Conducting and Performance Evaluation of a High-Resolution Regional Ocean Model in Yeosu-Gwangyang Bay using GFDL MOM6

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Introduction

- Accurate coastal current prediction is critical for effective accident response and ocean environmental improvement.
- The existing current observation are limited to pointwise or the sea surface.
- Ocean model can overcome the limitation of observational data by providing improved current fields. However, ocean model has the numerical error.
- In this study, we are trying to develop a data assimilation system that using Coastal Acoustic Tomography(CAT) data into a high-resolution ocean model to improved current prediction.

Ocean Model

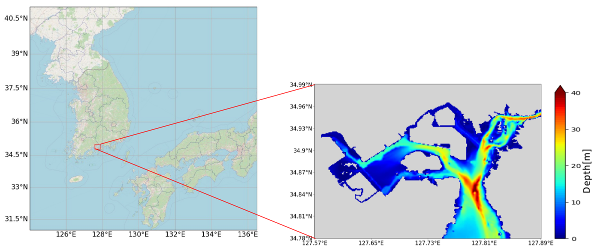


Fig 1. Domain of ROMS model, Yeosu, Korea

MOM6 (Modular Ocean Model)

Domain	Yeosu Bay, Korea (127.57-127.89°E, 34.78-34.99°N)
Horizontal resolution	≒ 100m (Arakawa C-grid)
Vertical layer	< 5m ,20 layer (Hybrid-coordinate)
Coastline, Topography	Korea Hydrographic and Oceanographic Agency
Initial condition	MOHID (KIOST KOOS, KHOA ROMS)
Open boundary condition	MOHID (KIOST KOOS, KHOA ROMS)
Atmospheric forcing	ERA5 /Korea Meteorological Administration/
River Discharge	WAMIS (Water Resources Management Information System; Korea)

Coastal Acoustic Tomography

- Coastal Acoustic Tomography(CAT) is a remote sensing technology using underwater sound wave.
- CAT can infer physical variables such as temperature, salinity, and current by using ocean acoustic propagation speed.
- CAT has been successfully to monitor the current field of coastal sea.
- CAT is powerful to monitor ocean regions and has been shown to improve an ocean model's ability (Park and Kaneko, 2000).

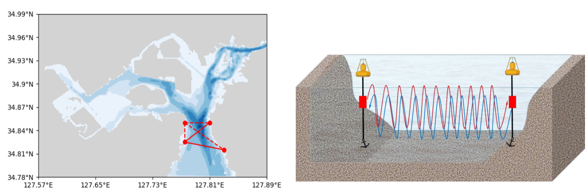


Fig 2. The Station of CAT observations are conducted, and illustration of the CAT

Results

- Salinity Result of with and without River Discharge

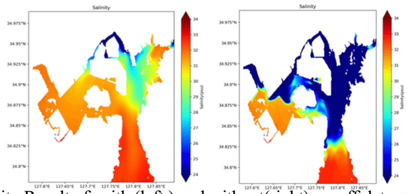


Fig 3. Salinity Result of with (left) and without(right) runoff data at August 2nd

- The result of containing the runoff well simulates the surface low salinity

- Vertical section of Temperature and Salinity

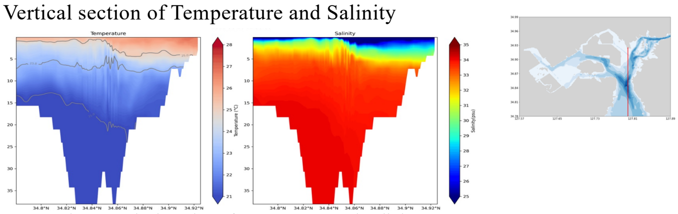


Fig 4. Vertical section of Temperature and Salinity

⇒Stratification is well simulated

- U,V current

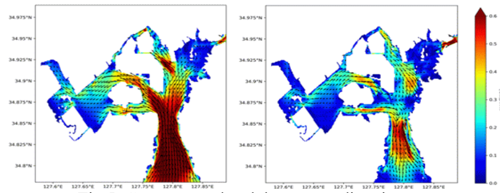


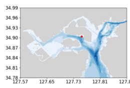
Fig 5. Current speed and the current direction

⇒Flood and Ebb current are well simulated

- Tide

- Observation data : Gwanyang Station Tide Gauge

	Hybrid	Z*	MOHID (Mother Model)
RMSE	0.1380 (0.13805128620789384)	0.1378 (0.13775477226228396)	0.1407 (0.14066473007234295)



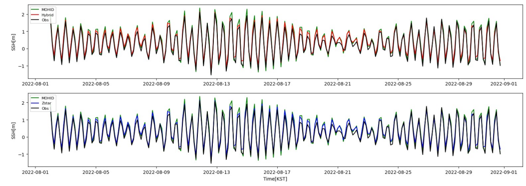


Fig 6. Comparison of Tide Gauge between Observation Data and Model Data

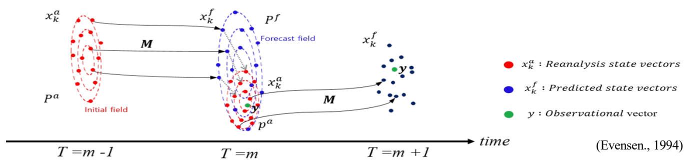
Data Assimilation

- **Ensemble Kalman Filter (EnKF)**

$$X_k^a = X_k^f + W[Y - H(X_k^f)]$$

$$W = P^f H^T \cdot [HP^f H^T + R]^{-1}$$

- H : Observation operator
- W : Kalman gain matrix
- X^a : analysis
- P_f : Model background error covariance matrix
- R : Observation error covariance matrix
- $x_k^f(t=m) = M_{0\to m}[x_k^a(t=0)], k = 1,2,3\cdots,N_e$: Forecast ensemble
- $X^f(t=m) = \{[x_k^f(t=m) - \overline{x^f(t=m)}] / \sqrt{N_e - 1}, k = 1,2,3\cdots,N_e\}$: Background field ,Forecast deviation



(Evensen., 1994)

Fig 7. Schematic diagram of the Ensemble Kalman Filter.
Each red and blue dots indicates the number of initial N_e Ensemble member.

- Assume the observed time differences are the difference of the current changes.
- In terms of the integration of temperature and velocity, it can be interpreted as the difference in sound speed.
- This research will evaluate the impact of sound speed influenced by sea temperature and velocity, aiming to reduce errors .

Reference.
1 . Evensen, G. 1994. Sequential data assimilation with a nonlinear quasi-geostrophic model using Monte Carlo methods to forecast error statistics. J. Geophys. Res., 99(C5), 10143-10162.
2. PARK, Jae-Hun. 2000. KANEKO, Arata. Assimilation of coastal acoustic tomography data into a barotropic ocean model. Geophysical research letters., 27.20: 3373-3376.