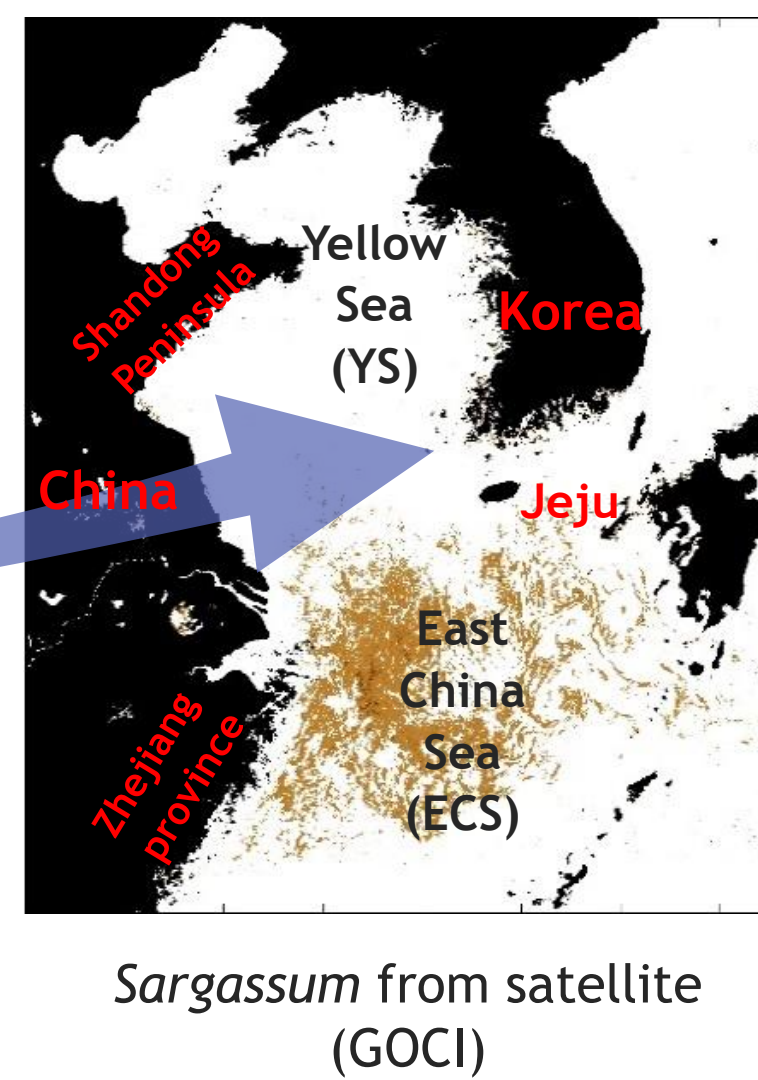# Origins and pathways of the floating Sargassum in the Yellow and East China Sea

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Introduction

- *Sargassum horneri* (Golden tide)

photo from https://www.jejumail.net/

Sargassum from satellite (GOCI)

- *S. horneri* has appeared from January to July on the coast of Korea since 2015
- Negative impact to fisheries and coastal communities.
- From Zhejiang Province, China (Feb–Mar) to ECS (Apr–May) (Qi et al., 2017)

- Arrival of *S. horneri* on the coast of Korea

	2015	2016	2017	2018	2019	2020	2021	2022
	Dec. 28	Mar. 09	Feb. 24	Jan. 09	Apr. 23	Apr. 07	Jan. 01	Jan. 03
First reported	South western Korea	Jeju	Jeju	South western Korea	Jeju	Jeju	South western Korea	South western Korea
Collected amount (10³t)	15.6	0.3	6.3	3.9	1	6.3	16	1.6

- Origin of *S. horneri* reaching the coast of Korea in January (Dec-Jan)?
- Interannual variability?

Purpose

- Locate the origin *S. horneri* found around Korea and its pathway using particle tracking modeling and satellite (GOCI) images
- Governing factors of interannual variability: arrival time at Jeju, bloom in ECS in 2015, 2017 and 2020

Method and data

- **2D Lagrangian Particle Tracking Model**

$$\vec{x}_{t+\Delta t} = \vec{x}_t + \int_t^{t+\Delta t} \{\vec{u}_c(\vec{x}_t, t) + W_f\vec{u}_w(\vec{x}_t, t)\}\Delta t + R\sqrt{\frac{2}{r}K_h\Delta t}$$

$\vec{x}$: particle position (x, y) $\vec{u}_c$: ocean current
t: time $\vec{u}_w$: atmosphere wind
Δt: time interval   at 10 m above surface
W_f: windage coeff, 1.5%
R: random number (-1 to 1)
r: Std. of random number
K_h: horizontal diffusion coeff.

- **Input data**

Var	Input	Source	
$\vec{u}_c$	Ocean current	HYCOM GLBv 0.08°	3hourly
	Tide	OSU TPXO Tide Model	
$\vec{w}_{10m}$	10 m wind	ECMWF ERA5	

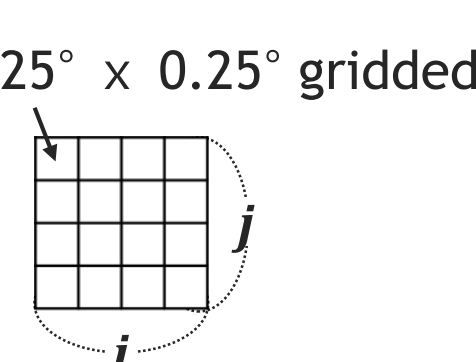$W_f\vec{u}_w$ (wind) $\vec{u}$ (current) $\vec{x}_{t+\Delta t}$ $\vec{x}_t$
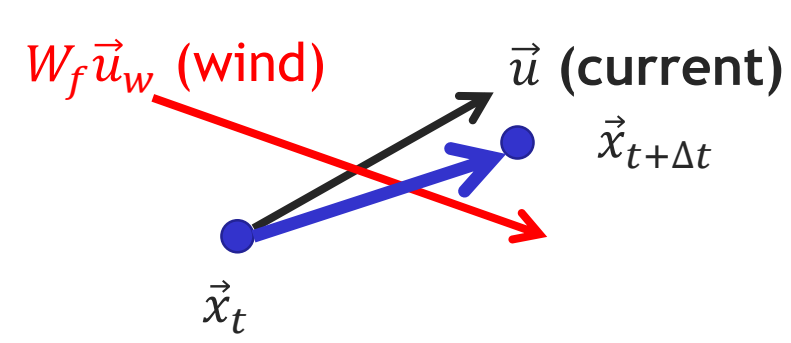
- **Experiments**
  - Origin: backward tracking from Jeju (no diffusion) 2015-2022 Jan-Jun
  - Pathway: forward tracking from origins 2014-2022 Dec-May

- **Probability function** Rypina et al. (2014)

$$P_{ij} = N_{ij}/N, \quad \overline{T_{ij}} = \sum T_{ij}/N,$$

P_{ij}: Probability of 'ij'th box
T_{ij}: Mean travel time of 'ij'th box
N_{ij}: Number of particles in 'ij'th box
N: Number of particles released
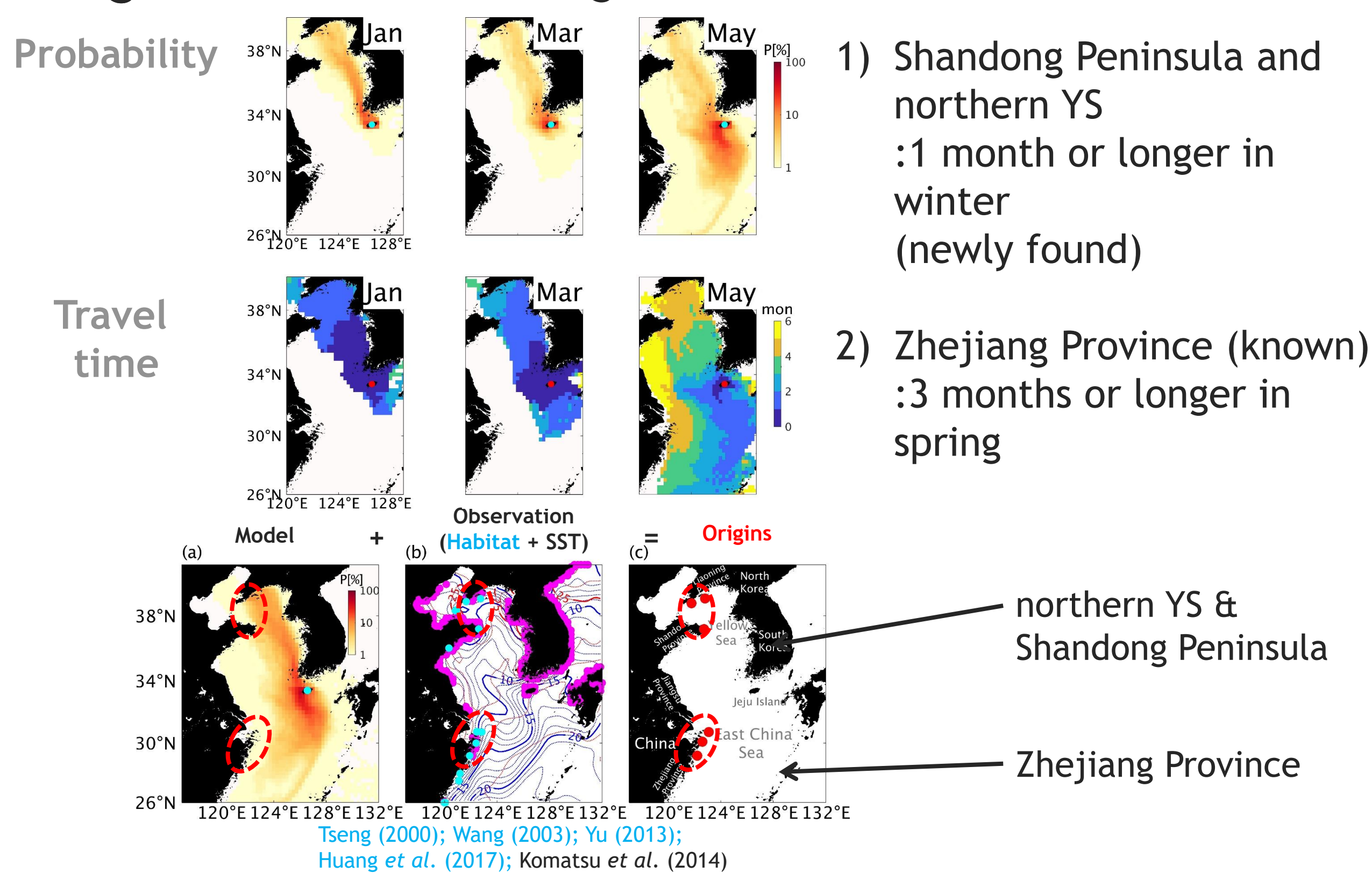
0.25° × 0.25° gridded

- **GOCI derived *S. horneri***
  - Geostationary Ocean Color Imager (GOCI)
  - Floating Algae Ratio (FAR) from GOCI-I & II 2015-2022
  - Spatial resolution : 500 m (GOCI-I) & 250 m (GOCI-II)
  - Probability of *S. horneri* appearance 0.25° × 0.25° : excluding cloud coverage
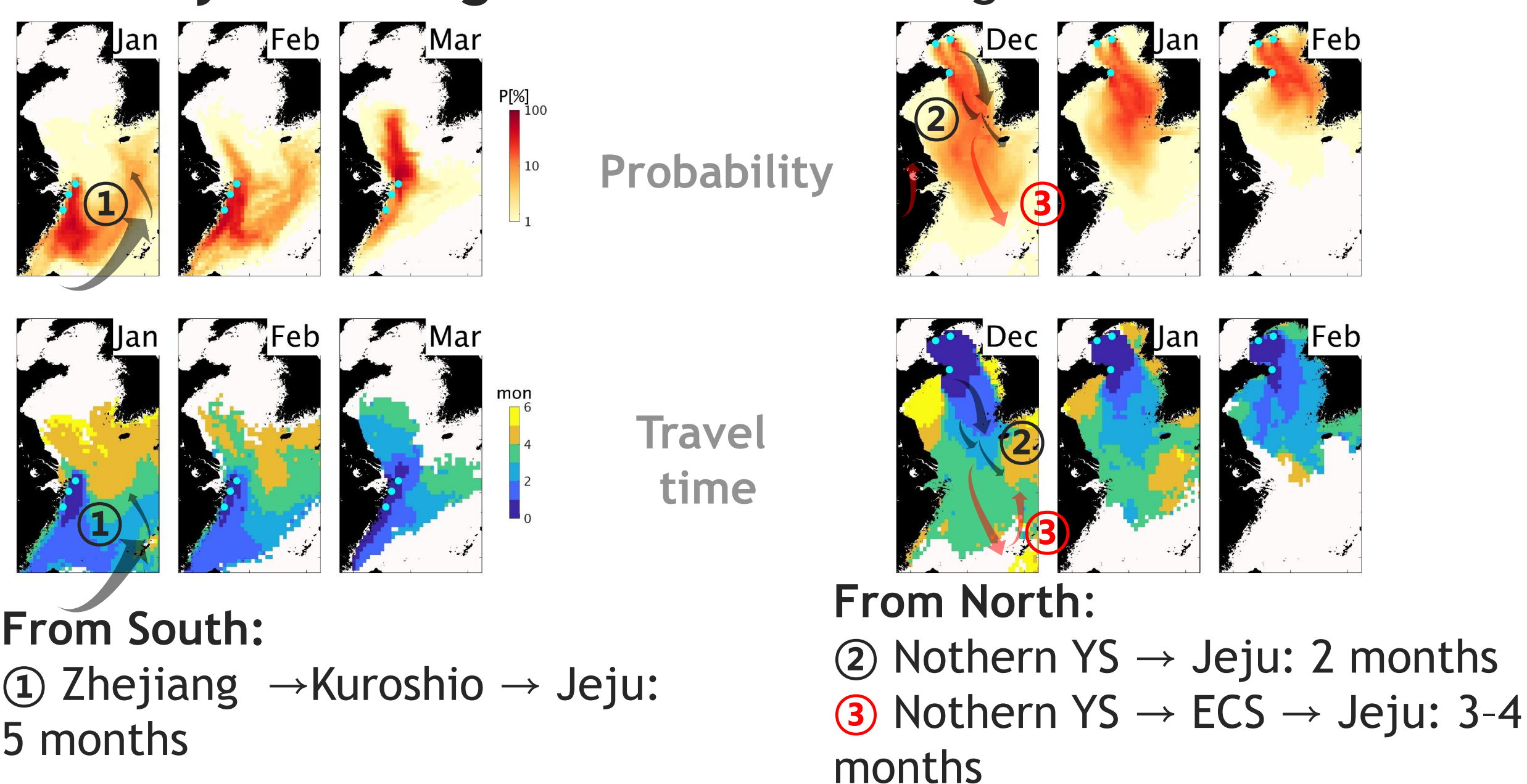
Origin and pathway

- **Origins:** backward tracking

Probability

Travel time

- Origin and Travel time

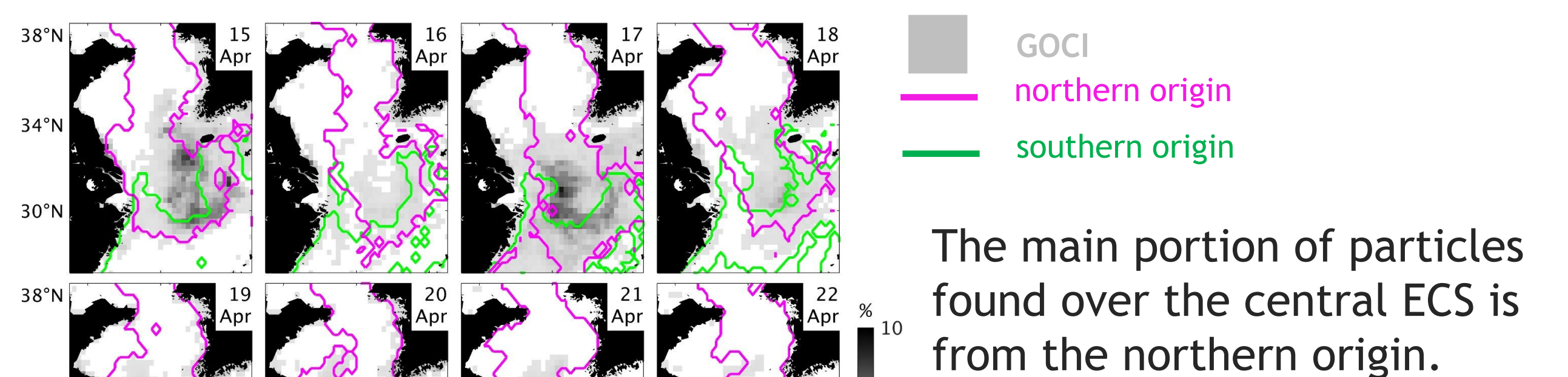1) Shandong Peninsula and northern YS :1 month or longer in winter (newly found)

2) Zhejiang Province (known) :3 months or longer in spring

Model + Observation (Habitat + SST) = Origins

Tseng (2000); Wang (2003); Yu (2013); Huang et al. (2017); Komatsu et al. (2014)

northern YS & Shandong Peninsula

Zhejiang Province

- **Pathway from origins:** forward tracking

Probability

Travel time

From South:
① Zhejiang →Kuroshio → Jeju: 5 months

From North:
② Nothern YS → Jeju: 2 months
③ Nothern YS → ECS → Jeju: 3-4 months

Interannual variability

- **Probability of the appearance of floating algae**

GOCI
northern origin
southern origin

The main portion of particles found over the central ECS is from the northern origin.

- **Effect of temperature**

(b) DJF, Chinese coast, Liaoning

- **Effect of wind**

Anomalous westerly wind during December made the algae appear in January around Korea.
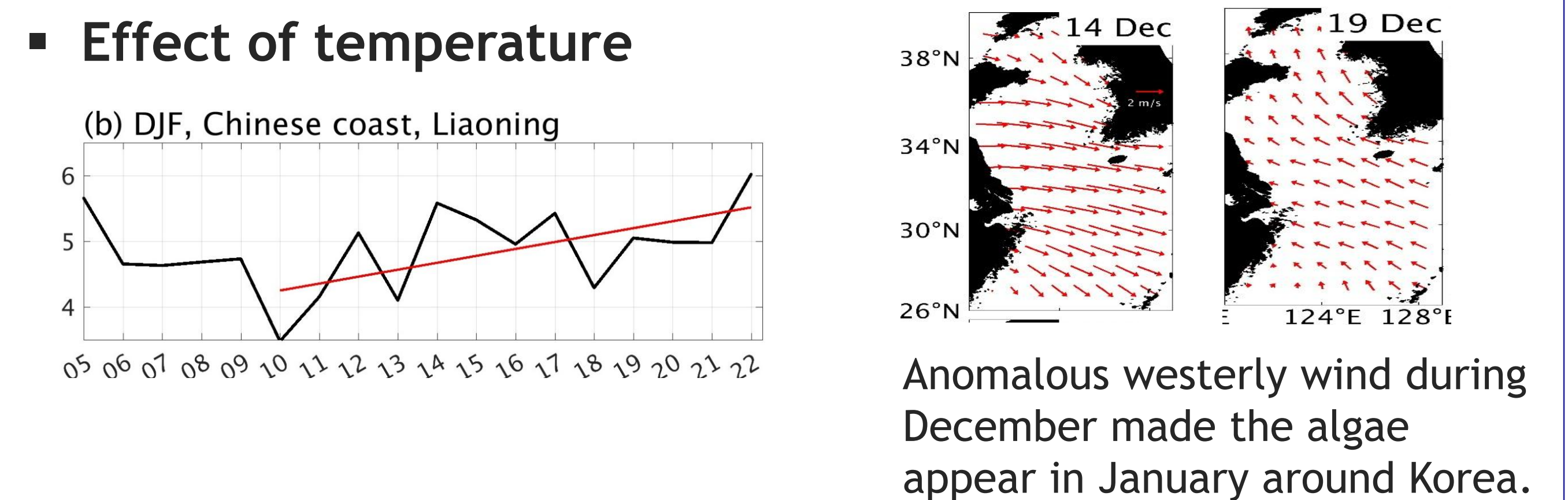
Summary and conclusion

- Origins: 1) Zhejiang coast of the ECS, 2) the northern coast of the YS.
- Three pathways from the origins to Jeju.
- Interannual variability: Temperature over northern Yellow Sea
- Global warming must have enhanced the northern origin to trigger the recent Sargassum blooms in the central ECS.
- Winter temperature and wind over the northern Yellow Sea provide predictability in bloom and arrival time, respectively.