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SYMPOSIUM OP'24

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Applying MOM6 for High-Resolution Coastal Modeling of Yeosu-Gwangyang Bay, Korea

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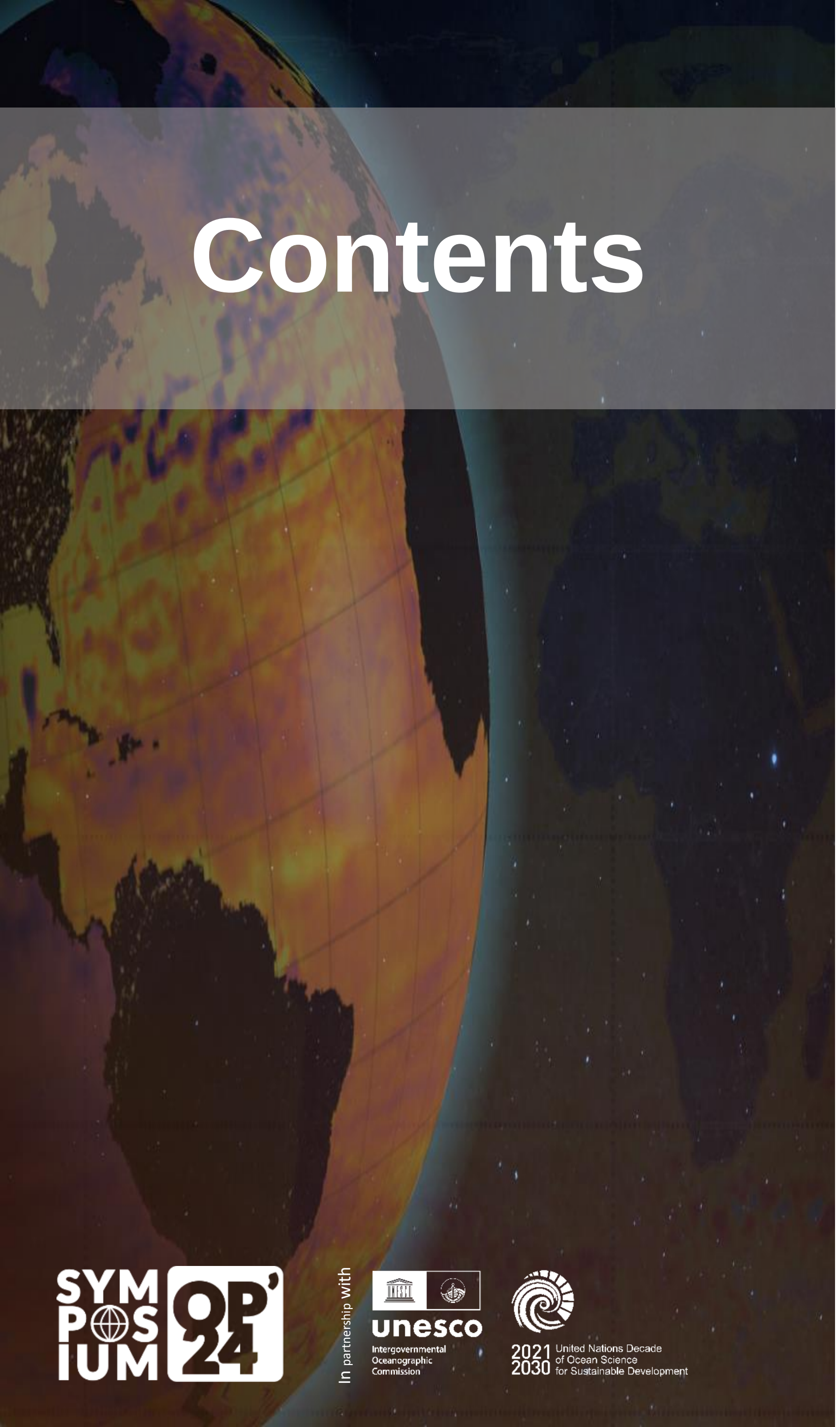

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Yeosu-Gwangyang Bay, Korea

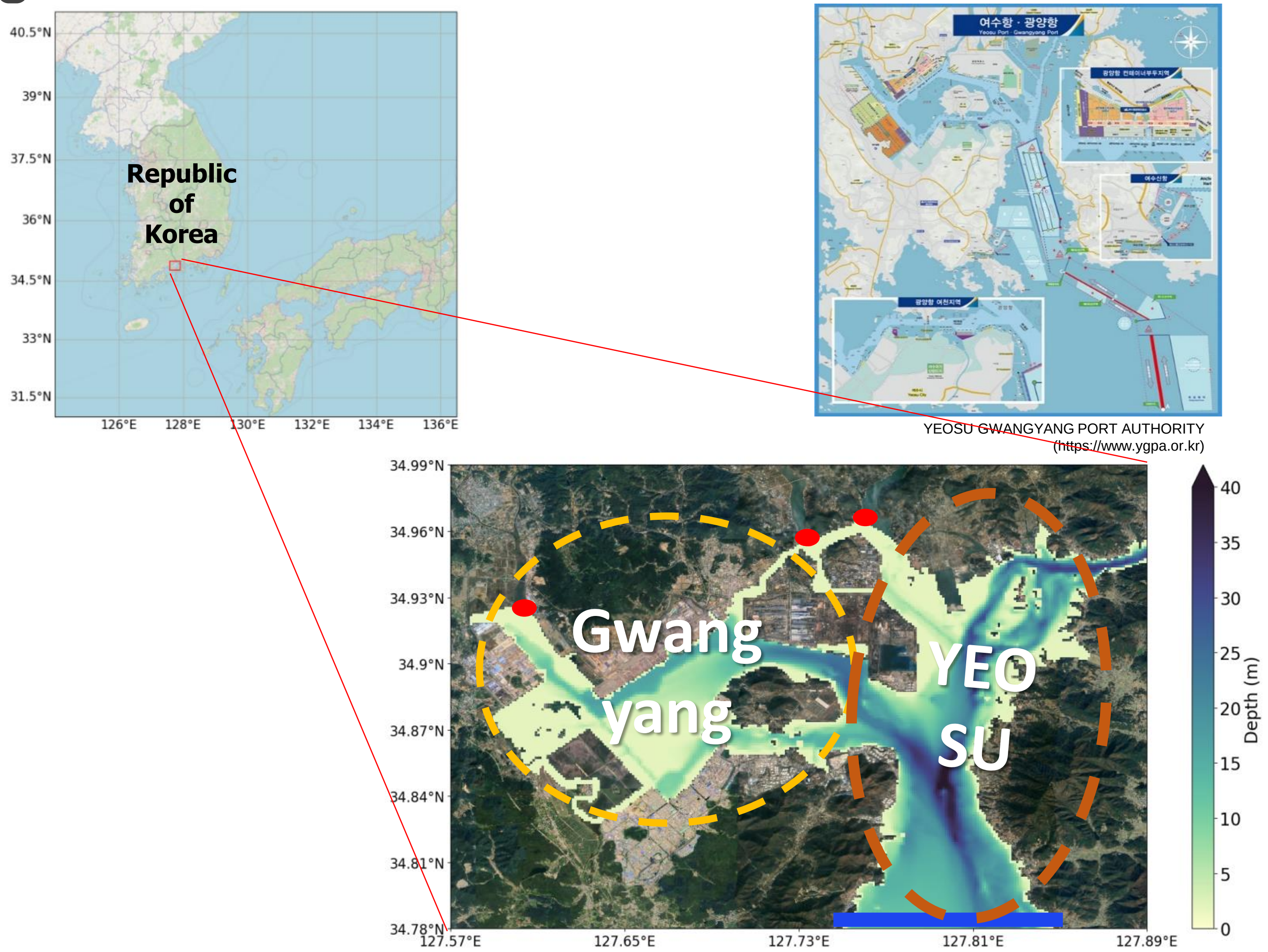

Fig 1. Study area in the Yeosu-Gwangyang (YG) Bay, Korea. YG bay located in south sea of Korea.
The red point is location where the river discharge flows in and the blue line is location where seawater in and out.

- Frequent ship traffic due to port, commercial activities ,ferry terminals and fishery activities
- Complex coastline and Shallow depth
- Semi-enclosed sea
- Freshwater inflow from Seomjingang River located in northern
- Seawater in and out through southern channel
- Tidal Currents dominated region

Complicated current expected
Understanding 3-Dimensional current is essential

Coastal Acoustic Tomography (CAT)

- Remote sensing technique by using underwater sound wave
- Measuring reciprocal acoustic signals travel time
- Assumption of the physical variables between through the difference in the sound travel time gap
- Providing the information for mapping complex ocean circulation pattern, by transmitting acoustic signals between multiple stations
- Powerful to monitor ocean regions and ability to improve numerical model performance (Park and Kaneko, 2000).

➡ Assimilate in Numerical Model

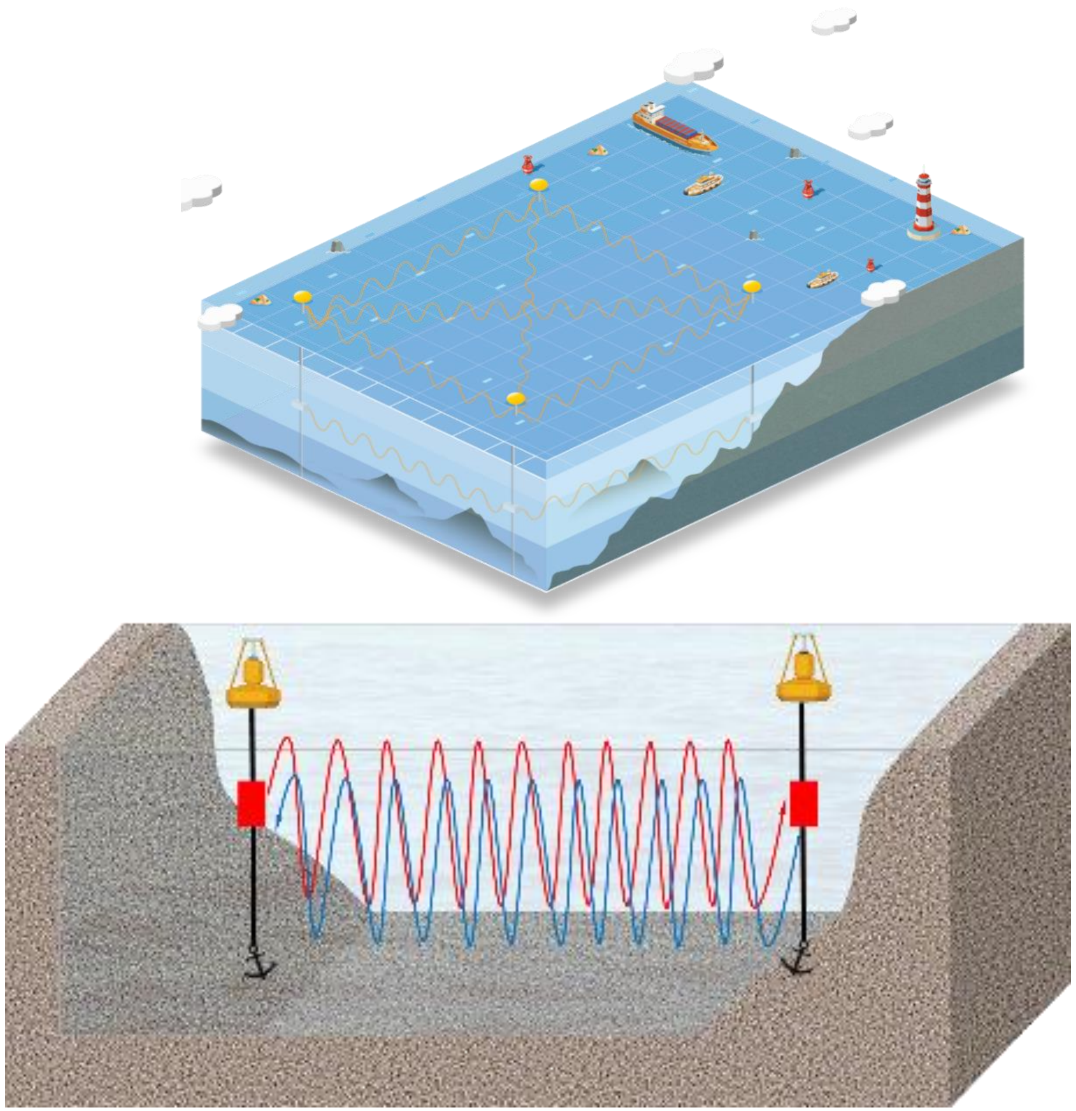

Fig 2. A schematic diagram of CAT.

Reference

PARK, Jae-Hun. 2000. KANEKO, Arata. Assimilation of coastal acoustic tomography data into a barotropic ocean model. Geophysical research letters., 27.20: 3373-3376.

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YG-MOM6

- Based model : GFDL-MOM6
- Domain : 34.78-34.99°N 127.57-127.89°E, (Yeosu-Gwangyang Bay, Korea)
- Resolution : 100m × 100m (Arakawa C-grid), 20 layer (Hybrid coordinate : Z* coordinate + Isopycnal)
- Coastline & Topography : Korea Hydrographic and Oceanographic Agency (KHOA)
- Initial Condition : MOHID (KIOST-KOOS)

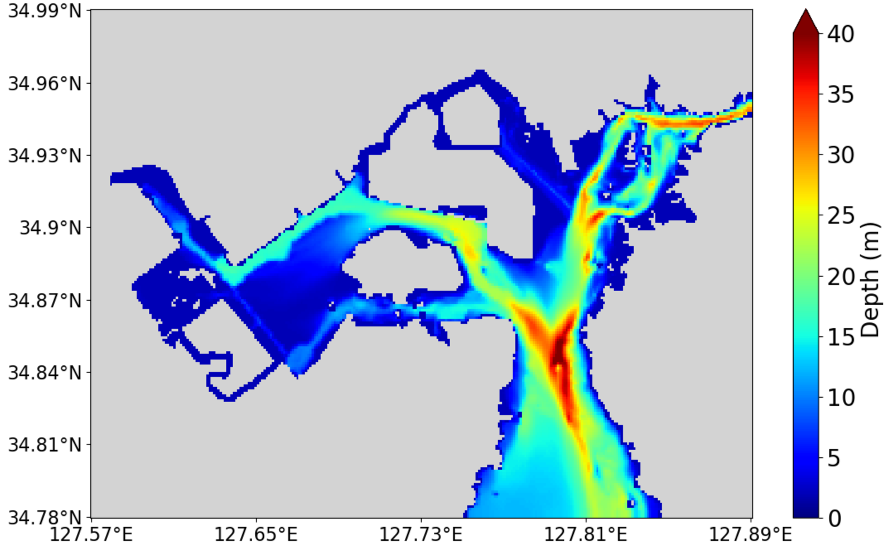

Fig 3. YG_MOM6 model domain and its depth

	Data source	Variables	Temporal resolution
Open Boundary Condition	MOHID (KIOST-KOOS)	Temperature, Salinity Velocity(U,V), SSH	3 Hourly
Surface Boundary Condition	KMA-KIM	Wind Velocity	Hourly
		Air Temperature	3 Hourly
	ECMWF ERA5	Air Pressure, Specific Humidity	6 Hourly
		Net Solar Radiation, Net Thermal Radiation, Total Precipitation	Hourly
River Discharge	WAMIS (Water Management Information System, Korea)	Runoff	Daily

Table 1. List of data source and variables used in this YG-MOM6

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Data Assimilation

- Data assimilation technique : Deterministic Ensemble Kalman Filter
- The number of ensemble member : 8

$$X^a = X^f + K(Y - HX^f)$$

$$K = P^f H^T (HP^f H^T + R)^{-1}$$

DEnKF analysis scheme

(i) Given the forecast ensemble X^f, calculate the ensemble mean, or forecast x^f by $x = \frac{1}{m}\sum_{i=1}^{m} X_i$, and the ensemble anomalies A^f by $A_i = X_i - x$

(ii) Calculate the analysis X^f, calculate the ensemble mean, or forecast x^a by using the Kalman analysis equation $X^a = X^b + K(Y - HX^b)$

(iii) Calculate the analysed anomalies by $A^a = A^f - \frac{1}{2}KHA^f$

(iv) Calculate the analysed ensemble by offsetting the analysed anomalies by the analysis : $X^a = A^a + [x^a, \cdots, x^a]$

(Sakov and Oke, 2008a)

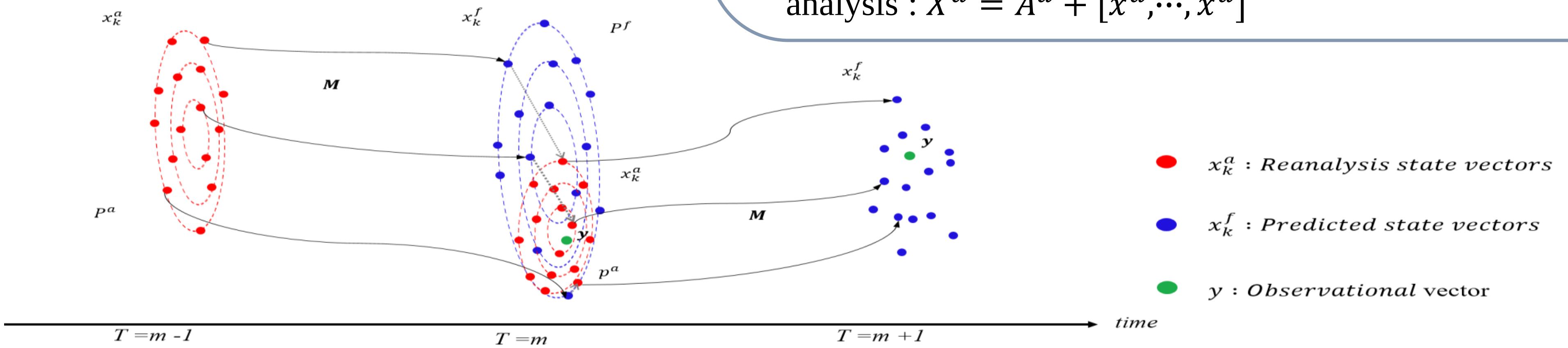

Fig 4. Schematic diagram of the Ensemble Kalman Filter. Each red and blue dots indicates the number of initial N_e Ensemble member.

Reference

Sakov, P., & Oke, P. R. (2008). A deterministic formulation of the ensemble Kalman filter: an alternative to ensemble square root filters. Tellus A: Dynamic Meteorology and Oceanography, 60(2), 361–371.https://doi.org/10.1111/j.1600-0870.2007.00299.x

2. Model and Method

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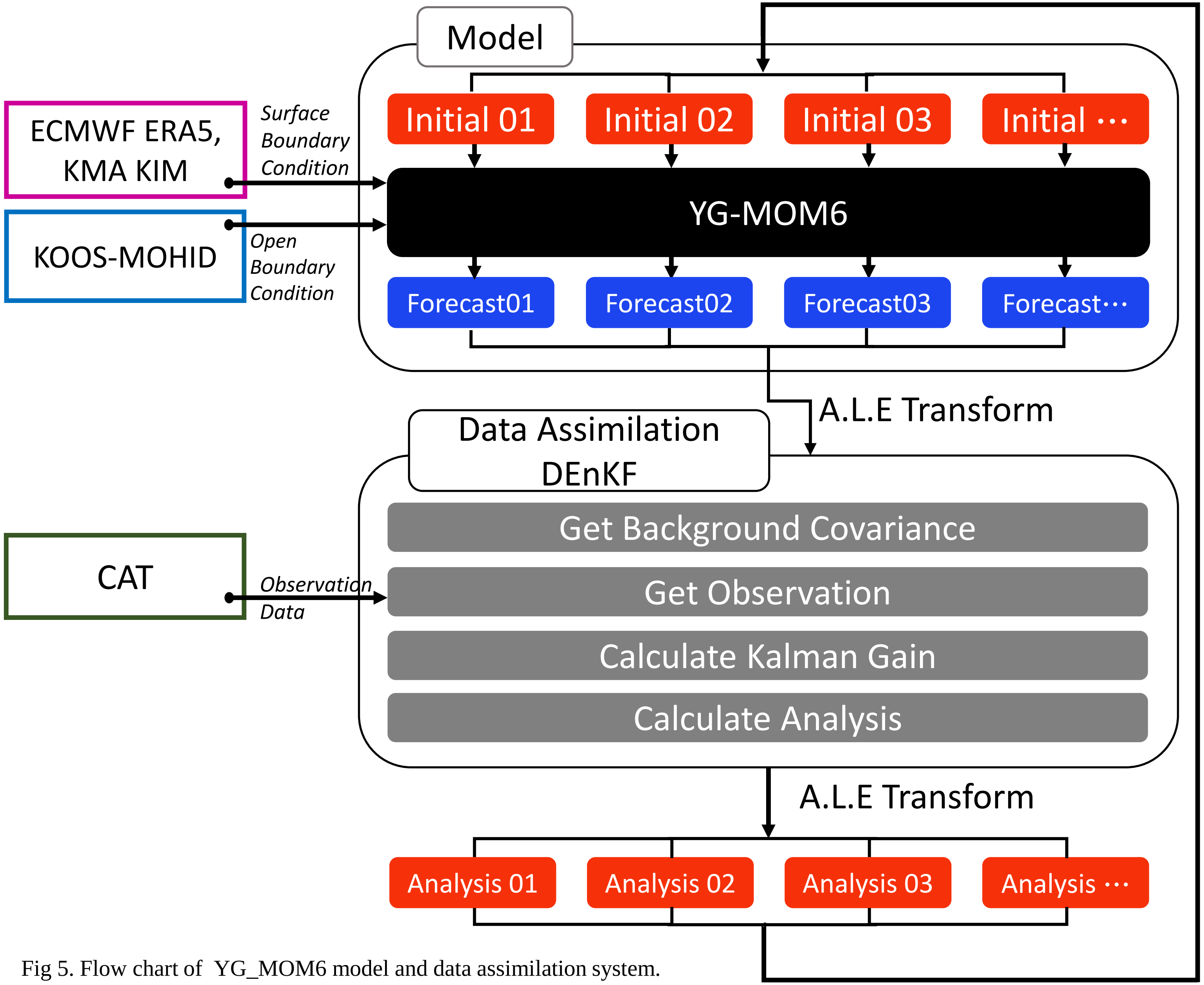
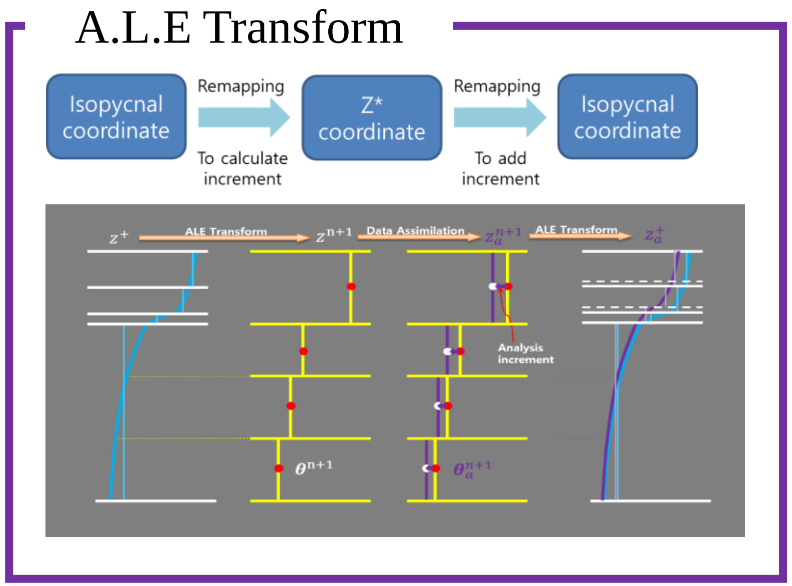
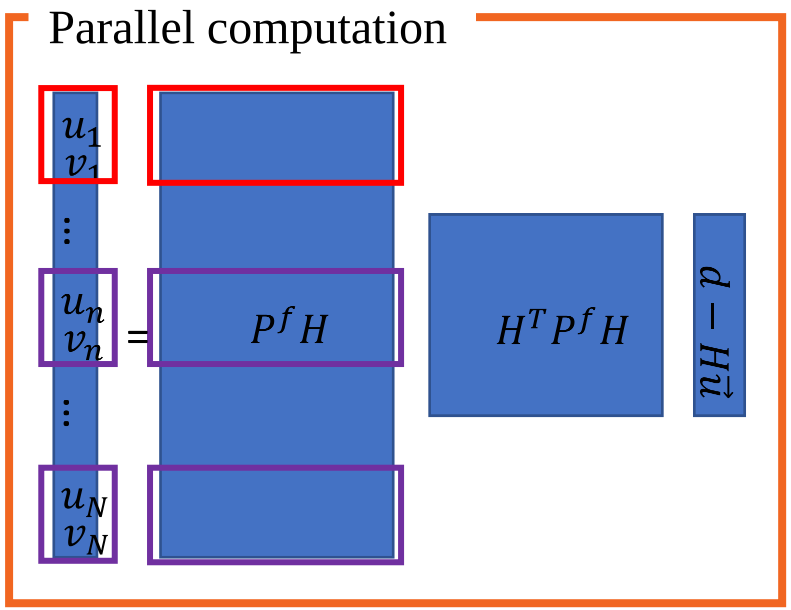


Fig 5. Flow chart of YG_MOM6 model and data assimilation system.





2. Model and Method

Perpetual Experiment

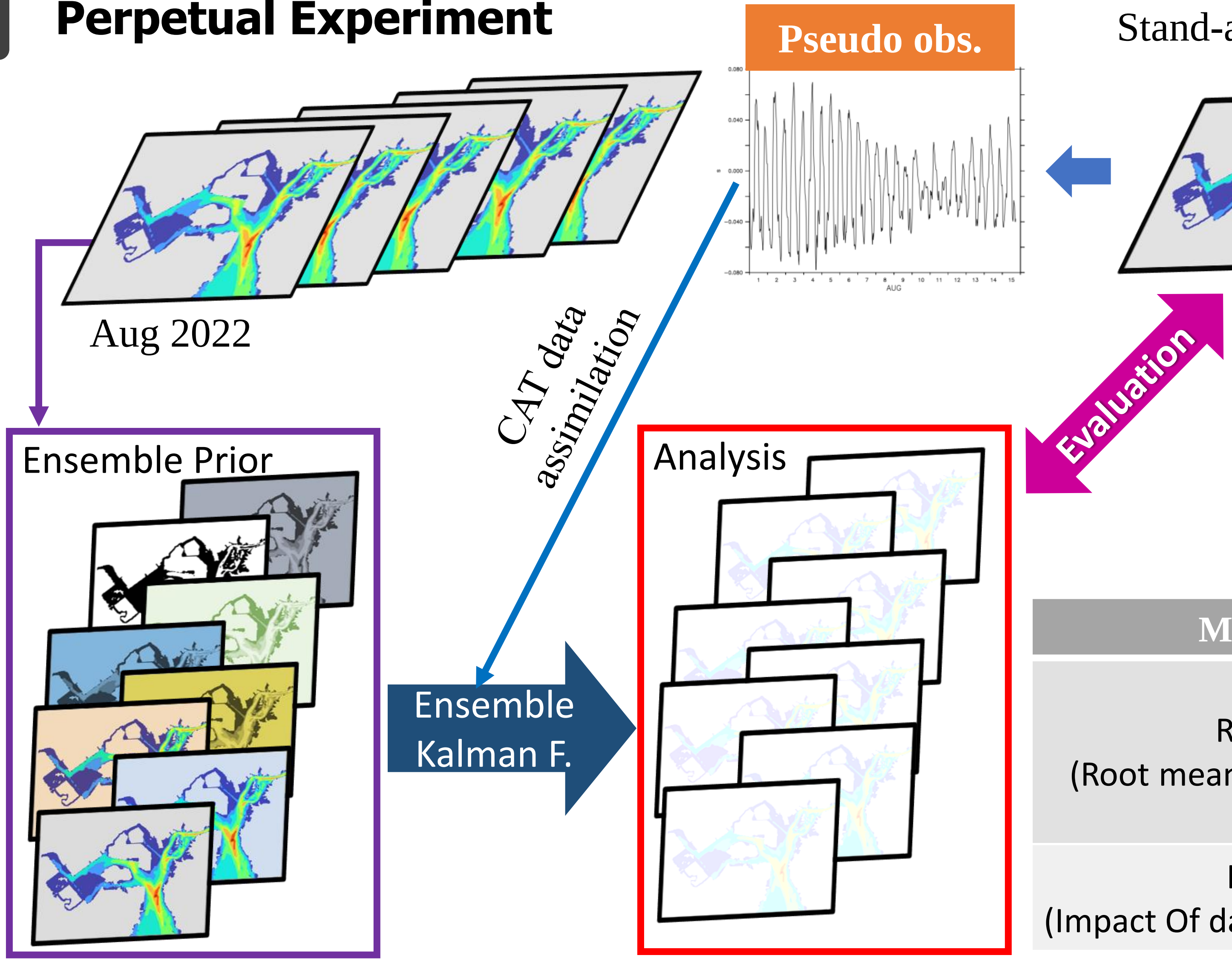
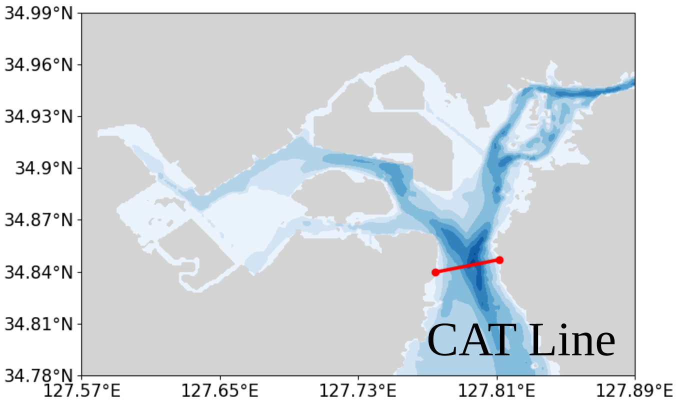


Fig 6. Schematic diagram of perpetual experiment



$$-\frac{C_o^2 \Delta\tau}{2L} = \sum_{i=1}^{N} \frac{l_i}{L}(u_i \cos\theta + v_i \sin\theta)$$

(Zhu et al., 2017)

$$time\ interval = \sum_{t=1}^{n} (H_u \cdot u_t + H_v \cdot v_t)$$

Metrics	Equation
RMSE (Root mean Square Error)	$\sqrt{\frac{1}{n}\sum_{i=1}^{n}(m_i - o_i)^2}$
IOA (Impact Of data Assimilation)	$\frac{RMSE_{without\_oda} - RMSE_{oda}}{RMSE_{oda}} \times 100$ [%]

Table 2. Statical metrics for estimation data assimilation performance

Zhu, Z.-N., X.-H. Zhu,X. Guo, X. Fan, and C. Zhang (2017), Assimilation of coastal acoustic tomography data using an unstructured triangular grid ocean model for water with complex coastlines and islands, J. Geophys. Res.Ocean , 122, 7013-7030, doi: 10.1002/2017JC012715

Model Performance

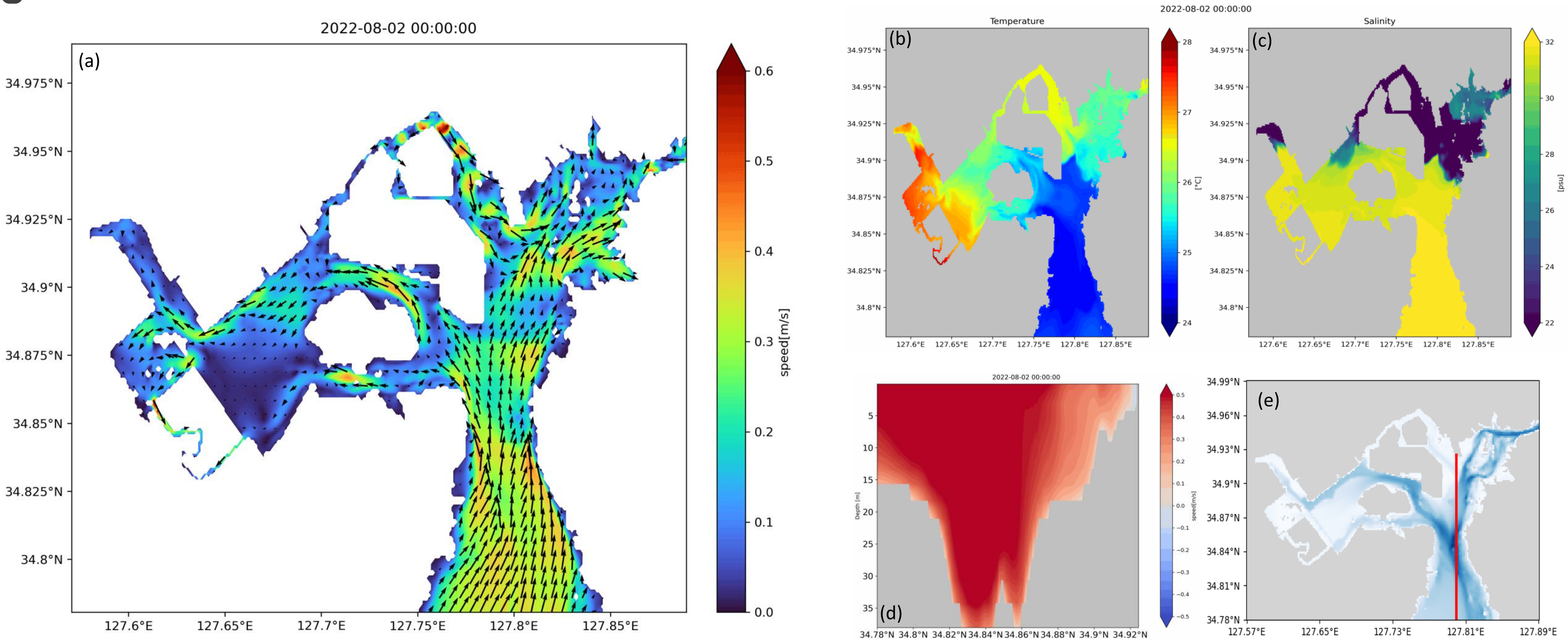


Fig 7. The result of the YG model in Aug 2022. (a), Current speed and direction, (b) Temperature, (c) Salinity, (d) Vertical section of V component at red line in (e).

➡ Stable model results despite narrow and shallow areas

Model Performance : Tide

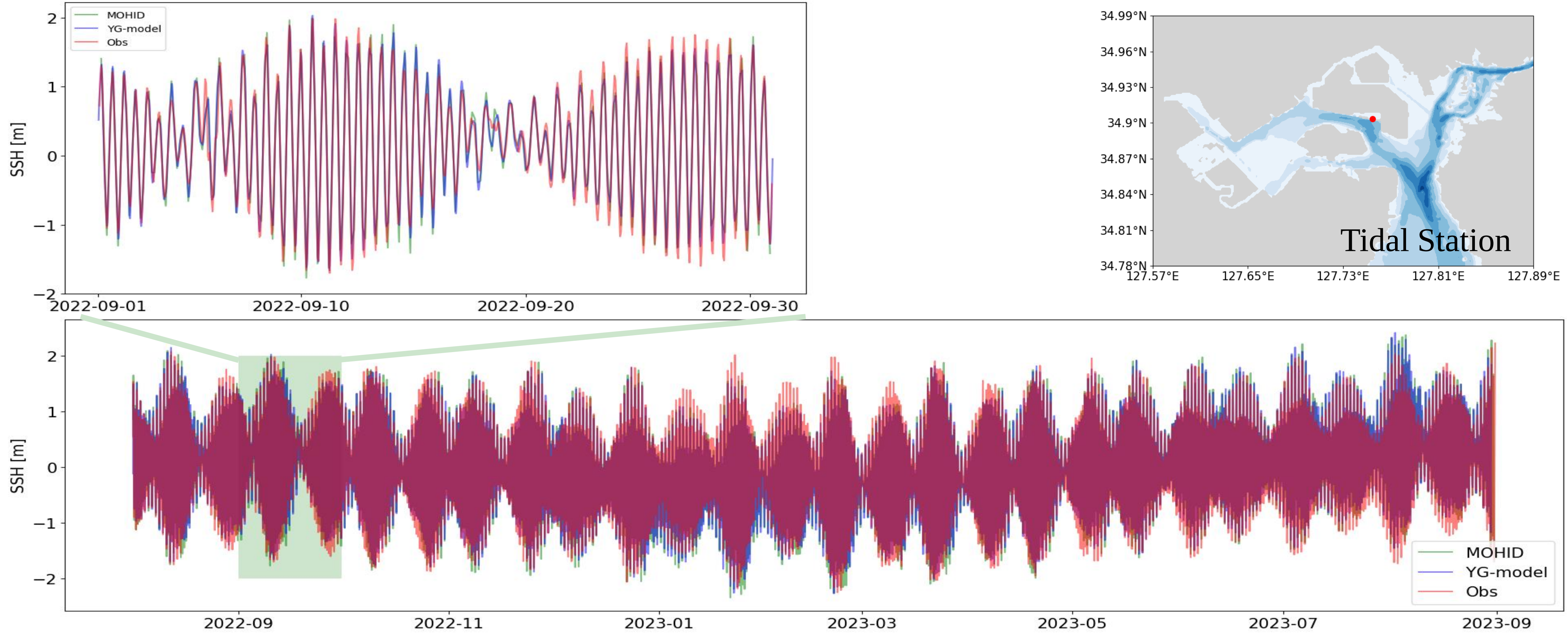


Fig 8 . YG Model and Observation Tidal Comparison Results

➡ YG Model tide tendency and peak consistent with observations

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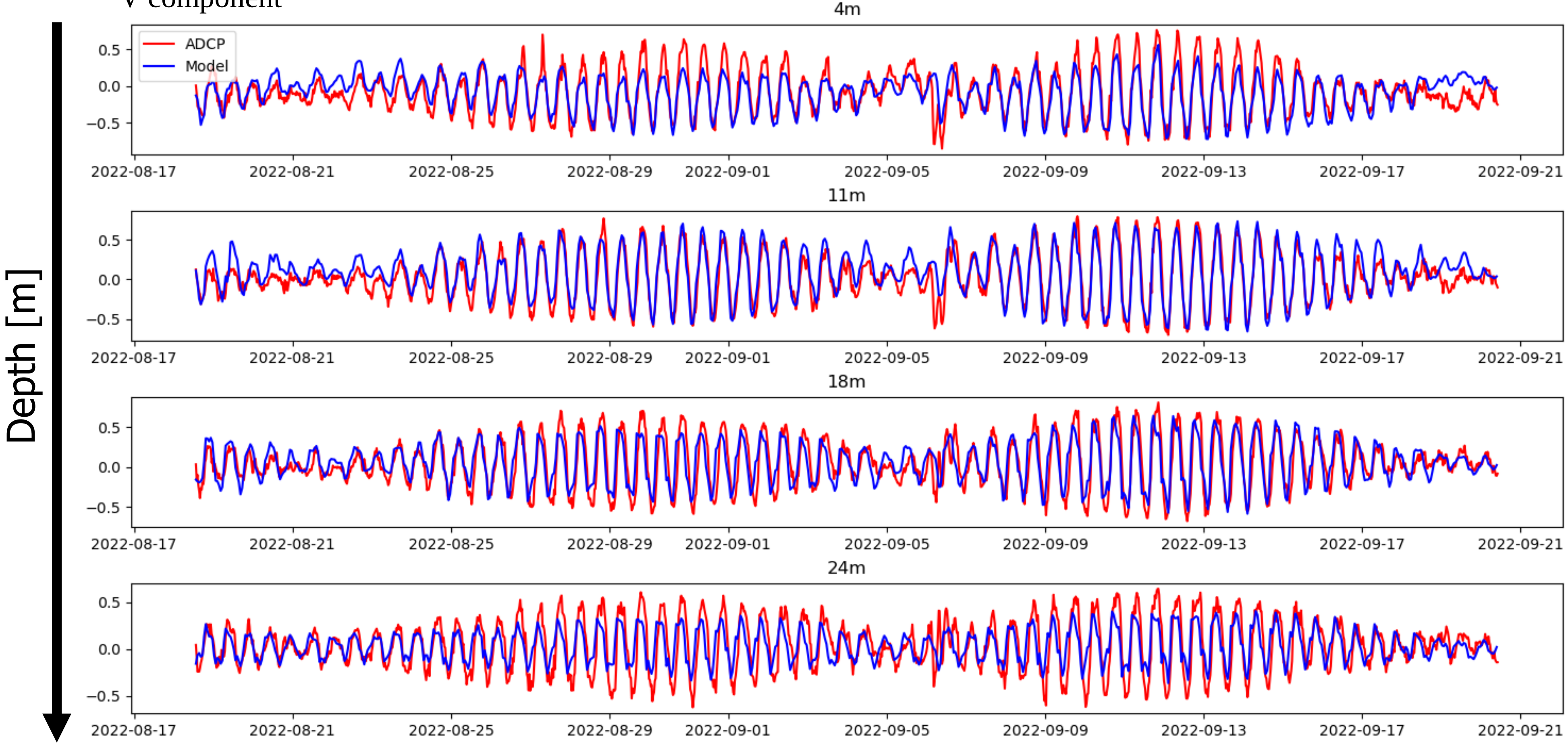
Model Performance : Current

V component



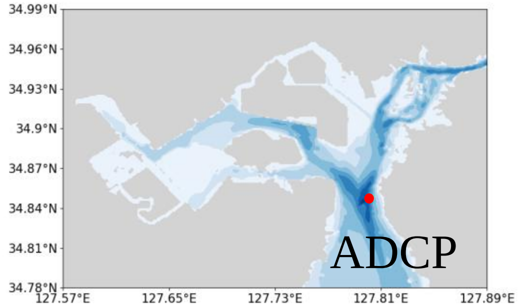
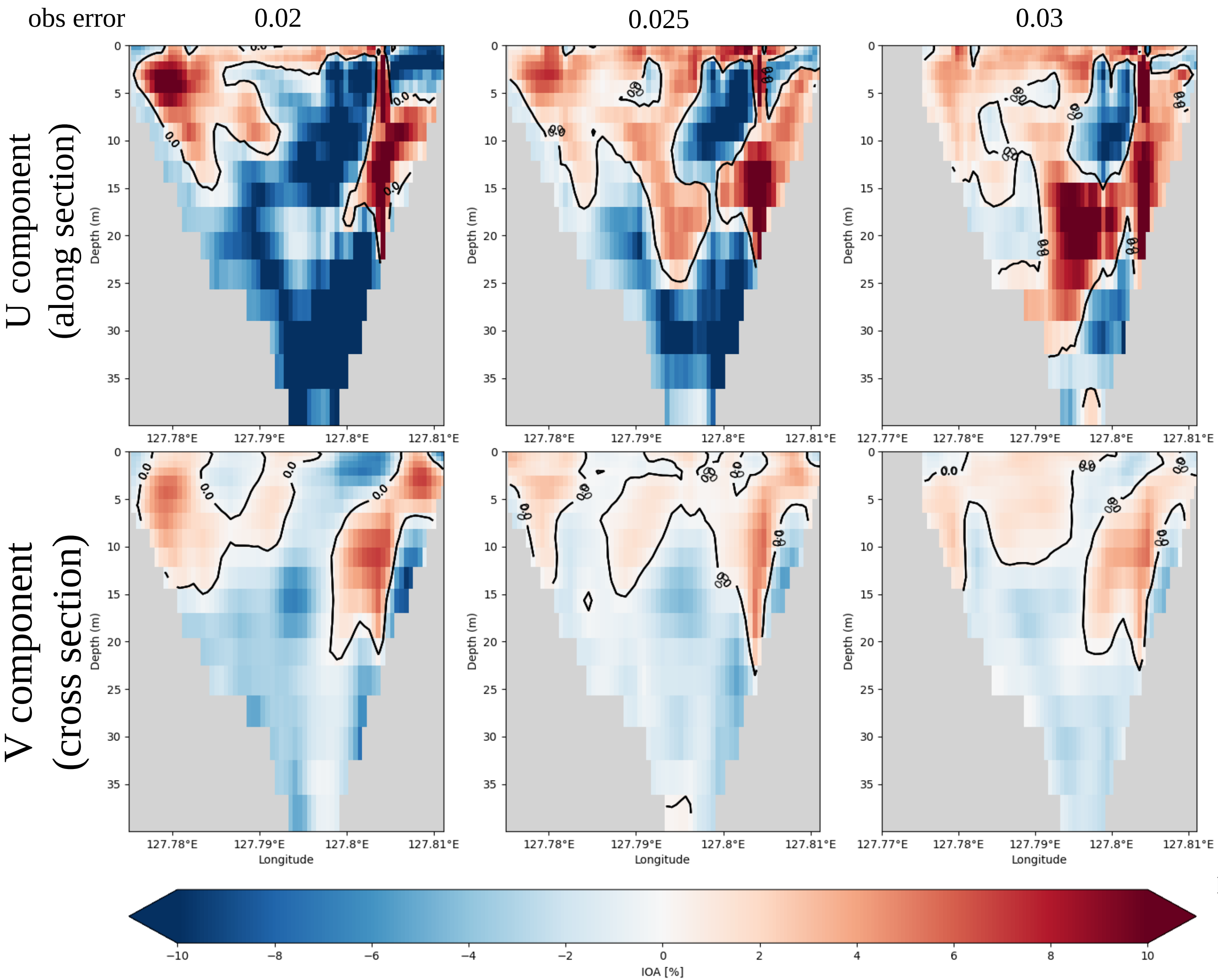


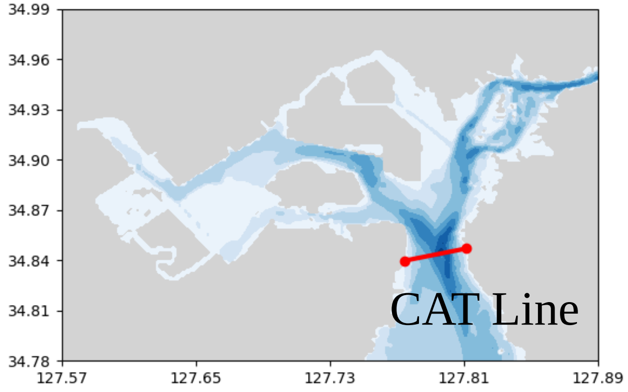
Fig 9. Comparison result of the YG model V component with ADCP observation.

Overall, V component fit well with ADCP observation, But underestimated in bottom layer

CAT Data Assimilation Result : U and V component



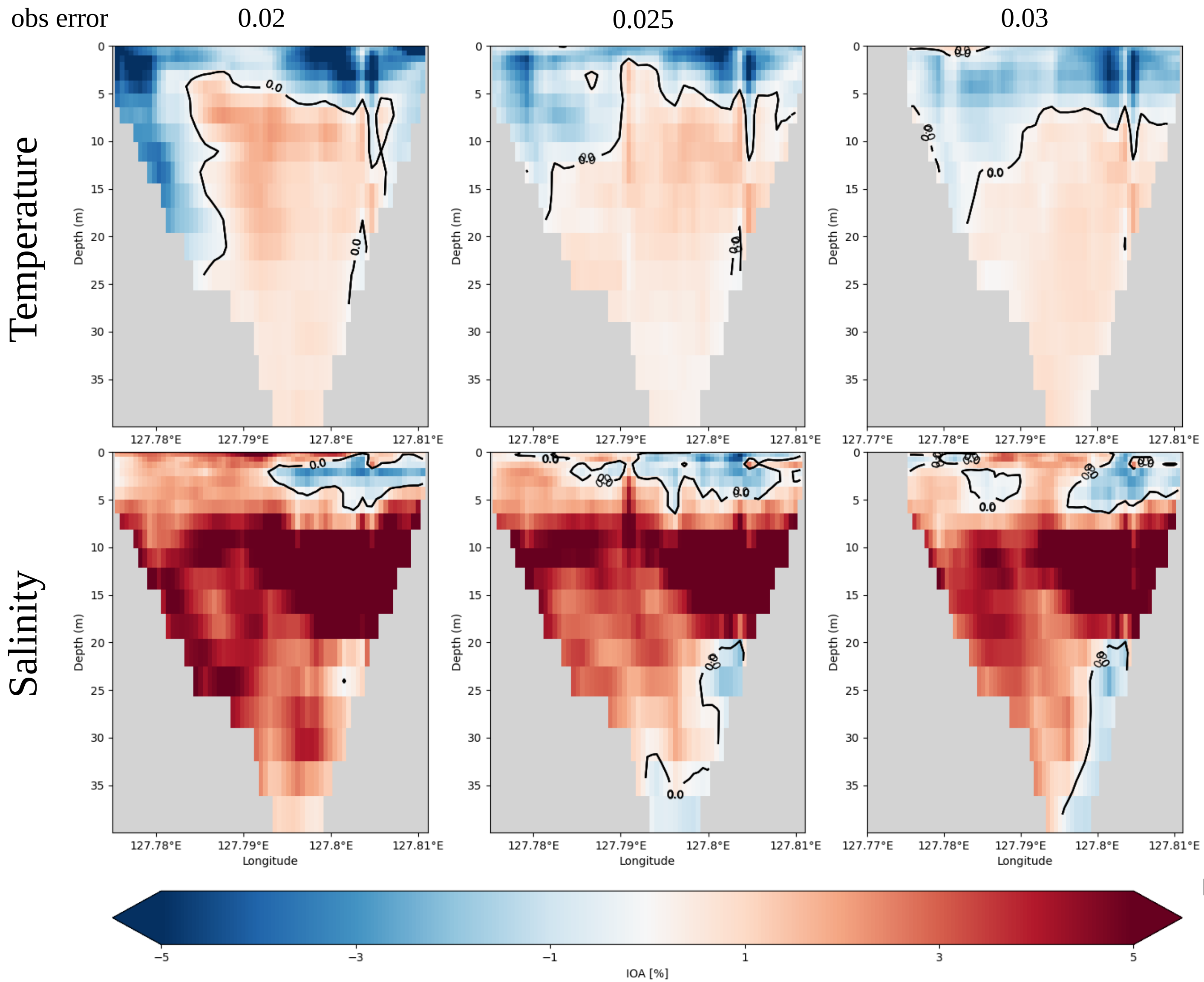
$$IOA = \frac{RMSE_{without\_oda} - RMSE_{oda}}{RMSE_{oda}} \times 100[\%]$$



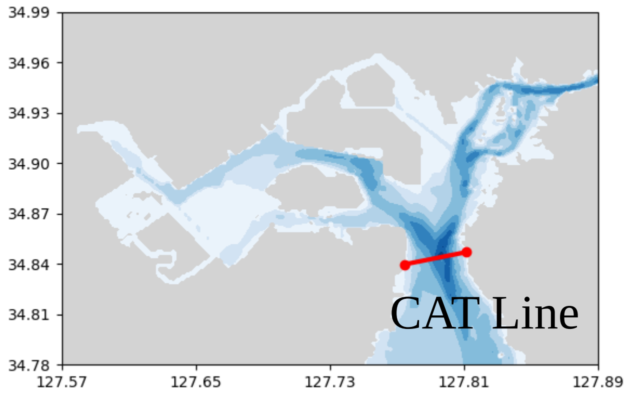
CAT : Coastal Acoustic Tomography

Fig 10. U and V component result of data assimilation IOA vertical section along CAT line

CAT Data Assimilation Result : Temperature and Salinity



$$IOA = \frac{RMSE_{without\_oda} - RMSE_{oda}}{RMSE_{oda}} \times 100[\%]$$



CAT : Coastal Acoustic Tomography

Fig 11. Temperature and salinity result of data assimilation IOA vertical section along CAT line

4. Conclusion & Discussion

- We have successfully set up a high-resolution MOM6 coastal model for Yeosu-Gwangyang Bay, Korea. (YG-MOM6).

- Tide from the model is consistent with observations, tidal station and ADCP measurements.

- We have also developed CAT data assimilation system.

- CAT assimilation improved not only the currents but also temperature and salinity.

- CAT observation system can improve coastal ocean prediction system.

5. Future Plan

- Quality Control of the CAT data
- Development of real-time Coastal Prediction System applying CAT data assimilation

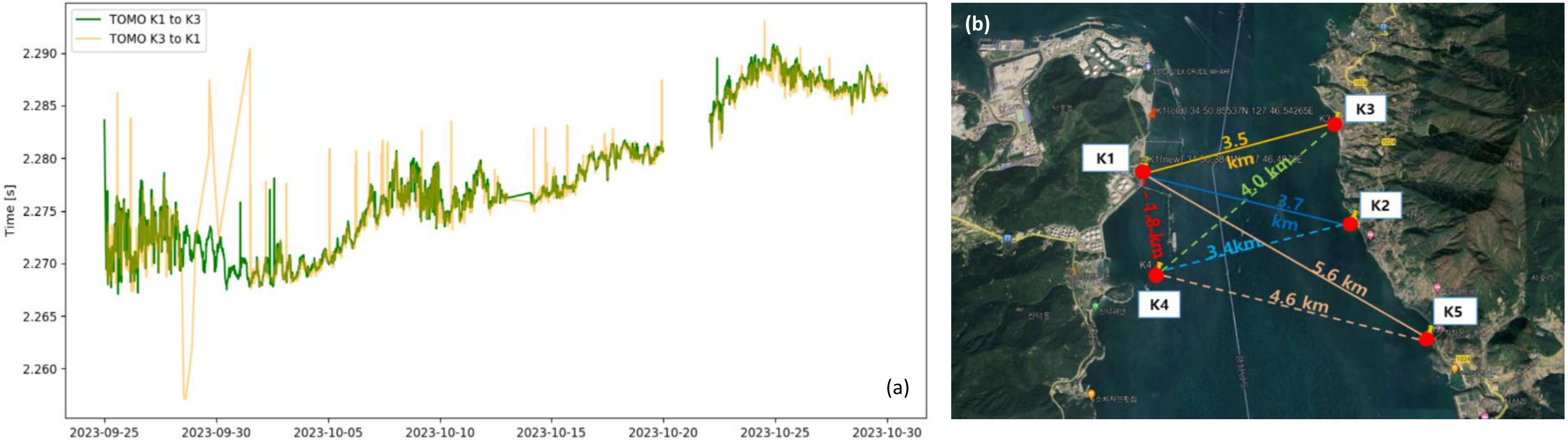


Fig 12 . The real CAT observation data obtain in K1-K3 (a) and location of the multiple CAT will operation (b) .

Thank you!

Applying MOM6 for High-Resolution Coastal Modeling of Yeosu-Gwangyang Bay, Korea

Keywords : Tomography Data Assimilation, DEnKF, MOM6 Regional Model

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