Ocean Physics & Prediction Lab
PUKYONG NATIONAL UNIVERSITY

Evaluation of impact on regional observing system through Observing System Experiment in Northwest Pacfic

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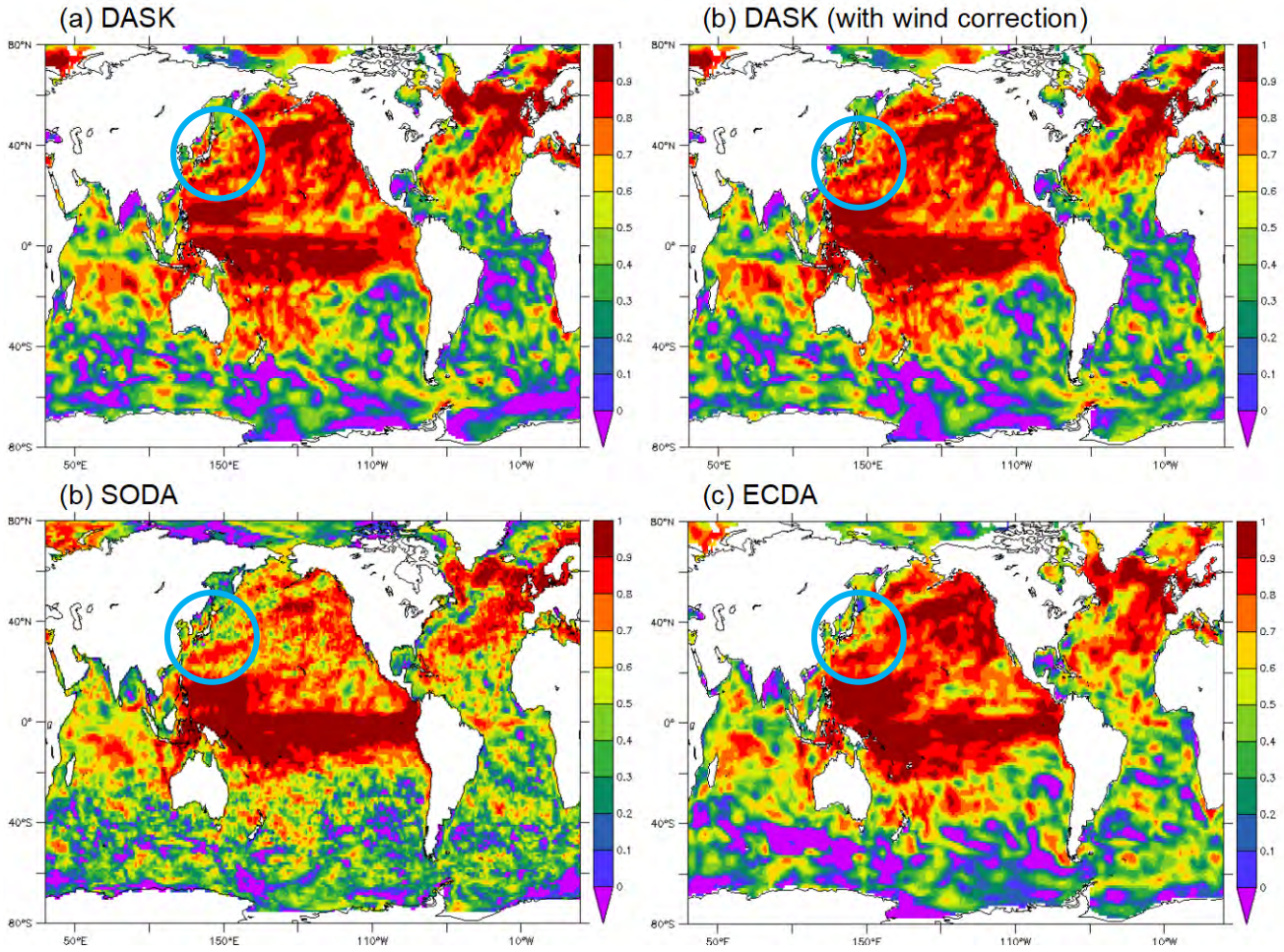
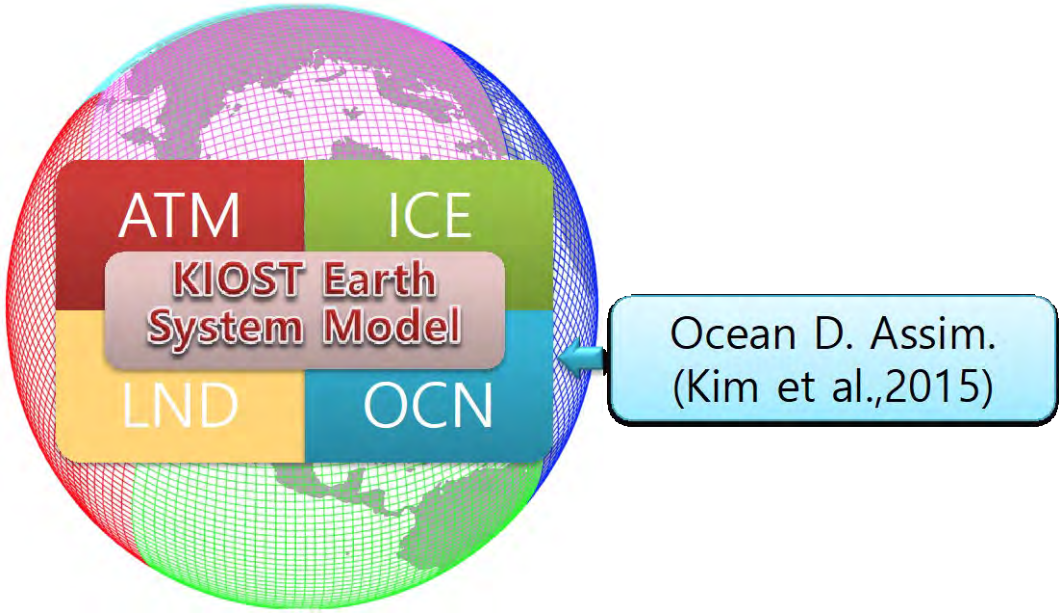
Motivation

Ocean Heat Content Correlation

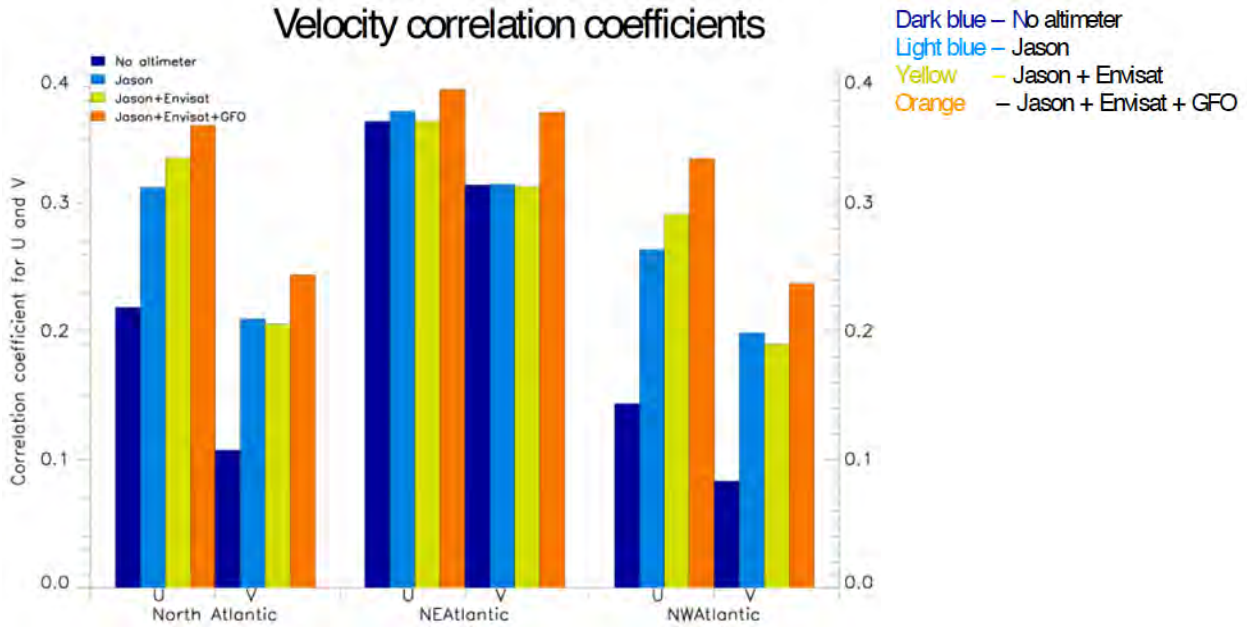


Kim et al. (2015)

DASK Climate Reanalysis by applying weakly coupled Data Assimilation



Motivation



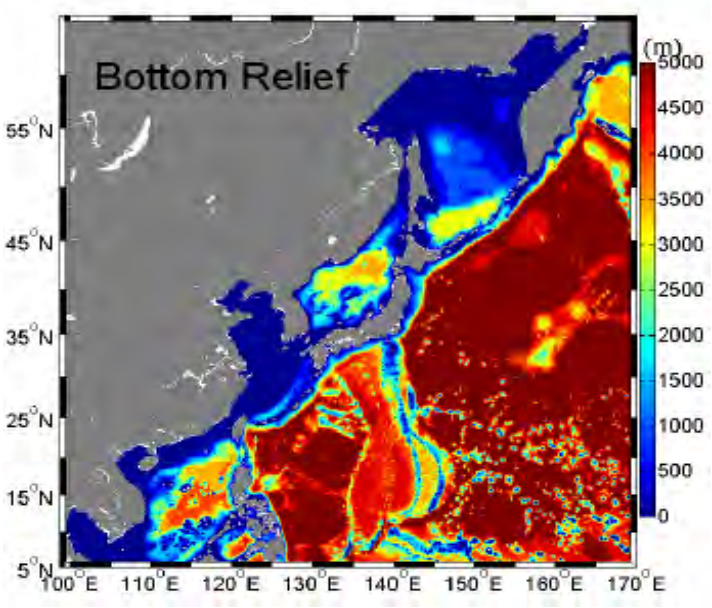
- The assimilation of SSH improves the performance of subsurface structure as well as ocean surface current.

- In this study, sensitivity experiments were conducted to diagnose the performance of data assimilation techniques for ocean prediction systems and to quantitatively evaluate the contribution of ocean observation data.

- In addition, by conducting an experiment about assimilation for Korea regional in-situ temperature data obtained from Korea Oceanographic Data Center(KODC), it was also investigated how assimilation of data obtained in marginal sea affects the ocean such as Northwest pacific.

Ocean prediction system

- System title : KOOS-OPEM (Ocean Predictability Experiment for Marine environment)
- Based model : GFDL-MOM5
- Domain : 5-63˚N, 99-170 ˚E (Northwestern Pacific)
- Resolution : 1/24 ˚x 1/24 ˚ (Arakawa B-grid) & 51 layers (z-star coordinate system)



- **Model domain and Bottom Relief**

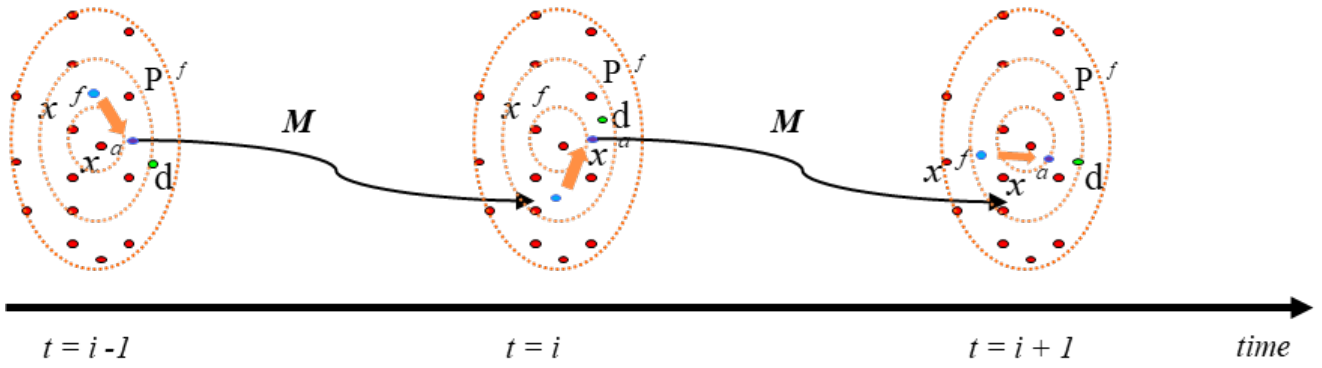
Table 1. Summary of Open boundary condition and surface forcing field

	Data source	Variables	Temporal resolution
Open boundary condition	GLORYS12V1	Temperature, Salinity Sea Surface Height (SSH) Velocity (Zonal, Meridional)	Daily
Surface forcing field	ERA5	Air temperature Wind velocity Air pressure Total cloud cover Specific Humidity	6-Hourly
		Runoff Net solar radiation Net thermal radiation Total precipitation Snow fall	3-Hourly

Data assimilation system

- Method : Ensemble Optimal Interpolation (Kim et al., 2015)
- Altimetry assimilation system : Cooper and Haines (1996, CH96)
- The number of ensemble members : 50
- Horizontal de-correlation length scale : 150km
- Vertical de-correlation length scale : 105m

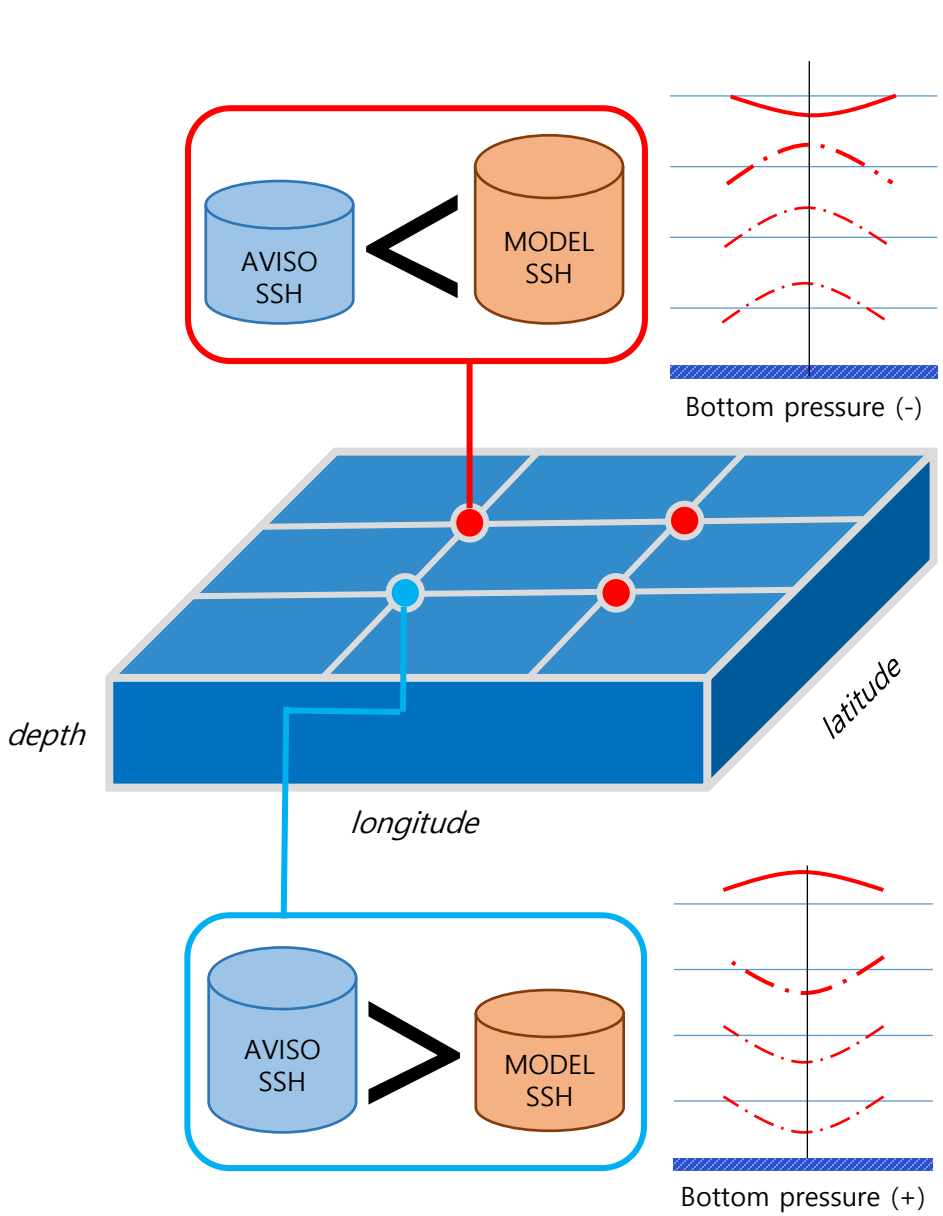
$$\psi^a = \psi^f + K\,(d - H\,\psi^f)$$

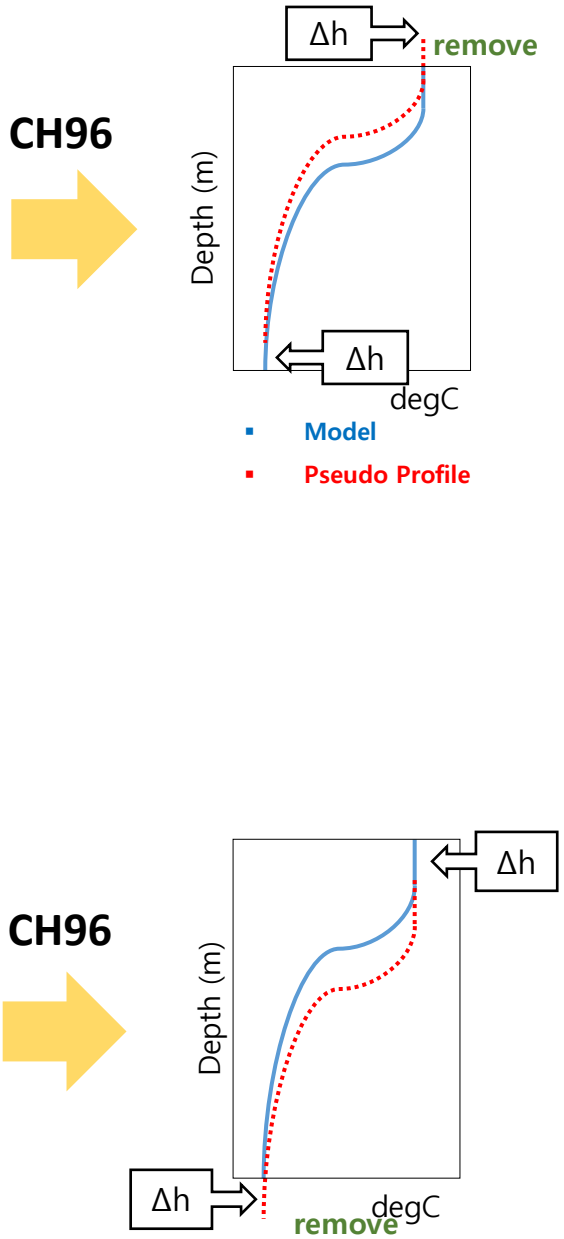


Where ;

- ψ^a = *Analysis fields*
- ψ^f = *Simulated fields*
- K = *Kalman gain*
- d = *Observations*
- H = *Spatial operator converting from the model data to observations*

Cooper and Haines (1996, CH96)





A) Assuming bottom pressure conservation

B) Conservation of Potential vorticity

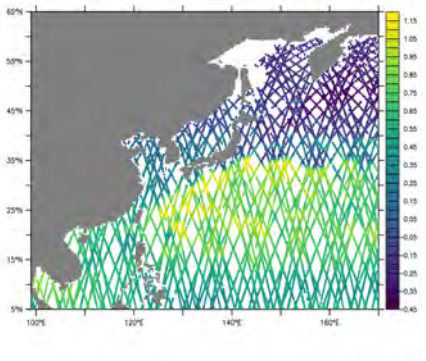
Bottom constraint

$$g \int_0^{-H} \Delta\rho \, dz = \Delta Ps$$

$$\Delta Ps = \rho_0 g \Delta\eta$$

$$\Delta h = \frac{\Delta Ps}{g[\rho_0 - \rho(-H)]}$$

✓ Creates a "Pseudo profile" using "Δh" and the "model's profile" at the specific grid points



Experiment setup and observation

Table 2. Summary of the sensitivity experiment

	Control variables	Experiment period
CTR	-	1 year (1993.01.01.~1993.12.31.)
EXP01	SST	
EXP02	SST, T/S profiles	
EXP03	SST, T/S profiles (+KODC)	
EXP04	SST, T/S profiles, SSH	
EXP05	SST, T/S profiles (+KODC), SSH	

Table 3. Summary of observations and errors

Observed variables	Data	Observation error	Assimilation window
in situ profiles	KODC WOD 2018	0.3˚C 0.025 psu	7 days
Sea Surface Temperature (SST)	OISST	1˚C	1 day
Sea Surface Height (SSH)	Along-track altimeter products (50km subsample)	0.9˚C 0.075 psu	1 day

	Assimilated Obs. Data			
CTR				
EXP01	SST			
EXP02	SST	T/S		
EXP03	SST	T/S	KODC	
EXP04	SST	T/S		SSH
EXP05	SST	T/S	KODC	SSH

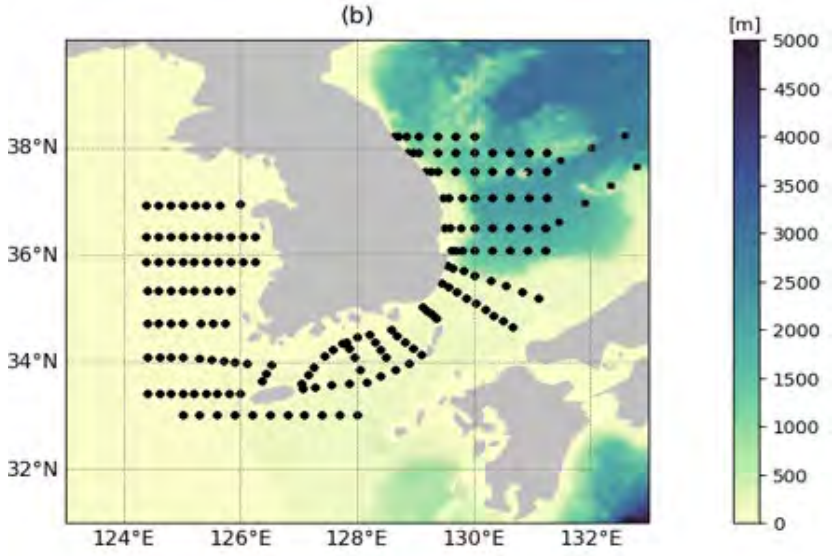


Figure 1. (a) Horizontal distribution of KODC observation stations used in this study.

Validation data set

Table 4. Summary of validation data

Variables	Data
T/S profiles	KODC
	WOD 2018
SSH	CMEMS-GLOBAL OCEAN GRIDDED L4 SEA SURFACE HEIGHTS AND DERIVED VARIABLES REPROCESSED (1993-ONGOING)
Ocean surface current	Ocean Surface Currents Analyses Real-time (OSCAR, 2009), 1/3˚

Table 5. The metrics used to assess the assimilation performance

Metrics	Equation
Root mean square error (RMSE)	$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(m_i - o_i)^2}$
Impact of data assimilation (IOA)	$IOA = \frac{RMSE_{CTR} - RMSE_{EXP}}{RMSE_{CTR}} \times 100$

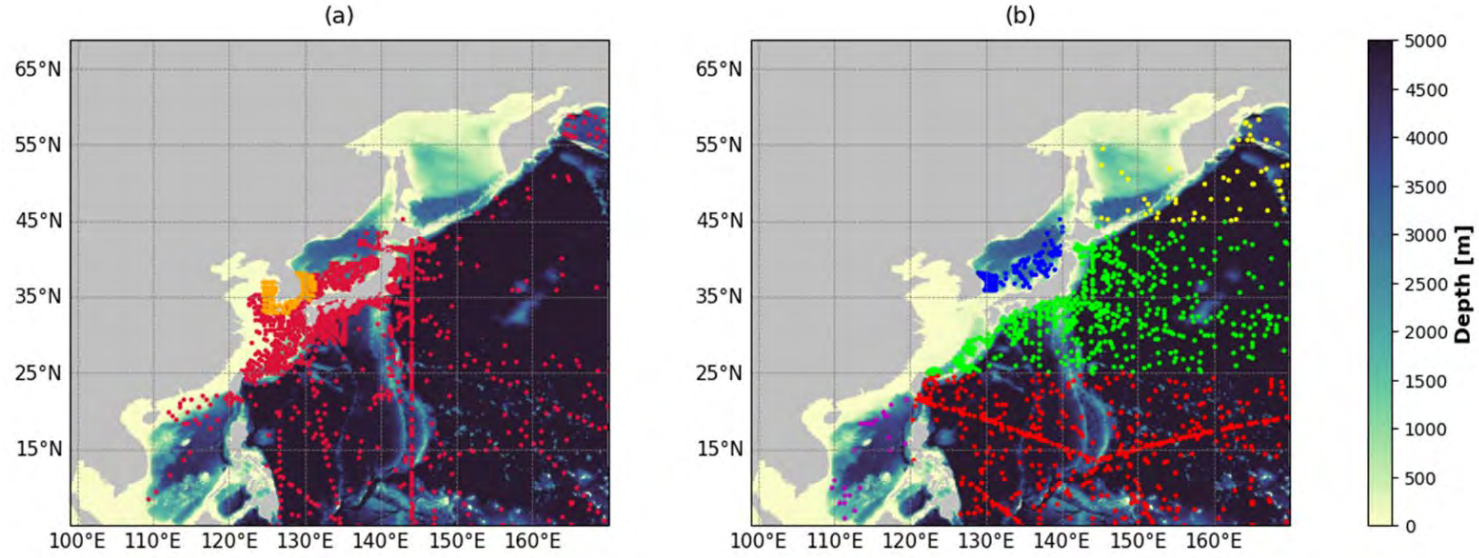
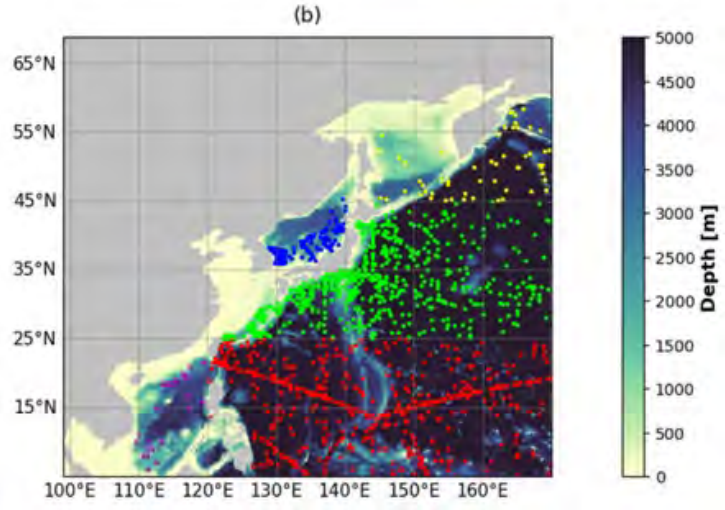
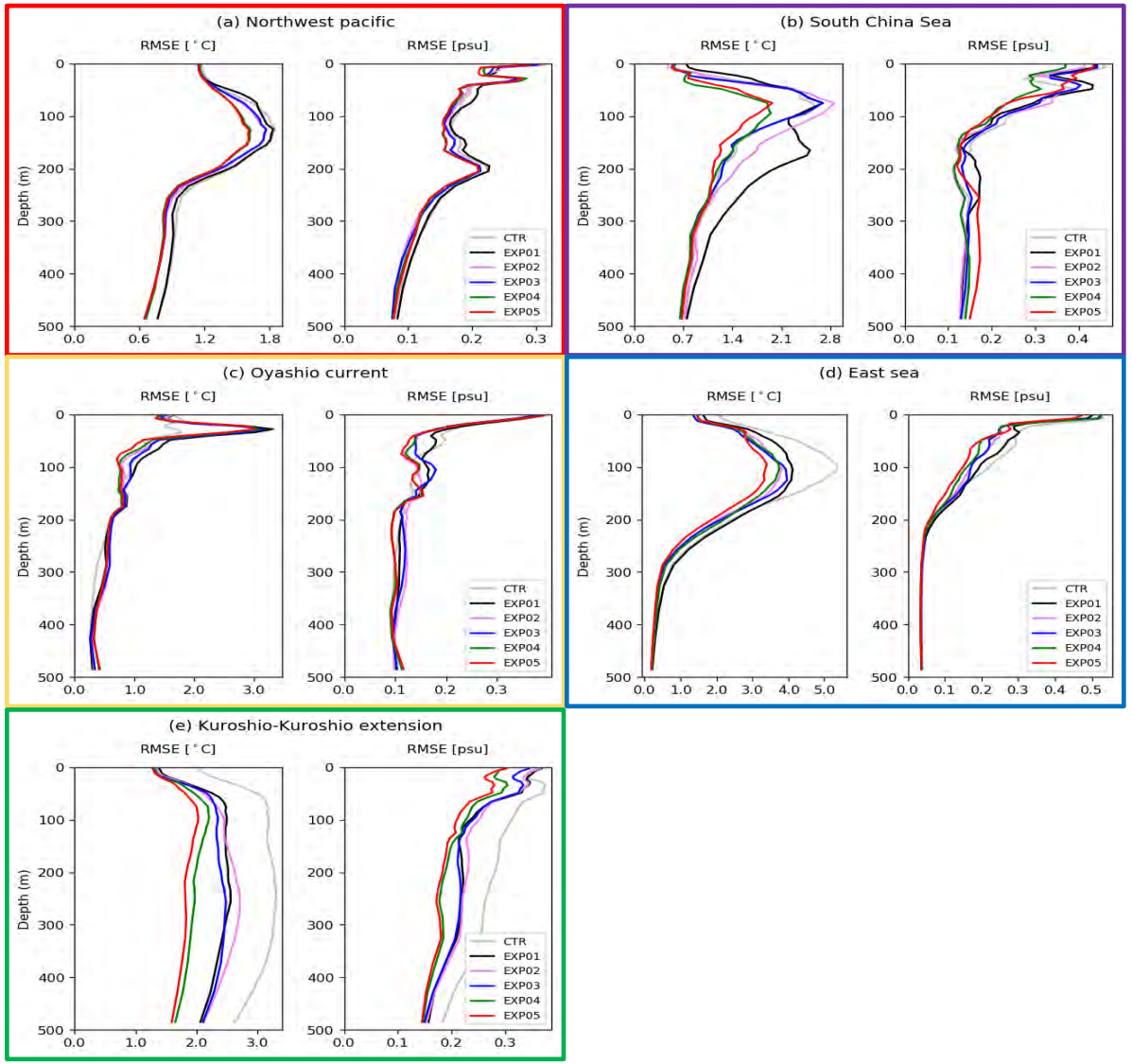


Figure 2. The distribution of in-situ temperature profile used in data assimilation and validation. (A) temperature profile used in data assimilation in February. (B) temperature profile used in validation.

RMSE of temperature/salinity profiles



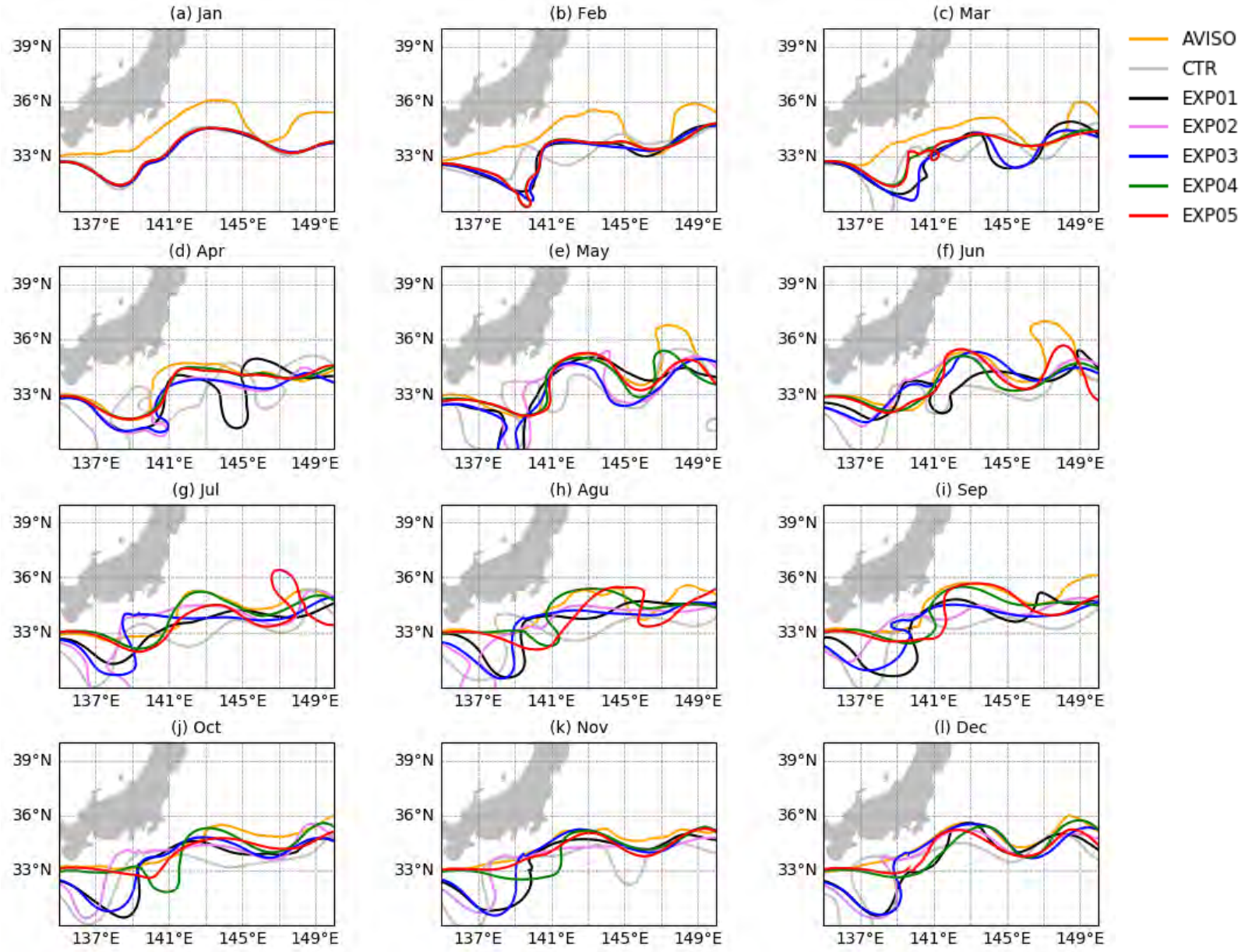
	Assimilated Obs. Data			
CTR				
EXP01	SST			
EXP02	SST	T/S		
EXP03	SST	T/S	KODC	
EXP04	SST	T/S		SSH
EXP05	SST	T/S	KODC	SSH



- ✓ The assimilation of satellite altimetry data improve the temperature/salinity structure in most regions.
- ✓ The assimilation of KODC data improves the temperature/salinity structure in Kuroshio extension as well as East/Japan sea.

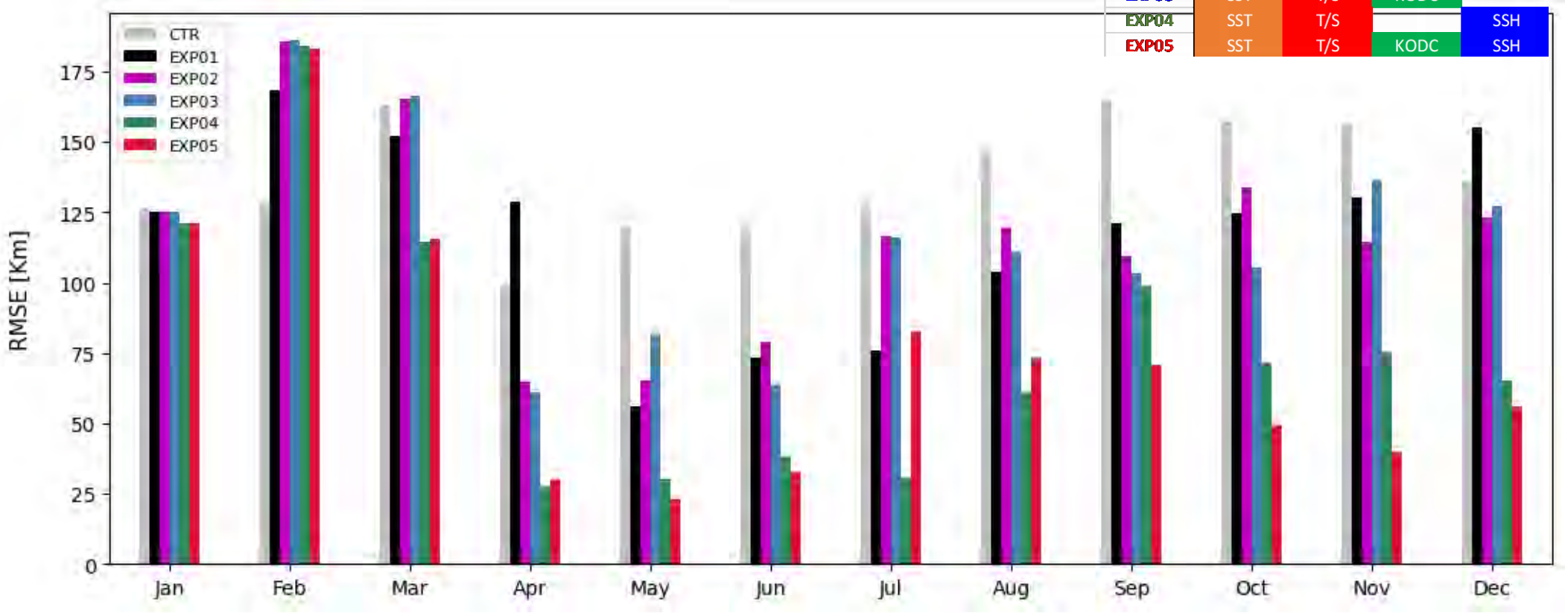
Representation of Kuroshio axis

	Assimilated Obs. Data			
CTR				
EXP01	SST			
EXP02	SST	T/S		
EXP03	SST	T/S	KODC	
EXP04	SST	T/S		SSH
EXP05	SST	T/S	KODC	SSH



RMSE for latitude of Kuroshio axis

	Assimilated Obs. Data			
CTR				
EXP01	SST			
EXP02	SST	T/S		
EXP03	SST	T/S	KODC	
EXP04	SST	T/S		SSH
EXP05	SST	T/S	KODC	SSH



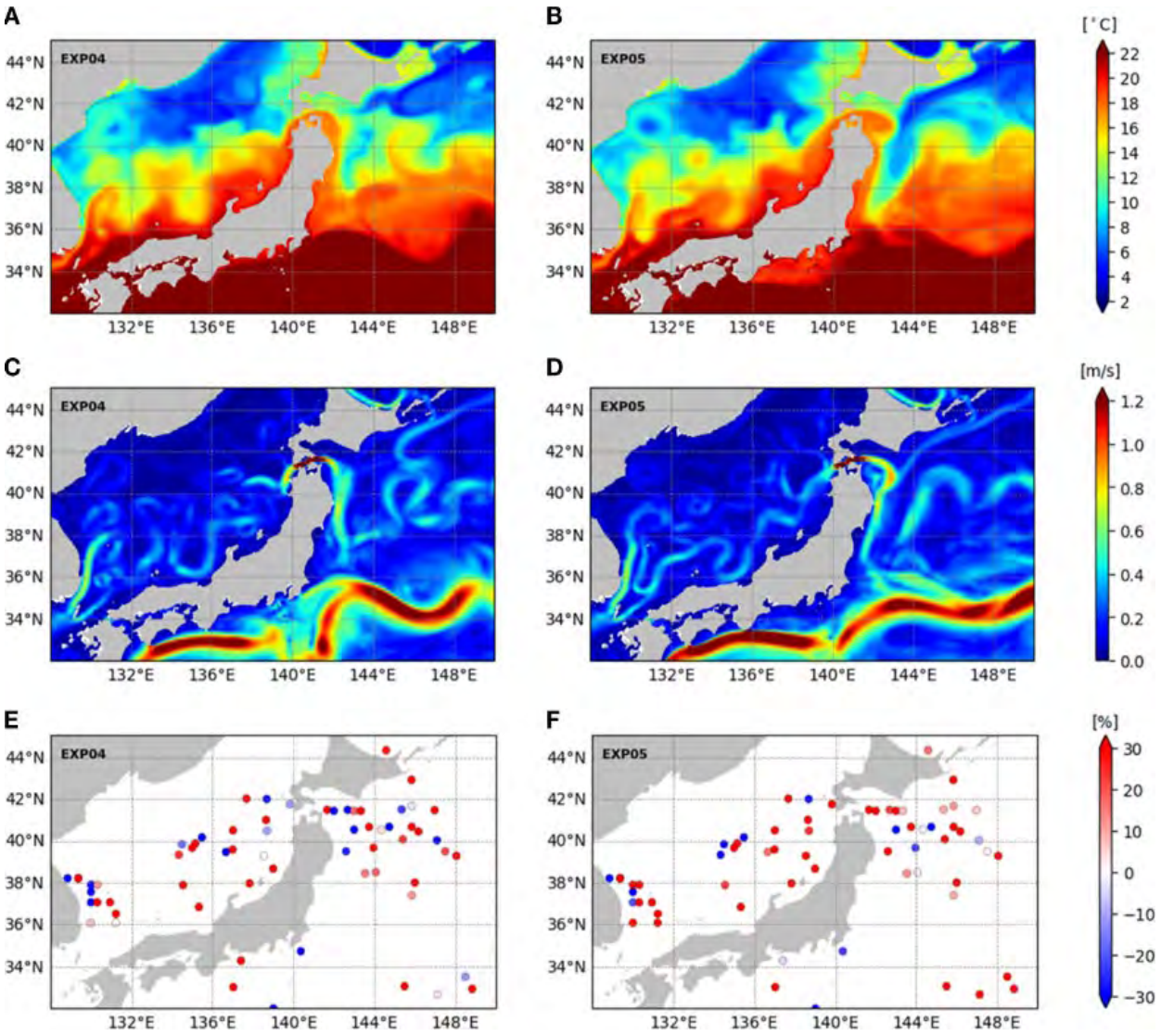
✓ The assimilation of satellite altimetry data and KODC data improve representation of Kuroshio axis

The monthly mean temperature, current speed and IOA

Temperature

Current speed

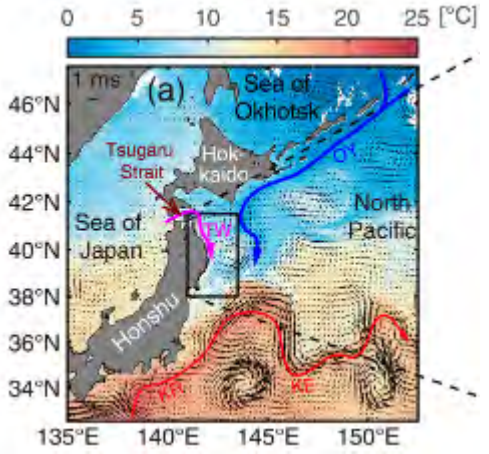
IOA



EXP04

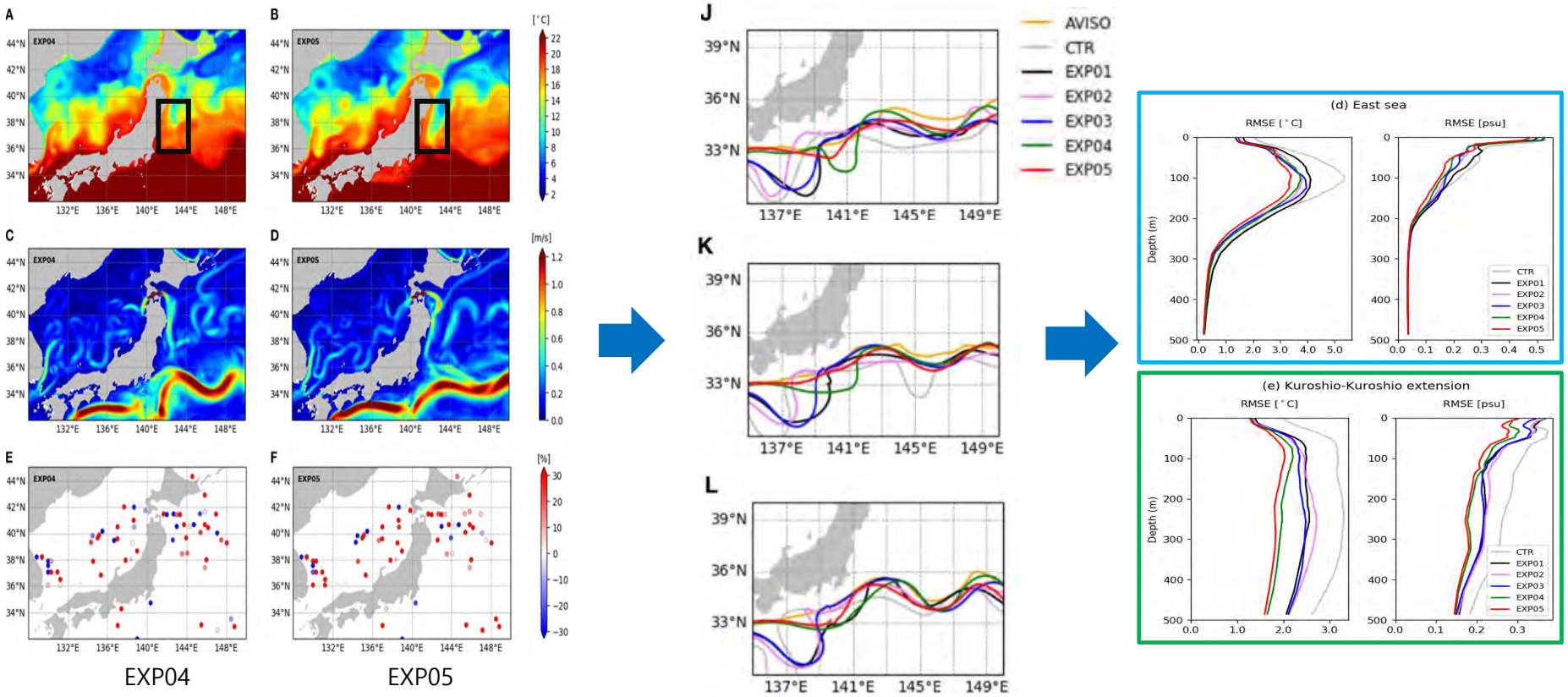
EXP05

	Assimilated Obs. Data			
CTR				
EXP01	SST			
EXP02	SST	T/S		
EXP03	SST	T/S	KODC	
EXP04	SST	T/S		SSH
EXP05	SST	T/S	KODC	SSH



(Itoh et al. 2022)

Summary and Discussion



- This result suggests that regional observation around the Korean Peninsula contribute to the improvement of ocean initialization in the northwest Pacific as well as the Korea marginal seas.
- This study also suggests that greater attention should be paid to the role of regional ocean observation networks to improve the forecast skill of the ocean prediction system in the open ocean, such as the Pacific Ocean and marginal seas.

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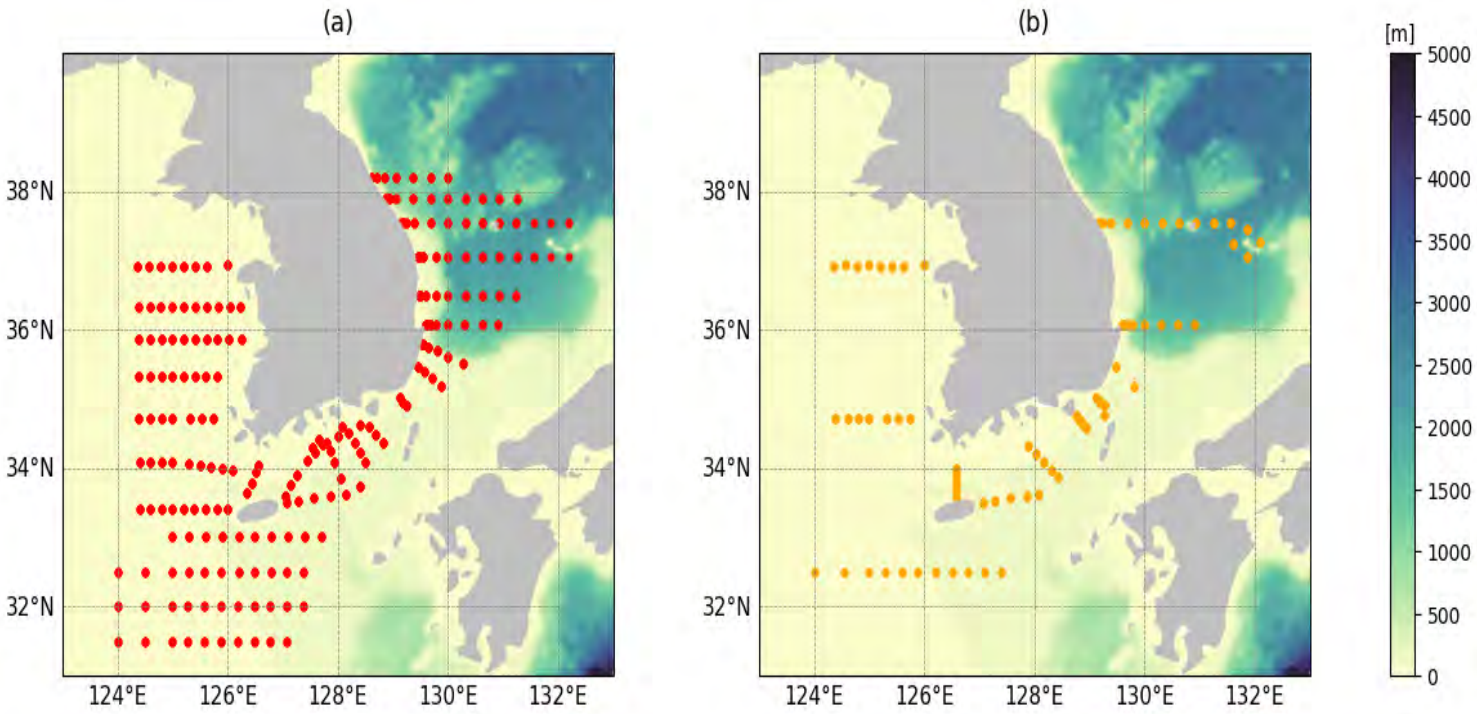
Another OSE



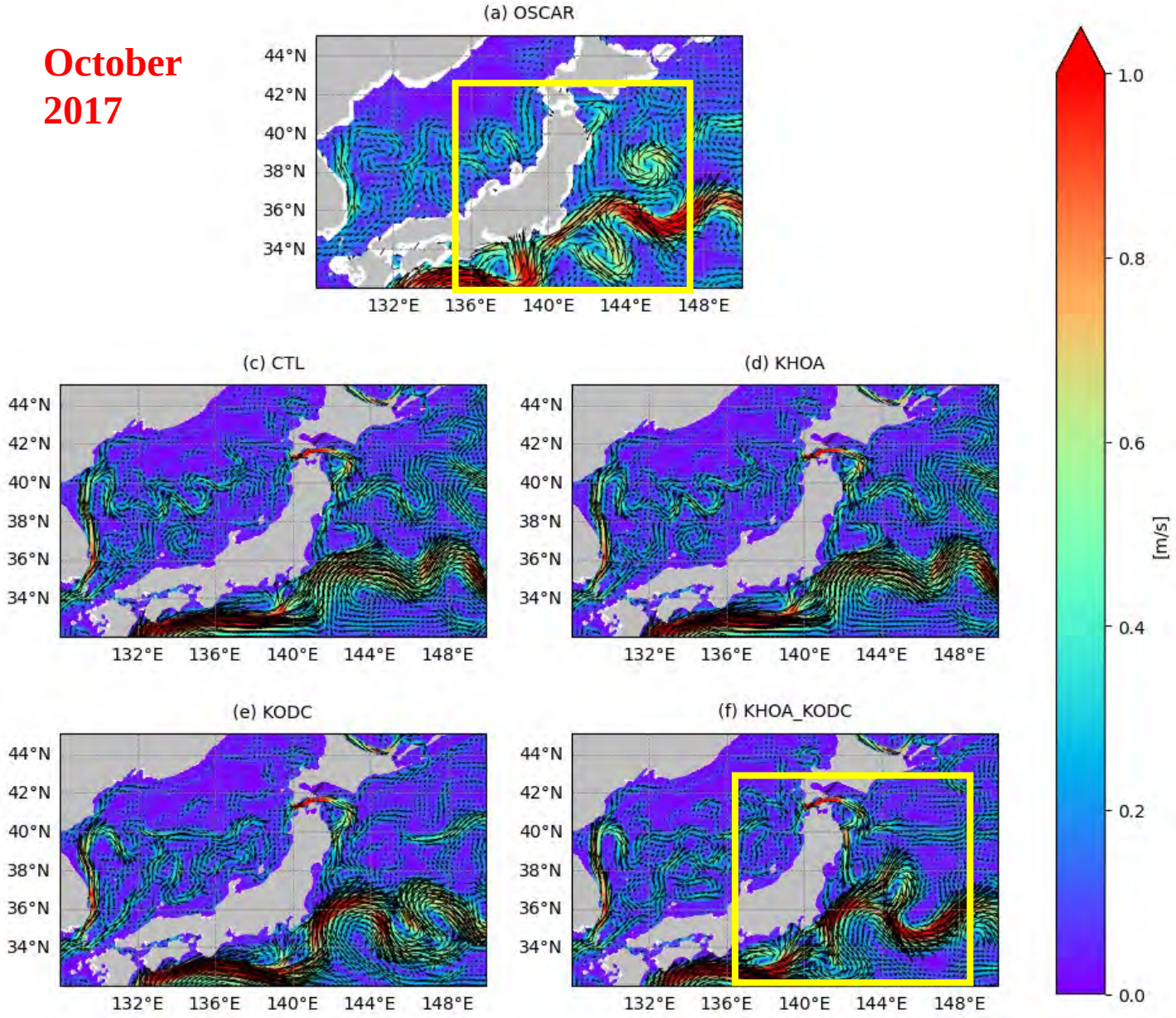
- **KODC Profiles**
- **KHOA Profiles**

Table 2. Summary of experiments

	Assimilated Obs. Data				
CTR	SST	T/S	SSH		
KHOA_t	SST	T/S	SSH		KHOA
KODC_t	SST	T/S	SSH	KODC	
KHOA_KODC_t	SST	T/S	SSH	KODC	KHOA

Another OSE - Preliminary Results

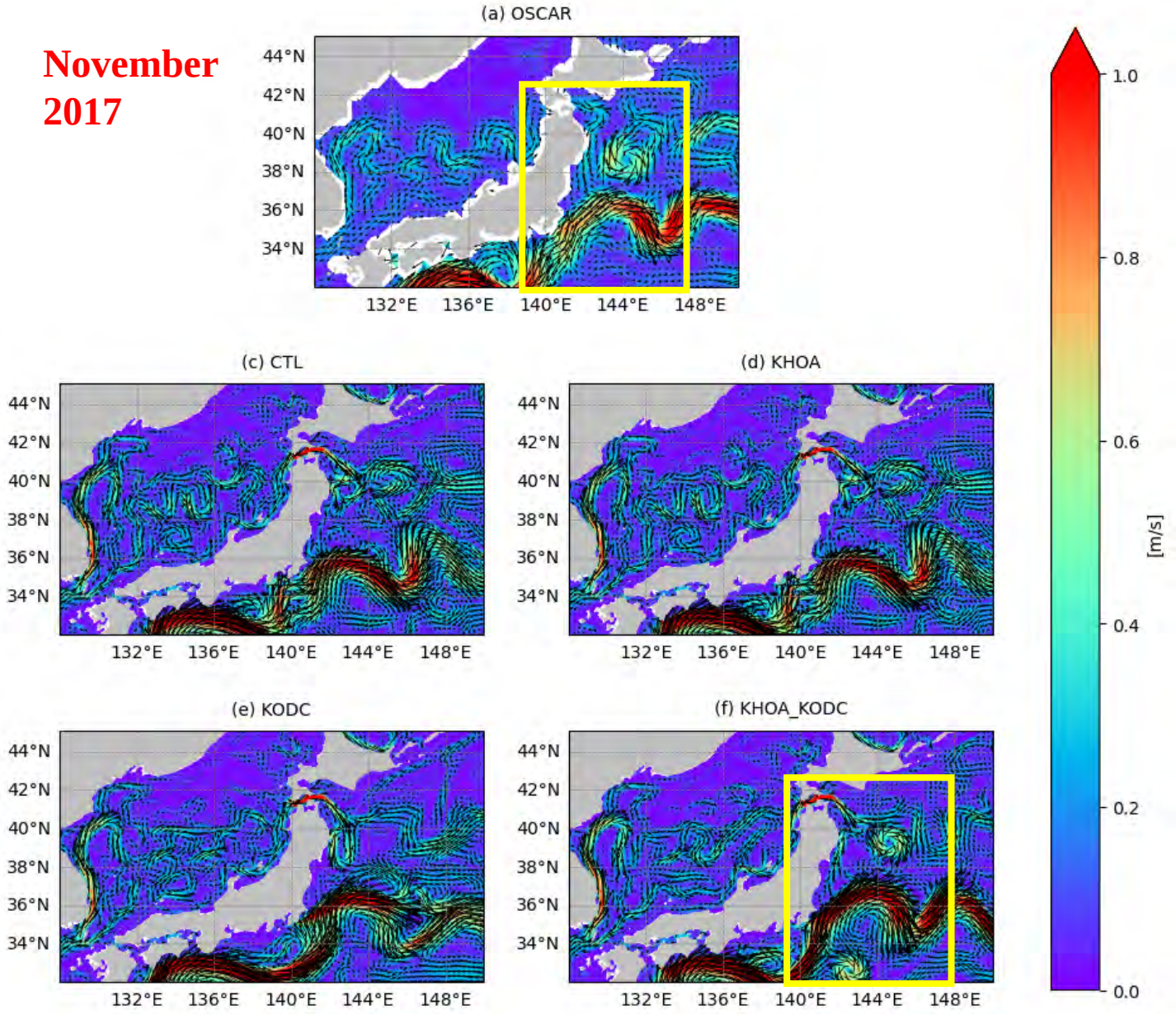
October 2017



✓ The KHOA_KODC, which assimilated all observation data obtained from both sources, shows the greatest improvement in reproducibility of ocean surface current.

Another OSE - Preliminary Results

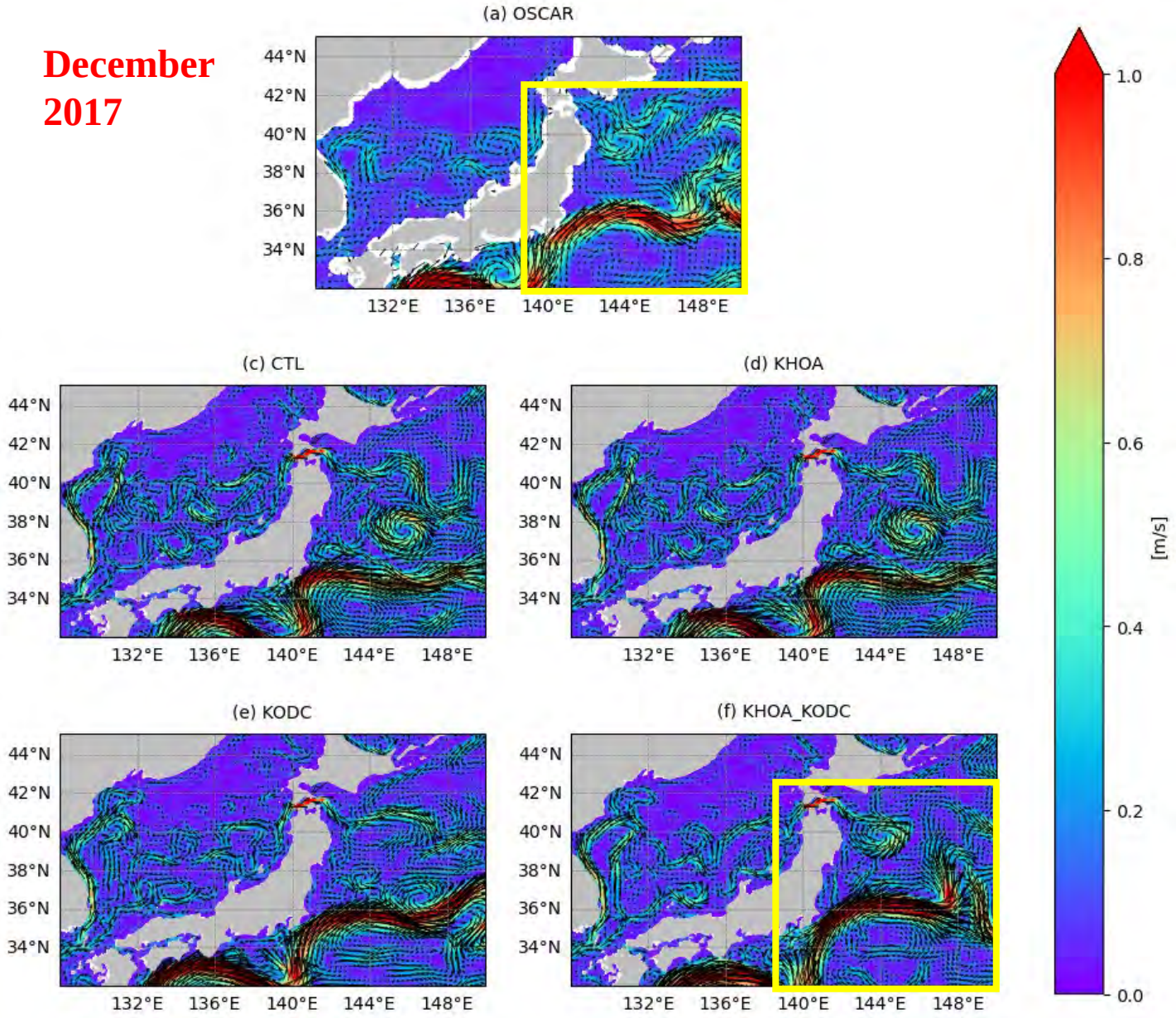
November 2017



✓ The KHOA_KODC, which assimilated all observation data obtained from both sources, shows the greatest improvement in reproducibility of ocean surface current.

Another OSE - Preliminary Results

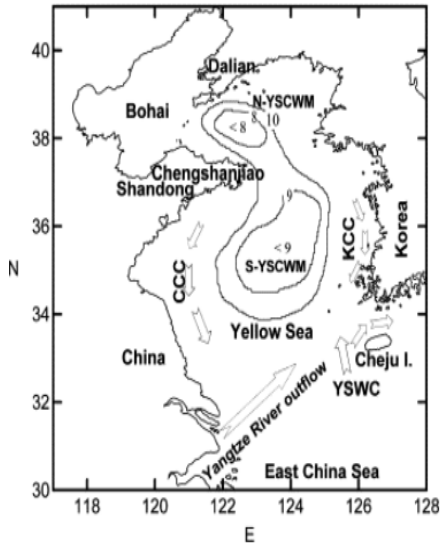
December 2017



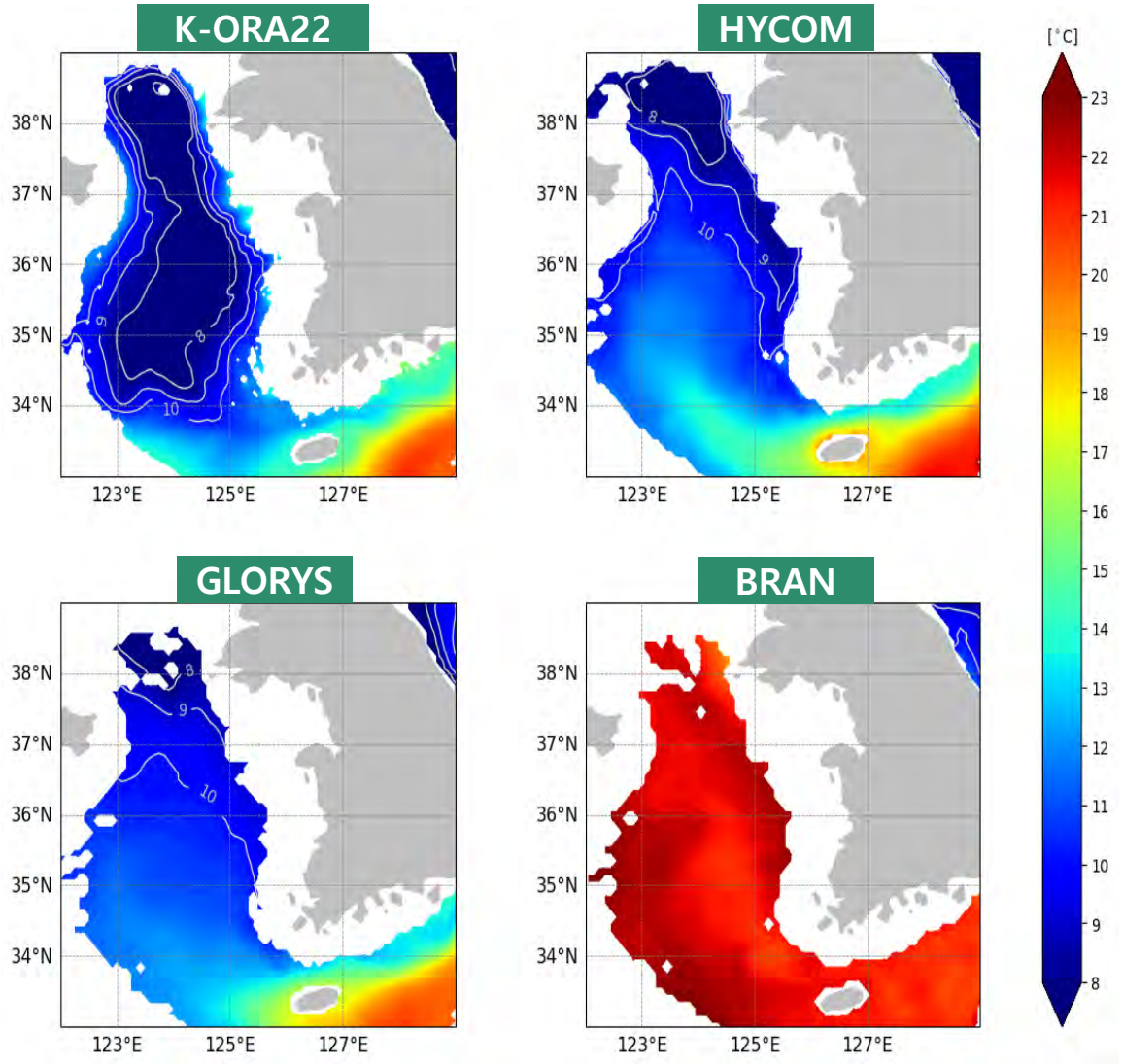
✓ The KHOA_KODC, which assimilated all observation data obtained from both sources, shows the greatest improvement in reproducibility of ocean surface current.

KOOS-OPEM Reanalysis (K-ORA22)

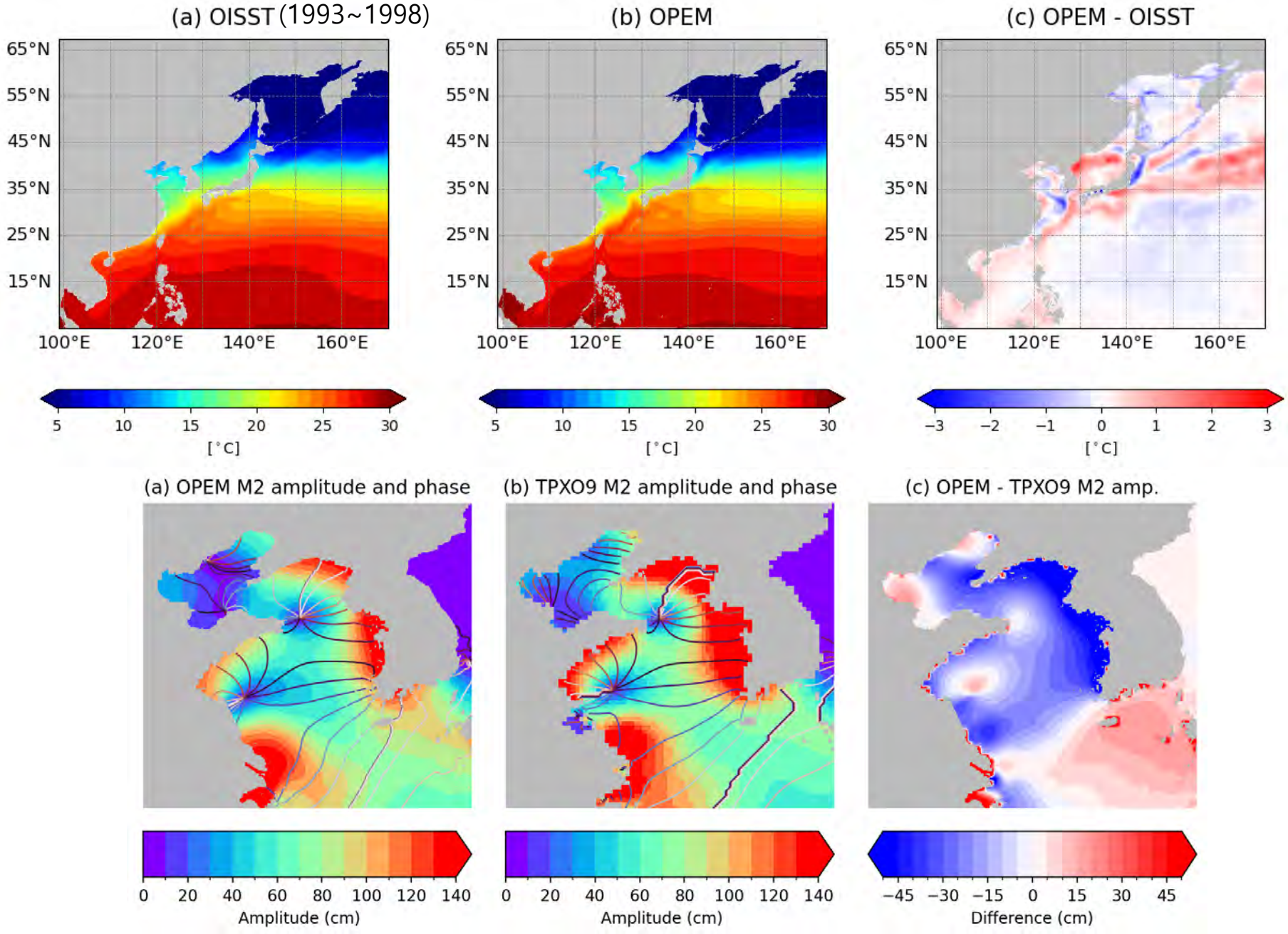
❖ Tempearture at 50m averaged (JJA) from 2011 to 2015



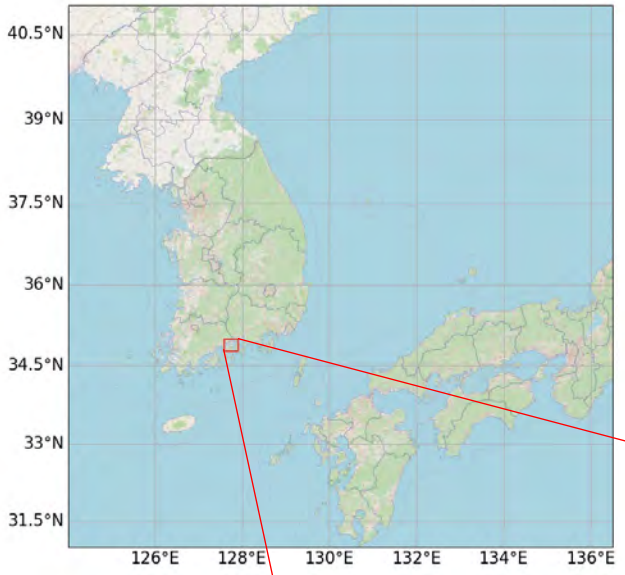
Zhang et al. (2008)



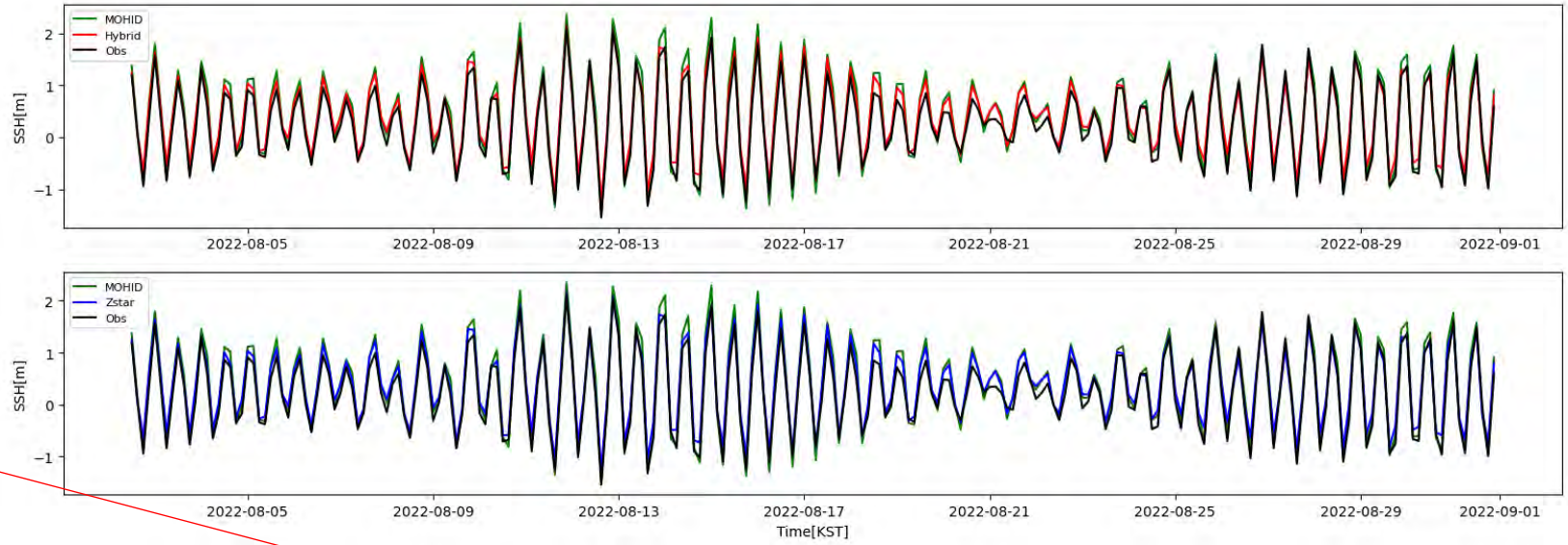
Regional Configuration of MOM6

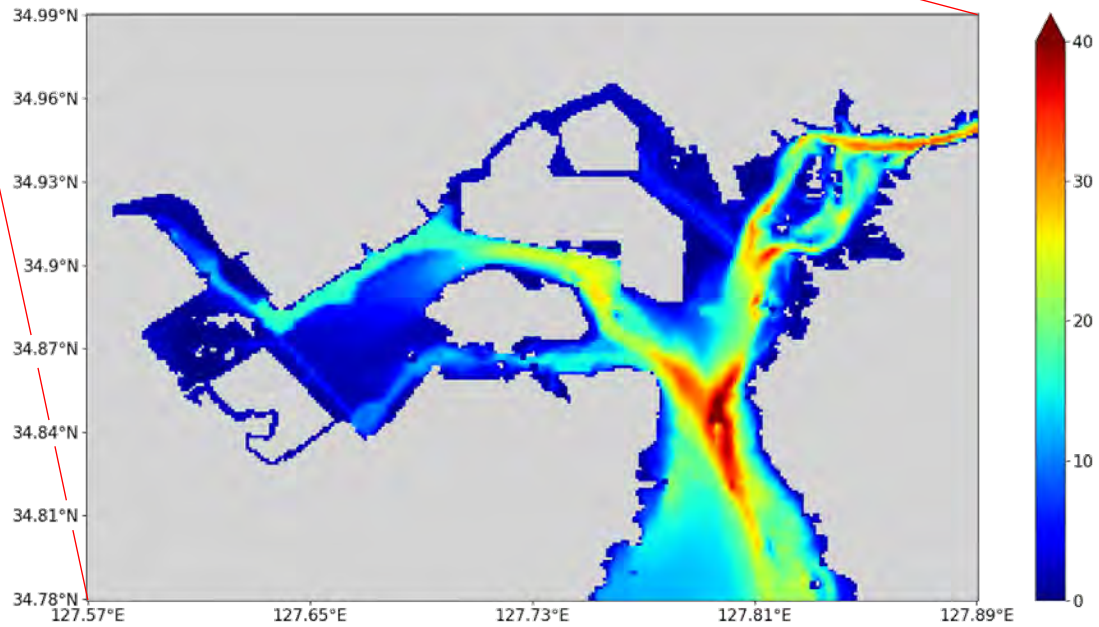


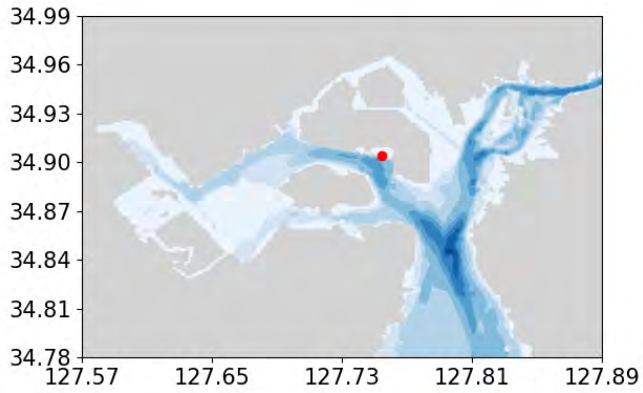
Regional Configuration of MOM6



Tide Simulation







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Thank you

제 6회 해양과학기지 기반 해양-대기 다학제 간 학술연구모임 (OASIS)

PUKYUNG NATIONAL UNIVERSITY 부경대학교

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