1ST INTERNATIONAL WORKSHOP ON

WAVES, STORM SURGES AND COASTAL HAZARDS

Numerical Study of the Wind Waves Effect on Air-sea Fluxes in the Yellow Sea during the Cold Wave Events

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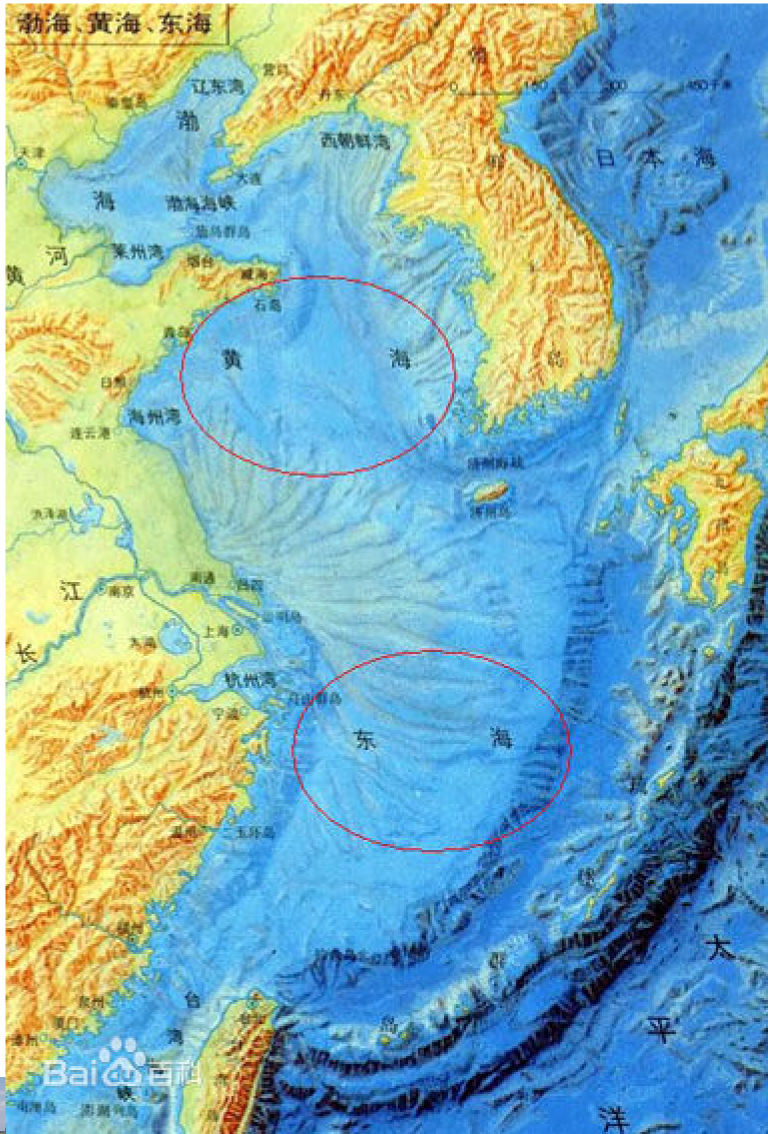
Contents

1 The basic features of the Yellow Sea



(1) The study mainly focuses on the Yellow Sea, which is featured with tidal-flat areas and complex terrains and peninsulas.

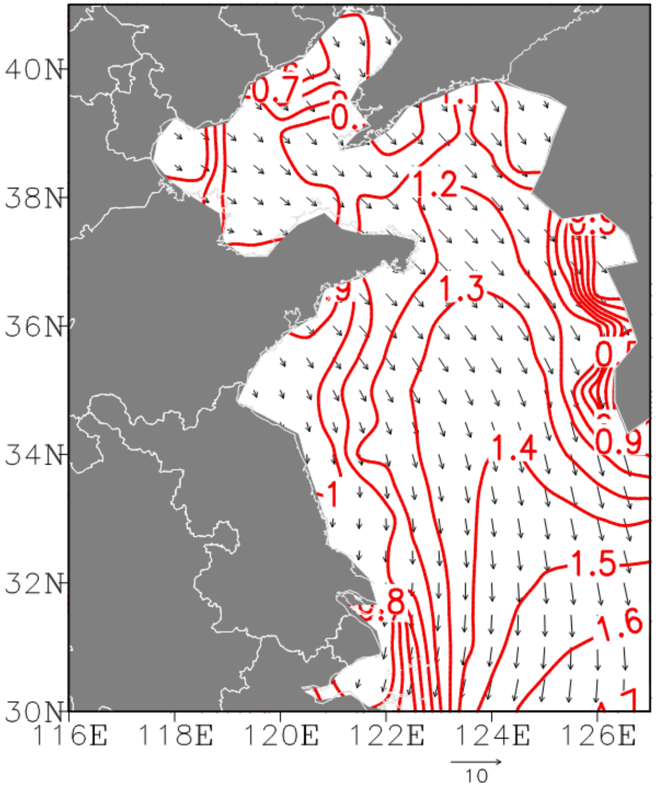
(2) The water depth is shallow with 80-100 m in Yellow sea, but on the east of Taiwan, the shelf in East sea area, the water depth is more than1000 m.

(3) Besides, a strong western boundary current, Kuroshio, is directly involved in the circulation therein.

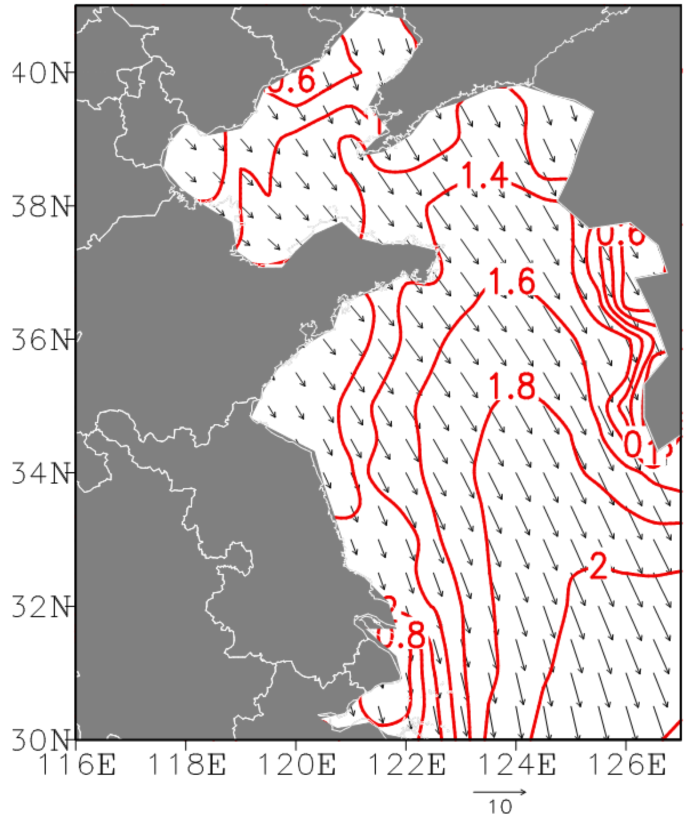
(4) Monsoon and seasonal systems impact strongly on the sea area.

These may significantly affect the air-sea fluxes of thermodynamics and momentum, making the fluxes different from those in the open sea.

2 The statistic features of the air-sea fluxes



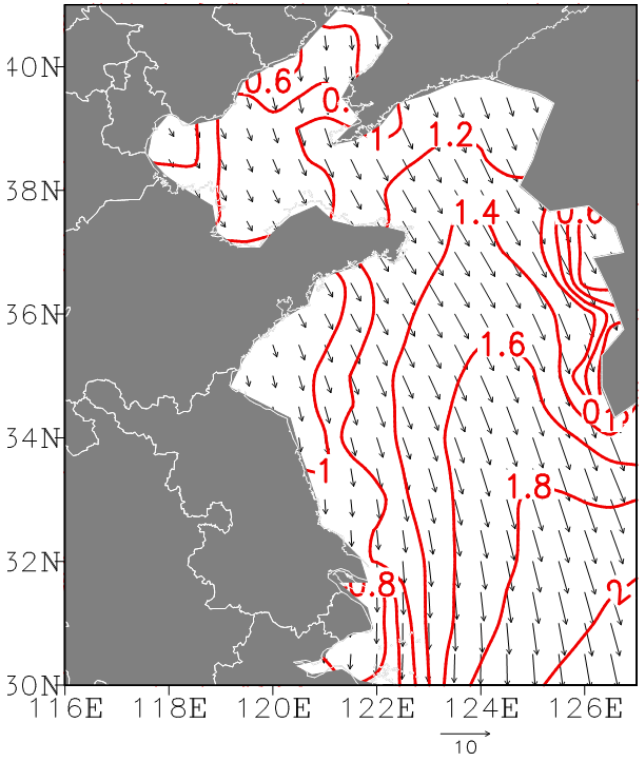
Nov.



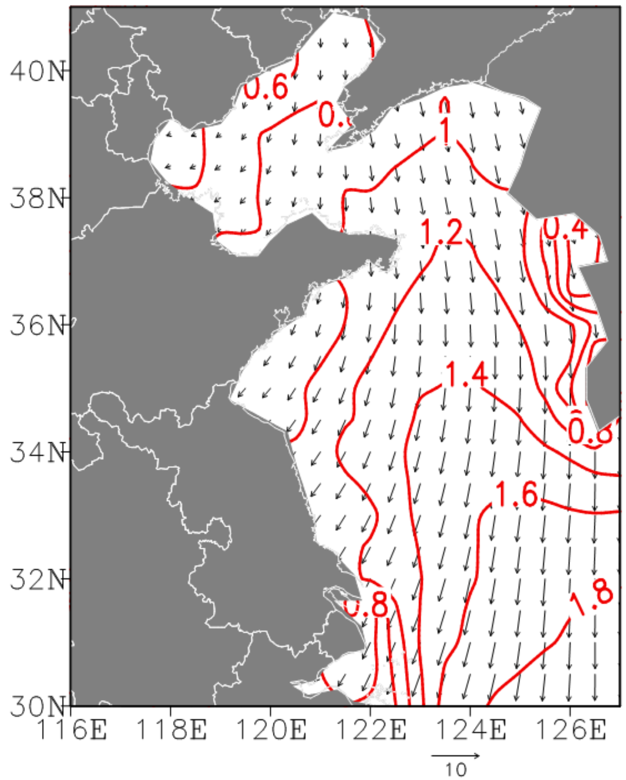
Dec.

The influence factors of the air-sea fluxes include SST, surface sea wind (SSW), surface air temperature, air moisture, cloud and waves, sea currents, etc.

The monthly average SSW and wave height fields of 2009-2013 in cold half of year in Yellow sea by data of CFSR

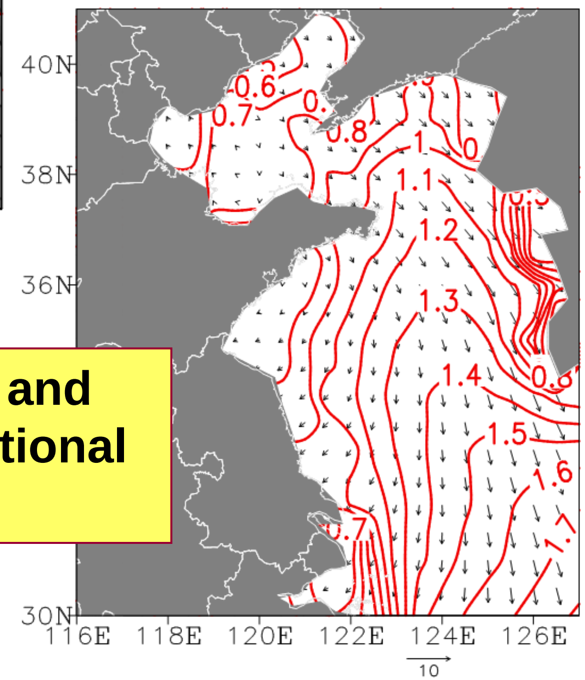


Jan.



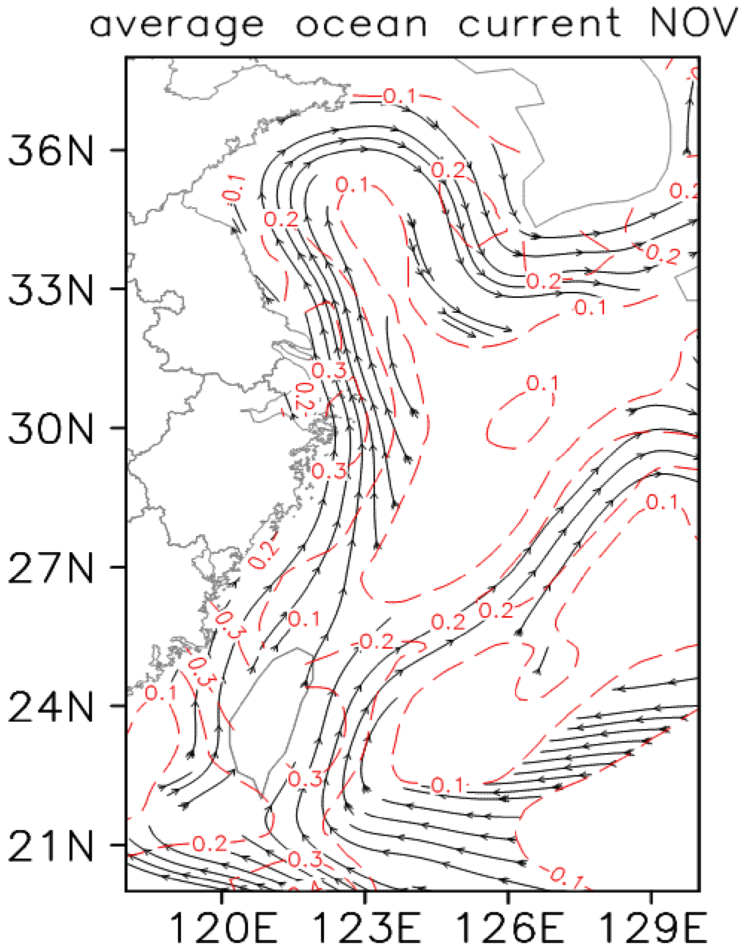
Feb.

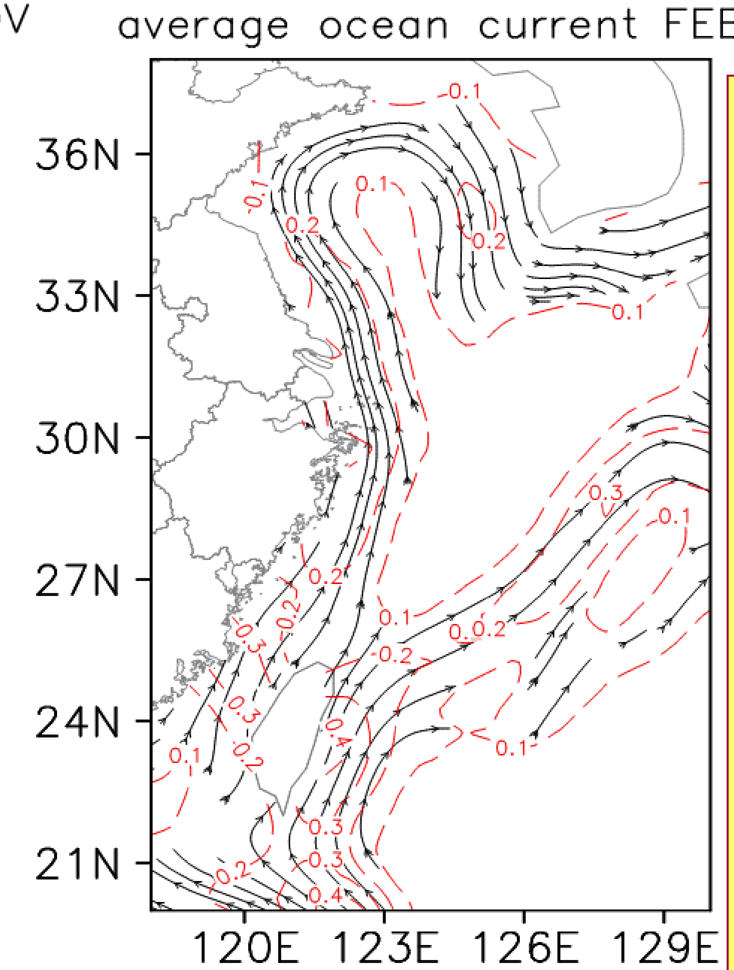
March



The average wind on the sea mainly comes from north and northwest during the period, the wave height is proportional to the wind speed and has a pick value at Dec.

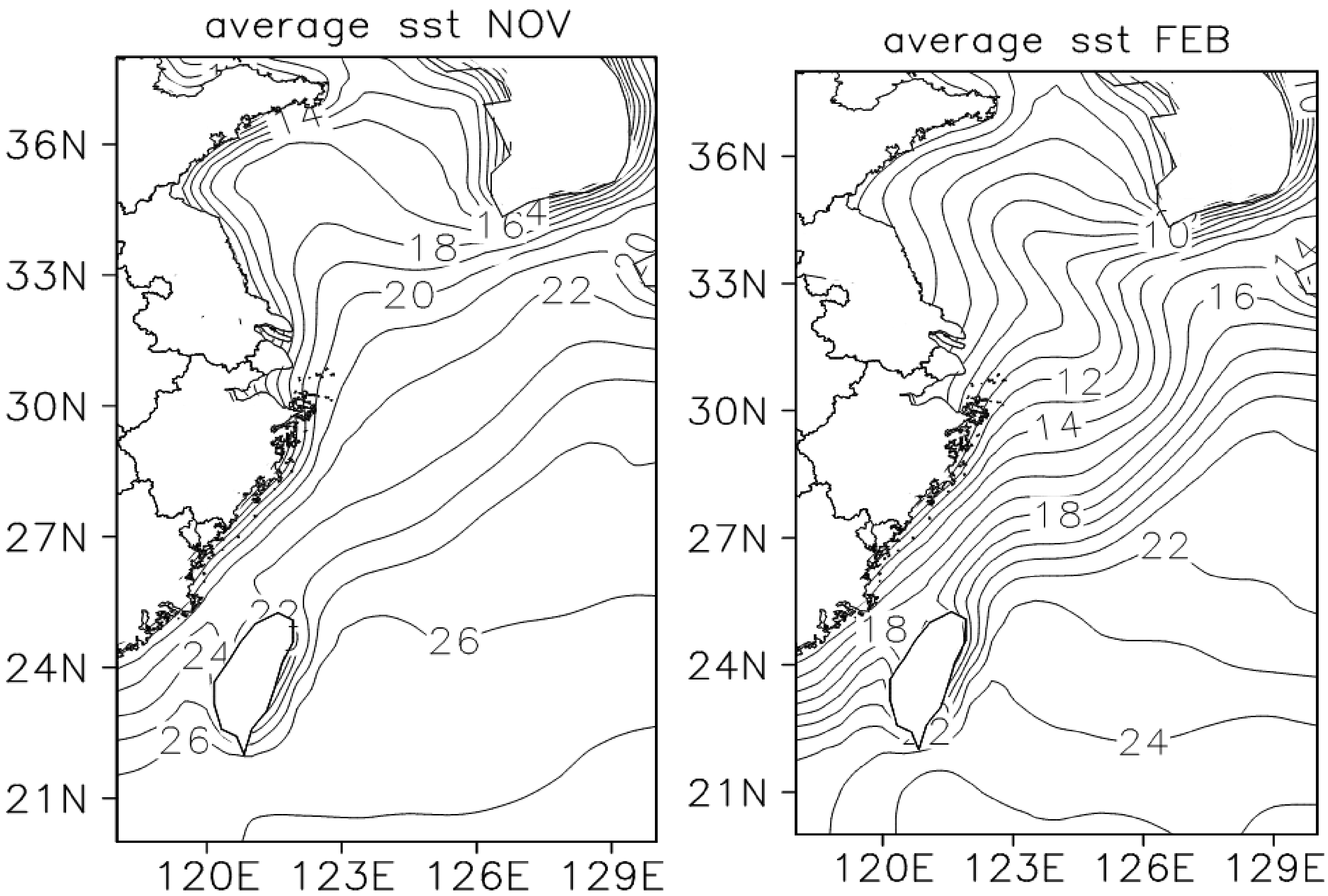
The monthly average SSW and wave fields of 2009-2013 in cold half of year in Yellow sea





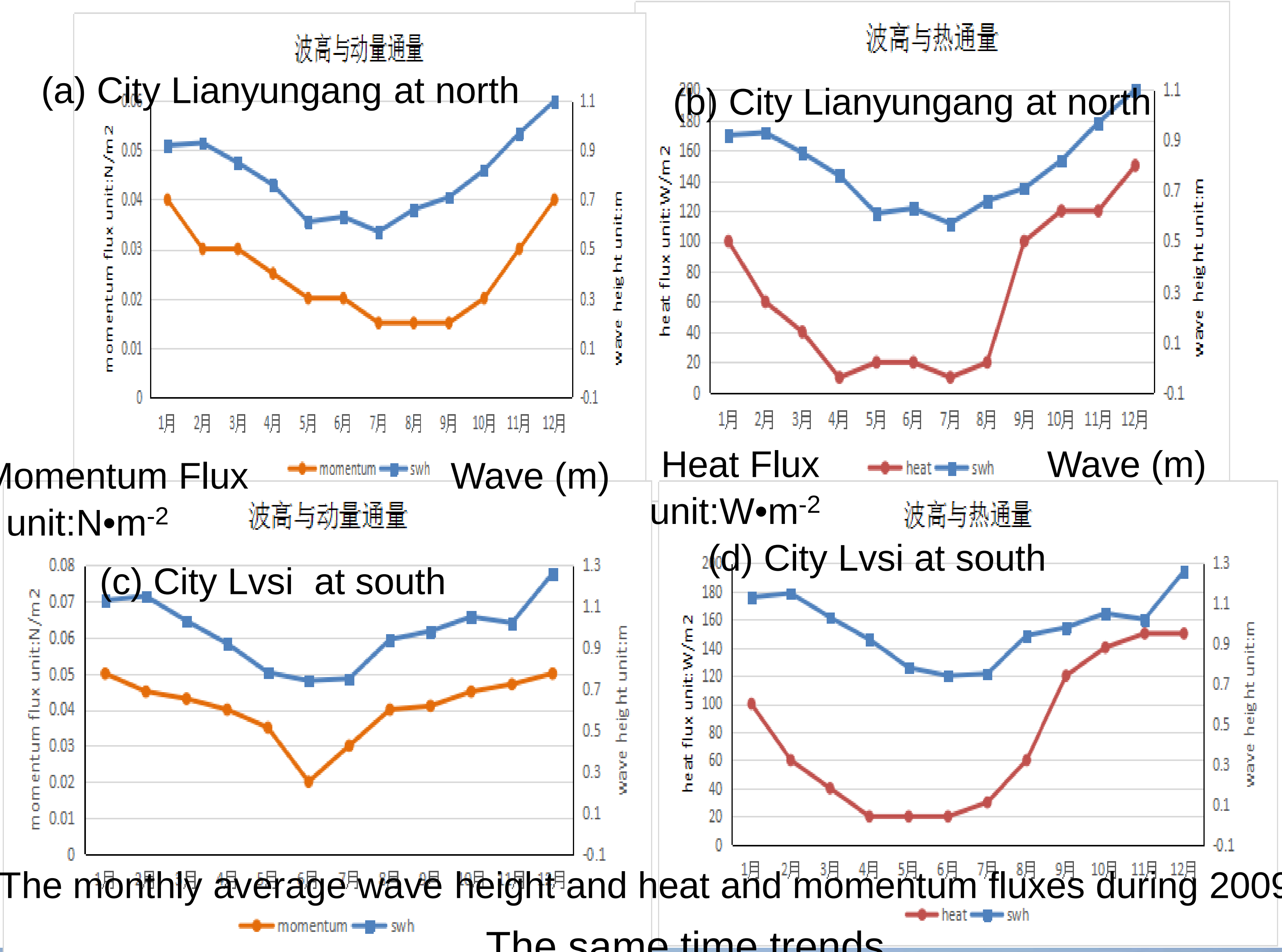
The sea current is weak during the period , especially the Kuroshio.
So the factor wave has a stronger impact on the momentum and heat fluxes than the current does in the period.

The monthly average currents (-5m under surface) and flow speed fields of 2004-2009 in cold half of year in Yellow sea



The monthly average SST fields of 2004-2009 in cold half of year in Yellow sea

The grads of SST between south and north of the Yellow Sea is the largest in Feb. It gets up to 8 ℃, then it is round near 4℃in summer.
There are stronger air-sea fluxes during cold half year than warm half year.



(a) City Lianyungang at north

(b) City Lianyungang at north

Momentum Flux unit:N•m^{-2} Wave (m)

Heat Flux unit:W•m^{-2} Wave (m)

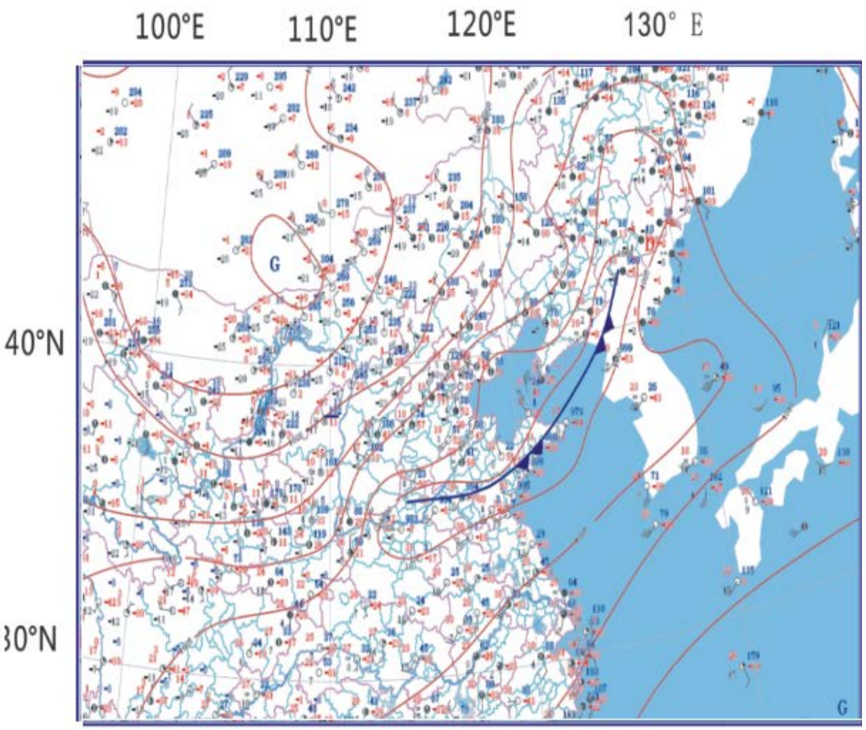
(c) City Lvsi at south

(d) City Lvsi at south

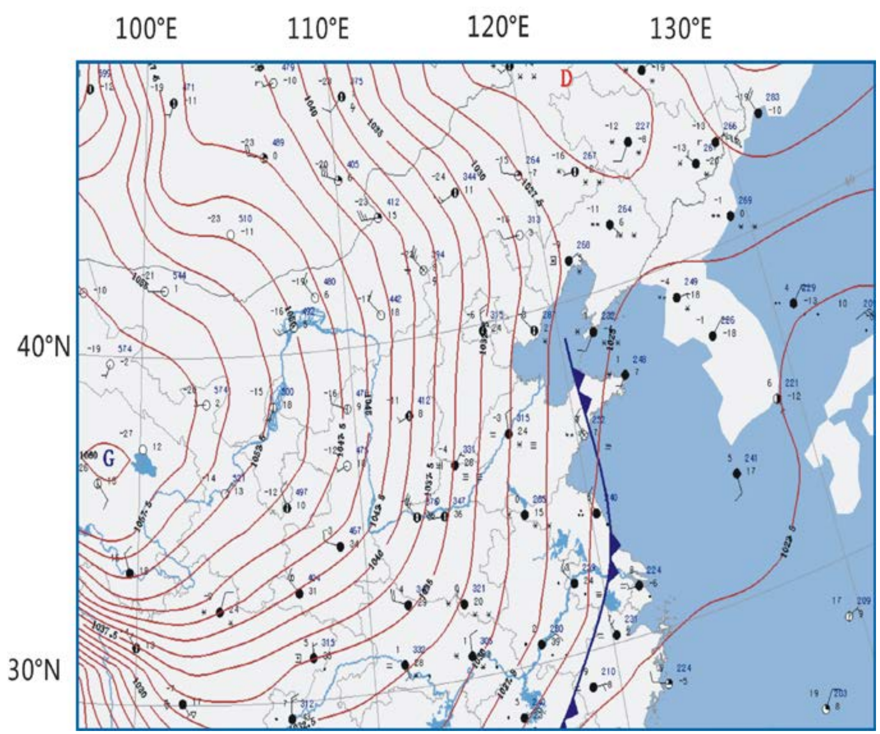
The monthly average wave height and heat and momentum fluxes during 2009-2013

The same time trends

3 The cold waves invaded the Yellow Sea



The cold front coming from north



The cold front coming from northwest

The sea-level pressure field and the cold fronts arriving the Yellow sea

Latitude shape with stronger part at the east area (16m/s , 6m/s)

Longitude shape with stronger part at the south area (17.4m/s , 12.1m/s

Table 1 Main element characteristics of two typical cold wave processes

The cold wave event	Temp. drop down In 24h.	Temp. drop down In 48h	Lowest Temp. in one day	Wind level	Wave height
① From north	**10~13℃**	**10~16℃**	**-1℃**	**7~9grade**	**3.4 m**
② From west	**7~10℃**	**9~10℃**	**2℃**	**7~9grade**	**3 m**

① 9 March.2013—11 march 2013

The momentum flux is larger 1-5 times than that of month average

The heat flux is larger 1-6 times than that of month average

② 28 Dec 2012.—30 Dec 2012

The momentum flux is larger 1-5 times than that of month average

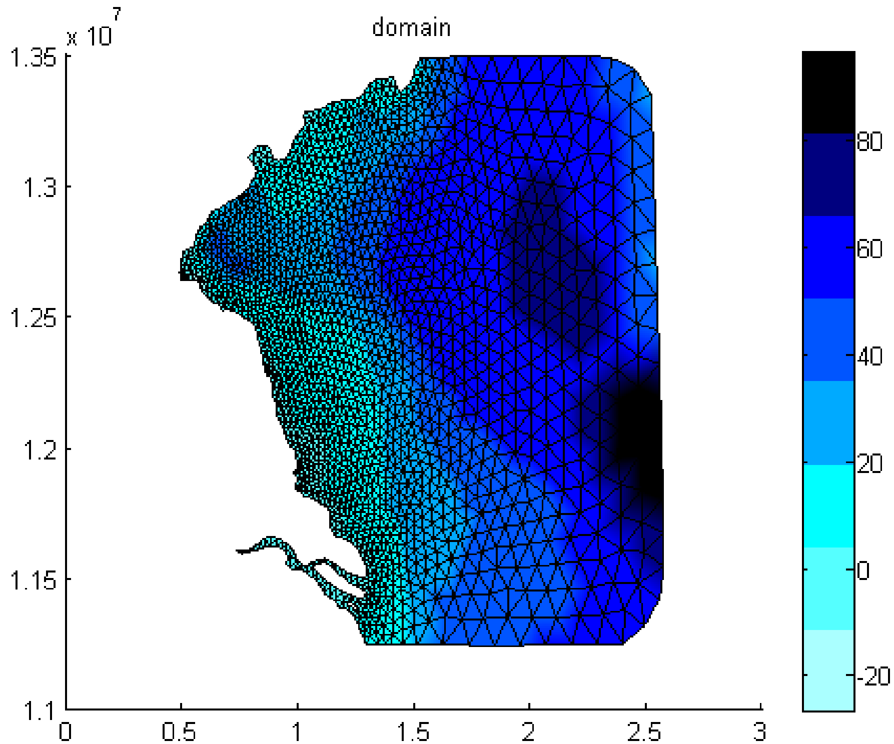
The heat flux is larger 1-4 times than that of month average

4 The simulation of the air-sea fluxes

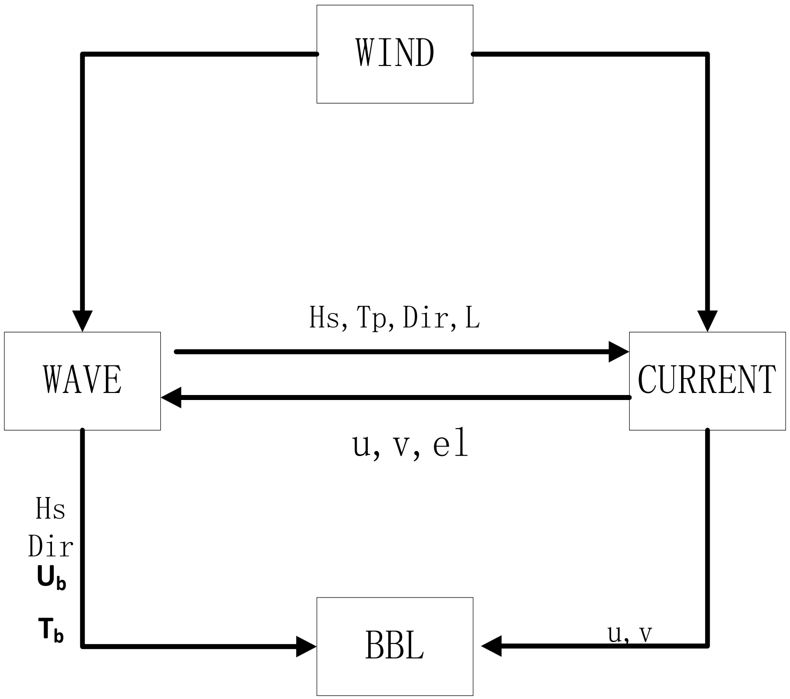
4.1 The numerical simulation scheme

Table 2 Simulating design and schemes

The cold wave event	Forcing factors	if coupled waves	Type of simulation
① **From north**	The cold wave, tide	No	Control exp. by FVCOM
	The cold wave, tide	Yes Waves × 1.0	Sensitive exp. by FVCOM-SWAVE
	The cold wave, tide	Yes Waves×0.5	Sensitive exp. by FVCOM-SWAVE
② **From west**	The cold wave, tide	No	Control exp. by FVCOM
	The cold wave, tide	Yes Waves × 1.0	Sensitive exp. by FVCOM-SWAVE
	The cold wave, tide	Yes Waves× 1.5	Sensitive exp. by FVCOM-SWAVE

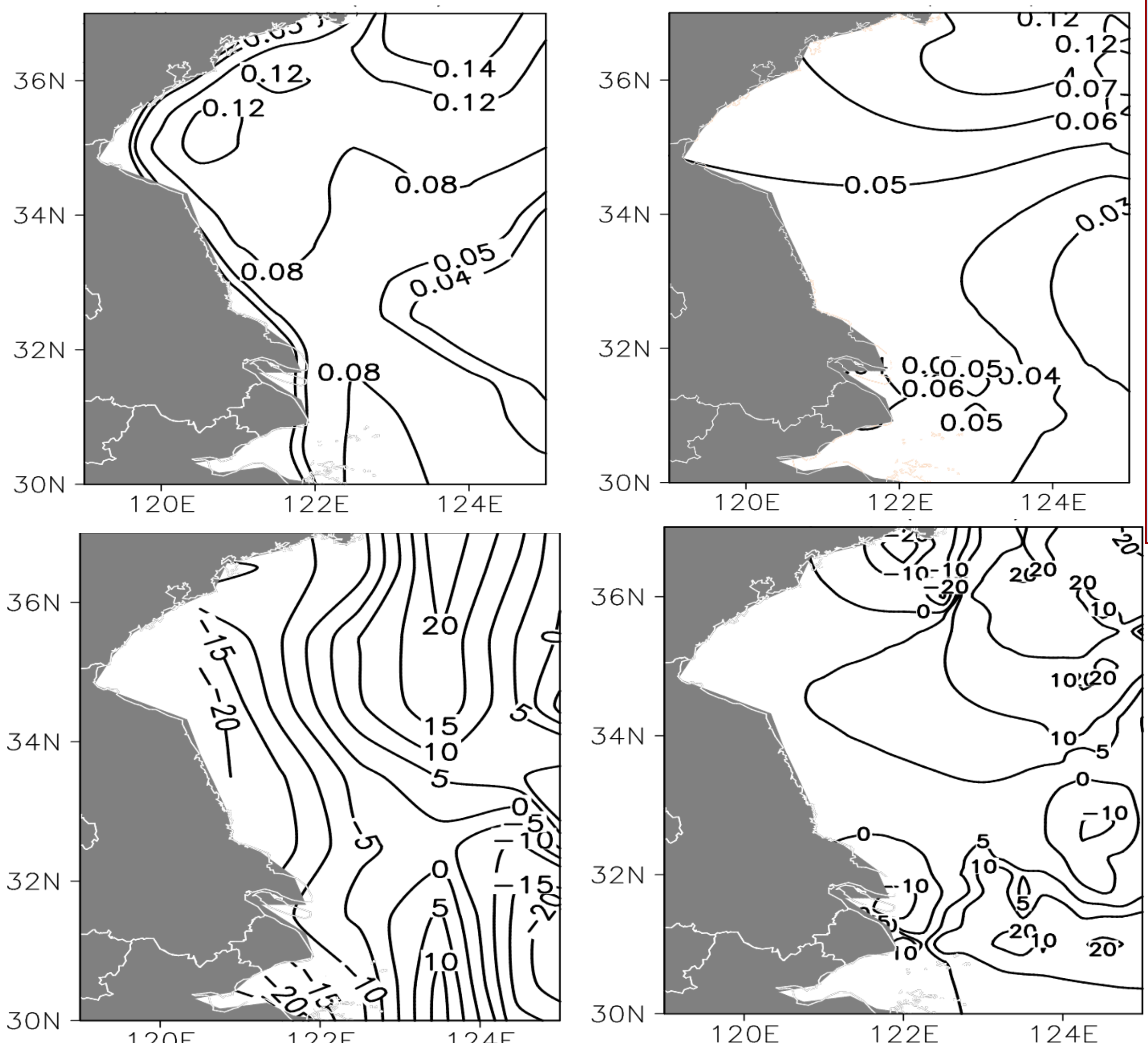


sea mesh and water depth (land form) of the model in the Yellow sea



FVCOM-SWAVE coupled model

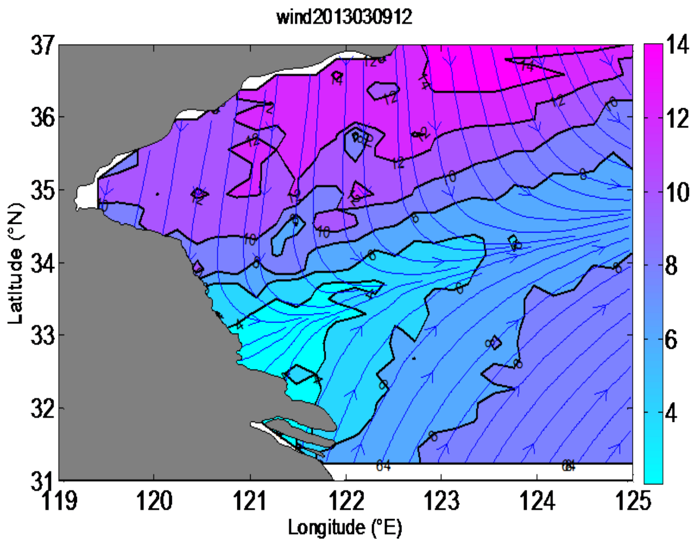
4.2 The numerical simulation verification

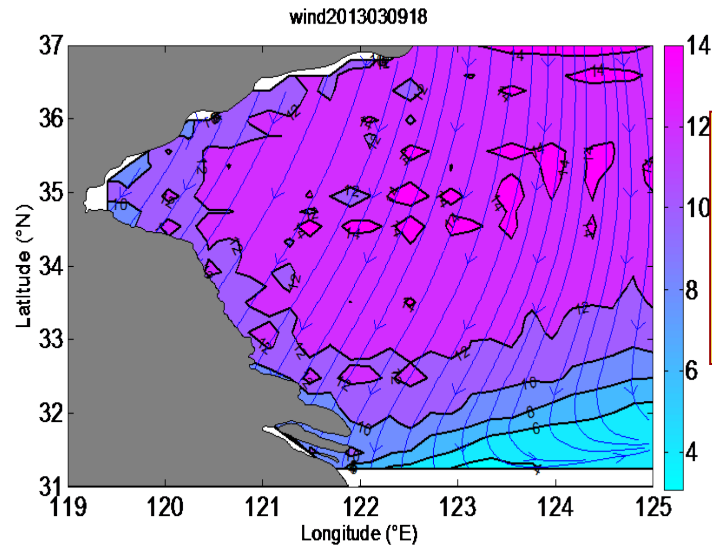


Figs on left side are OAFlux ,
Figs on right side are simulations
Figs on up side are momentum fluxes unit:N•m^{-2}
Figs on down side are heat fluxes unit:W•m^{-2}

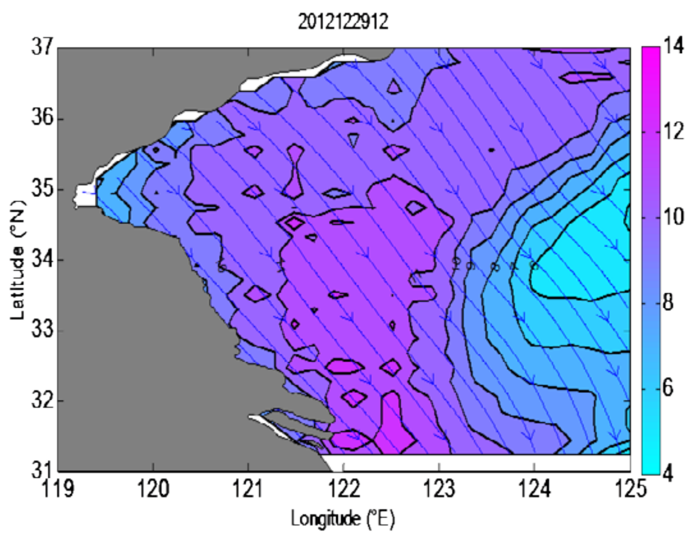
Distributions are similar , the magnitudes are a little less without waves coupled.

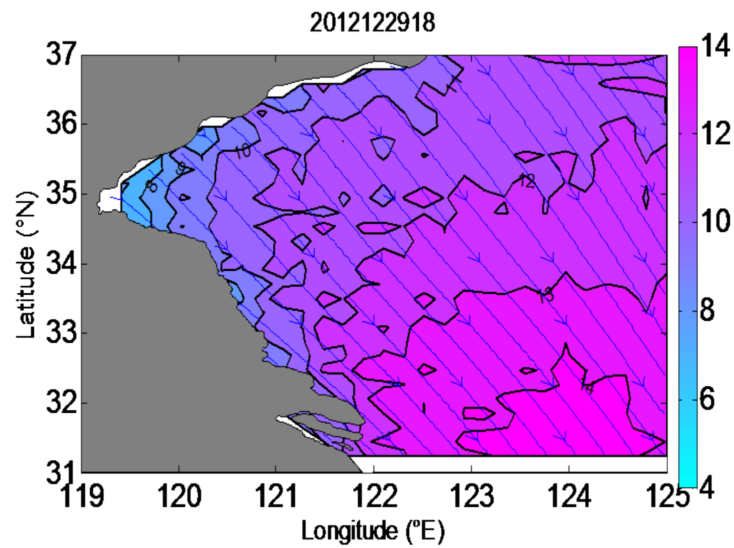
4.3 The numerical simulation of the air-sea flux evolution





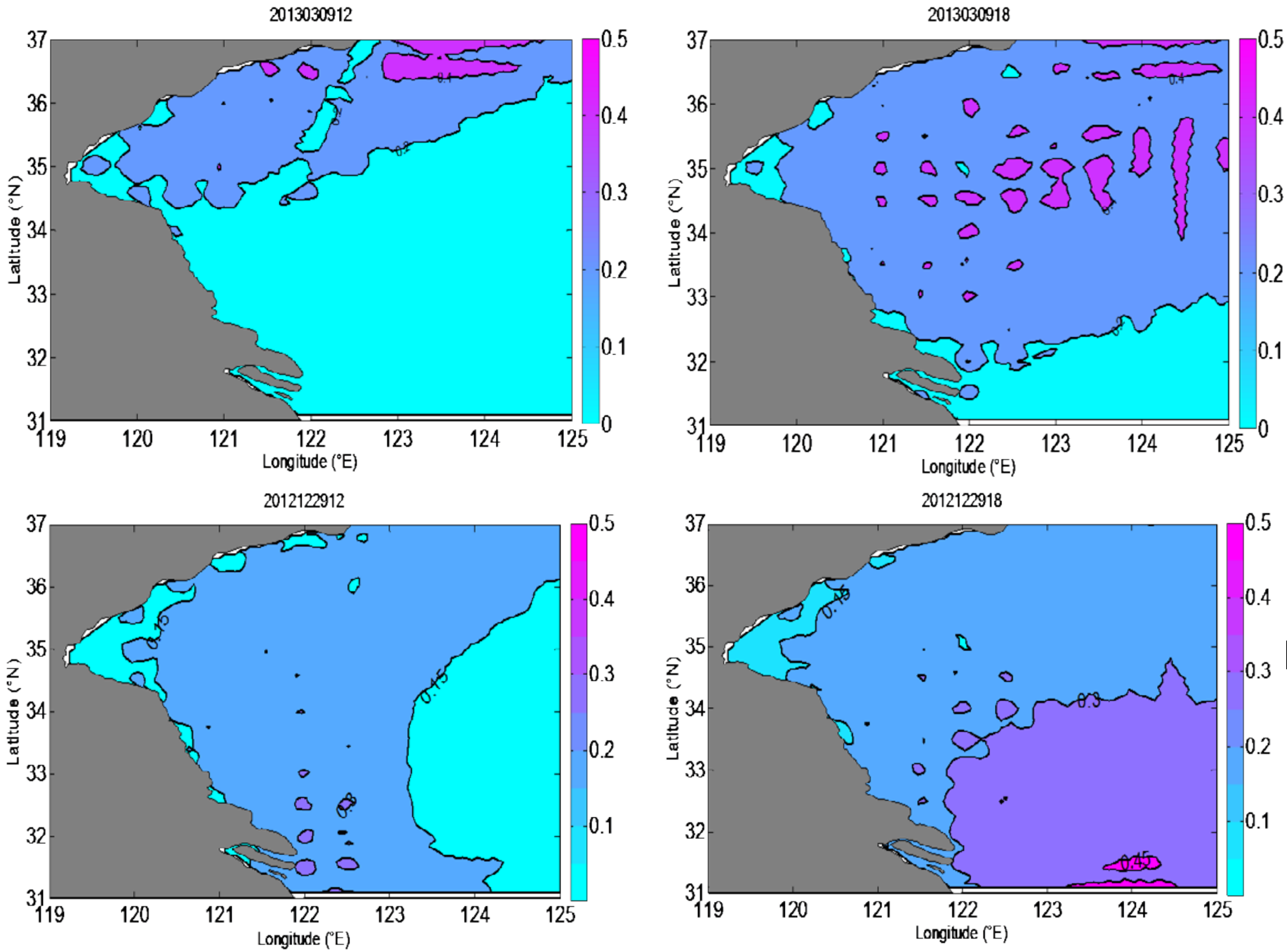
The cold wave invaded with a north path





The cold wave invaded with a northwest path

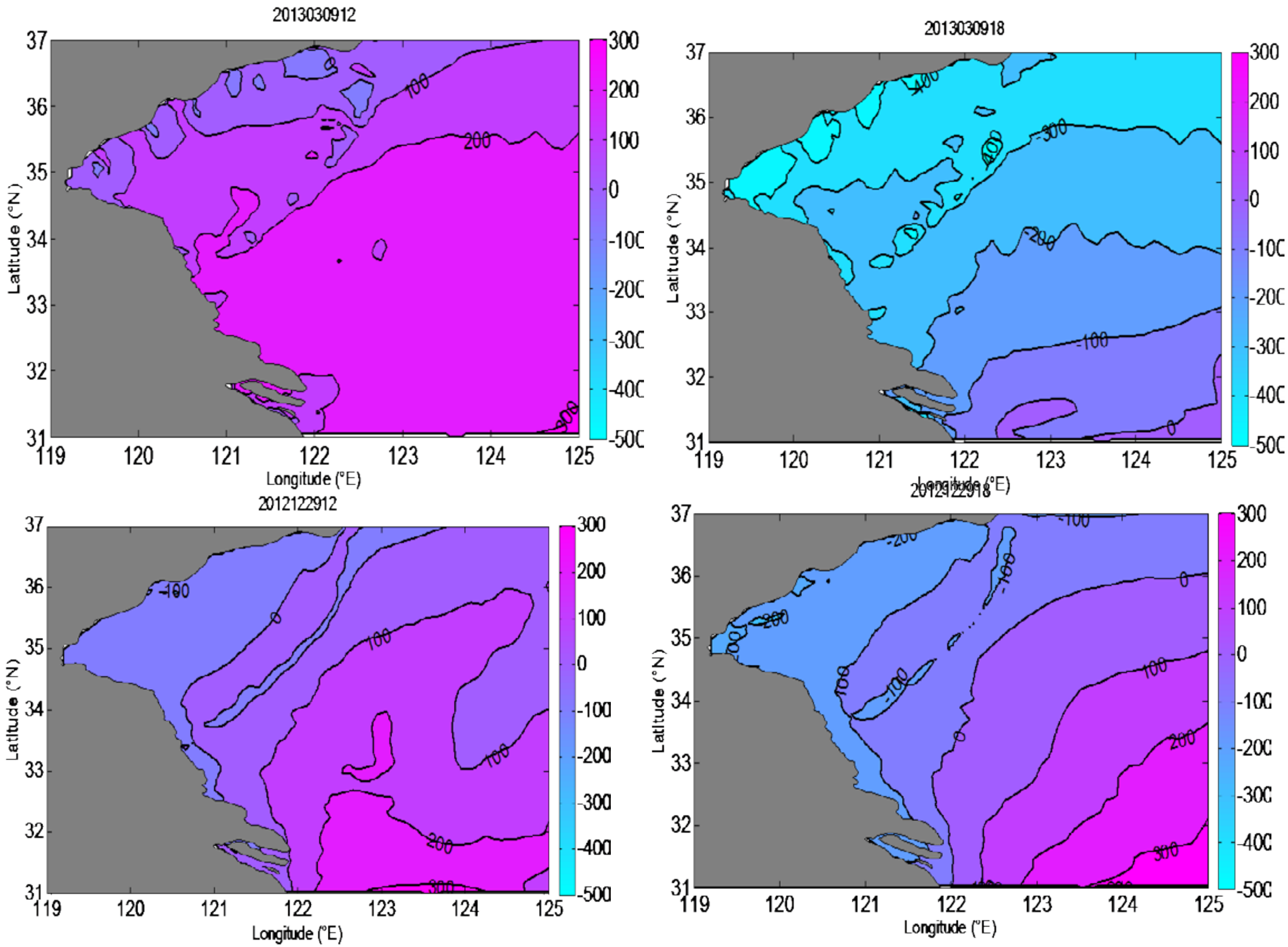
the wind field evolution during cold wave processes (unit : m/s)



From north

From west

the momentum flux evolution during the cold wave processes, unit:N•m^{-2}



From north

Heat lost center:

-400 W/m^2

From west

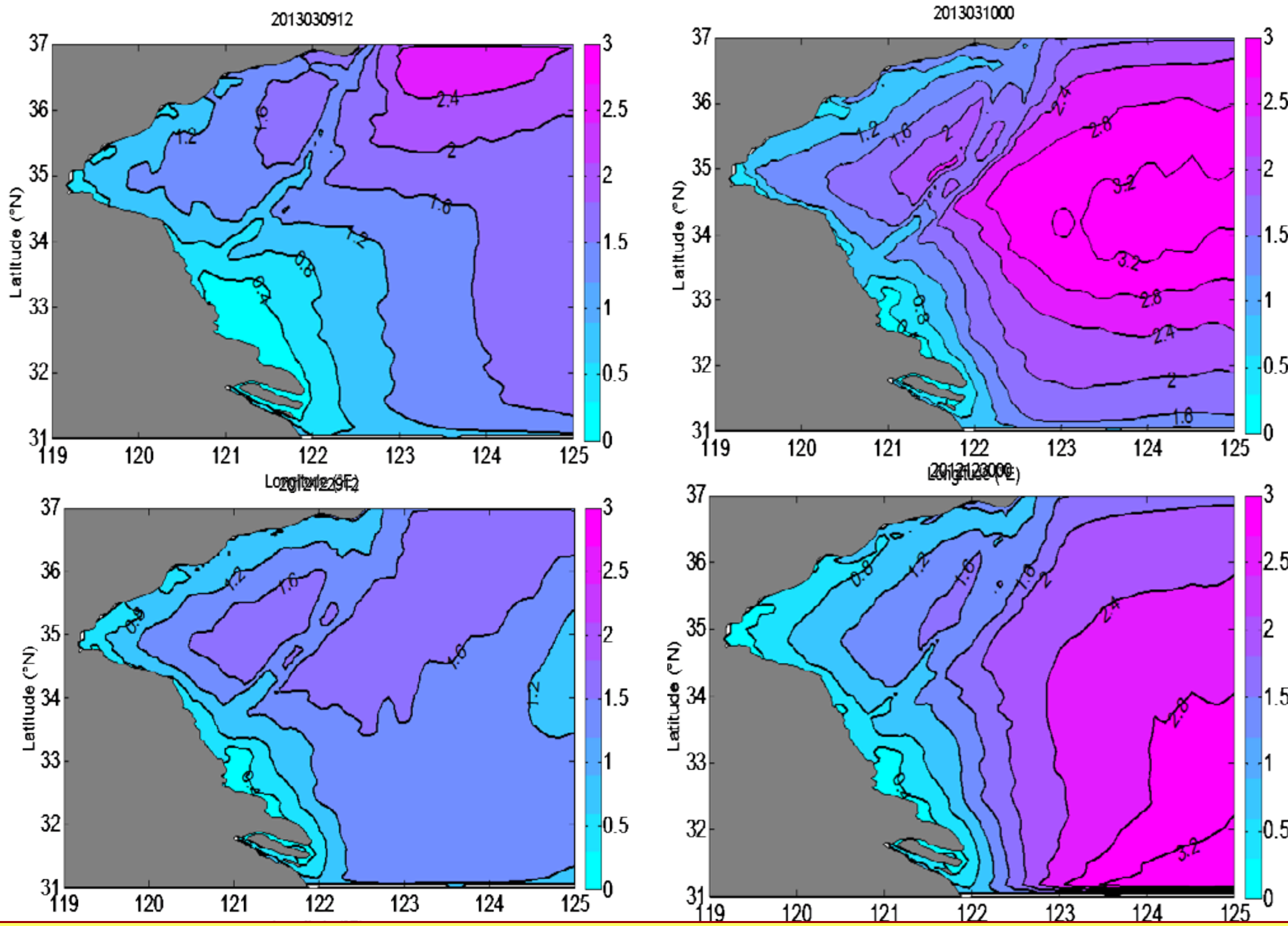
Heat lost center:

-200 W/m^2

the heat flux evolution during cold wave processes (unit :W•m^{-2})

5 The wave influence on the air-sea fluxes

5.1 The wave height responded to the cold wave



From north

Wave height :3m

Its distribution is east part stronger than west part.

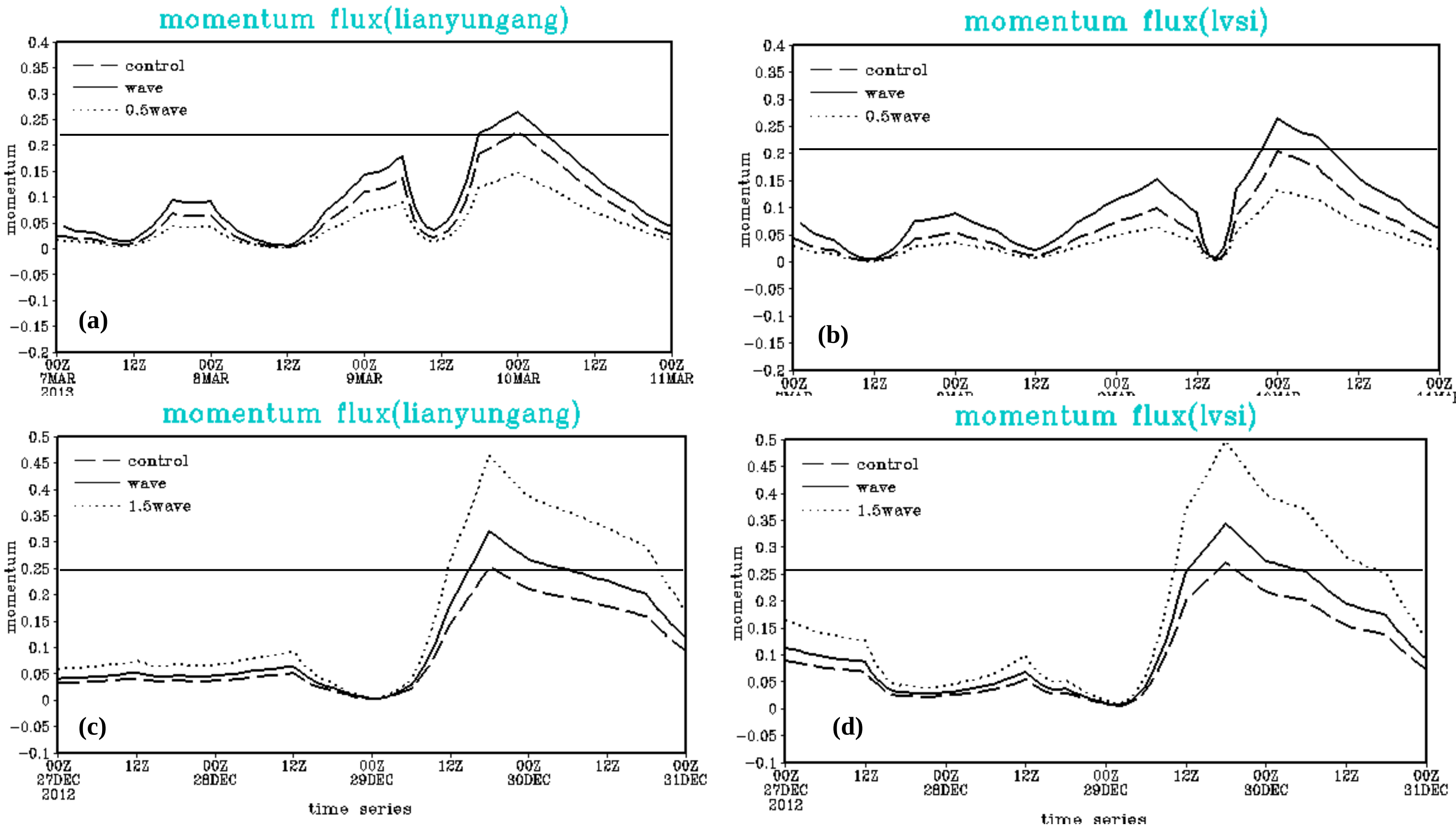
From west

Wave height :3.2m

Its distribution is south part stronger than north part.

the wave height evolution responded to cold wave processes (unit :m)

5.2 wave impacted on the air-sea momentum flux



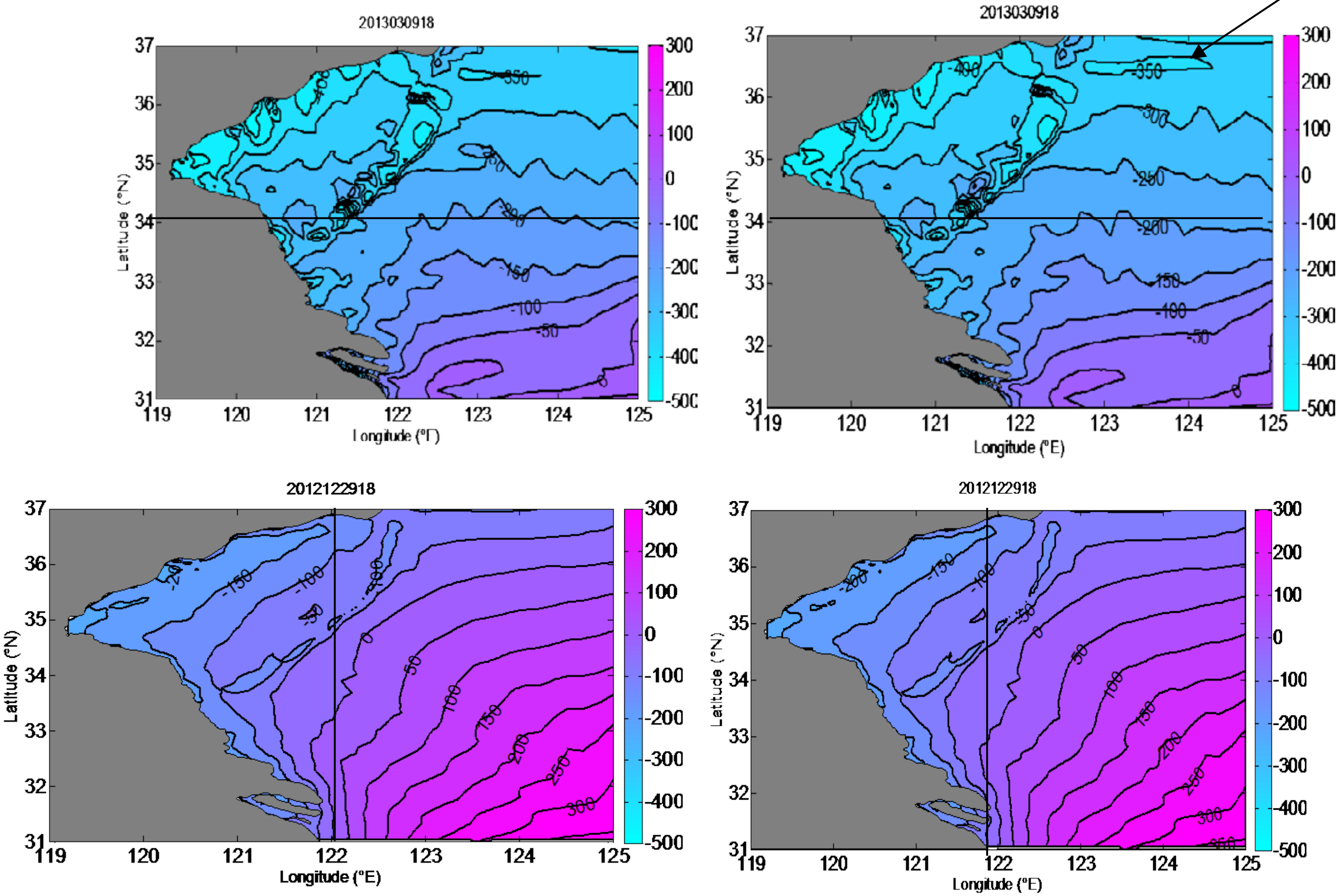
From north

From west

The momentum flux evolution at lianyungang(north coast) and lvsi (south coast) during two cold wave processes,unit:N•m^{-2} by FVCOM-SWAVE

5.3 wave impacted on the air-sea heat flux

See Contour line



From north

Waves made more loss of heat flux from sea

Its distribution is east part stronger than west part.

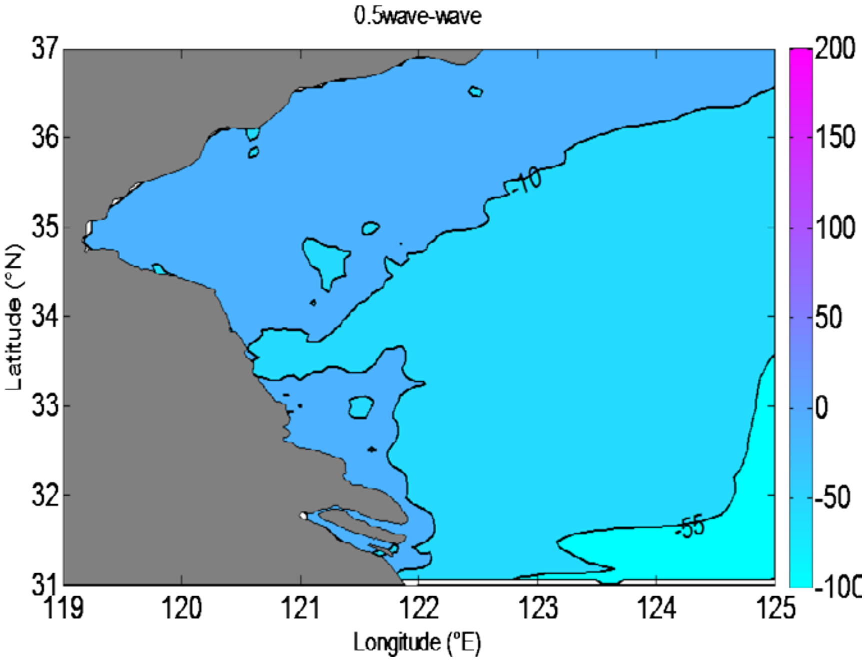
From west

Wave impact isn't clear and has a little loss increase.

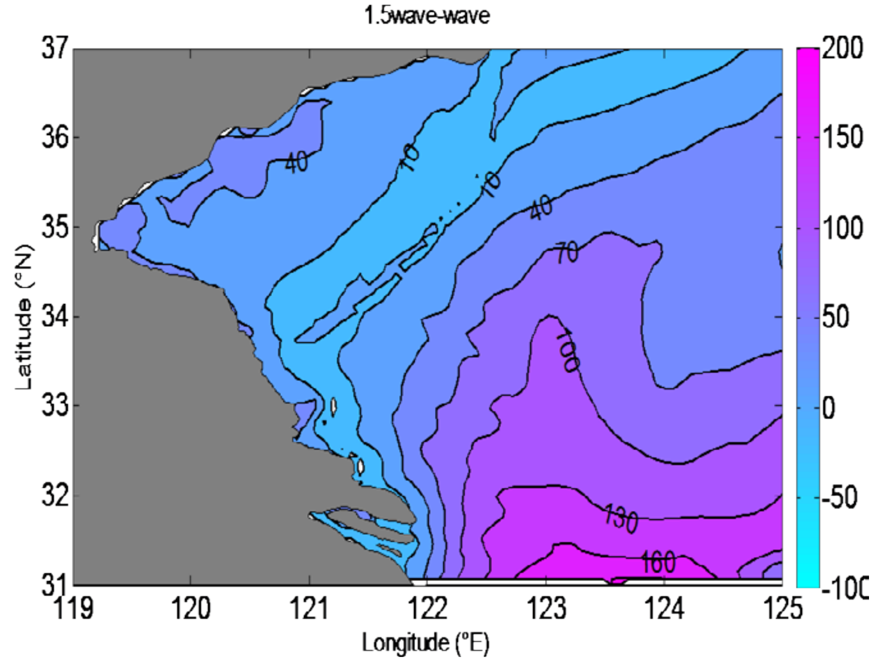
Its distribution is south part stronger than north part.

the heat flux response in control and sensitivity tests during two cold wave processes,unit:W•m^{-2}

From north



From west



the heat flux difference (non-coupled and coupled waves) of the different sensitivity experiments for two cold wave events, unit:W•m^{-2}

Wave height decreases 0.5-1, made less loss

Wave height increases 1.5-1 made more active flux.

6 Summary and discussion

(1) The wind intensity , wave height , air-sea momentum flux and heat flux are stronger during the cold season on the Yellow sea. Wind and wave have more statistical contribution to the air–sea fluxes in the current weak season.

(2) Under the cold wave impact, both the air-sea momentum flux and heat flux increase remarkable than that of the monthly average.

(3) The two typical cold wave simulations by FVCOM-SWAVE showed that

1) the effect of wind waves in the first event on two kind of fluxes is stronger, and its moving from north to south follows the cold front. It causes stronger active fluxes at east part than at west part of the yellow sea.

2) the effect of wind waves in the second event on two kind of fluxes is strong, too. and its moving from west to east follows the cold front. It causes stronger active fluxes at south part than at north part of the yellow sea.

(4) The wind waves motivate more air-sea momentum flux and heat flux. the wind wave increase 1.5 times, the momentum flux increasing near 2 times . The heat flux increases 10-160 W/m^2 . The wind wave reduce 0.5 time, the momentum flux decreasing 40%. The heat flux decreases 10-55 W/m^2


Thank You