A numerical study on the dispersion of the Yangtze River water in the Yellow and East China Seas

by

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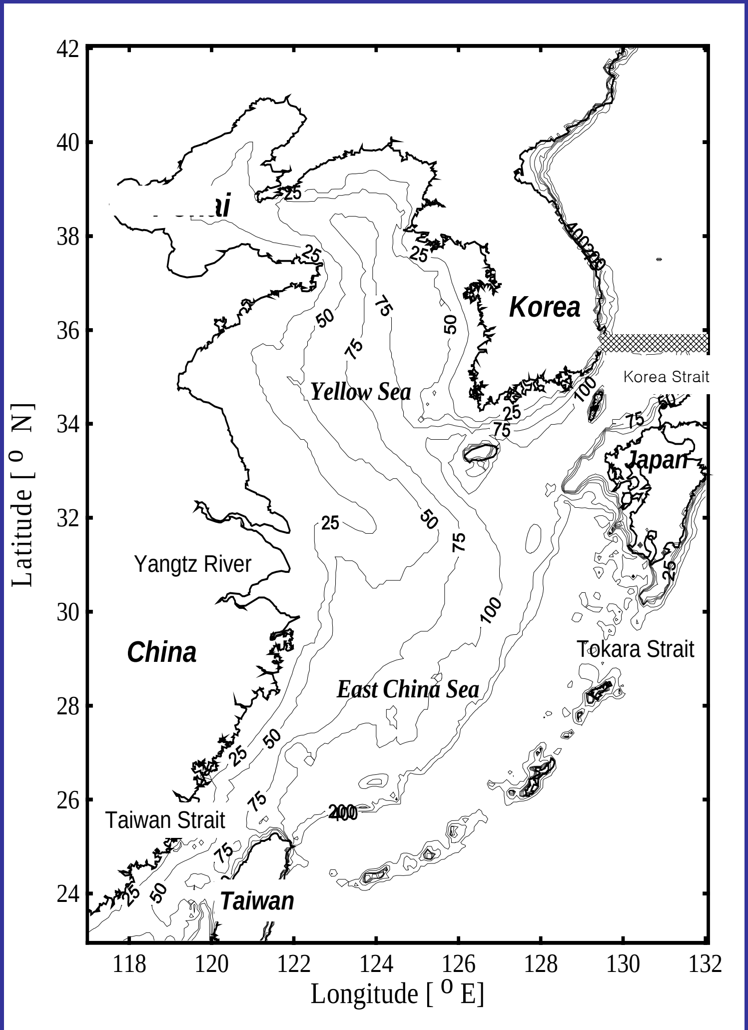


A bathymetry of the Yellow and East China Seas.
Isobaths are in meters.

Characteristics of the Yellow and East China Sea

- Shallow and wide continental shelf, a steep continental shelf break
- Strong tides
- Seasonally variable winds
- Strong ocean current
- River discharge (Yangtze River et al.)

Previous Studies

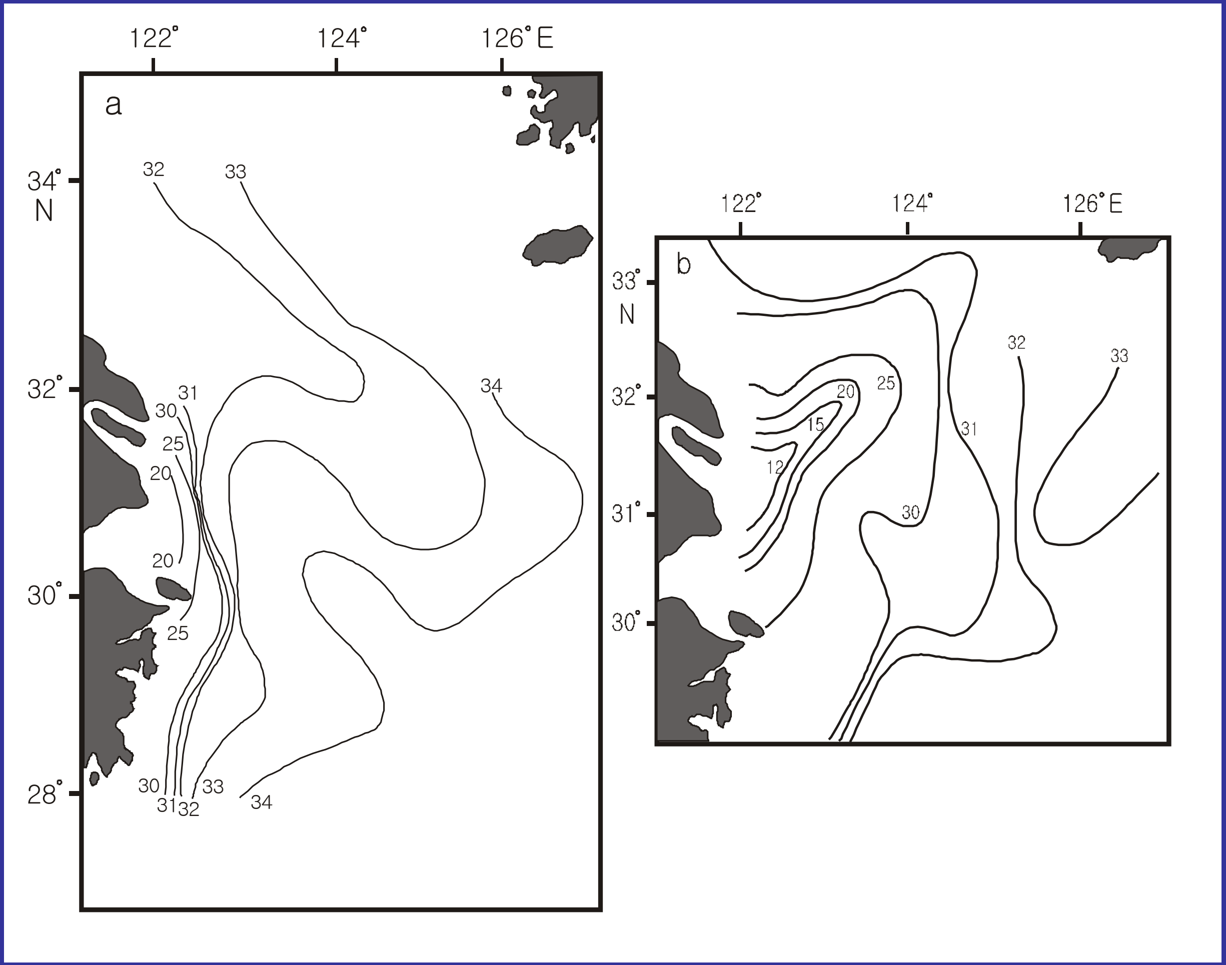
• Seasonal variations of Yangtze River plume direction

 - by the wind and the Kuroshio Current (Hu, 1994)
 - by the fluctuation of River water, wind, bottom topography
 (Mao et al., 1963; Beardsley et al, 1985; Guan, 1994)

• Coastal density currents induced by buoyancy supply
 (Chao and Boicourt, 1986; Qui and Imasato, 1988)

• Stratified tidal rectification is an important process in the summertime subtidal flow in numerical model (Lee and Beardsley, 1999)

• Some numerical experiments considering wind variation, topography, and river discharge (Bang and Lee, 1999)



The surface salinity distributions off the Yangtze River mouth
(a) February, 1978, (b) June, 1975 (Hu, 1994)

Aim and Scope of the Present Study

In the former studies,

The circulation pattern of winter by wind effect in the YECS is relatively well known.

However, The circulation pattern of summer seems to be unclear. Especially the role of the tide is not clarified.

In the present study,

For the understanding of the circulation and the dispersion of the Yangtze River water, two major controlling factors, **tide and wind effects**, are systematically analyzed, and compared with observed data.

Numerical Model

Model configuration

Princeton Ocean Model (Blumberg and Mellor, 1987)

Horizontal Resolution : 1/6° × 1/6°, 117° ~ 132 °E, 23 °~42 °N

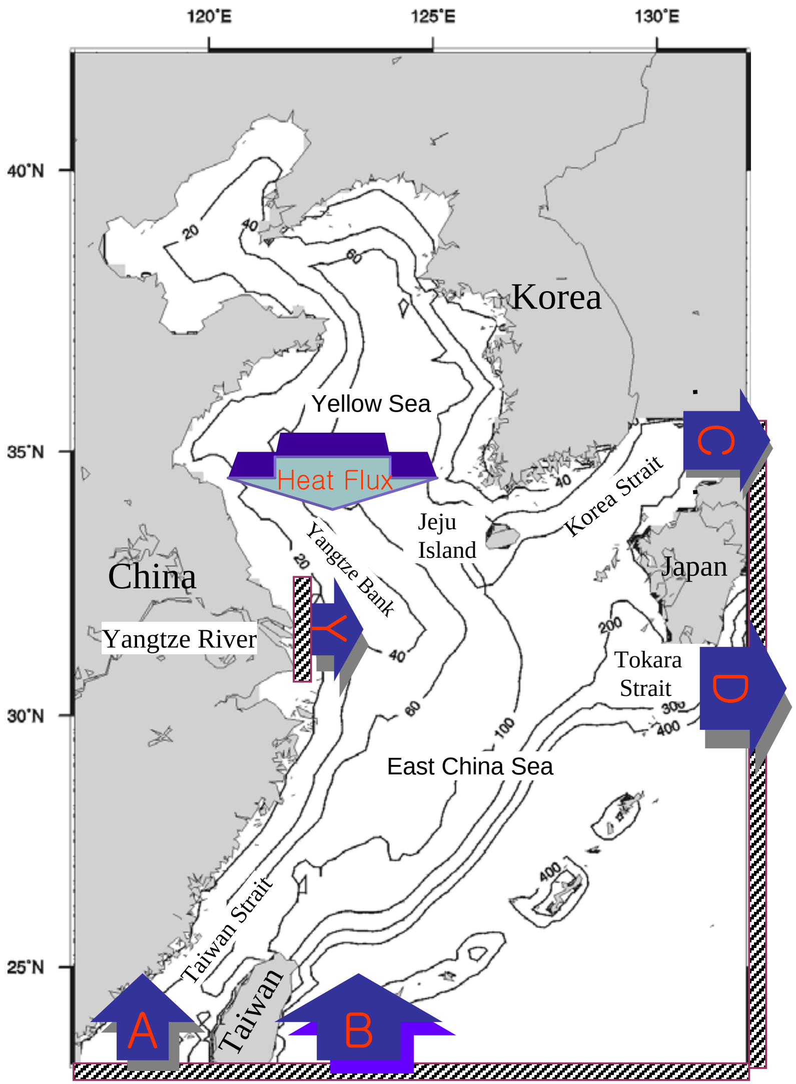
Vertical Resolution : 12 sigma levels

Time step : Internal mode 1863 seconds, External mode 48 seconds

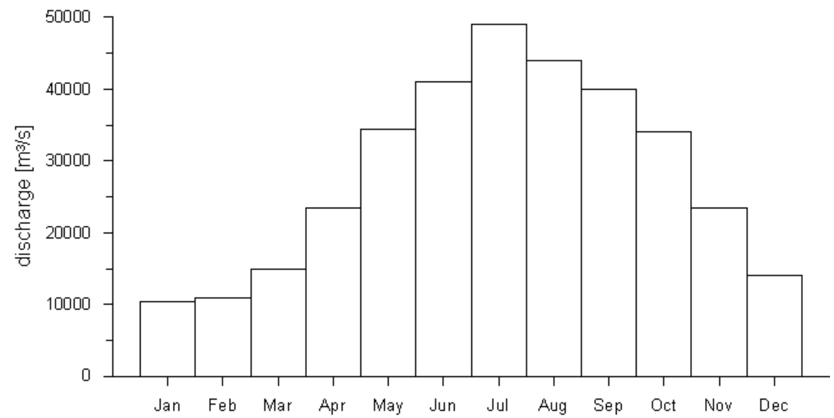
➢ Characteristics of POM

- Free surface model
- Arakawa C grid
- Sigma grid system
- Mode splitting (external mode, internal mode)
- Turbulence closure sub-model : vertical eddy coefficients

❑ Model domain and inflow/outflow at boundaries



The model domain and bathymetry in meters.



Monthly variation of the mean discharge of the Yangtze River from January 1950 to December 1985 (from Shen et al., 1998).

A : 1.1 ± 0.9 Sv (Max. in Aug., min. in Feb.)

B : 23 ± 0.35 Sv (Max. in Sep., min. in Mar.)

C : 2.2 ± 0.35 Sv (Max. in Sep., min. in Mar.)

Y : monthly variation as above

D : A+B+Y−C

Heat Flux : mpnthly variations

Input Data

Sea surface wind : Na and Seo (1998), 18-year (‘78~’95) monthly mean

- Tide : M_2 constituent, η (elevation) and *U* (current velocity)

  from Oh and Lee, 1998

- Temperature and Salinity : Levitus (1994), monthly mean
- Heat Flux : COADS data (1997), monthly mean
- Yangtze River discharge : 36-year averaged monthly mean

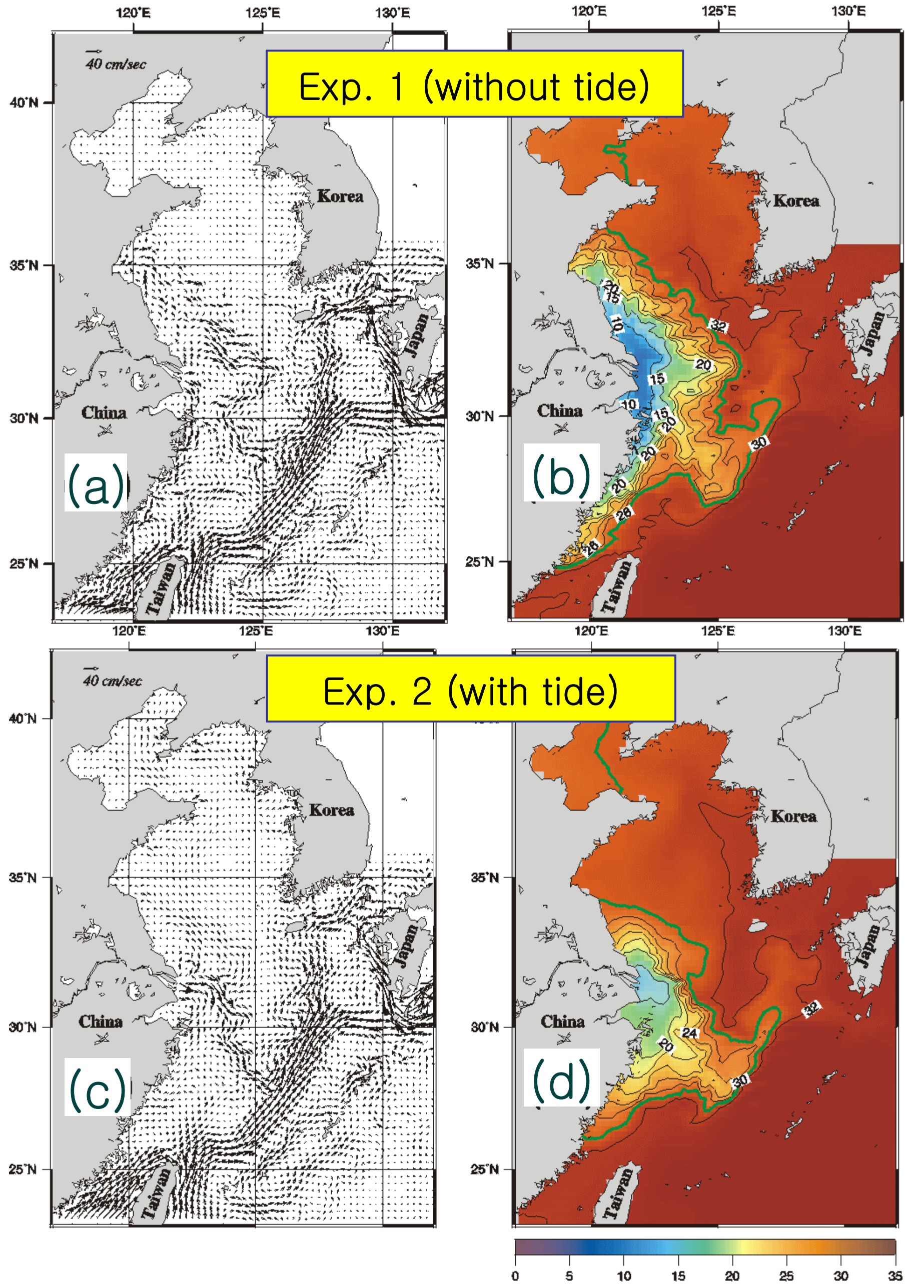
  (Shen et al., 1998)

Experimental conditions

- Applied forcing for prognostic calculation

Experiments	External Forcing
Exp. 1	Kuroshio Current + YRD
Exp. 2	Kuroshio Current + YRD + M_2 Tide
Exp. 3	Kuroshio Current + YRD + Sea Surface Wind
Exp. 4	Kuroshio Current + YRD + M_2 Tide + Sea Surface Wind

(YRD : Yangtze River Discharge)



When TIDE is included in August

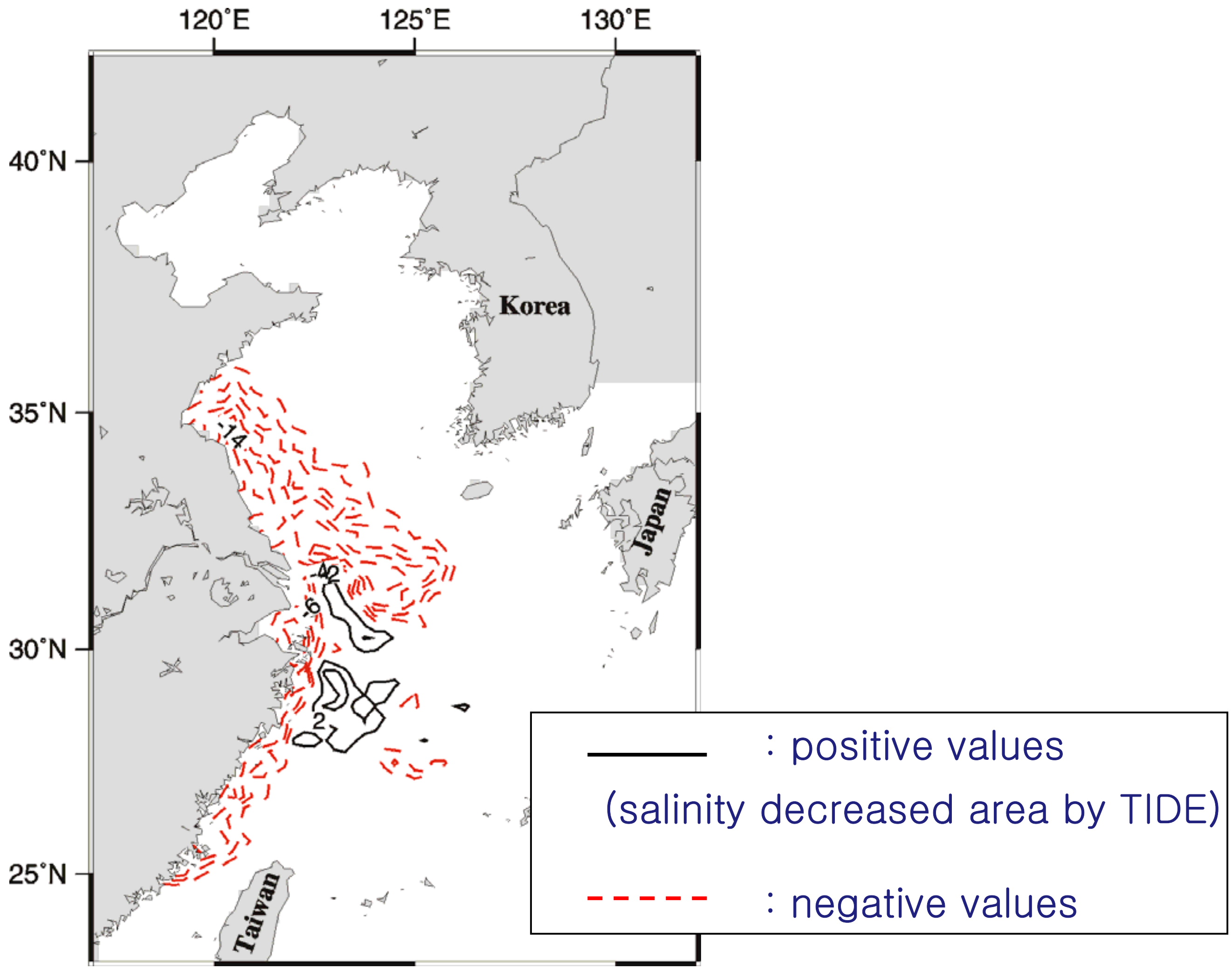
✓ The currents of the northern part of 32 deg. N. are suppressed.

✓ The northward dispersion of the low salinity water is reduced.

✓ The low salinity water converges the southeastern area off the Yangtze Bank.

Distributions of the sea surface (a)current, (b)salinity in Exp. 1 and (c)current, (b)salinity in Exp. 2 in August

TIDE effect in August

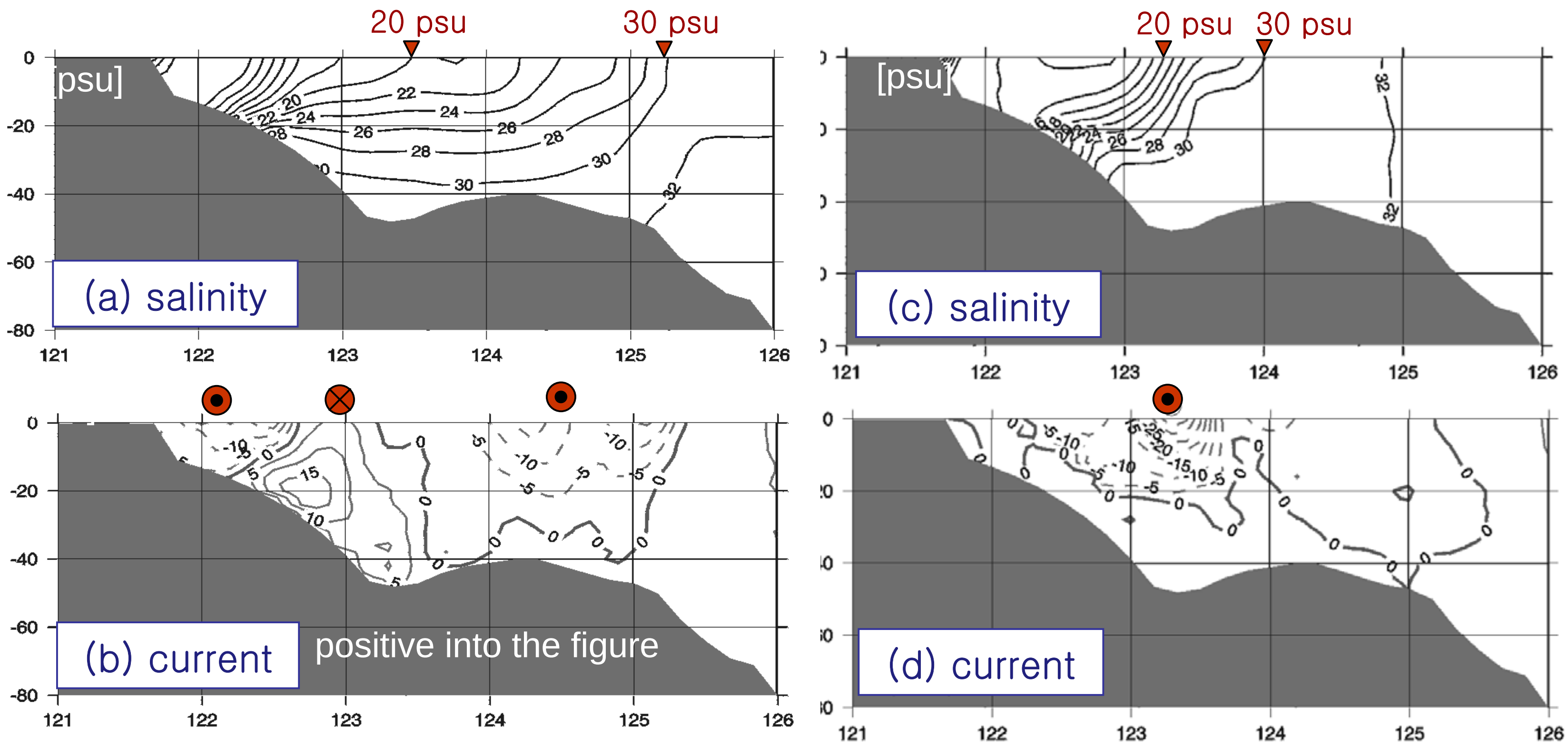


The differences in surface salinity [psu] between those without tide and wind (Exp. 1) and with tide (Exp. 2) in August. Solid lines indicate the areas whose salinities are decreased by tidal effect.

TIDE effect in August

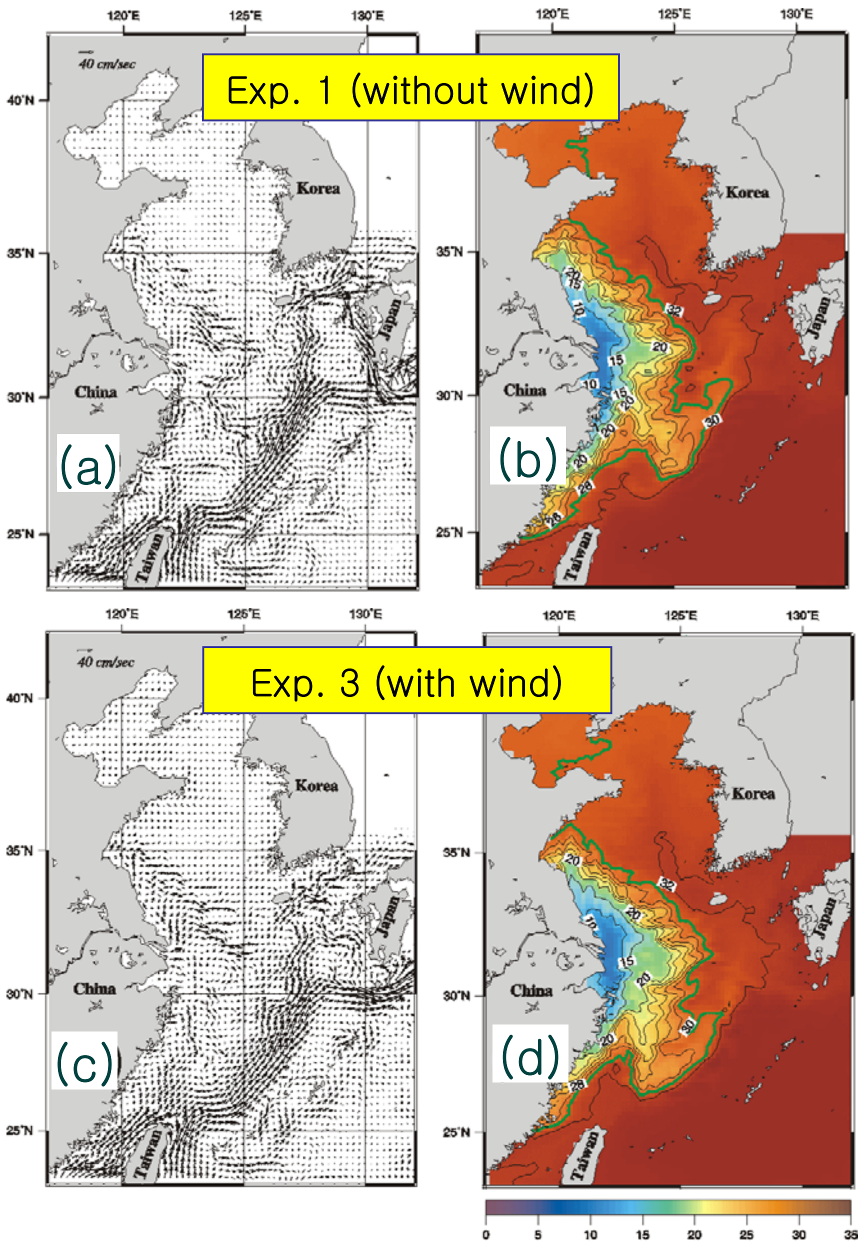
Exp. 1 (without tide)

Exp. 2 (with tide)



Vertical distributions of (a),(c) salinity, (b),(d) cross section current in Exp. 1,Exp. 2 respectively in August

When WIND is included in **August**

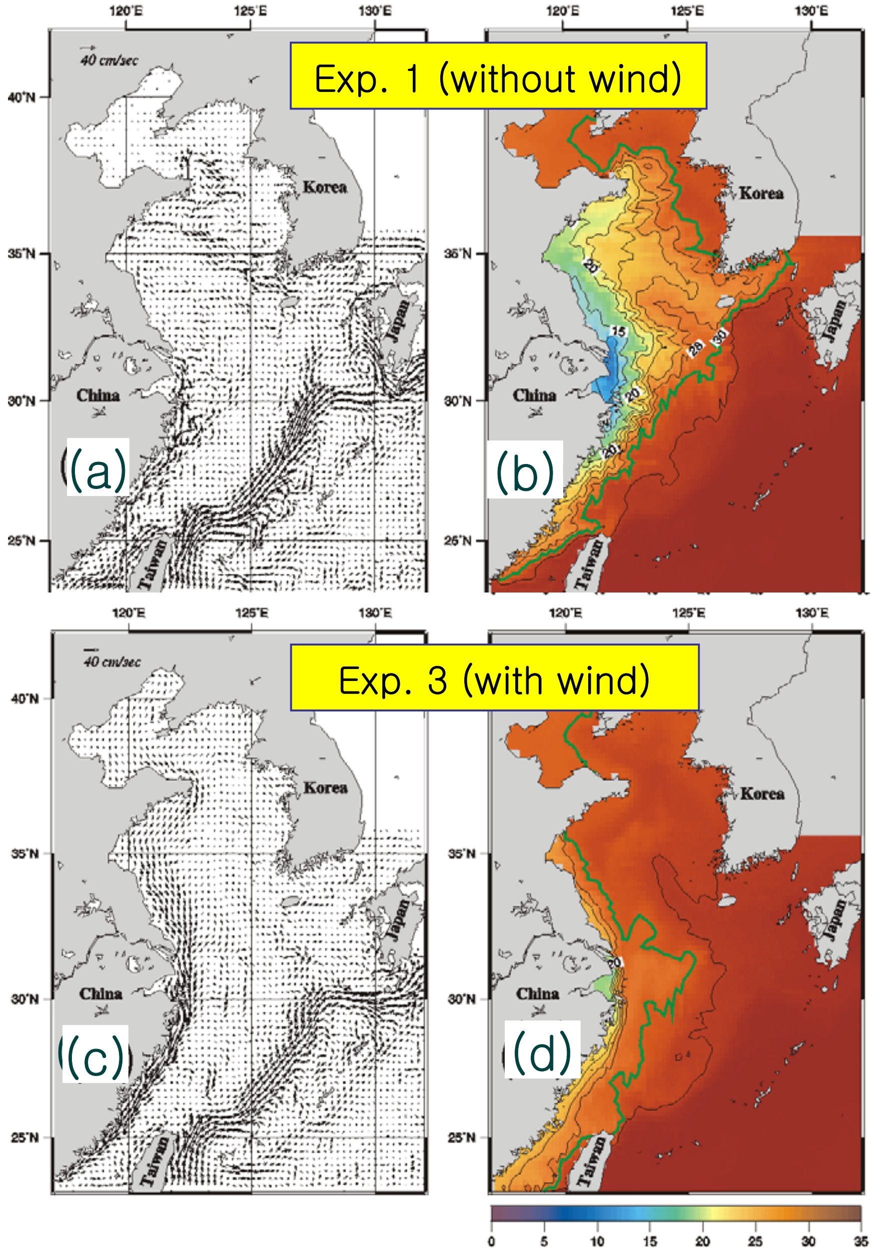


Distributions of the sea surface (a)current, (b)salinity in Exp. 1 and (c)current, (d)salinity in Exp. 3 in Aug.

1. The eastward flows are somewhat intensified.

✓ The southward flows near southeastern area of the Yangtze River are much weakened.

wind stress : 0.007 N/m^2



When WIND is included in **February**

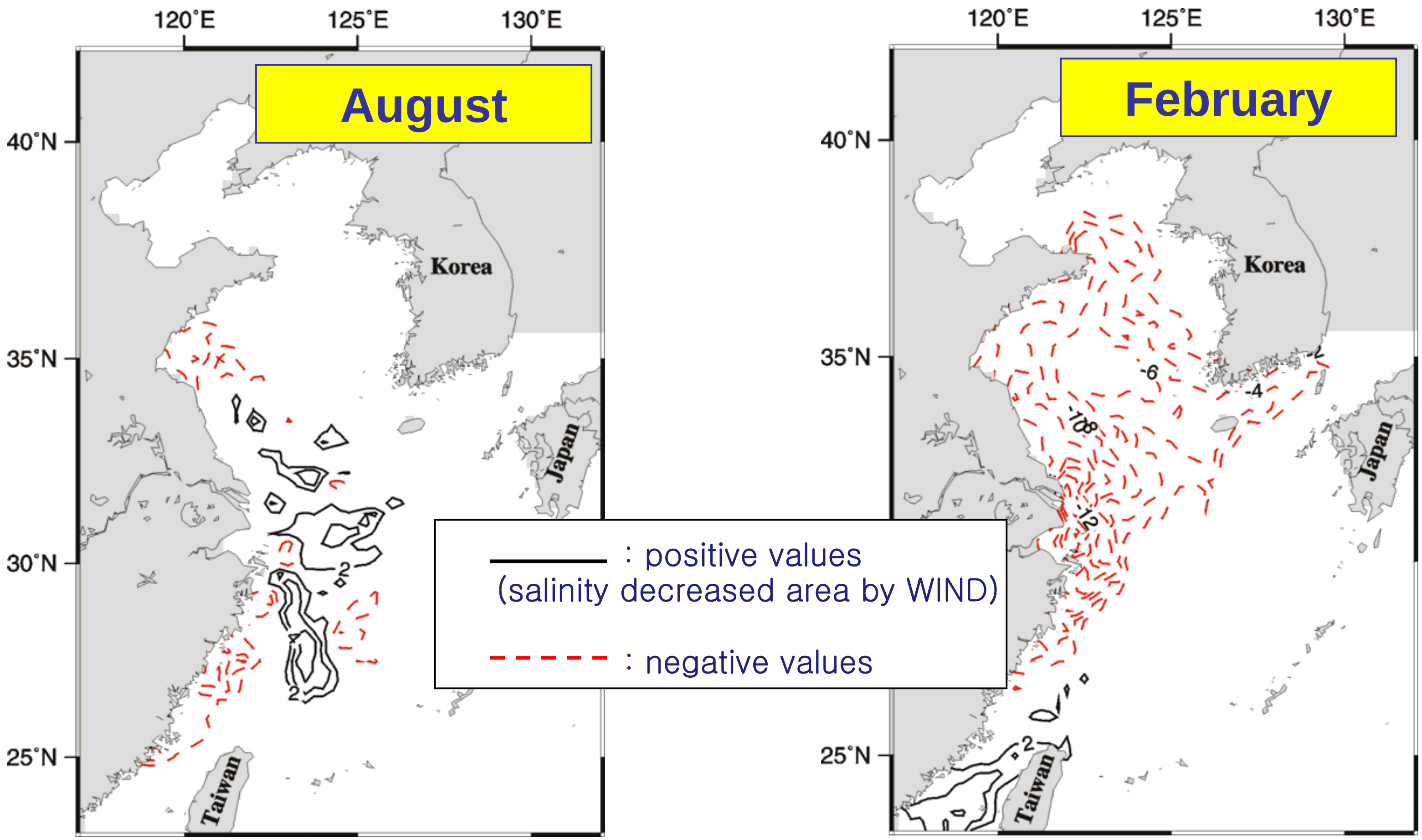
✓The current of the northern part of 33 deg N are suppressed.

✓The low salinity water is directed southward and reaches the Taiwan Strait

↙ wind stress : 0.056 N/m^2

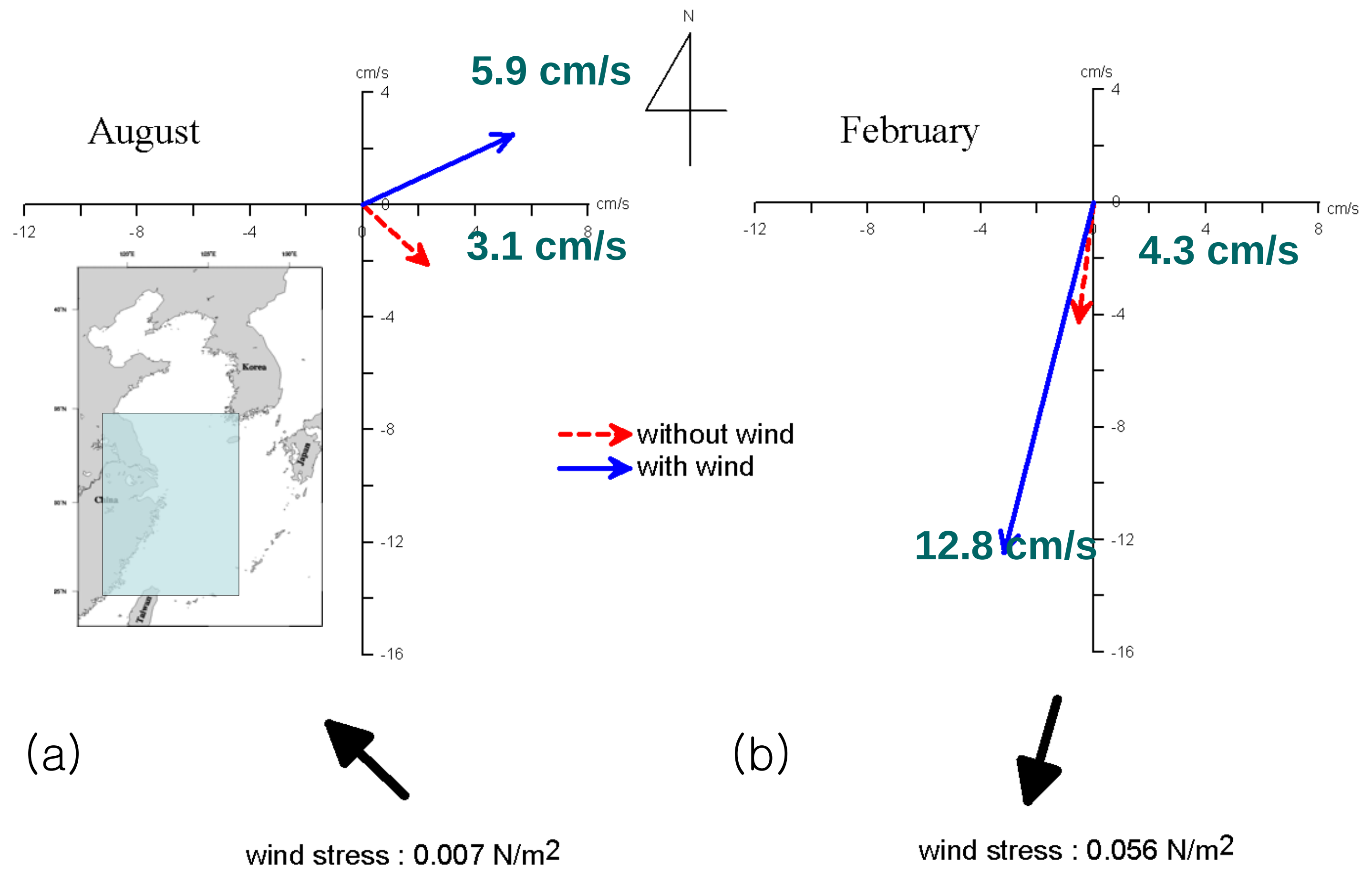
Distributions of the sea surface (a)current, (b)salinity in Exp. 1 and (c)current, (d)salinity in Exp. 3 in Feb.

WIND effect in August and February



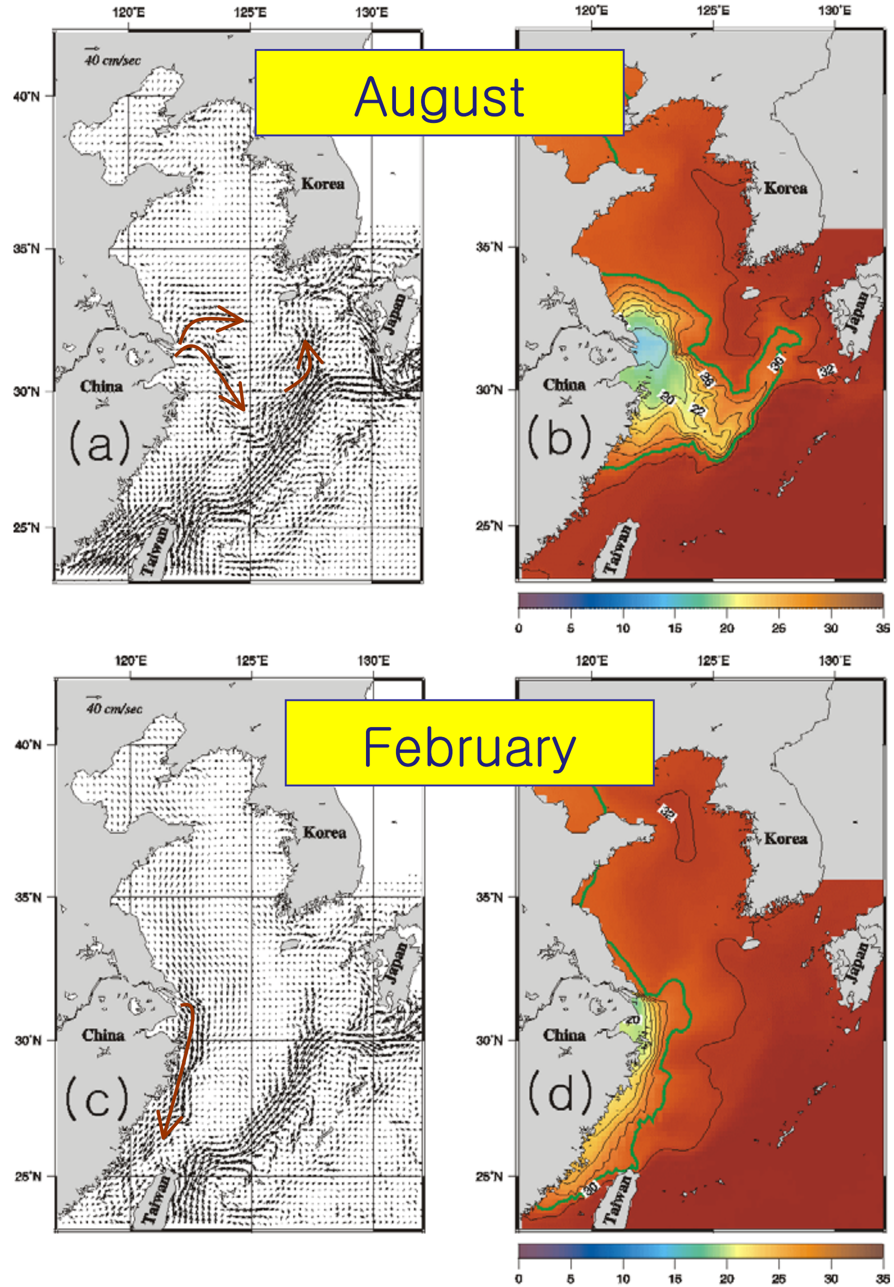
The differences in surface salinity [psu] between those without tide and wind (Exp. 1) and with wind (Exp. 3) in August and February.
Solid lines indicate the areas whose salinities are decreased by wind effect.

WIND effect in August and February



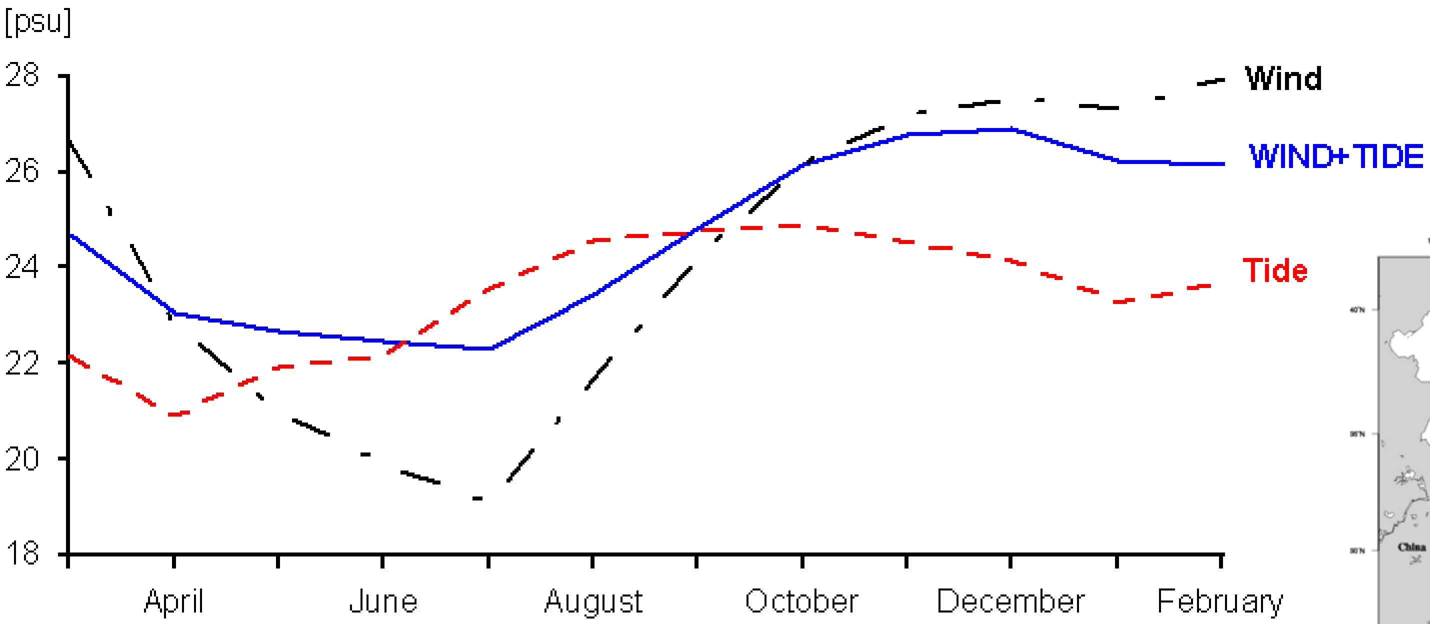
The changes in the surface current on the box area (averaged below 30 psu) without tide and wind (dotted arrow) and addition of wind effect (solid arrow) in (a) August and (b) February.

When WIND + TIDE are included (Exp. 4)



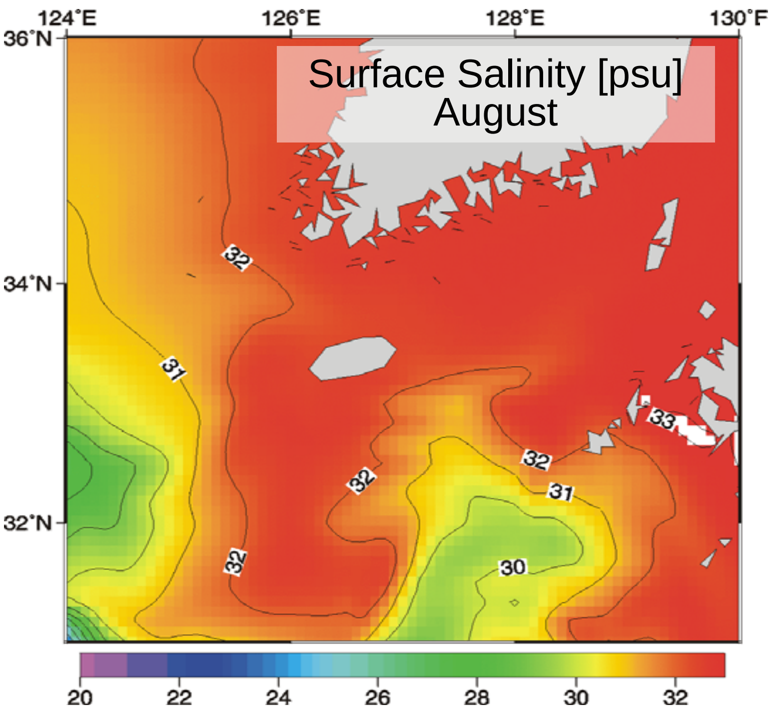
Distributions of the sea surface (a),(c) current and (b),(d) salinity in Aug. and Feb. respectively in Exp. 4

Monthly variations of surface salinity in each Experiment

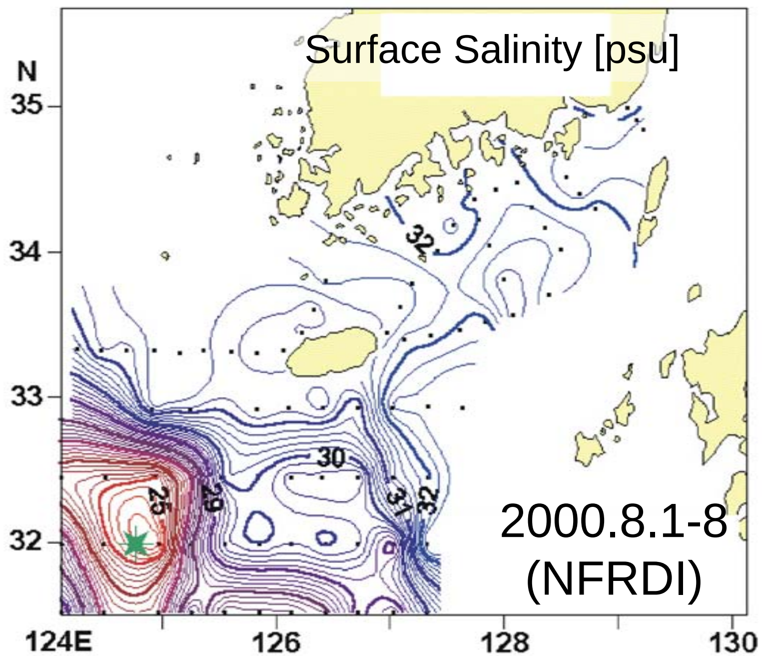


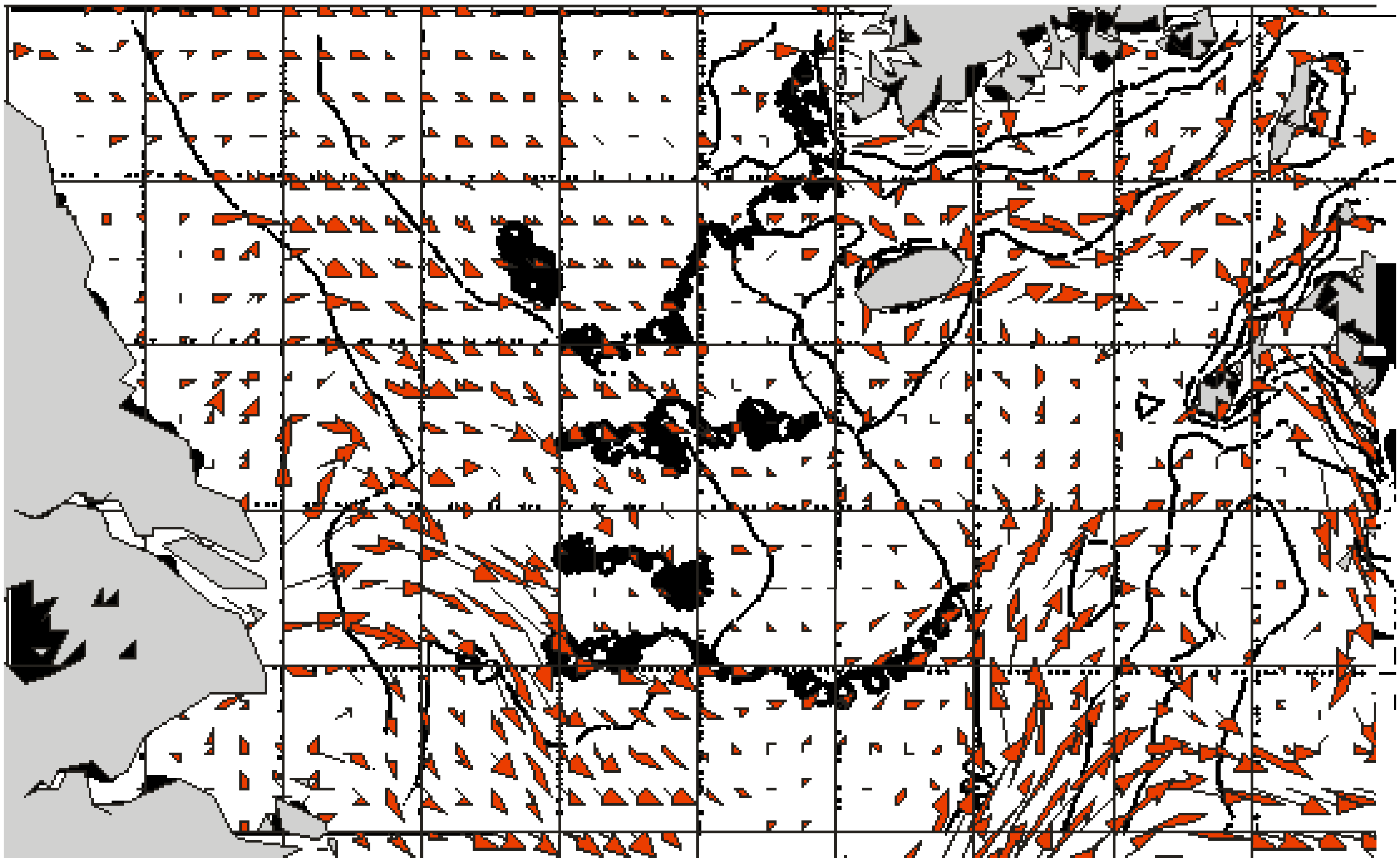
The monthly variations of surface salinity (below 30 psu) in the box domain in case of wind and tide (Exp. 4), with tide only (Exp 2), and with wind only (Exp. 3).

Present Model Calculation
(Exp. 4 : TIDE+WIND)



Salinity from Drifter
Survey

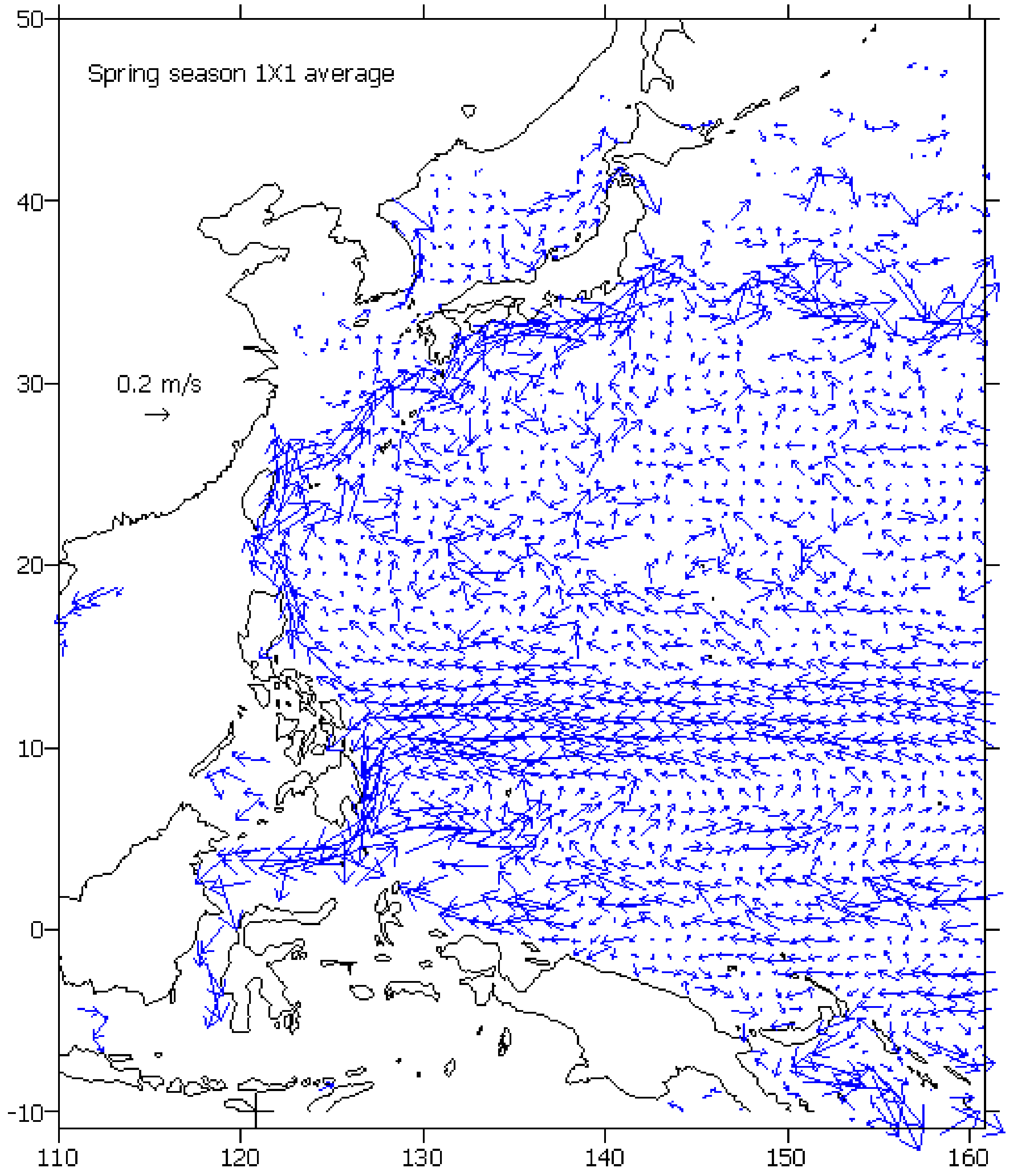




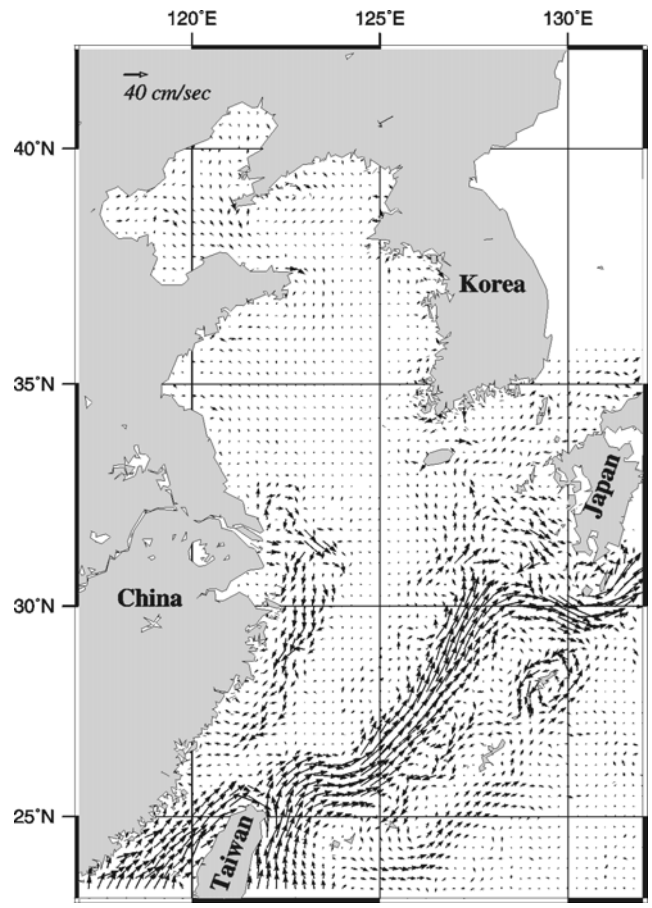
Comparisons of model calculation and drifter experiments in July.

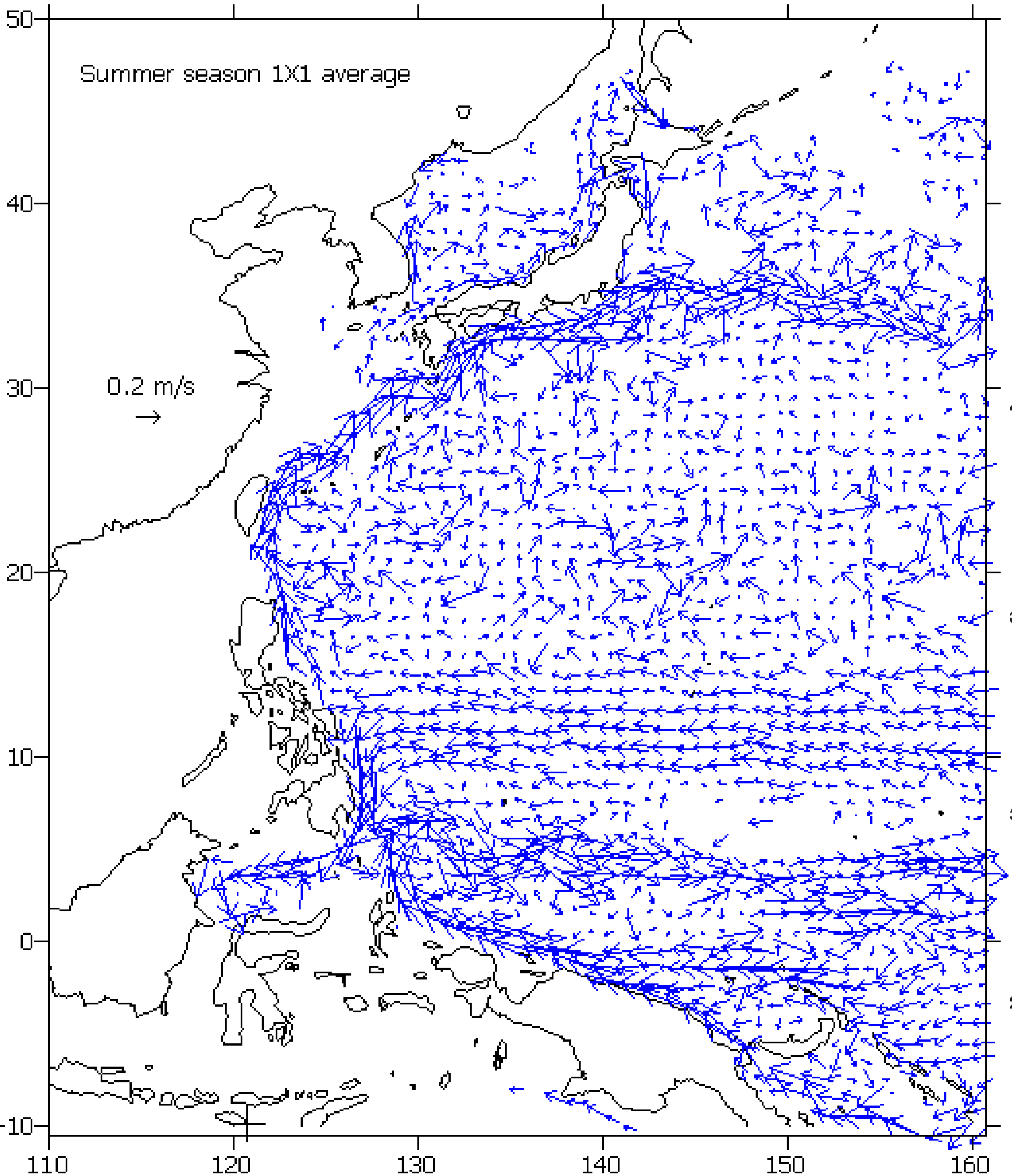
Red arrows : surface currents from the present model calculation

Black lines : trajectories of five drifters from 8th June to 9th July, 2003 (Matsuno, 2003).

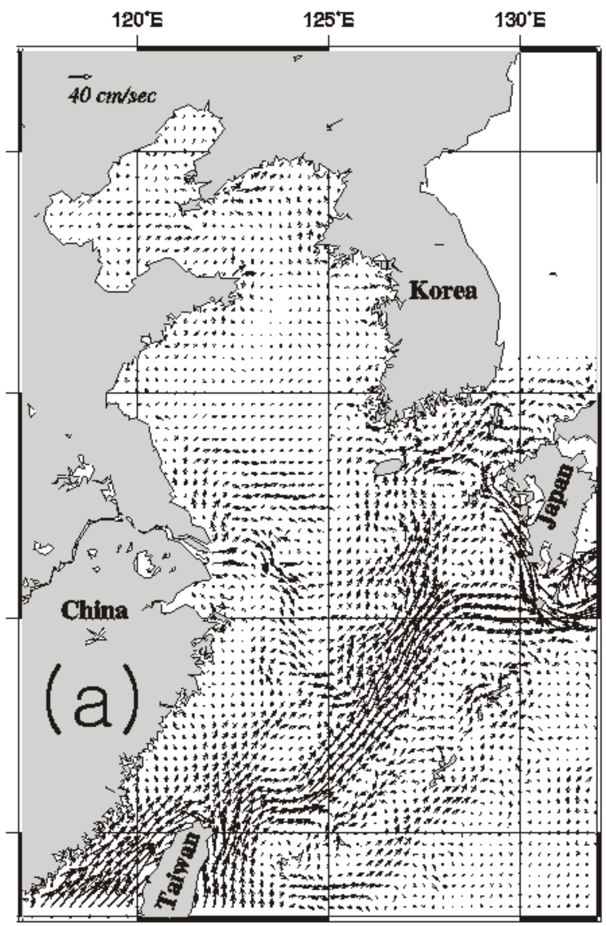

Spring season 1X1 average
0.2 m/s
50
40
30
20
10
0
-10
110
120
130
140
150
160

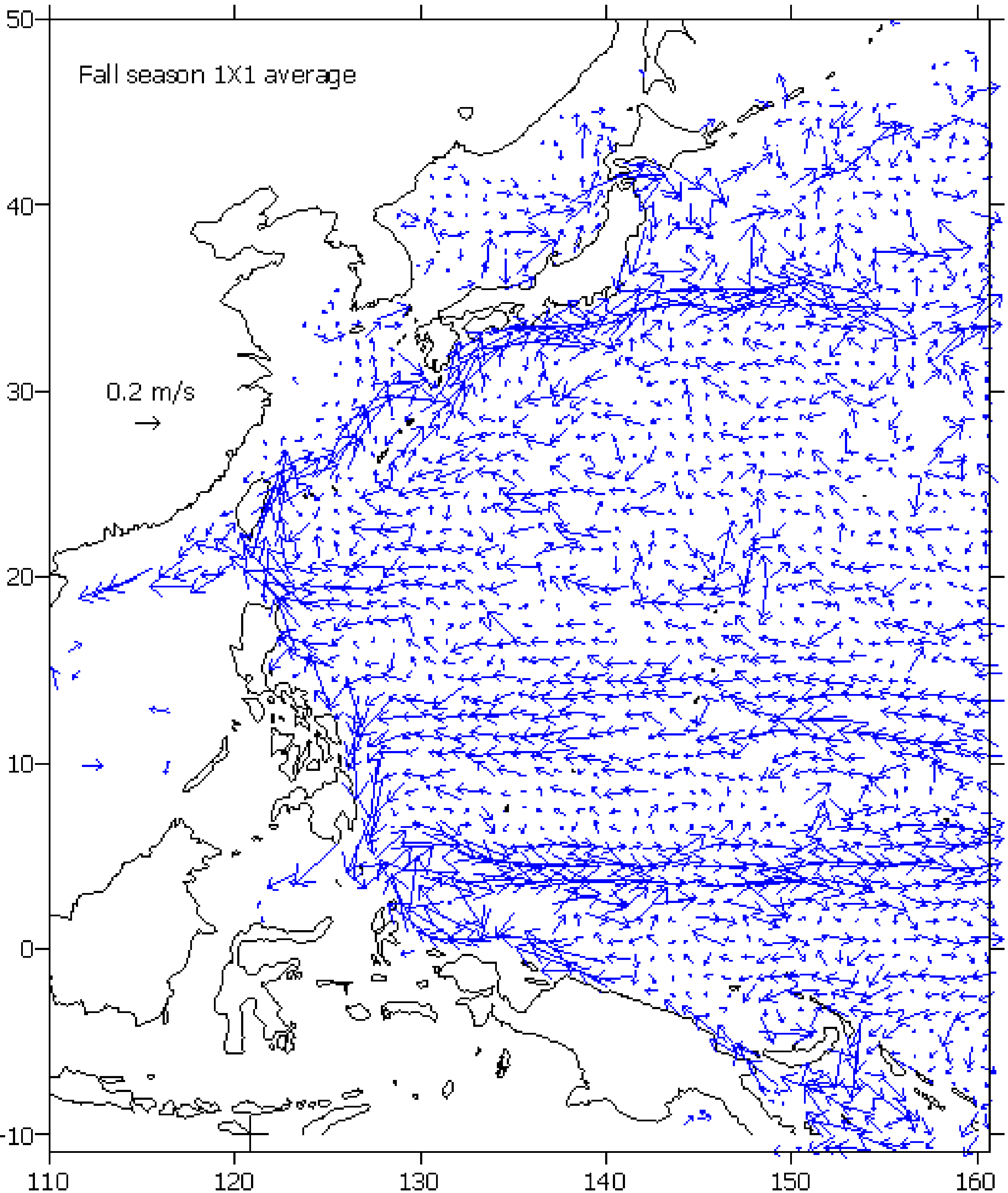
spring


120˚E
125˚E
130˚E
40 cm/sec
40˚N
35˚N
30˚N
25˚N
Korea
Japan
China
Taiwan

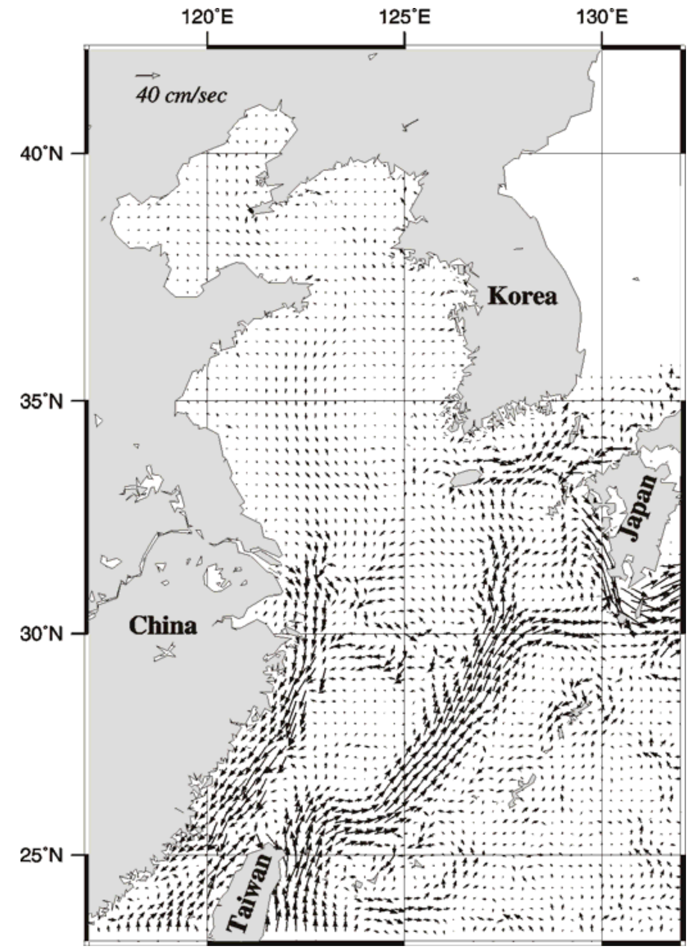

Summer season 1X1 average
0.2 m/s
50
40
30
20
10
0
-10
110
120
130
140
150
160

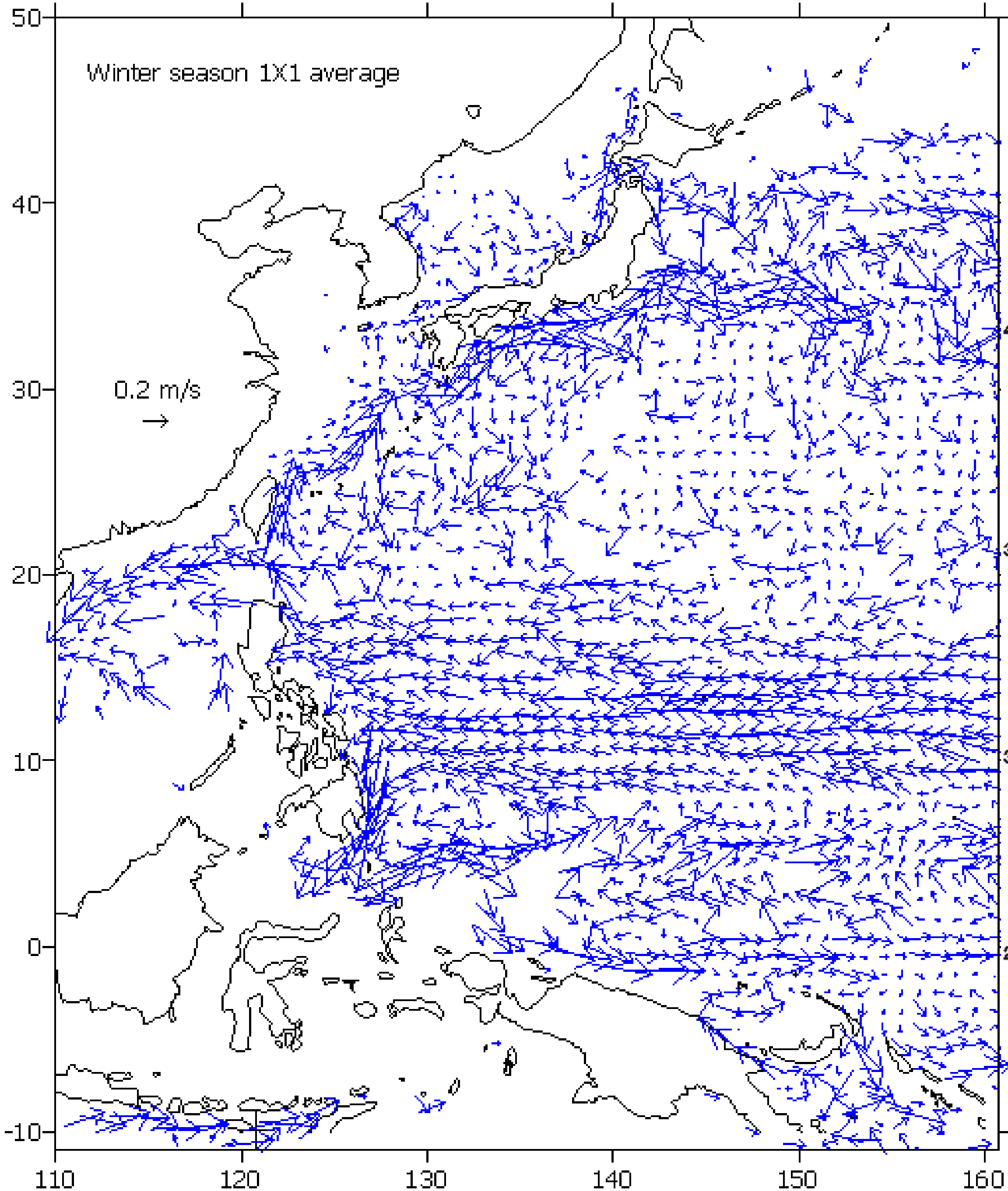
summer


120°E
125°E
130°E
40 cm/sec
40°N
35°N
30°N
25°N
Korea
China
Japan
Taiwan
(a)

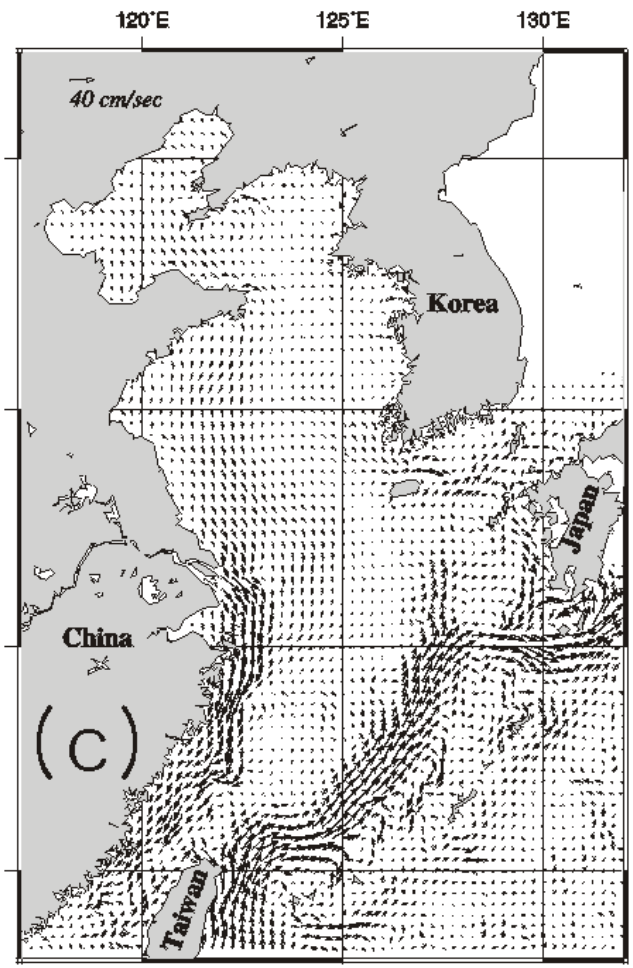

Fall season 1X1 average
0.2 m/s
50
40
30
20
10
0
-10
110
120
130
140
150
160

fall

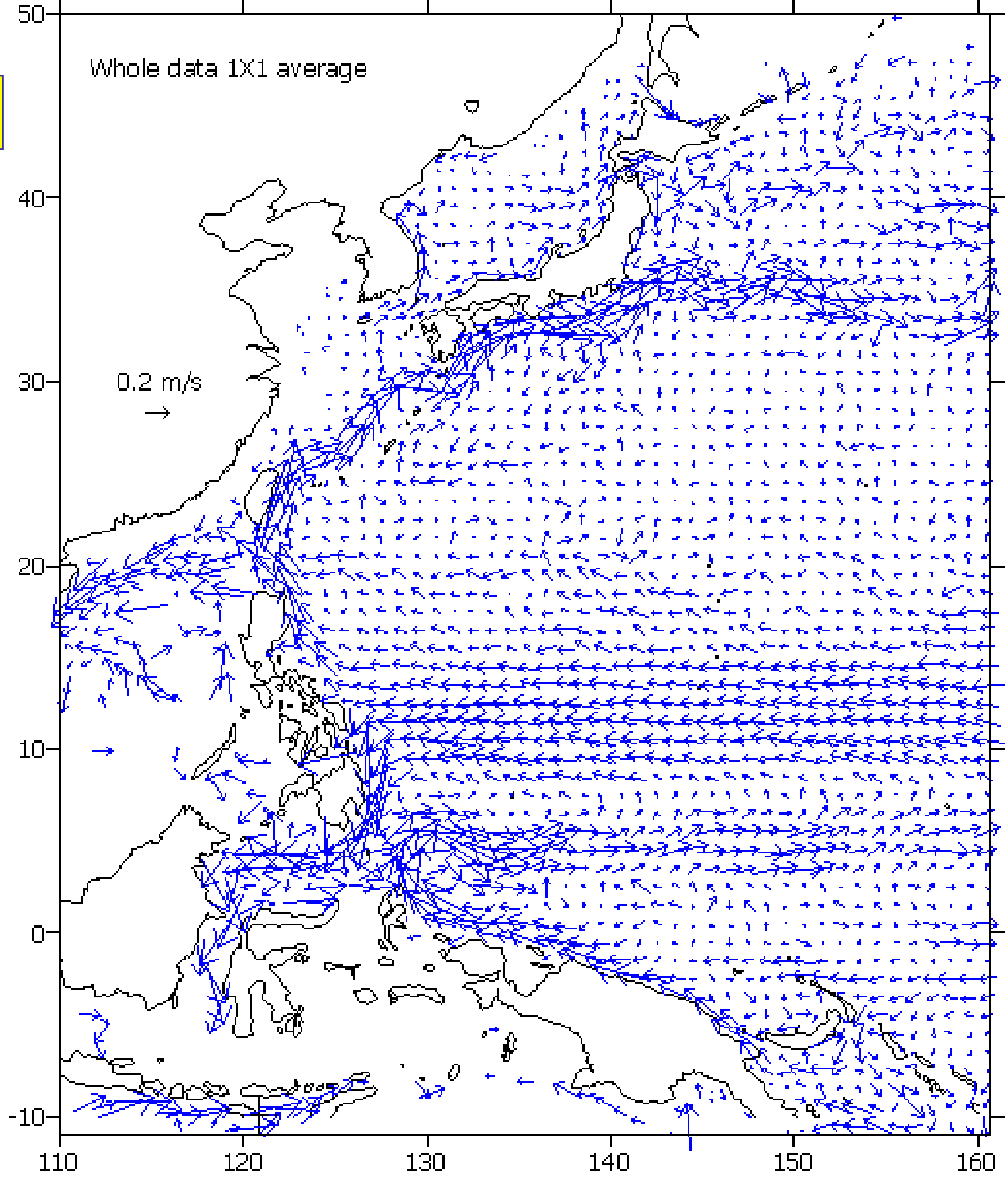

120°E
125°E
130°E
40 cm/sec
40°N
35°N
30°N
25°N
Korea
China
Japan
Taiwan


Winter season 1X1 average
0.2 m/s
50
40
30
20
10
0
-10
110
120
130
140
150
160

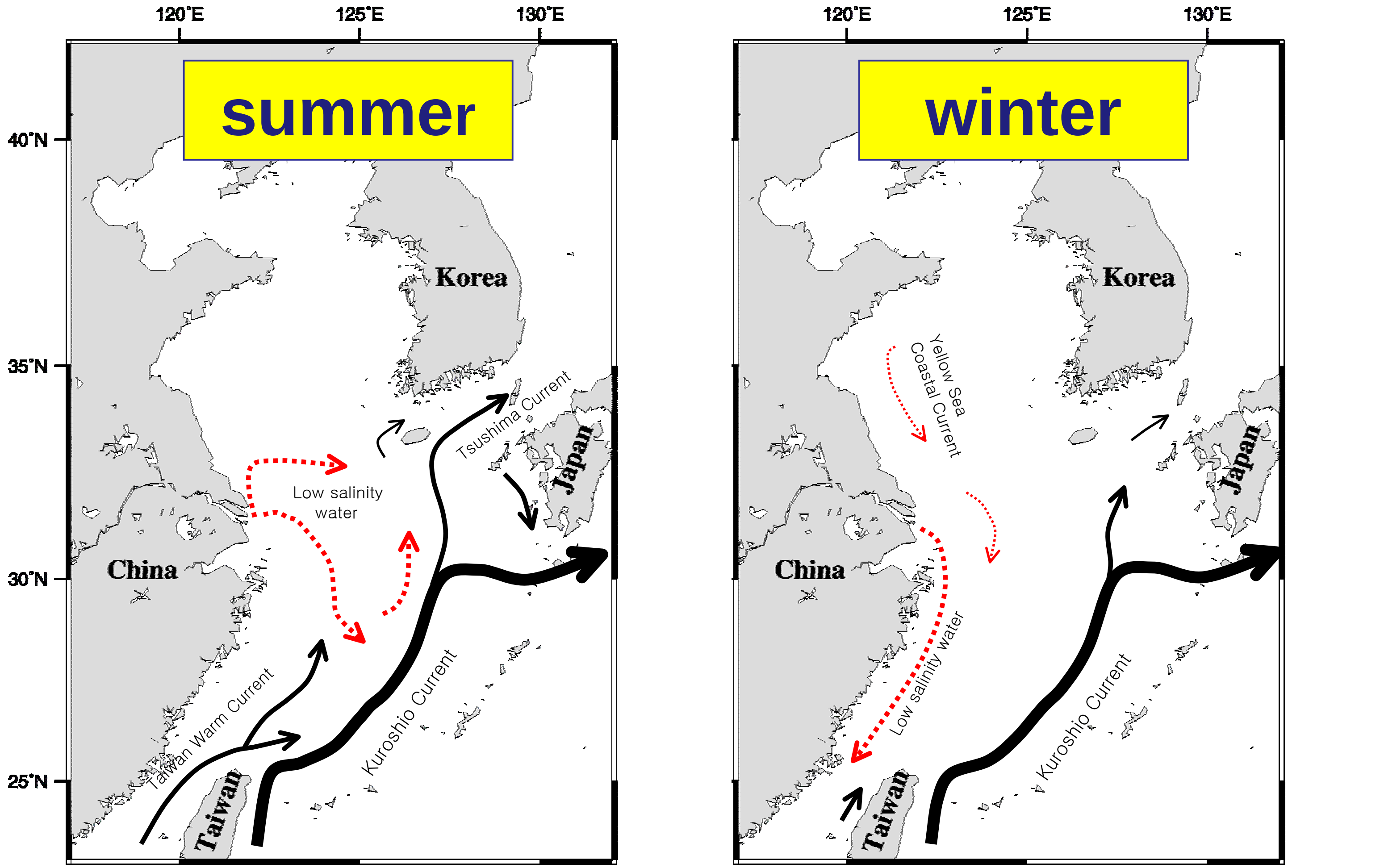
winter


120°E
125°E
130°E
40 cm/sec
40°N
35°N
30°N
25°N
Korea
China
Japan
Taiwan
(c)

average


Whole data 1X1 average
0.2 m/s
50
40
30
20
10
0
-10
110
120
130
140
150
160

Schematic diagram calculated by this numerical model



Schematic diagram of the typical seasonal current system and dispersion of the Yangtze River’s low salinity water at sea surface

Conclusions

1. Circulation of the Yellow and East China Seas;

Winter : dependent on the very strong monsoon N, NE wind

Summer : Tide is a dominant factor in the circulation near Yangtze river mouth,
but the weakened S, SE wind still a considerable factor.

Conclusion

2. Dispersion of the Yangtze River water :

General follows the circulation pattern fair well

Summer :

The tidal effect on the dispersion tends to spread southward and eastward by energetic vertical mixing processes.

The southerly wind effect tends to spread the low salinity water eastward.

Salinity of some northern area of the Yangtze River mouth increases more than 10 psu as compared with the reference case.

Winter :

The dispersion exactly follows the flow pattern southward along the east Chinese coast.

Thank You