

# Development of a new operational ocean system for monitoring and forecasting coastal and open ocean states around Japan

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## 1. MOVE/MRI.COM-JPN system

- ✓ A new operational ocean system (MOVE/MRI.COM-JPN) for monitoring and forecasting coastal and open ocean around Japan is developed in MRI, which will run in JMA in 2020.
  - ✓ Target: sub-mesoscale phenomena (e.g. frontal waves causes sudden temperature rises with strong current) in addition to mesoscale phenomena (e.g. Kuroshio path variation)
- In this poster, we show present
- ✓ Overview of this new operational system
  - ✓ Statistical evaluation and event performances

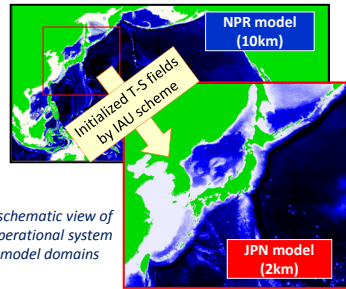


Fig. 1 schematic view of new operational system and model domains

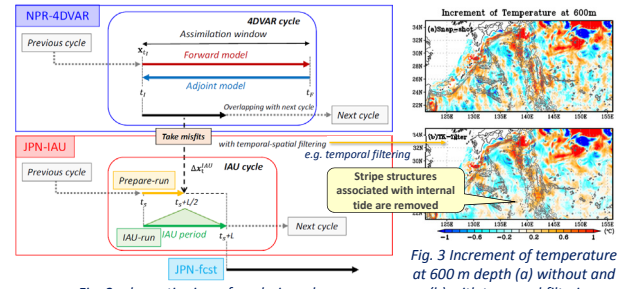


Fig. 2 schematic view of analysis cycle

Fig. 3 Increment of temperature at 600 m depth (a) without and (b) with temporal filtering.

### NPR-4DVAR

- North Pacific with 10 km horizontal resolution
- MOVE-4DVAR(Usui et al., 2015)
  - Vertical coupled T-S EOF modes (Fujii and Kamachi, 2003)
- Optimize Temperature and Salinity (T-S) fields
- Observation data assimilated
  - In-situ temperature and salinity profiles (WOD, GTSP)
  - Satellite-based sea surface temperatures (MGDSST)
  - Along-track sea level anomalies (AVISO/CEMIS)

### JPN model (JPN-IAU, JPN-fcst)

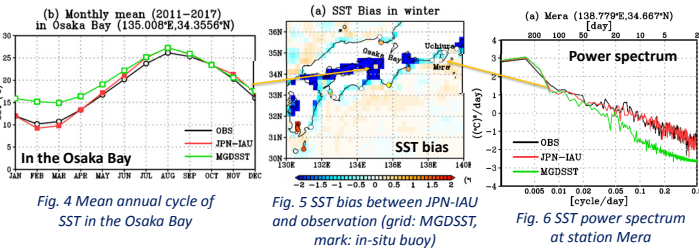
- OGCM: MRI.COM version 4 (Tsujino et al., 2017)
- Free surface,  $z^*$  vertical coordinate, 60 levels
- 2-way online nesting (Global-North Pacific-JPN)
- Horizontal resolution :  $1/33^\circ \times 1/50^\circ$  (~2km)
  - Explicit tidal forcing (Sakamoto et al., 2013)
  - Depression and suction by sea level pressure
  - Surface forcing : JRA55-do (Tsujino et al., 2018)
  - River discharge: CaMa-Flood model+ runoff from JRA55 (Suzuki et al., 2018)

### Analysis cycle

- NPR-4DVAR is run with 5-day assimilation window
- Incremental Analysis Updates (IAU) (Bloom et al., 1996) is used to obtain T-S increments for JPN model constraint
  - 5-day IAU period
  - Temporal (Lanczos) and spatial (Gaussian) filters are applied for the T-S increments
- Sea ice data assimilation by nudging scheme
- Experiment period: 2008.1.1-2017.12.31

## 2. Analysis and Forecast results

### 2.1. Sea surface temperature (SST)



- ✓ SST biases in JPN-IAU are small, especially in winter, in semi-enclosed Sea (Seto Inland Sea) compared to satellite SST product (MGDSST)
- ✓ JPN-IAU has a potential to represent short-term variability, with higher SST power spectrum in the high-frequency region.

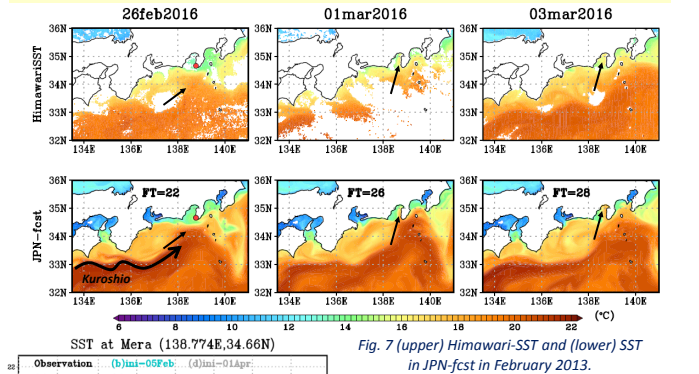


Fig. 8 SST at station Mera (red mark in Fig. 7) and JPN-fcst result at corresponding grid

- ✓ Frontal waves along the Kuroshio path causes the rapid warming at the coastal area
- ✓ One month forecast by JPN-fcst represents the warming event.

### 2.2. Sea surface height (SSH)

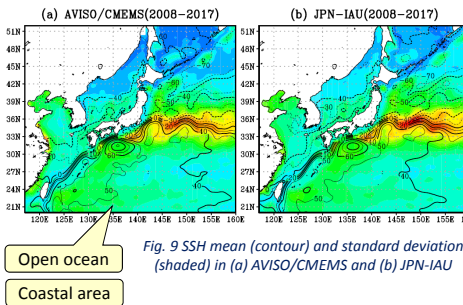


Fig. 10 (a) Standard deviation of SSH in JPN-IAU, (b) ratio of SSH standard deviation, (c) capture ratio (skill score), and (d) correlation between JPN-IAU and observation.

- ✓ Variability in JPN-IAU almost equal to observation, except for east coast of Japan Islands
- ✓ Capture ratio (skill score) and correlation are high at the most stations

JPN-IAU : analysis result for the JPN model constrained by NPR-4DVAR  
JPN-fcst : forecast run started from the JPN-IAU initial conditions

- ✓ SSH variation in open ocean is well reproduced in JPN-IAU compared with AVISO grid dataset, through T-S fields assimilation only.

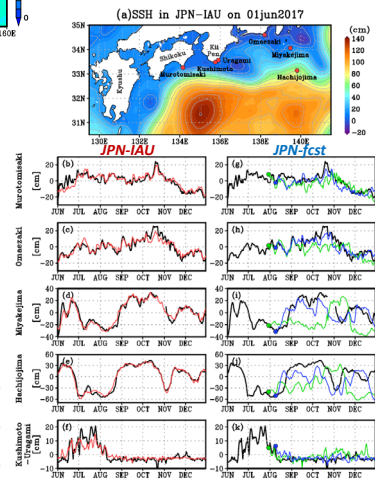


Fig. 11 (upper) SSH map in JPN-IAU on Jul 1st 2017. Time series of sea level in observation compared with (left) JPN-IAU and (right) JPN-fcst. Black line is observation

- ✓ Short term (few days) to seasonal scale variations are well represented.
- ✓ Large sea level variability associated with the Kuroshio path variation (e.g. at Hachijojima, Miyakejima) is also captured.

## 3. Sea ice in the Okhotsk Sea

- Sea ice concentration (SIC) data area assimilated by nudging scheme
- $C^a = C^f + K(C^o - C^f)$ 
  - $C^f$ ,  $C^a$ : first guess, analysis
  - $C^o$ : observation
  - Sea ice analysis product by JMA operation
  - $0.02 \times 0.02$  resolution
  - $K$ : weighting coefficient

JPN-fcst from Jan 1<sup>st</sup> 2013

- ✓ Sea ice initialization reproduces well observed SIC map (FT=1)
- ✓ Sea ice reached to the Japan coast (FT=30), although the southward extent of sea ice is weak in forecast

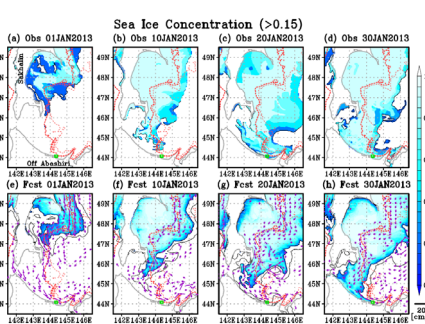


Fig. 12 Sea ice concentration (shaded) in (upper) observation and (lower) JPN-fcst on January 1<sup>st</sup>, 10<sup>th</sup>, 20<sup>th</sup>, and 30<sup>th</sup> 2013. Vector denotes sea surface current and red dotted lines are contour of (thick) 50 and (thin) 200 m depths.

## 4. Summary and Future work

- We have developed a monitoring and forecasting system for coastal and open ocean states around Japan (MOVE/MRI.COM-JPN)
  - High-resolution model (JPN model) around Japan with 2-km horizontal resolution
  - Low-resolution (~10 km) analysis model using 4D-Var assimilation (NPR-4DVAR)
  - IAU scheme for the forecast model initialization
  - Temporal-spatial filter not to weaken high-resolution model variability
  - Sea ice assimilation by nudging scheme
- JPN-IAU well reproduces observed features in terms of SST, SSH and SIC.
  - Successful forecasts are performed by JPN-fcst.
- Future work
  - Direct assimilation for coastal scale phenomena in the high-resolution model
  - Control of current fields by using observation such as HF radar, satellite product
- Further detail: manuscripts submitted to Ocean Dynamics (COSS-TT Topical Collection 2)
  - Sakamoto et al.: Coastal ocean model (MRI.COM-JPN) :
  - Hirose et al.: MOVE/MRI.COM-JPN system