SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Theme 5.4

Assessing the impact of assimilating high-resolution SLA fields (SWOT) into MOVE/MRI.COM-JPN

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1.Introduction

- ✓ The Japan Meteorological Agency (JMA) operates an ocean data assimilation and forecasting system (MOVE-JPN), which assimilates sea level anomaly (SLA) data from various satellites as well as in situ observation data.
- ✓ It has been a year since the release of the Level 3 products from SWOT. In addition to the conventional Nadir altimeter, SWOT is equipped with the KaRIn altimeter, which has a wide observation swath of 120 km. We assessed the KaRIn advantages by assimilating Nadir and KaRIn altimeter into our operational system respectively and comparing the results.

2. Outline of MOVE-JPN system

Model and Data assimilation scheme

MRI.COM (MRI Community Ocean Model; Sakamoto et al., 2019)
- 60 vertical levels from the surface to 6500m (GLB with bottom boundary layer)

MOVE (Multivariate Ocean Variational Estimation system; Usui et al., 2015, Hirose et al., 2019)
- Observation window is 7 days. An initialization scheme of Incremental Analysis Updates (IAU) technique is used to correct the model fields with the analysis result. IAU period is set to 3 days.

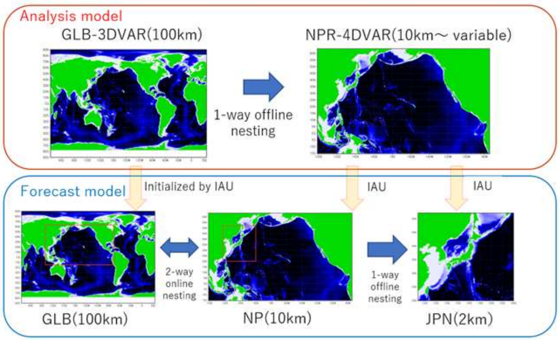


Fig.1. Model domain for MOVE-JPN.

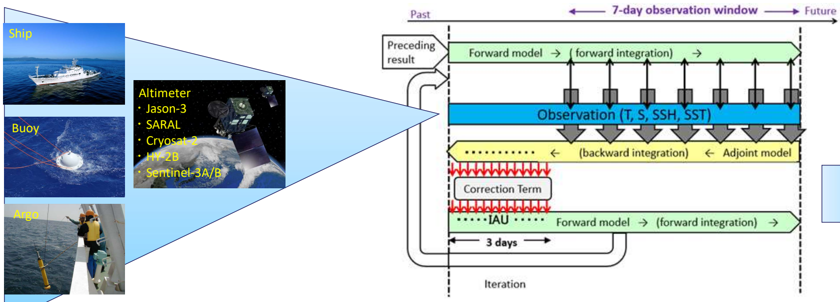


Fig. 2 Schematic of assimilation cycle for NPR-4DVAR.

Product

Analysis data on ocean currents and several layers of subsurface water temperatures from 2020 are available on the **NEAR-GOOS Regional Real Time Database** for research users (Fig. 3: https://ds.data.jma.go.jp/gmd/goos/data/database.html).
- Region: the seas adjacent to Japan.
- Format: text (for data), gif (for map).

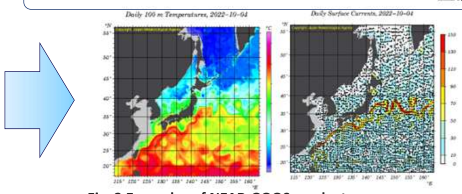


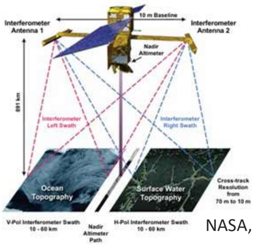
Fig. 3 Examples of NEAR-GOOS products.
(Left: daily 100m temperatures. Right: daily surface currents.)

3. Impact of SWOT KaRIn altimeter SLA assimilation

JMA has a plan to introduce KaRIn data to the operational MOVE–JPN, which can complement the data-sparse areas of observations (Fig. 4). Experiments were conducted to assess the impact of the entirely new KaRIn altimeter compared to the conventional nadir altimeter. In this study, data from other operationally assimilated satellites were excluded to isolate the impact of the KaRIn.

- Assimilated data (Level-3 Product released around December 2023)
  CNTL: Nadir altimeter alone from CMEMS
  TEST: KaRIn altimeter alone from AVISO+*
  * Due to the large volume of data, it is thinned out at approximately 7 km intervals (Both Exp. use in situ temperature and salinity data)
- Calculation Period: 6 Jan. 2024 – 30 Jun. 2024

Results
- Contrary to our expectations, the RMSE for TEST worsened in the Kuroshio Extension and the eastern tropical Pacific (Fig. 5).
- Although we have not yet reached a conclusion, one possible reason is the excessive number of observations provided.
- In our current method, the cost function is defined by terms related to T-S profile data derived from platforms like Argo and terms derived from SLA data. A higher number of SLA observations results in a relatively reduced impact of the observation term related T-S data such as Argo, Buoy, Ship.
- This suggest that an excessive amount of SLA data may lead to the underestimation of internal ocean observations, potentially causing bias.



NASA, 2024

The Surface Water and Ocean Topography (**SWOT**) mission has been jointly developed by NASA and CNES. The primary payload on SWOT is Ka-band Radar Interferometer (**KaRIn**), which measure the surface across a 120km wide swath with a ~20km gap along nadir.

Satellite :	SWOT
Launch on :	12 Dec. 2022
Altitude:	890km
Inclination:	77.6°
Cycle:	21 days

CNTL : Nadir NOBS:~38000 → ×16 → **TEST : KaRIn** NOBS:~612000 (after super-obs)

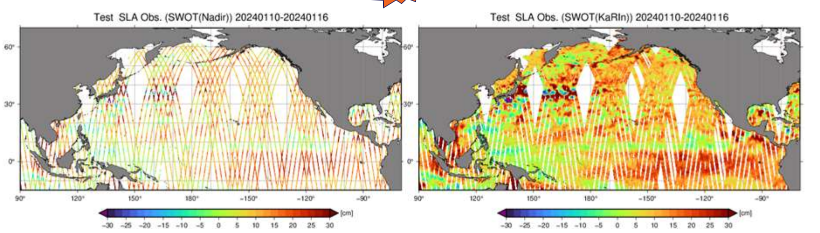


Fig. 4 Coverage map of SWOT altimeter SLA in an assimilation window(7 days).

Cost function:

$$J(\mathbf{z}) = \frac{1}{2}\mathbf{z}^T\mathbf{B}_H^{-1}\mathbf{z} + \frac{1}{2}\sum_i^N \left[\mathbf{H}_i\mathbf{x}_i(\mathbf{z}) - \mathbf{y}_i^{\mathrm{TS}}\right]^T \mathbf{R}^{-1}\left[\mathbf{H}_i\mathbf{x}_i(\mathbf{z}) - \mathbf{y}_i^{\mathrm{TS}}\right]$$

observation term relate to T-S

$$+ \frac{1}{2\sigma_h^2}\sum_i^N \left[\mathcal{H}_i(\mathbf{x}_i(\mathbf{z})) - \mathbf{y}_i^{\mathrm{SSH}}\right]^T \left[\mathcal{H}_i(\mathbf{x}_i(\mathbf{z})) - \mathbf{y}_i^{\mathrm{SSH}}\right] + J_c$$

observation term relate to SLA

Observation operator for altimeter data: $\mathcal{H}_i(\mathbf{x}) = -\frac{1}{\rho_s}\int_0^{z_m}\rho_i'(T,S,p)\,dz$

$\mathbf{z}$	Amplitudes of vertically coupled T-S EOF modes (control variables)
$\mathbf{x}$	Temperature and salinity analyses
$\mathbf{H}$	Observation operator for T-S profiles
$\mathbf{B}_H$	Horizontal correlation matrix for background errors
$\mathbf{R}$	Observation error covariance matrix for in-situ T-S profiles
σ_h	Observation error for altimeter-derived sea-level anomalies
$\mathbf{y}^{TS}$	T-S profile data
$\mathbf{y}^{SSH}$	Altimeter-derived sea level anomaly
z_m	Reference depth for the SDH(surface dynamic height) calculation
ρ_s	Surface density
ρ'	Density deviation from reference state(T=0°C and S=35psu)

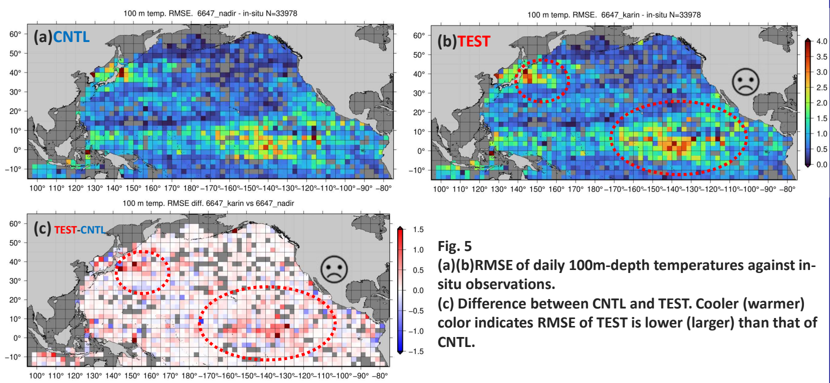


Fig. 5
(a)(b)RMSE of daily 100m-depth temperatures against in-situ observations.
(c) Difference between CNTL and TEST. Cooler (warmer) color indicates RMSE of TEST is lower (larger) than that of CNTL.

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