PICES XVII Annual Meeting, Dalian, 2008/10/28 14:00 - 14:20

Eddy Variability from Direct Current Measurements in the Southwestern East/Japan Sea

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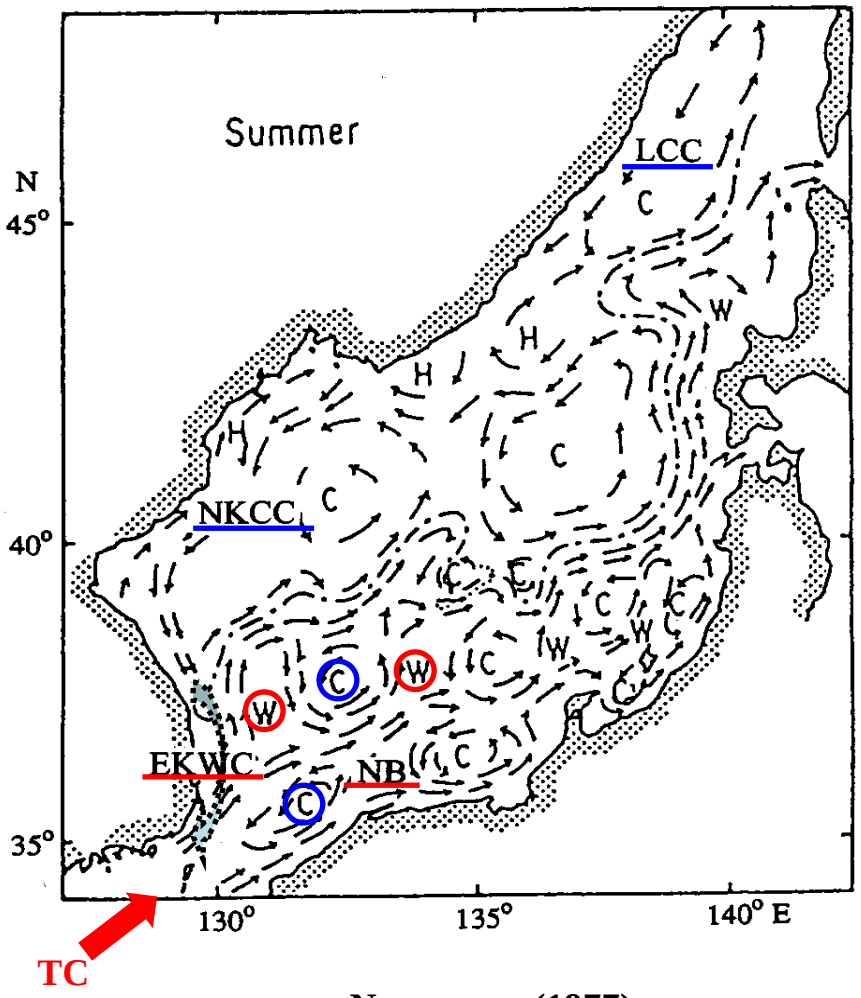
Kim et al. (2008)

Schematic Upper Circulation



TC: Tsushima Current

EKWC: East Korean Warm Current

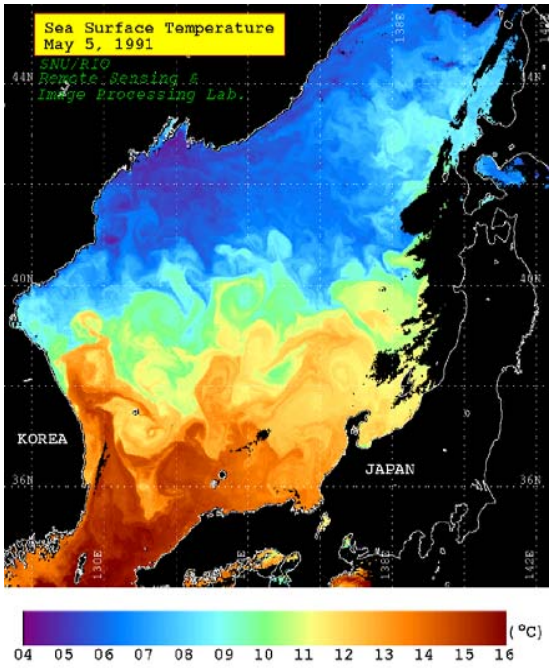
NB: Nearshore Branch

LCC: Liman Cold Current

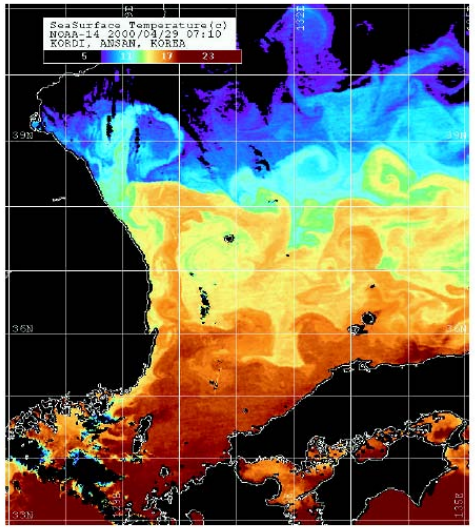
NKCC: North Korean Cold Current

W: Warm eddies

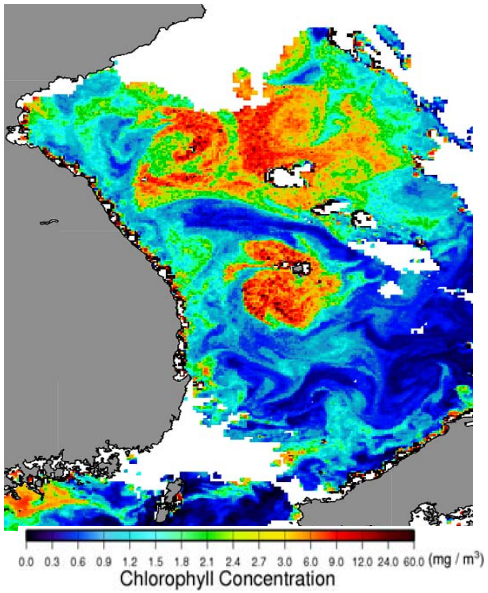
C: Cold eddies



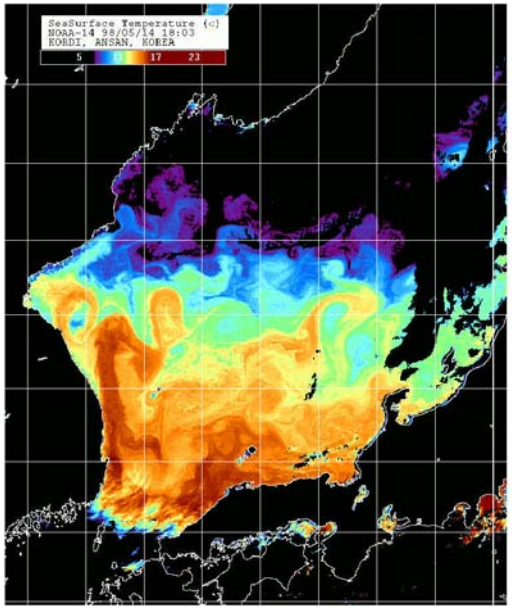
SST (Apr. 29, 2000)



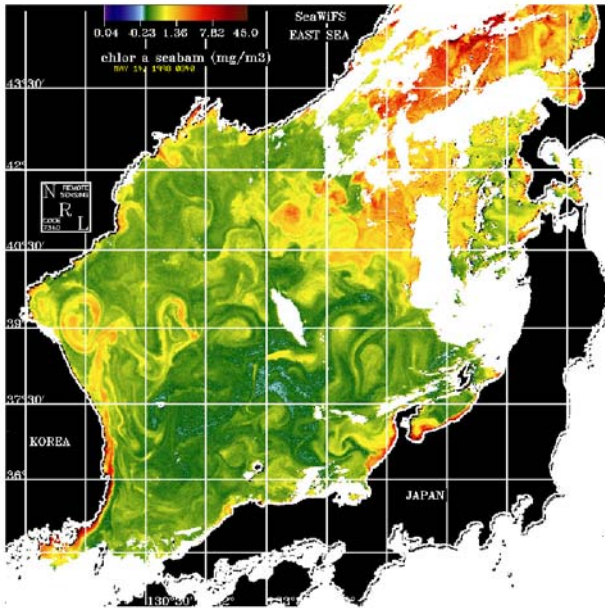
SeaWiFS(May 3, 2000)



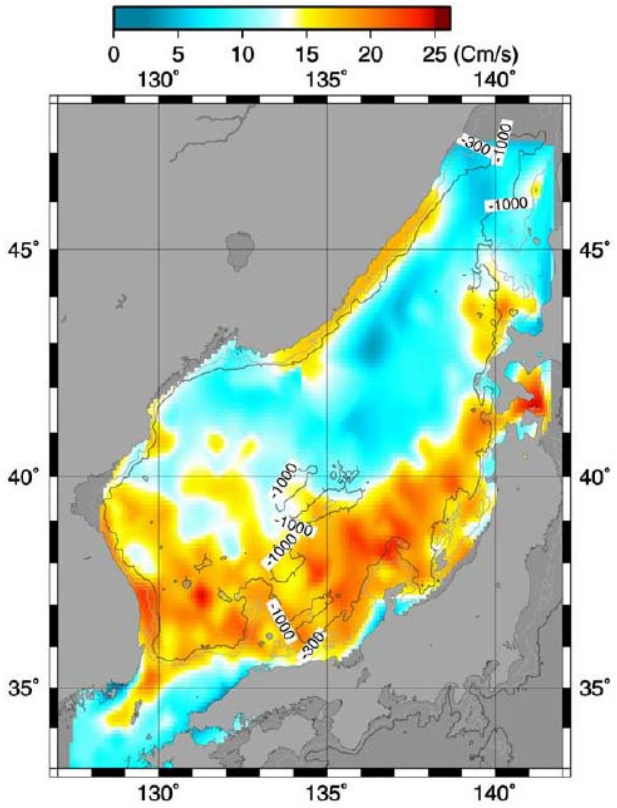
(a) MCSST on May 14, 1998

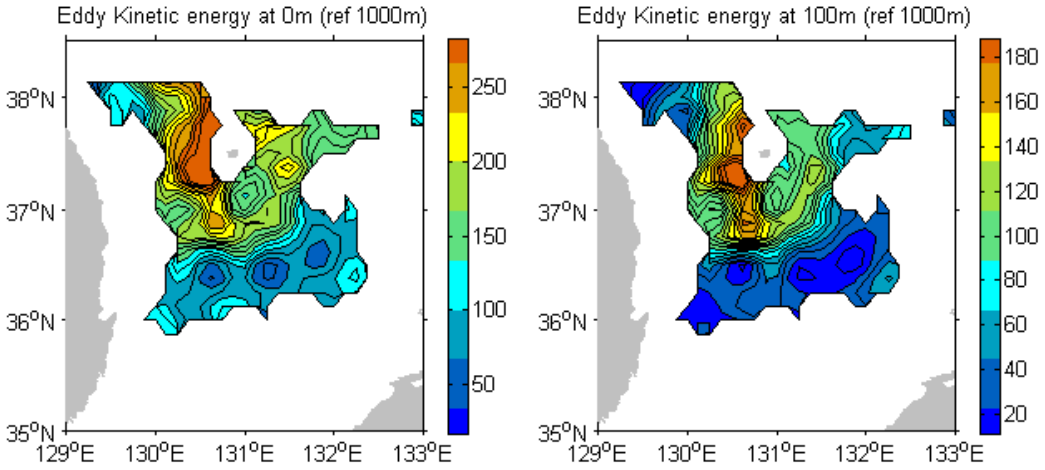


(b) Ocean color on May 14, 1998



Surface Eddy Kinetic Energy



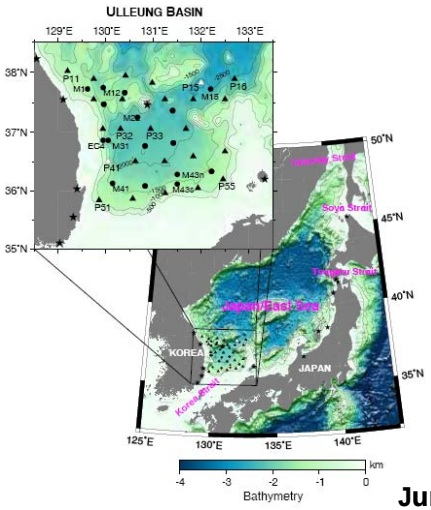


EKE at 0 m & 100 m based on a two-year-long PIES data set during the period of June 1999 – June 2001

Square root of EKE at 15 m based on a long-term surface drifter data set (1988-2001).

EKE=200~600 cm^2/s^2; Lee & Niiler (2005)

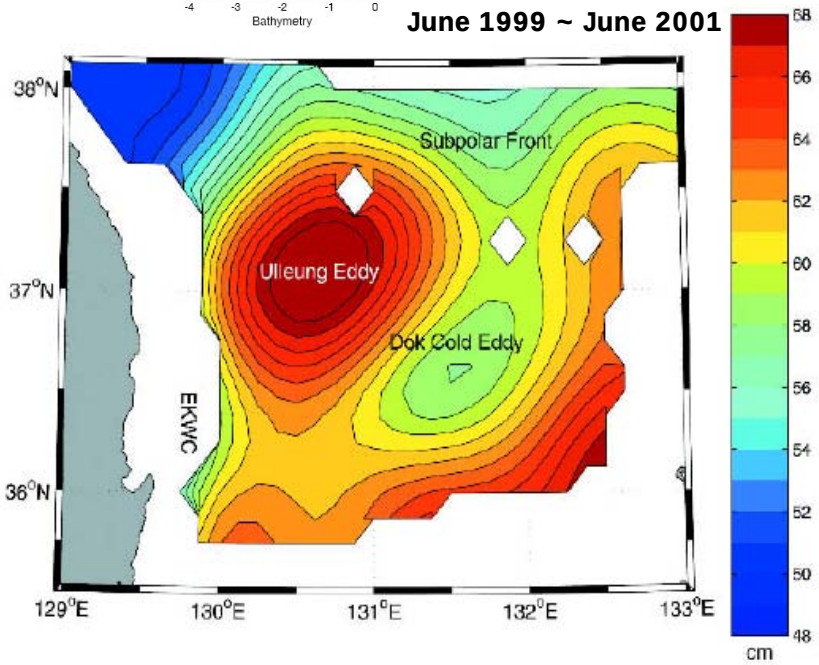
Eddies in the Ulleung Basin



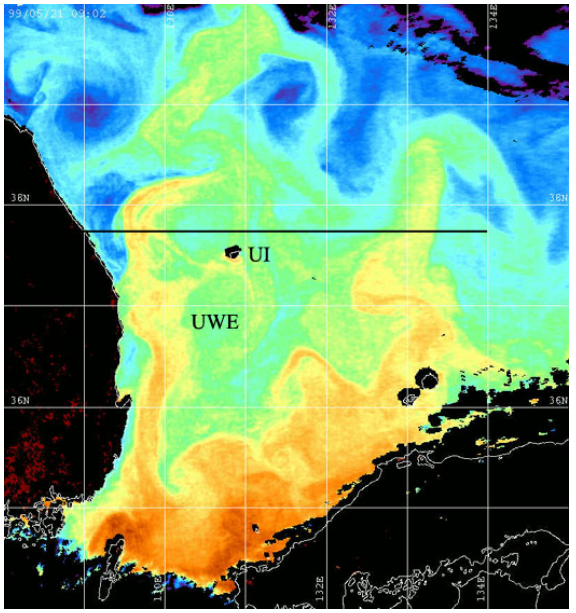
Quasi-permanent eddies in the Ulleung Basin

- Ulleung Warm Eddy
- Dok Cold Eddy

Shin et al. (2005); Mitchell et al. (2005)

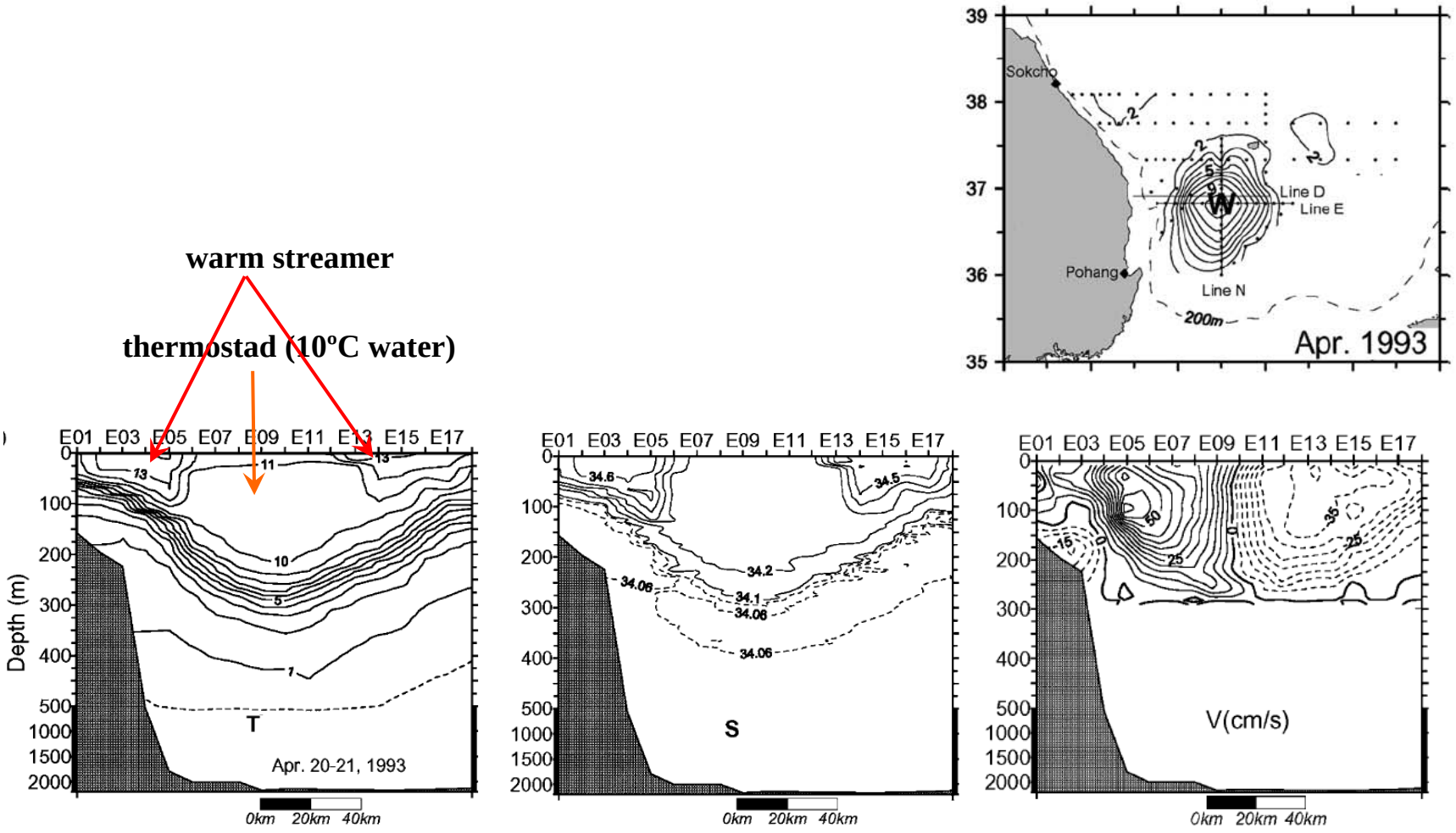


Mean geopotential height anomaly at surface relative to 500 dbar (Mitchell et al., 2005)



Surface signature (Chang et al., 2004)

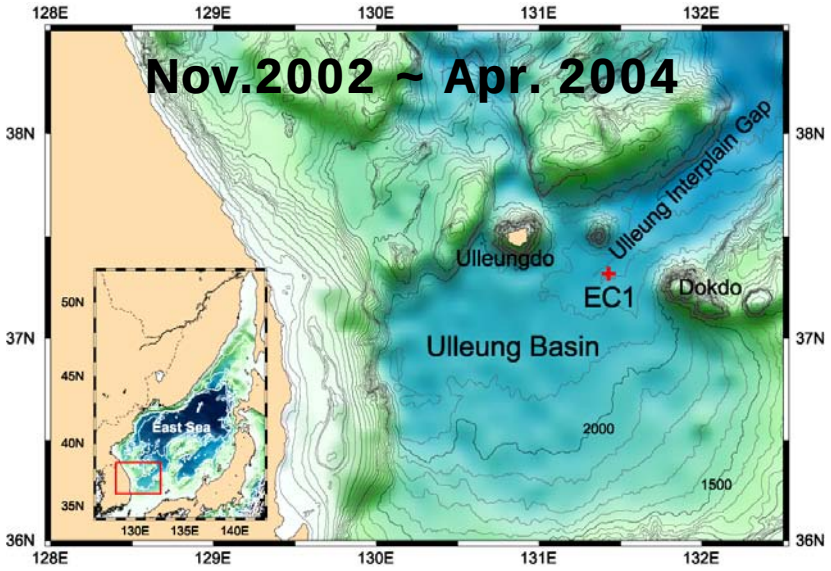
The Ulleung Warm Eddy

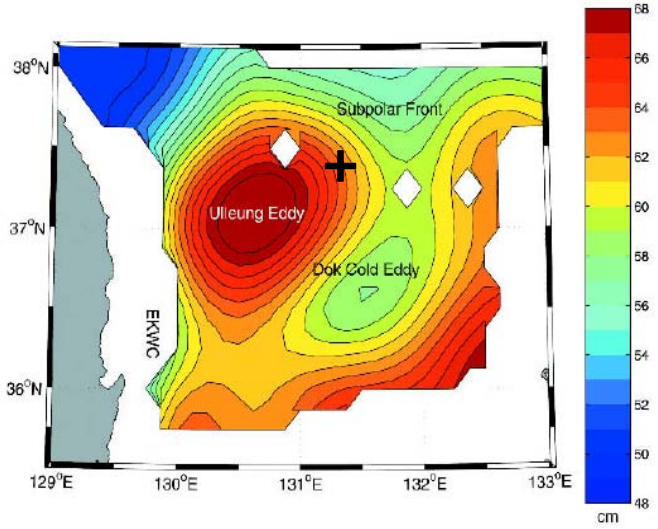


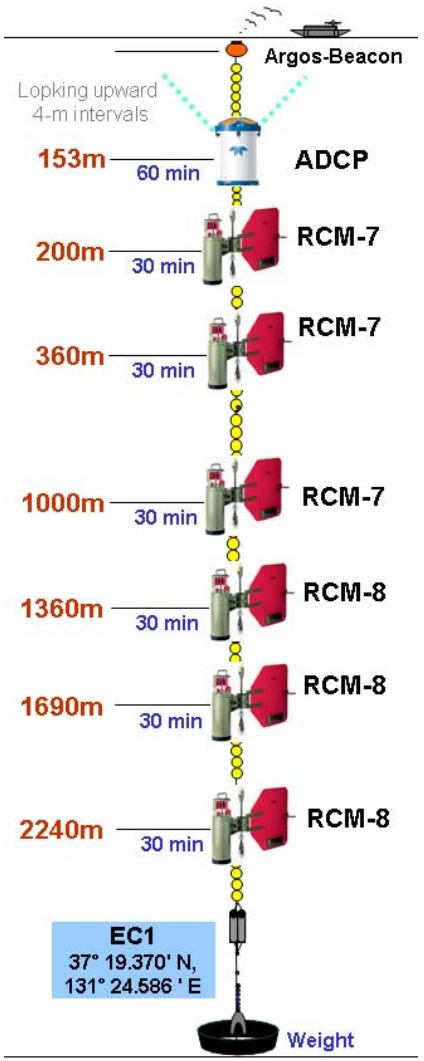
Zonal sections of temperature, salinity, and geostrophic velocity

Shin et al. (2005)

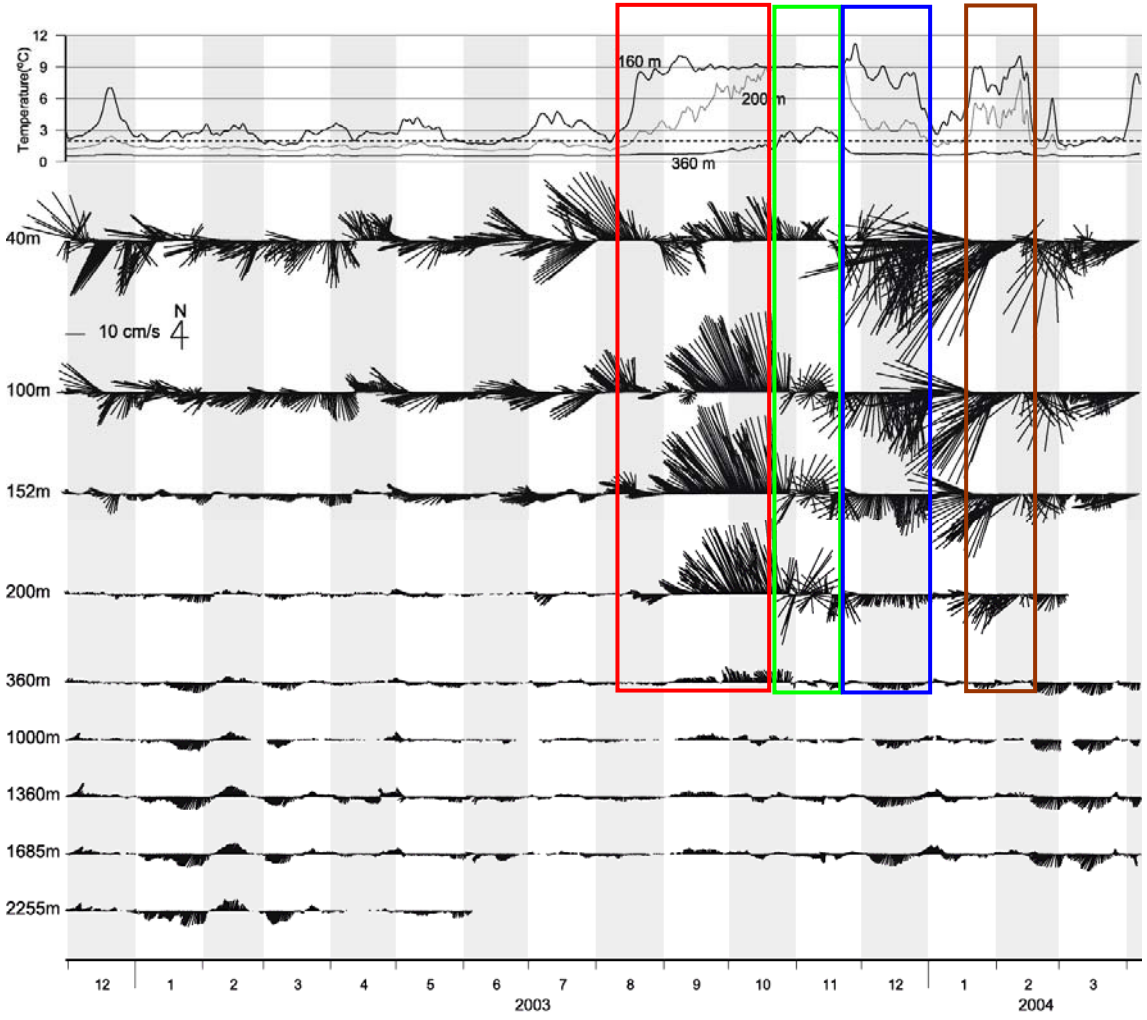
Moored Current Meter Observation







Low-passed Currents and Temperature



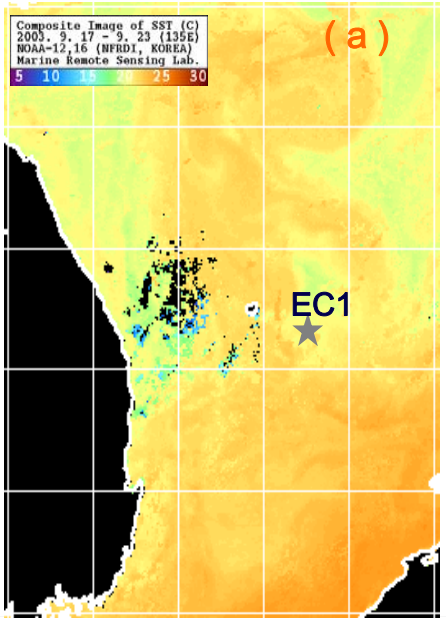
1. Gradual warming at 200 m from mid-Aug. to mid-Oct. (but a sharp T increase at 160 m) concomitant with the development of strong northwestward currents in the upper 200 m in Sept. & Oct. 2003, the core of which occurred at 152 m.

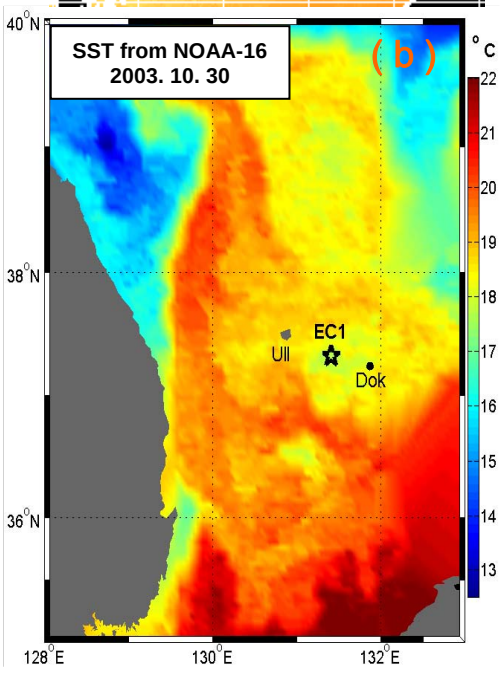
2. Development of thermostad during mid-Oct. and the end of Nov. with the weakening of currents

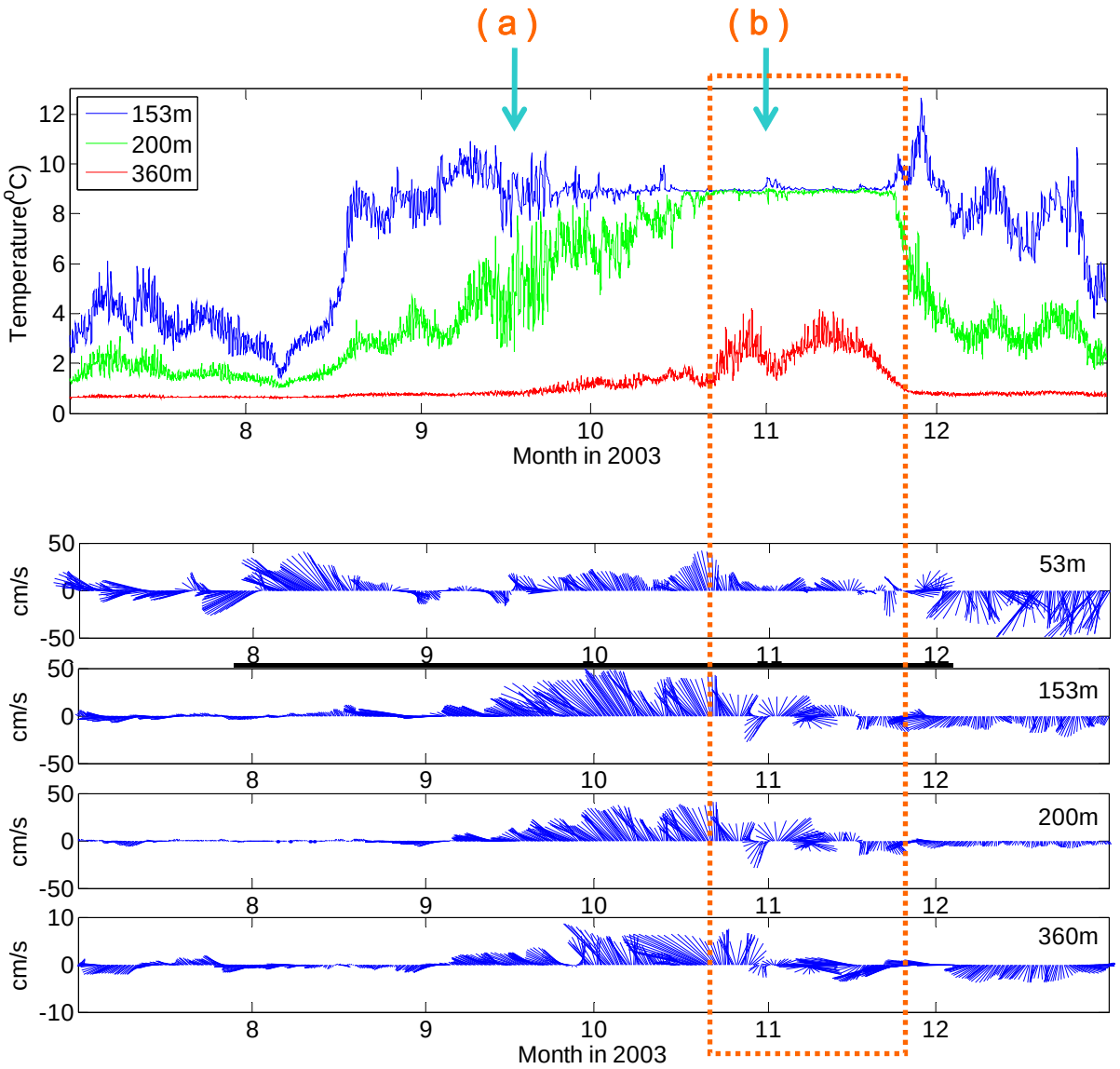
3. Sharp T decrease at 200 and more gradual cooling at 160 m between the end of Nov. and the end of Dec. with strong southward currents with max. speed at 40 m.

4. Second warming event with strong southwestward currents in Jan. & Feb. 2004

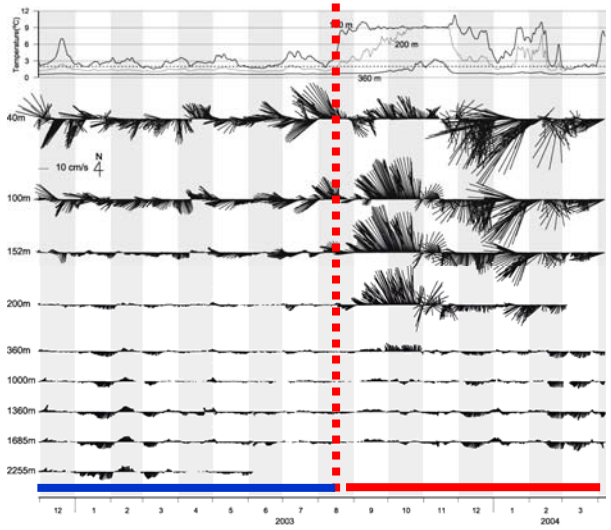
Currents and Temperature during Warm Event



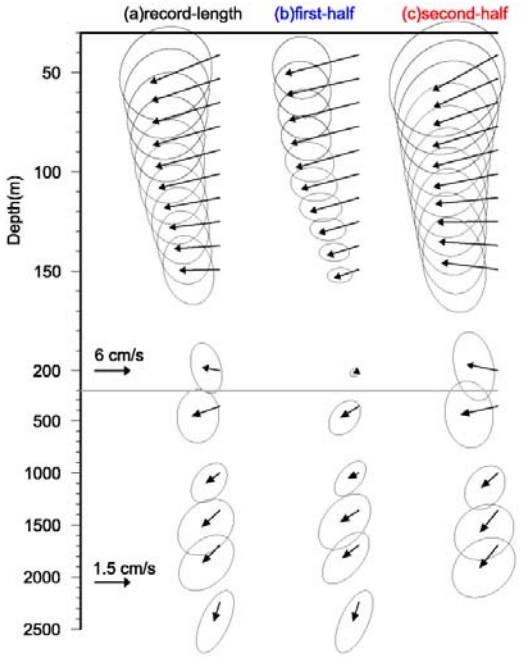


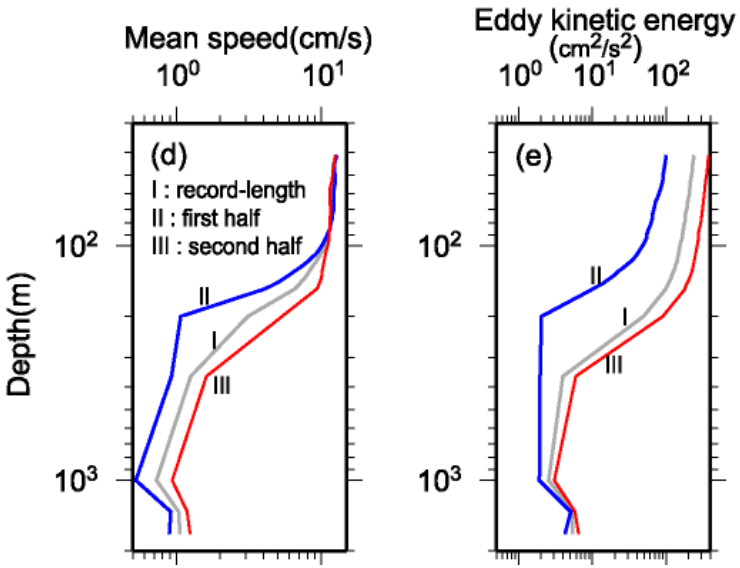


Mean Currents & EKE



Period	Moor-ing depth (m)	Velocity compo-nent	Mean (cm/s)	SD (cm/s)	Vector mean Speed (cm/s)	Vector mean Dir. (°)	Vector mean Max. speed (cm/s)	MKE (cm^2/s^2)	EKE (cm^2/s^2)	EKE/ MKE	Principal axis (°)	Direction stability
First half	40	Ur Vr	-11.6 5.4	9.9 10.2	12.8	255	37.7	82.0	100.9	1.2	172	0.7
(2002/11/30 - 2003/8/3)	100	Ur Vr	-9.1 4.3	6.8 7.0	10.0	255	35.9	50.2	47.0	0.9	98	0.8
	152	Ur Vr	-3.7 1.4	3.4 2.9	4.0	251	21.5	8.0	9.8	1.2	85	0.8
	200	Ur Vr	-1.0 0.3	1.6 1.2	1.1	243	7.9	0.6	2.0	3.5	58	0.6
	360	Ur Vr	-0.9 0.1	1.6 1.1	0.9	238	5.9	0.4	2.0	4.6	39	0.5
	1000	Ur Vr	-0.5 0.1	1.7 1.0	0.5	244	7.2	0.1	1.9	14.0	40	0.4
	1360	Ur Vr	-0.9 0.1	2.7 1.7	0.9	238	8.7	0.4	5.1	12.3	40	0.3
	1685	Ur Vr	-0.9 -0.0	2.6 1.4	0.9	232	8.2	0.4	4.3	10.8	40	0.4
Second half	40	Ur Vr	-12.3 2.4	20.9 17.9	12.6	241	78.7	78.6	377.7	4.8	46	0.5
(2003/8/4 - 2004/4/7)	100	Ur Vr	-9.7 5.3	15.8 16.5	11.0	259	68.4	60.8	260.6	4.3	1	0.5
	152	Ur Vr	-6.2 6.9	11.7 14.8	9.3	278	50.6	45.6	177.4	4.2	169	0.5
	200	Ur Vr	-3.4 4.2	8.0 10.9	5.3	281	40.5	14.3	90.7	6.4	168	0.5
	360	Ur Vr	-1.4 0.8	2.3 2.6	1.6	258	9.6	1.3	5.9	4.6	173	0.5
	1000	Ur Vr	-0.9 0	2.0 1.5	0.9	229	8.3	0.4	3.1	7.0	38	0.5
	1360	Ur Vr	-1.2 -0.2	2.6 2.2	1.2	220	9.0	0.7	5.8	8.3	56	0.4
	1685	Ur Vr	-1.2 -0.2	2.9 2.2	1.2	219	9.7	0.8	6.5	8.6	50	0.4





East-west comp.

North-south comp.

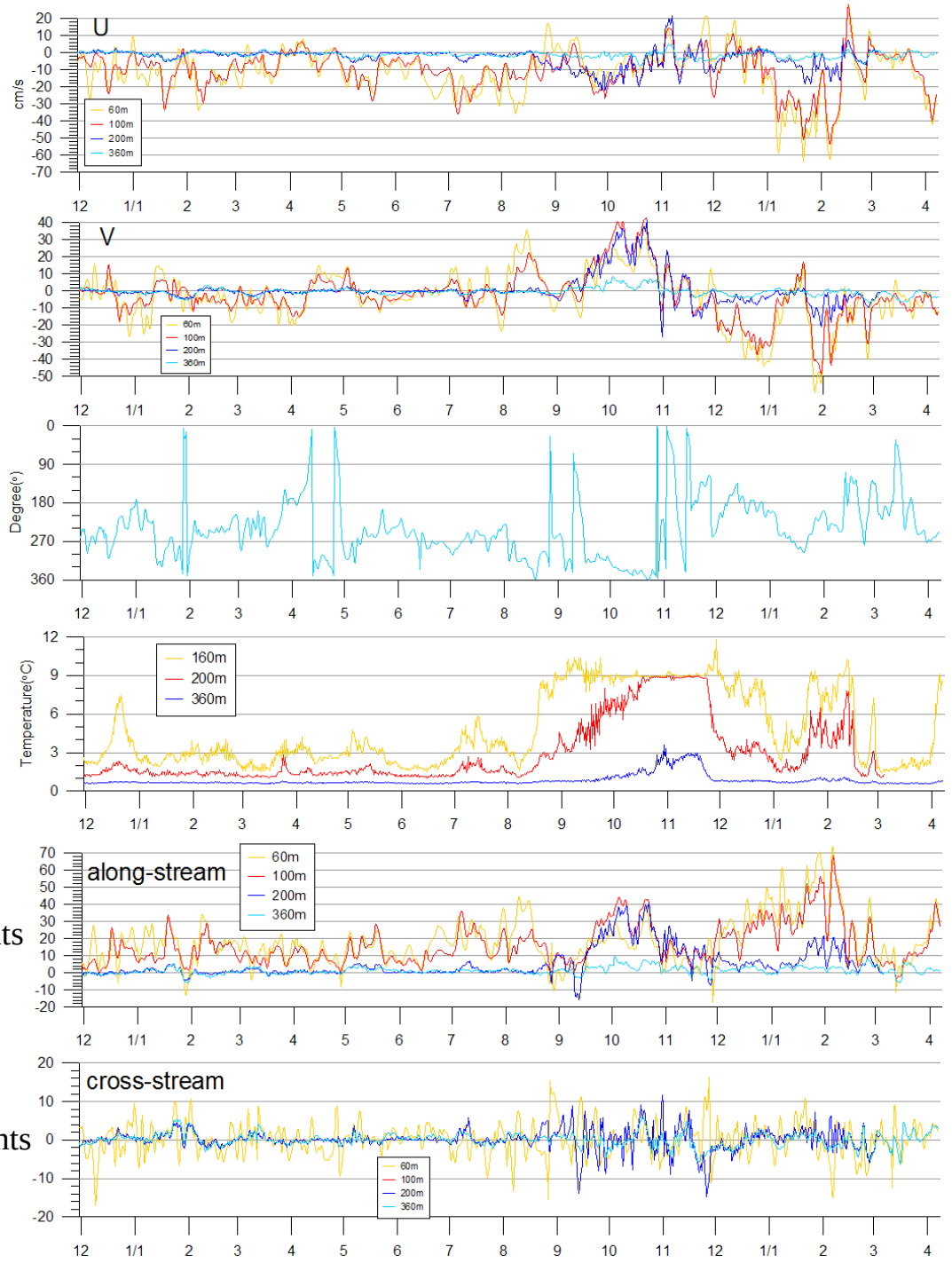
Along-stream dir.

Stream coordinate
100 m vs 360 m;
Phillips & Rintoul (2000)

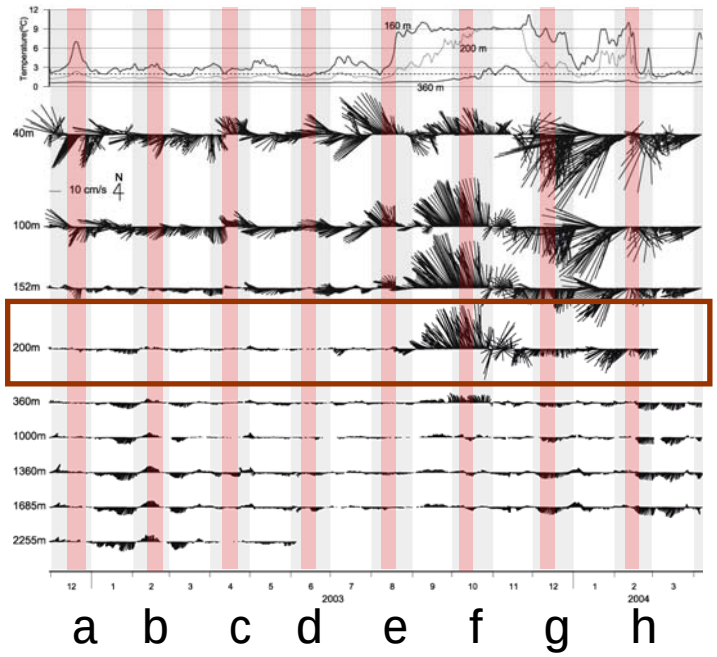
Temperature

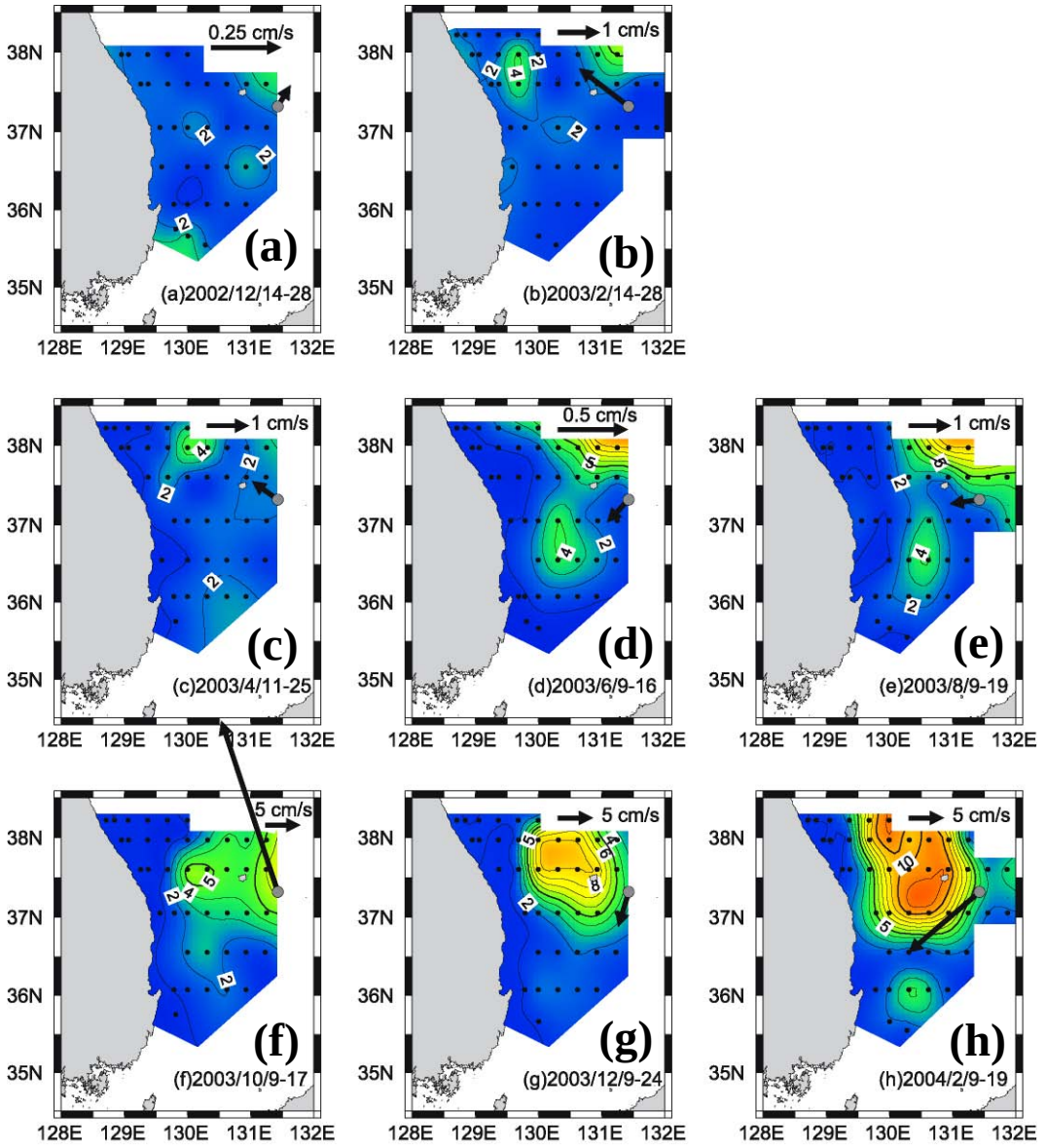
Along-stream currents

Cross-stream currents



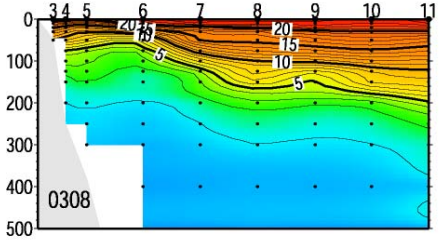
Bimonthly Temperature Distribution at 200 m



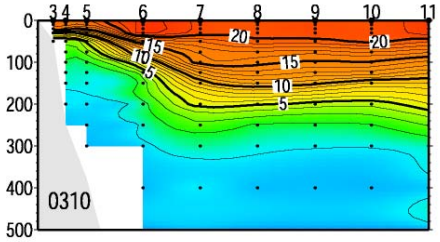


Vertical Sections of Temperature

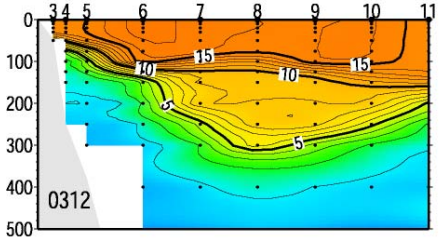
(a) Aug. 2003



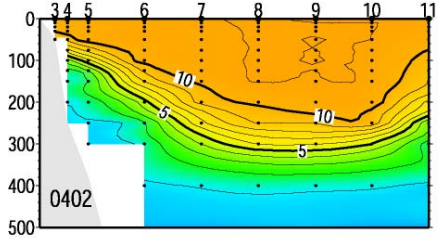
(b) Oct. 2003

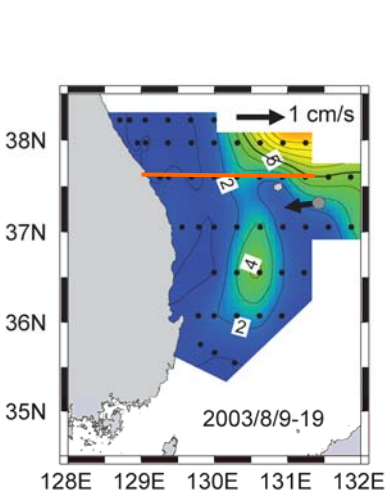


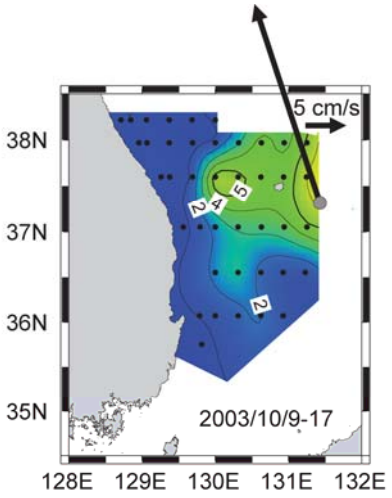
(c) Dec. 2003

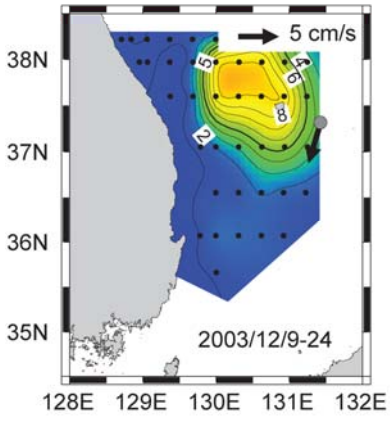


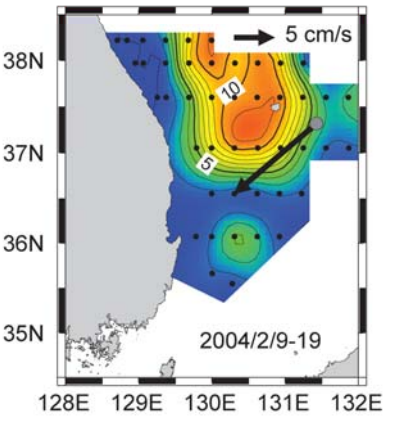
(d) Feb. 2004









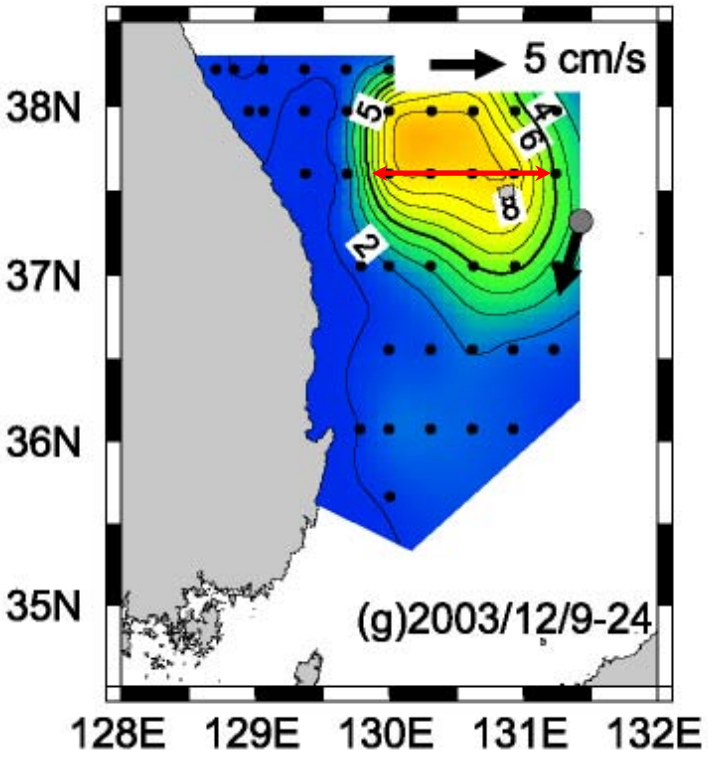


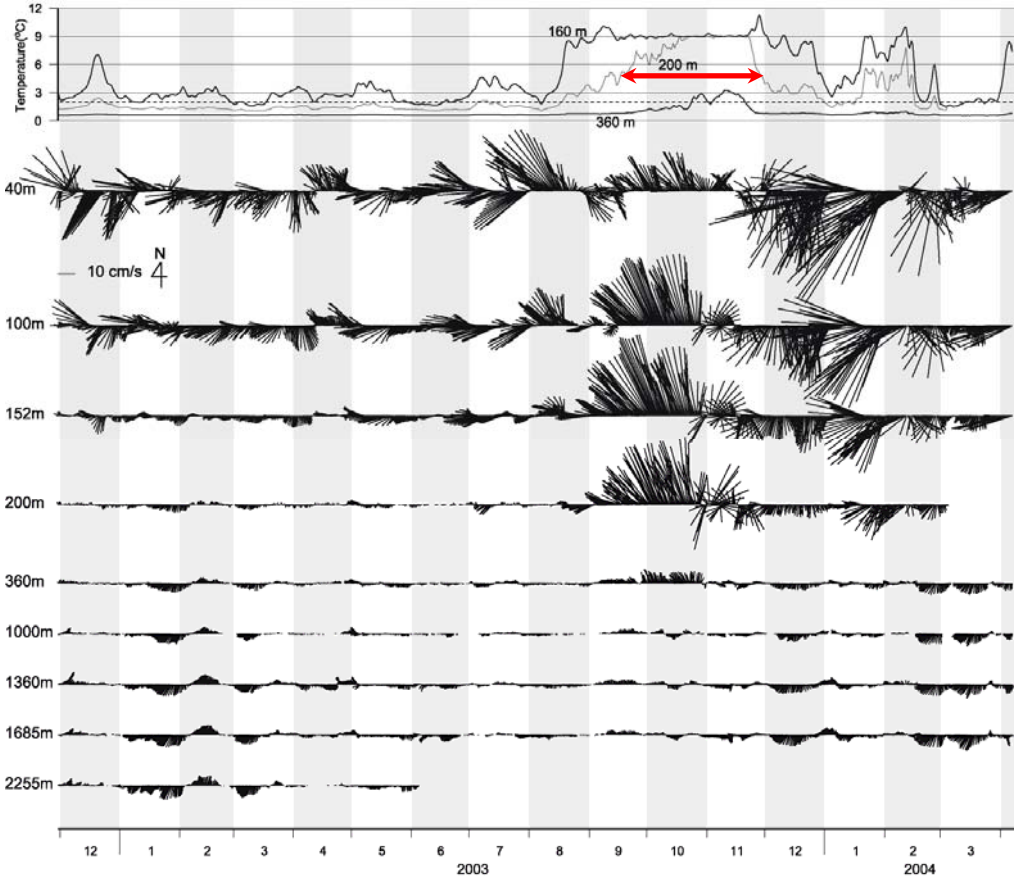
Translational speed of an eddy : ~2.0 cm/s

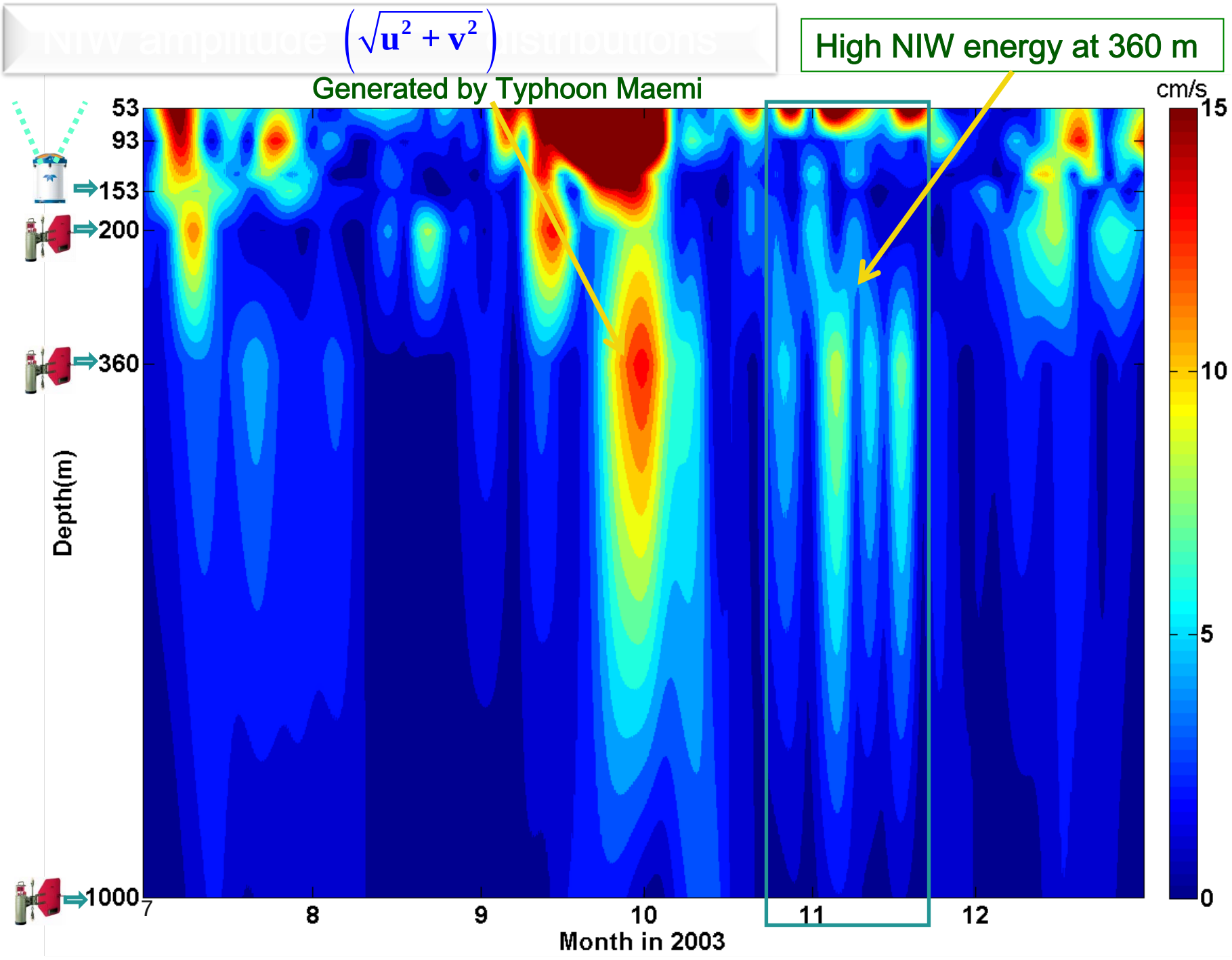
horizontal distance between 5^{o} isotherms at 200m : ~123 km

duration of T>5^{o} at 200 m : 71 days

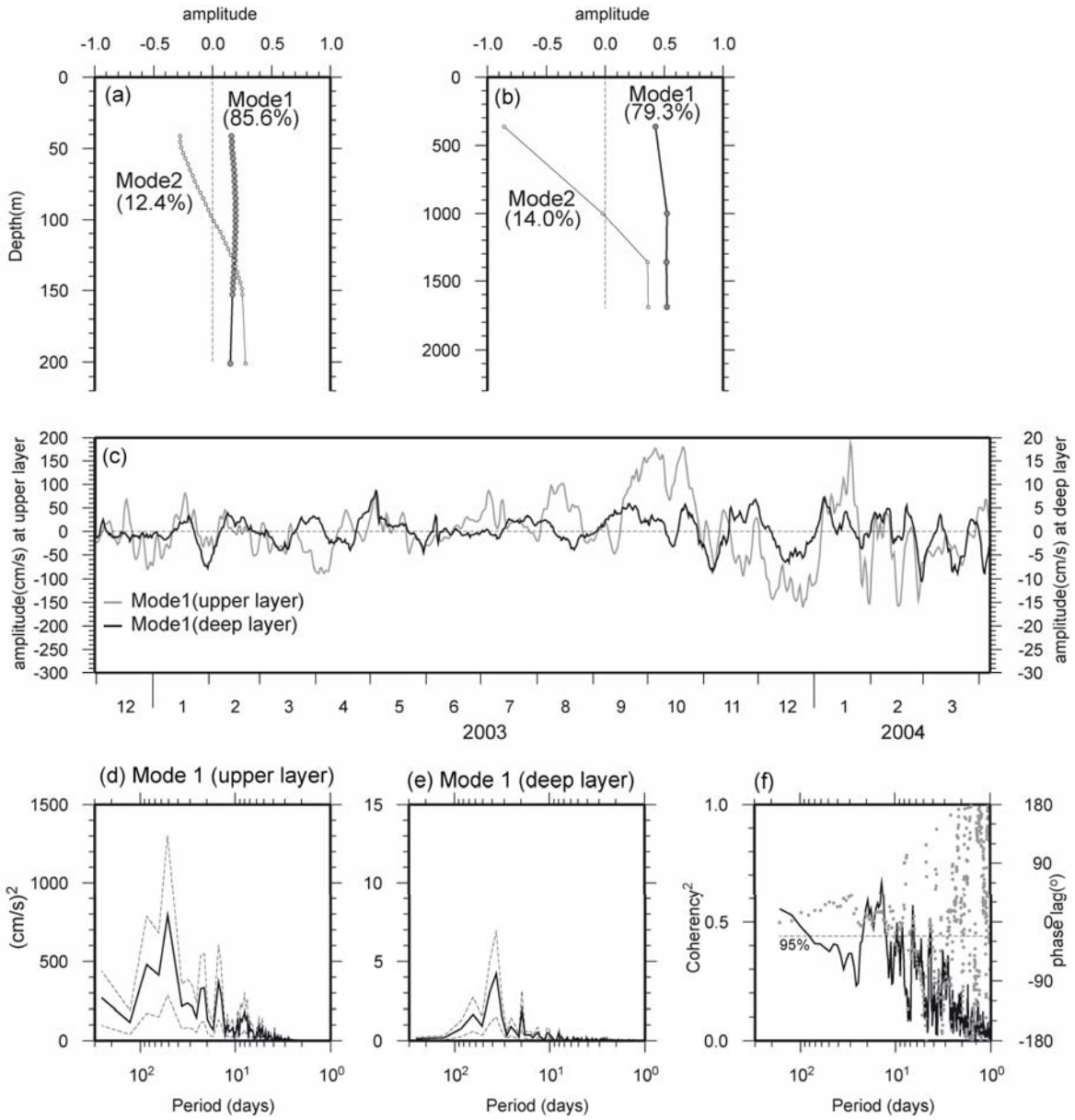
Ro = U/fL ~ 0.1






NIW amplitude $\left(\sqrt{u^2+v^2}\right)$ distributions
High NIW energy at 360 m
Generated by Typhoon Maemi
cm/s
15
10
5
0
53
93
153
200
360
1000
Depth(m)
7
8
9
10
11
12
Month in 2003

Upper & Deep Currents



Summary

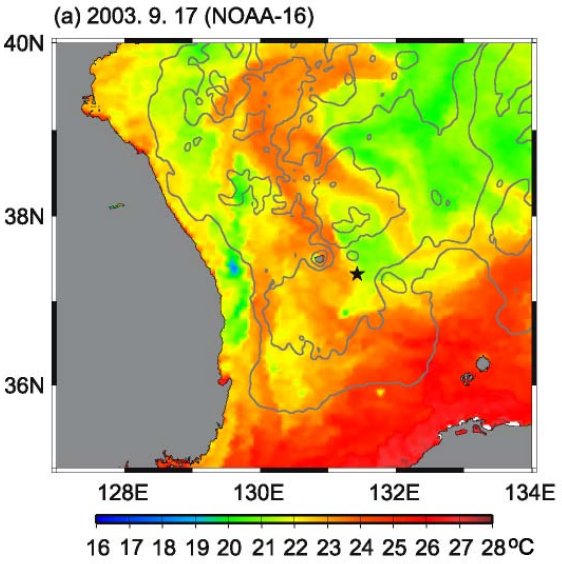
- **A 16.5-month-long moored current observation between Nov. 2002 and Apr. 2004 captured a westward migrating anticyclonic warm eddy feature during the second half of the observation period.**

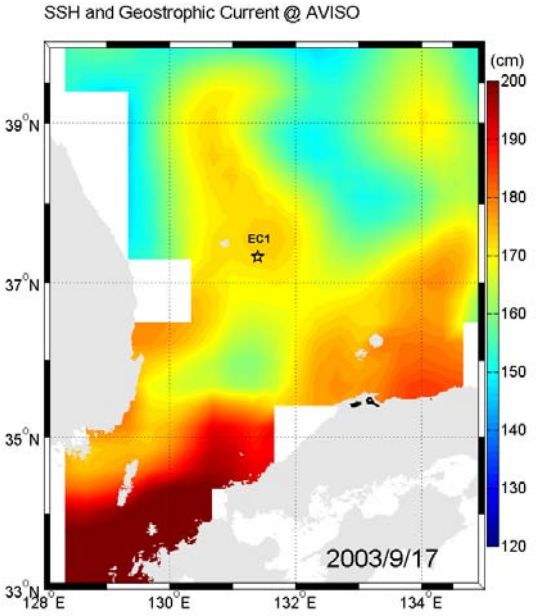
- **Eddy kinetic energy in the upper 200 m during the second half (~400 cm^2/s^2 at 40 m) is about three to forty times higher than the EKE during the first half.**

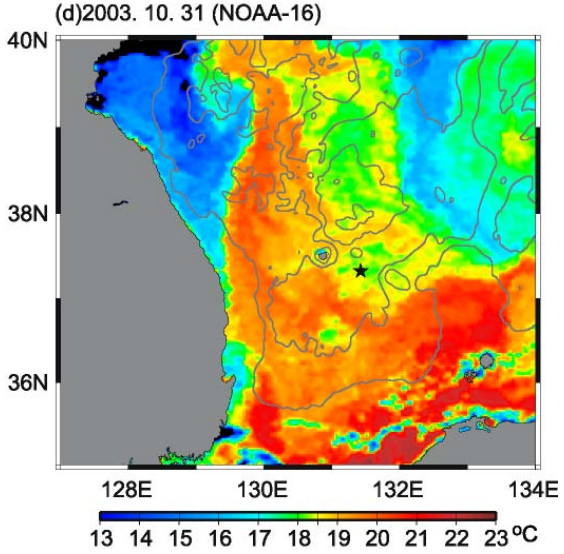
- **An increase in the subsurface temperature was observed during this period down to at least 360 m. The temperature increased to about 6 °C at 160 m. Upper currents responded to the passage of the eddy, and an intensification of northwestward (> 51 cm/s) and southwestward (> 78 cm/s) upper currents occurred when EC1 was placed near the western and eastern periphery of the eddy feature.**

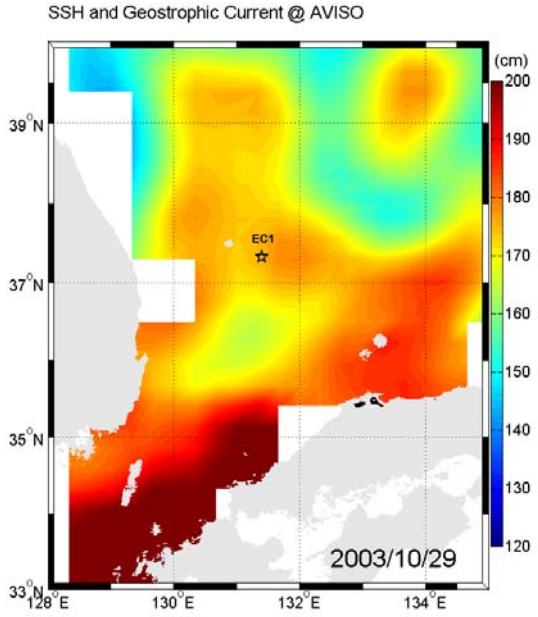
- **When EC1 was close to the center of the eddy, a thermostat developed and upper currents became weak. An amplification of the NIW energy occurred during this period.**

- **Fluctuations of upper and deep currents are poorly related.**


(a) 2003. 9. 17 (NOAA-16)
40N
38N
36N
128E
130E
132E
134E
16 17 18 19 20 21 22 23 24 25 26 27 28 ºC

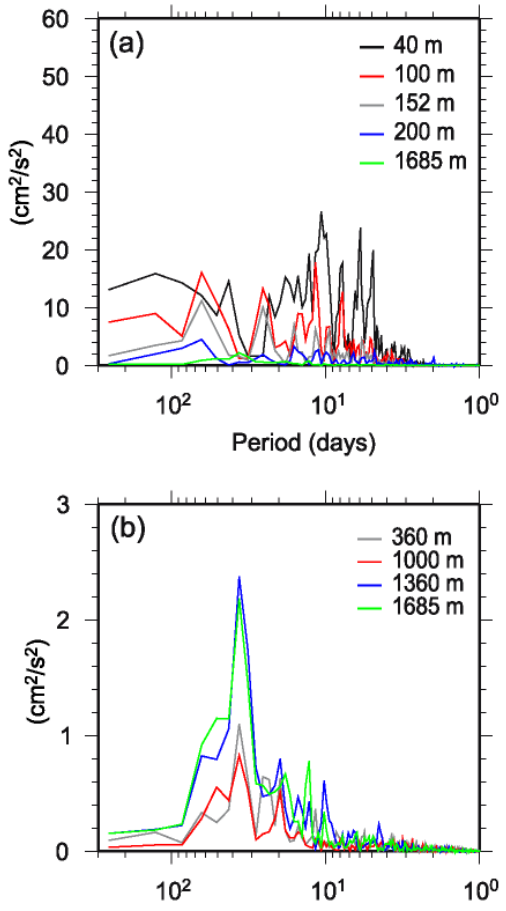
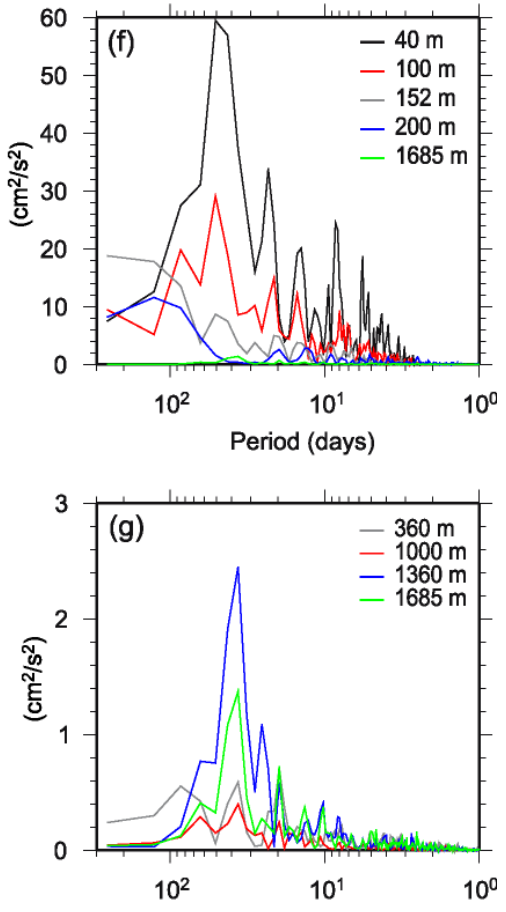

SSH and Geostrophic Current @ AVISO
(cm)
200
190
180
170
160
150
140
130
120
39°N
37°N
35°N
33°N
EC1
2003/9/17
128°E
130°E
132°E
134°E


(d)2003. 10. 31 (NOAA-16)
40N
38N
36N
128E
130E
132E
134E
13 14 15 16 17 18 19 20 21 22 23 ºC


SSH and Geostrophic Current @ AVISO
(cm)
200
190
180
170
160
150
140
130
120
39°N
37°N
35°N
33°N
EC1
2003/10/29
128°E
130°E
132°E
134°E

Power spectra

First half (cold period)



Second half (warm period)