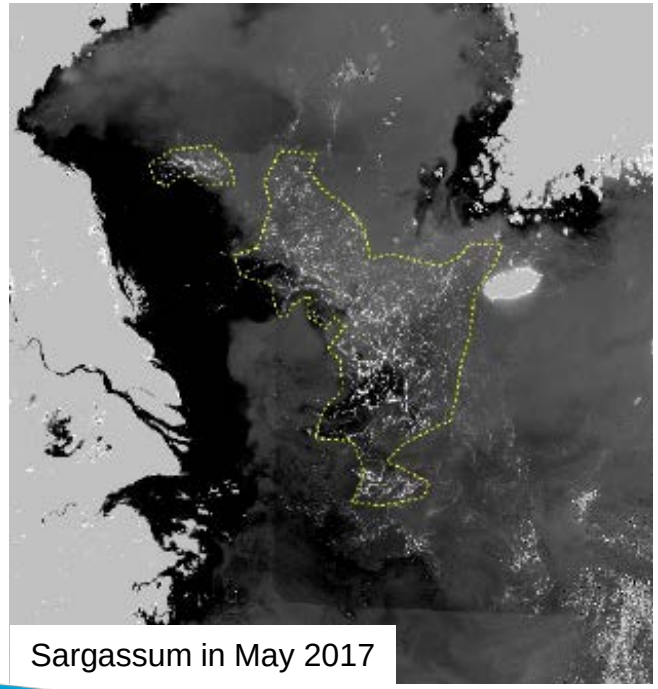
Tracking the drifting of pelagic *Sargassum* rafts in the East China Sea and Yellow Sea using a coastal ocean modeling system

Byoung-Ju Choi[1], Kyungman Kwon[2], Kwang Young Kim[1] and Keunyong Kim[3]

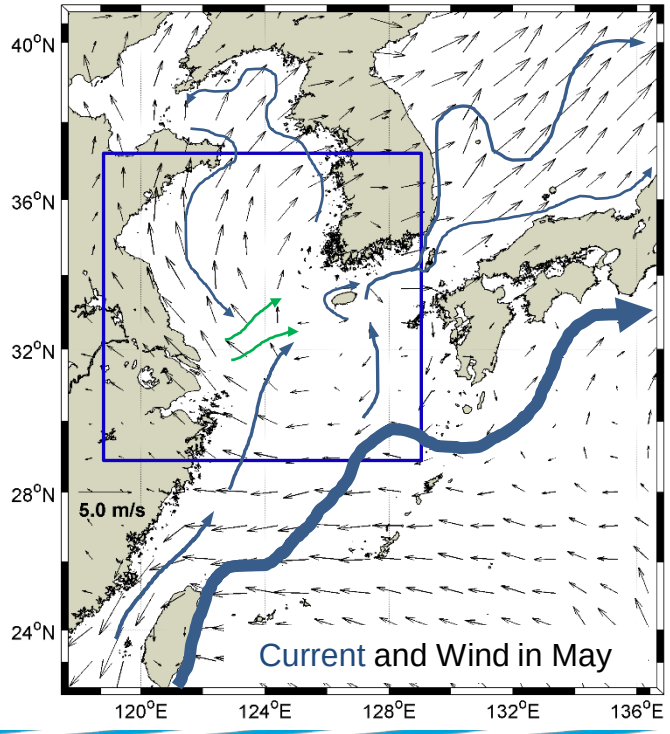
[1]Department of Oceanography, Chonnam National University, Korea
[2]Research Institute for Basic Science, Chonnam National University, Korea
[3]Korea Ocean Satellite Center, Korea Institute of Ocean Science and Technology, Korea



Sargassum in May 2017

```
newXpos = par(n,pX) + AdvectX + TurbHx
newYpos = par(n,pY) + AdvectY + TurbHy
newZpos = par(n,pZ) + AdvectZ + TurbV

!Check vertical boundaries and reflect
!  if particle above surface, particle
reflect=0.0
if (newZpos.GT.P_zetac) then
  reflect = P_zetac - newZpos
  NewZpos = P_zetac + reflect
endif
```



Outline

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2 **Data and Methods**

- Geostationary Ocean Color Imager (GOCI) data
- A coastal ocean circulation modeling system

3 **Results**

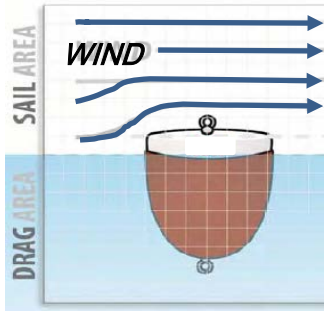
- Lagrangian particle tracking experiments
- Sensitivity to the windage factor
- Forward and backward particle tracking simulations
- Role of winds on northward *Sargassum* drift into the YS

4 **Summary**

Introduction

wind

Sargassum patch in the Jeju Strait



Leeway (direct wind drag)

Drift of Sargassum patches is controlled by current, wind, and waves. Leaves and branches of Sargassum exposed above the sea surface feel direct drag of wind (leeway).

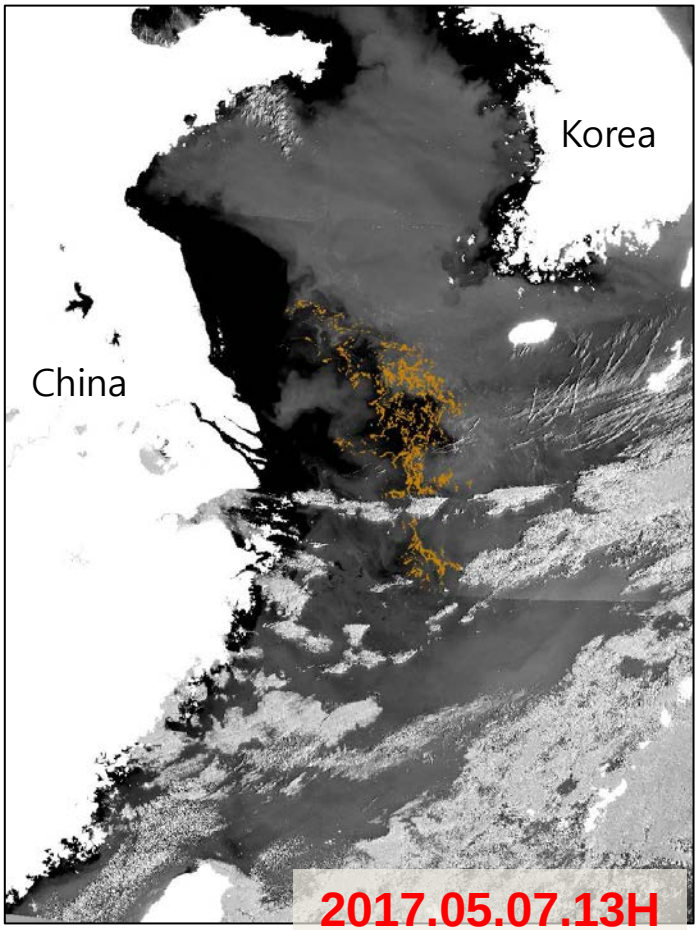
$$X(t+1) = X(t) + \boldsymbol{V_{current}}(\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z}) \times \Delta t + \boldsymbol{V_{wind}}(\boldsymbol{x}, \boldsymbol{y}) \times \Delta t \pm random\ \ walk$$

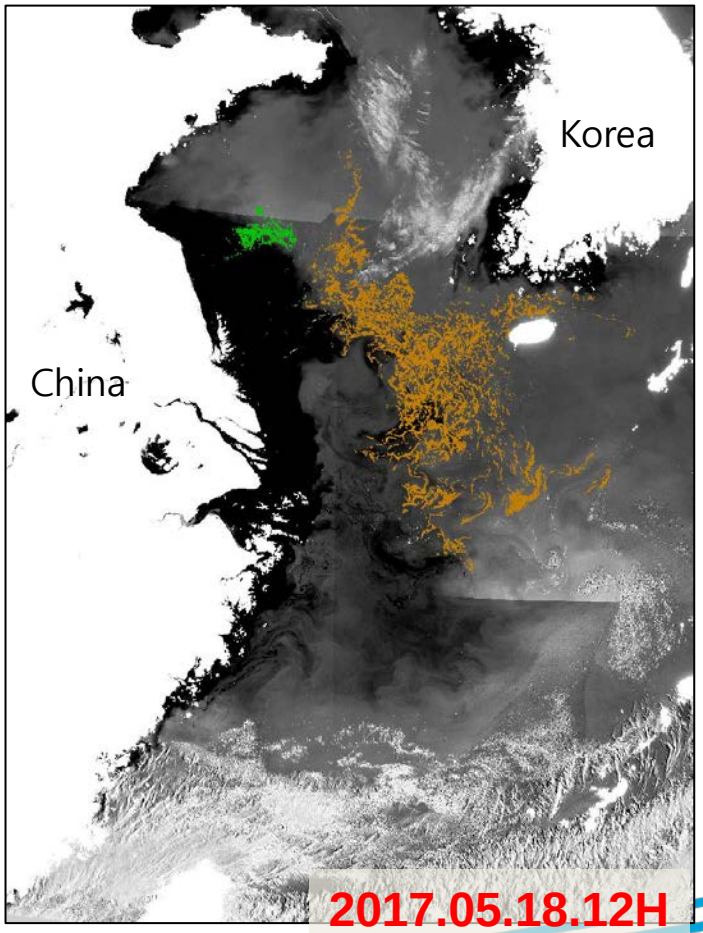
Objectives

1. To trace the trajectories of pelagic *Sargassum* patches in May 2017 in the Yellow Sea and East China Sea using satellite remote sensing data and Lagrangian particle tracking simulations
2. To restore the missing parts of pelagic *Sargassum* patches in satellite images by forward and backward particle tracking
3. To determine the physical factors that drove the northward intrusion of the massive *Sargassum* patches into the Yellow Sea in May 2017

Data and Methods

- Geostationary Ocean Color Imager (GOCI) data
- Normalized difference vegetation index (NDVI) algorithm was applied to detect floating macroalgae





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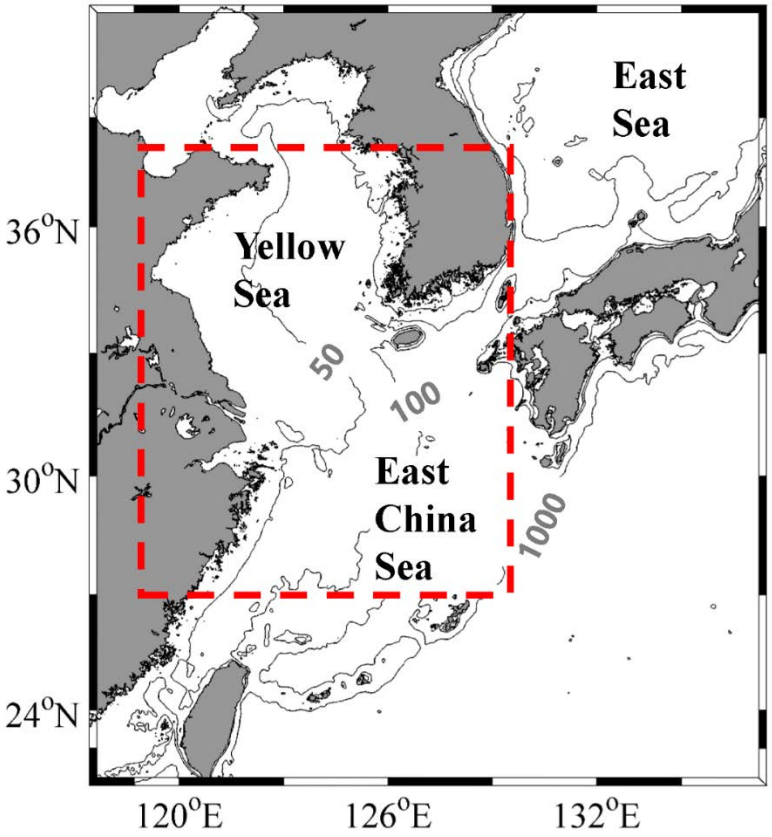
Data and Methods

Model domain for the Yellow Sea and East China Sea



- Based on **ROMS**
- Model Domain: the YS and the ECS
- Average horizontal grid spacing: **3 km (642 x 610)**
- vertically 41 sigma levels
- Boundary Data from HYCOM
  (0.08° x 0.08° x 33 level grid spacing)
- Initial Data from HYCOM
- Atmospheric forcing data: ECMWF-era5
- River Discharge from 14 rivers
- 10 tidal constituents along the open boundary (TPXO7)
- data assimilation: **EnKF**
  (SST, T and S profiles, SSHA)
- It has provided current data to **LTRANS** model

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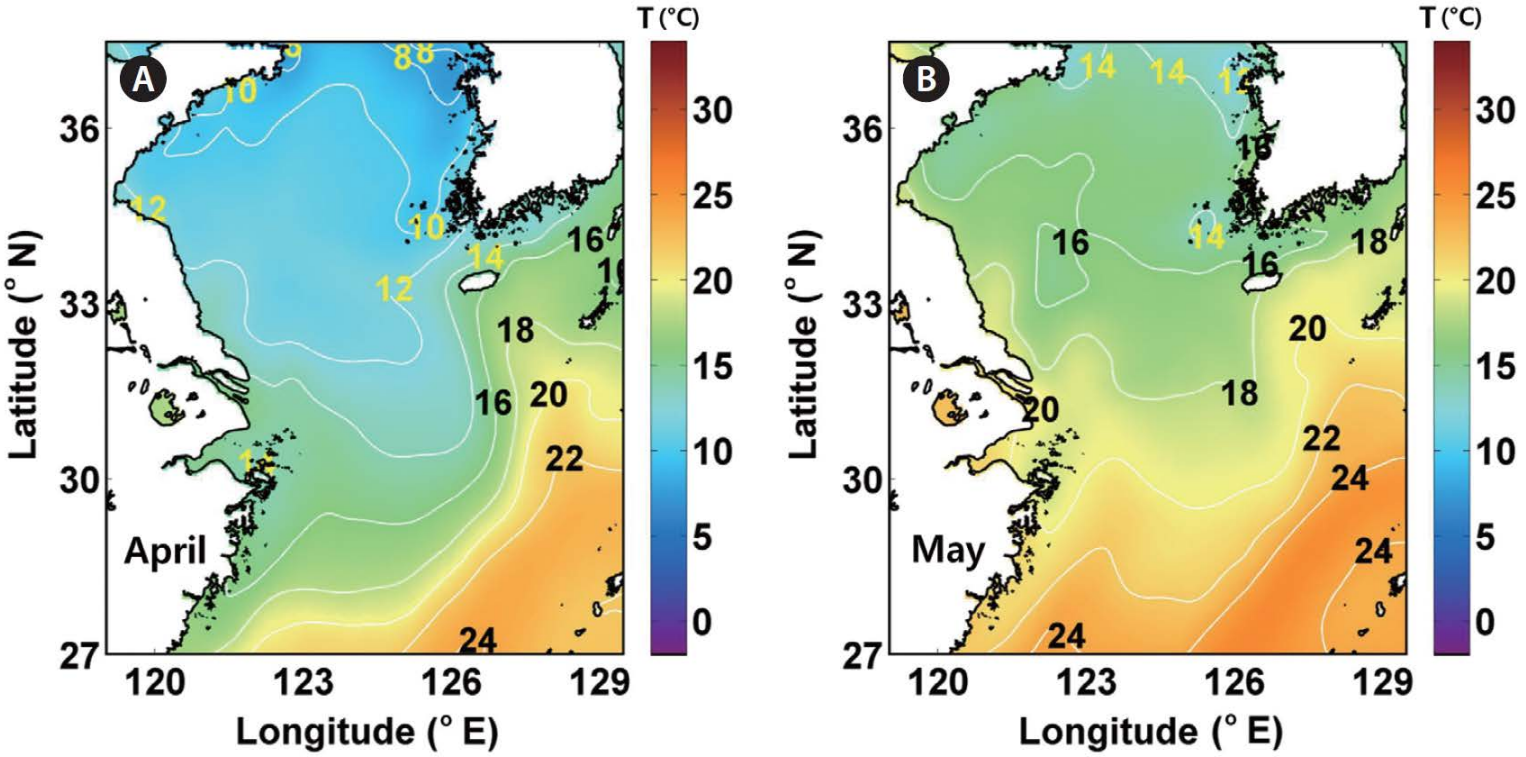
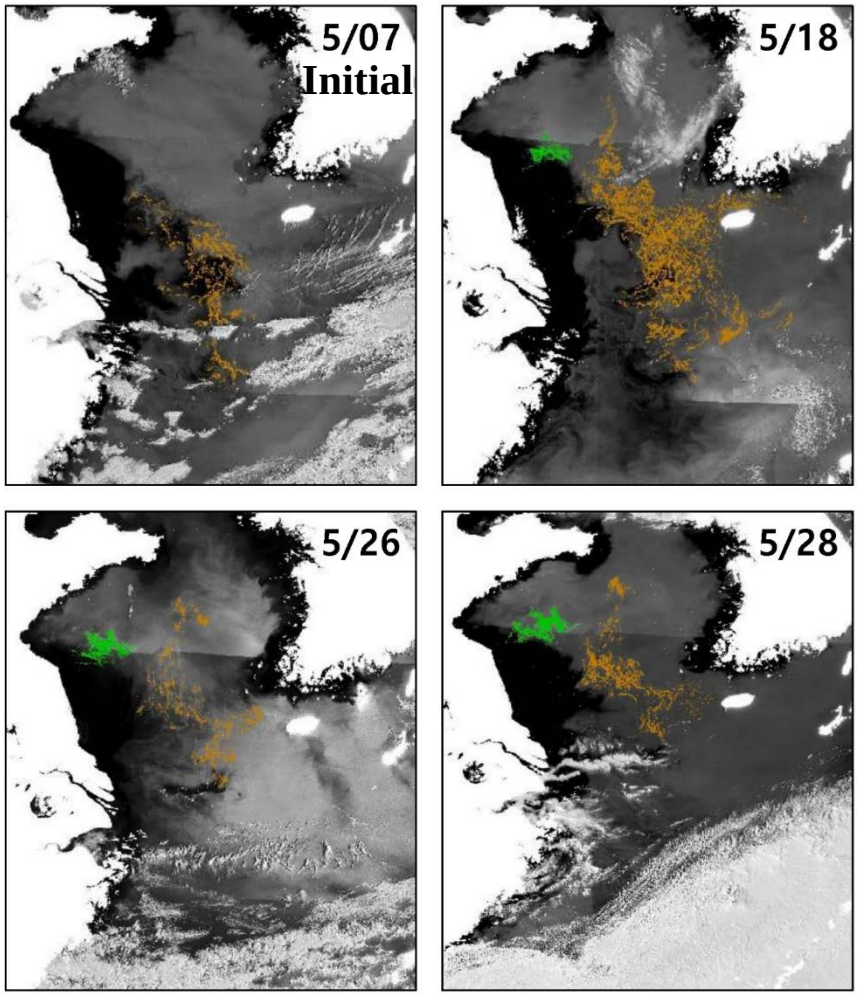
MODEL

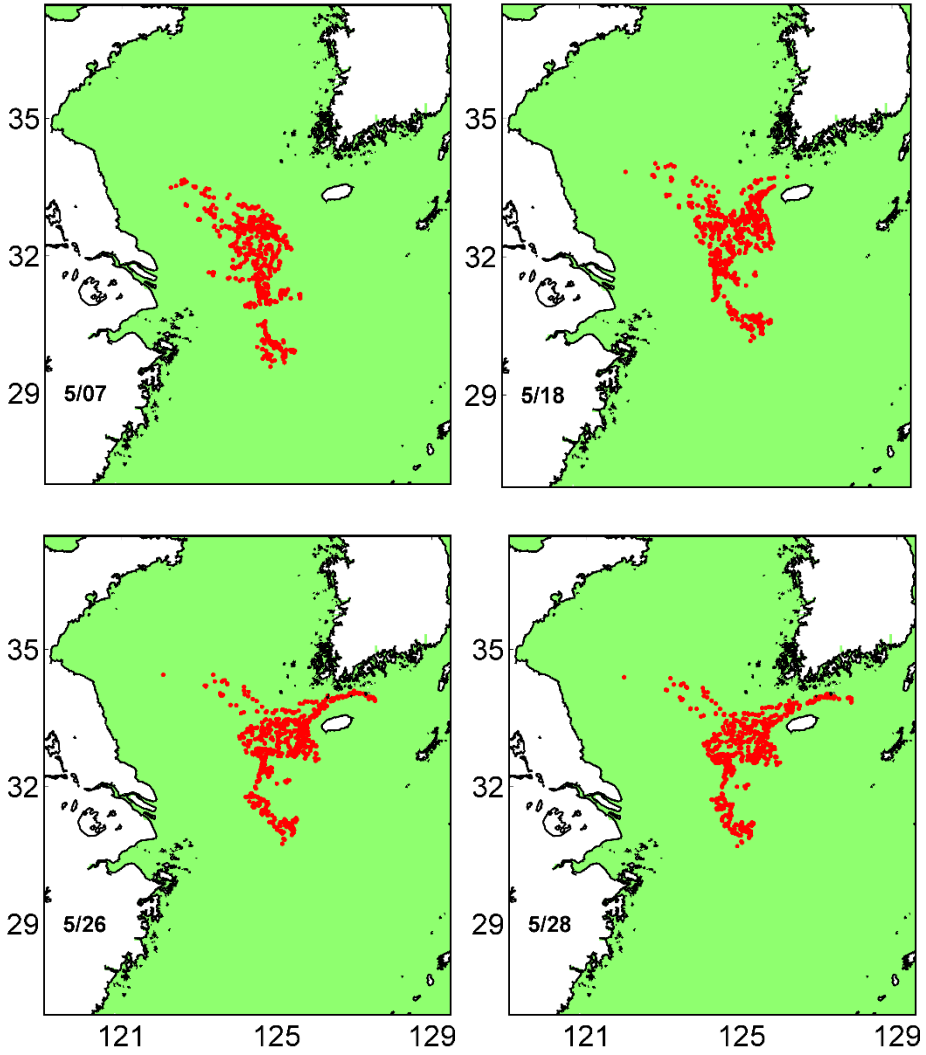


Monthly mean of sea surface temperature (°C) from a numerical model in the East China Sea and Yellow Sea in (A) April and (B) May 2017. Contour interval is 2°C.

Results - Lagrangian particle tracking experiments



Sargassum horneri (brown patches) in May 2017



Synthetic floating particles (red patches) in May 2017.

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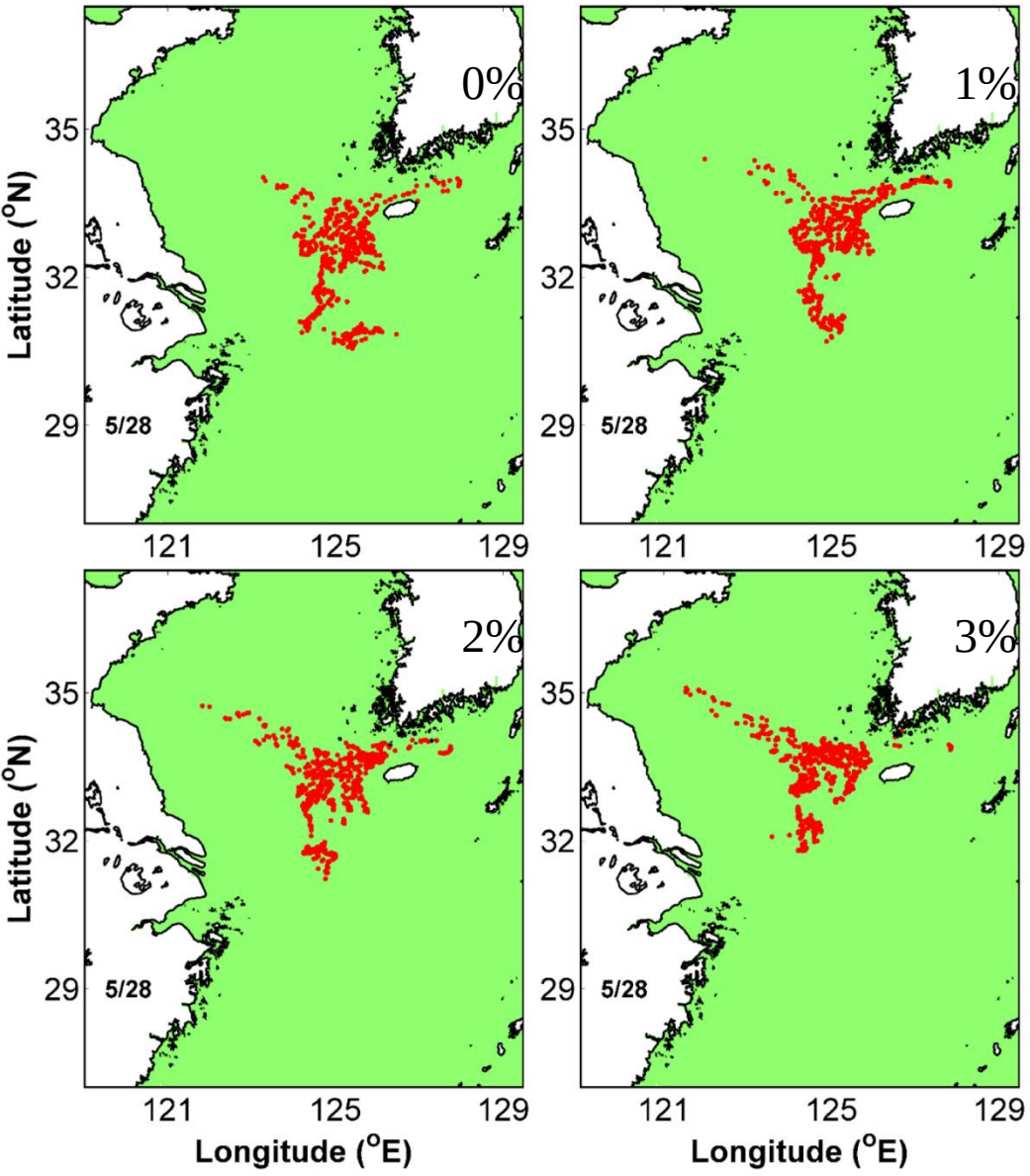
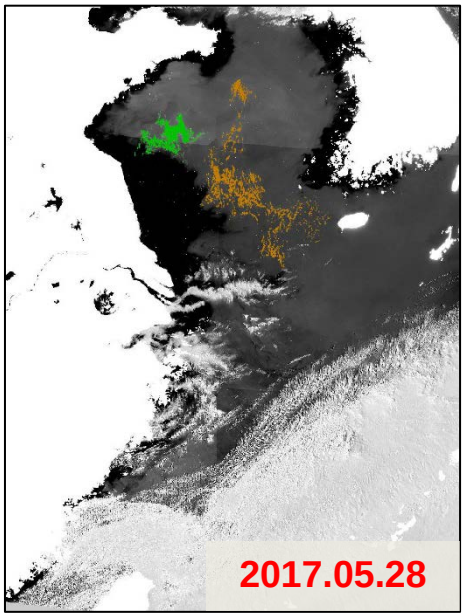
Results - Sensitivity to the windage factor (a)





$\mathbf{V_{wind}}$ = a W

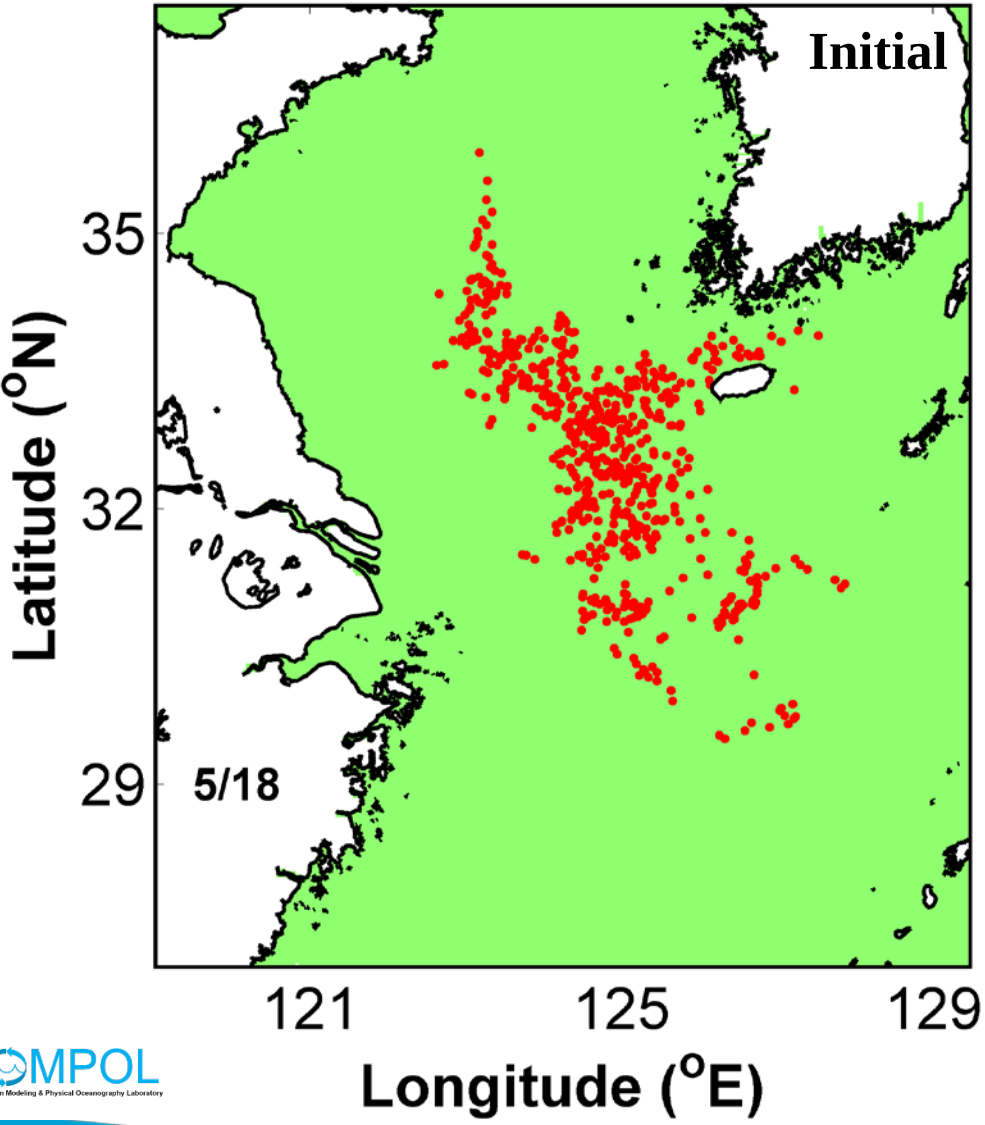
V_{wind}: downwind windage

W: wind speed

a : windage (leeway) factor

$$X(t+1) = X(t) + \boldsymbol{V_{current}}(x, y, z) \times \Delta t + \boldsymbol{V_{wind}}(x, y) \times \Delta t \pm random\ \ walk$$

Results - Sensitivity to the windage factor



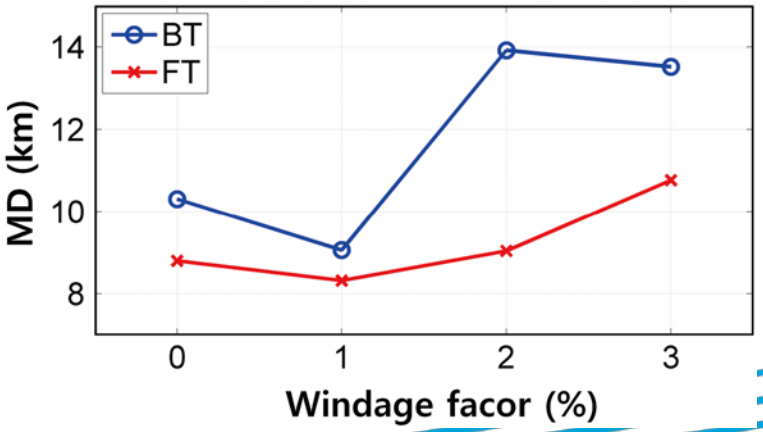
$$D_k = \sqrt{[x_s(i) - xo(j)]^2 + [y_s(i) - yo(j)]^2}$$

$$MD = \frac{1}{N}\sum_{k=1}^{N} D_k$$

model particle $\{x_s(i), y_s(i)\}$

macroalgae patch $\{x_o(j), y_o(j)\}$

Mean distance (MD)



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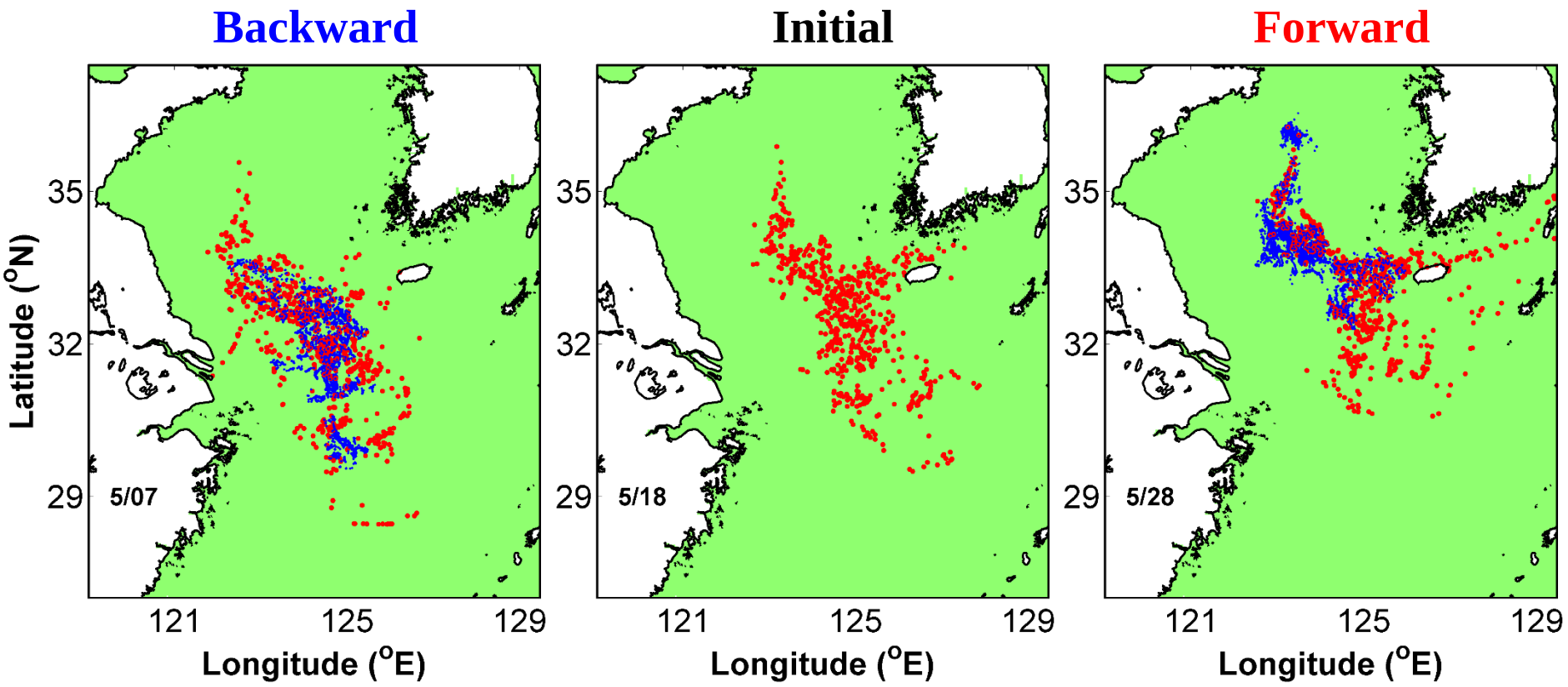
Results

Backward and Forward particle tracking simulations

(Windage factor = 1%)



MD = **9.1 km**

Blue dots: observed patches
Red dots: synthetic particles

MD = **8.3 km**

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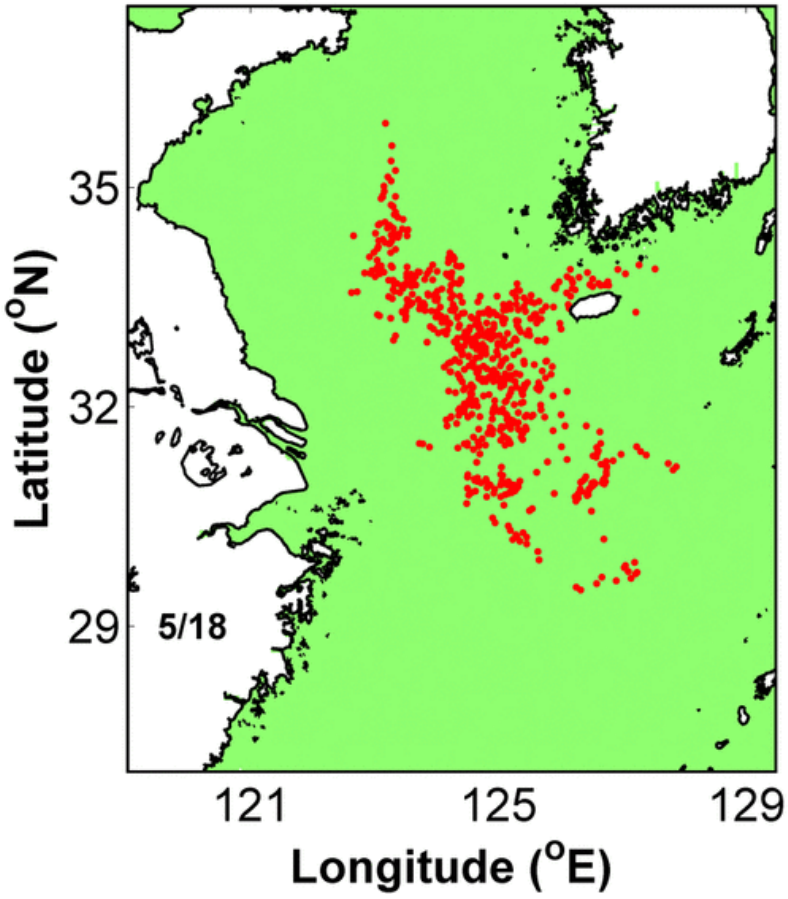
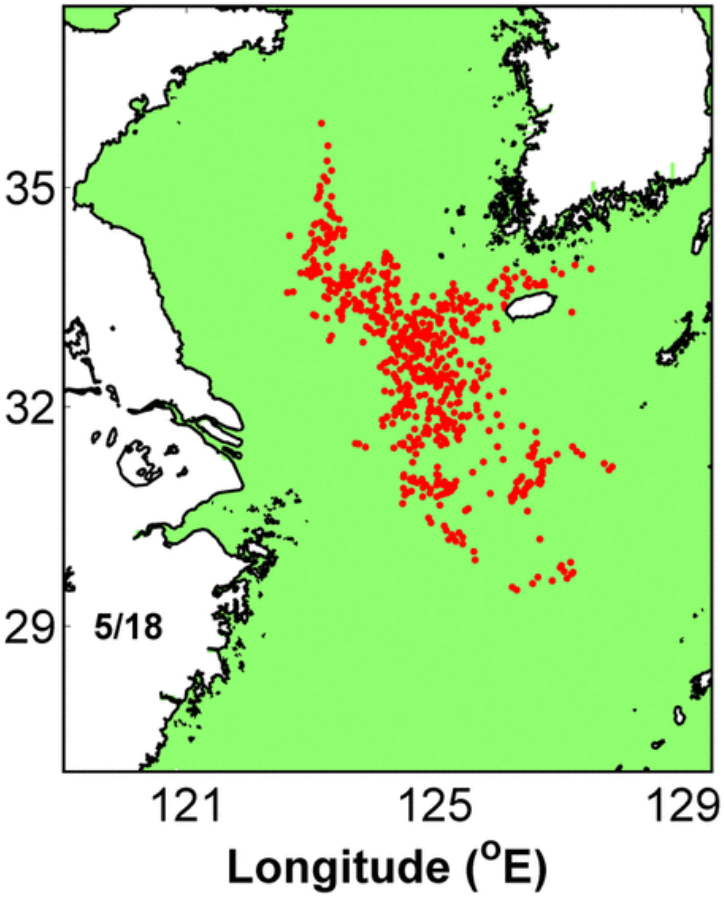
Results - Forward and backward particle tracking simulations



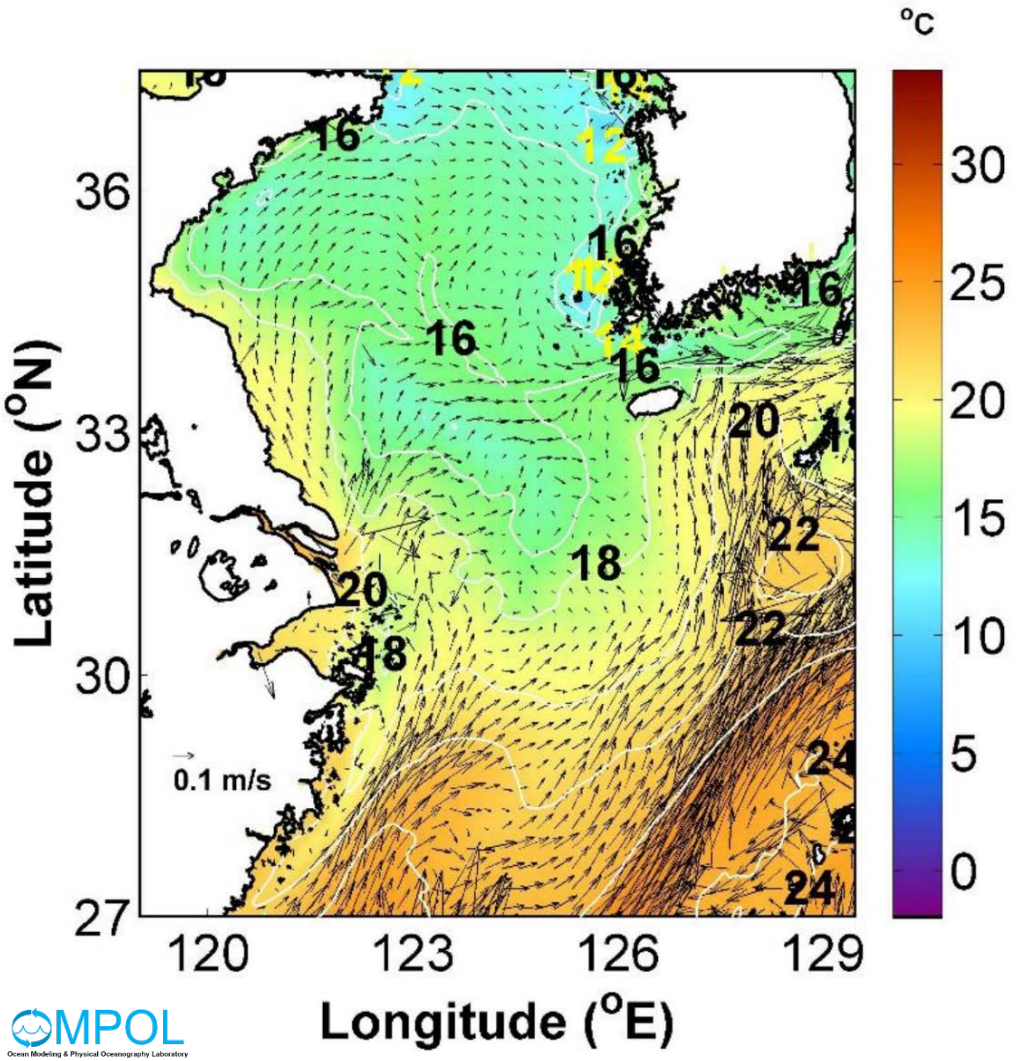
Forward tracking

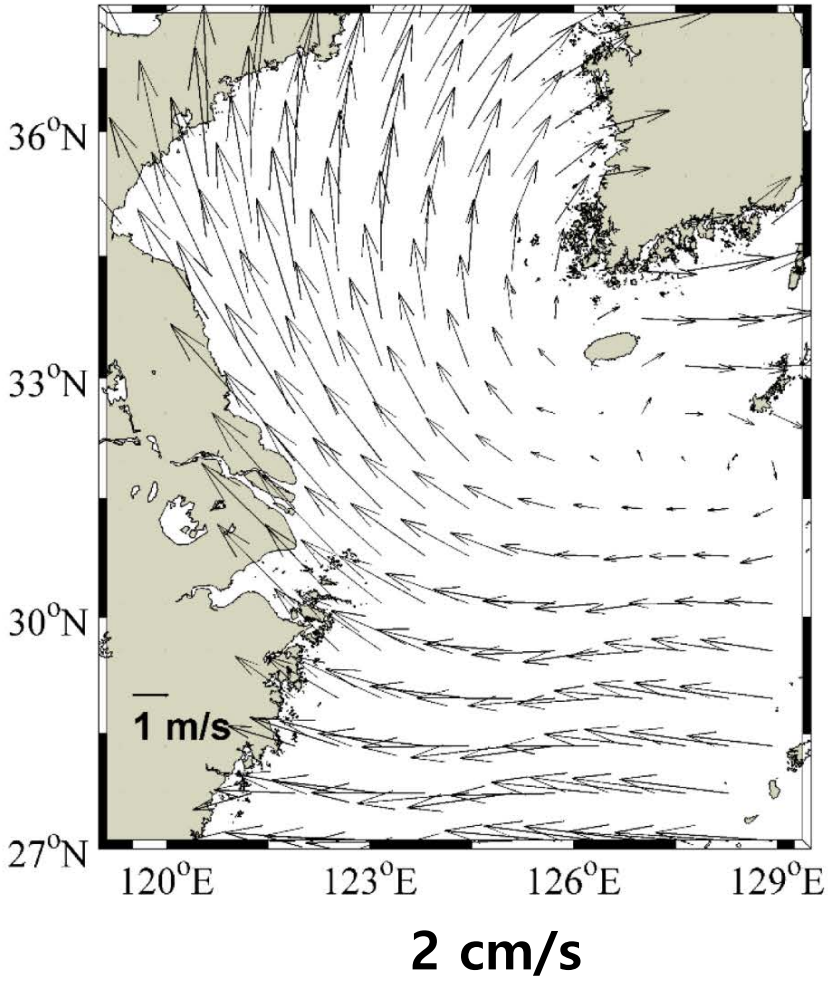


Backward tracking

Results - Role of winds on northward *Sargassum* drift into the YS

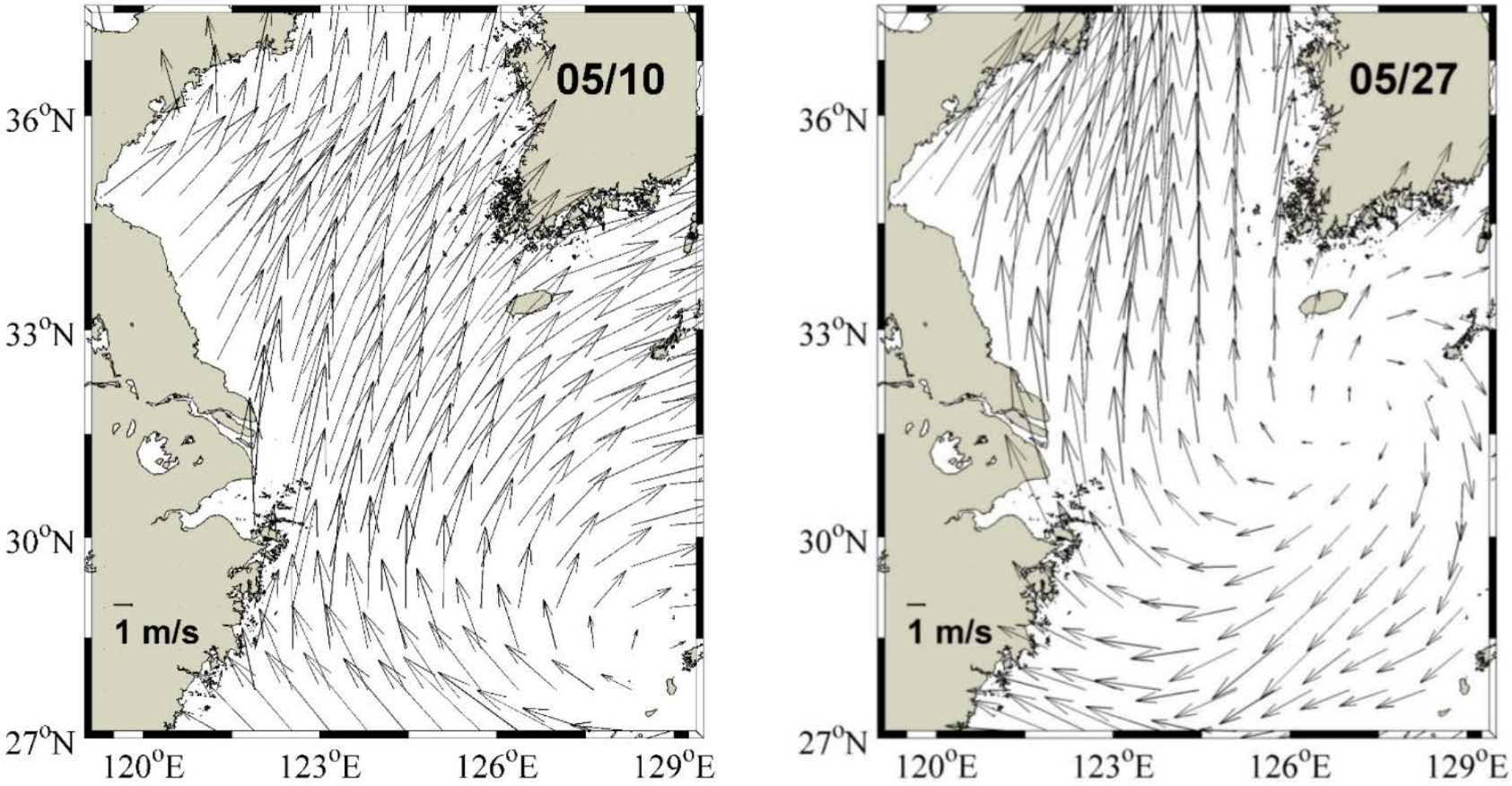
Monthly mean **surface current** and **wind** in May 2017





Results - Role of winds on northward *Sargassum* drift into the YS

daily mean of **wind** on May 10 and 27, 2017



8-9 cm/s

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Summary

- Northeastward drifts of massive *Sargassum* patches were observed in the East China Sea (ECS) and Yellow Sea (YS) by the Geostationary Ocean Color Imager (GOCI) in May 2017.

- The trajectories of the macroalgae patches were controlled by winds as well as surface currents. A windage (leeway) factor of 1% was chosen based on sensitivity simulations.

- Southerly winds in May 2017 contributed to farther northward intrusion of the brown macroalgae into the YS.

- Although satellite observation and numerical modeling have their own limitations and associated uncertainties, the two methods can be combined to find the best estimate of *Sargassum* patch trajectories.