The summary of the atmospheric circulation over East Asia in summer 2007

Norihisa FUJIKAWA

Climate Prediction Division
Japan Meteorological Agency

The 8th Joint Meeting for Seasonal Prediction of East Asia Winter Monsoon, 17-19 October 2007

Structure of this presentation

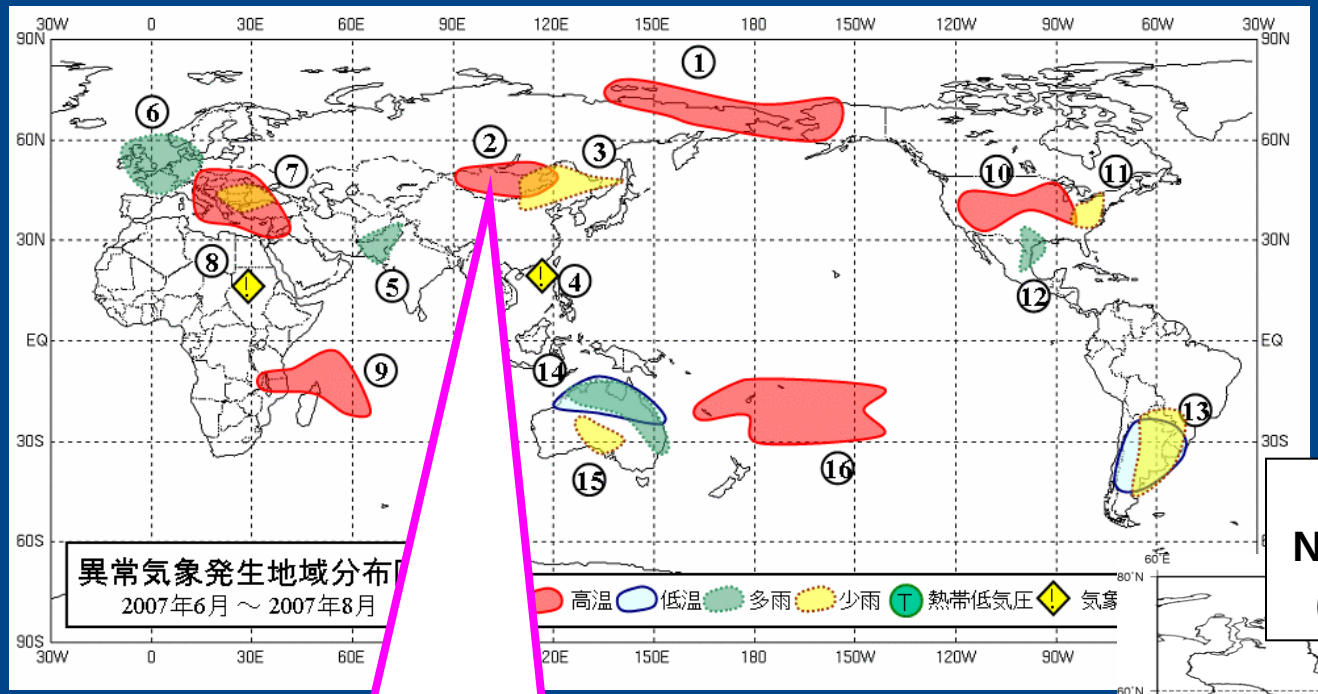
Part I Observed extreme climate in summer 2007

Part II Background field (Oceanic & monsoon condition)

Part III Analysis of the strong anti-cyclone causing extreme climate over East Asia in August 2007

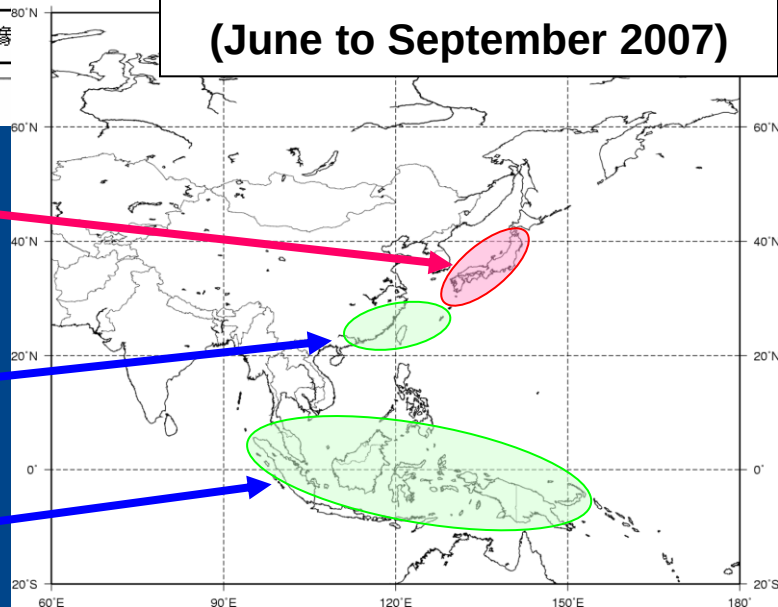
Part I Observed extreme climate in summer 2007

Extreme climate events in the world in summer (JJA) 2007



Hot and Dry summer in Mongolia and the northern part of China

Possible influence of La Niña event on Asian climate (June to September 2007)



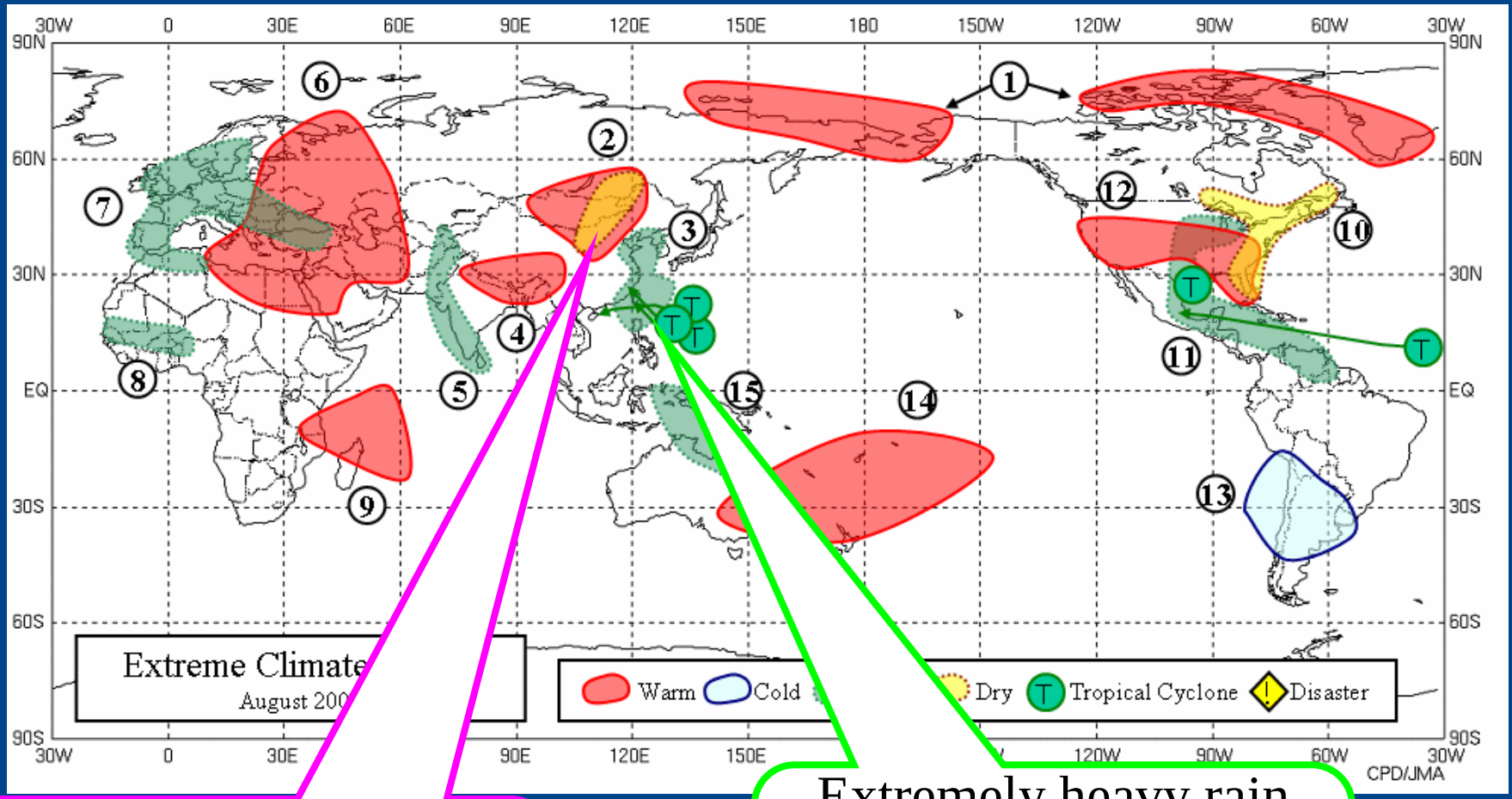
Japan (Aug.- Sep.) Hot

Southern China to southern Japan (Aug.) Wet

Malaysia and Indonesia (Jun.- July.) Wet

Eastern Indonesia (Aug.- Sep.) Wet

Extreme climate events in the world in August 2007

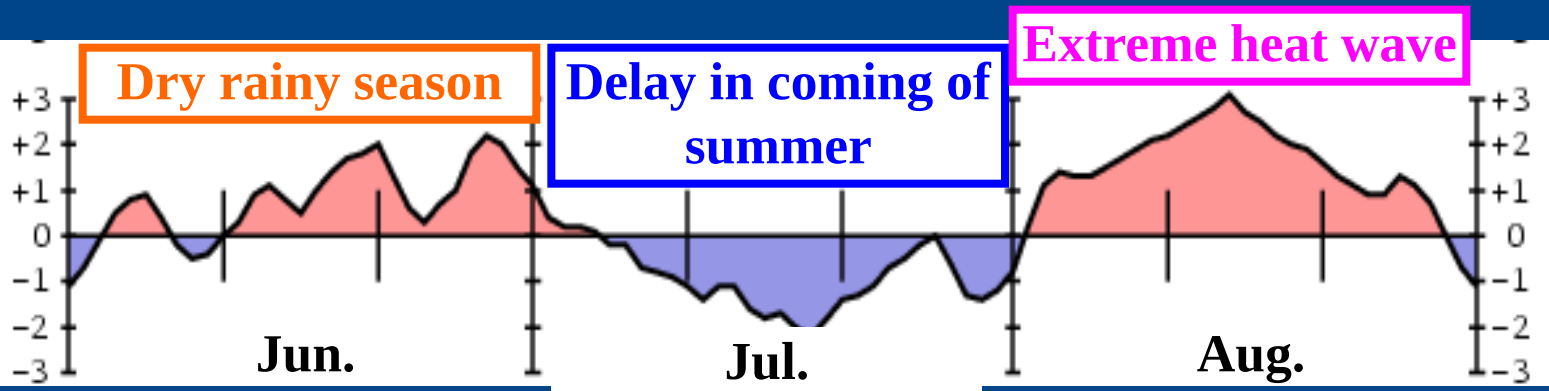


Hot and Dry in Mongolia and northern part of China

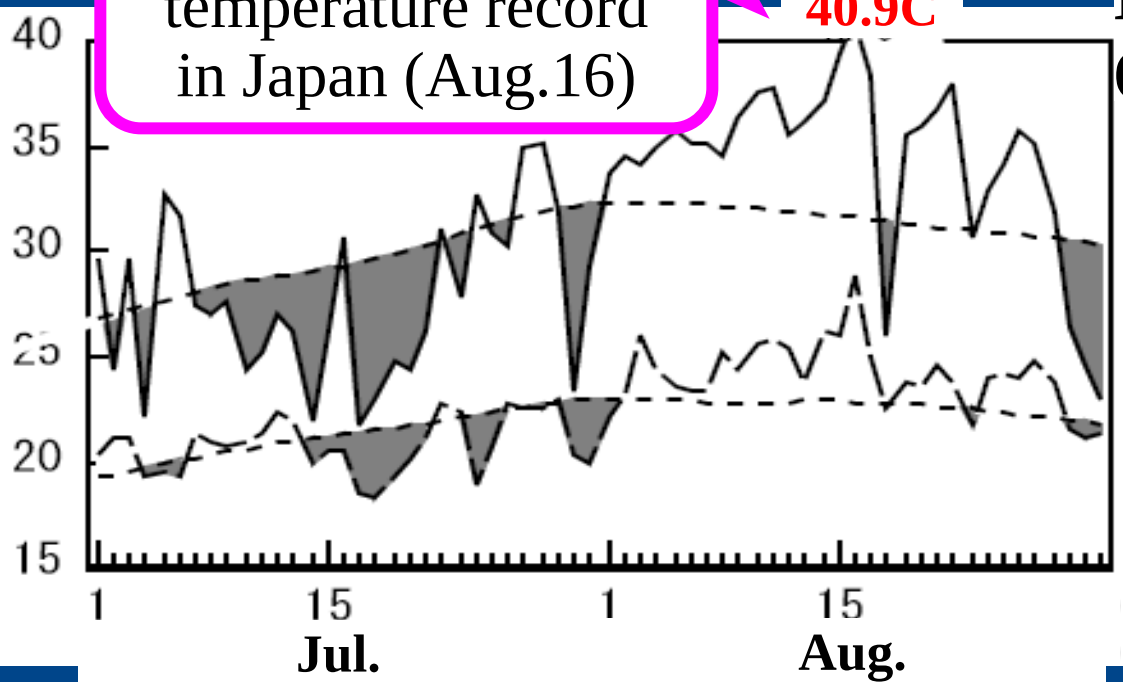
Extremely heavy rain around the Yellow Sea, the East China Sea and the Korean Peninsula

Extreme climate events in Japan in summer 2007

Time Sequence of Temperatures in Eastern Japan



Broke the highest temperature record in Japan (Aug.16)



Kumagaya
(60km north of Tokyo)

Maximum Temperature

Minimum Temperature

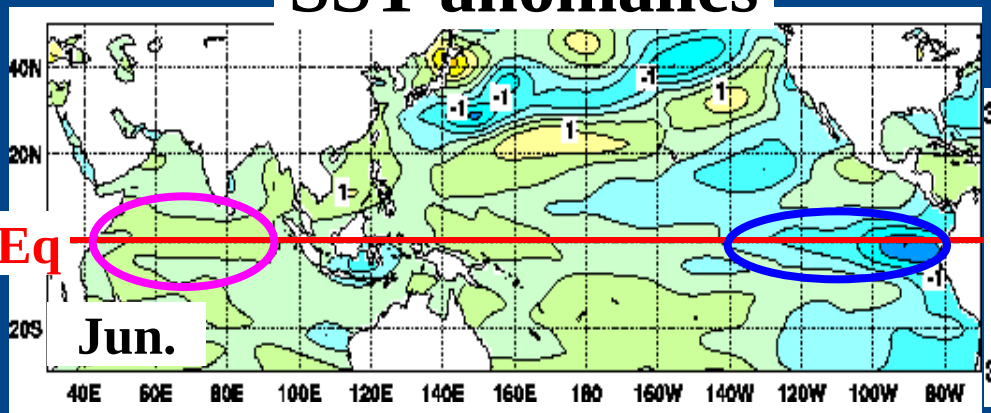
Part II Background field

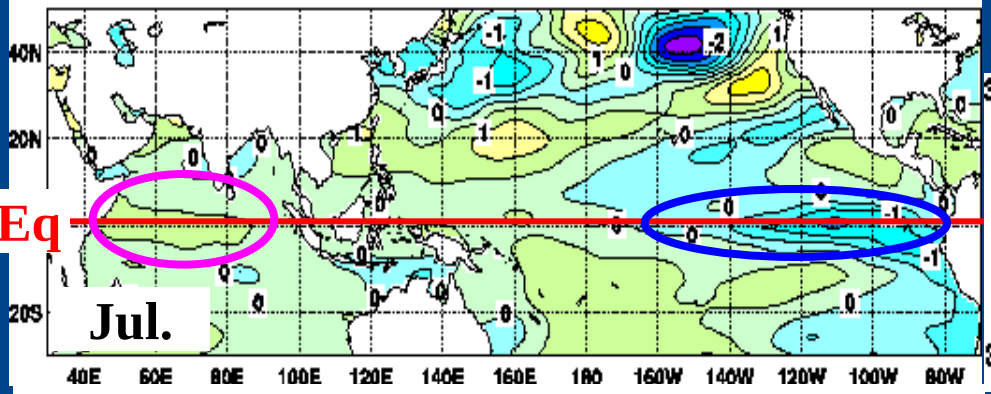
Oceanic condition and Asian summer monsoon condition

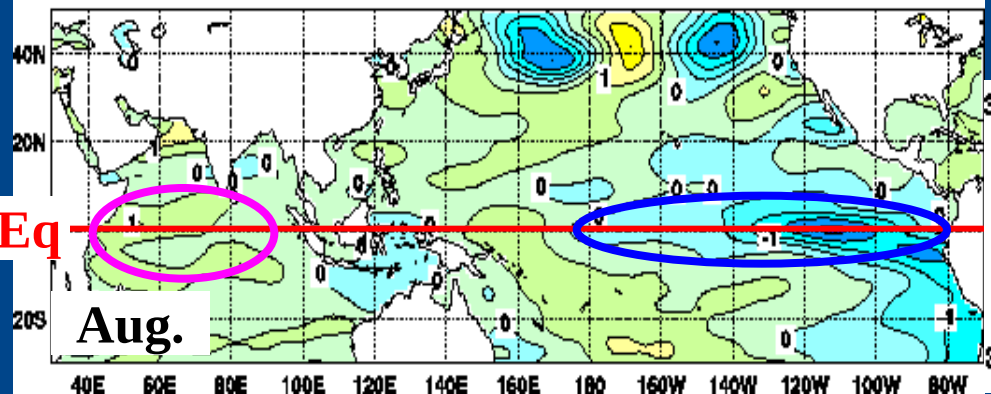
La Niña developed

Active Asian summer monsoon

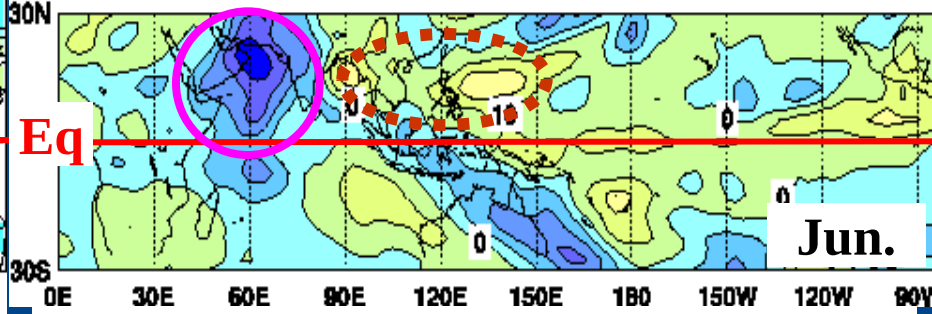
SST anomalies



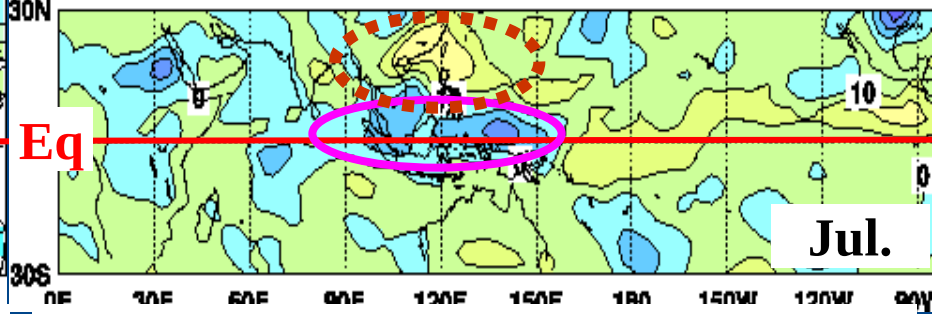




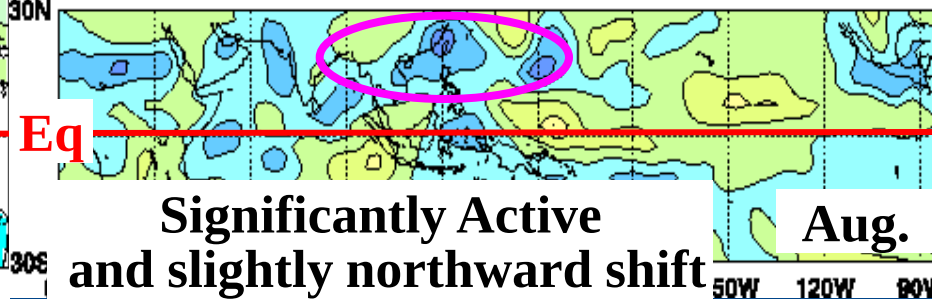
OLR anomalies



Westward shift of Active convection

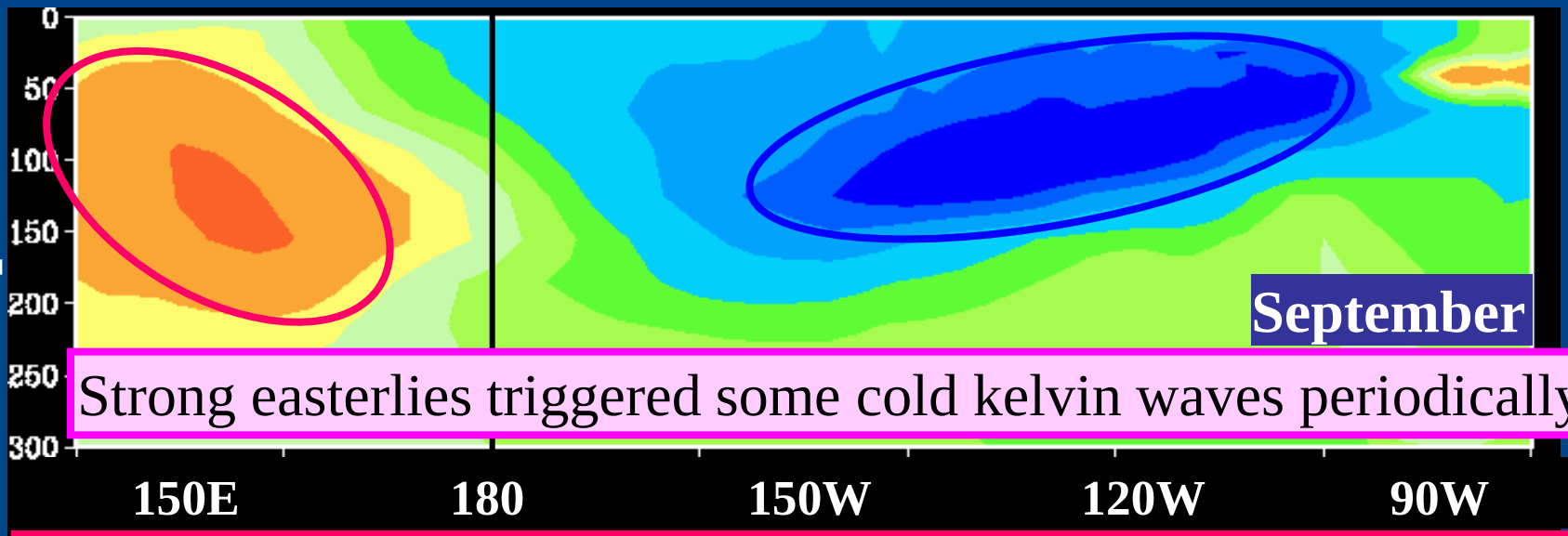


Southward shift of Active convection



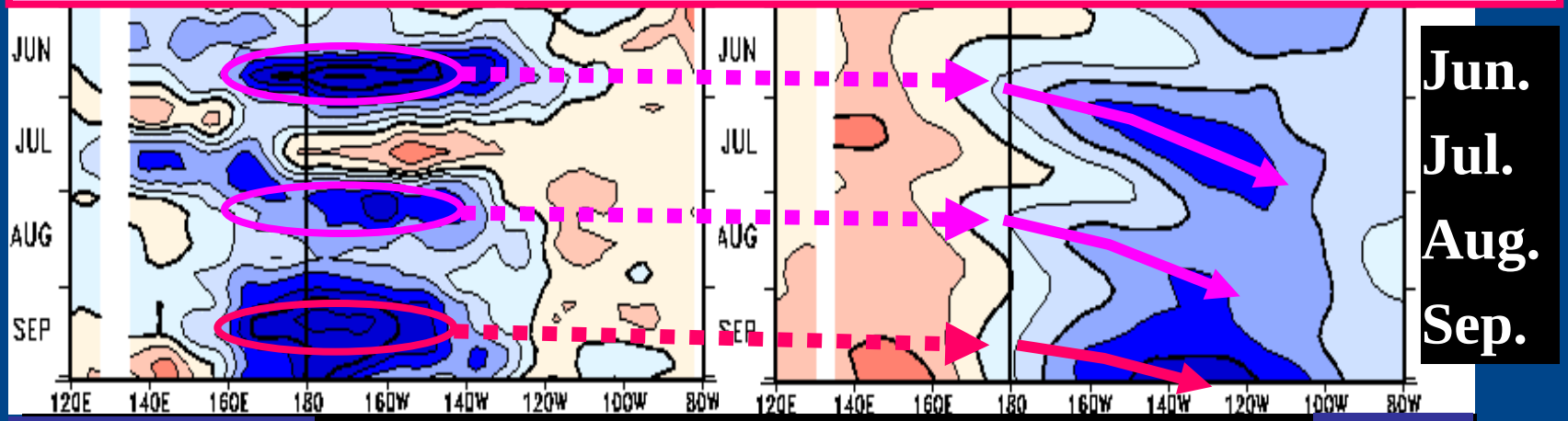
Significantly Active and slightly northward shift

Subsurface temperature anomalies along the equator in the Pacific



Strong easterlies triggered some cold kelvin waves periodically.

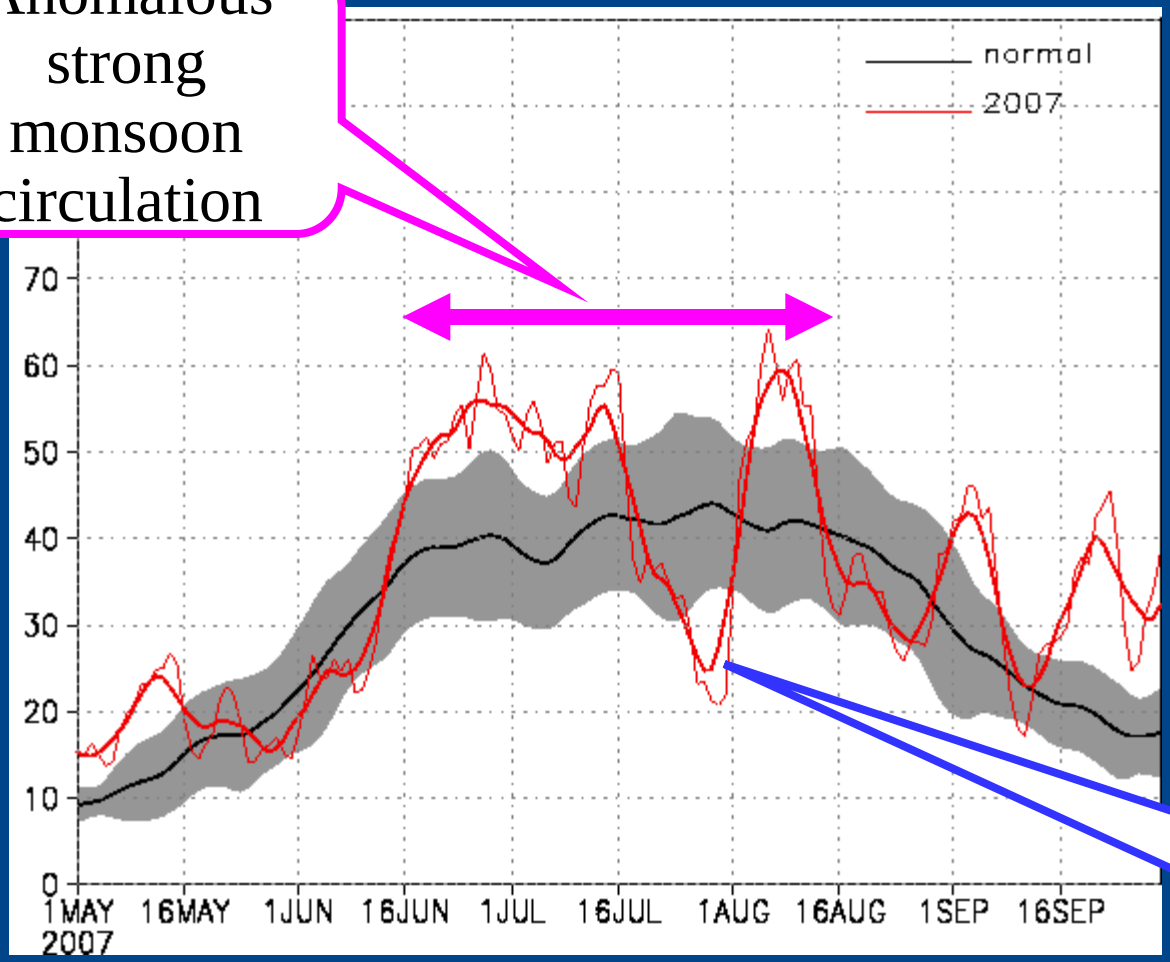
Largely amplified cold kelvin wave was triggered in September.



Wind stress | Time Longitude cross section | OHC

The time series for the strength of Indian summer monsoon circulation at 850hPa

Anomalous strong monsoon circulation



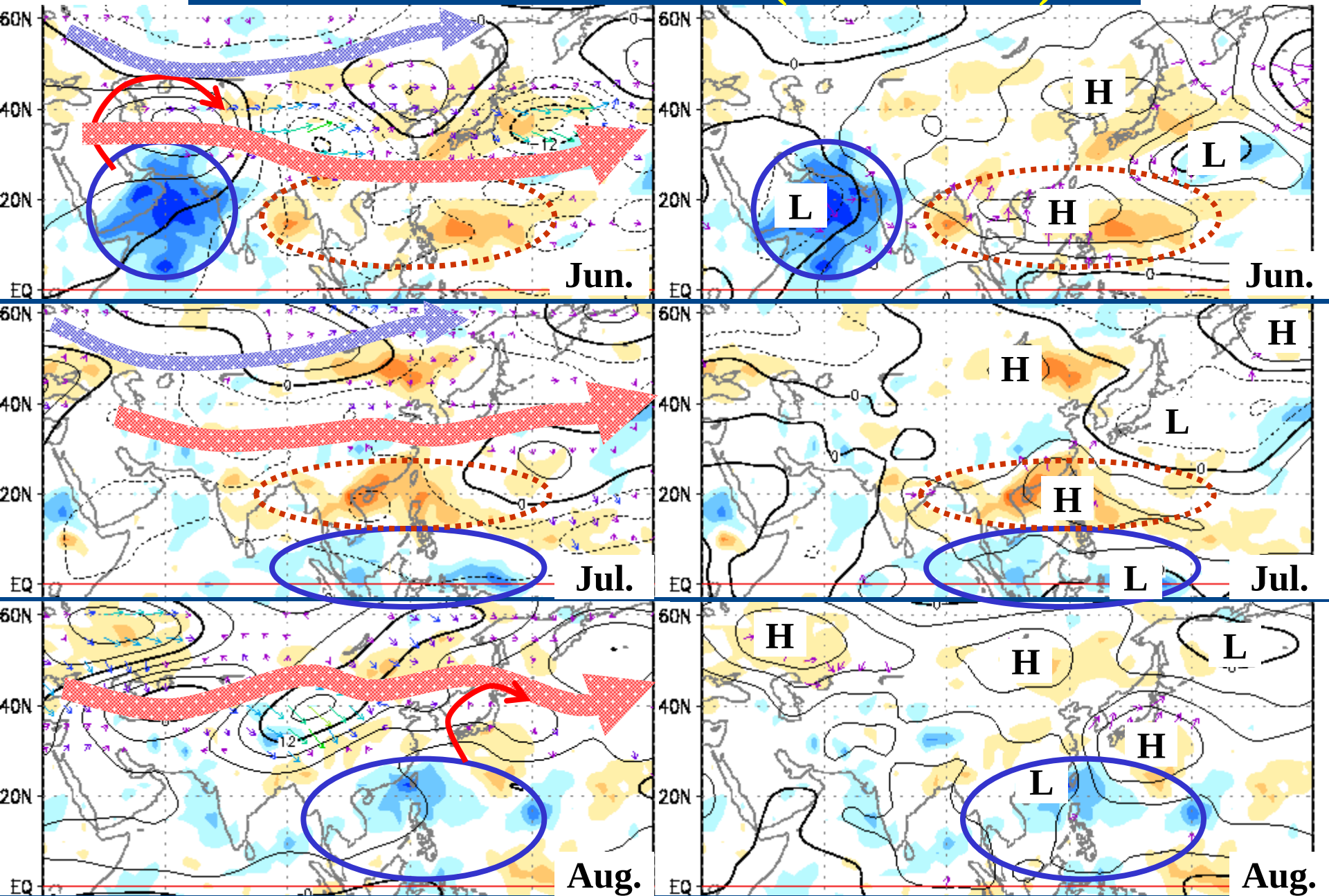
Kinetic energy of the rotational component of the wind over the northern Indian Ocean

Significant break in late July

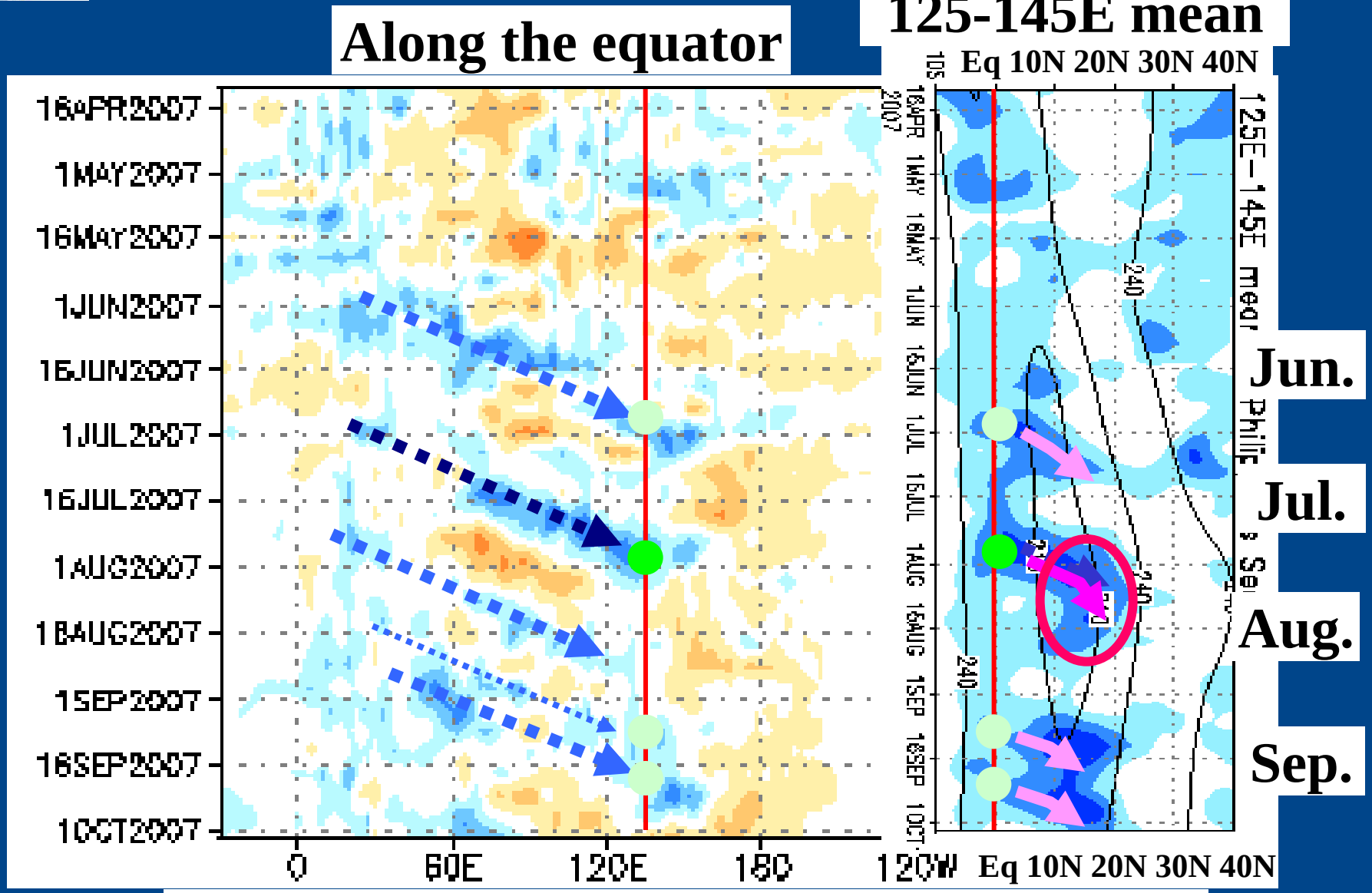
Stream function anomalies (contour) and OLR anomalies (color shade)

200hPa

850hPa



Intra-seasonal oscillation of active convection (associated with Madden Julian Oscillation)

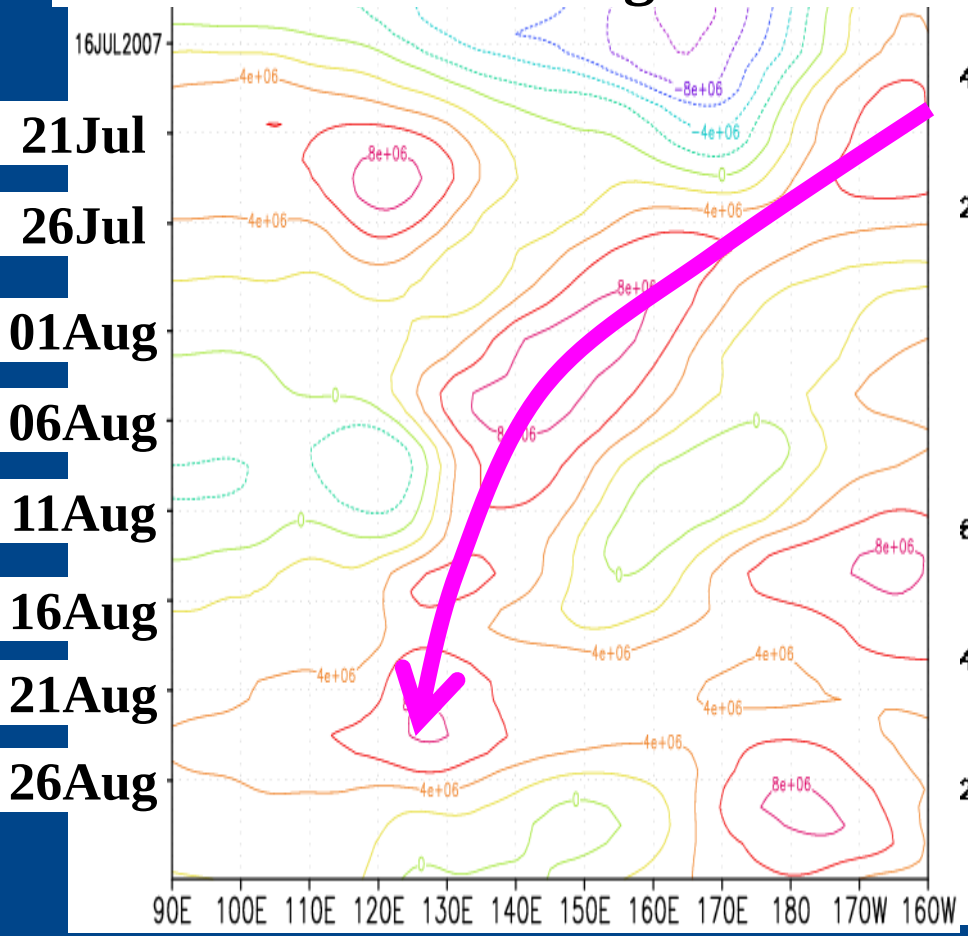


Cross section of OLR anomalies

Part III Analysis the strong anti-cyclone causing extreme climate over East Asia in August 2007

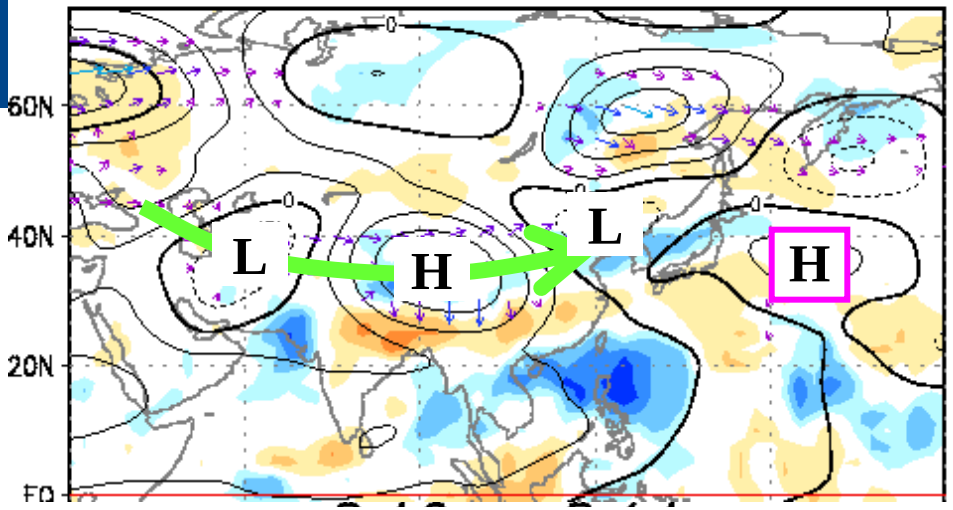
Westward moving anti-cyclone & propagation of quasi-stationary Rossby wave packet

850hPa stream function anomalies along 35N

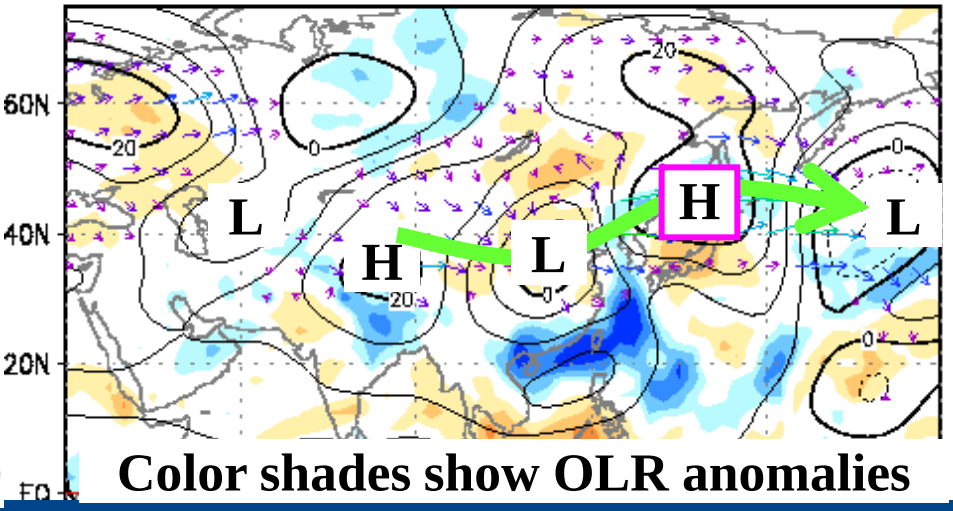


stream function anomalies & wave activity flux in 200hPa

5-day mean (5-9 Aug.)

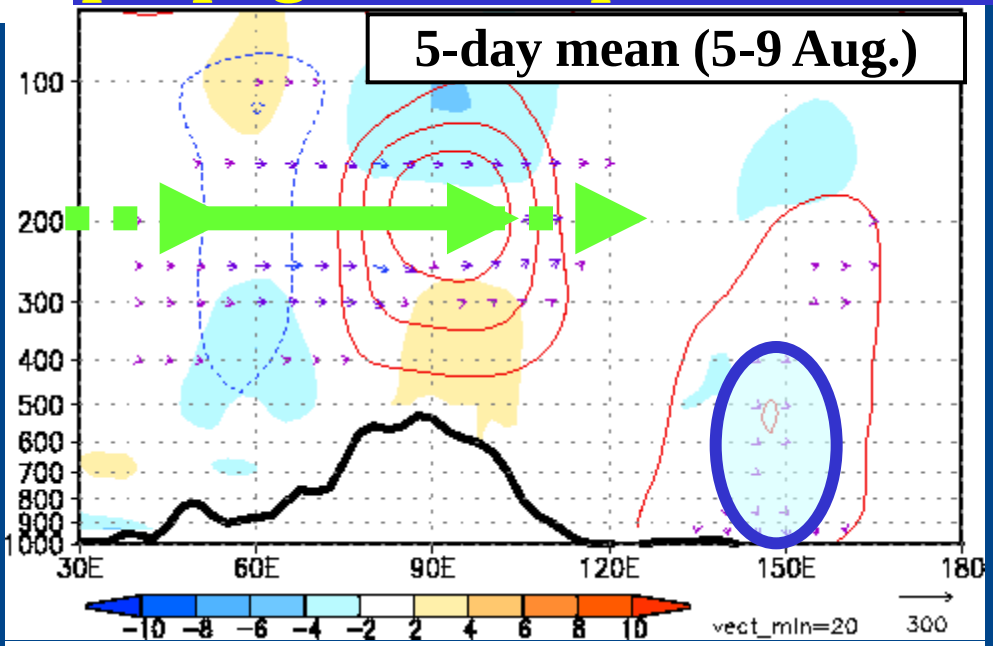


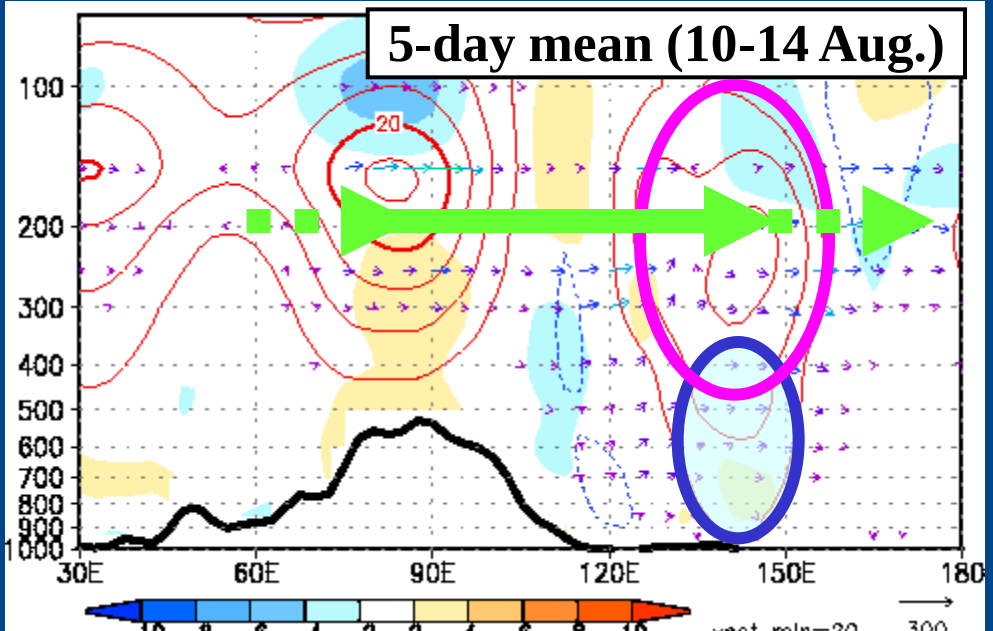
5-day mean (10-14 Aug.)



Color shades show OLR anomalies

Westward moving anti-cyclone & propagation of quasi-stationary Rossby wave





Height-longitude cross section of stream function anomalies & wave activity flux (color shade shows temperature anomalies) along 35N

Anti-cyclone in the lower troposphere moved westward over Japan

Anti-cyclonic circulation in the upper troposphere was strengthened due to the propagation of Rossby wave packet

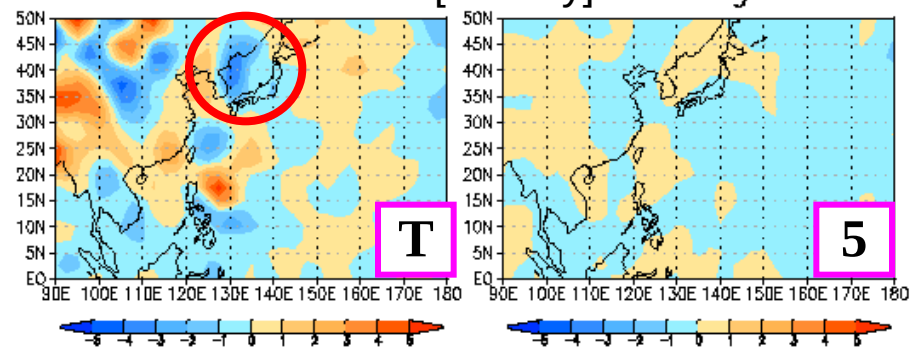
Vorticity budget analysis at 850hPa

Vorticity budget from 11th to 15th Aug.

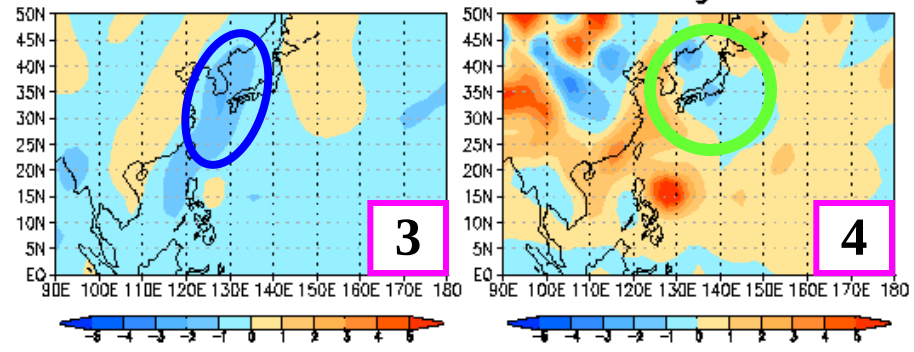
$$\frac{\partial \zeta}{\partial t} = \underbrace{-\left(u\frac{\partial \zeta}{\partial x} + v\frac{\partial \zeta}{\partial y}\right)}_{1} \underbrace{-\omega\frac{\partial \zeta}{\partial p}}_{2} \underbrace{-\beta v}_{3} \underbrace{-(f+\zeta)\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right)}_{4} + \underbrace{\left(\frac{\partial \omega}{\partial y}\frac{\partial u}{\partial p} - \frac{\partial \omega}{\partial x}\frac{\partial v}{\partial p}\right)}_{5}$$

T

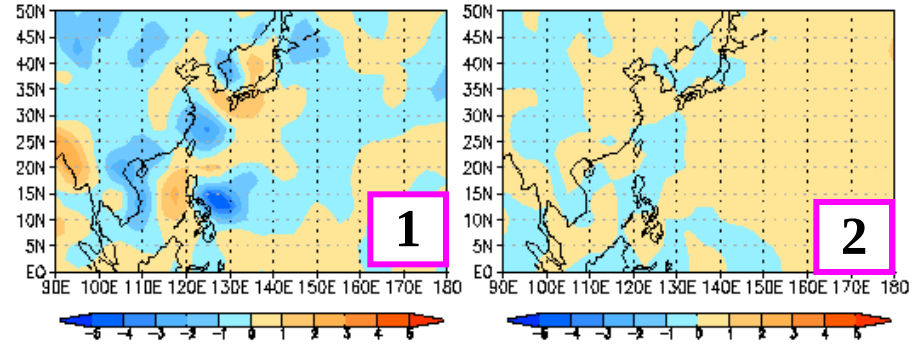
Total unit=[1/s/day] Tilting



Beta advection Divergence

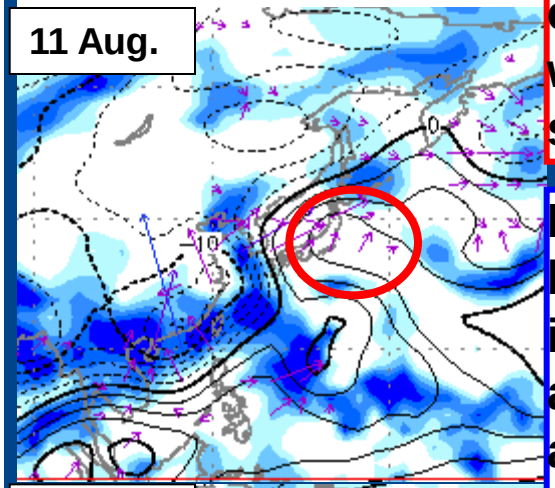


Horizontal advection Vertical advection

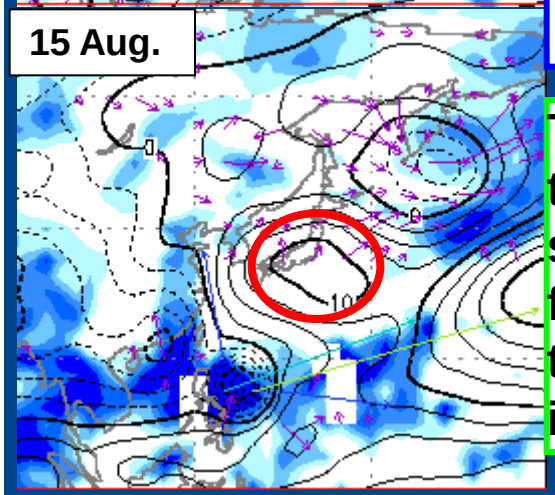


Stream function in 850hPa and OLR

11 Aug.



15 Aug.



The anti-cyclonic circulation moved westward and was strengthened

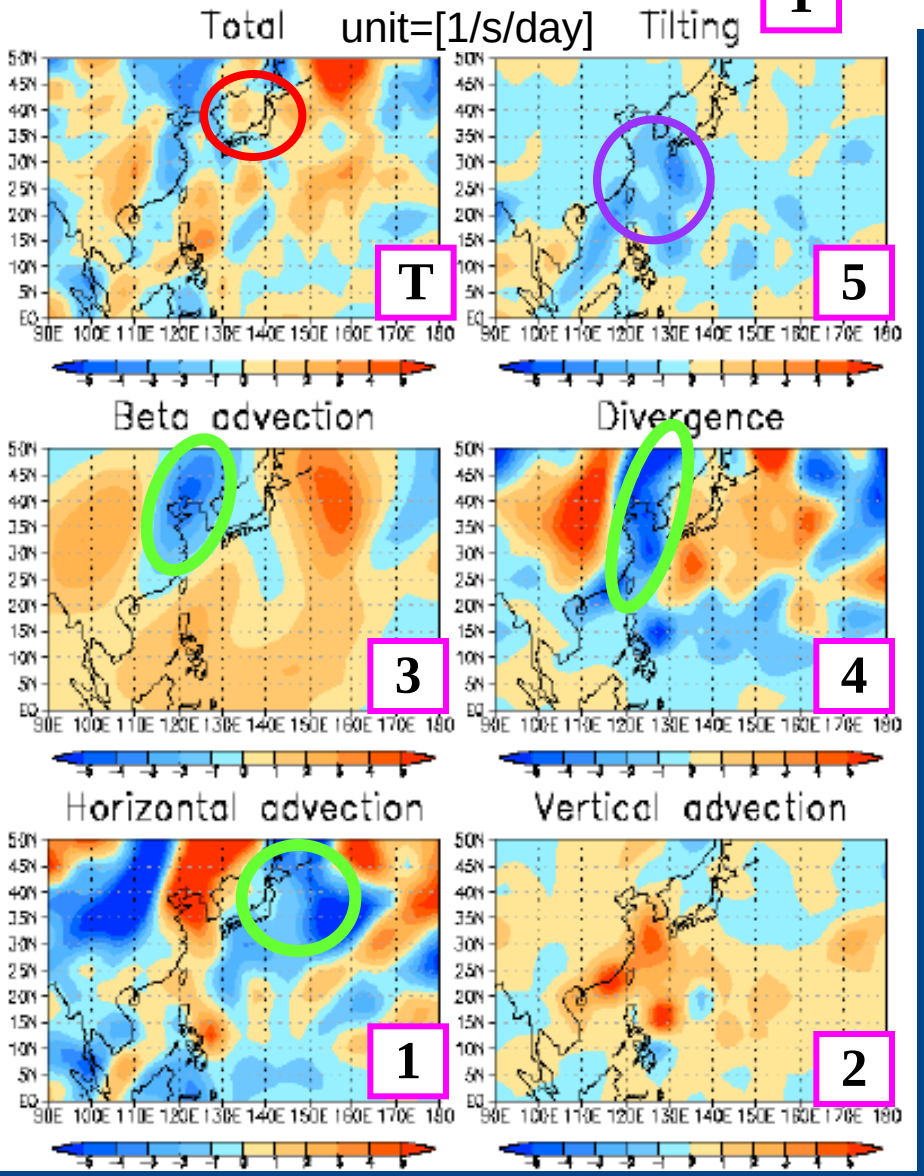
In the balance, the beta advection term is larger, so this anti-cyclone seems a Rossby wave.

The divergence term is also large, so the down flow from upper troposphere is also important.

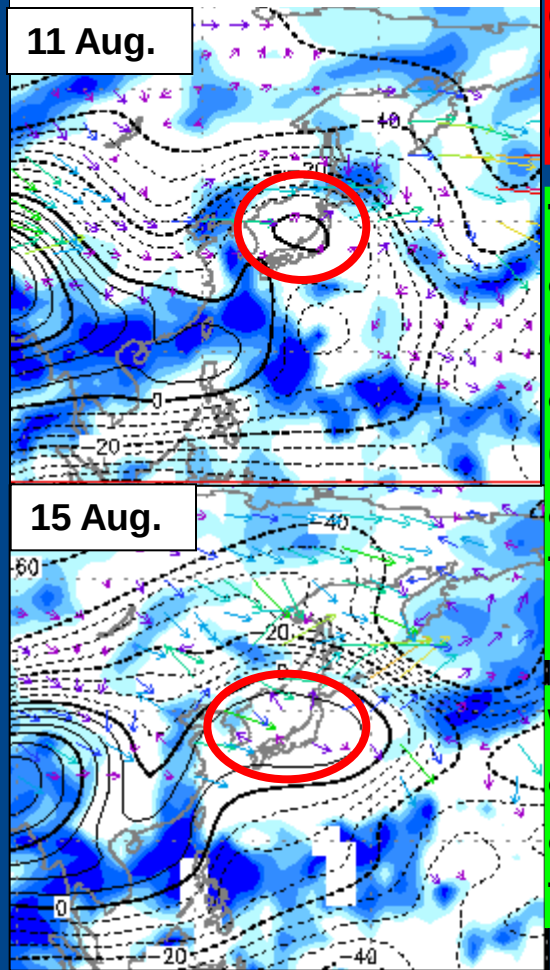
Vorticity budget analysis at 200hPa

Vorticity budget from 11th to 15th Aug.

$$\underbrace{\frac{\partial \zeta}{\partial t}}_{T} = \underbrace{-\left(u\frac{\partial \zeta}{\partial x} + v\frac{\partial \zeta}{\partial y}\right)}_{1} \underbrace{-\omega\frac{\partial \zeta}{\partial p}}_{2} \underbrace{-\beta v}_{3} \underbrace{-(f+\zeta)\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right)}_{4} + \underbrace{\left(\frac{\partial \omega}{\partial y}\frac{\partial u}{\partial p} - \frac{\partial \omega}{\partial x}\frac{\partial v}{\partial p}\right)}_{5}$$



Stream function in 200hPa and OLR

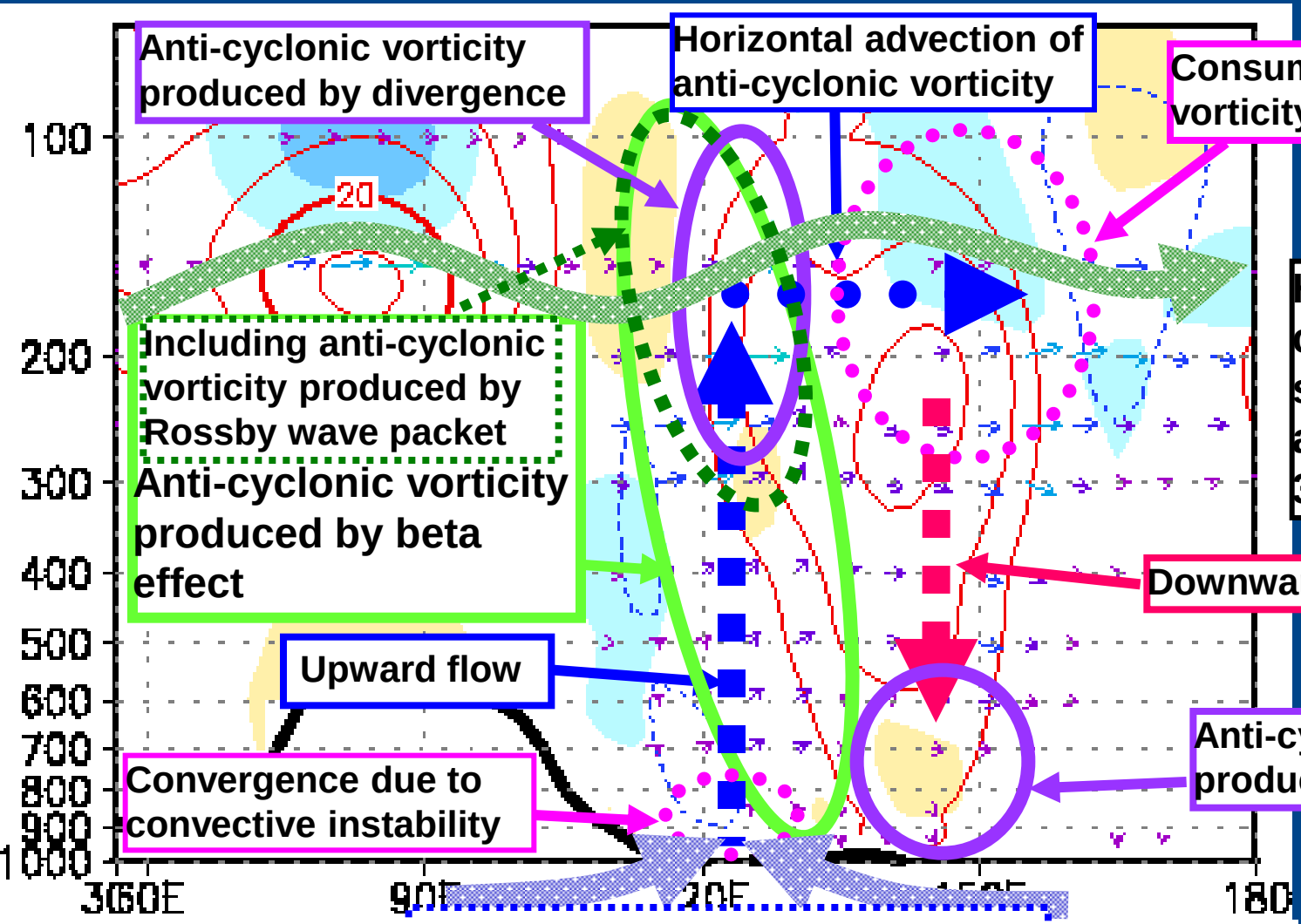


The anti-cyclonic circulation stayed over Japan and extended westward

To maintain the anti-cyclonic circulation, the beta advection and the divergence terms are main sources in the western part

while horizontal advection term is an only source in the eastern part.

Schematic chart for the vorticity balance of the anti-cyclone over East Asia in mid-August 2007



Conclusion (1)

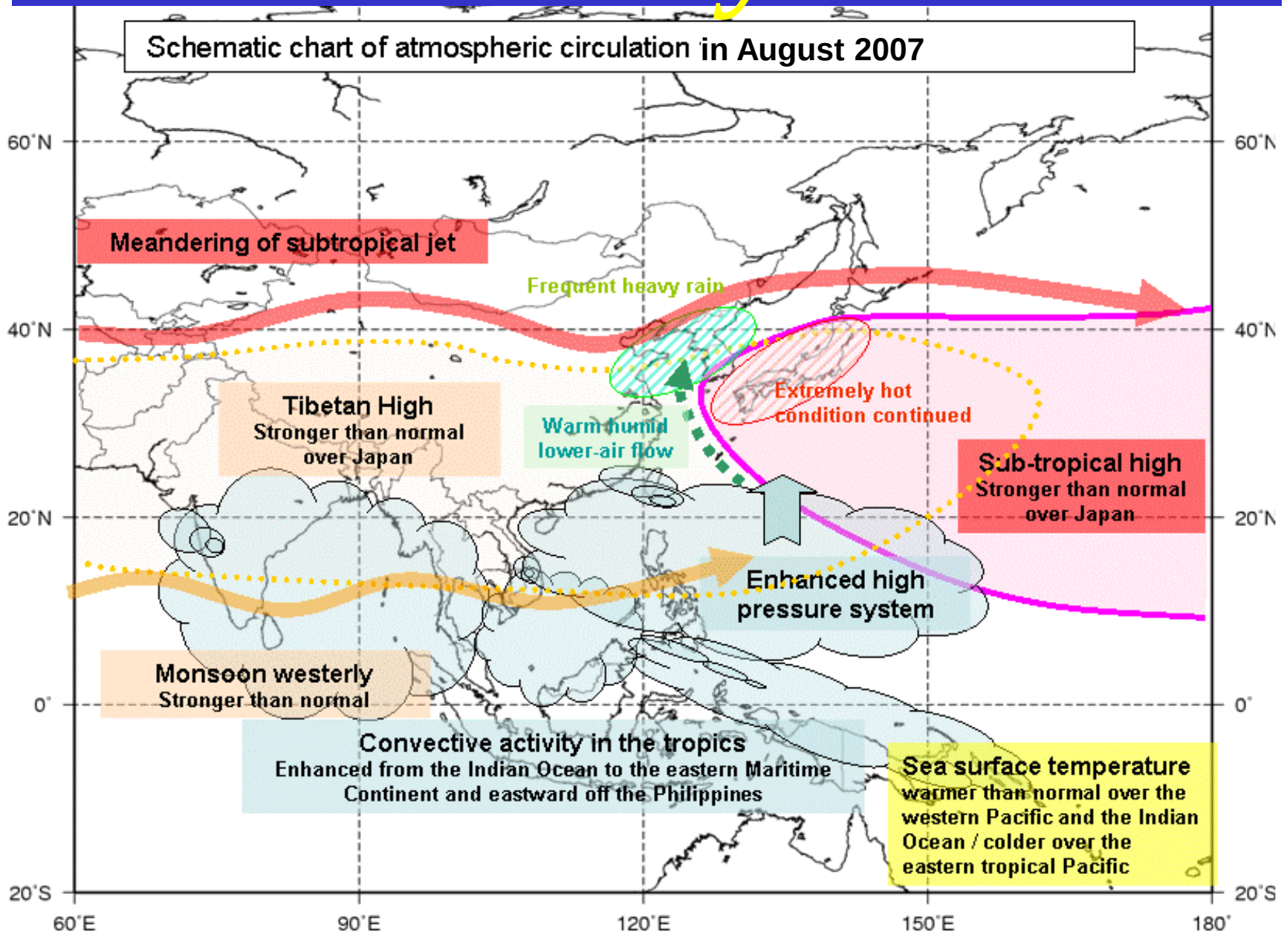
- Extreme weather events or climate were observed over East Asia in summer 2007.
- As the base factor for anomalous climate, developing La Niña and active Asian summer monsoon were considered.
- Active convection area changed month by month, affected by the MJO phase and the positive SST anomalies in the Indian Ocean.
- The anti-cyclone was strengthened in mid-August and caused extreme weather events over East Asia.

Conclusion (2)

According to the vorticity budget analysis,

- **This anti-cyclone which migrated from the area of the mid-Pacific trough was a Rossby wave.**
- **Following three effects were important in the balance of the vorticity budget, the beta effect yielded by the strong southerly, the generation of anticyclonic vorticity by the upper troposphere divergence accompanied by active convection around the East China Sea, and the eastward advection of anticyclonic vorticities in the upper troposphere.**

Thank you.


Schematic chart of atmospheric circulation in August 2007
60°N
40°N
20°N
0°
20°S
60°E
90°E
120°E
150°E
180°
Meandering of subtropical jet
Frequent heavy rain
Extremely hot condition continued
Tibetan High
Stronger than normal over Japan
Warm humid lower-air flow
Sub-tropical high
Stronger than normal over Japan
Enhanced high pressure system
Monsoon westerly
Stronger than normal
Convective activity in the tropics
Enhanced from the Indian Ocean to the eastern Maritime Continent and eastward off the Philippines
Sea surface temperature
warmer than normal over the western Pacific and the Indian Ocean / colder over the eastern tropical Pacific

Thank you.