Seasonal Circulation in the Yellow and the East China Seas driven by the monsoon winds

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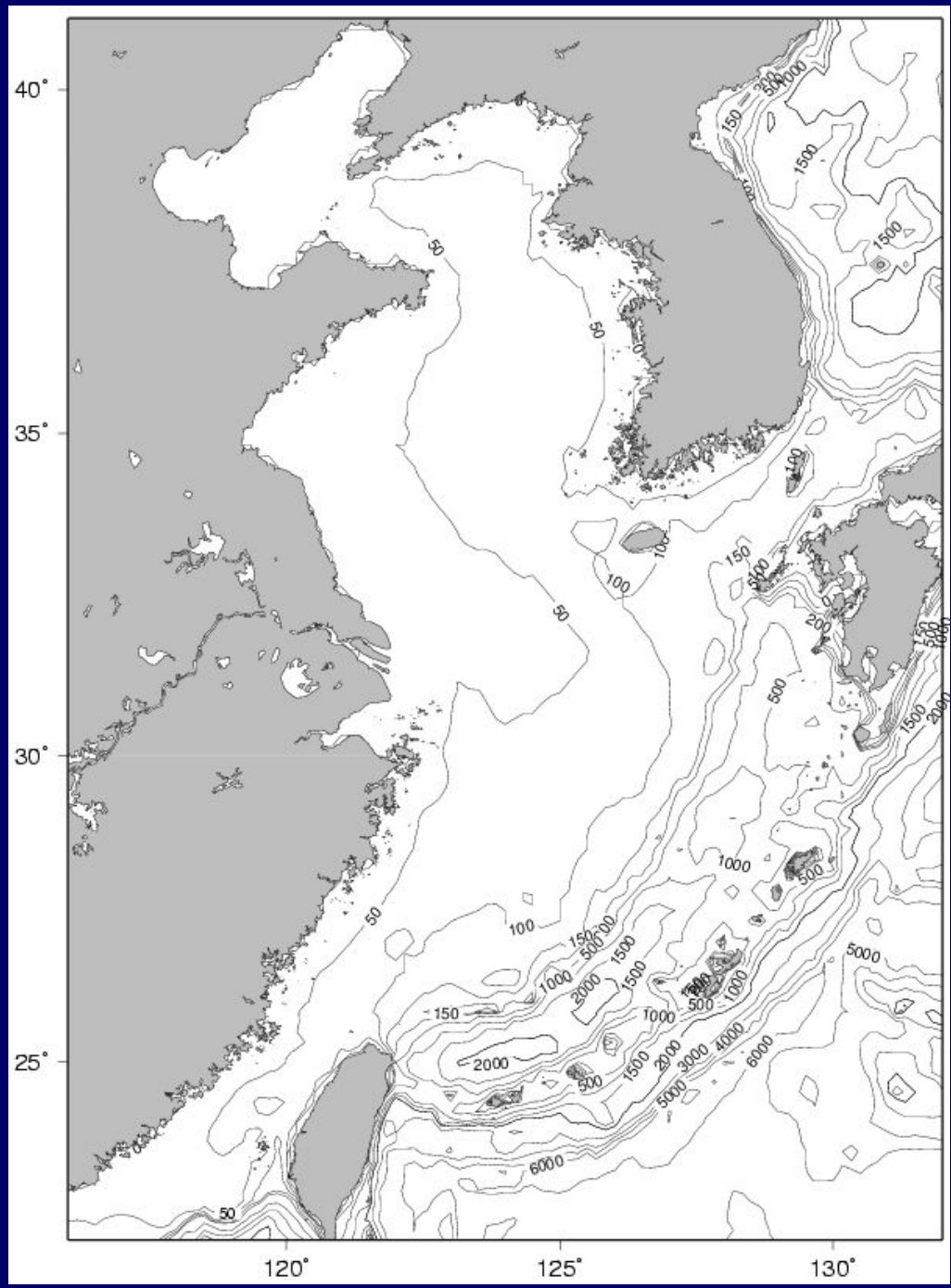
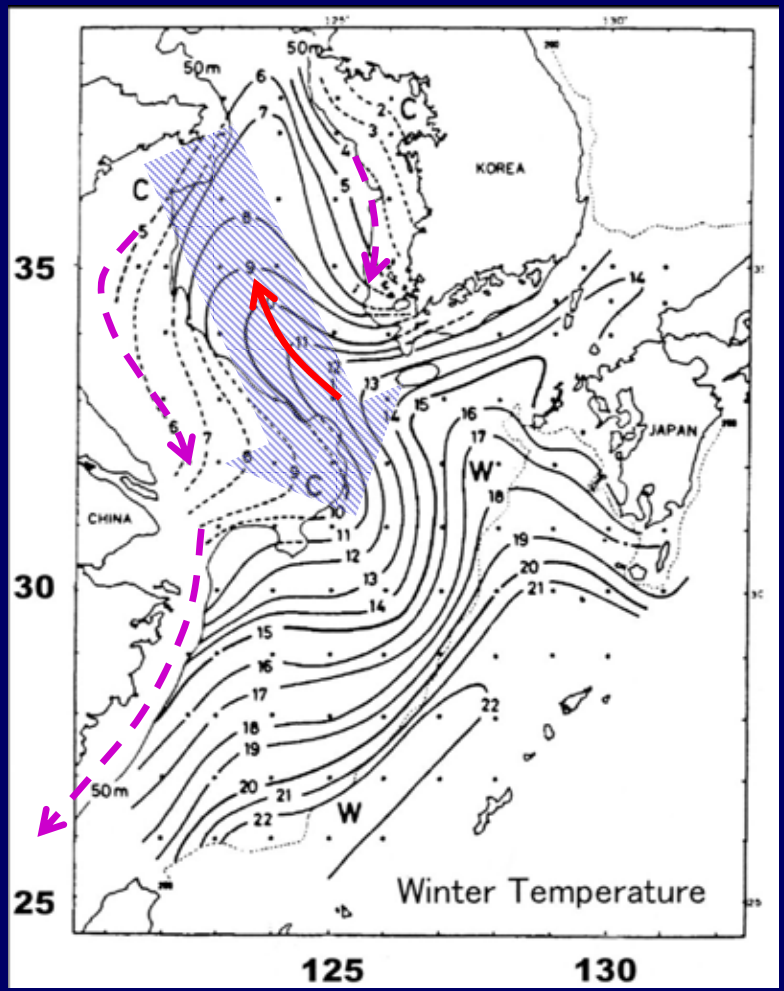
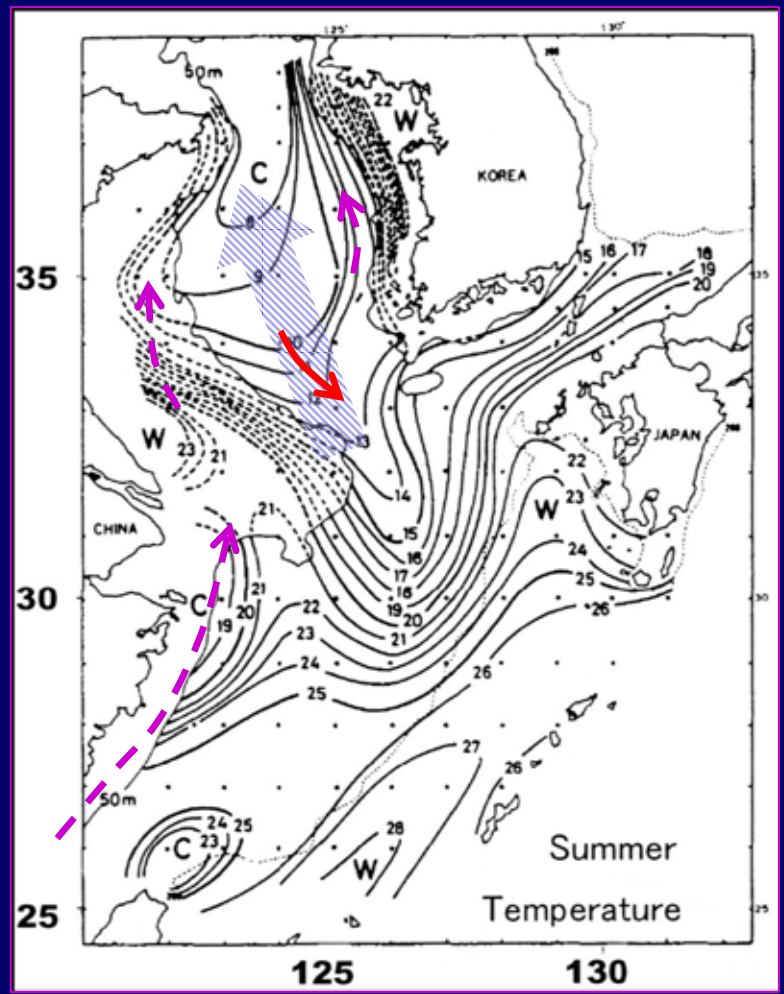

40°
35°
30°
25°
120°
125°
130°

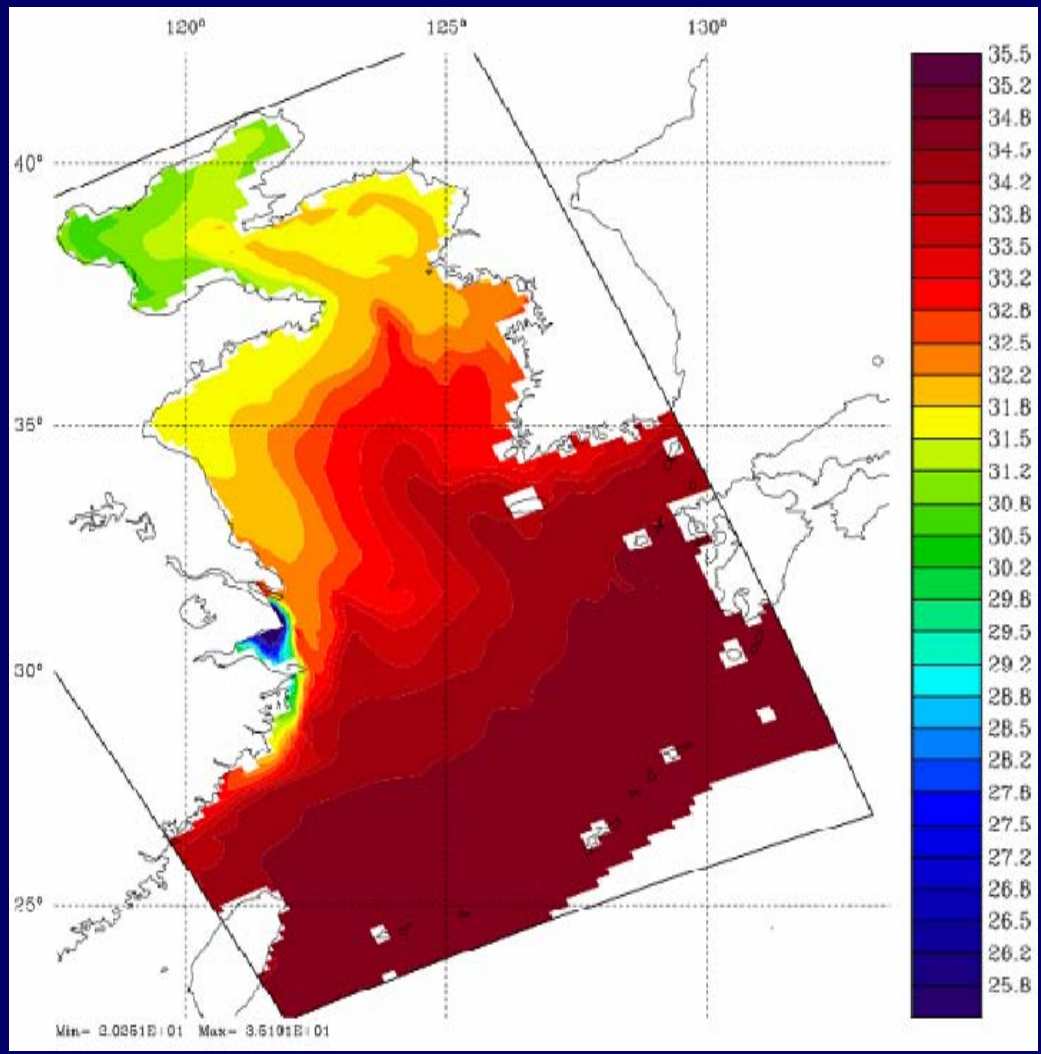
Northward Expansion of Yellow Sea Warm Current Water in winter

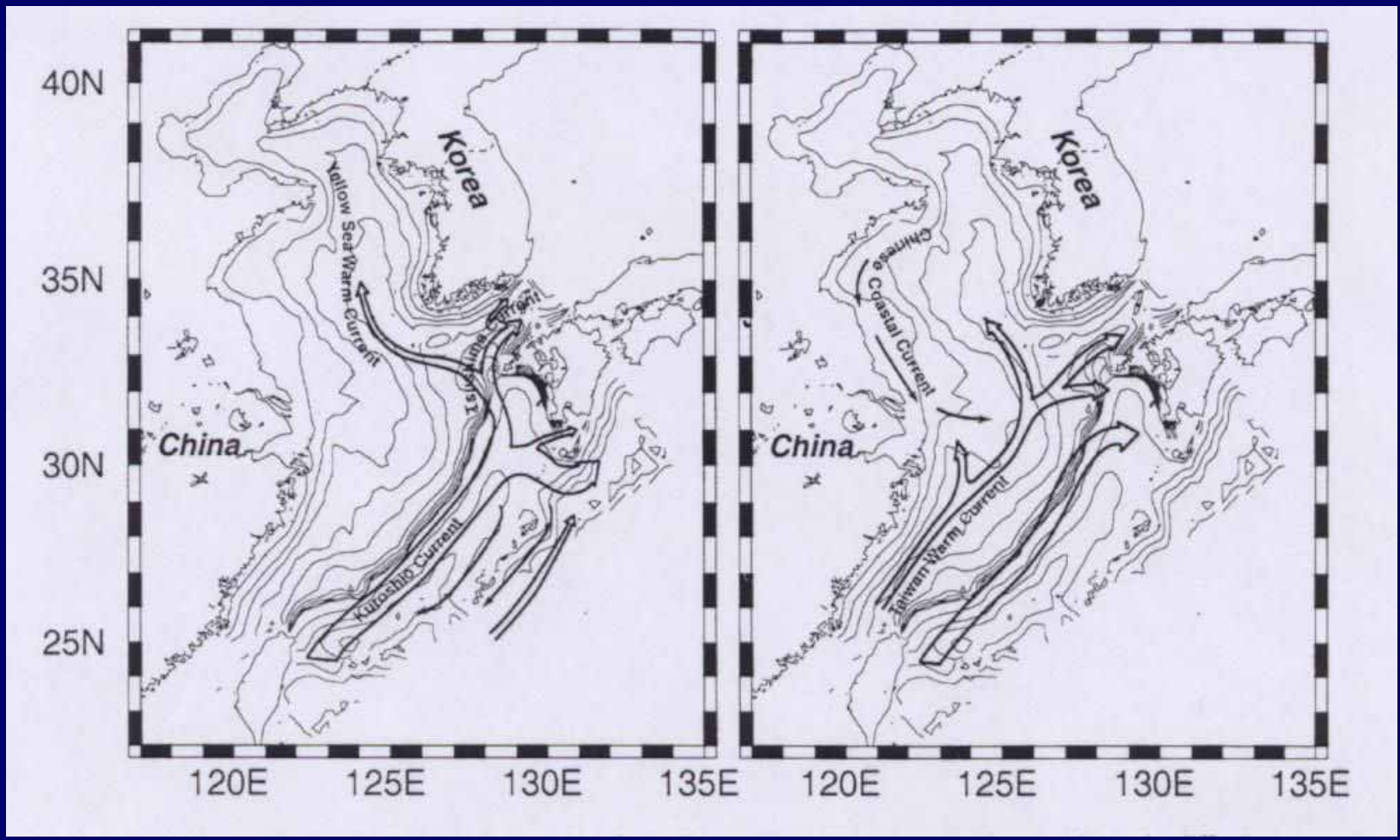


Southward Expansion of Yellow Sea Bottom Cold Water in summer



from Kondo (1985)


120°
125°
130°
40°
35°
30°
25°
35.5
35.2
34.8
34.5
34.2
33.8
33.5
33.2
32.8
32.5
32.2
31.8
31.5
31.2
30.8
30.5
30.2
29.8
29.5
29.2
28.8
28.5
28.2
27.8
27.5
27.2
26.8
26.5
26.2
25.8
Min= 2.0351E+01 Max= 3.5191E+01


40N
35N
30N
25N
120E
125E
130E
135E
Korea
China
Yellow Sea Warm Current
Tsushima Current
Kuroshio Current
Korea
China
Chinese Coastal Current
Taiwan Warm Current
120E
125E
130E
135E

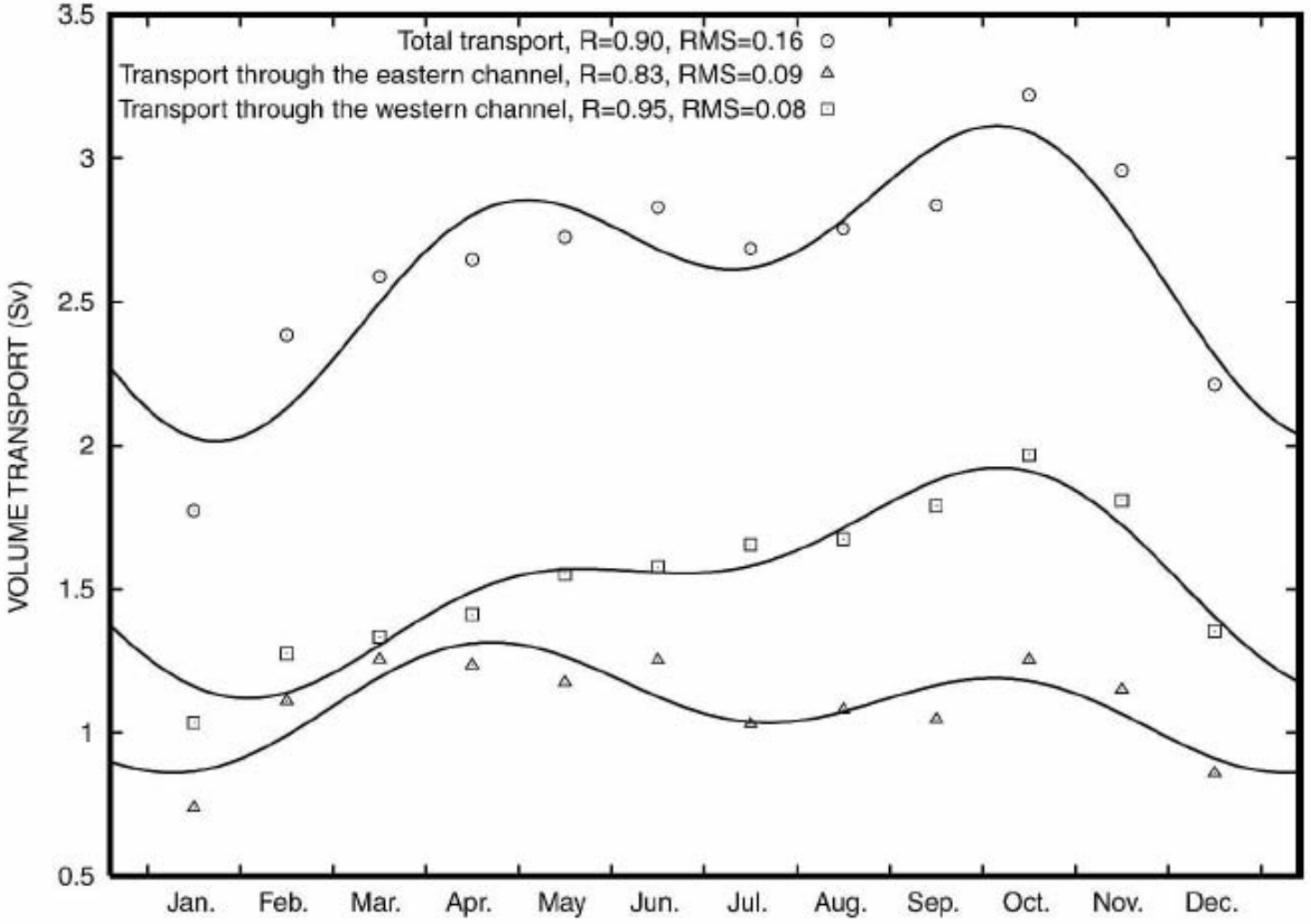
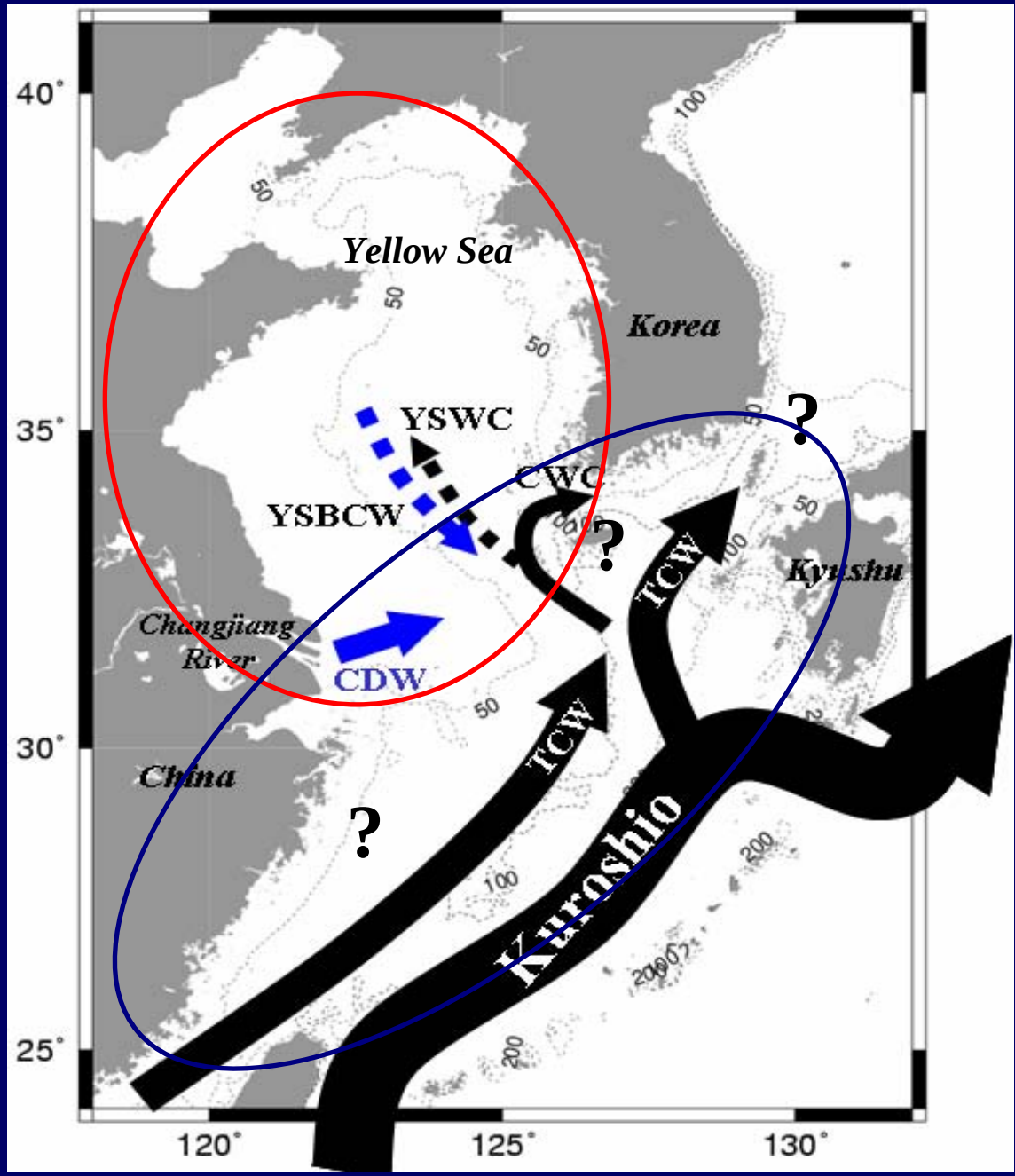


FIG. 12. The total volume transport (Sv; open circle) of the Tsushima Warm Current through Tsushima Straits averaged monthly for 5.5 yr, and those of the eastern (open triangle) and western (open square) channels. Each solid line is fitted by functions with annual and semiannual cycles.

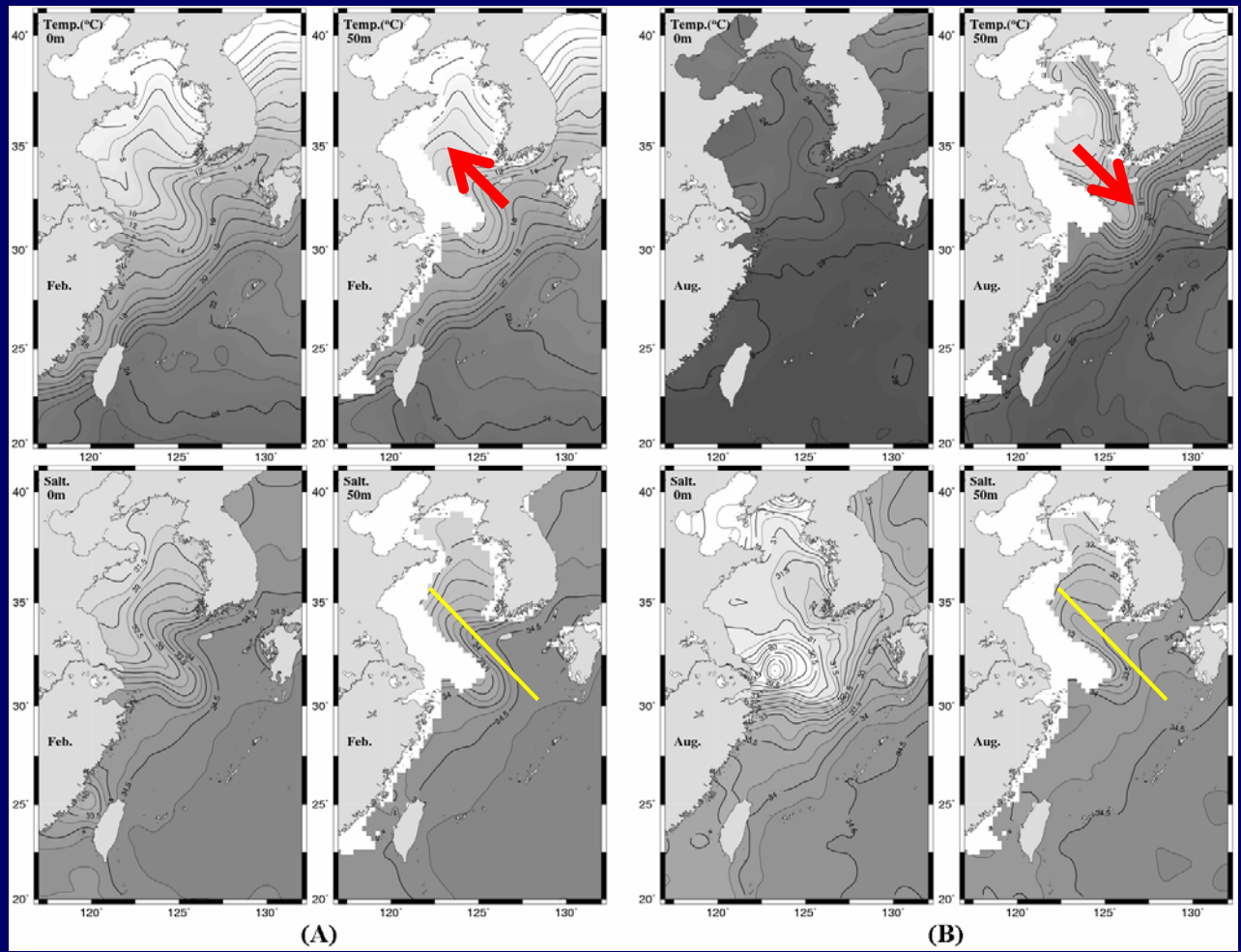
from Takikawa (2005 JGR)


40°
35°
30°
25°
120°
125°
130°
Yellow Sea
Korea
YSWC
YSBCW
CWC
CDW
Changjiang River
China
Kyushu
TCW
TCW
Kuroshio
?
?
?
50
100
200

Water Mass Distributions

Horizontal distributions of mean temperature and salinity at the depth of 0m and 50m in (A) February and (B) August data from GDEM

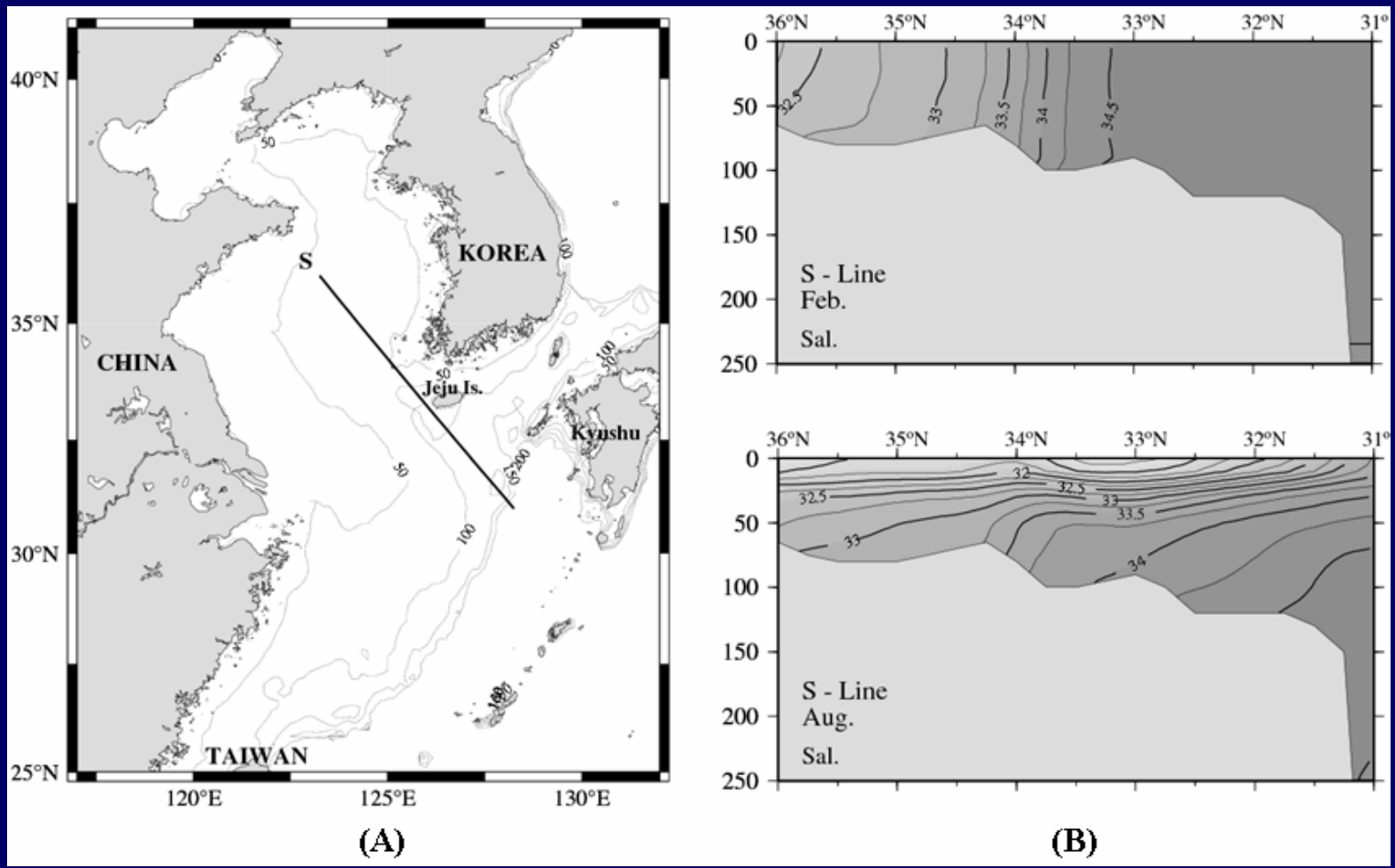
Feb.



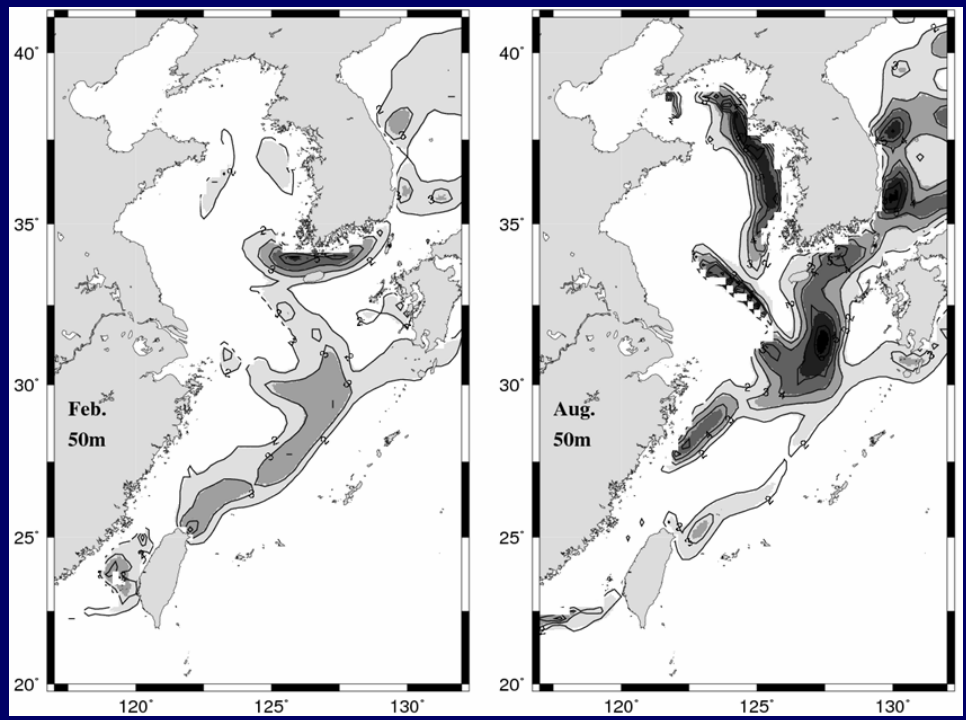
Aug.

The TWCW distribution expands northwestward in winter
retreats southeastward in summer

The TWCW distribution expands northwestward in winter
retreats southeastward in summer



Thermal Front



in winter **in summer**

from the Kuroshio toward the YS **from the TS to the KTS**

- **Then, what current system makes these seasonal variations?**

General description of Model (ROMS)

- **Horizontal resolution : 1/8 degree**
- **Vertical resolution : 30-vertical levels**
- **Temperature and Salinity : WOA2001**

  (World Ocean Atlas, 2001)
- **COADS (Comprehensive Ocean and**

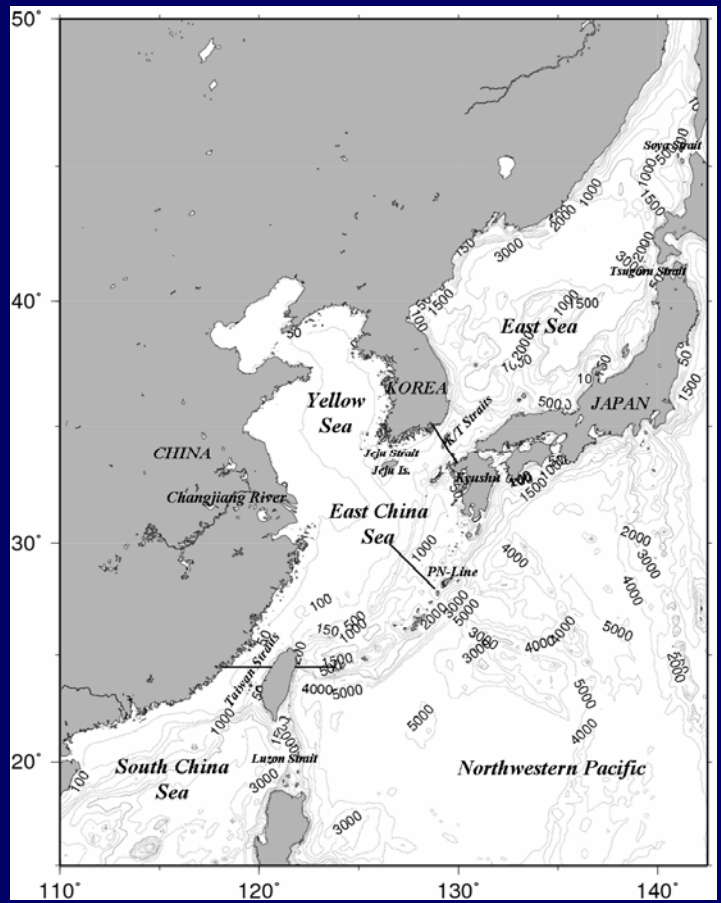
  Atmosphere Data Set)

  - wind stress

  - heat flux and freshwater flux

  - heat flux sensitivity
- **River source : Changjiang River discharge**

  (Shen et al., 1994)

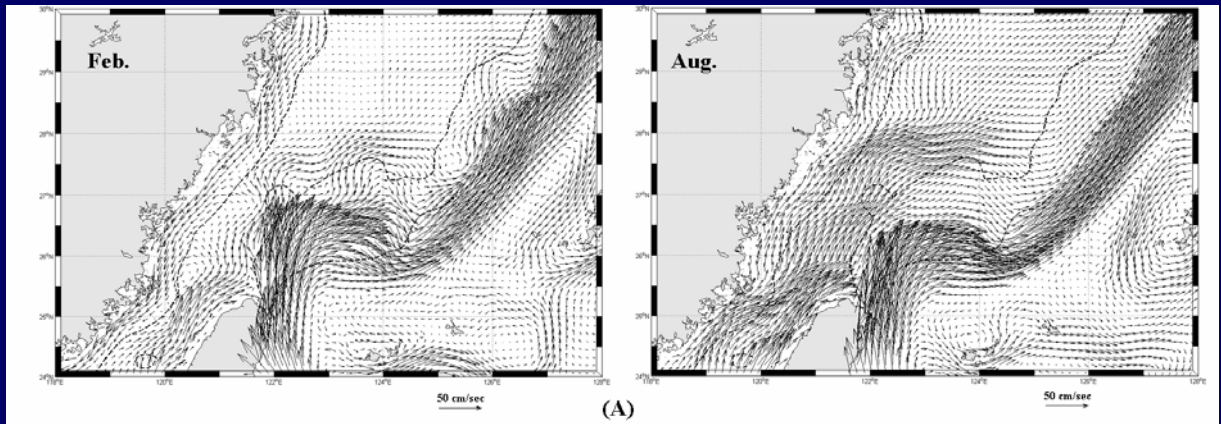


Model domain and bottom topography (m)

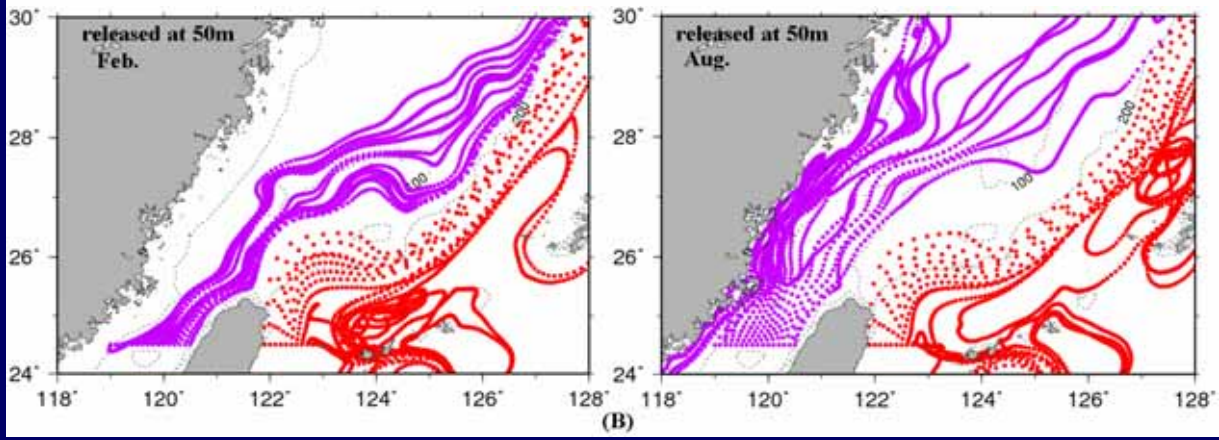
In the adjacent seas of Taiwan

Northerly wind **Southerly wind**

current



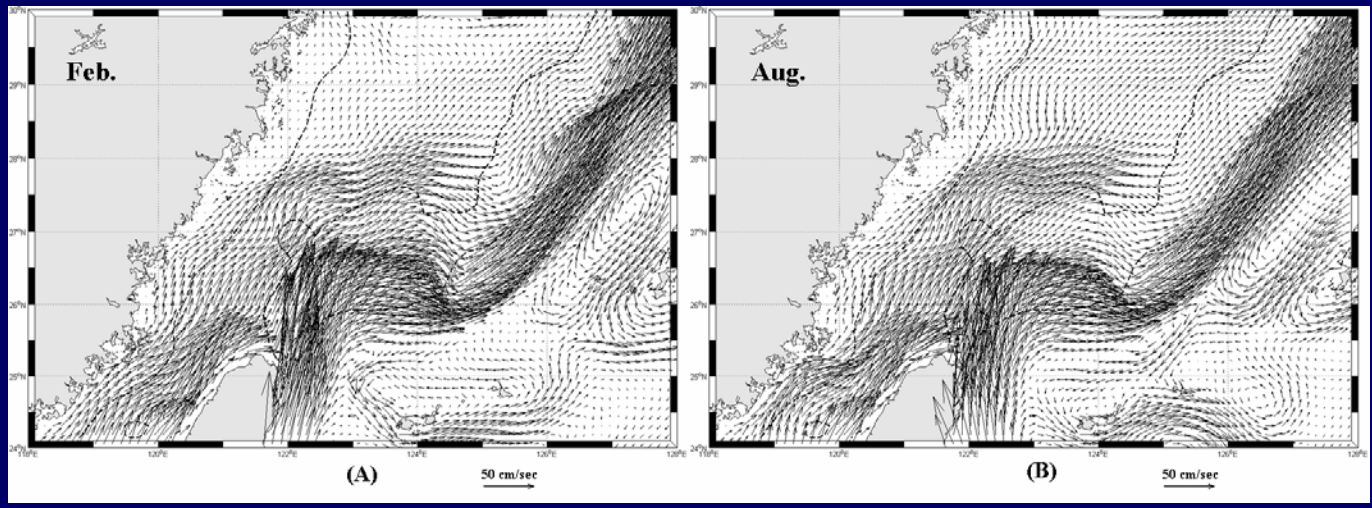
tracers



winter **summer**

- **Seasonal variation of transport in the TS**
- **No significant seasonal variation in the east of Taiwan related with the ECS**

Without the monsoon winds



	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Wind	0.57	0.83	1.32	2.07	2.56	2.77	2.96	2.36	1.57	0.85	0.44	0.33
No wind	2.43	2.53	2.57	2.67	2.78	2.81	2.82	2.80	2.77	2.69	2.58	2.46

in winter *in summer*

The transport in the TS : not vary significantly in season without monsoon wind.

critically influenced by monsoon wind.

In the central region of the ECS

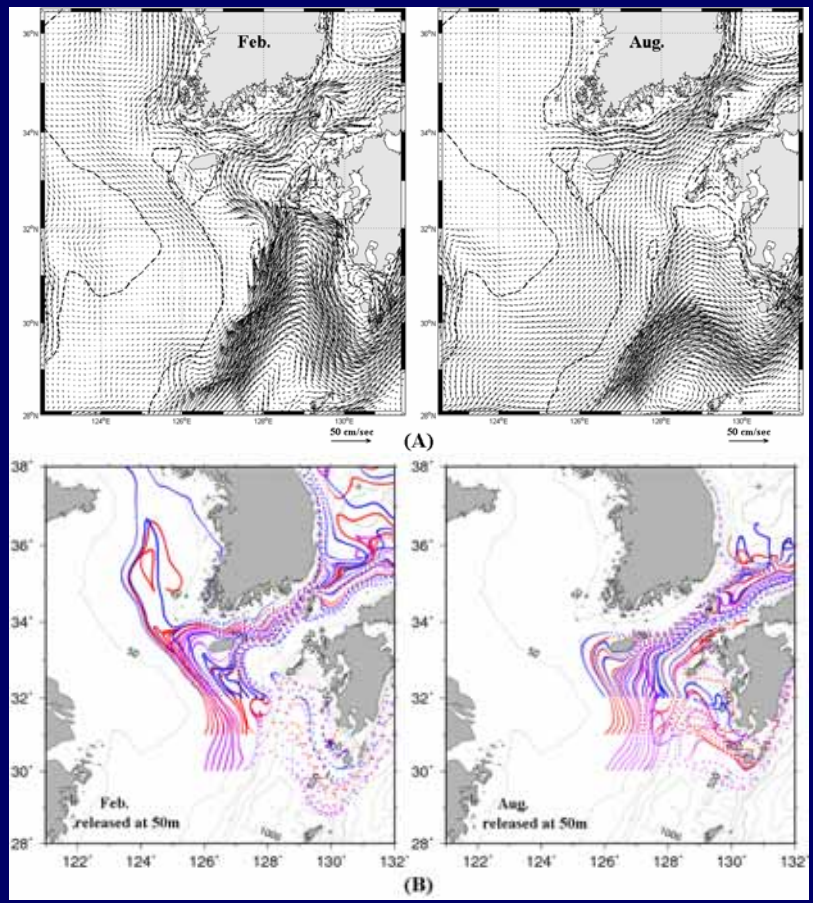
Northerly wind

↓

southward drift of China coastal water out of the YS

↓

pull water into the YS along the YS trough



winter **summer**

Southerly wind

↓

northward drift of China coastal water into the YS

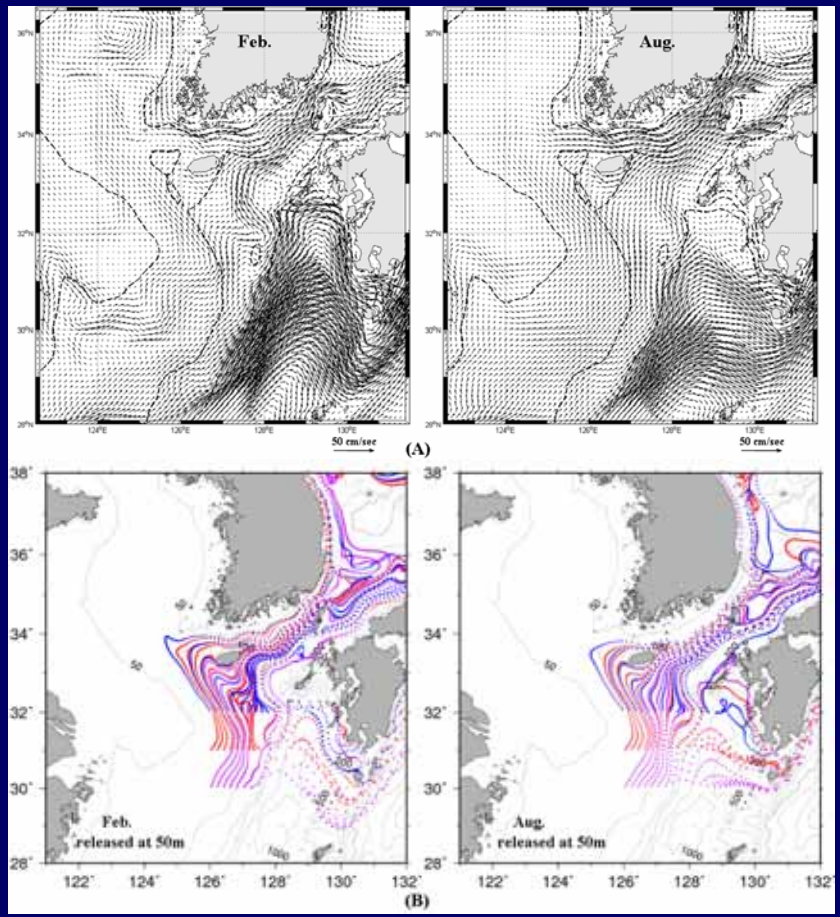
↓

push water out of the YS along the YS trough

- **in winter : northwestward current to the YS (* mostly flow out through the JS)**
  in summer : northward current to the KTS

(good agreement with the seasonal variations of the thermal front)

Without wind forcing

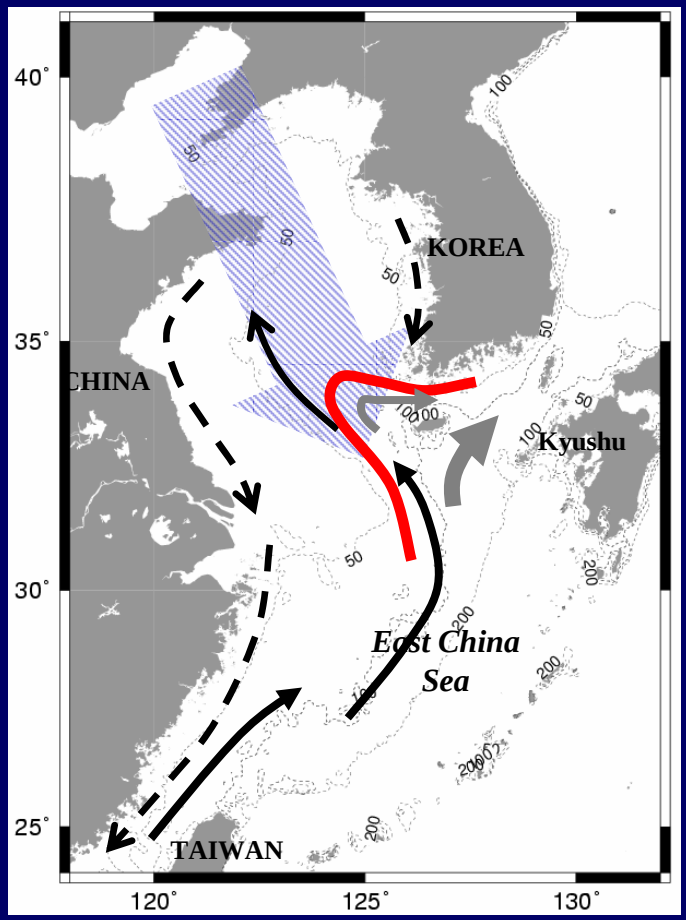


no seasonal variation of the TWC and no seasonal circulation in the YS

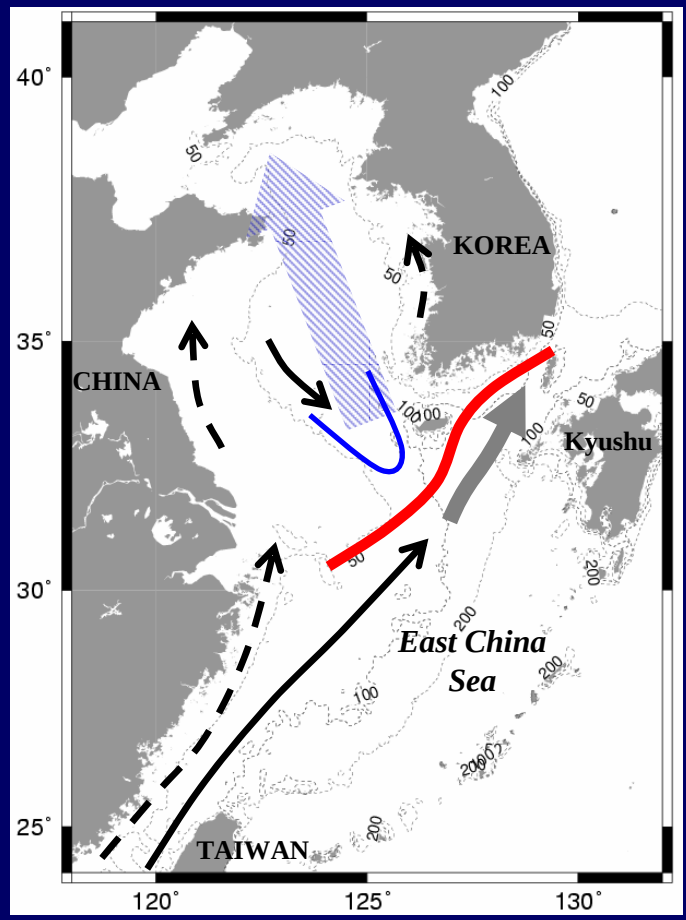
→ The seasonal variation of the TWC is caused by monsoon wind.

Relation with the seasonal circulation in the YS and the TS

in winter



in summer



Seasonal variation of the TWC in the ECS

• related with the seasonal circulation in the YS and the seasonal variation in the TS, which are driven by the monsoon winds

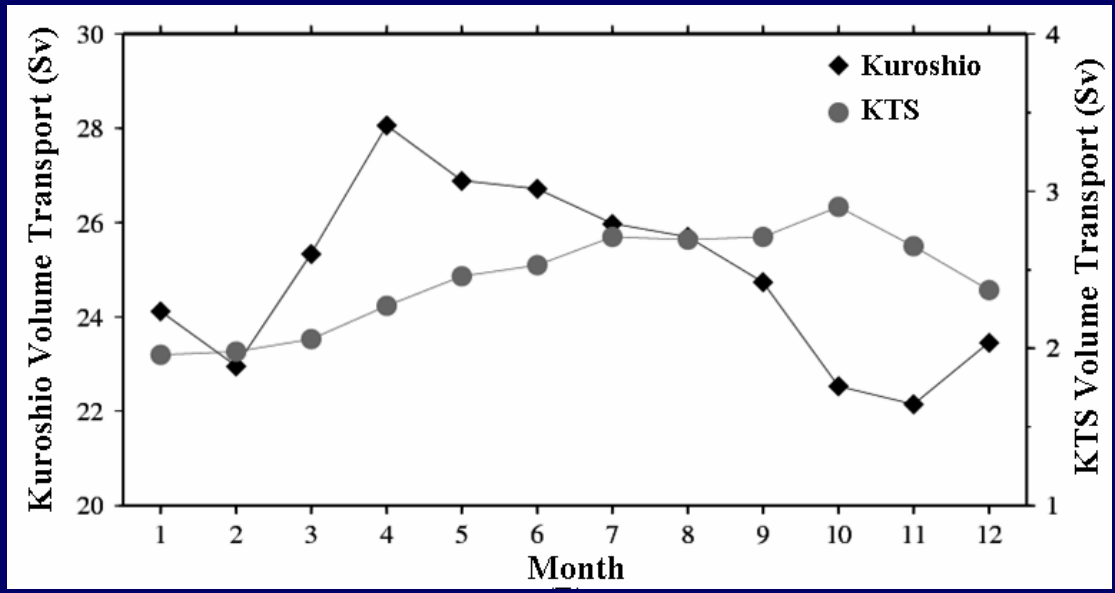
• The TWC is mostly supplied from the Kuroshio in winter

flow from the TS to the KTS in summer.

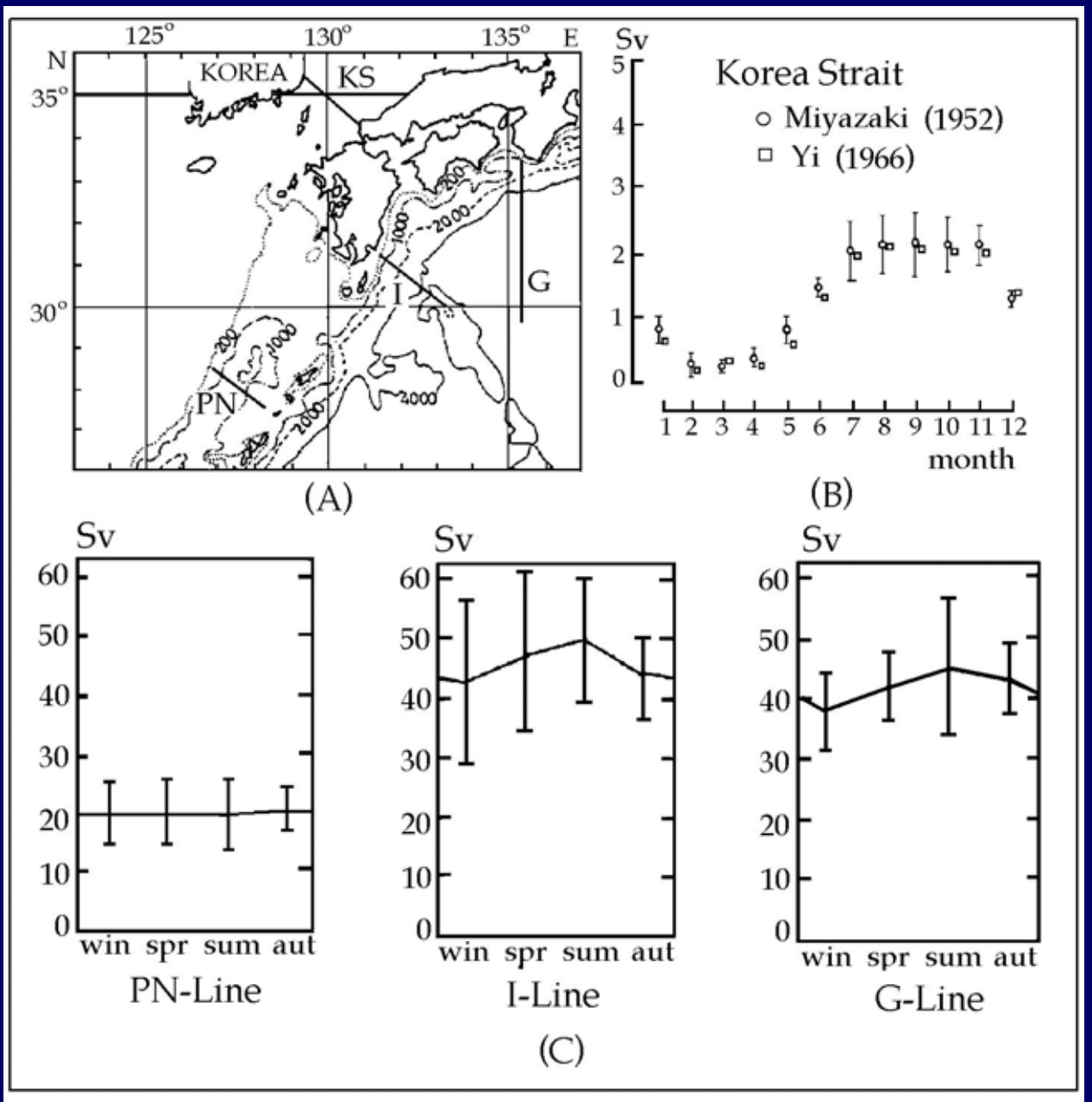
Influence by the variation of the Kuroshio

The Kuroshio could not be the cause of the seasonal variation of transport in the KTS

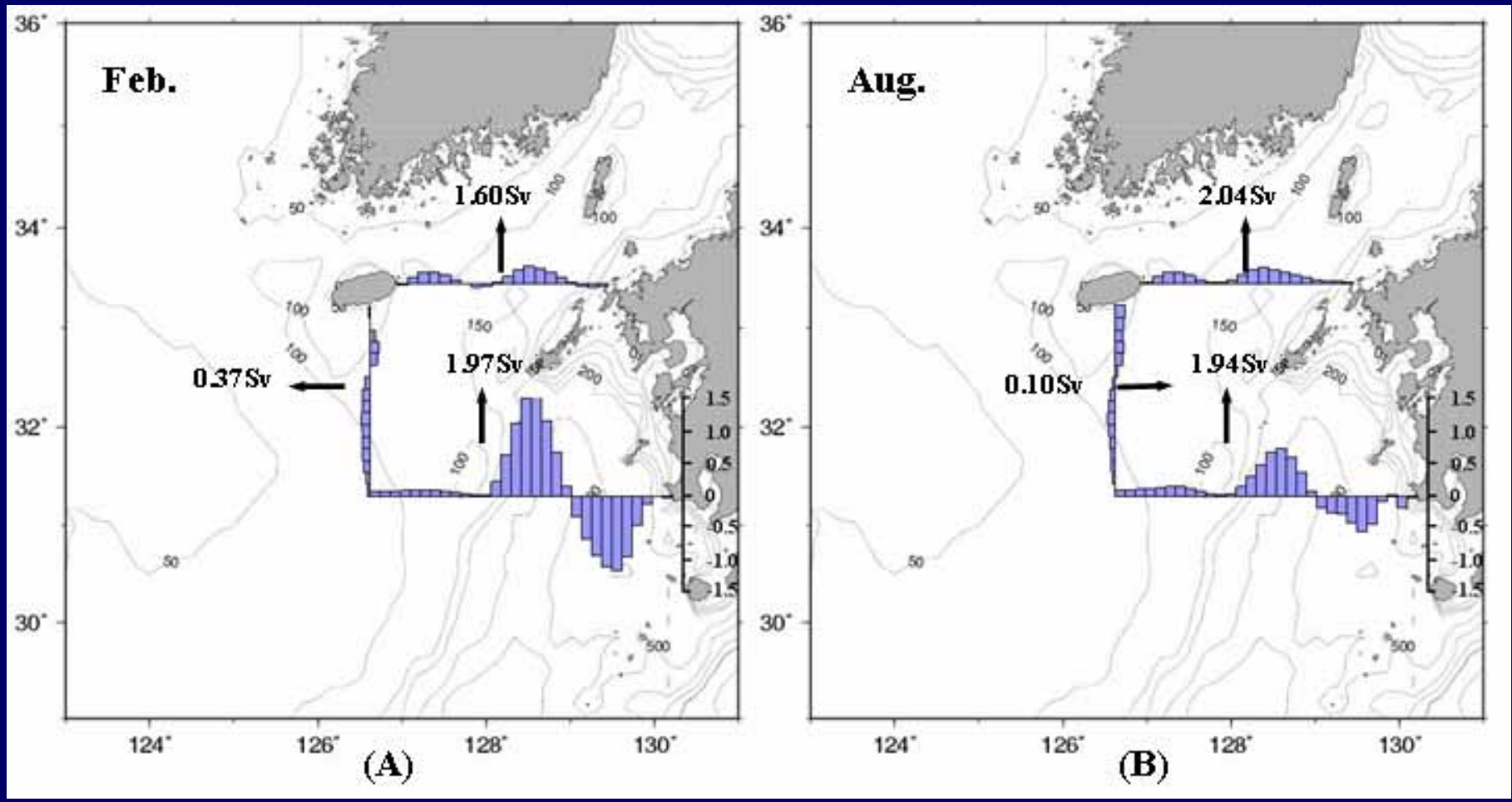
∵ The transport variations in the Kuroshio and the KTS have different phases.



The model transport in the east of Taiwan and the KTS


125°
130°
135°
E
N
35°
30°
KOREA
KS
I
G
PN
100
200
1000
2000
(A)
Sv
Korea Strait
Miyazaki (1952)
Yi (1966)
month
(B)
win spr sum aut
PN-Line
I-Line
G-Line
(C)

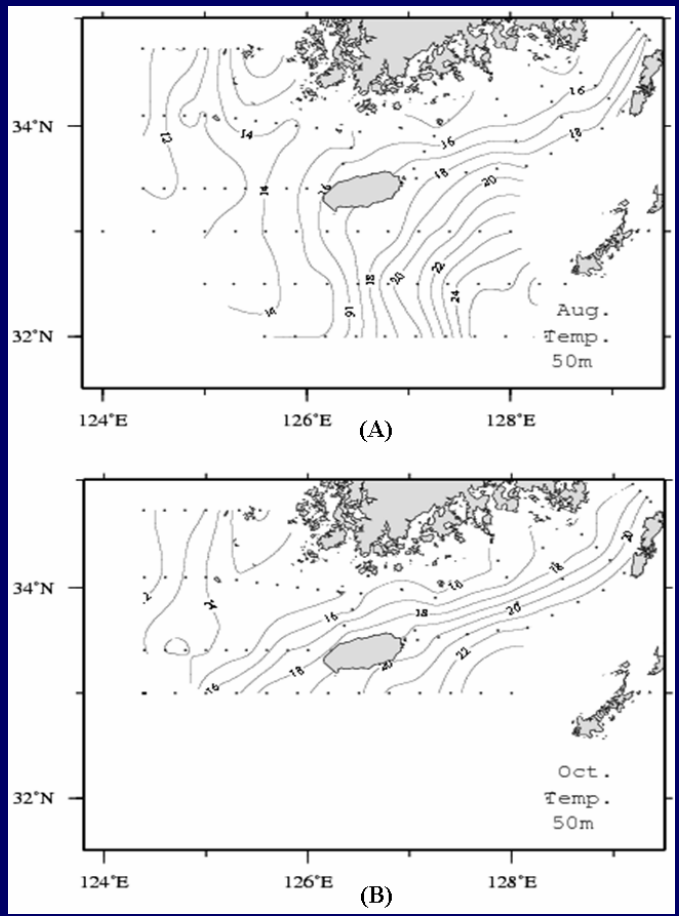
Relation with the seasonal variation of the TWC



The seasonal variation of the transport in the KTS is influenced by the TWC, which is connected with the wind-driven circulation in the YS

Relation with the monsoon winds

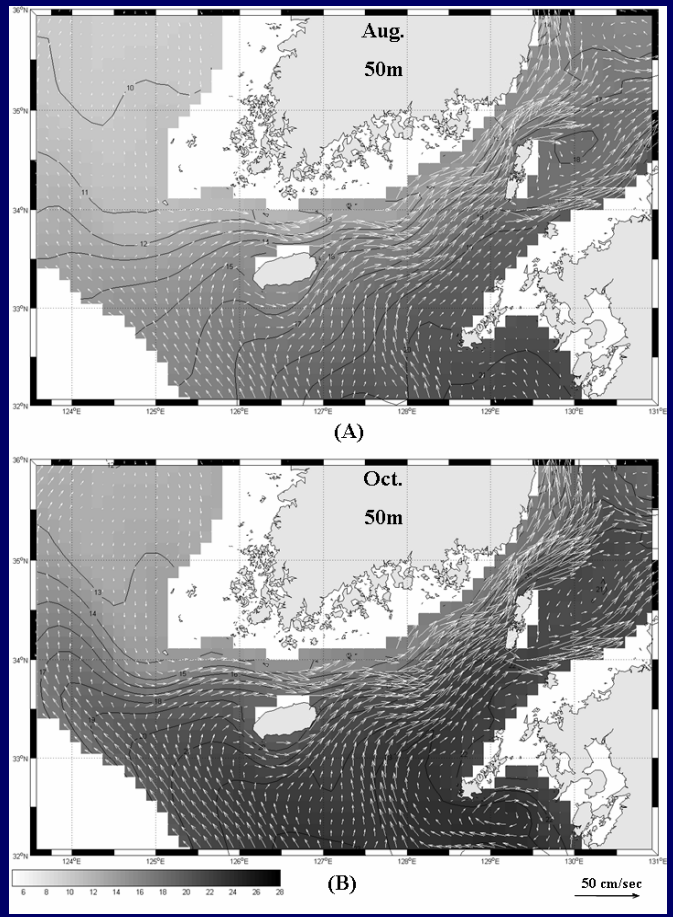
If the transport in the KTS is influenced by monsoon wind, why does it have its maximum in October when the northerly winter monsoon wind start to blow instead of July or August when the southerly summer wind has its maximum?



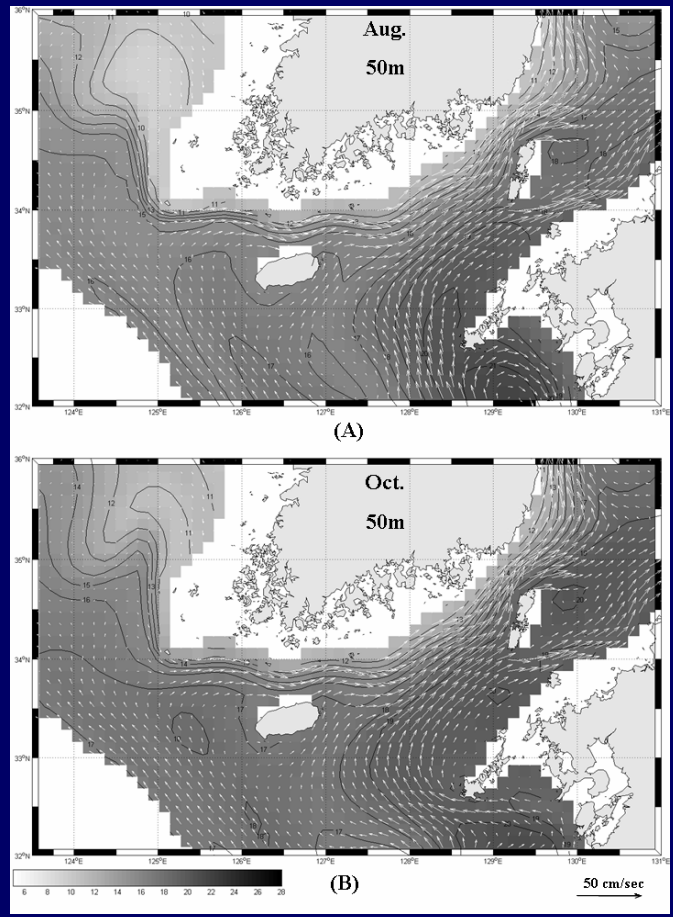
Monthly mean temperature distributions at the depth of 50m in (A) August and (B) October data from NFRDI (National Fisheries Research and Development Institute) during 1970~2000

Winter monsoon wind drives the warmer TWCW northward and colder coastal water southward to make the thermal front stronger.

Relation with the monsoon wind



with wind forcing



without wind forcing

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Wind	1.96	1.98	2.06	2.27	2.46	2.53	2.71	2.69	2.71	2.90	2.65	2.37
No wind	2.24	2.27	2.37	2.37	2.47	2.50	2.55	2.53	2.50	2.44	2.37	2.28

Conclusion

- **The seasonal variation in the YECS are connected to comprise a large-scale seasonal circulation in the YECS.**
- **The seasonal circulation is driven by the monsoon wind.**
- **The maximum transport in the KTS in October is caused by the monsoon wind.**

Thanks!

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Kuroshio	24.12	22.96	25.34	28.06	26.89	26.72	25.98	25.70	24.74	22.53	22.15	23.46
PN line	22.81	23.83	25.22	24.87	26.72	26.53	24.50	24.51	25.62	21.74	21.61	22.62
Tokara St.	22.25	23.67	23.52	25.42	27.76	25.12	23.40	22.21	21.62	20.57	22.10	24.43
ASUKA	42.52	40.83	39.71	41.22	43.56	37.65	35.43	31.46	31.12	34.44	37.65	41.67
TS	0.57	0.83	1.32	2.07	2.56	2.77	2.96	2.36	1.57	0.85	0.44	0.33
KTS	1.96	1.98	2.06	2.27	2.46	2.53	2.71	2.69	2.71	2.90	2.65	2.37
JS	0.47	0.38	0.38	0.43	0.57	0.59	0.67	0.65	0.59	0.70	0.69	0.57
Tsugaru St.	1.35	1.21	1.22	1.39	1.53	1.60	1.74	1.77	1.73	1.93	1.80	1.60