EASCOF-4, Ulaanbaatar, Mongolia, 8-9 November 2016

Characteristics of 2016 summer monsoon in East Asia

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- Overview of 2016 summer monsoon in East Asia and associated atmospheric circulations
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  - Case: Typhoon "Lionrock" track
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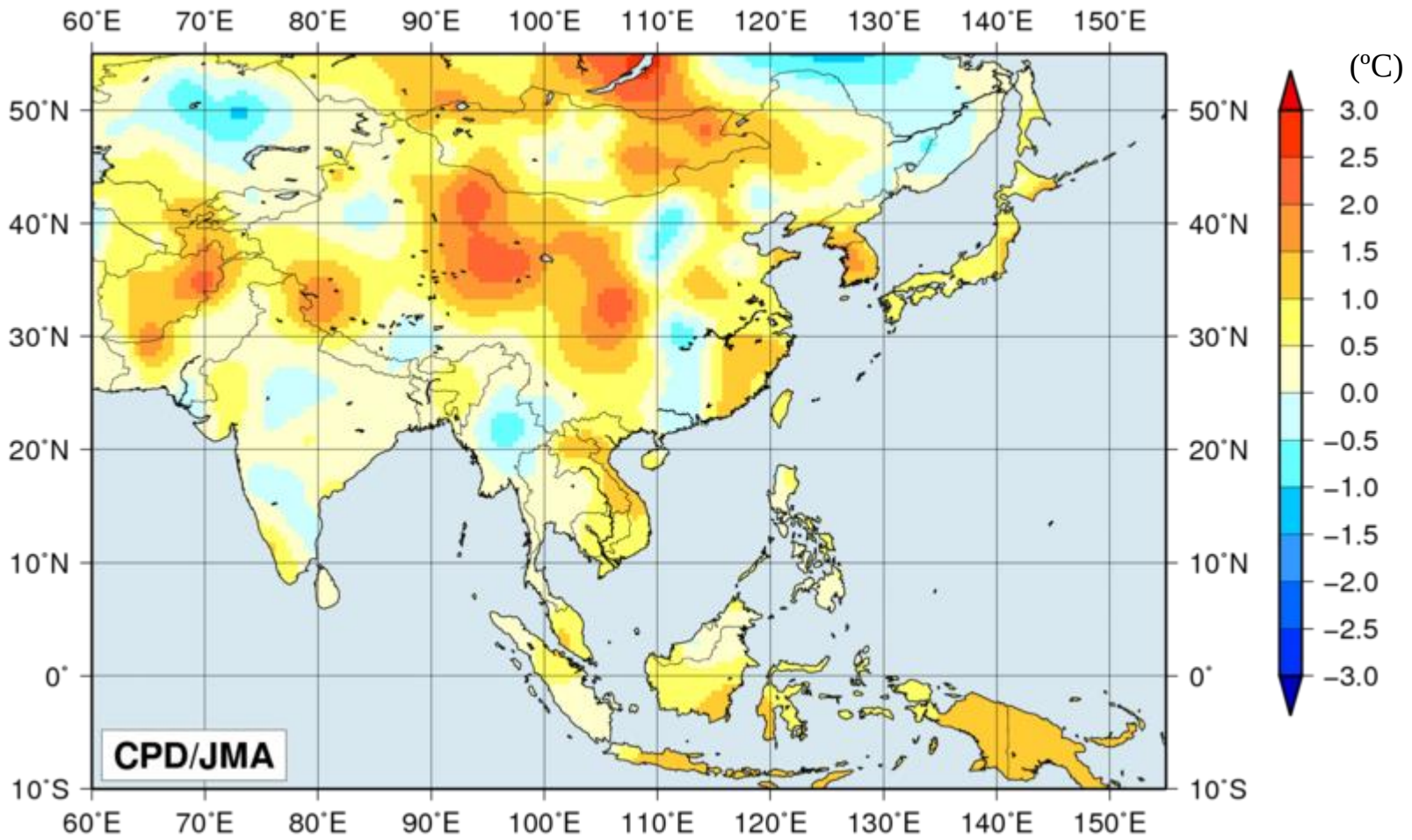
3-month mean surface temperatures for Jun-Aug

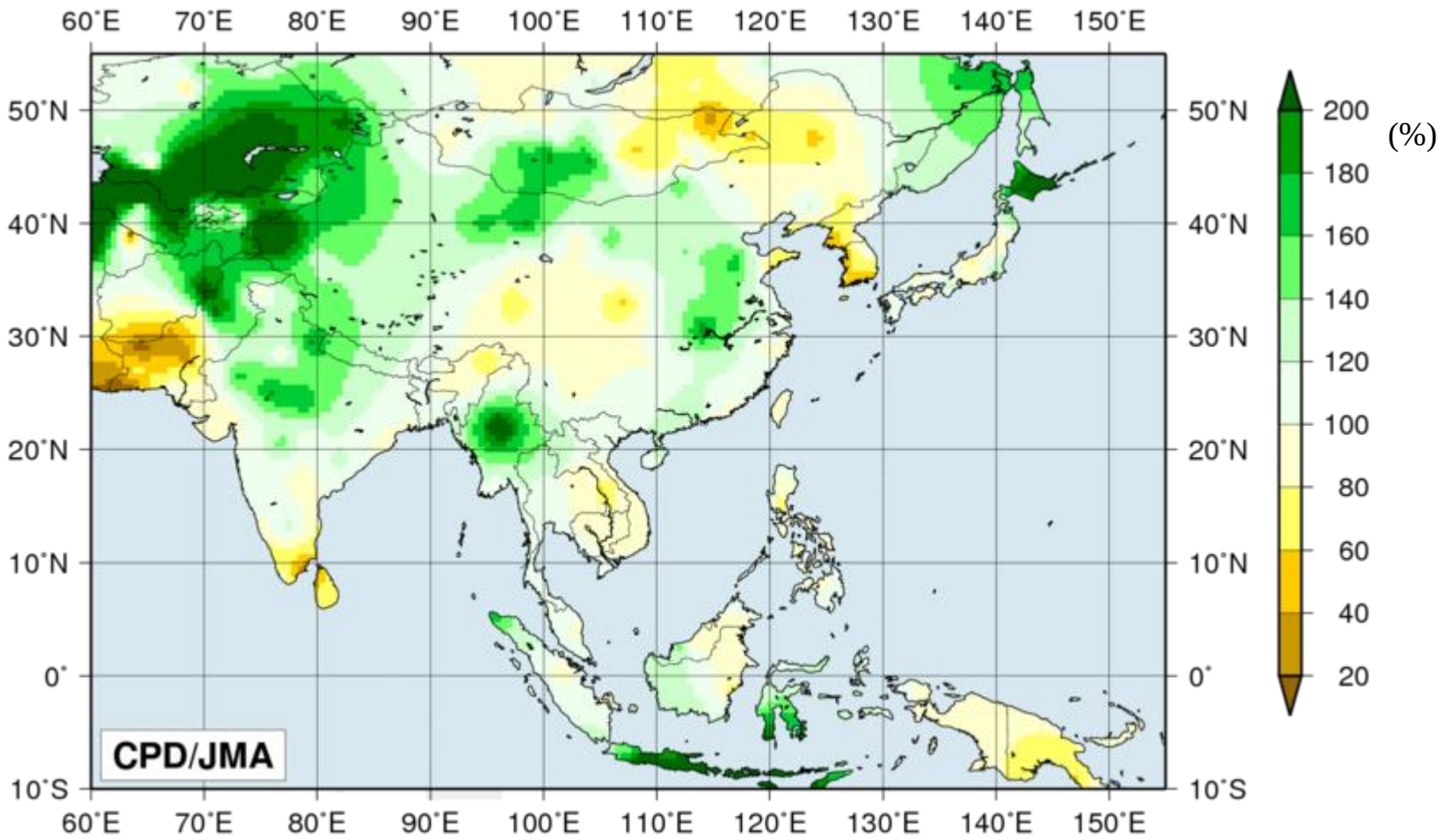
Warmer than normal: Japan, Korea, parts of China, and eastern Mongolia
Cooler than normal: parts of China



Temperature anomalies for Jun-Aug

3-month precipitation amounts for Jun-Aug

Wetter than normal: northern Japan, western China, and southwestern Mongolia
Drier than normal: Korea, northeastern China, and eastern Mongolia



Precipitation ratio against normal for Jun-Aug

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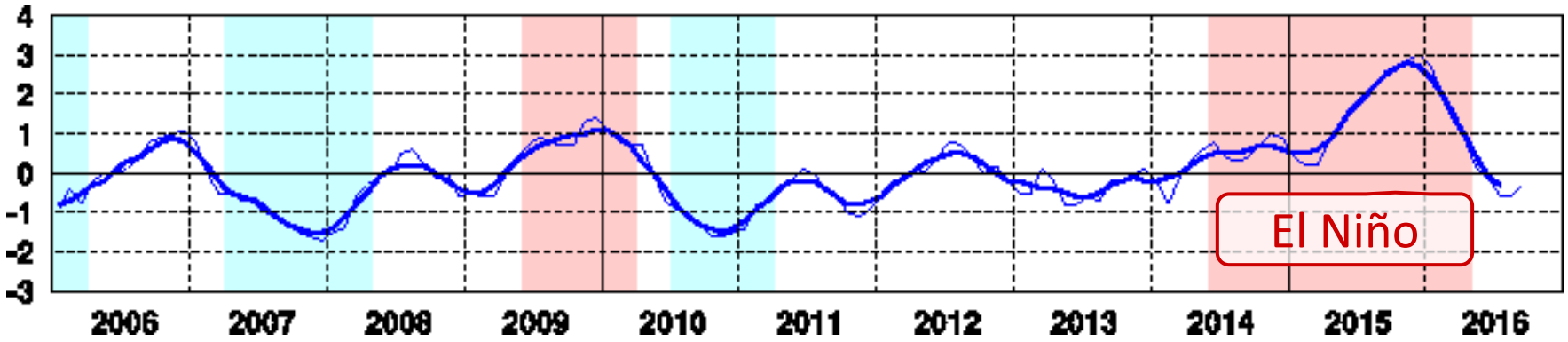
ENSO monitoring indices (NINO.3 SST)

Definition of El Niño (La Niña) by JMA

- 5-month running mean of NINO.3 SST deviation stays +0.5ºC or higher (-0.5ºC or lower) for 6 consecutive months or longer.

The SST is monthly mean sea surface temperature averaged over NINO.3 (5˚N-5˚S, 150˚W-90˚W).

	2015			2016								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Monthly mean SST (˚C)	27.6	27.9	28.1	28.2	28.3	28.7	28.3	27.2	26.4	25.2	24.6	24.7
SST deviation (˚C)	+2.7	+2.9	+3.0	+2.7	+2.0	+1.6	+0.8	+0.1	-0.1	-0.6	-0.6	-0.3
5-month mean (˚C)	+2.7	+2.8	+2.7	+2.4	+2.0	+1.4	+0.9	+0.4	-0.1	-0.3		



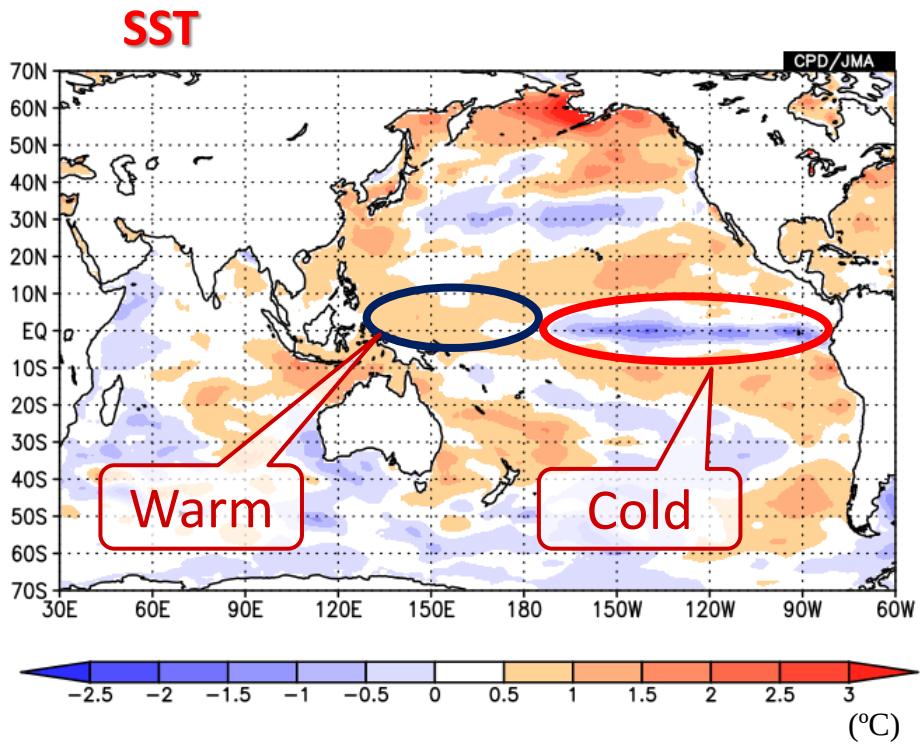
Sea surface temperature (SST) deviations from the climatological mean based on a sliding 30-year period for NINO.3

Thin lines indicate a monthly mean value, and smoothed thick curves, a five-month running mean.

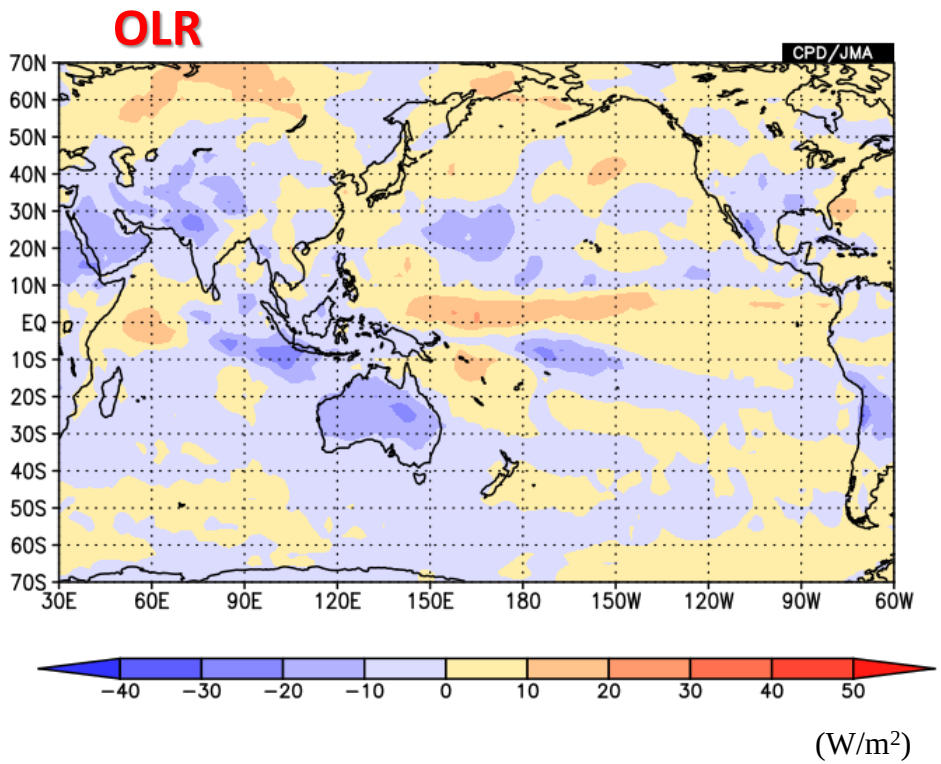
Red shaded areas denote El Niño periods, and blue, La Niña ones.

SST and Convective activity (OLR) for Jun-Aug

- In the equatorial Pacific, positive SST anomalies were observed in the western part, and negative SST anomalies were observed from the central to eastern parts.
- Convective activity in the tropics was enhanced over the eastern Indian Ocean and suppressed over the western Indian Ocean and the western to central Pacific.



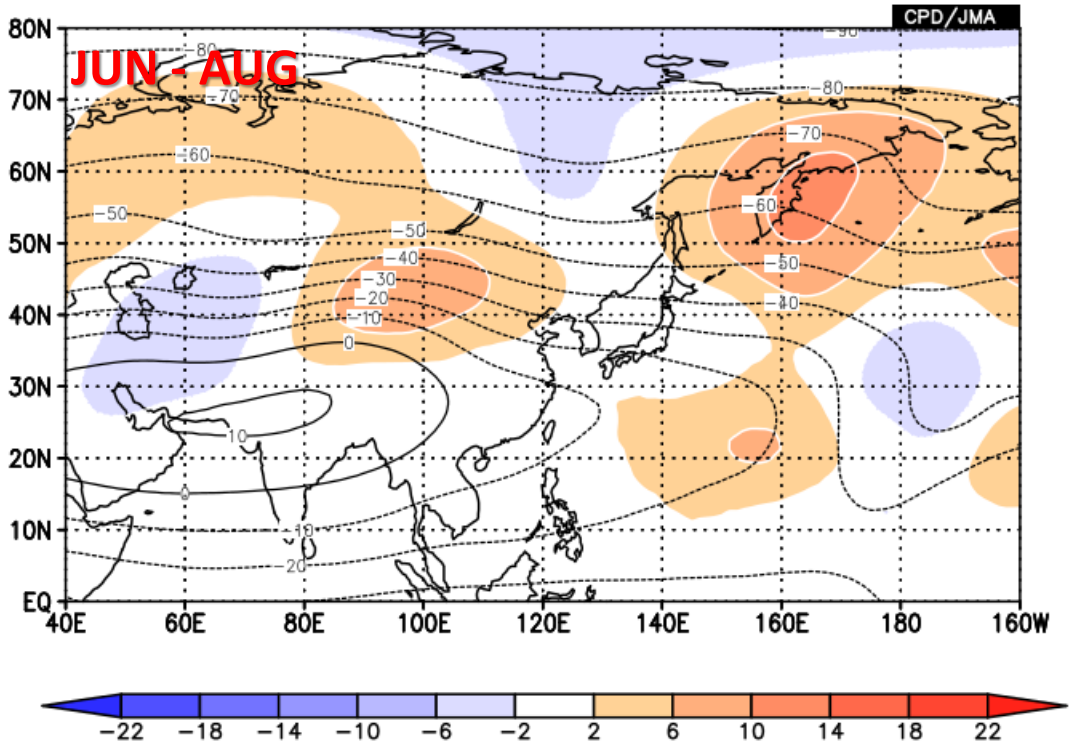
SST anomalies for the three months of Jun-Aug

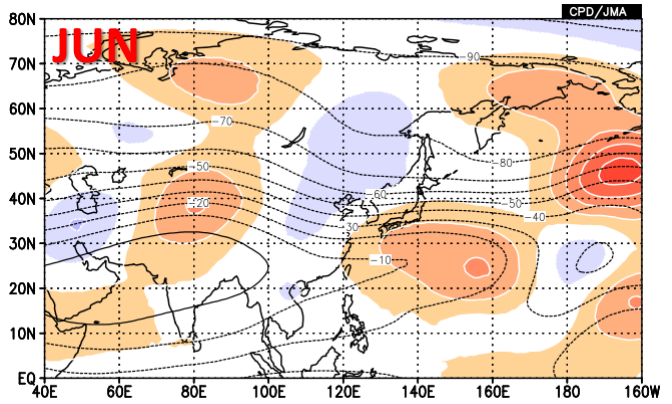


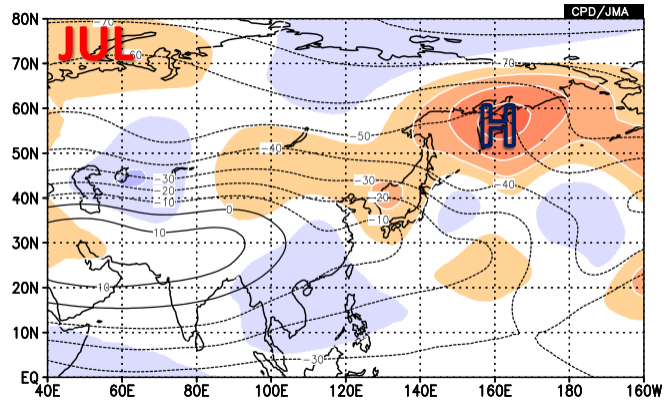
OLR (contour) and anomaly (shade) for the three months of Jun-Aug

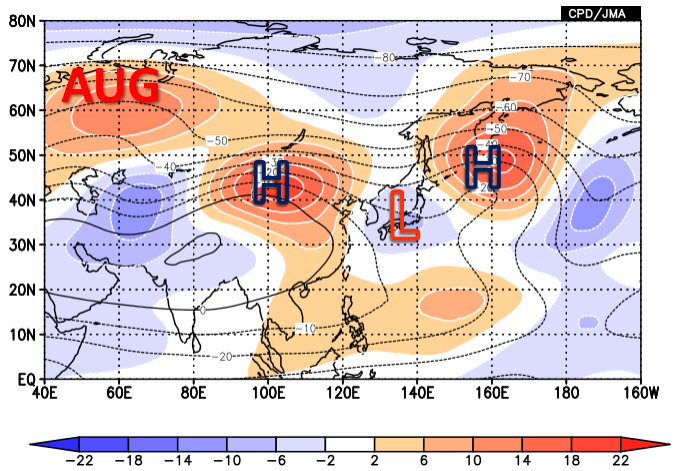
Stream function at 200hPa for Jun-Aug

- The three month mean featured anticyclonic circulation anomalies over the Kamchatka Peninsula and Mongolia.
- From July to August, The Tibetan High was stronger than normal over its northeastern part





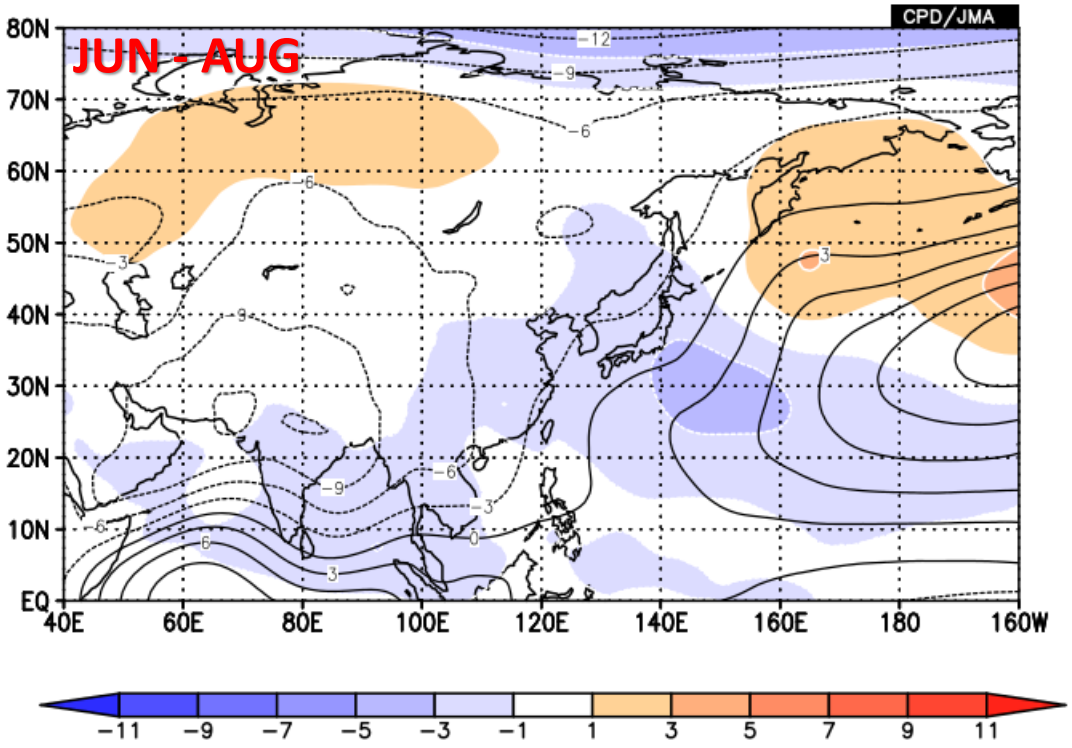


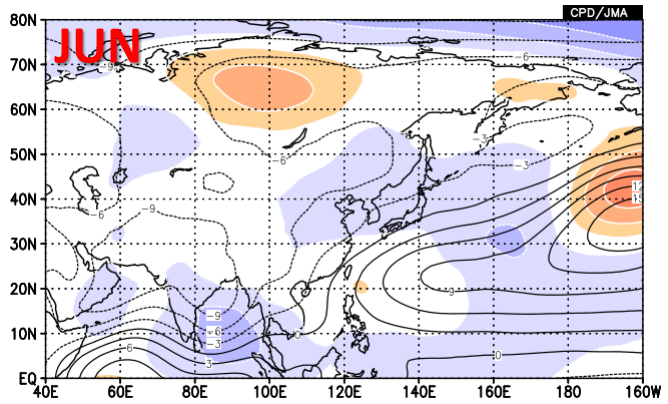


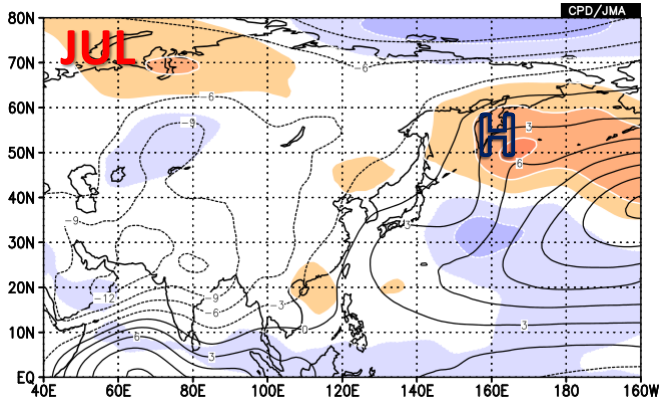
Stream function (contour) and anomaly (shade) at 200hPa for the three months of Jun-Aug (above) and for individual months (right)

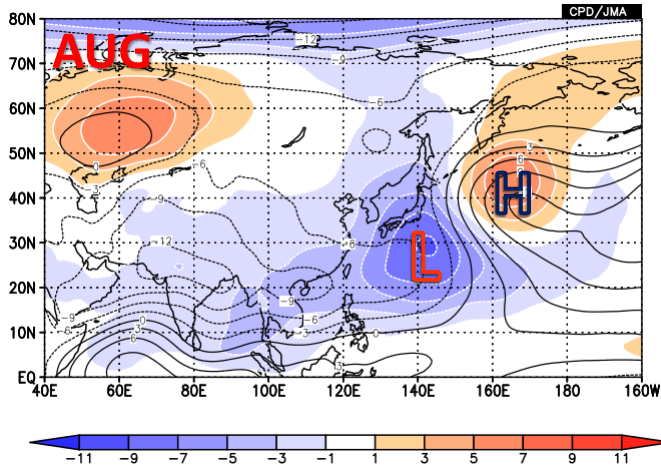
Stream function at 850hPa for Jun-Aug

- For the three month mean, the Pacific High was weaker than normal over its western part and stronger than in the far east of Japan
- From July to August, a blocking high over the Kamchatka Peninsula









Stream function (contour) and anomaly (shade) at 850hPa for the three months of Jun-Aug (above) and for individual months (right)

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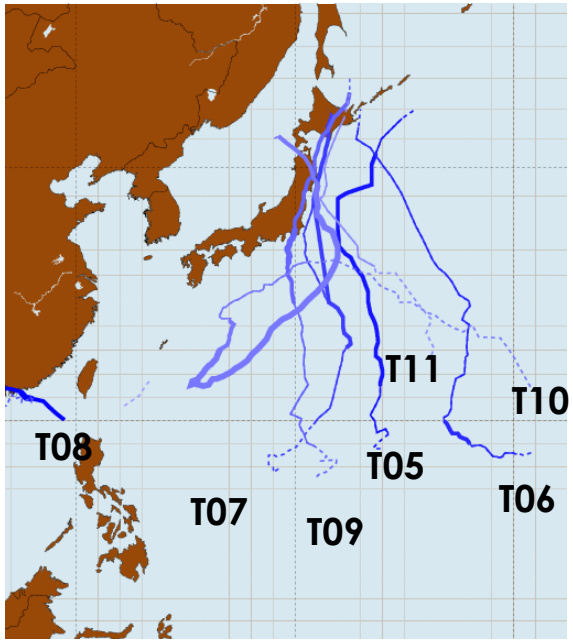
Tropical cyclone tracks in the western Pacific in August

- During August, seven TC[1] in the western North Pacific (climatological normal: 5.9).

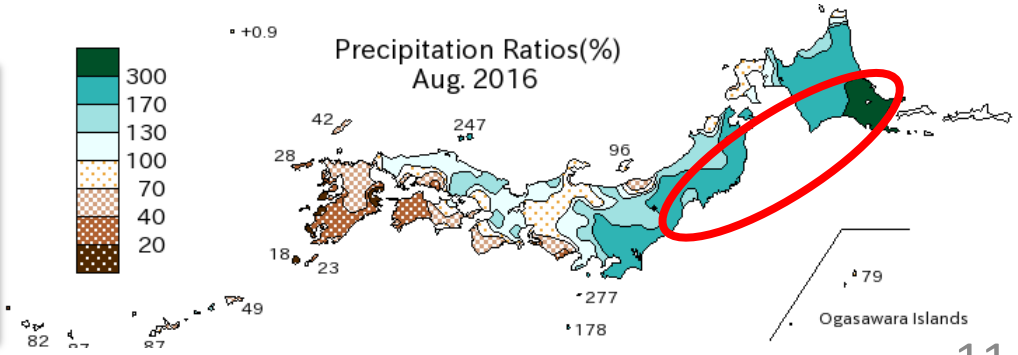
- Six TC approached or made landfall on East Asian countries and five TC approached or made landfall on mainland Japan (climatological normal number of landfall on mainland Japan is 1.7).



[1] TC is defined as a tropical cyclone with a maximum sustained wind speed of 34 knots or more.

Record-breaking precipitation in August

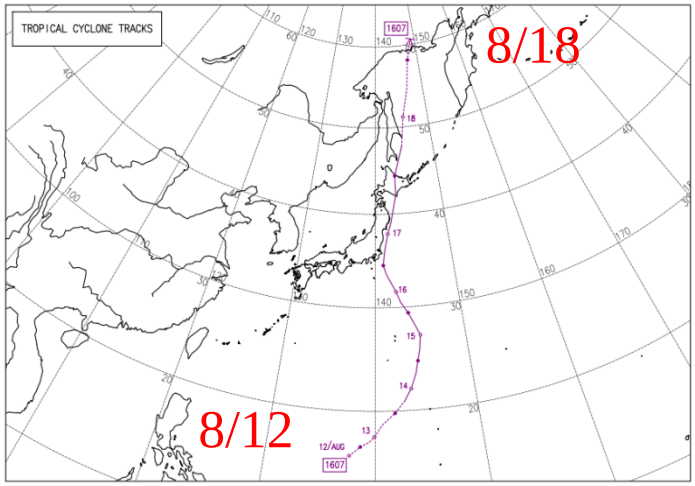
- Monthly precipitation for August averaged over the Pacific side of northern Japan was the highest since 1946 at 231% of normal



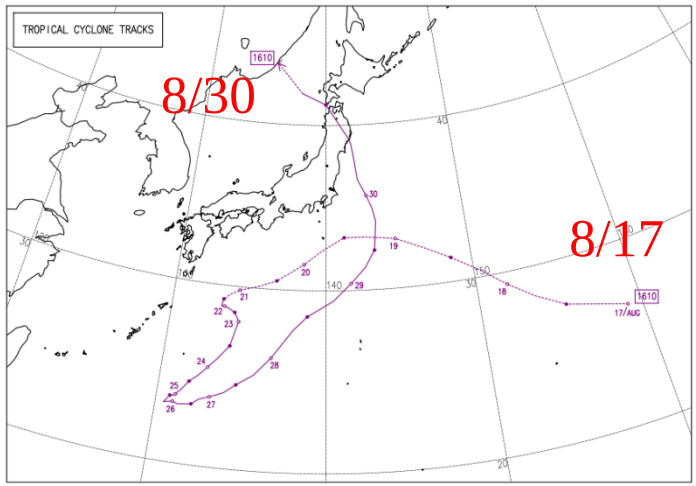
Four typhoons in the second half of August

- Typhoon Chanthu, Kompasu, Mindulle, Lionrock made landfall on northern Japan in the second half of August, which was also unusual.

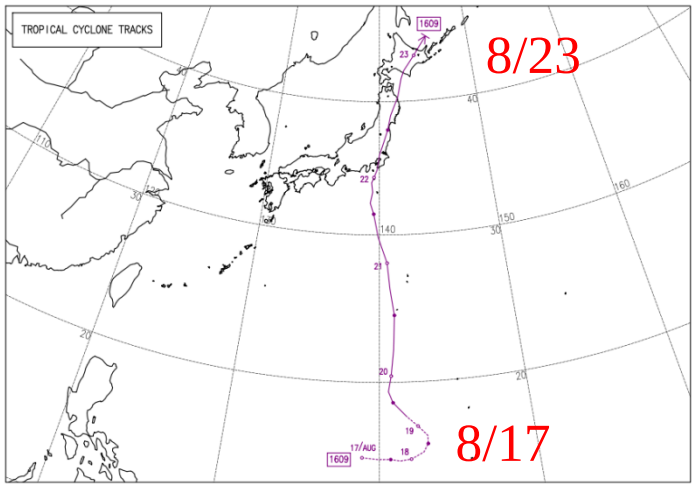
T1607 Chanthu



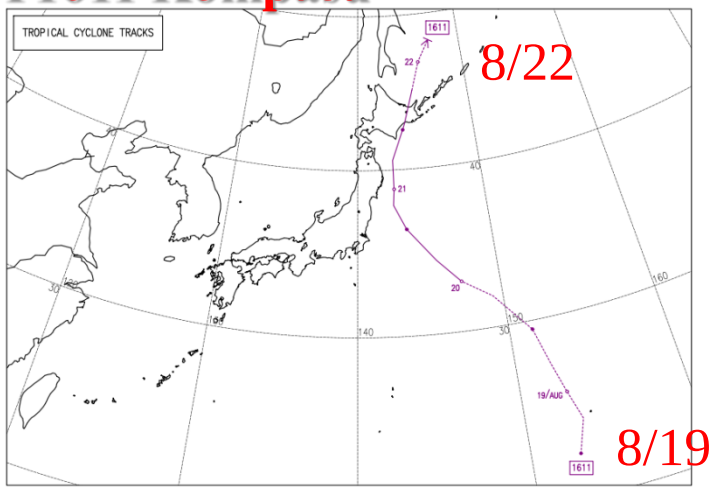
T1610 Lionrock



T1609 Mindulle

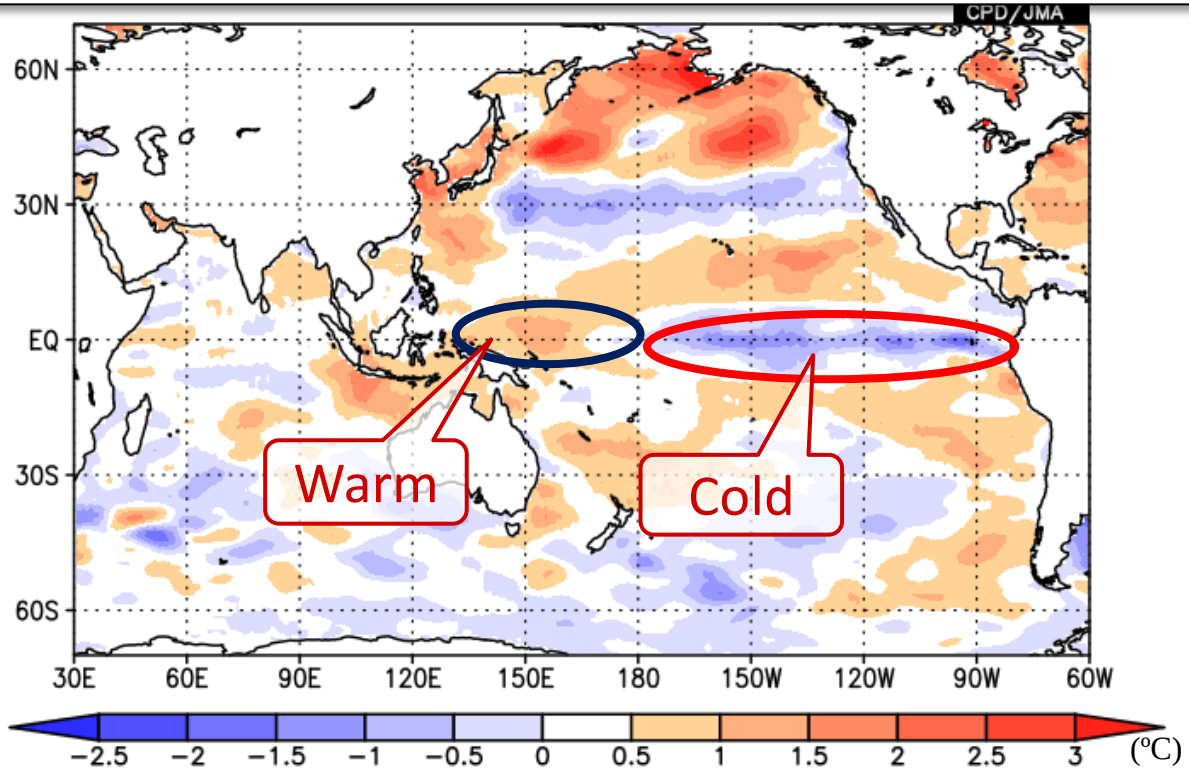


T1611 Kompasu



SST in August

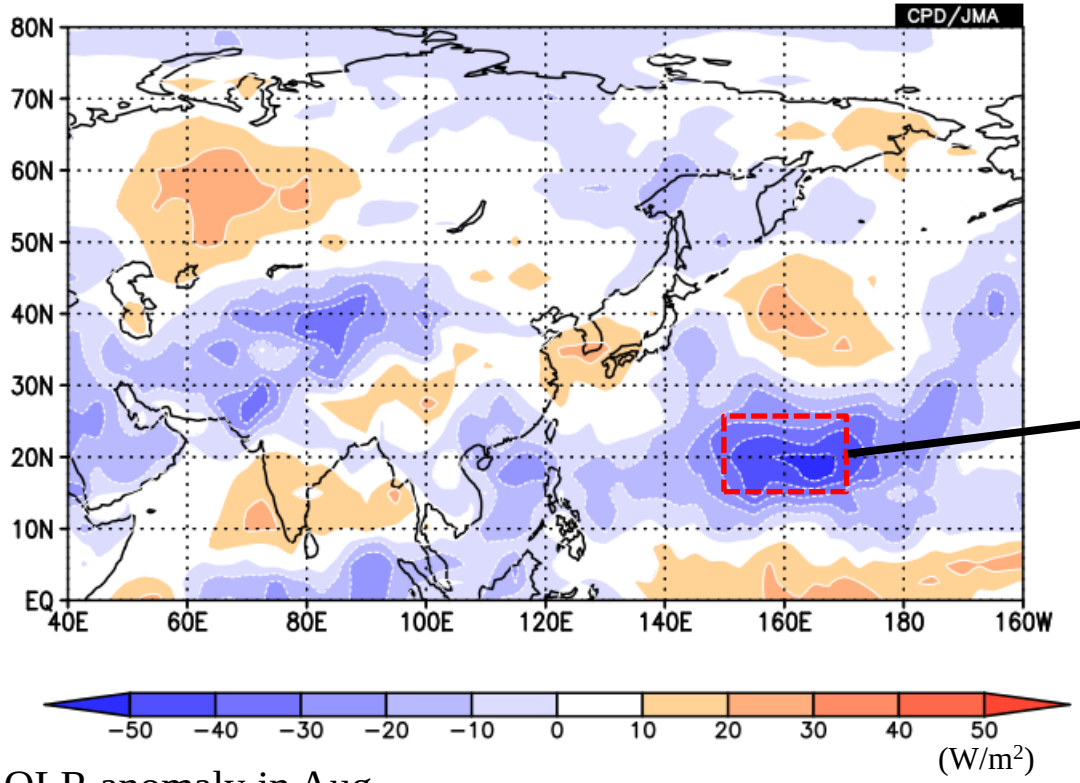
- In the equatorial Pacific, remarkably positive SST anomalies were observed in the western part, and negative SST anomalies were observed from the central to eastern parts.
- In the North Pacific, remarkably positive SST anomalies were observed in almost the entire region except along 30˚N where remarkably negative SST anomalies were observed.



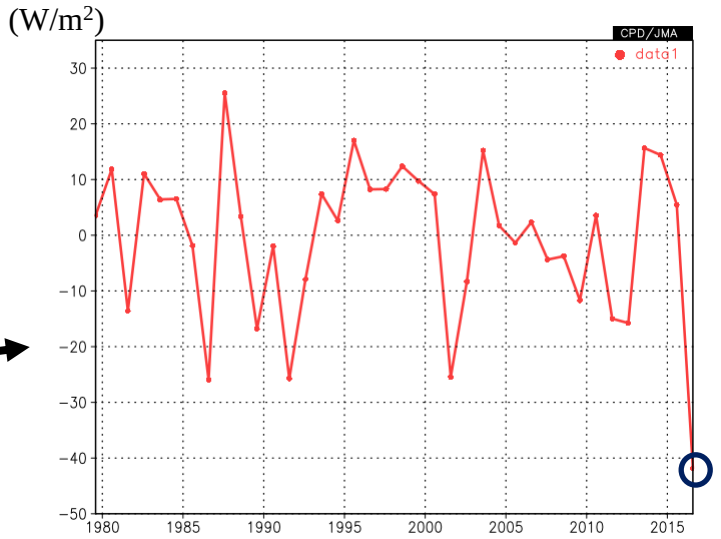
SST anomalies in Aug

Convective activity (OLR) in August

- Enhanced convective activity was seen from the South China Sea to the western tropical North Pacific
- The monthly anomalies of OLR over the box in the below map were lowest since 1979



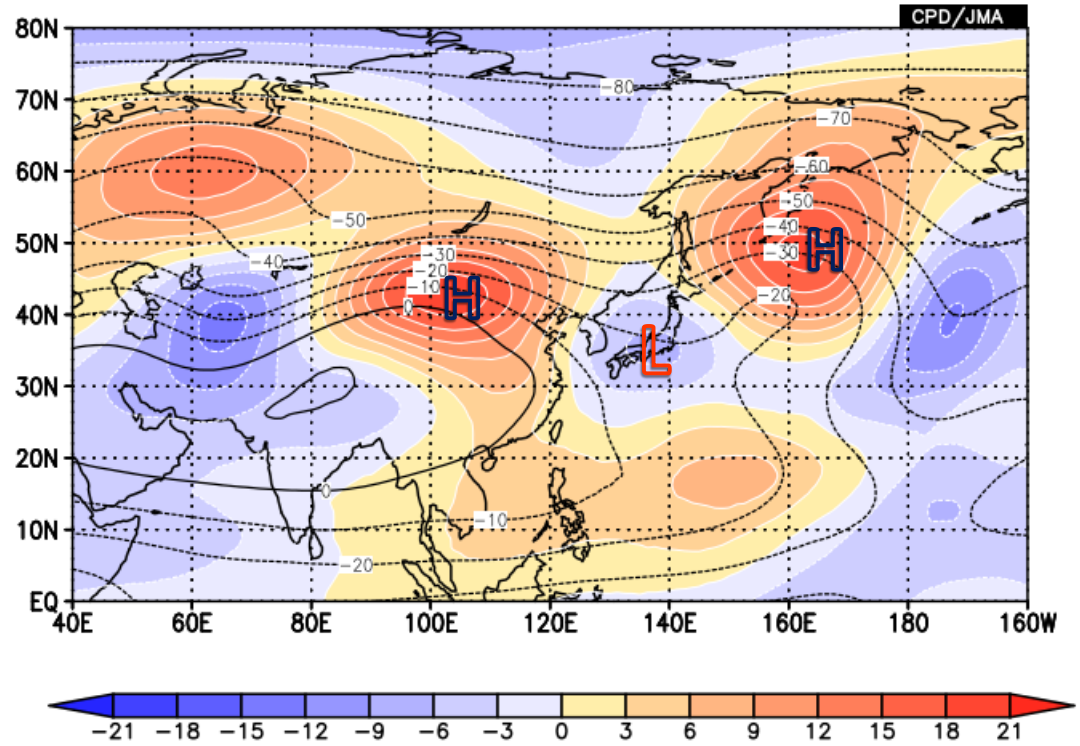
OLR anomaly in Aug



OLR anomaly for Aug 1979-2016 over the boxes in the map left

Stream function at 200hPa in August

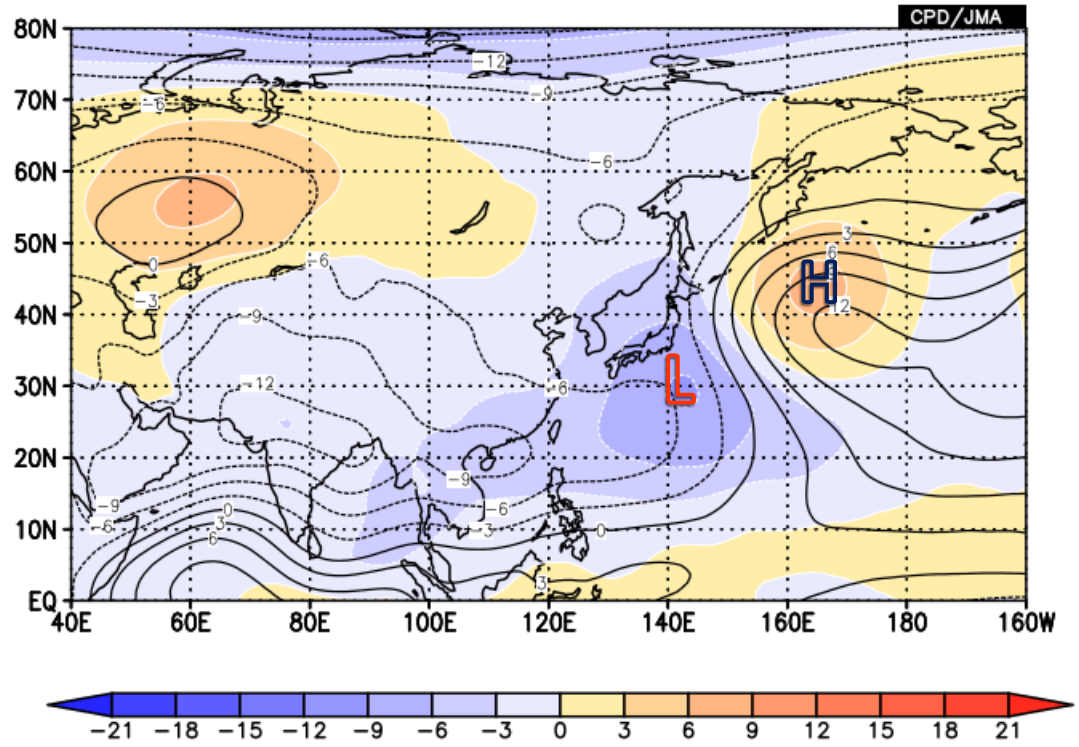
- Anticyclonic circulation anomalies from northern China to Mongolia and in the south of the Kamchatka Peninsula, cyclonic circulation anomalies in Japan
- The Tibetan High was stronger than normal over its northeastern part



Stream function (contour) and anomaly (shade) at 200hPa in Aug

Stream function at 850hPa in August

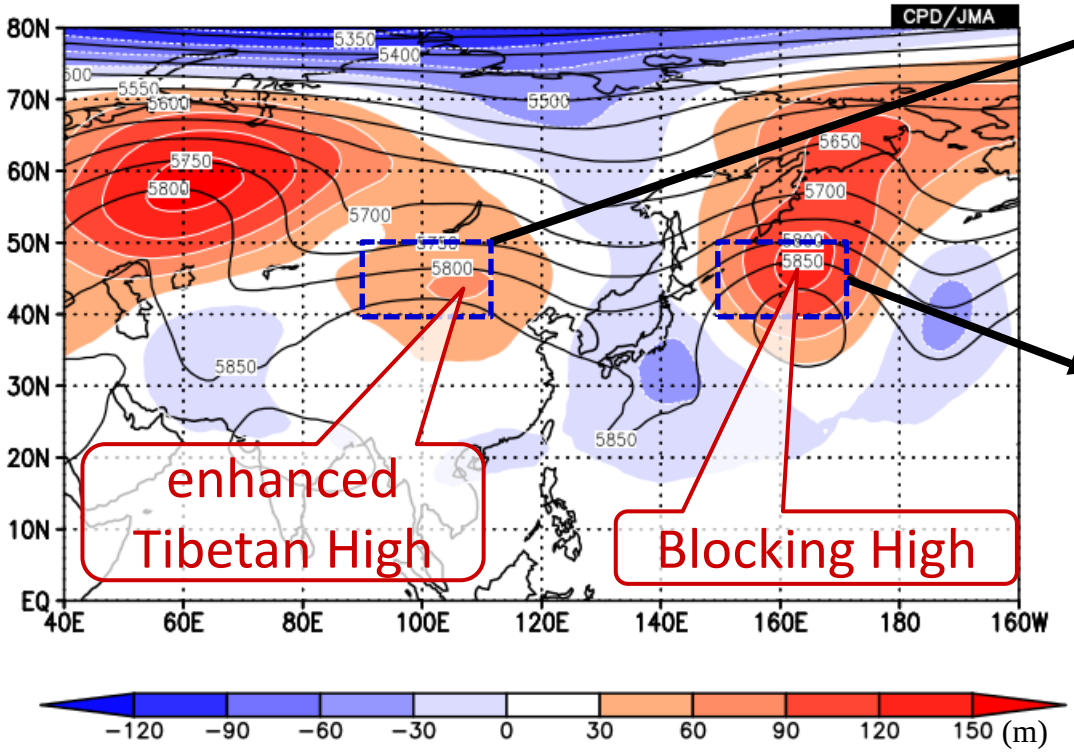
- Cyclonic circulation associated with a deep monsoon trough was clearly seen over the seas to the southeast of Japan in response to enhanced convective activity to the southeast of it.
- The Pacific High was weaker than normal over its western part and stronger than in the far east of Japan



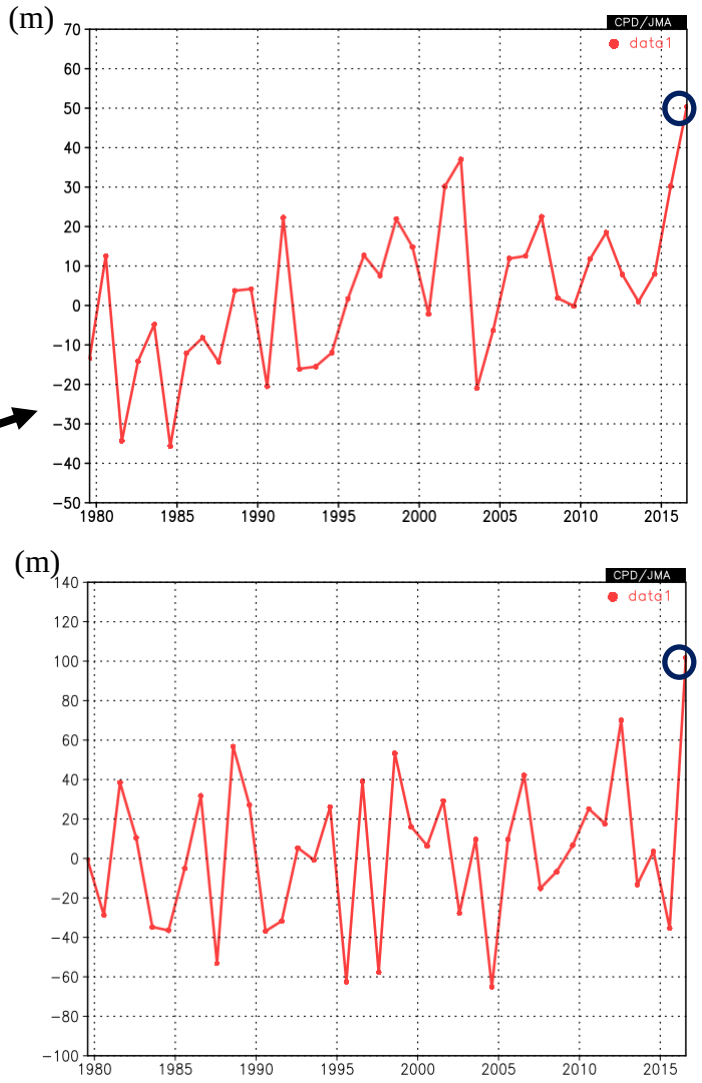
Stream function (contour) and anomaly (shade) at 850hPa in Aug

Geopotential height at 500hPa in August

- Negative anomalies over Japan and positive anomalies from northern China to Mongolia and in the far east of Japan
- The monthly anomalies of potential height over the boxes in the below map were highest since 1979



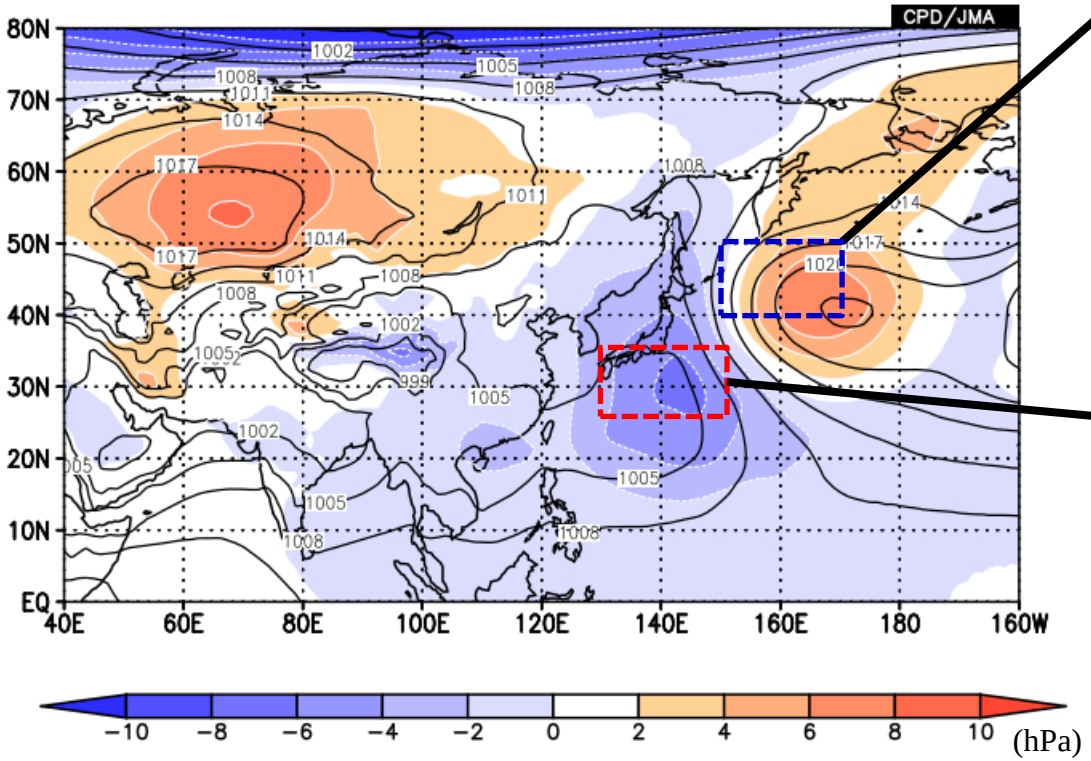
Geopotential height (contour) and anomaly (shade) at 500hPa in Aug



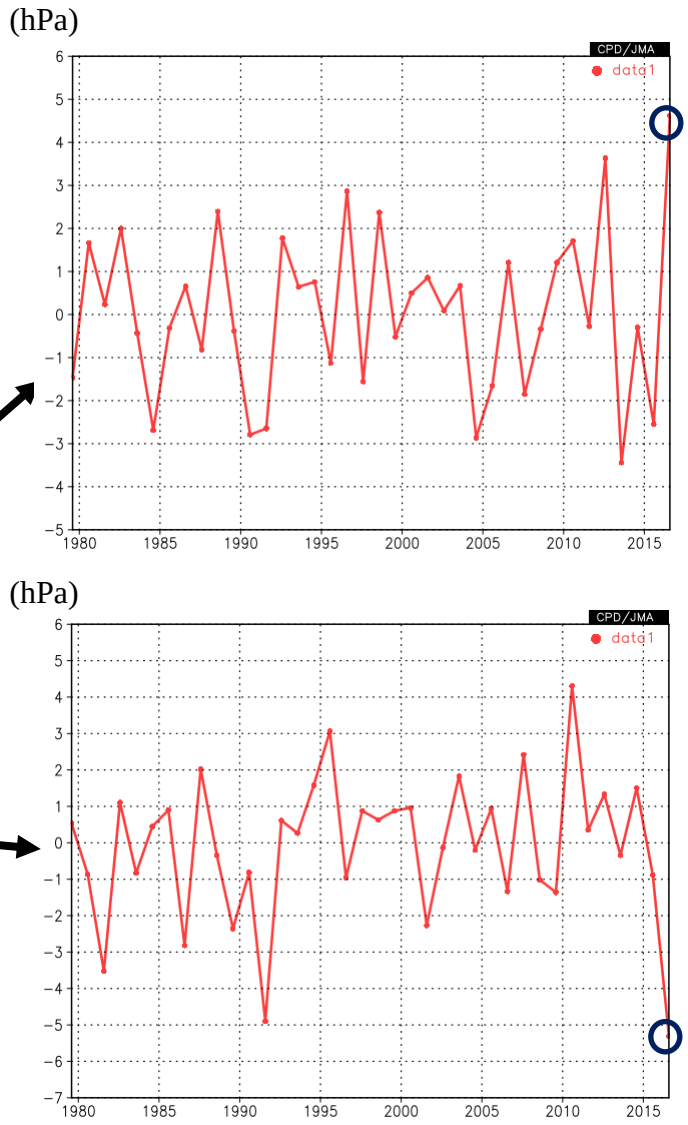
Geopotential height anomaly at 500hPa for Aug 1979-2016 over the boxes in the map left

Sea level pressure in August

- Positive anomalies over the far east of Japan and negative anomalies over Japan
- The monthly anomalies of sea level pressure over the right (left) box in the below map were highest (lowest) since 1979



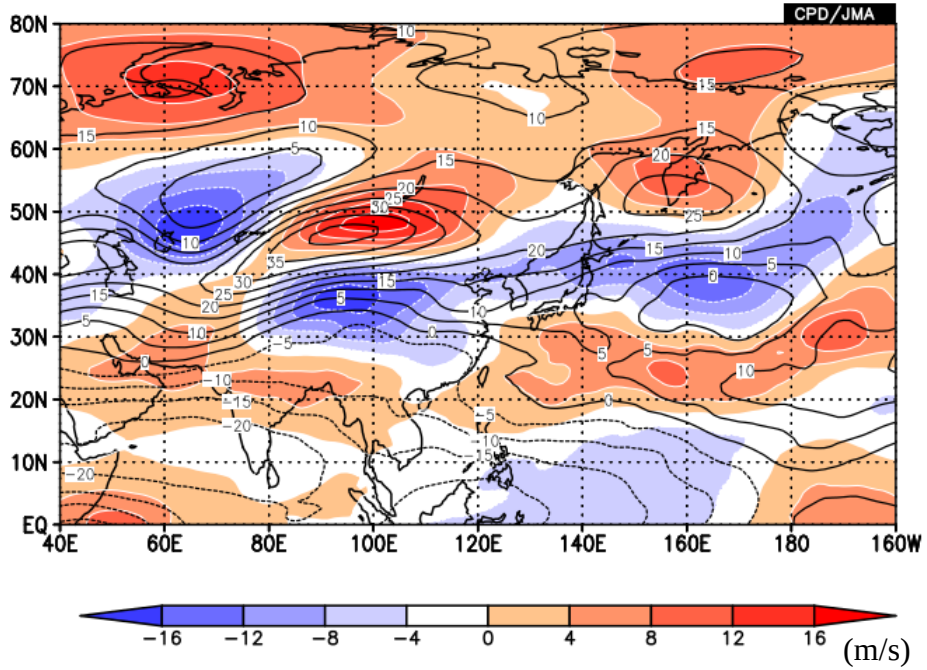
Sea level pressure (contour) and anomaly (shade) in Aug



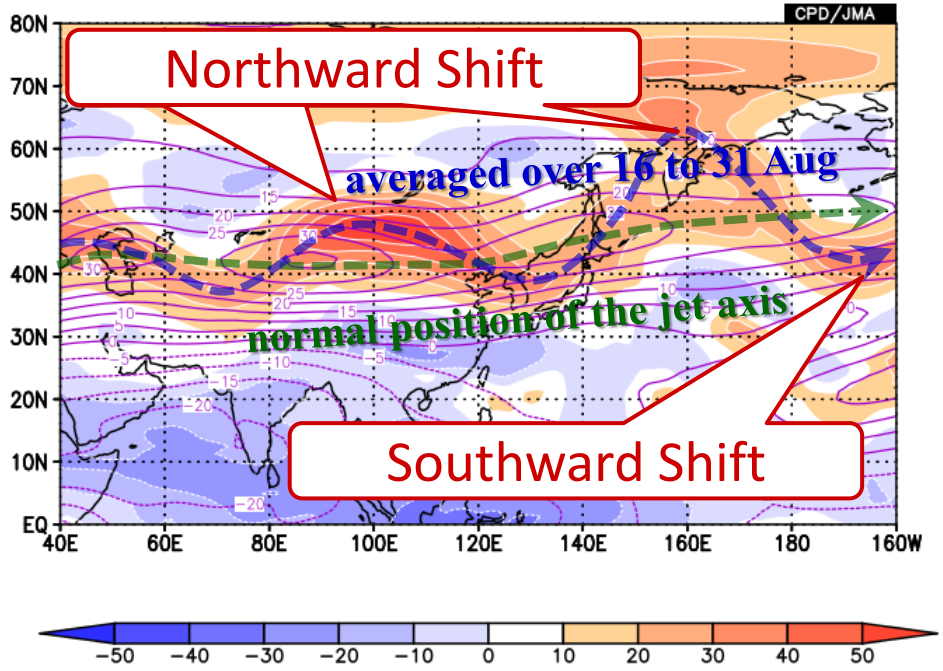
Sea level pressure anomaly for Aug 1979-2016 over the boxes in the map left

Zonal wind speed at 200hPa in August

- In August, the subtropical jet stream tended to flow north of its normal position over East Asia
- In the second half of August, the subtropical jet stream meandered significantly from East Asia to the western North Pacific



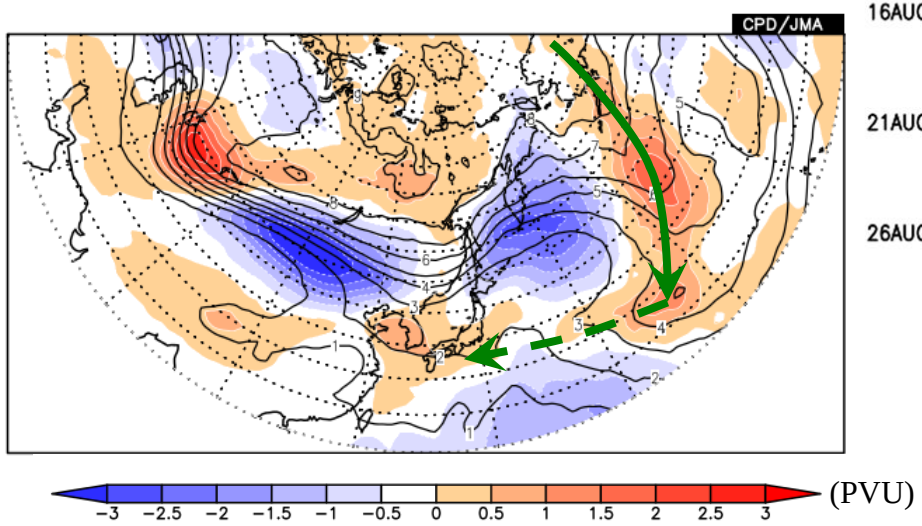
Zonal wind speed (contour) and anomaly (shade) at 200 hPa in Aug



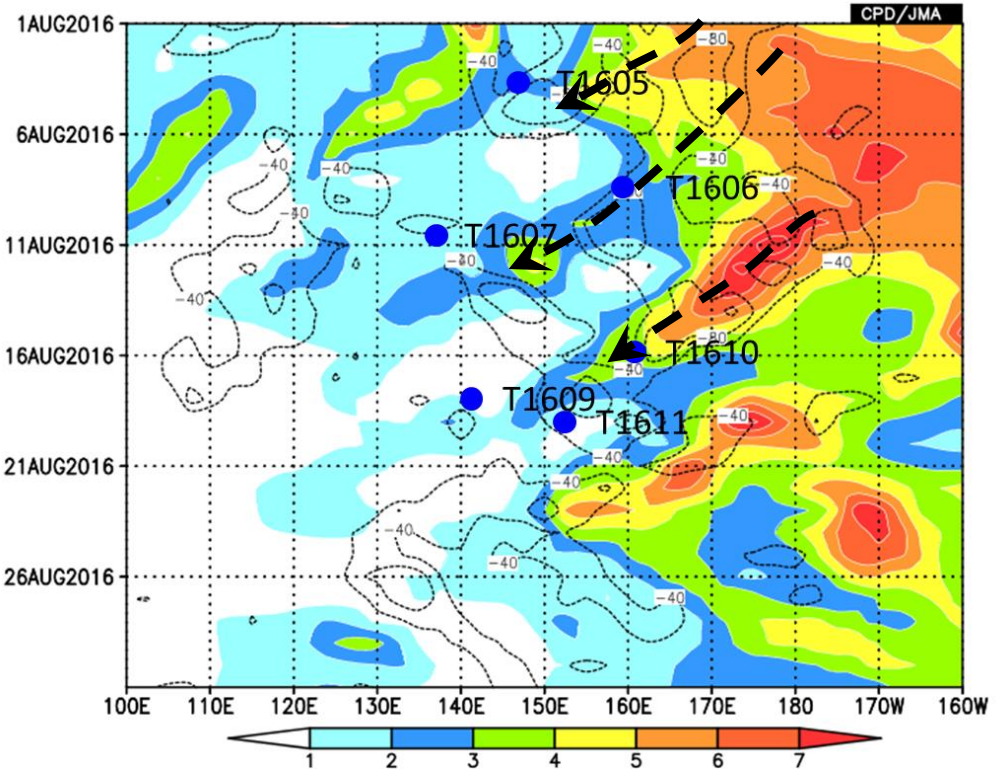
16-day mean zonal wind speed (shade) at 200 hPa for 16-31 Aug, compared with its normal (contour)

Potential vorticity at 360K in August

- An air mass with high potential vorticity repeatedly advected southwestward from the mid-Pacific trough
- The high potential vorticity contributed to activate TC genesis over the south of Japan



Potential vorticity at 360K (contour) and anomaly (shade) in Aug



Longitude-Time cross section of Potential vorticity at 360K averaged in the latitude 25N-35N (shade) and OLR anomaly averaged in the latitude 15N-25N (contour) for Aug 2016

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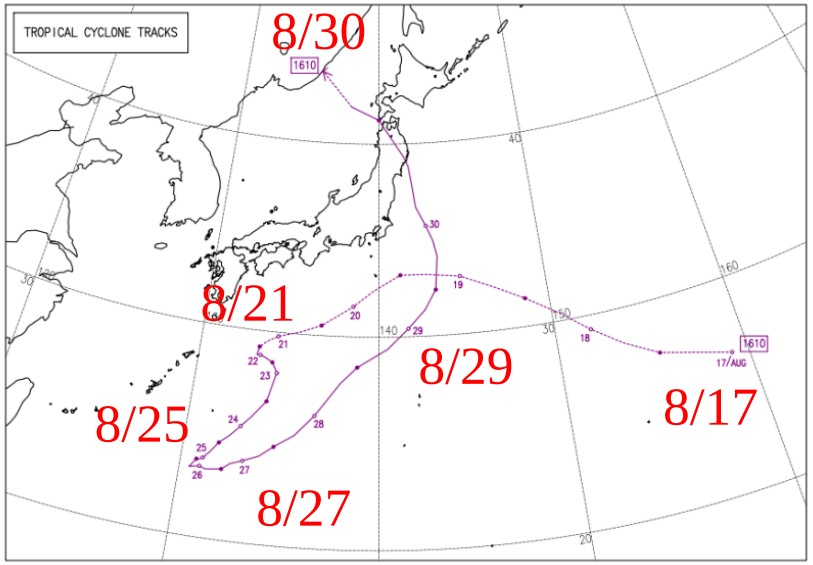
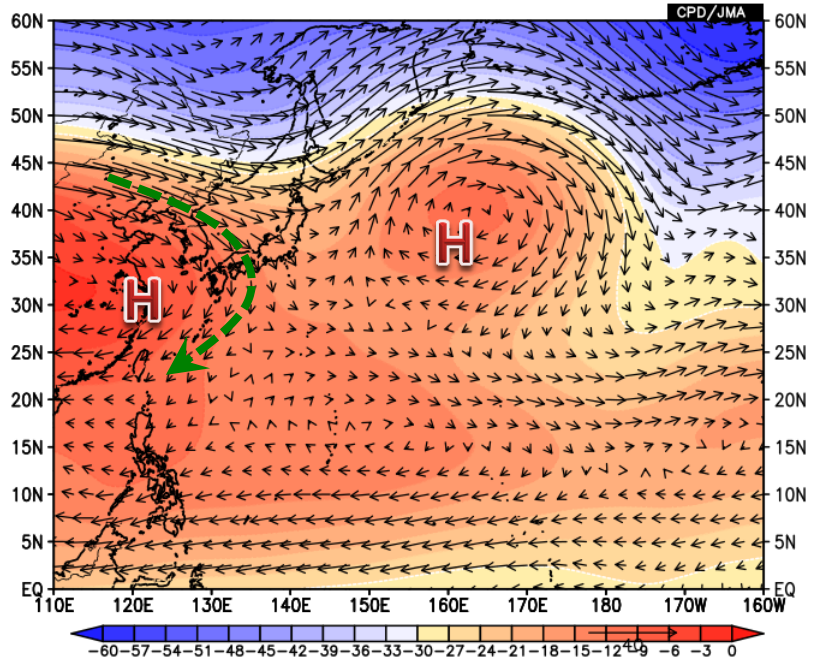
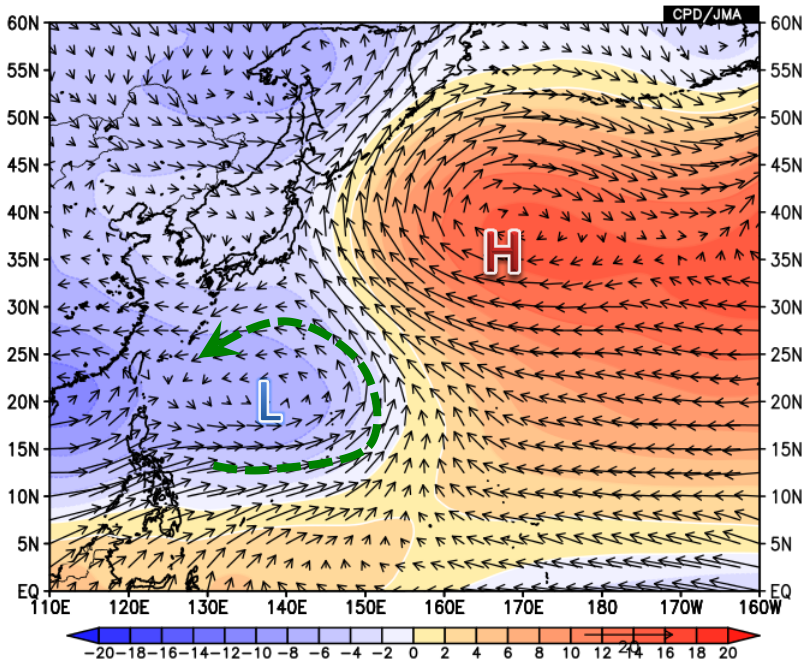
Typhoon “Lionrock” track for 8/21～8/25

- For 21-25 Aug, typhoon “Lionrock” moved southwest slowly.
- Tibetan High enhanced in its northeastern part and a huge cyclonic circulation in the lower troposphere (monsoon gyre) contributed to track of typhoon “Lionrock”.



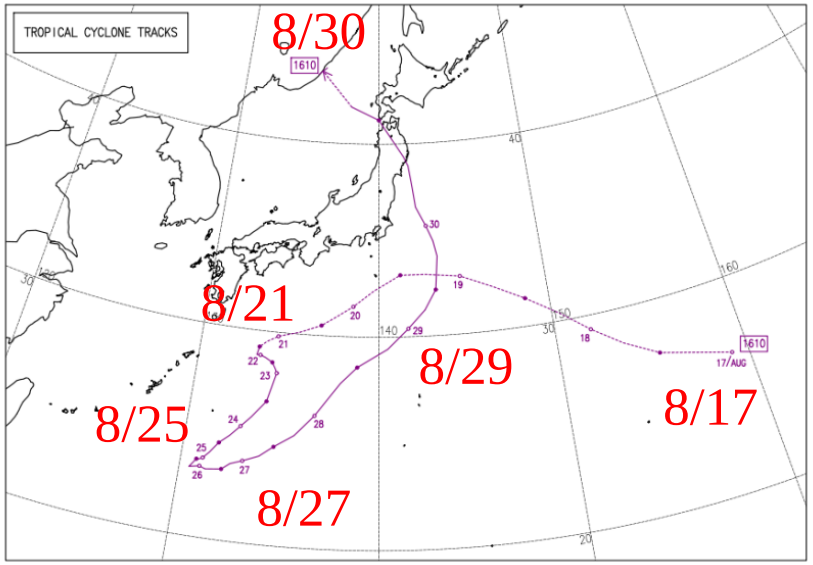


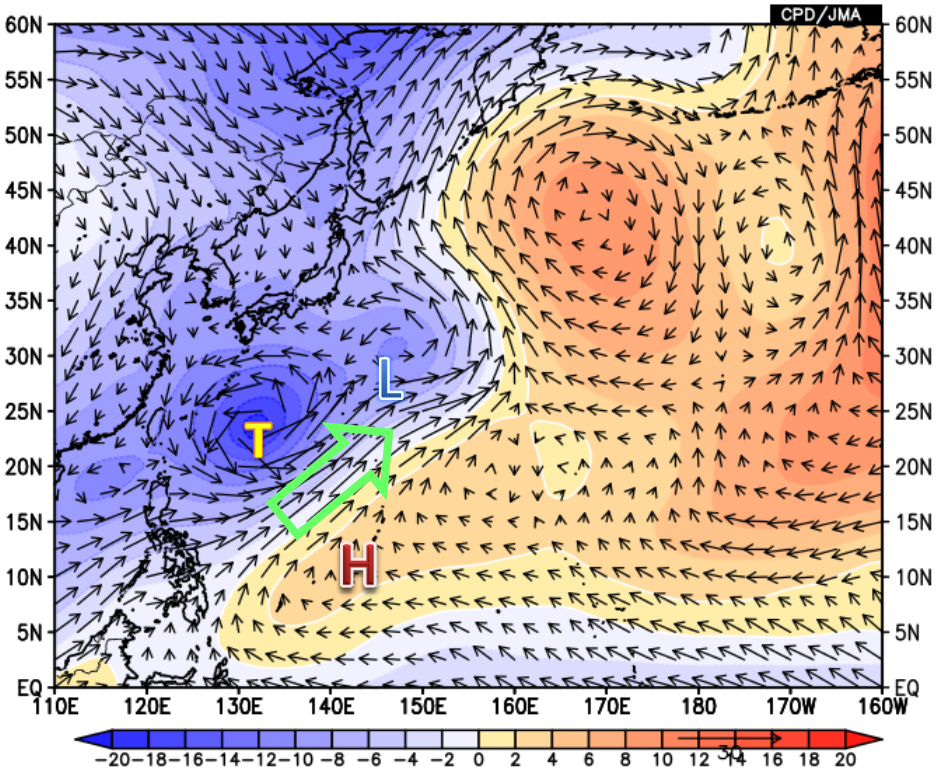


5-day mean stream function anomaly(shade) at 200hPa(left) and 850hPa(right) for 21-25 Aug

Typhoon “Lionrock” track for 8/25～8/27

- For 25-27 Aug, typhoon “Lionrock” change the direction of movement, in relation to intensified anticyclonic circulation to the southeast of it.

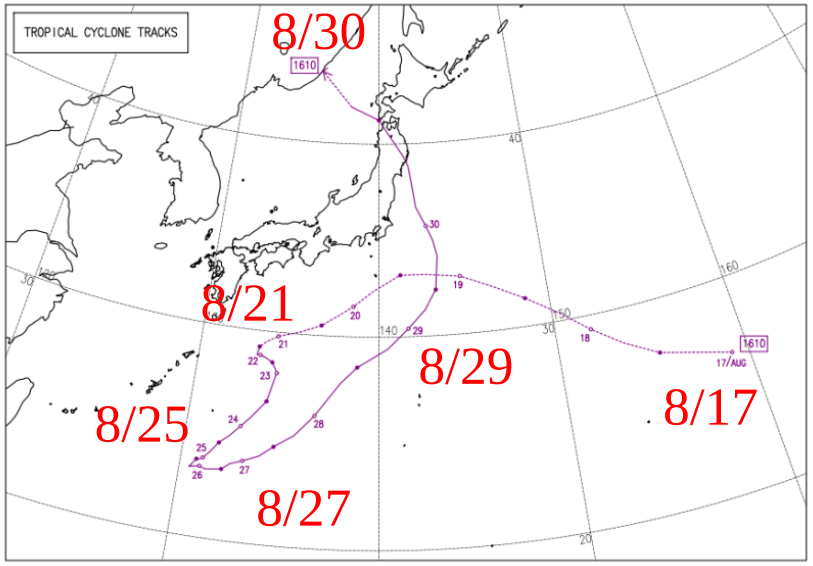


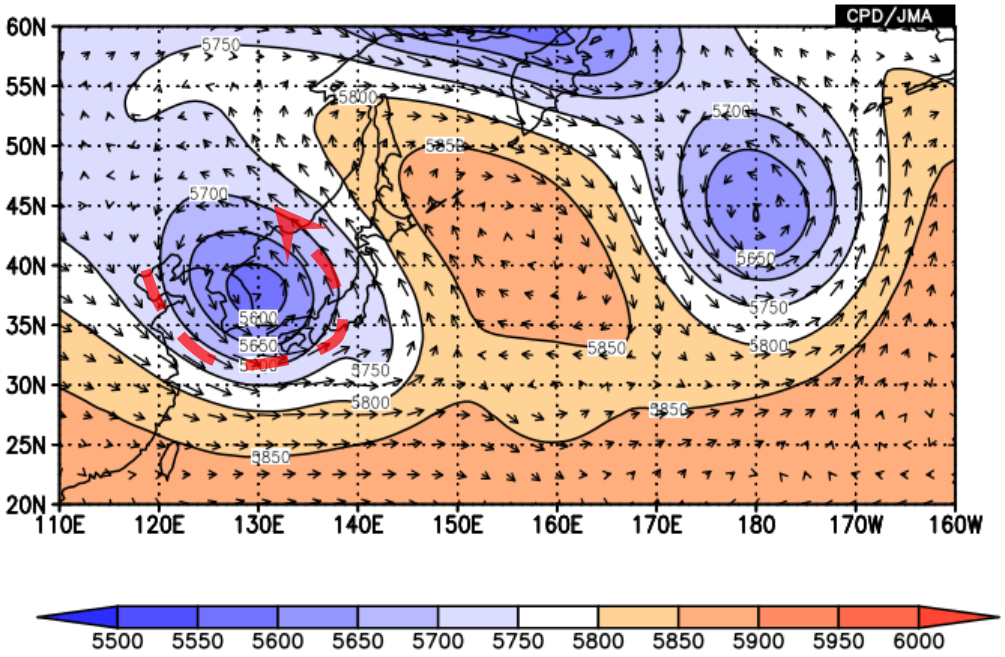


3-day mean stream function anomaly(shade) at 850hPa for 25-27 Aug

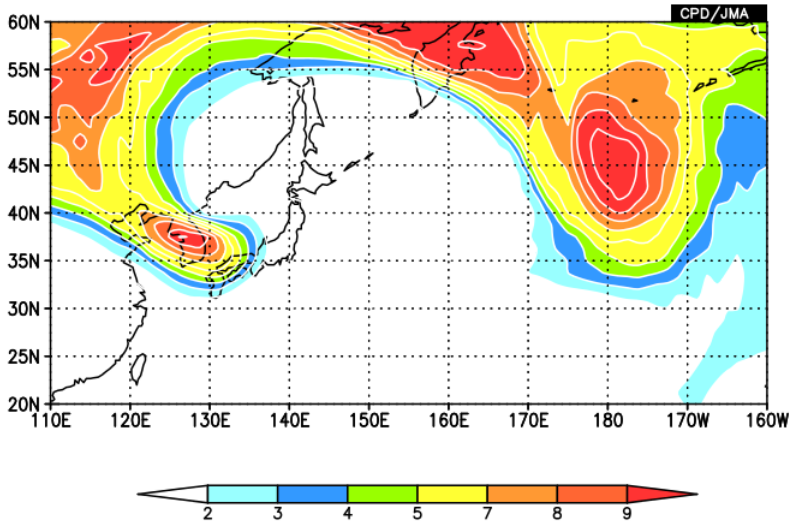
Typhoon “Lionrock” track for 8/29～8/30

- From 29-30 Aug. typhoon “Lionrock” once again changed it course and started to head northwestward, steered by southeasterly associated with the deep trough over western Japan in relation to the cold vortex in upper troposphere.





2-day mean wind(vector) and geopotential height(shade) at 500hPa for 29-30 Aug



2-day mean potential vorticity(shade) at 350K for 29-30 Aug

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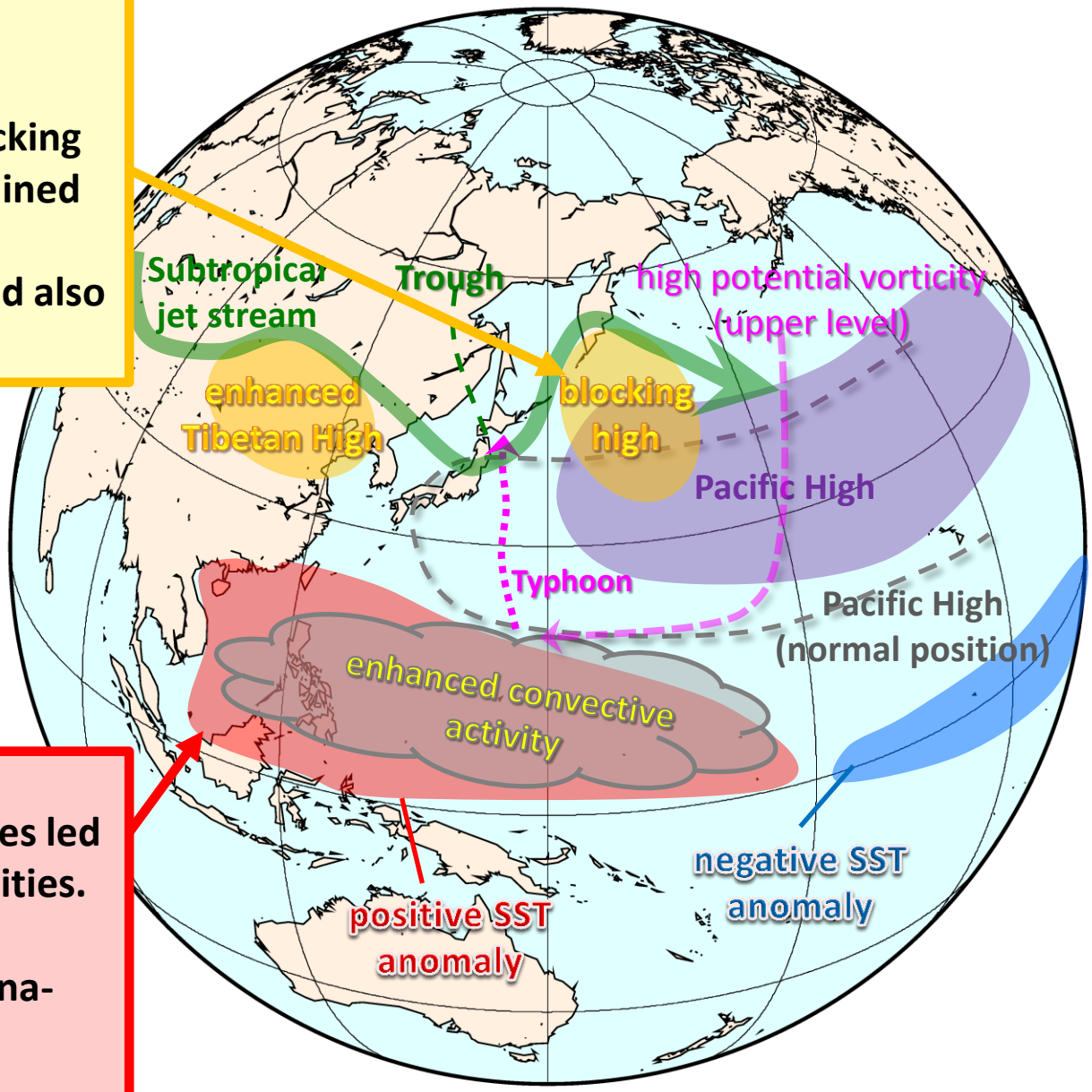
Conclusion -schematic figure in August 2016- No.1

In the south of the Kamchatka Peninsula, a blocking high was persistent. To the east of this blocking high, the mid-Pacific trough remained deeper than normal. An upper tropospheric trough was sustained also over Japan.



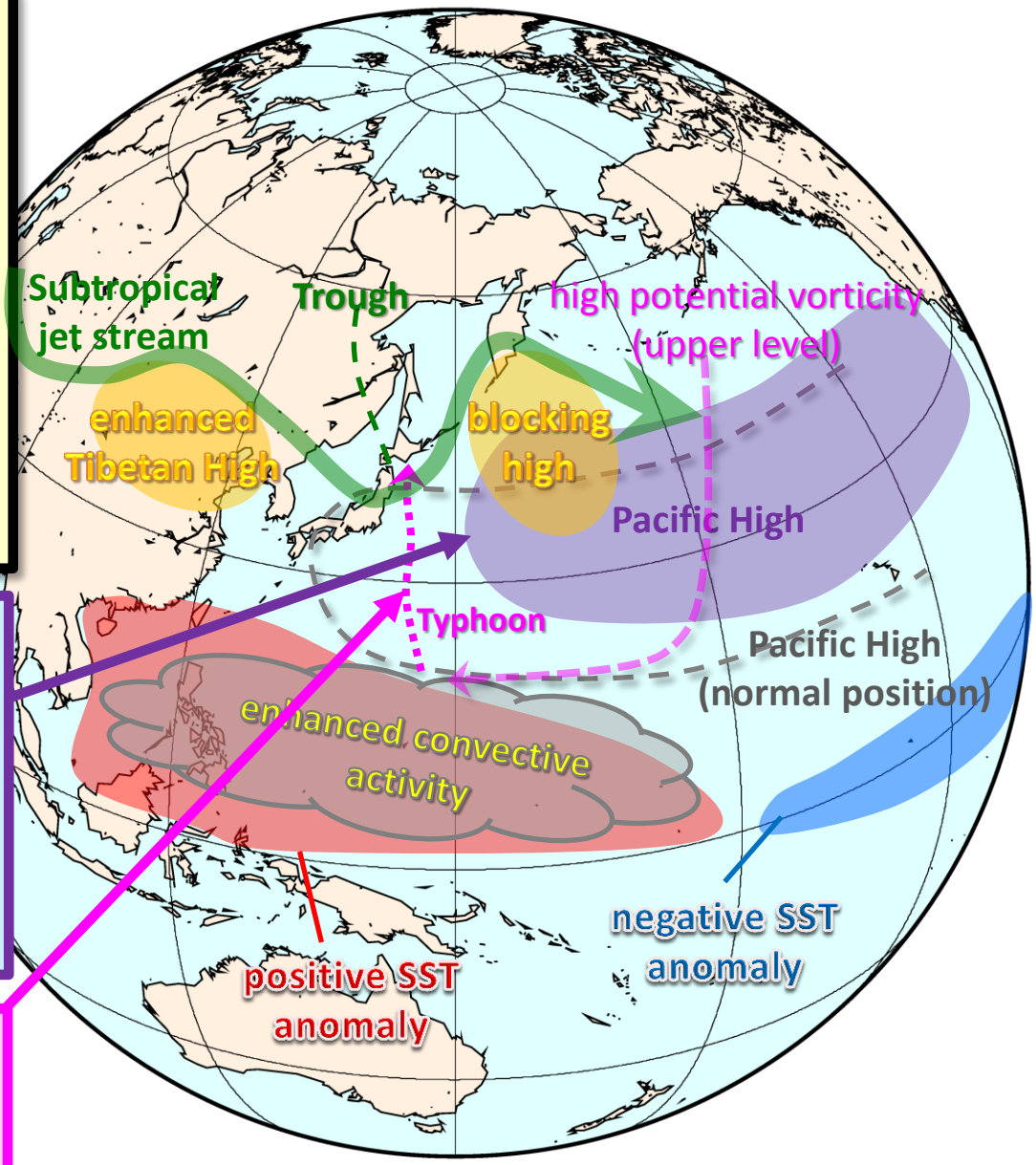
Around and to the east of the Philippines, positive SST anomalies led to the enhanced convective activities. These warm SST anomalies are associated with developing La Nina-like conditions. This is related to formation of some of the TC.

Conclusion -schematic figure in August 2016- No.2

An air mass with high potential vorticity repeatedly advected southwestward from the mid-Pacific trough and contributed to enhanced convective activity over the western North Pacific. The enhanced convection and a huge cyclonic circulation (monsoon gyre) contributed to activate TC genesis over the ocean south of Japan.

In relation to the trough over Japan and the blocking high in the south of the Kamchatka Peninsula, the Pacific High was weaker than normal over its western part and stronger than in the far east of Japan.

The weaker-than-normal Pacific High around Japan allowed TC to take unusual tracks into northern Japan.

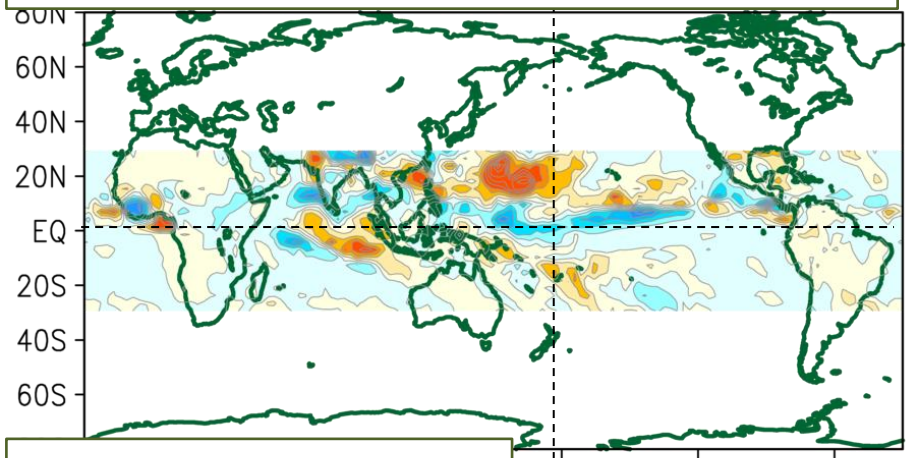


Thank you for your attention…

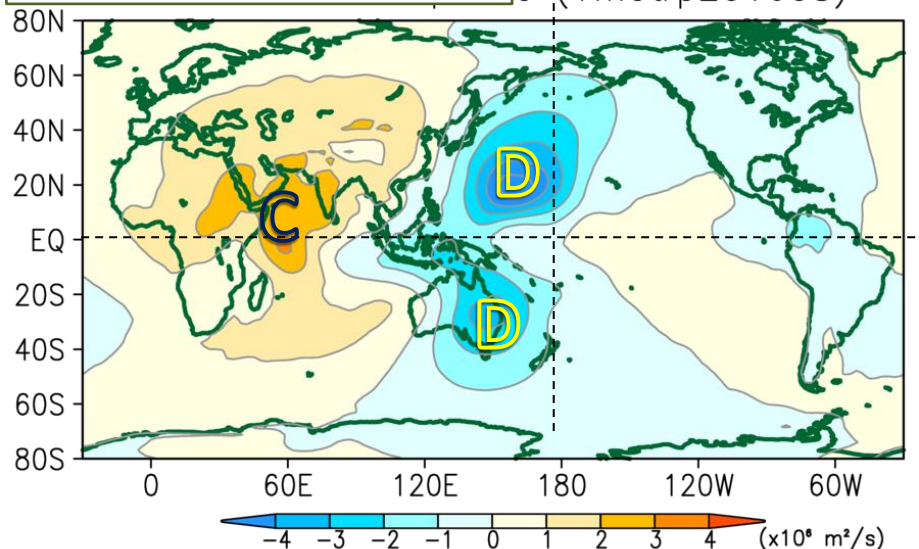
Attribution experiment using Linear Baroclinic Model

Heat anomalies in tropics give rise to a convergence/divergence distribution well resembling observation

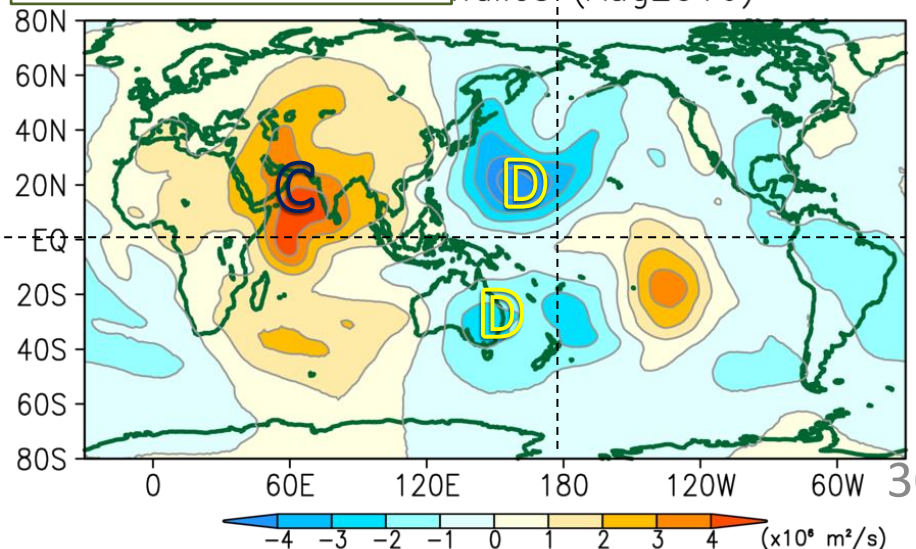
Forcing (observed heat anomaly)



Response in χ200



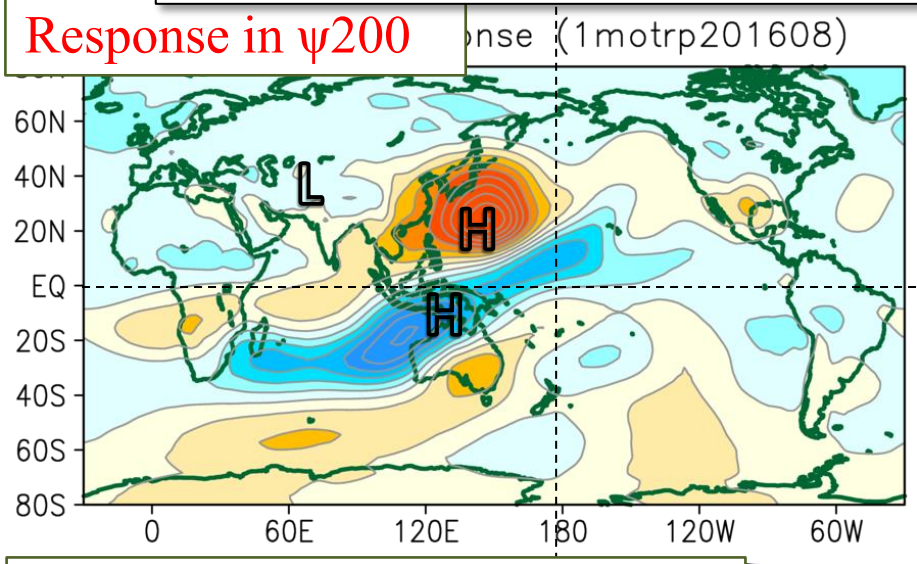
Observed χ200



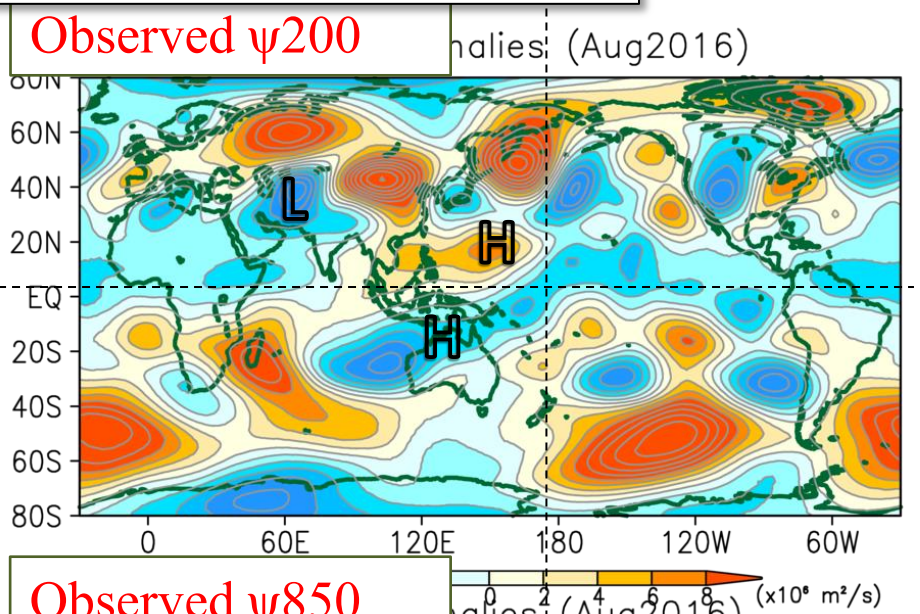
Attribution experiment using Linear Baroclinic Model

Heat anomalies in tropics also give rise to circulation patterns in good agreement with observation

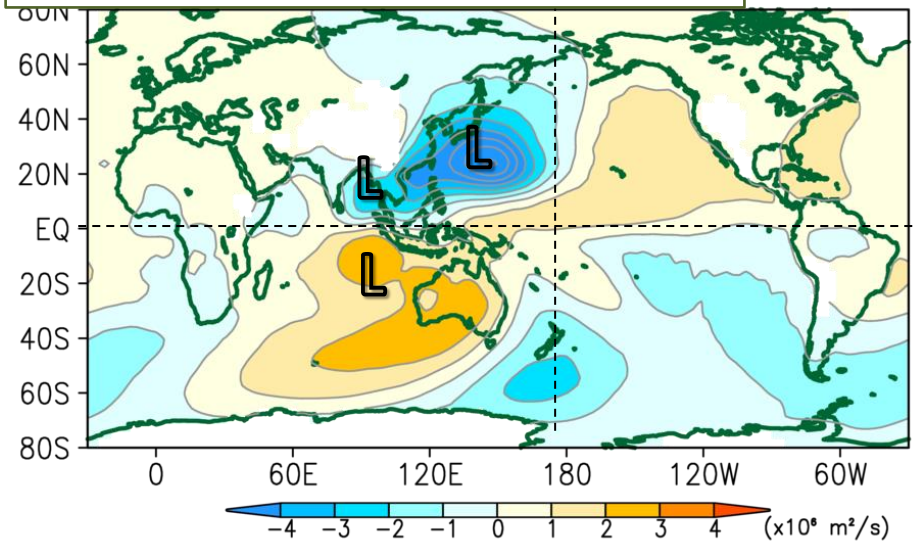
Response in ψ200



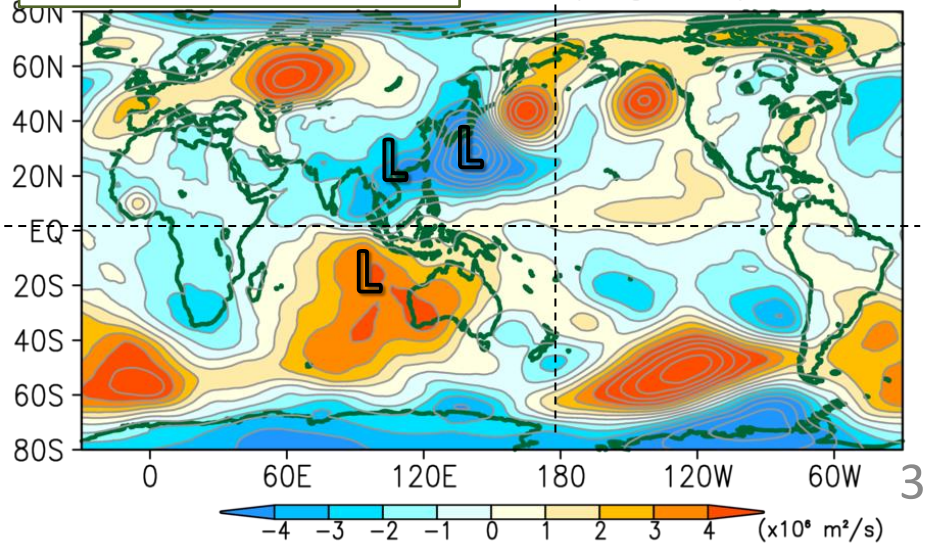
Observed ψ200



Response in ψ850



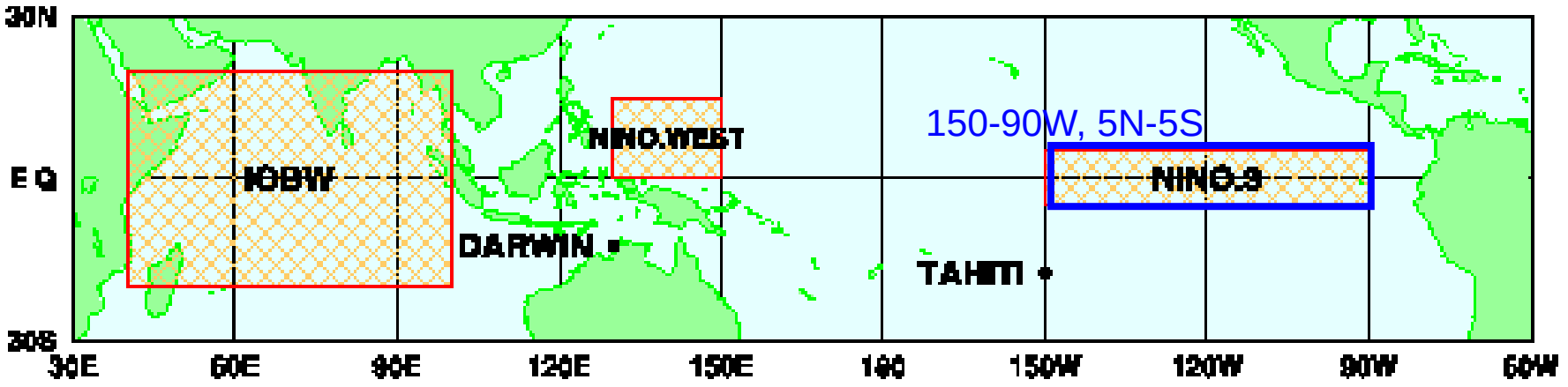
Observed ψ850



Quantitative definition of El Niño (La Niña) event

Definition of El Niño (La Niña) by JMA

- 5-month running mean of NINO.3 SST deviation stays +0.5ºC or higher (-0.5ºC or lower) for 6 consecutive months or longer.
- NINO.3 SST deviation is defined as deviation from the latest 30-year (e.g. 1986-2015 for the year 2016) average.

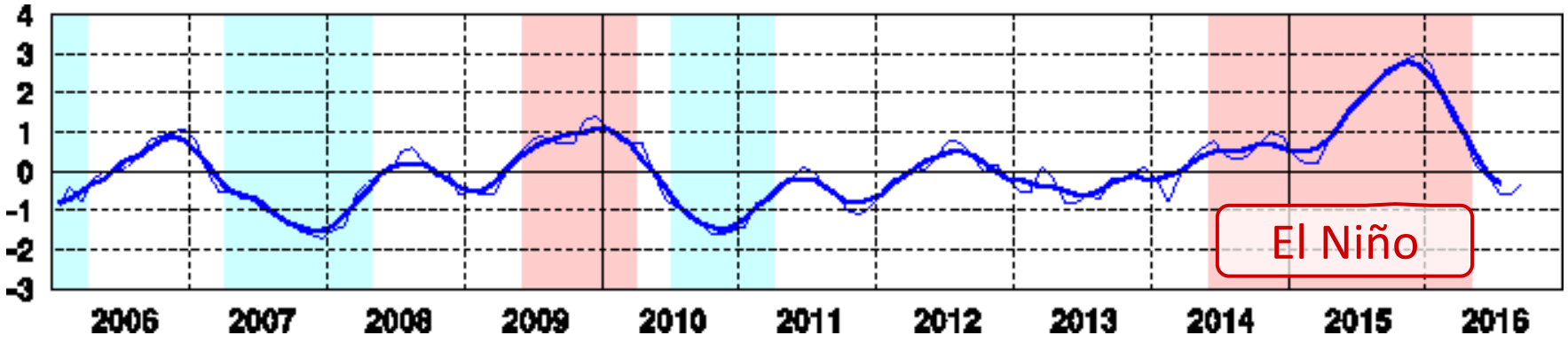


JMA's monitoring region (NINO.3)

ENSO monitoring indices (NINO.3 SST)

The SST is monthly mean sea surface temperature averaged over NINO.3 (5˚N-5˚S, 150˚W-90˚W).

	2015			2016								
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Monthly mean SST (˚C)	27.6	27.9	28.1	28.2	28.3	28.7	28.3	27.2	26.4	25.2	24.6	24.7
SST deviation (˚C)	+2.7	+2.9	+3.0	+2.7	+2.0	+1.6	+0.8	+0.1	-0.1	-0.6	-0.6	-0.3
5-month mean (˚C)	+2.7	+2.8	+2.7	+2.4	+2.0	+1.4	+0.9	+0.4	-0.1	-0.3		



Sea surface temperature (SST) deviations from the climatological mean based on a sliding 30-year period for NINO.3

Thin lines indicate a monthly mean value, and smoothed thick curves, a five-month running mean.

Red shaded areas denote El Niño periods, and blue, La Niña ones.