Ocean Predict

SYMPOSIUM OP'24

In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Evaluation of Marine Heatwave Forecast Skill in GEOS-S2S Version 3 System

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- Acknowledgement: GMAO Seasonal Prediction Development Group and Participants

OUTLINE

- Introduction of GEOS-S2S systems
- Comparison of Sea Surface Temperature (SST) forecast skill between GEOS-S2S-2 and GEOS-S2S-3 (1992 to 2023)
- Comparison of Marine Heatwave (MHW) forecast skill from SST and Ocean Heat Content (OHC) in GEOS-S2S-3 (1992 to 2023)
- Summary and future work

GEOS-S2S-3 System Characteristics

Model

- AGCM: Recent GMAO NWP (including aerosol model) + two-moment cloud microphysics
- OGCM: **MOM5, ~0.25 deg, 50 levels with 10 m spacing in the top 100 m; Improved Ice Sheet runoff**
- **New "atmosphere-ocean interface layer" - diurnal warm/cool layer (no SSS yet)**
- Sea Ice: CICE-4.0

Coupled Ocean Data Assimilation System

- Atmosphere is "replayed" to **GEOS_IT**; precipitation correction over land, **modified "replay" methodology = "Dual Ocean"**
- Ocean Data Assimilation System - LETKF (Penny et al, 2013), using **(updated)** static background error statistics

GEOS-S2S-3 Ocean improvements to Molod et al., 2020 are in blue text

Forecast Skill Metrics

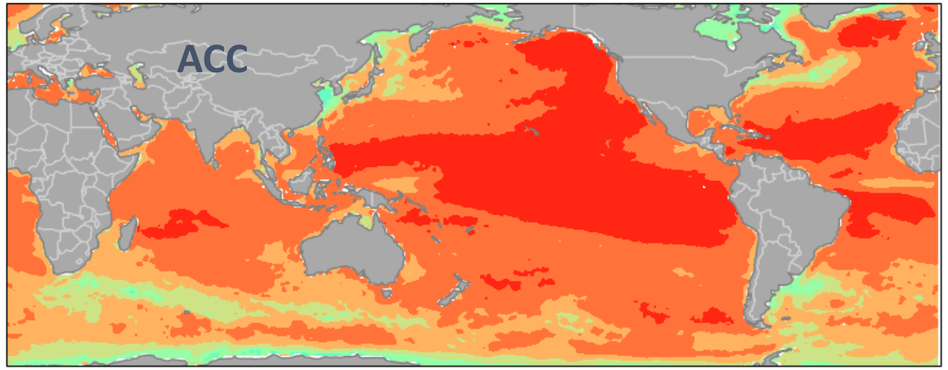
- Anomaly Correlation Coefficient (ACC)
- Bias
- Root Mean Square Error (RMSE)
- Symmetric Extremal Dependence Index (SEDI):

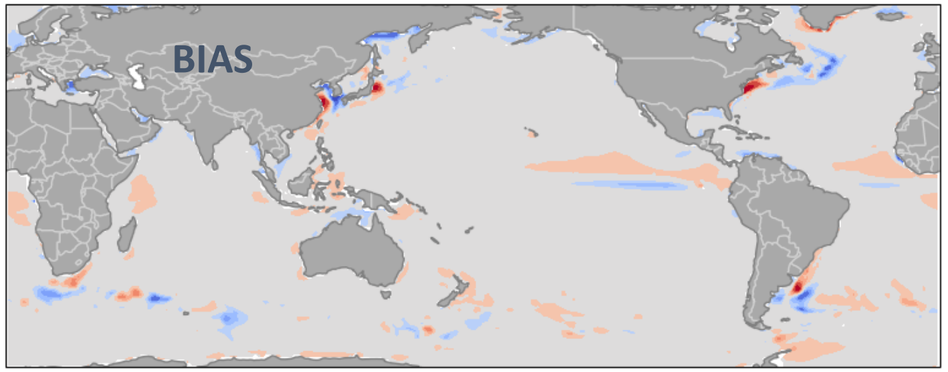
$$SEDI = \frac{\log F - logH - \log(1-F) + \log(1-H)}{\log F + logH + \log(1-F) + \log(1-H)}$$

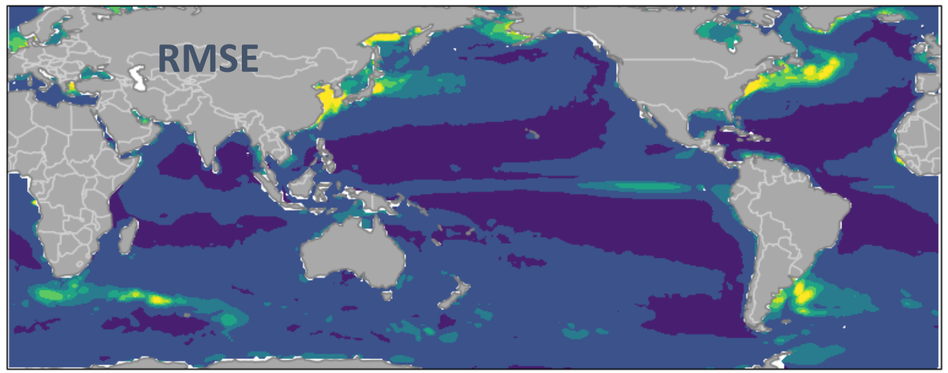
where H is the hit rate and F is the false alarm rate

SST : Lead 0-month

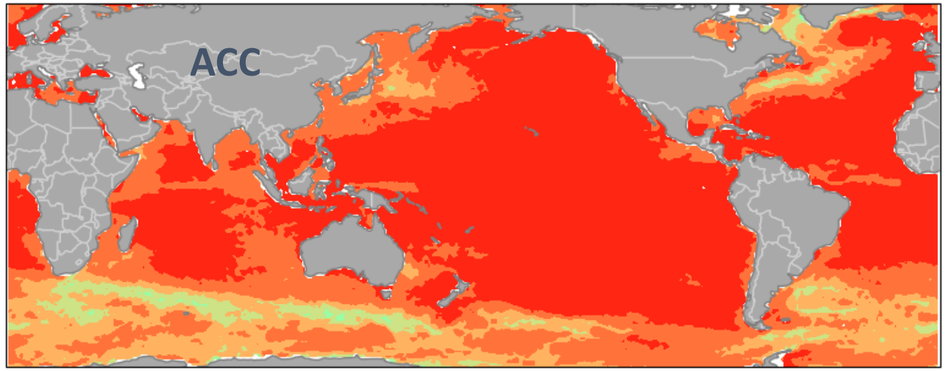
GEOS-S2S-2

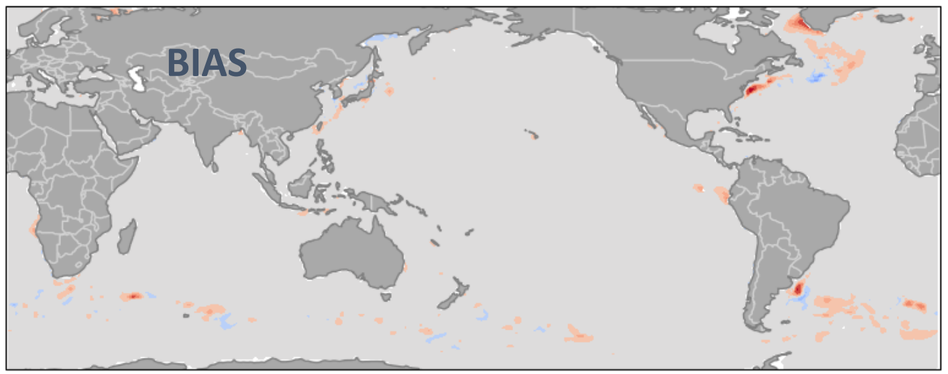


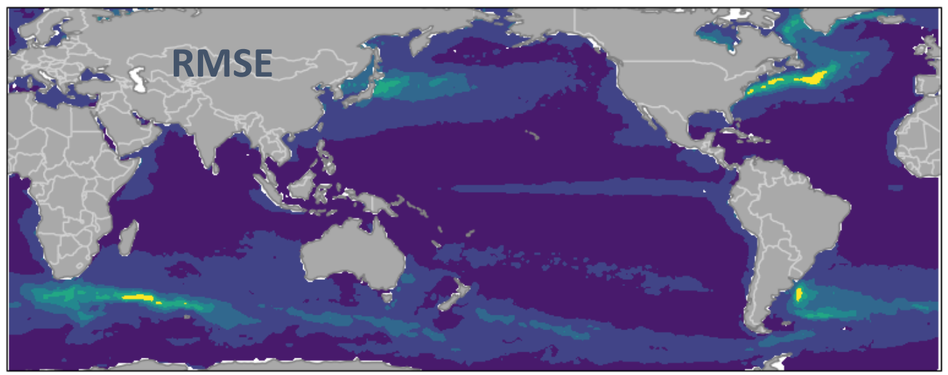




GEOS-S2S-3

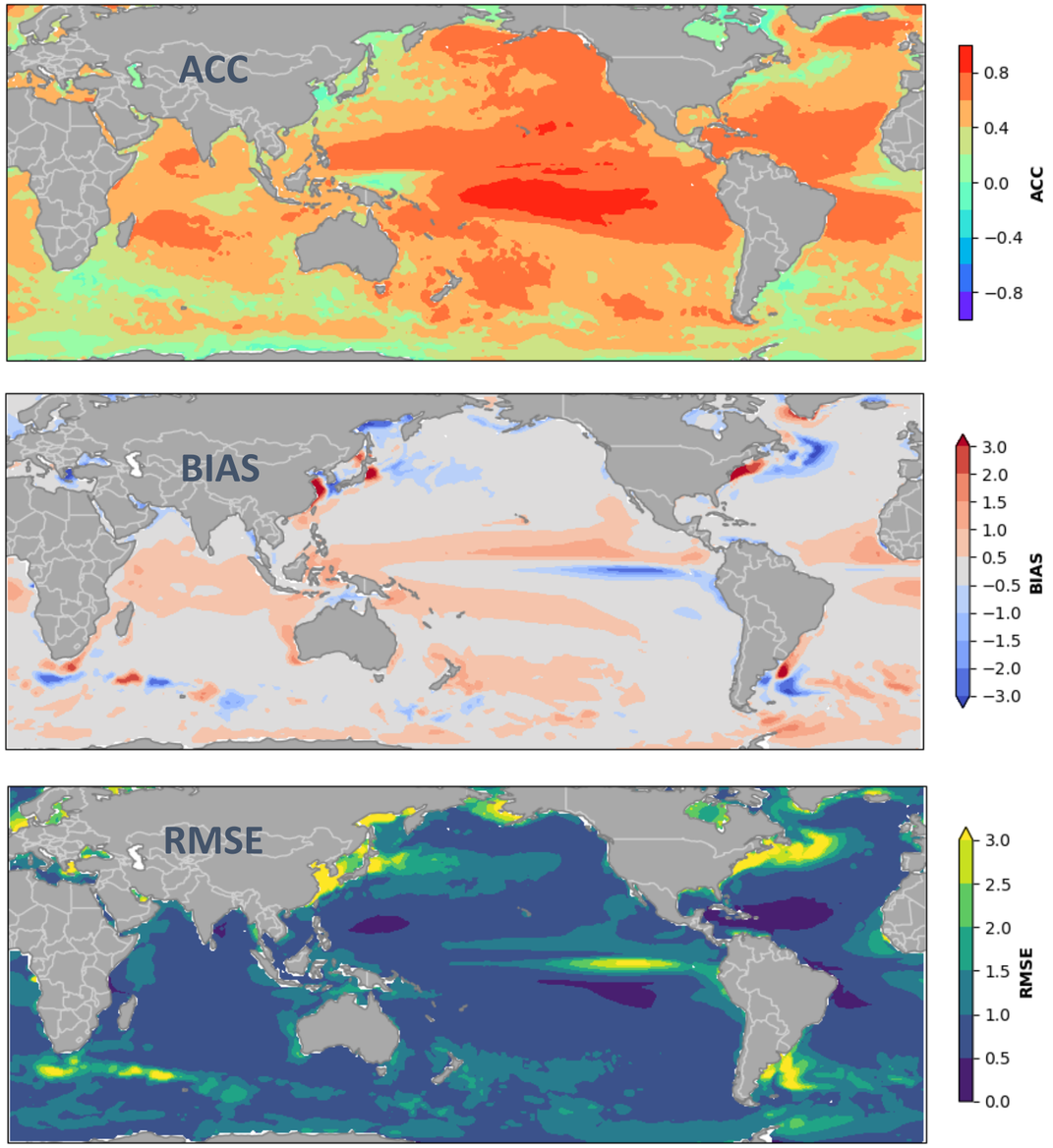




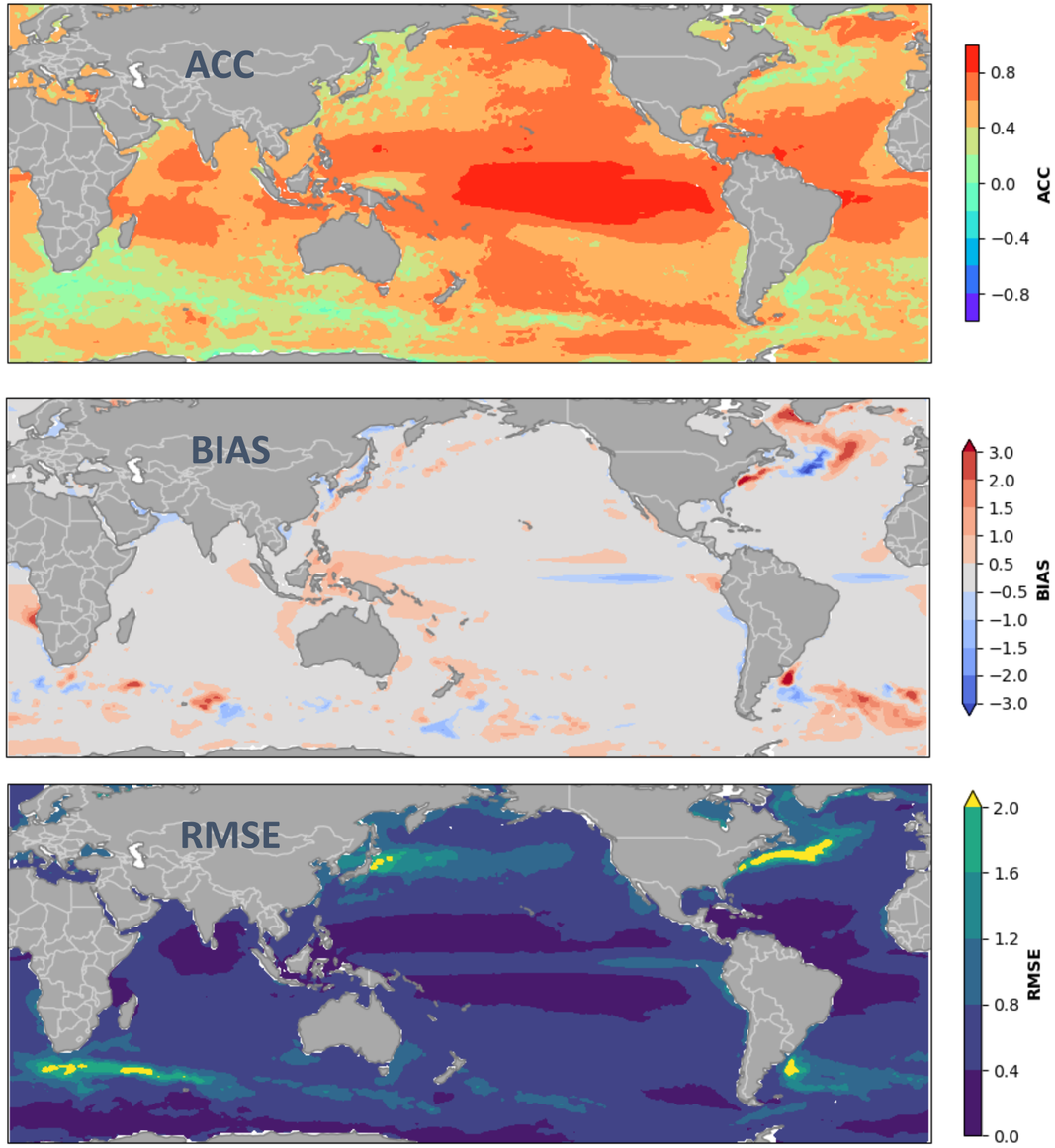


SST : Lead 2-month

GEOS-S2S-2

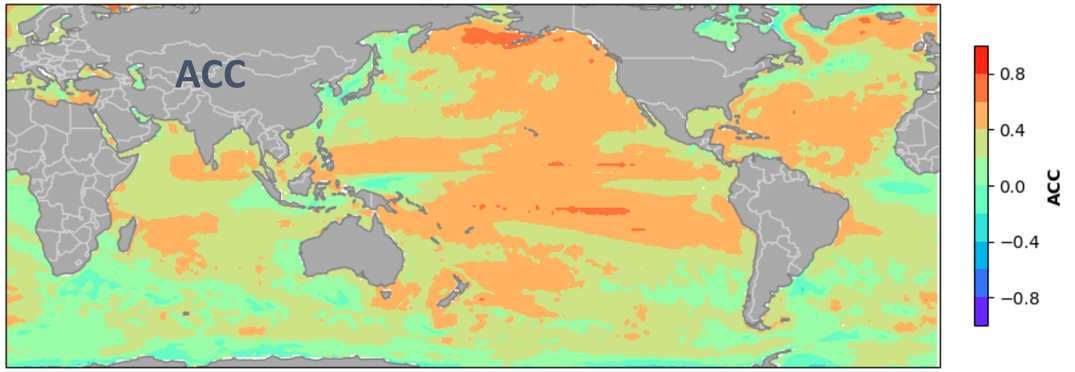


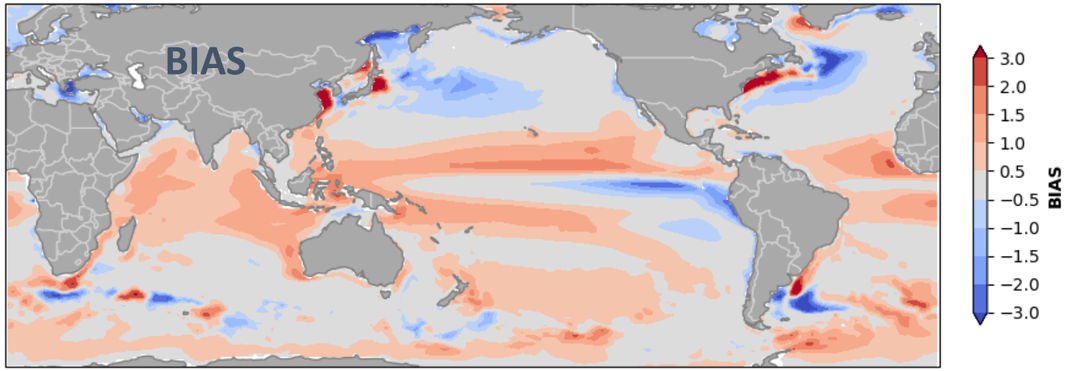
GEOS-S2S-3

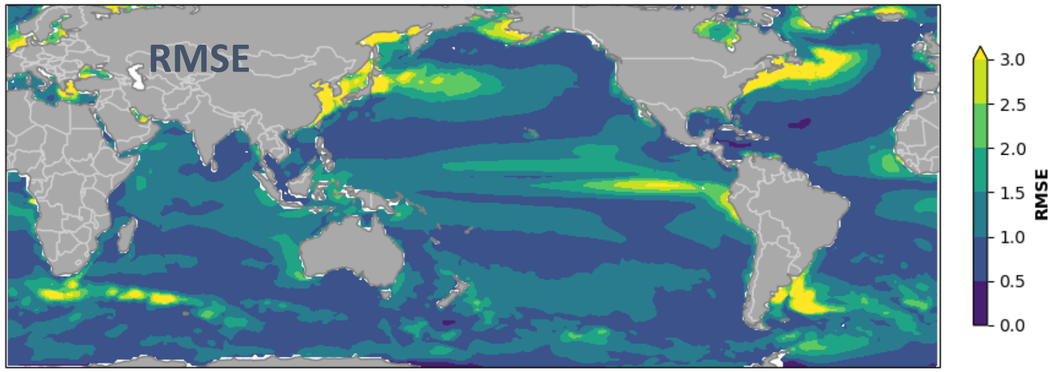


SST : Lead 6-month

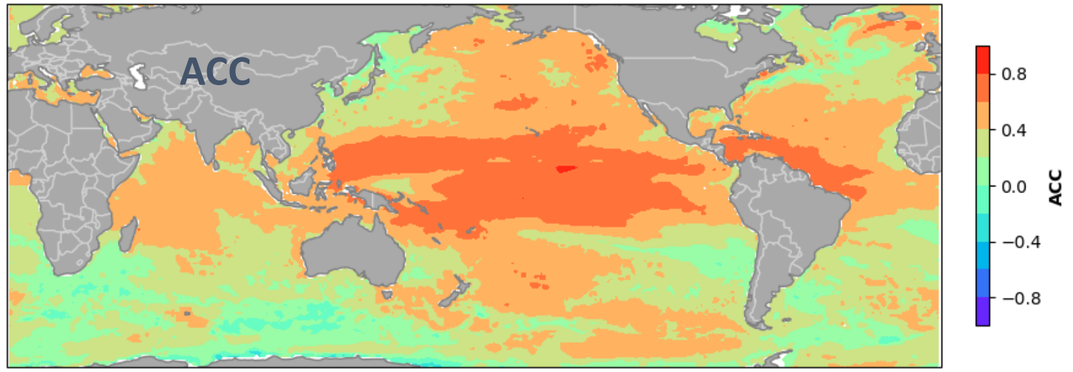
GEOS-S2S-2

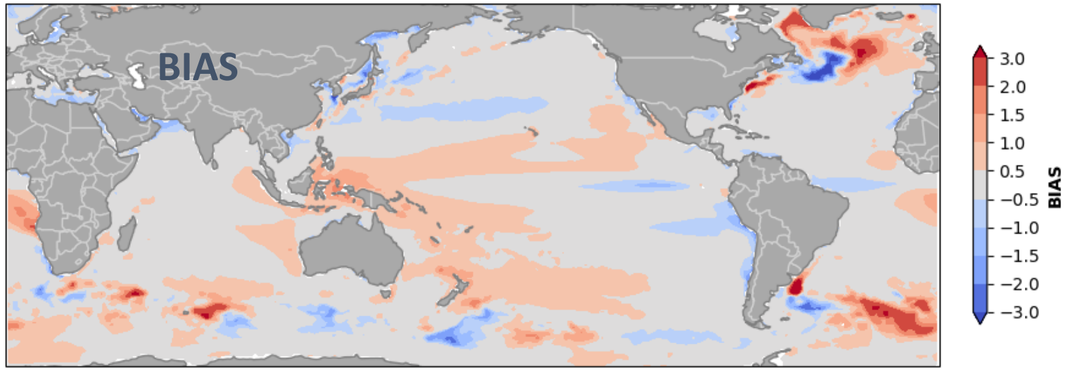


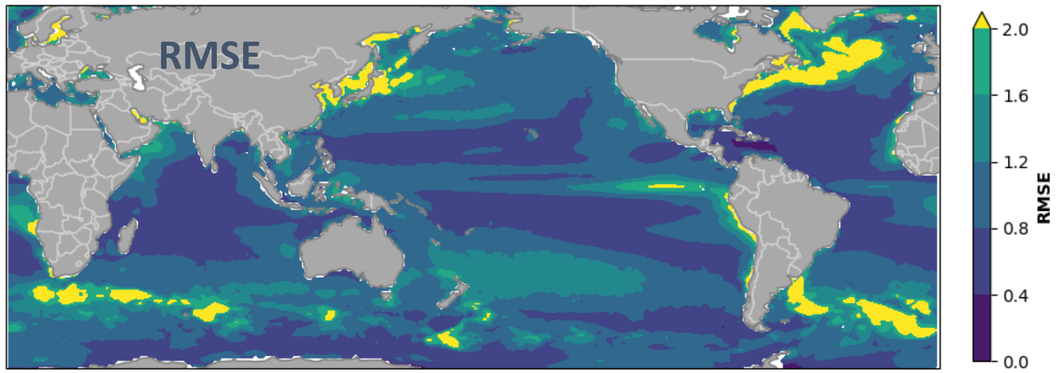




GEOS-S2S-3

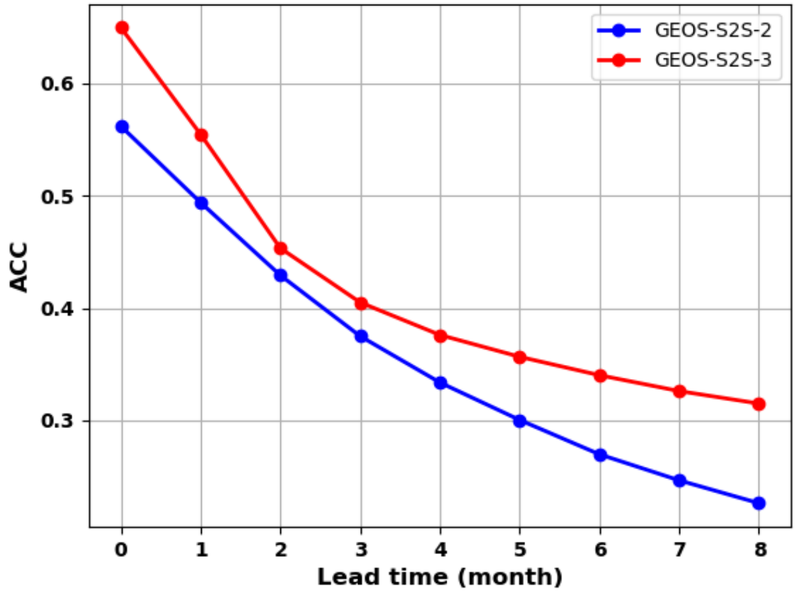




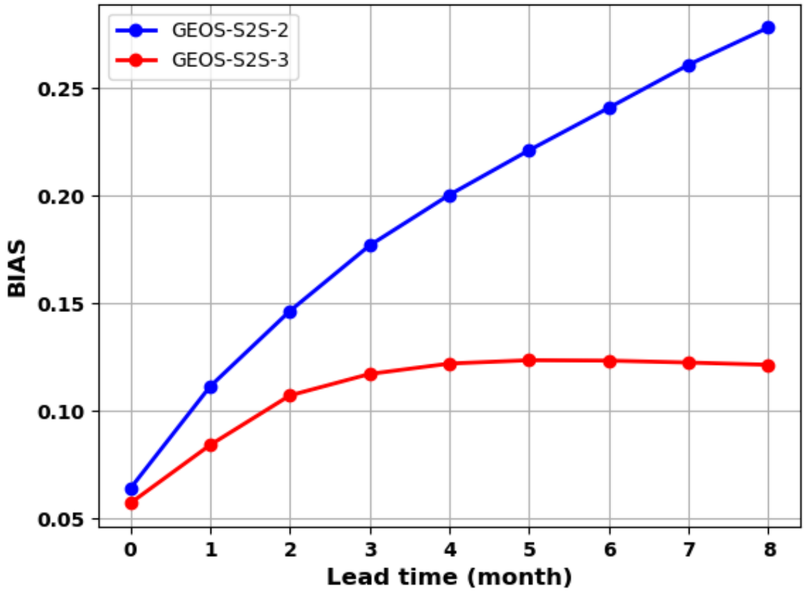


Averaged ACC, Bias and RMSE

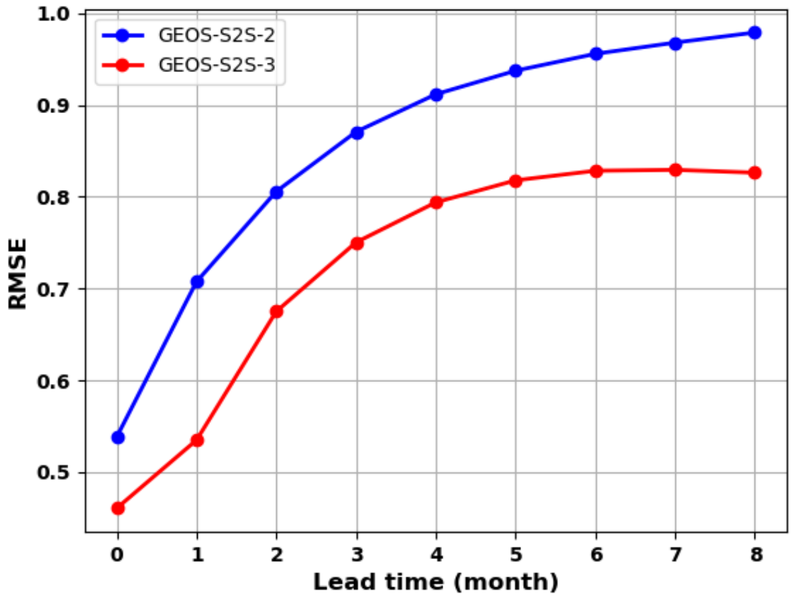
ACC



BIAS



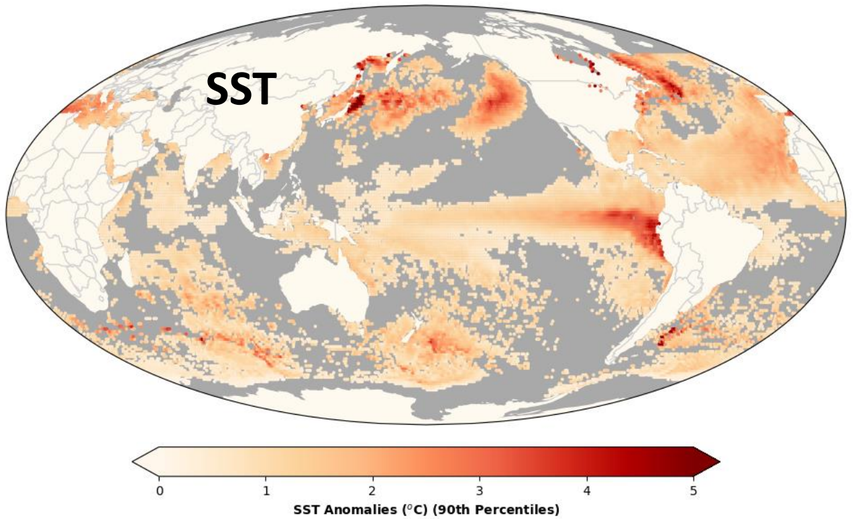
RMSE



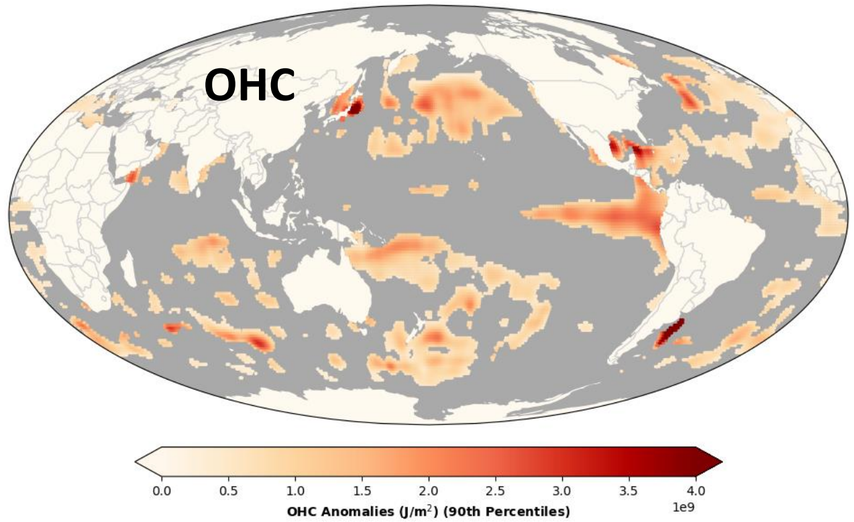
What is Marine Heatwave?

July 2023

Data from NOAA OISST (Huang et al. 2020)



Data from Met Office Hadley Center EN4 dataset (Good et al. 2013)



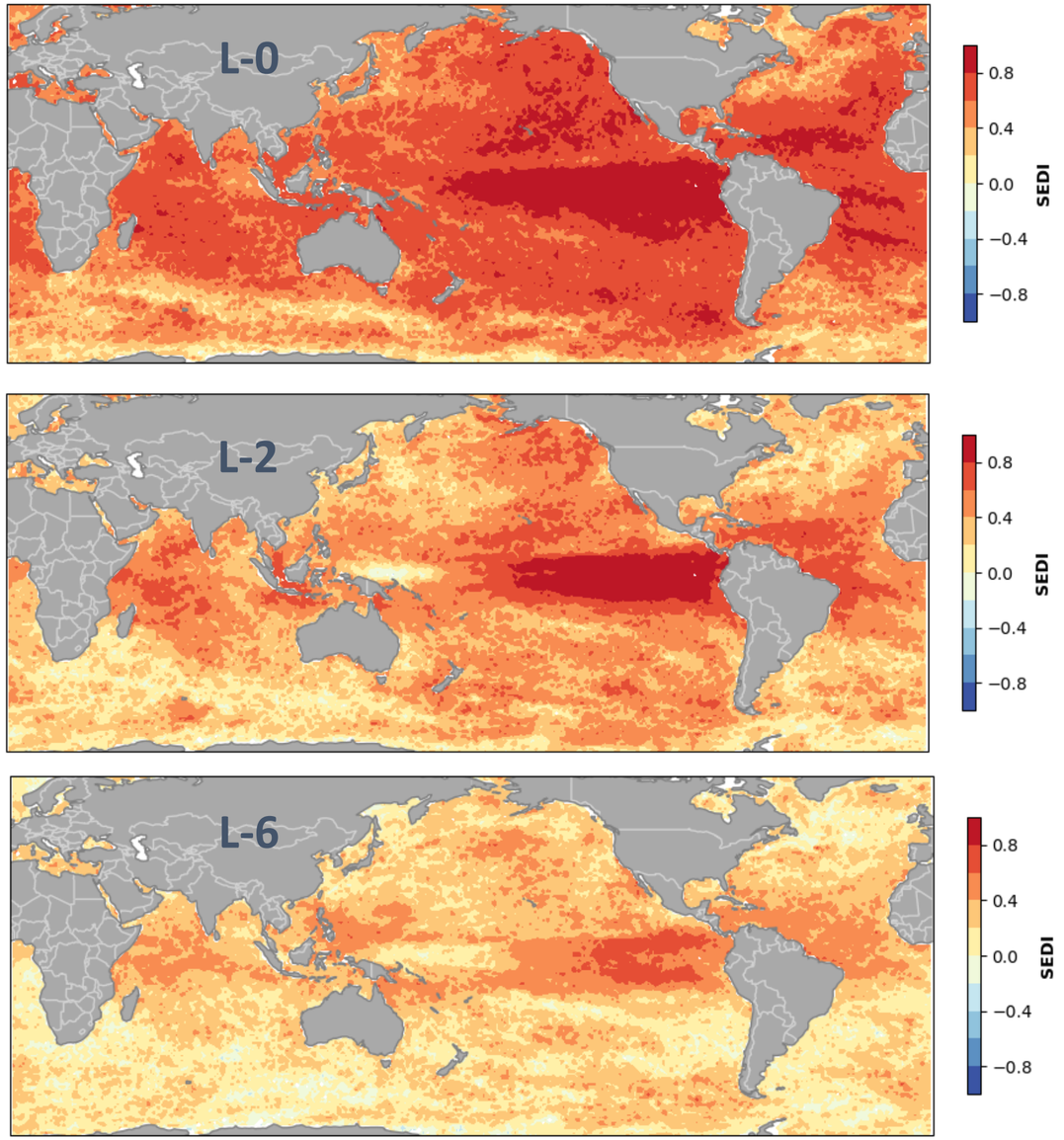
A MHW is an extended period during which SST is significantly higher than average.

Definition: A MHW is defined when the sea surface temperature (SST) is above the 90th percentile for at least five consecutive days. Here, the 90th percentile is estimated from the three consecutive months centered at the target month.

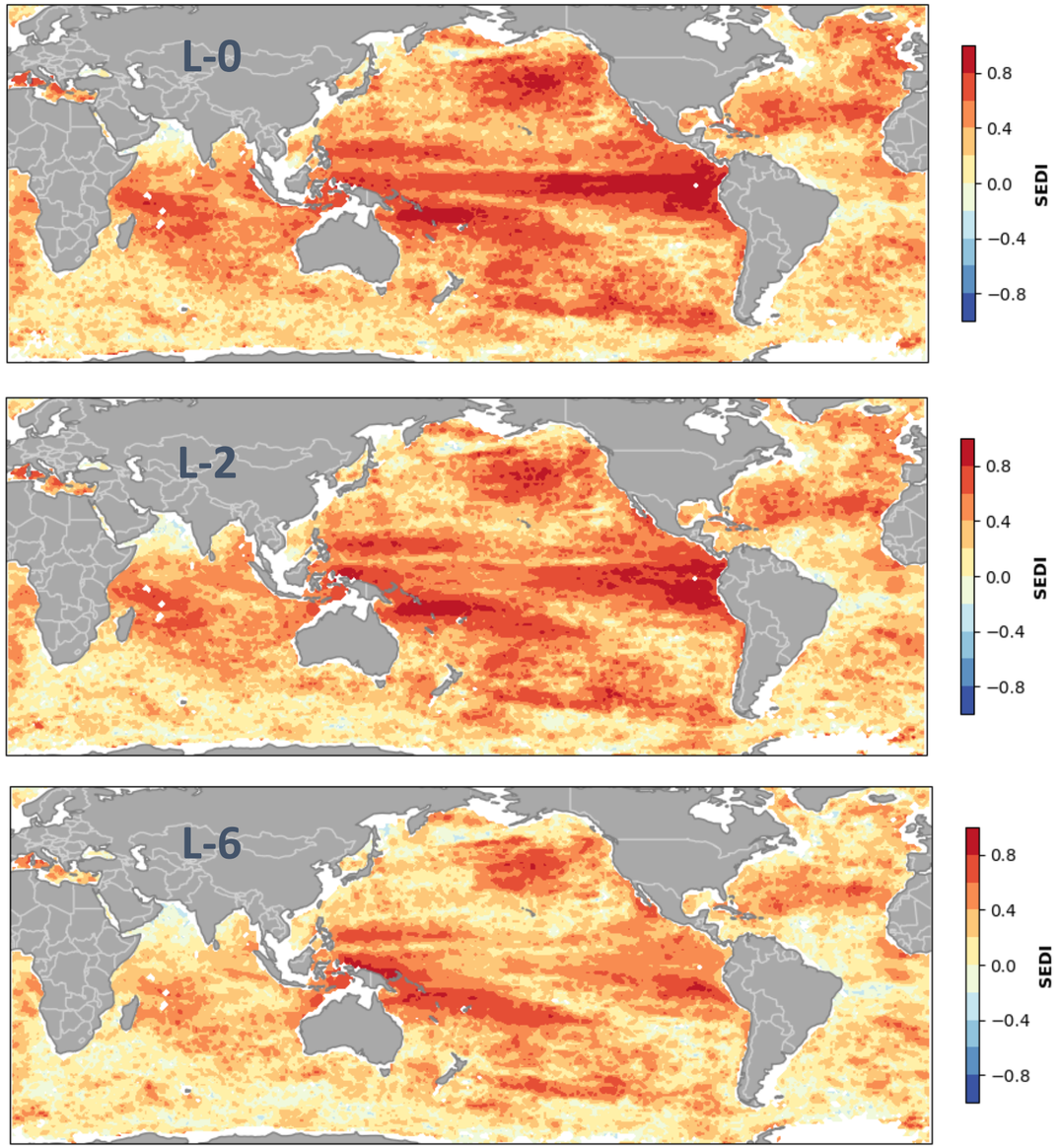
MHWs have major impacts on marine ecosystems, fisheries, and coastal communities.

Marine Heatwave Forecast Skill: SEDI

SST

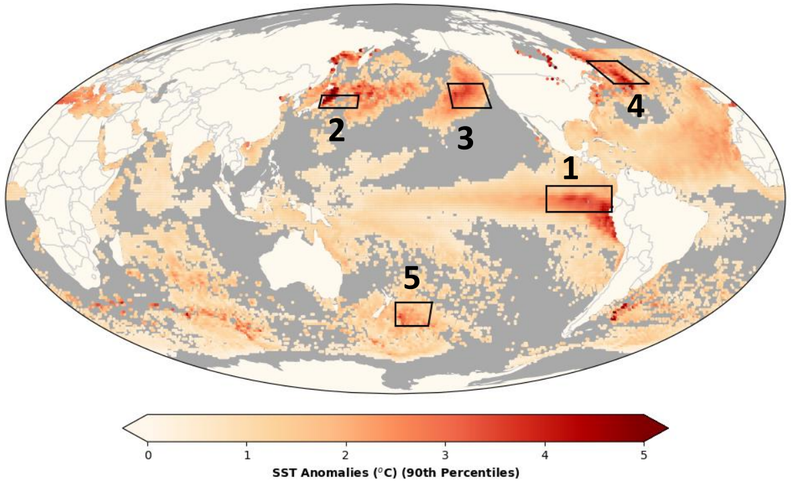


OHC

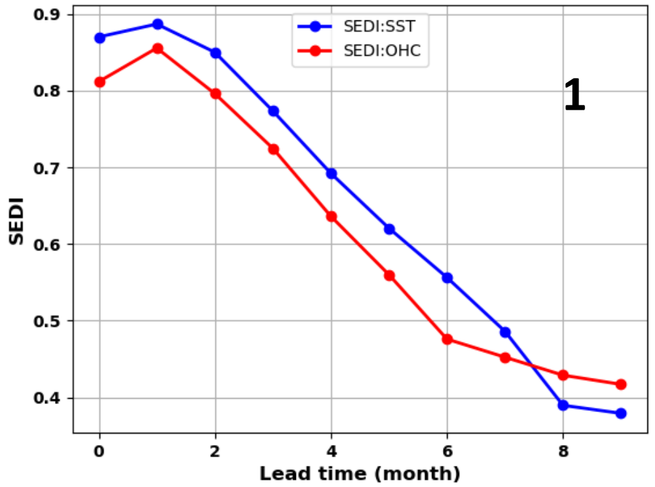


Regional Averaged SEDI

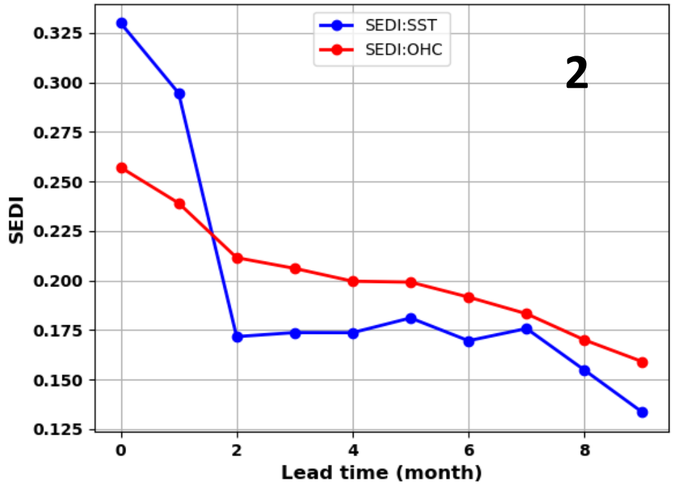
Marine Heatwave (July 2023)



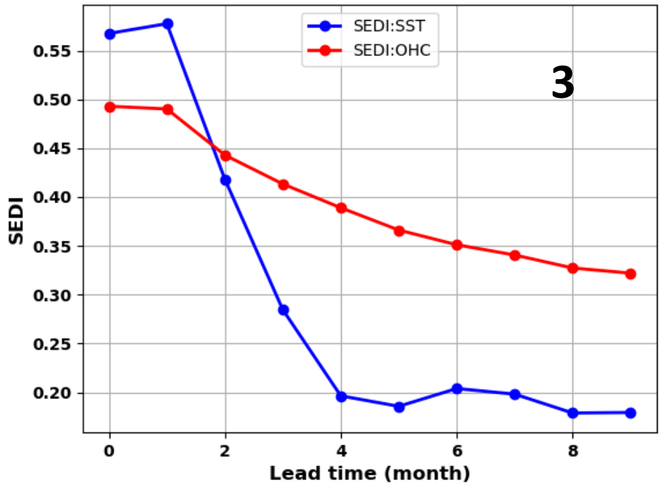
Eastern Tropical Pacific



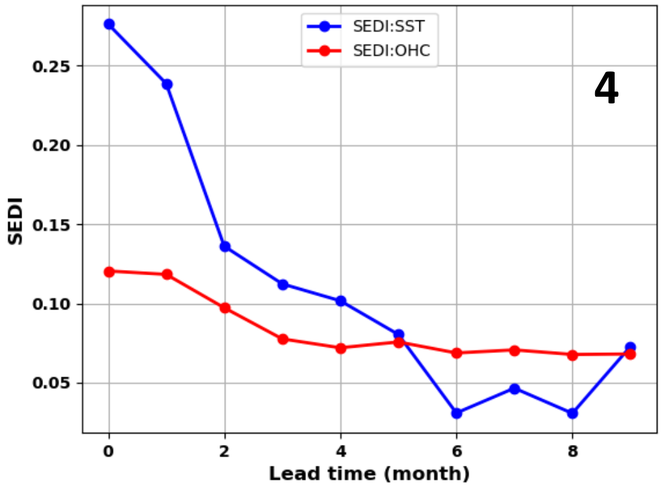
Kuroshio Region



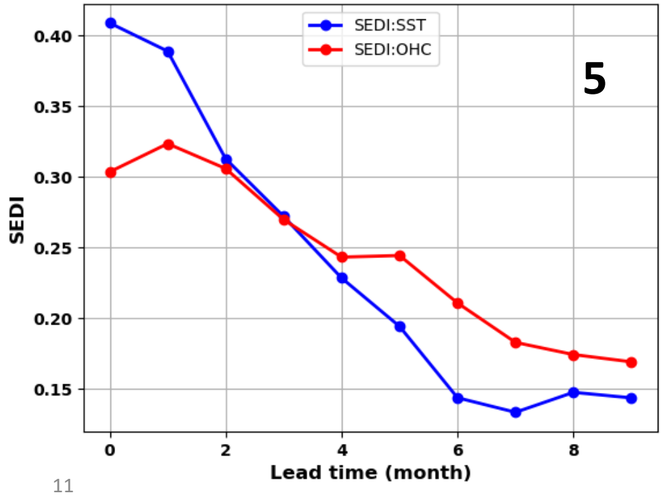
Northeast Pacific



Gulf Stream



South Pacific



Summary & Future Work

- Seasonal SST forecast performs substantially better in GEOS-S2S-3 than GEOS-S2S-2 based on ACC, bias and RMSE

- The MHW forecast in GEOS-S2S-3 has the best performance in the central and eastern tropical Pacific ocean (skillful with longer 6-month lead); in the northeastern Pacific Ocean, western basin of subtropical Atlantic Ocean and Indian Ocean (skillful with longer than 2-month lead)

- The MHWs defined from OHC and SST are well correlated, MHWs from OHC has better forecast skill with longer lead time.

- In the future, the forecast skill of OHC against various ocean reanalyses will be assessed; the daily SST/OHC for MHWs will be examined.

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ADVANCING OCEAN PREDICTION
SCIENCE FOR SOCIETAL BENEFITS

Thank you!

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