Report

Ocean Observing System Experiments for Tropical Pacific Observing System

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Budget Summary
FY 2023: $62,727

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1. Project Summary

Sea surface temperature (SST) variability related to El Niño – Southern Oscillation (ENSO) is one of the key phenomena in constraining weather and climate variability over different parts of the globe, and further, is the underpinning of the operational long-range climate predictions. An adequate ocean observing system in the equatorial tropical Pacific is required for (a) real-time monitoring of ENSO and (b) more importantly, for providing initial conditions for the ocean component of the operational coupled prediction systems. Central to ENSO monitoring and predictions is the Tropical Pacific Observing System (TPOS). With difficulties in maintaining TAO moorings, and recent advances in ocean observing technologies, for example, Argo and satellite altimetry, an ongoing assessment of the observing system is required to test the adequacy and complementarity of different ocean observing platforms to meet the requirements for ENSO monitoring and prediction. The focus of this project is on developing and maintaining an observing system experiment (OSE) capability (including an assessment of surface forcing that is used for driving ocean models) to provide guidance on questions such as: how effective are ocean observations in correcting biases in the mean and variability of the analyzed ocean state; what spatial and temporal density for observational data is required to reduce analysis biases; what are the gains for constraining the ocean state as more and more observational data becomes available; what is the relative contribution of different observing platforms and surface forcings. Answers to some of these questions will assist informing the evolution of the next generation TPOS.

2. Scientific and Observing System Accomplishments

2.1 Development of a new global ocean reanalysis (GLORe) and its assessments

At NOAA, the UFS modeling infrastructure is being combined with the Joint Effort for Data Assimilation Integration (JEDI) project to establish NOAA's next generation ocean-alone and coupled data assimilation systems. GLobal Ocean Reanalysis (GLORe) is a newly developed ocean and sea ice data assimilation system. It is based on MOM6 ocean and CICE6 sea ice models and the JEDI-Sea-ice, Ocean, and Coupled Assimilation (SOCA) 3DVar scheme. When implemented, it will replace the current operational Modular Ocean Model version 3 (MOM3)-based Global Ocean Data Assimilation System (GODAS) that was implemented circa 2001.

In FY23, we introduced a new sea ice disaggregation scheme in GLORe which fixed a sea ice thickness issue in previous JEDI-SOCA-based system and improved the sea ice analysis in GLORe. Based on the new configuration, we completed a reanalysis run for more than 40 years (1979-2022). Evaluations suggested encouraging performance with GLORe. Fig. 1 present a comparison of the quality of GLORe with the two operational ODA systems at NOAA – GODAS and CFSR, by validating against the EN4 (Good et al. 2003) during 2004-2020, a period chosen as the EN4 is more reliable after the advent of Argo, particularly for salinity. Overall, GLORe is clearly better than GODAS and CFSR for salinity, and close to GODAS but better than CFSR for temperature. In addition, we also noticed that the GLORe performance improvement in temperature over the extratropical oceans is not as evident as in the tropical Pacific, but its improvement in salinity is still evident.

Further, the quality of GLORe is assessed by initialized ENSO prediction experiments using the NOAA Unified Forecast System (UFS). Initialized by GLORe, 9-month ensemble hindcasts are conducted from each May/November during 1982-2021. The ENSO prediction skill is compared to the current NOAA operational system CFSv2, and other latest NMME models (Fig. 2). It is seen that UFS initialized with GLORe has an encouraging skill in ENSO predictions.

In FY24, we will finish the transition of the GLORe system on the NOAA HPC Gaea, as it is undergoing a significant upgrade till early 2024. We also plan to further refine the GLORe configuration by introducing additional optimizations that have been well tested and implemented in GODAS and CFSR, i.e., widening data insertion window from one day to 3~4 weeks.

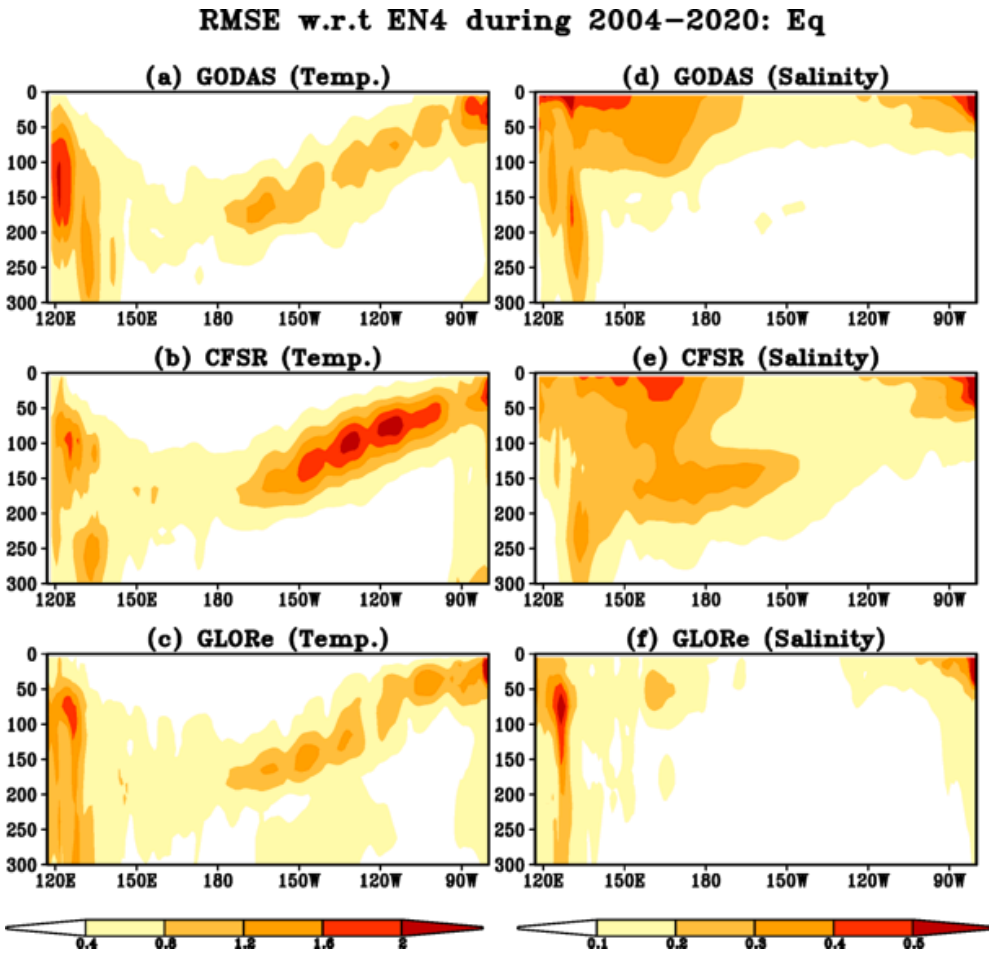

Fig. 1: Root-mean-squared-errors (RMSEs) of (a-c) temperature (unit: °C) and (d-f) salinity (unit: psu) along the equator during 2001-2020 with respect to the EN4 analysis in (a, d) GODAS, (b, e) CFSR, and (c, f) GLORe.

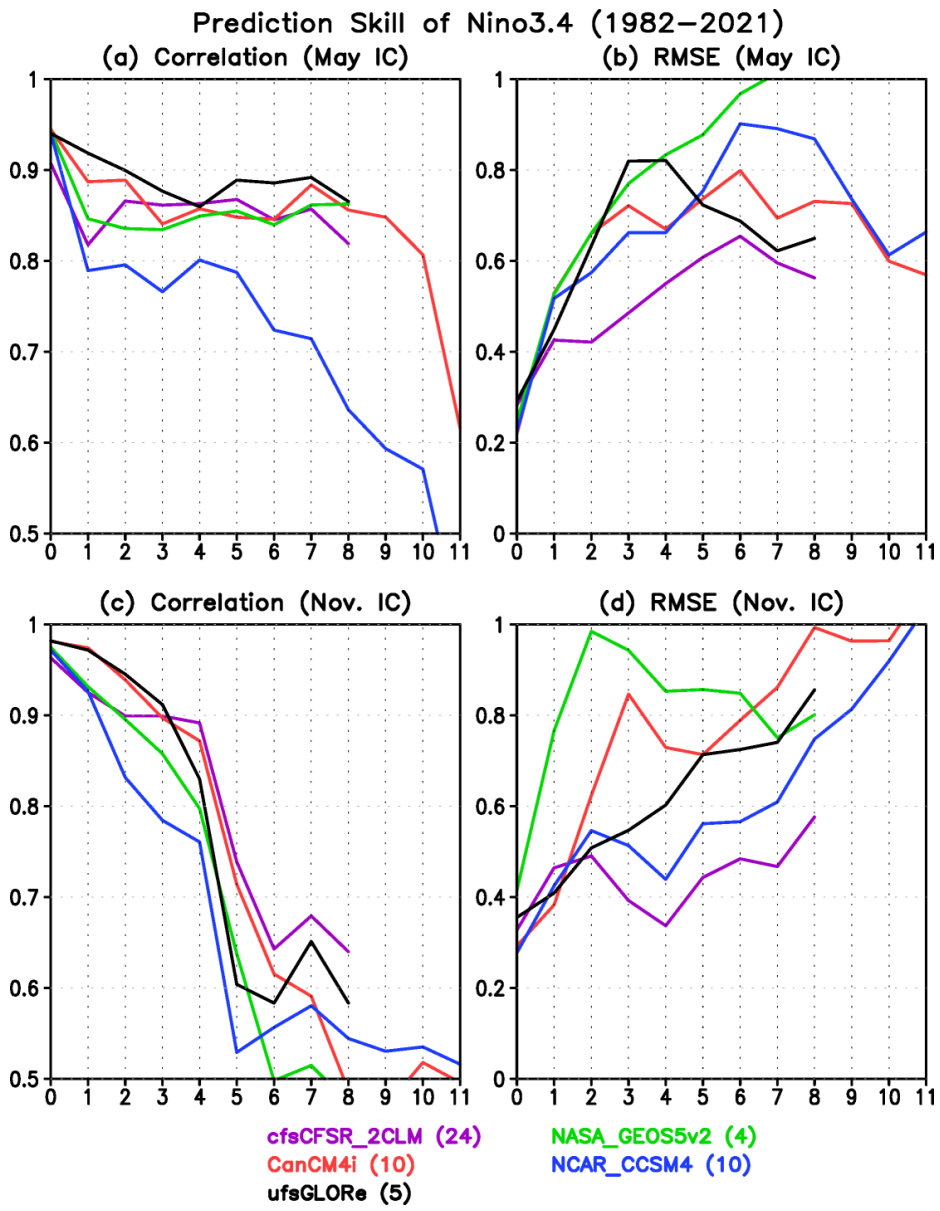

Fig. 2: (a, c) Anomaly correlation coefficients and (b) RMSEs (ºC) of Niño-3.4 index as a function of forecast lead months (x-axis) for hindcasts starting from the (a, b) May and (c, d) November initial conditions during 1982-2021. The purple, green, red, and blue curves are respectively for CFSv2 (i.e., cfsCFSR_2CLM), NASA_GEOS5v2, CanCM4i, and NCAR_CCSM4, four component systems of the latest NMME with hindcasts back to 1982. The black curves are for ufsGLORe. The numbers in parenthesis indicate the ensemble size for each system.

3. Outreach and Education

None

4. Publications and Reports

4.1. Publications by Principal Investigators

Reeves Eyre, J., J. Zhu, A. Kumar, and W. Wang, 2023: Diurnal variability of the upper ocean simulated by a climate model. *Geophysical Research Letters* (accepted).

Jhu, J., and Co-authors, 2023: Assessment of a new global ocean reanalysis in ENSO predictions with NOAA UFS. *Geophysical Research Letters,* conditionally accepted.

4.2. Other Relevant Publications

None

5. Data and Publication Sharing

We plan to share the data from ocean data assimilation experiments with the community.

6. Project Highlight Slides

Provided.