Factors of extreme summer conditions in East Asia in 2013

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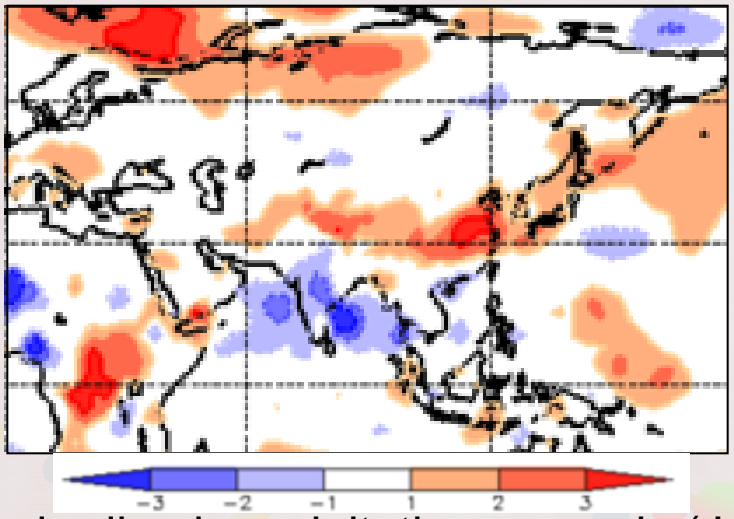
Structure of this presentation

- Climatic feature in East Asia in summer 2013
- Oceanic and Atmospheric conditions in Jul. to Aug. 2013
- What enhanced two unti-cyclones, Tibetan and Pacific high?
  - Statistical analysis
  - Simple model (LBM) experience
- Significant feature
  - No.1 : Heatwave in the first half of Aug.
  - No.2 : Heavy and torrential rain in the northern East Asia
- Summary

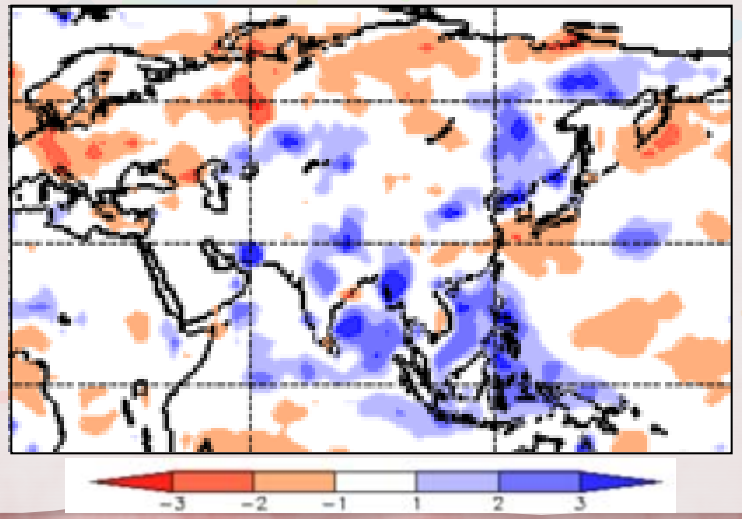
Asian climate in summer 2013

Standardized surface temperature anomaly (Jul. – Aug.)



• Significantly high temperature area covered East Asia along 30-40N.

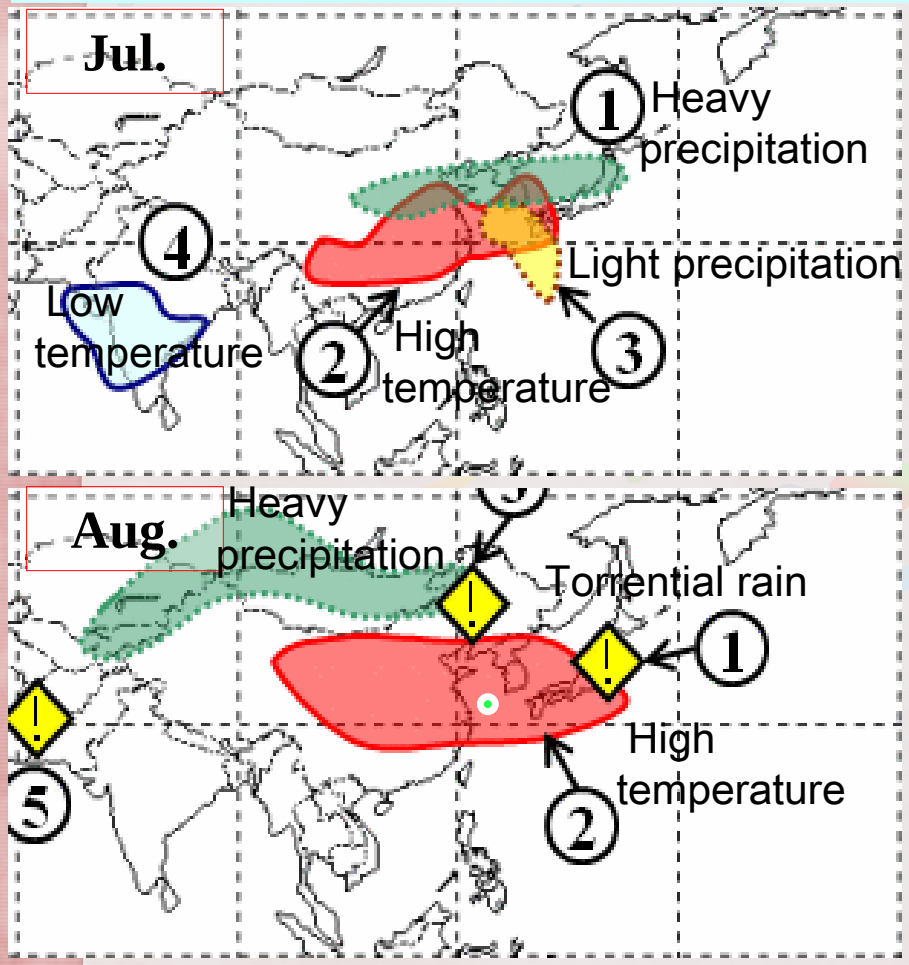
Standardized precipitation anomaly (Jul. – Aug.)

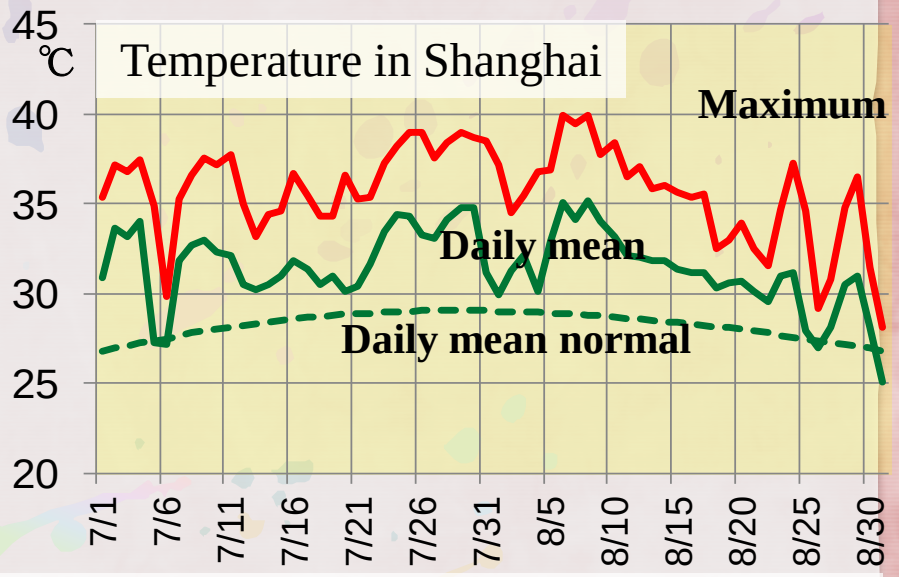


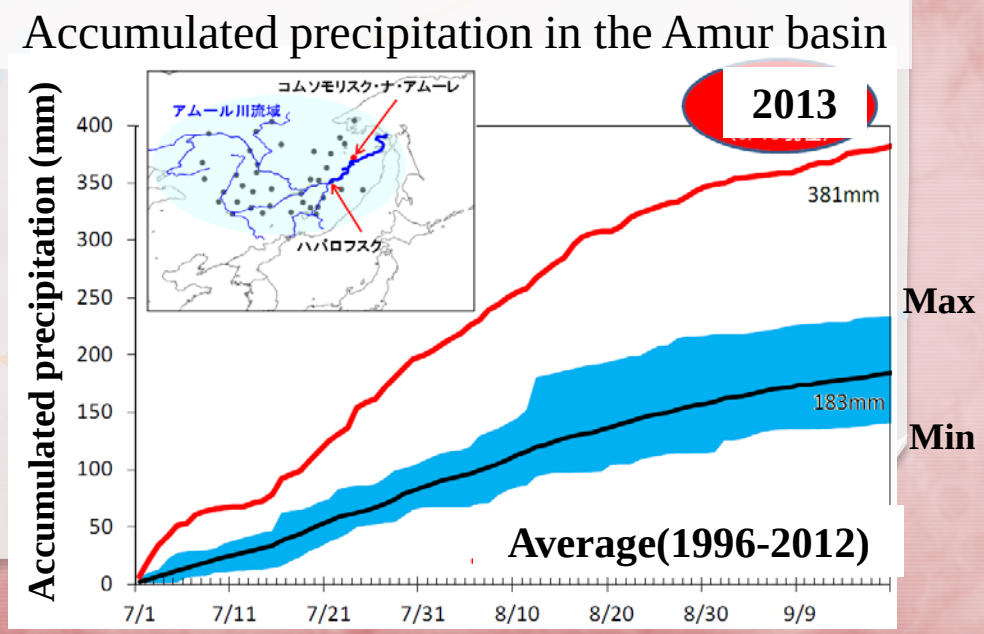
• Significantly heavy precipitation area covered the Amur basin and the northern China and Korea, while light precipitation area covered around the East China Sea.

Abnormal climate in East Asia

Distribution of abnormal climatic events

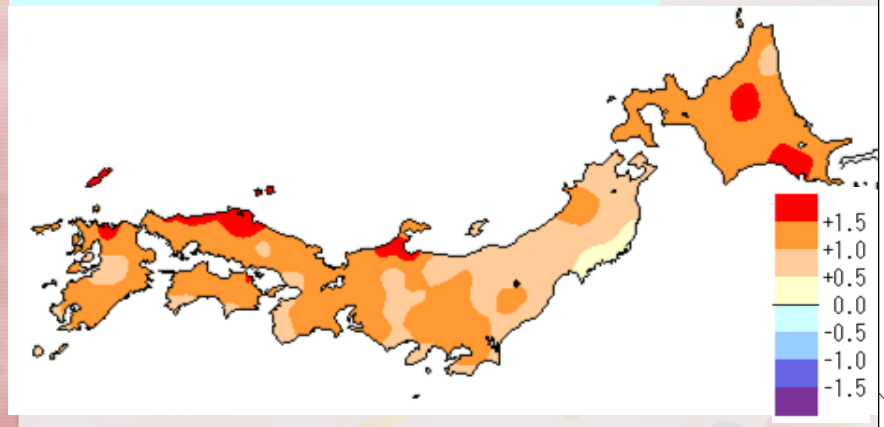




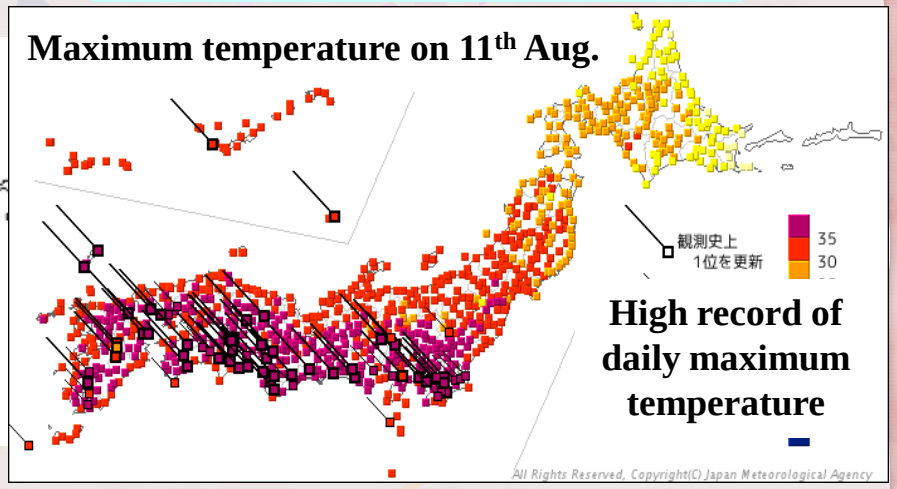


Hot summer in Japan

Distribution of temperature anomaly in summer 2013



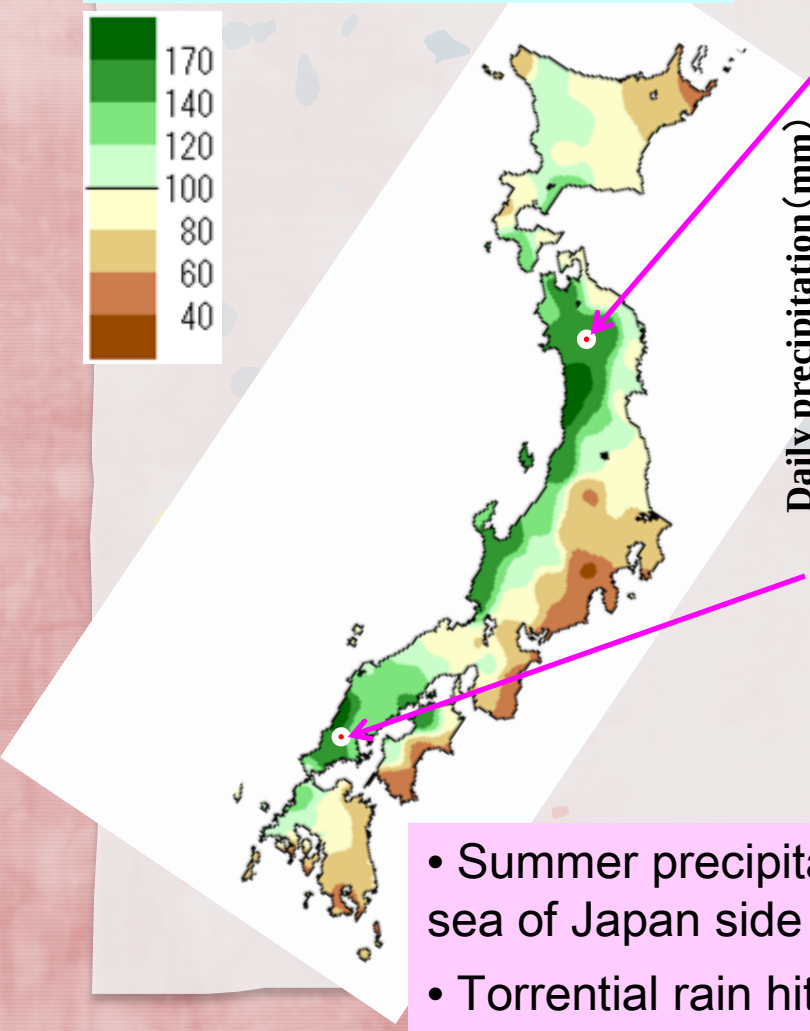
Heat wave in the mid-Aug.

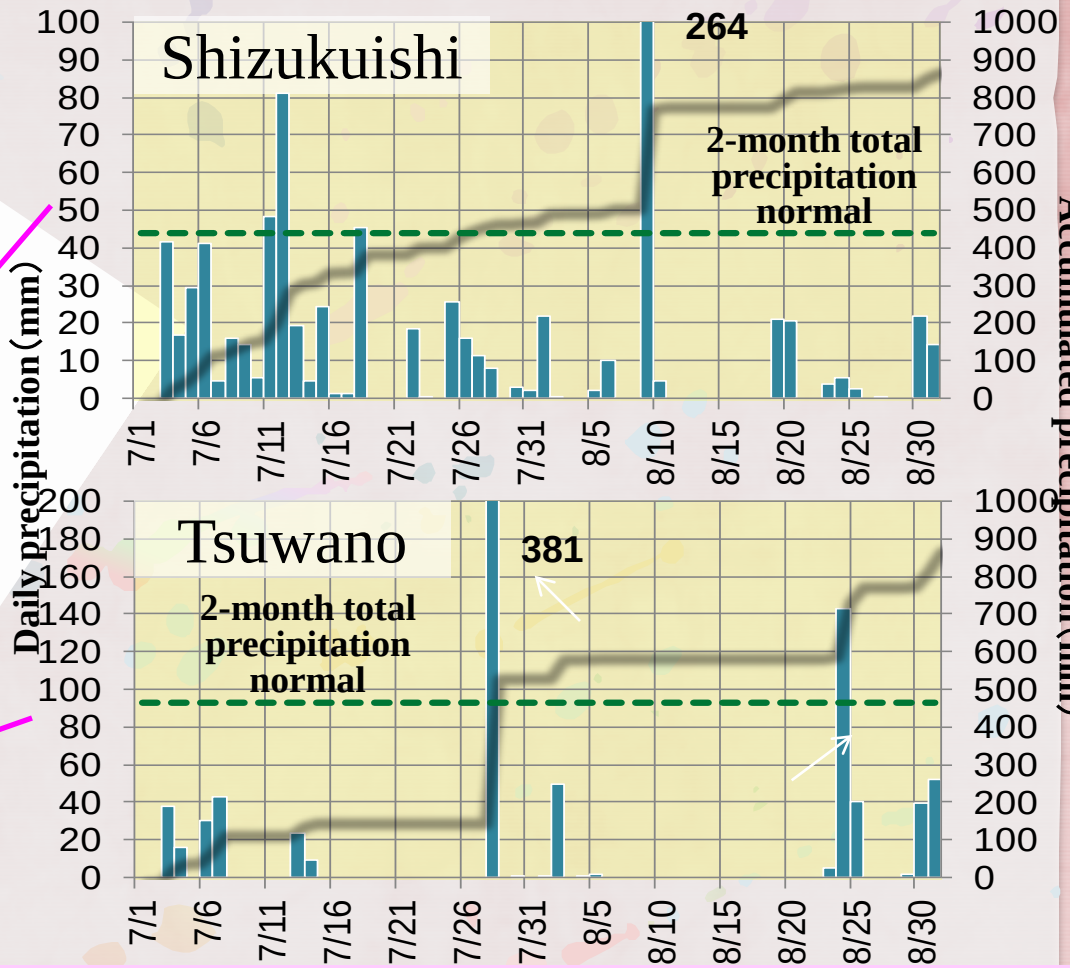


- Summer mean temperatures were above normal nationwide.
- Western Japan experienced the hottest summer since 1946.
- 41.0 C.deg was observed as the Japanese high record of daily maximum temperature.

Heavy and light precipitation in Japan

Distribution of precipitation ratio in summer 2013

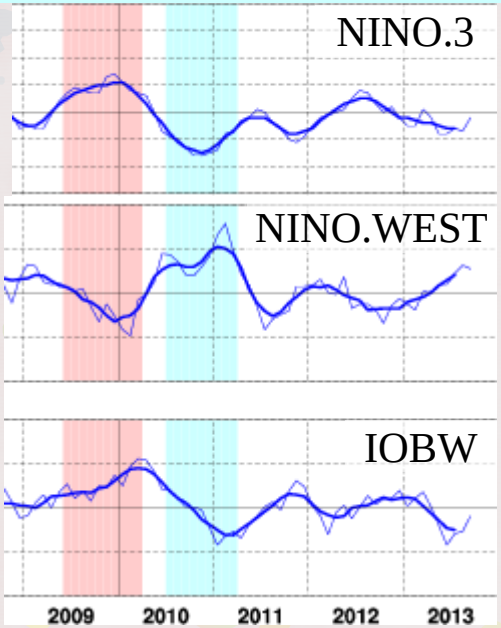




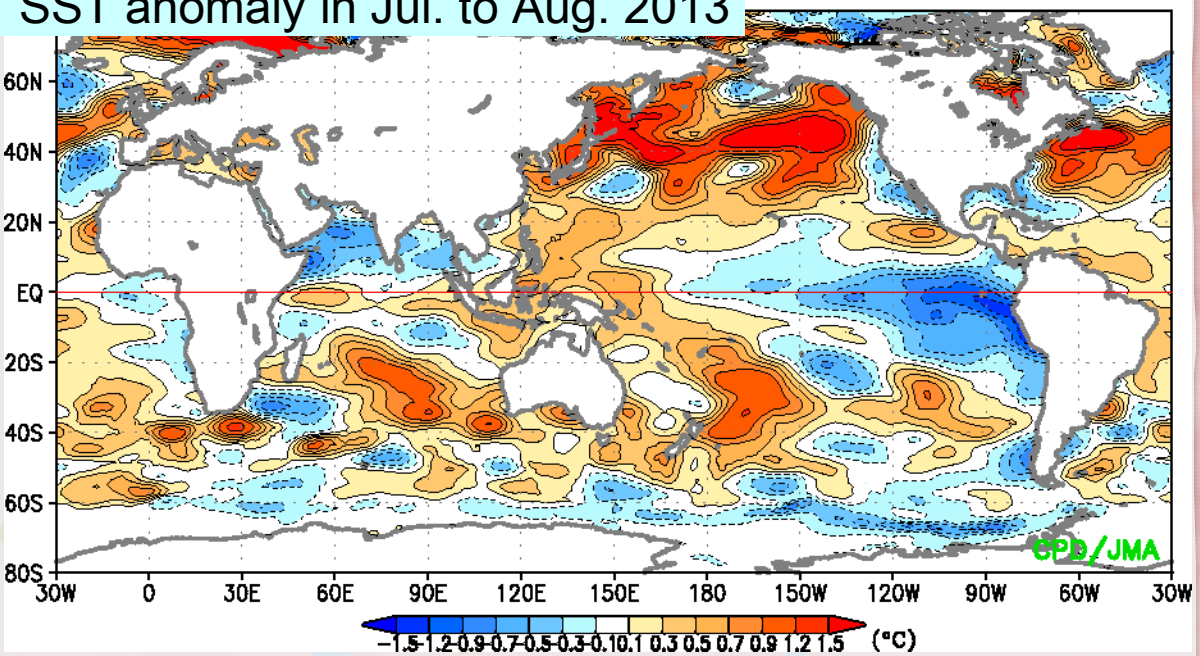
- Summer precipitations were significantly above normal on the sea of Japan side and below normal on the Pacific side.
- Torrential rain hit some places and caused floods and disasters.

Oceanic conditions in Jul. to Aug. 2013

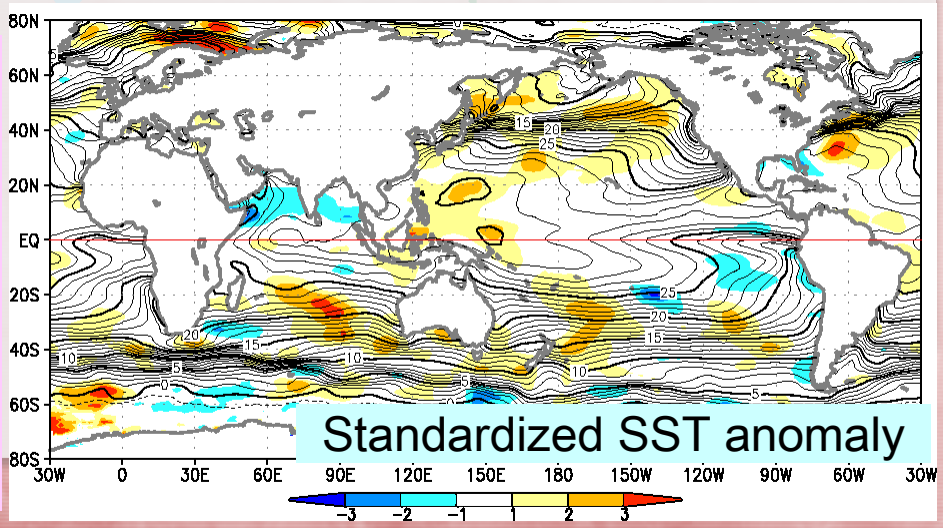
El Nino monitoring indices



SST anomaly in Jul. to Aug. 2013

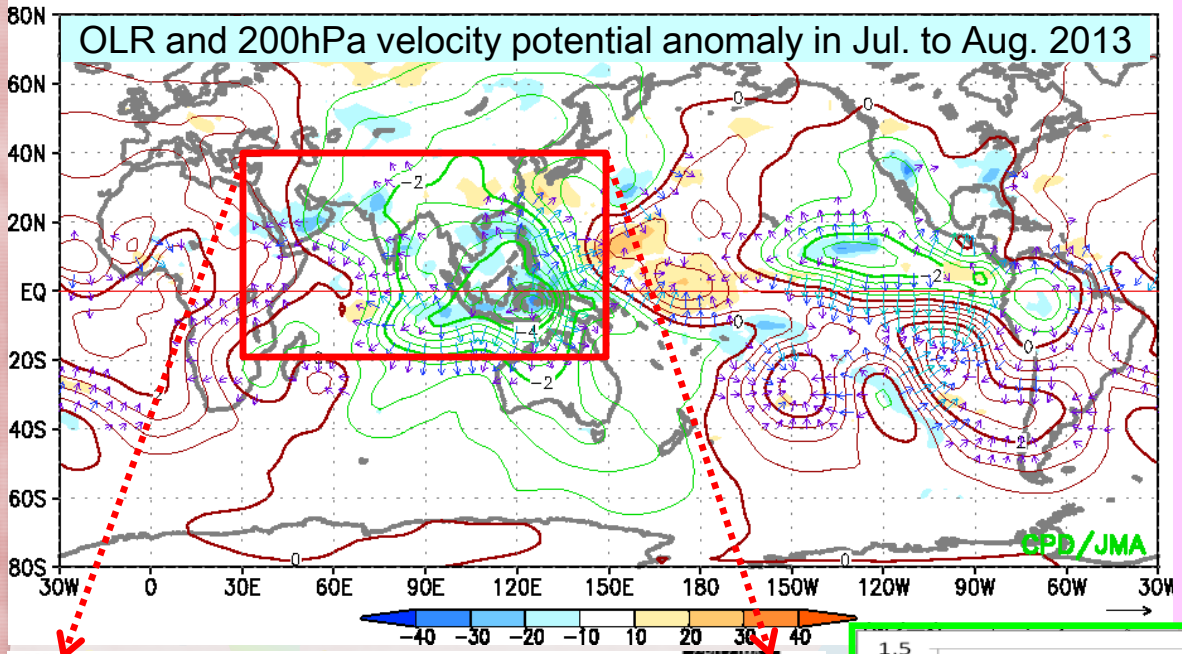


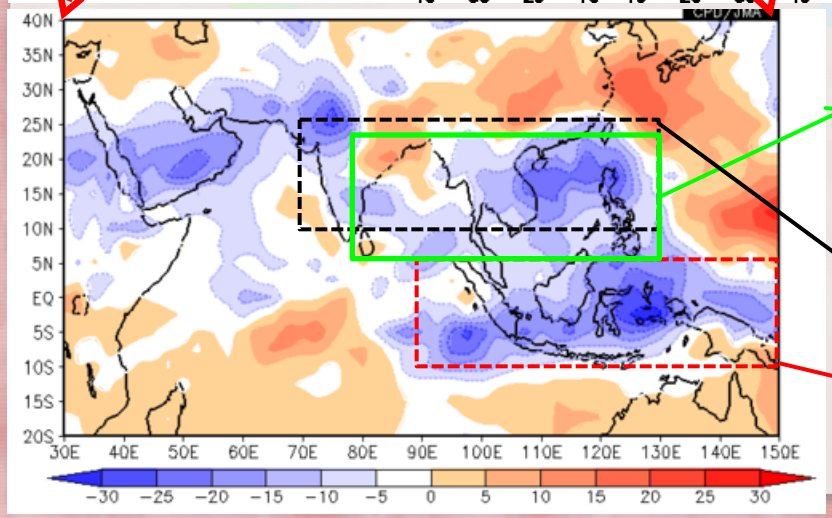
- Dominant positive anomaly in the maritime continent and western Pacific.
- Negative anomaly in the northern Indian Ocean and eastern Pacific.
- La Nina-like condition continued. (it weakened in September)

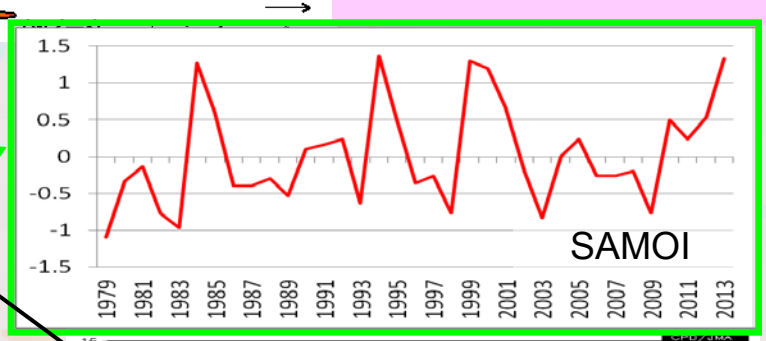


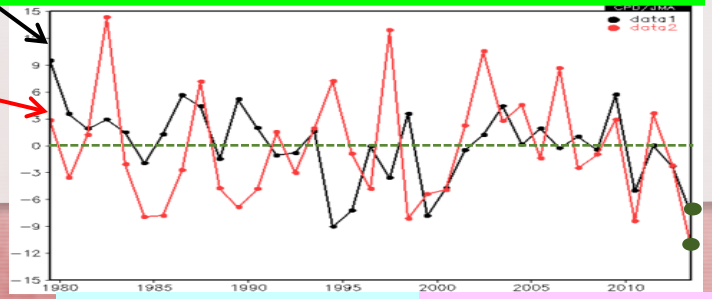
Standardized SST anomaly

Convective activities in Jul. to Aug. 2013









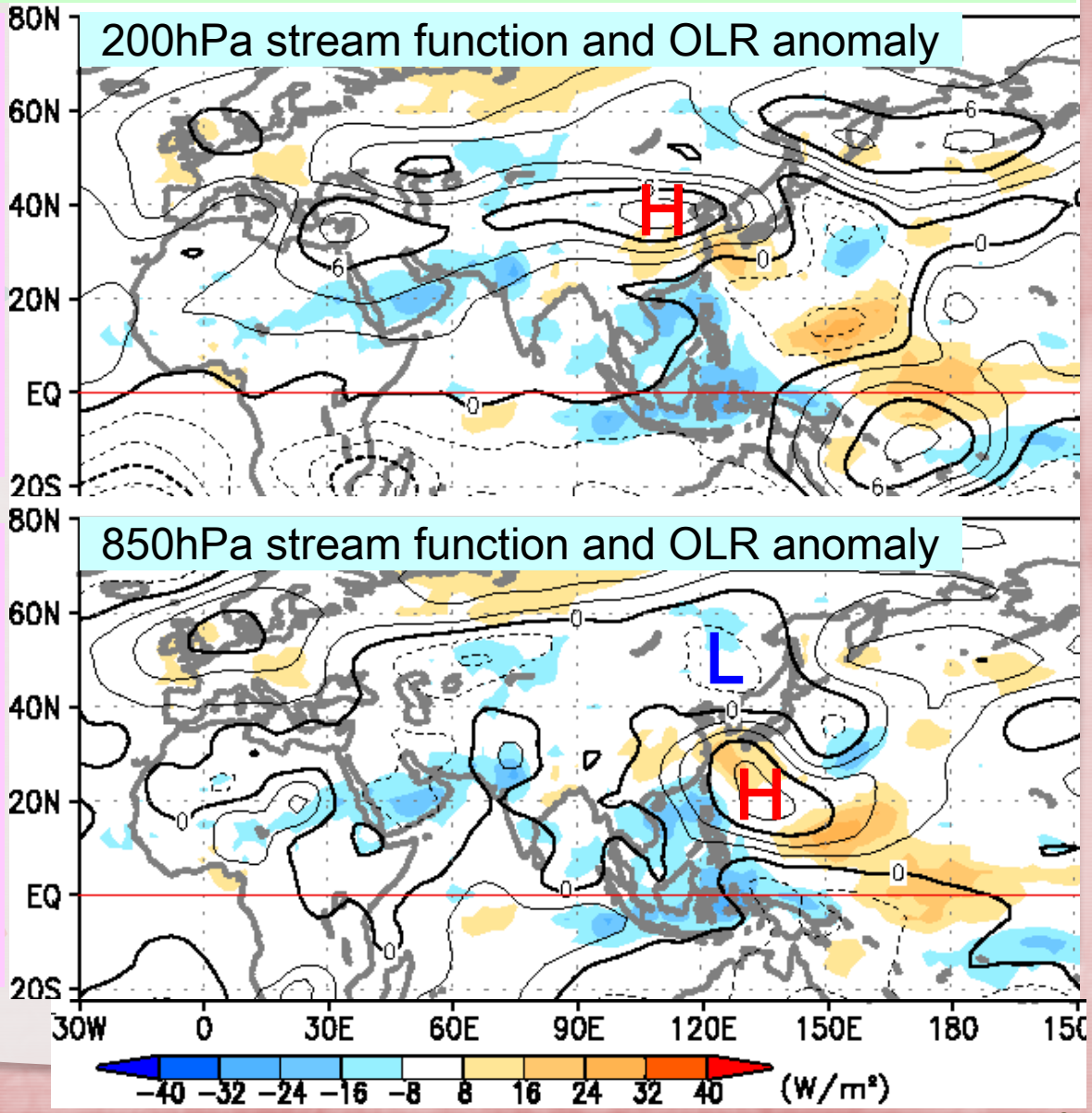
- Enhanced convective activities in Asian summer monsoon area.
- Summer Asian Monsoon Index (SAMOI) is the 2nd Largest behind 1994.
- Convection was active not only along 20N but also around Indonesia as well as recent relationship.

Negative correlation | Positive correlation

Atmospheric circulation in Jul. to Aug. 2013

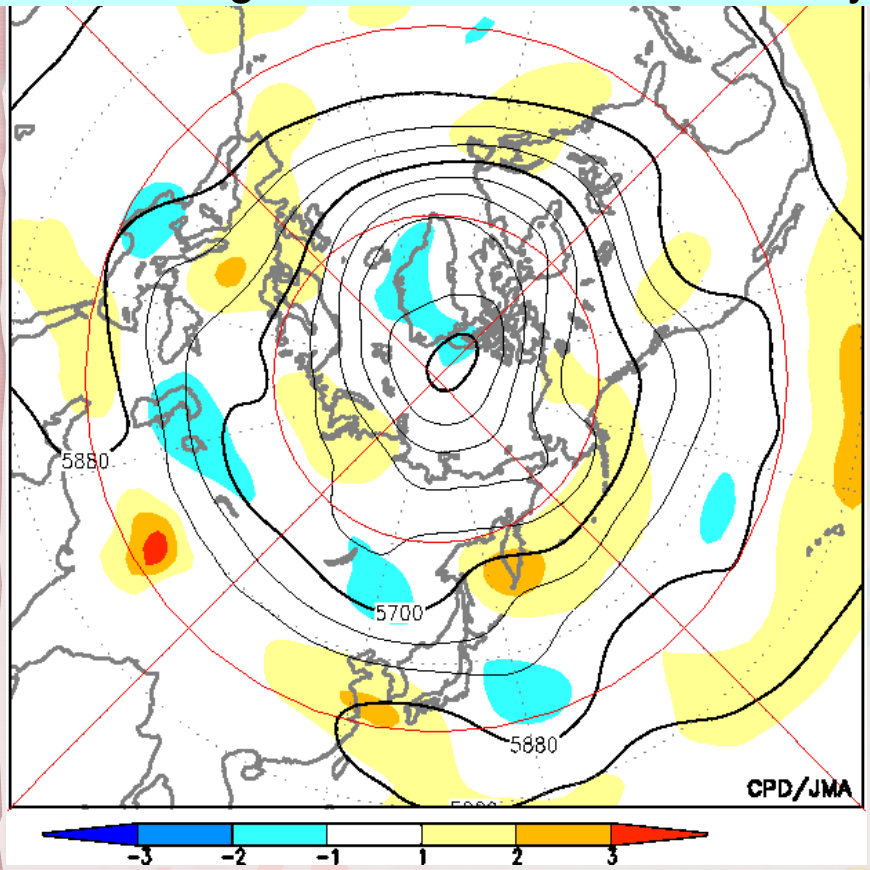
- unti-cyclonic circulation anomaly were dominant over Eurasia in the mid-latitude. → Strong Tibetan high.
- Subtropical jet stream shifted northward and stronger than normal.

- unti-cyclonic circulation anomaly were extremely dominant over the western north Pacific. → Strong Pacific high.
- cyclonic circulation anomaly stayed over the Amur basin.

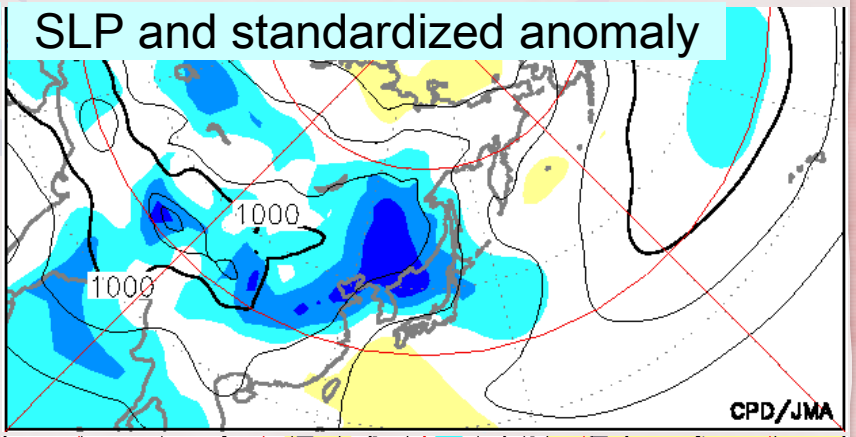


Atmospheric conditions in East Asia in Jul. to Aug. 2013

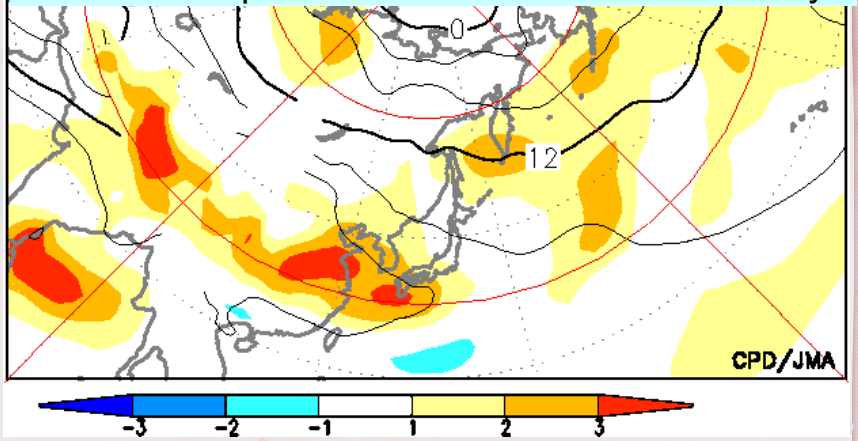
500hPa height and standardized anomaly



SLP and standardized anomaly

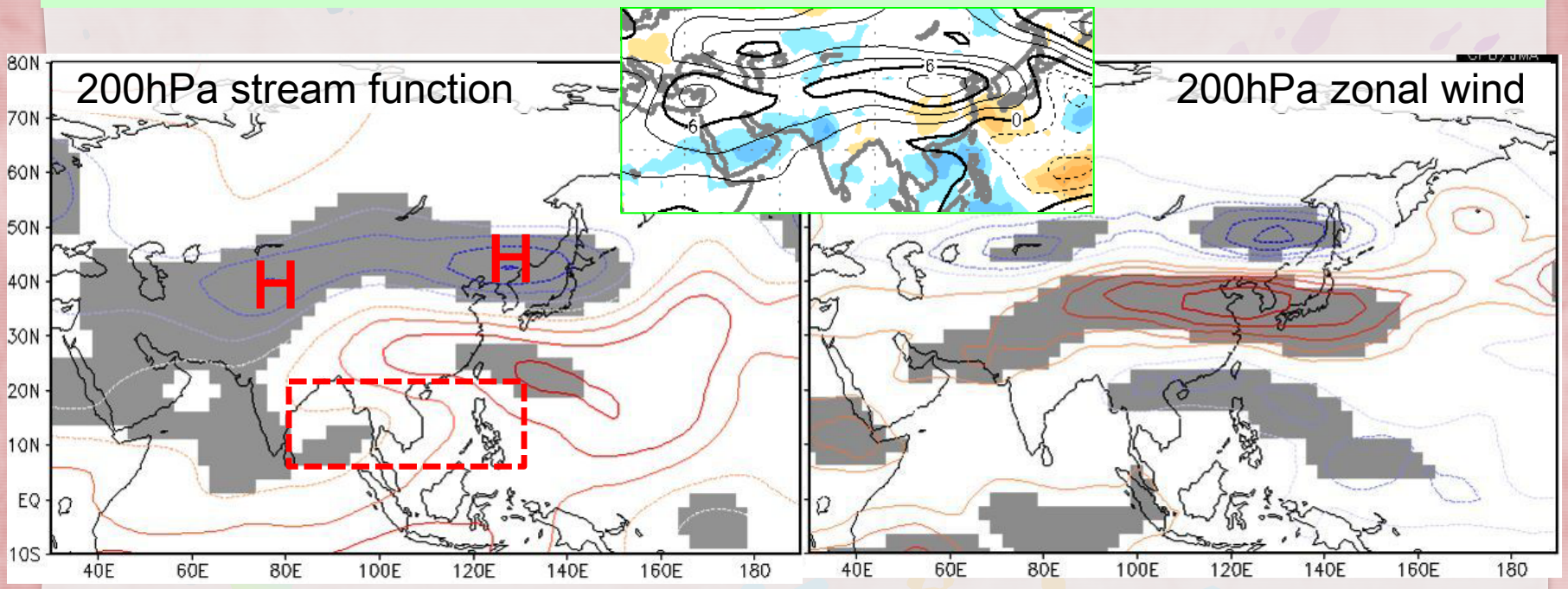


850hPa temperature and standardized anomaly



- Significant positive 850hPa temperature anomaly overlay East Asia accompanied with strong subtropical high.
- Significant low pressure anomaly was dominant over the northern East Asia.

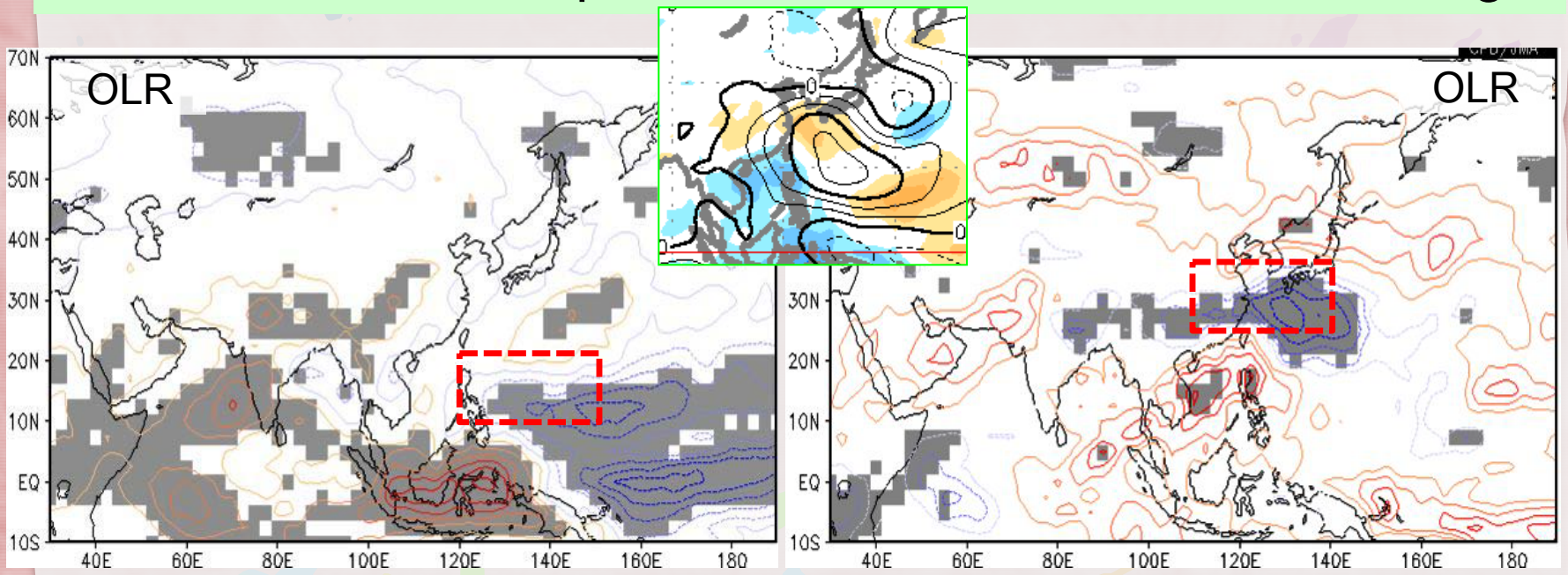
Statistical relationship between convection and Tibetan high



Regression coefficient to the OLR averaged within the red rectangle area in 1979-2012. Gray shade show significant area with 95% significant level.

- In case of active Asian monsoon, the Tibetan high tends to be stronger than normal. Also westerly jet tends to shift northward and be stronger than normal.
- The features in summer 2013 are quite similar to this relationship.
- So, active monsoonal convection is one of the factors of the strong Tibetan high in summer 2013.

Statistical relationship between convection and Pacific high

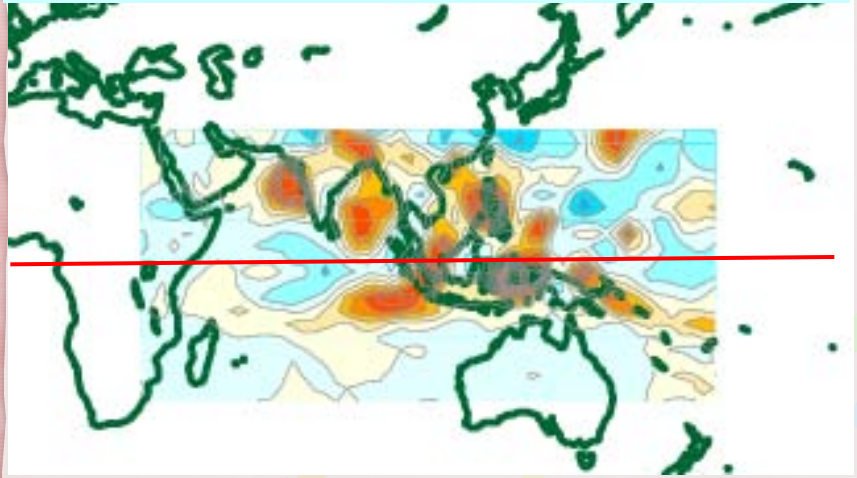


Regression coefficient to the 850hPa vorticity averaged within the red rectangle area in 1979-2012.
Gray shade show significant area with 95% significant level.

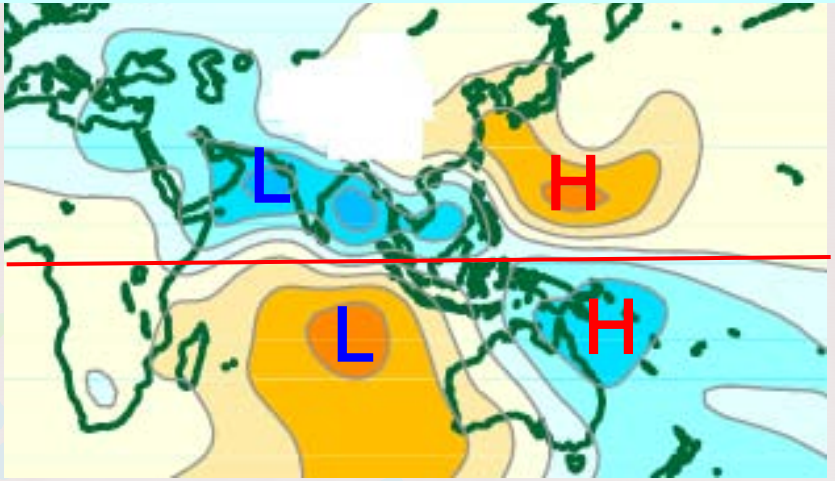
- The southern part of the strong Pacific high seems to be a result of Rossby response to the cooling anomaly in west of the date line.
- The northern part of the strong Pacific high seems to be a result of the P-J pattern excited by the active convection around the South China Sea.

Simple model response to the heating anomaly in Asian monsoon area

Input heating anomaly in Jul. to Aug. into the linear baroclinic model (LBM)



The response in 850hPa stream function by LBM

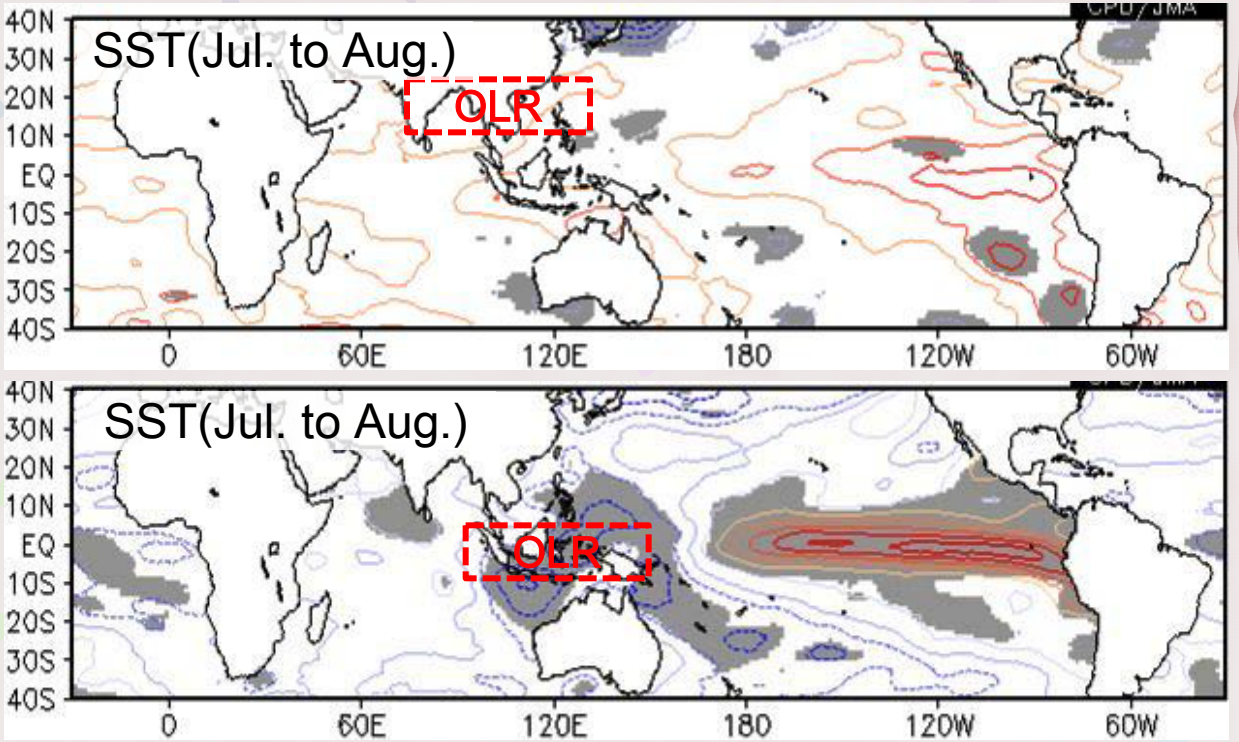


The LBM is developed by Watanabe and Kimono. The resolution of LBM is T42L40.

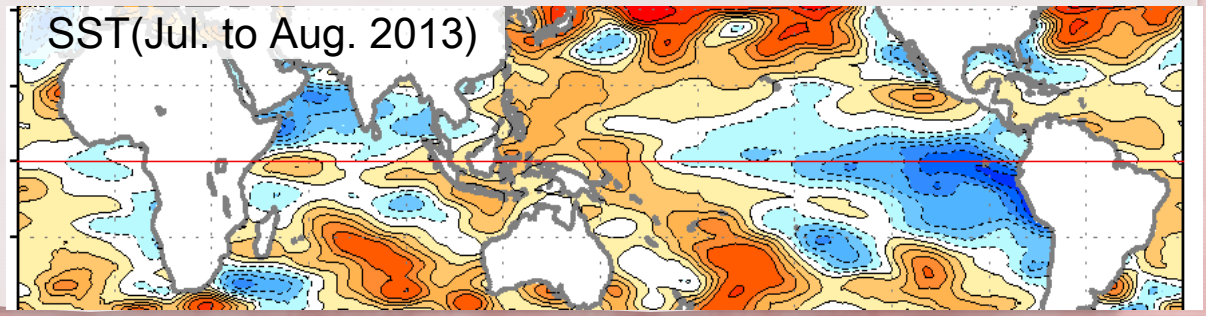
- The response in the lower troposphere is quite similar to the analysis.
- This response is considered as a result of Rossby response to the heating/cooling anomalies in Asian monsoon region.

Statistical relationship between convection and SST

- In case of enhanced convective activity around Indonesia, distribution of SST anomaly shows the La Nina-like pattern.
- This relationship is consistent with the feature in 2013.
- Meanwhile, no relationship is found in the relationship between convection around the northern part of Asian monsoon area and tropical SST .

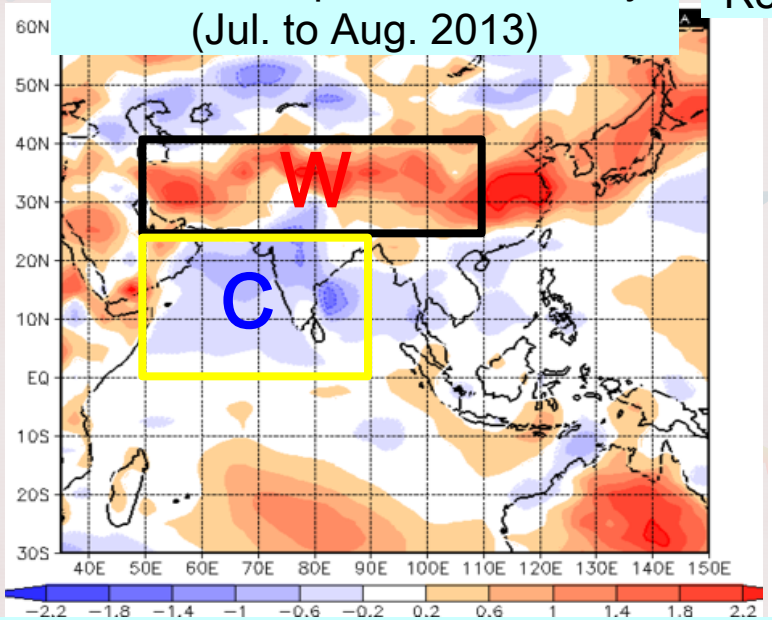


Regression coefficient to OLR averaged within the red rectangle area in 1979-2012. Gray shade show significant area with 95% significant level.

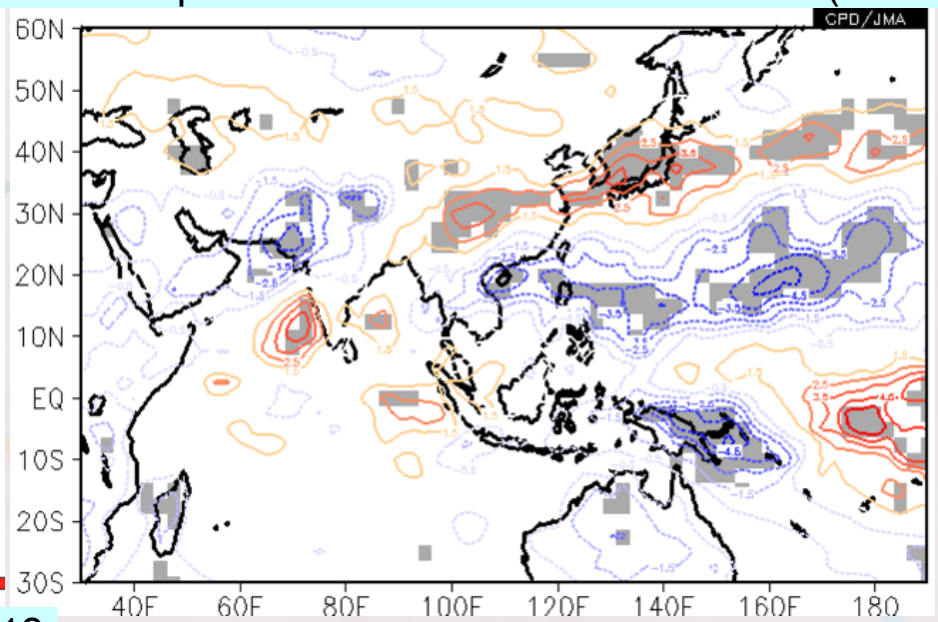


Statistical relationship between convection and heat contrast over Eurasia and the Indian Ocean

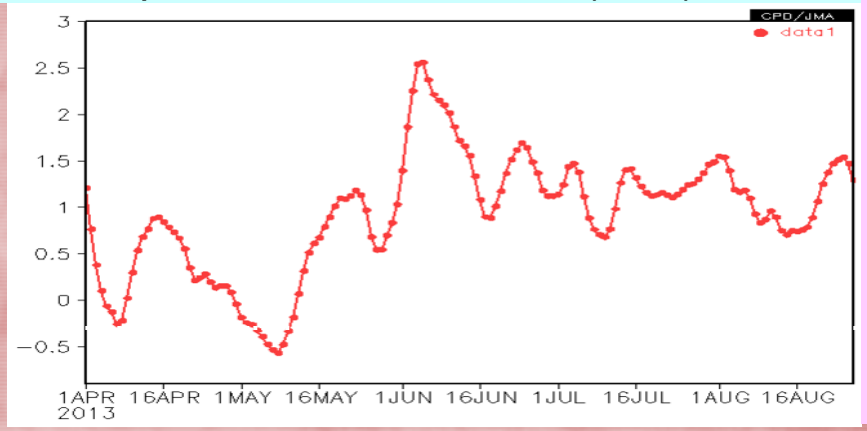
Surface temperature anomaly (Jul. to Aug. 2013)



Relationship between OLR and heat contrast (W – C)



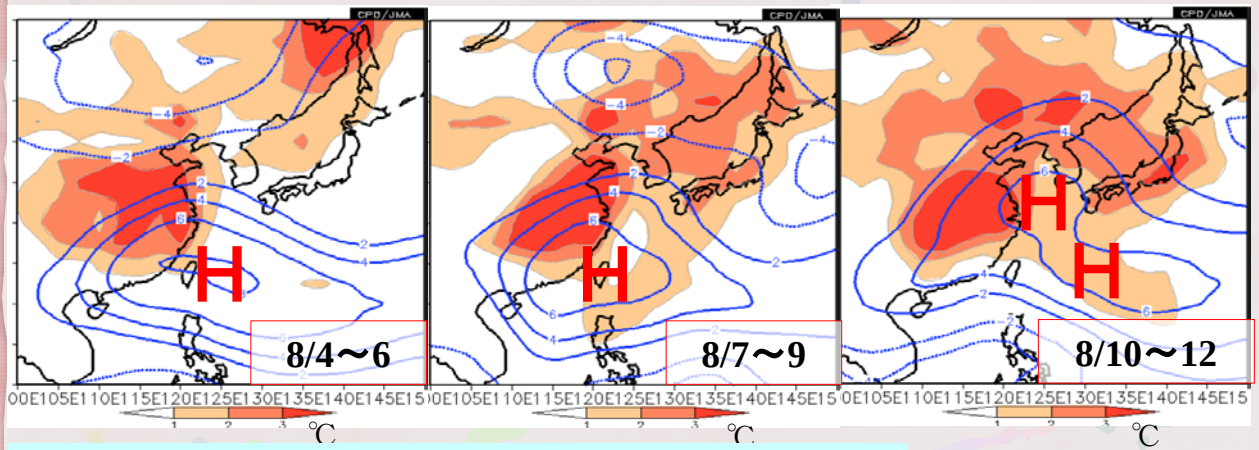
Time sequence of heat contrast (W-C) in 2013



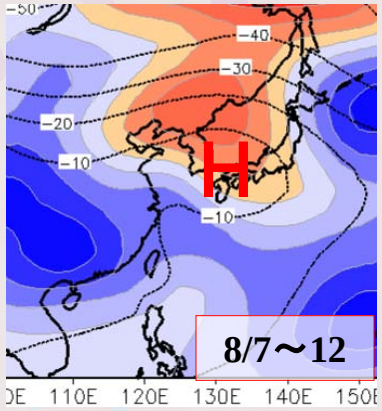
- In case of large heat contrast over Eurasia and the Indian Ocean, convection in the northern part of Asian monsoon area tends to be more active.
- Although this relationship maybe a result of active monsoon, it is possible that there is a positive feedback mechanizm.

Significant heatwave in the first half of Aug.

850hPa stream function and surface temperature anomaly

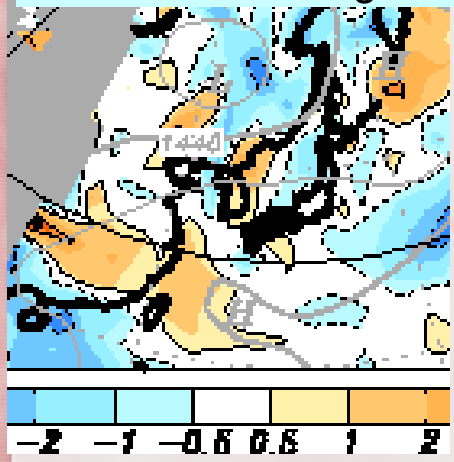


250hPa stream function anomaly

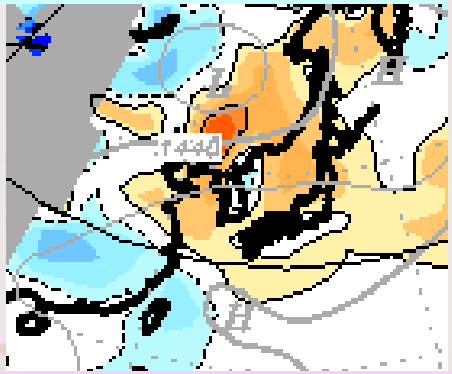


Heat budget analysis (K/day)

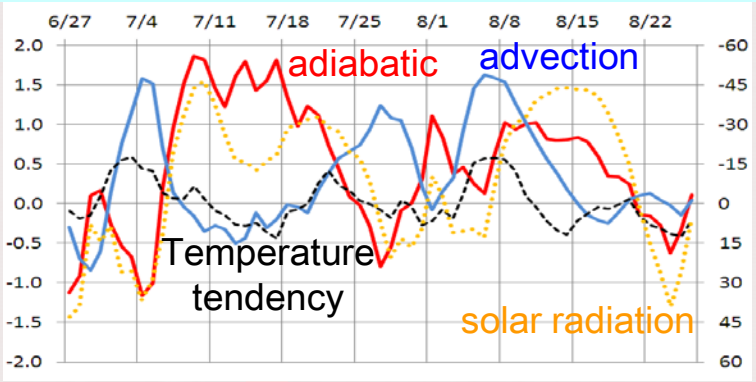
adiabatic heating



horizontal advection



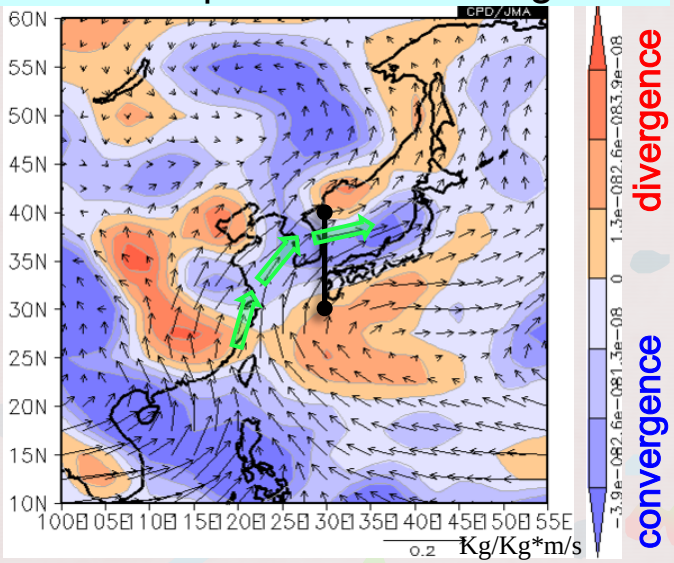
Time sequence for each item of heat budget around western Japan



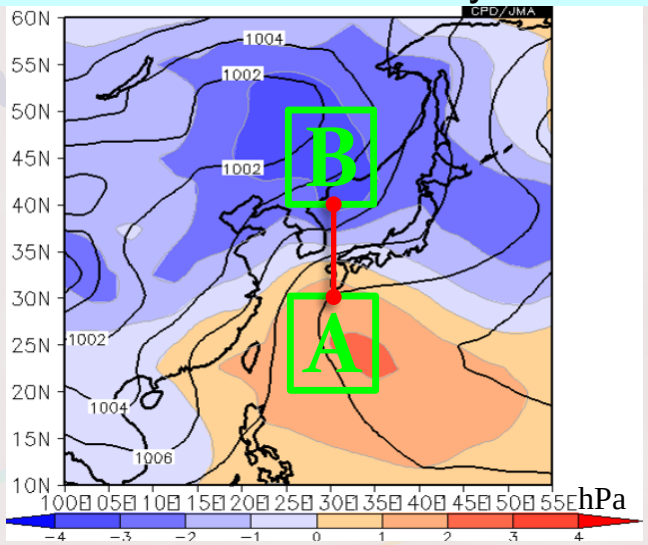
- Two heatwave hit western Japan. They were brought by meridionally tilted strong barotropic unti-cyclones.
- In both cases, horizontal advection followed by adiabatic heating and solar radiation played an important role.

Heavy rain and torrential rain in the northern East Asia

925hPa water vapor flux and divergence

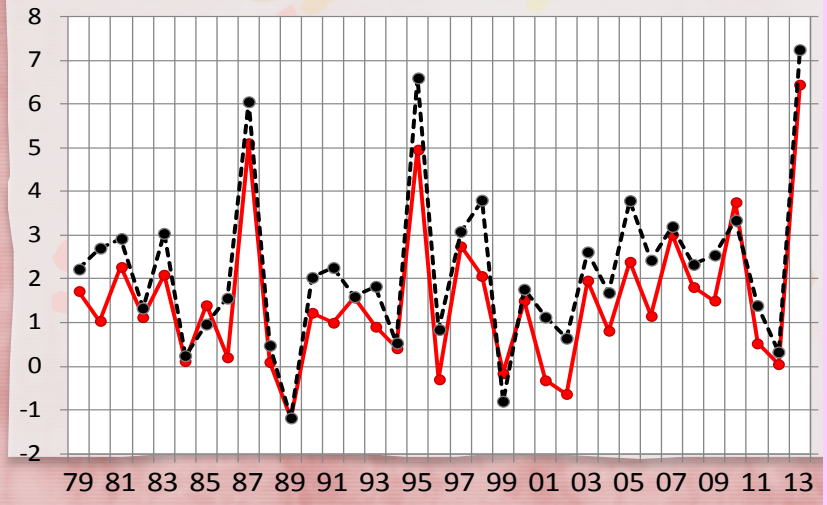


SLP and anomaly



Black: Zonal component of 925hPa water vapor flux across the black line

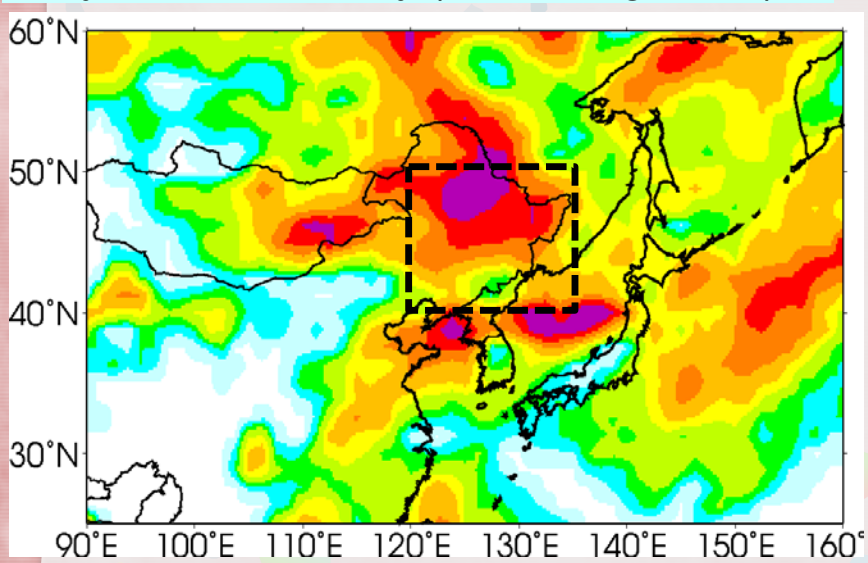
Red: Difference of SLP anomaly between area A and B



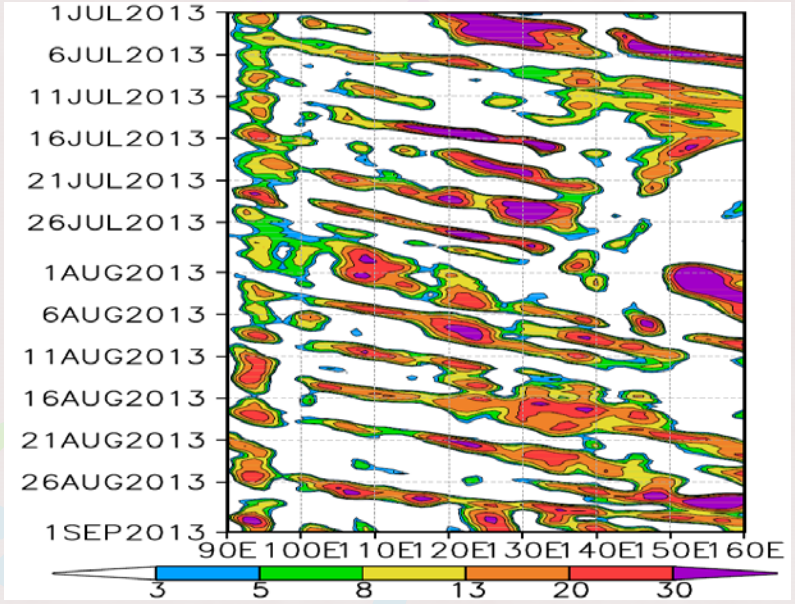
- Northward water vapor flow accompanied with the strong Pacific high was strong over the East China Sea.
- Further northward flow over the continent and eastward flow over the Japan Sea were also significantly strong.
- These two flow were accompanied with the dominant cyclone over the Amur basin.

Cyclone activity over the Amur basin

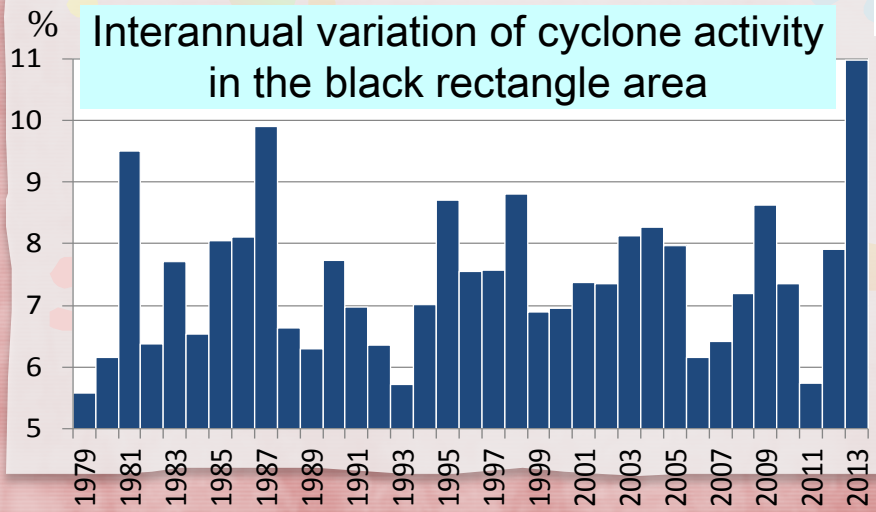
Frequency of cyclone existence calculated by 850hPa vorticity (Jul. to Aug. 2013)



Time-Longitude cross section of 850hPa vorticity along 40-50N in Jul. to Aug. 2013



Interannual variation of cyclone activity in the black rectangle area

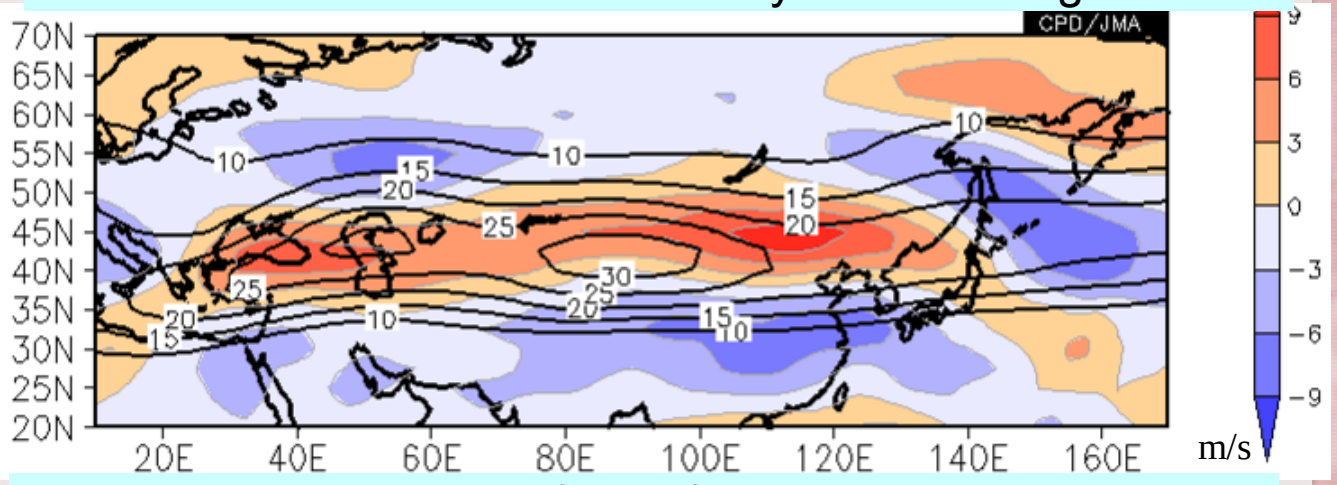


- Cyclone frequently passed and brought much precipitation over the Amur basin in summer 2013.
- The cyclone activity over the Amur basin is the strongest since 1979.

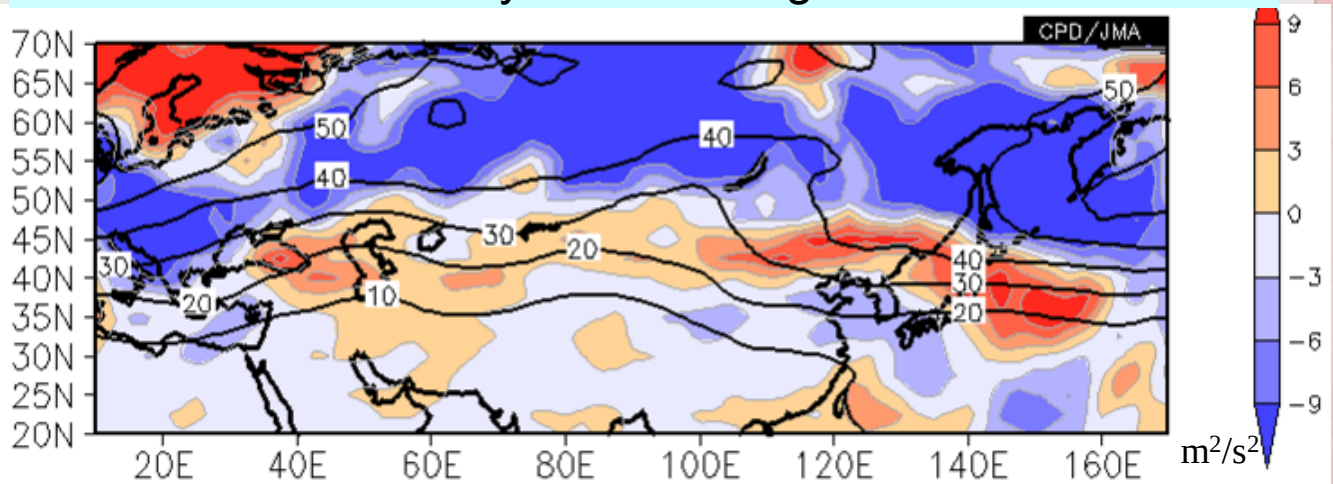
Relationship between cyclone activity and subtropical jet

- Strong cyclone activity was accompanied with the strong subtropical jet.

200hPa zonal wind and anomaly in Jul. to Aug. 2013



300hPa kinetic energy of high-frequency disturbance and anomaly in Jul. to Aug. 2013



Summary

- Central part of East Asia experienced extremely hot summer.
- Northern part of East Asia was hit by heavy and torrential rain in Jul. and Aug..
- Dominant Tibetan high and Pacific high brought hot .summer to central part and wet summer to northern part.
- These highs were enhanced by active convective activity in Asian monsoon region.
- It is possible that La Nina-like condition and large heat contrast are contributed to active convection.
- Meridionally tilted barotropic unti-cyclone brought extreme heatwave.
- Strong subtropical jet and strong water vapor flow along Pacific high induced many synoptic disturbances and they brought heavy and torrential rain.

Thank you