Diagnosis of the atmospheric circulation in winter 2007/08 focusing on unusually strong Siberian high and cold surges over Asia

Kumi HAYASHI
林　久美

Tokyo Climate Center, Climate Prediction Division, Japan Meteorological Agency
http://ds.data.jma.go.jp/tcc/tcc/index.html

Outline

１. Climate in Japan and the World in 2007/08 winter

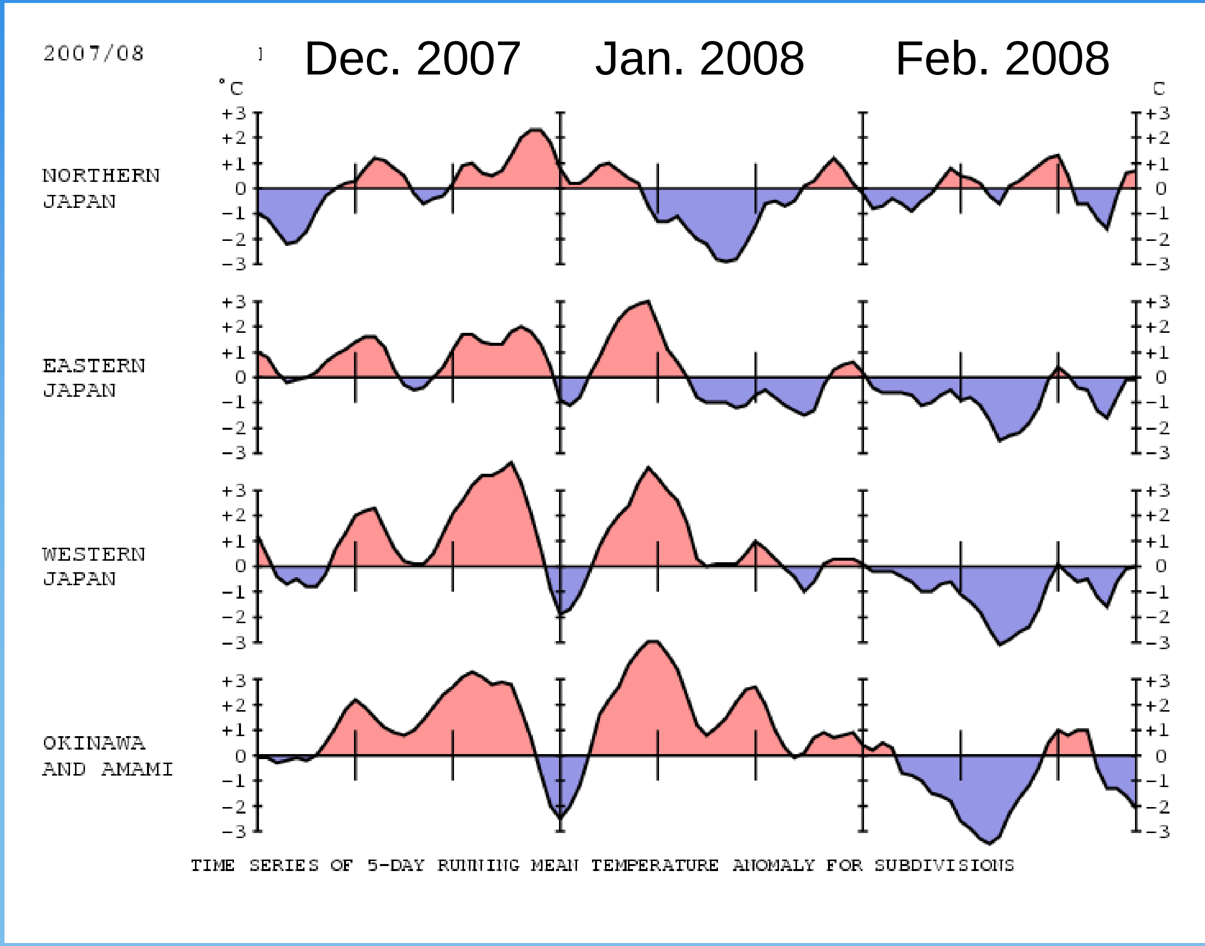
２. Diagnosis of the atmospheric circulation and Oceanographic conditions

３. Prediction by the JMA numerical seasonal prediction system

４. Summary

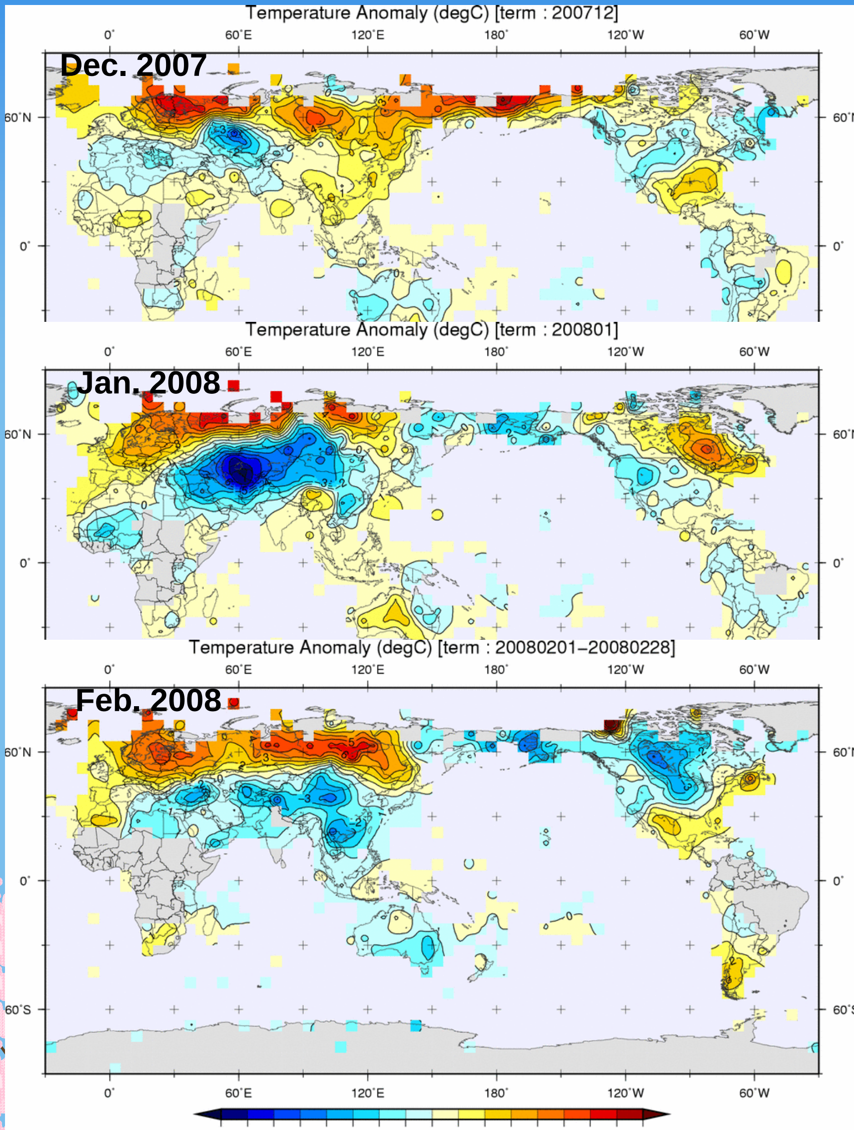
1． Climate in Japan and the World in 2007/08winter

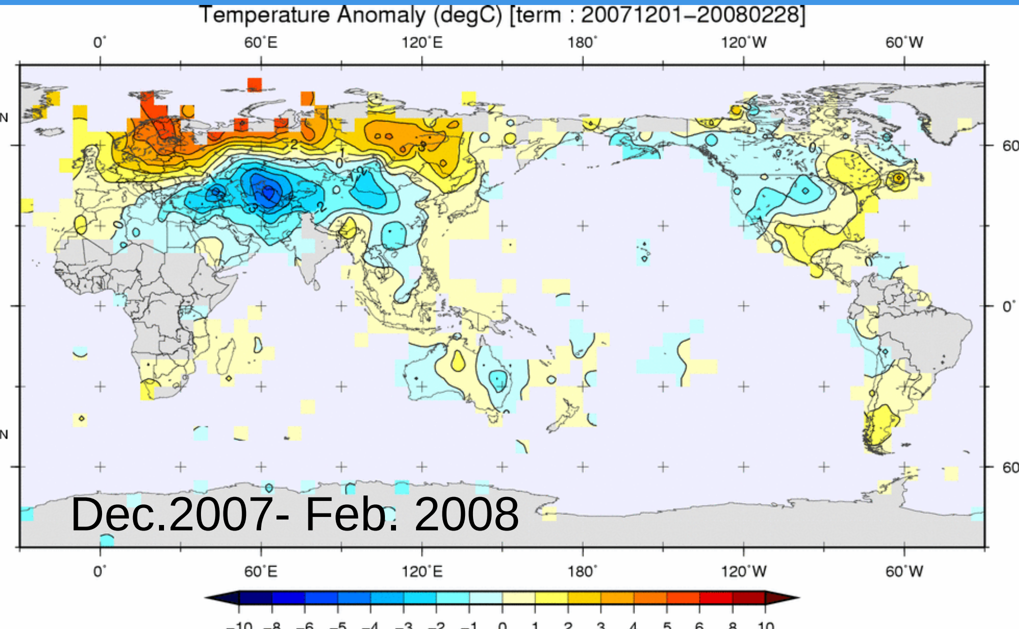
Temperature anomalies in Japan



- High in early winter mainly from Western Japan to Okinawa/Amami
- Low in late winter in the whole country
- The coldest February in this twenty years in Eastern Japan, Western Japan, and Okinawa/Amami

Temperature anomalies in the world

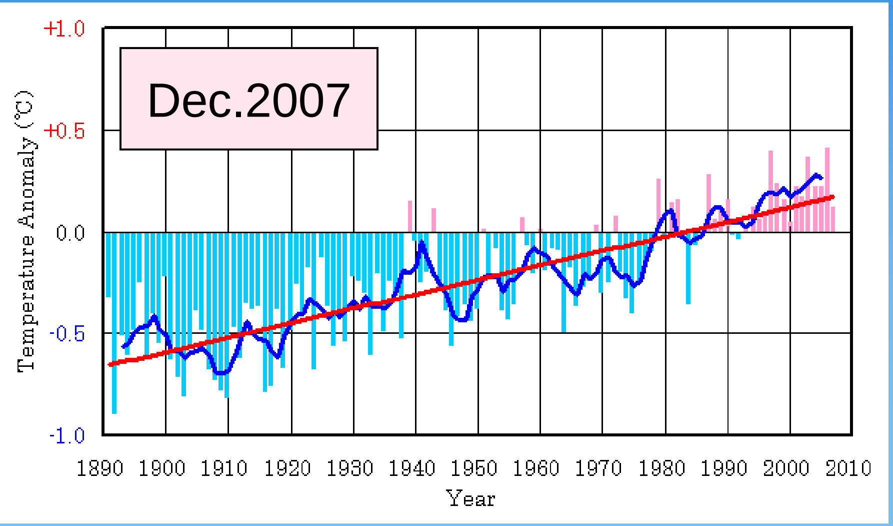


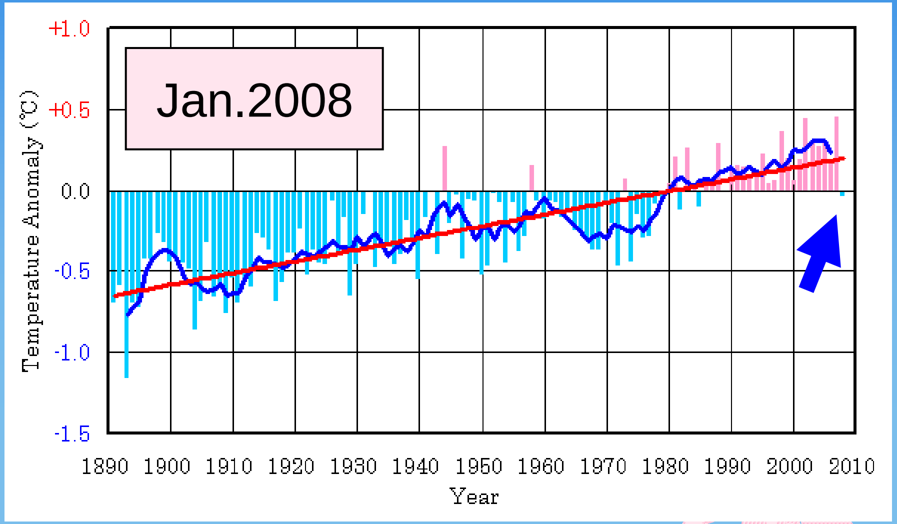


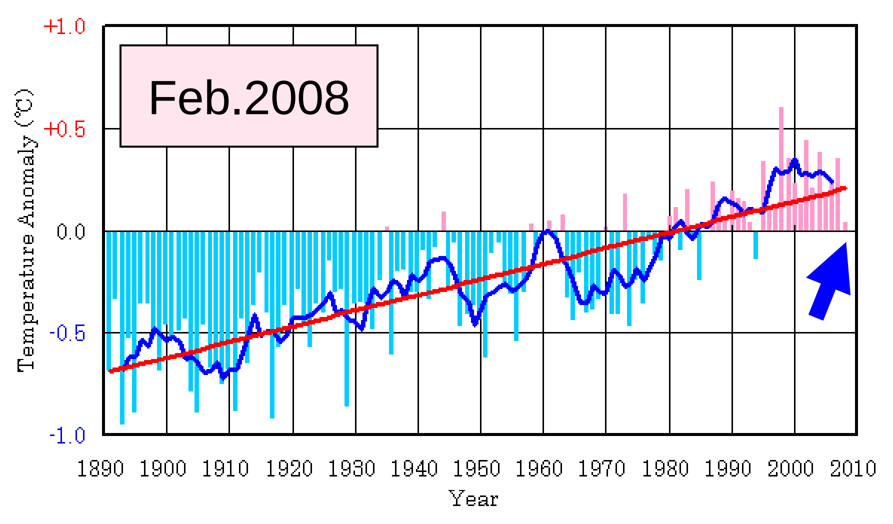
- High temperature anomalies have been persisted from Oct.2007 in the northern part of the Eurasia Continent.
- Low temperature anomalies were remarkable from Jan.2008 in the southern part of the Eurasia Continent.

http://ds.data.jma.go.jp/tcc/tcc/products/climate/monthly.html

Global Average Temperature







- The coldest Jan. in 19 years
- The coldest Feb. in 14 years

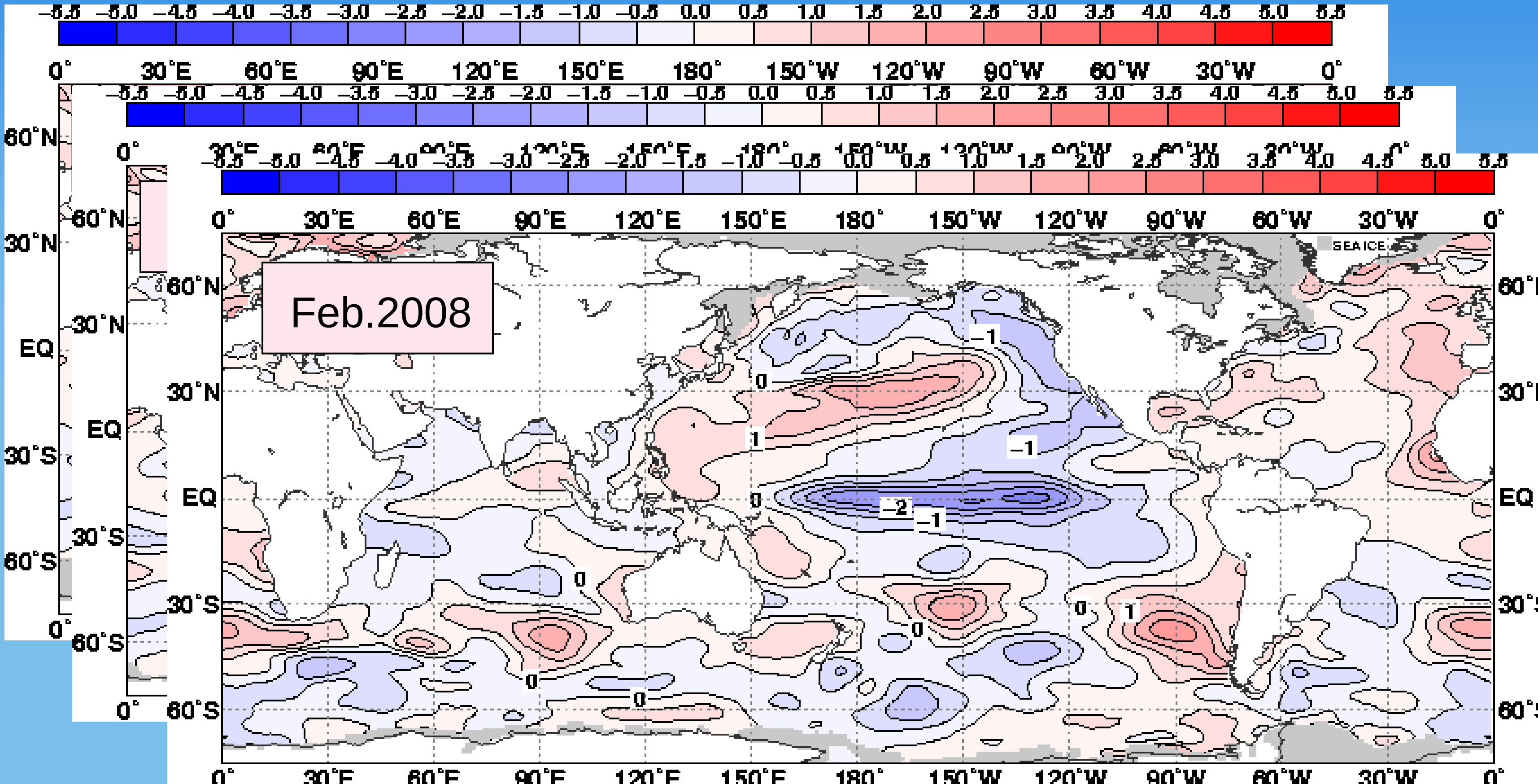
Cold winter in the global warming trend

http://ds.data.jma.go.jp/tcc/tcc/products/gwp/temp/dec_wld.html

2. Diagnosis of the atmospheric circulation and Oceanographic conditions

・ Influence of La Niña
・Development and persistence of the Siberian High

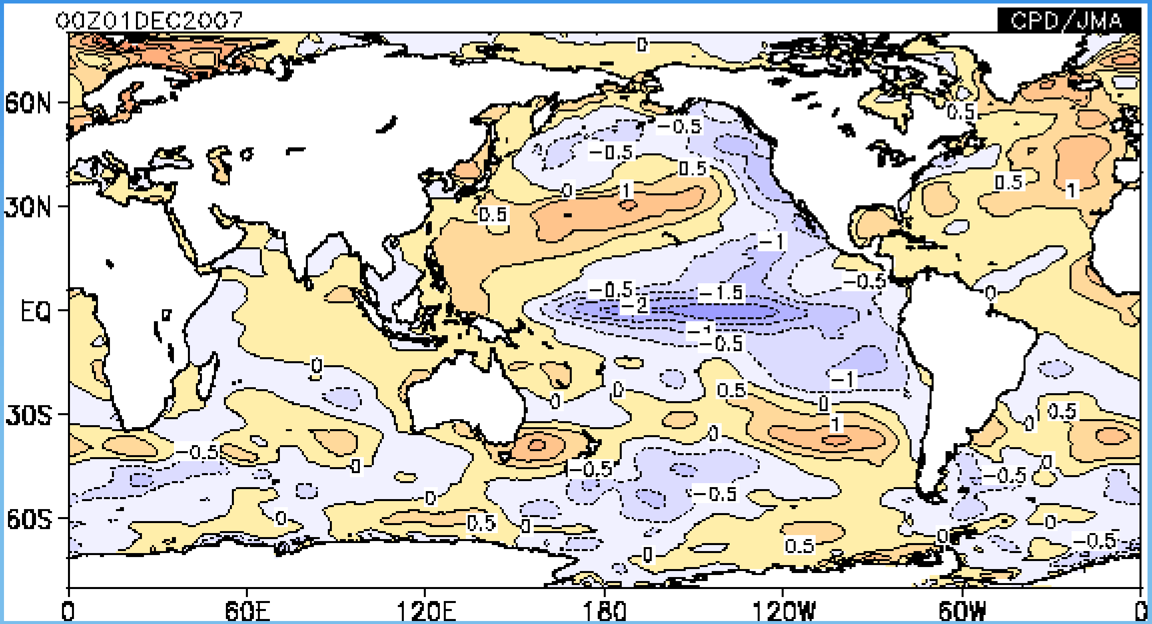
SST anomalies



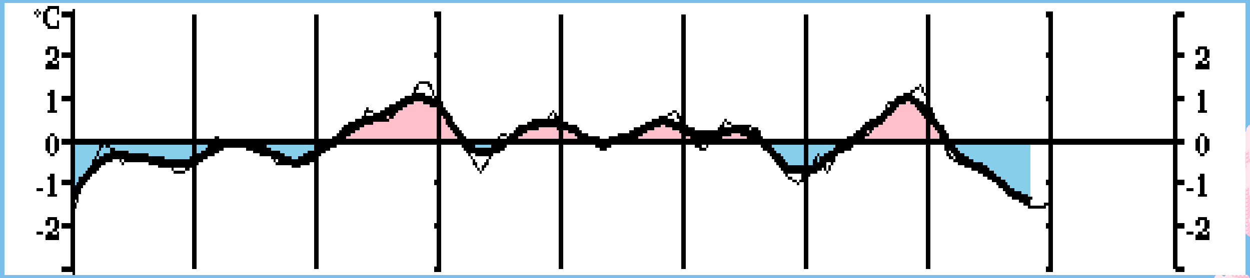
The contour interval is 0.5° C. Maximum coverage of sea ice is shaded in gray. Anomalies are departures from the JMA climatology (1971-2000).

http://ds.data.jma.go.jp/tcc/tcc/products/elnino/ocean/sst-ano-global_tcc.html

3-month mean (Dec.2007-Feb.2008) SST anomalies



NINO.3

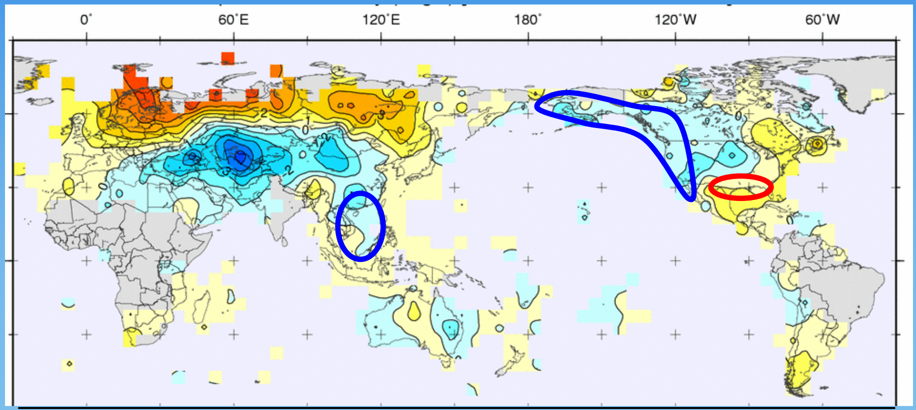


・La Niña has been persisted from spring in 2007

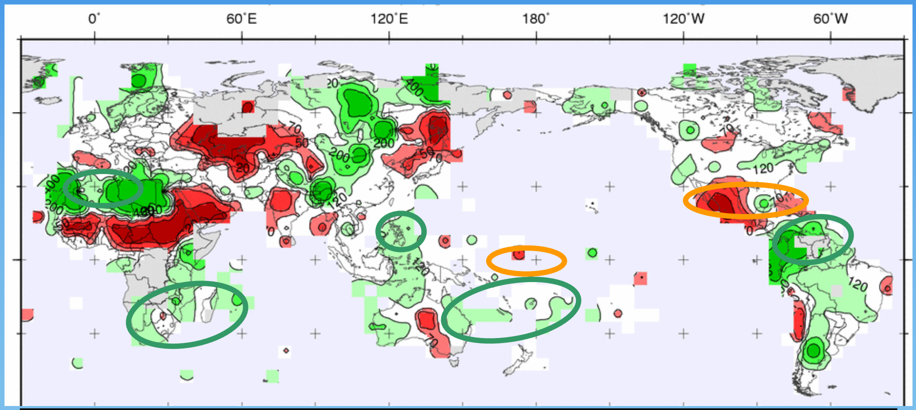
・the third lowest NINO.3 in 13 La Niña events since 1949

Climate in the World and La Niña

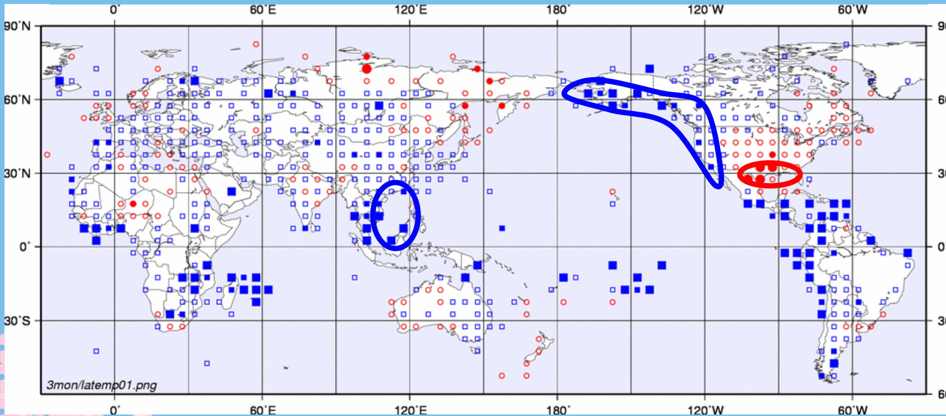
Temperature anomaly (Dec. 2007-Feb.2008)



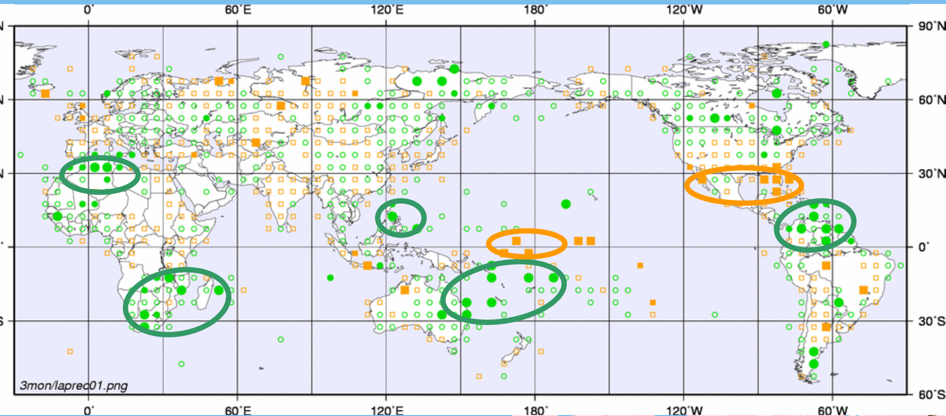
Precipitation ratio (Dec. 2007-Feb.2008)



Temperature anomaly in La Niña winter



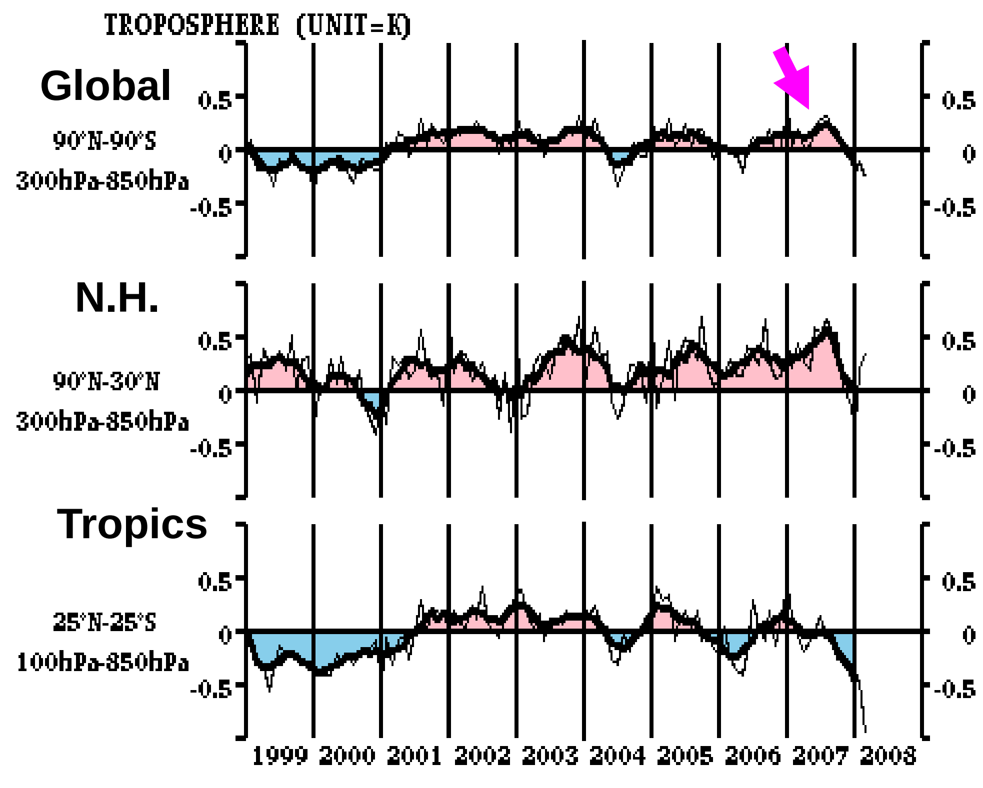
Precipitation ratio in La Niña winter



Composite of La Nina years for Winter: 1950,55,56,65,68,71,74,76,85,89,96,99,00
Filled marks show statistical significant areas (5%)

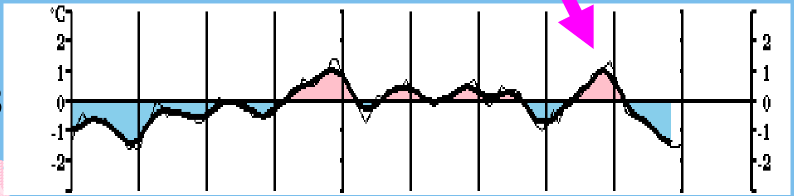
- Typical climate features in La Niña winter were observed in 2007/08 winter

Temperature anomalies in the troposphere



- Global and N.H. temperature in the troposphere changed from above normal to below normal in Dec. 2007.
- The peak of positive anomaly of Global temperature in the troposphere was observed in Jul. 2007 with 2 to 3 seasons lag of the peak of NINO.3. The lag is consistent with Angell(2000).

NINO.3

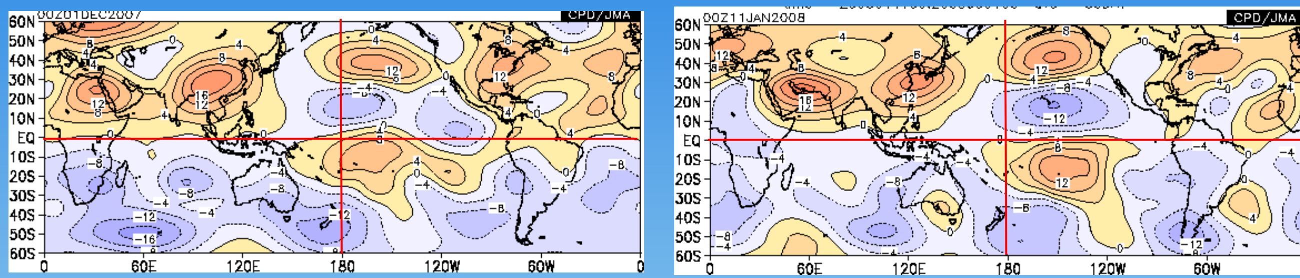


Angell, J. K., 2000: Tropospheric temperature variations adjusted for El Nino. 1958-1998, 2000: J. Geophys. Res., 105, D9, 11841-11849.

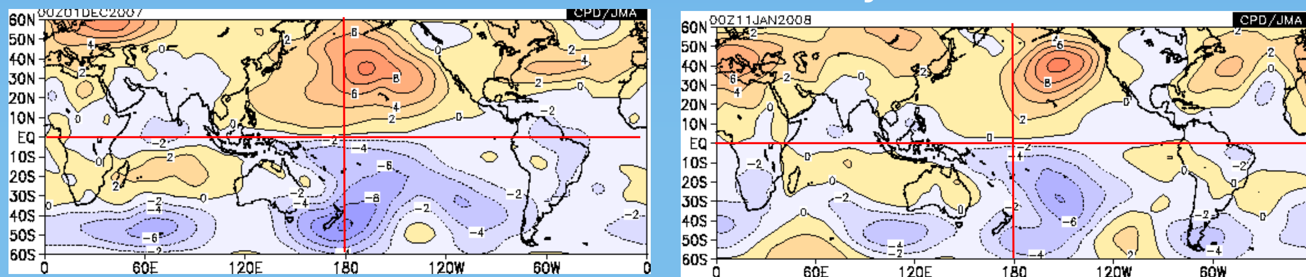
http://ds.data.jma.go.jp/tcc/tcc/products/clisys/figures/db_hist_indx_tcc.html

Convective activities and atmospheric circulation in the tropics

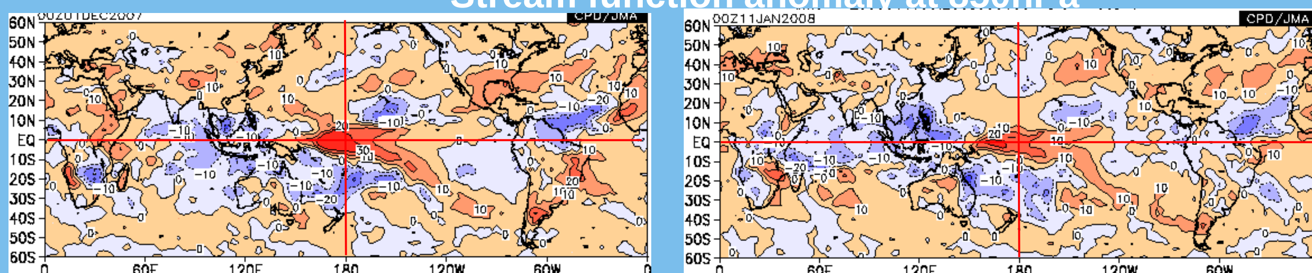
Dec.1 2007～ Jan.10 2008　　Jan.11 2008～Feb. 2008



Stream function anomaly at 200hPa



Stream function anomaly at 850hPa



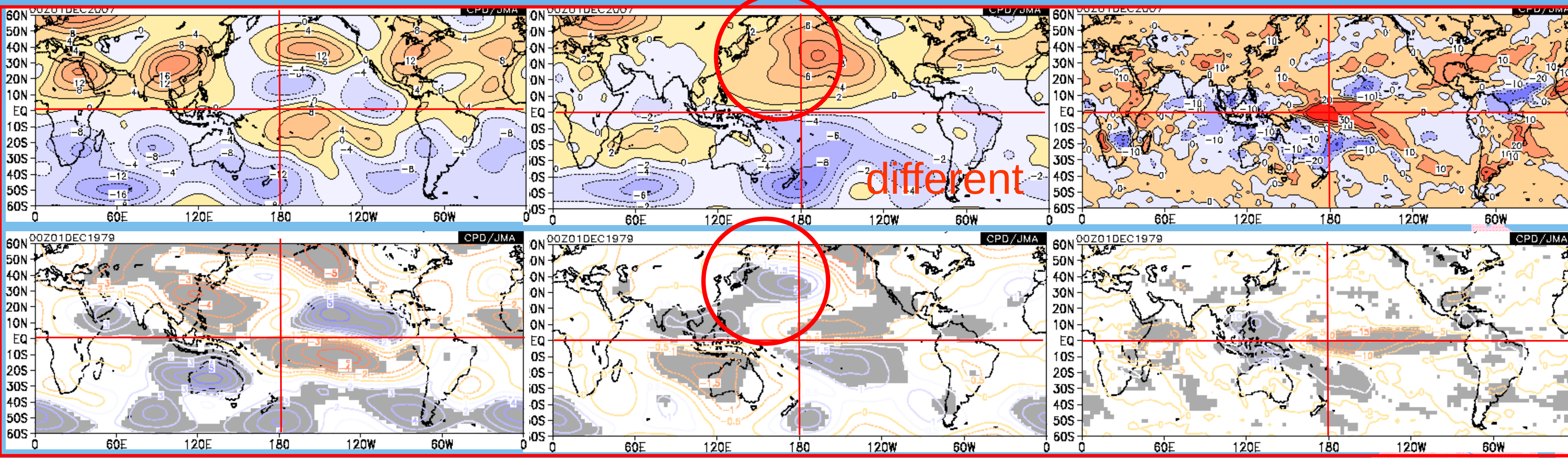
OLR anomaly

- Enhanced convective activities around Indonesia, the South China Sea, the Philippines and SPCZ, while inactive in the western and central Pacific Ocean
- Equator symmetrical circulation anomaly patterns in the Pacific and the Indian Ocean in the upper and lower troposphere.
- Apparent reversed PNA pattern
- Common features in early and late winter

Linear Regression: NINO.3 and ψ200,ψ850,OLR)

OBS. : Dec.1 2007～Jan.10 2008

Stream function anomaly at 200hPa **Stream function anomaly at 850hPa** **OLR anomaly**



Linear Regression: Dec.

statistical significant areas (5%) are shaded

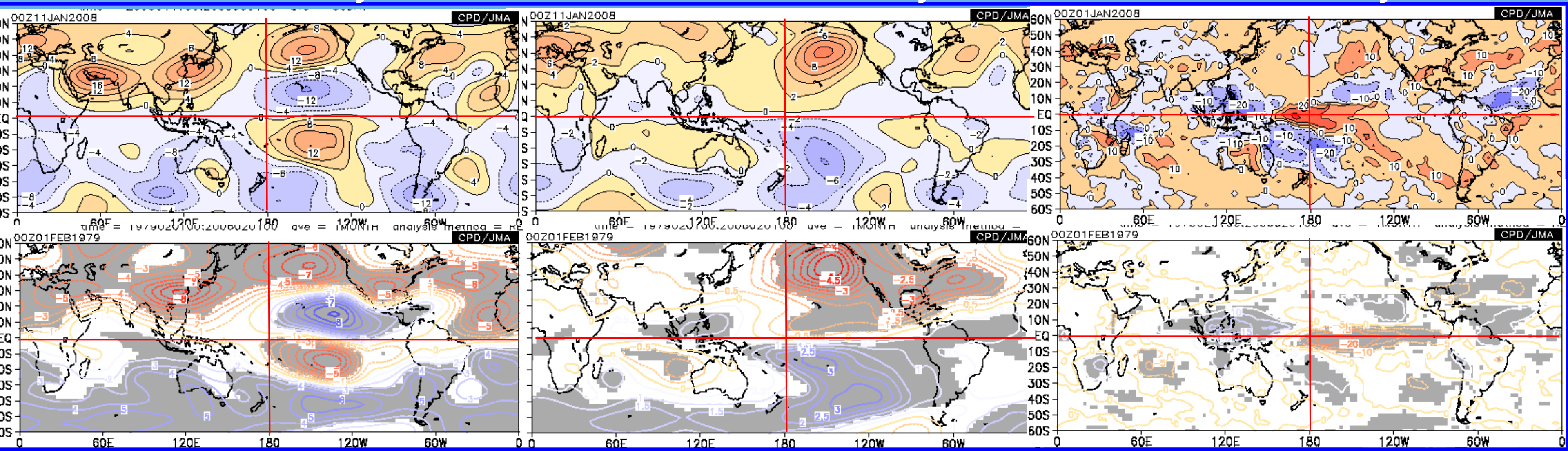
・Typical patterns of convective activities, circulation anomalies in the upper and lower troposphere　in La Niña early winter are apparent in this early winter.

・But, cyclonic circulation anomaly in mid and western North Pacific in La Niña early winter was not observed in this early winter.

Linear Regression: NINO.3 and ψ200,ψ850,OLR)

OBS.: Jan.11 2008～Feb.29 2008

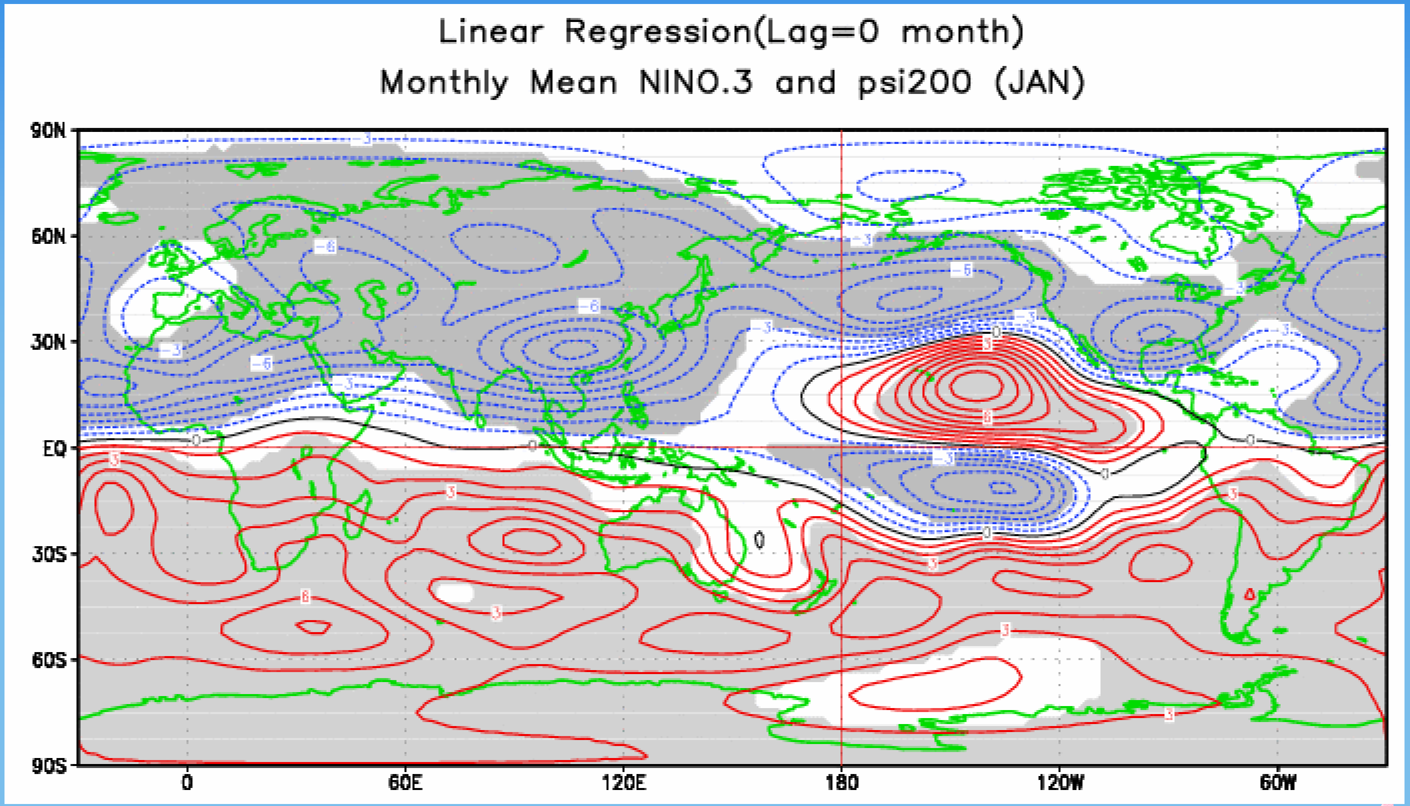
Stream function anomaly at 200hPa **Stream function anomaly at 850hPa** **OLR anomaly**



Linear Regression: Feb.

statistical significant areas (5%) are shaded

・Typical patterns of convective activities, circulation anomalies in the upper and lower troposphere in La Niña late winter are apparent in this late winter.



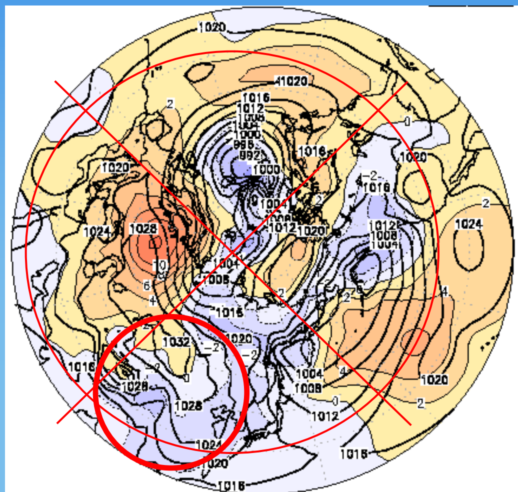
Contour intervals are 0.2.

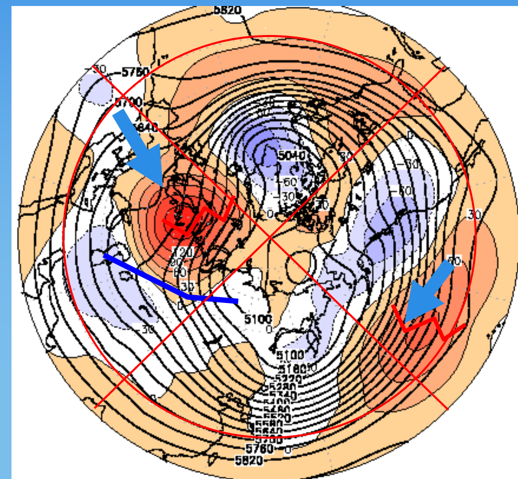
Shadings show 95% confidence level based on f-test.

http://ds.data.jma.go.jp/tcc/tcc/products/clisys/REGR/index.html#sst

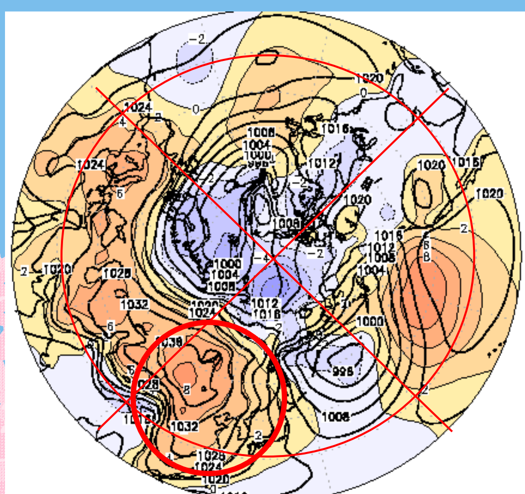
Atmospheric circulation in N.H.

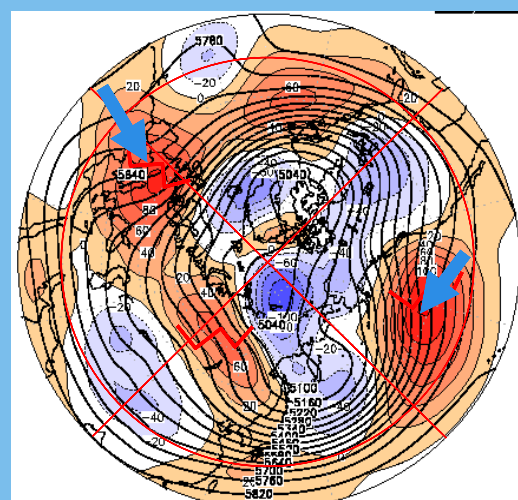
Dec.1 2007～Jan.10 2008





SLP Jan.11 2008～Feb.29 2008 Z500



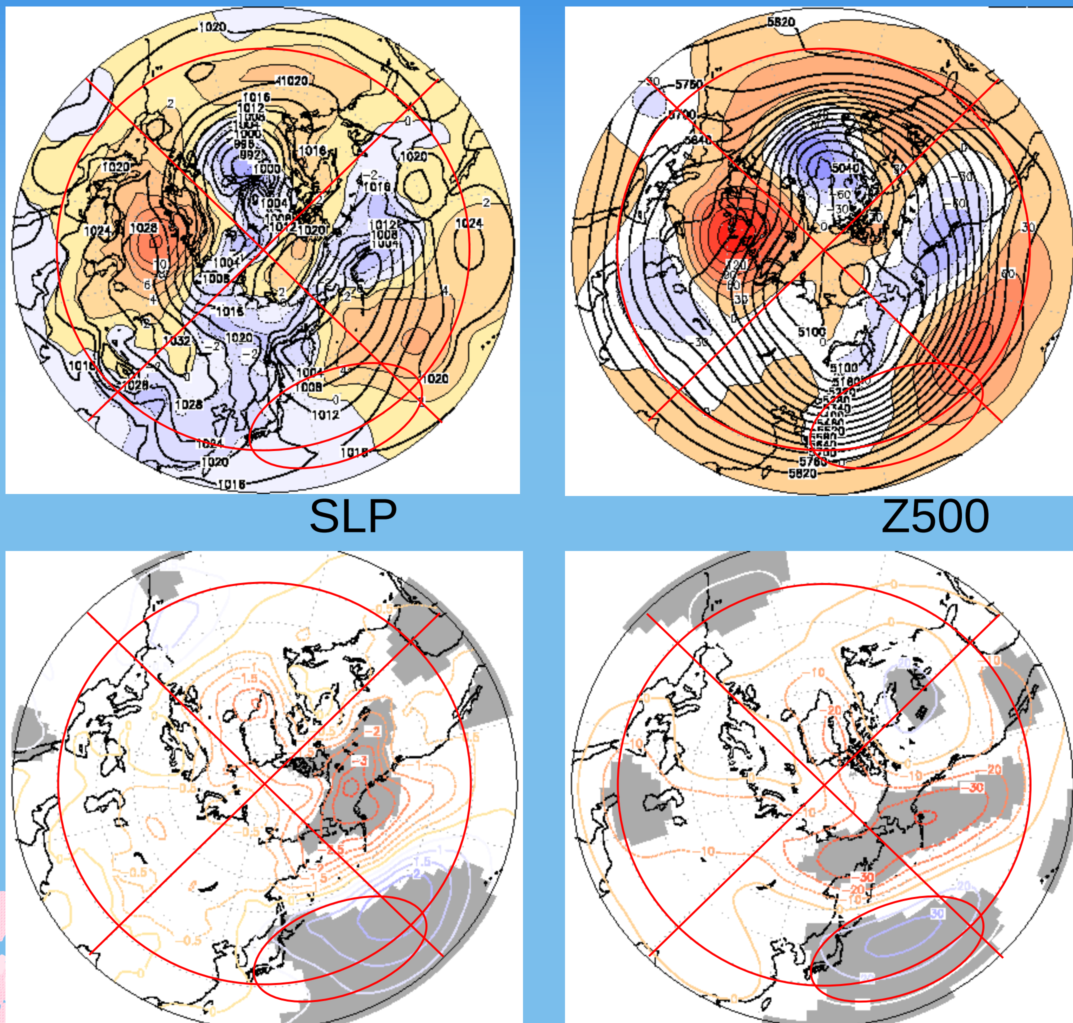


・Through the winter, ridges in Europe and eastern Pacific persisted.

・ In mid-January, strength of the Siberian high drastically changed from rather weak to very strong.

Linear Regression: NINO.3 and SLP, Z500)

OBS.: Dec.1 2007～Jan.10 2008



Linear Regression: Dec.

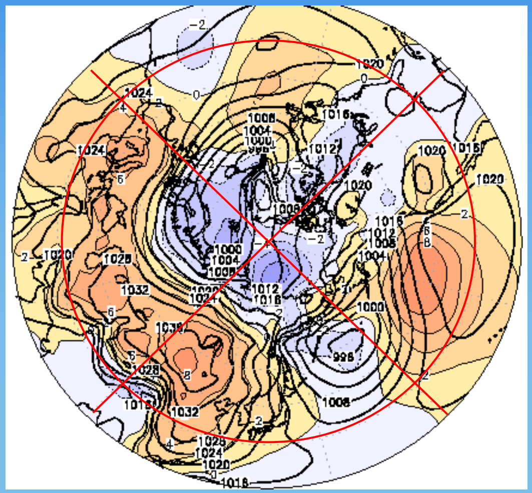
statistical significant areas (5%) are shaded

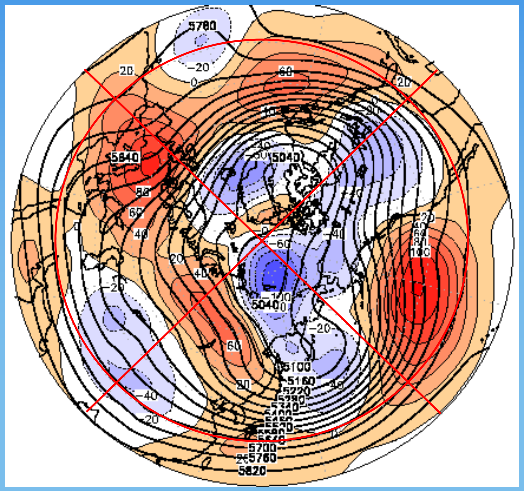
・WP pattern in La Niña early winter was not observed in 2007/2008 early winter.

・No significant statistical relationship between NINO.3 and the Siberian high

Linear Regression: NINO.3 and SLP, Z500)

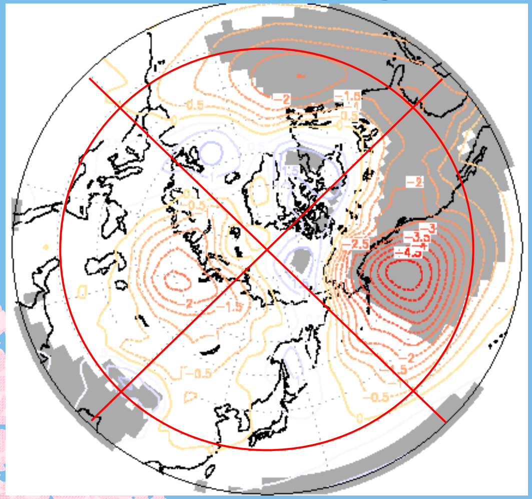
OBS.: Jan.11 2008～Feb.29 2008

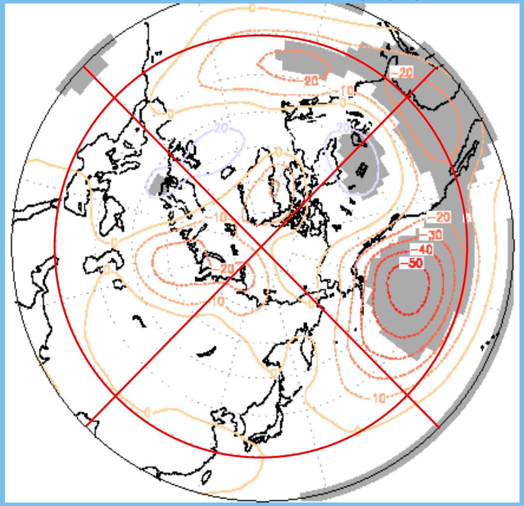




SLP

Z500





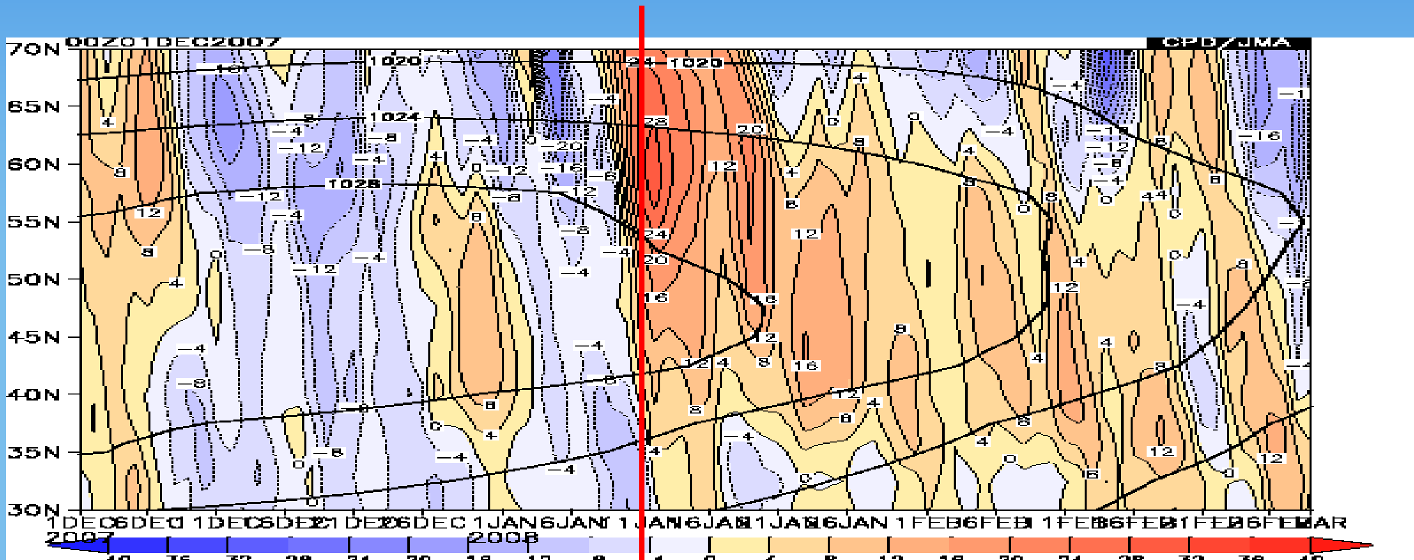
・No statistical characteristic features in the lower circulation in East Asia in La Niña late winter

・No significant statistical relationship between NINO.3 and the Siberian high

Linear Regression: Feb.

statistical significant areas (5%) are shaded

Rapid growth of the Siberian high



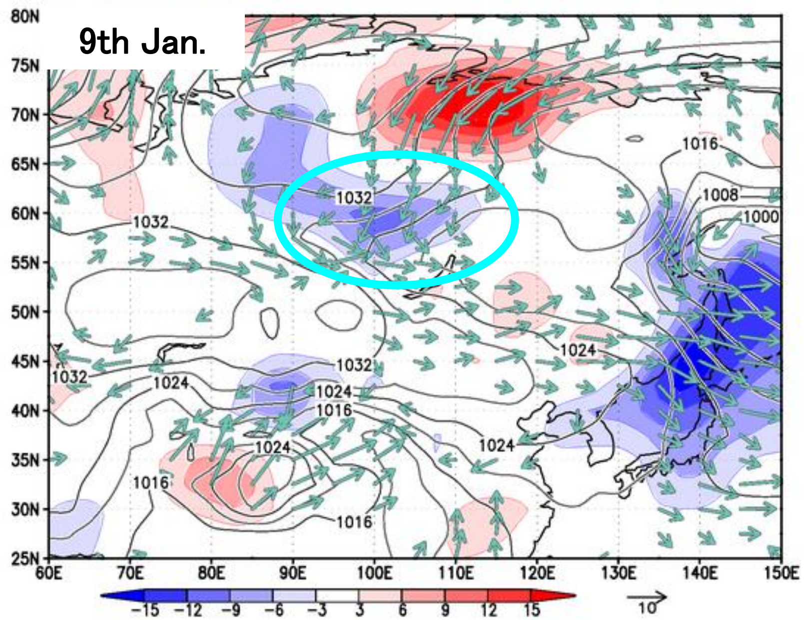
1 Dec. 1 Jan. 1 Feb.

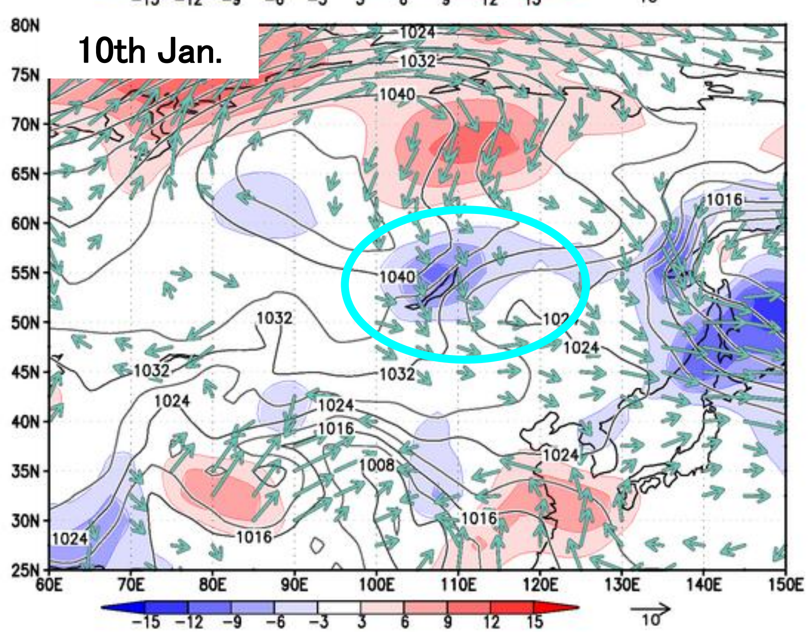
Latitude-time cross section of area averaged SLP anomaly (90E-120E)

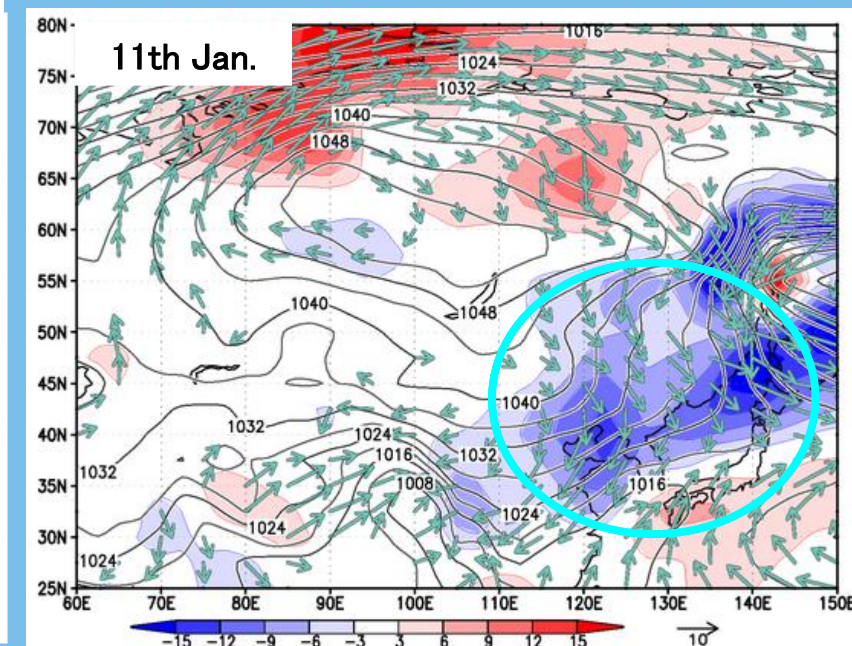
・The Siberian high developed rapidly in mid-January in East Siberia, and persisted until mid-February.

Horizontal Temperature Advection at 925-hPa level

SLP (contour, unit in hPa), wind at 925-hPa level (vector, unit in m/s) and horizontal temperature advection at 925-hPa level (shadings, unit in K/day).

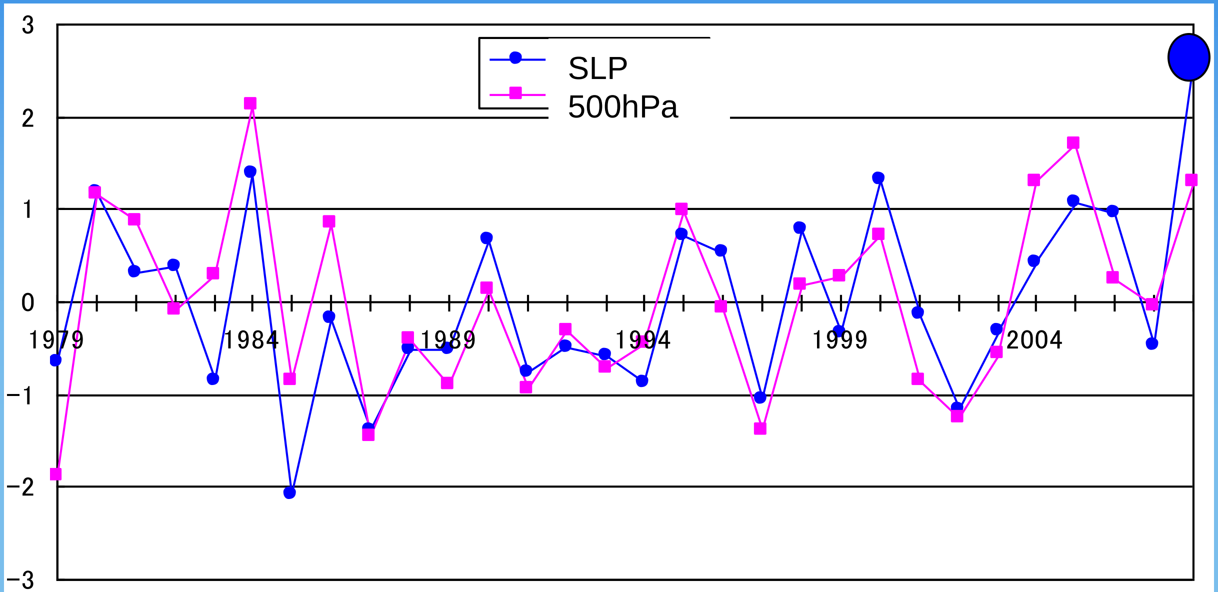


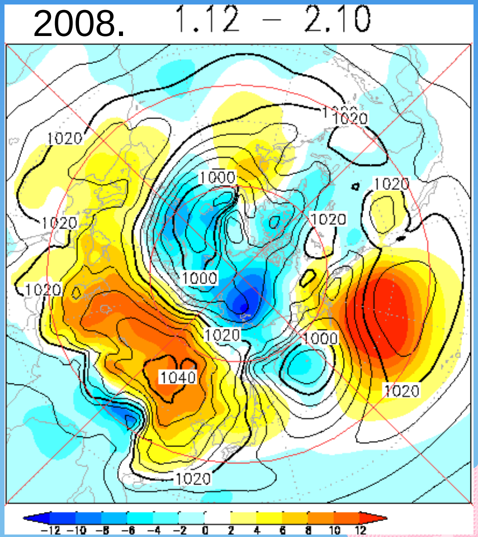


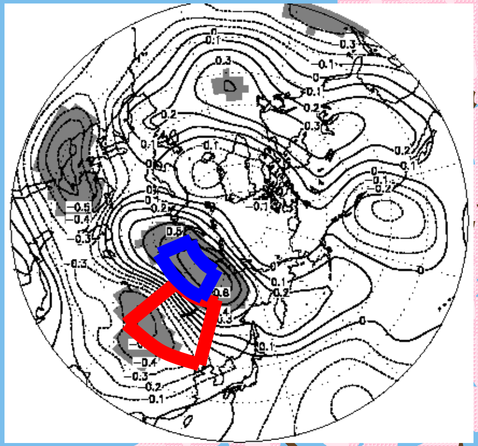


Cooling by horizontal temperature advection was seen on the south edge of the Siberian high on 9 and 10 January. This was consistent with the development tendency of the Siberian high. On 11 January, strong cold surge was observed from northeastern China to Japan.

Strength of the Siberian high







1979 → 2008

Time series of normalized 30-day mean (12 Jan.-10 Feb.) area averaged SLP (90E-120E,40N-60N) and Z500 (70E-110E,60N-70N) anomalies. From 1979-2008. SLP: blue, Z500:red.

・The highest 30-day mean (12 Jan.-10 Feb.) SLP (90E-120E,40N-60N) since 1979.

Amplification of the Siberian high and propagation of Rossby wave packet

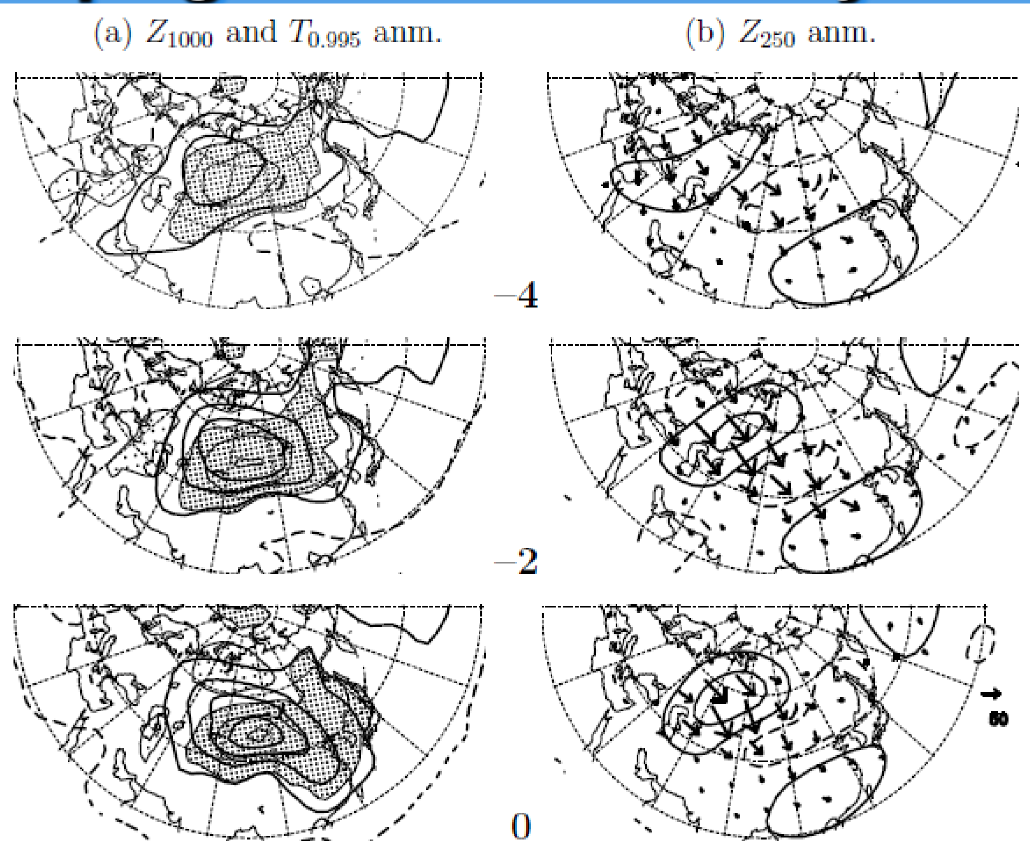
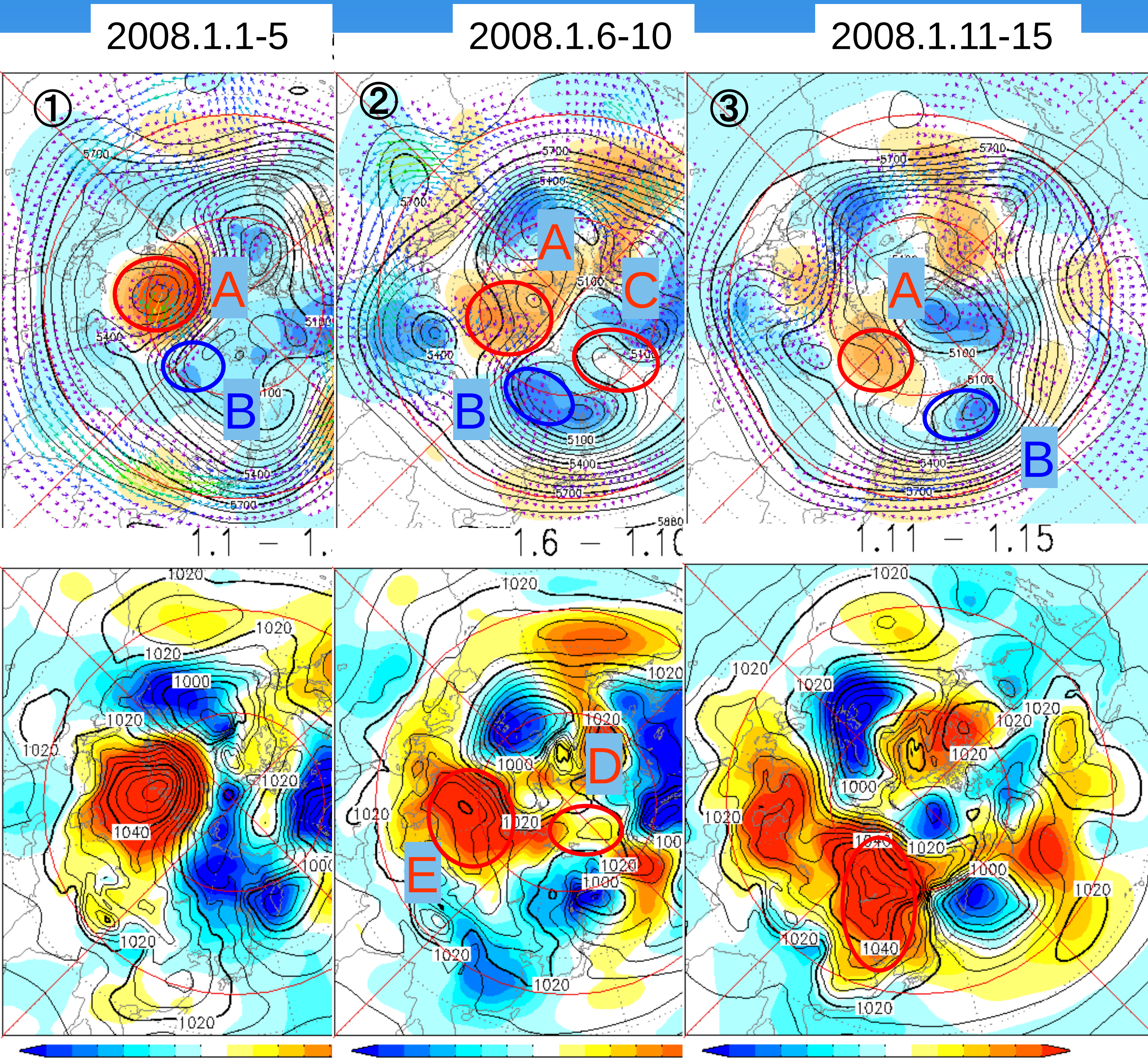


図 2: シベリア付近 (47°N, 90°E) を中心とした、高気圧偏差増幅時の長周期変動の時間発展。最近 40 年 (1958-98) で最も強い 20 のイベントの合成図。ピーク時を 0 とした日付を参照。(a) 等値線は 1000-hPa 高度場偏差合成図で、20m から 40m 毎。影は、地表付近における温度偏差で、濃いものは負。2K より 4K 毎。(b) 等値線は 250-hPa 高度場偏差で 50m から 100 m。矢印は wave-activity flux (Takaya and Nakamura 1997, 2001) で、スケーリングは右下参照。

composite map of the 20 highest events

Takaya K., and H. Nakamura, 2005: Mechanisms of intraseasonal amplification of the cold Siberian high. J. Atmos. Sci., 62, 4423–4440.

Z500 and SLP in Jan. 2008



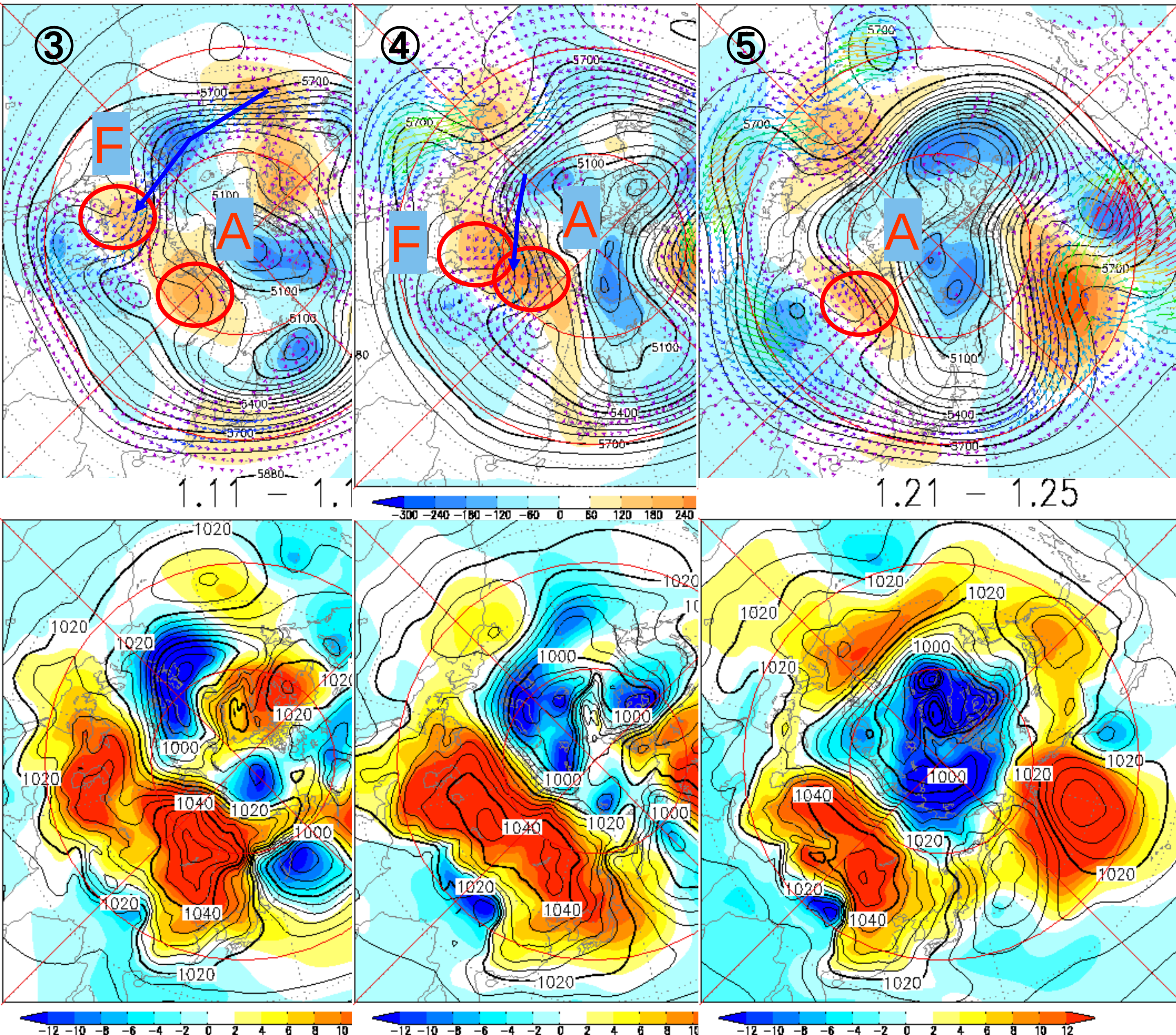
Z500 and wave-activity flux at 250hPa

(Takaya and Nakamura, 2001)

SLP

Z500 and SLP in Jan. 2008

2008.1.11-15 | 2008.1.16-20 | 2008.1.21-25



Z500 and wave-activity flux at 250hPa

SLP

3. Prediction by the JMA numerical seasonal prediction system

Initial : Nov.15 2007

・3-month mean field prediction for DJF 2007/2008

Initial : Dec.13 2007

・1-month mean field prediction for Jan.2008

Initial :Jan.3 2008

・1-week mean field prediction for 12-18 Jan. 2008

Could we predict the unusually strong Siberian high?

Outline of the JMA numerical seasonal prediction system

One-month Forecast

- T_L159: 1.125deg ~**110km**
- **L40**: model top=0.4hPa
- Ensemble size: **50**
- I. Perturbation: **BGM/LAF**
- Frequency: **Once a week**
- Forecast period: **34 days**
- Land: SiB
- SST: **Persisted anomaly**

Seasonal Forecast

- T_L95: 1.875deg ~**180km**
- **L40**: model top=0.4hPa
- Ensemble size: **51**
- I. Perturbation: **SV**
- Frequency: **Once a month**
- Forecast period: **120/210 days**
- Land: SiB
- **SST: Prescribed using persisted anomaly, climatology and ENSO prediction by CGCM**

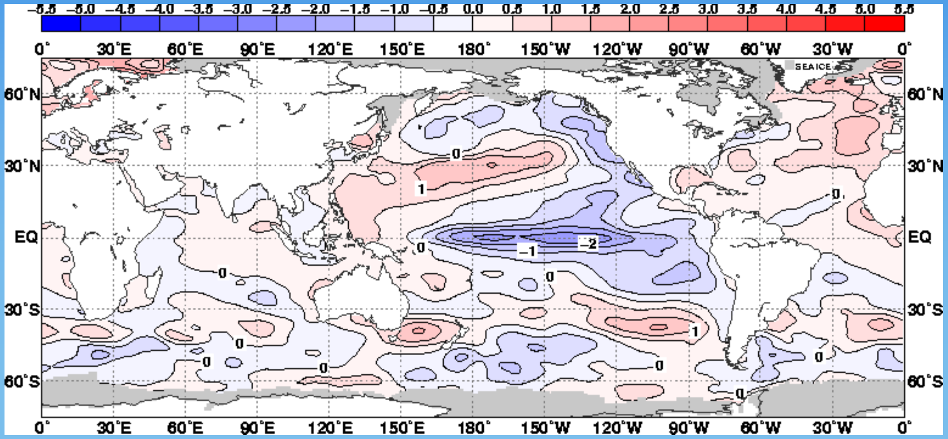
http://ds.data.jma.go.jp/tcc/tcc/products/model/index.html

Initial : Nov.15 2007

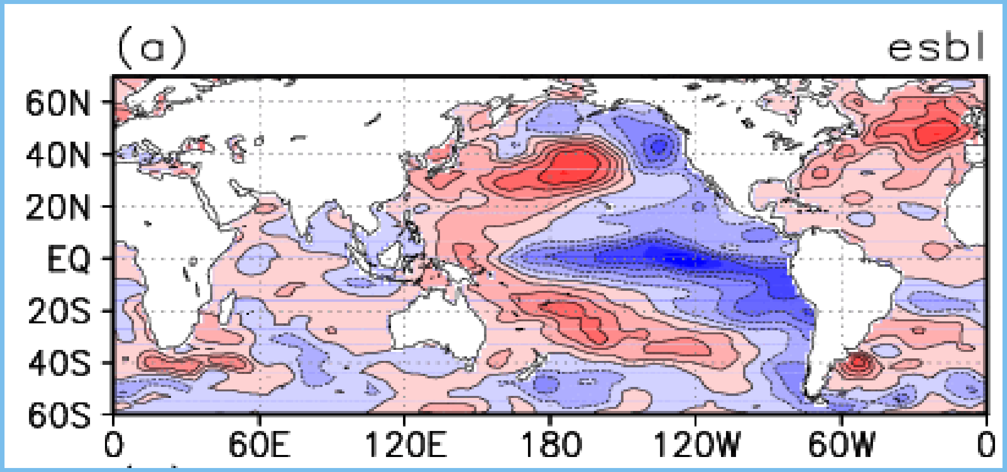
- 3-month mean field prediction for DJF 2007/2008

SST anomalies

OBS.



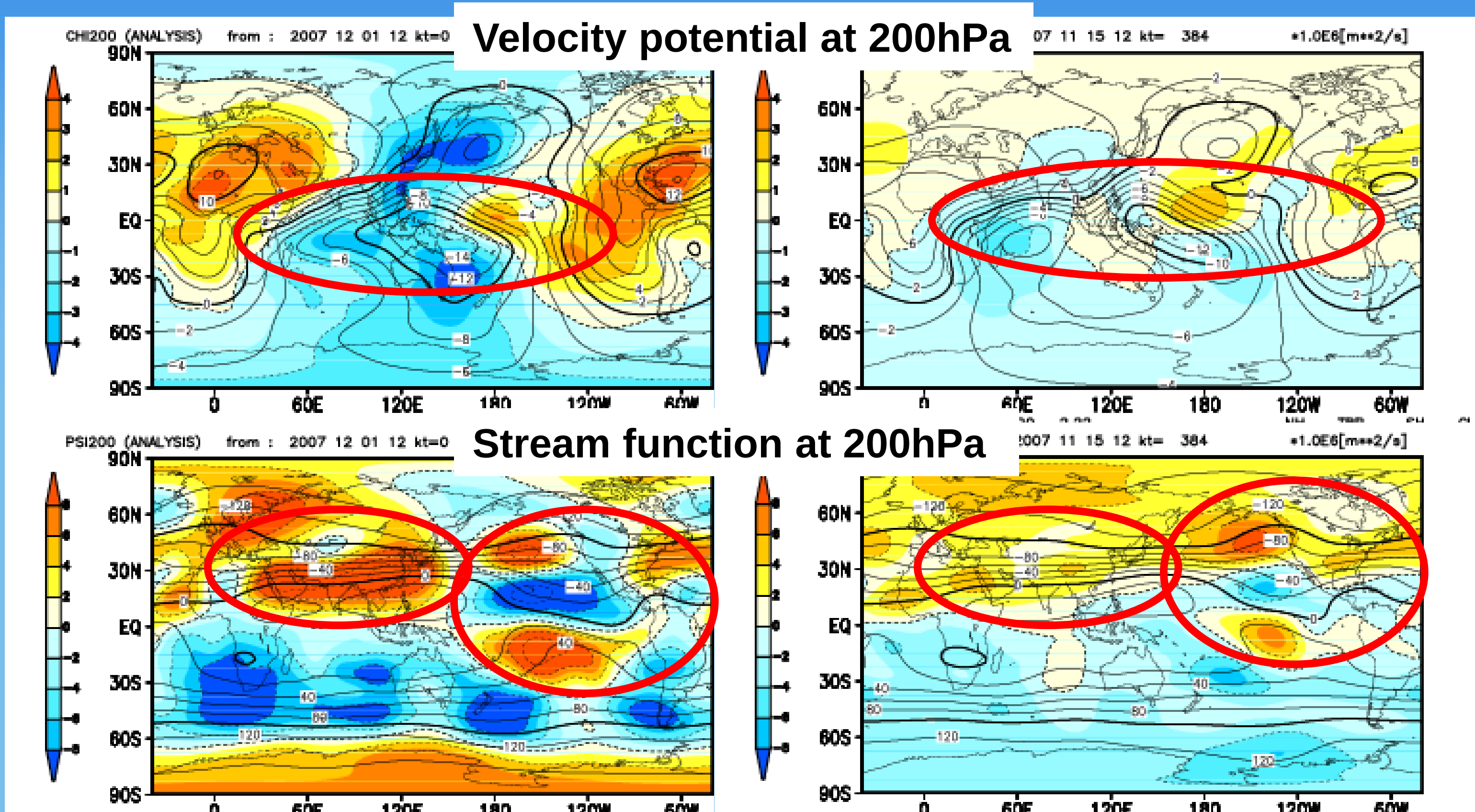
Prediction



The anomaly pattern of La Nina and “horse shoe” around the Pacific Ocean was predicted well.

Tropics

OBS. FCST (Ensemble mean)

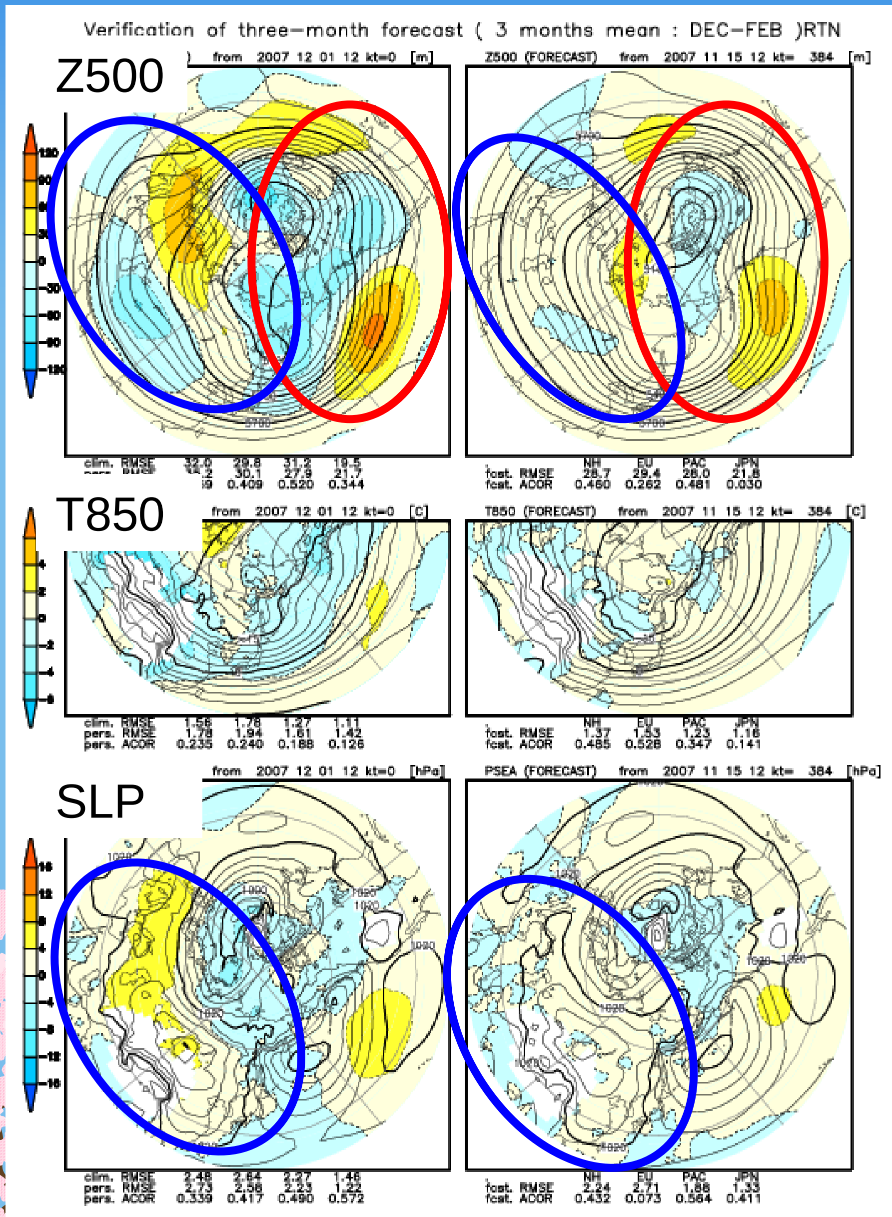


In the Tropics, the typical features of La Nina influence were predicted,

- The center of divergence anomalies
- A pair of cyclonic circulation anomalies across the equator in the eastern Pacific
- Anti-cyclonic circulation anomalies over the southern Eurasian Continent .

N.H.

OBS. FCST (Ensemble mean)



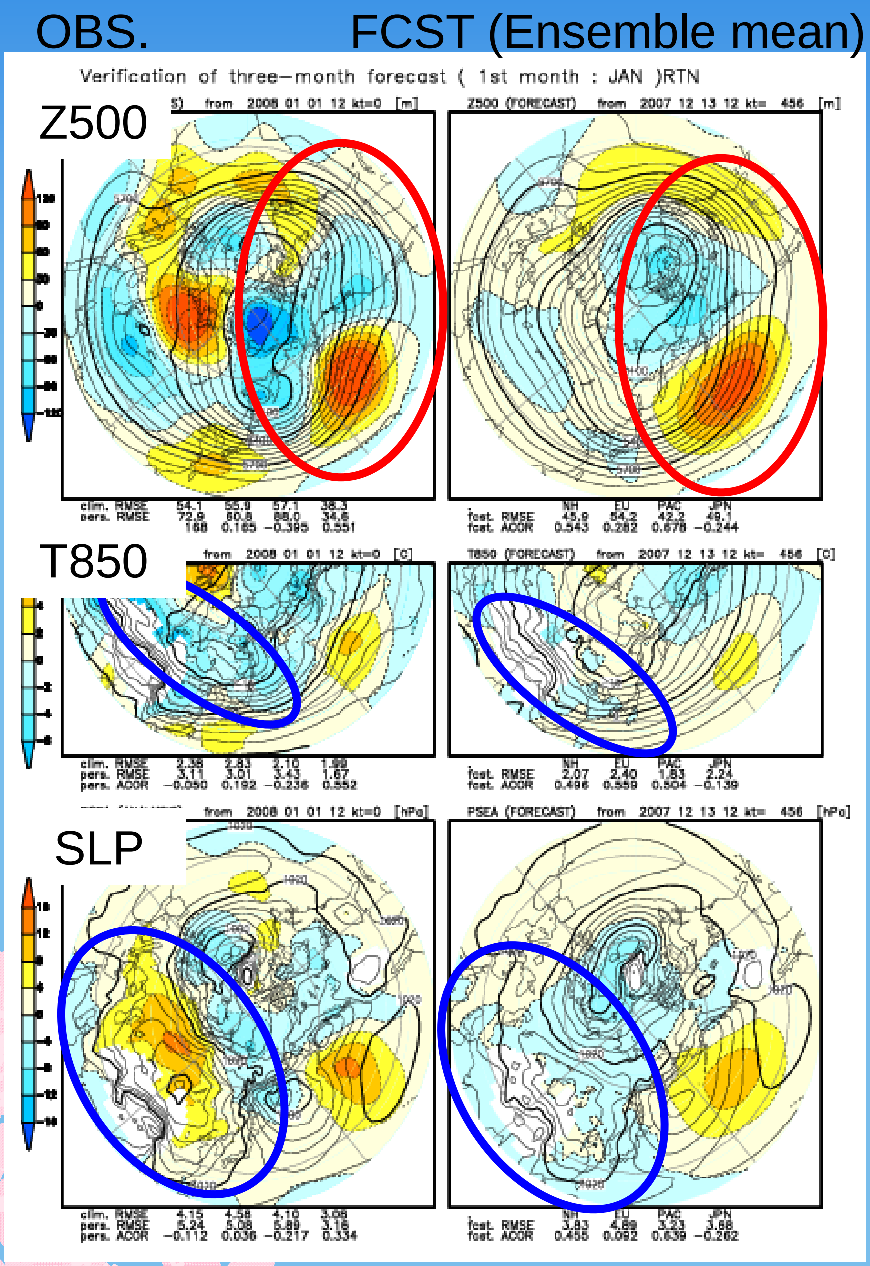
In mid and high latitude, the circulation pattern from the North Pacific to North America, which is considered to be associated with La Nina influence, was predicted relatively good .

While the numerical model could not predicted the split of westerly jets and the strengthened Siberian high.

Initial : Dec.13 2007

・1-month mean field prediction for Jan.2008

N.H.



- The circulation pattern from the North Pacific to North America, which is considered to be associated with La Nina influence, was predicted well .
- The split of westerly jets over the Eurasian Continent was predicted not so bad.
- The strengthen Siberian high could not be predicted.

Initial :Jan.3 2008

・1-week mean field prediction for 12-18 Jan. 2008

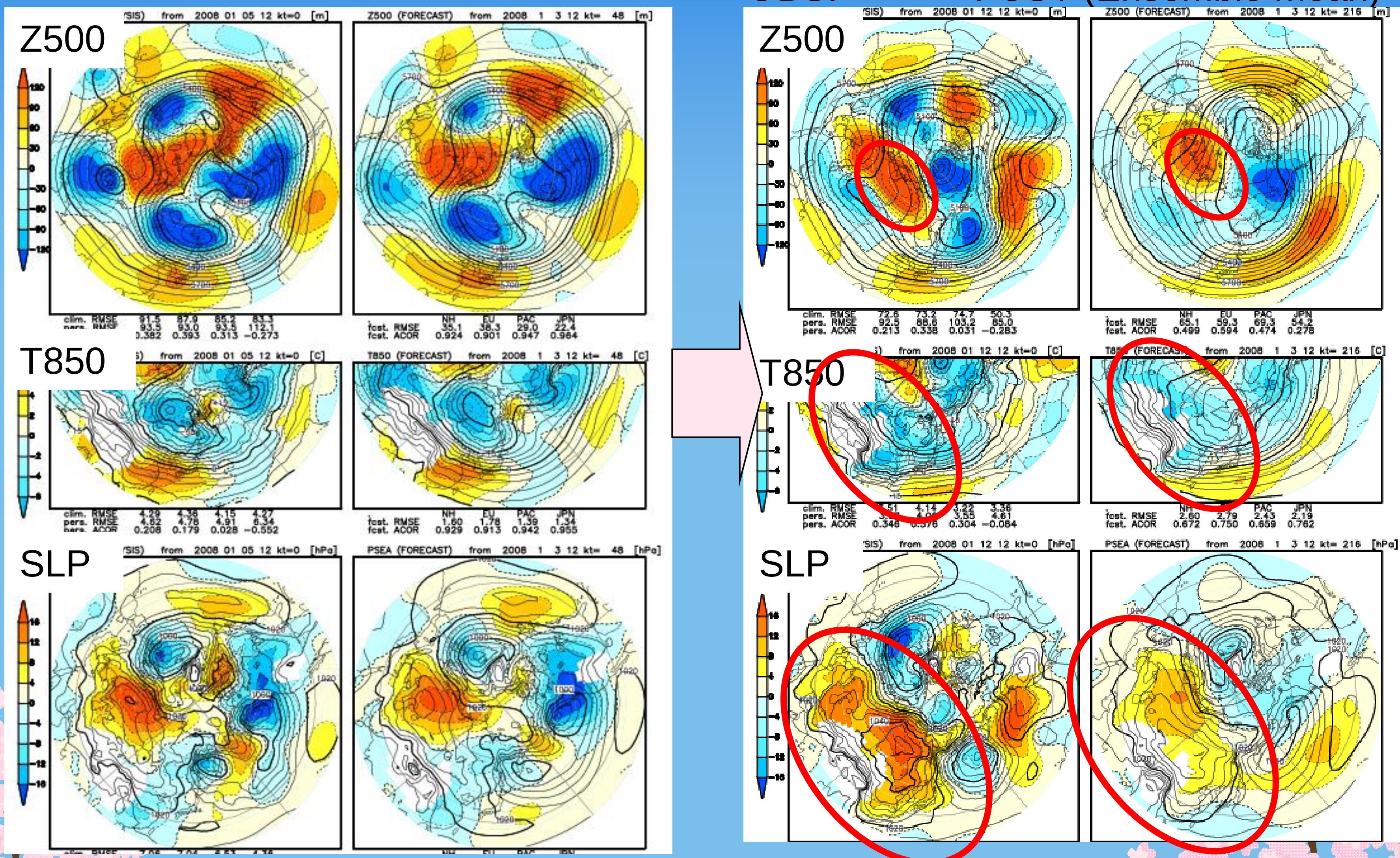
N.H.

5-11 Jan. (lead time :2nd week)

OBS. FCST (Ensemble mean)

12-18 Jan. (lead time :2^{nd} week)

OBS. FCST (Ensemble mean)



This model could predict low temperature around southern China associated with strengthened the Siberian high.

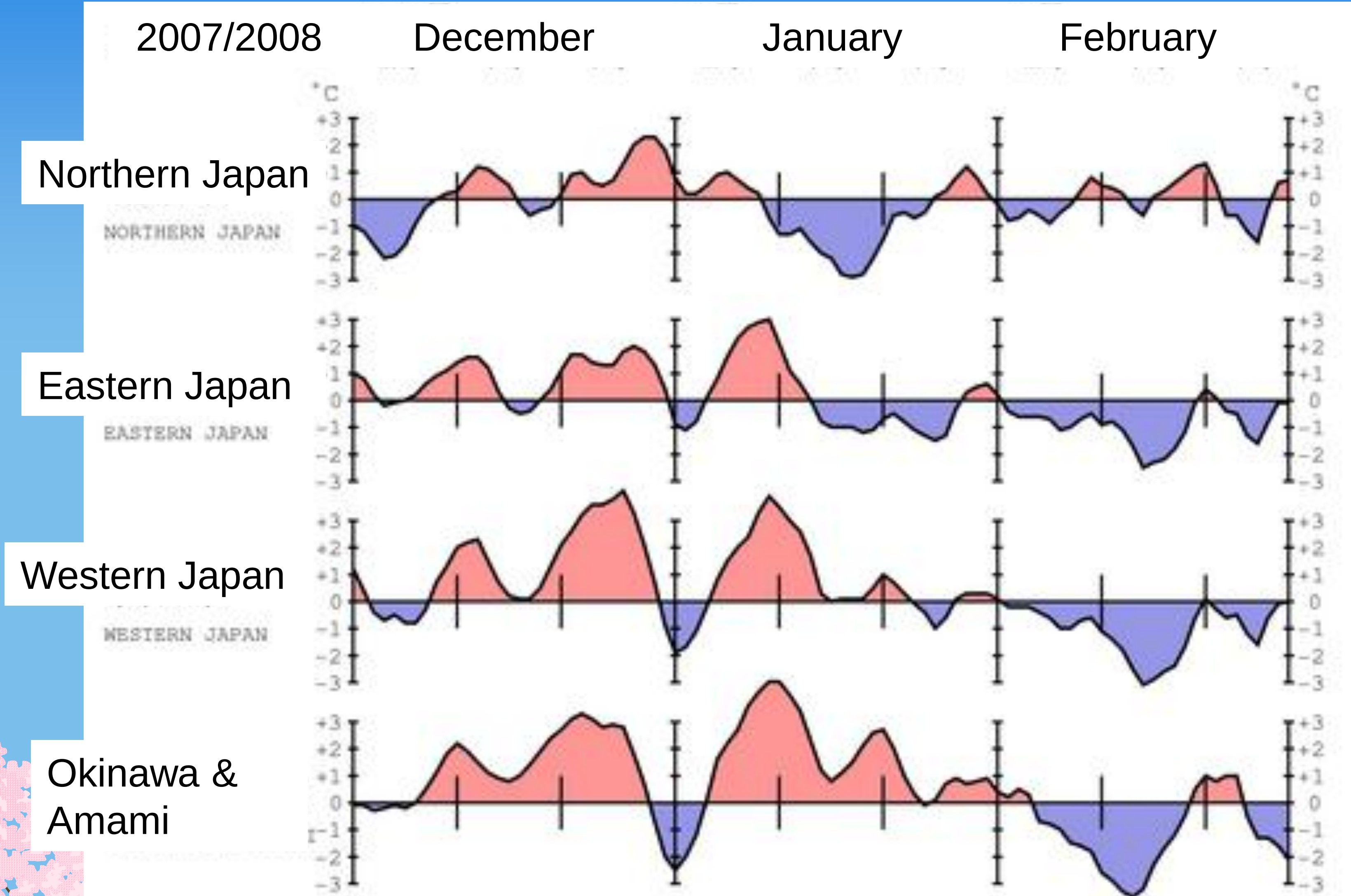
4. Summary

- In 2007/2008 winter, the atmospheric circulation anomaly pattern associated with La Niña influence was dominant mainly in tropics.
- In mid-January, the Siberian high drastically changed from rather weak to very strong, and persisted to mid-February.
- La Niña influence on the Siberian high is not evident.
- Quasi stationary Rossby wave packet is closely related to the growth and persistent of the Siberian high.
- The rapid growth of the Siberian high in mid-January was not predicted one month ahead, but predicted two weeks ahead.

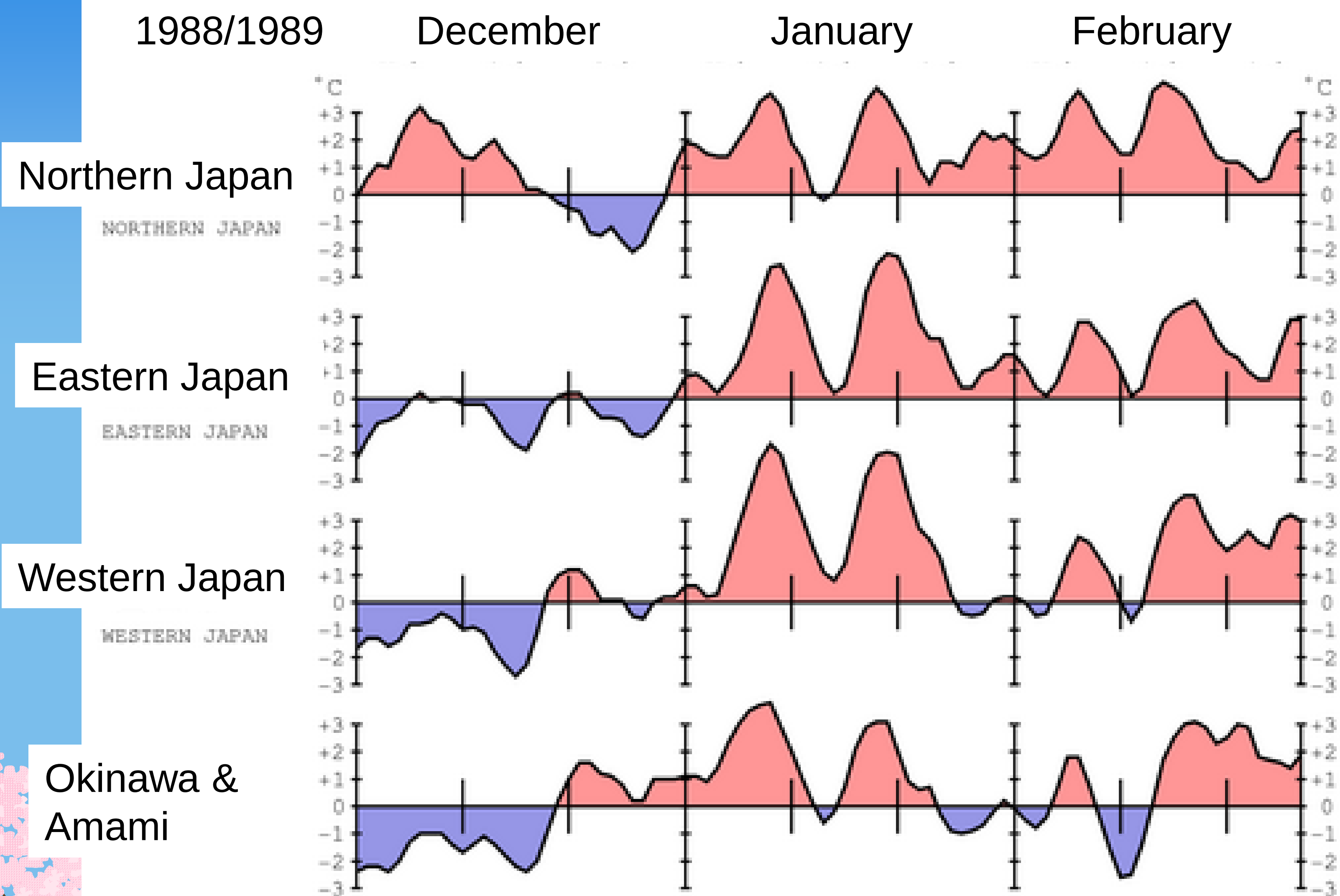
These results suggest that the Siberian high has the properties of the internal mode of the atmosphere.

Appendix

Comparison of Feb.1989 with Feb.2008

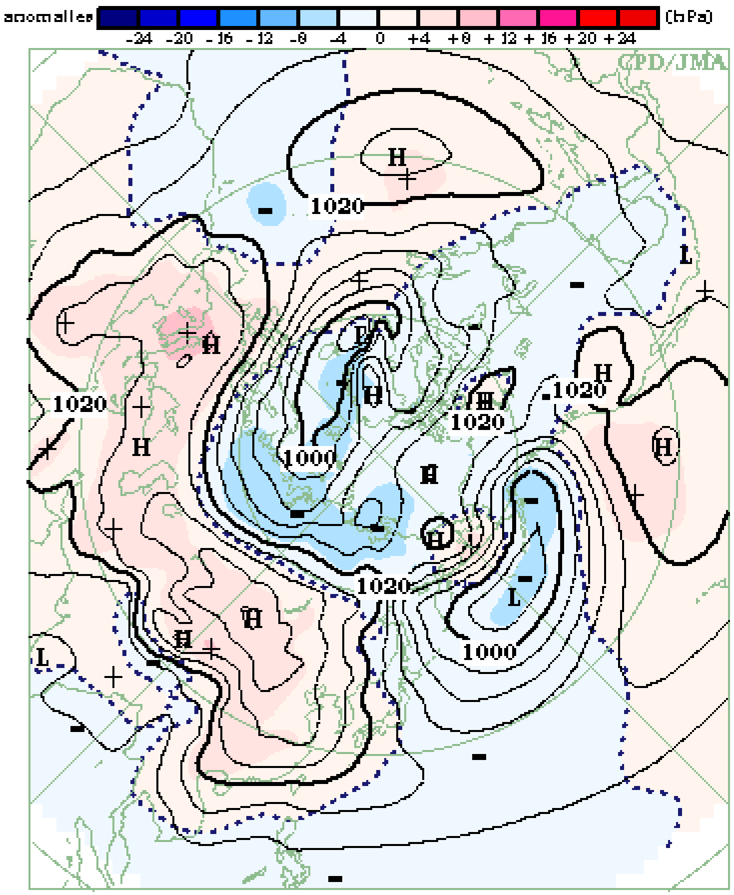


Time series of 5-day running mean temperature anomaly for subdivisions
during Dec. – Feb. 2007/2008



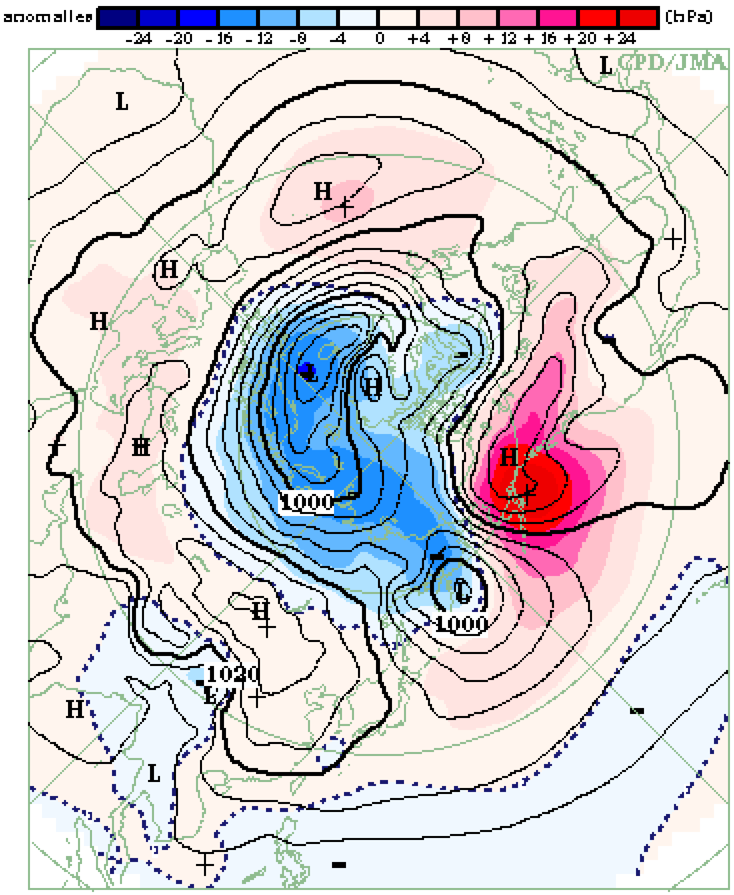
Time series of 5-day running mean temperature anomaly for subdivisions
during Dec. – Feb. 1988/1989

Feb. 2008



MONTHLY MEAN SEA LEVEL PRESSURE AND ANOMALY
IN THE NORTHERN HEMISPHERE (Feb. 2008)
Contours show sea level pressure in an interval of 4hPa.
Shaded patterns show SLP anomalies.
Base period for normal is 1979-2004.

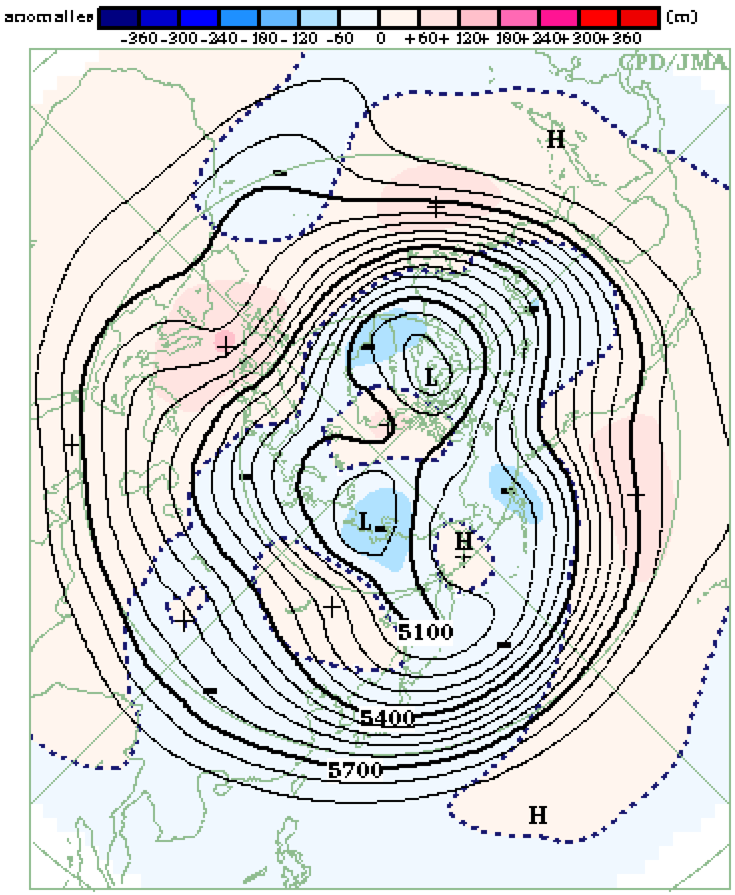
Feb. 1989



MONTHLY MEAN SEA LEVEL PRESSURE AND ANOMALY
IN THE NORTHERN HEMISPHERE (Feb. 1989)
Contours show sea level pressure in an interval of 4hPa.
Shaded patterns show SLP anomalies.
Base period for normal is 1979-2004.

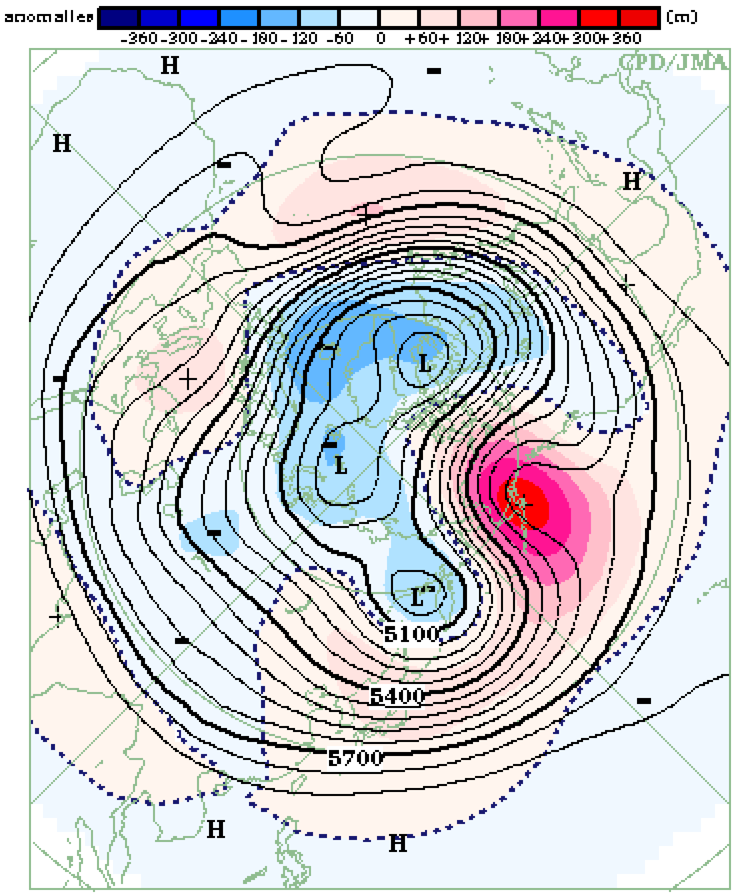
http://ds.data.jma.go.jp/tcc/tcc/products/clisys/figures/db_hist_mon_tcc.html

Feb. 2008



MONTHLY MEAN 500hPa HEIGHT AND ANOMALY
IN THE NORTHERN HEMISPHERE (Feb. 2008)
Contours show heights in an interval of 60m.
Shaded patterns show height anomalies.
Base period for normal is 1979-2004.

Feb. 1989



MONTHLY MEAN 500hPa HEIGHT AND ANOMALY
IN THE NORTHERN HEMISPHERE (Feb. 1989)
Contours show heights in an interval of 60m.
Shaded patterns show height anomalies.
Base period for normal is 1979-2004.