Exercise

Considering mechanisms of the relationship between Primary Modes of Climate Variability and atmospheric circulation

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Objective of this exercise

Considering the mechanisms of the relationship between primary modes of climate variability (ENSO, AO, EU) and atmospheric circulation, which were found in the previous exercise

- Statistical relationship do **NOT** always mean the existence of physical system or structures, because statistical analyses are just mathematical calculations and consideration based on physics aren't included.
- Therefore, considering the mechanisms of the relationship is necessary in order to understand the effect of primary modes on atmospheric circulation and regional climate adequately.

Outline

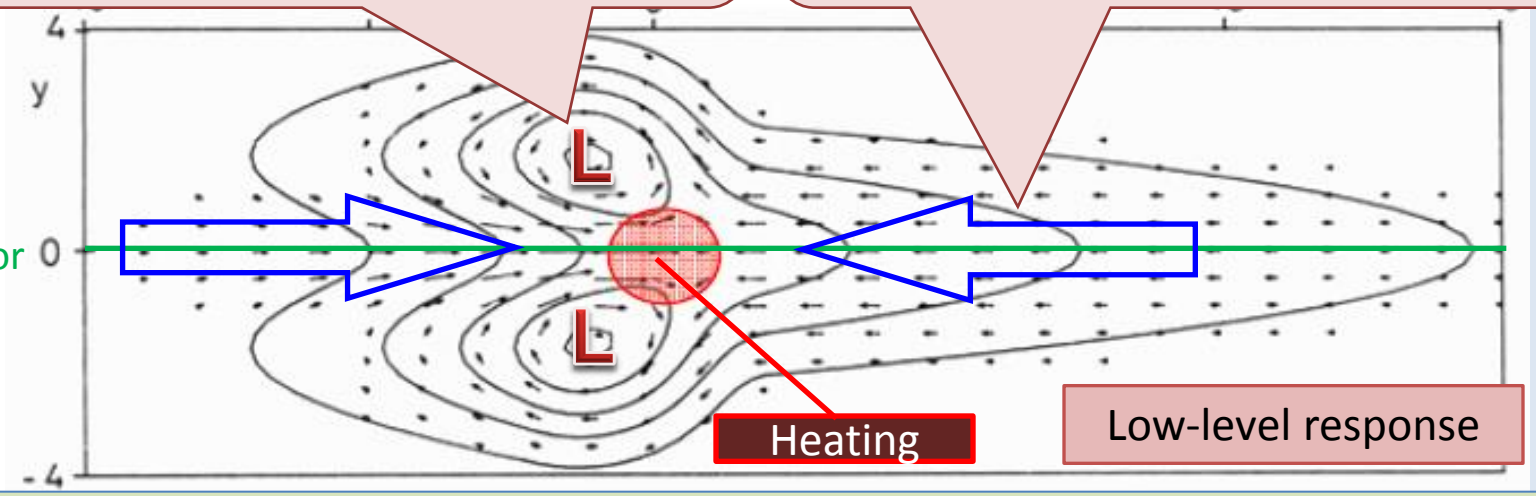
1. Review : response in atmospheric circulation to atmosphere-ocean variability
2. Review : Relationship between ENSO and climate variability for boreal winter
   - Atmospheric circulation
   - Climate in Japan
3. Exercise : Apply to your own country!

[Review] Matsuno-Gill pattern

- Gill (1980) elucidated some basic features of the response of the tropical atmosphere to diabatic heating (related to convective activity).

A pair of cyclonic circulation straddling the equator on the western side of the heating (equatorial Rossby wave).

Low pressure and easterly winds along the equator east of the heating (equatorial Kelvin wave).



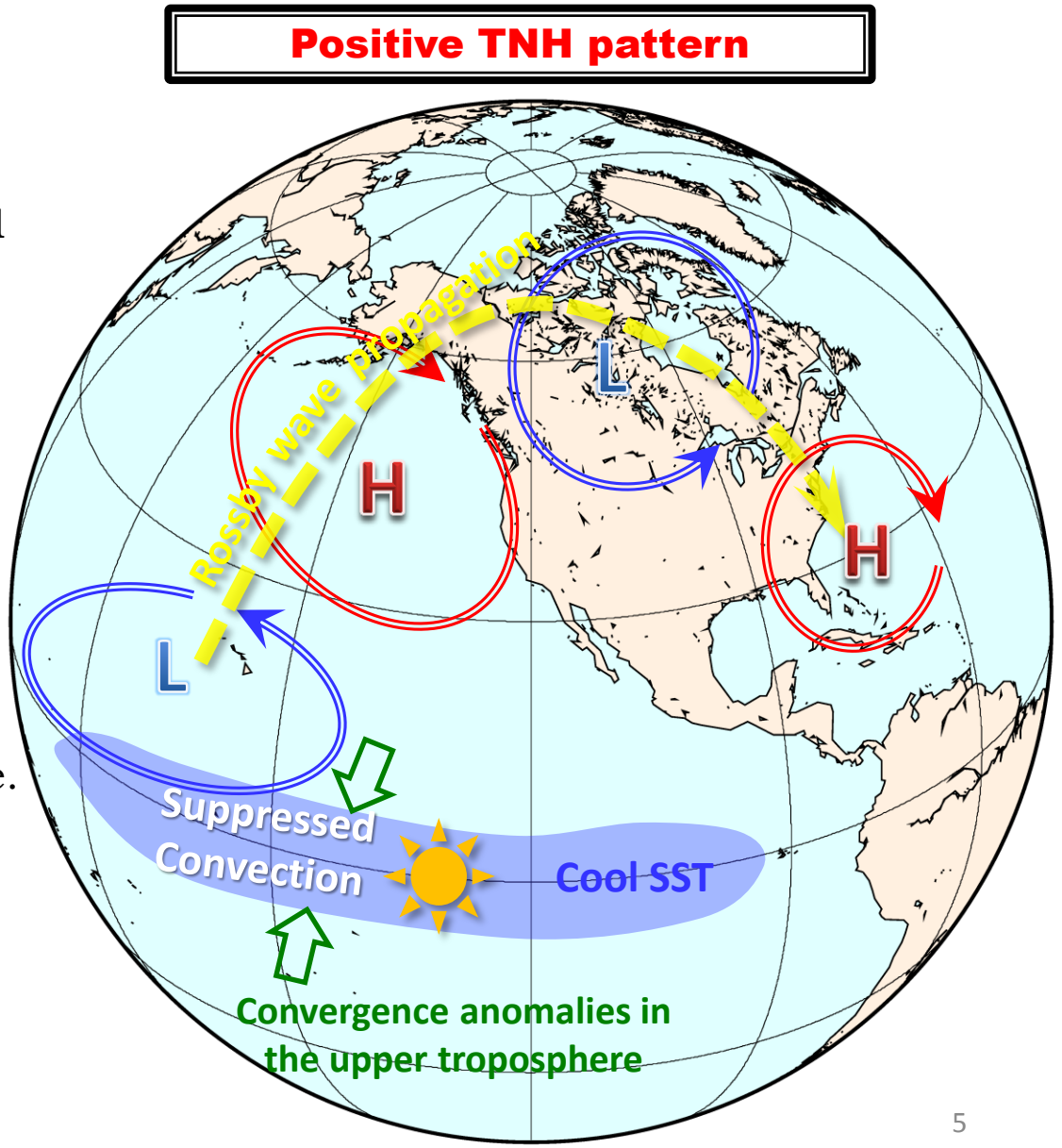
Atmospheric response in the lower troposphere to the heating symmetric about the equator

Contours indicate perturbation pressure, and vectors denote velocity field.
Red circle indicates the position of the heating. (Source: Gill 1980)

Upper-level response shows the reverse of the low-level response.

[Review] Teleconnection

- A primary mode of variability is closely related to an important concept of ***Teleconnection***.
- Teleconnection refers to a causal connection of the atmospheric circulation anomalies between remote regions.
- Teleconnection is possible because ***Rossby waves*** (alternate cyclonic and anticyclonic anomalies in the right figure) transport anomalous energy and momentum over a great distance.
- The source of Rossby waves can be often traced back to convection anomalies in the tropics, though this is not always true.



Example:
ENSO and Climate in Japan

- El Niño and Southern Oscillation (ENSO) is one of the most important mode of climate variability.

- In this section, we consider the effect of El Nino event on Japan's temperature for boreal winter (DJF) using the TCC product "Composite map for El Nino/La Nina event" providing the statistical relationship between ***El Nino/La Nina event and global atmospheric circulation***.
  http://ds.data.jma.go.jp/tcc/tcc/products/clisys/enso_statistics/index.html

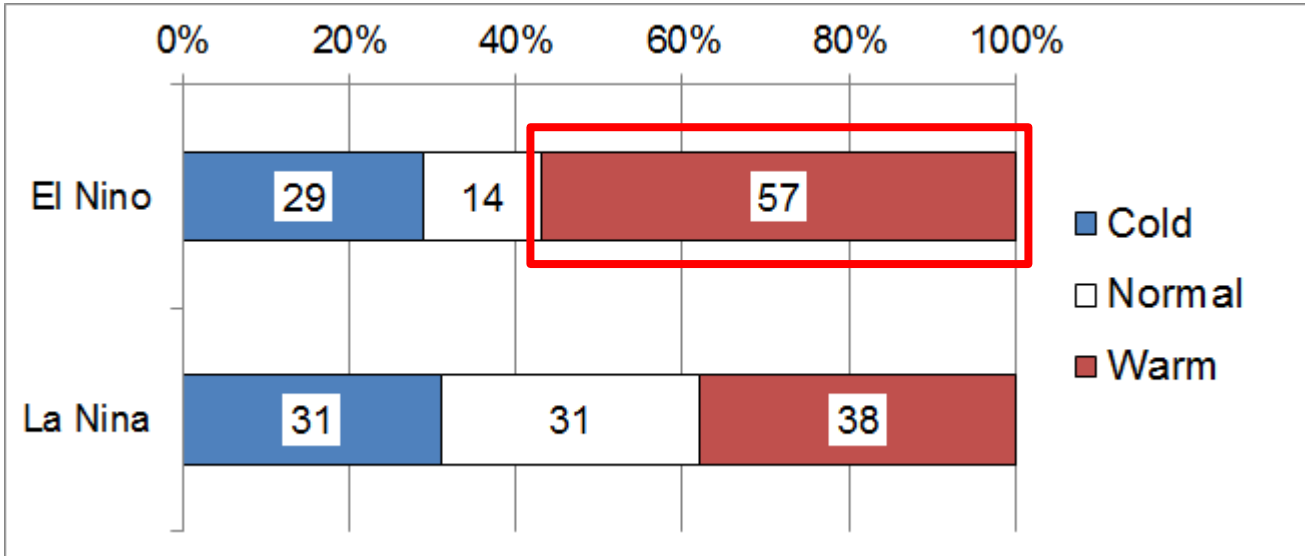
- This is one simple example of understanding the effect of primary modes on atmospheric circulation and regional climate.

ENSO and winter temperature in Japan (El Niño January)

In January of El Niño years,

- It tends to be warmer (57%) in Tokyo.
- Statistically significant at 90% confidence level

Binomial test: (p-value)					
	Cold	Normal	Warm	Not Cold	Not Warm
El Nino	0.7388066	0.9725961	0.0576163	0.4755005	0.9825663
Neutral	0.4152404	0.166011	0.9645458	0.7238644	0.0838384
La Nina	0.677576	0.677576	0.4479613	0.5520387	0.7586919

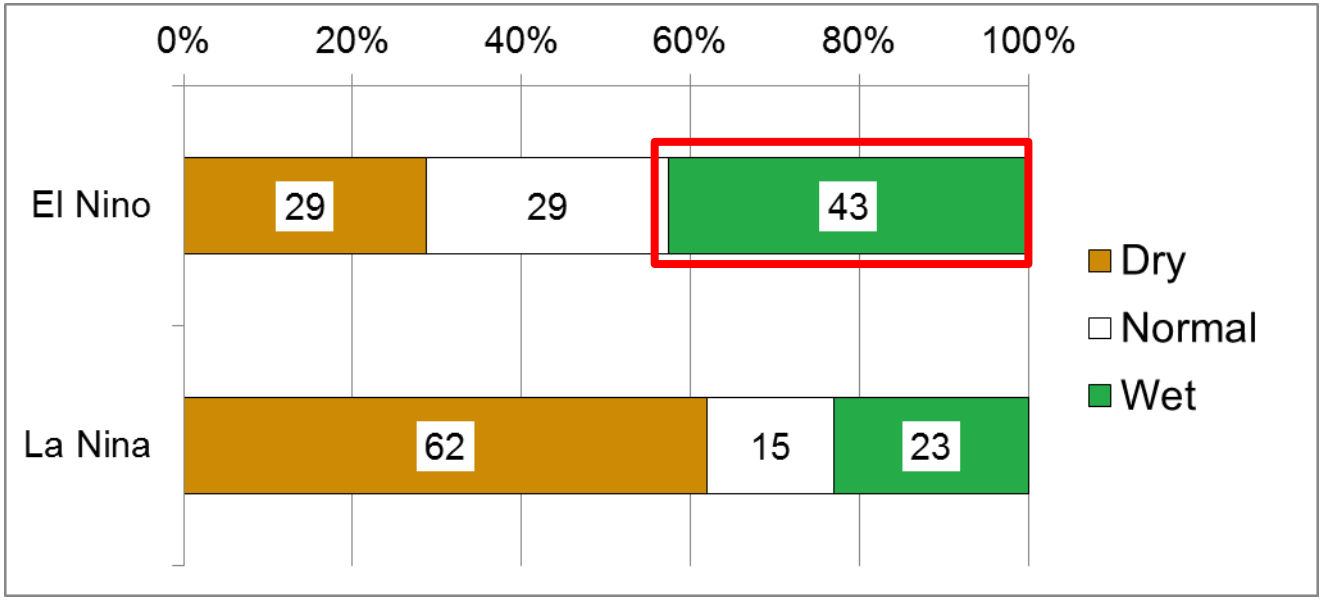


ENSO and winter precipitation in Japan (El Niño January)

In January of El Niño years,

- It slightly tends to be wetter (43%) in Tokyo.
- Statistically insignificant

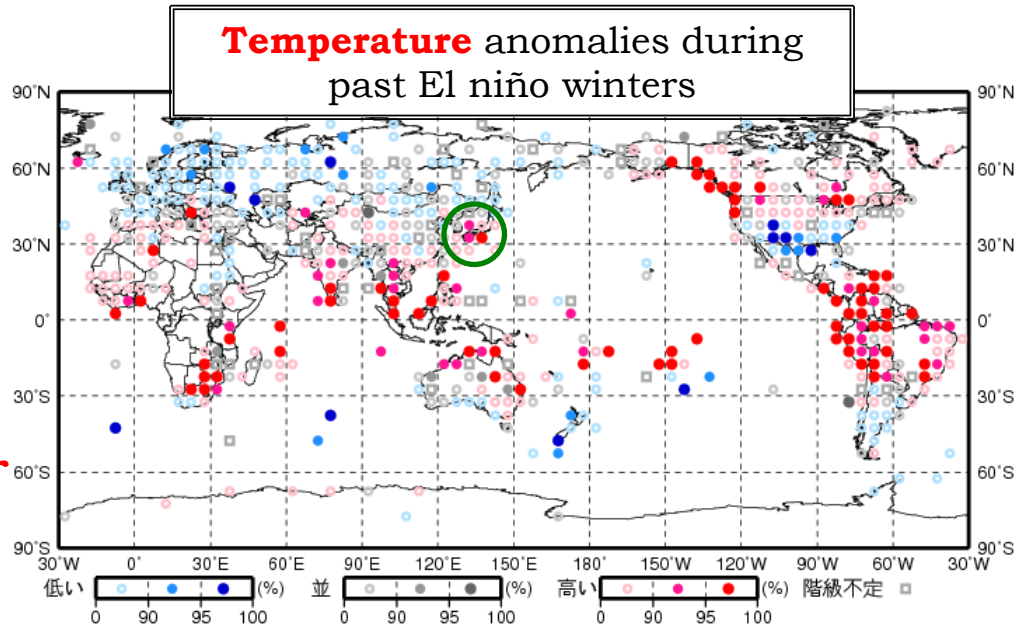
Binomial test: (p-value)					
	Dry	Normal	Wet	Not Dry	Not Wet
El Nino	0.7388066	0.7388066	0.3101925	0.4755005	0.8505378
Neutral	0.9161616	0.166011	0.5682556	0.1667829	0.5847596
La Nina	0.0346548	0.9614633	0.8612678	0.9911768	0.322424

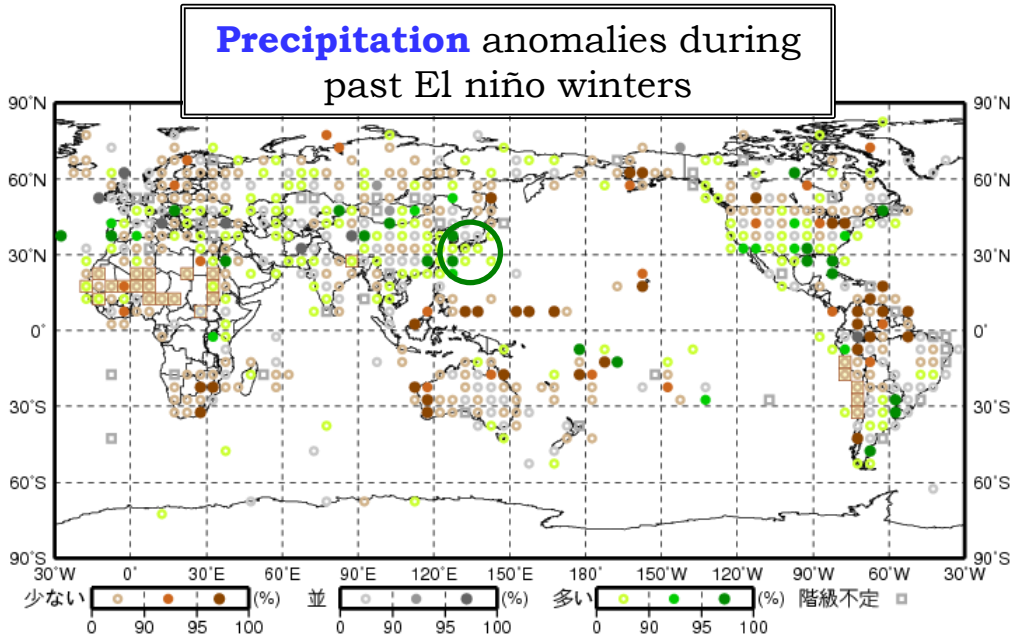


[Review] ENSO and climate in Japan (El Niño winter (DJF))

- Statistical analysis indicates that in winters with El Niño conditions, it is likely that parts of Japan experience warmer and wetter than normal conditions.

- But how do we explain this pattern of anomalies in terms of climatology?

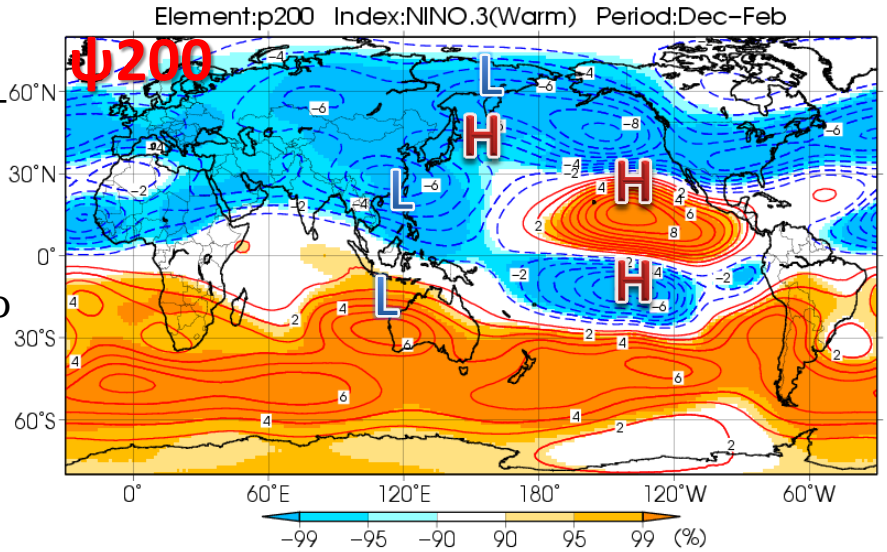


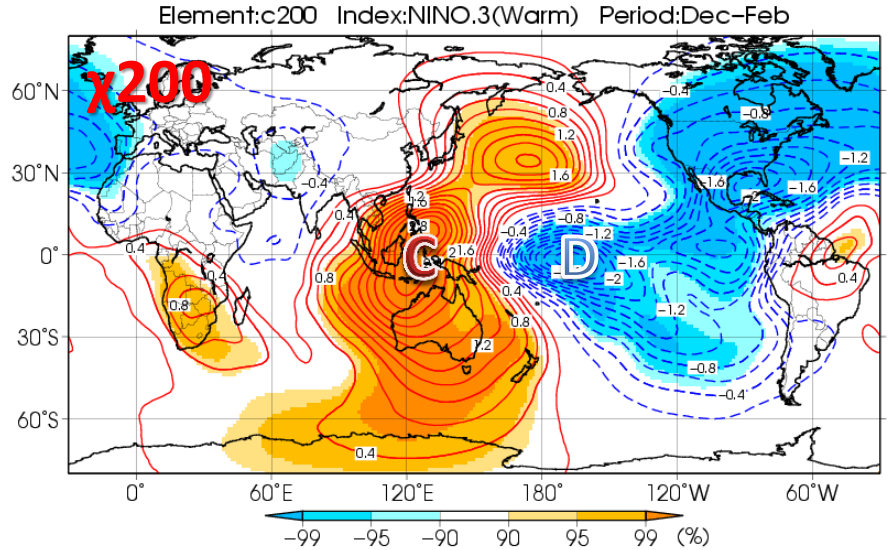


[Review] ENSO and atmospheric circulation (El Niño DJF)

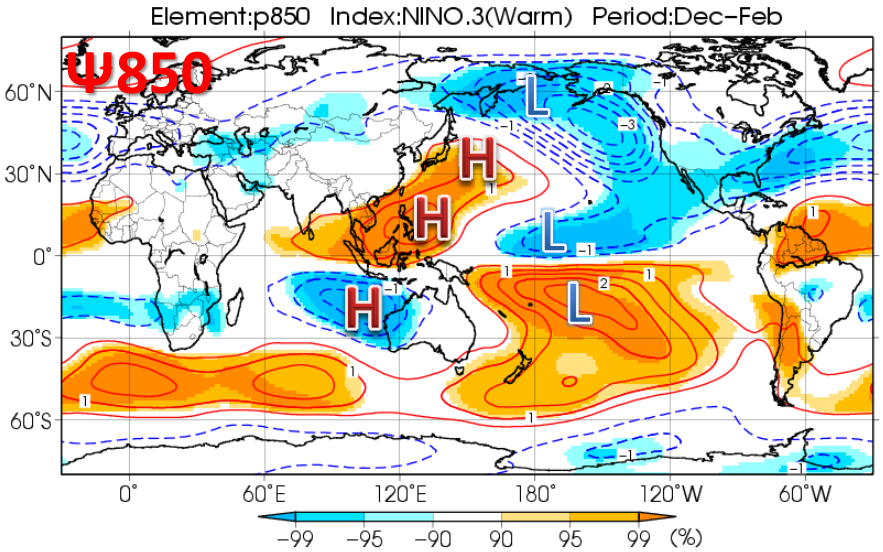
In December to February of El Niño years,

- In the upper troposphere, cyclonic and anti-cyclonic anomalies develop in the western and eastern Pacific, respectively.
- A Rossby wave train extends from cyclonic anomalies centered over South China Sea to the North Pacific.
- In the lower troposphere, anti-cyclonic and cyclonic anomalies develop in the western and eastern Pacific, respectively.





Composite **velocity potential anomalies** for DJF during past El Niño events. "C" and "D" stand for convergence and divergence anomalies, respectively.



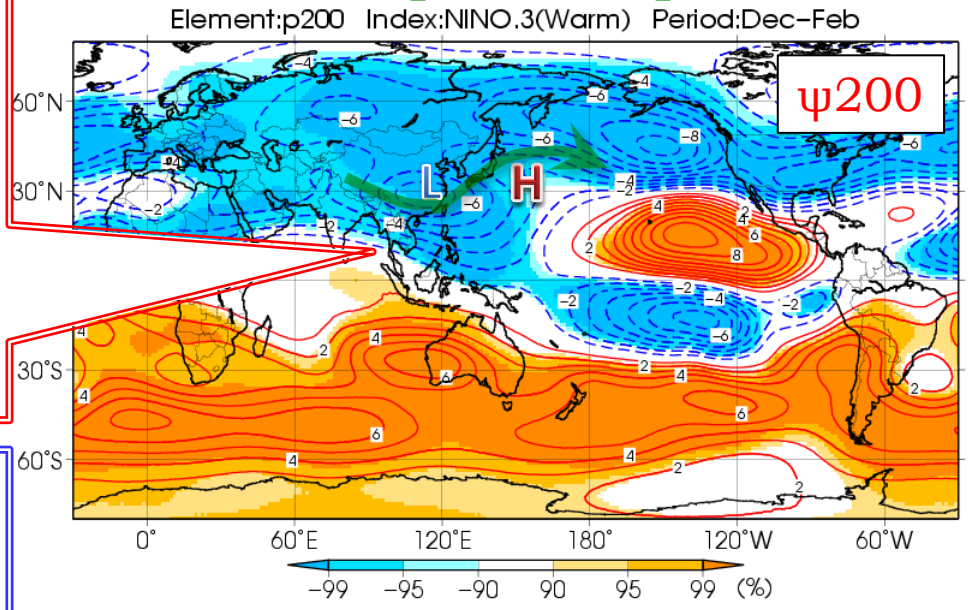
Composite **stream function anomalies** at 200hPa (top panel) and 850hPa (bottom panel) for DJF during past El Niño events

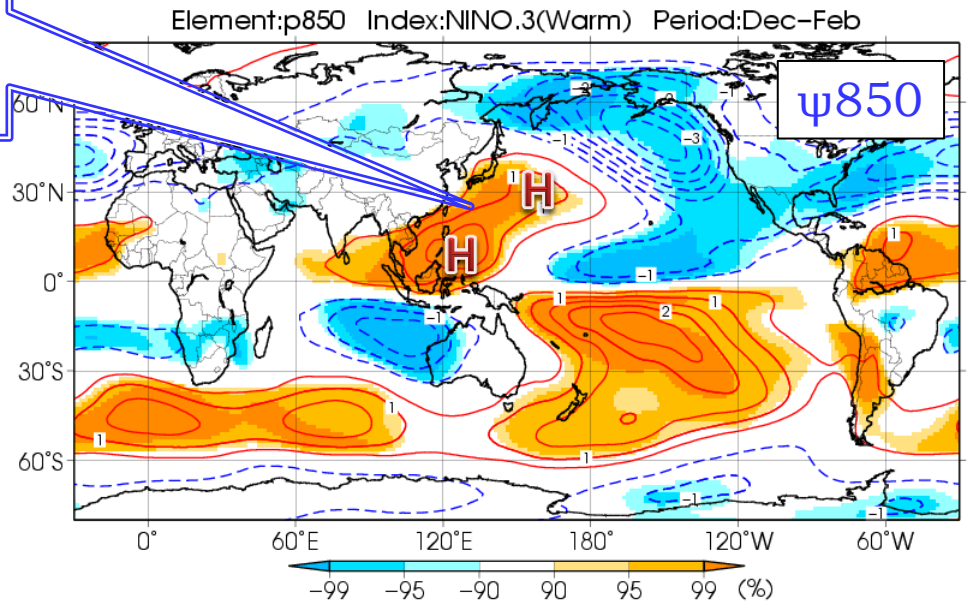
[Review] ENSO and climate in Japan (El Niño winter (DJF))

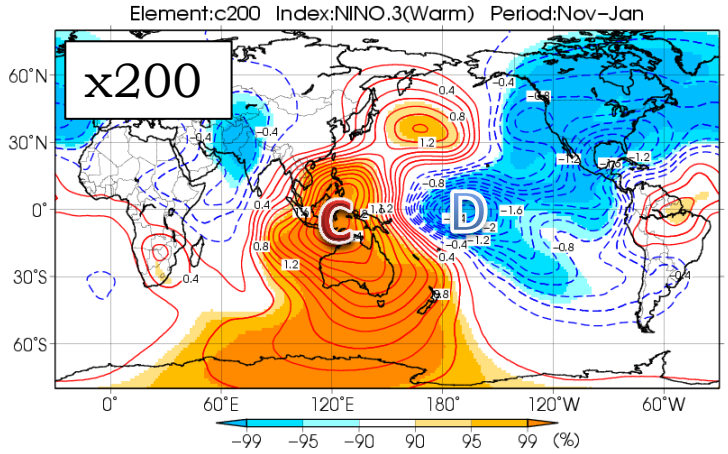
- **In the upper troposphere**, cyclonic anomalies centered over southeastern China and anticyclonic anomalies to the east of Japan, as a result of the convergence anomalies over the Maritime Continent and Rossby wave propagation.
- In association, the subtropical jet stream is displaced southward over China and northward to the east of Japan.
- This induces barotropic anticyclone to the east of Japan as well as anomalous southwesterly warm air advection which leads to enhanced extratropical cyclone activity.

- **In the lower troposphere**, anticyclonic anomalies develop centered over the Philippines and to the east of Japan in response to convection anomalies and upper-tropospheric circulation.
- This induces anomalous warm and wet air advection toward Japan, and leads to weaker northwestern winter monsoon.

Composite map







[Let's try] Apply to your own country

Materials are prepared in the previous lectures and exercises.

(1) Knowledge of climate dynamics such as response to tropical convective activity, Rossby wave propagation, and so on.

(2) Relationship between Climate Characteristics Associated with Primary Modes.

(3) Statistical relationship between Primary Modes of Climate Variability and Atmospheric Circulation.

Let's consider the mechanisms of the relationship between primary modes and atmospheric circulation, which supposed to affect climate in your own country.

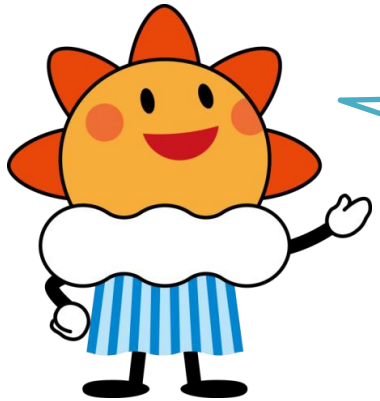
[Let's try] Apply to your own country

[Contents on TCCHP]
- iTacs
http://extreme.kishou.go.jp/itacs5/analyze/form_auth

- Composite map for El Niño / La Niña events
http://ds.data.jma.go.jp/tcc/tcc/products/clisys/enso_statistics/index.html

- Temperature and precipitation anomalies appeared in the past events (Detailed Chart)
http://ds.data.jma.go.jp/tcc/tcc/products/climate/ENSO/month.html

- Analysis Charts and Monitoring Indices
http://ds.data.jma.go.jp/tcc/tcc/products/clisys/acmi.html



Please feel free to ask TCC staff your question.