Comparison between Surface Cyclonic and Anticyclonic Eddies along the Kuroshio in the Northwestern Pacific Ocean

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- Introduction
- Data & methods
- Eddy Analysis
- Summary

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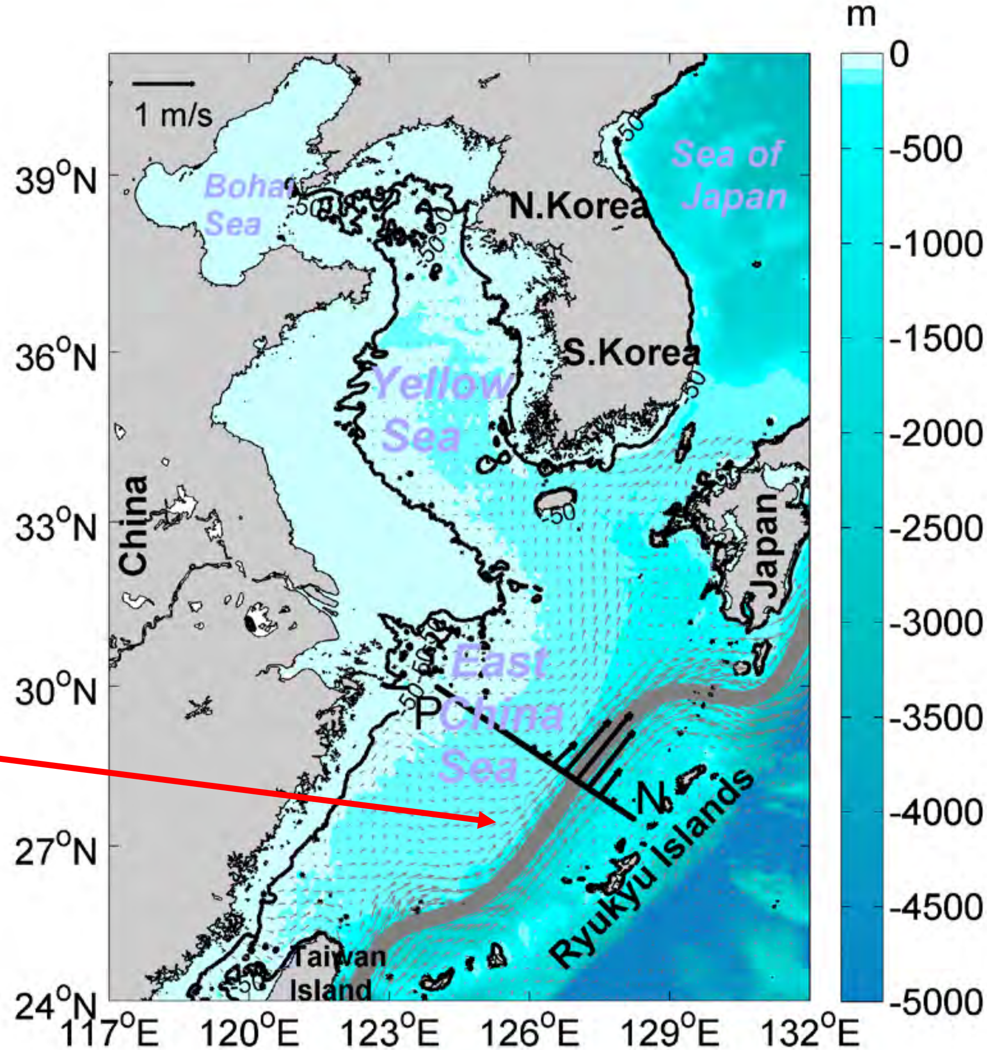
Study Area

117° E-132° E,
24° N-41° N

Excluding the Sea of Japan and waters shallower than 50m.

Kuroshio



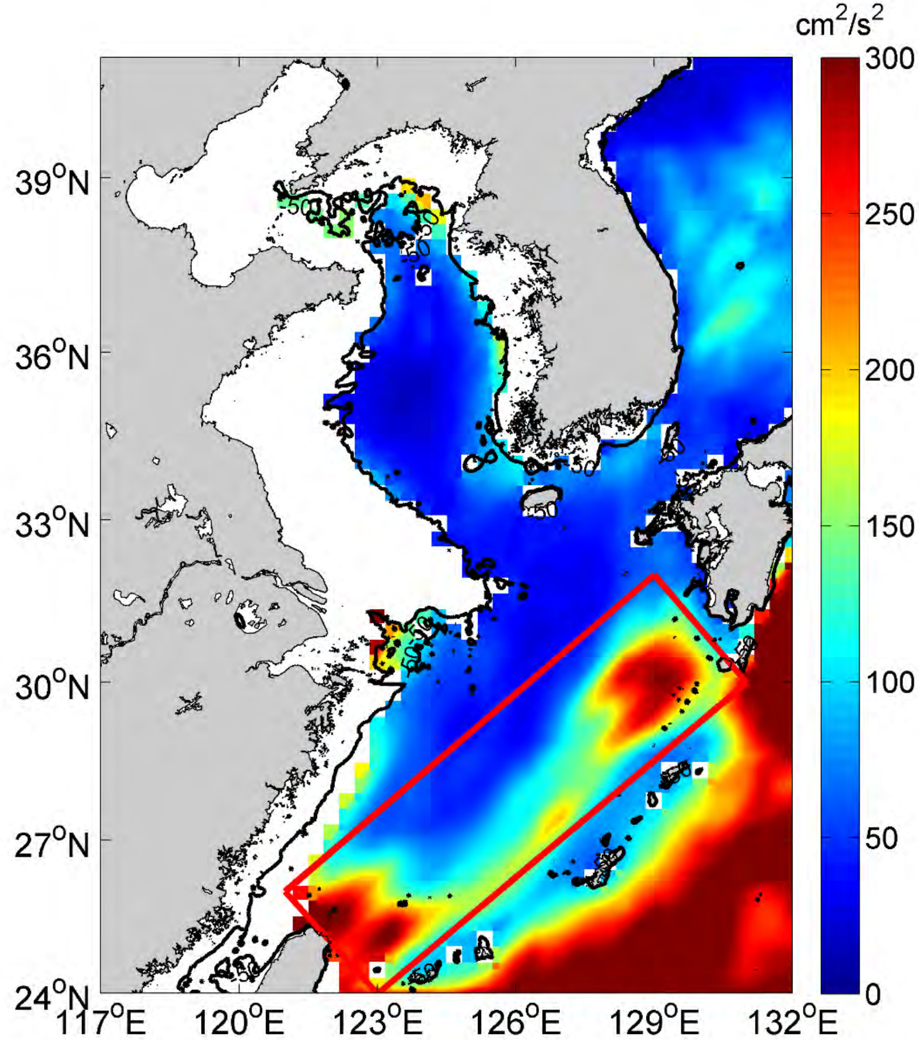
Map of study area.

Eddy Kinetic Energy (EKE)

$$u' = -\frac{g}{f}\left(\frac{\partial h'}{\partial y}\right); v' = \frac{g}{f}\left(\frac{\partial h'}{\partial x}\right),$$

$$EKE = \frac{1}{2}\left(u'^2 + v'^2\right),$$

- ✓ The EKE is calculated from the velocity anomalies with respect to the mean time.
- ✓ A majority of the EKE is contributed by the individual eddies.



Spatial distribution of the 90-day high-passed average EKE over the period of 1993–2010.

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Eddy Data Set

- Time, Location
- Intensity
- Size
- Polarity (cyclonic or anticyclonic)
- Trajectory

From
http://web.atmos.ucla.edu/~cdong/Global_Eddy_Data_SSHA/

Data

- Multiple-satellite-merged SSHA data from AVISO

  1993.1-2010.12, 7 days, 1/3° × 1/3° .
- CCMP sea surface wind vector data

  1993.1-2010.12, 6 hours, 1/4° ×1/4° .

Method

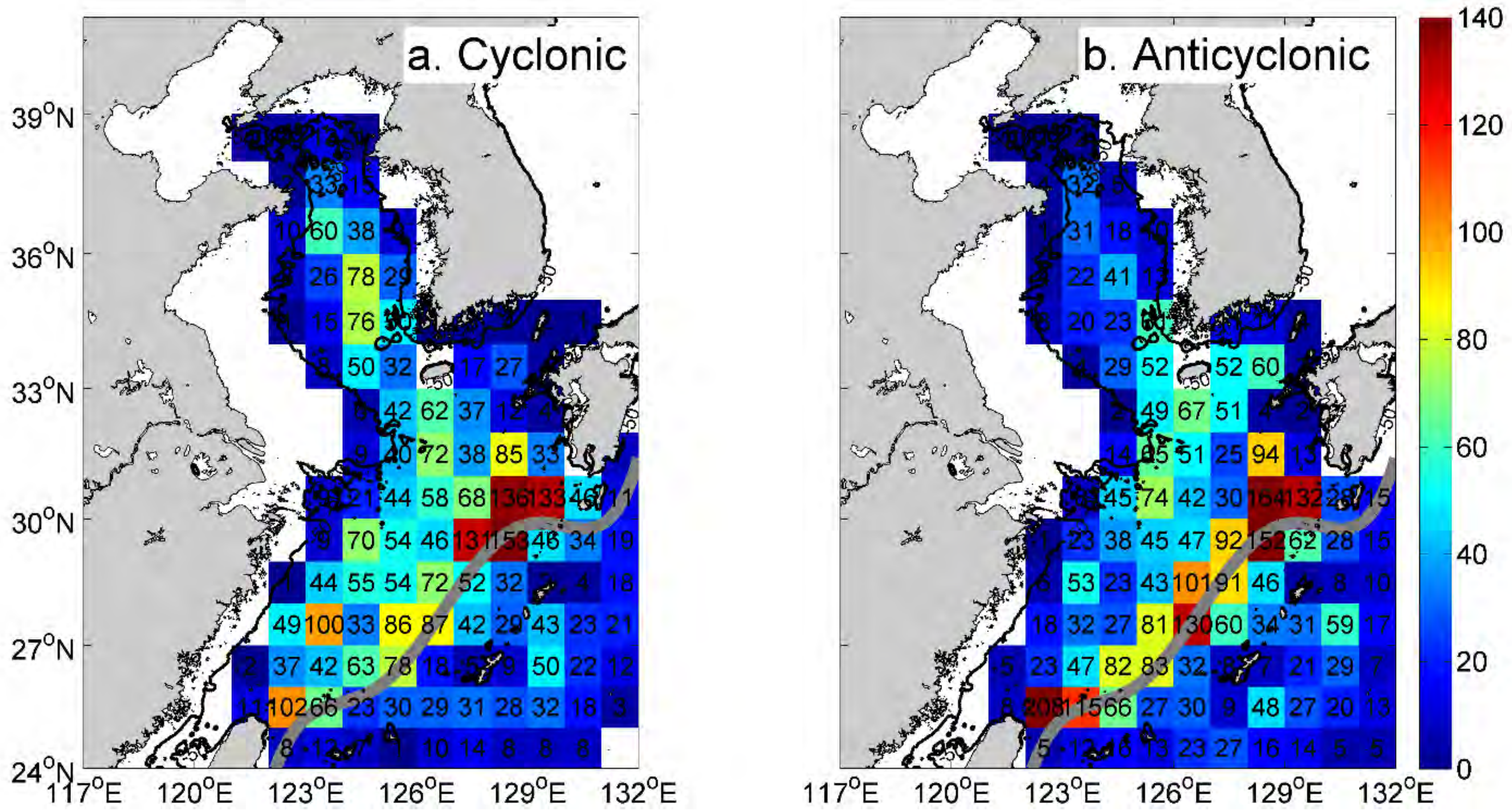
- A velocity geometry-based automated eddy detection scheme

  (Nencioli et al., 2010)

Eddy Analysis

7716 eddies based on each snapshot = 1096 eddy tracks

CEs ≈ AEs

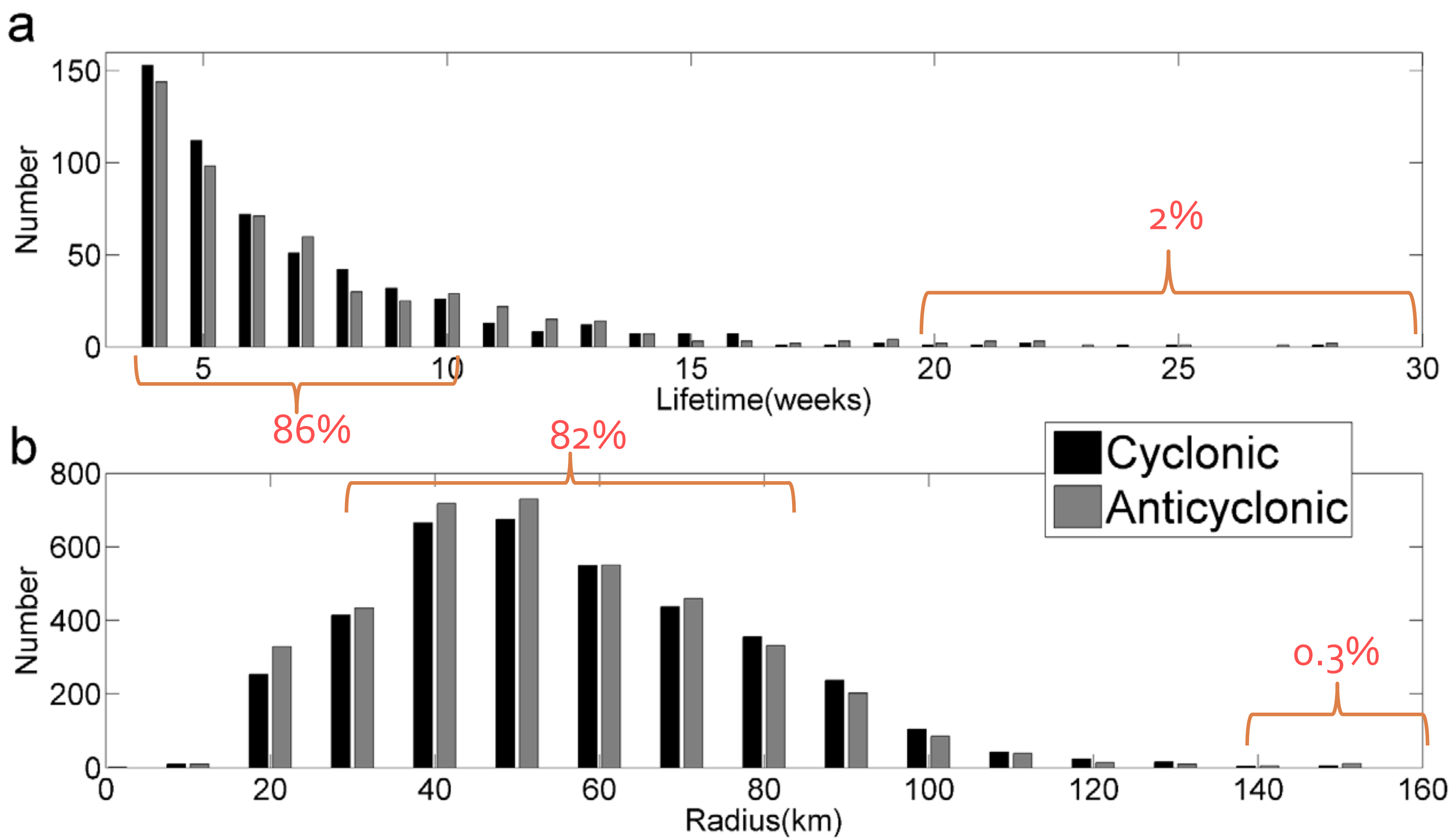


Spatial distribution of average eddy number (lifetime≥4 weeks) over 1° ×1° bins for CEs (a) and AEs (b).

Eddy Analysis

Mean **lifetime** is 6.9 weeks for CEs and 7.2 weeks for AEs.

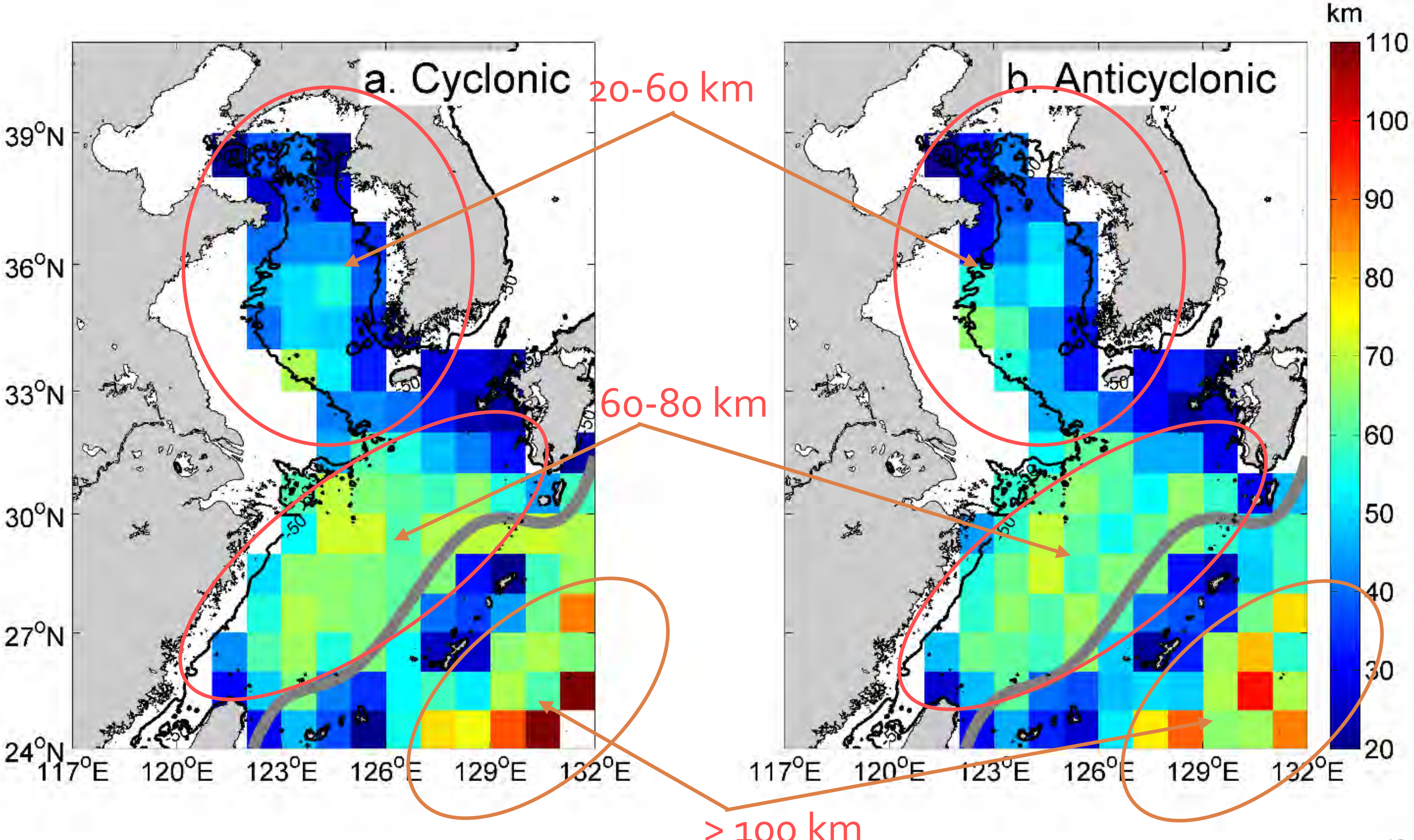
Mean **radius** is 56 km for CEs and 54 km for AEs.



Histograms of (a) eddy lifetime and (b) eddy size (radius, unit: km).

Eddy Analysis

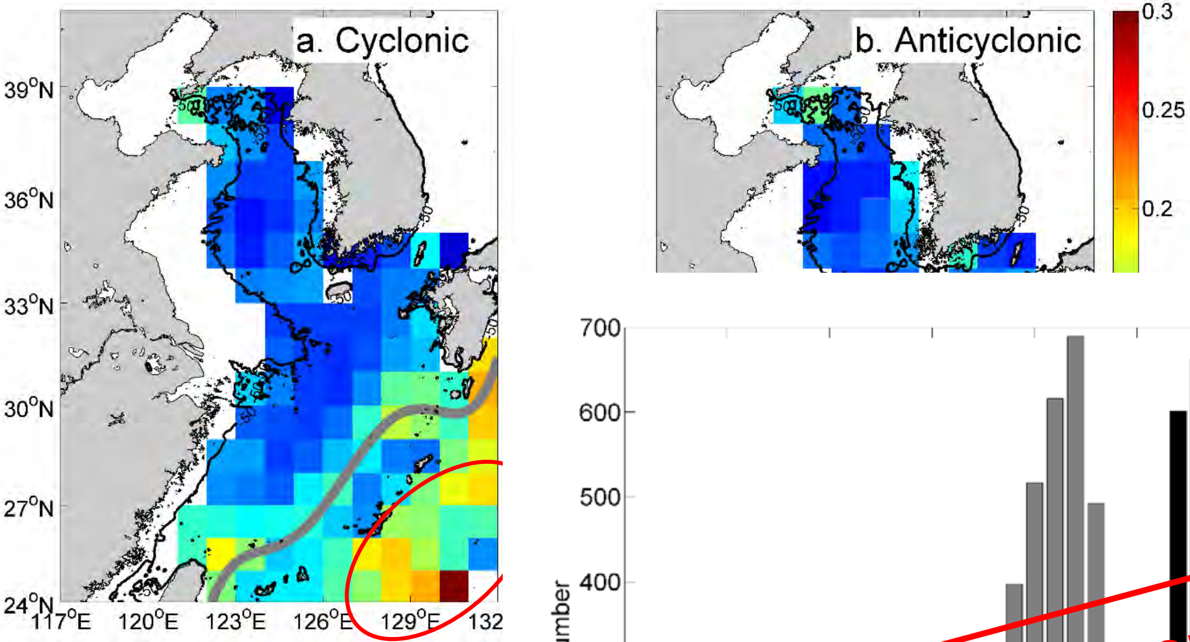
Size: Eddies are much larger east of the Ryukyu Islands than other parts of this region.



Spatial distribution of eddy size (radius, unit: km) for CEs (a) and AEs (b).

Eddy Analysis

<u>Mean **normalized relative vorticity**</u>: 0.1 for CEs and -0.1 for AEs.



Spatial distribution of normalized eddy
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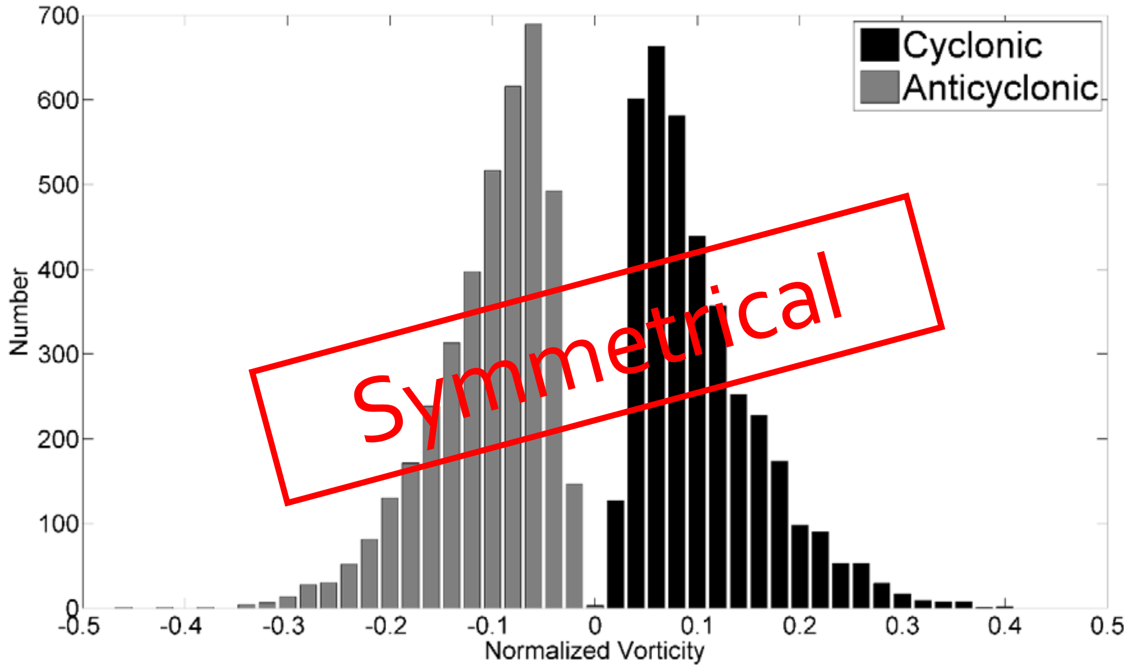
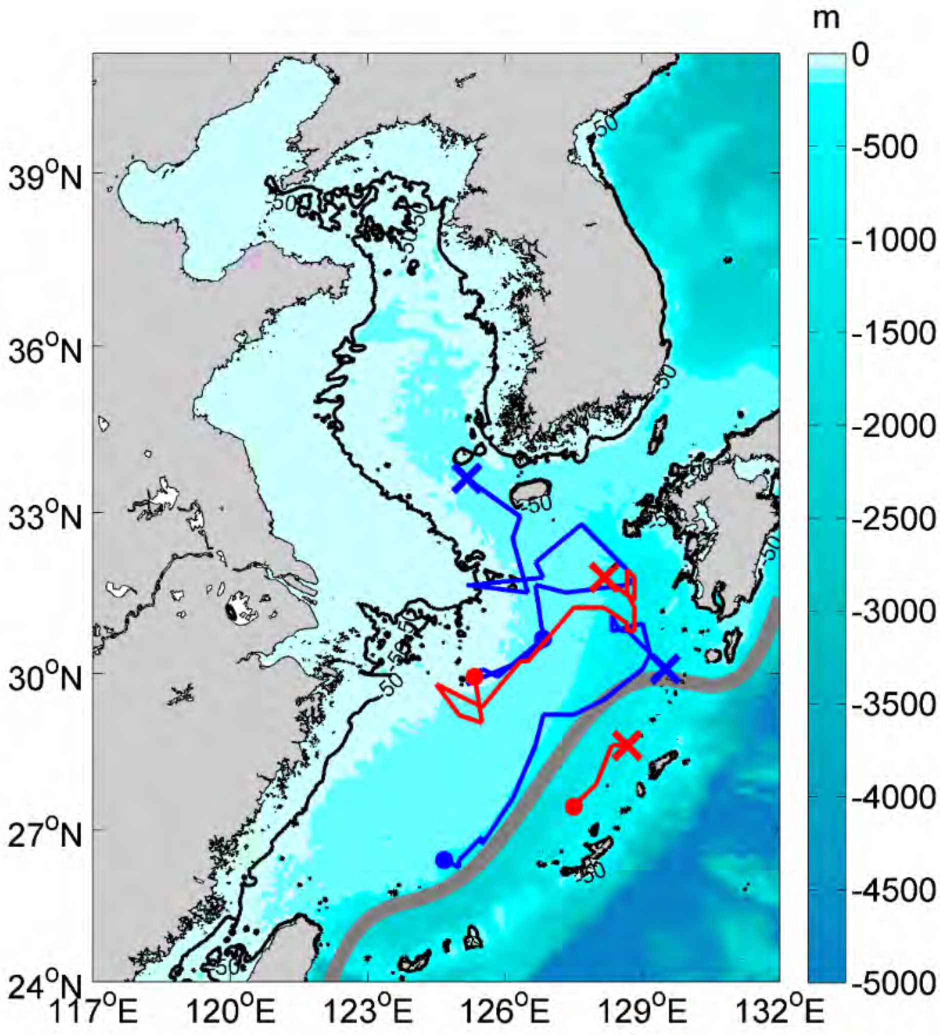


Histogram of normalized eddy relative vorticity (divided by local Coriolis parameter f).

Eddy Analysis

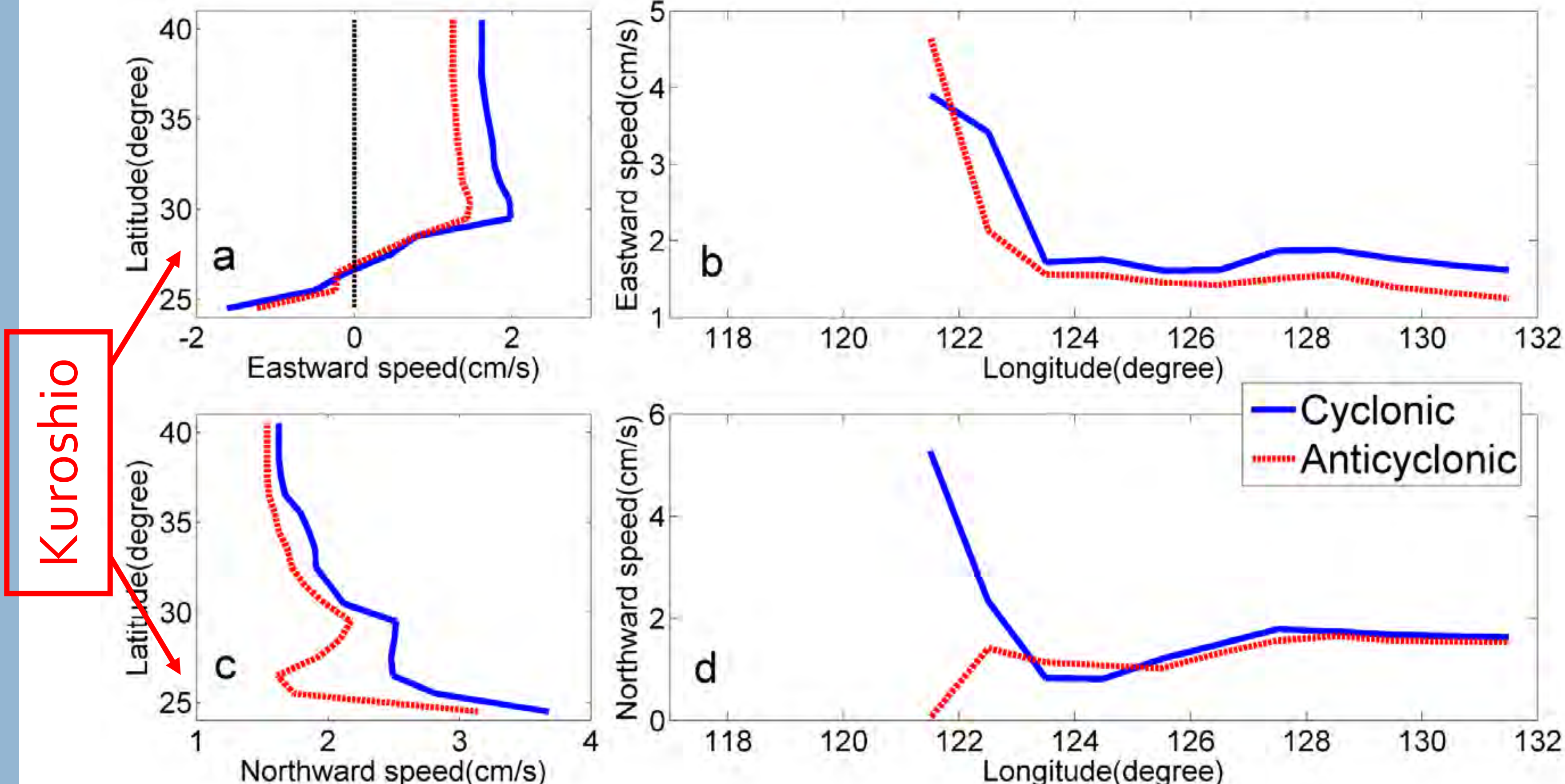


Movement trajectories of four eddies as examples

Eddy Analysis

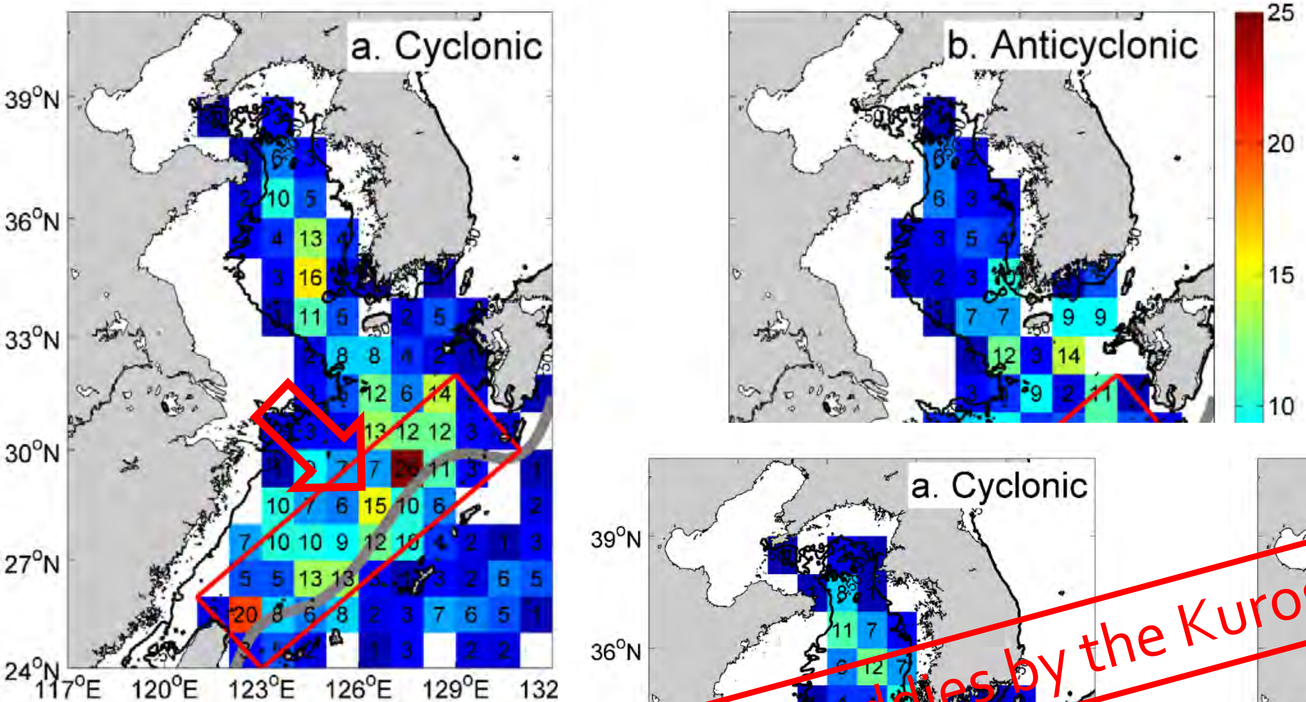
<u>Eddy movement</u> ::Northeast for CEs and AEs.

The eddy movement is most likely due to both the β effect and advection of background current.

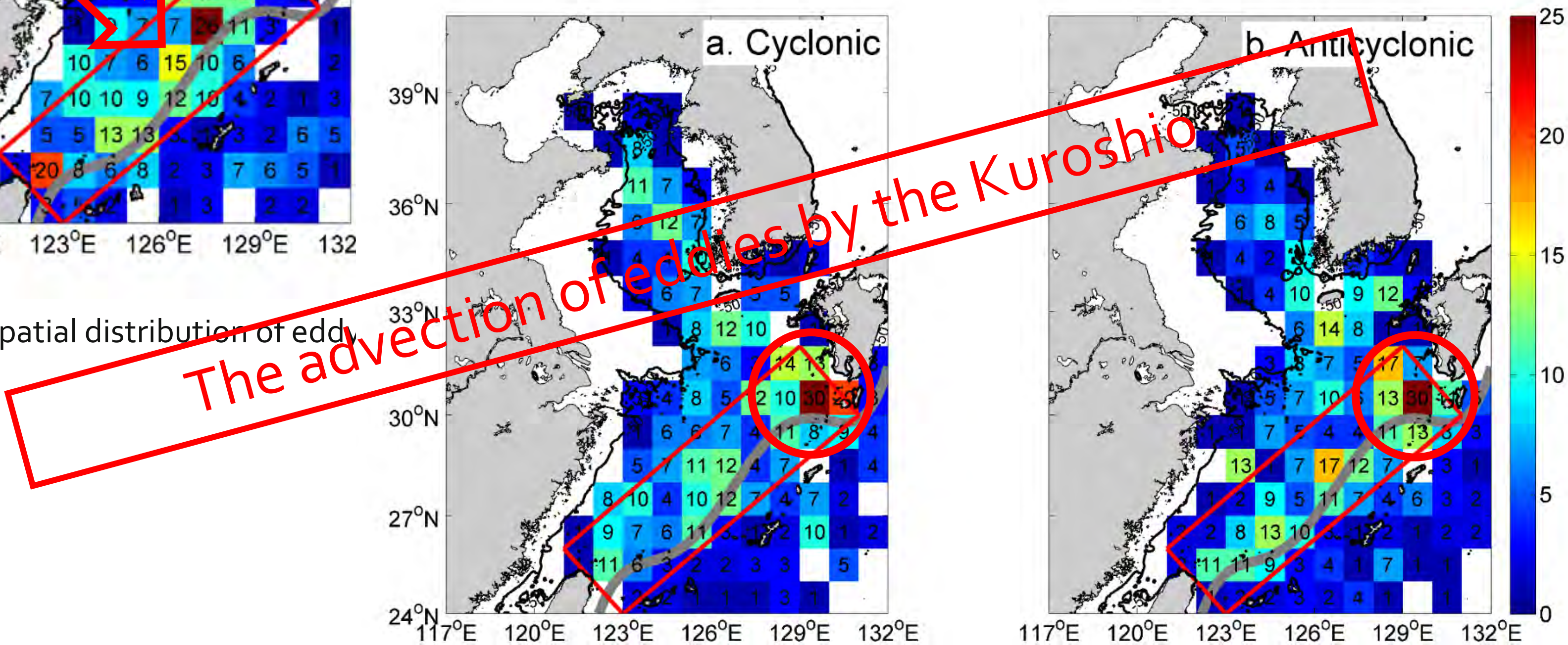


Zonal and meridional average propagation speeds of eddies (lifetime≥4 weeks).

Eddy Analysis



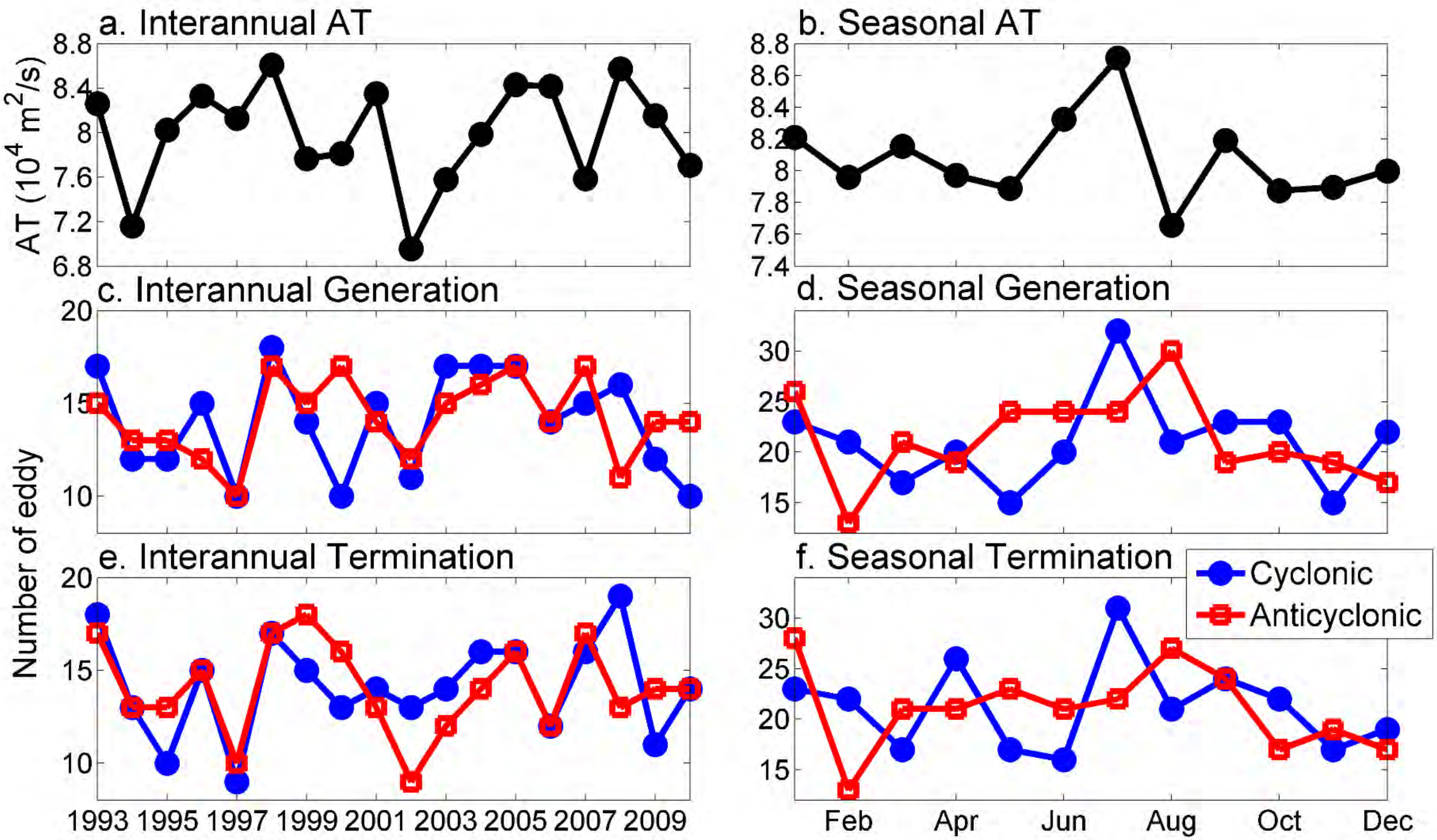
Spatial distribution of eddy



Spatial distribution of eddy termination number (lifetime≥4 weeks).

Eddy Analysis

AT agrees better with the CE generation than the AE generation.

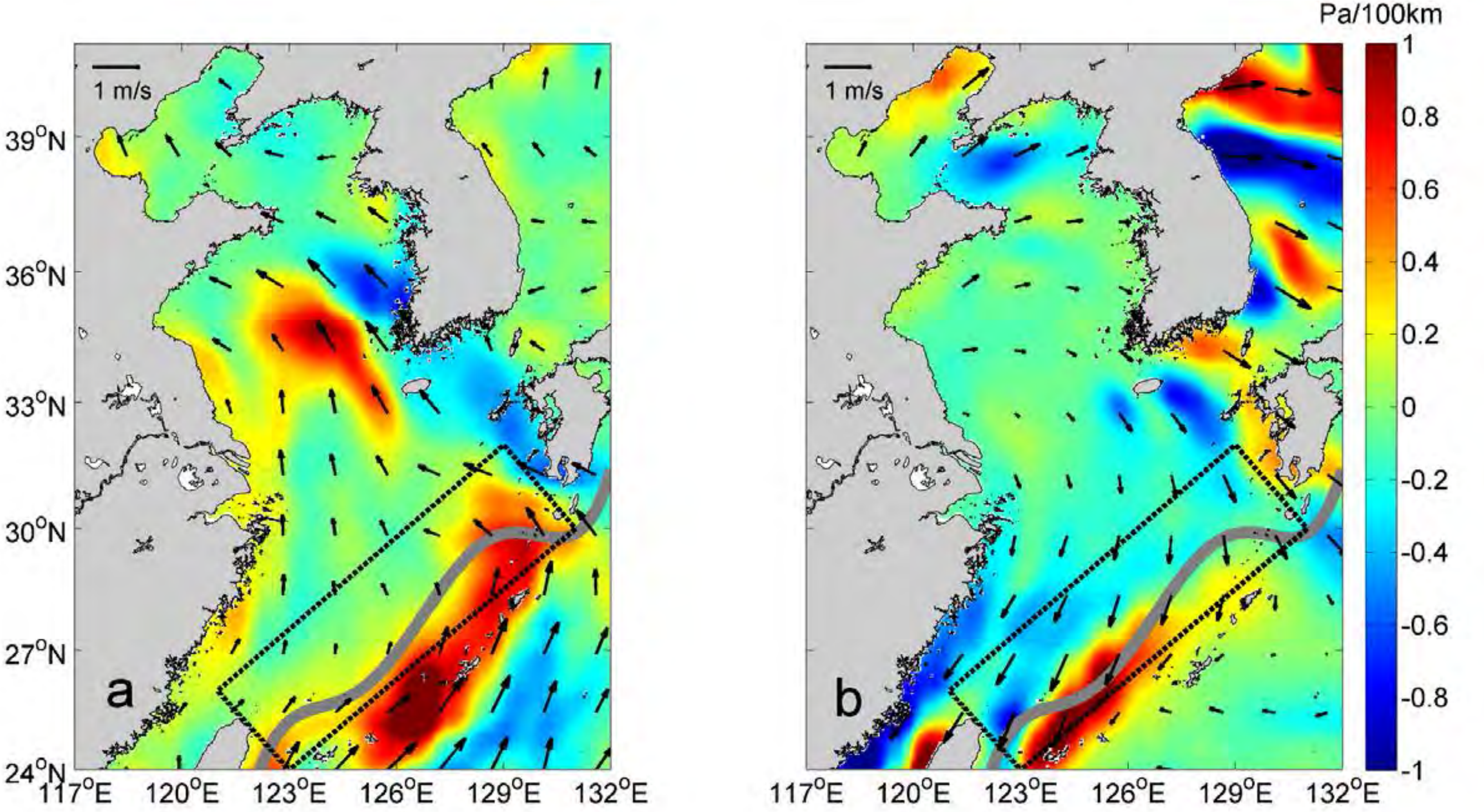


Interannual and seasonal variations of the surface along-stream transport (AT, black lines, unit: $10^4 m^2/s$) of Kuroshio (a, b), eddy generation and termination numbers (lifetime≥4 weeks, c–f) in the marked area.

Eddy Analysis

CE ~ Kuroshio;

AE ~ Kuroshio, disturbance from the open sea, and wind stress curl due to the Ryukyu Islands.



Two example snapshots of wind stress curl in the summer and winter: at UTC-12:00 August 3 (a) and UTC-00:00 January 4 (b).

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Summary

- This study investigates an 18-year dataset of sea surface geostrophic vector anomalies to detect cyclonic and anticyclonic eddies for the East China Sea and the Kuroshio in the Northwestern Pacific Ocean.
- More than one thousand eddy tracks are counted by a velocity geometry-based automated eddy detection scheme, it is found that the number and lifetime of the cyclonic and anticyclonic eddies are similar in the sea area, and that there are more eddies adjacent to both sides of Kuroshio Current.
- East of the Ryukyu Islands cyclonic eddies are much larger and stronger than anticyclonic eddies. Along the Kuroshio, more cyclonic eddies are generated on its western side and more anticyclonic eddies on its eastern side, and most eddies propagate northeastward following the direction of the Kuroshio.
- Statistical analysis indicated there are more eddies having diameters between 40-50 km than any other size, and an eddy duration of 4-5 weeks is most common.
- The current magnitude and velocity side-shear of the Kuroshio cause flow instabilities that lead to eddy generation; thus the variation of the Kuroshio transport is one of the major mechanisms of eddy generation.
- Other factors, including topography and seasonal flow circulations during monsoon, also impact cyclonic and anticyclonic eddy generation, but the genesis mechanisms are complex.

References

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