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The development of a wave-tide-circulation coupled model and its application in the Yellow Sea

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outline

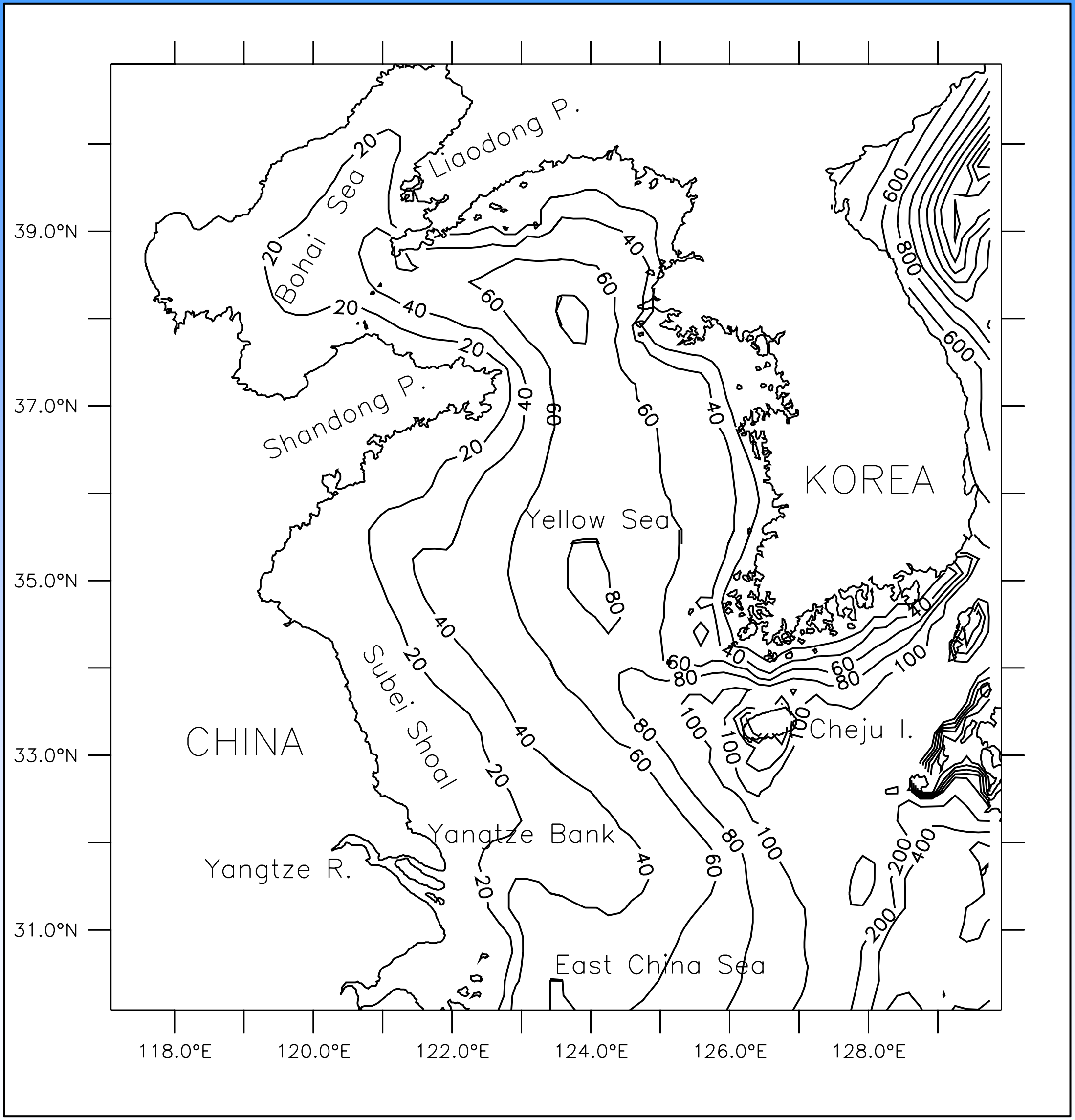
1. **Introduction**
2. **The description of MASNUM wave-tide-circulation coupled model**
3. **The simulated temperature**
4. **The simulated summer Yellow Sea circulation**
5. **Conclusion**

1. Introduction

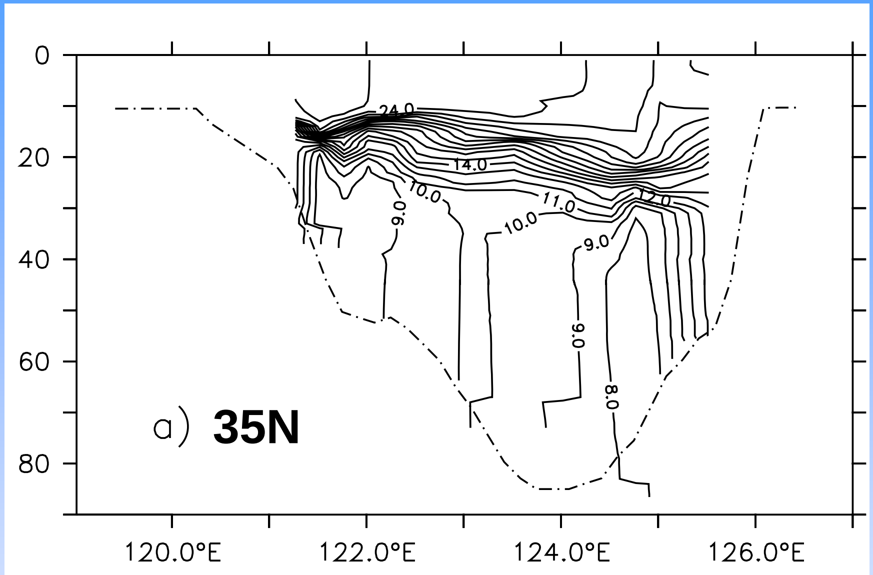
Study area: the Yellow Sea

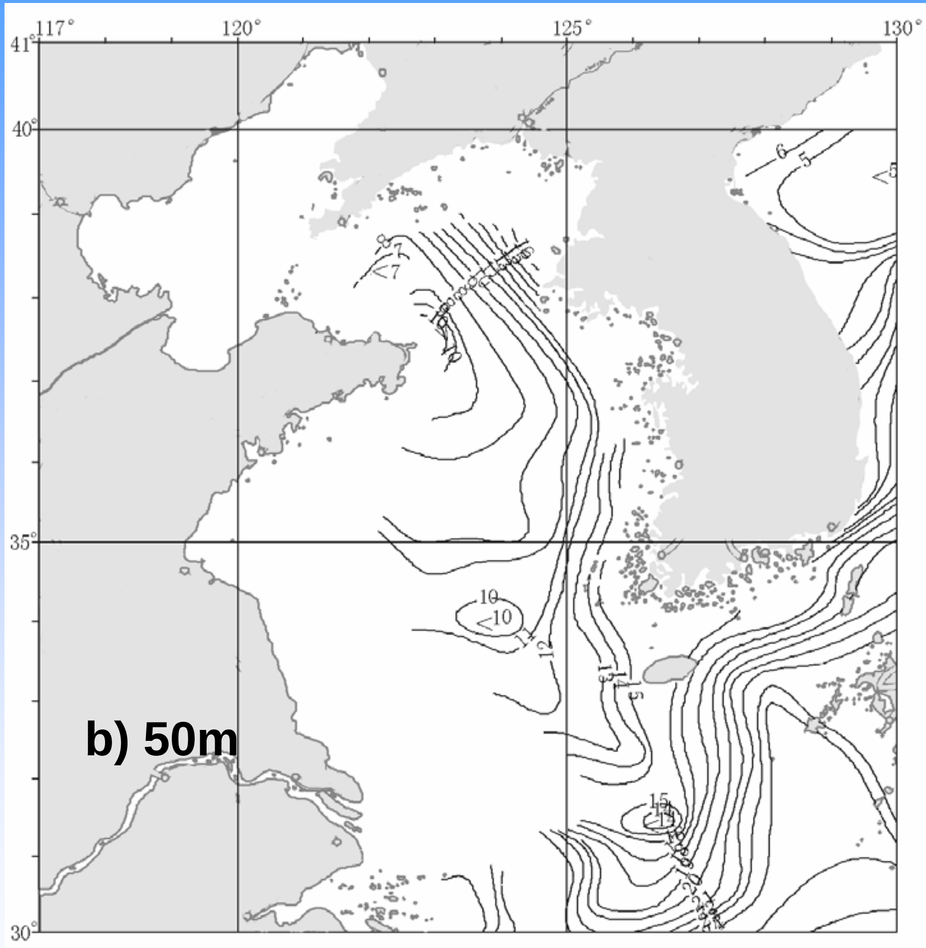
The main forcing factors on the YS circulation (Guo 1993):

- **the wind stress and heat exchange with atmosphere**
- **the tides propagating from the outer ocean**
- **large amount of fresh water input from the Yangtze River**
- **Flow from the East China Sea and the Bohai Sea**



Main Characteristics of the summer YS circulation:





Observed summer temperature distribution in the YS

(a) along 35N section

(b) At the depth of 50m

Main Characteristics of the summer YS circulation:

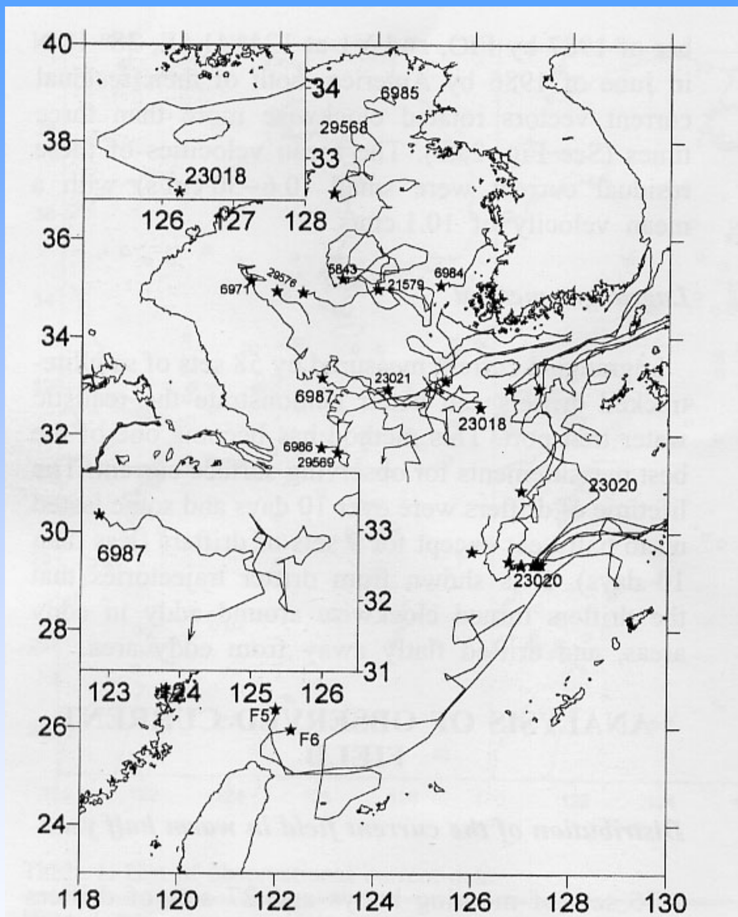


Fig. 3. Trajectories of satellite-tracked drifter.

Trajectories of satellite-Tracked drifters (from Lin,2000)

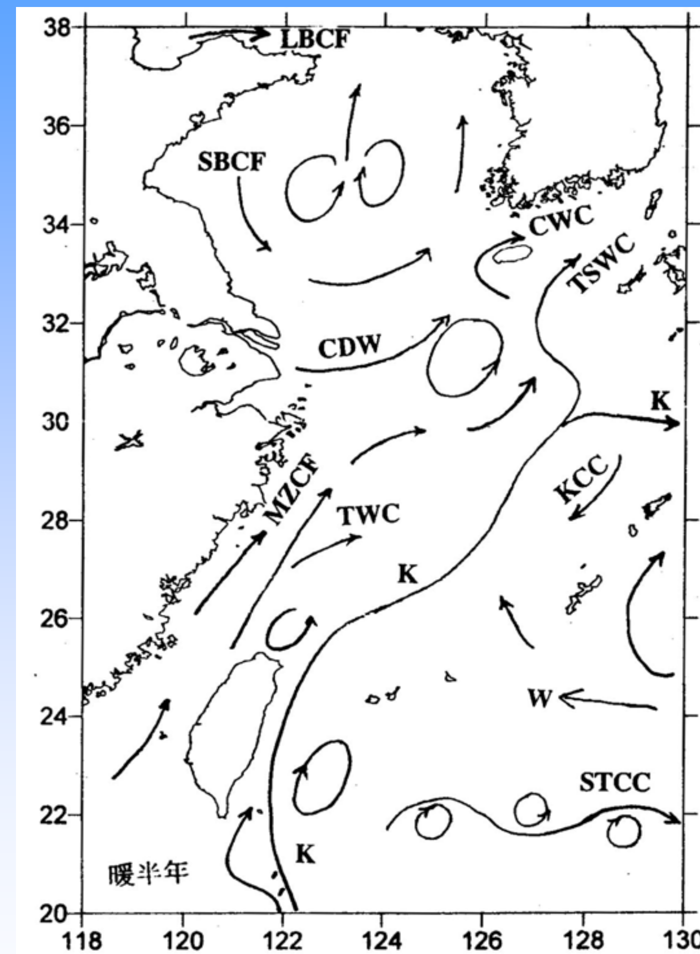
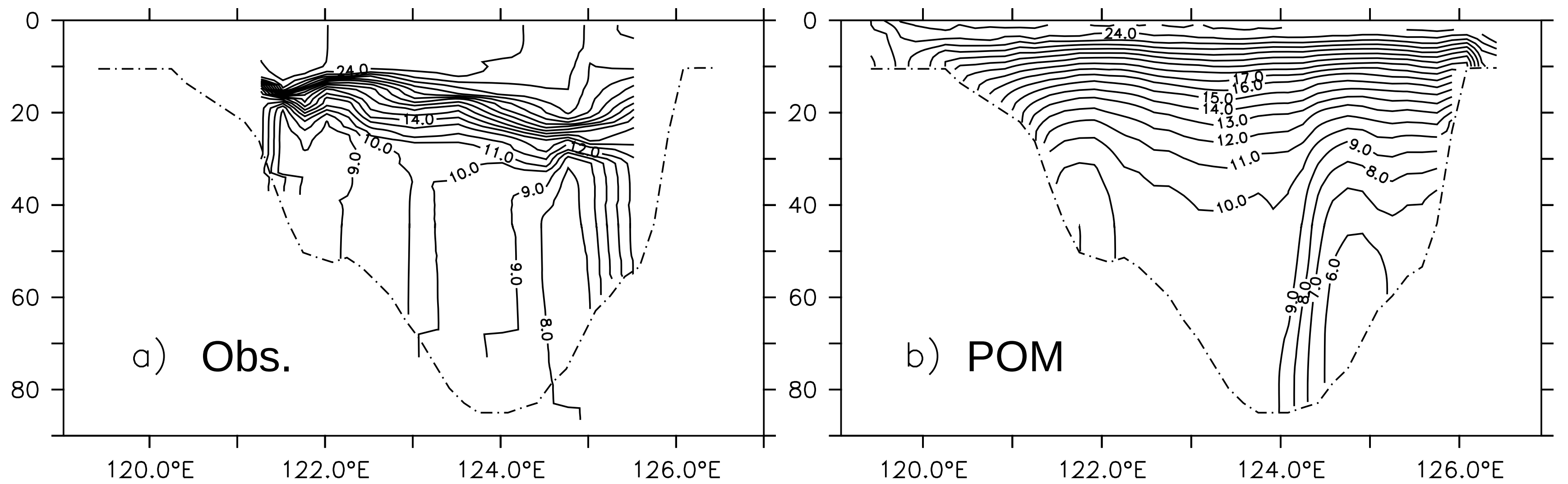


Diagram of circulation pattern base on observation in the warm season (from GUO, 2004)

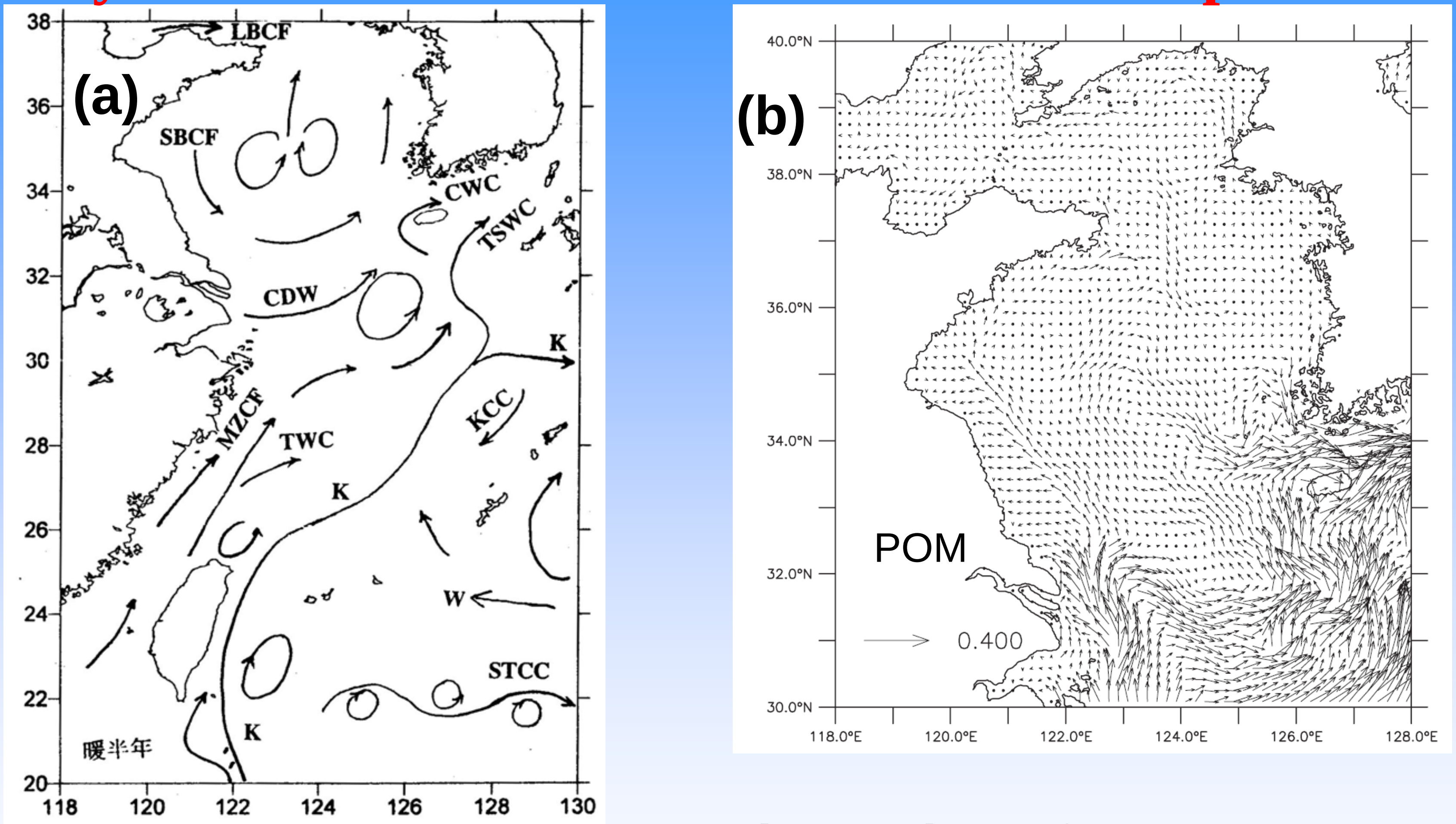
Why do we need a wave-tide-circulation coupled model?



Summer vertical temperature structure along 35N section in the Yellow Sea

a) Observation b) Original POM result

Why do we need a wave-tide-circulation coupled model?

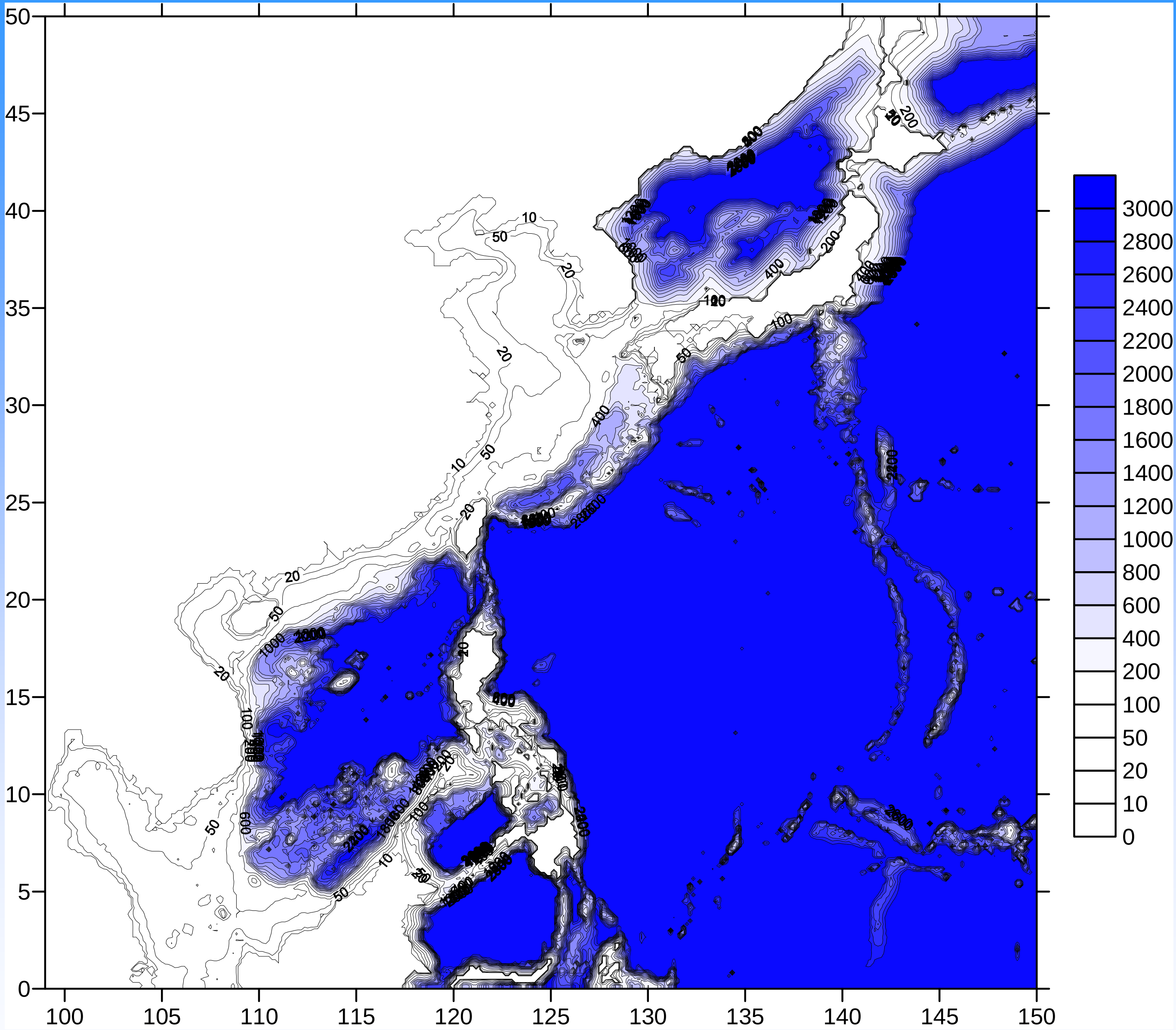


Upper layer circulation of the Yellow Sea in summer

a) Diagram based on observation b) Original POM result

2.The MASNUM wave-tide-circulation coupled numerical model

- **The circulation part is based on POM**
- **The wave part is LAGFD-WAM model**
- **Add the wave-induced mixing coefficient *Bv* to the vertical mixing coefficient provide by the M-Y scheme in POM**
- **Simulate the circulation and the tide current simultaneously**



The model domain and the topography

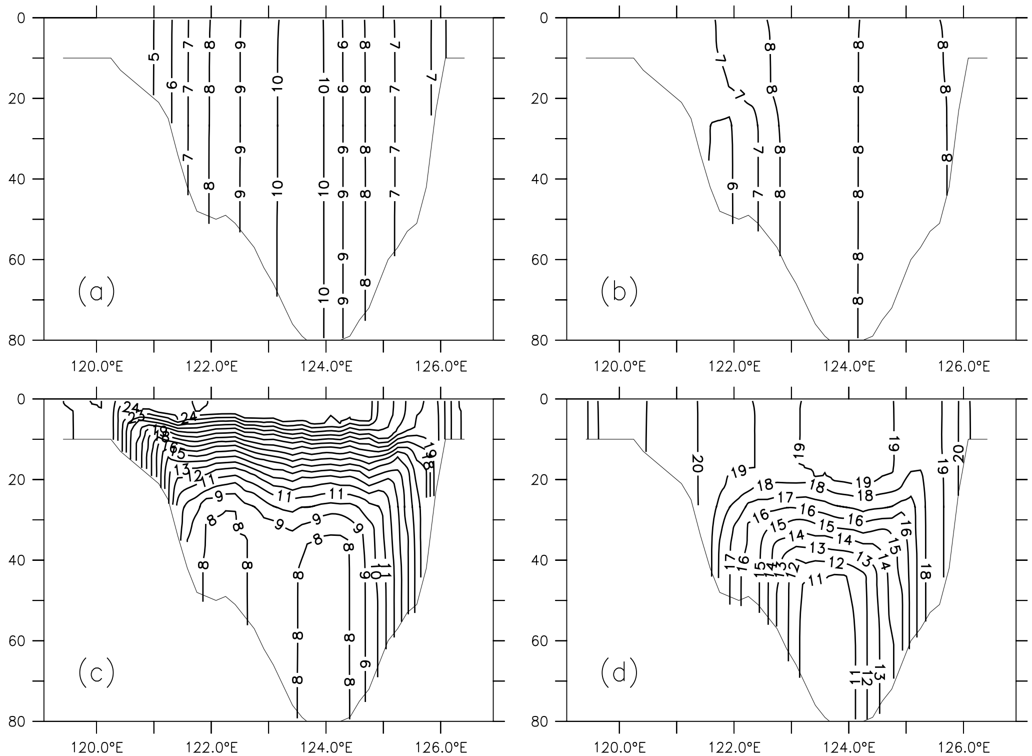
The circulation model is driven by monthly climatological (COADS) wind stresses and heat fluxes

The initial temperature and salinity field are set to the Levitus annually averaged temperature and salinity

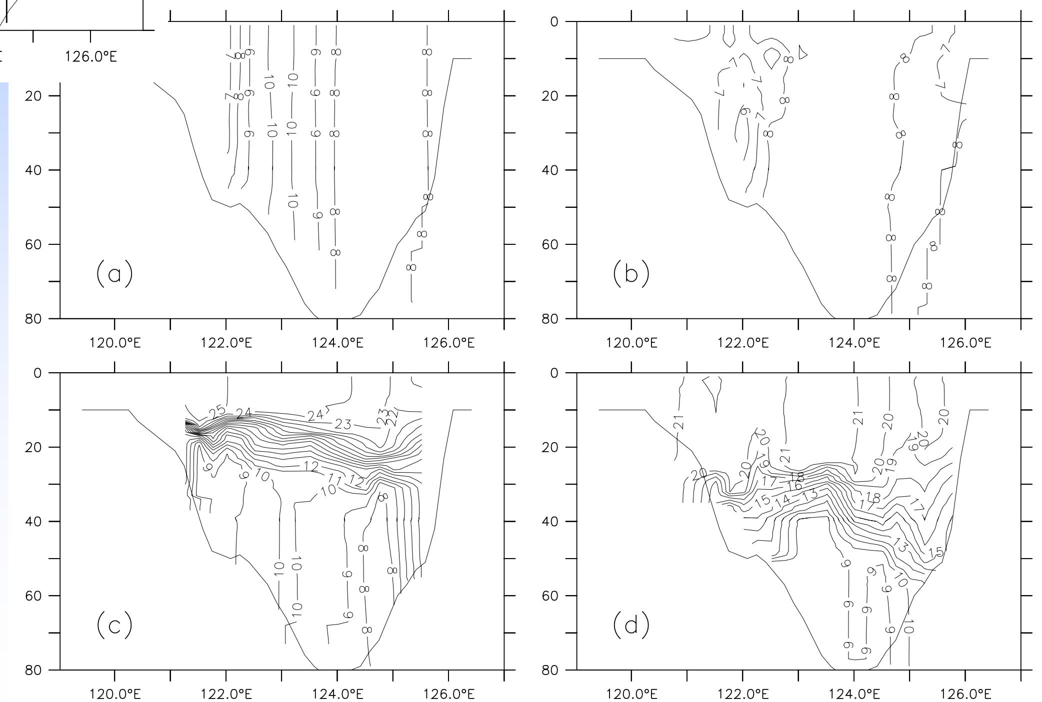
The variables (temperature, salinity, sea level and velocity) along the open lateral boundary is obtained by interpolation of the global 1/2°×1/2° model result

The Changjiang Diluted water (CDW) is considered

3. The simulated temperature

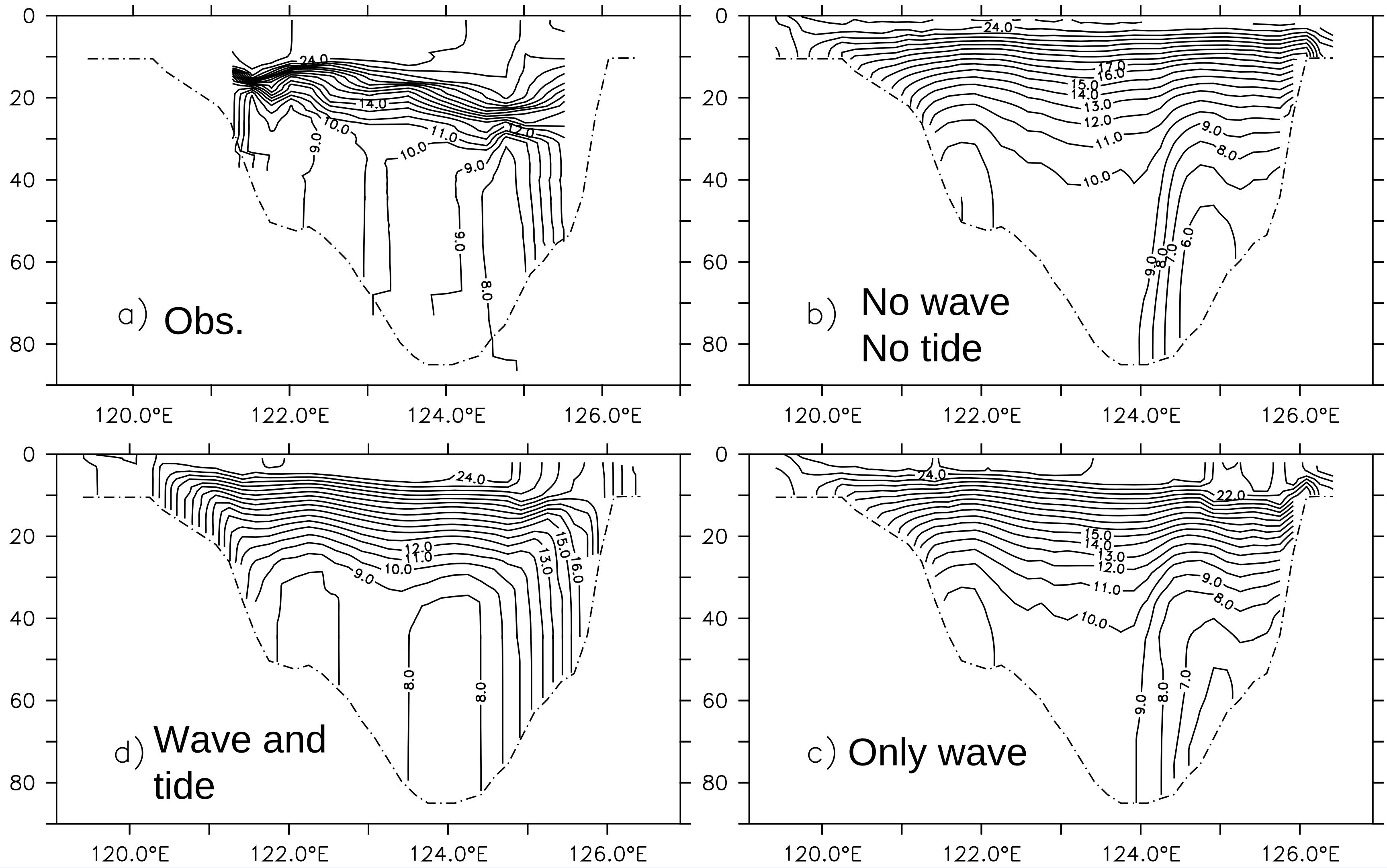


CTD data collected by China-Korea joint cruises in Apr. and Oct. 1996, Feb. and Jul. 1997



The vertical temperature Structure along 35°N **transect**
(upper: simulated Right observation)

a),b),c),d) represent February, April, July and October

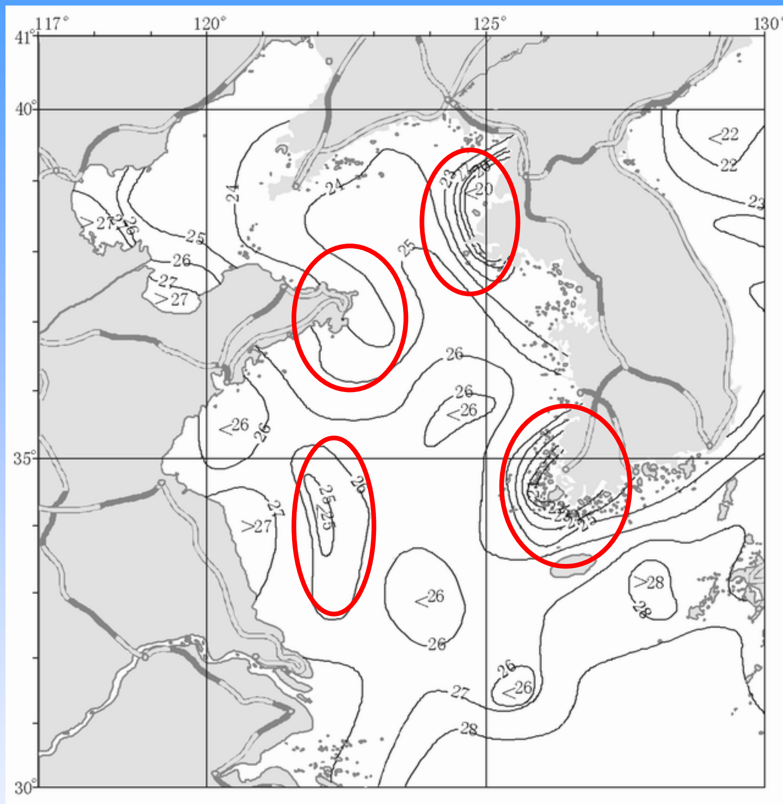


The Effect of wave-induced Mixing and the tide-induced Mixing on the vertical Temperature structure along 35N in July

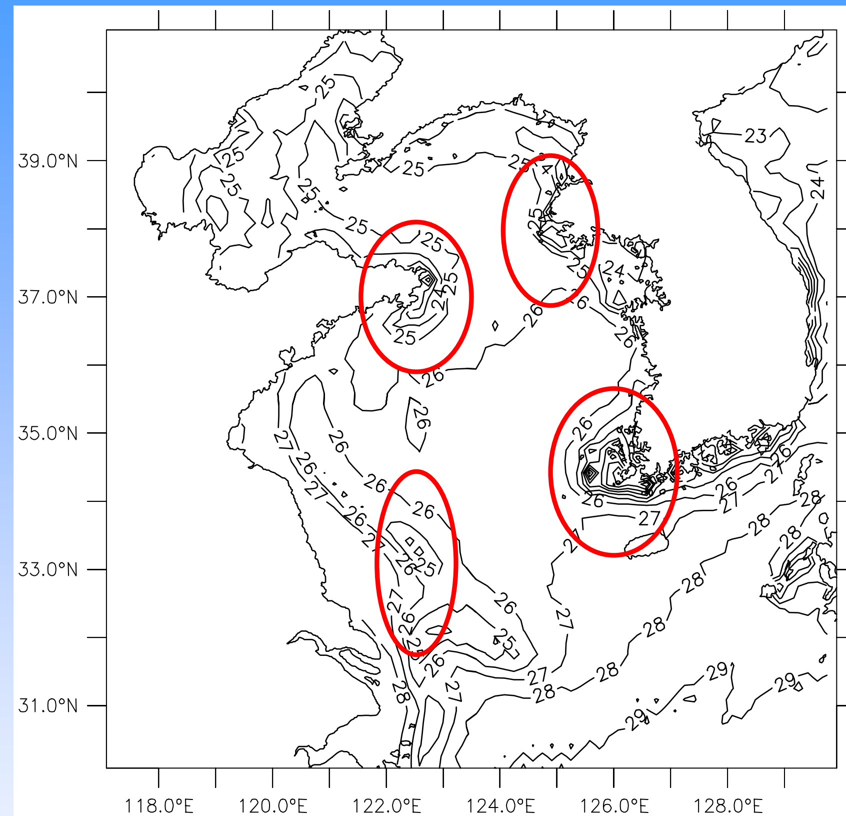
a) Observation b) No wave no tide

c) only wave d) wave+tide

Surface tempearure



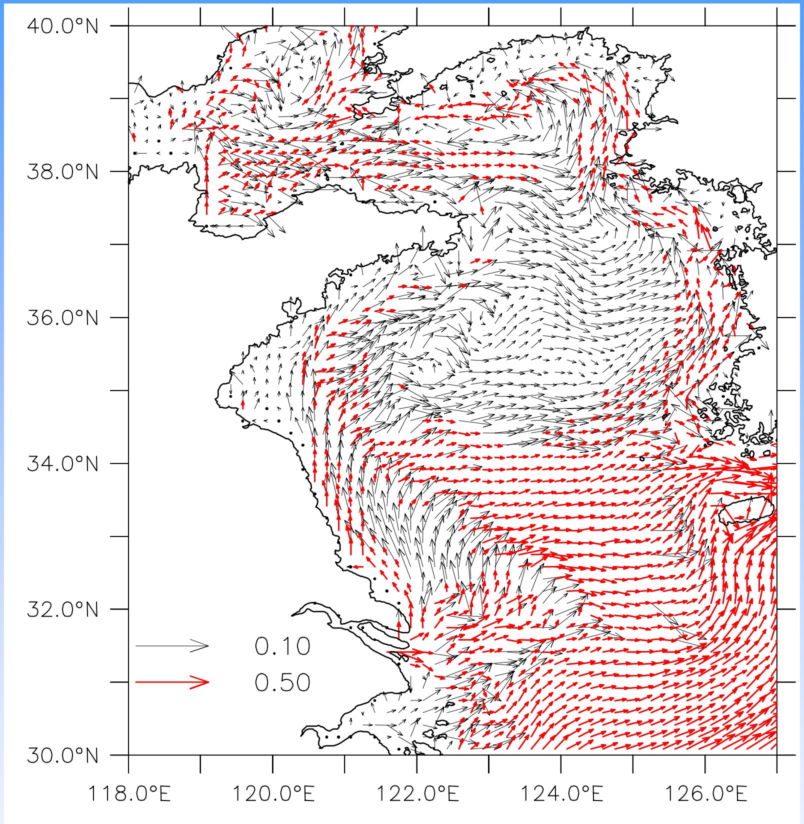
Observed surface temperature in Summer(Aug.) from Guo(2004)



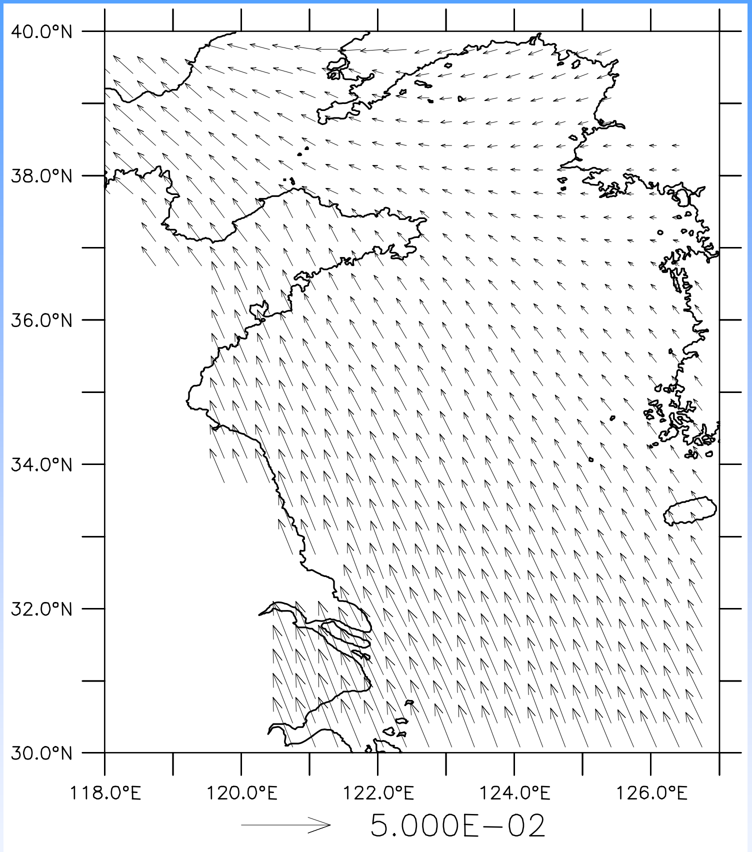
Simulated surface temperature in Summer (Aug.)

4. The simulated summer Yellow Sea circulation

Surface layer (0-4m)

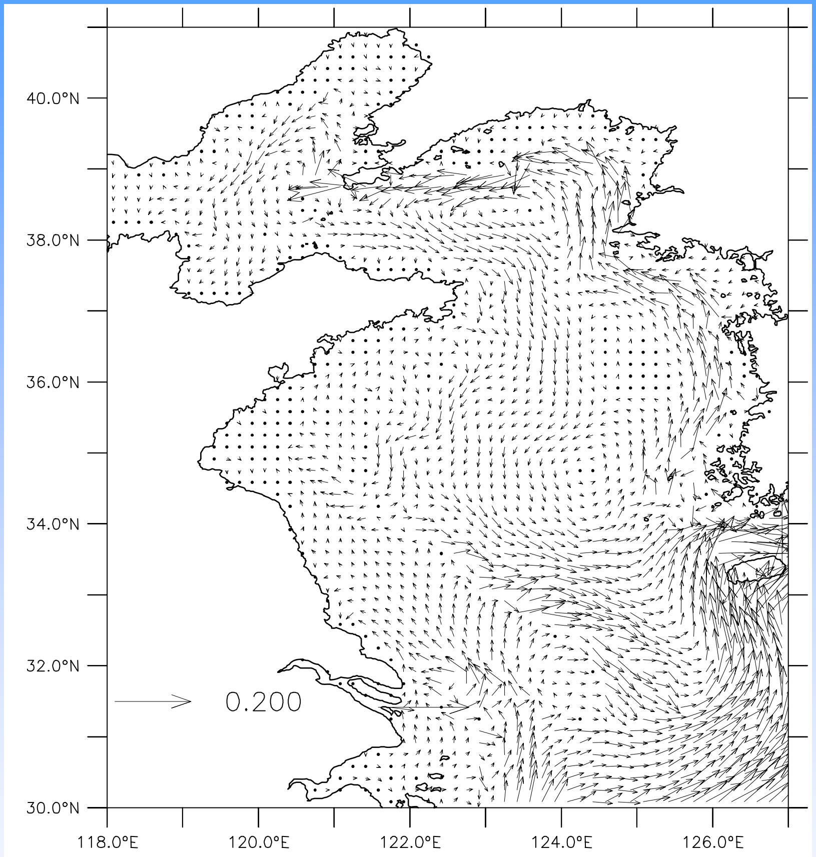


The simulated surface layer (0-4m averaged) circulation in Aug. unit: m s-1

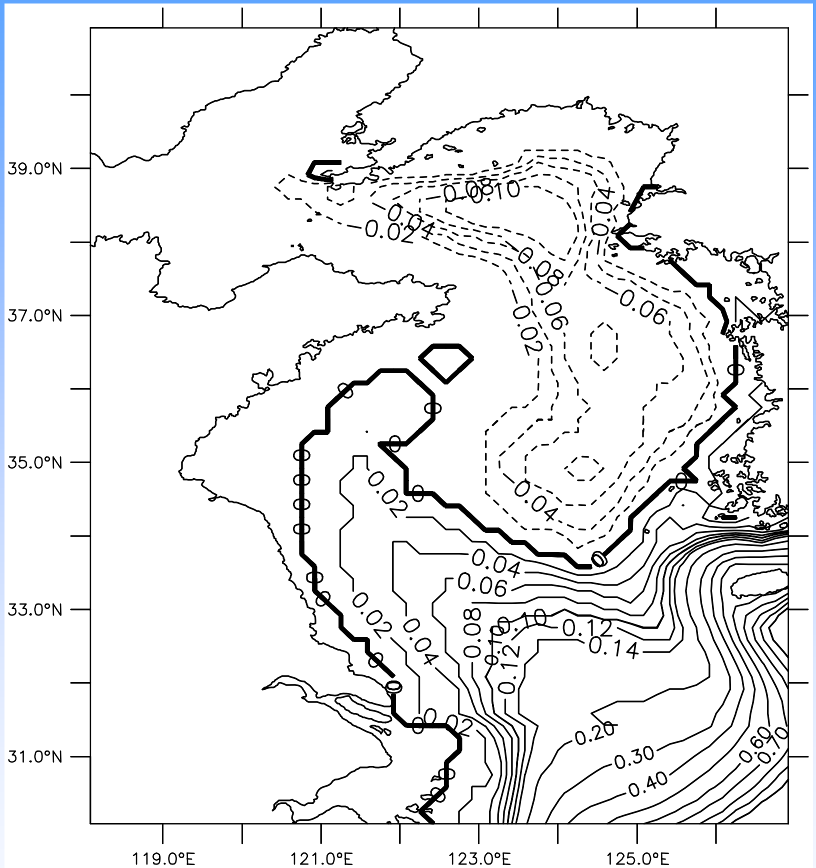


Wind Stress field in Aug. Unit: N/m2

Upper layer circulation

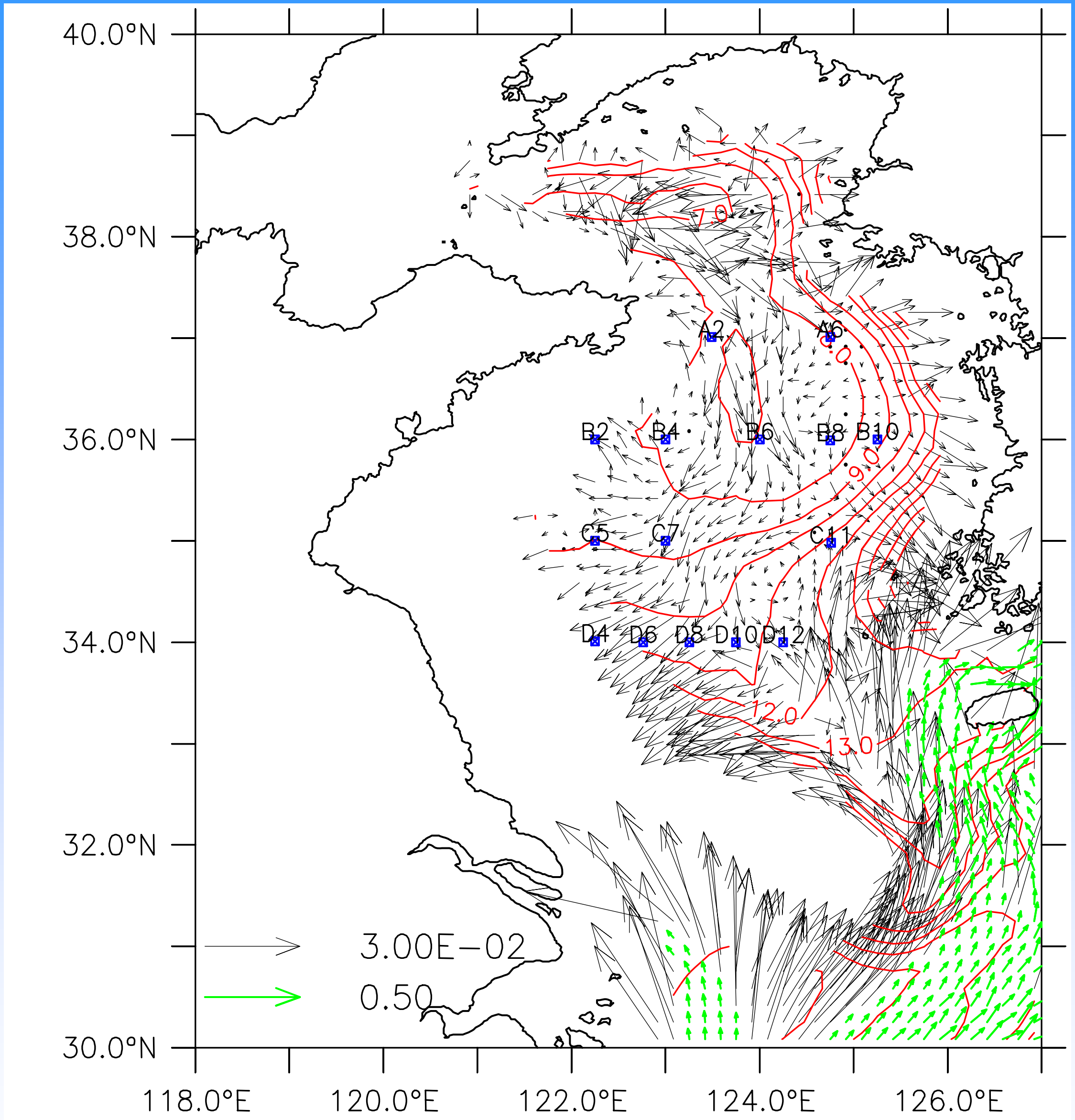


Simulated flow field at the depth of 10 m in August in m s-1.



Stream functions in August
unit: Sv

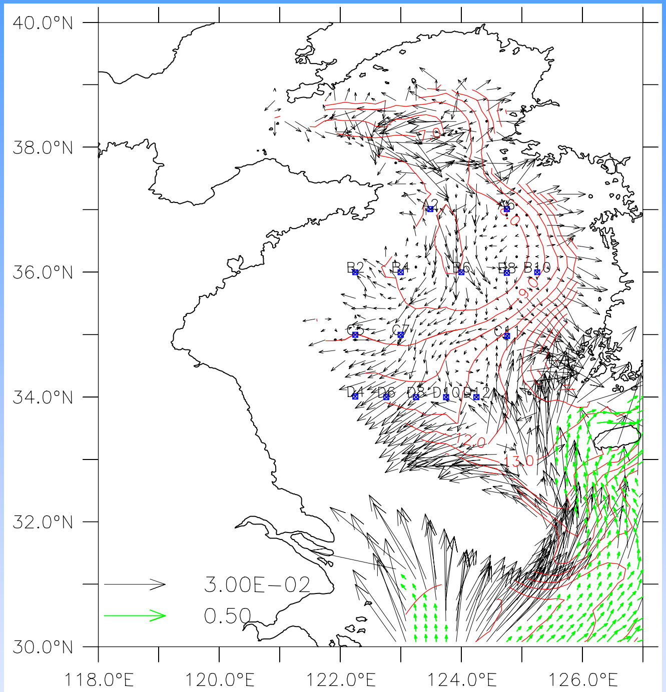
Bottom layer

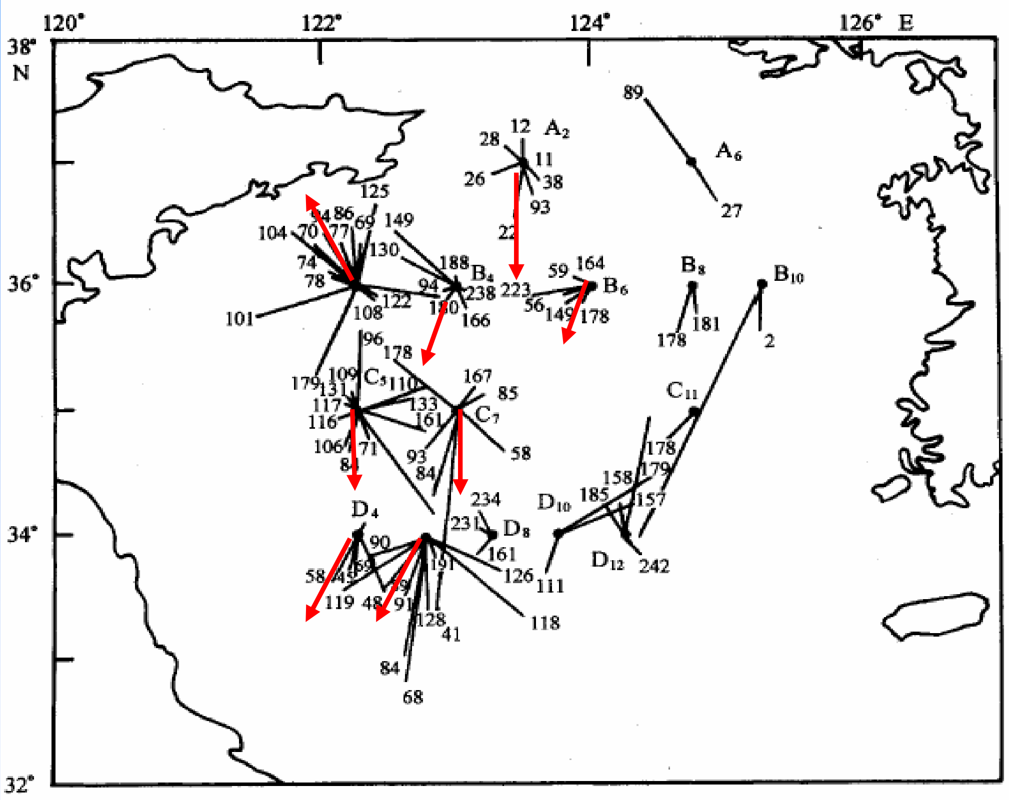


The simulated bottom layer (50 m) circulation in August (in m s-1)
Red line: temperature.

1.water diverges from the YS trough towards seashore

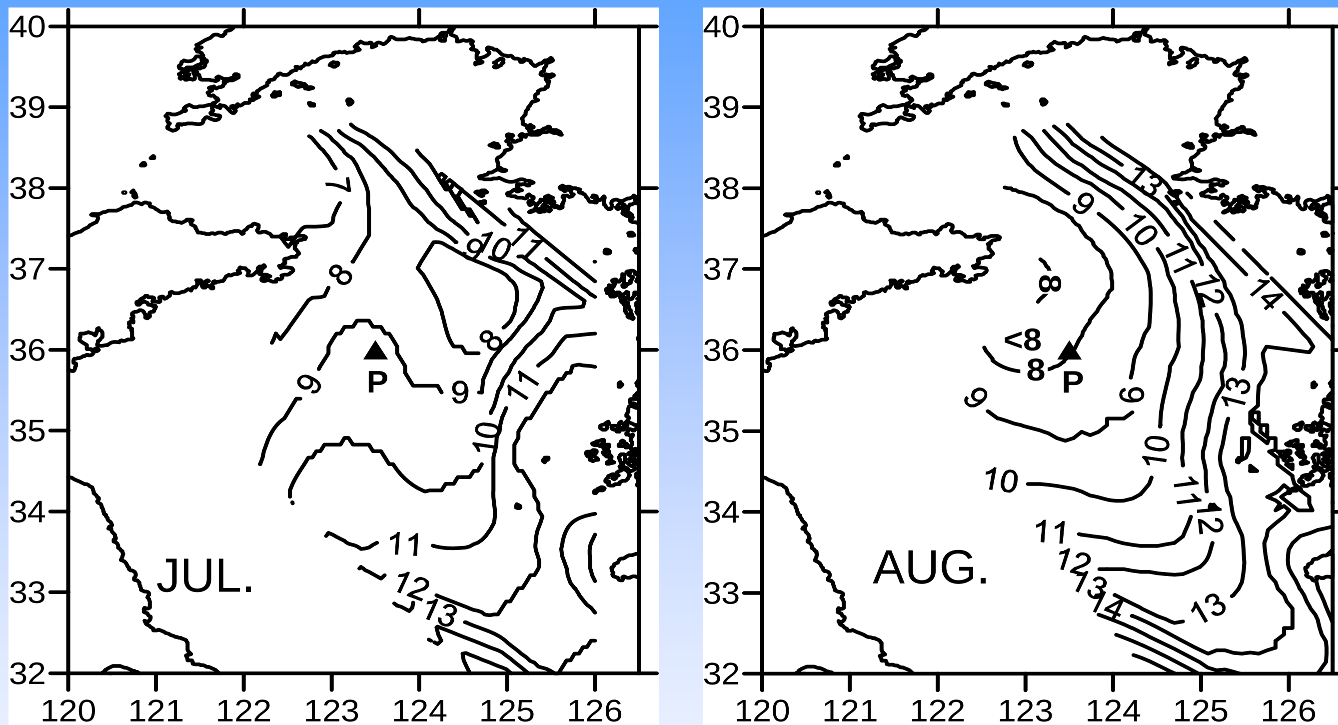
2. There also exists a weak southward current





The path of bottom floater in summer.
from *Tang et al*., 2000

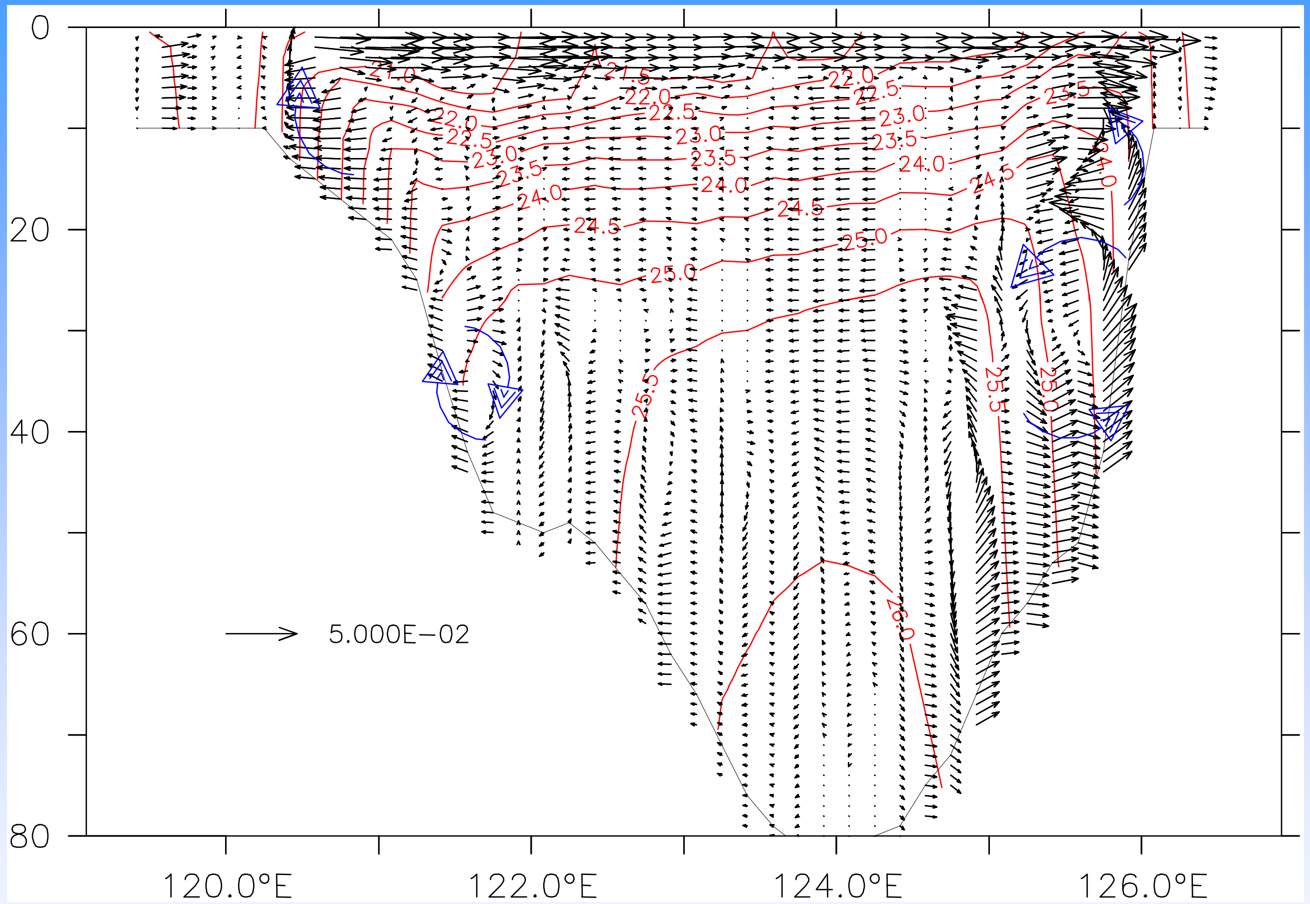
indirect evidence of the existence of the southward flow in the YS at the depth Of 50m P (36°N,123.5°E) the temperature drops from 9.2℃ in July to 8.0℃ in August.



The observed temperature distribution at the depth of 50 m in July and August

redrawn after *Chen et al.*, (1992). The triangle stands for the comparison point

vertical circulation



The vertical circulation (u,w) along the 35°N section in August (in m s-1, the w component is multiplied by 1000, the wind direction is northward, the red line is the density field).

Conclusions:

1. **The MASNUM wave-tide-circulation coupled numerical model is developed and used in the study of the circulation in the summer Yellow Sea**
2. **The surface wave-induced mixing plays a key role in the formation of the upper mixed layer in summer.**
3. **Tidal mixing forms the subsurface temperature front and "table" shape temperature structure in the Yellow Sea.**

Conclusions:

The circulation of the Yellow Sea in summer has three-layer structure:

1. The surface layer (0-5m) northeastward current is controlled by wind.
2. The upper layer(5-50m) is dominated by a basin scale anti-clockwise (cyclonic) gyre. It is mainly formed by the strong tidal-induced temperature front and strengthened by the tidal residual current.
3. The bottom layer (below 50m) exists a weak southward current located nearly along the center of the basin, while divergent current exists in the coastal front areas.

Thank you!