The Response of Marine Environment in the Offshore Area of China and Its Adjacent Ocean to Recent Global Climate Change

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Outline

- Overview of global climate change and its impacts
- The responds of regional climate and marine environment to the global climate change
- The impact of global warming on the marine ecosystem
- Summary and discussion

1、Overview of global climate change and its impacts

- As it is well known, the global surface air temperature has been increasing persistently since the mid 19th century. Substantial changes associated with the climate warming also occurred during the past century.

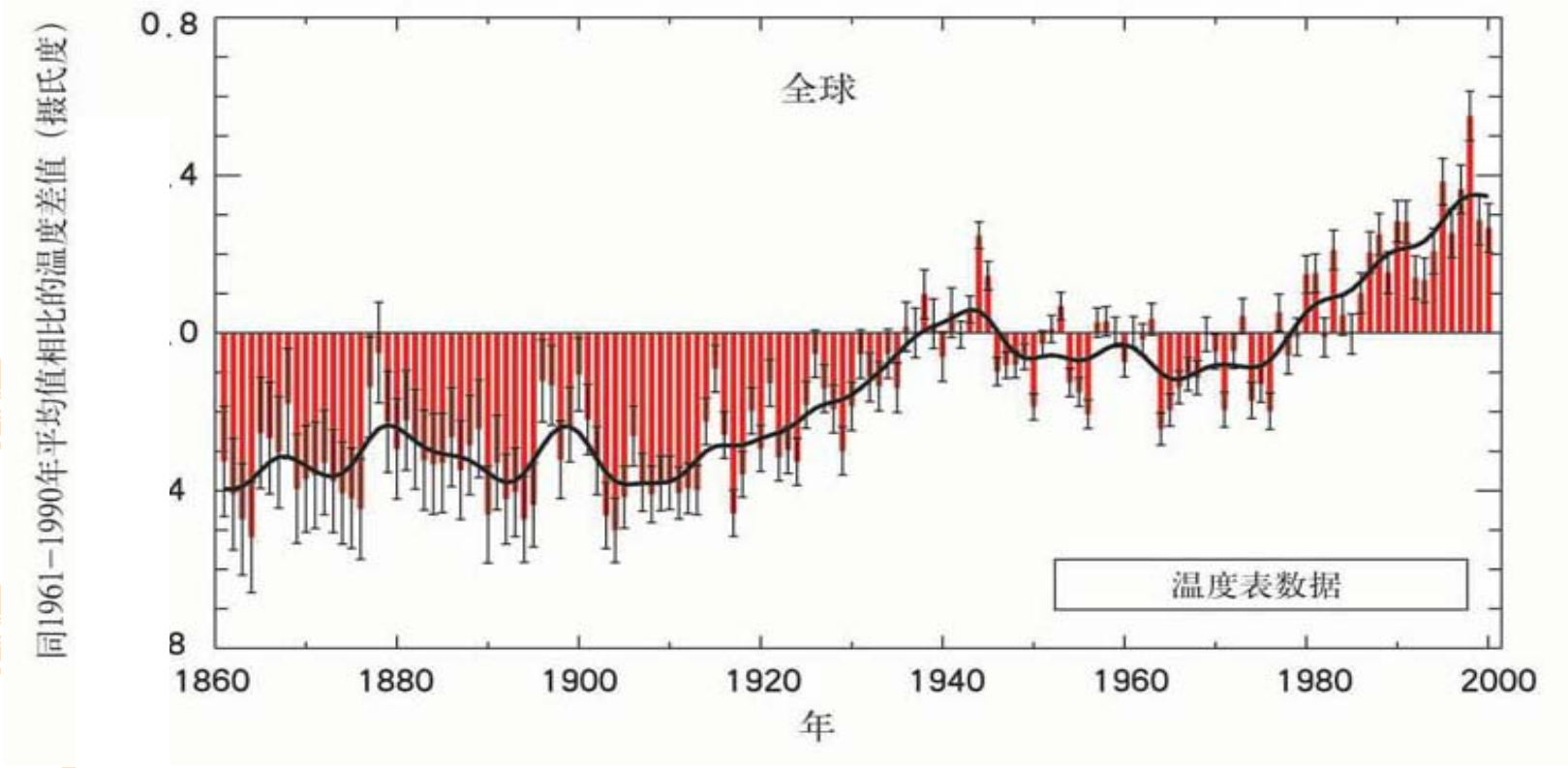
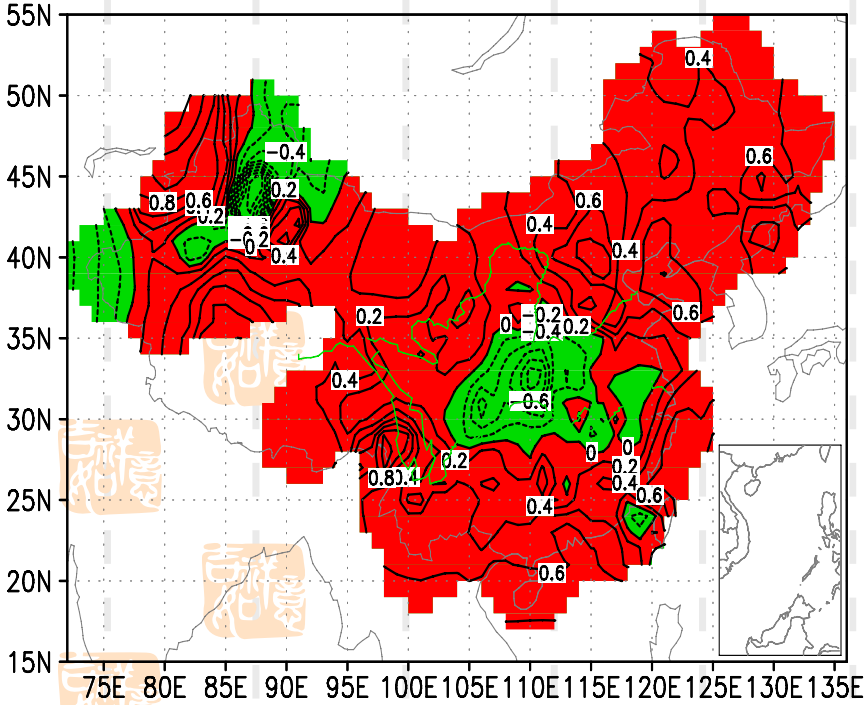


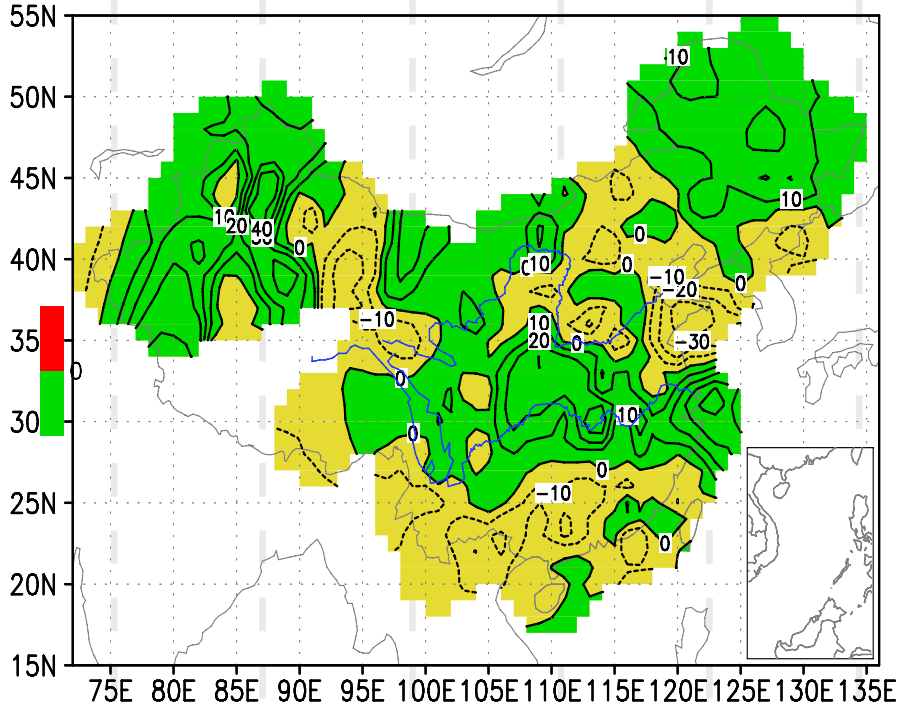
Fig.1 Annual anomalies of global average land-surface air temperature (°C), 1861 to 2000, relative to 1961 to 1990 values.（ From IPCC, 2001 ）

Due to the impacts of global warming, many different responds of regional climate and marine environment to the global climate change appear.

Example 1: Summer temperature (ST) has been going up and precipitation has been going down in north China since 1980's; On the contrary, ST has been going down, but precipitation increased in Yangtze up and middle river area. (From Huang 1999，2003，2004)



Temperature Anomaly of Summer in (1977_2000)-(1967_1976)



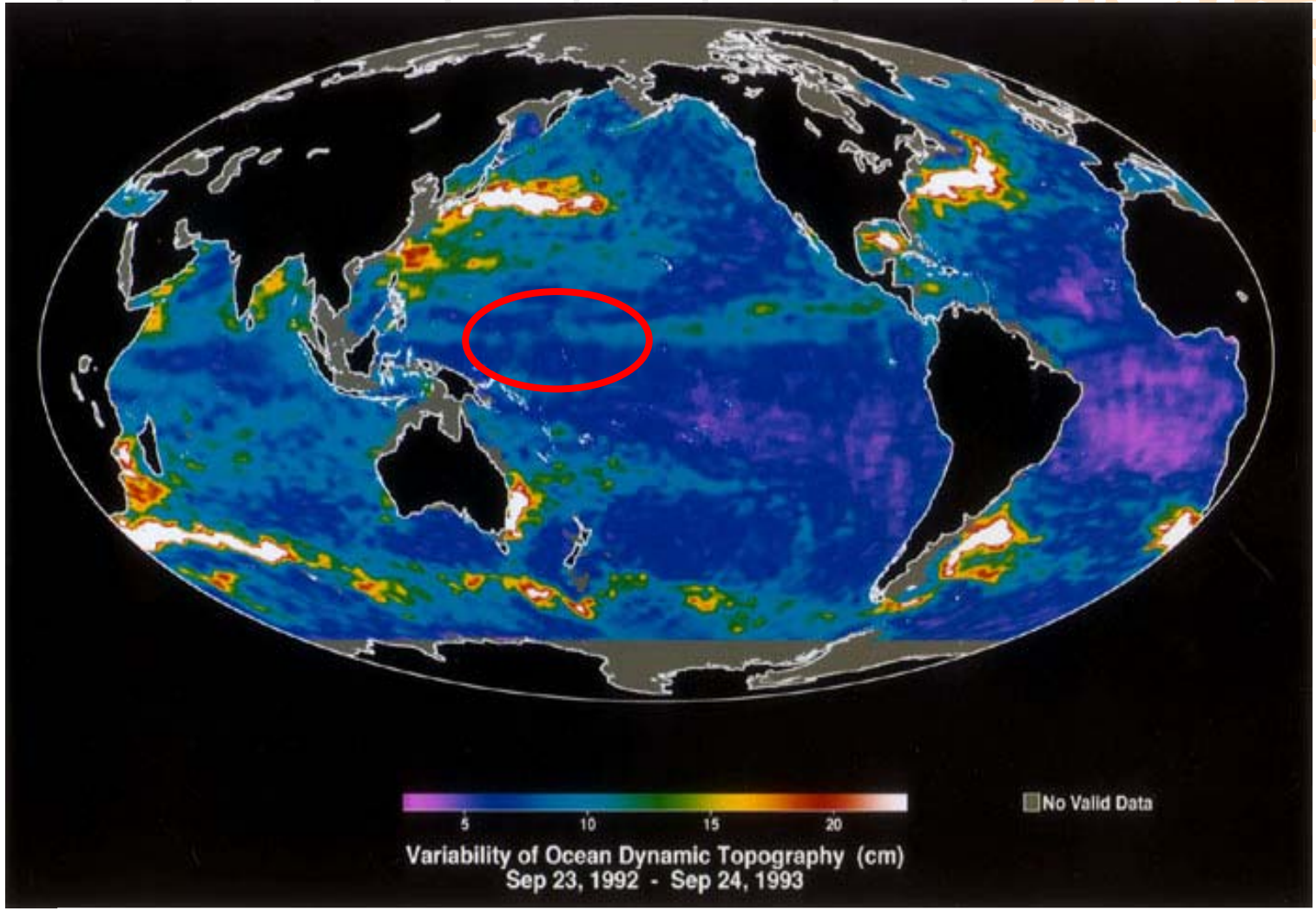
Precipitation Anomaly of Summer in (1977_2000)-(1967_1976)

From Huang et al

Example 2

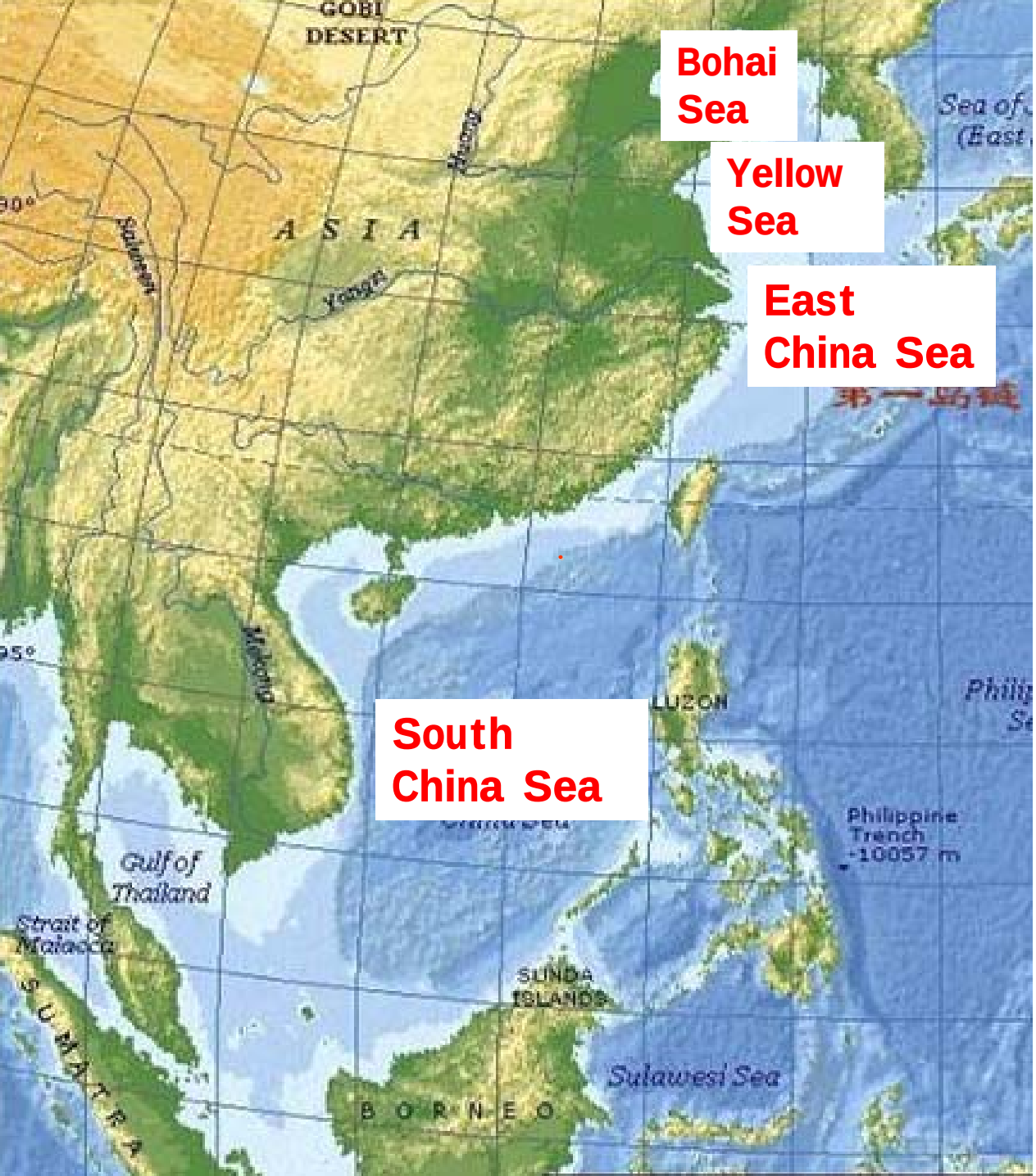
- Because of the different characteristics, the responds of ocean and land to the global warming are also very different. Furthermore, distinct responds also appear in different sea area.

The observed results show the sea level rising is unequal in the spatial.



From NOAA

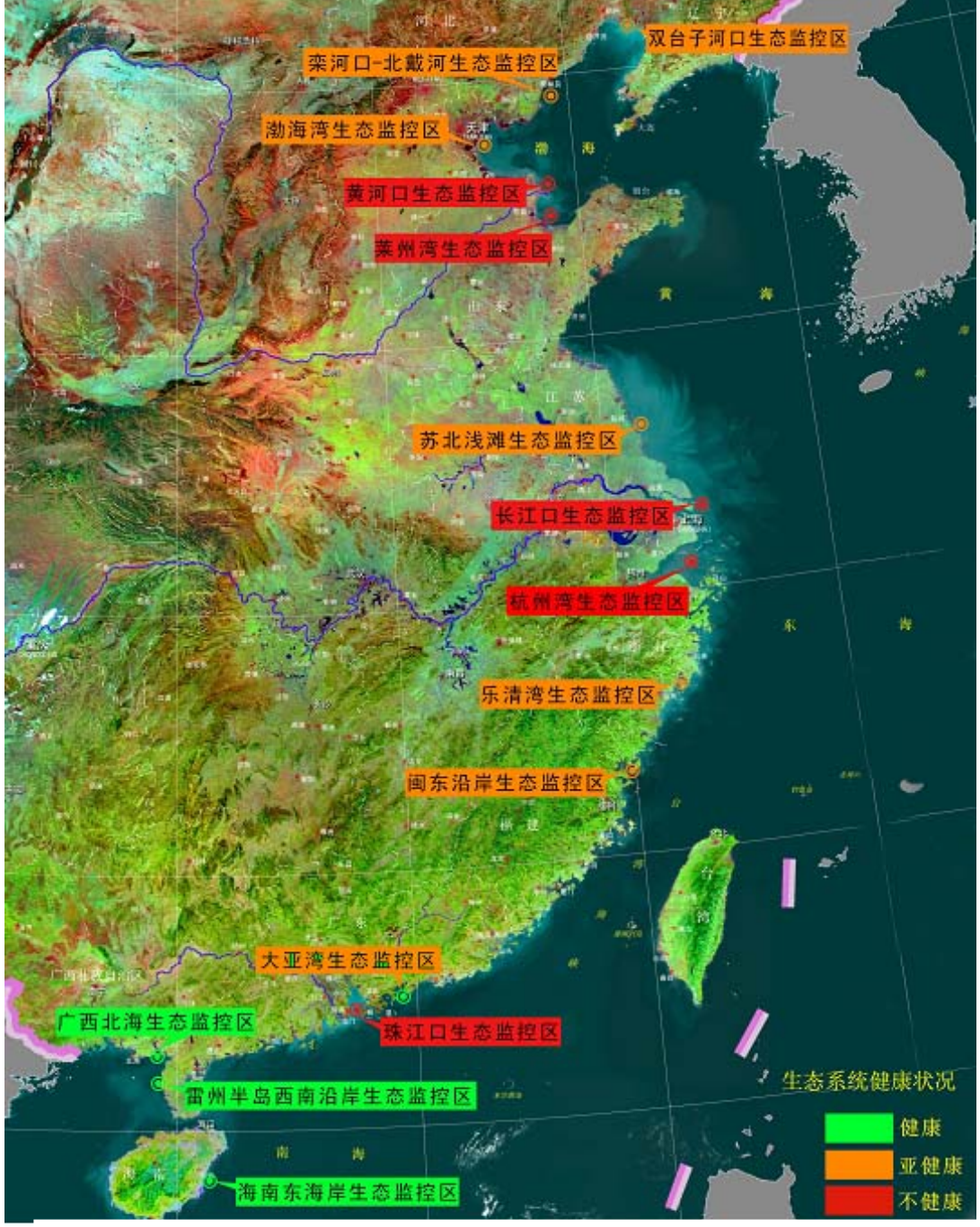
According to T/P Satellite Altimetry data analyzing，the rising speed of local sea level in the tropic western pacific is about the two times as that of the global sea level in 1993-1999.



Questions:

What's the responds of Atmospheric-Oceanic environment in the offshore area of China to the Global Climate Warming?

How will the marine ecosystem in the offshore area change?



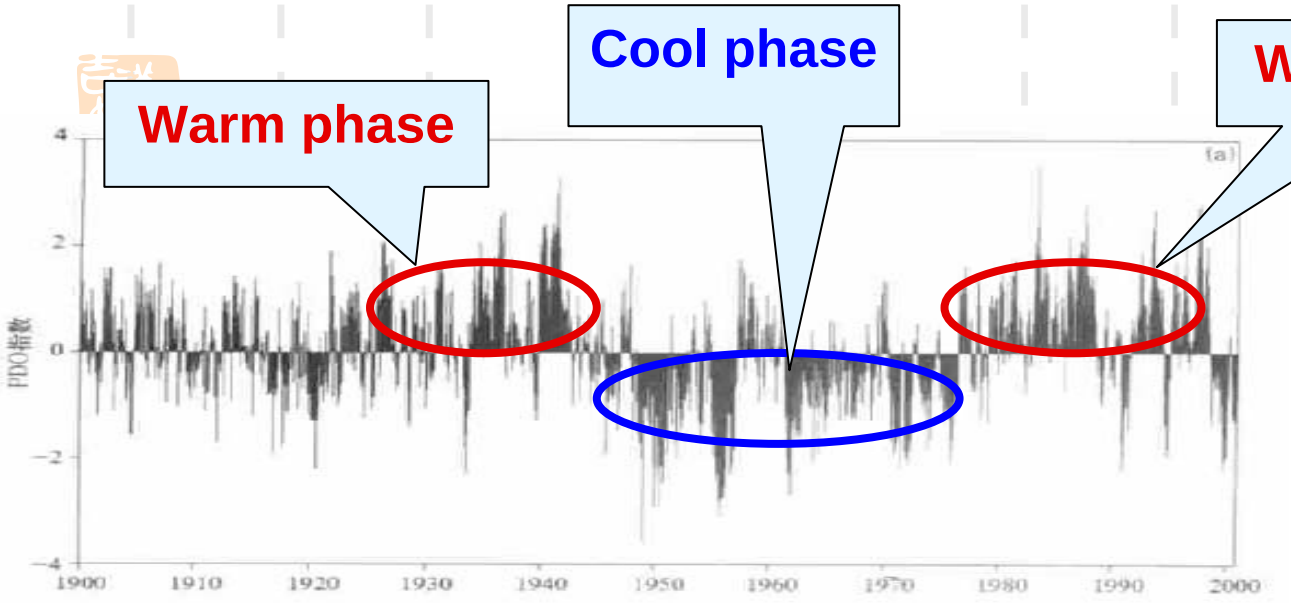
From China Marine Environmental Report

According to China marine environment investigating in 2004-2005, the results show that the marine ecosystem in the offshore area of China is in the poor situation, and the red tides appear frequently than before and seemly become more and more severely.

Therefore, we wonder if the situation will become worse under the background of global warming?

2. The responds of regional climate and marine environment to the global climate change

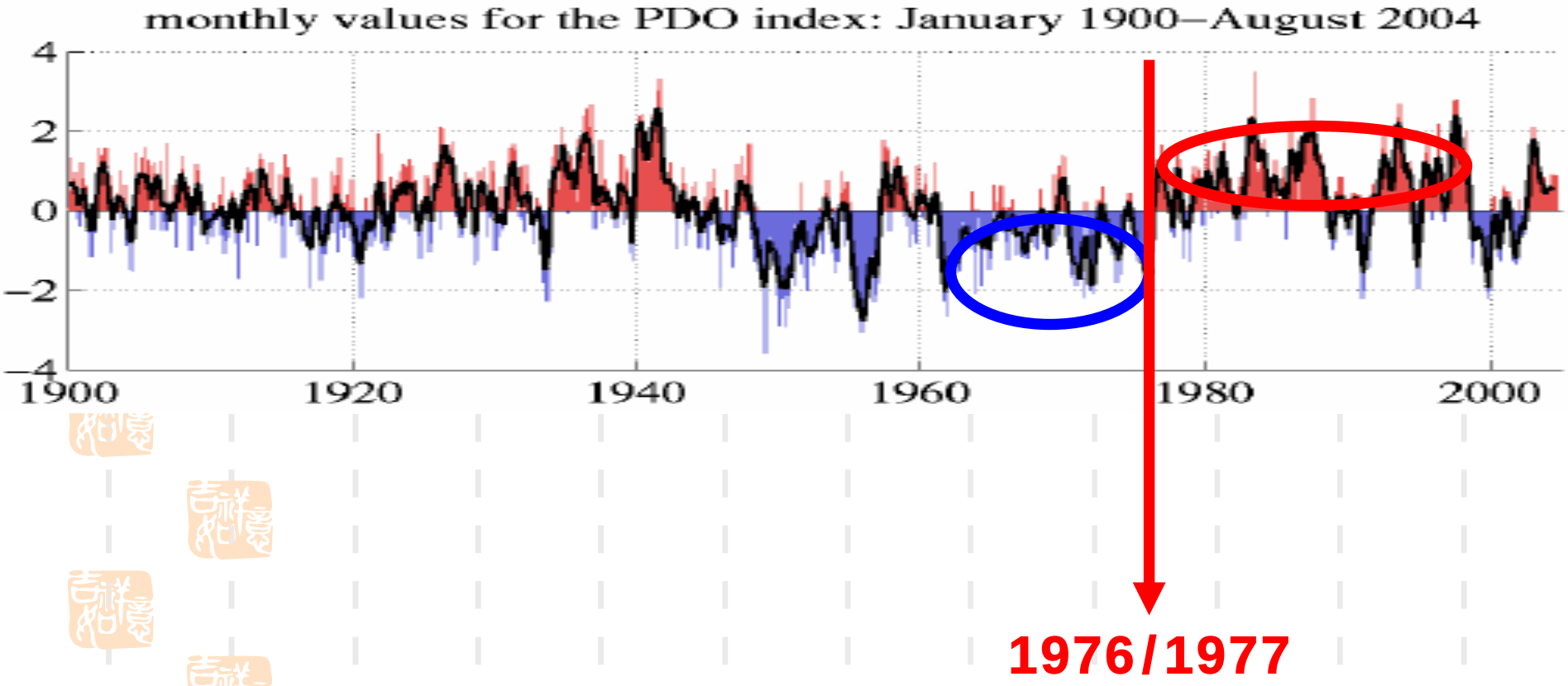
- Many studies show that there is a closely relationship between the climatic jump in the East Asia and the North Pacific Decadal Oscillation (PDO); especially, the atmospheric and oceanic conditions in north pacific ocean had a abrupt change in 1976/1977 (Namias J., Trenberth K E. et al).



From Zhu Yimin, Yang Xiuqun

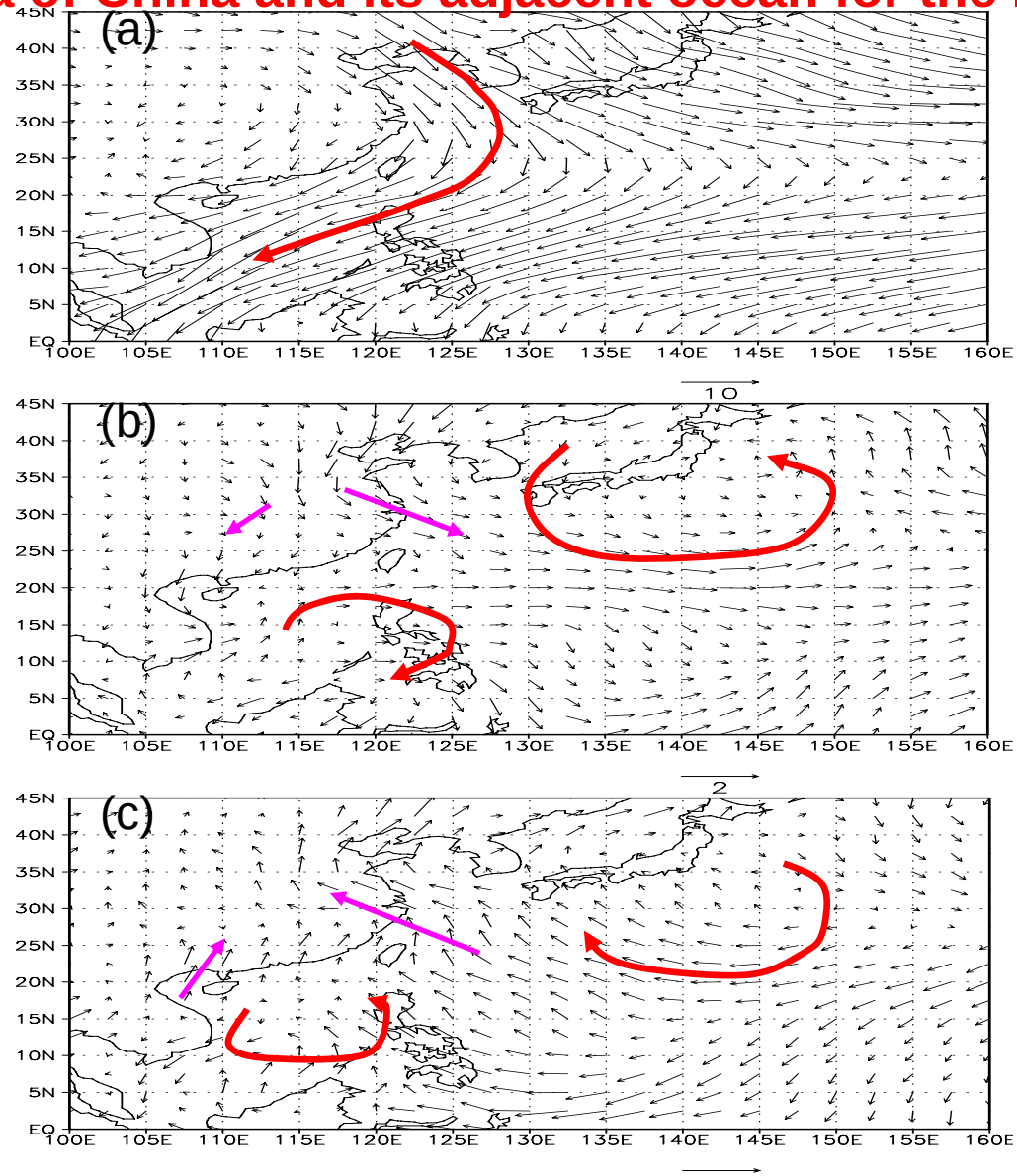
PDO Index: 1900-2000

Pacific Decadal Oscillation



2.1 Variations of wind field at 925hPa over the eastern China sea, the offshore area of China and its adjacent ocean for the last 50 years

Winter



Climatological mean wind field at 925hPa for 1961-1990 (a)

Wind anormalies for the periods of 1958-1976(b)

Winter monsoon strong

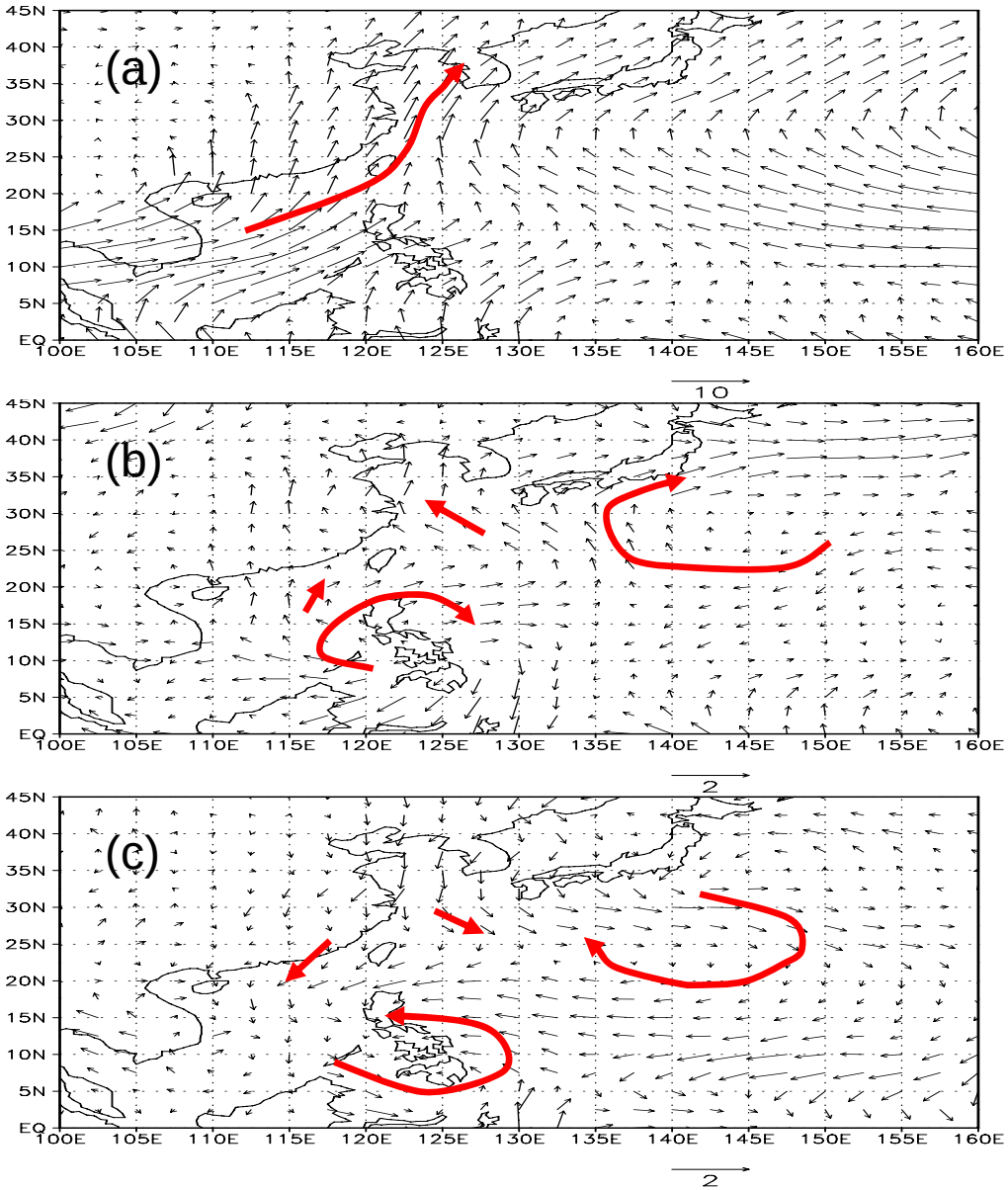
Wind anormalies for the periods of 1977-2000(c)

Winter monsoon weak

Mean winter wind field has become weaker since 1977.

Fig.2-1-1 **Distributions of climatological mean winter(DJF) wind field at 925hPa over eastern China, the offshore area of China and its adjacent ocean for 1961-1990(a), and wind anormalies for the periods of 1958-1976(b) and 1977-2000(c). Unit : m/s. Data are from ERA-40 reanalysis data.**

Summer



Climatological mean wind field at 925hPa for 1961-1990

Wind anomaly for 1958-1976

Summer monsoon strong

Wind anomaly for 1977-2000

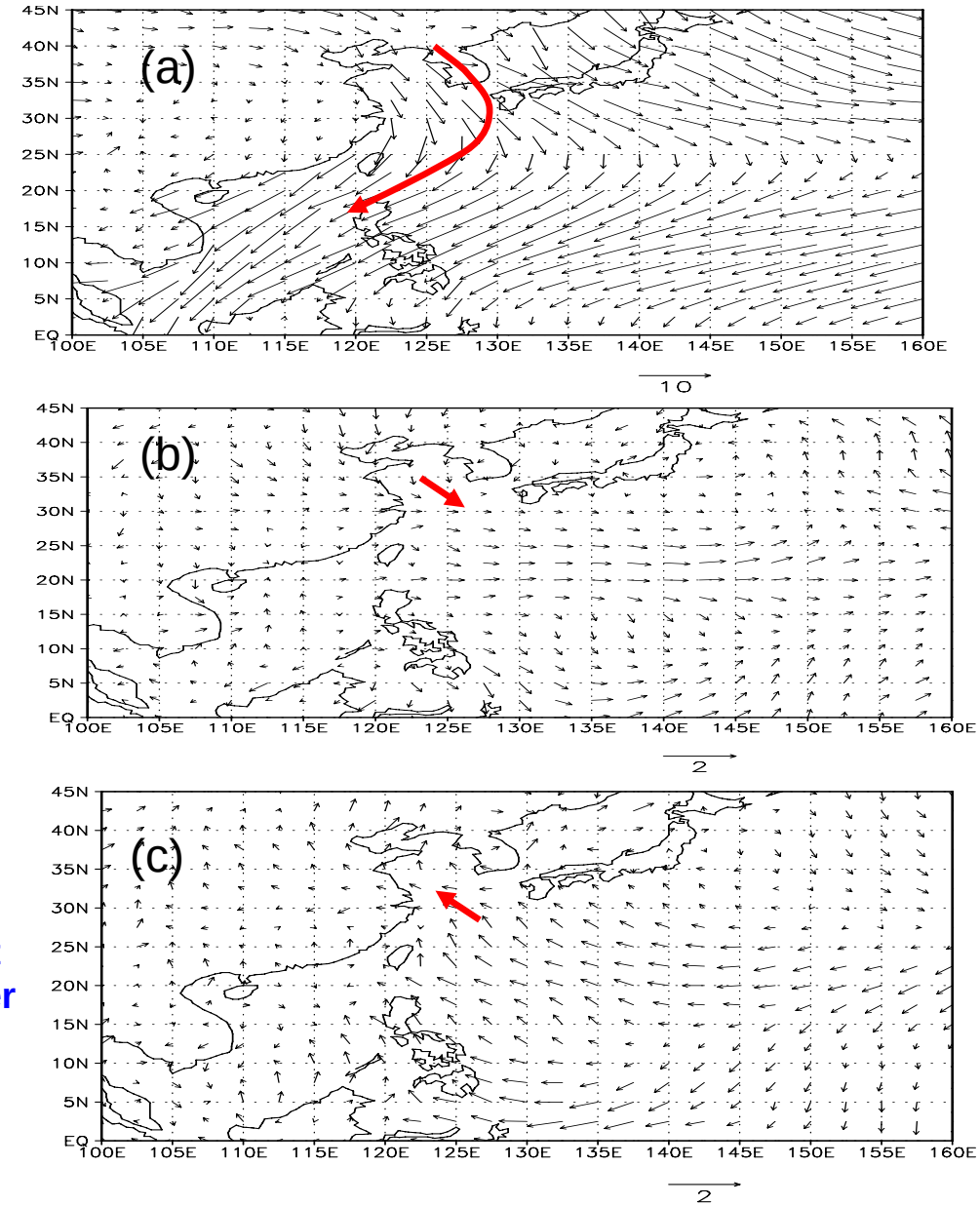
Summer monsoon weak

Mean summer wind field has become weaker since 1977.

Fig.2-1-2 Distributions of climatological mean summer(JJA) wind field at 925hPa over eastern China, the offshore area of China and its adjacent ocean for 1961-1990(a), and wind abnormalies for the periods of 1958-1976(b) and 1977-2000(c). Unit：m/s. Data are from ERA-40 reanalysis data.

2.2 Variation of wind field at 10m height form sea surface for the last 50 years

Winter



Climatological mean wind field at 10m height for 1961-1990

Anormaly for 1958-1976

Northward wind field strong

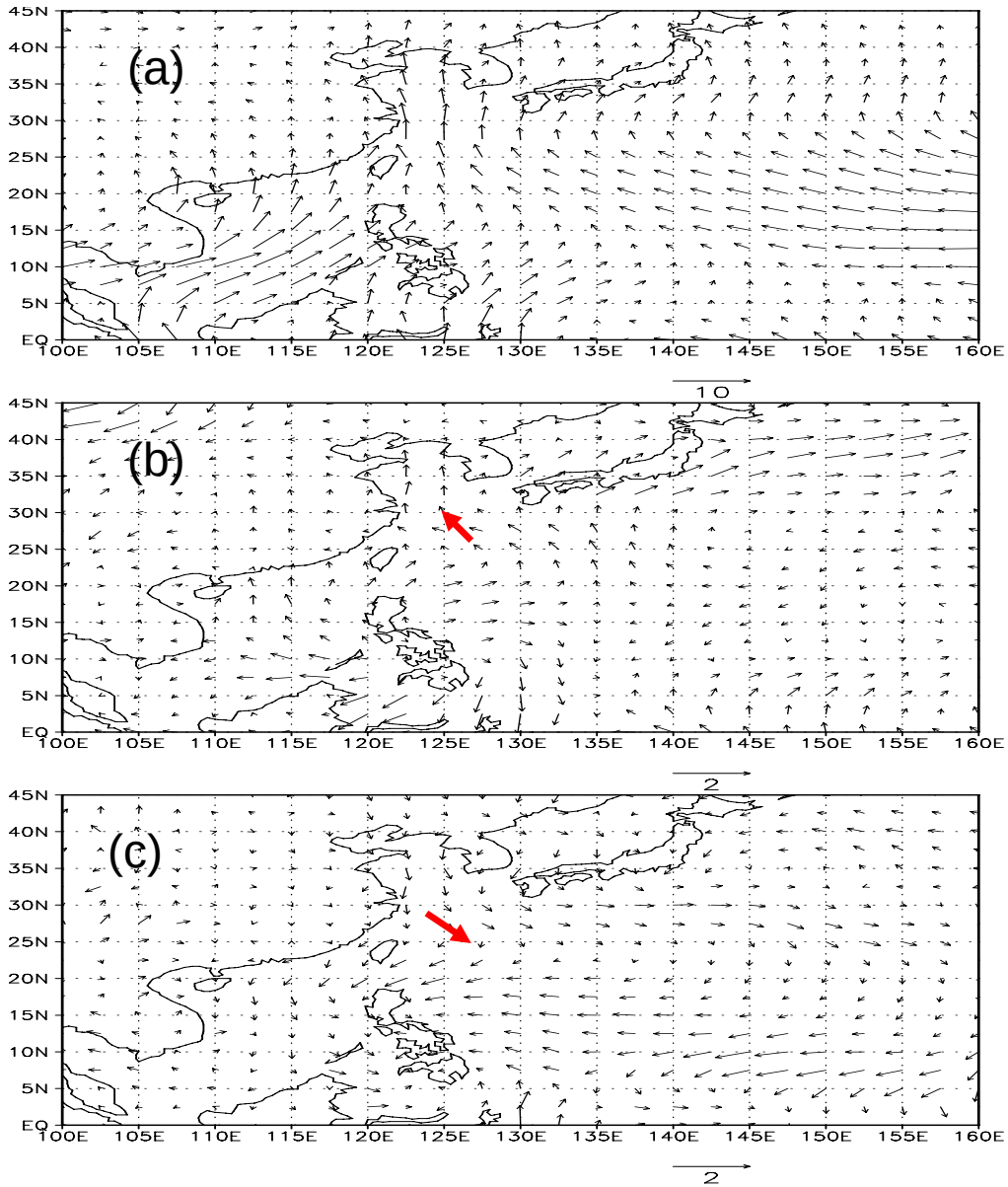
Anormaly for 1977-2000

Northward Wind field weak

Mean winter wind field at 10m height has become weaker since 1977.

Fig. 2-2-1 **Distributions of climatological mean winter(DJF) wind field at 10m height over eastern China, the offshore area of China and its adjacent ocean for 1961-1990(a), and wind anomalies for the periods of 1958-1976(b) and 1977-2000(c). Unit：m/s. Data are from ERA-40 reanalysis data.**

Summer



1961-1990

1958-1976

Southward strong

1977-2000

Southward weak

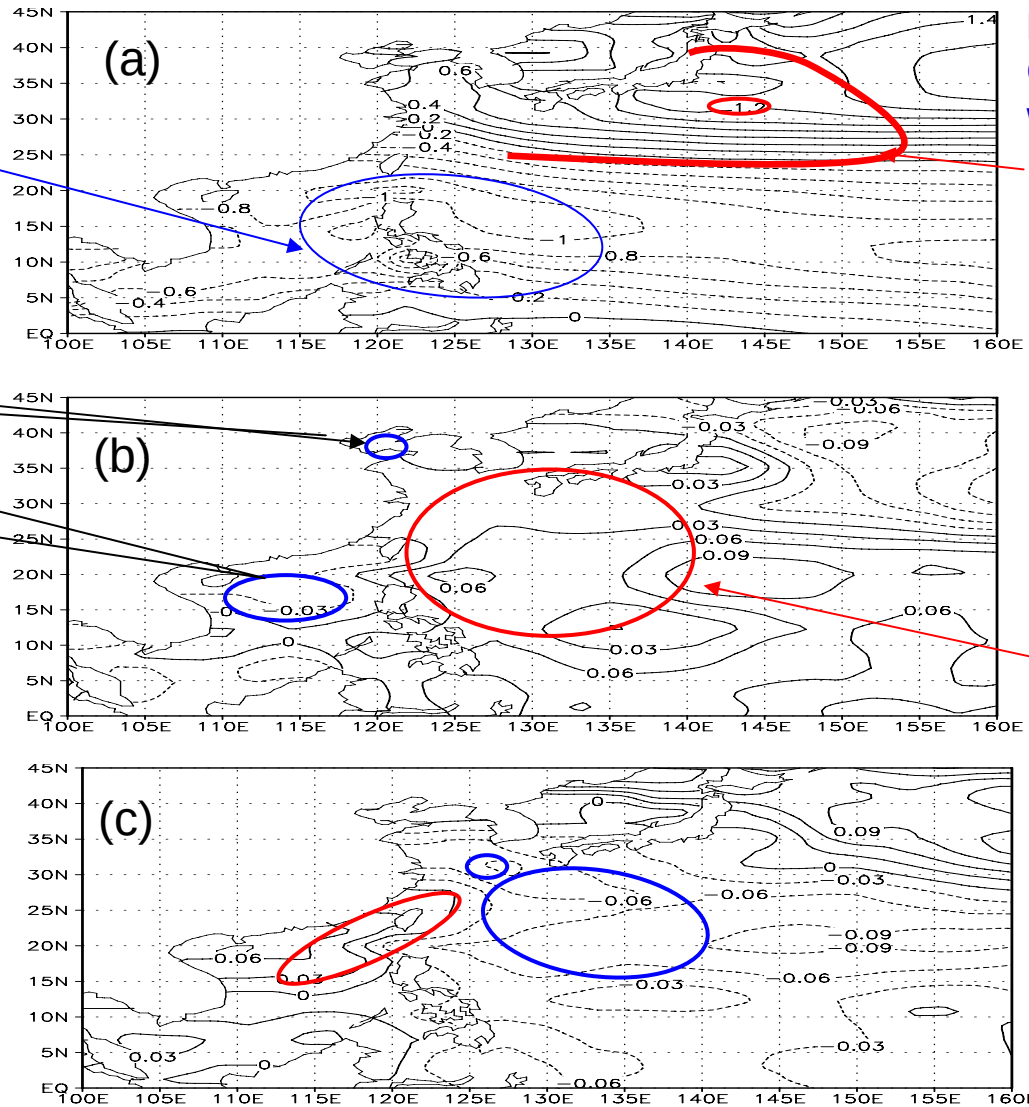
Mean summer wind field at 10m height has become weak since 1977.

Fig.2-2-2 Distributions of climatological mean summer(JJA) wind field at 10m height over eastern China, the offshore area of China and its adjacent ocean for 1961-1990(a), and wind anomalies for the periods of 1958-1976(b) and 1977-2000(c). Unit：m/s. Data are from ERA-40 reanalysis data.

2.3 Variations of sea surface zonal wind stresses over the offshore area and its adjacent ocean for the last 50 years

winter

Eastern wind stress increase from north to south



Distributions of Climatological mean wind stress for 1961-1990

Western wind stress increase from west to east

Eastern wind stress anomaly averaged

Anomalies averaged for 1958-1976(b)

Western wind stress anomaly averaged

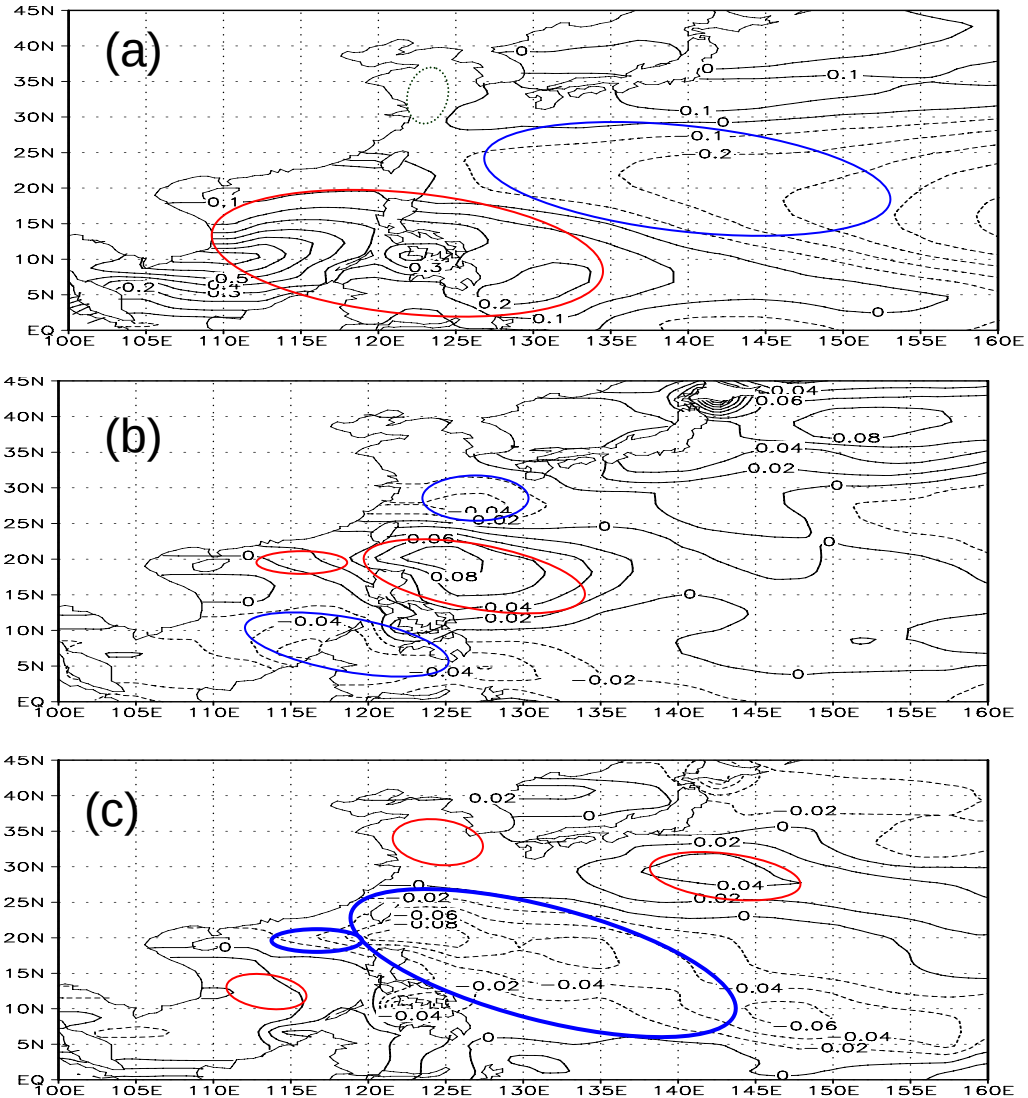
Wind stresses become weaker than before about 0.08dynes/cm^2 since 1977.

Anomalies averaged for 1977-2000(c)

After 1976, the situation is different before.

Fig.2-3-1 Distributions of climatological mean winter(DJF) sea surface meridional wind stresses (10^{-5}N/cm^2) over the offshore area of China and its adjacent ocean for 1961-1990(a), and zonal wind stress anomalies averaged for 1958-1976(b) and 1977-2000年. Data are from SODA.

Summer



Distributions of Climatological mean summer wind stress for 1961-1990

Anomalies averaged for 1958-1976(b)

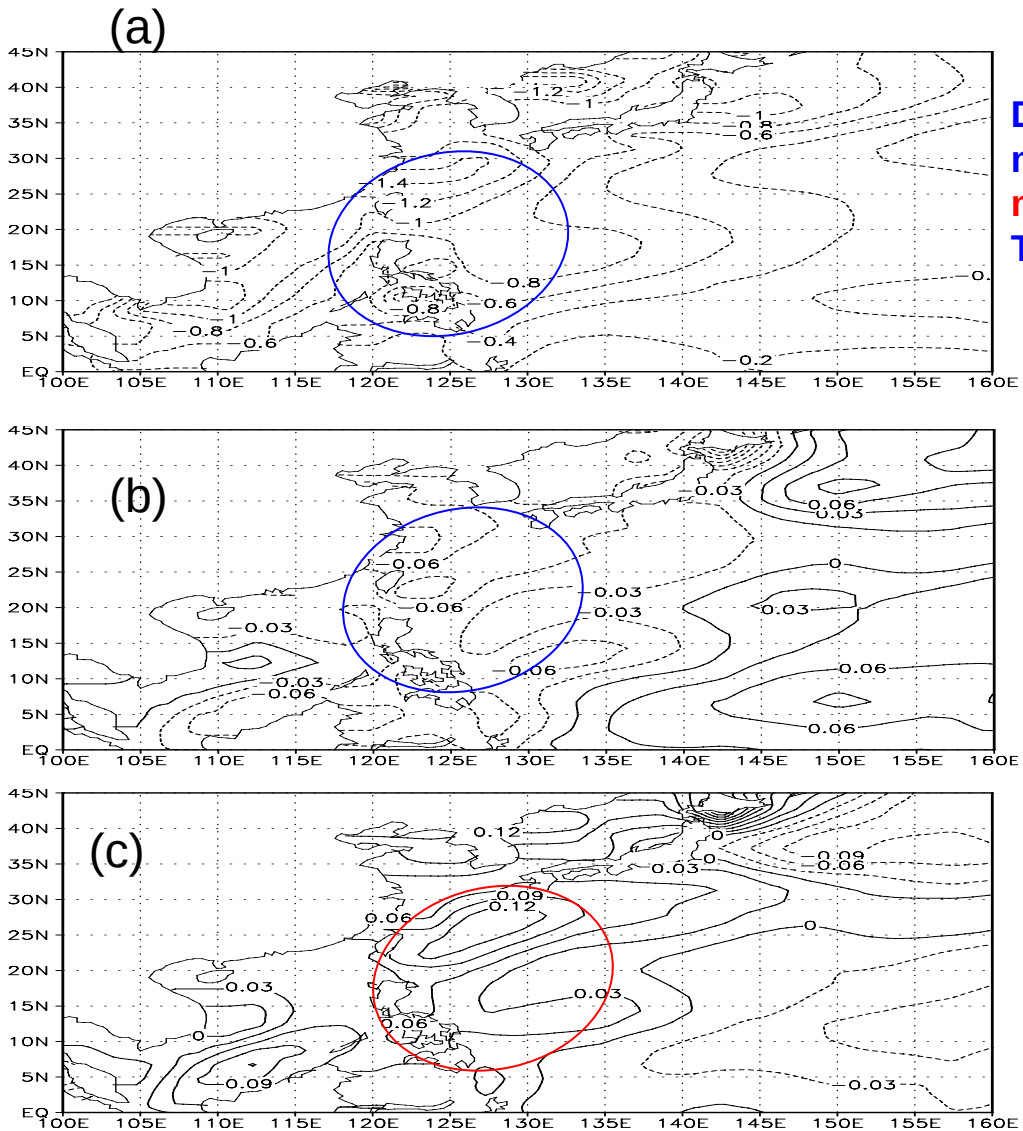
Anomalies averaged for 1977-2000(c)

Wind stresses become weaker, especially in the north of South China Sea, south of East China Sea, and Bashi Channel.

Fig.2-3-2 **Distributions of climatological mean summer(JJA) sea surface zonal wind stressess(10^{-5}N/cm^2) over the offshore area of China and its adjacent ocean for 1961-1990(a), and zonal wind stress anomalies averaged for 1958-1976(b) and 1977-2000年. Data are from SODA.**

2.4 Variations of sea surface meridional wind stresses over the offshore area and its adjacent ocean for the last 50 years

Winter



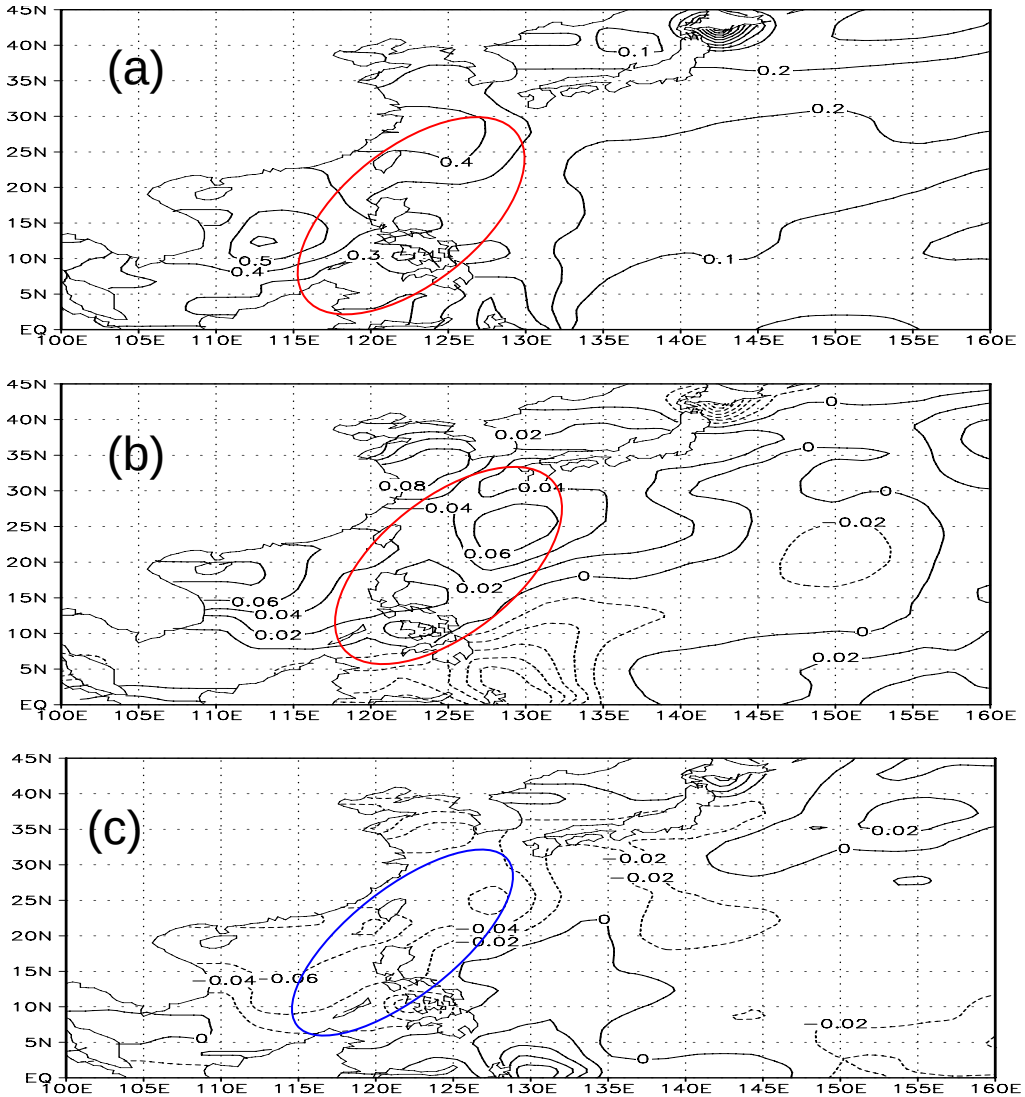
Distributions of climatological mean winter(DJF) sea surface meridional wind stressess; They are northward

Anomalies averaged for 1958-1976(b) They are northward

Anomalies averaged for 1977-2000(c) They are southward That means northward wind stresses become Weak.

Fig.2-4-1 Distributions of climatological mean winter(DJF) sea surface meridional wind stressess(10^{-5}N/cm over the offshore area of China and its adjacent ocean for 1961-1990(a), and zonal wind stress anomalies averaged for 1958-1976(b) and 1977-2000年. Data are from SODA.

Summer



1961-1990年

经向风应力为一致的南风风应力

1958-1976年

经向风应力为一致的南风风应力距平

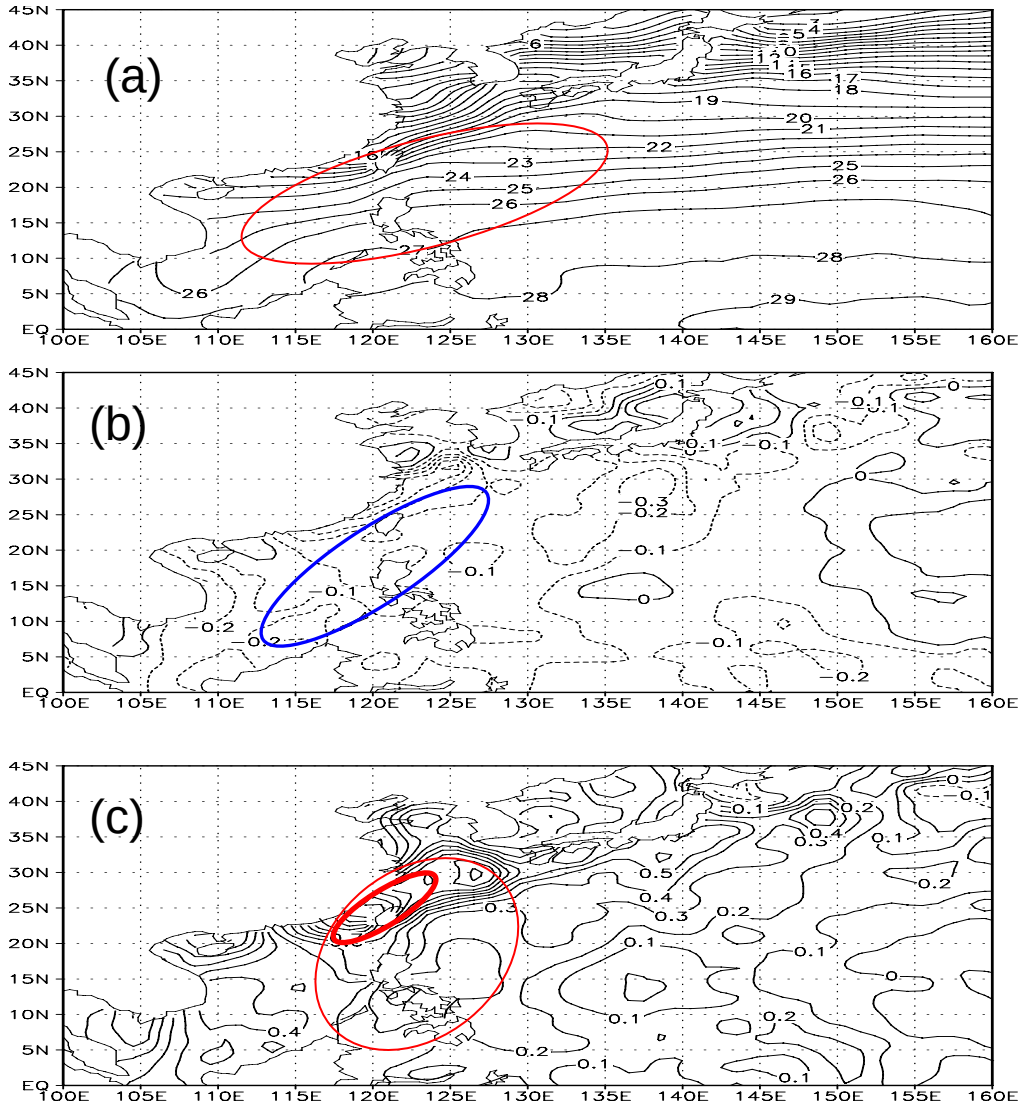
1977-2000年

经向风应力为一致的北风应力距平表明，76年之后，南风应力减弱，反映了东亚夏季风减弱

Fig.2-4-2 **Distributions of climatological mean summer(JJA) sea surface meridional wind stress (10^{-5}N/cm^2) over the offshore area of China and its adjacent ocean for 1961-1990(a), and zonal wind stress anomalies averaged for 1958-1976(b) and 1977-2000年. Data are from SODA.**

- **2.5 Responds of SST in the offshore area of China and its adjacent ocean to the global warming for the last 50 years**

Winter



Distributions of climatological mean winter(DJF) SST(℃) in 1961-1990

SST anomalies averaged for the periods of 1958-1976(b) SSTA is negative.

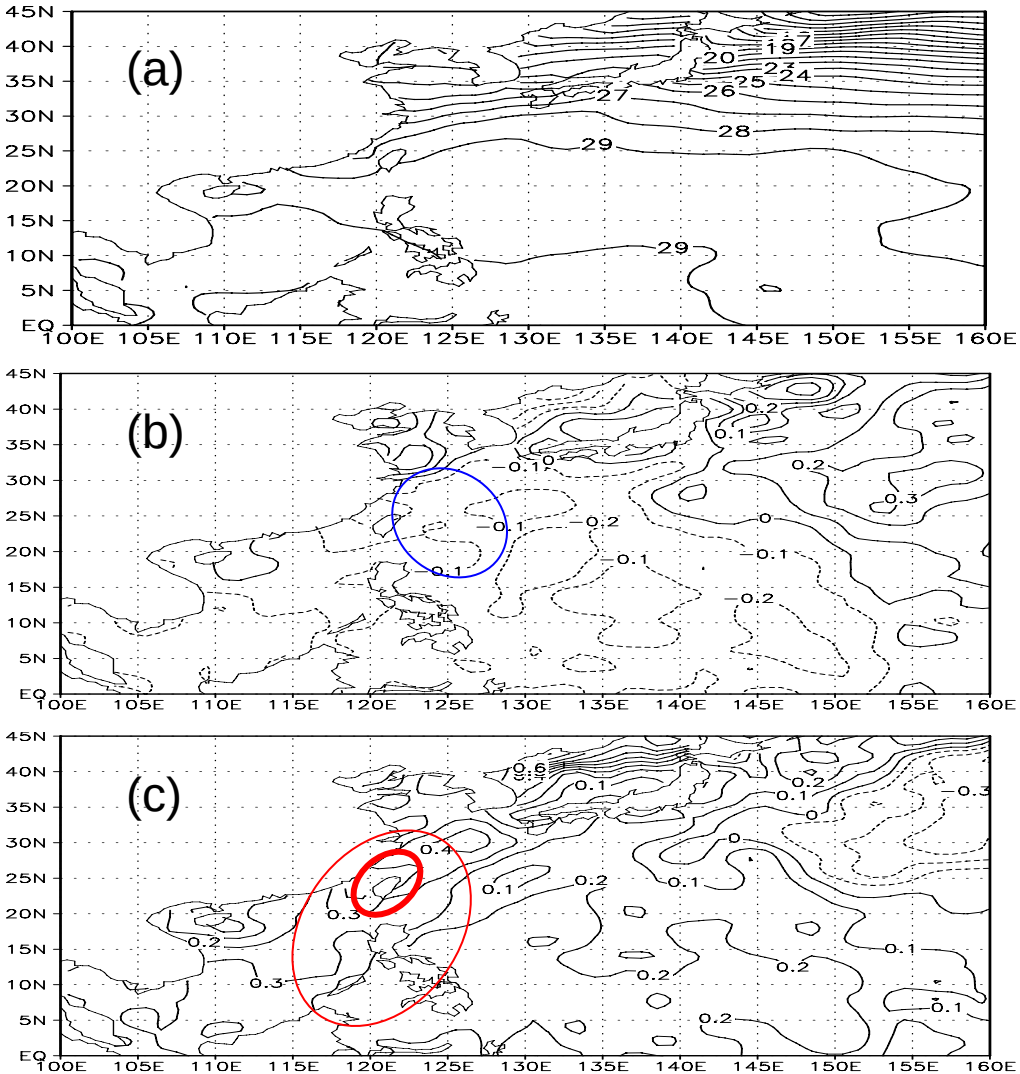
SST anomalies averaged for the periods of 1977-2000(c) SSTA is positive and SST increases quickly after 1976.

- **1977年起，近海、邻近海冬季海表温度较大上升，特别是在东海**

Distributions of climatological mean winter(DJF) SST(℃) in the offshore area of China and its adjacent oceans for 1961-1990(a), and SST anomalies averaged for the periods of 1958-1976(b) and 1977-2000(c). Data are from HadISST dataset.

Fig 2-5-1

Summer



Distributions of climatological mean summer (JJA) SST(℃) in 1961-1990

1958-1976年

SSTA is also negative.

1977-2000年

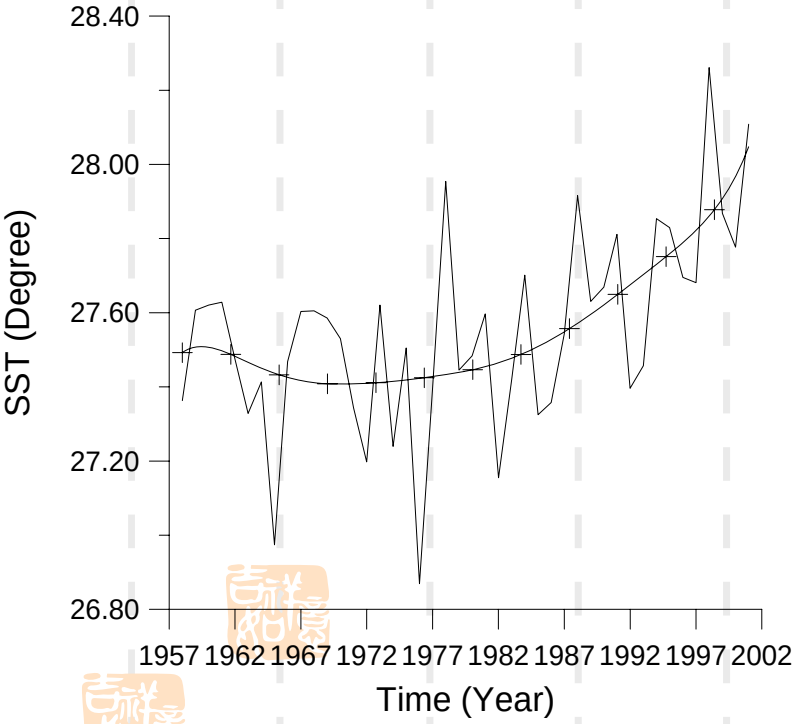
SSTA is also positive and SST increases quickly after 1976.

1977年起，近海、邻近海夏季海表温度较大上升，特别是在东海

Fig.2-5-2

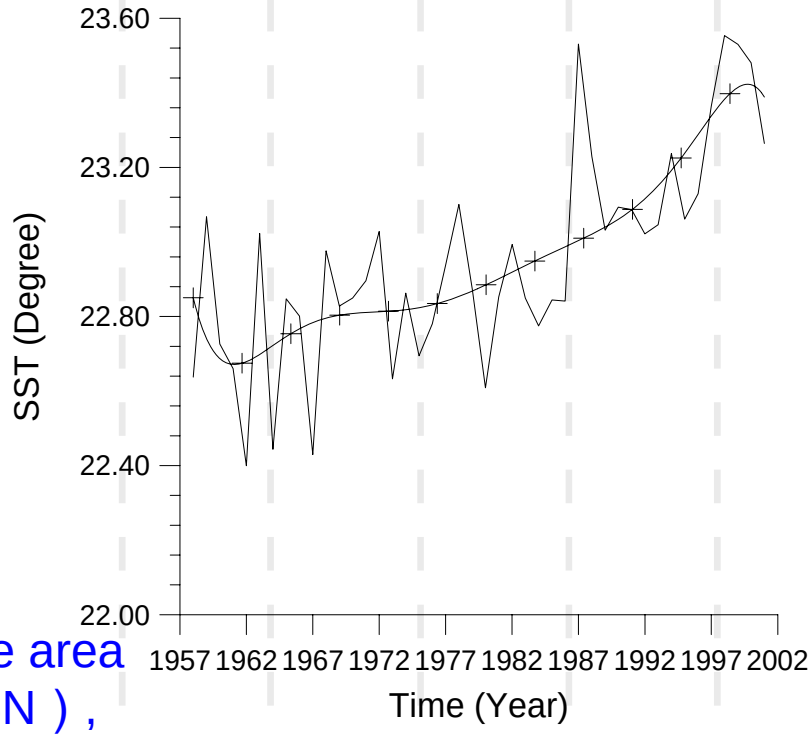
Distributions of climatological mean summer(JJA) SST(℃) in the offshore area of China and its adjacent oceans for 1961-1990(a), and SST anomalies averaged for the periods of 1958-1976(b) and 1977-2000(c). Data are from HadISST dataset.

Summer



Summer(JJA) SST trend in the the offshore area and its adjacent sea (100～160E，0～45N），increases about +0.60℃。
Data from HadISST,1°×1°, SST

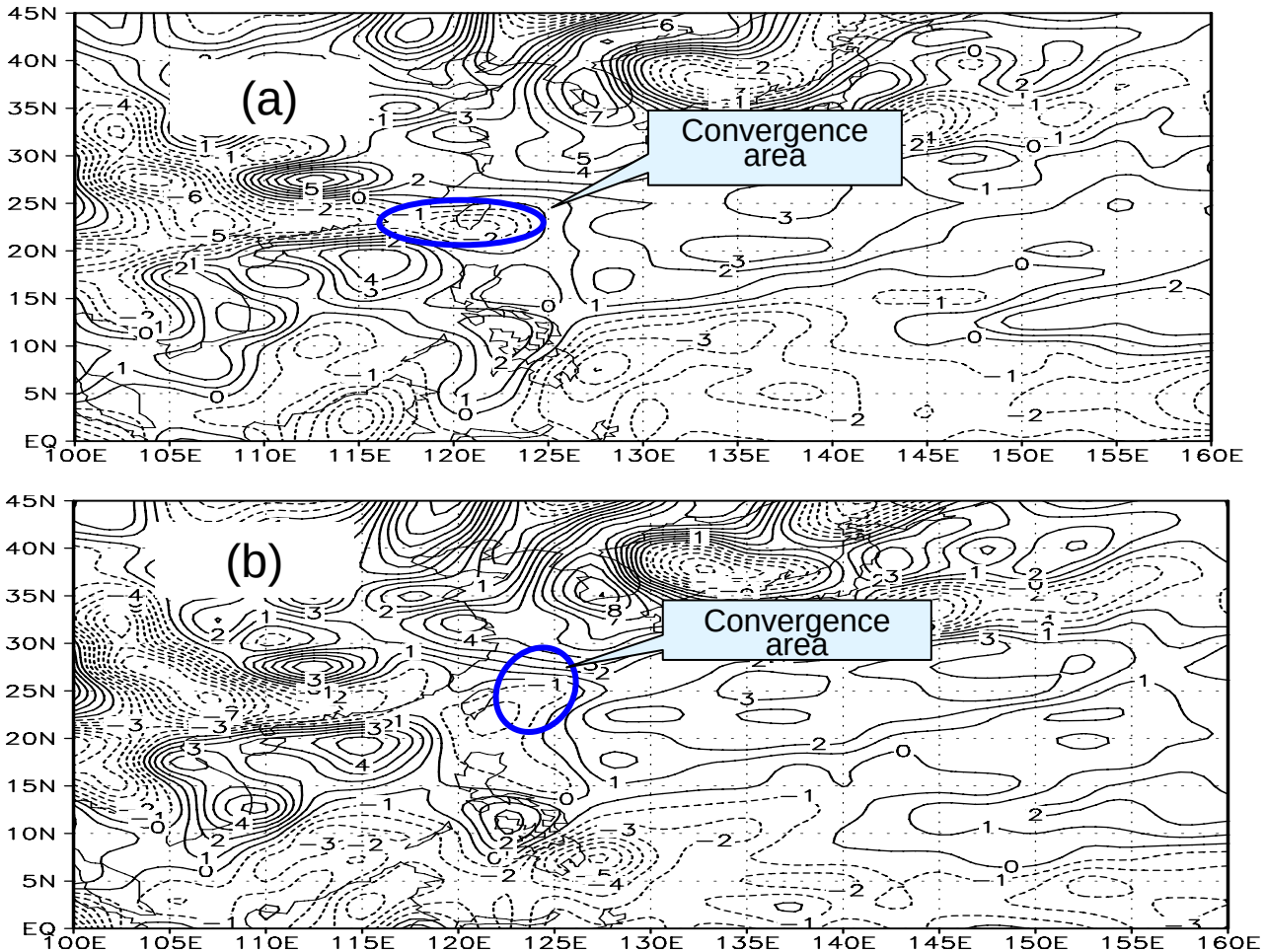
Winter Summer



Winter(DJF) SST trend in the the offshore area and its adjacent sea (100～160E，0～45N），increases about +0.80℃。
Data from HadISST,1°×1°, SST

- **2.6 Preliminary study of the influence of global warming on marine ecosystem in the offshore area of China and its adjacent oceans**

Winter



1958-1976

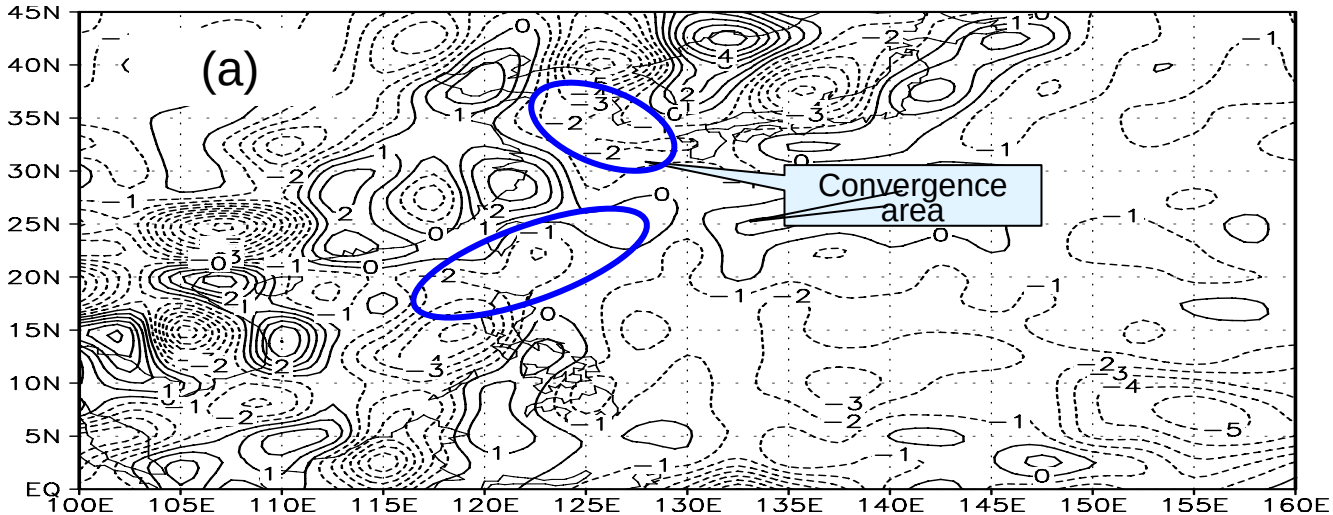
Distributions of Winter circulation divergences, Convergence area located in the north of South China Sea and Twain Strait.

1977-2000

Convergence move eastwardly after 1976. Circulation divergence make intense, and it is not helpful for the upwelling flow forming.

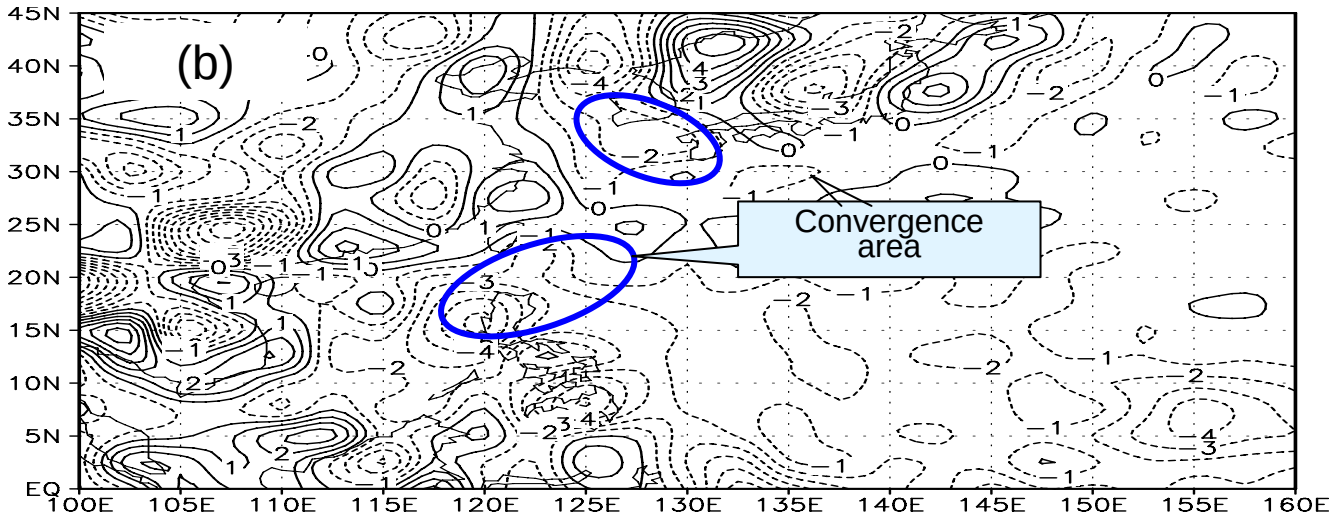
Fig 2-6-1 **Distributions of winter circulation divergences($10^{-6}s^{-1}$) at 925 hPa over East China, the offshore area of China and its adjacent ocean averaged for the periods of 1958-1976(a), and 1977-2000(b). Data are from the ERA-40 reanalysis.**

Summer



1958–1976年

Distributions of summer circulation divergences, Convergence area located in Yellow Sea, East China Sea and South China Sea



1977–2000年

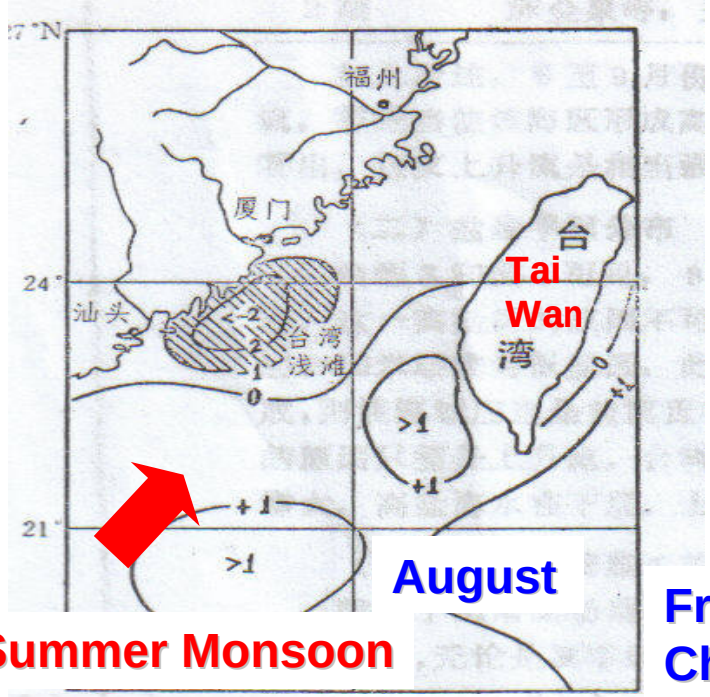
Convergence over Yellow Sea, East China Sea and South China Sea move eastwardly after 1976. Circulation divergence make intense, and it is not helpful for the upwelling flow forming.

Fig.2-6-2

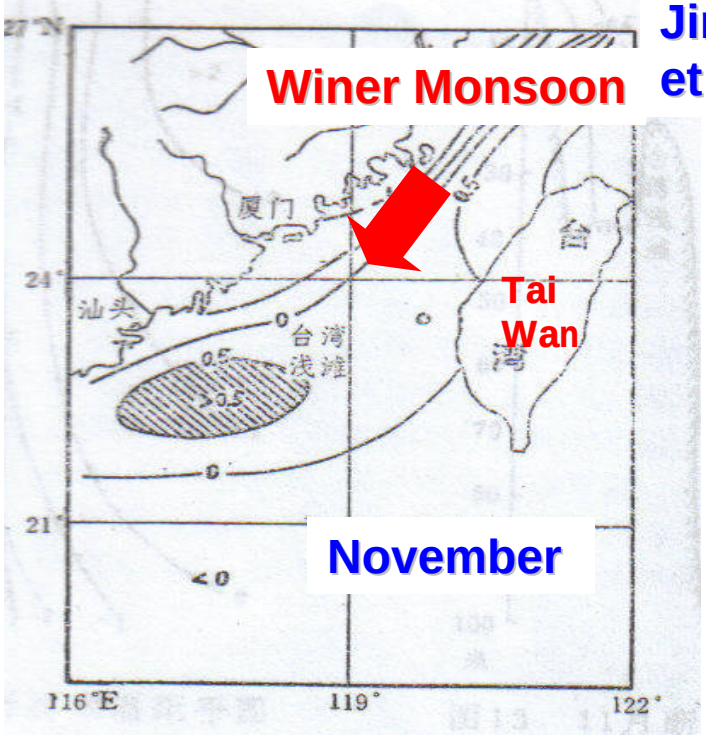
Distributions of summer circulation divergences($10^{-6}s^{-1}$) at 925 hPa over East China, the offshore area of China and its adjacent ocean averaged for the periods of 1958-1976(a), and 1977-2000(b). Data are from the ERA-40 reanalysis.

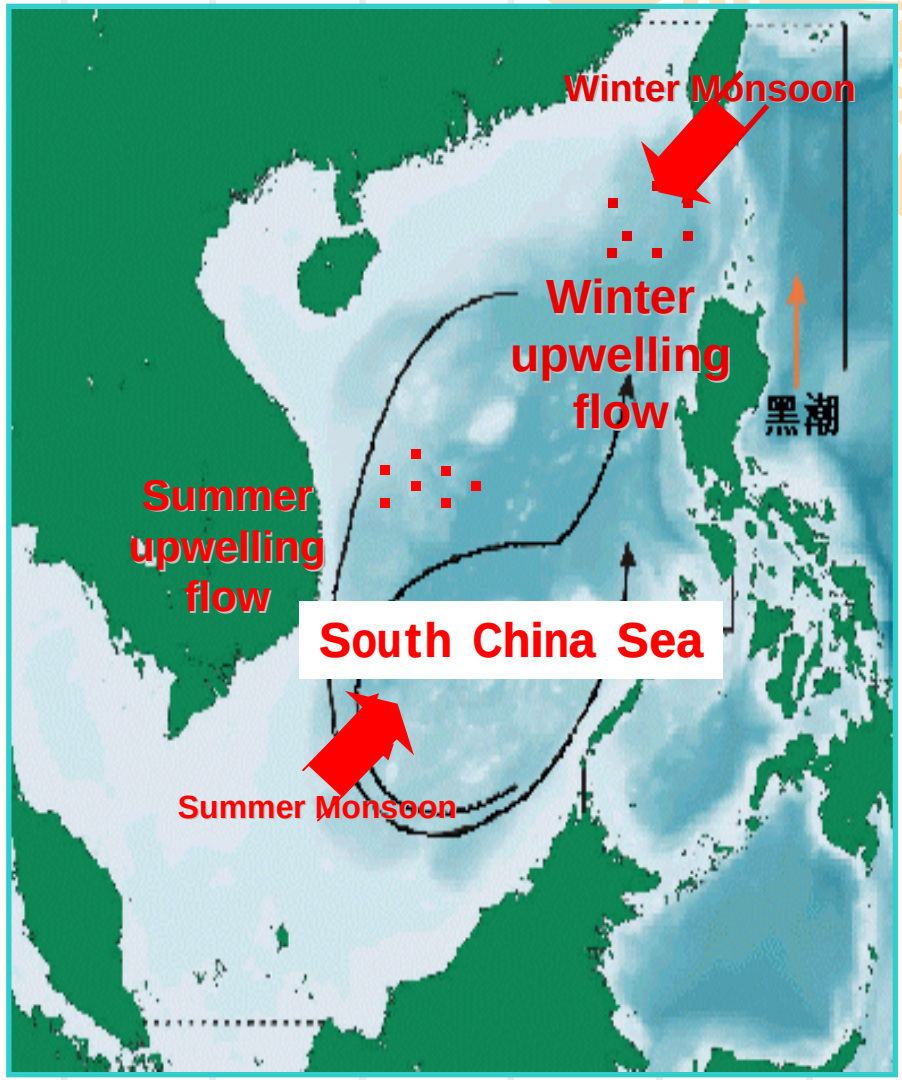
2.6.1 Preliminary analyses of the influences of sea surface wind stresses and divergence on the upwelling flow in the offshore area

- From the variation of the distributions of circulation divergences over the offshore area of China, it can be clearly seen that after 1976, the circulation divergences over this area intensified, which are not helpful to the formation of upwelling flow in the offshore area of China.
- It will have an influence on the nutrients transportation in the coastal water.

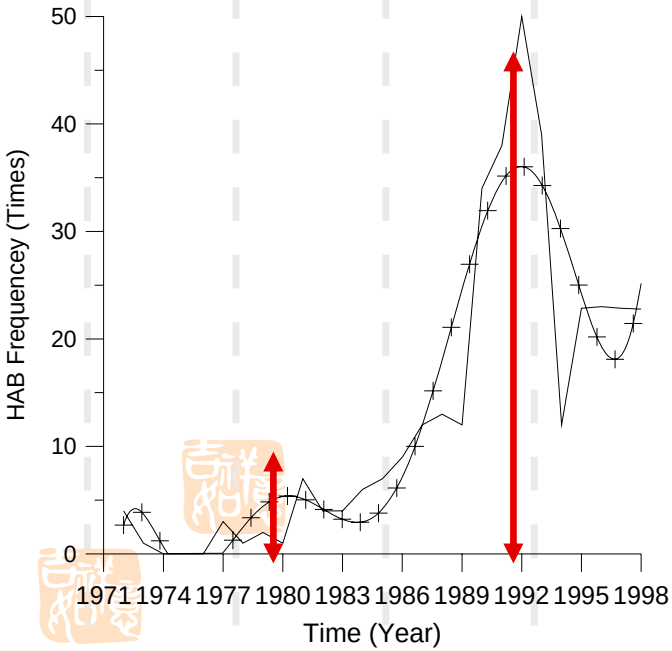


From Chen Jinquan et al



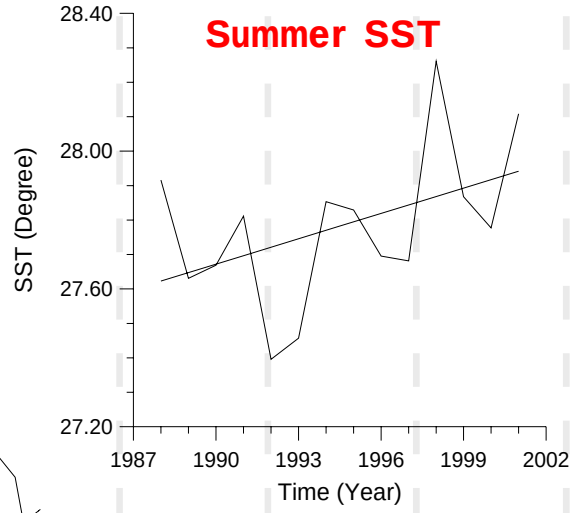


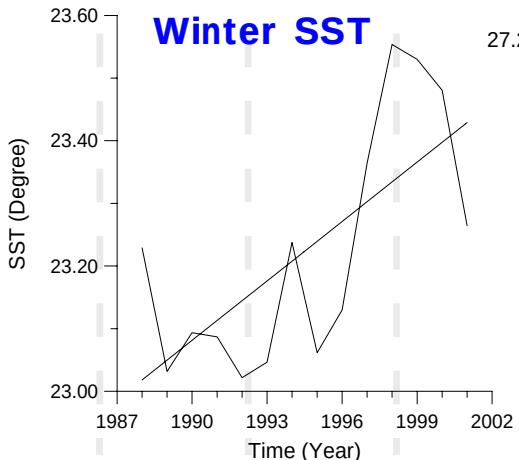
2.6.2 Preliminary analyses of the relationship between SST and the frequent occurrence of Red tide



Data from Lu et al

The frequency of red tide(HAB) in the offshore area have distinct decadal variation. There were only several times before 1980's. However, the occurrence times of red tide increase quickly since 1980's, and especially in the East China Sea.



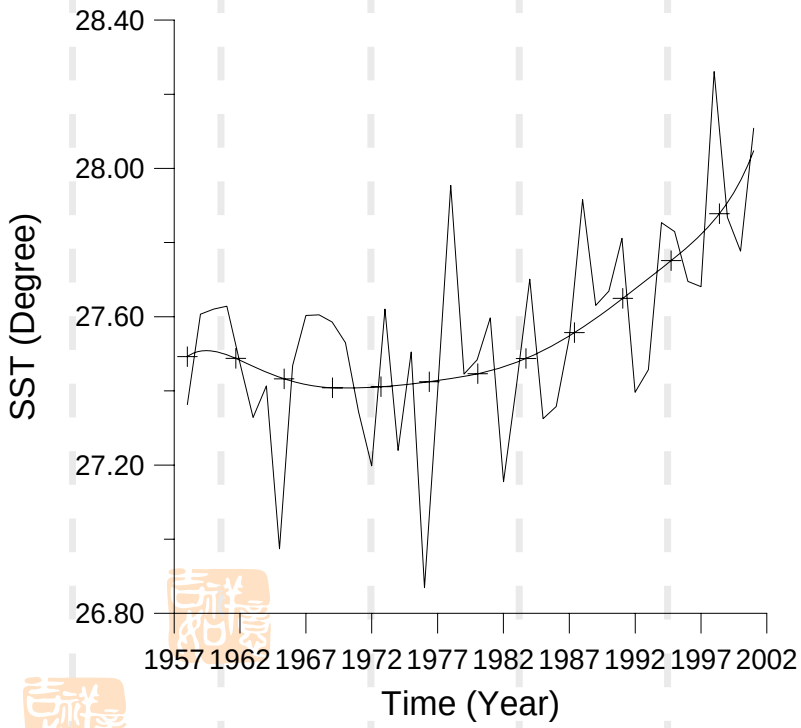


- **The abnormal phenomenon in marine ecosystem is not only related to the pollutants from land sources, but also closely related to the marine environment change which is caused by wind stress becoming weaker and SST rising.**

Region:100 ~ 160E , 0 ~ 45N

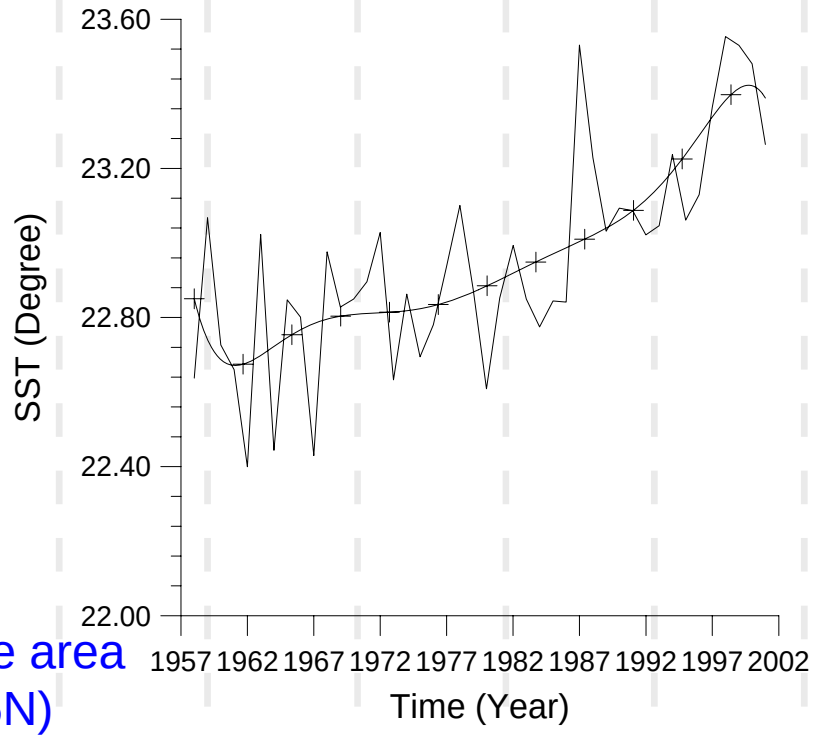
Data from HadISS

Summer



Summer(JJA) SST trend in the the offshore area of China and its adjacent sea (100～160E，0～45N) increases about +0.60℃ from 1958-2002.
Data from HadISST, 1°×1°

Winter



Winter(DJF) SST trend in the the offshore area and its adjacent sea (100～160E，0～45N) increases about +0.80℃ from 1958-2002.
Data from HadISST,1°×1°, SST

- **4.1 Summary and discussion**
- **4.1.1 Due to the impact of global climate warming, the winter and summer monsoon flows become weak over the offshore area of China and its adjacent ocean after 1976, which causes the weakening of winter and summer sea surface wind stress, especially the meridional sea surface wind stresses, and the obvious increase of SST in the area. And that is significant in the East China Sea. Those can provide a favorable marine environment for the frequent occurrence of red tide in the offshore area of China.**

- **4.1.2 Besides, from the variation of the distributions of circulation divergences over the offshore area of China, it can be clearly seen that after 1976, the circulation divergences over this area intensified, which are not helpful to the formation of upwelling flow in the offshore area of China. It will have an influence on the nutrients transportation in the coastal water and marine primary production.**

- **4.2 Discussion**
- **What's the relationship between SST anomaly in the offshore area and the west pacific ocean?**


Thank you !