National Report

a. Japan – MOVE/MRI.COM – JMA/MRI

Background

The main Japanese contribution, as a national assimilation/prediction center, to OceanPredict consists of the Japan Meteorological Agency (JMA) operational systems for ocean weather forecasting and ocean climate (El Nino and seasonal) forecasting, and a research/development group in Meteorological Research Institute (MRI) for ocean weather, climate, and coastal disaster prevention.

Japan Meteorological Agency (JMA) operates the data assimilation systems for global ocean and Japan area based on MOVE/MRI.COM developed by MRI. These developments and operation are under the JMA's national support. MRI has a cooperation of Japanese OceanPredict groups such as JAMSTEC, Kyushu University, Fisheries Research Agency (FRA), Japan Aerospace Exploration Agency (JAXA), and Japan Atomic Energy Agency (JAEA). The groups have continuously held the Data Assimilation Summer School every summer since 1995 under the support of Japan Marine Science Foundation as an outreach activity of OceanPredict.

1. Input data

   MOVE/MRI.COM uses atmospheric forcing data from the JMA operational NWP output and reanalyses (JRA 55).

   MOVE/MRI.COM assimilates in situ profile data delivered in GTS for operation and those in GTSPP and WOD for research and development. These messages include VOS XBTs, Argo and tropical mooring data. Both temperature and salinity data are assimilated. MOVE/MRI.COM uses a variational QC procedure as well as conventional quality checks (Fujii and Kamachi, 2005).

   Along track altimeter data from the TOPEX/POSEIDON, Jason-1/2/3, ERS1/2, ENVISAT, GFO, Cryosat-2, SARAL, HY-2A, and Sentinel-3A are also assimilated in MOVE/MRI.COM.

   The Japan area (JPN) system uses MGDSST (JMA-GHRSST), the sea surface dataset produced from satellite SST data together with SST data from ships and drifting and moored buoys. The global system for the operational seasonal forecasting uses in-situ-data based SST analysis, COBE-SST.

   Sea ice concentration (SIC) retrieved from SSM/I and SSMIS, which is included in the MGDSST product, is assimilated in the JPN system.

   Satellite sea surface salinity data from Aquarius and sea ice concentration data from SSM/I are experimentally assimilated in the global system (Toyoda et al., 2015a,b).

2. Data serving

   See section 5.

3. Models

   The models in the global and JPN systems are based on the Meteorological Research Institute Community Ocean Model (MRI.COM; Tsujino et al. 2011) version 3 and 4 (Tsujino et al. 2017). MRI.COM version 3 employs z-σ hybrid coordinate, which was upgraded to z* coordinate in version 4. The model can be multi-nested at various resolutions.

   The operational global version has a resolution of 1 degree for longitude and 0.5 degree for latitude with tri-polar coordinate system. The JPN system consists of a forecast model and an analysis model. The forecast model covers the seas around Japan with a resolution of 1/33 x 1/50 degree (Sakamoto et al. 2019). The model incorporates explicit tidal forcing (Sakamoto et al. 2013) and realistic river runoff calculated by a hydrodynamic model (CaMa-Flood) using JRA55 land surface components (Suzuki et al. 2018). Data assimilation is applied to the analysis model covering North Pacific with a resolution of 1/10 x 1/11 degree, and model settings are somewhat simplified compared to those for the forecast model.

4. Assimilation method

   The global version of MOVE/MRI.COM employs the 3DVAR-IAU scheme originally developed by Fujii and Kamachi (2003a,b,c). The 3DVAR scheme was extended to 4DVAR (Usui et al. 2015), which is employed in the JPN system (Hirose et al. 2019). Both the 3DVAR and 4DVAR schemes deal efficiently with multivariate temperature-salinity coupled EOF vertical modal decomposition and horizontal Gaussian off-diagonal elements of the background error covariance matrix (Fujii and Kamachi 2003a,b) with a new nonlinear descent method (POpULar) by Fujii and Kamachi (2003c) and nonlinear constraints, especially variational dynamic QC (Fujii and Kamachi 2005).

   Non-linear and non-Gaussian type constraints are implemented for improving strong frontal structures (Usui et al. 2011). Bias correction and FGAT schemes are also adopted (Fujii et al. 2017).

   Sea ice concentration data (in MGDSST) is also assimilated with a nudging and 3DVAR (Toyoda et al., 2015b) techniques with optimizing atmospheric fields. For further improvement of sea ice assimilation, an adjoint sea ice model that incorporate sea ice rheology was developed and a series of sensitivity experiments were conducted (Toyoda et al. 2019).

   In the JPN system, the forecast model is initialized with 4DVAR analysis model results through IAU as a Down-Scaling Technique (IAU-DST). In the IAU initialization, spatial and temporal filters are applied to forecast model results in order to take into account differences in resolution and model physics between the forecast and analysis models (Hirose et al. 2019).

   Coupled atmosphere-ocean assimilation system based on the outer-loop coupling technique is being developed for future reanalysis and seasonal prediction.

   An improved assimilation method for altimeter data, in which seawater mass variations are corrected to represent steric height properly (Kuragano et al., 2014), has been introduced to the operational system in 2018.

5. Assimilation products and dissemination

   A part of MOVE/MRI.COM state variables (temperature and velocity) is made available on the NEAR GOOS Database.

   Analysis and predicted variables (temperature, salinity and velocity) became available for commercial users through the Japan Meteorological Business Support Center in August 2014.

   Reanalysis datasets (see section 10) are available. FORA-WNP30 (Usui et al. 2017), which is based on older version of the 4DVAR system and was produced under collaboration between JAMSTEC and MRI is disseminated through the web site at http://www.godac.jamstec.go.jp/fora/e/index.html. MOVE/MRI.COM-JPN Dataset, which is a 10-year reanalysis product based on the JPN system, is also available upon request.

6. Systems

   The present operational MOVE/MRI.COM includes the global (-G2) and Japan area (-JPN) systems. The new global (-G3) will be in operation in 2021. See Tables for detailed information.

7. Observations - Links to (Argo, GHRSST, etc.)

   MOVE/MRI.COM assimilates both temperature and salinity profiles from Argo floats and tropical mooring buoys. Climatological velocity fields are compared. The assimilation result recovers well the frontal and velocity structures in the mid-depth derived from Argo data. Several sensitivity studies (OSE experiments) have been carried out (e.g., Fujii et al. 2011, 2015ab, 2019). MOVE/MRI.COM also assimilates MGDSST (JMA's operational GHRSST).

8. Internal metrics and intercomparison plans
9. Assimilation results and forecast skill of MOVE/MRI.COM-JPN, which has been in operation at JMA since the end of October 2020, have been evaluated according to GODAE North Pacific Metrics (Kamachi and Minato, 2001).

   Global operational products generated by MOVE/MRI.COM-G2 are provided for Real-Time Multi-Ocean Reanalysis intercomparison project (Xue et al. 2017).

10. Targeted Users and envisioned external metrics

    JMA reports seasonal and ocean forecasting results to Japanese citizens. JMA provides output to regional forecasting system by the Fisheries Research Agency and Japan Coast Guard. JMA provides the output of analysis and prediction to JAEA for the prediction of marine nuclear contamination. MRI delivered data for predicting the distribution neon flying squids to JAMSTEC.

11. Reanalysis activities

    Several global reanalysis products are provided for Ocean Reanalysis Intercomparison projects products (ORA-IP: Balmaseda et al., 2015). A global ocean reanalysis dataset between 1980-2010) generated by MOVE/MRI.COM-G2 was provided to CREATE-IP project as MOVE-G2i (https://cds-cv.nccs.nasa.gov/CREATE-V/). The latest version is inter-compared through the EU COST-EOS-1402 project and the GCOS activity.

    A long-term high-resolution reanalysis dataset for the western North Pacific named Four-dimensional variational Ocean ReAnalysis for the Western North Pacific over 30 years (FORA-WNP30; Usui et al. 2017) was produced under the collaboration between MRI and JAMSTEC using the Earth Simulator. A 10-year (2008-2017) reanalysis experiment using the MOVE/MRI.COM-JPN was carried out and results were validated against various observation data (Hirose et al. 2019). Using the JPN reanalysis data, 10-year statistics such as monthly climatological temperature, salinity, and their standard deviation was summarized as JPN Atlas 2020 (Hirose et al. 2020).

12. Computing resources

    The MRI group uses MRI supercomputing facility of FUJITSU PRIMERGY CX2550M5 (880 nodes, 40 cores/node, 2.81 PFlops).

13. Consolidation phase and transition to operational system (activities)

    The Japan-area system (MOVE/MRI.COM-JPN) started in operation in October 2020. The new global system (MOVE/MRI.COM-G3) will be in operation in 2021 as a part of the updated seasonal forecasting system.

14. related achievements and measures of success

    JMA operational system predicted the Kuroshio large meandering that occurred in August 2017 well. The El-Nino events in 2015 and 2018 are also predicted.

Operational System information overview

System name	**Global system: MOVE/MRI.COM-G2**
Ocean Models	
OGCM	MRI.COM version 3
Domain	Global
Horizontal resolution	1 deg. x 0.5 deg.
Vertical sampling	50 levels
Atmospheric Forcing	JRA55 (JMA's Operational analysis and Reanalysis) and NWP output
Assimilation characteristics	
Assimilation Scheme	3DVAR-FGAT
SST	COBE-SST

SSH	Along-track sea level anomalies including Jason-3, Cryosat-2, SARAL
Other	Temperature and Salinity profiles from GTS (Argo floats and tropical moorings are included.)
System Set-ups	
Forecast range	7 months (seasonal-El Nino forecast with CGCM)
Update frequency	5 days
Hindcast length	1980-2014+
System website links	
General information	http://ds.data.jma.go.jp/tcc/tcc/products/elnino/move_mricom-g2_doc.html
Technical description	
Viewing service	http://ds.data.jma.go.jp/tcc/tcc/products/elnino/

System name	**Japan area system: MOVE/MRI.COM-JPN**
Ocean Models	
OGCM	MRI.COM version 4
Domain	[Forecast model] Japan area (JPN) [Analysis model] North Pacific (NP)
Horizontal resolution	(JPN) 1/33deg. x 1/50deg, (NP) 1/10deg. x 1/11deg
Vertical sampling	60 levels
Atmospheric Forcing	GSM (real-time analysis and forecast) and JRA55 (delayed mode analysis)
Assimilation characteristics	
Assimilation Scheme	4DVAR and IAU-DST
SST	MGDSST (JMA-GHRSST product)
SSH	T/P, Jason-1,2,3, ERS-1,2, ENVISAT, GFO, Cryosat-2, SARAL, HY-2A, and Sentinel-3A
Other	Temperature and Salinity profiles from GTS (Argo floats are included), Sea Ice concentration from SSM/I and SSMIS
System Set-ups	
Forecast range	(JPN) 11 days (NP) 30 days
Update frequency	1 days

Hindcast length	2008-2017+
System website links	
General information	N/A
Technical description	N/A
Viewing service	N/A

Developing System information overview

System name	**Global system: MOVE/MRI.COM-G3**
Ocean Models	
OGCM	MRI.COM version 4
Domain	Global
Horizontal resolution	[Analysis model] 1 deg. x 0.5 deg. [Forecast model] 0.25 deg. x 0.25 deg.
Vertical sampling	60 levels
Atmospheric Forcing	JRA55-do (JRA55-based forcing adjusted for driving ocean; Tsujino et al. 2018)
Assimilation characteristics	
Assimilation Scheme	4DVAR and IAU-DST
SST	MGDSST (JMA-GHRSST product)
SSH	T/P, Jason-1,2,3, ERS-1,2, ENVISAT, GFO, Cryosat-2, SARAL, HY-2A, and Sentinel-3A
Other	Temperature and Salinity profiles from GTSPP and WOD (Argo and tropical moorings are included), Sea Ice concentration from SSM/I and SSMIS
System Set-ups	
Forecast range	7 months (seasonal-El Nino forecast with CGCM)
Update frequency	1 day
Hindcast length	1992-2017+
System website links	
General information	N/A
Technical description	N/A
Viewing service	N/A

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