JMA operational ocean prediction system - MOVE/MRI.COM

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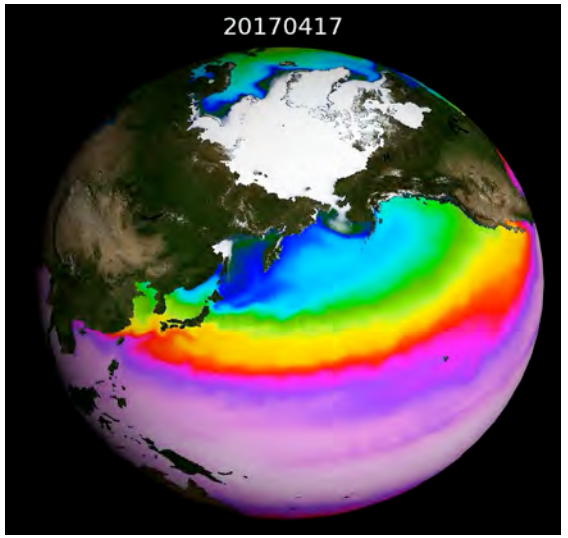
Overview of JMA operational systems

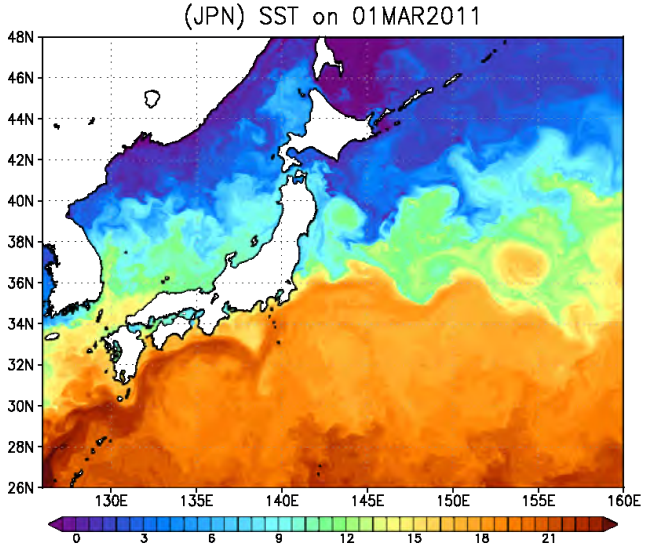
Global System - MOVE/MRI.COM-G3

- To monitor global ocean conditions and initialize a coupled atmosphere-ocean model for subseasonal-to-seasonal prediction.



Regional System – MOVE/MRI.COM-NP/JPN

- To monitor and predict coastal and open ocean around Japan, including the meandering of the Kuroshio, the intrusion of the Oyashio, and sea level rise in the coastal areas.



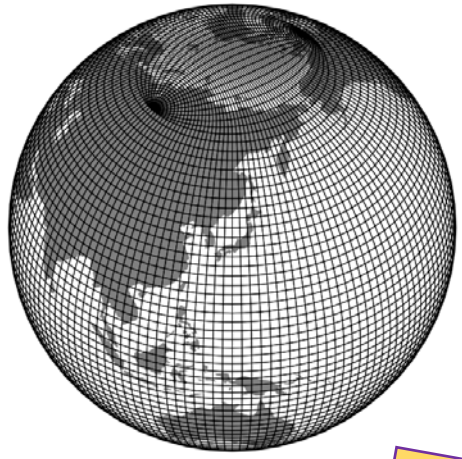
Global System - MOVE/MRI.COM-G3

- **Analysis model (G3A)**
  - Resolution: 1ºx0.3-0.5º
  - Global tripolar grid coordinate
  - In-situ TS profiles, satellite altimetry data, and SST objective analysis are assimilated through 4D-Var.
  - Sea Ice: 3D-Var

- **Forecast model (G3F)**
  - Resolution: 0.25º x 0.25º
  - Global tripolar grid coordinate
  - Constrained to TS fields of G3A by IAU downscaling
  - Sea Ice 3D-Var（the same as G3A）

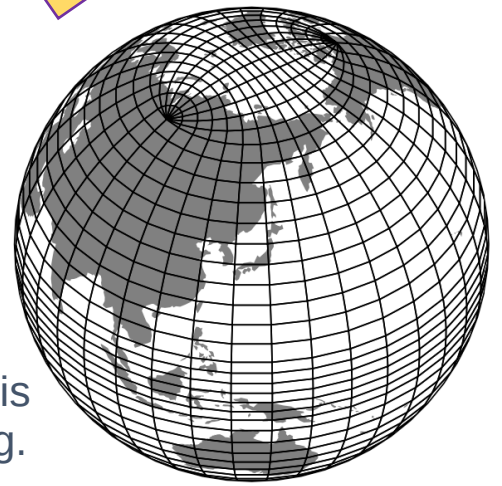
- You can find the details in Fujii et al. (2023), *Frontier in Climate* (DOI:10.3389/fclim.2022.1019673)

◆ MOVE/MRI.COM-G3 (Global System)



Coupled predictions

G3F
Initialization of fcst.
0.25×0.25 deg.



G3A
4D-Var analysis
1×0.3-0.5 deg.

★ JMA Seasonal Prediction System Updated in Jan. 2022

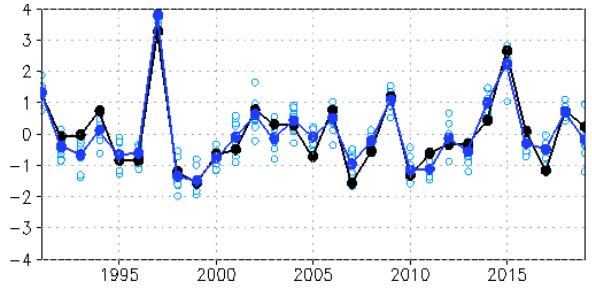
◆JMA/MRI-CPS3

- Atmospheric Model: TL319L100 (GSM2003)　~55km
- Ocean Model: 0.25 ˚× 0.25 ˚ L60 (MRI.COM v4.6)
- Initial Condition: JRA-3Q for atmosphere
  MOVE/MRI.COM-G3 for ocean
  T, S, SSH (4D-Var) sea-ice (3D-Var)
- Forecast Period: 6 months
- Ensemble: 5-members per day × 11 LAF

NINO.3

New System

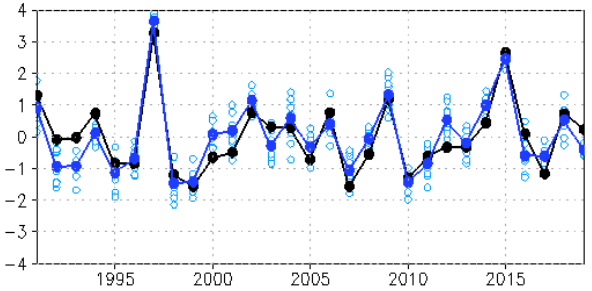
CPS3



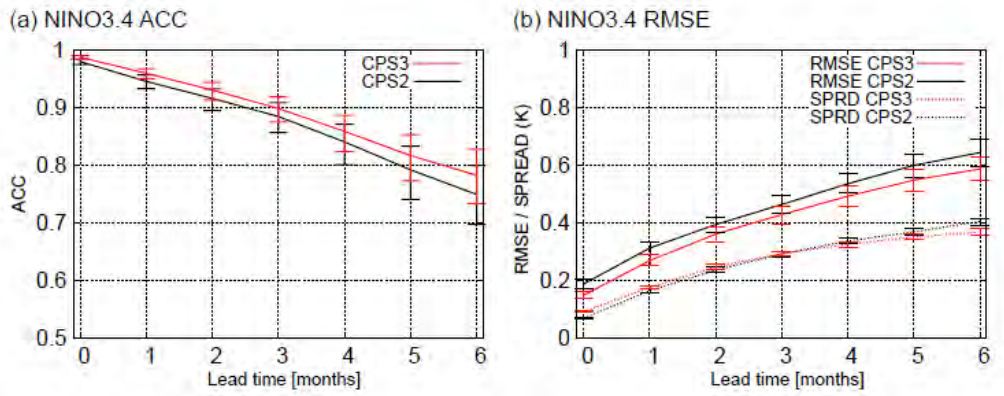
ACC= 0.94

Old System

CPS2



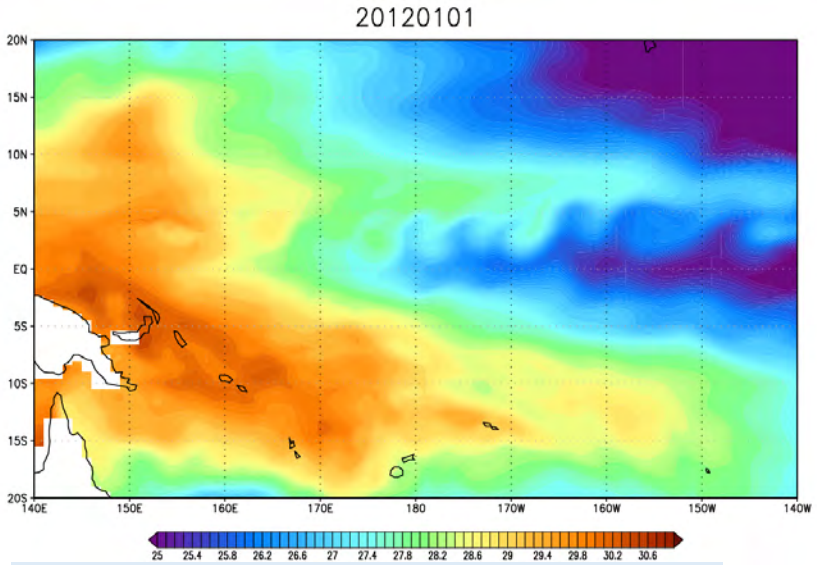
ACC= 0.90



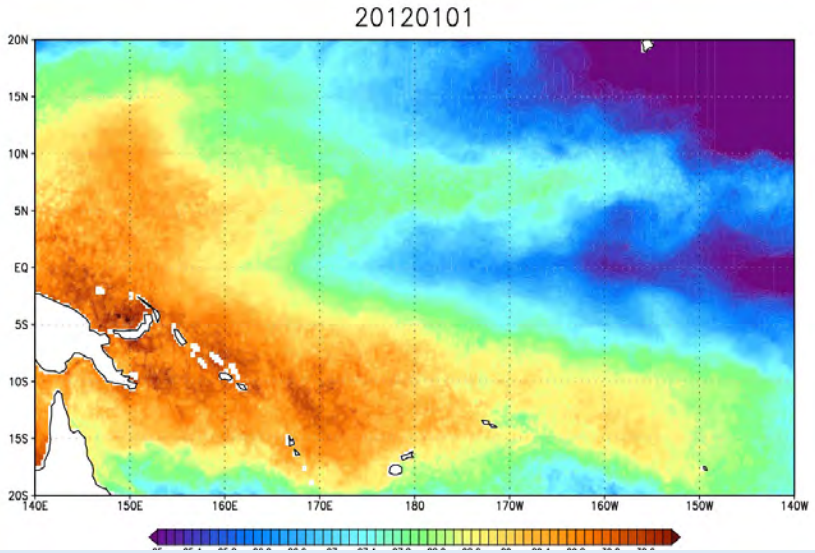
Hirahara et al. (2023) JMSJ

Representation of Tropical Instability Waves

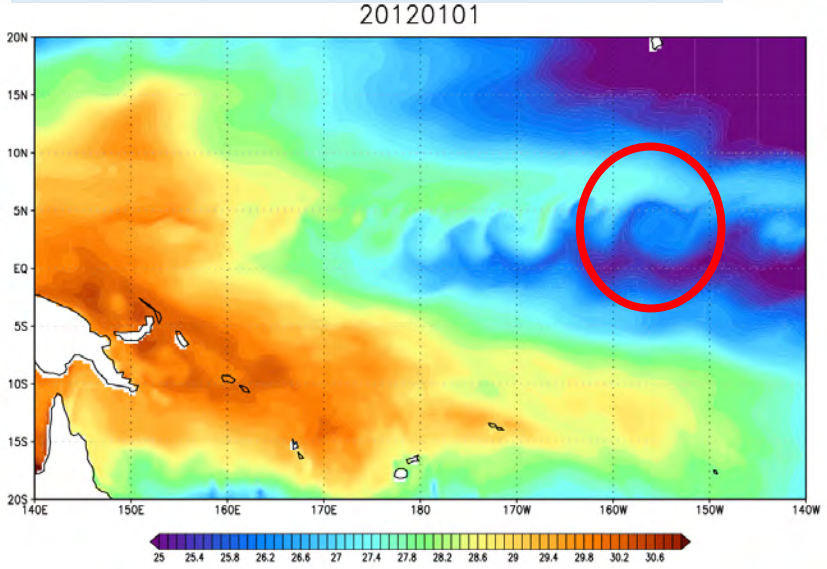
G3A-4DVar SST (1º × 0.3-0.5º)



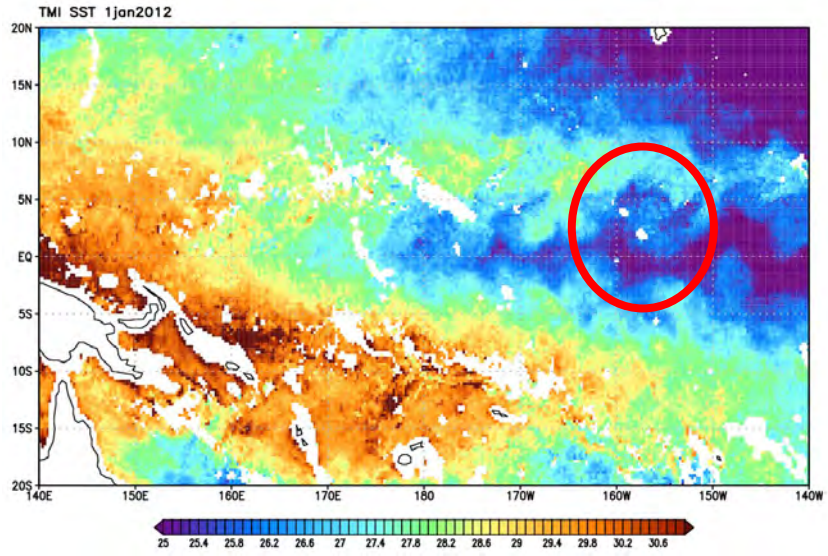
MGD-SST (0.25º × 0.25º)



G3F-IAU SST (0.25º × 0.25º)



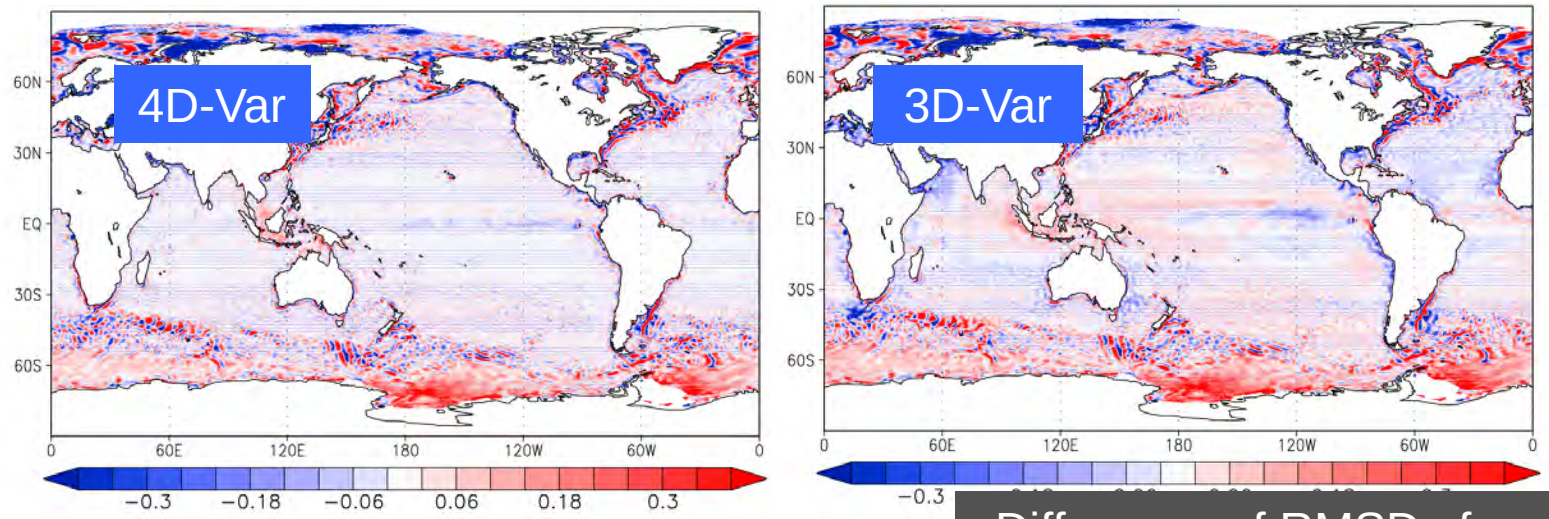
TRMM Microwave Imager (0.25º × 0.25º)



- Tropical Instability Waves (TIWs) are not clear in MGD-SST due to smoothing property of optimum interpolation.
- In contrast, DA systems reproduce SST variation associated with TIWs reasonably thanks to dynamical interpolation using forward and adjoint models.

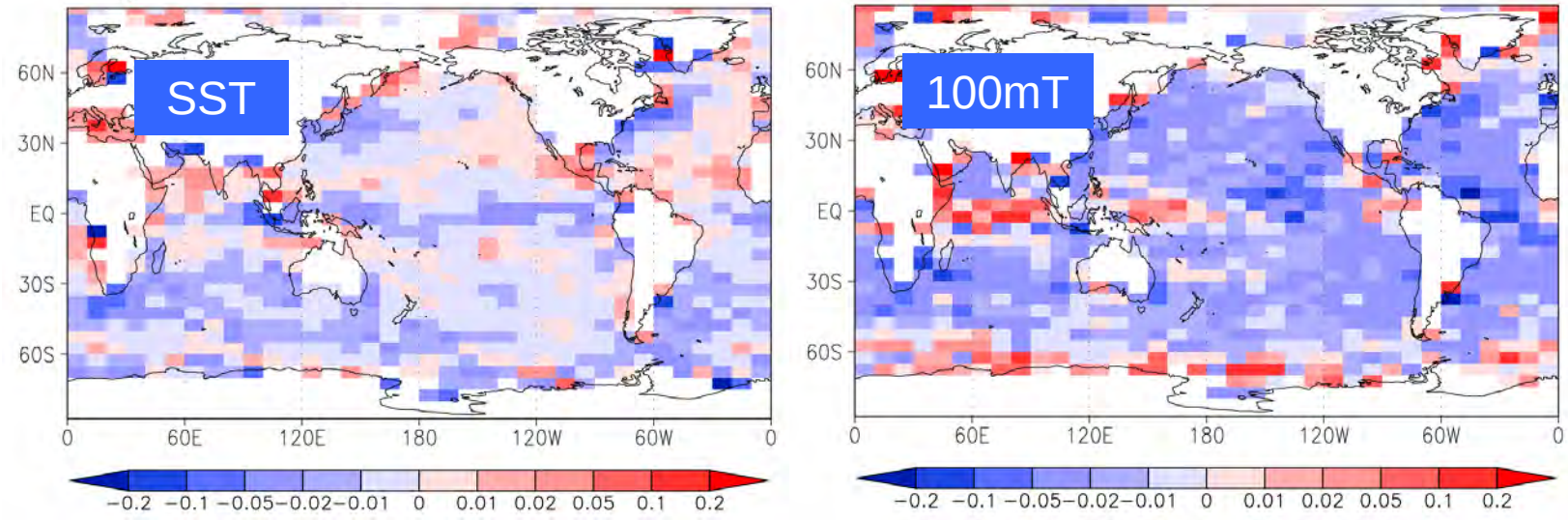
☆ Capacity to reduce data-misfits effectively (Comparison with assimilated data)

Bias from the objective SST analysis



- 4D-Var effectively reduces the SST bias from the objective SST analysis which is assimilated, compared with 3D-Var.

Difference of RMSDs from assimilated Argo data (4D-Var − 3D-Var)



- RMSDs from assimilated Argo data are also generally reduced by 4D-Var.
- Thus, 4D-Var more effectively reduces the data-misfits.

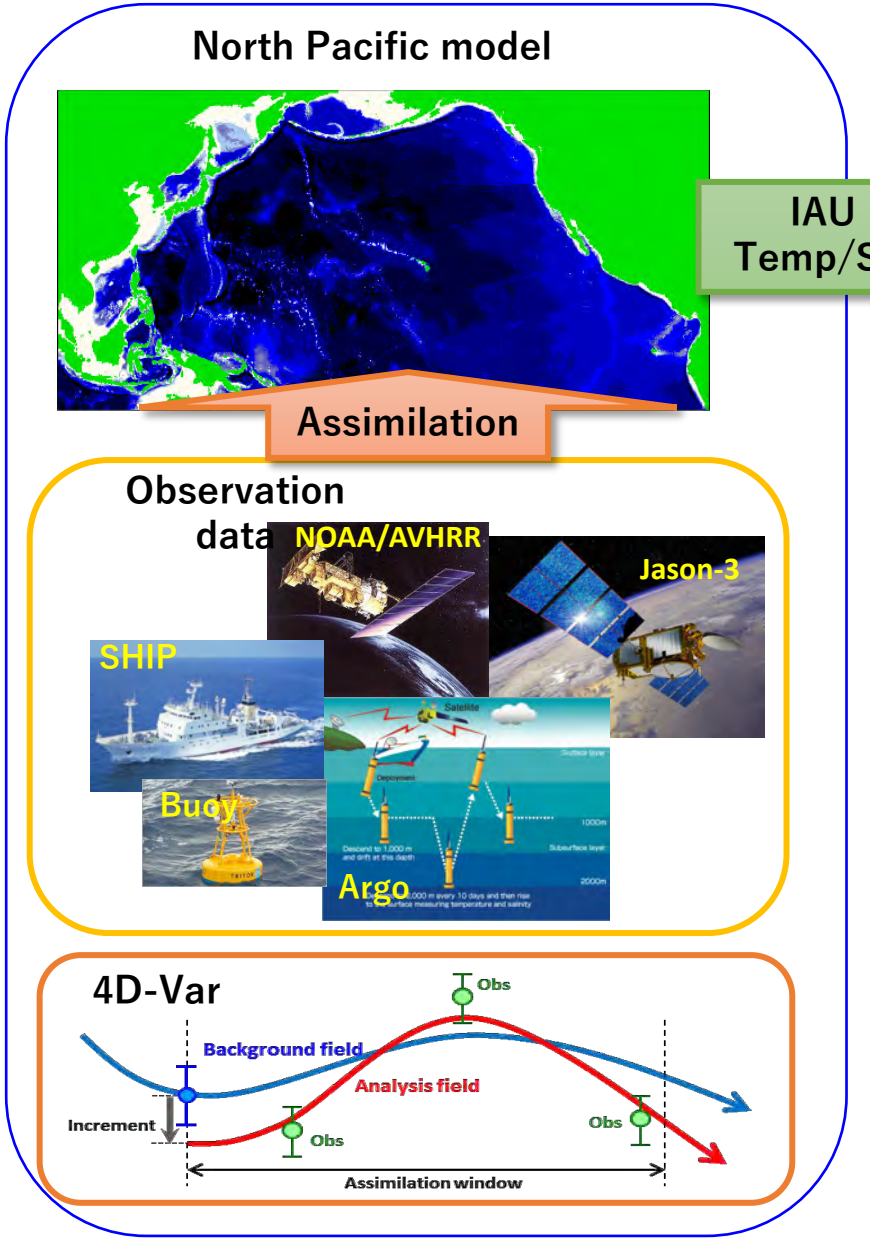
Blue: 4D-Var is better

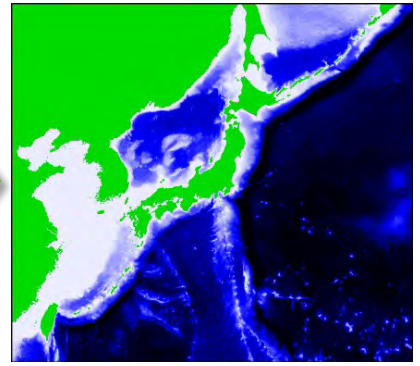
Regional System - MOVE/MRI.COM-NP/JPN

- **Analysis model - MOVE/MRI.COM-NP**
  - Domain: North Pacific (15ºS-65ºN, 100ºE-75ºW)
  - Resolution: 10km (1/9º x 1/11º)
  - In-situ TS profiles, satellite altimetry data, and SST objective analysis are assimilated through 4D-Var
  - Sea Ice: A simplified filter

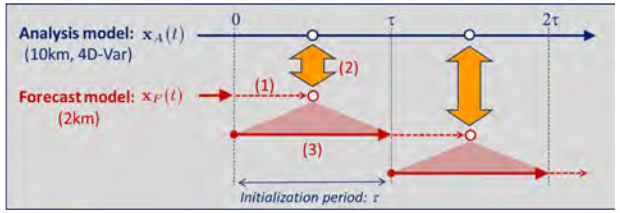
- **Forecast model - MOVE/MRI.COM-JPN**
  - Domain: Japan Area (20-52ºN, 117-160ºE)
  - Resolution: 2km (1/50º x 1/33º)
  - Tide/SLP including
  - Initialized with MOVE-NP through IAU downscaling
  - 30-day forecast for NP area
  - 11-day forecast for Japan-area

  - You can find the details in Hirose et al. (2019), *Ocean Dynamics* (DOI: 10.1007/s10236-019-01306-x)

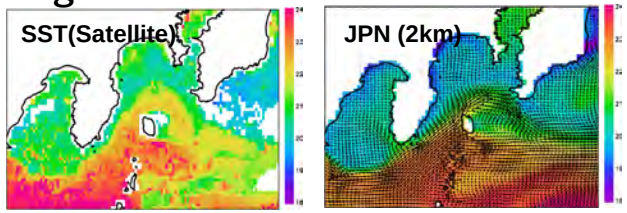




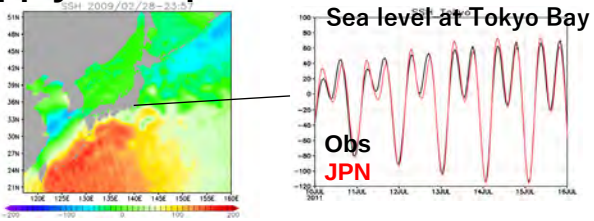
Incremental method (IAU)



High resolution

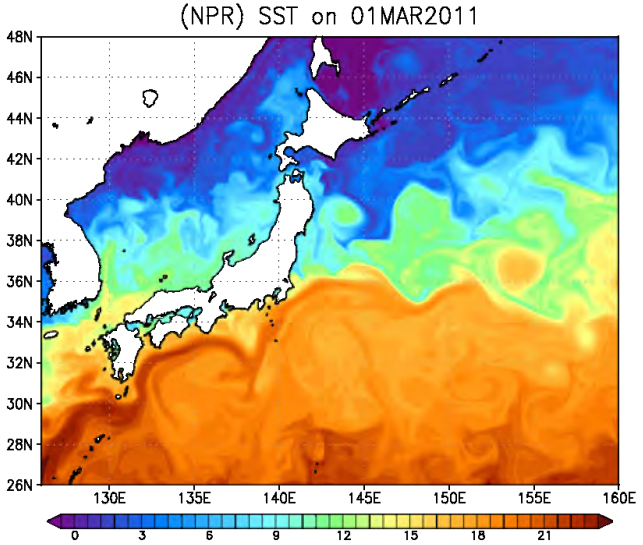


Apply Tidal potential



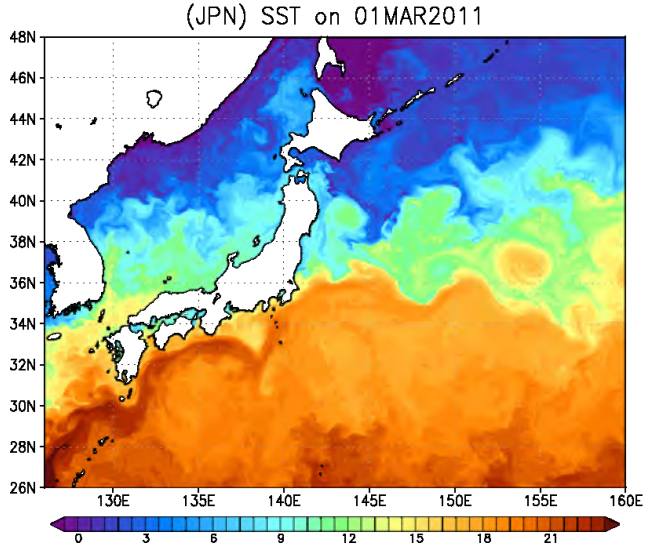
★ The JMA regional system has been updated since Oct 2020

SST (4D-Var Model)



☺ **Mesoscale variability is well analyzed by the 4D-Var scheme.**

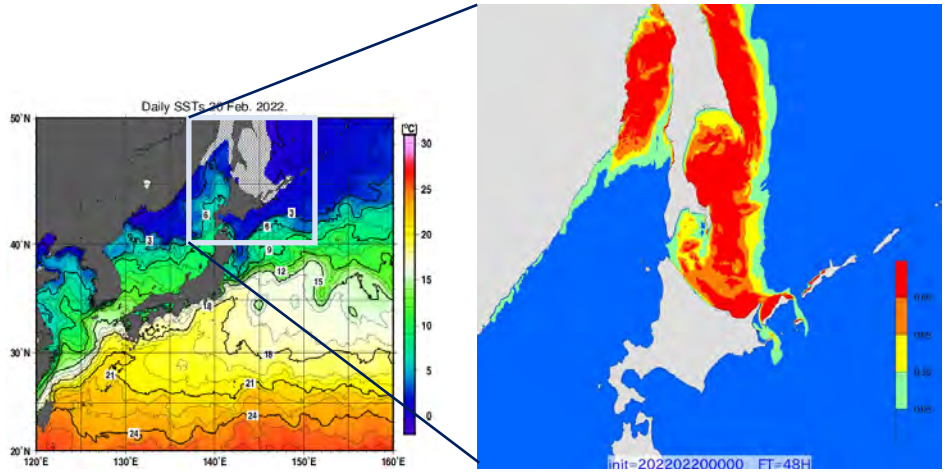
SST (Japan-Area Model)



☺ **Fine-scale structures are additionally resolved**

MOVE/MRI.COM-JPN has been used for **sea-ice prediction in the Sea of Okhotsk** since December 2021.

Sea-ice concentration



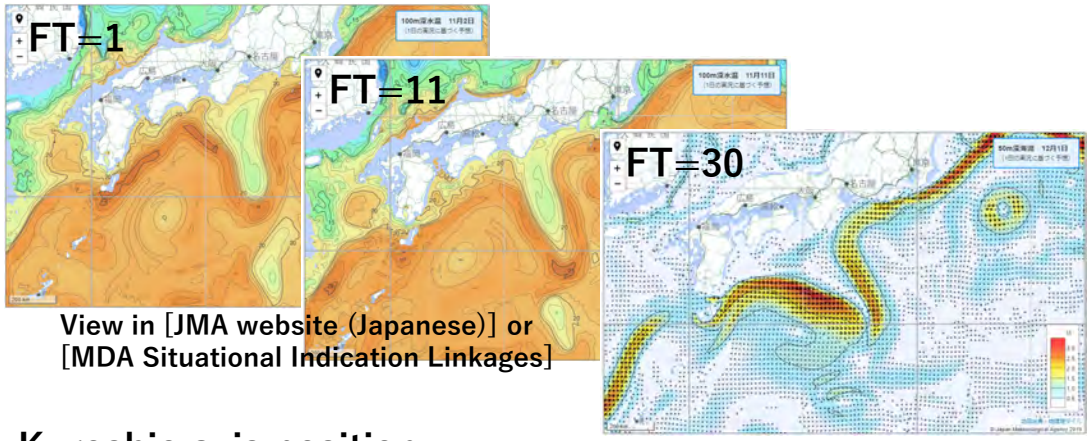
Products and Services

Ocean Products

Analysis & Forecast data

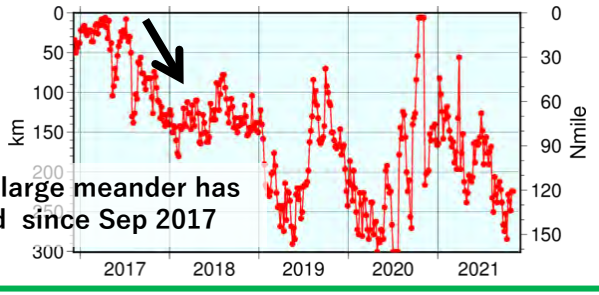
- SST, subsurface temperature
- Ocean currents
- Sea ice concentration(Okhotsk Sea)
- Tropical Cyclone Heat Potential (TCHP)

Forecast results

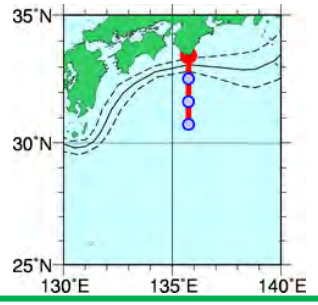


View in [JMA website (Japanese)] or
[MDA Situational Indication Linkages]

Kuroshio axis position



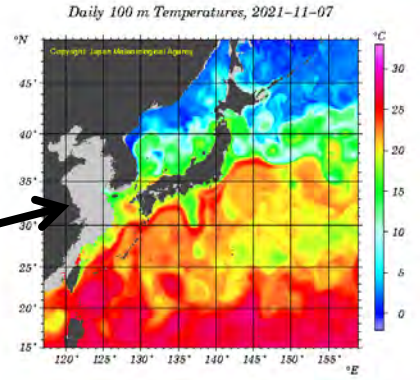
Kuroshio large meander has continued since Sep 2017



Data Service

Analysis & Forecast data

- NEAR-GOOS (only Analysis)
- Japan Meteorological Business Support Center



GPV can be downloaded via the website.

https://ds.data.jma.go.jp/gmd/goos/data/database.html

Users

Japanese citizens, organizations, researchers

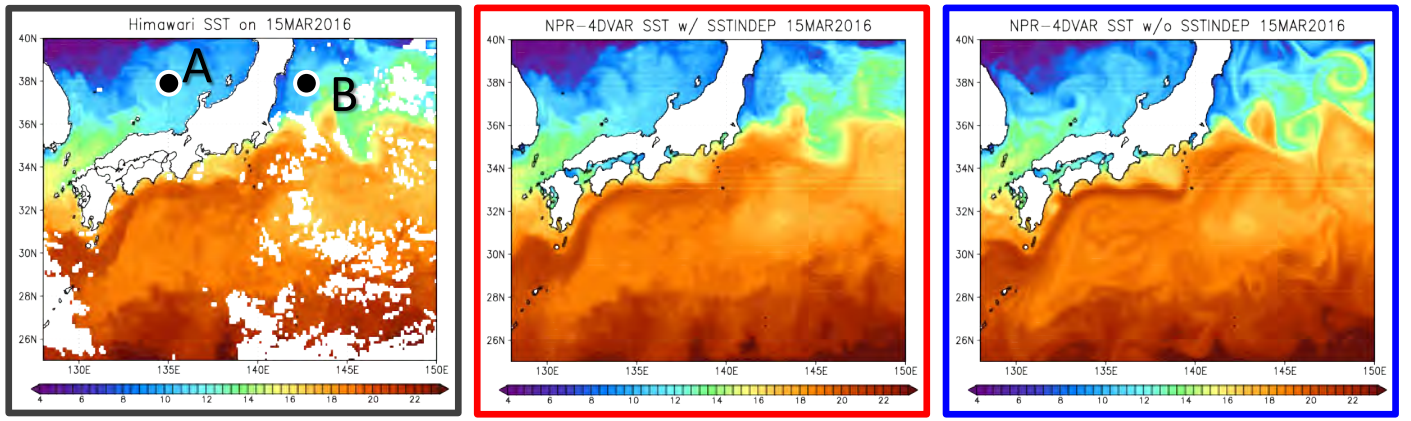
- Fisheries Research Agency, Japan Coast Guard, etc.
- University of Tokyo, JAMSTEC, etc.

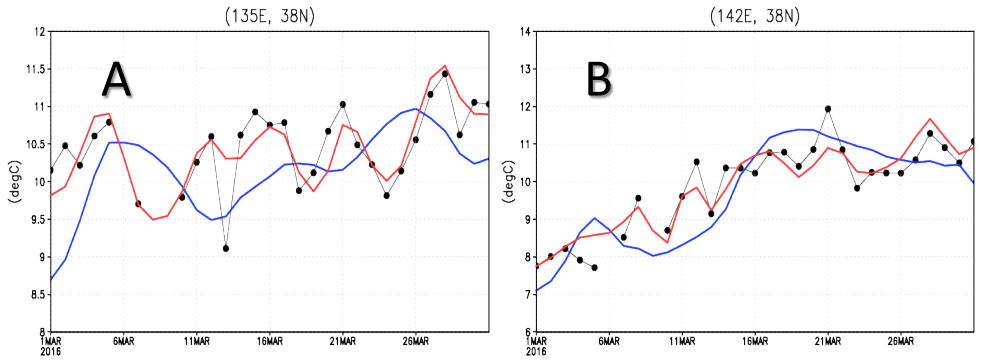
Development for future system update

◆ New 4D-Var scheme for assimilation of high-resolution satellite SST

- Daily SST increments are added to the control variables in the new 4D-Var scheme
- Test experiments with a North Pacific 4D-Var system

  - ☐ “**NEW**” experiment
    - ➢ Himawari/AHI SST as well as altimeter SLAs and in-situ TS profiles are assimilated with the NEW scheme
  - ☐ “**OLD**” experiment
    - ➢ Same obs data are assimilated with the original 4D-Var scheme





◆ New global ocean 4D-Var system with a resolution of 0.25˚×0.25˚

◆ New weakly coupled DA system with the oceanic 4D-Var scheme

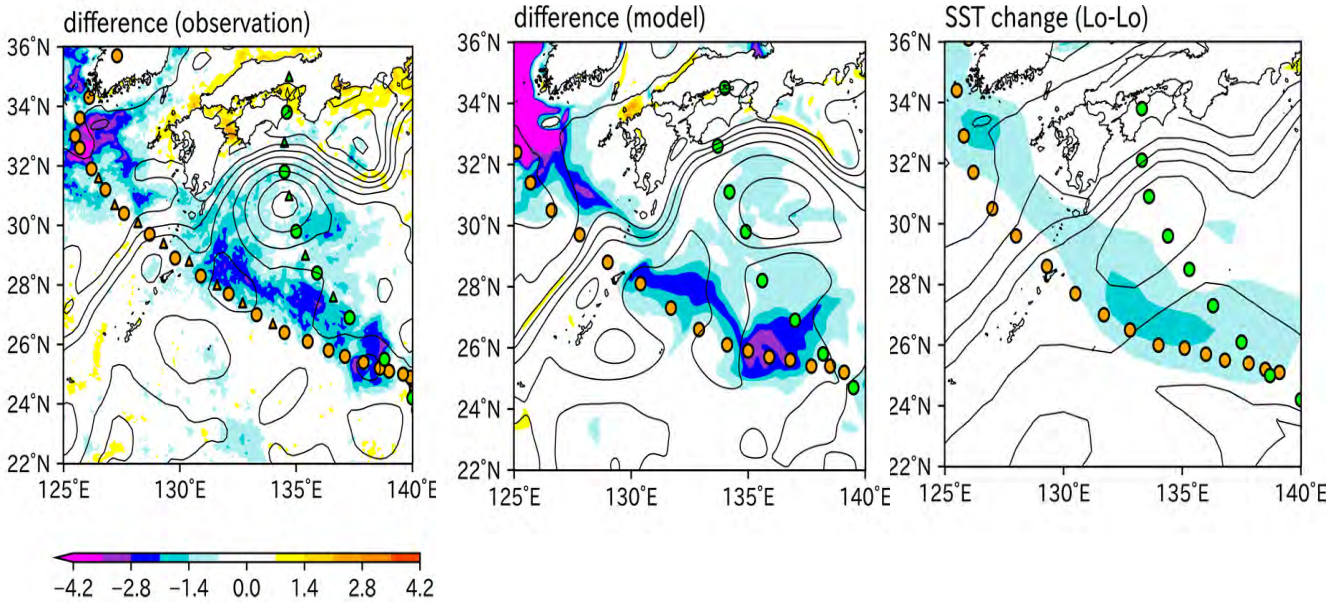
Plans for digital twins and AI/ML

- **digital twins**
  - JAMSTEC DIAS server

- **AI/ML**
  - downscaling (e.g., from regional scale to harbor scale)
  - surrogate modeling for time-consuming processes

Relationship and communalities with NWP groups

- **Collaboration with NWP groups**
  - Some pilot studies on the impact of ocean coupling
    - Typhoon prediction in the northwestern North Pacific
    - Heavy rainfall prediction around Japan



SST changes after typhoon passing（℃）
- observation (left)
- high-resolution CGCM result (middle)
- low-resolution CGCM result (right)

Kawakami et al. (2022）JGR-Oceans

OP-DCC interactions, best practice approaches

- **OP-DCC interactions**
  - DCC-Atlas will become a good communication tool to connect ocean prediction systems over the world.

- **Best practice approaches**
  - We have much interest in a best practice for societal benefit of high-resolution regional system.

Sharing information and experience will make it possible to develop ocean operational system more efficiently!