SYMPOSIUM OP'24

ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

KIAPS KOREA INSTITUTE OF ATMOSPHERIC PREDICTION SYSTEMS

Theme #5.2 (Data assimilation)

Development of a global ocean data assimilation system for the NEMO-SI^3 model.

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1 Background

- KIAPS has changed the atmospheric forcing from KMA UM to KIM (The Korean Integrated Model) that drives the ocean data assimilation (DA) system, and has modified the ocean DA analysis window cycle from 24 hours to 6 hours to match the atmospheric DA stragegy for a weakly-coupled atmosphere-ocean DA system.
- The ocean model has been upgraded from the NEMO version 3.6 to 4.0, and the sea ice model has been changed from CICE to SI^3. Additionally, a pressure-correction algorithm (Bell et al.,2004) is applied to DA4.0 (see Table 1 for experiments), and their effects were evaluated.

	reference	NEMO/CICE	NEMO/SI^3
Ocean	NEMO v3.6	NEMO v3.6	NEMO v4.0
Sea-ice	CICE v5.1.2	CICE v5.1.2	SI^3
Resolution	extORCA025L75		
Atm. forcing	KMA UM	KIM	
Bulk formula	NCAR		COARE3.0
DA method	3DVar-FGAT based on NEMOVAR		
DA window	2-day hindcast	6 hour(-3hr ~ 3hr)	

2 Objectives and Methods

- **Validation of the stability of the newly developed ocean DA system.**
- ✓ Resolution: extORCA025L75 (~25km)
- ✓ Atmospheric forcing: KIM ne360np3 (~12km), interval: 1 hourly
- ✓ NEMOVAR 3Dvar-FGAT DA scheme is used to assimilate SST, SLA, T/S profile, and SIC
- ✓ Period: 05/01-08/31/2022, 6-hour cycling
- ✓ Initial condition: restart from NEMOv3.6-CICE ocean DA system(05/01/2022)

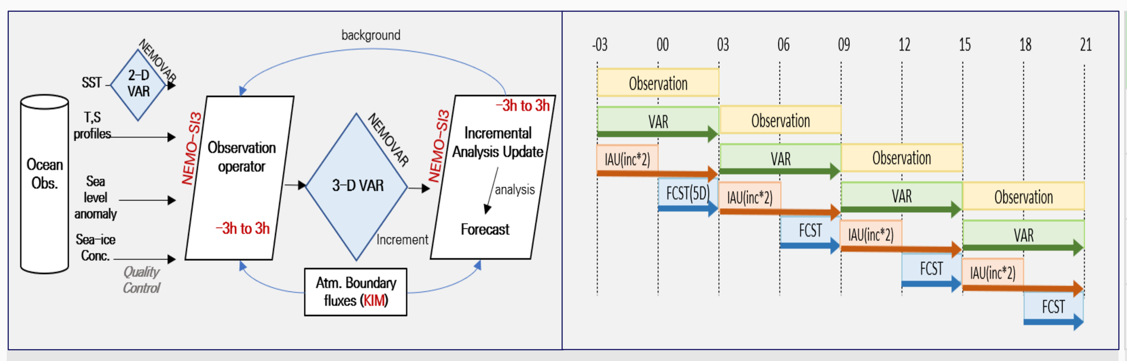

Fig 1. A diagram of NEMO-SI^3 ocean DA experiments with a 6-hour cycle.

Exp	Model config.	DA
DA4.0	NEMO4.0/SI^3	Y
NODA4.0		-
DA3.6	NEMO3.6/CICE5	Y
NODA3.6		-

Table 1. List of experiments.

3 Results

Innovations statics

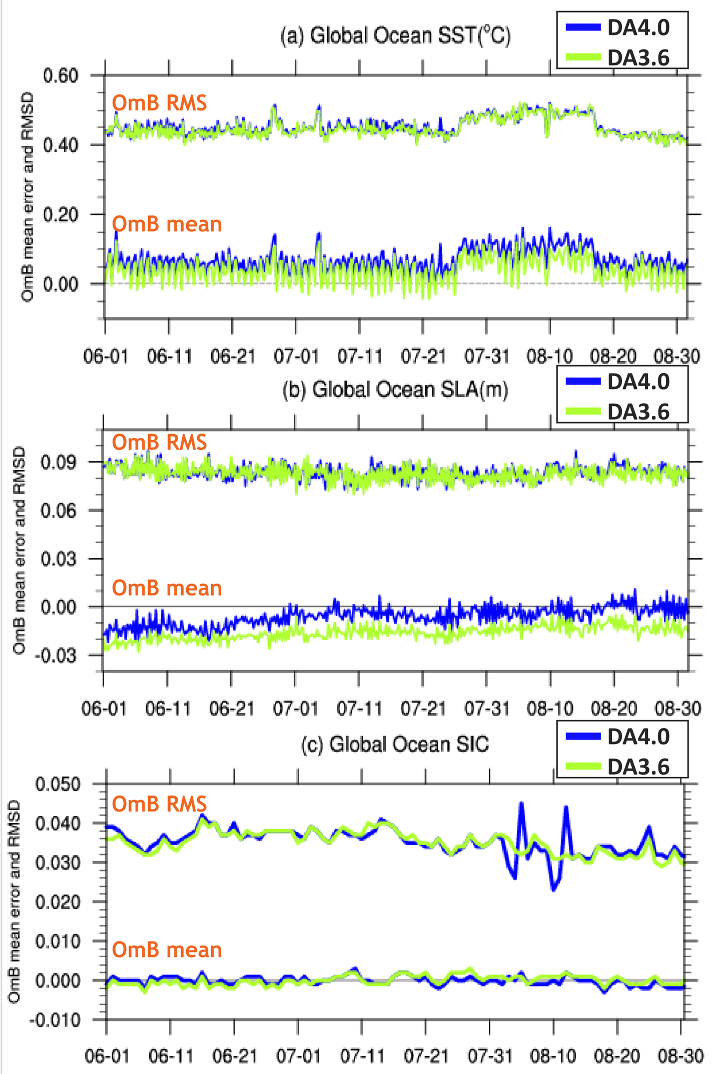

Fig 2. Time series of spatially averaged innovation (O-B) and RMSD for the global ocean (a) in-situ SST (°C), (b) SLA (m), and (c) SIC.

Analysis validation

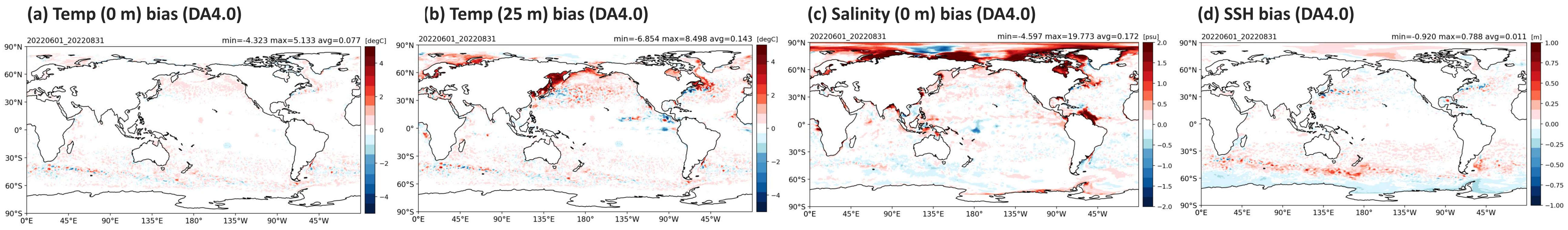

Fig 3. The DA4.0 analysis RMSE (a-b: potential temperature at 0 m and 25 m, respectively; c: salinity at 0 m; d: SSH; ref.: ORAS5)

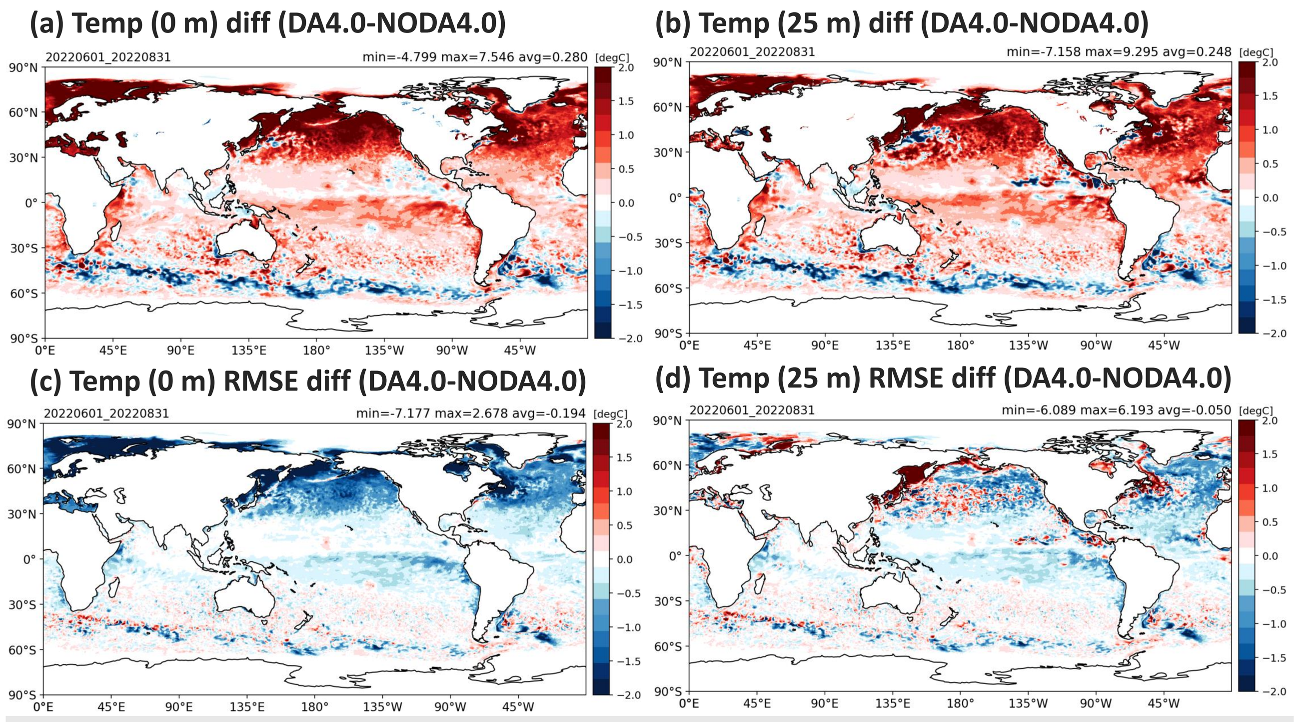

Fig 4. Potential temperature analysis difference (DA4.0-NODA4.0) at (a) 0 m, (b) 25 m, and RMSE difference (DA4.0-NODA4.0) at (c) 0 m and (d) 25 m (ref.: ECMWF ORAS5)

- ✓ (Fig.2) Generally, higher OmB values for DA4.0 indicate a small degradation in the SST and SIC performances. Better SLA performance, measured by lower bias innovations, is mainly accounted for by the Southern Ocean.
- ✓ (Fig.3) When ORAS5 is used as reference data, the temperature bias at 0 m is very small, but at 25 m, it significantly increased in the Korean coastal area and the Sea of Okhotsk. As for salinity, there is a large positive bias in the Arctic region.
- ✓ (Fig.4) Ocean DA (i.e., DA4.0) in general increased the potential temperature (at 0 and 25 m) in the Northern Hemisphere compared to the NODA case while it leads to cooler potential temperature of the Antarctic Circumpolar Current. This resulted in a reduction of the surface temperature RMSE while degradations are also witnessed at 25 m in the coastal waters of the Korean Peninsula and the Sea of Okhotsk.

Validation using in-situ observation data

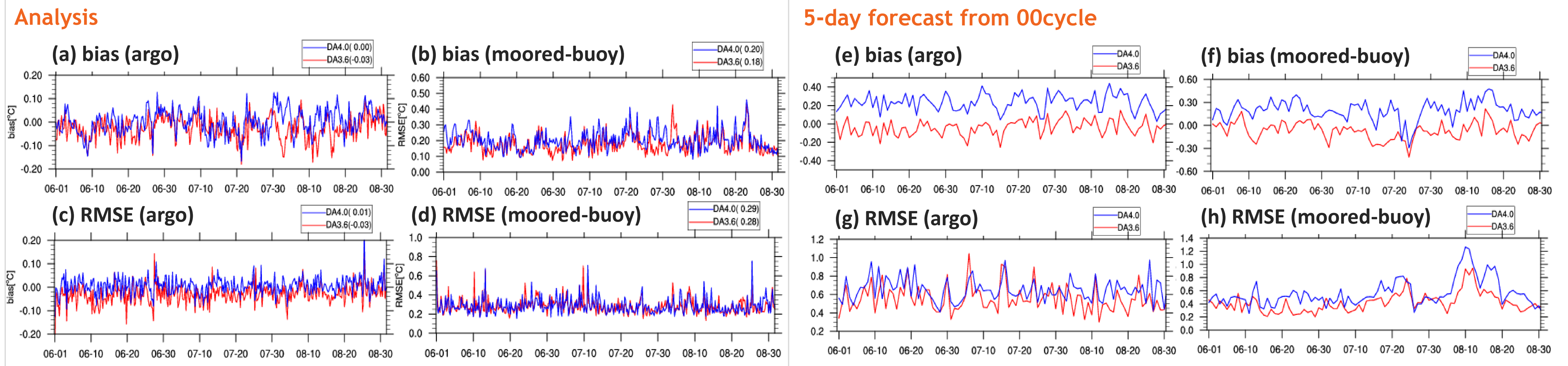

Fig 5. SST analysis bias (a and b) and RMSE (c and d) calculated using in-situ iQuam argo (a and c) and moored-buoy (b and d). The same evaluations for the 5-day forecasts are presented in right panels (e and g: ref. in-situ iQuam argo; and f and h: ref. moored-buoy).

- ✓ The analysis (Fig 5 a-d) and 6-h SST forecast (figure not shown) show that DA4.0 and DA3.6 are comparable when evaluated using in-situ SST (iQuam).
- ✓ DA4.0 showed higer bias and RMSE values than DA3.6 for the 120-h forecast of the 00Z cycle (Fig 5 e-h).

Pressure correction

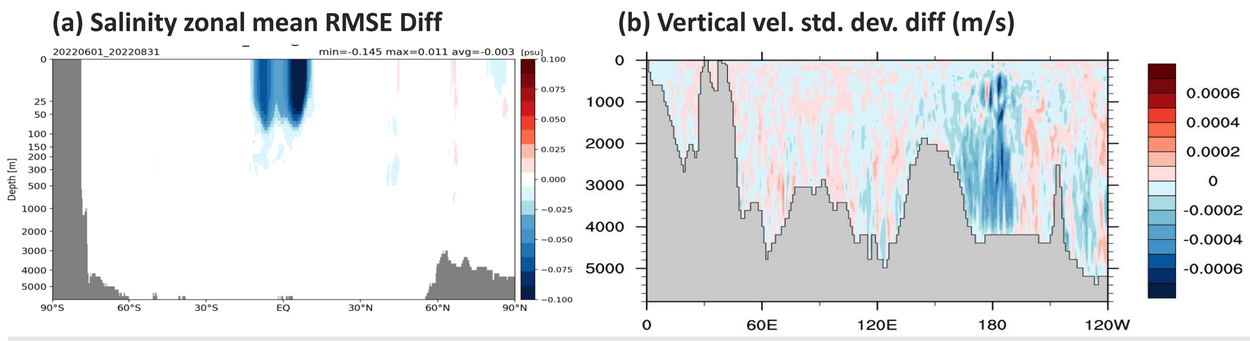

Fig 6. (a) Salinity zonal mean RMSE difference (PC_{ON}-PC_{OFF}), (b) Vertical velocity standard deviation difference (PC_{ON}-PC_{OFF})

- ✓ When pressure correction is not applied, salinity becomes abnormally low in the equatorial region, leading to large RMSE.
- ✓ Applying the presure correction (i.e., PC_{ON}) significantly reduced the RMSE as compared to PC_{OFF} while difference in temperature between PC_{ON} and PC_{OFF} was not observed.
- ✓ This may be attributed to the variability of vertical motion, which was weakened by applying pressure correction.

4 Conclusion & Discussion

- The NEMOv4.0-SI^3 models were implemented in the KIAPS ocean DA system. The performance of the SST analysis field was comparable to that using the previous model, NEMOv3.6-CICE. However, in the case of the 5-day forecast, the performance degradation was observed compared to the previous model.
- A significant bias of DA4.0 was observed between 25 m and 100 m depth in the coastal waters of the Korean Peninsula and the Sea of Okhotsk. The bias pattern was similar to that of the SST bias of the NODA4.0, and is also linked to the increment pattern at a depth of 0 m. However, the increment at a depth of 25 m was not large in that region. There was also a significant bias in salinity, particularly in the Arctic.
- The results imply that pressure correction needs to be applied in the ocean DA to mitigate the negative impacts of DA on salinity near the equator that is presumably caused by the variability of vertical motion.