Tokyo Climate Center, Japan Meteorological Agency

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Contents

El Niño Outlook (April – October 2010)

The current El Niño conditions are likely to come to an end in boreal spring. It is likely that the SST in the IOBW region will continue to be above normal into boreal summer.

Pacific Ocean

In March 2010, the SST deviation from a sliding 30-year mean SST averaged over the NINO.3 region was +0.7°C. The five-month running-mean value of NINO.3 SST deviations was +1.1°C for January, and the Southern Oscillation Index for March was -0.7. In March, positive SST anomalies were remarkable in the central equatorial Pacific (Figs. 1 and 3 a), while subsurface temperature anomalies were remarkably positive in the eastern equatorial Pacific and negative near the date line (Figs. 2 and 3 b). In the equatorial Pacific, convective activities were above normal near the date line in March, and westerly wind anomalies in the lower troposphere were found across the equatorial Pacific during early March. On the other hand, easterly wind anomalies were seen in the western part in late March.

Subsurface warm waters in the equatorial Pacific that will migrate eastward are likely to keep SST anomalies positive over the central and eastern Pacific for one or two months ahead, and subsurface cool waters west of the warm waters are expected to migrate eastward and help to cancel out the positive SST anomalies in the equatorial Pacific in the months ahead.

JMA's El Niño prediction model predicts that NINO.3 SST deviations will become closer to normal in the months

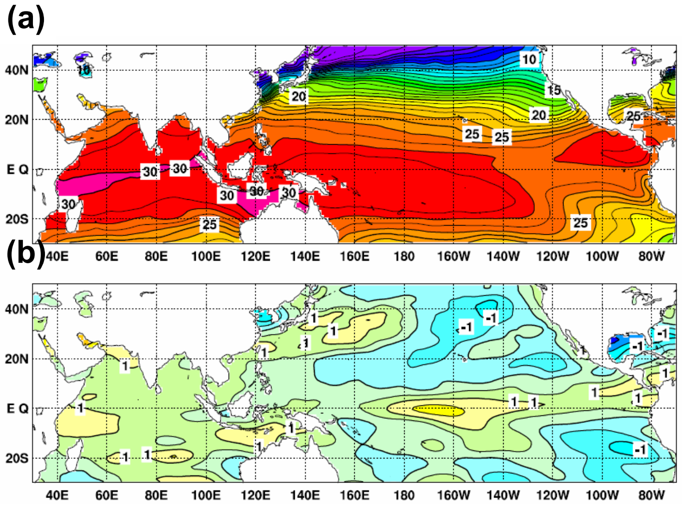


Figure 1 Monthly mean (a) sea surface temperatures (SSTs) and (b) SST anomalies in the Pacific and Indian Ocean sectors in March 2010
The contour intervals are 1˚C in (a) and 0.5˚C in (b). The base period for the normal is 1971 – 2000.

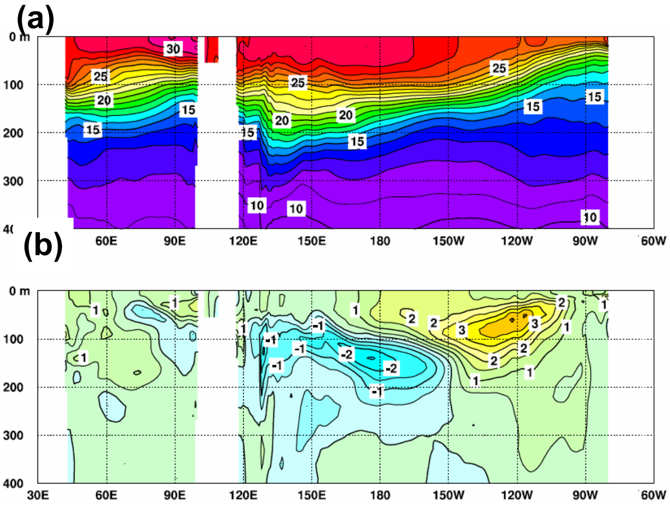


Figure 2 Monthly mean depth-longitude cross sections of (a) temperatures and (b) temperature anomalies in the equatorial Pacific for March 2010
The contour intervals are 1˚C in (a) and 0.5˚C in (b). The base period for the normal is 1979 – 2004.

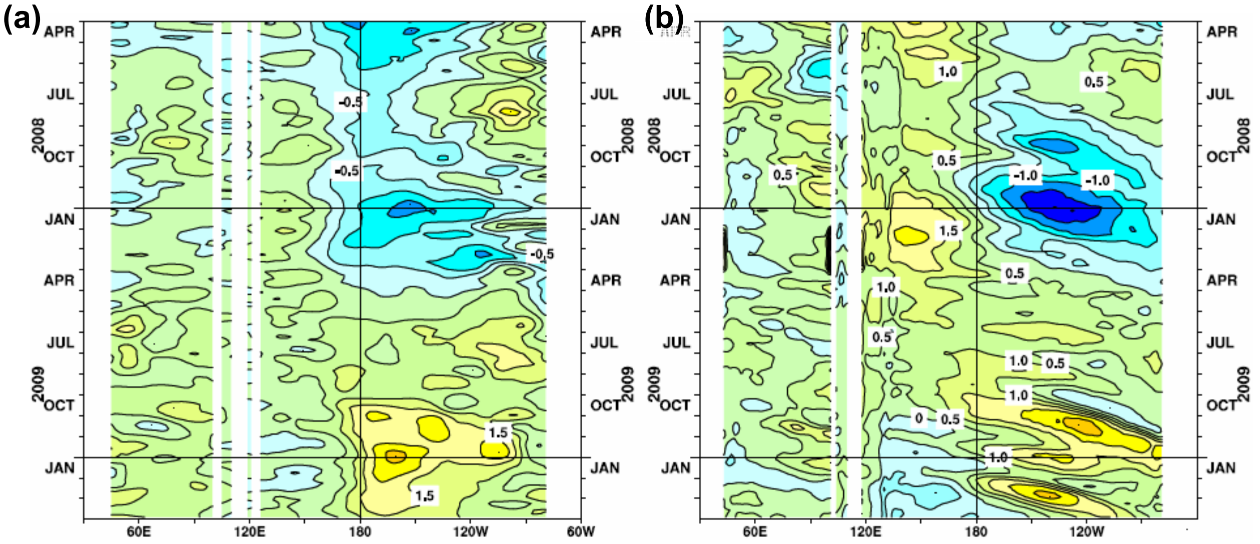


Figure 3 Time-longitude cross section of (a) SST and (b) ocean heat content (OHC) anomalies along the equator in the Pacific Ocean
OHC is defined here as the vertical average temperature to a depth of 300 m. The base periods for the normal are 1971 – 2000 for (a) and 1979 – 2004 for (b).

ahead, and that they will be near normal in boreal summer (Fig. 4).

Considering all the above factors, the current El Niño conditions are likely to come to an end in boreal spring.

It is likely that the SST in the NINO.WEST region will continue to be near normal* into boreal summer.

Indian Ocean

The SST averaged over the tropical Indian Ocean (IOBW) region has been mostly above normal* since boreal autumn of last year. It is likely that the SST in the IOBW region will continue to be above normal* into boreal summer.

Impacts on the global climate

In March, warmer-than-normal conditions over the regions from South Africa to Madagascar and the northern part of South America were consistent with common patterns seen in past El Niño events.

*The normals for NINO.WEST (Eq. – 15°N, 130°E – 150°E) and IOBW (20°S – 20°N, 40°E – 100°E) are defined as linear extrapolations with respect to a sliding 30-year period in order to remove the effects of long-term trends

(Ichiro Ishikawa, Climate Prediction Division)

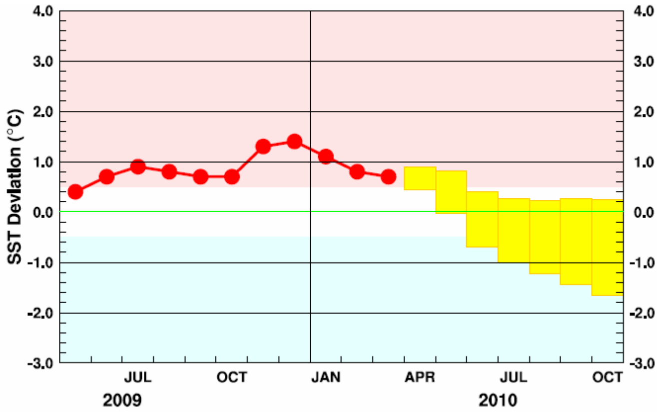


Figure 4 SST deviation outlook for NINO.3 as predicted by the El Niño prediction model
This figure shows a time series of monthly SST deviations for NINO.3 (5˚N – 5˚S, 150˚W – 90˚W). The thick line with closed circles shows the observed SST deviation values, and the boxes show the values predicted for the next six months by the El Niño prediction model. Each box denotes the range into which SST deviation is expected to fall with a probability of 70%.

JMA's Seasonal Numerical Ensemble Prediction for Summer 2010

The JMA seasonal ensemble prediction for summer 2010 indicates that convections will be active in the Indian Ocean and the Atlantic but inactive in the central and eastern part of the tropical Pacific. As for the Asian monsoon region, inactive convections are predicted east of the Philippines, and are expected to induce westward extension of the North Pacific High. In the upper troposphere, cyclonic circulation anomalies are predicted over the Eurasian continent, implying a weak Tibetan High and a southward shift of the subtropical jet over the Eurasian continent.

1. Introduction

This report outlines JMA's summer 2010 (June – August, JJA) dynamical seasonal ensemble prediction, which was used as a basis for the Agency's operational warm-season outlook issued on 22 April 2010.

JMA operates the Coupled Ocean-atmosphere General Circulation Model (CGCM) as a seasonal prediction tool. The Ensemble Prediction System (EPS) used with the CGCM for seasonal prediction adopts a combination of the initial perturbation method and the lagged average forecasting (LAF) method. The prediction consists of fifty-one members from six different initial dates (nine members are run every five days from 17 March to 11 April). Details of the prediction system and verification maps based on 30-year hindcast experiments (1979 – 2008) are available at http://ds.data.jma.go.jp/tcc/tcc/products/model/index.html.

Section 2 presents predicted global SST anomalies, and Section 3 describes predicted circulation fields in the tropics and sub-tropics associated with these anomalies. Finally, the predicted circulation fields in the middle and high latitudes of the Northern Hemisphere are explained in Section 4.

2. SST anomalies (Figure 5)

In March 2010, remarkable positive SST anomalies were seen in the central equatorial Pacific, and SSTs in the tropical Indian Ocean were mostly above normal. The NINO.3 region's El Niño monitoring index value, which shows the deviation from a sliding 30-year mean SST averaged over the NINO.3 region, was +0.7°C. This indicates that El Niño conditions continued after summer 2009. According to JMA's El Niño outlook, it is likely that the current El Niño conditions will come to an end this spring.

The SST anomalies forecast by JMA's seasonal numerical ensemble prediction system are shown in Figure 5. Above-normal SSTs are predicted in the tropical Indian Ocean and the tropical Atlantic, while below-normal values are expected from the central to the eastern part of the equatorial Pacific.

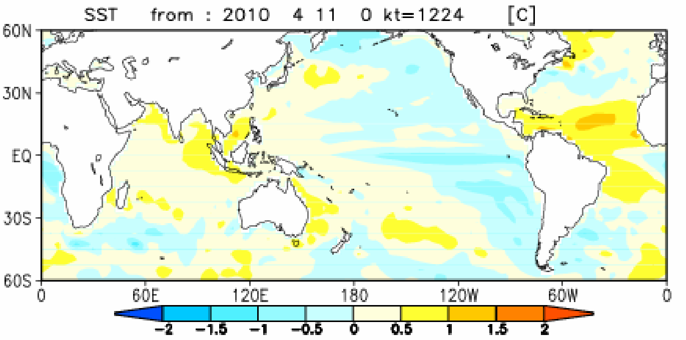


Figure 5 Predicted SST anomalies for June – August 2010 (ensemble mean of 51 members)

3. Circulation fields in the tropics and sub-tropics (Figure 6)

Above-normal precipitation is predicted over most of the Indian Ocean and the equatorial Atlantic. In the Asian monsoon region, above-normal precipitation is predicted from the equatorial Indian Ocean to the Maritime Continent, while below-normal amounts are expected east of the Philippines.

Upper tropospheric velocity potential anomalies in the tropics are expected to be negative (i.e., more divergent) over the Indian Ocean and the Atlantic, reflecting active precipitation patterns in the tropics, while positive (i.e., more convergent) anomalies are forecast from the central to the eastern part of the Pacific. Positive velocity potential anomalies east of the Philippines imply inactive convection in the region.

In the upper troposphere, cyclonic circulation anomalies are predicted in the northern part of the Eurasian continent and the northwestern part of the tropical Pacific, while anti-cyclonic anomalies are expected around the Caribbean Sea. In the lower troposphere, anti-cyclonic anomalies are predicted in the northwestern part of the tropical Pacific, while cyclonic anomalies are expected around the Caribbean Sea. Anomaly patterns of atmospheric circulation in the northwestern part of the tropical Pacific and the Caribbean Sea reflect those of tropical convection activities. These features imply that the Tibetan High seen in the upper troposphere is weaker than normal, especially in northern and eastern parts, and that the subtropical jet over the Eurasian continent shows a southward shift. They also imply that the westward extension of the North Pacific High is stronger than normal.

4. Circulation fields in the middle and high latitudes of the Northern Hemisphere (Figure 7)

Predicted 500-hPa height anomalies are expected to be generally positive in the mid-latitudes and negative in parts of eastern Siberia and in the west of the United States. Negative anomalies of sea level pressure are predicted around the Sea of Okhotsk, implying that the northward extension of the North Pacific High is possibly weaker than normal.

(Takayuki Tokuhiro , Climate Prediction Division)

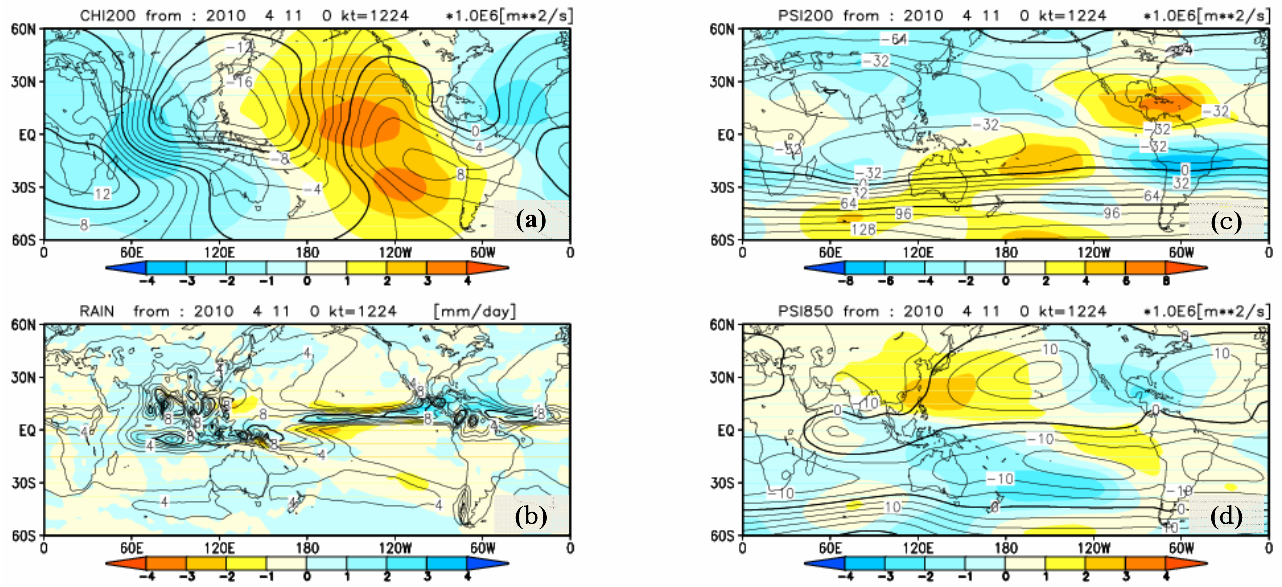


Figure 6 Predicted atmospheric fields in the tropics and sub-tropics for June – August 2010 (ensemble mean of 51 members)

(a) Velocity potential at 200 hPa (contours) and anomaly (shading). The contour interval is 2 x 10^6 m^2/s.

(b) Precipitation (contours) and anomaly (shade). The contour interval is 2 mm/day.

(c) Stream function at 200 hPa (contours) and anomaly (shading). The contour interval is 16 x 10^6 m^2/s.

(d) Stream function at 850 hPa (contours) and anomaly (shading). The contour interval is 5 x 10^6 m^2/s.

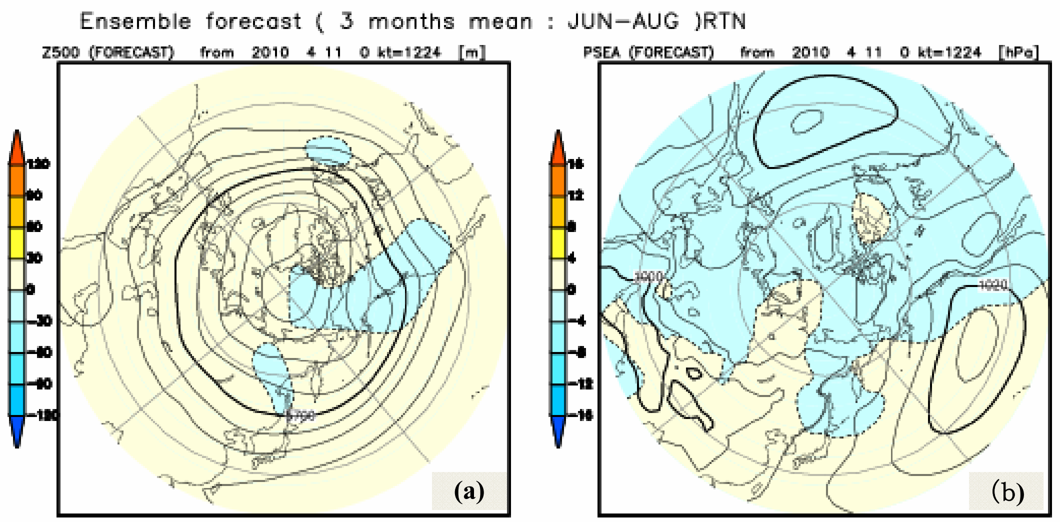


Figure 7 Predicted atmospheric fields in the middle and high latitudes of the Northern Hemisphere for June – August 2010 (ensemble mean of 51 members)
(a) 500 hPa height (contours) and anomaly (shading). The contour interval is 60 m.
(b) Sea level pressure (contours) and anomaly (shading). The contour interval is 4 hPa.

Warm Season Outlook for Summer 2010 in Japan

For summer 2010, mean temperatures are likely to be below or near normal in northern Japan, above or near normal in western Japan, and above normal in Okinawa/Amami. Warm-season precipitation amounts are likely to be above or near normal in northern and eastern Japan.

1. Outlook summary

JMA issued its outlook for the coming summer over Japan in February, and updated it in March and April. For summer 2010, mean temperatures are likely to be below or near normal in northern Japan with 40% probability for both categories, above or near normal in western Japan with 40% probability for both categories, and above normal with 60% probability in Okinawa/Amami. Warm-season precipitation amounts are likely to be above or near normal in northern and eastern Japan with 40% probability for both categories (Figure 8) .

2. Outlook background

Simply put, the lingering impacts of the currently decaying El Niño on atmospheric circulation in East Asia are the main influences behind the outlook.

According to the JMA/MRI atmosphere-ocean coupled model, the current El Niño conditions are likely to come to an end this boreal spring, while the IOBW-region SST (see Article 1), whose variation is influenced by El Niño, will remain above normal into boreal summer. In association with the above-normal SST in the IOBW region, a characteristic atmospheric circulation anomaly pattern in the tropics and the sub-tropics (consisting of lower three-month precipitation anomalies around the Philippines and stronger westward extension of the North Pacific High with weaker northward extension around Japan) is predicted in the western Pacific.

The predicted anomalous circulation pattern suggests that the northern part of Japan may be influenced by fronts and cold air from the north due to the weaker northward extension of the North Pacific high, while the southern part of the country is expected to be covered by the westward-extended North Pacific high with above-normal temperatures.

Since the predicted anomalous circulation pattern is consistent with the results of statistical studies on the impacts of the above-normal IOBW SST after El Niño events, and the 30-year hindcast calculated using the JMA/MRI atmosphere-ocean coupled model shows a high level of skill in predicting this pattern, the outlook for this summer is based mainly on the model's results.

(*Shuhei Maeda, Climate Prediction Division*)

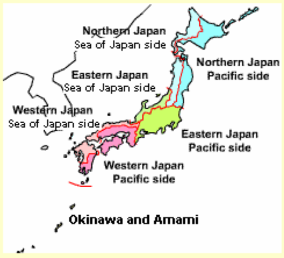
Temperature

Forecast Period	3 months		
	Jun-Aug		
category	−	0	+
Northern Japan	40	40	20
Eastern Japan	30	30	40
Western Japan	20	40	40
Okinawa and Amami	10	30	60

(category − : below normal, 0 : near normal, + : above normal, Unit : %)

Precipitation

Forecast Period		3 months		
		Jun-Aug		
category		−	0	+
Northern Japan	Sea of Japan side	20	40	40
	Pacific side	20	40	40
Eastern Japan	Sea of Japan side	20	40	40
	Pacific side	20	40	40
Western Japan	Sea of Japan side	30	30	40
	Pacific side	30	40	30
Okinawa and Amami		40	30	30



(category − : below normal, 0 : near normal, + : above normal, Unit : %)

Figure 8 Probabilistic forecasts of seasonal mean temperatures (upper) and precipitation amounts (lower) for June – August

Summary of Asian Winter Monsoon 2009/2010

- Extremely low temperatures in northern Asia and extremely high temperatures in southern Asia

Surface climate conditions

In winter 2009/2010, northern Asian countries experienced lower than normal temperatures, and southern Asian countries experienced higher than normal temperatures (Figure 9).

Figure 10 shows extreme climate events from December 2009 to February 2010. In December and February, extremely low temperatures were observed from western Siberia to Mongolia, and extremely high temperatures were observed from Indonesia to India. Furthermore, extremely heavy precipitation (snow) amounts were observed from eastern China to Central Asia. In January, extremely low temperatures were observed in southwestern Siberia and in northeastern India, and extremely high temperatures were observed from central China to Indonesia and in western India. Extremely heavy precipitation (snow) amounts were also observed around northeastern China and around southern Central Asia.

(Takafumi Umeda, Climate Prediction Division)

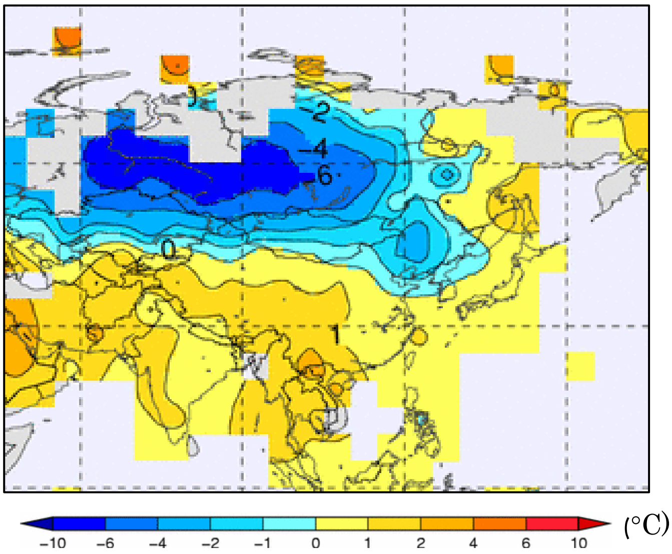


Figure 9 Seasonal temperature anomalies for winter (December – February) 2009/2010
Anomalies are deviations from the normal (i.e., the 1971 – 2000 average). The contour interval is 1°C.

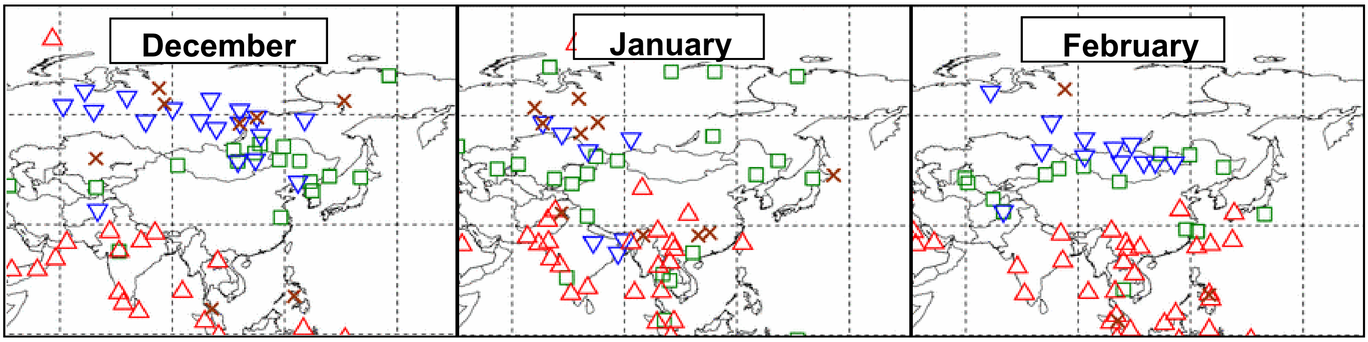


Figure 10 Extreme climate events from December 2009 to February 2010

△ Extremely high temperature (ΔT/SD≧ 1.83)
▽ Extremely low temperature (ΔT/SD≦ −1.83)
□ Extremely heavy precipitation (Rd=6)
× Extremely light precipitation (Rd=0)

Conditions of convective activity and atmospheric circulation

During boreal winter 2009/2010 (December 2009 – February 2010), the negative phase of the Arctic Oscillation (AO) was significantly dominant (Figure 11). Associated with the AO pattern, below-normal anomalies in the 850-hPa temperature field were observed from western Siberia to Mongolia (Figure 12). The Siberian High was enhanced in its northern part, and the Aleutian Low shifted eastward from its normal position, which is usually around the date line (Figure 13). In Japan and the southern part of China, zonal gradients of sea level pressure were reduced in comparison with their normal forms, indicating a weaker-than-normal winter monsoon over these areas. In the tropics, an El Niño event that started in summer 2009 continued into boreal winter. In association with this, convective activities were weaker than normal in Indonesia and the western Pacific, while they were stronger than normal in the central Pacific (Figure 14). In the lower troposphere, anticyclonic circulation was seen across Southeast Asia and south of Japan with its center in the Philippines. Above-normal surface temperatures in Japan, the Philippines and Malaysia were consistent with the features of past El Niño events (Figure 15).

(Shotaro Tanaka, Climate Prediction Division)

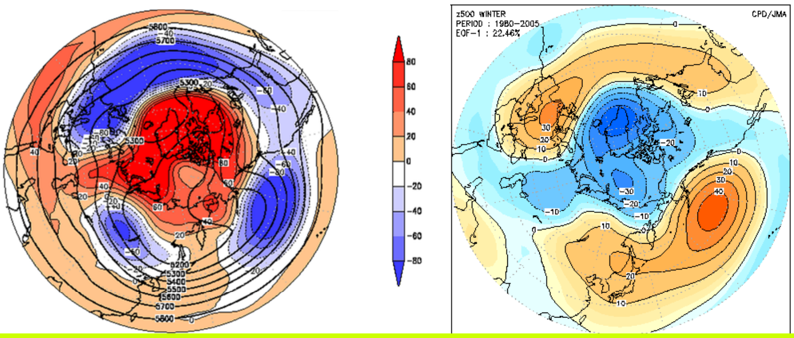


Figure 11 Left panel: three-month averaged 500-hPa height (contour) and anomaly (shading) for December 2009 – February 2010;
right panel: regression map of the first leading mode from empirical orthogonal function analysis of three-month averaged 500-hPa height (20 – 90°N) for December – February in the period 1979/1980 – 2004/2005
The base period for the normal is 1979 – 2004. JRA/JCDAS data were used in the analysis.

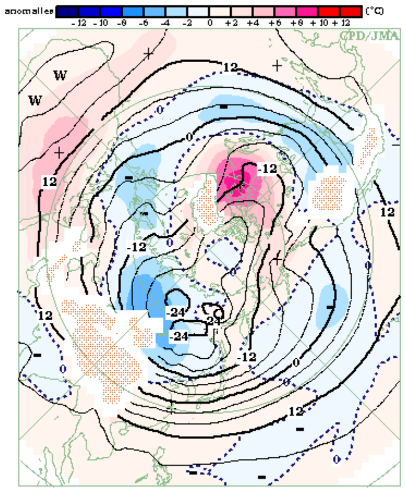


Figure 12 Three-month averaged 850-hPa temperature (contours) and anomaly (shading) for December 2009 – February 2010
The contour interval is 4˚C, and the base period for the normal is 1979 – 2004. Wavy hatch patterns indicate areas with altitudes higher than 1,600 m. JRA/JCDAS data were used in the analysis.

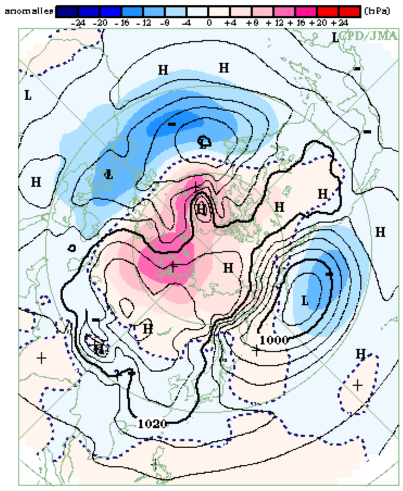


Figure 13 Three-month averaged sea level pressure (contours) and anomaly (shading) for December 2009 – February 2010
The contour interval is 4 hPa, and the base period for the normal is 1979 – 2004. JRA/JCDAS data were used in the analysis.

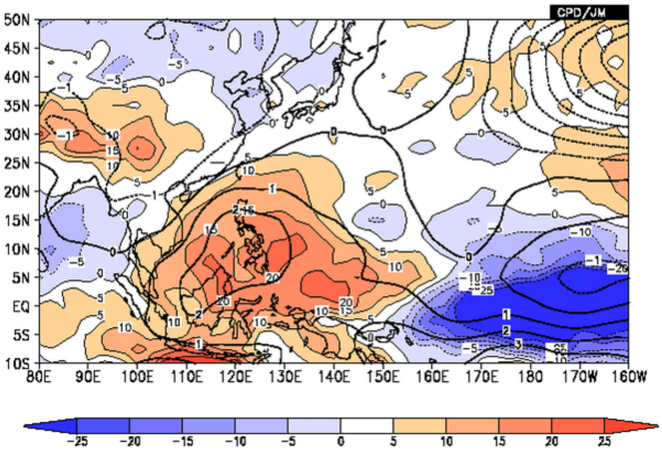


Figure 14 Outgoing Longwave Radiation (OLR) anomaly (shading) and 850-hPa stream function anomaly (contours)
Warm/cold-color shading indicates weaker/stronger-than-normal convective activities. Original OLR data were provided by NOAA. The contour interval is 1 x 10^6 m^2/s, and the base period for the normal is 1979 – 2004. JRA/JCDAS data were used in the stream function analysis.

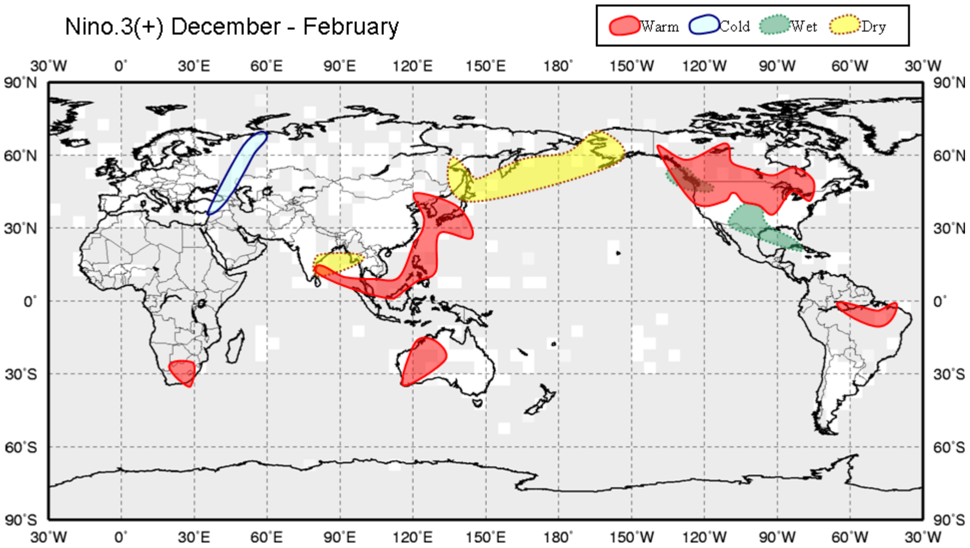


Figure 15 Schematic map of typical temperatures and precipitation in El Niño events for December – February
Shading indicates warm/cold and wet/dry areas at a 90% level of confidence, comparing El Niño years with both non-El Niño and non-La Niña years for boreal winter (December – February) in the period 1979/1980 – 2008/2009.

Stratospheric Sudden Warming Events in winter 2009/2010

In winter 2009/2010, stratospheric sudden warming (SSW) events were observed in December 2009 and in February 2010, with the latter one being a major event.

JMA's Climate Prediction Division (CPD) routinely monitors stratospheric circulation with a focus on detecting SSW events and providing early notification of them. When SSW occurs for the first time in a winter season, a STRATALERT report is issued by JMA and disseminated via WMO's Global Telecommunication System (GTS) on that day and every day thereafter.

In November 2009, easterly wind anomalies in the zonal-mean wind field were observed over the polar region, and higher-than-normal temperatures were seen over Canada in the stratosphere. However, this event did not satisfy the criteria to qualify as SSW.

From early to mid-December 2009, a minor SSW event occurred and the polar vortex split into two in mid-December.

In January 2010, the polar vortex moved southward until its center reached the vicinity of Lake Baikal, and a second SSW event occurred. It grew into a major occurrence of SSW in early February 2010, and significantly above-normal temperatures continued in the polar region throughout the month (Figure 16). During the period of the major SSW event, the polar vortex maintained its split form, and a reversion of zonal winds from westerlies to easterlies was observed in the region north of 60ºN (Figure 17).

In the troposphere, the negative phase of the Arctic Oscillation (AO) dominated throughout winter. It is conceivable that the stratospheric warm conditions seen in November 2009 contributed to the development of this negative AO, and that the SSW events and negative AO influenced each other during this winter period.

(Hiroshi Hasegawa and Nobuyuki Kayaba, Climate Prediction Division)

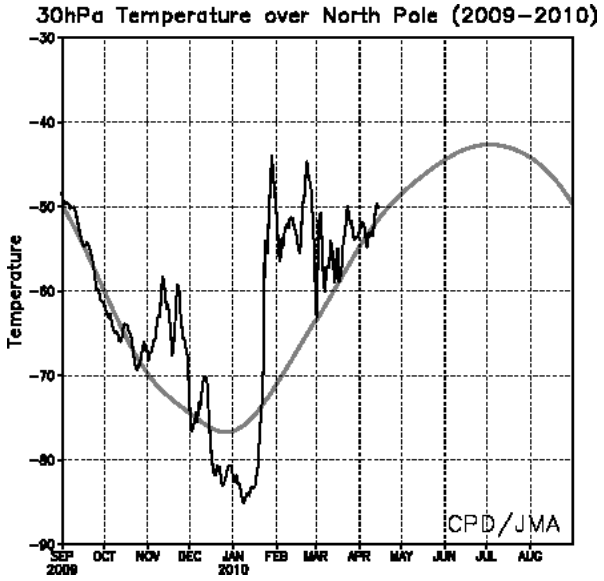


Figure 16 Time series of temperatures at 30-hPa level over the North Pole in winter 2009/2010
The black line shows temperatures for winter 2009/2010.
The gray line shows the climatological mean.

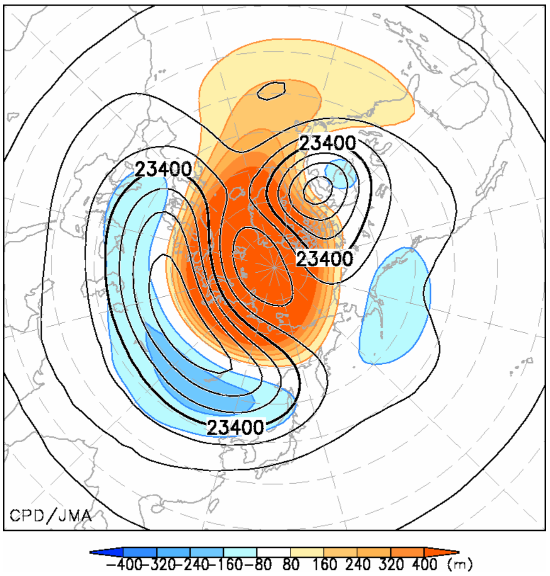


Figure 17 30-hPa geopotential height (contours) and anomalies (shading) during the major SSW event (9 – 27 February 2010)
The contour interval is 120 m.

Global Temperature in 2009

The annual global average surface temperature anomaly for 2009 was +0.31ºC – the third highest on record since 1891.

The annual global average surface temperature anomaly for 2009 (i.e., the average of the near-surface air temperature over land and the sea surface temperature) was +0.31°C ±0.13°C above normal (based on the 1971 – 2000 average), which tied with 2006, 2003 and 2002 as the third highest on record since 1891 (Table 1, Figure 18).

Annual land surface temperatures were above normal in most parts of the world except for North America and central Siberia. Sea surface temperatures were high, especially in the tropical Pacific and the Indian Ocean (Figure 19).

Table 1 Annual global mean temperature rankings

Rank	Year	Temperature anomaly
1	1998	+0.37
2	2005	+0.32
3	2009	+0.31
	2006	+0.31
	2003	+0.31
	2002	+0.31
7	2007	+0.28
8	2004	+0.27
	2001	+0.27
10	1997	+0.24

On a longer time scale, global average surface temperatures have been increasing at a rate of 0.68°C per century (Figure 18).The high temperatures seen in recent years have been influenced by fluctuations over different time scales ranging from several years to several decades, as well as by global warming resulting from the increased presence of greenhouse gases such as CO_2.

In particular, the high global temperature for 2009 can be attributed to the El Niño phenomenon, which started to develop in the summer of that year.

For more information, please refer to http://ds.data.jma.go.jp/tcc/tcc/products/gwp/temp/ann_wld.html.

(Shoji Hirahara, Climate Prediction Division)

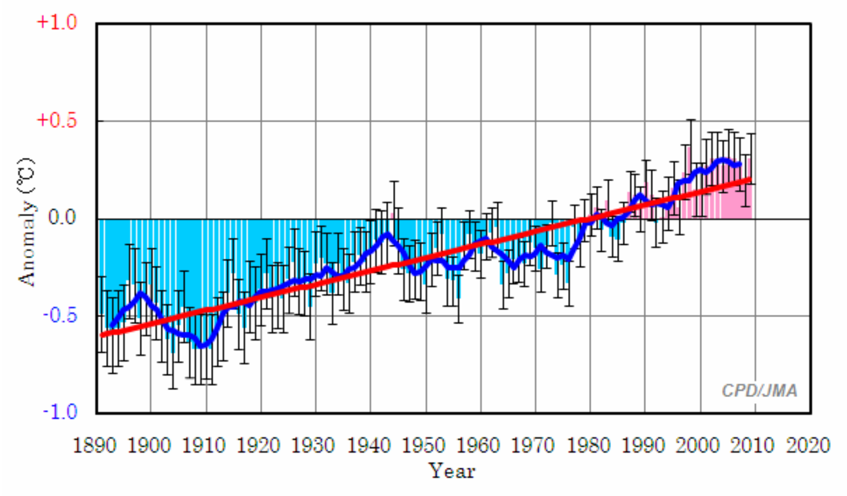


Figure 18 Annual anomalies in global average surface temperature from 1891 to 2009
The bars indicate the annual anomaly of the global average surface temperature and 90% confidence intervals for each year. The blue line indicates five-year running mean, and the red line shows the long-term linear trend.

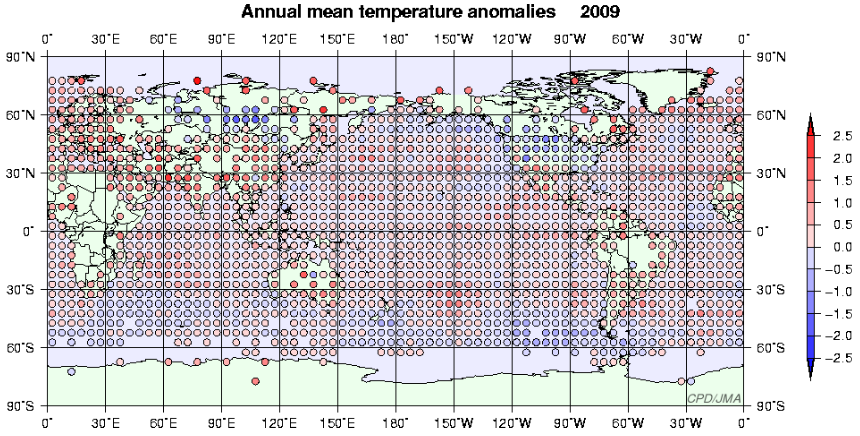


Figure 19 Annual surface temperature anomalies for 2009
The circles indicate temperature anomalies from the climatological normal (i.e., the 1971 – 2000 average) averaged in individual 5° x 5° grid boxes.

Extremely Negative Arctic Oscillation in winter 2009/2010

Overview of the climate in winter 2009/2010

Many parts of the mid-latitudes in the Northern Hemisphere experienced severely cold days during the winter of 2009/2010. In particular, seasonal mean temperatures were extremely low in Siberia, Mongolia, northern China, the United States of America and Europe (except for the Mediterranean region), and record-breaking heavy snowfall was observed in some of these regions. Meanwhile, from the northeastern part of Canada to Greenland, extremely high temperatures were observed (Figure 20). The Japan Meteorological Agency (JMA) held a meeting of the Advisory Panel on Extreme Climatic Events, which consists of 10 prominent experts from universities and research institutes, to provide it with advice on the causes of these prevailing extreme cold waves. Based on the guidance of the Panel, JMA issued a statement on the atmospheric circulation that had led to the extreme climatic events. This article is based on that statement.

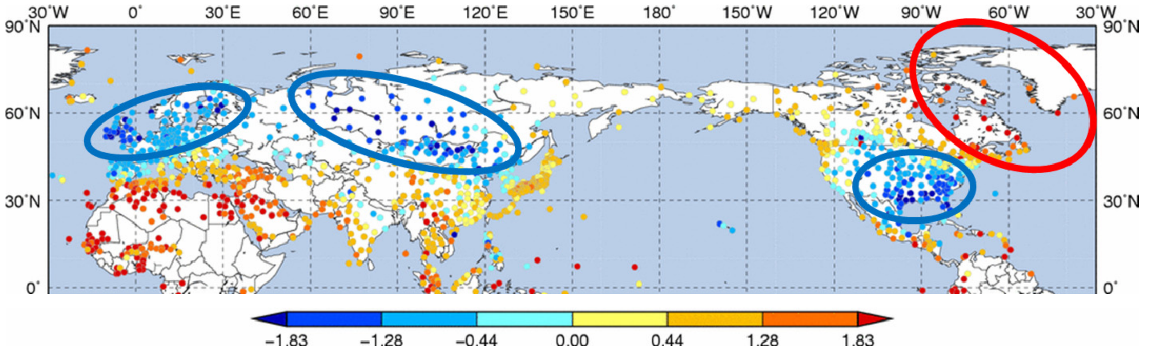


Figure 20 Normalized three-month mean temperature anomaly for winter (Dec. – Feb.) 2009/2010

Characteristics of the extremely negative Arctic Oscillation (AO) seen in winter 2009/2010

In the winter of 2009/2010, high-pressure systems developed over the Arctic, while low-pressure anomalies were dominant in the surrounding mid-latitudes with the southward-shifted and enhanced Icelandic low and Aleutian low (Figure 21). The Arctic Oscillation (AO) is well known as an annular mode representing the first dominant mode of atmospheric circulation variation in boreal winter as obtained from EOF analysis. The anomaly distribution in the sea-level pressure field during this winter reflected an extremely negative phase of the AO. The AO index, which was developed based on EOF analysis of monthly mean sea level pressure, showed its lowest value in the winter of 2009/2010 since 1979/1980 (Figure 22). It can be said that the dominance of the negative AO was an important feature of atmospheric circulation in the winter of 2009/2010. The negativity developed in December 2009 before temporarily weakening in mid-January 2010 and then developing again in early February 2010. In association with this remarkable negative AO, cold air masses frequently flowed to the Eurasian continent and North America. Nonetheless, temperatures were above normal over Japan because the Aleutian low shifted eastward from its normal position and high pressure with warm air masses developed to the south of Japan. These features of atmospheric circulation around Japan are consistent with those commonly seen during El Niño events.

Development and maintenance of negative AO

In association with the negative phase of the AO, the subtropical jet was relatively strong, while the polar front jet was unclear (weaker-than-normal zonal winds between 50°N and 60°N) during winter 2009/2010 (Figure 23). This anomaly pattern of zonal winds seemed to be maintained through positive feedback between the mean flow and eddies (e.g., Kimoto *et al*., 2001). A blocking high-pressure system developed over Alaska through the propagation of Rossby wave packets from active convection over the tropical western Pacific, thereby triggering a negative AO. Stratospheric sudden warming events occurring in early December may also have played an important role in the development and maintenance of this negative AO. It is necessary to further investigate the effects of these events on the features of this negative AO.

(*Shingo Ushida, Climate Prediction Division*)

Reference

Kimoto, M., F. Jin, M. Watanabe and N. Yasutomi (2001), Zonal-eddy coupling and a neutral mode theory for the Arctic Oscillation, *Geophys. Res. Lett.*, 28 (4), 737 – 740

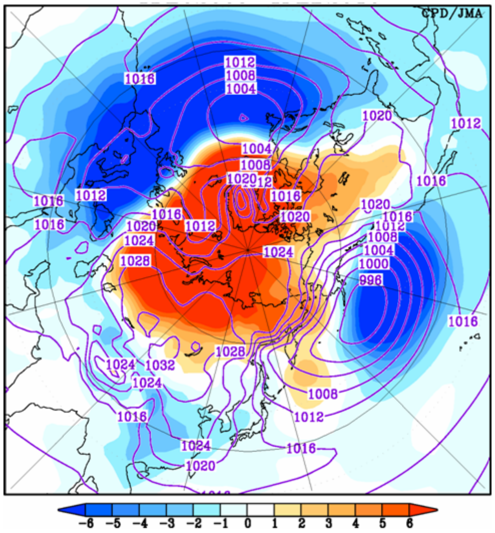


Figure 21 Three-month mean sea level pressure for winter (Dec. – Feb.) 2009/2010

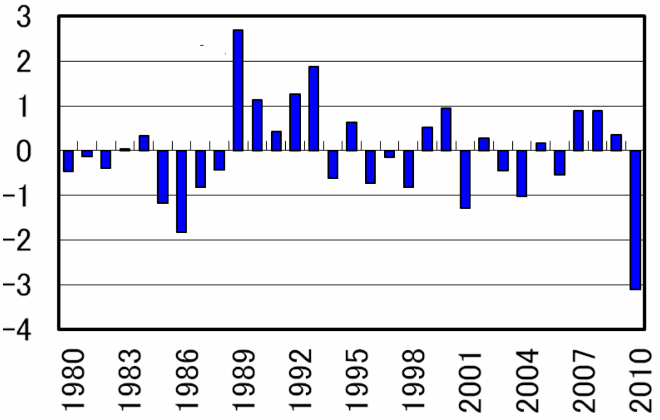


Figure 22 Time-series of the AO index for winter (Dec. – Feb.)

EOF analysis is applied to each monthly mean sea-level pressure (SLP) north of 20°N year-round, then the annular modes of each EOF are averaged to give an annual AO mode. Scores are calculated by projecting historical SLP fields to the AO mode.

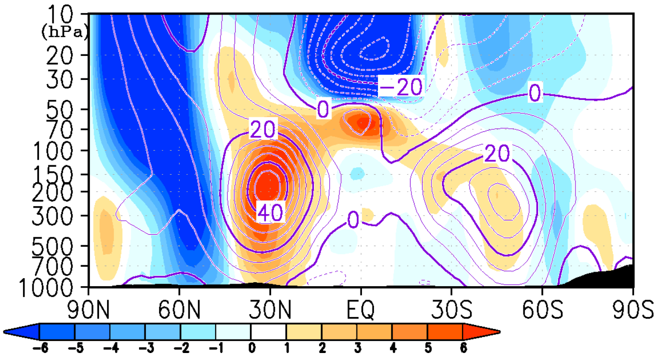


Figure 23 Three-month mean zonal averaged zonal wind speed and anomaly in winter (Dec. – Feb.) 2009/2010

Any comments or inquiries on this newsletter and/or the TCC website would be much appreciated. Please e-mail to: tcc@climar.kishou.go.jp
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