KOOS
Korea Operational Oceanographic System

# The Achievement of KOOS in national agencies and industries

2023.11.09

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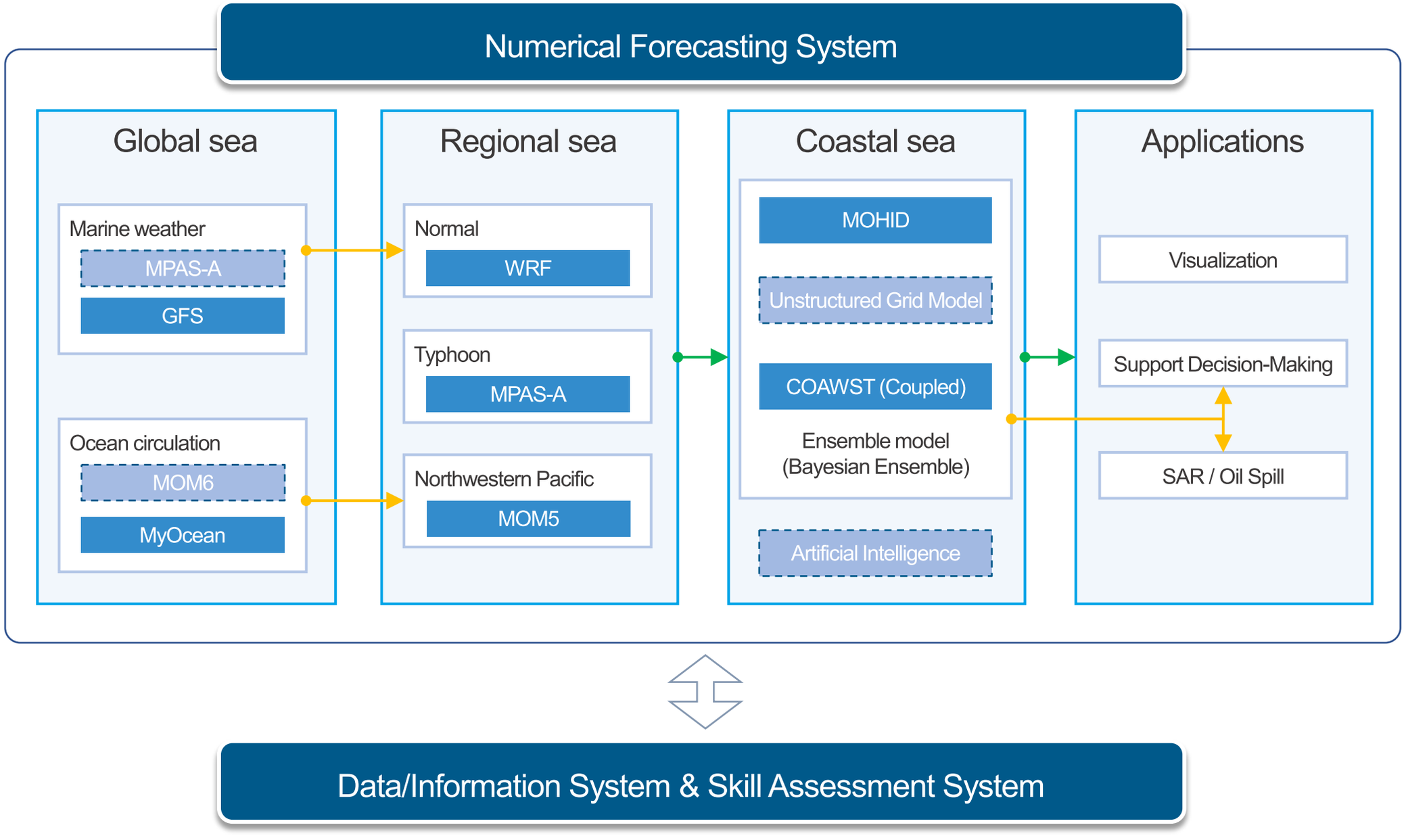
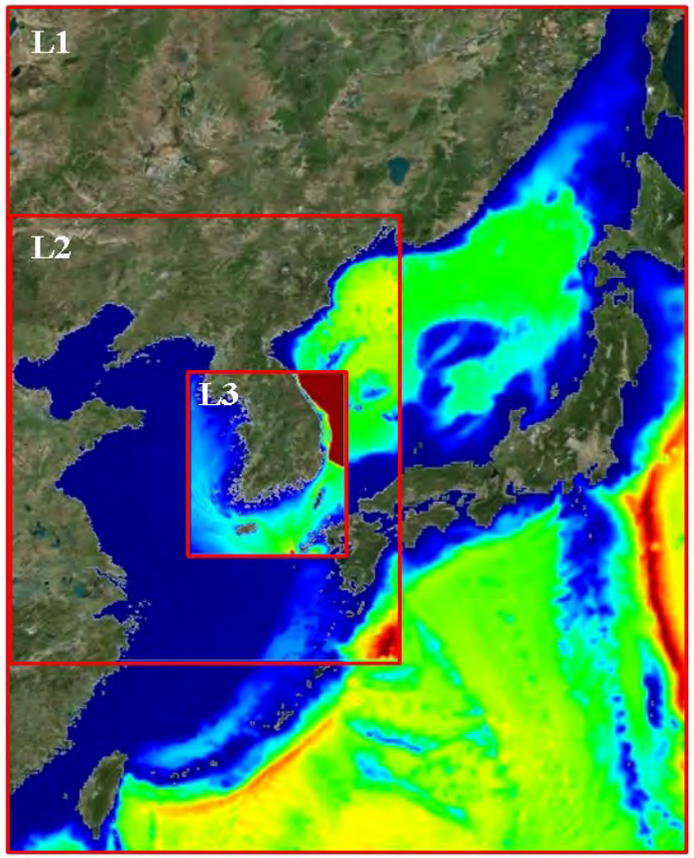
# KOOS

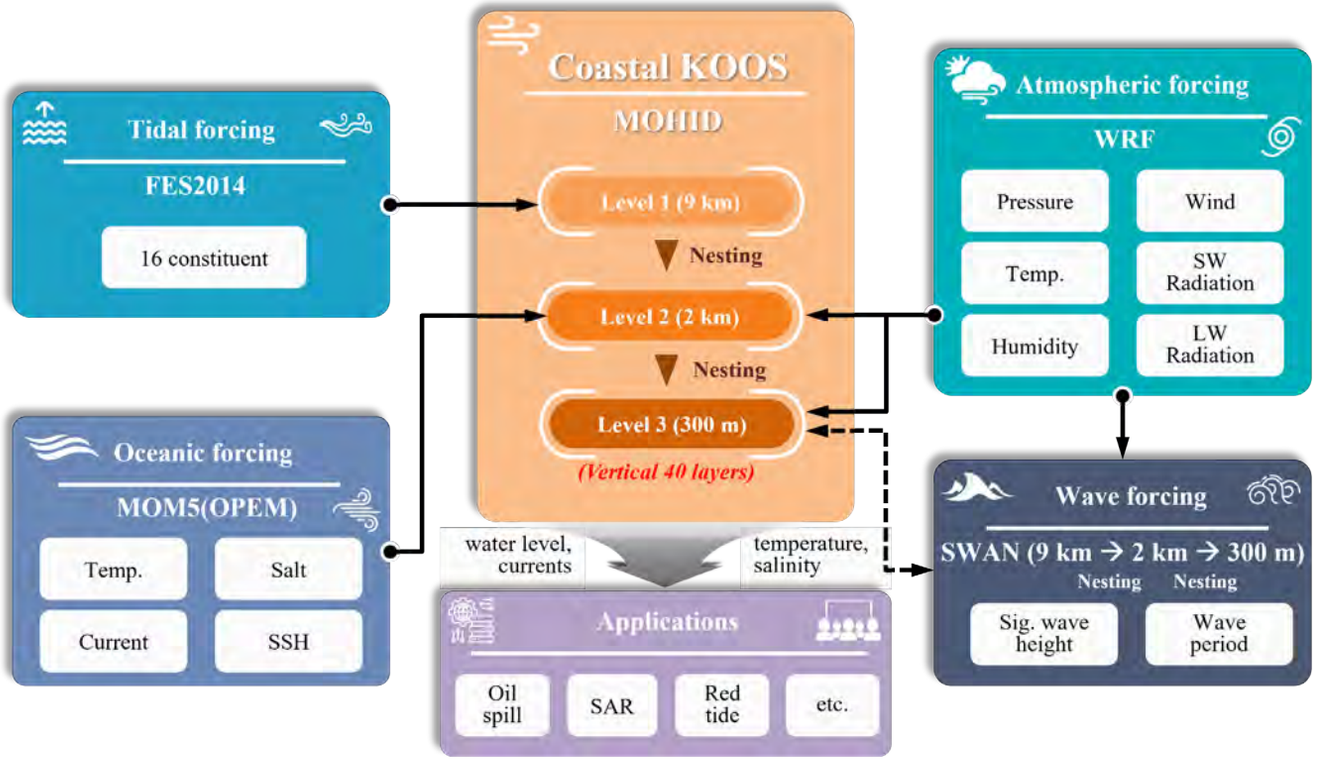

Numerical Forecasting System
Global sea
Marine weather
MPAS-A
GFS
Ocean circulation
MOM6
MyOcean
Regional sea
Normal
WRF
Typhoon
MPAS-A
Northwestern Pacific
MOM5
Coastal sea
MOHID
Unstructured Grid Model
COAWST (Coupled)
Ensemble model
(Bayesian Ensemble)
Artificial Intelligence
Applications
Visualization
Support Decision-Making
SAR / Oil Spill
Data/Information System & Skill Assessment System

# KOOS – Numerical Forecasting System (Coastal)

## Coastal KOOS

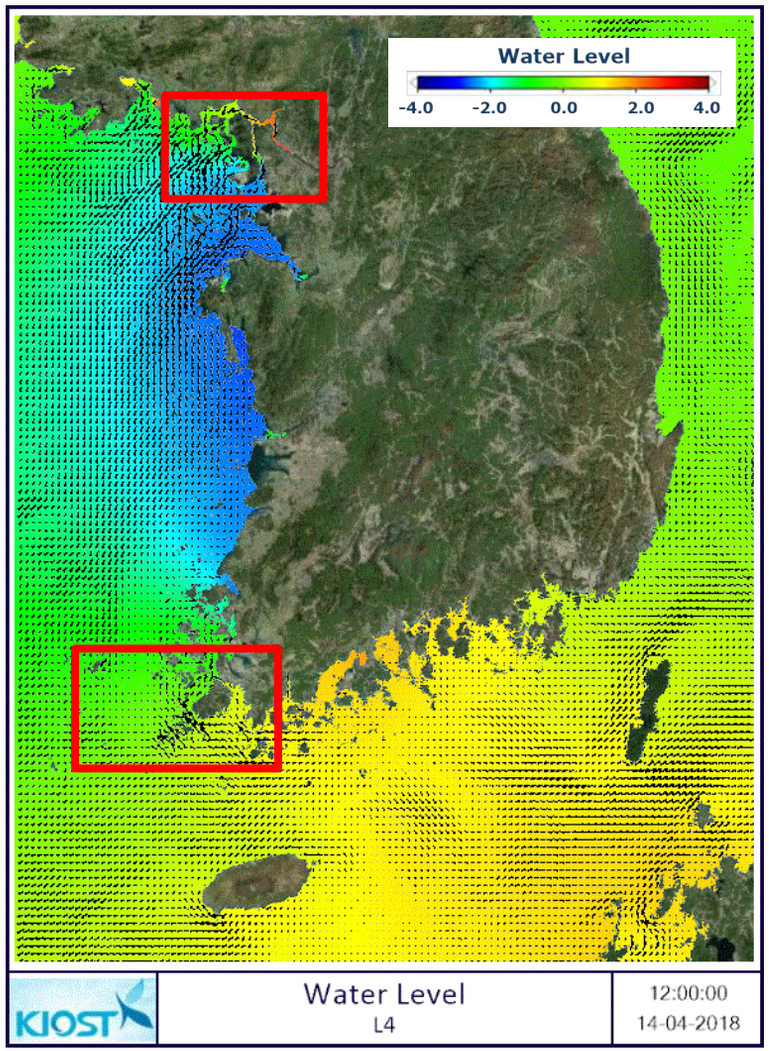
- Model : MOHID
- Domain : Territorial seas of the Korean Peninsula
- Resolution : (L2) 1/48° x 1/48° (about 2 km) & (L4) 1/288°x1/288° (about 300 m) in horizontal & 40 vertical layers
- Running period : Forecast 7 days

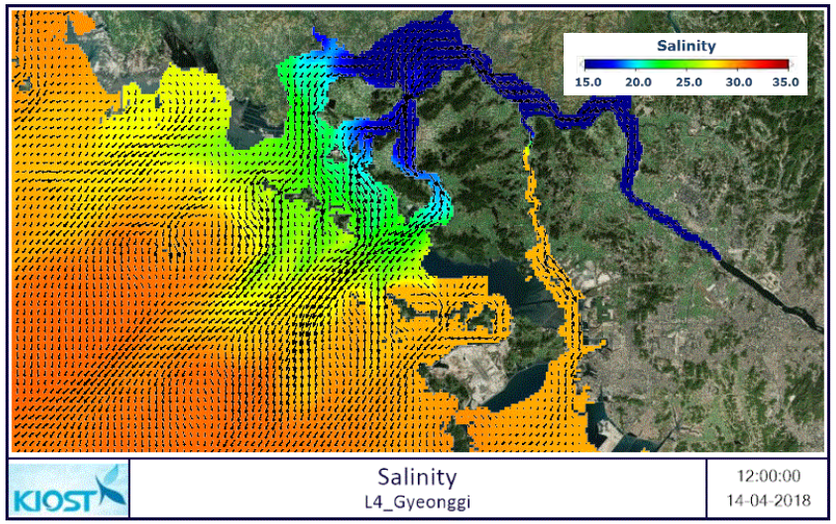


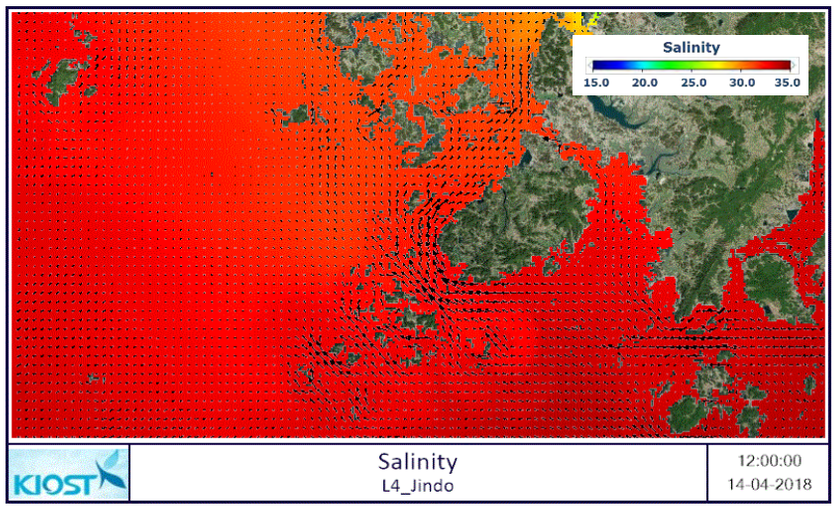



# KOOS – Numerical Forecasting System (Coastal)

## Coastal KOOS

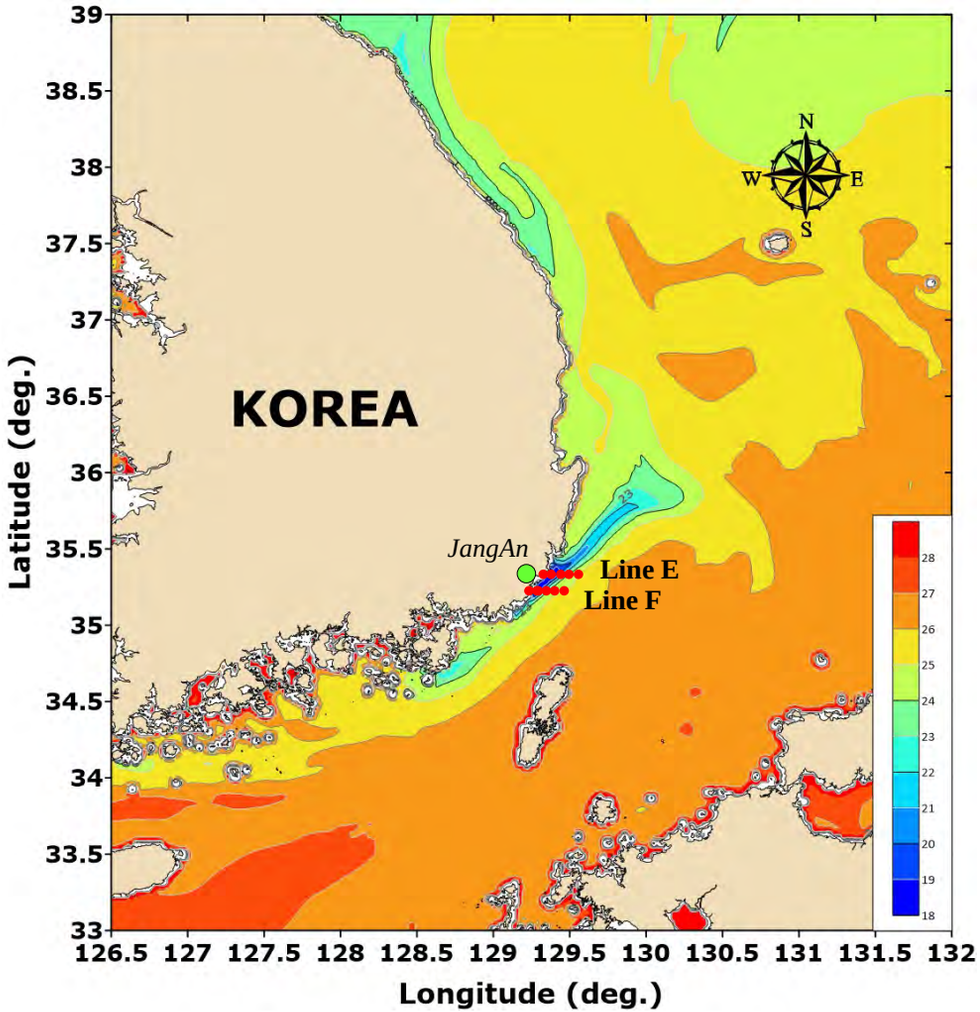


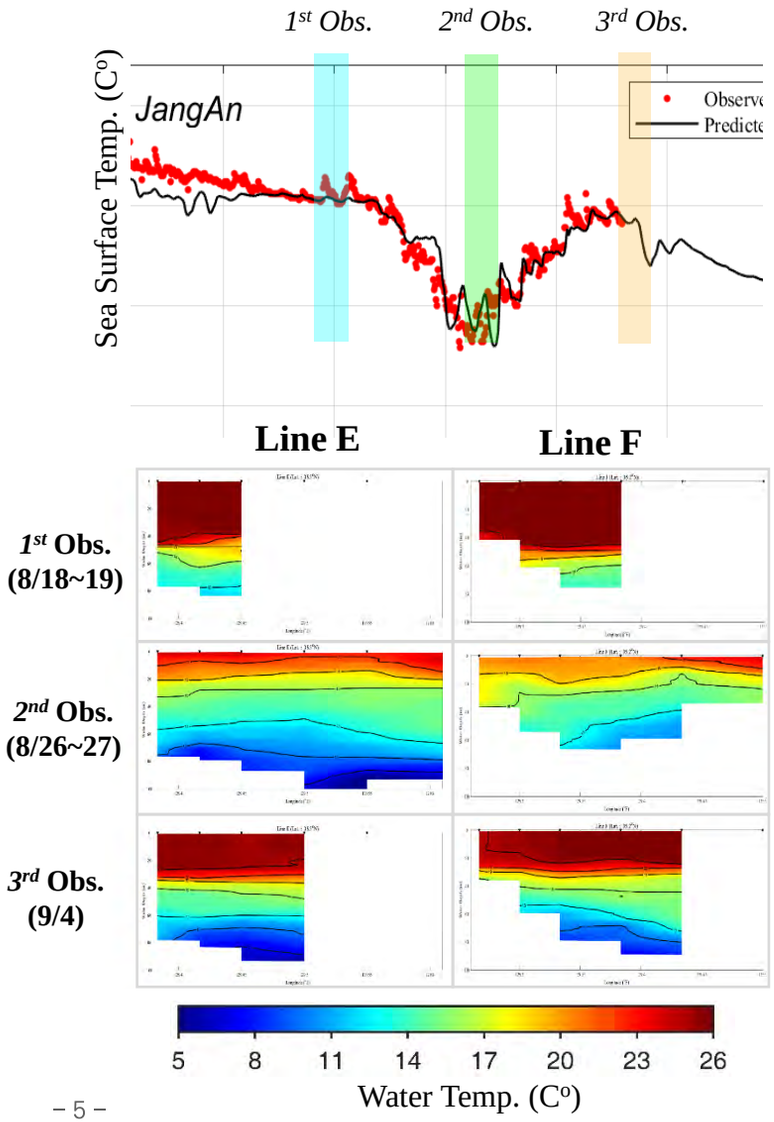



# Application of the coastal-KOOS

## Cold-water upwelling

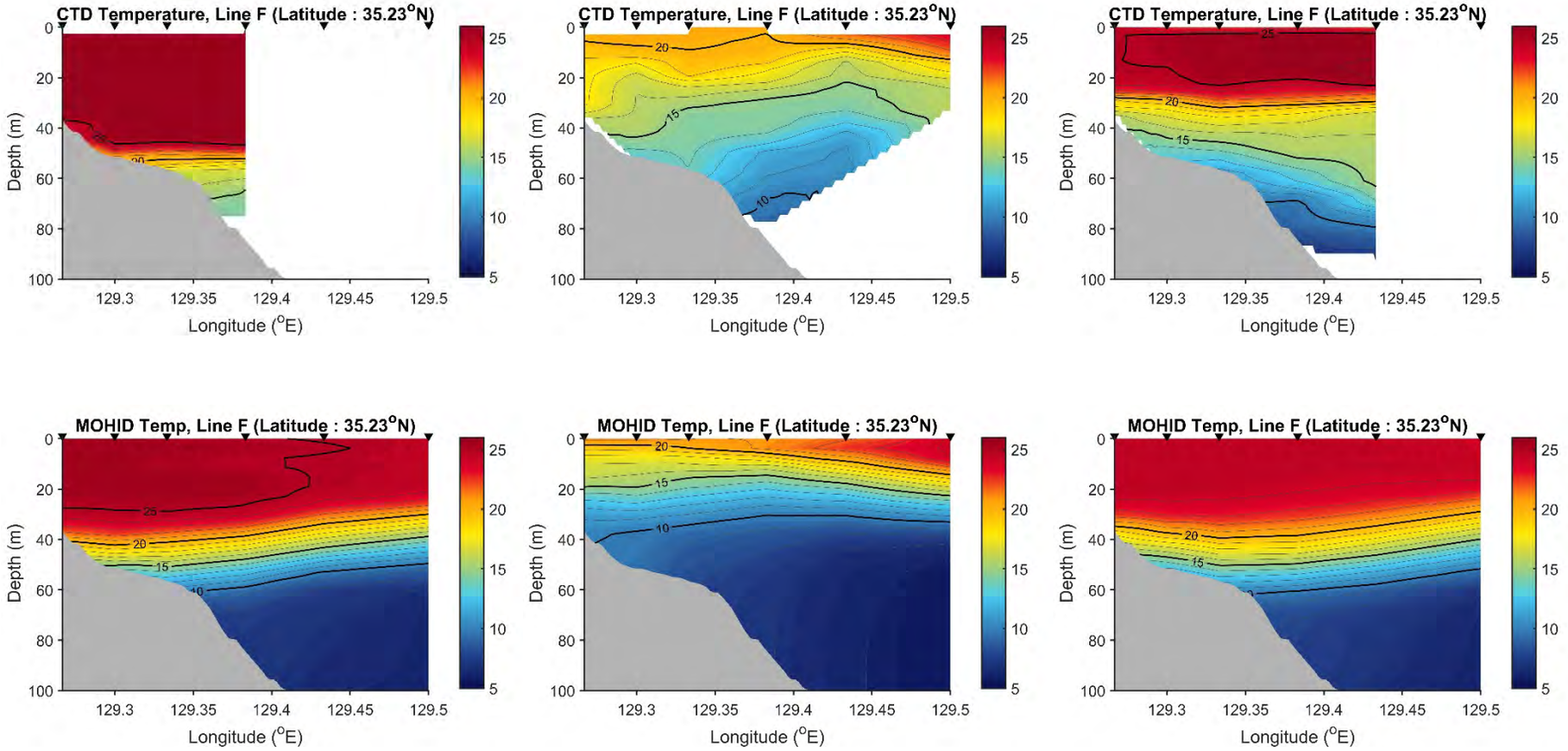


# Application of the coastal-KOOS

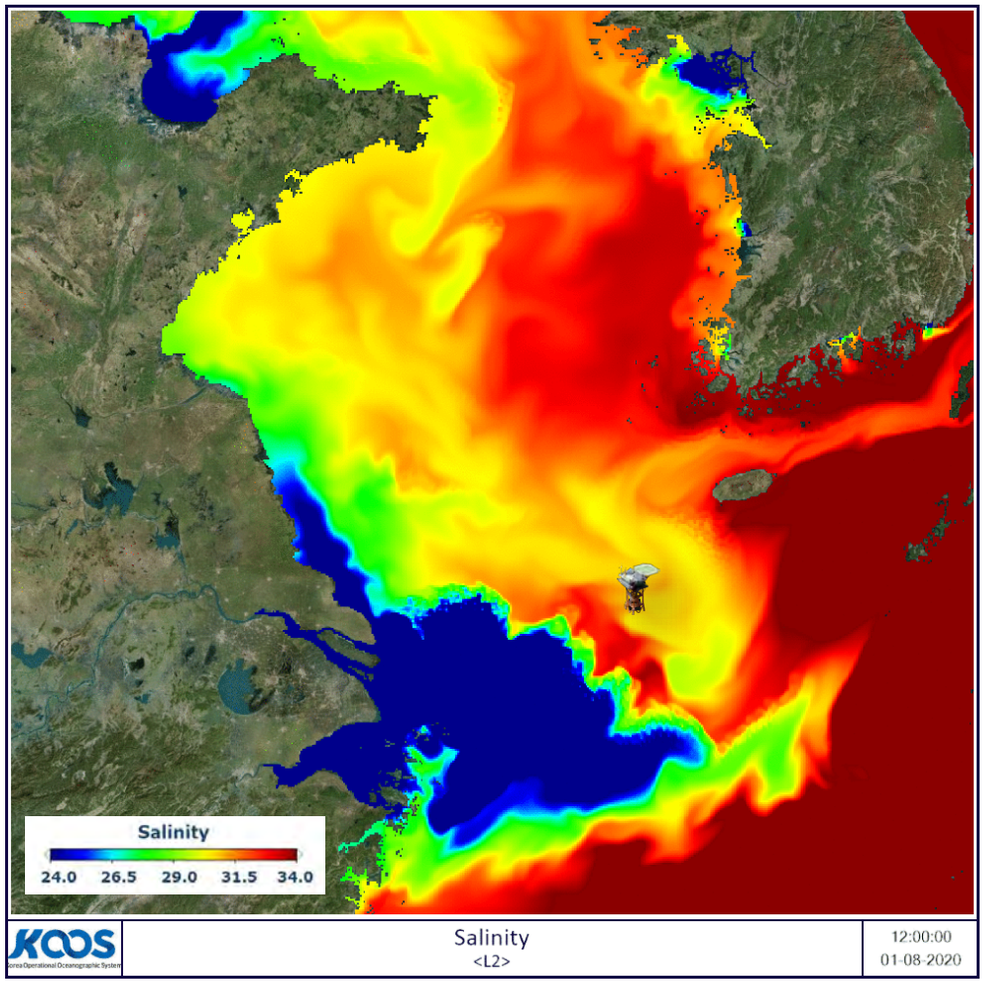
## Cold-water upwelling

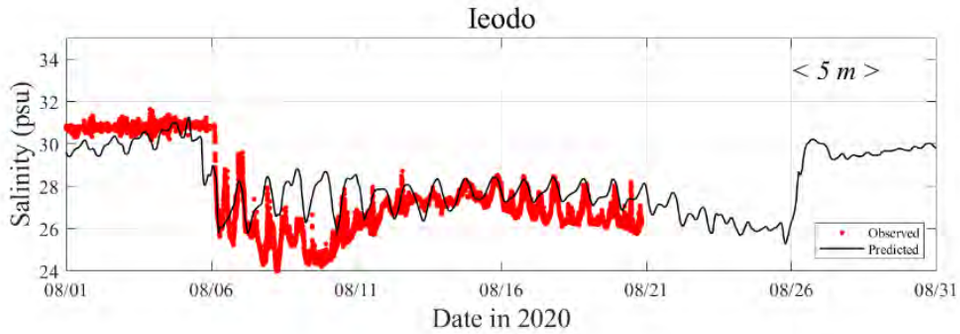
**Before** | **During** | **After**

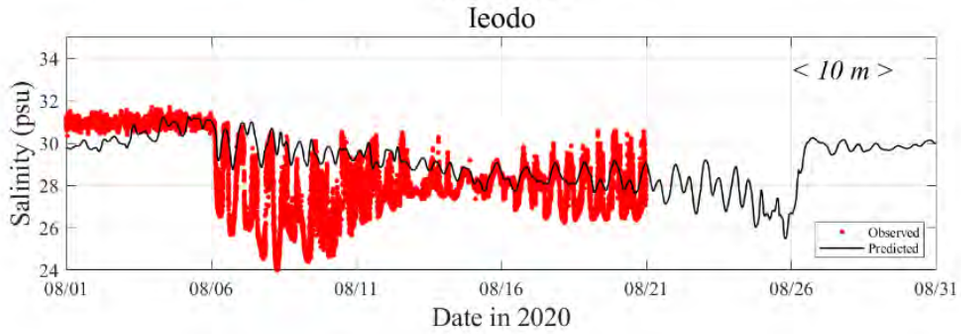


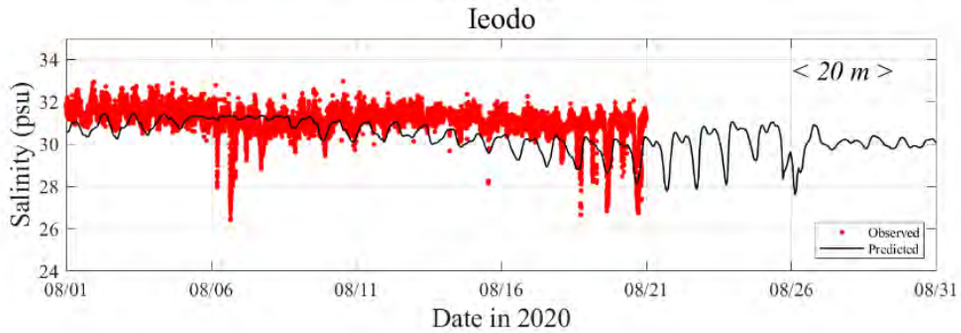
# Application of the coastal-KOOS

## Low-salinity water front



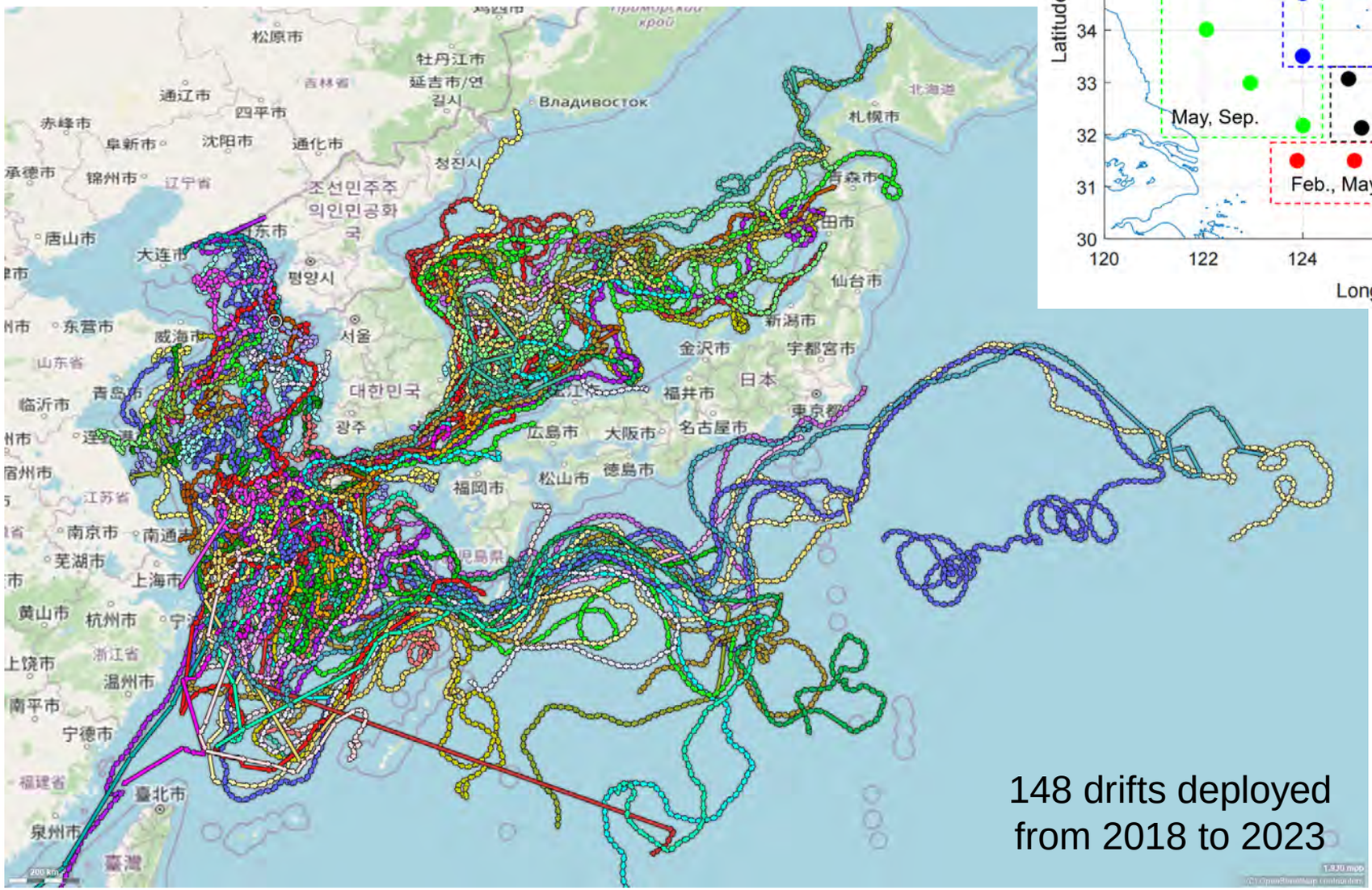



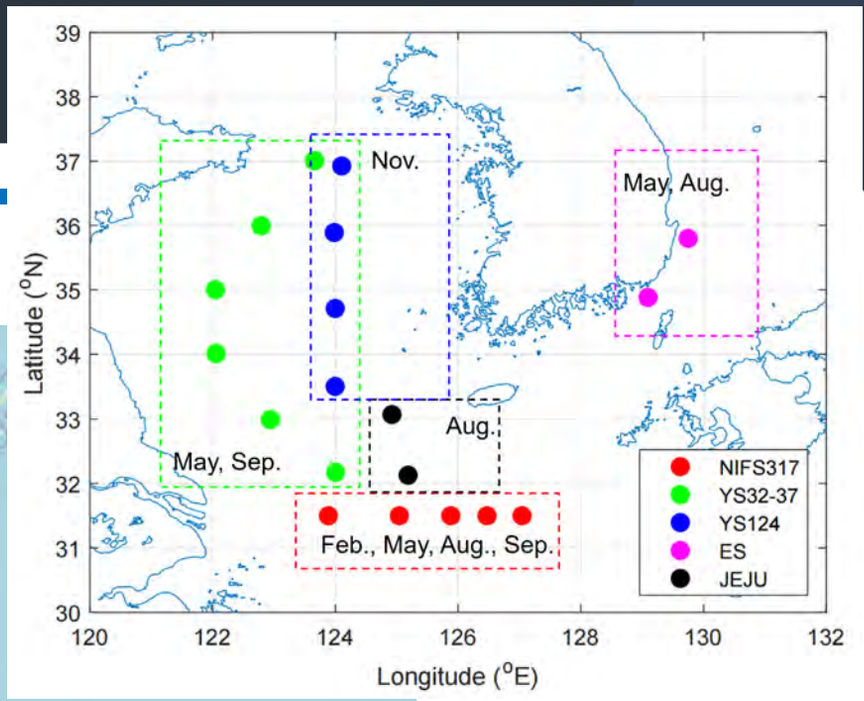



# Application of the coastal-KOOS

## Surface drift assessment

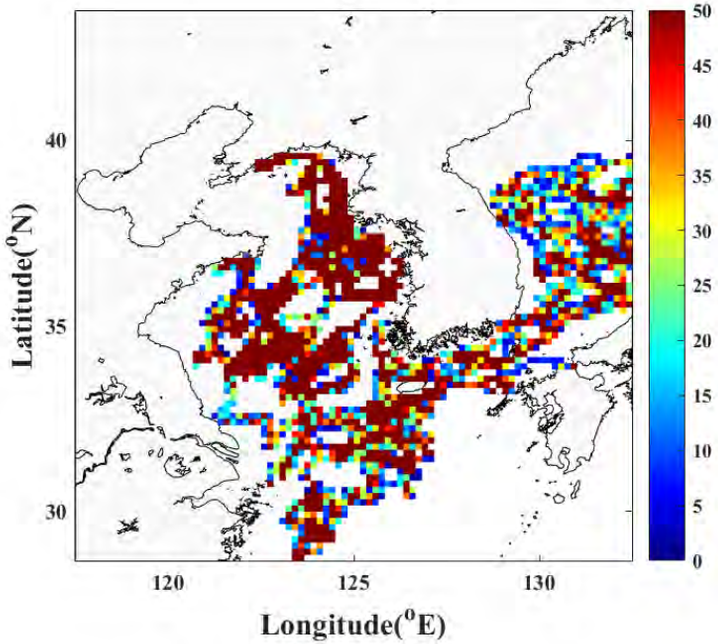


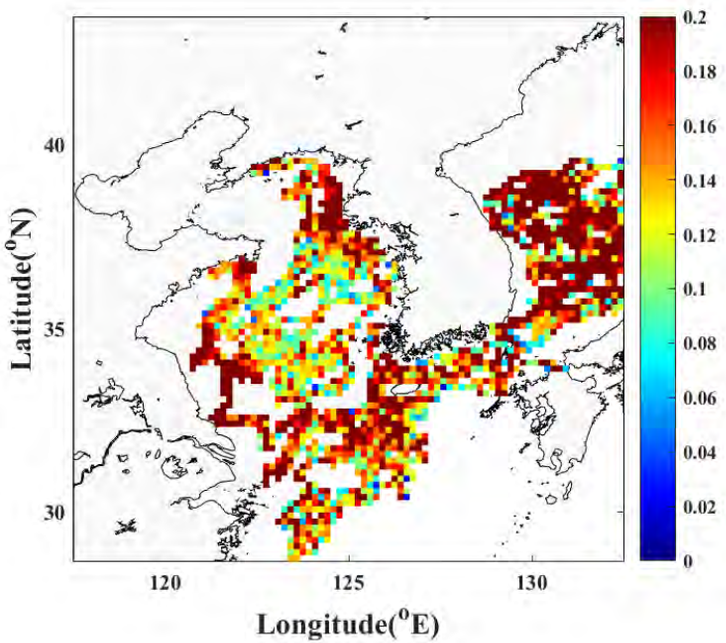

# Application of the coastal-KOOS

## Surface drift assessment

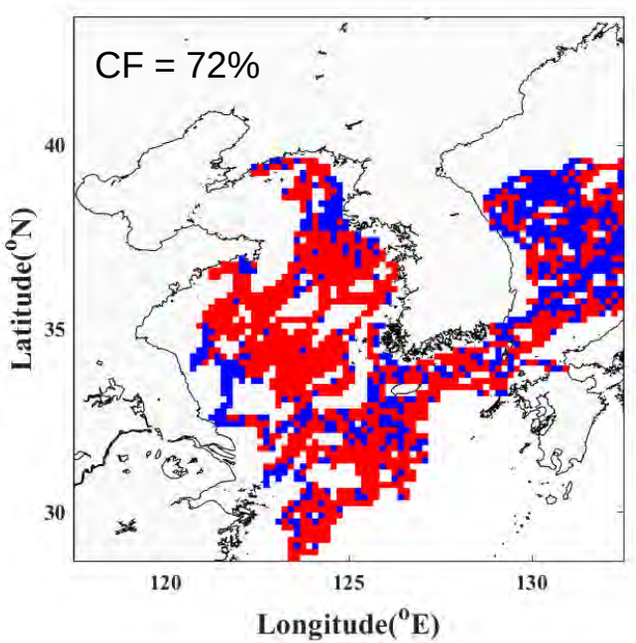
# of data per grid (coastal KOOS L2)




RMSE (coastal KOOS L2)




Evaluation of forecasting accuracy




RMSE <= 0.2 m/s  RMSE > 0.2 m/s

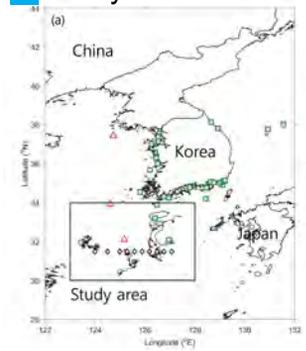
# Application of the coastal-KOOS

## Surface drift assessment (AI system)

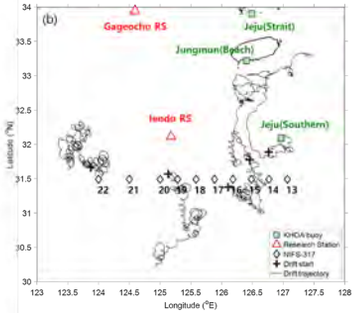
Improve the forecasting results using AI model

- Training model: Multi-Layer Perceptron Neural Network (MLP-NN)
- Input : Coastal KOOS L2 (2 km) surface current
- Output : Surface current calculated by the trajectory of surface drifts
- Time-series based learning network → Spatial distribution network

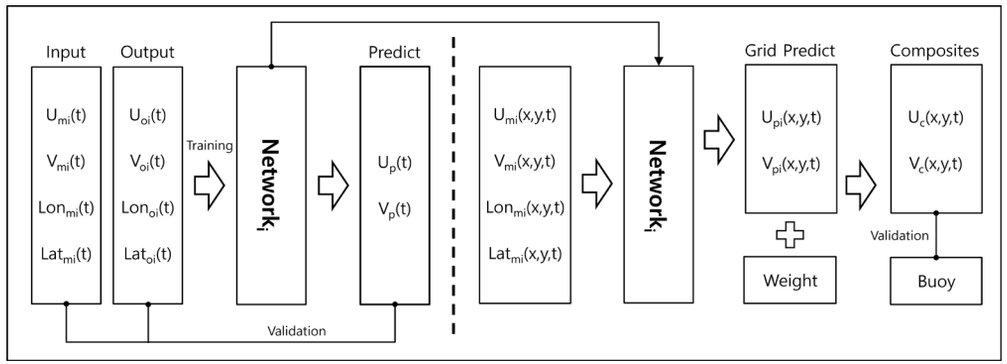
### Study area



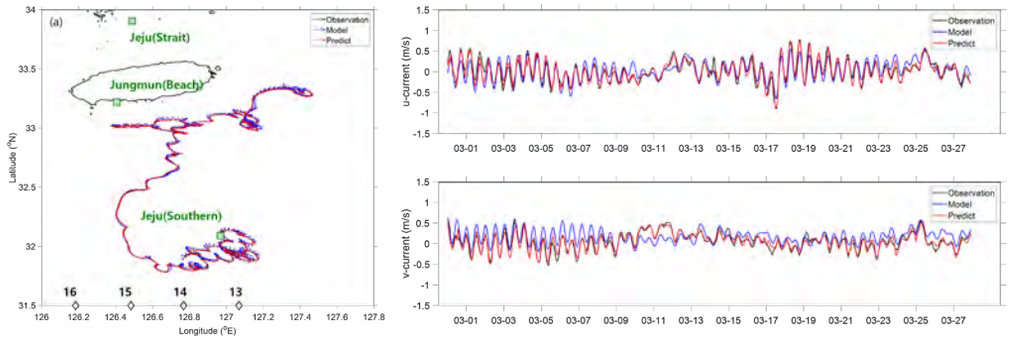

### Surface drift




### Schematic diagram of composites for surface current (MLP-NN)

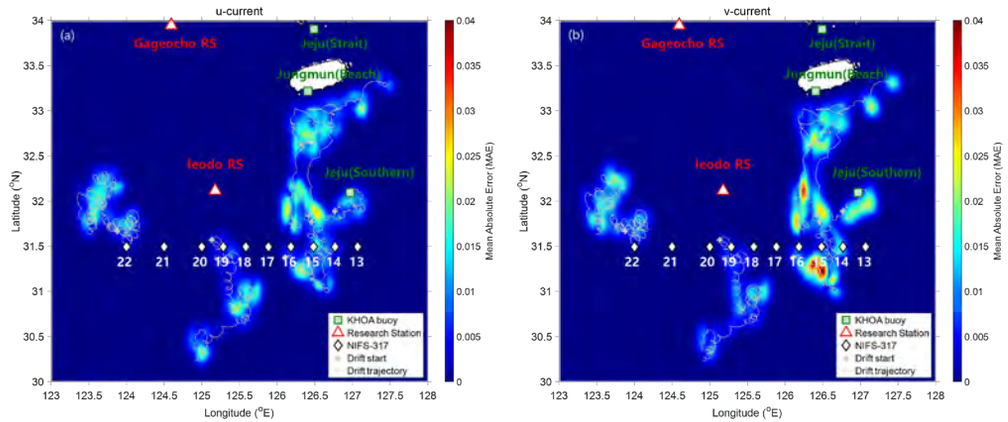



### Comparison of surface current between drift, coastal KOOS, MLP-NN



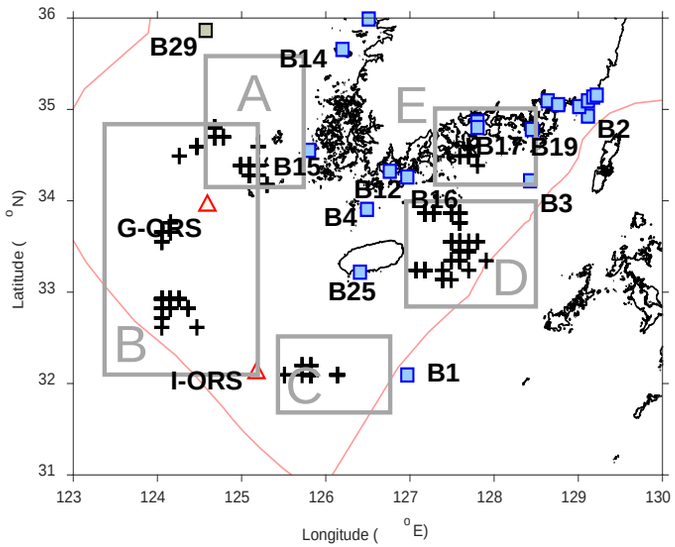

- A network trained using coastal-KOOS and surface drifts generates a composite of surface current by setting influence radius (weight constrains) around trajectories
- Improvements confirmed only within the influence of radius on the trajectories of surface drifts

### MAE of the composite current of surface current

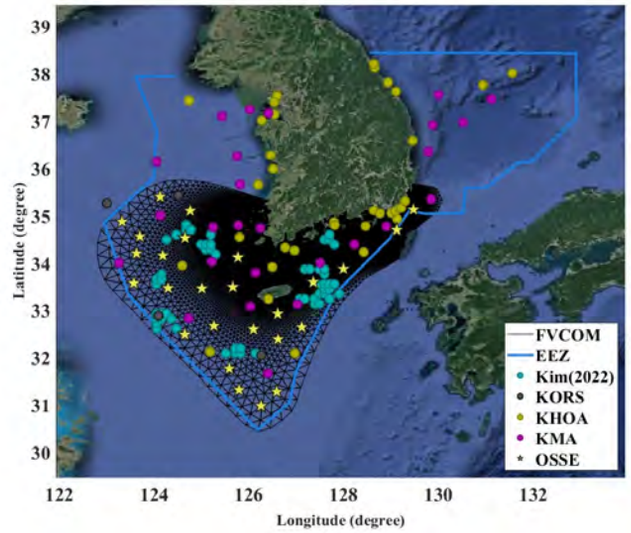


# Application of the coastal-KOOS

## Design of buoy network



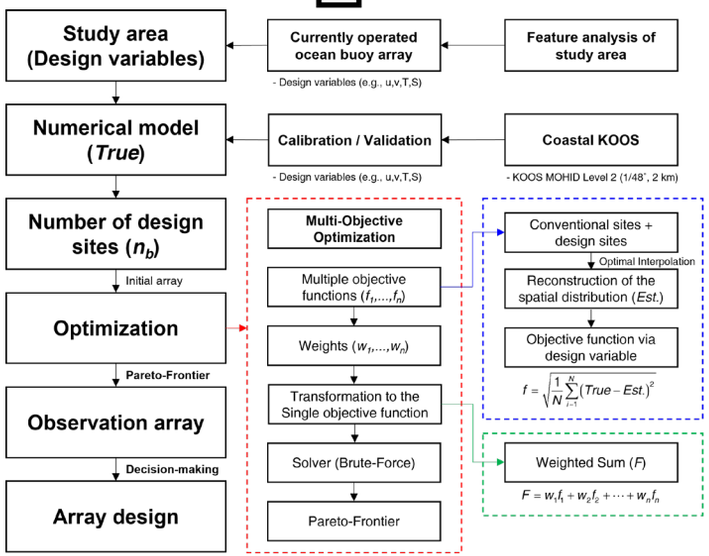

OSSE

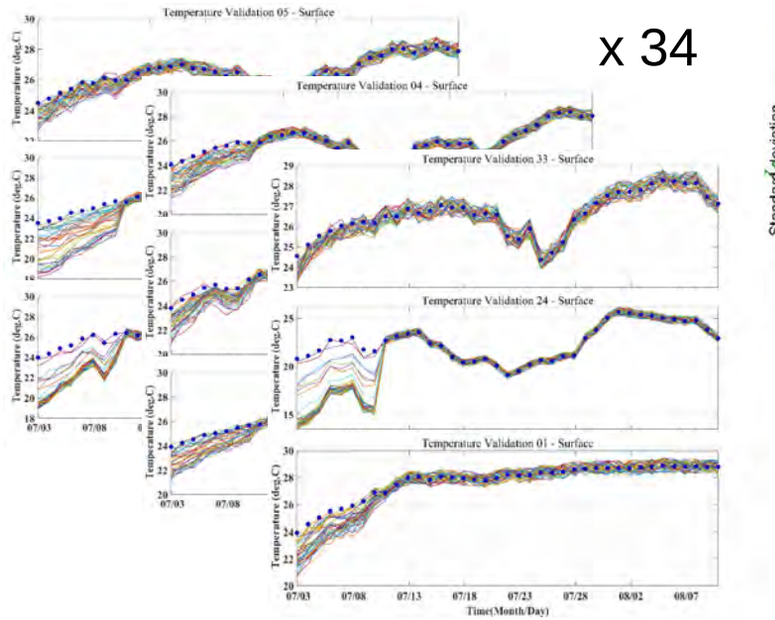



Coastal-KOOS

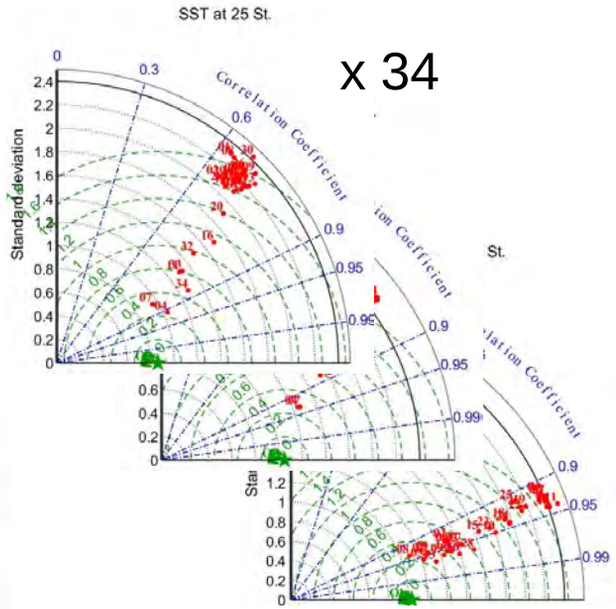
- 34 cases of OSSEs (temp. by OI)
  - Reference sites
    1) Research station (4)
    2) Synthetic obs. sites (26)
    3) Kim et al. (2022) (8 regions)
- Validation (36)
  - KMA (15)
  - KHOA (21)

Optimization ← Coastal-KOOS L2




x 34

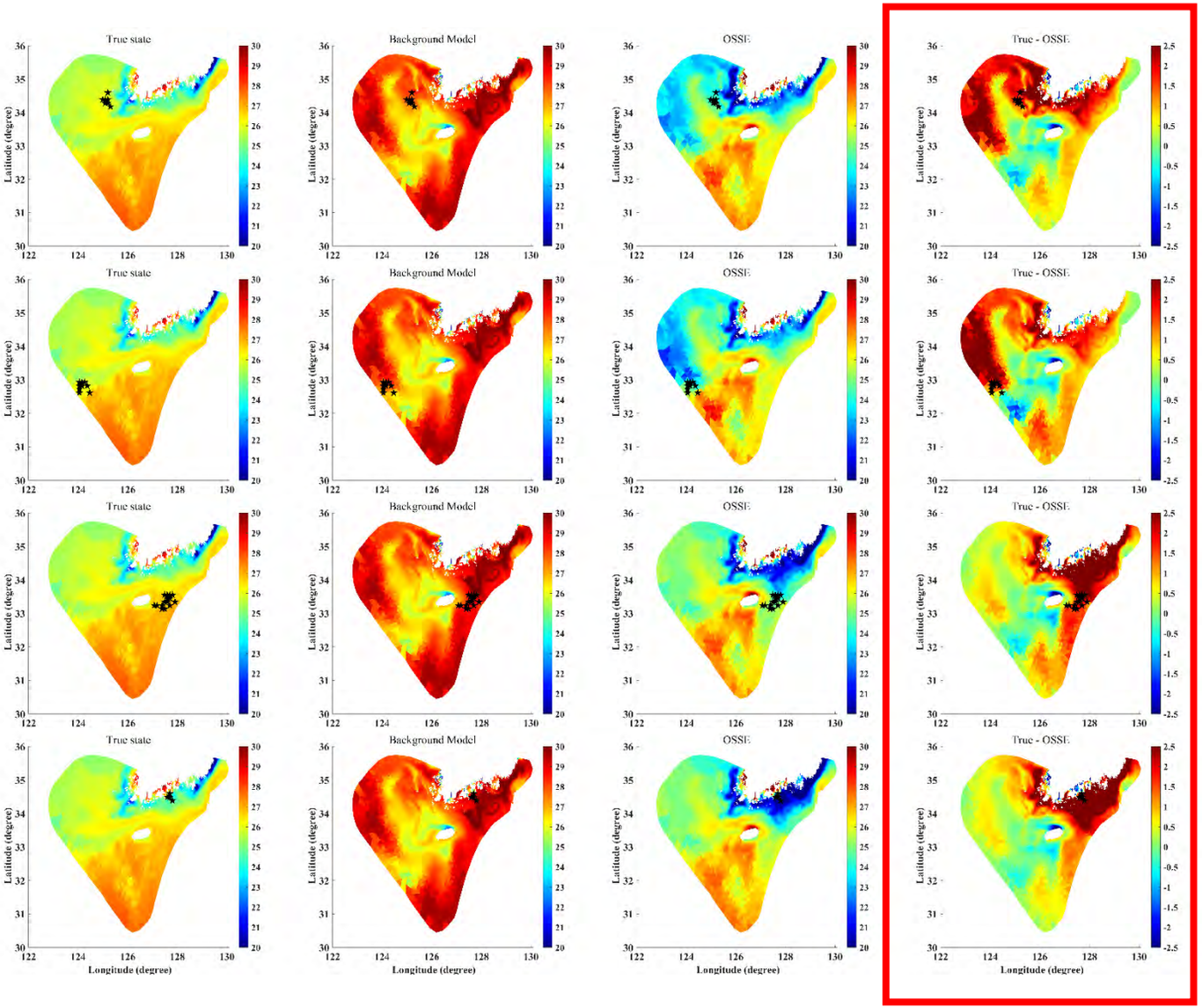



x 34

- Statistical analysis was conducted by assimilating data from all but the buoy intended for evaluation among the 34 candidate sites

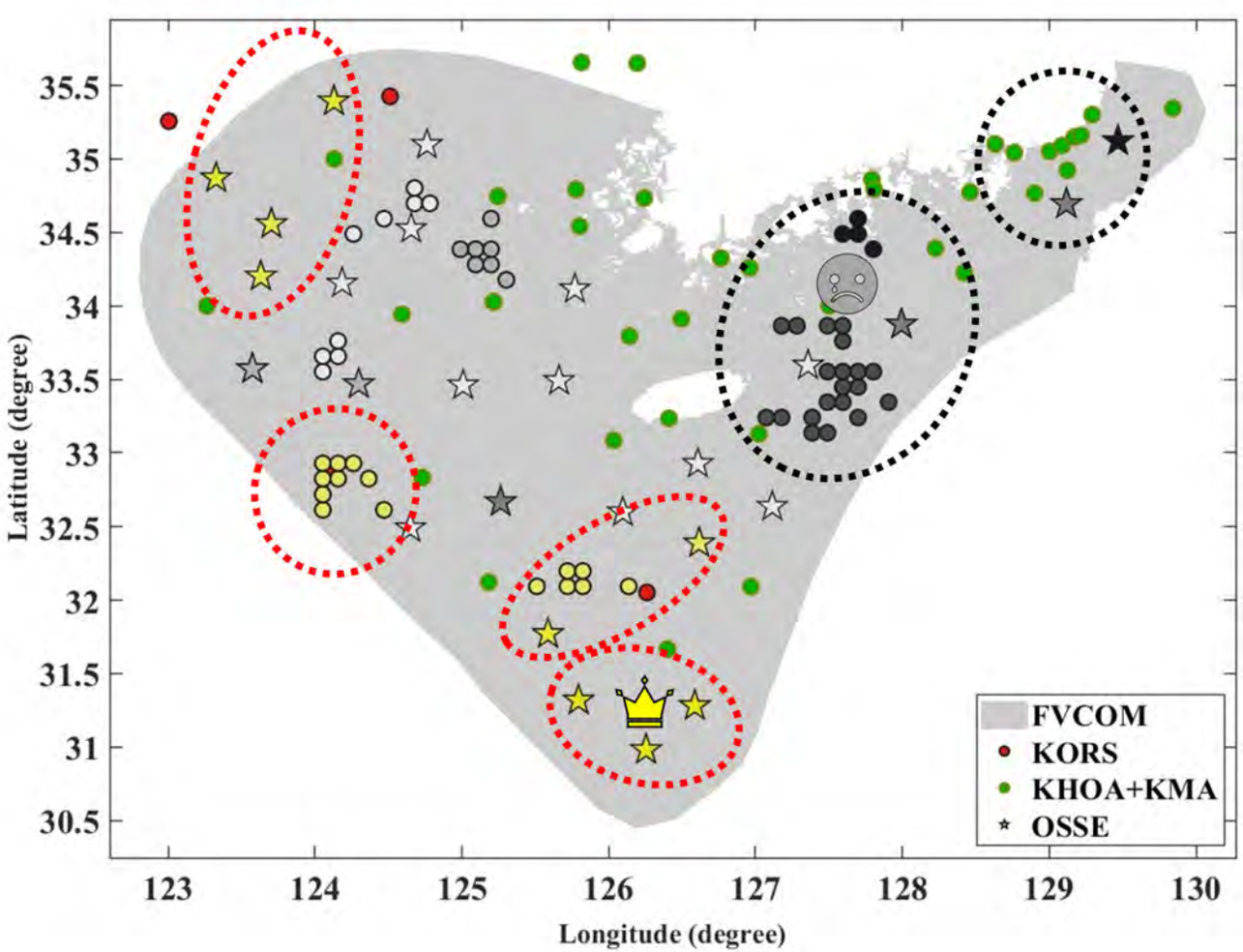
# Application of the coastal-KOOS

## Design of buoy network



# Application of the coastal-KOOS

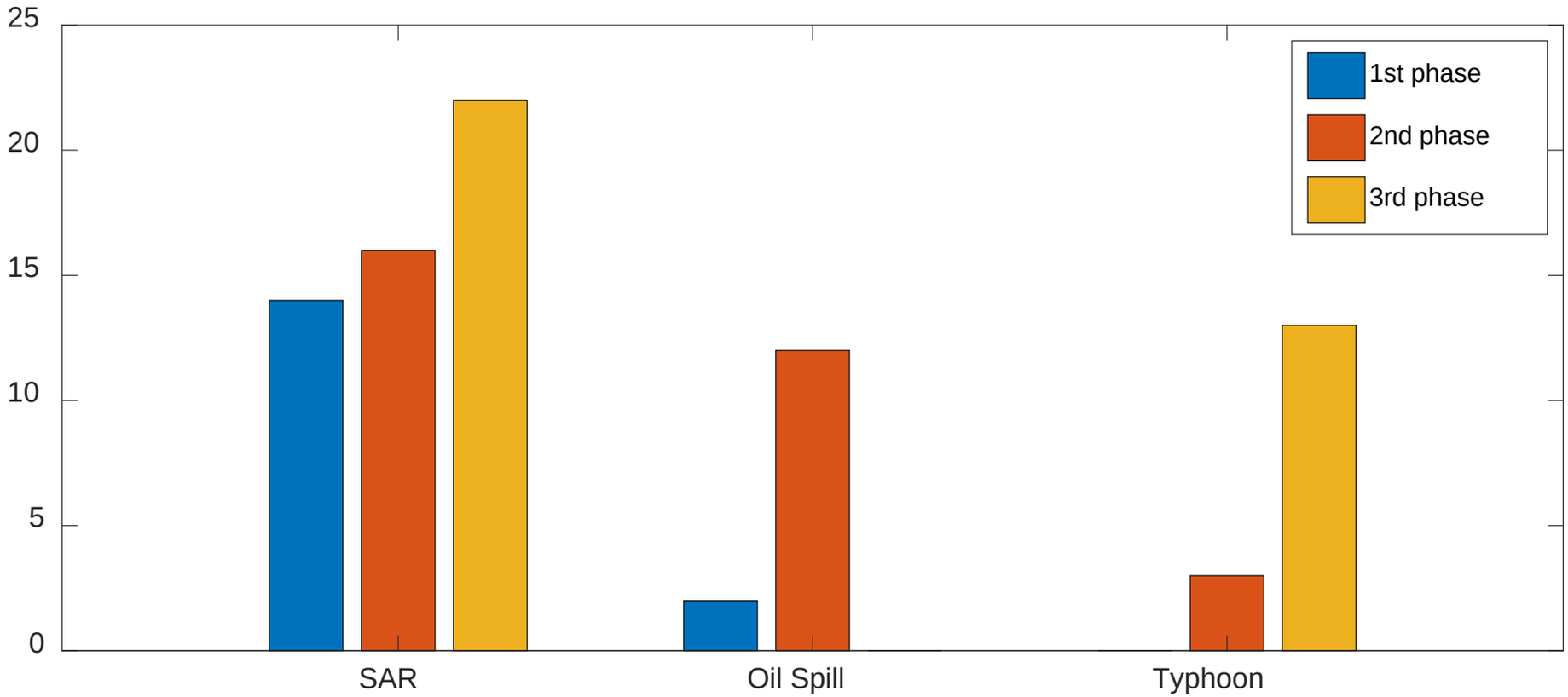
## Design of buoy network




| Rank | Case No. | RMSE(℃) |
|---|---|---|
| 1 (Worst) | 7 | 0.498 |
| 2 | 4 | 0.528 |
| 3 | 34 | 0.597 |
| 4 | 11 | 0.624 |
| 5 | 33 | 0.684 |
| 6 | 32 | 0.721 |
| 7 | 16 | 0.772 |
| 8 | 20 | 0.986 |
| 9 | 10 | 0.987 |
| 10 | 28 | 1.006 |
| 11 | 15 | 1.009 |
| 12 | 14 | 1.033 |
| 13 | 6 | 1.060 |
| 14 | 19 | 1.060 |
| 15 | 27 | 1.061 |
| 16 | 17 | 1.068 |
| 17 | 18 | 1.070 |
| 18 | 13 | 1.074 |
| 19 | 29 | 1.080 |
| 20 | 9 | 1.081 |
| 21 | 3 | 1.094 |
| 22 | 21 | 1.099 |
| 23 | 30 | 1.099 |
| 24 | 22 | 1.112 |
| 25 | 31 | 1.118 |
| 26 | 8 | 1.122 |
| 27 | 12 | 1.123 |
| 28 | 5 | 1.128 |
| 29 | 23 | 1.141 |
| 30 | 2 | 1.155 |
| 31 | 1 | 1.169 |
| 32 | 24 | 1.186 |
| 33 | 25 | 1.224 |
| 34 (Best) | 26 | 1.234 |

- Higher RMSE is considered that additional observation sites are needed
- Lower RMSE is considered that there is no need for additional observation sites

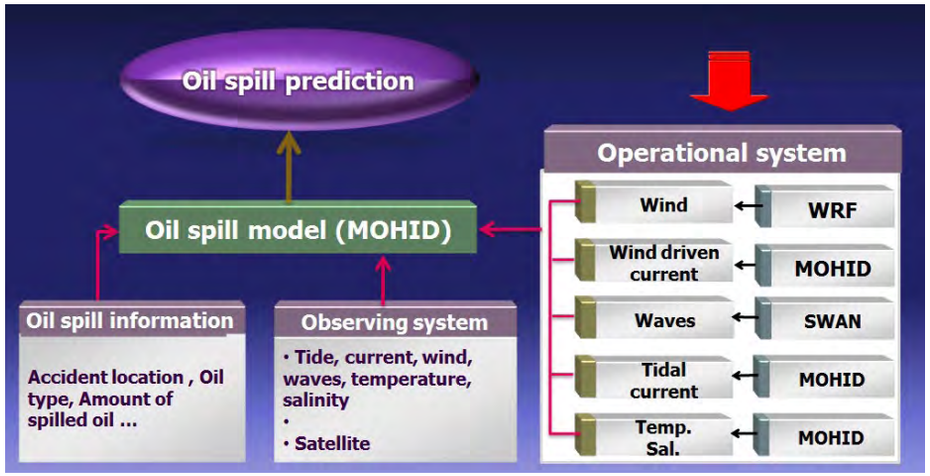
# Achievements for Marine Disaster Support

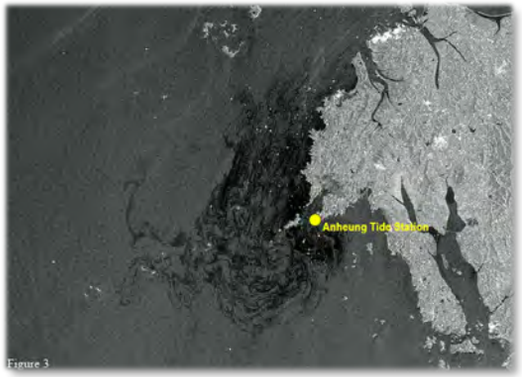



| | 1st phase | 2nd phase | 3rd phase |
|---|---|---|---|
| SAR | 14 | 16 | 22 |
| Oil Spill | 2 | 12 | 0 |
| Typhoon | 0 | 3 | 13 |

# Achievements for Marine Disaster Support

## Oil Spill Model and Response System

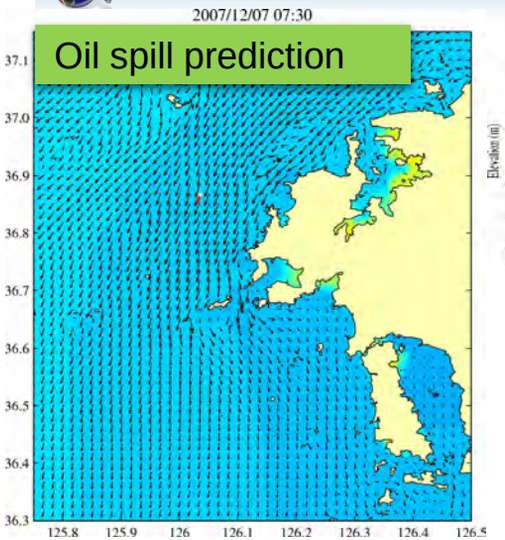


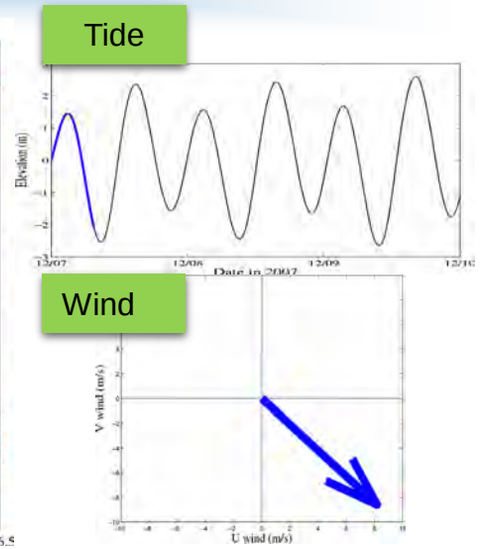



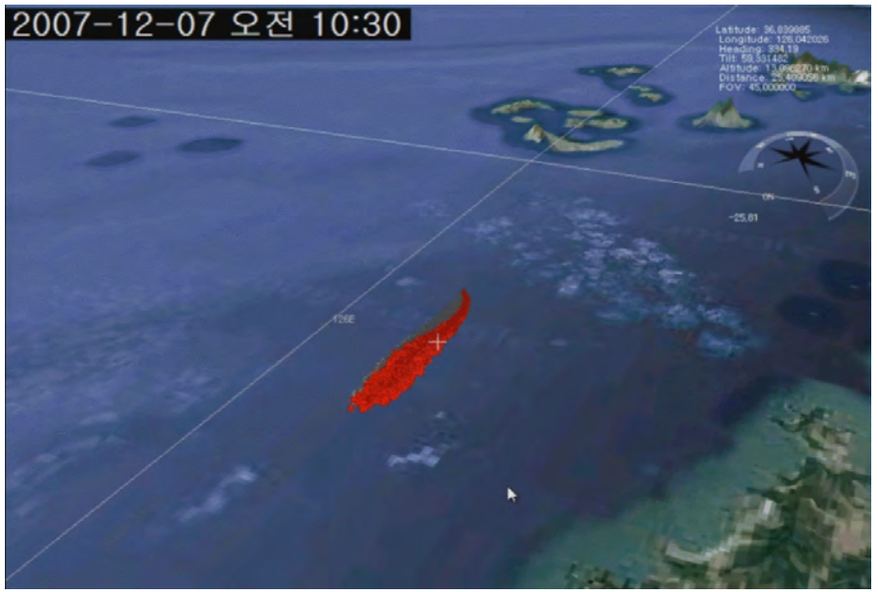


Tanker *Hebei Spirit* leaking crude o

Hebei Spirit Oil Spill Accident (Dec/07/2007)



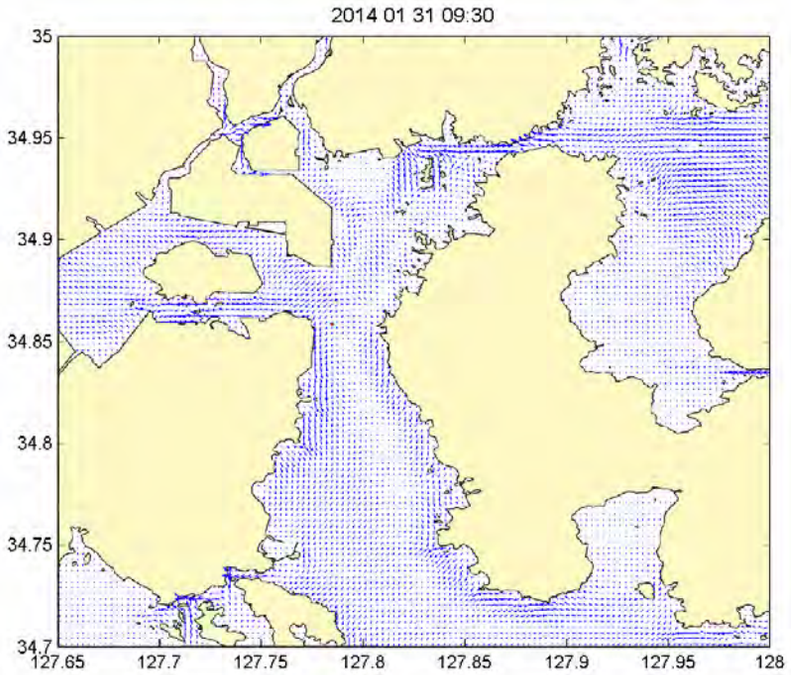



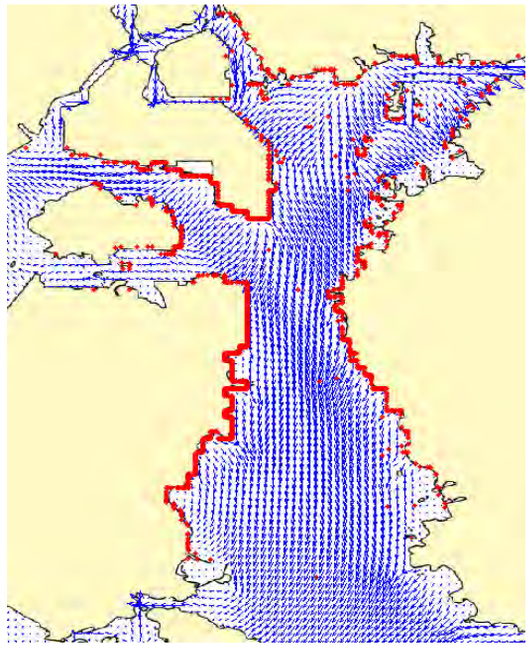
# Achievements for Marine Disaster Support

## Oil Spill Model and Response System

- Oil spill accident by Wuyishan oil tanker (169t-class) in 2014
- Date : Jan. 31, 2014
- Location : GS Caltex Pier #2 (127.781˚E; 34.841˚N), Yeosu city
- 899 ㎘ of crude oil spilled, contaminating 407 hectares




Coastal KOOS (300 m)




Comparison of the predicted results and aerial photograph

# Achievements for Marine Disaster Support

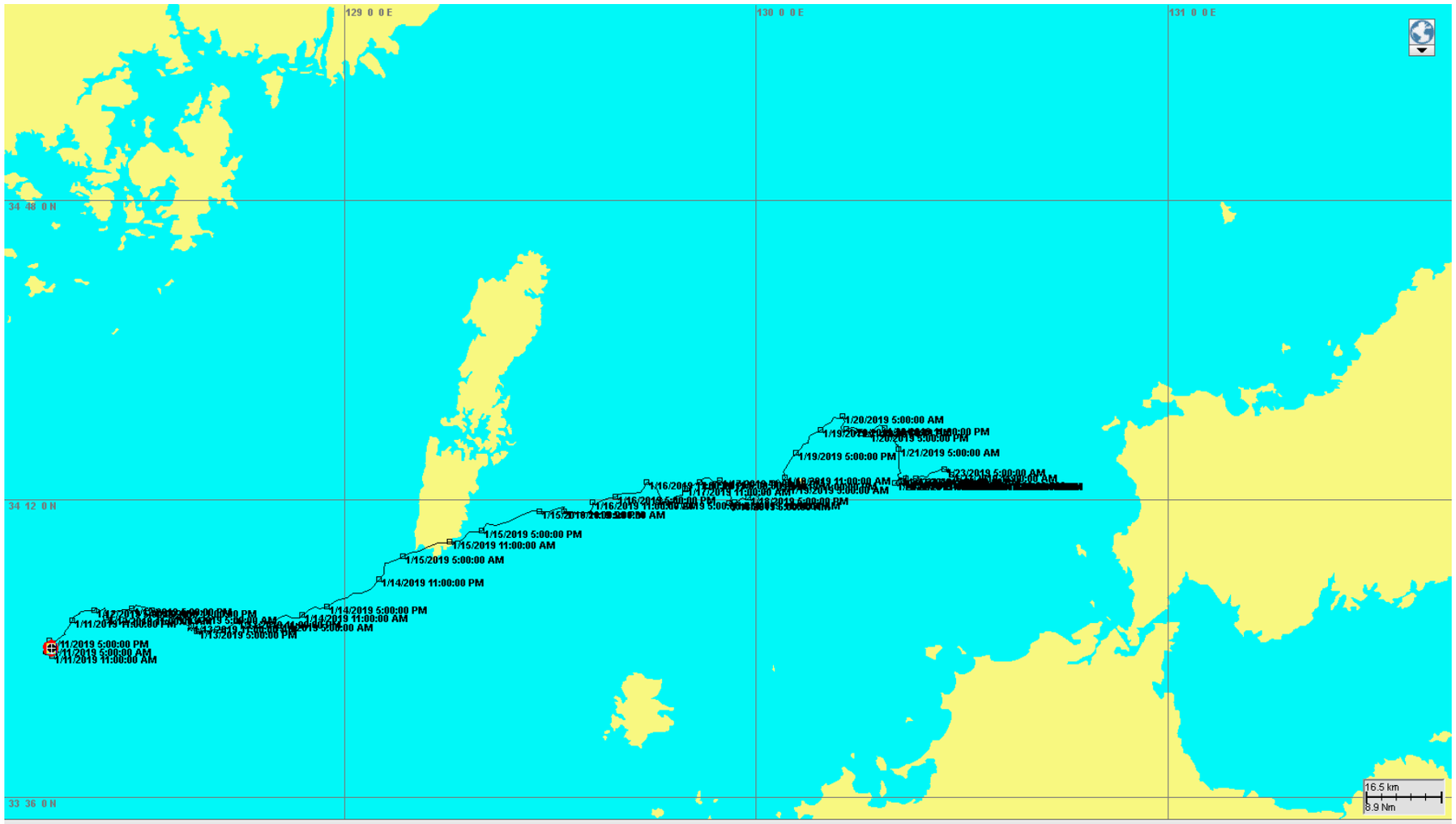
## Oil Spill Model and Response System

- Oil spill response system (oil fence & dispersant)
  - Oil spill accident by Wuyishan oil tanker in 2014 (an oil fence and spraying emulsifier)
  - The amount of oil spill : 899 kℓ
  - Resolution : 4 km (Atmospheric model), 300 m (Ocean circulation)
  - Containment : Oil fence (1.5 km, limit of current : 2 m/s, limit of wave height : 2 m), 100 ℓ of spraying emulsifier

No Action | Installation of oil fence (6 h later) | Additional installation of oil fence (12 h later) | spraying emulsifier (24 h later)

# Achievements for Marine Disaster Support

## Search and Rescue support system



# Achievements for Marine Disaster Support

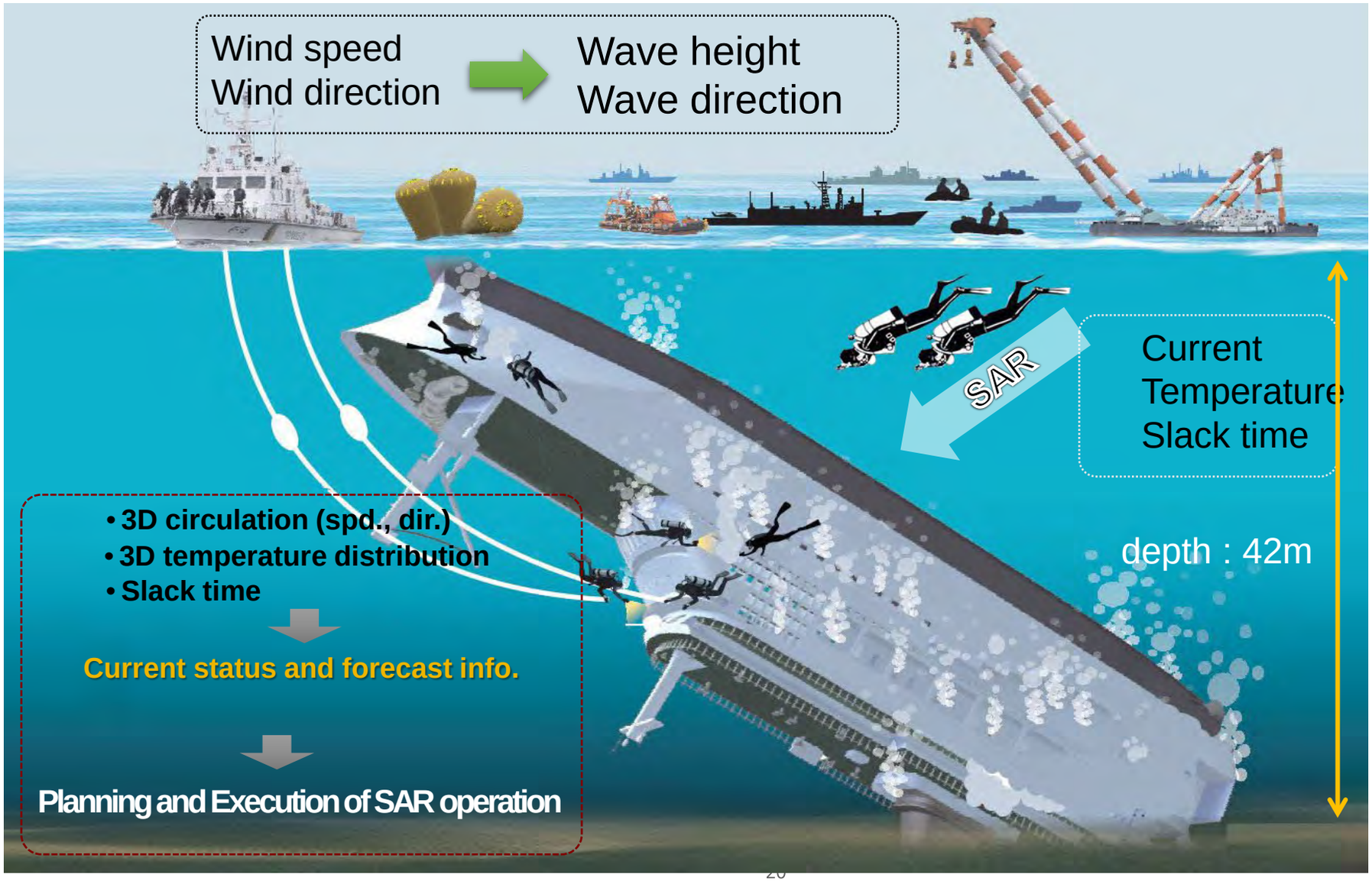
## Search and Rescue support system

▶ MV Sewol-Ferry sinking accident



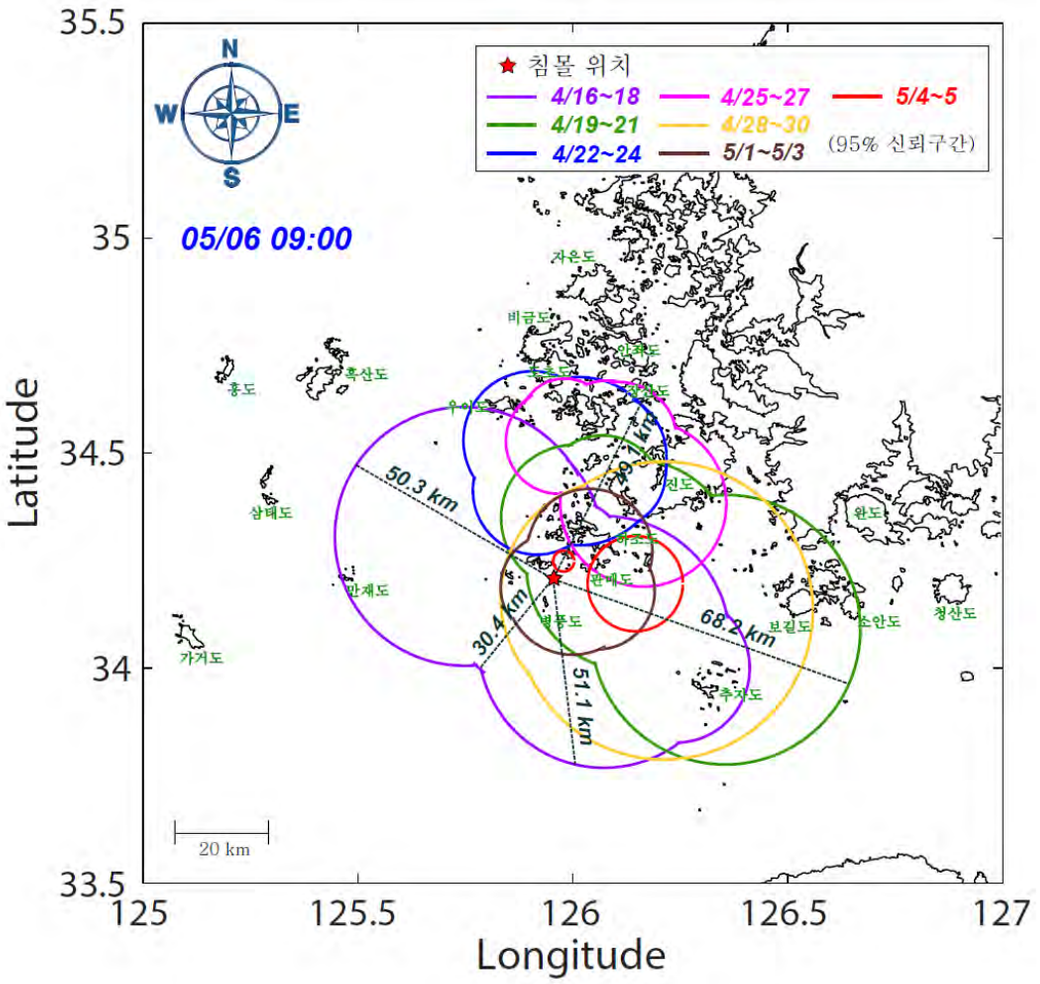
# • Achievements for Marine Disaster Support

## Search and Rescue support system



# Achievements for Marine Disaster Support

## Search and Rescue support system





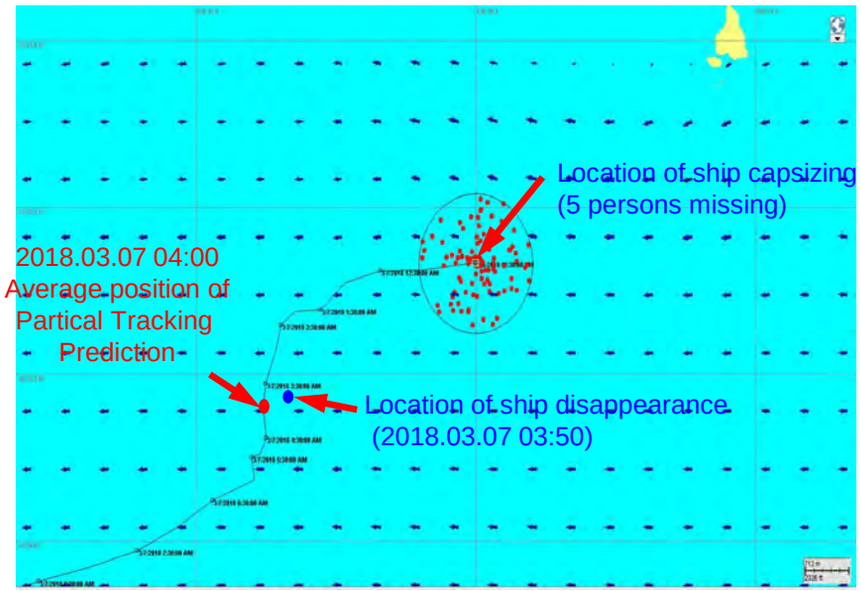
장예진 기자 / 20140508
@yonhap_graphics(트위터)

# Achievements for Marine Disaster Support

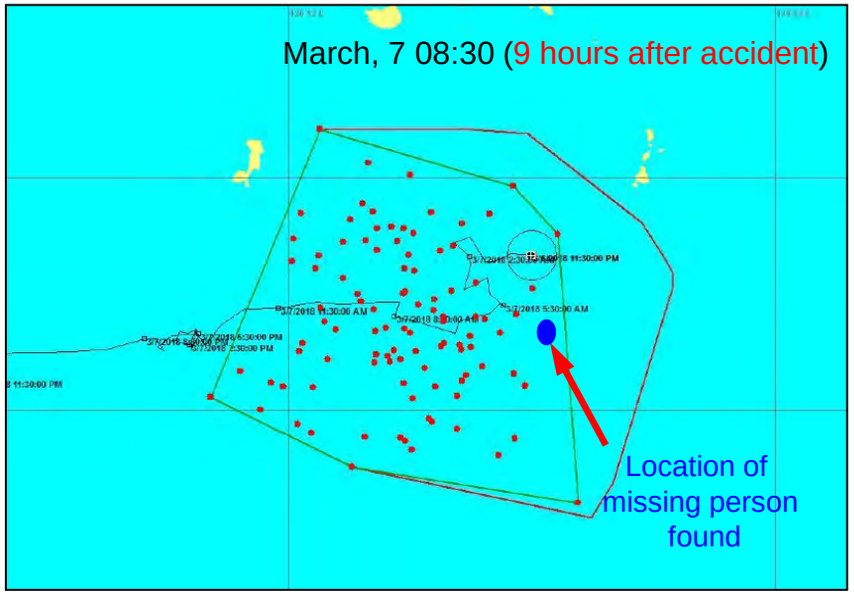
## Search and Rescue support system

- On March, 6, 2018, around 23:30, the fishing boat 11 Jae-Il capsized near Yokjido area
- KCG request to support SAR
- The capsized ship drifted and then disappeared
- Out of 11 crew members, 6 were rescued and 5 went missing

### Ship Drift Prediction

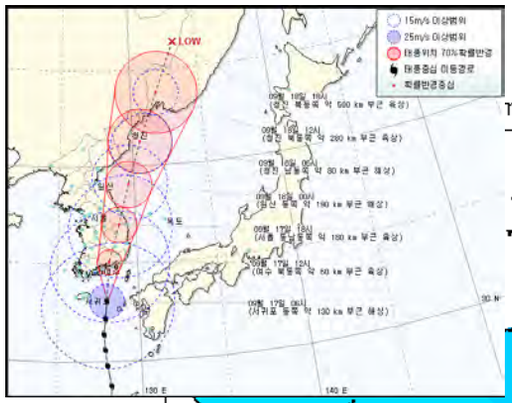



### Missing person Drift Prediction



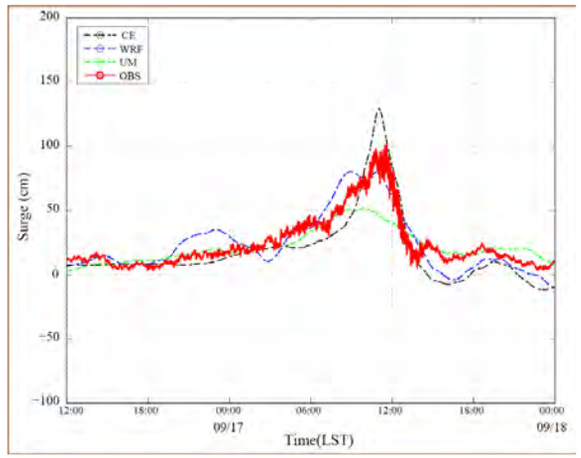
# Achievements for Marine Disaster Support

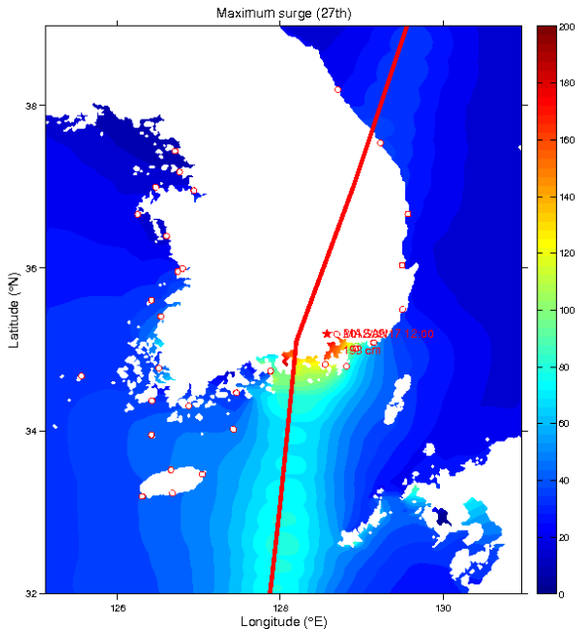
## Typhoon-induced Storm Surge Prediction









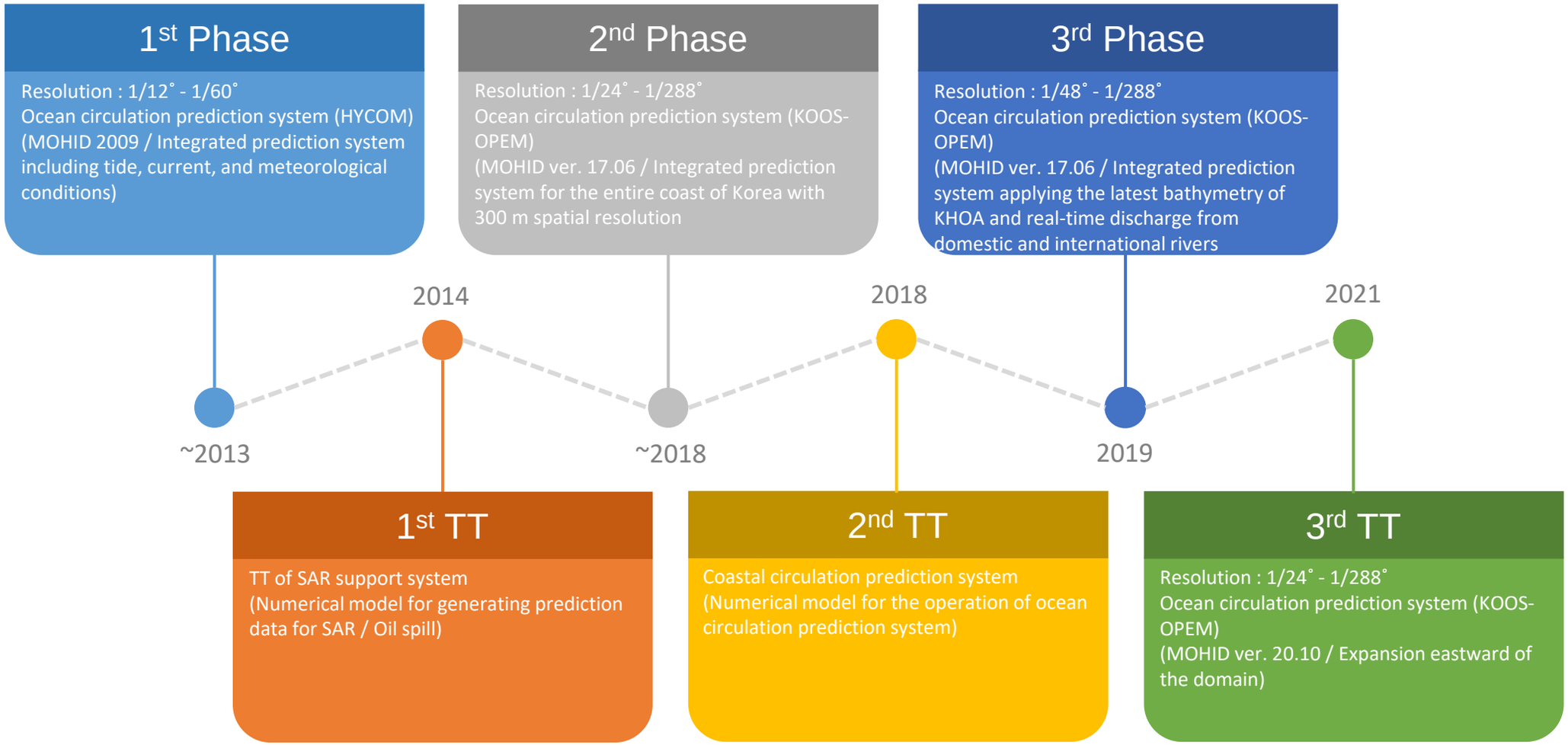

**Typhoon “SANBA” (1216)**

# Achievements of Technology Transfer to national agency

Technology Transfer to KHOA (2012-present)

- Marine Weather Prediction System (WRF)
- Wave Prediction System (WW3)
- Coastal Circulation Prediction System (MOHID)
- Storm Surge Prediction System (KORDI-S)
- Regional Ocean Circulation System (MOM5)

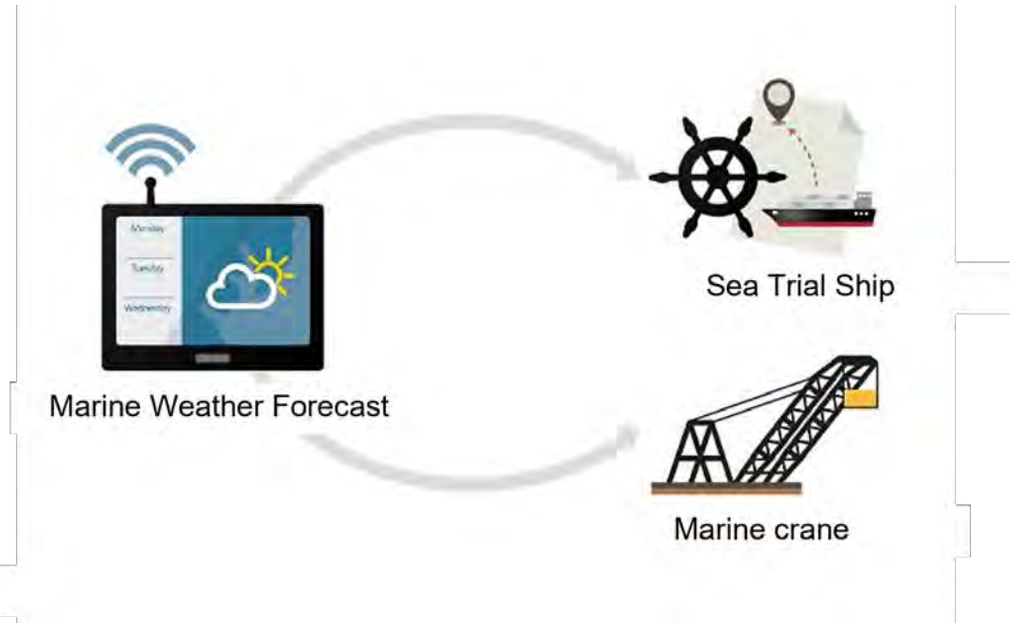
# Achievements of Technology Transfer to national agency




- Since 2013, the KOOS has been transferred to the KHOA in three phases (phase 1, 2, and 3) free of charge and are currently in operational use.
- The output from the transferred system simulated by the KHOA is being utilized effectively by related organizations such as Korea Coast Guard and Korea Navy.

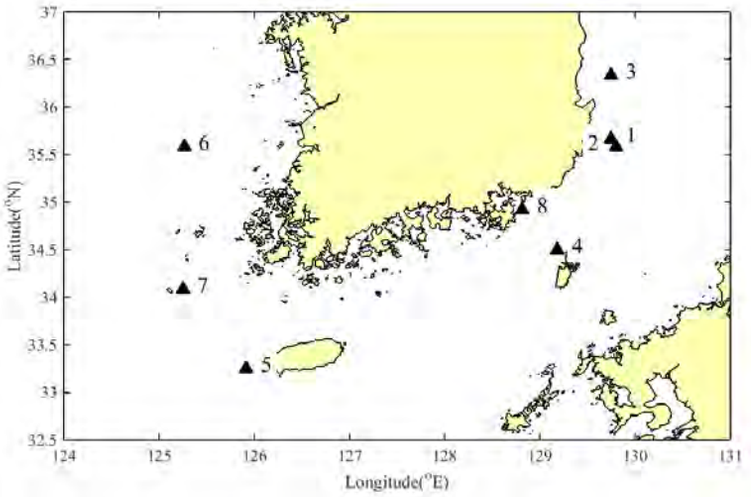
# Achievements of Technology Transfer to industries

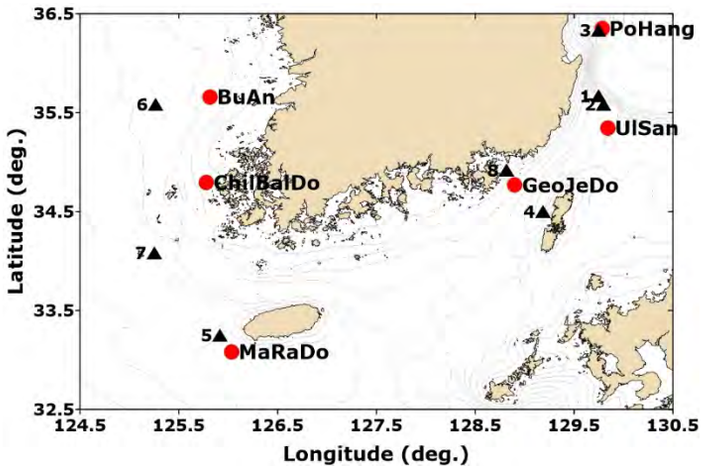
- **HD Hyundai Heavy Industries (2014.07) : Coastal prediction system (coastal-KOOS) – Sea trial**
- The East (2015.10) : Coastal prediction system (coastal-KOOS)
- Sea & River Technology (2019.06) : Coastal prediction system (coastal-KOOS)
- **HD Korea Shipbuilding & Offshore Engineering (2020.08) : Coastal prediction system (coastal-KOOS) – Sea trial**
- UST21 (2021.07) : Coastal prediction system (coastal-KOOS)

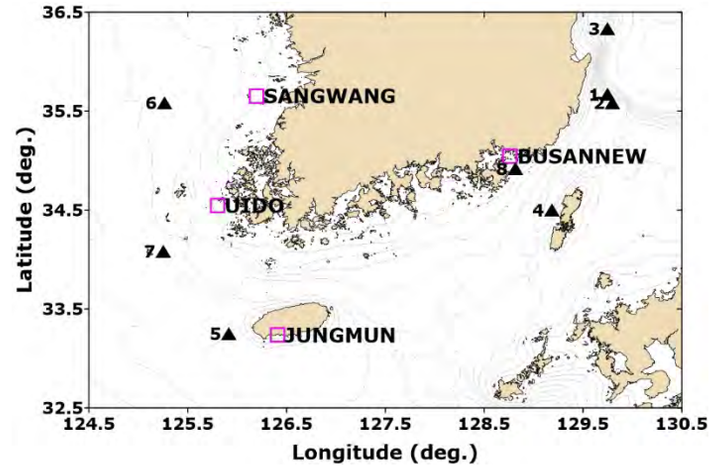


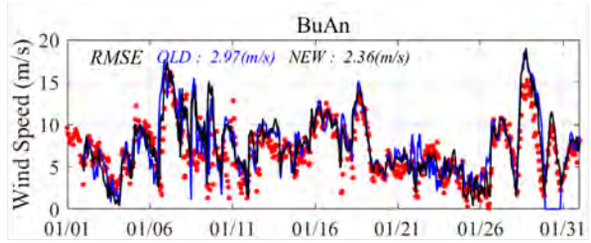
# Achievements of Technology Transfer to industries

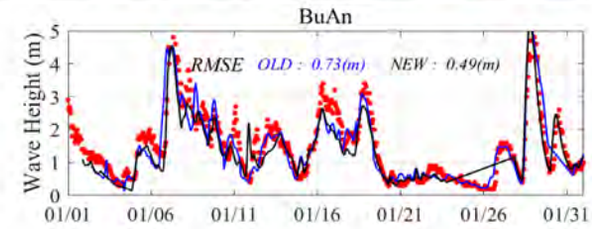
## HD Korea Shipbuilding & Offshore engineering

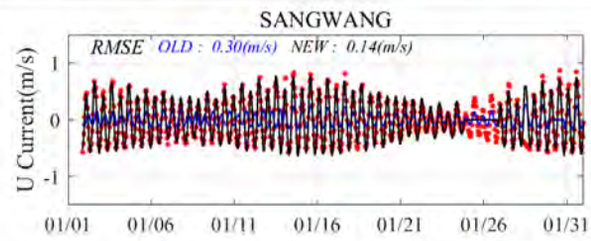


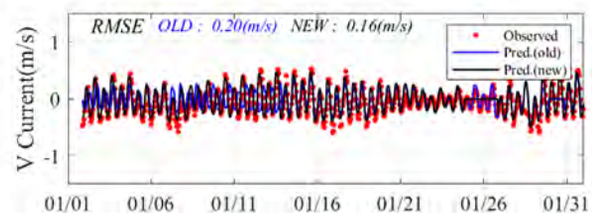



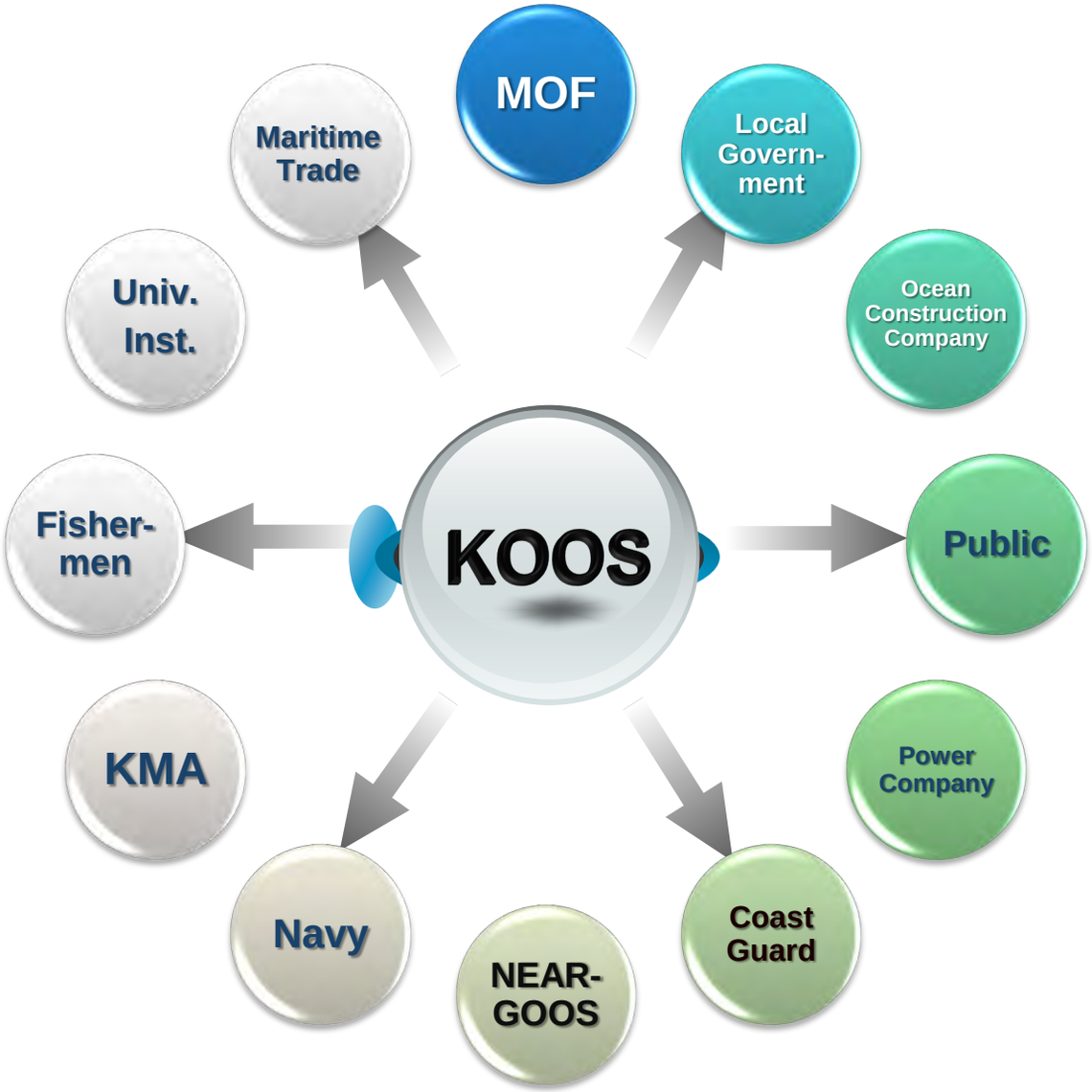




| | RMSE (Old) | RMSE (New) | Improvement |
|---|---|---|---|
| Wind spd. (m/s) | 2.58 | 1.97 | 24 % |
| Wind dir. (deg) | 30.56 | 27.51 | 10 % |
| u-current (m/s) | 0.20 | 0.15 | 25 % |
| v-current (m/s) | 0.20 | 0.16 | 20 % |
| Hs (m) | 0.52 | 0.31 | 40 % |

- Prediction of weather and ocean circulation 72 hours in advance for 8 area conducting sea trials for newly built ships
- By identifying information such as wave height, wind speed, and currents on an hourly, the sea trial schedule can be adjusted in advance, resulting in cost savings
- By selecting a location on the navigation chart to ascertain the weather and ocean conditions, the system minimized work delays due to sudden weather change during marine crane operations

# Closing Remarks




- KOOS has made significant strides, notably establishing a high-resolution forecasting system for the Korean Peninsula and serving as a diverse decision-support tool
- Next step? We are planning to develop a system that can respond in advance to various marine disasters that occur along the coast of Korea
- We hope that how we can effectively utilize the operational oceanographic system for various marine disasters with OPST

# Thank you !