Improving the Accuracy of Coastal Sea Surface Temperature using Merged SST with Satellite and Buoy Data in Southwest Sea of Korea

Jimyeong Seo (Inha University): tjwlaud4@mpl.inha.ac.kr
Hyeon-Jae Kim (Inha University): hyunjae@mpl.inha.ac.kr
Seung-Buhm Woo (Inha University): sbwoo@inha.ac.kr
Dong-Hoon Kim (Inha University): mail@dhkim.info
Chaewook Lim* (Inha University): lichwo@gmail.com

Introduction

- The satellite data is typically used for data assimilation.
- However, satellite data has low accuracy near the coastal areas with complex coastline such as the Southwest Sea of Korea.
- To improve this, research is needed to merge satellite and observation data.

Study Area & Observation Data

- Study area is the Southwest Sea of Korea, which is characterized by a complex shoreline with many islands and a location where various water masses, tides, and currents interact.

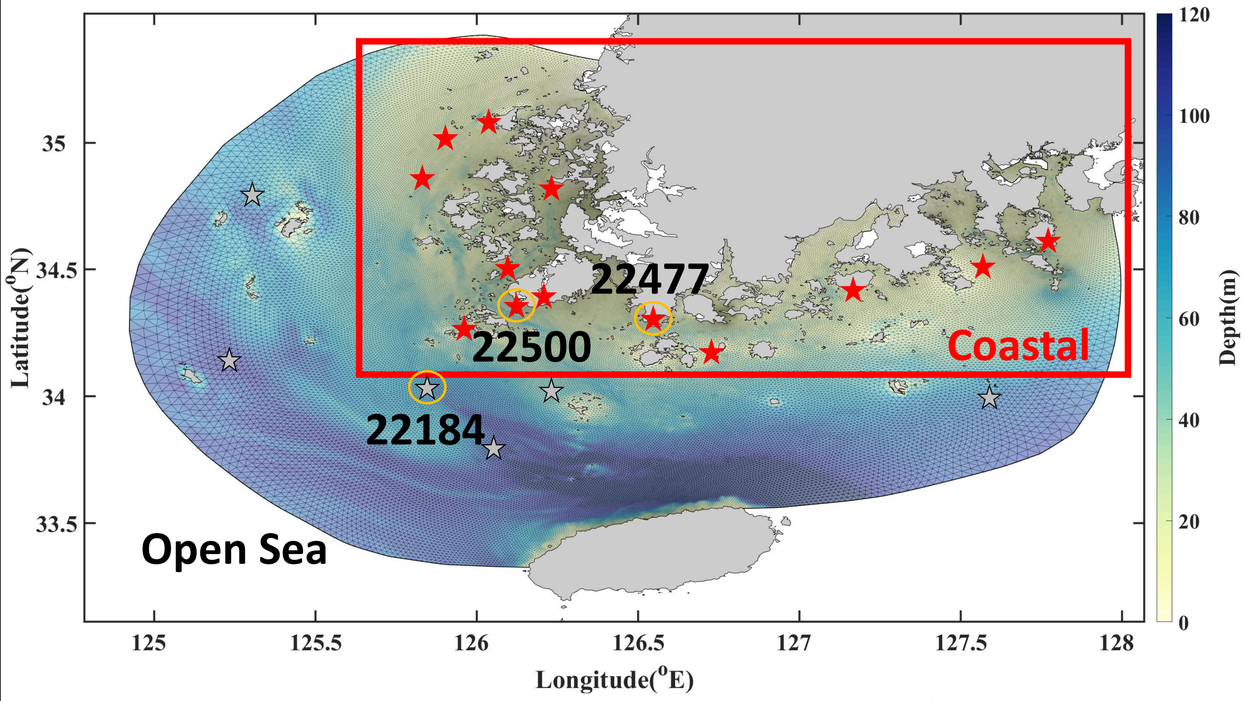


Figure 1. Location of Southwest sea of Korea and the model domain. (Red Star: Coastal buoy data, Gray star: open sea data, Number means Buoy Number of Korea Meteorological Administration)

- In each area, 22184 was selected to represents the open sea area, and 22500 and 22477 is selected to represents the coastal area.
- Satellite used Operational Sea Surface Temperature and Ice Analysis (OSTIA) data, observation data used the buoy data of Korea Meteorological Administration.
- In Figure 3, It can be seen that satellite data is less accurate than observation data.
- OSTIA is 2D spatial data. And a buoy data is timeseries station data, so it can not provide spatial data.
- To overcome this limits, Research on how to merge satellite data and observation data is needed.

Merged SST Field

- Various merging method of SST field have been proposed so far. However, it did not reflect the characteristics of the ocean well. in this study, we propose a new merging method using weight function and correlation coefficients to reflect the characteristics of the oceans. It is simplified to

$$A^{n+1} = \frac{\sum\left(A^n(i) + W^n * R\left(Buoy(j) - A^n(j)\right)\right)}{j}$$

$$W^n = \frac{\left(\frac{L}{N/(N-n)}\right)^2 - l^2}{\left(\frac{L}{N/(N-n)}\right)^2 + l^2}$$

Where, $A^n(\mathrm{n} = 1, 2, .. \mathrm{N})$ is the nth merged SST field. The variables W^n and R represent the weight function and correlation coefficient respectively, between the satellite and buoy data, and ' j ' is the number of observation points.

- ' l ' means the distance from the data and points.
- 'L ' means the impact radius, N means the maximum value of n.
- This new merged SST field named as mOSTIA.

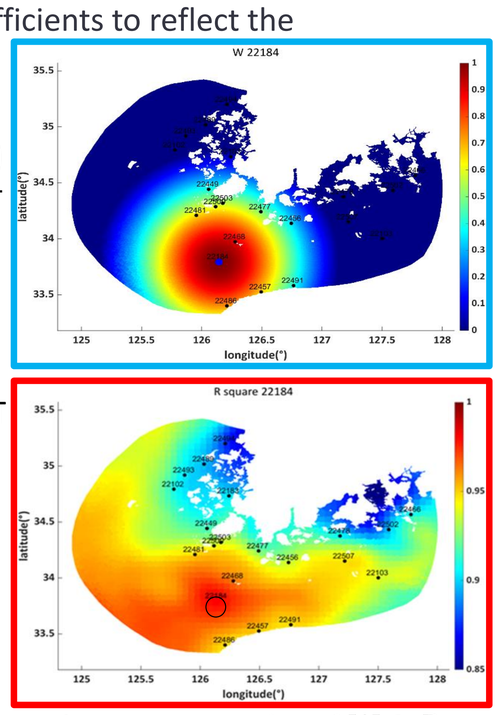


Figure 2. Examples of W & R. (buoy number is 22184)

Model Configuration

Table 1. Model Configuration.

		FVCOM_Base	FVCOM_DA	FVCOM_mDA
Surface Boundary condition		WRF (Wind, Air Pressure, Heat Flux)		
Latteral Boundary condition	Tidal condition	TMD (5 major constituents: M2, S2, K1, O1, N2)		
	Temperature & Salinity condition	**HYCOM**		
Initial condition				
Data Assimilation condition		**None**	**OSTIA**	**mOSTIA**

- The base model is Finite Volume Community Ocean Model (FVCOM_Base) with Weather Research and Forecasting (WRF) as surface boundary condition, Tide Model Driver (TMD) as tidal condition, Hybrid Coordinate Ocean Model (HYCOM) for temperature and salinity condition.
- FVCOM_DA is data assimilation model using OSTIA data. And FVCOM_mDA is data assimilation model using mOSTIA data.

Result

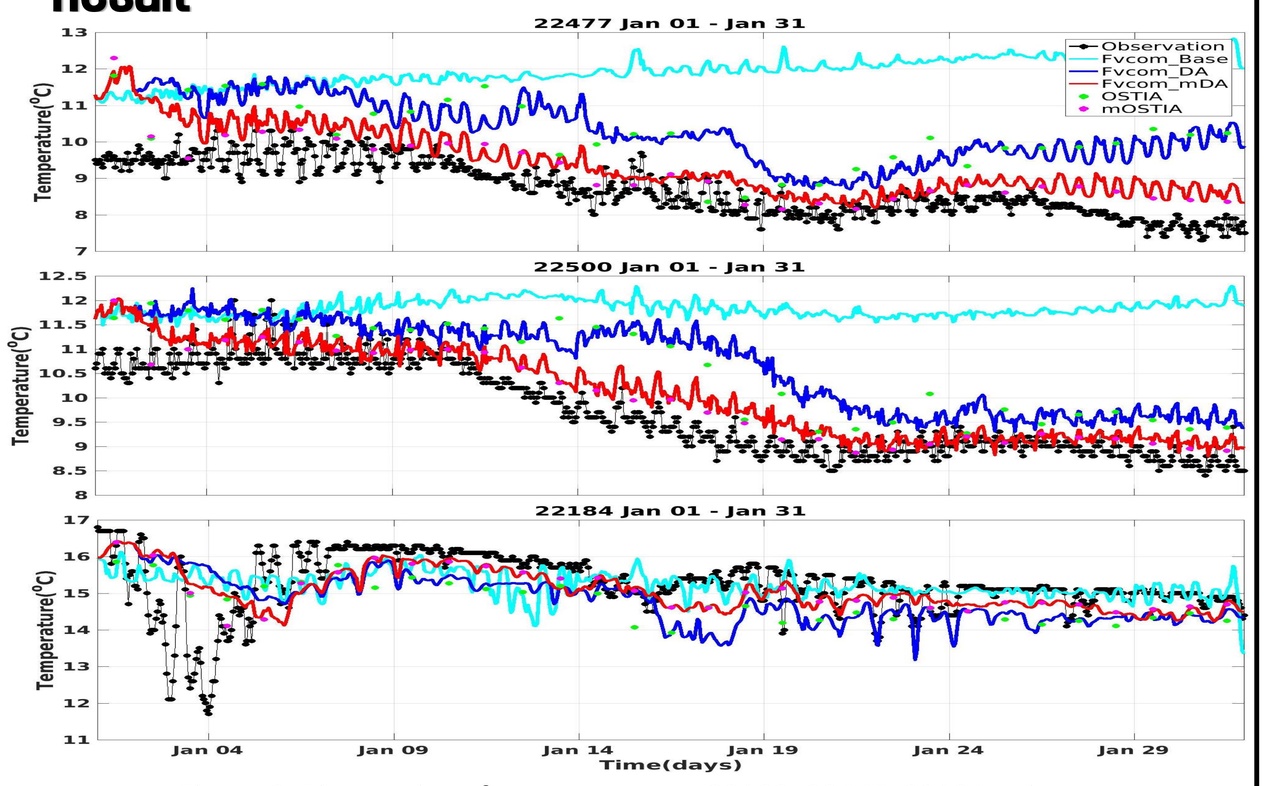


Figure 3. Time series of temperature at 22183, 22477, 22184 point. (Black line: Observation, Cyan line: FVCOM_Base, Blue line: FVCOM_DA, Red line: FVCOM_mDA, Green dot: OSTIA, Magenta dot: mOSTIA)

- OSTIA has relatively high accuracy in the open sea (22184) compared to the observed (buoy) data, but low accuracy in coastal area (22477, 22500).
- FVCOM_Base is significantly less accurate in coastal area due to the characteristics of the HYCOM used as boundary fields.
- It can be seen that mOSTIA is significantly closer to the buoy data in coastal area compared to OSTIA.
- FVCOM_mDA performs best in the coastal area, especially around January 14th, when the temperature changes rapidly in the coast.
- In the open sea, FVCOM_Base reproduces the buoy data well, and OSTIA shows a similar behavior to the observations, so the performance improvement by data assimilation is smaller than in coastal area.

Table 2. Root mean square error (RMSE) and correlation coefficient of models.

	RMSE (°C)			Correlation Coefficient		
	Mean	Coastal	Open Sea	Mean	Coastal	Open Sea
FVCOM	2.8772	3.2698	1.6994	-0.2376	-0.3424	0.0770
FVCOM_DA	1.1811	1.2831	0.8753	0.6692	0.7032	0.5674
FVCOM_mDA	**0.7356**	**0.7479**	**0.6988**	0.7515	0.7807	0.6641

- FVCOM_mDA has an overall performance improvement of about 38% over FVCOM_DA.
- In particular, the RMSE is significantly improved in coastal waters by over 40%.
- The RMSE improvement in the open sea is about 20%, but it is considerably smaller compared to the coast.
- By data assimilation of mOSTIA, the accuracy of the model results can be improved.
- The correlation coefficient has improved but not significantly.

Acknowledgments

- This work was supported by Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (RS-2022-00155915, Artificial Intelligence Convergence Innovation Human Resources Development (Inha University))
- This research was supported by the National Information Society Agency (NIA) with funding from the Korean government's Ministry of Science and ICT (No. 2022-데이터-위 145).

Conclusions

- This study proposed a method to merging satellite data and buoy data using a weight function and correlation length that reflect the characteristics of the ocean.
- The data assimilation using merged OSTIA improved the RMSE by more than 38% in coastal areas compared to the results using OSTIA.
- When the accuracy of satellite data is low due to regional characteristics, it is necessary to study using merging fields.