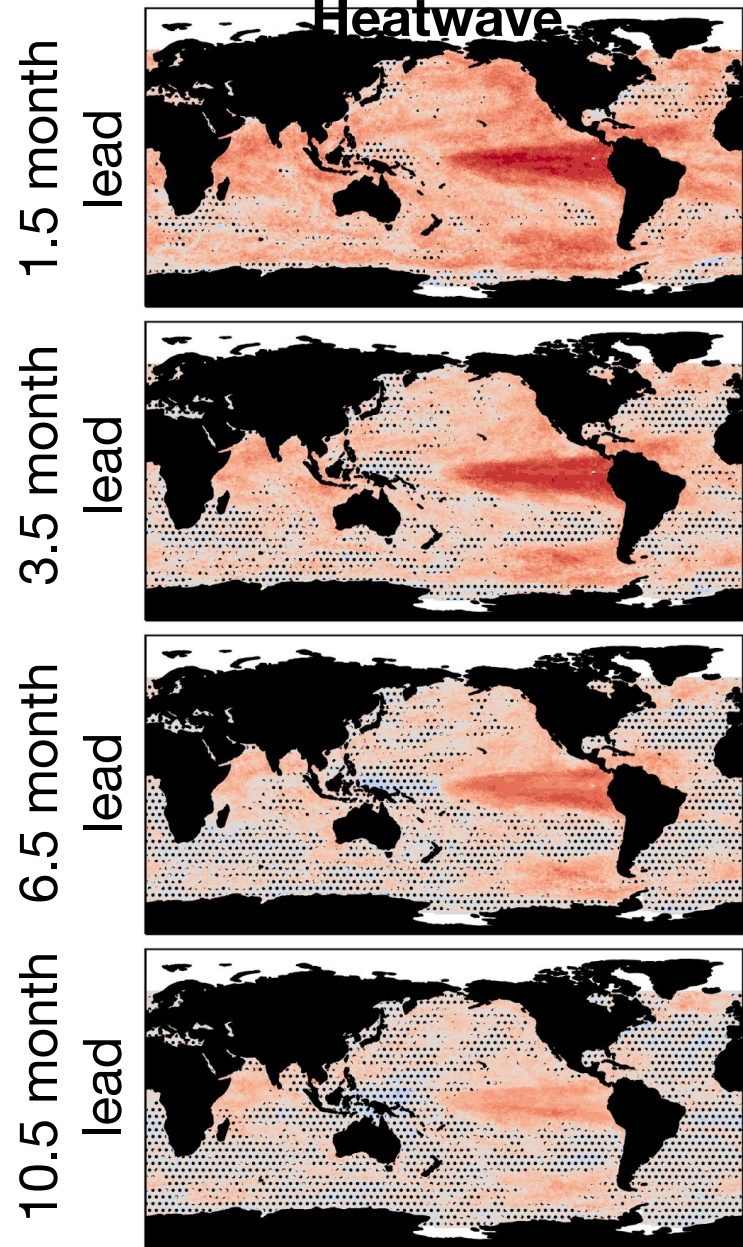
Compare to observation-based product (Gregor et al. 2020)



SEDI = Symmetric
Extremal Dependence
Index

Stippling indicates
insignificant skill

Marine Heatwave

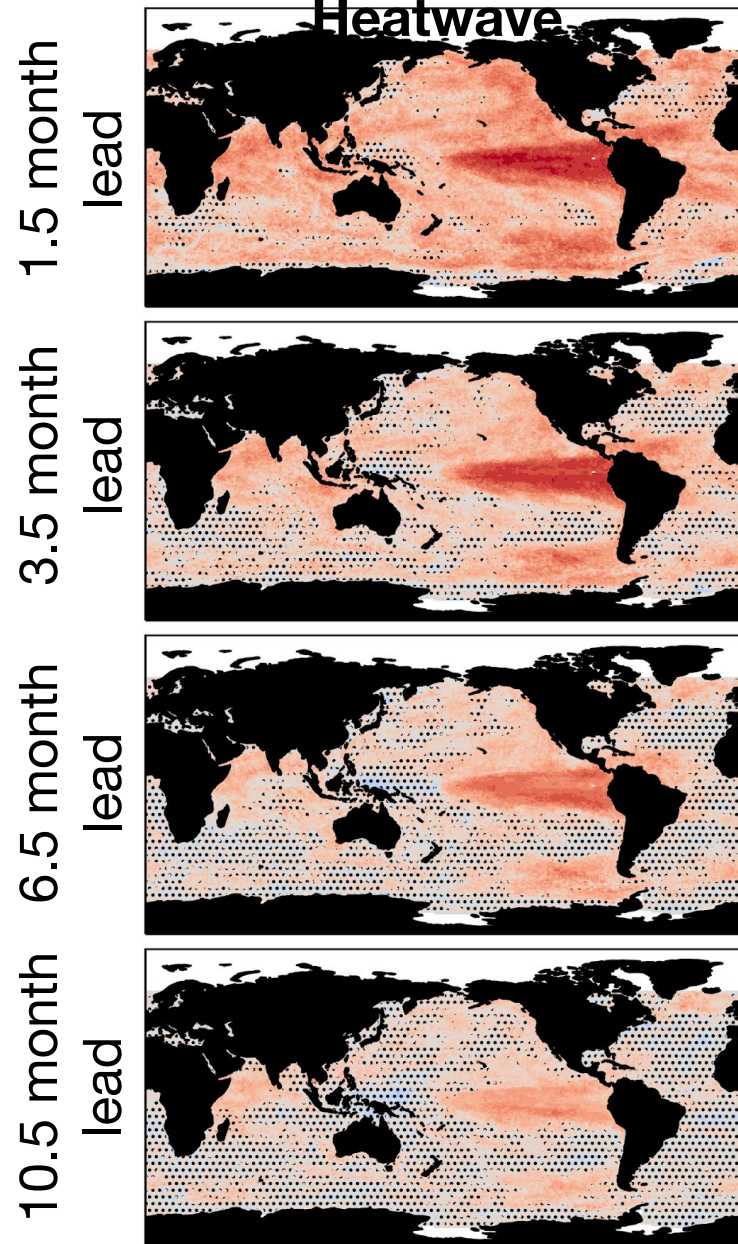


SEDI = Symmetric
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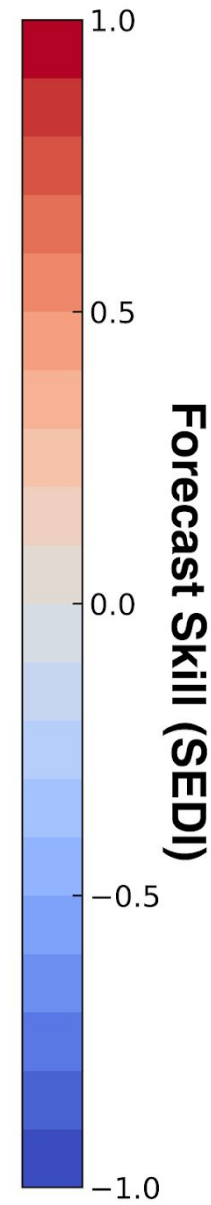
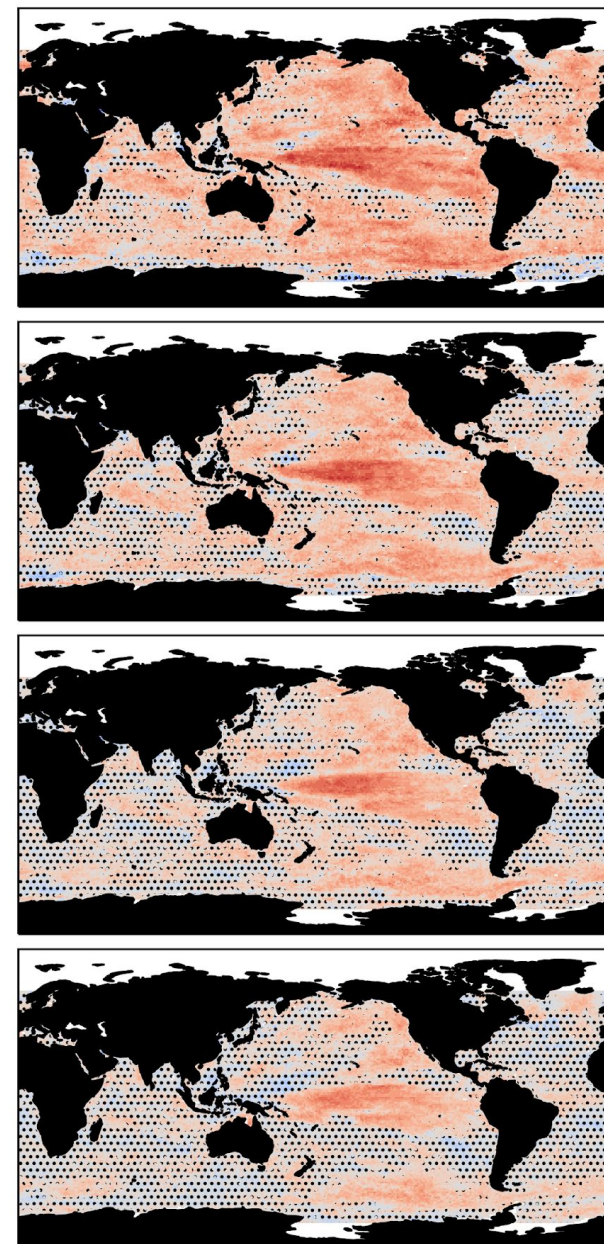
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Marine

Heatwave



Ocean Acidification Extreme



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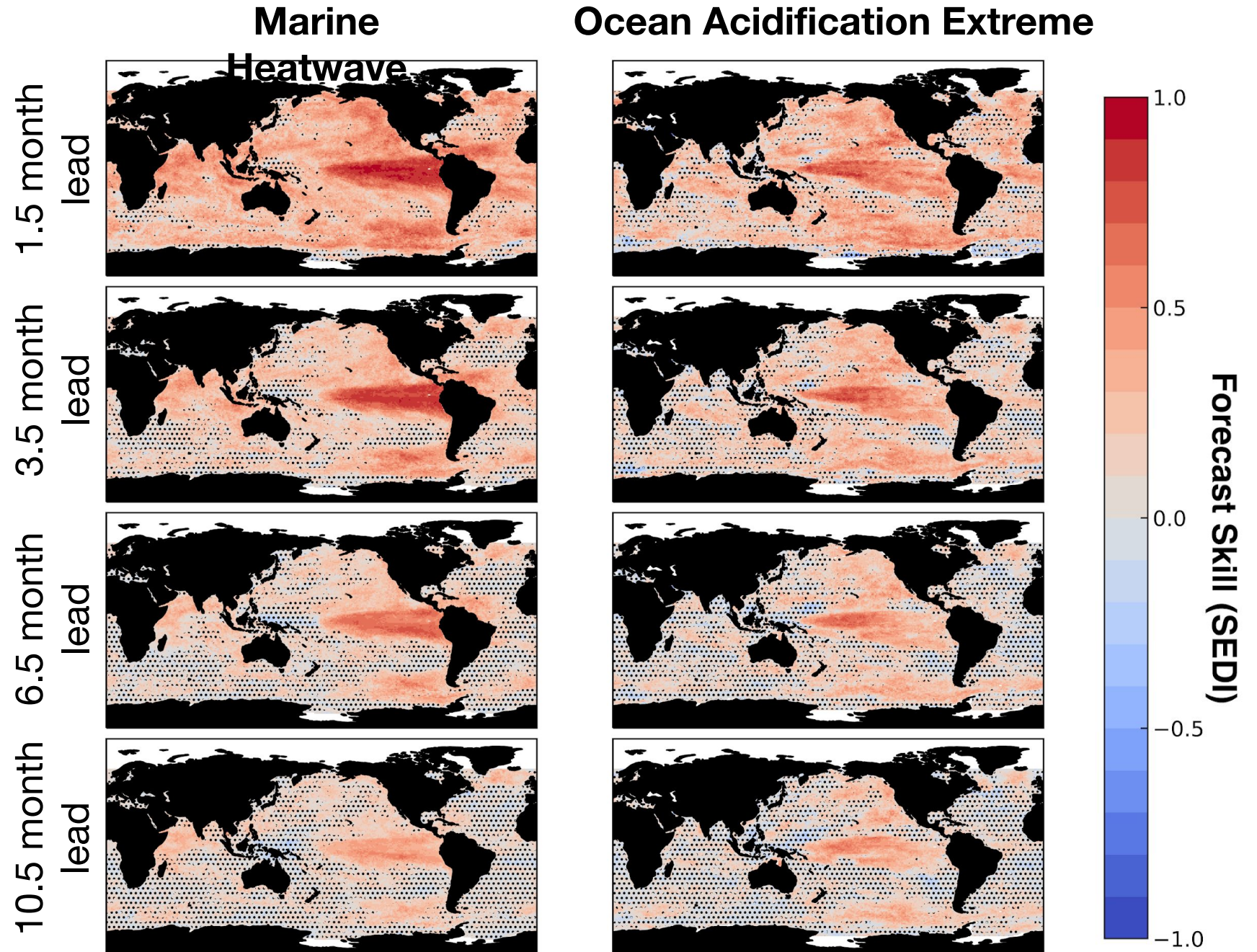
We find high skill for both MHW and OAX

Skill is highest in the eastern Pacific

SEDI = Symmetric Extremal Dependence Index

Stippling indicates insignificant skill

Mogen et al., in review *Nature Geoscience*



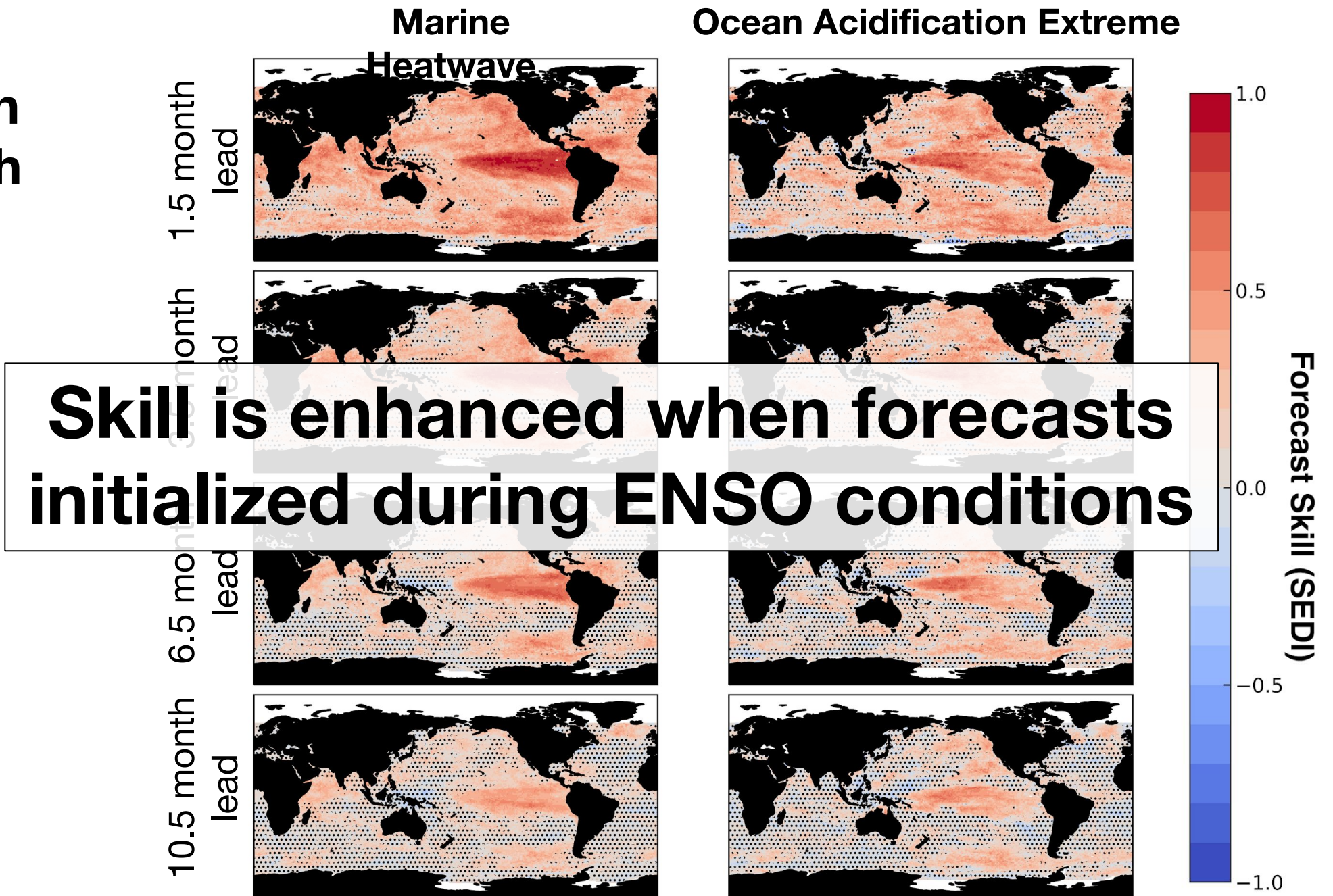
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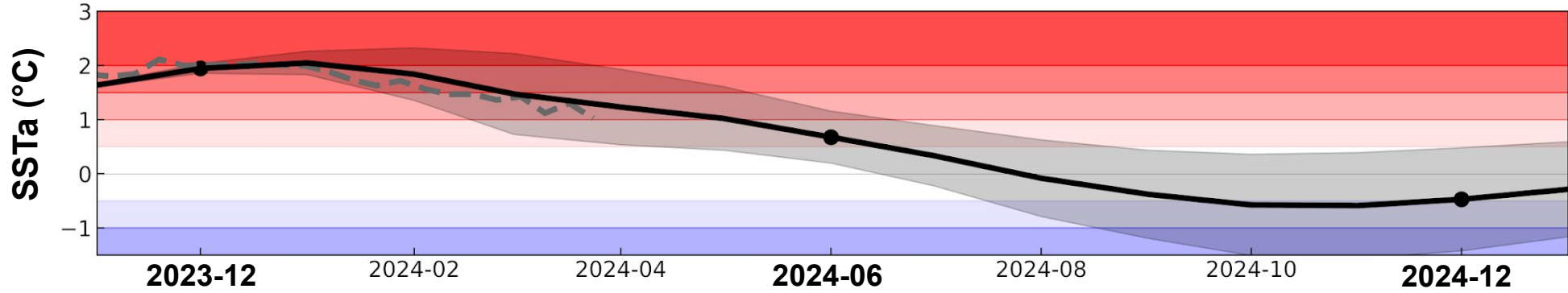
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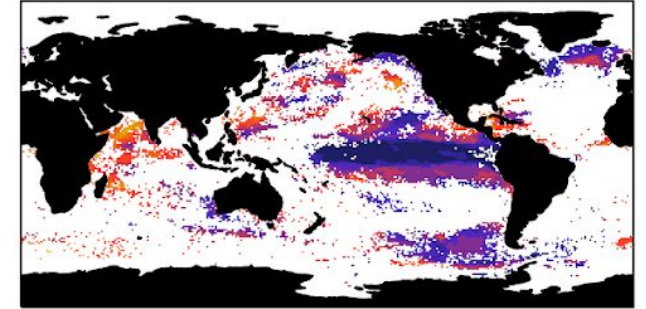
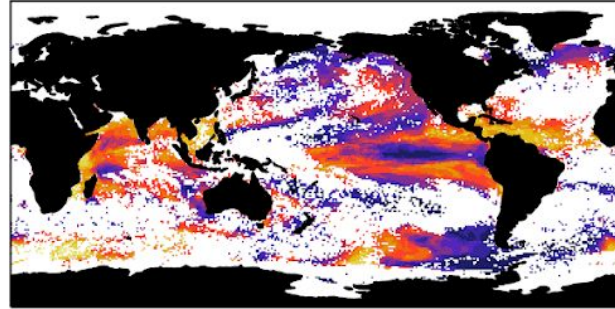
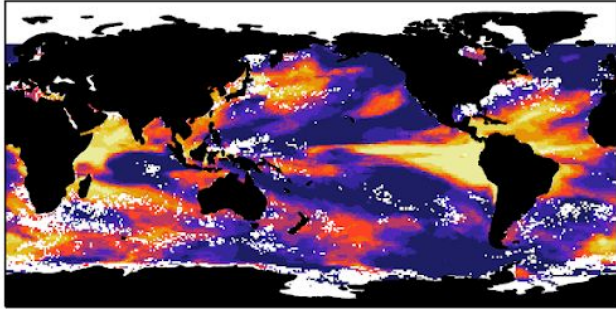
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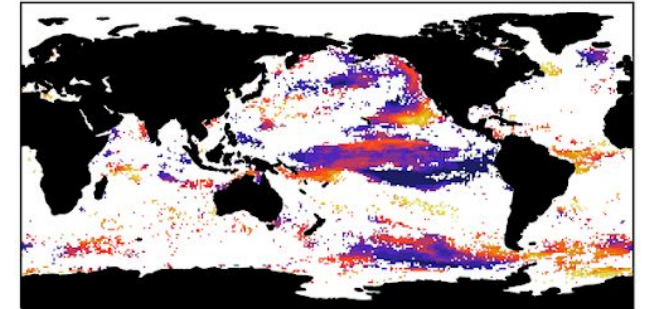
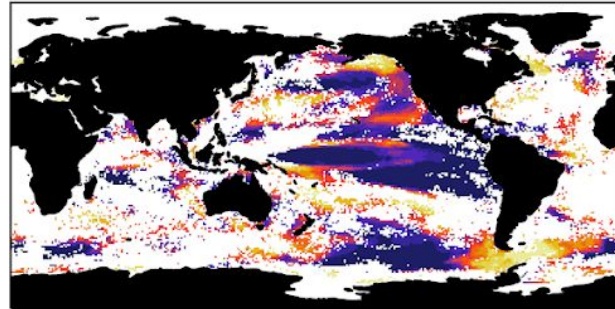
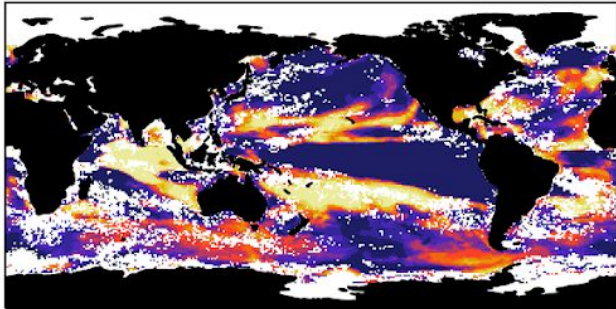
Niño3.4
Anomaly



Marine
Heatway
e



Ocean
Acidification
Extreme



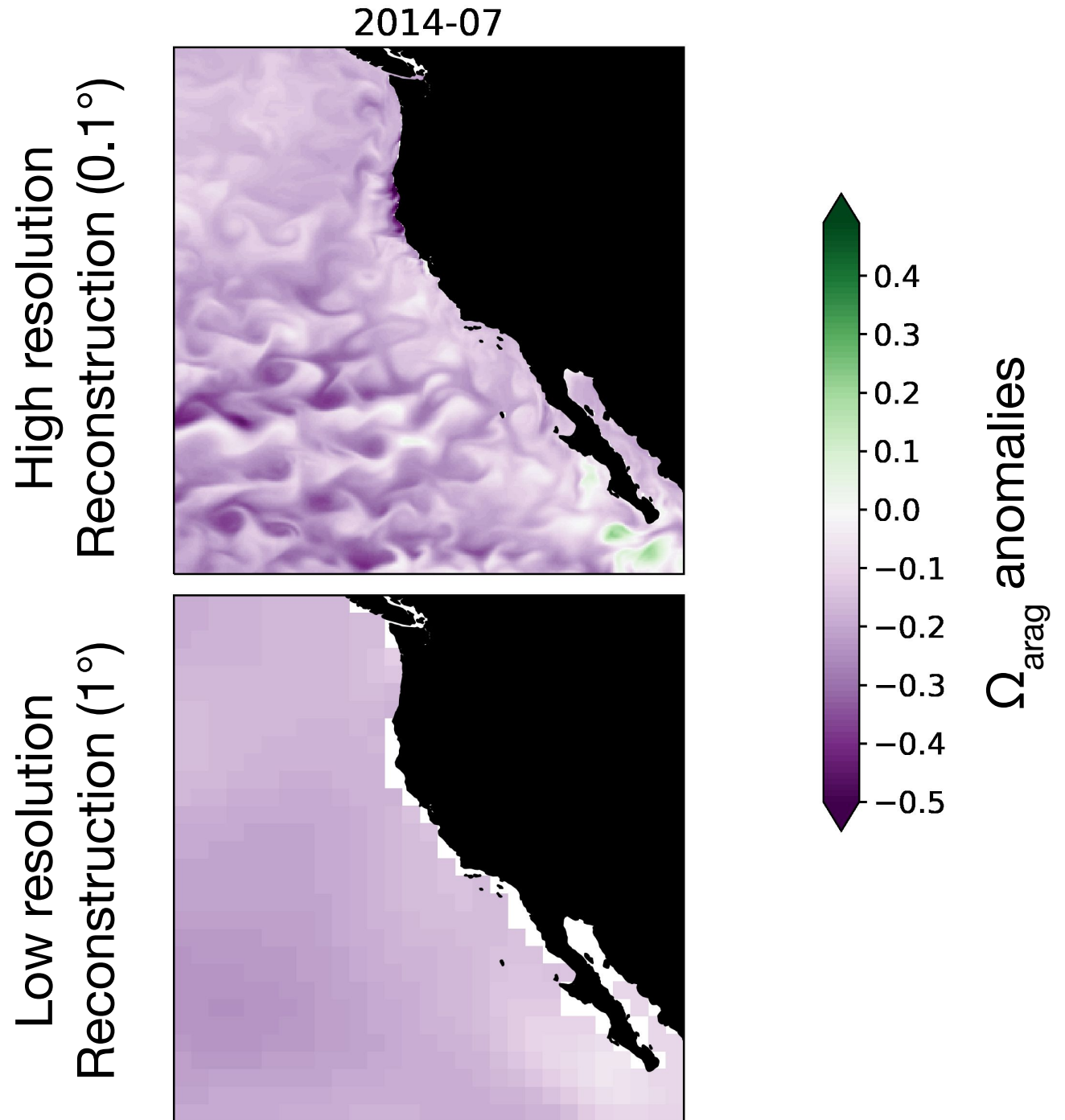
Forecast initialized in November 2023

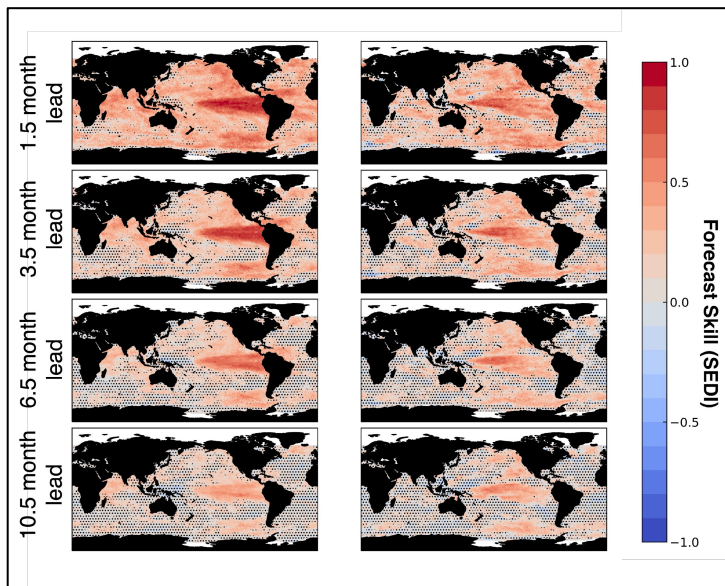
We forecast widespread MHW and OAX through 2024

Future work:

High resolution CESM
SMYLE experiments
(including ocean
biogeochemistry)

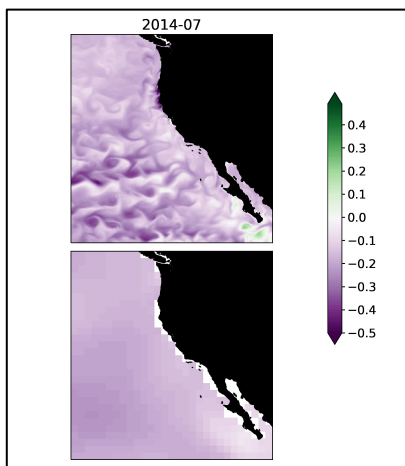
Actionable predictions
on the scales of
fisheries



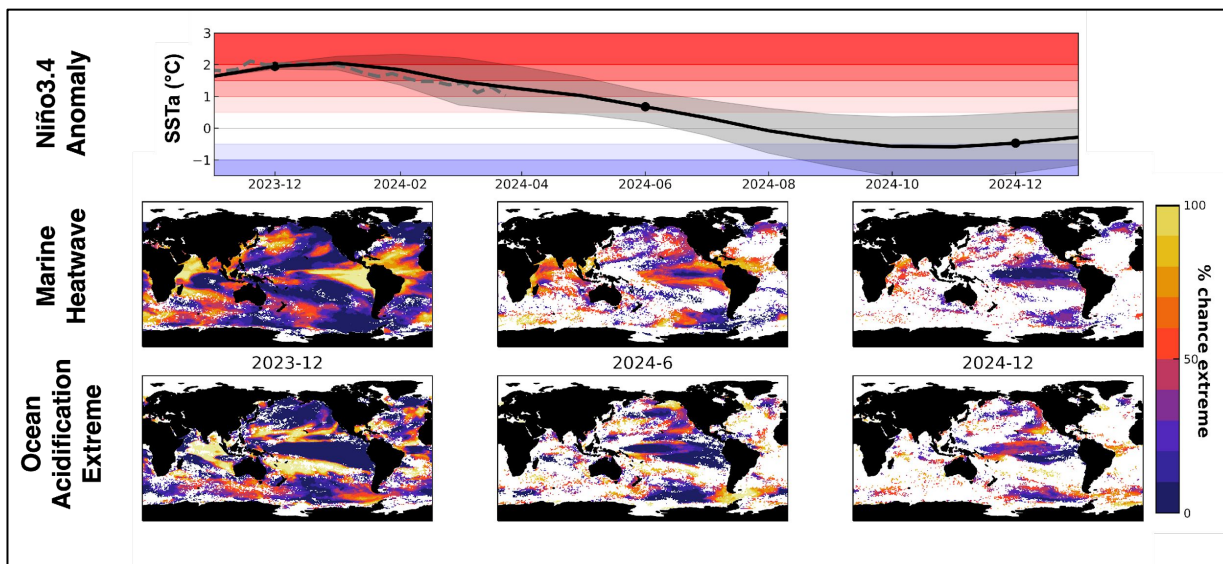


CESM SMYLE skillfully forecasts MHW and OAX up to a year in advance

CESM SMYLE forecasts widespread MHW and OAX in key regions in 2024

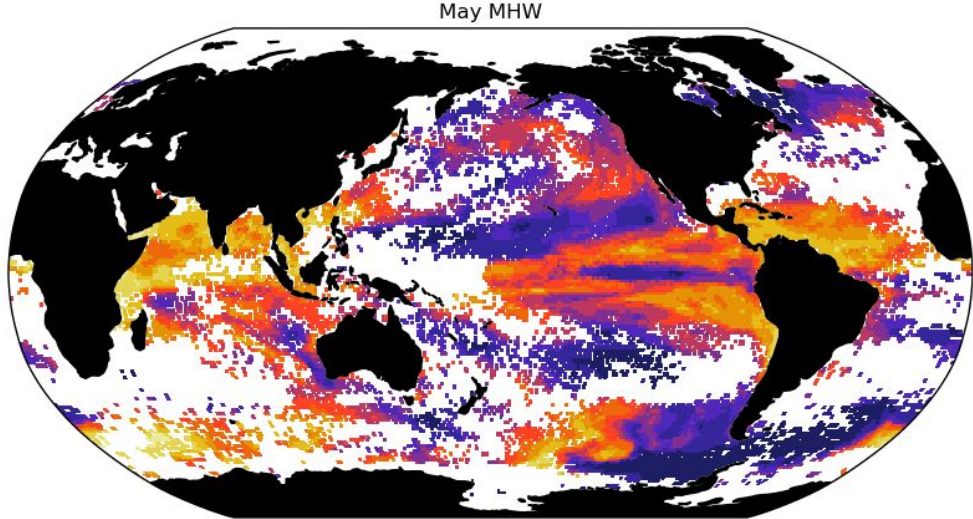


Next, we plan to generate high resolution forecasts of regional biogeochemical signals



supplemental

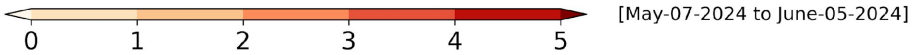
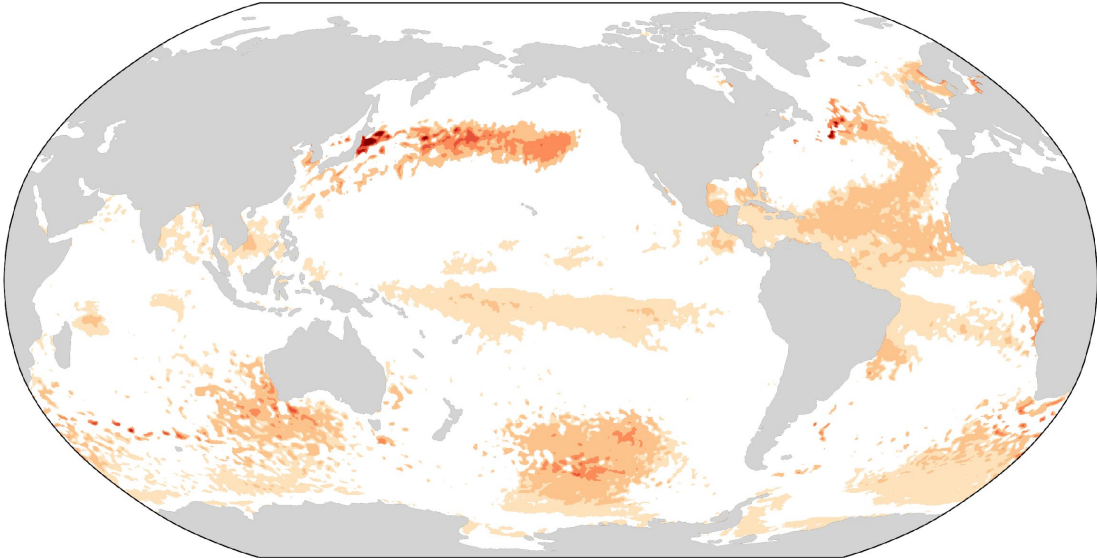
CESM SMYLE Nov., 2023 Forecast of May, 2024



May MHW

MHW in May, 2024

OISS 2024

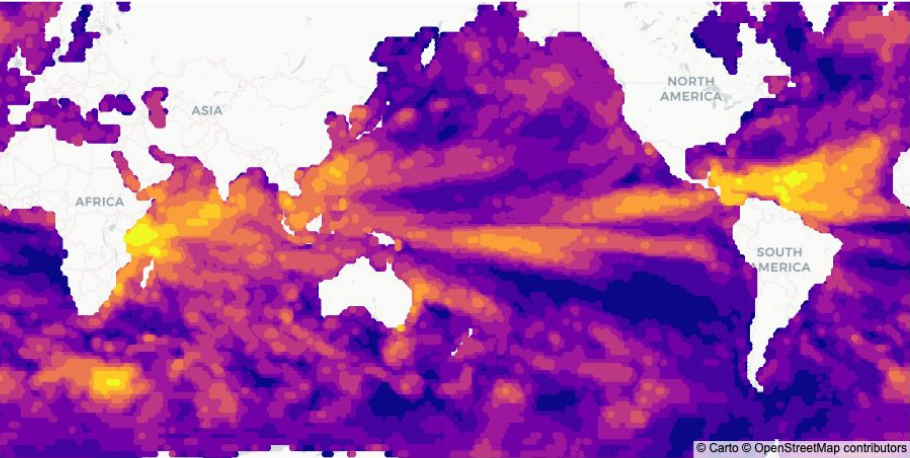


Past 30 Days Marine Heatwave Magnitude (°C)

[May-07-2024 to June-05-2024]

NMME Nov., 2023 Forecast of May, 2024

Marine Heatwave (MHW) Forecast [Jacox et al. 2024]
Derived from : NMME



- MHW probability
- 0-10%
- 10-20%
- 20-30%
- 30-40%
- 40-50%
- 50-60%
- 60-70%
- 70-80%
- 80-90%
- 90-100%



Lead time = 6.5 months (05/2024)

Symmetric Extremal Dependence Index

$$SEDI = \frac{\log(F) - \log(H) - \log(1 - F) + \log(1 - H)}{\log(F) + \log(H) + \log(1 - F) + \log(1 - H)}$$

Forecasts initialized during strong ENSO events* demonstrate higher skill

