Observations of surface drifters in the Korea Strait in spring

Jun Choi, Wonkook Kim, and Young-Gyu Park
Korea Institute of Ocean Science and Technology (KIOST)

Ministry of Science and ICT
National Research Foundation of Korea
KIOST KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY
해양위성센터 Korea Ocean Satellite Center

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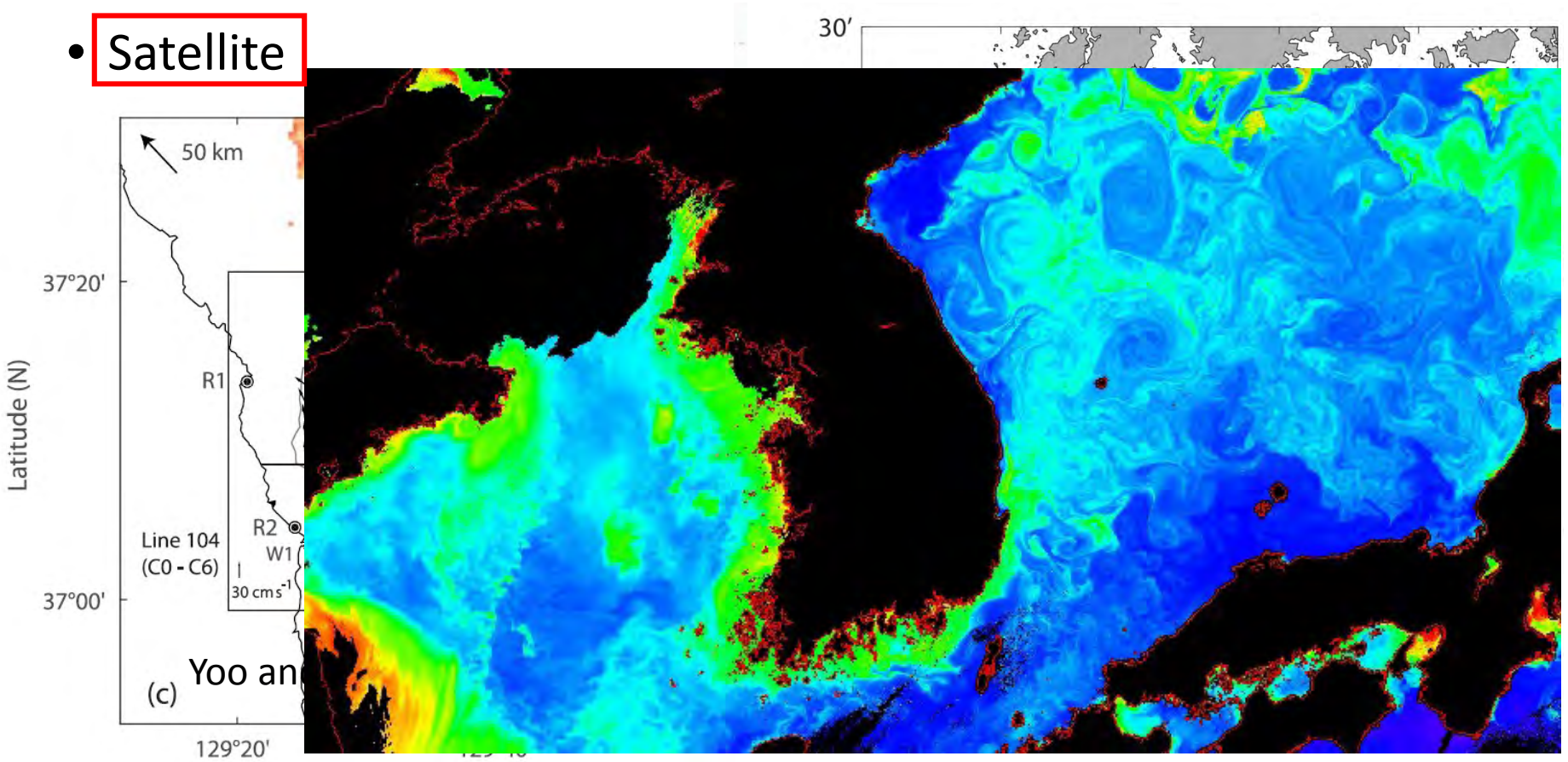
- Motivation
- Methods / Observations
  - Drifter experiments
  - Surface current derivation
- Conclusions

Motivation

- Submesoscale processes are physical processes that comprise between microscale turbulence and balanced mesoscale circulations.
- We need submesoscale observations
  - To parameterize (or validate) submesoscale and sub-grid circulations in ocean modelings
  - To characterize energy transfer and dispersion characteristics
- However, the observations are scarce.

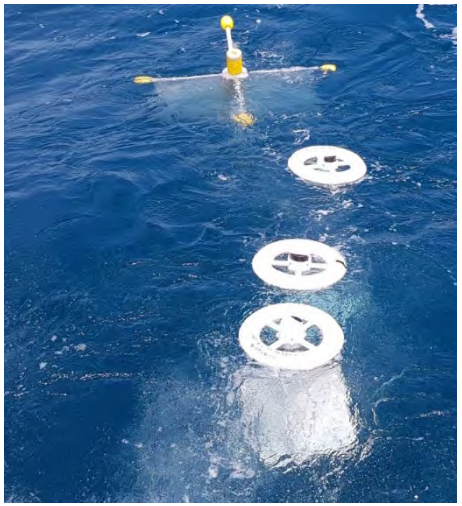
Observations of submesoscale processes

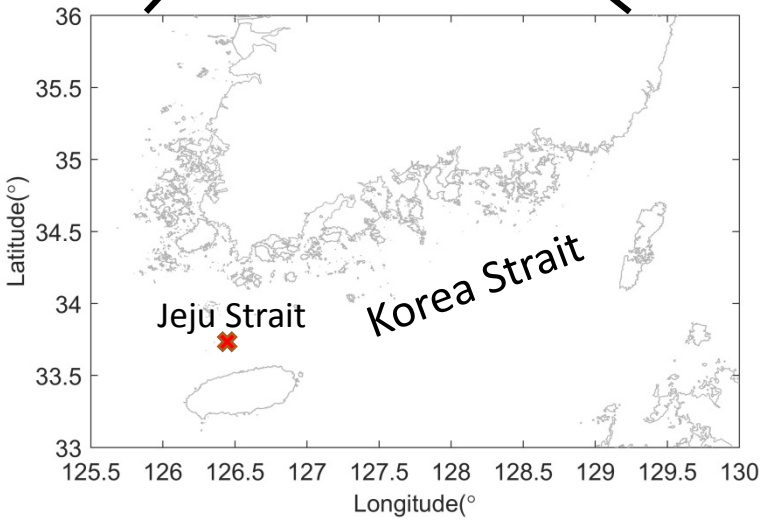
- Surface drifters
- HF radar
- Satellite



Surface Drifter experiment

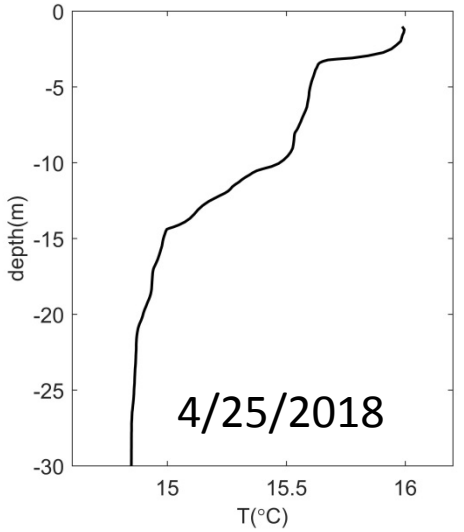
- Released 35 surface drifters in April 25 ~ at the Korea strait
- 30 CARTHE drifters + 5 KIOST drifters (5 mins interval)



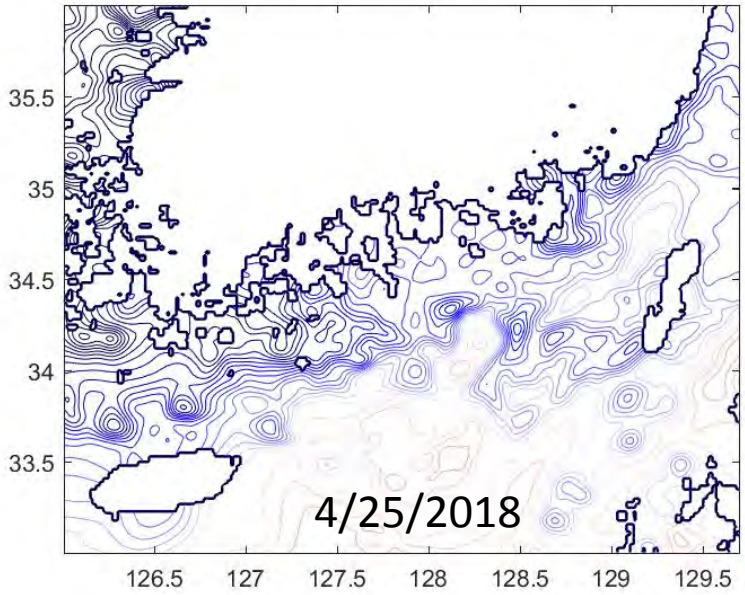


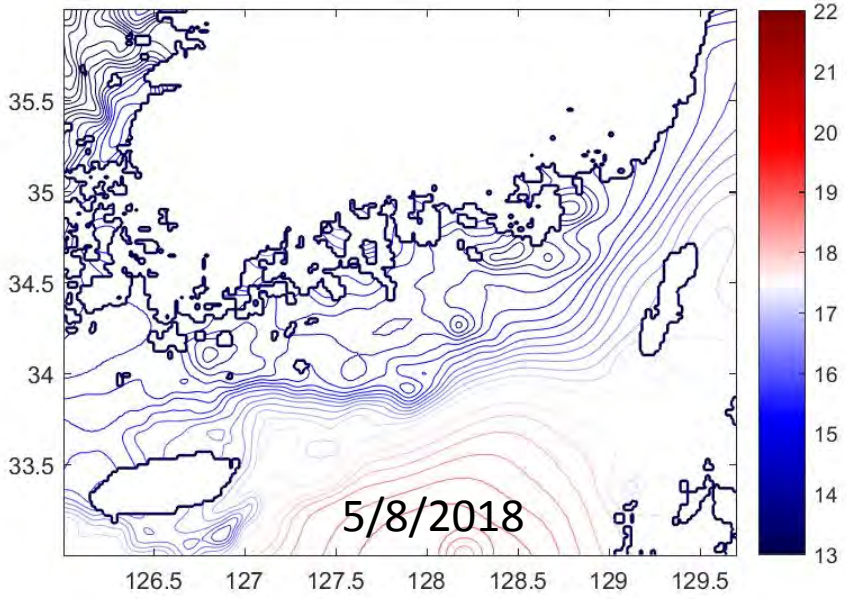
Vertical and horizontal temperature structures

CTD near the release location

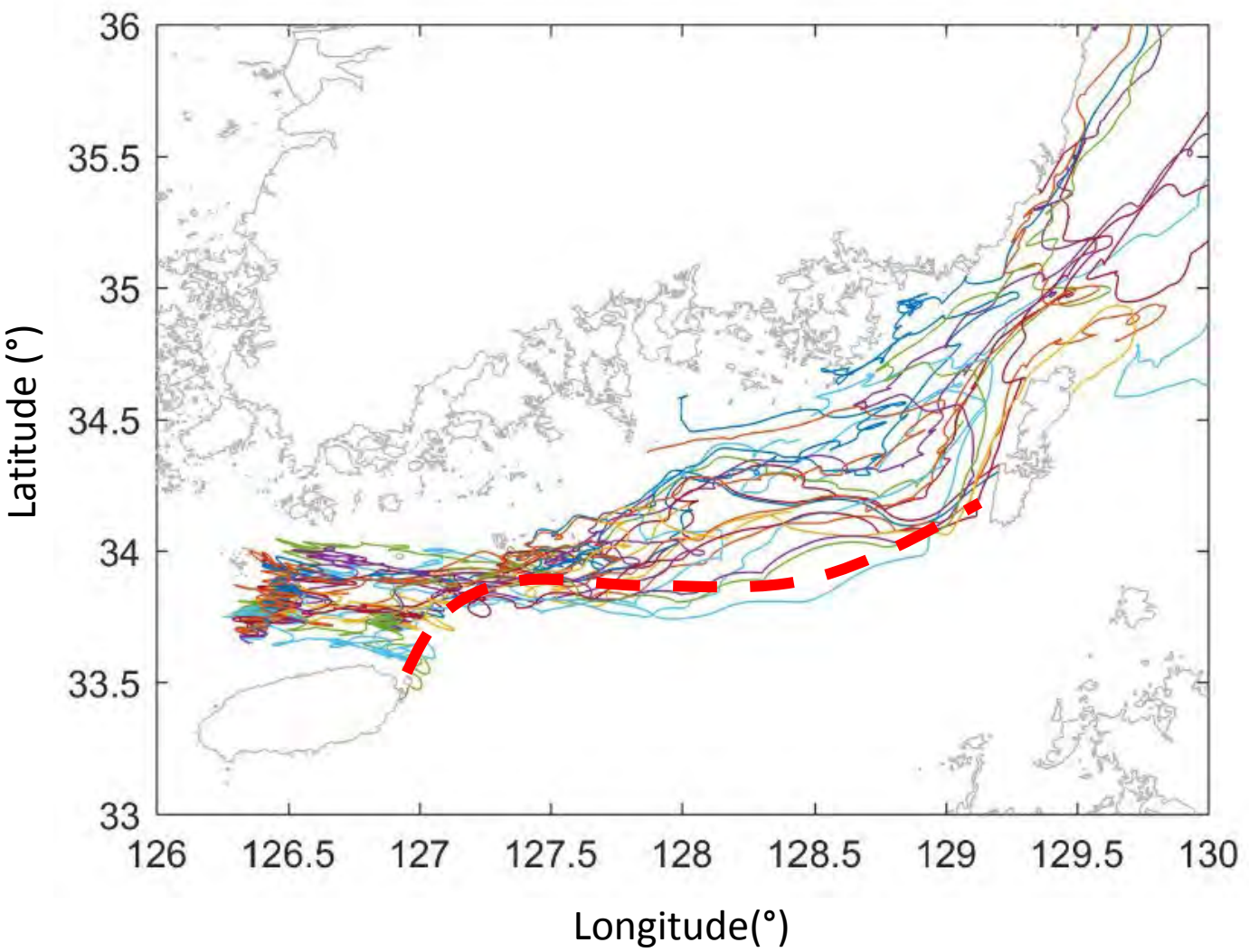


G1SST

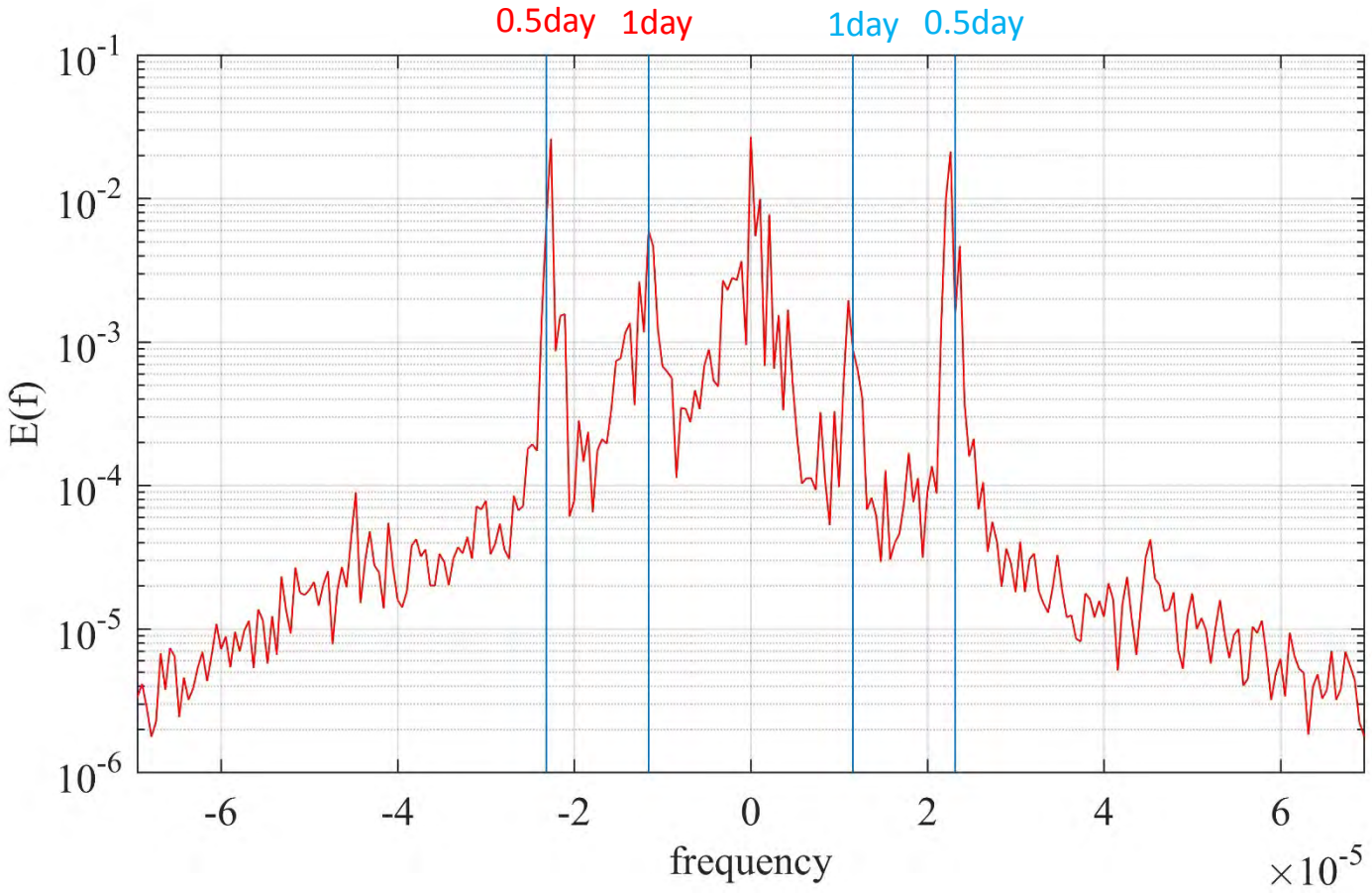




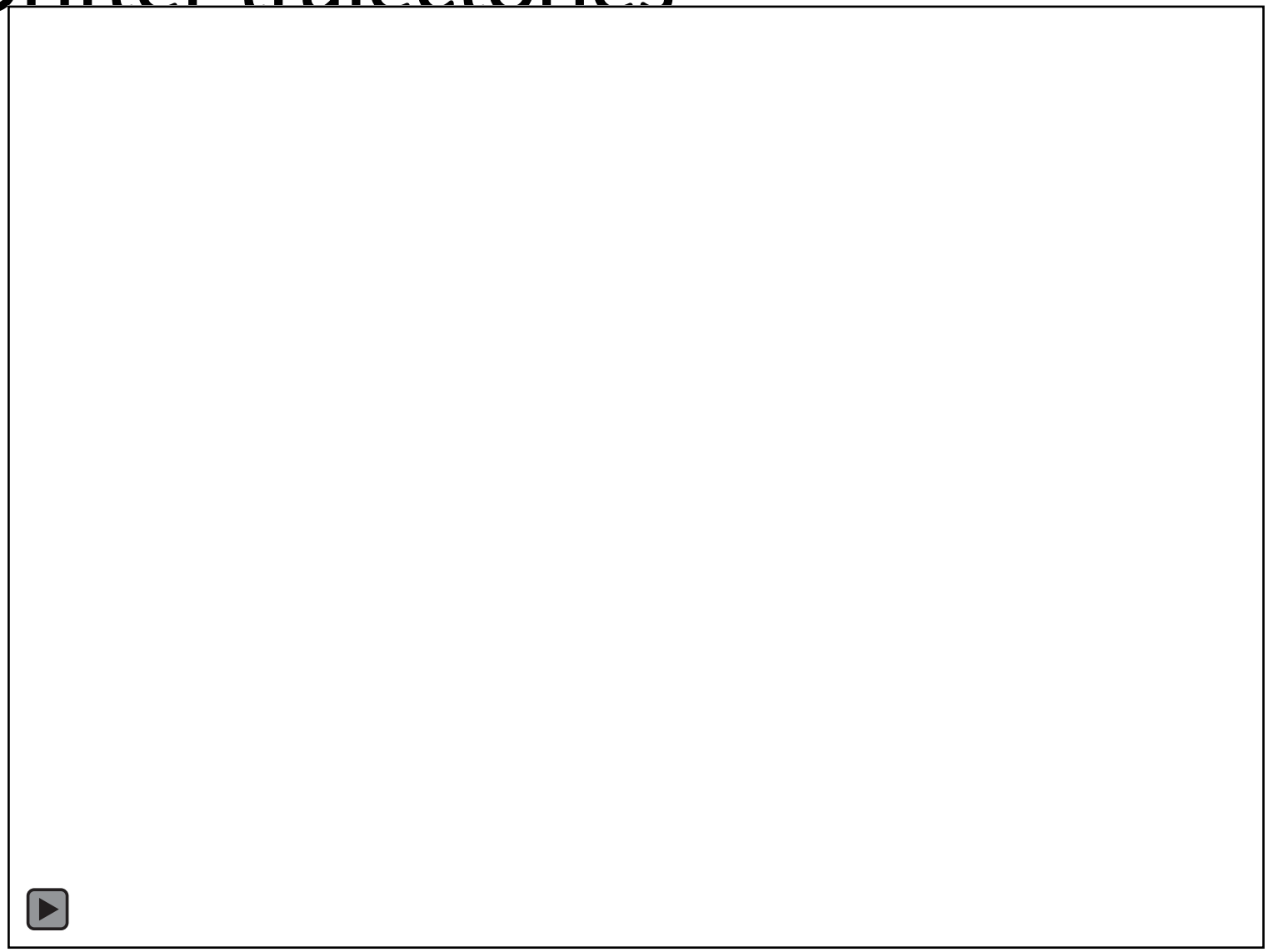
Drifter trajectories

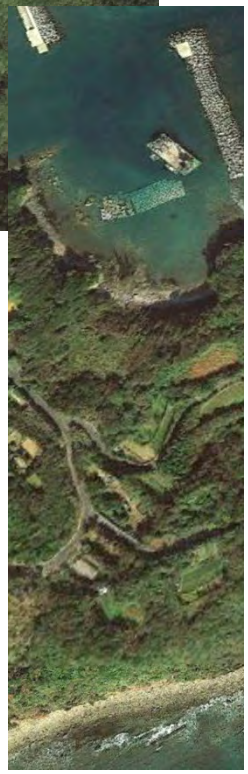


Rotary power spectra



Drifter trajectories





Tsushima island beach garbage

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Videos

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TheBusanilbo 'Btube'
YouTube - May 30, 2013

부산 대학생들 10년째 일본 쓰시마서 쓰레기 정화 활동

TheBusanilbo 'Btube'
YouTube - Oct 10, 2012

쓰시마~부산 고속선 파도에 앞유리 깨져 / YTN (Yes! Top News)

YTN NEWS
YouTube - Dec 27, 2016

Images for 쓰시마섬 해변 쓰레기

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Oct 9, 2007 - 동아대는 지난 7일 일본 대마도 **해변**에서 일본 대학생들과 환경정화활동 ... 과 더 가까운 섬으로 해마다 해류를 타고 한국서 떠내려온 **쓰레기**로 몸살 ...

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'쓰레기 청소 14년, 일본인 마음 얻었죠' - 부산일보

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May 22, 2016 - 이처럼 일본 **쓰시마섬**까지 떠내려간 해양 **쓰레기**를 치우기 위해 14년째 ... 는 "매년 한국 학생들이 **쓰시마섬**으로 와 **해변** 청소를 벌인다는 것을 알고, ...

'10년째 쓰시마섬에서 우리 쓰레기 청소' - 부산일보

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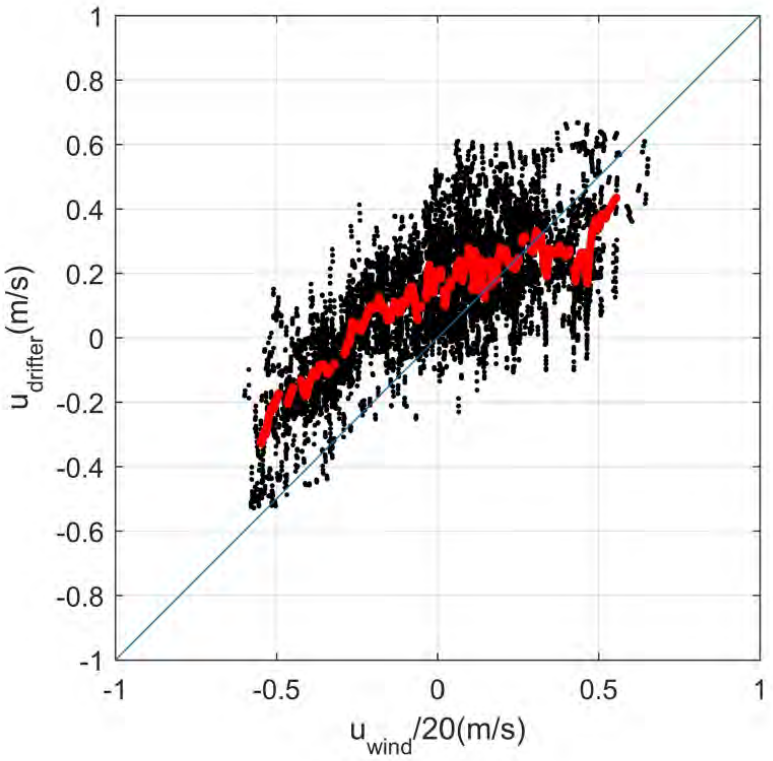
Oct 9, 2012 - "10년째 일본에서 우리 **쓰레기**를 치워 뿌듯하네요. ... 자발적으로 청소 봉사에 참여한 부산외대 학생 70여 명은 **해변**에서 무려 150t의 **쓰레기**를 수거했다. ... **쓰시마** 인구가 4만여 명에 불과하고, **쓰레기**를 섬 내에서 자체적으로 소각할 ...

"쓰시마로 떠내려간 한국쓰레기 치워요" -동아일보 ... - 쓰시마 부산사무소

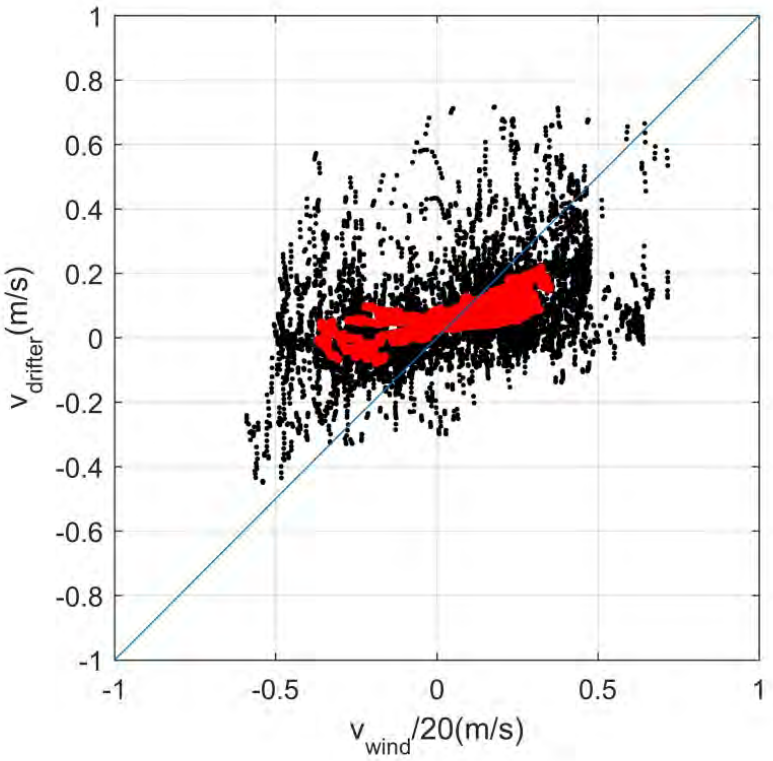
Wind velocity vs. drifter velocity

Drifter speed

Easat-West component



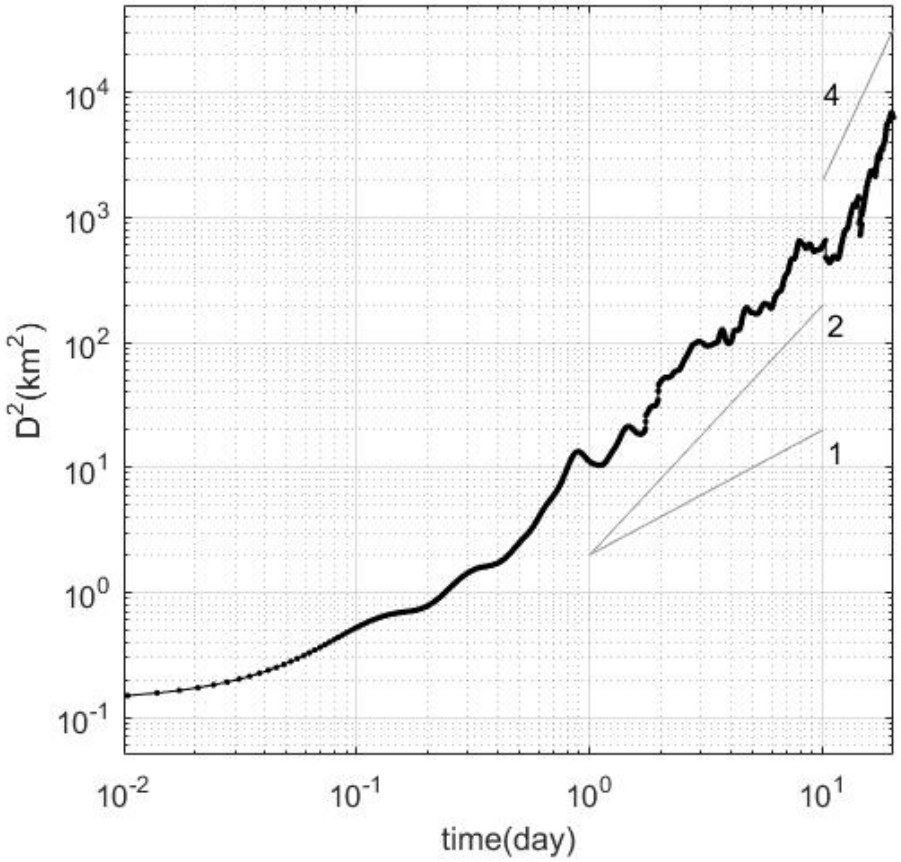
North-South component

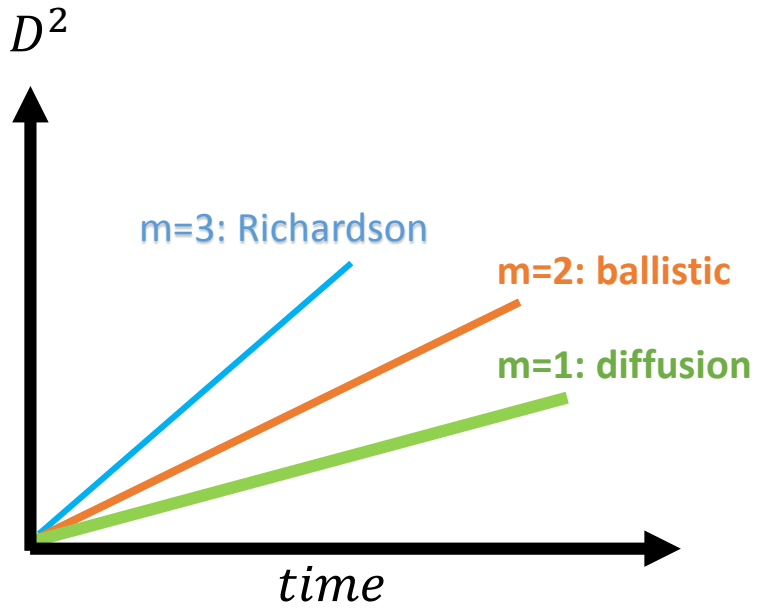


Wind speed

Relative dispersion D^2

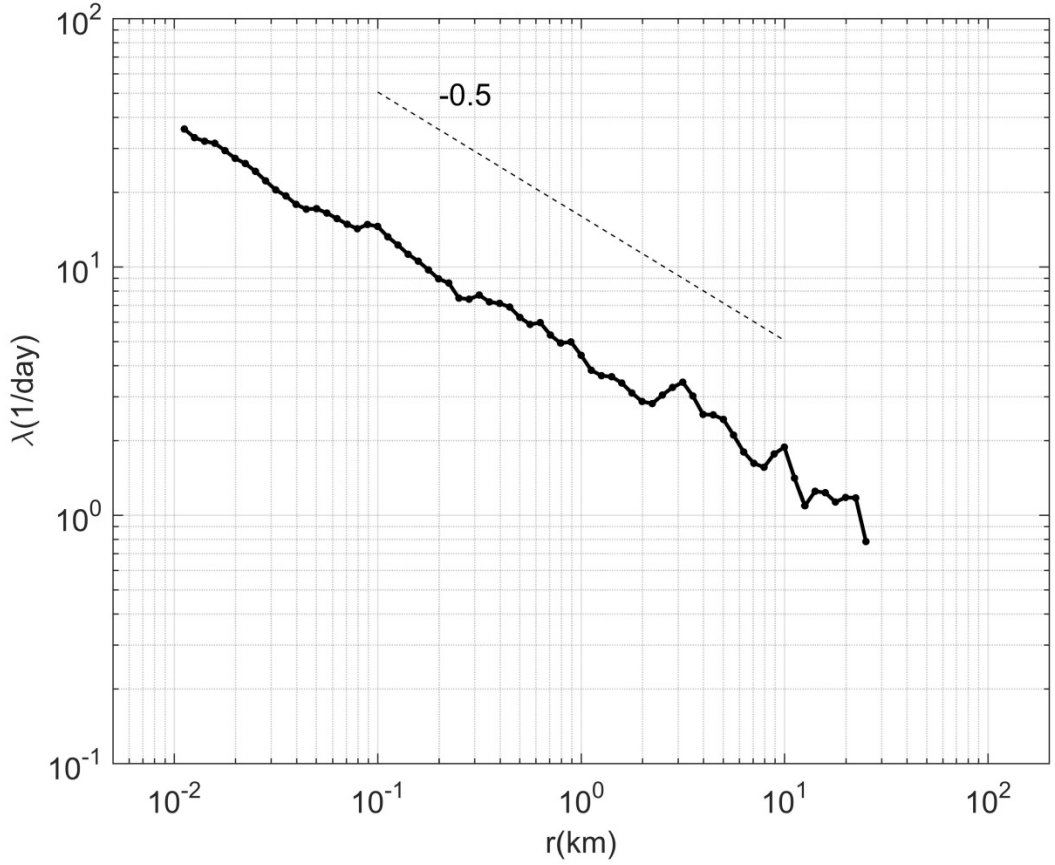
- $D^2(t) = \left\langle [x_i - x_j]^2 \right\rangle$ x_i: locations of particles i and j at time t





Finite Size Lyapunov Exponent λ (FSLE)

Using data for first 5 days



$$\lambda(\delta) = \frac{1}{\log(\alpha)} \left\langle \frac{1}{T} \right\rangle$$

δ: separation distance

α: constant (=1.2)

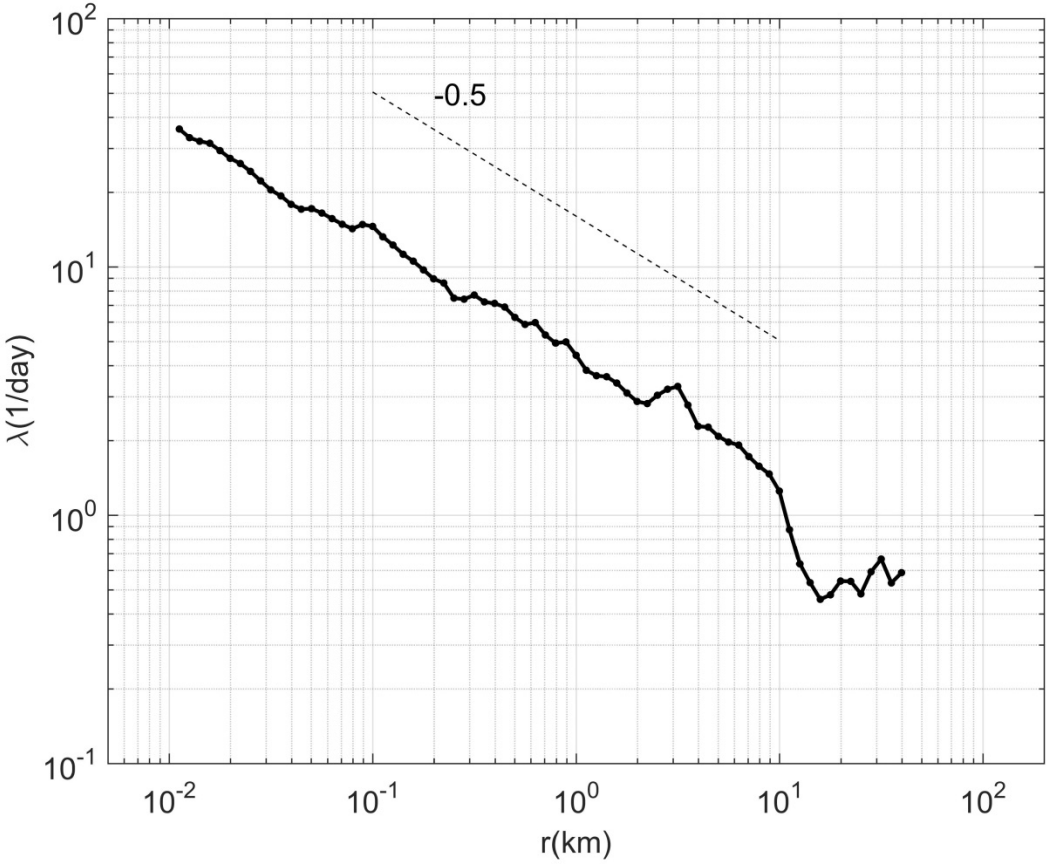
T: average time that two particles take to separate from δ to $\alpha\delta$

m	disperion
-2	Diffusion
-1	Shear
-2/3	Richardson
-1/2	Submesoscale
0	exponential

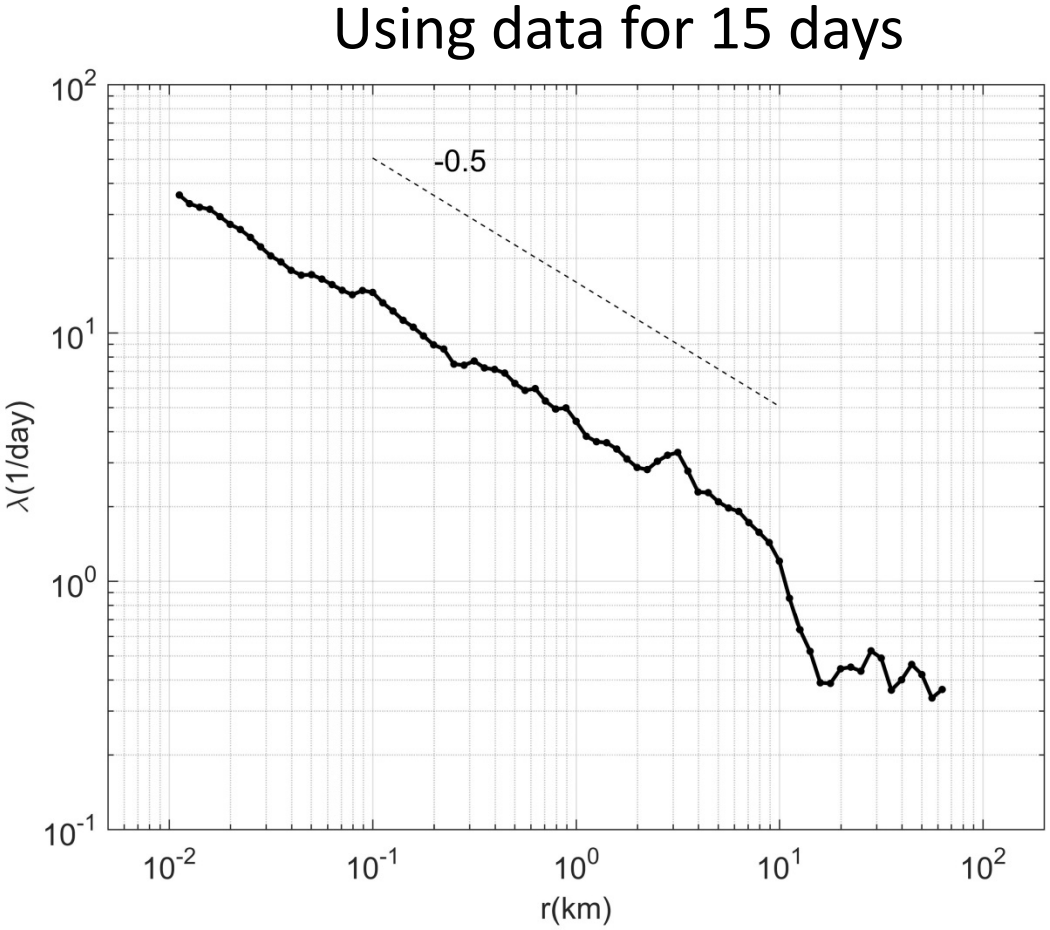
McWilliams 2016

Finite Size Lyapunov Exponent (FSLE)

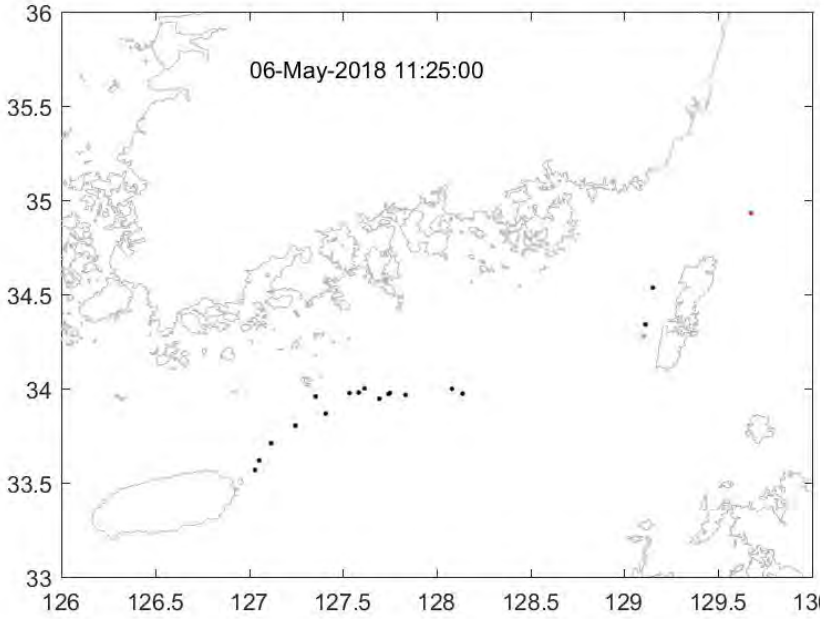
Using data for first 10 days

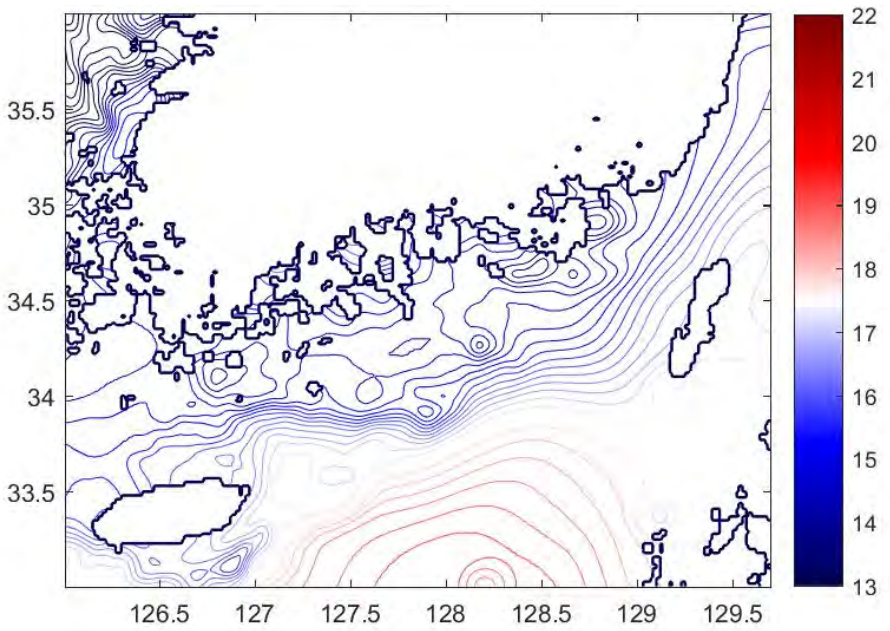


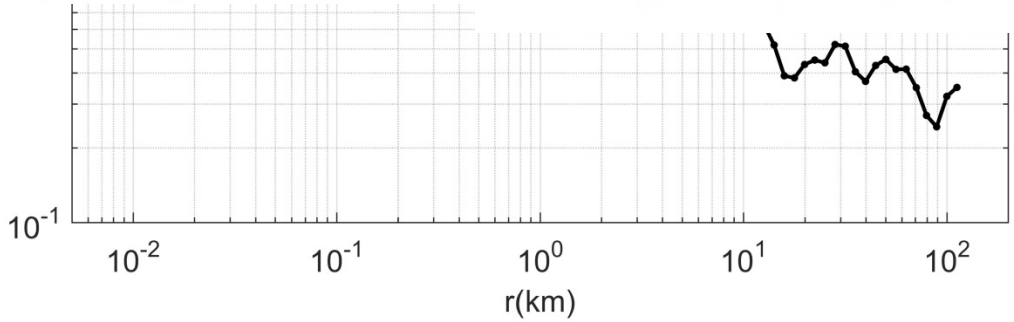
Finite Size Lyapunov Exponent (FSLE)



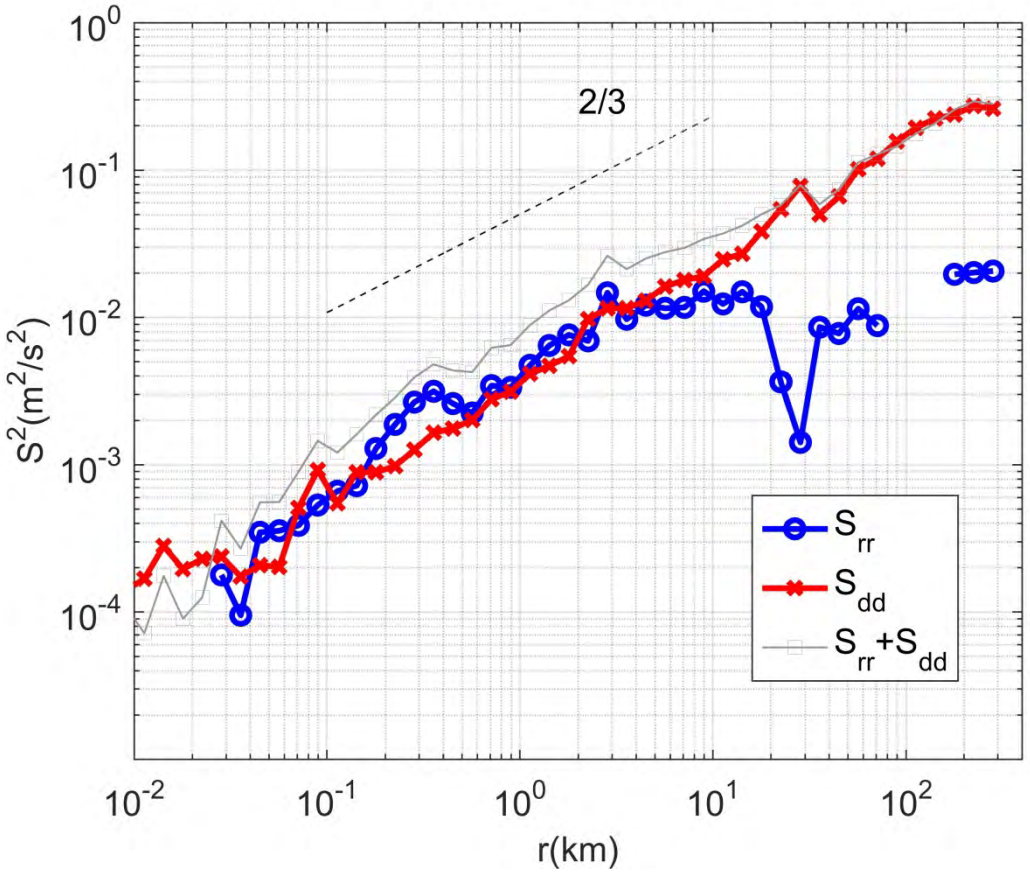
Finite Size Lyapunov Exponent (FSLE)







Velocity 2nd order structure function



$$D_L^n(r) = \left[(\underline{u}(\underline{x}+\underline{r}) - \underline{u}(\underline{x})) \cdot \underline{\hat{r}}\right]^n$$

where *n* is an order, $\hat{r}$ is a unit vector, *u* is east-west velocity, and *r* is a separation vector between two points

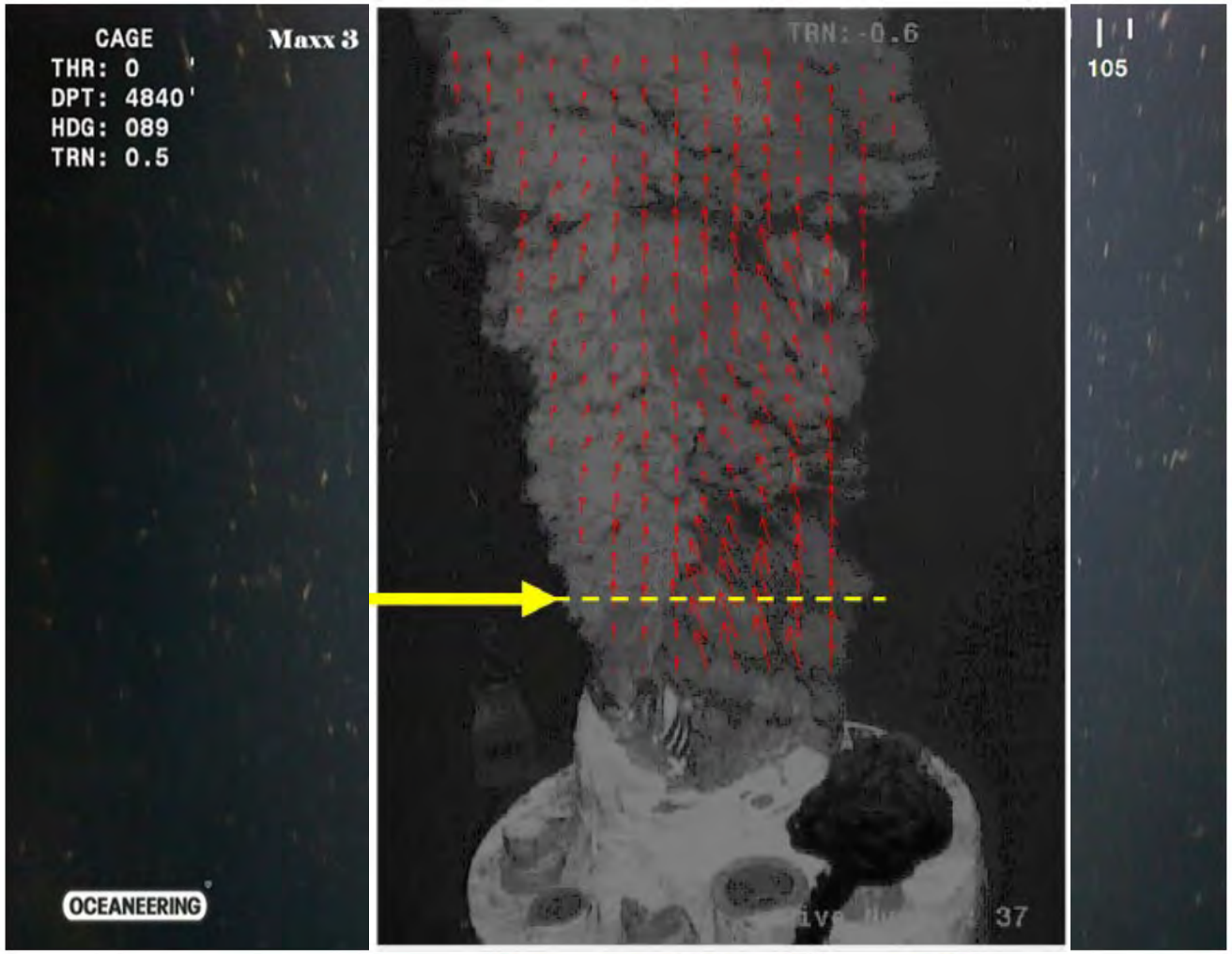
Helmholtz decomposition to decompose 2nd order velocity structure function to divergent and rotational components (Bu¨hler et al. (2014)

Submesoscale observation from ge ostationary satellite

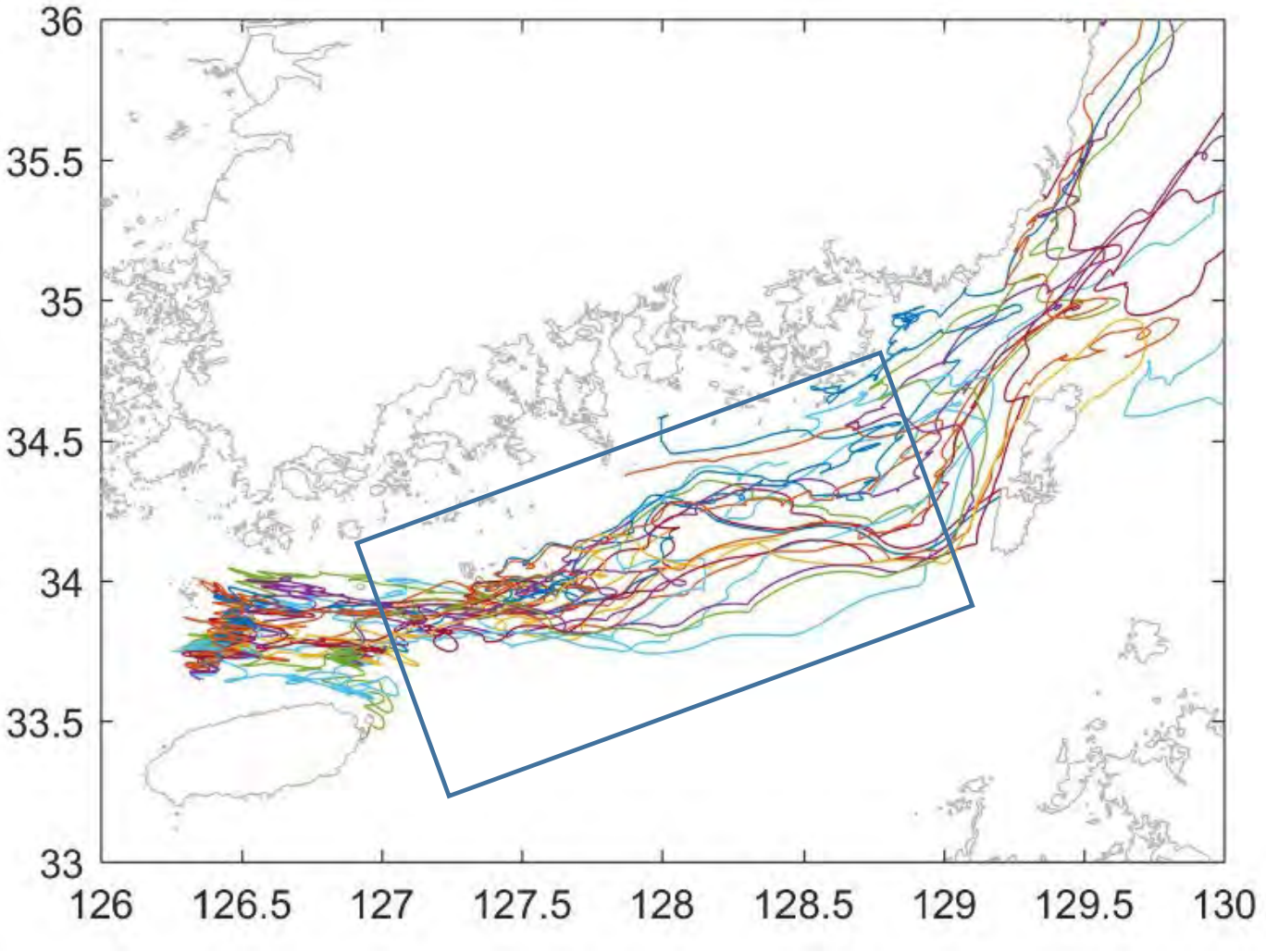
- Scalar tracers such as SST and Chla have been used to deriv e the surface current through maximum cross correlation method (Emery et al. 1986; Zavialov et al. 2002; Yang et al. 2014; Kim et al. 2016; Park et al. 2018).
- We used a similar method called the Particle Image Veloci metry (PIV) to derive the surface velocity field.
  - PIV matlab code (PIV lab, Thielicke and Stamhuis 2014)
  - Chl concentration (hourly, 500m resolution) on 4/19 an d 5/4 is used to determine velocity field.
  - Need strong Chl signal and no cloud

Derivation of velocity field - Particle Image Velocimetry (PIV)

- https://www.youtube.com/watch?v=IPpKZx854VQ

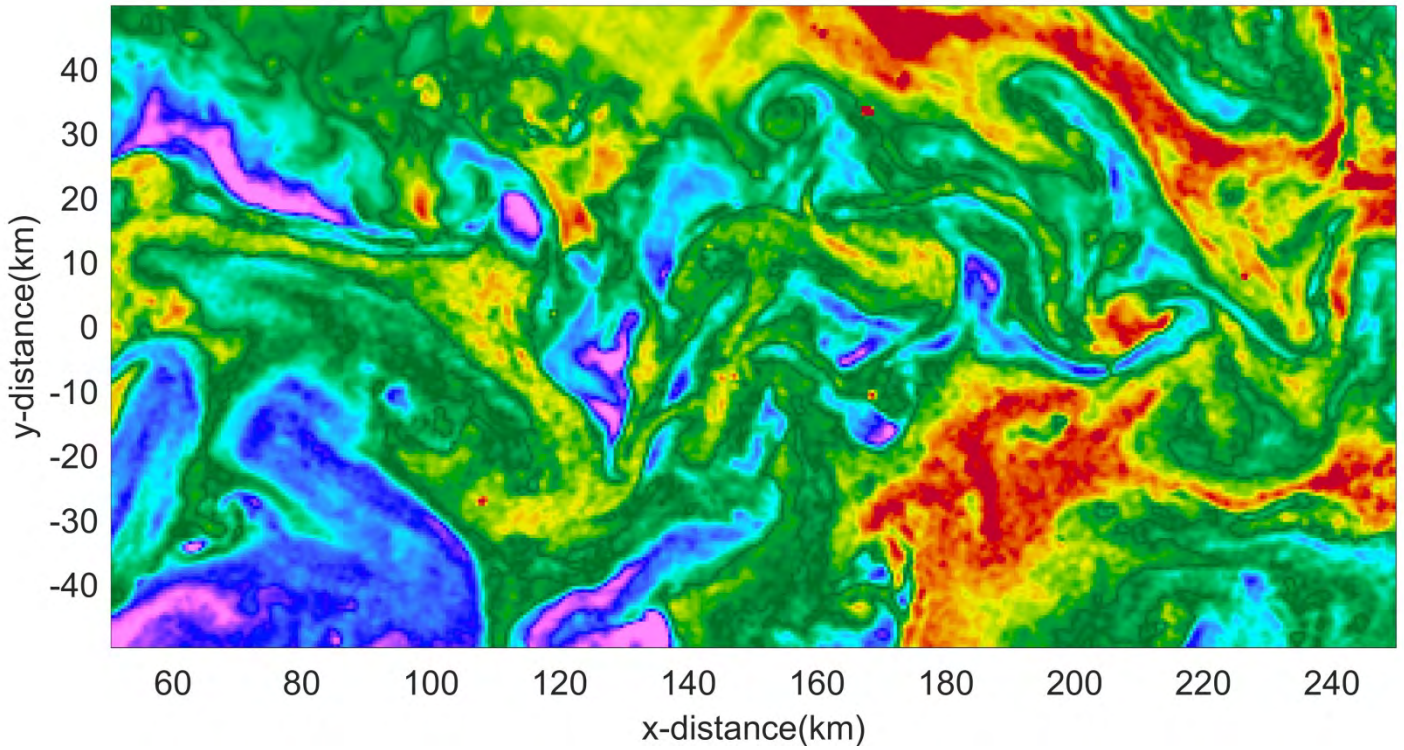


PIV velocity field (4/19 & 5/4)



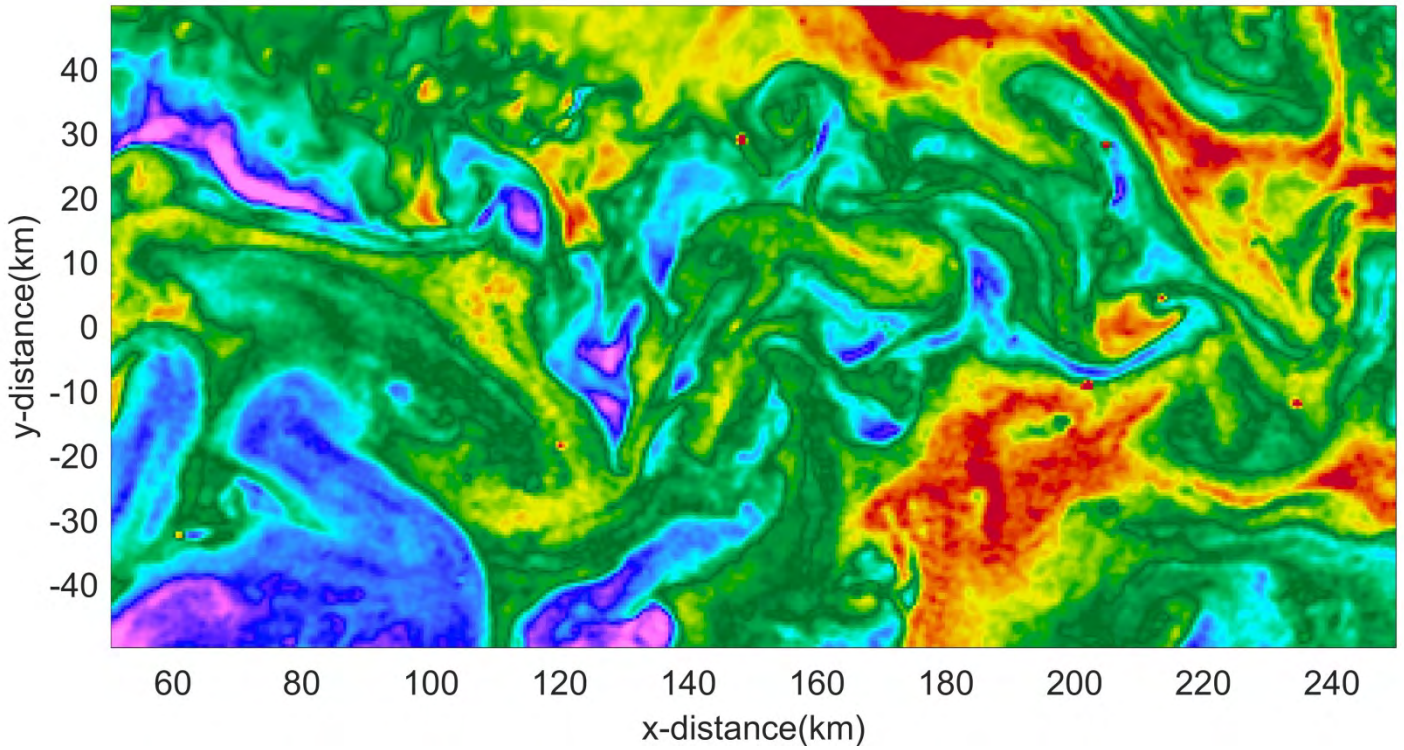
GOCI Chla in 4/19/2018

Log scaled

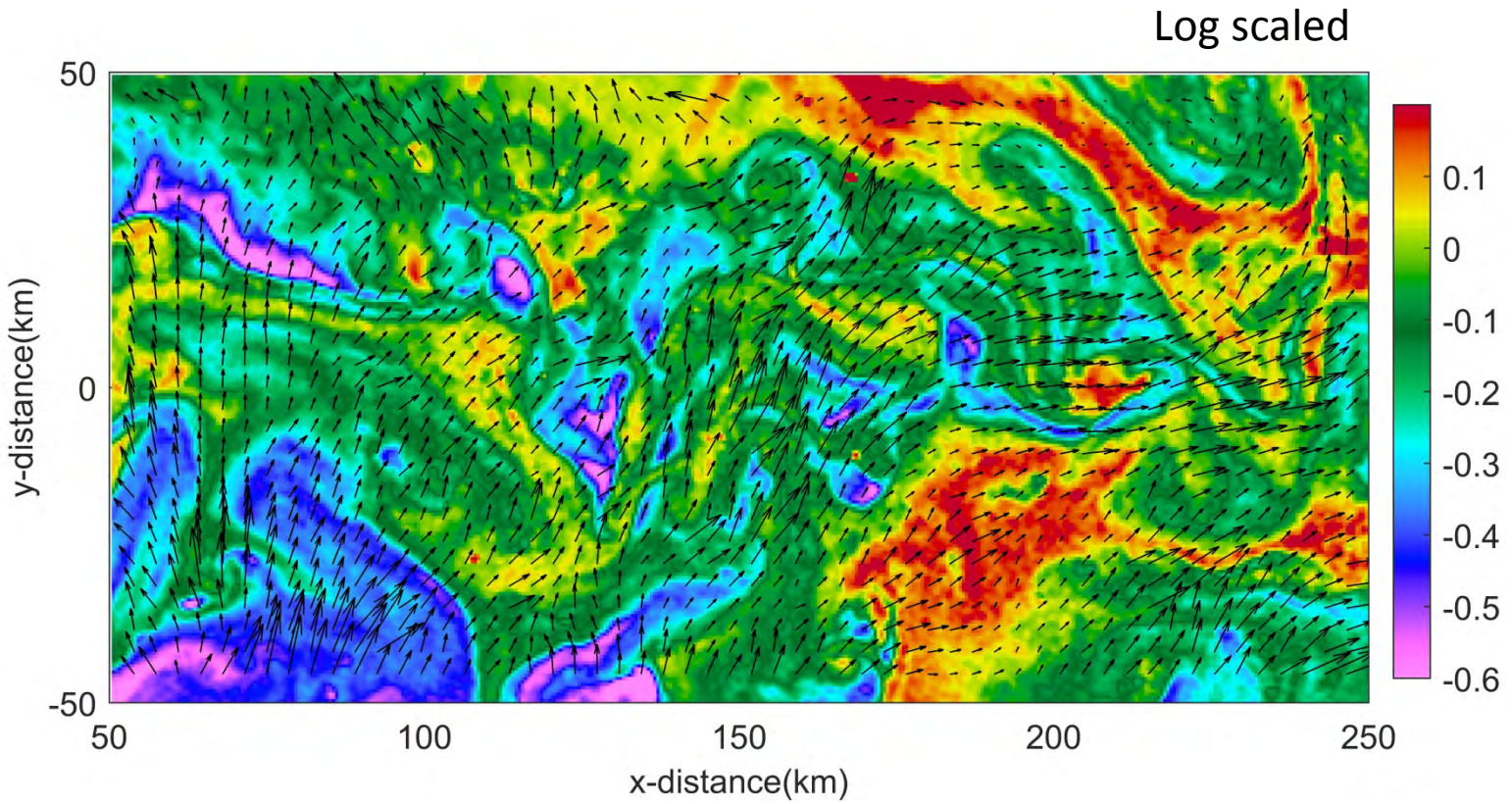


GOCI Chla in 4/19/2018

Log scaled

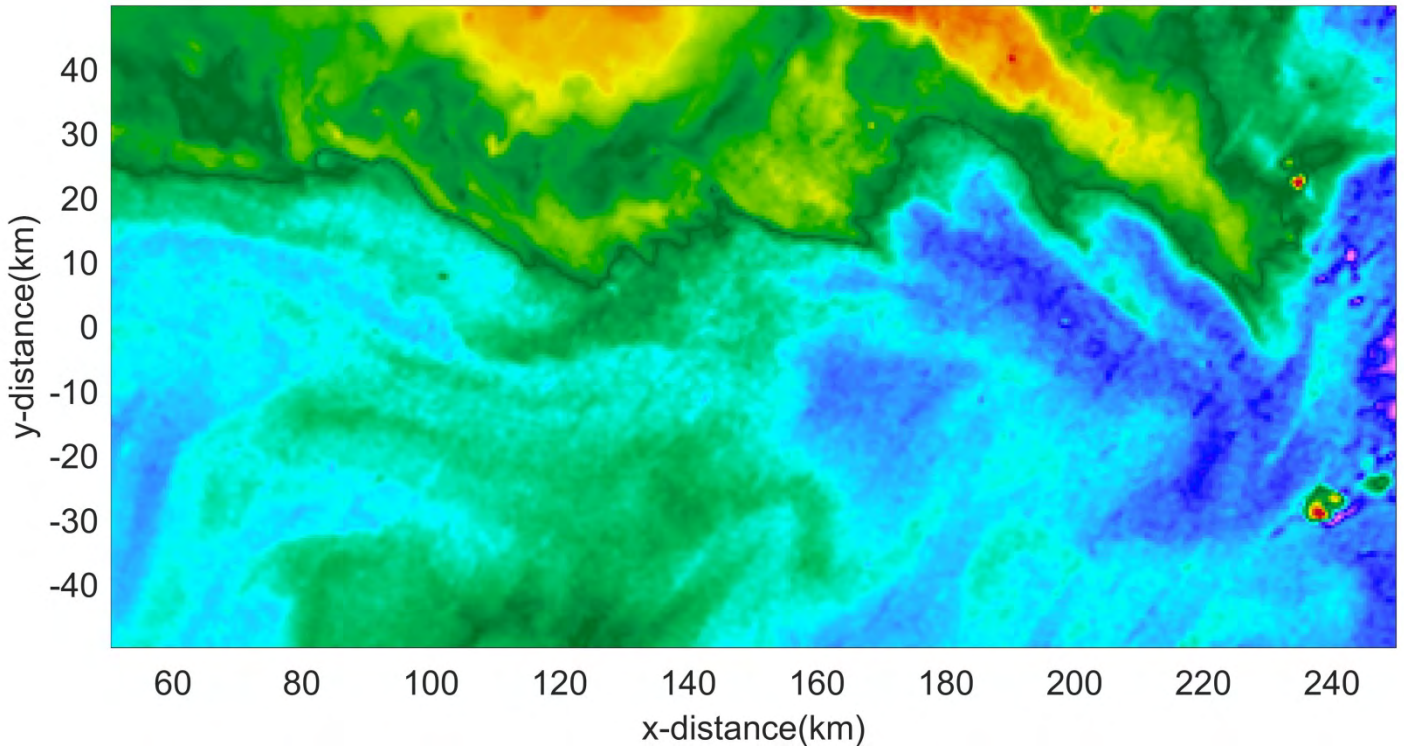


Near-surface current in 4/19/2018



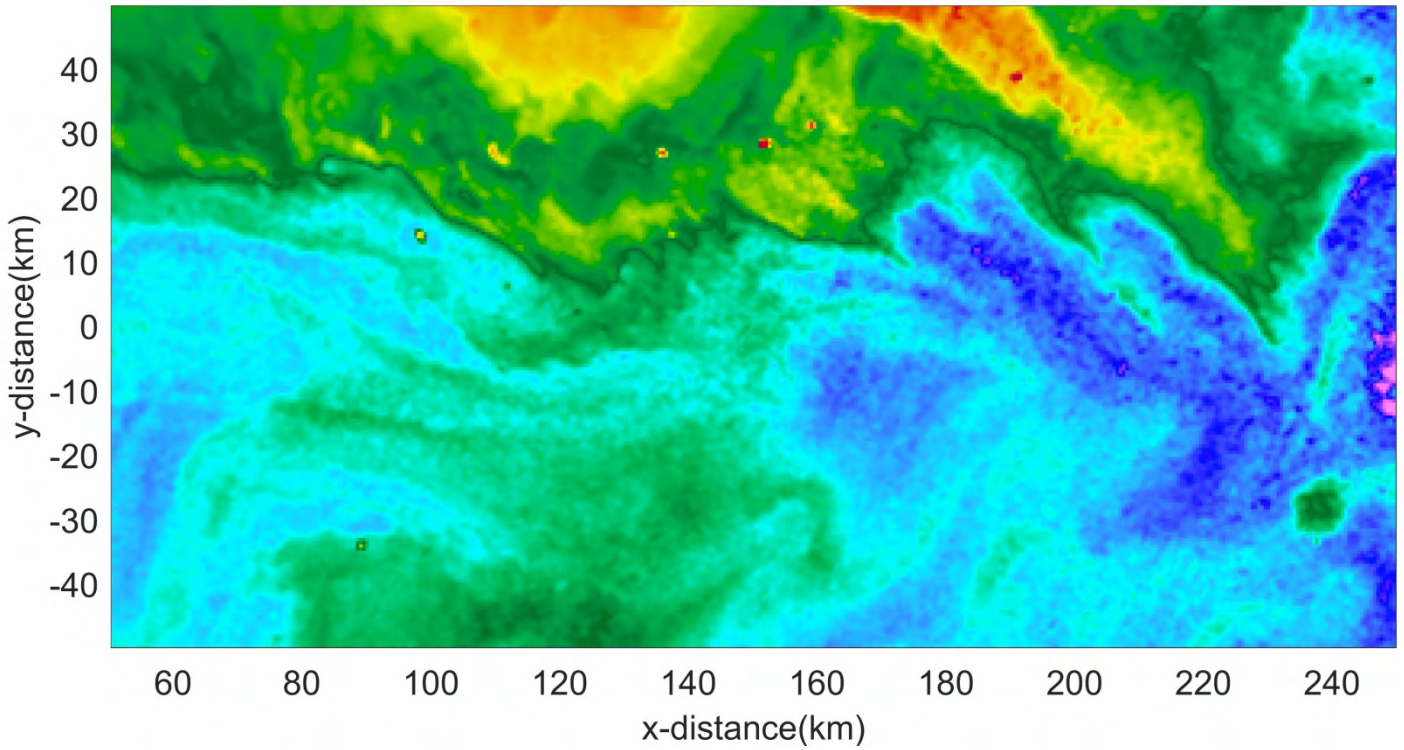
GOCI Chla in 5/4/2018

Log scaled

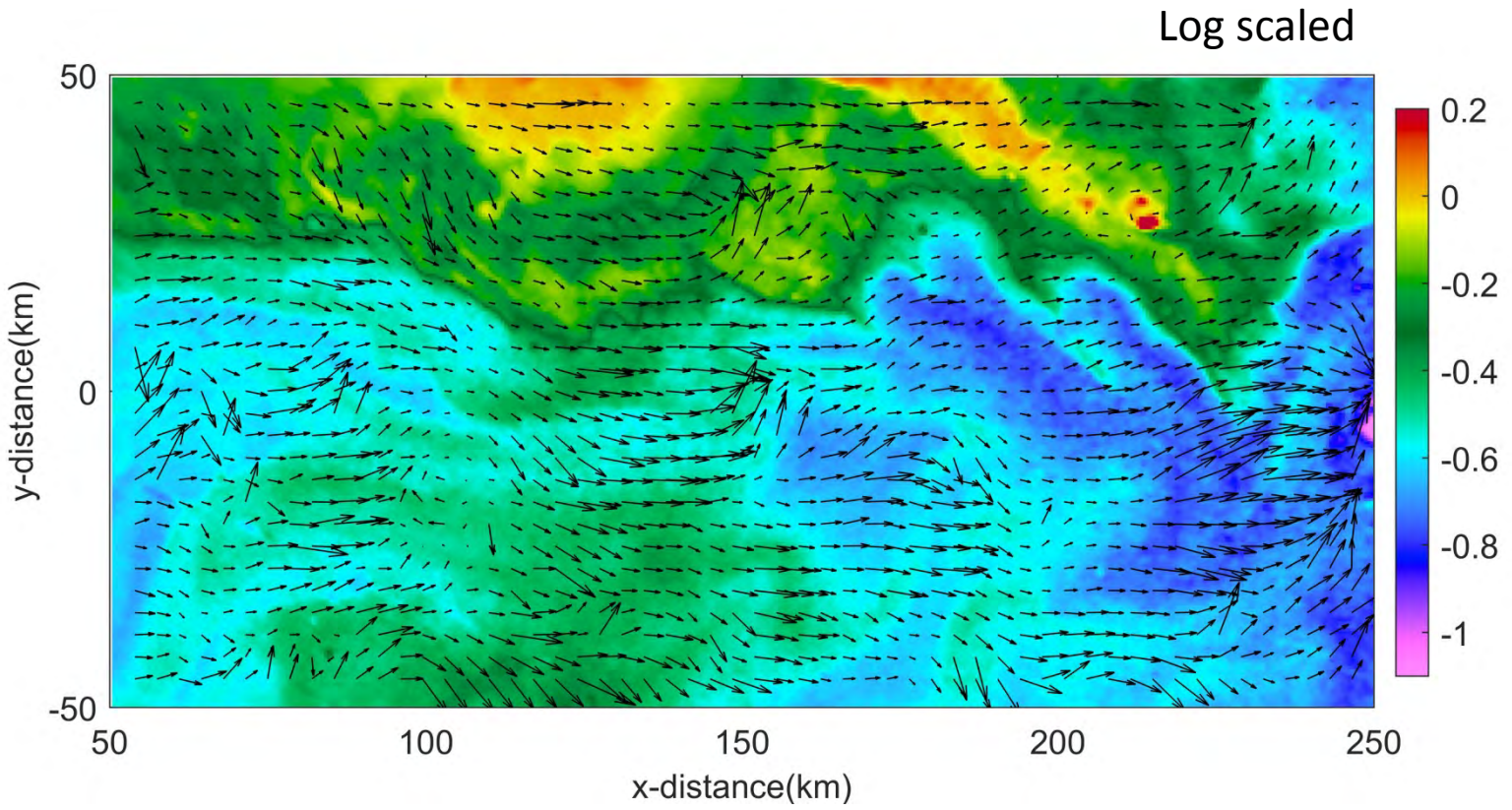


GOCI Chla in 5/4/2018

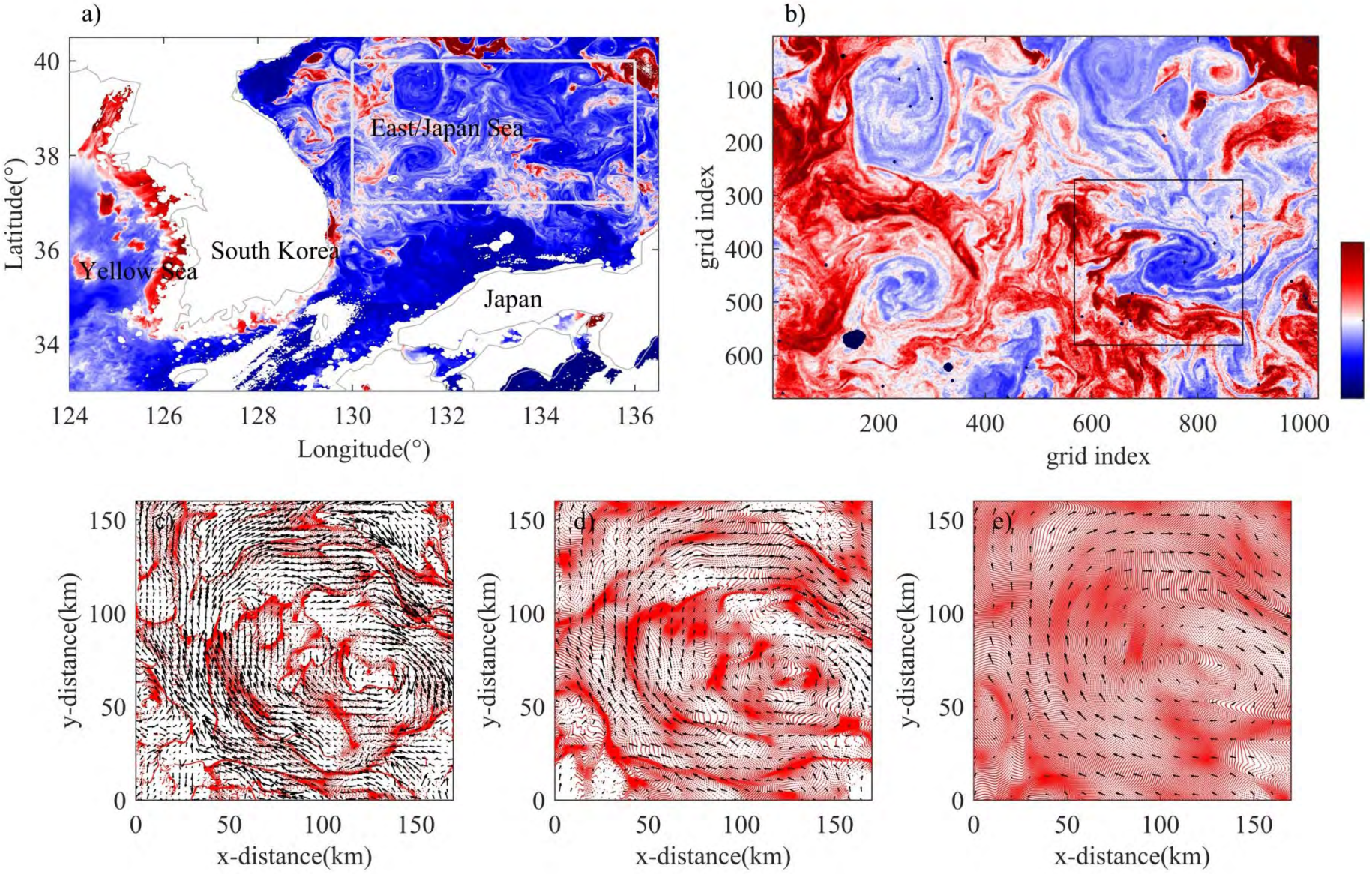
Log scaled



Near-surface current in 5/4/2018



Surface current in the East/Japan sea in 4/5/2011



Summaries

- Submesoscale observations were conducted by drifter experiment and geostationary satellite in the Korea Strait in April
- Strong semidiurnal and diurnal variabilities found in the drifter trajectories. Strong temperature gradient was found along the Korea Strait.
- We found two dispersion stages:
  - In the Jeju strait, strong semidiurnal tidal forcing resulted in $D^2 \sim t^2$ and $\lambda \sim r^{1/2}$
  - In the Korea Strait, strong mean current with temperature gradient resulted in $D^2 \sim t^4$ and $\lambda \sim r^0$
- For future works, Lagrangian and Eulerian statistics will be compared.