Ocean Observing Co-Design

by The Global Ocean Observing System

Day 2: Diving deeper and building the Work Plan

January 15th , 2025

Core Team Ocean Observing Co-Design Meeting

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

This programme is endorsed by the **UN Decade of Ocean Science**

Ocean Observing Co-Design
Strategy and Planning Meeting
Online Participation, Jan. 15th, 2025

Sharing SynObs Outcomes and Experiences

Agenda

1. Introduction of SynObs background and the outline of activities
2. Some examples of outcomes
3. Points need to keep in mind for conducting OSEs
4. Possible collaborations
5. Future meetings and sessions planned by SynObs

Synergistic Observing Network for Ocean Prediction

Led by OceanPedict OS-Eval TT

- Objective

  SynObs will seek the way to extract maximum benefits from the combination among various observation platforms, typically between satellite and in situ observation data, in ocean predictions.

- Strategy

  SynObs aims to identify the optimal combination of different ocean observation platforms through observing system design/evaluation, and to develop assimilation methods with which we can draw synergistic effects.

- Co-chairs Y. Fujii (JMA/MRI), Elisabeth Remy (Moi)

SynObs Info.

Contact E-Mail : synobs@mri-jma.go.jp

Webpage: https://oceanpredict.org/un-decade-of-ocean-science/synobs-2/

Mailing List: Request to the contact e-mail for joining

Outline of SynObs activities

1. Collaboration for evaluation and design

- Coordinated Multi-System OSE and OSSE
- Sharing observing system evaluation outcomes

2. Supporting DA scheme development for better use of observation data

- Share the information through workshops and webs
- Observation campaign?

3. Framework to provide information from ocean prediction systems in real time

- Sharing information of QC, Analysis Increments, ensemble spread, etc.

4. OS-Eval showcase and reporting

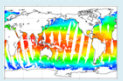
- Contributing to GOOS and Ocean Observing Co-design
- Contributing to WMO Observation Impact Workshop and Rolling Review of Requirement (RRR)
- Frontiers in Marine Science Special Collection (Almost Completed)

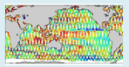
  https://www.frontiersin.org/research-topics/58025/demonstrating-observation-impacts-for-the-ocean-and-coupled-prediction

SynObs Flagship OSE/OSSE

- Collaborative OSEs/OSSEs using ocean DA and prediction systems with a common setting
- To make robust evaluation which does not depend on a particular system

Planned OSE Settings





Control （CNTL)	✓	✓	✓	✓	✓
Without satellite altimetry(NoALT)	✓	✓	×	✓	✓
Without Argo data (NoArgo)	×	✓	✓	✓	✓
Without Mooring(NoMoor)	✓	✓	✓	✓	×
Without satellite SST (NoSST)	✓	×	✓	✓	✓
Satellite only (NoInsitu)	×	✓	✓	×	×
Satellite SST only (SSTOnly)	×	✓	×	×	×
Half Argo (HalfArgo)	50%	✓	✓	✓	✓
Model only(Free)	×	×	×	×	×

- OP (Ocean Prediction) OSEs
  - Use higher-resolution ocean DA and prediction systems.
  - Assimilation run for 2020-2022 and 10 day predictions
  - 10-day predictions: Started from every pentad
- S2S (Subseasonal-to-seasonal) OSEs
  - Use coupled prediction systems including lower-resolution ocean DA for initialization
  - Reanalysis run for 2003-2022 and 1 or 4 month predictions
- OP (Ocean Prediction) OSSEs is also planned to evaluate future observing systems
- Results will be open and shared with prediction centers and volunteer analysis groups, including observational specialists and stake holders.

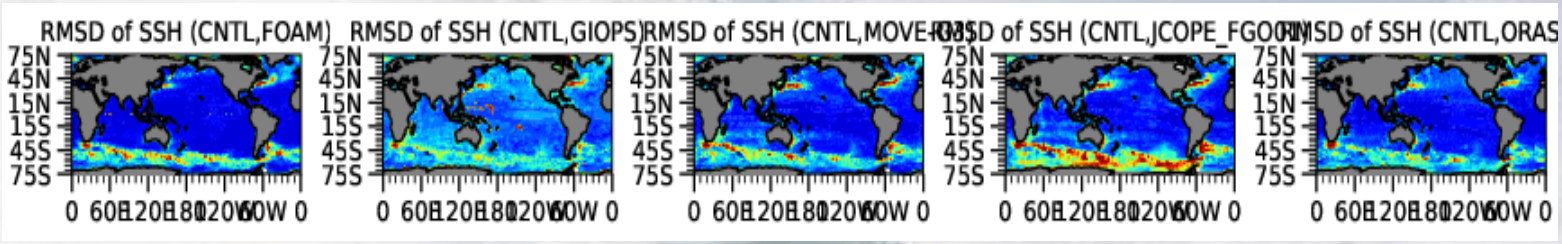
Participating ocean prediction systems

System		Resolution
FOAM (UKMO)	UK	Global, 1/12 deg.
GIOPS (ECCC)	CA	Global, 1/4 deg.
MOVE-G3 (JMA/MRI))	JP	Global, 1/4 deg.
ORAS6 (ECMWF)	EU	Global, 1/4 deg.
JCOPE-FGO (JAMSTEC)	JP	Semi-Glob. 1/10 deg.
GLORe (NOAA-CPP)	US	Global, 1 deg.
GEO-S2S V3 (NASA-GMAO)	US	Global, 1 deg.
MOVE-NPR (JMA/MRI)	JP	N. Pac. 1/10 deg.
Pukyong University	SK	N. Pac. 1/10 deg. ?

Observation Impacts on SSH RMSEs in each system

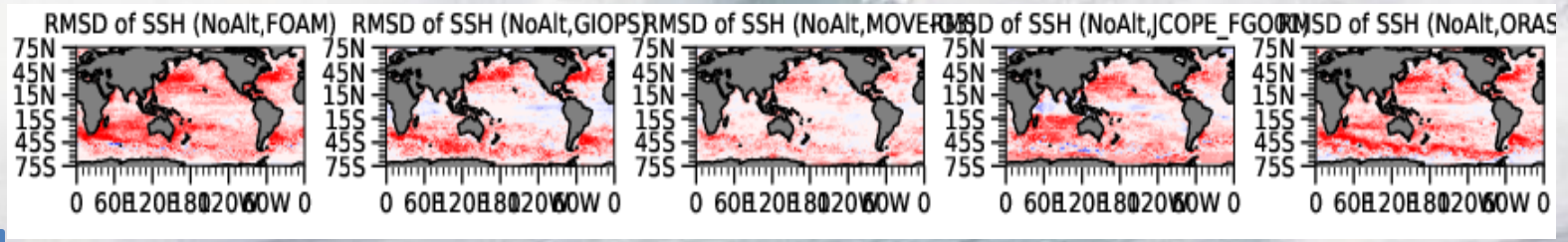
FOAM | GIOPS | MOVE-G3 | JCOPE-FGO | ORAS6

CNTL



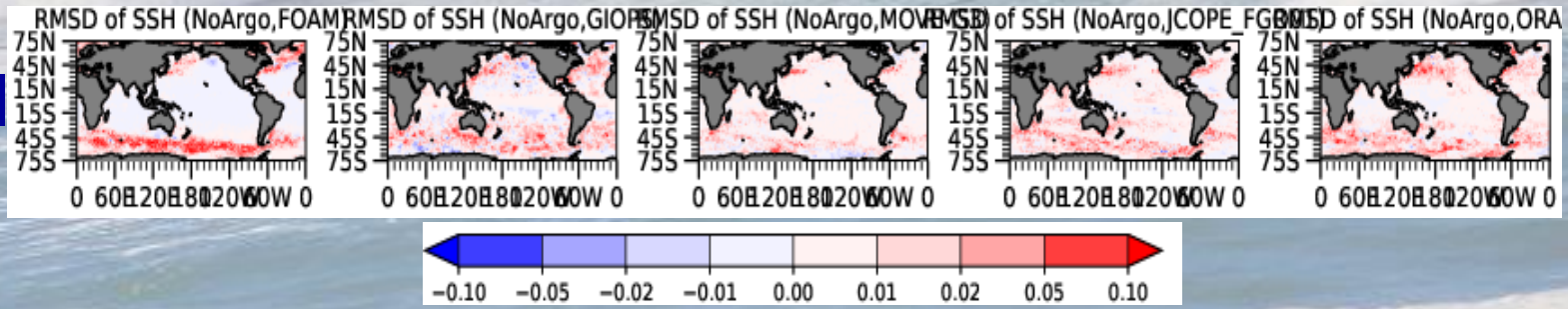
NoALT - CNTL

Impact of satellite altimeters



NoArgo - CNTL

Impact of Argo floats

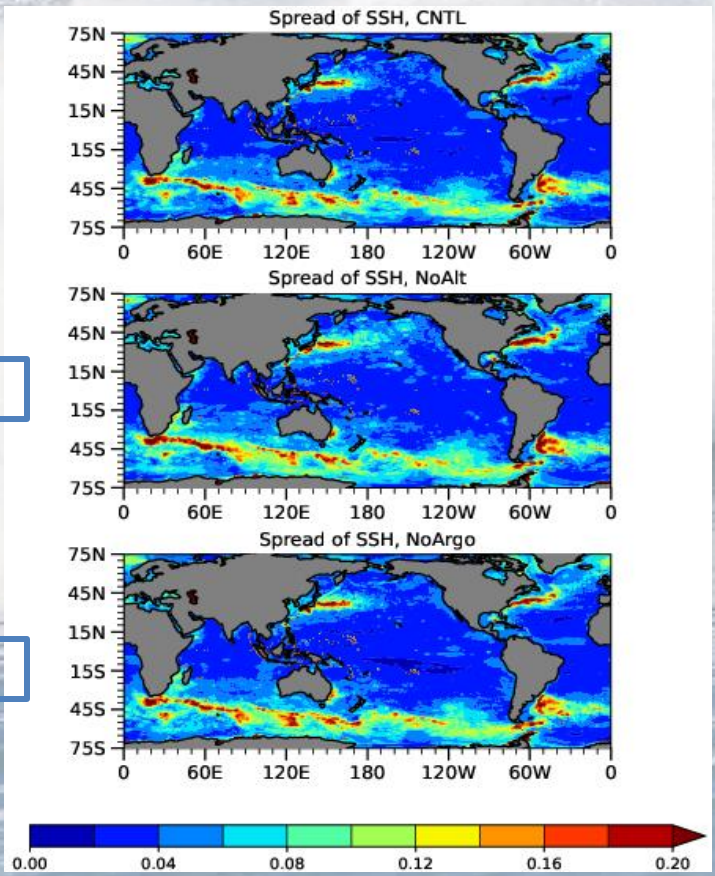


Impacts on SSH (multi-system ensemble spread)

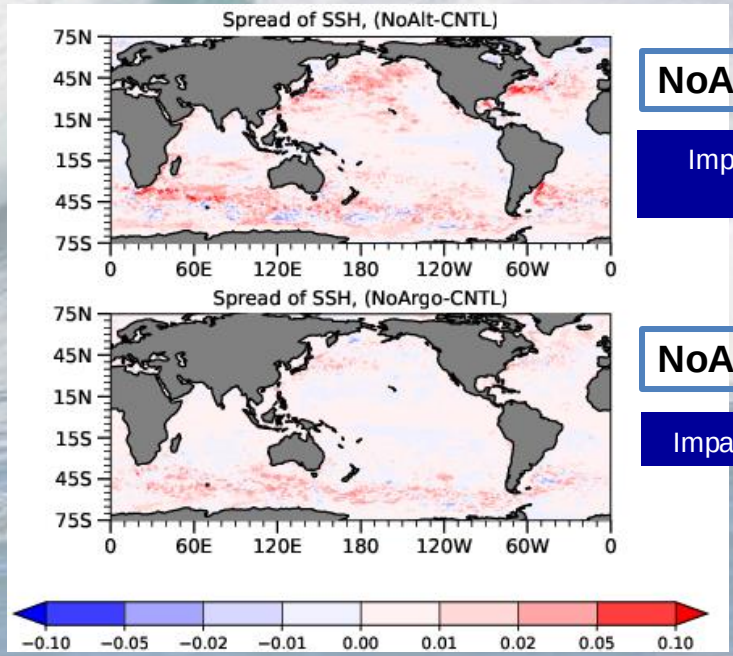
CNTL

NoALT

NoArgo



$$Spread = \frac{1}{365}\sum_{t=1}^{365}\sqrt{\sum_{i=1}^{4}\frac{\left(\left(A_i(t)-\overline{A(t)}\right)^2\right.}{4}}$$



NoALT - CNTL

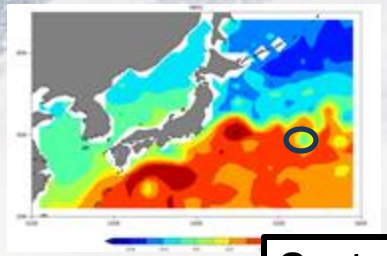
Impact of satellite altimeters

NoArgo - CNTL

Impact of Algo floats

Initial result of the SynObs Flagship OSE–Comparison of sea level fields–

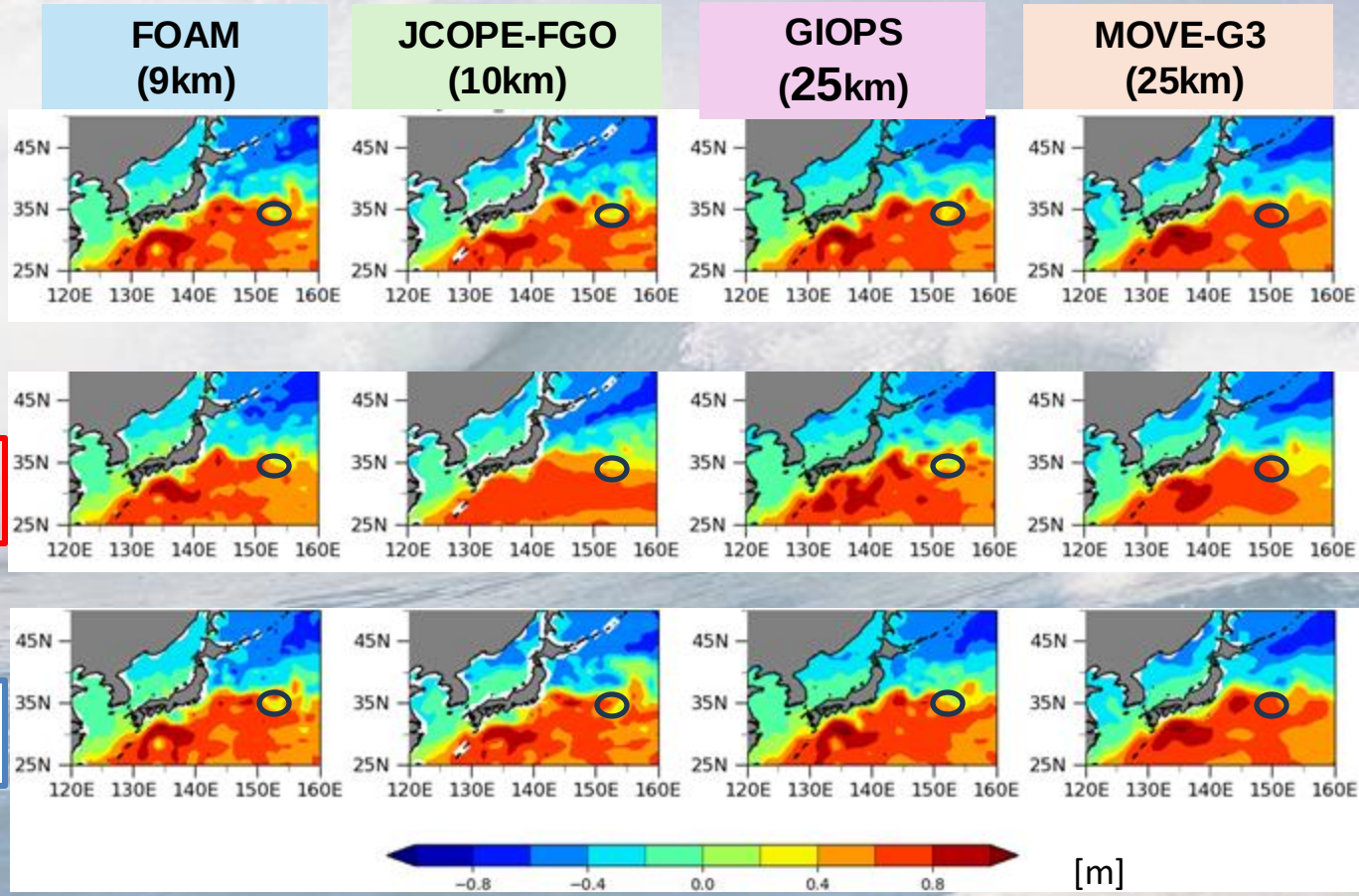
Example: Snapshot of sea level anomalies on Dec.15, 2024 from satellites and each system



Control (CNTL)

Without satellite altimetry (NoALT)

Without Argo profiles (NoArgo)



Eddy Tracking (Analysis by ECCC)

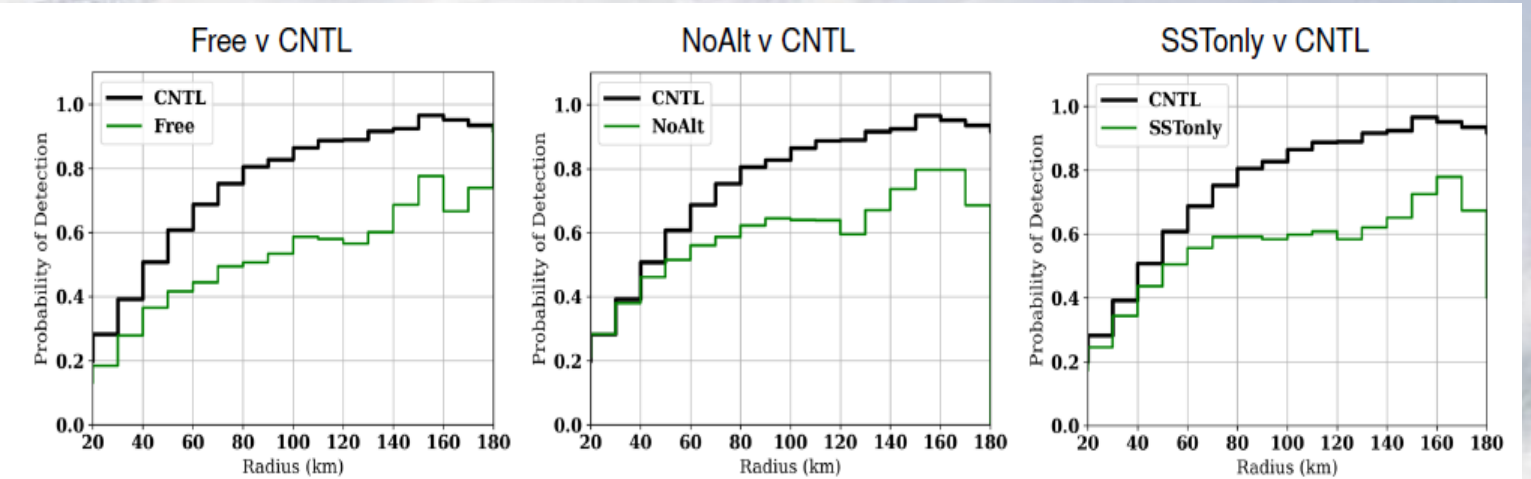


Figure 2: *Probability of matching an observed eddy through cost function based on amplitude, radius and distance. Higher probability of detection implies increased skill.*

- The ability is considerably increased by assimilating altimetry data which can be seen from the comparison between NoAlt and CNTL.
- Comparison between NoAlt and SSTonly indlctaes some impacts of in-situ observation data on the eddy tracking.
- Comparison of SSTonly and Free shows that SST data are also effective for tracking eddies.

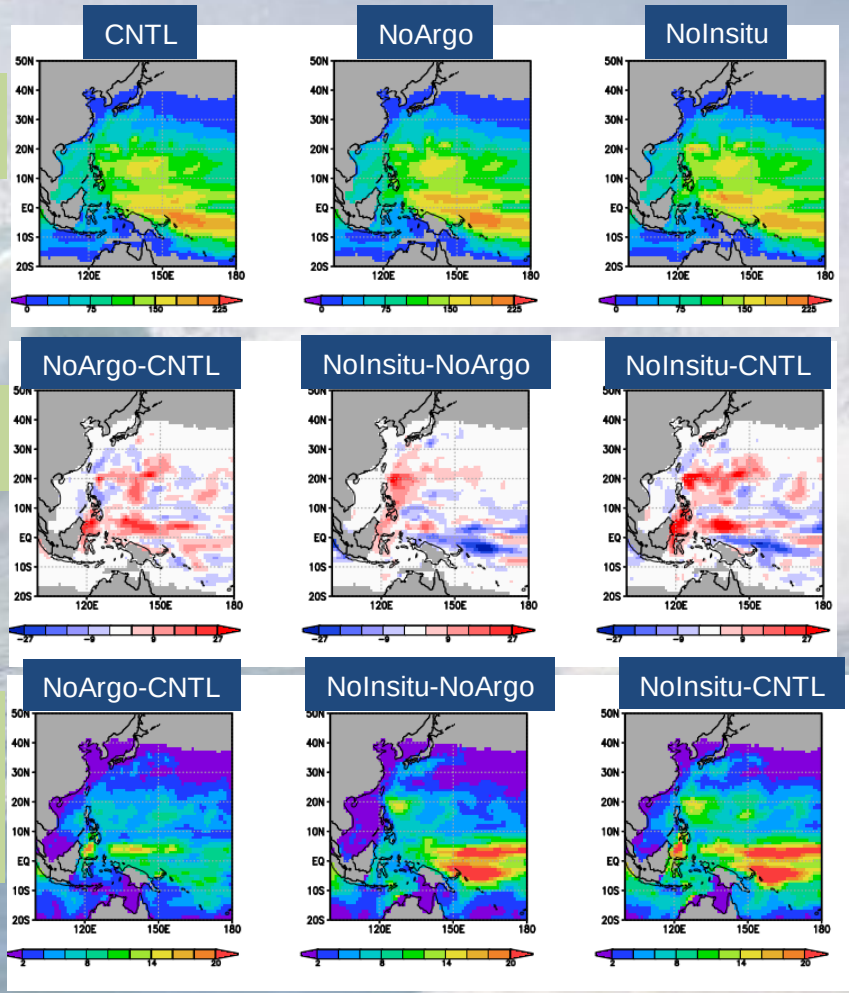
Example of regional evaluation 1 (Impact on TCHP in the JMA's result)

- Argo data has a large impact complementary to other in-situ data
- But, other in-situ data also has a substantial impact when Argo data are absent
- Thus, not only Argo but also other in-situ data are necessary for Typhoon predictions
- This figure was used for securing the building cost of the new research vessel as the base of ocean gliders in JMA.

TCHP field in Aug. 2020

Diff of TCHP in Aug. 2020

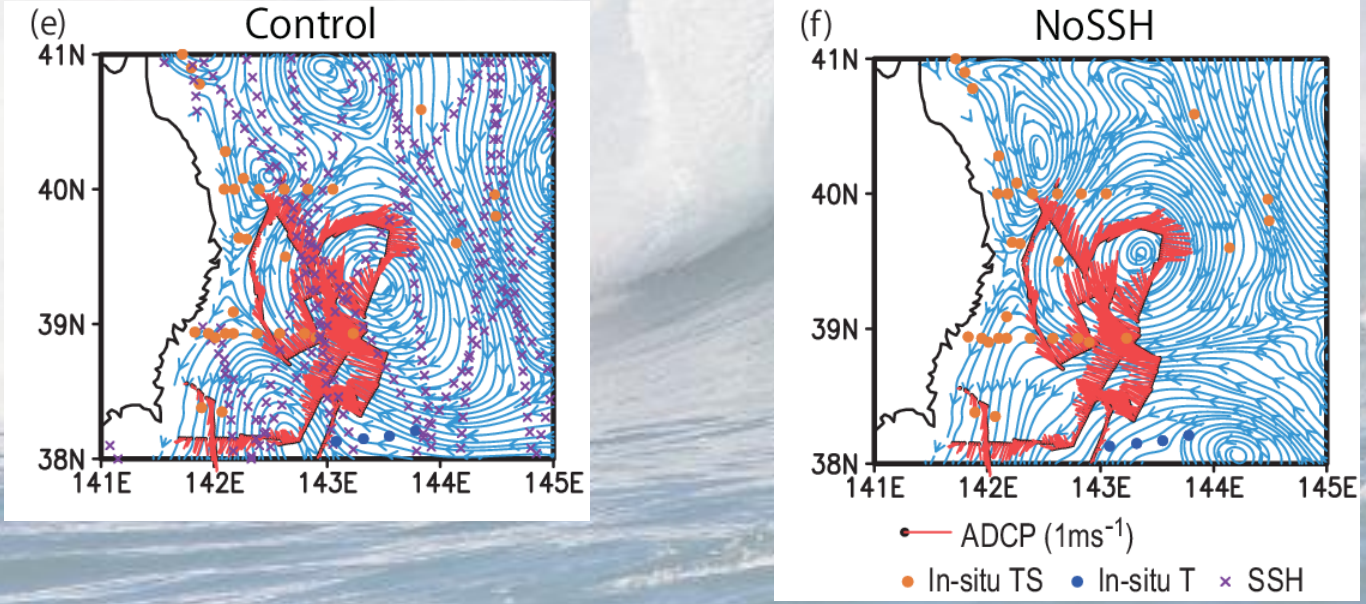
Diff of TCHP Climatorogy, 2015-2020



☆ Example of regional evaluation 1 (Impact of Satellite SSH)

➢ We conducted an OSE in which SSH data are withheld in the 1/10˚-resolution system, and compared it with a control experiment (regular assimilation run).

100-m current fields at Apr. 16th,2011 with plots of ADCP data and observed positions

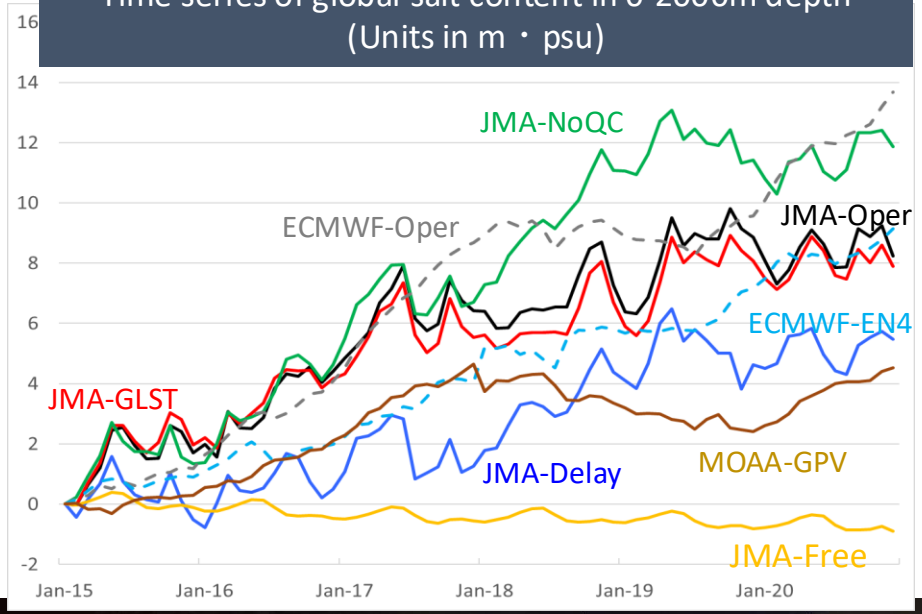


➢ The shape of the eddy reproduced in the control experiment is much more consistent with ADCP observations.

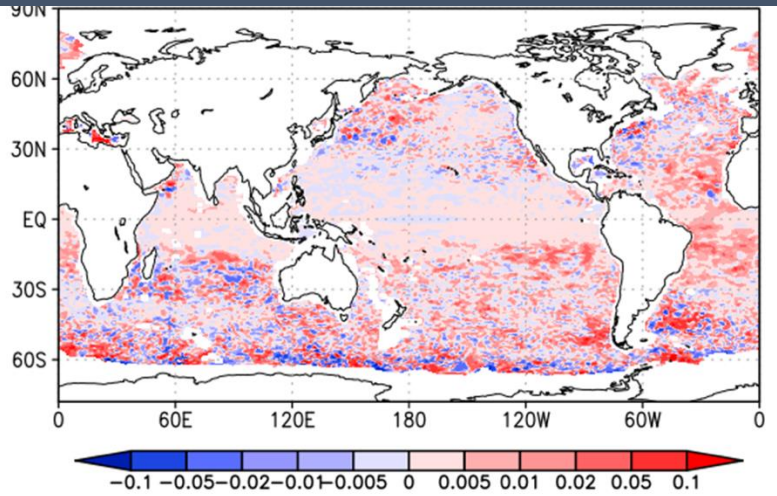
Impact of Argo QC

- Argo floats with high salinity drift increases after 2015.
- Coordinated OSEs were conducted in JMA, ECMWF and NERSC to assess the impacts of Argo QC, which removes such float measurements.

Time series of global salt content in 0-2000m depth (Units in m・psu)



Improvement of ACC of SSH temporal variation with satellite altimetry data in JMA-Delay compared to JMA-NoQC



- Global salt content should be conserved, but all OSEs has an increasing trend, as well as objective analyses (incl. MOAA-GPV).
- Real Time QC (applied to the operational data) and delayed-mode QC mitigates the salinity trend.
- Argo QC also improves the consistency of SSH temporal variation, including the increasing trend, with the satellite altimetry data.

Ishikawa et al. 2015, FMARS

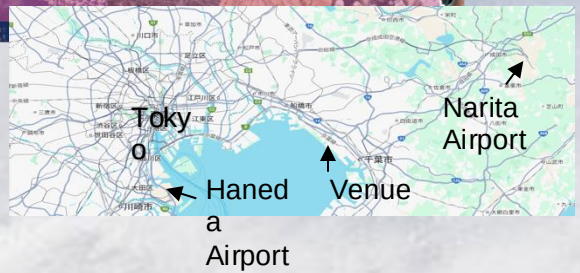
★ Points to keep in mind for conducting OSE/OSSE

- OSEs/OSSEs require considerable times and computational and human resources.
  - ✓ People in prediction centers understand importance of appealing observation impacts.
  - ✓ But they need to spend most of their time maintaining the prediction system.
  - ✓ Thus, effective strategy is required. (not possible to perform OSEs for every regions.)
- Advices of observational specialists are necessary for designing effective OSEs, and make useful analysis.
  - ✓ Information on error properties, possible enhancement of observations, etc. are necessary.
- Difficult to identify a positive impact of a single observation (or sparse observations)
  - ✓ Observing systems should be evaluated not as individual elements, but a whole network.
- Observation impacts considerably depend on the targets (spatial and time scales, target variables, etc.)
  - ✓ Important to collaborate among wide-range of stakeholders.
- Observation impacts also depend on maturity of the prediction system.
  - ✓ Systematic errors or model biases severely affect the results of OSEs
  - ✓ No impact may not mean that the observation is meaningless, but that the system is not enough mature.
  - ✓ Need cautions for interpreting OSE results.
  - ✓ Multi-system evaluation is meaningful.

★ Possible Collaboration

- Collaboration for analyzing SynObs flagship OSE /OSSE results.
  - The flagship OSE/OSSE results will be shared everyone and we need several volunteer groups to analyze the observation impacts in the results.
- Collaboration for a new OSEs/OSSEs to identify the impact of specific observing system
  - Need to prepare financial, human, computational resources. (OSEs/OSSEs are very resource-consuming.)
  - Supports from observation communities for executing prediction runs, processing the data, and analyzing the results are very valuable.
- Observation campaign? Targeted Observations?
  - Coordinating observation campaign may be possible to support the development of data assimilation procedure, to evaluate the analysis and prediction fields, and validate effectiveness of observations, which are theoretically, or technically recommended.
- Information on the observation qualities (noise level and systematic errors) should be shared
  - It is necessary to assimilate the observation properly.
  - In turn, prediction centers can share the information on observation quality.

★ Sessions in Academic Meetings



- Japan Geoscience Union (JpGU) Annual Meeting 2025

  Meeting Period: 25 (Sun) – 30 (Fri), May 2025

  Location: Chiba (near Tokyo), Japan

  Session Title: Earth System Observation Impacts on Climate and Ocean Predictions

  Session Date & Time: May 27th (Tue), AM

  Convenors: Y. Fujii, S. Kido, Y. Tseng, and J. Xie

  Invited Speakers: K. A. Peterson, W. Kessler, T. Lee

  Call for Abstracts: Jan. 16th – Feb. 18th (Early bird Deadline Feb. 6th)

- We aim to propose a science session in AGU Fall Meeting 2025 or Ocean Science Meeting 2026

- SynObs International Workshop 2026

  Location: Mutsu, Aomori, Japan

  Period: 24 (Mon) – 27 (Sat), Aug., 2026.

  ✓ Jointly organized with 30th Japanese Summer School on Data Assimilation.

Boundary Currents and Core Team Co-Design Programme

Exemplar Leads

- Tamaryn Morris, South African Environmental Observation Network (SAEON)
- Ann-Christine Zinkann, NOAA, USA

Jan 15th , 2025

Highlights and results achieved for 2024

1. Presentation of Boundary Current Exemplar at UN Ocean Decade conference as a poster and during the pan-tropical side event
2. Boundary Current Design Workshop: 9-12 September 2024
3. Start of the Algoa Bay coast to core connectivity project - a pilot within a pilot. This project is helping us establish what instruments work well for observing such a powerful Western Boundary Current, but also how to look at connectivity between the coast and the Agulhas Current

Issues and challenges 2024

1. …
2. …
3. …
4. …

Exemplar Activities for 2025

1. Continuation of ACEP surveys; additional surveys to establish needs and possible solutions (pilot within pilot ideas)
2. Final workshop report and detailed proposal
3. Agulhas Current review paper
4. Cost benefit assessment of observations within the Agulhas (and Benguela) Current(s) - ???

Exemplar Plans 2026 - 2027

1. Fund-raising
2. Implementation stage of plans
3. Modelling strategies linked to tangible products / services

Exemplar Opportunities for 2025

1. South Africa are hosting the G20 in 2025, and will be handing over to the USA in 2026. SAEON has been asked to facilitate the Ocean20, which started with dialogues in Brazil in 2024 but which we are pushing to turn into Ocean Actions in 2025, with focus on -
    a. Cooperative Science and Innovation
    b. Public-Private-Philanthropic Partnerships
2. We have been awarded funding looking at connectivity in the Mozambique Channel (with focus on their MPAs) but which links ultimately with the Agulhas Current. The project is called SIOMPA (Southwest Indian Ocean Marine Protected Areas). This gives us an opportunity to -
    a. Create political connections
    b. Deploy instruments into the northern Agulhas Current region
    c. Validate the CROCO model over this region and couple to BGC models

What support is needed from the Programme or other organizations ?

Communications, visibility, and messaging?

Connections (WMO, Ocean Decade, GOOS Panels, networks, GRAs, IOC, philanthropic organisations, others)? If WMO, which parts of WMO do you want to strengthen your links to?

Funding for specific actions:
Meetings, workshops, equipment - USVs, drifters, low-cost technologies, Argo floats, others.

Other ? (writing proposals, writing reports, organising meetings, providing timely feedback, strategic advice)?

Marine Heat Waves and Core Team Co-Design Programme

Exemplar Leads

- Melanie Juza SOCIB, ES

Jan 15th , 2025

Highlights and results achieved for 2024

Reviving the exemplar…

- Meetings with key people (GOOS, GCOS, WMO, OOPC, Co-design leaders…)

Envisioned governance structure

- Transition to new leadership (3 co-chairs across regions)
- Steering committee: experts along the value chain (letter of commitment)
- Co-design support (OOPC, CLIVAR, WMO, WCRP…)

Issues and challenges 2024

What challenges hampered the progress of the Exemplar?
What are the most relevant issues preventing the implementation of the Exemplar?
Issues in general?
→ Not applicable

Exemplar Activities for 2025

Steering committee

- revival and complete the existing team (letter of commitment)
- meetings (February 2025)

Assessment of the MHW exemplar

- Assess the MHW exemplar status, update state-of-the-art
- Exemplar pilot areas - criteria
- Template for the Mediterranean Sea

Exemplar Plans 2026 – 2027

What plans has the exemplar in the term of 2026-2027?
→ To be discussed with the Steering Committee when reactivated

What support is needed from the Programme or other organizations ?

Communications, visibility, and messaging?

Connections (WMO, Ocean Decade, GOOS Panels, networks, GRAs, IOC, philanthropic organisations, others)? If WMO, which parts of do you want to strengthen your links to?

Funding for specific actions:
Meetings, workshops, equipment ?

Other ? (writing proposals, writing reports, organising meetings, providing timely feedback, strategic advice)?

Storm Surge and Core Team Co-Design Programme

Exemplar Leads

- Giovanni Coppini, CMCC, IT
- Mairead O'Donovan

Jan 15th , 2025

Highlights and results achieved for 2024

Engagement of GlobalCoast Pilot Sites

Pacific Islands
Tropical Americas and Caribbean
South East Asia Seas

-> first stakeholder consultation about priorities
-> engagement of regional and local Pilot Site partners

Successful funding for Citizen Science project: CS-MACH1

Low-cost sea level sensor deployment -> Storm Surge forecasting as part of MH-EWS

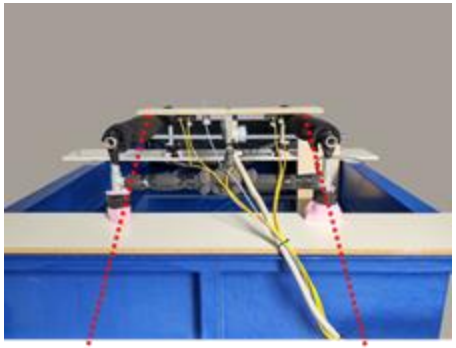
Need of Early Warning Systems and Marine Monitoring for Sea Level Rise and Extreme Events

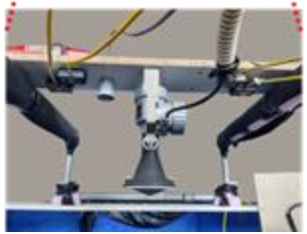
180 mm within 24h

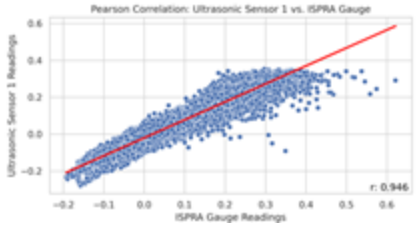
490 mm within a few hours

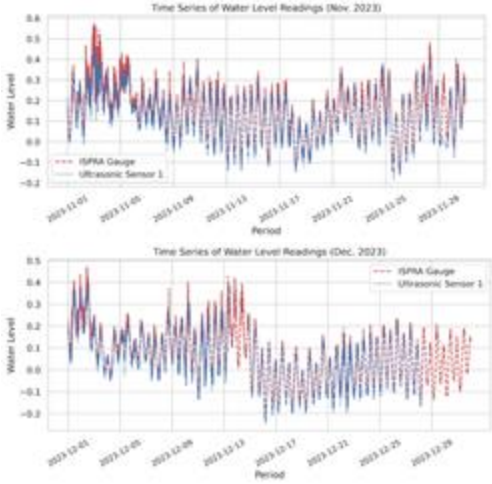
CMCC Technological Development: Low-Cost, Citizen Science Sea Level Sensor

Low-cost Sea Level Sensor
(in collaboration with Univ. Tuscia)









EMODnet Physics

Exemplar Activities for 2025 – 2030

Fundraising - project component: Design and implement Coastal Multi-Hazard People Centred Early Warning System

Expected outcomes:

1- Enhanced Real-Time Forecasting Capacity: Improved ability to predict coastal environmental conditions for up to 15 days. Operational readiness for addressing coastal hazards in real time.

2- Improved Understanding of Multi-Hazard Events: Advanced insights into the compounding effects of multi-hazard events (e.g., **storm surges**, waves, pollution). Clearer understanding of their impacts on coastal regions and communities.

Expected outputs:

1- Real-Time Forecasting Systems: Operational real-time forecasting systems tailored to Pilot Site coastal areas.

2- Customized Multi-Hazards Mapping: Hazard maps identifying potential risks from various sources (e.g., **storm surges**, tsunamis, pollution, erosion).

3- AI-Based Short-Term Forecasting for **Storm Surge**: Predictive tools leveraging AI to enhance storm surge forecasting accuracy and lead time