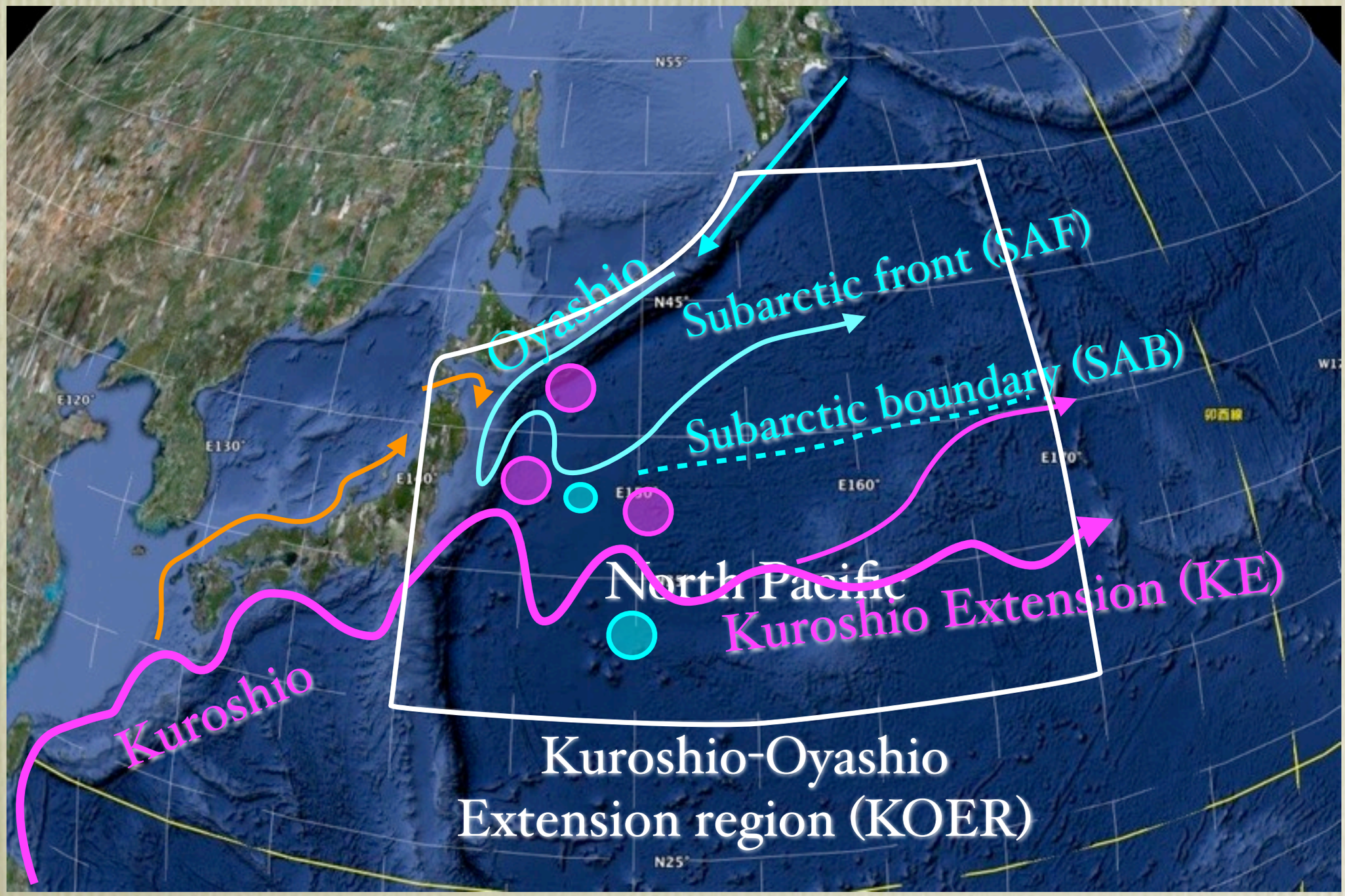
Characteristics of mesoscale eddies in the Kuroshio–Oyashio Extension Region detected from the distribution of the sea surface height anomaly

Sachihiko Itoh and Ichiro Yasuda
(Ocean Research Institute, The Univ. of Tokyo)

(Journal of Physical Oceanography, *in press*)

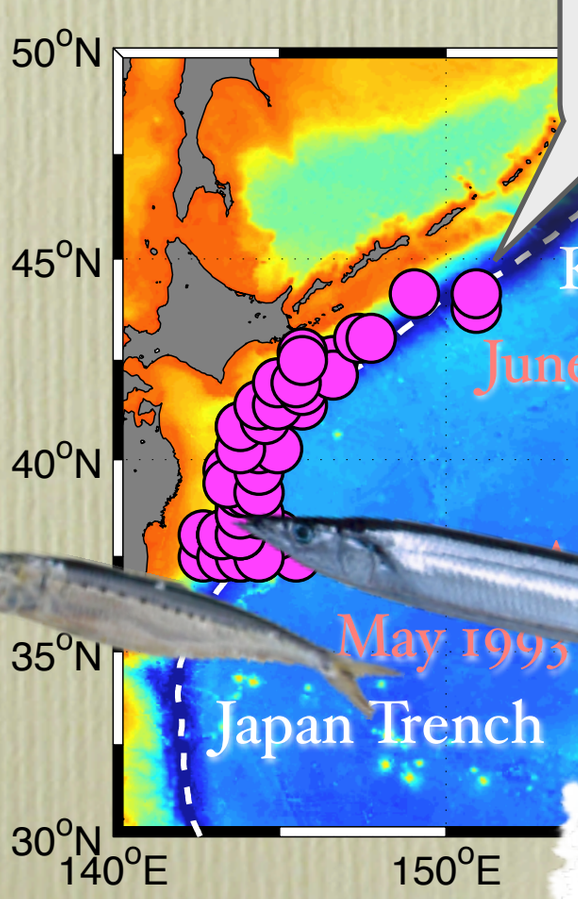
The Kuroshio-Oyashio Extension Region (KOER)



Mesoscale eddies in KOER

- Important role of eddies in poleward heat trasnport (Stammer, 1998; Wunch, 1999)
- Significant influence of eddies on heat transport around the Kuroshio Extension (Qiu and Chen, 2005)

- Pseudo β-effect of a deep current? (Yasuda et al. 2000)
- Image effect of the steep slope ? (Itoh and Sugimoto, 2001)



Bottom topography of KOER

Transporting not only heat
but also materials and biota !

Also important for fisheries !!

Previous studies on the characteristics of mesoscale eddies in KOER

- Analyses of subsurface temperature maps based on hydrographic observations
  (Mizuno & White, 1983; Ito & Shimizu, 1997)
  - ➡ Insufficient temporal and spatial coverage
- Recent studies based on satellite observations
  (Chelton et al., 2007; part of global study)
  - ➡ Low detectability in KOER, possibly due to low-pass filtering

Objective and Strategy

Objective

To quantify characteristics of mesoscale eddies in the Kuroshio-Oyashio Extension region

Strategy

- Analysis of Sea Surface Height Anomaly (SSHA) maps
- Modified version of the procedure proposed by Chelton et al.(2007)

Data

- Gridded Sea Surface Height Anomaly (SSHA) maps provided by AVISO
  (Ducet et al., 2000, Le Taron, 2003, Pascual et al., 2006)
  - Oct. 1992 – Feb. 2008
  - Spatial resolution of 1/3° × 1/3°
  - Analyses for the region 25–55°N, 130°E—180°

Detection: first guess

1. Eddy area (rotation is dominant over deformation):
Okubo-Weiss Parameter W is less than the critical value

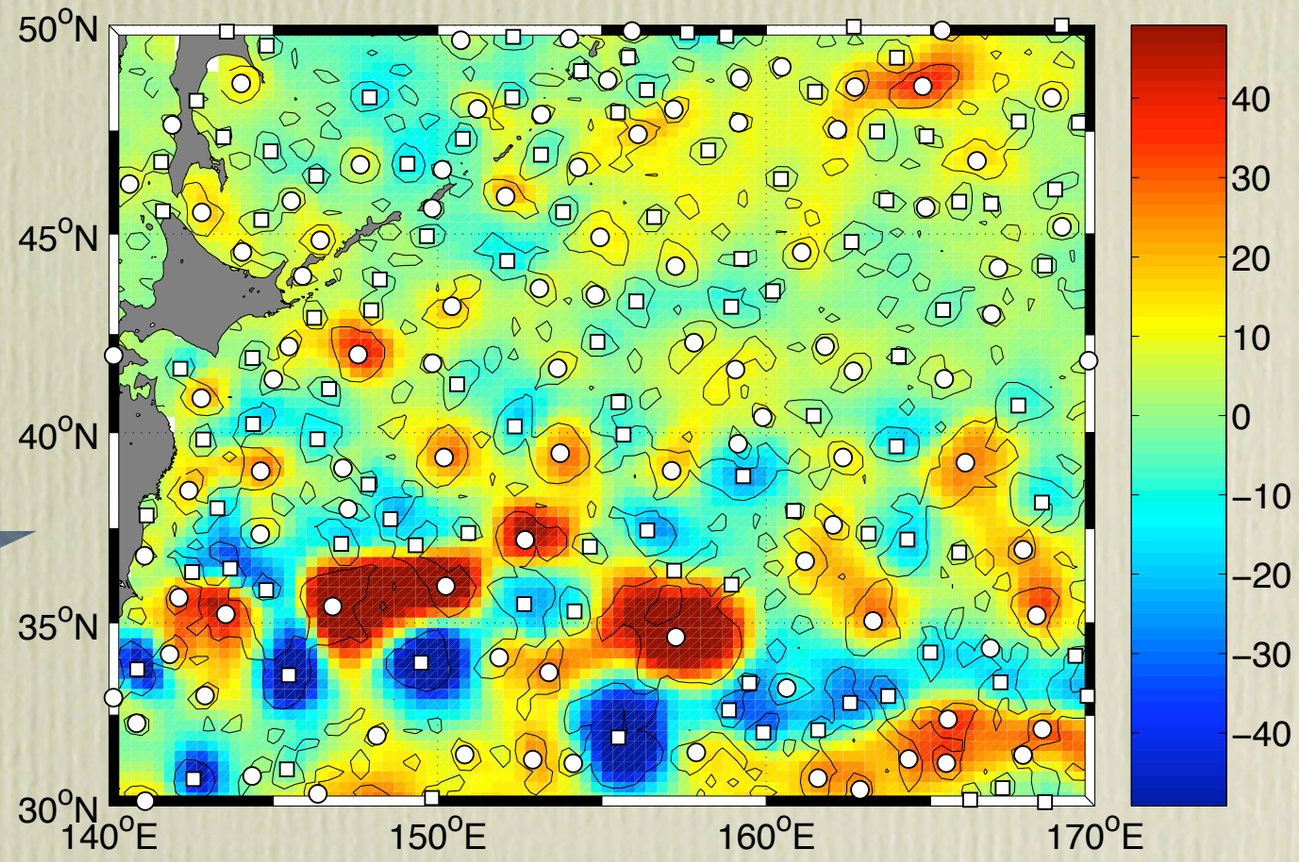
$$W = 4[(\partial u/\partial x)^2 + (\partial v/\partial x)(\partial u/\partial y)] \leq -2 \times 10^{-12}\ s^{-2}$$

(As in Chelton et al. (2007), but without low-pass filtering)

2. Mesoscale eddy

- Eddy areas ≥ 4 grid cells
- Polarity:
  determined by vorticity

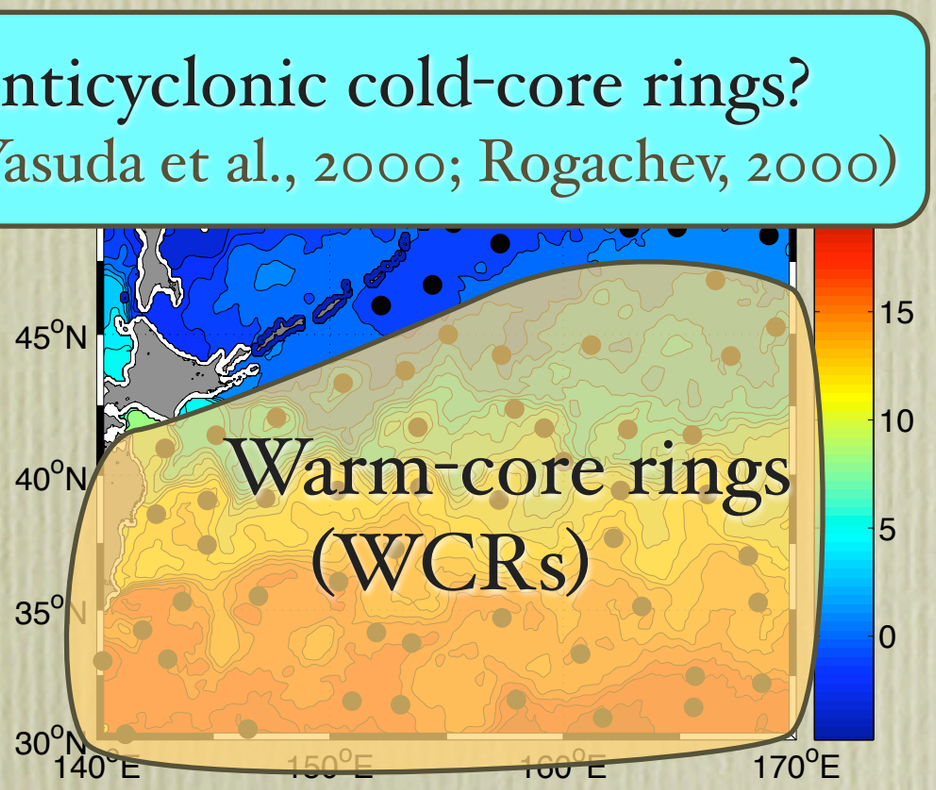
Example for 26 Dec. 2007
Color scale: *SSHA*
○ : Anticyclonic eddies (AEs)
□ : Cyclonic eddies (CEs)



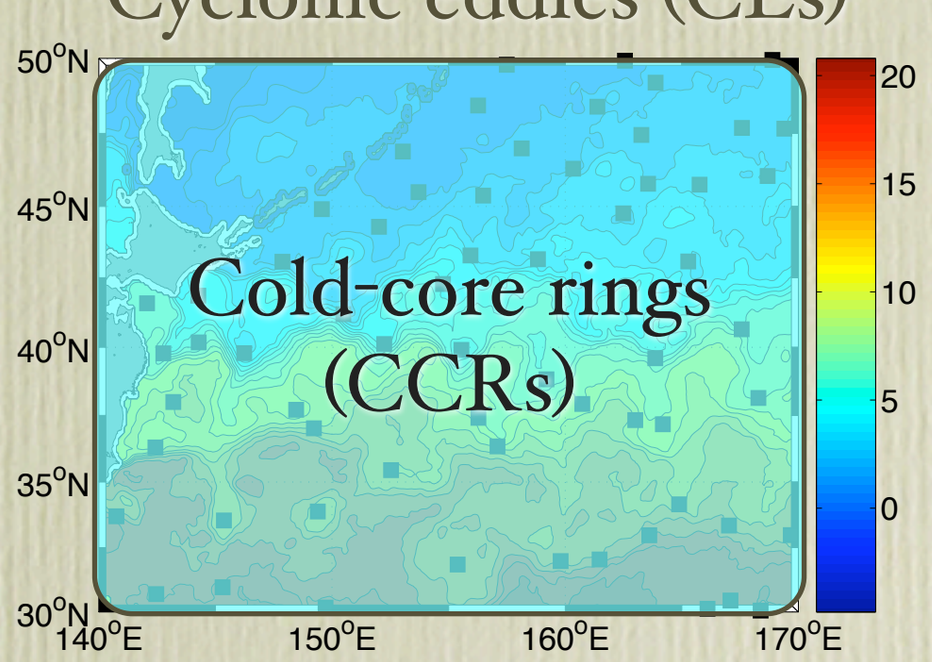
Tracking and determination

- Search the nearest eddy within a range of 100 km
- Eliminate those with a lifetime $T_0 < 4$ weeks

Anticyclonic cold-core rings?
(Yasuda et al., 2000; Rogachev, 2000)



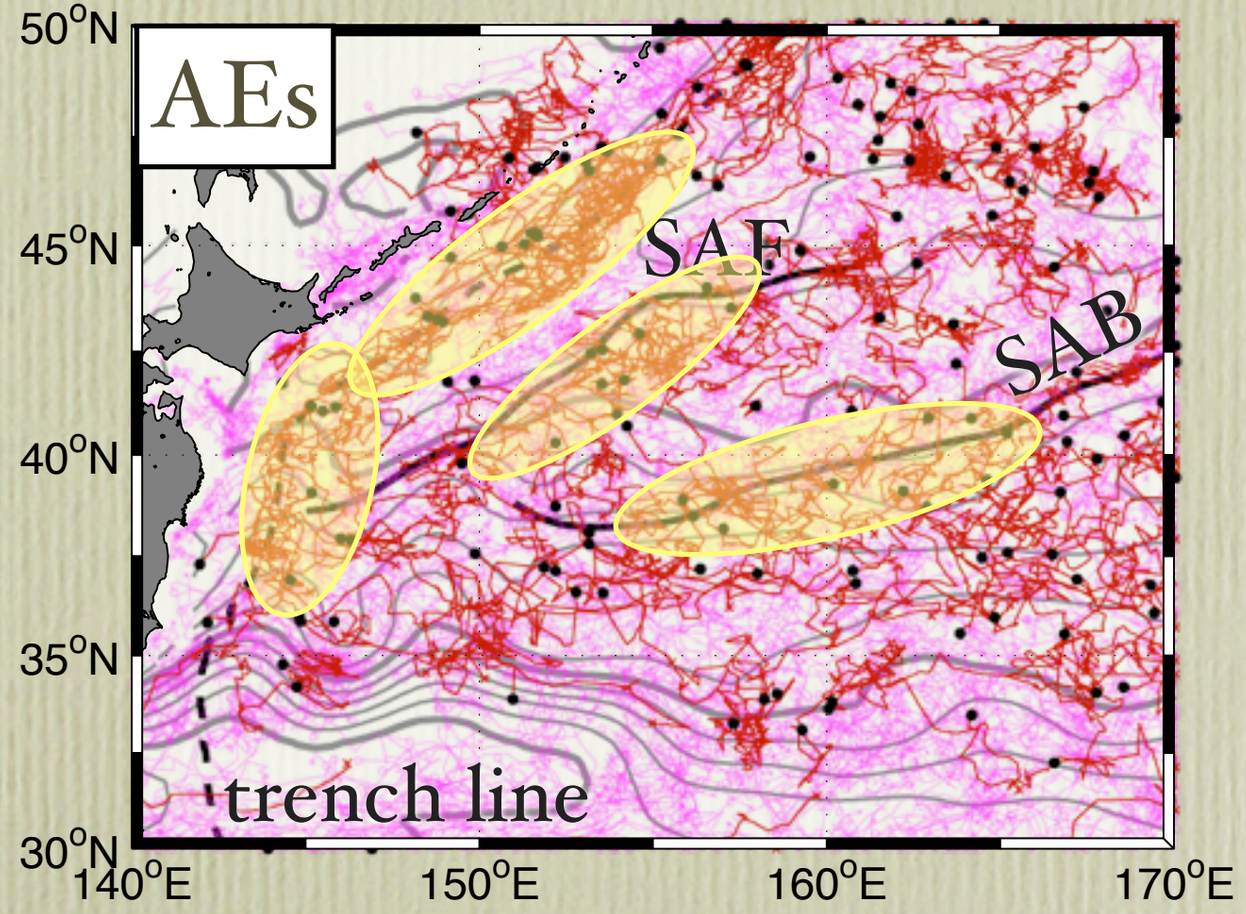
Cyclonic eddies (CEs)

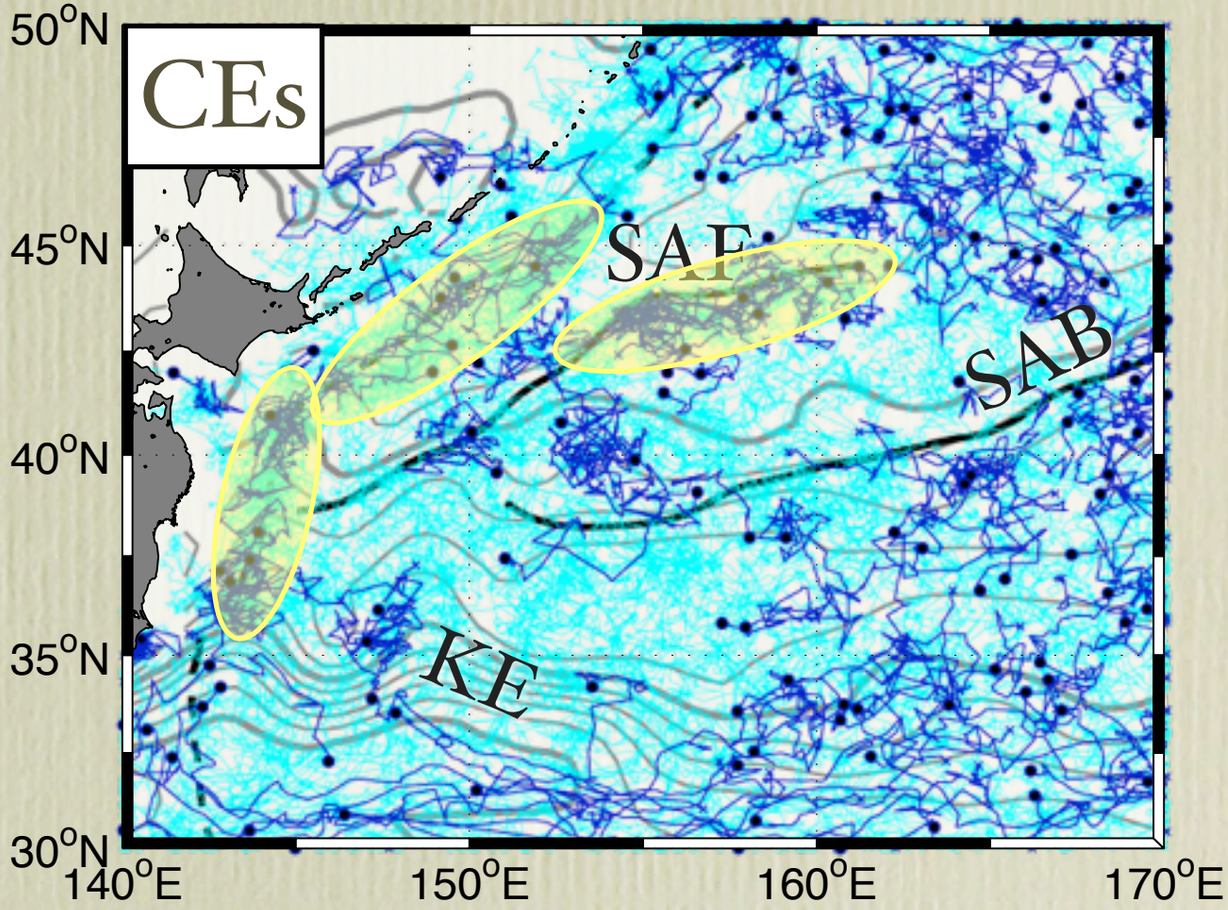


Eddies determined on 26 Dec. 2007 (on a SST map)

→ Explains 48 % of the total SSHA variance

Distribution (trajectories)

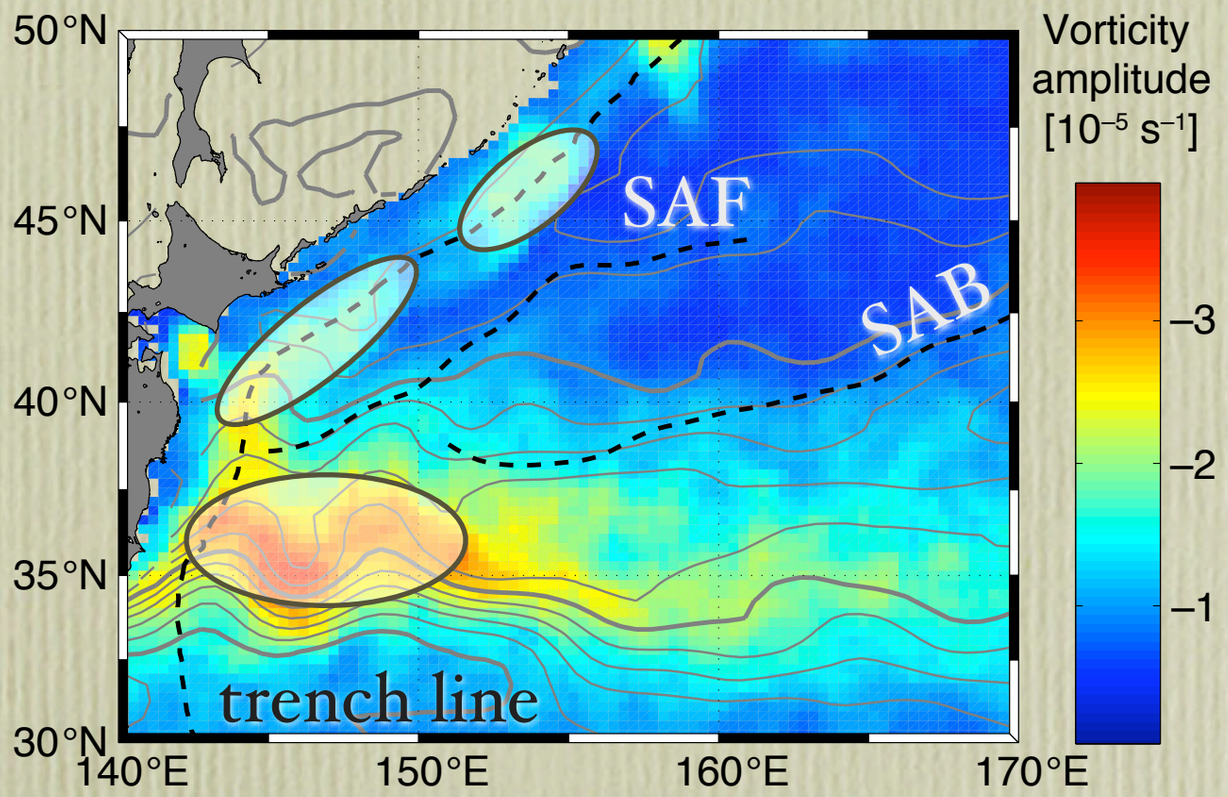




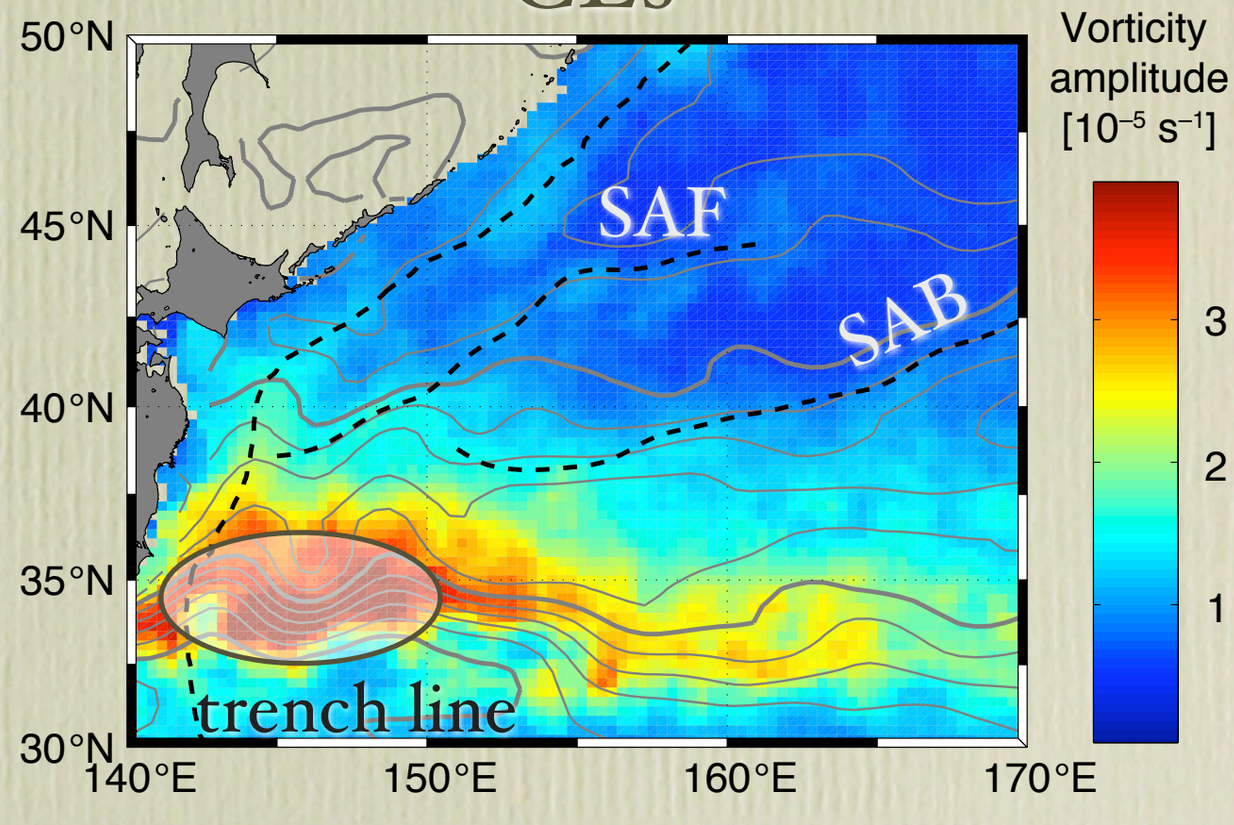
	AEs		CEs	
4 w ≤ T_0	N = 8886		N = 9551	
12 w ≤ T_0	31.1%		31.3%	
52 w ≤ T_0	2.8%		2.4%	

Mean vorticity amplitudes

AEs

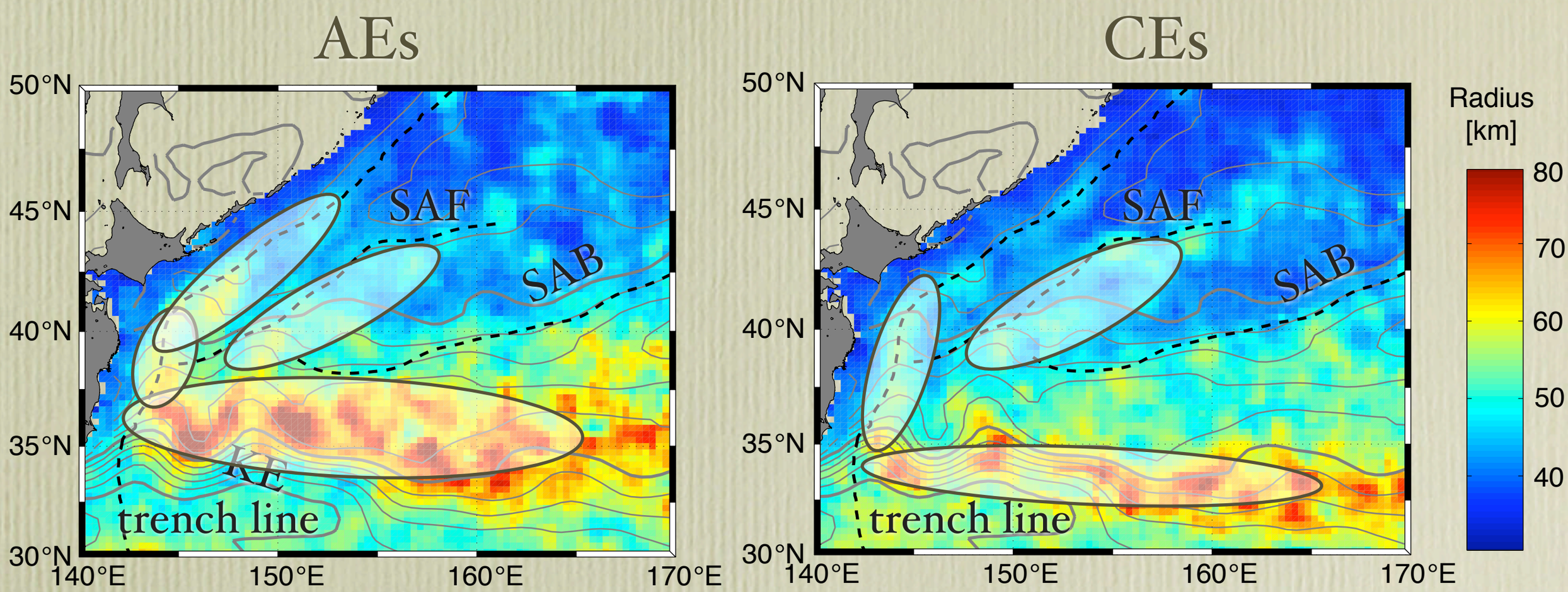


CEs



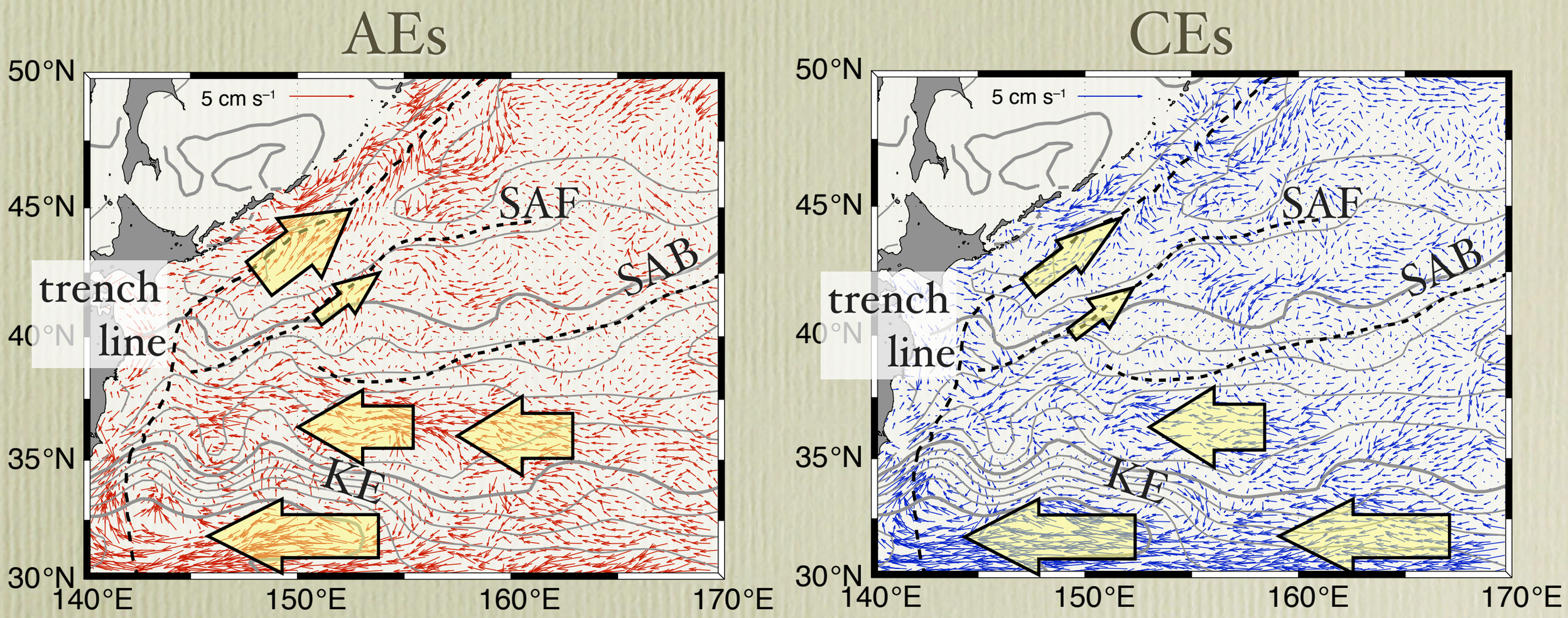
- Very high values along northern (southern) flank of KE for AEs (CEs)
- Moderately large along the trenches for AEs

Mean radius



- Very large (≥ 70 km) in the area north of KE for AEs and on the axis of KE for CEs
- Moderately large (50–60 km) along the trenches and southern margin of SAF for both polarities

Mean propagation speed



- Westward propagation: 1–2 (1–5) cm/s north (south) of KE
- NE-ward propagation with 1–2 cm/s along the trenches and their offshore flanks
- NE-ward propagation with 0.5–1 cm/s along SAF

Flux estimation

★ Estimate elevation flux by summing all eddy contributions

$$(\overline{u'\eta'}, \overline{v'\eta'}) = \frac{1}{T_{obs} A_{grid}} \left(\sum (U_A \Lambda_A + U_C \Lambda_C), \quad \sum (V_A \Lambda_A + V_C \Lambda_C) \right)$$

Elevation flux = $\frac{1}{\text{Observation period} \times \text{area of grid cell}}$ Σ (propagation speed × area-integrated SSHA)

★ Expression in terms of heat and salinity fluxes

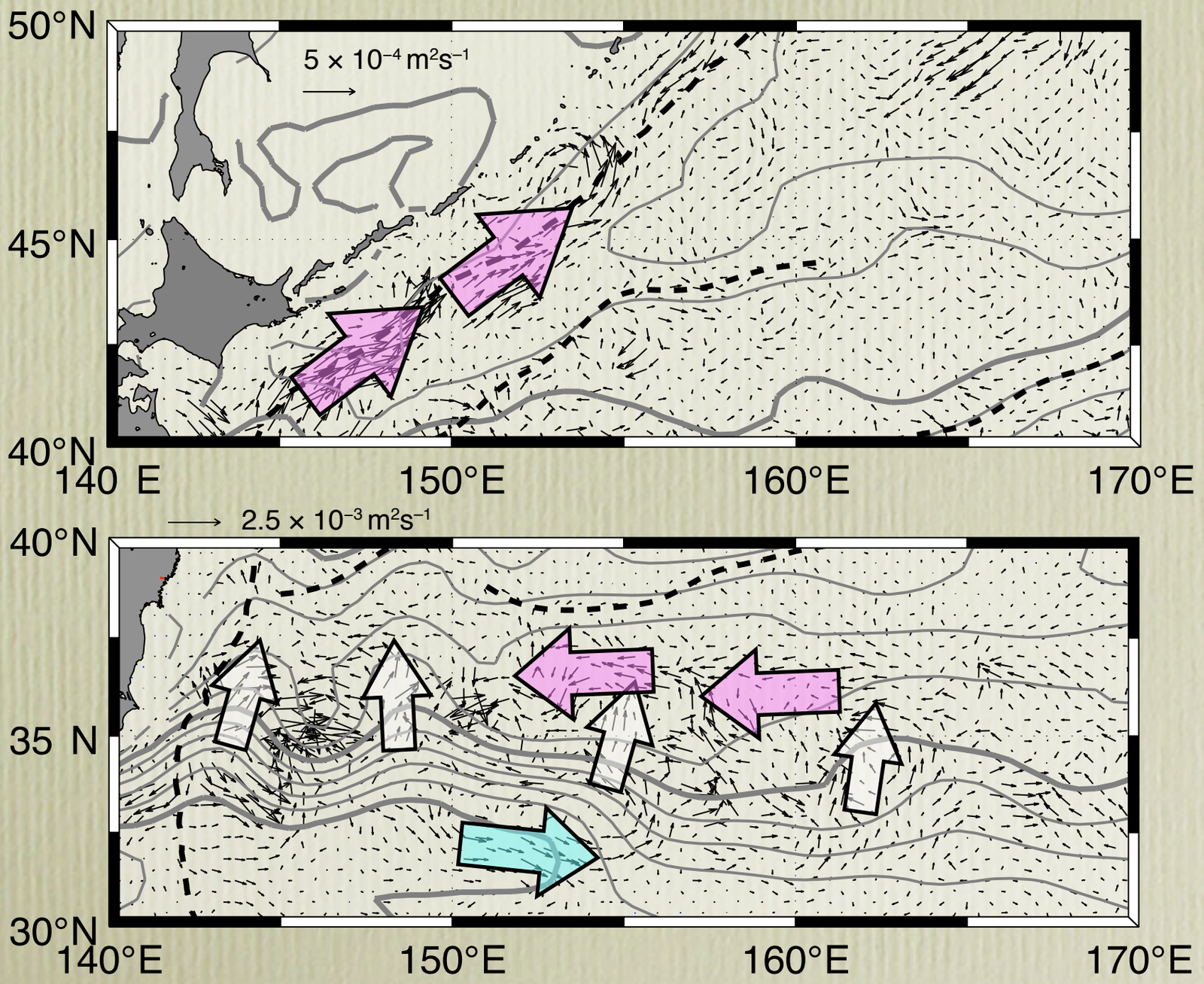
$$\overline{u'\eta'} = \overline{u' \int \delta \, dp} \cong \overline{u' \int \left[\alpha_T T' - \alpha_S S' \right] dp} = \frac{\alpha_T}{\rho_0 C_p} \overline{u'q'} - \alpha_S \overline{u'S'}$$

★ Rough conversion from elevation to heat flux

Heat flux [MW/m] ~ 2–3 × 10^4 [MWs/m^3] × Elevation flux [m^2/s]

Estimated elevation flux

Elevation flux

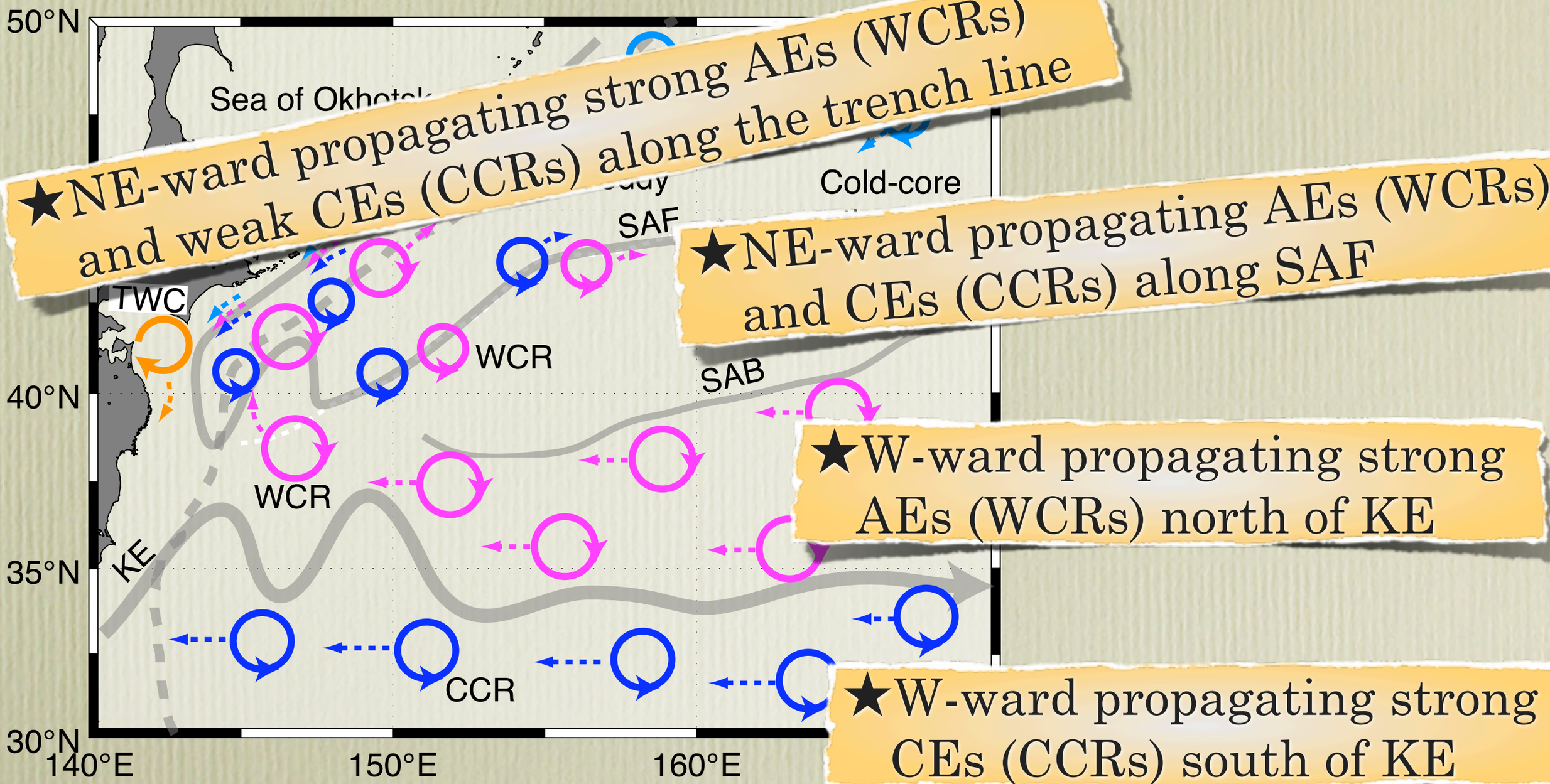


Net NE-ward flux
along the trench
(~ 10 MW/m)

Net W-ward (E-ward)
fluxes in the zone
north (south) of KE
(20 ~ 30 MW/m)

Summary:

Characteristics of mesoscale eddies in the Kuroshio-Oyashio Extension region



Schematic diagram of the observed eddy behavior