Observation and dynamics of baroclinic eddies southeast of Okinawa Island

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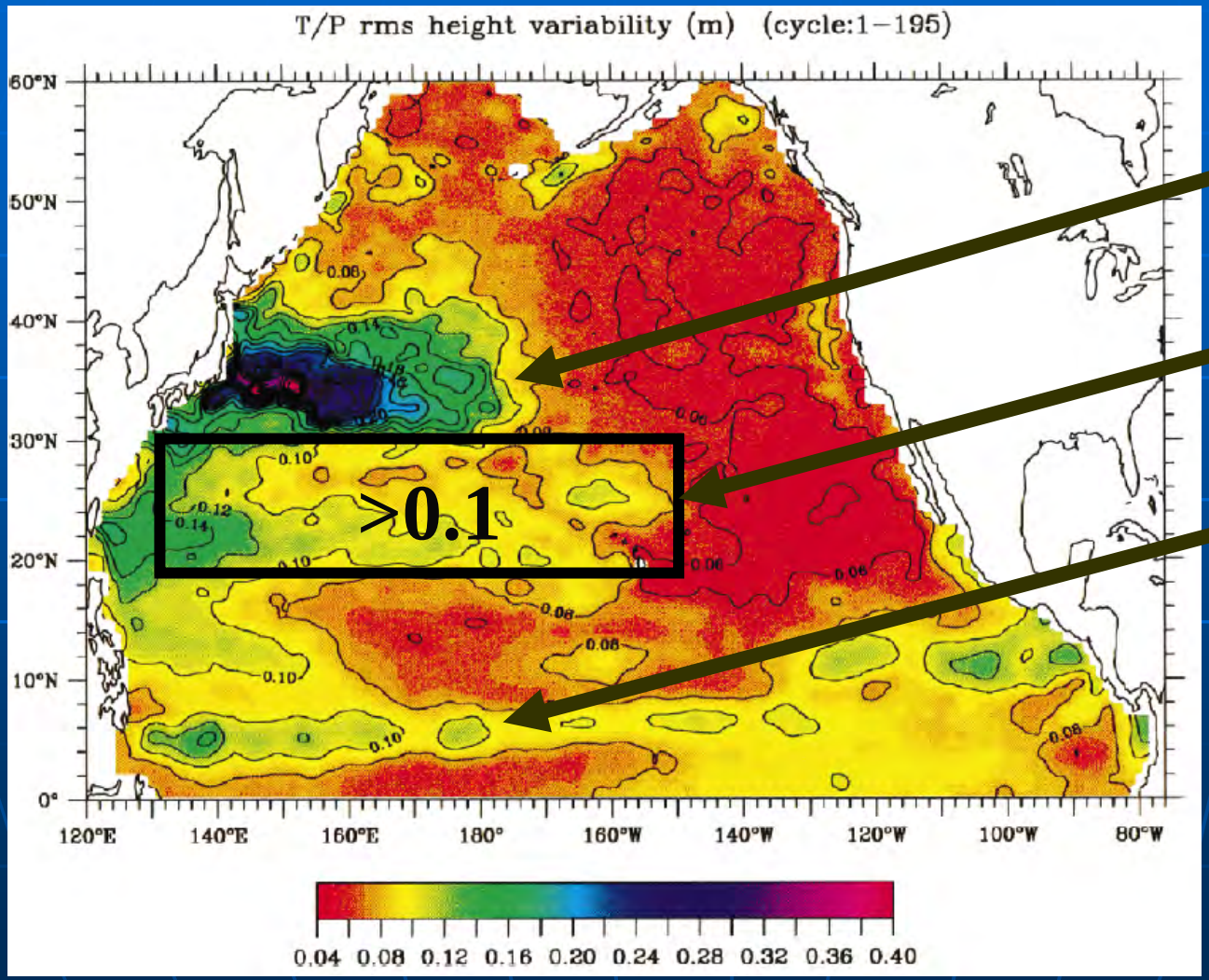
Outline

1. Background
2. Observation
3. Water properties
4. Dynamic characteristics
5. Origin of the eddies
6. Summary

1.Background

1992-1997 SSHA rms



KE

STCC

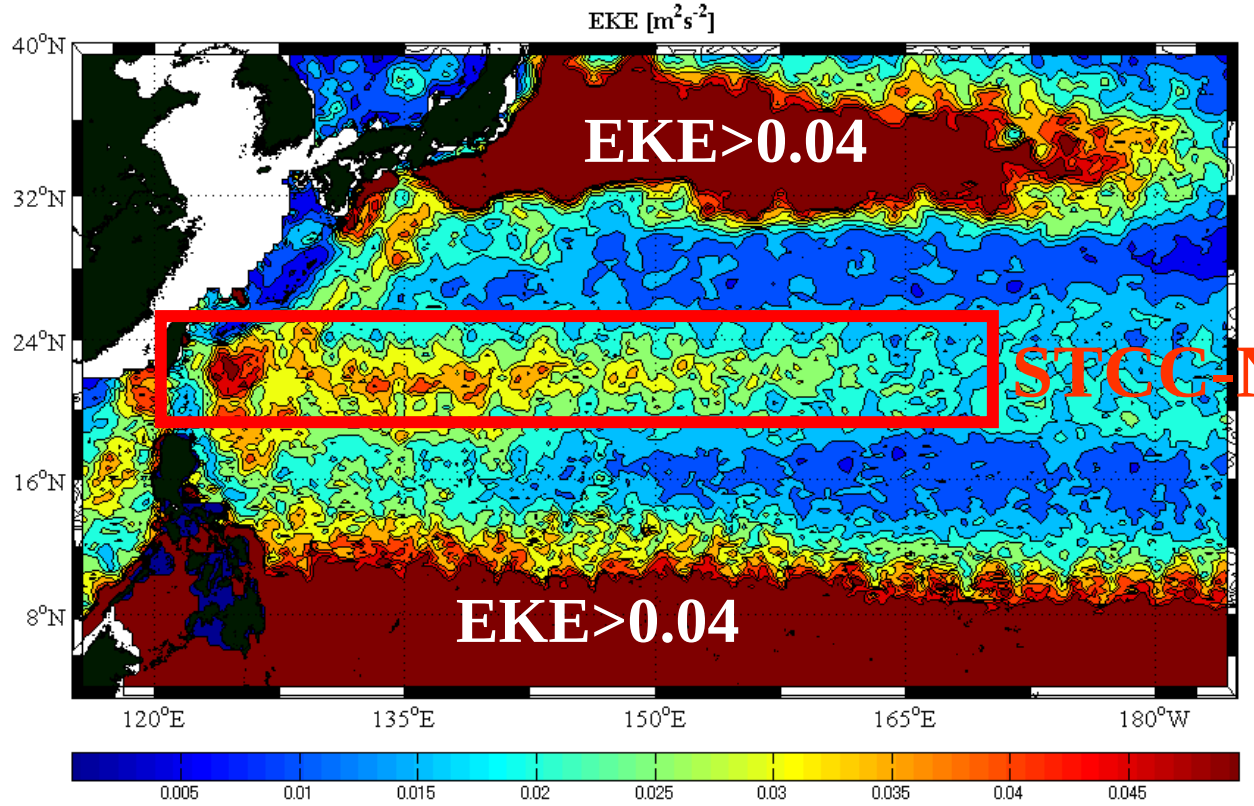
NEC

30N

19N

Qiu (1999, JPO)

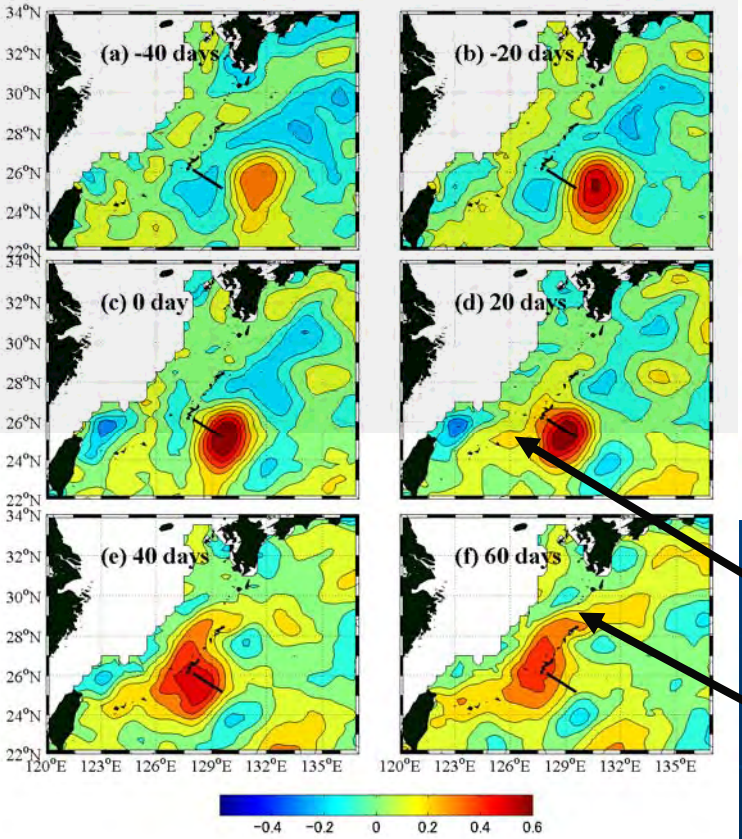
Mean eddy kinetic energy (EKE) map calculated using the TOPEX/Poseidon data during 1992-2005



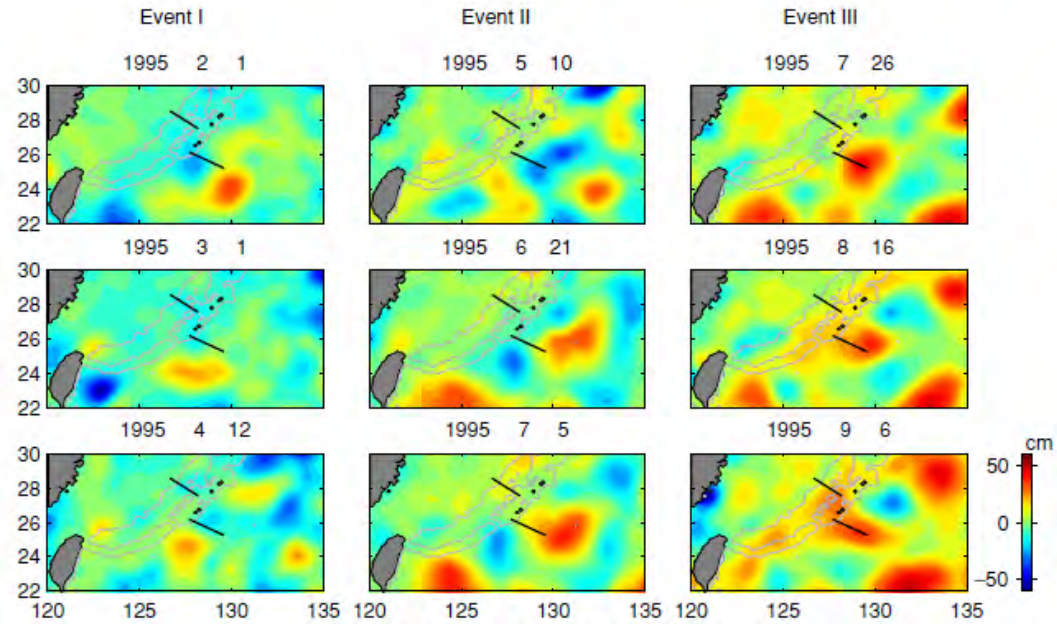
STCC-NEC eddy

STCC-NEC eddy usually arrive at the western boundary of the Pacific after propagating along a 15−25° N band.

STCC-NEC eddy approached Ryukyu Island and strongly influenced RC and KC



Correlation coefficients between RC transport and SSHA



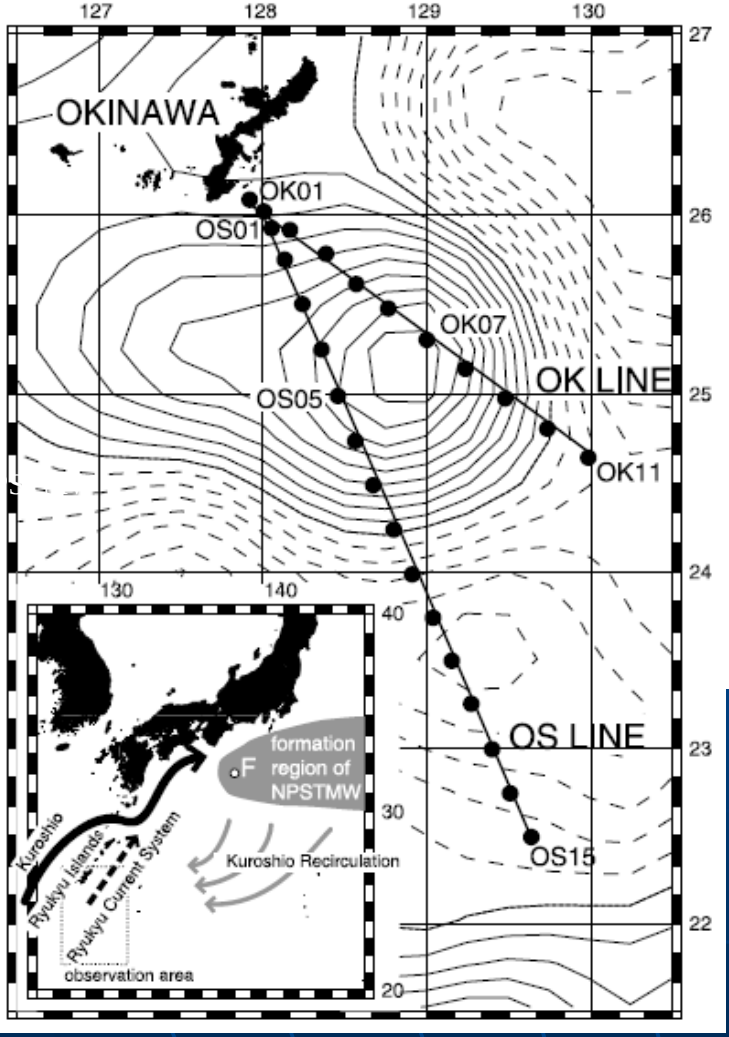
SSHA map *(Andres et al.2008)*

Karama gap

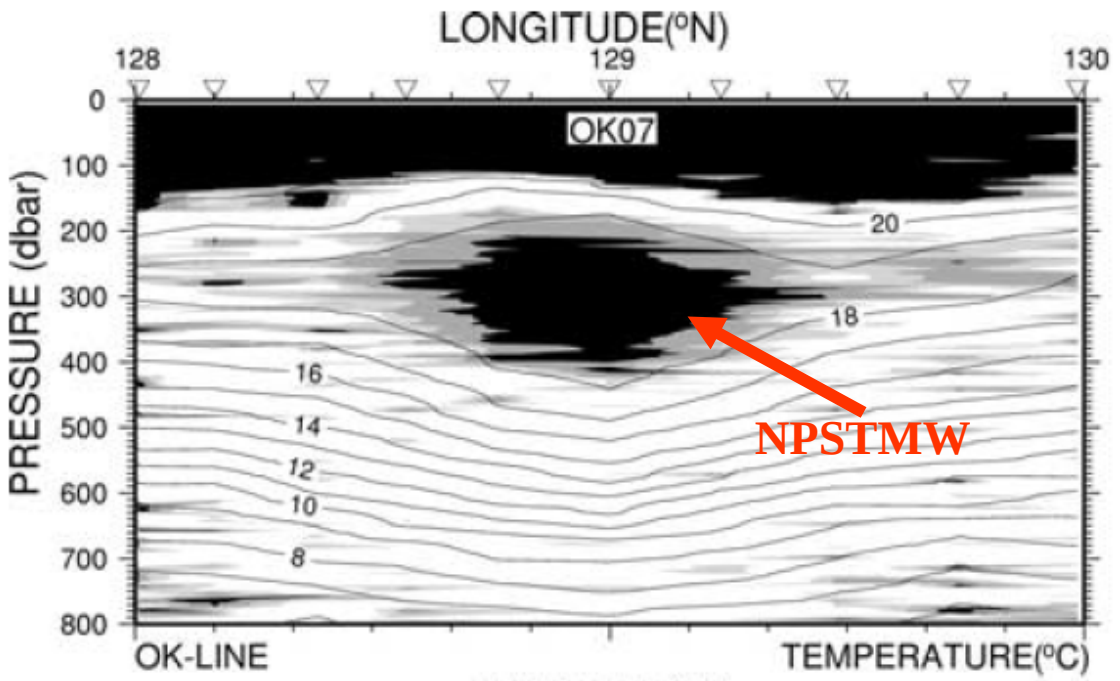
Tokara strait

(Zhu et al.2003)

Eddy from the Kuroshio Extension region



(*Takigawa et al.*, 2005)

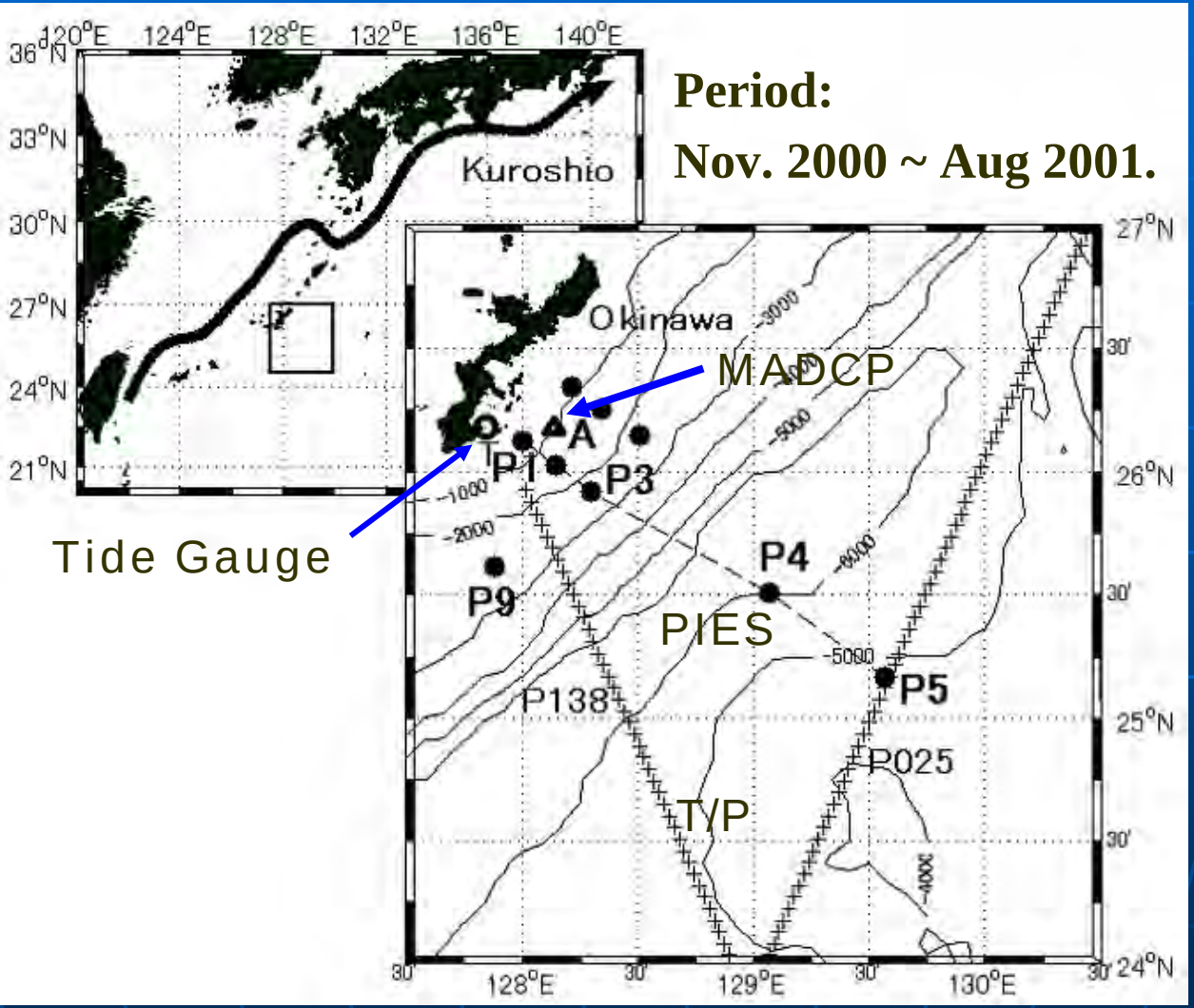


- A subsurface mesoscale eddy (called T-eddy) observed in February 2002.
- Originated from the Kuroshio Extension region
- North Pacific Subtropical Mode Water near the core.
- Only one time in the past 15 years

July-August, 2001, Naha City (Okinawa), Japan

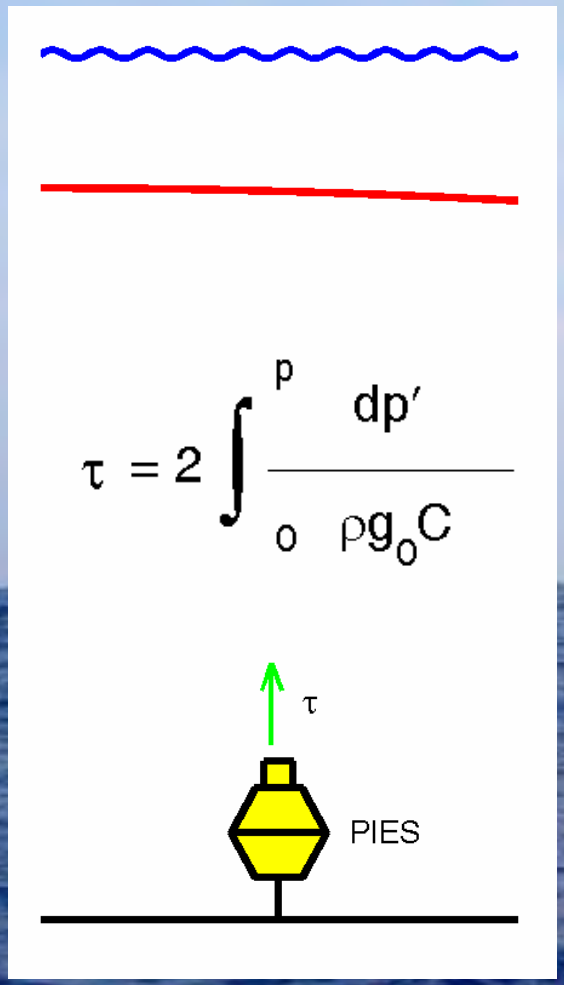
The abnormal sea level rise occurred around the Naha city (Okinawa) during July-August 2001 due to a warm eddy approaching.

2. Observation



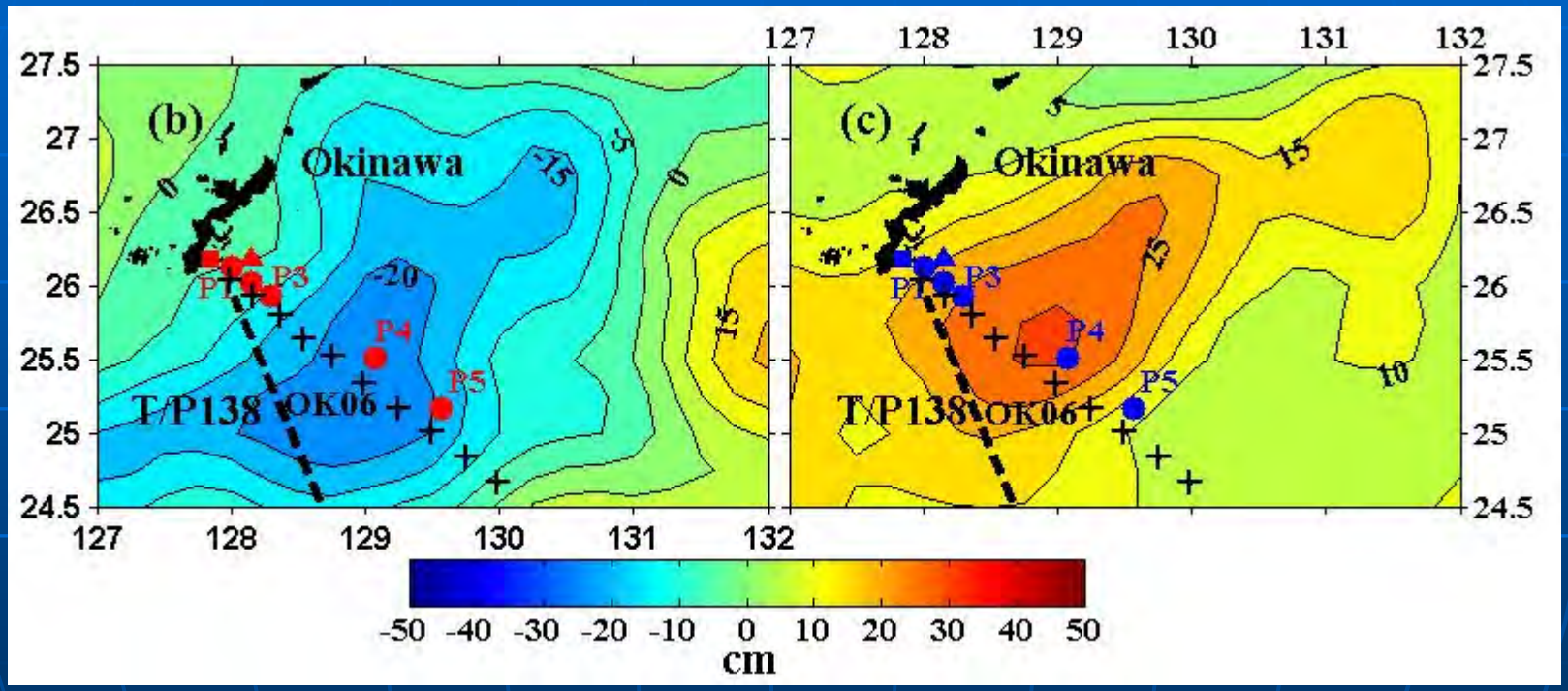
Location map of the observation sites (JAMTEC)

Pressure-recording Inverted Echo Sounder (PIES)



- Emits 12 kHz sound pulses
- Measures τ - round trip travel times of acoustic pulses from the bottom to the surface
- Measures bottom pressure (P_{bot})
  - resolution < 1mm
- A robust empirical relationship exists between τ and vertical profiles of T, δ, and σ_θ

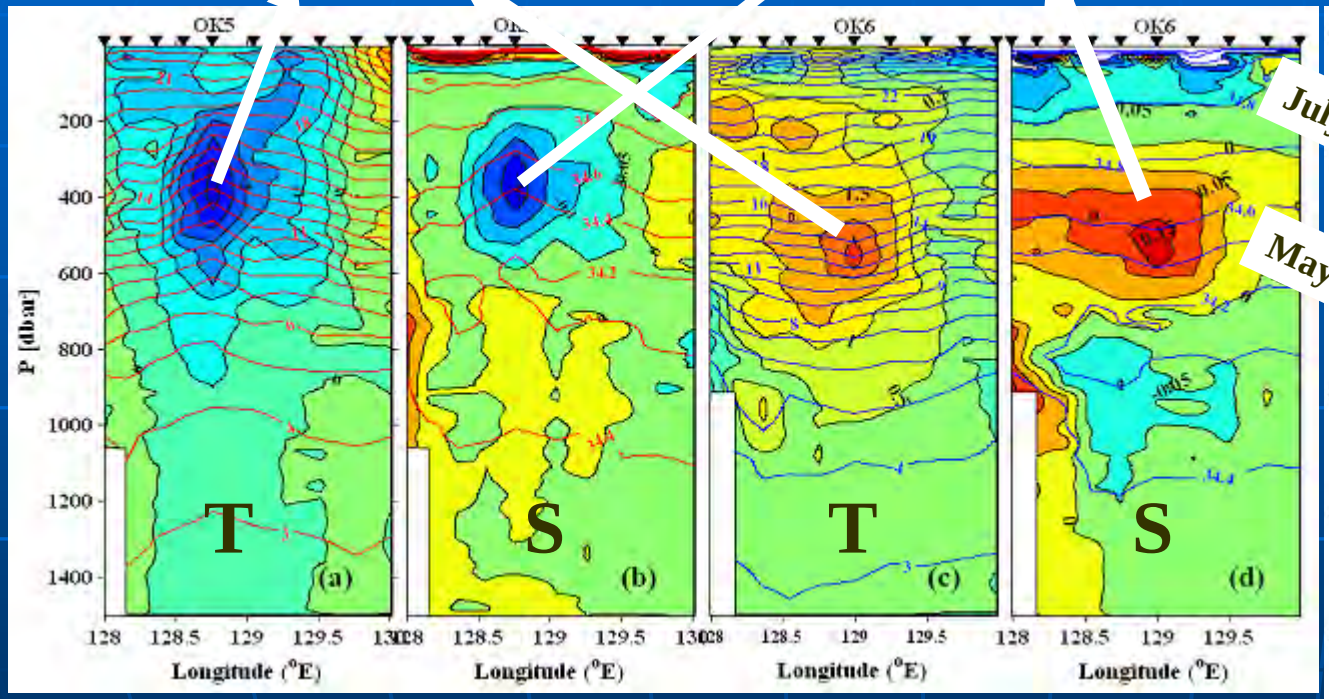
A cyclonic and an anticyclonic eddy invaded into the mooring site

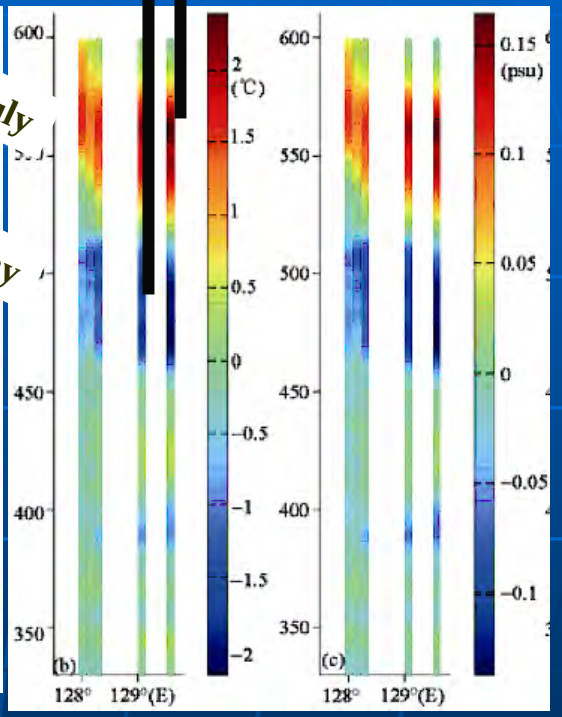


May 4−7 and July 13−17, 2001
SSHA maps

3. Water properties

–3.0/+2.5 ℃ **–0.20/+0.15 psu** **–2/2 ℃**



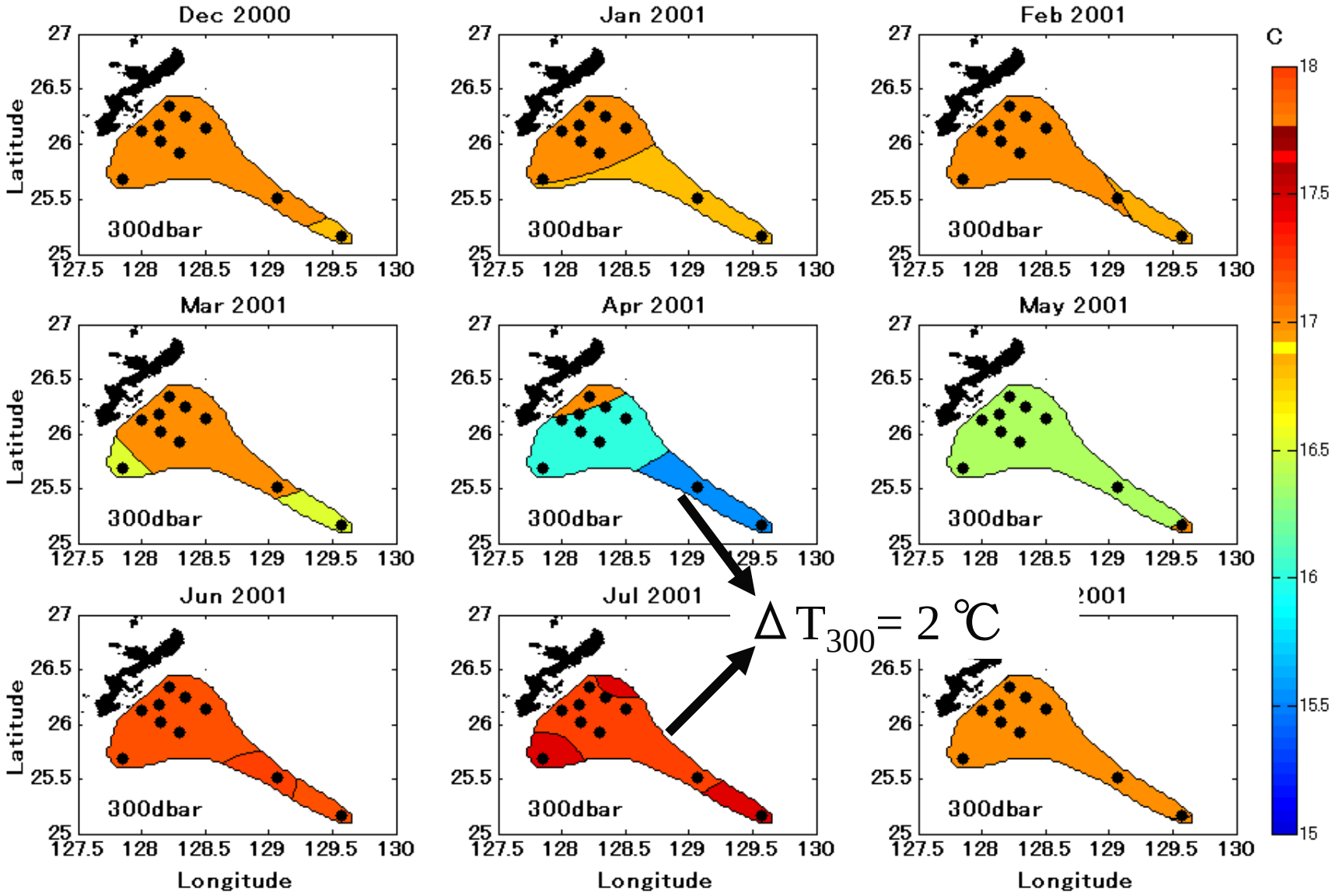


May,2001 **July,2001**

Temperature and Salinity sections and their anomalies (color) from 13-year mean in the same season

CTD DATA

Temperature Salinity from PIES

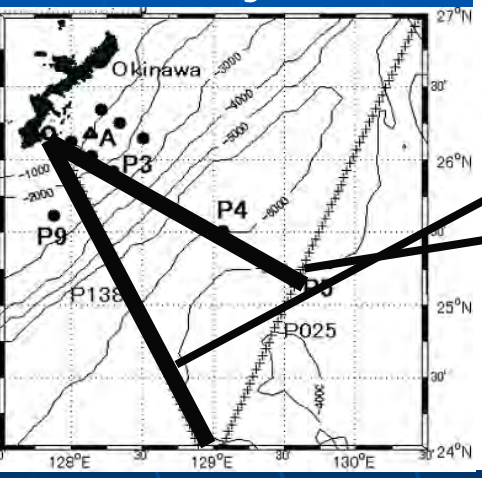


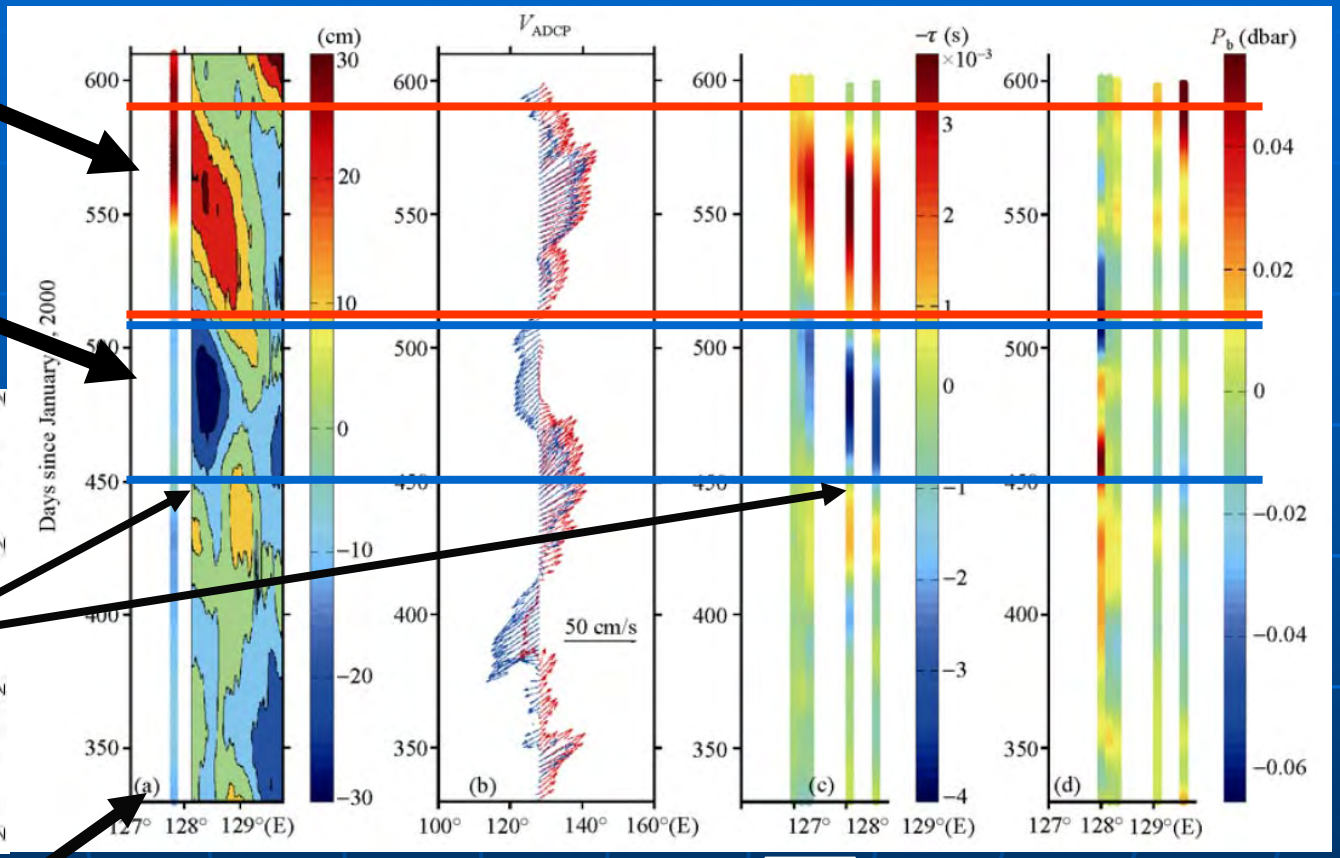
Monthly means of Temperature at 300 dbar

4. Dynamic characteristics

Anticyclonic eddy

Cyclonic eddy

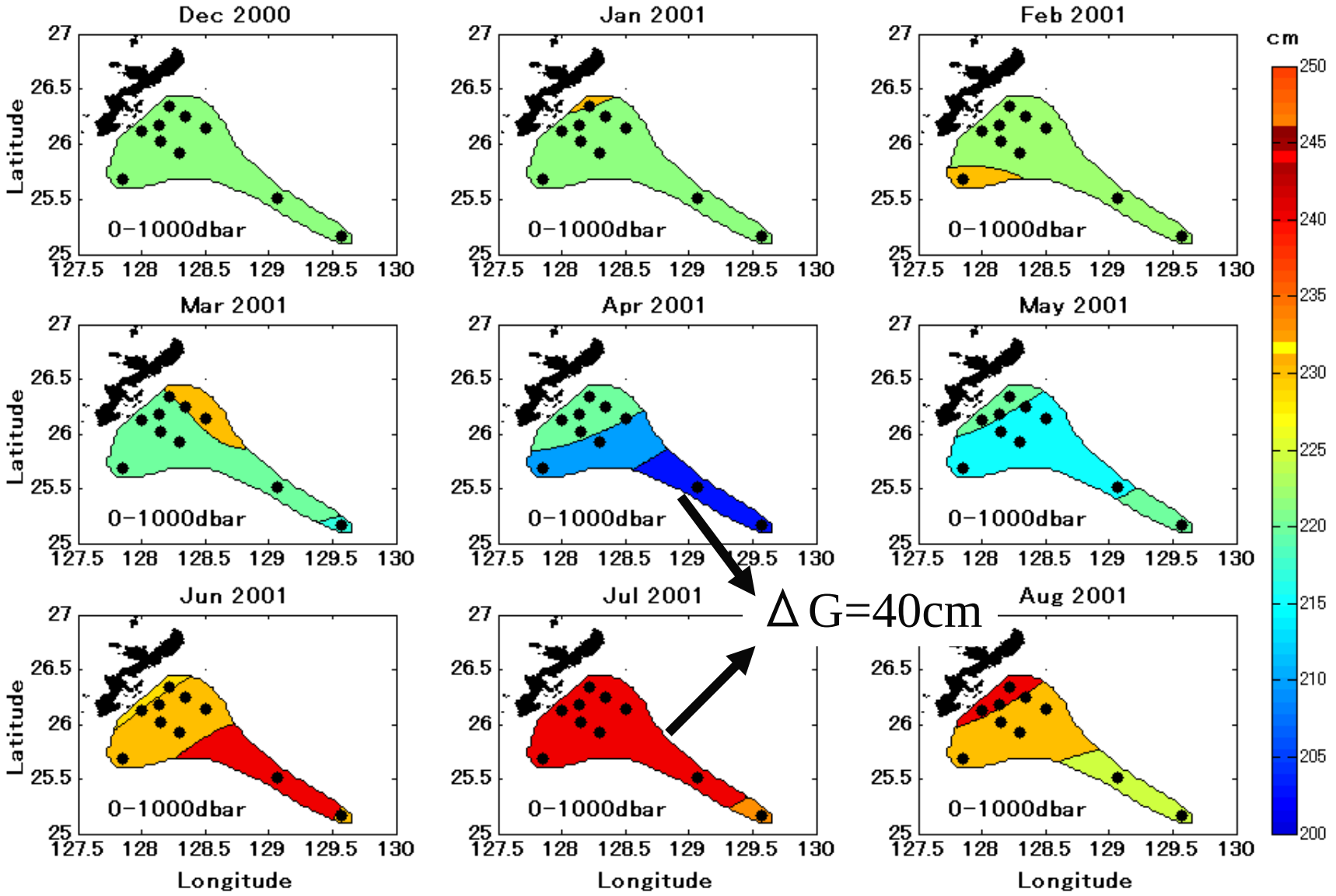




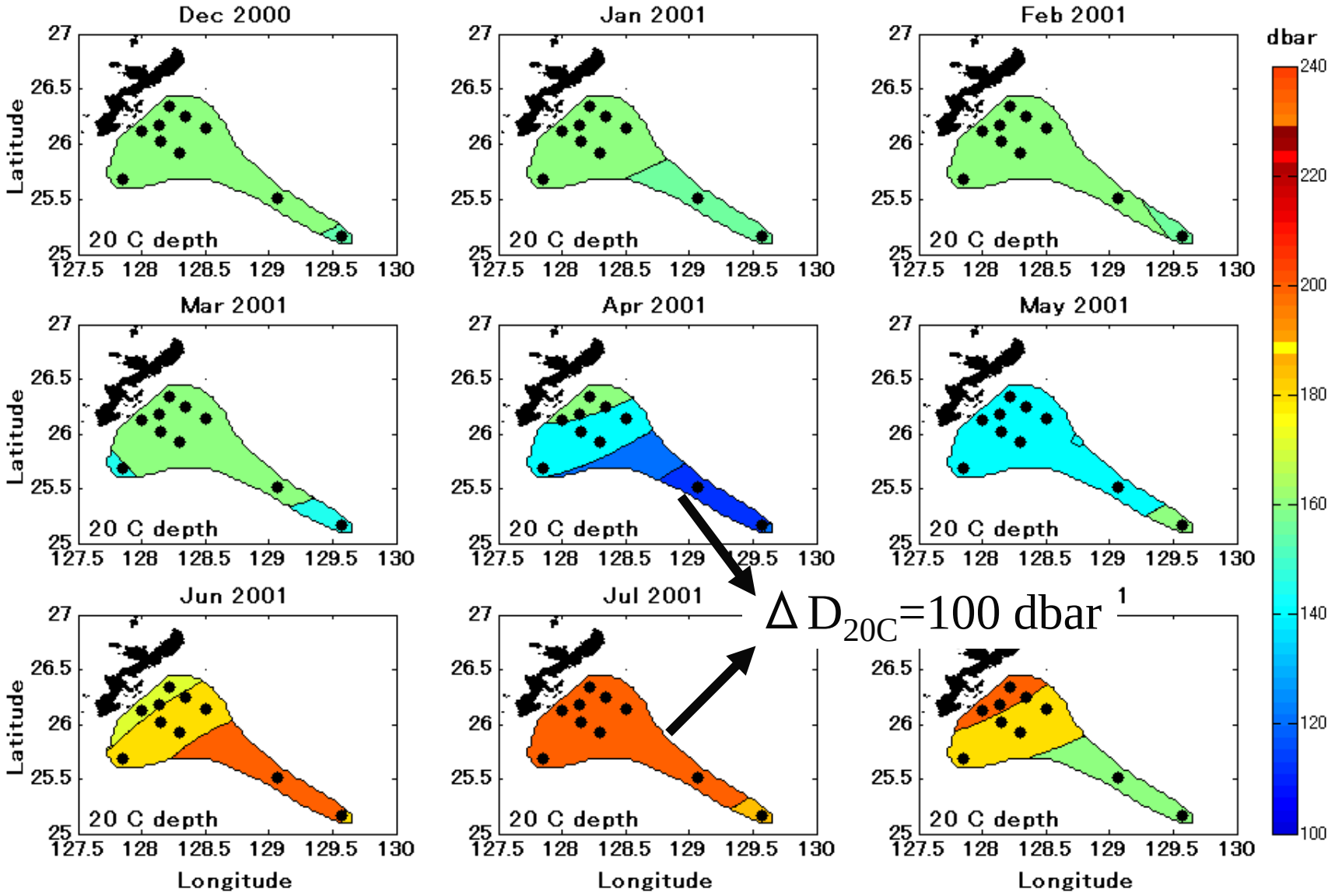
SL **SSHA** **MADCP** (200dbar) τ (0-1000dbar) P'_b

P'_b was different from τ, SSHA and V_{ADCP}

P'_b did not respond to the passage of eddy



Monthly means of Geopotential anomaly referred to 2000 dbar



Monthly mean depths of 20 ℃ isotherm

Comparison of the baroclinic and barotropic contributions to the SSHA variations during the passage of the eddies

Baroclinic

SSHA: 20—30 cm
Tide gauge: 20cm
Geopotential anomaly from PIES: 24 cm

Barotropic

± 0.02 dbar

$$H_p = \frac{P_b'}{\rho g} \rightarrow 2 \text{ cm}$$

$$H_{bc}/H_{br} > 12$$

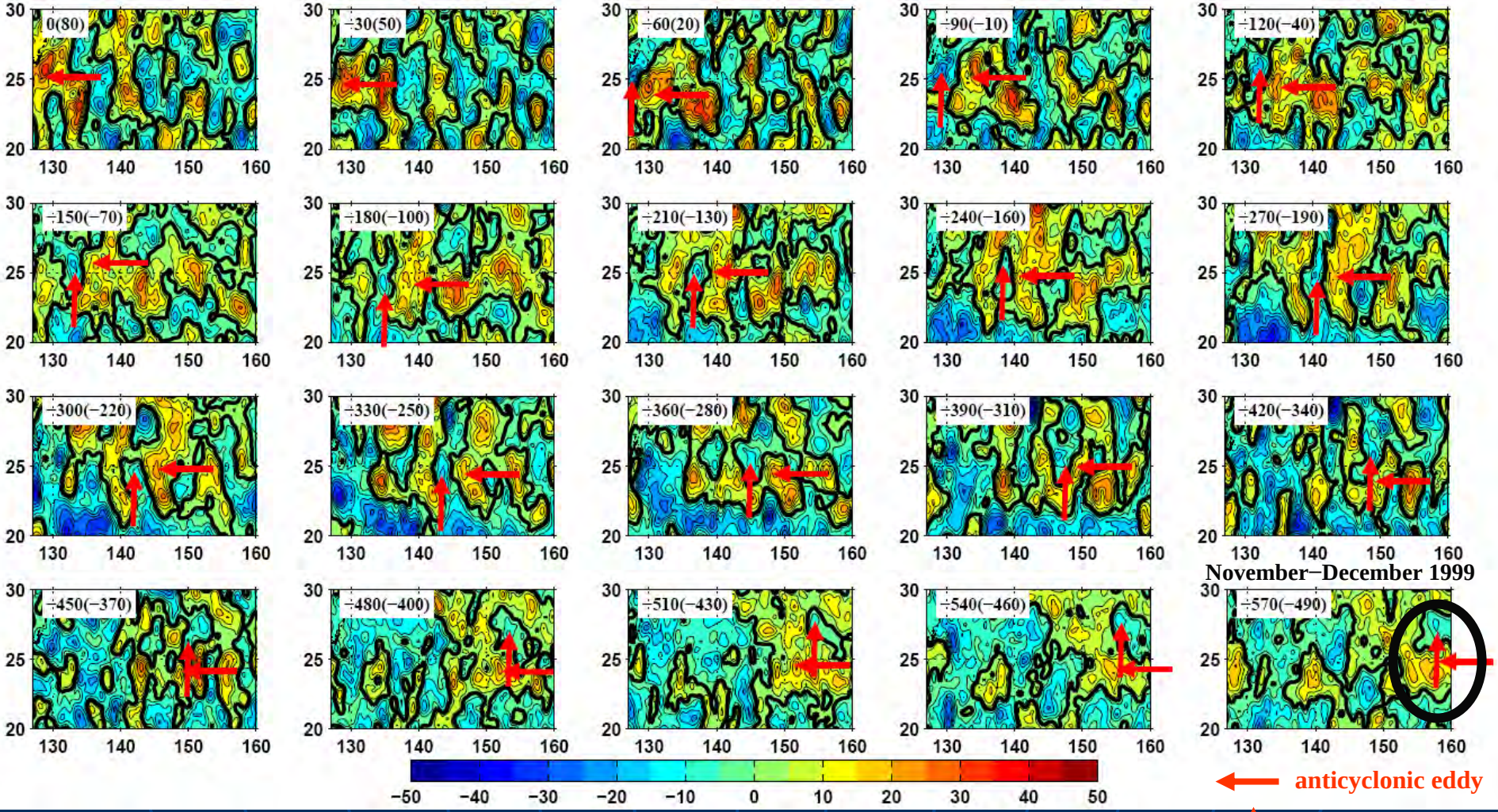
This indicates that the eddies are dominated by baroclinicity.

Why baroclinicity?

1. **The effect of Izu-Ogasawara Ridge**
2. **The eddy formation mechanism (baroclinic instability)**

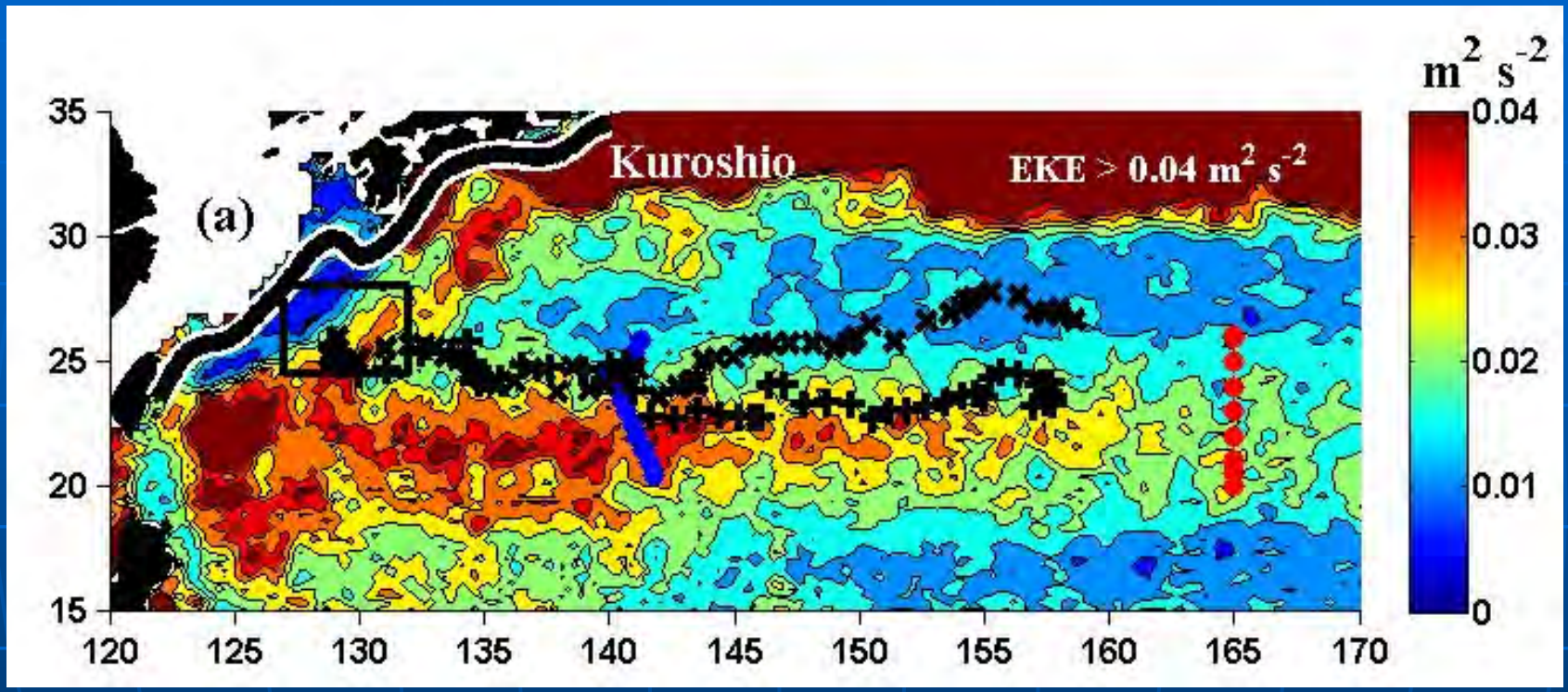
5. Origin of the eddies

May 2001



Time series of the SSHA maps from May 2001 back to November 1999 (unit: cm)

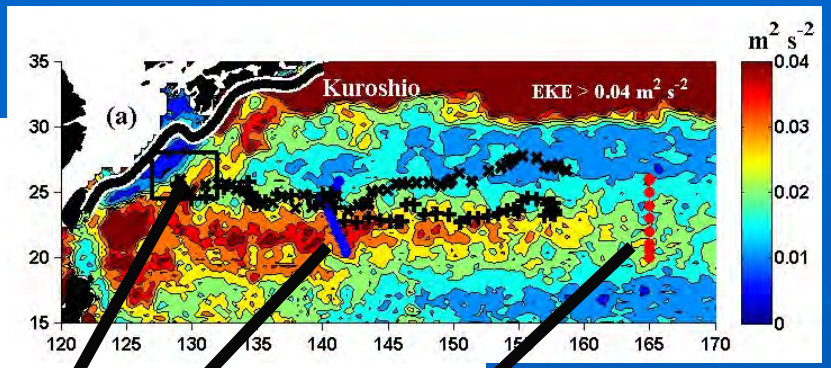
Mean eddy kinetic energy (EKE) map and eddy positions

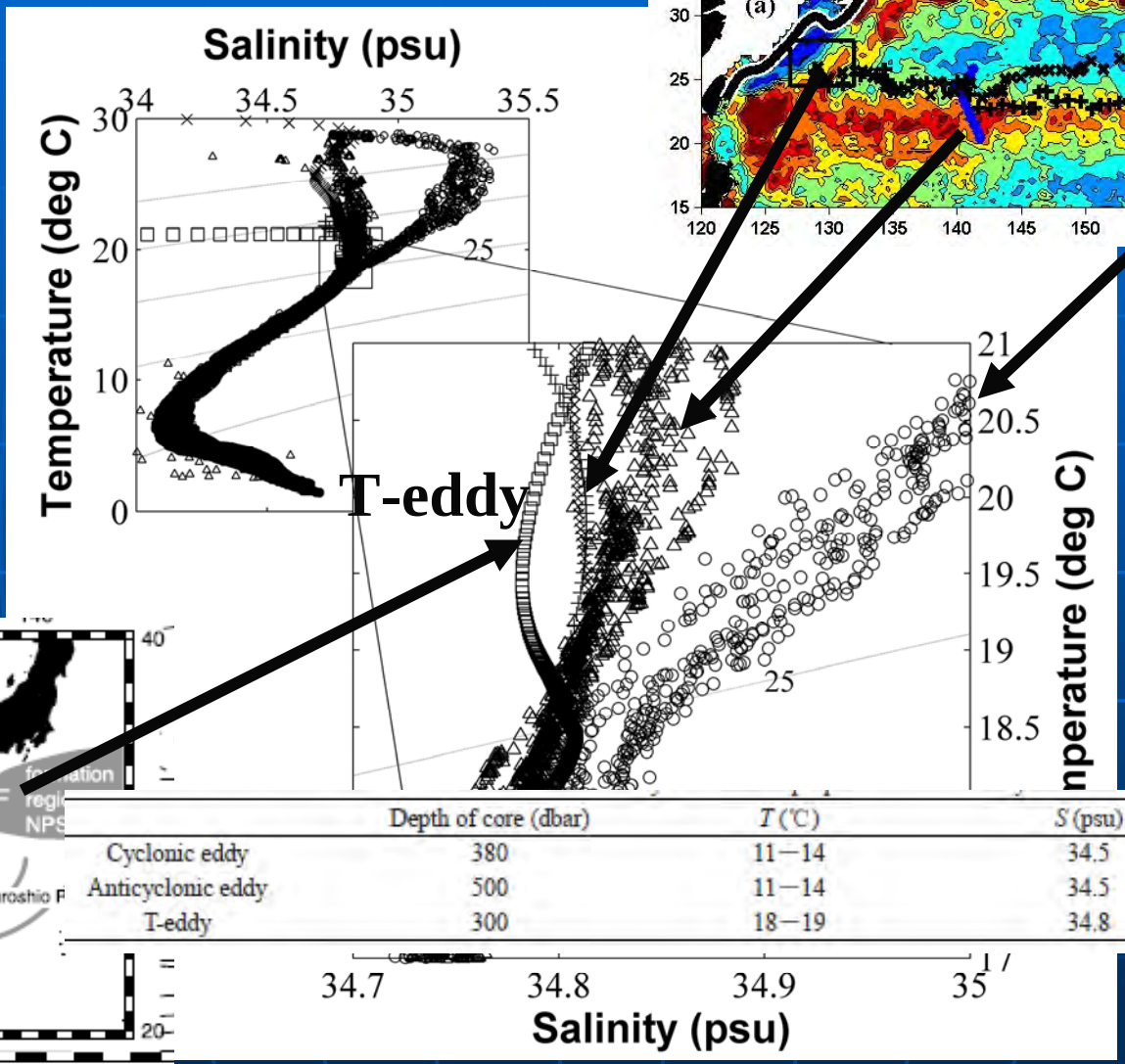


The two eddies traveled about 3000 km during 18−19 months with mean westward propagation speed of about 6 cm s^{-1}.

The phase speed for the baroclinic first-mode Rossby wave at this latitude is about 4.5 cm s^{-1}.

Comparison of the water properties



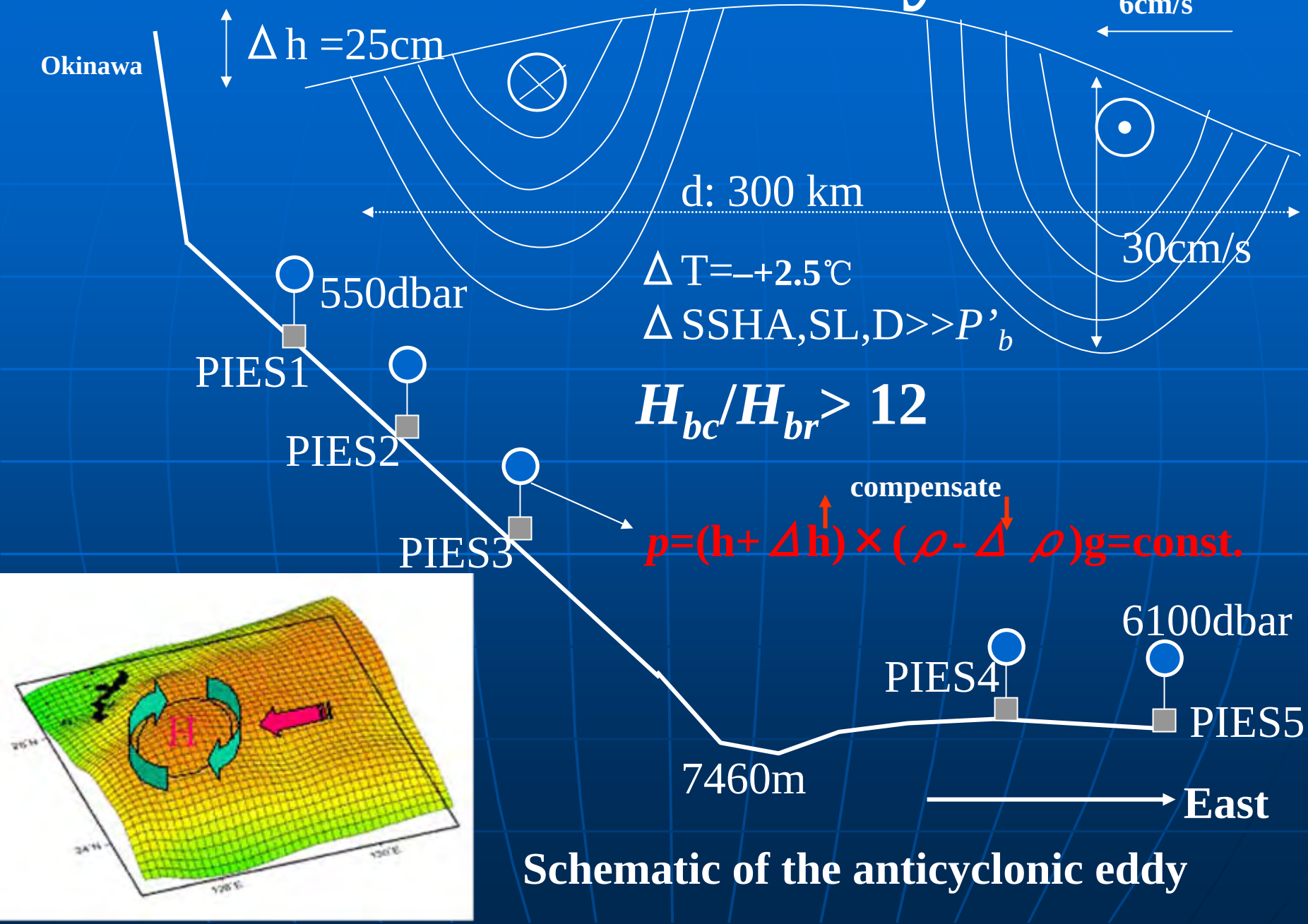


The vertical T gradients are more than 2 times larger than that of the T-eddy

	Depth of core (dbar)	*T* (℃)	*S* (psu)	*T* gradient (℃/100 m)
Cyclonic eddy	380	11—14	34.5	3.0
Anticyclonic eddy	500	11—14	34.5	3.2
T-eddy	300	18—19	34.8	<1.5

Temperature and salinity diagram

6. Summary



$H_{bc}/H_{br} > 12$

Schematic of the anticyclonic eddy

6. Summary

The combination of data from hydrographic casts, MADCP, PIESs, satellite altimeter, and coastal tide gauge exhibits the water properties and dynamic characteristics of a cyclonic and an anticyclonic eddies southeast of Okinawa Island in 2001:

- **The lowest/highest T and S anomalies from the same season 13-year mean are –3.0/+2.5℃ and –0.20/+0.15 psu, respectively. The northeastward current anomaly at 200 dbar observed by the MADCP changed from –20 cm/s to 40 cm/s.**

- **SSHA, SL and D were almost same (–20/30 cm). P_b were uncorrelated and their equivalent SSHA variations were much smaller.**

- **These two eddies were generated at the STCC-NEC region near 20−30° N and 150−160° E, and traveled about 3000 km to arrive at the region southeast of Okinawa Island for about 18−19 months with mean westward propagation speeds of about 6 cm s^{-1}.**

Thank you!