Cold Waves and Heavy Snow in Japan from December 2017

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

Summary

- Surface air temperatures throughout Japan fell repeatedly due to a series of cold waves from December 2017 onward, and some parts of the country intermittently experienced heavy snowfall during the peaks of these waves. A possible cause of these extreme climatic conditions was enhanced convective activity over the Maritime Continent in association with the persisting La Niña event from boreal autumn 2017 onward. This caused meandering of the subtropical jet stream over East Asia, resulting in continuous cold-air-mass flow over the country.
- A tendency for cold air to cover northern Japan and its surrounding areas is expected until the end of February 2018. Be sure to check the latest weather forecasts and information for updates.

1. Weather conditions

A series of extreme cold spells hit Japan and its surrounding areas from December 2017 (Figure 1) onward, and cold air consequently prevailed nationwide. Some parts of the country intermittently experienced heavy snowfall associated with the peaks of these spells, with notable events in early-to-mid-January, late January and early February 2018. These led to unprecedented cumulative snow depths at certain observation stations throughout Japan (Figure 2).

2. Influence of La Niña conditions on the subtropical Jet stream around East Asia

La Niña conditions are expected to continue in the equatorial Pacific (see the El Niño Outlook updated on 9 February 2018). Over Eurasia, westerly jet streams exhibited clear meandering from December 2017 onward with southward meandering over Japan, resulting in continuous cold-air-mass flow over the country. In the upper troposphere (Figure 3 and 4), an anticyclonic circulation anomaly over southern China and a cyclonic circulation anomaly downstream of the anticyclonic anomaly were clearly observed. Such meandering is recognized as a typical circulation anomaly pattern that has accompanied past La Niña events, and is thought to be due to stronger-than-normal convective activity over the Maritime Continent (Figure 4) as illustrated in Figure 5.

A numerical model experiment using the Linear Baroclinic Model (Watanabe and Kimoto 2000) was conducted to help clarify the relationship between convective activity over the Maritime Continent and the meandering of the subtropical jet stream over Japan in winter 2017/18. The LBM experiment result showed the Matsuno-Gill response (Matsuno 1966, Gill 1980) in the tropical troposphere and associated wave patterns (teleconnections) propagating in the mid-latitudes in background westerly wind fields. They were consistent with the observed circulation patterns of this winter, indicating stronger-than-normal and northwestern expansion of upper-level anti-cyclonic circulation over Southeast Asia (Figure 6). These anomalies resulted in the southward meandering of the subtropical jet stream over Japan. The results of statistical and numerical analysis indicate that the cold-air inflow observed over the country during this winter can be partly attributed to the current La Niña event.

3. Outlook

A tendency for cold air to cover Northern Japan and its surrounding areas is expected until the end of February 2018. Snowfall along the Sea of Japan side of the country is expected to exceed the climatological normal until the end of the month. Be sure to check the latest weather forecasts and information for updates.

References

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Matsuno, T., 1966: Quasi-geostrophic motions in the equatorial area. *J. Meteor. Soc. Japan*, **44**, 25-43.

Takaya, K., and H. Nakamura, 2001: A formulation of a phase-independent wave-activity flux for stationary and migratory quasigeostrophic eddies on a zonally varying basic flow. *J. Atmos. Sci.*, **58**, 608-627.

Watanabe, M., and M. Kimoto, 2000: Atmospheric-ocean thermal coupling in the Northern Atlantic: A positive feedback. *Quart. J. Roy. Meteor. Soc.*, **126**, 3343-3369.

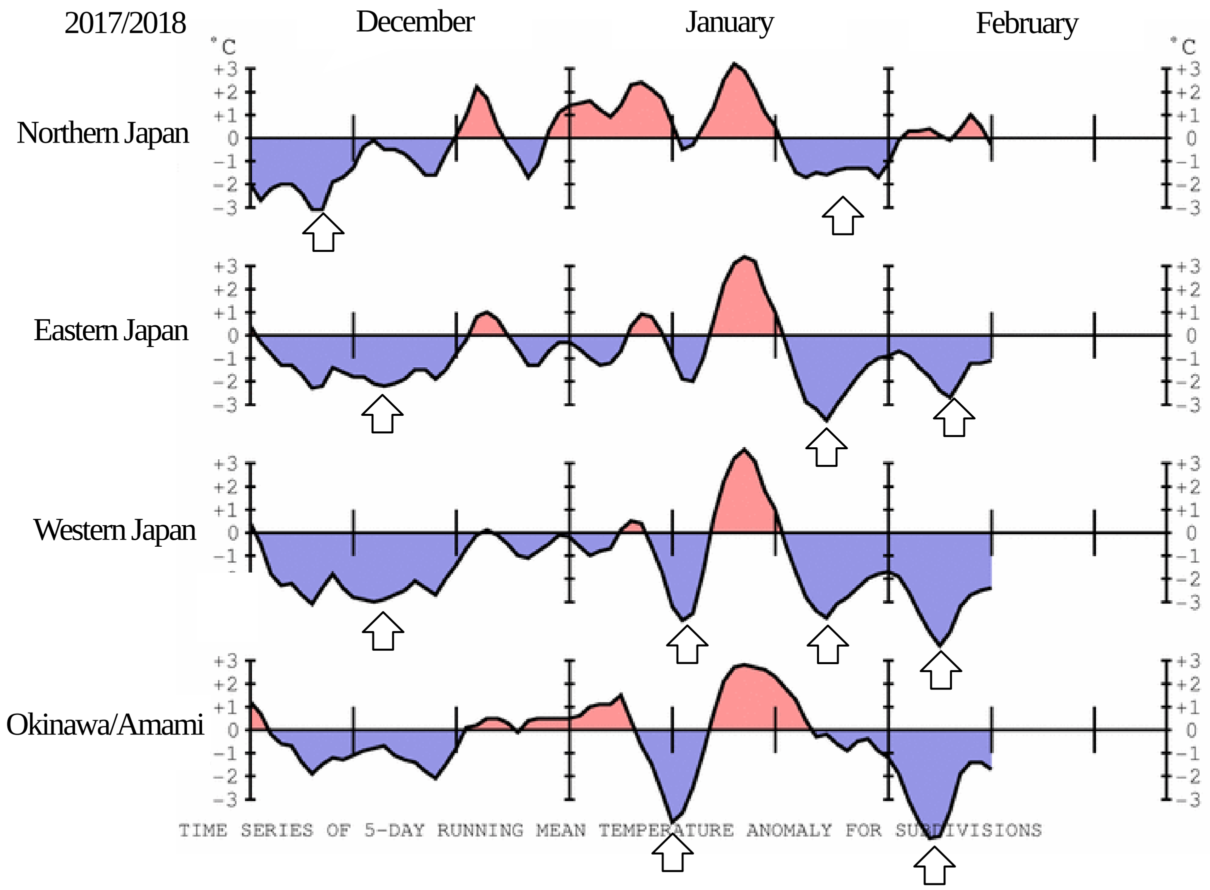

Figure 1. Time-series representations of 5-day running mean temperature anomalies [°C] from December 2017 onward (as of 15 Feb. 2018)
The base period for the normal is 1981 – 2010. Arrows indicate peak low temperatures. For more details of the cold spell in late January, see the press release Cold Spell in Japan from late January 2018 dated 2nd February 2018.

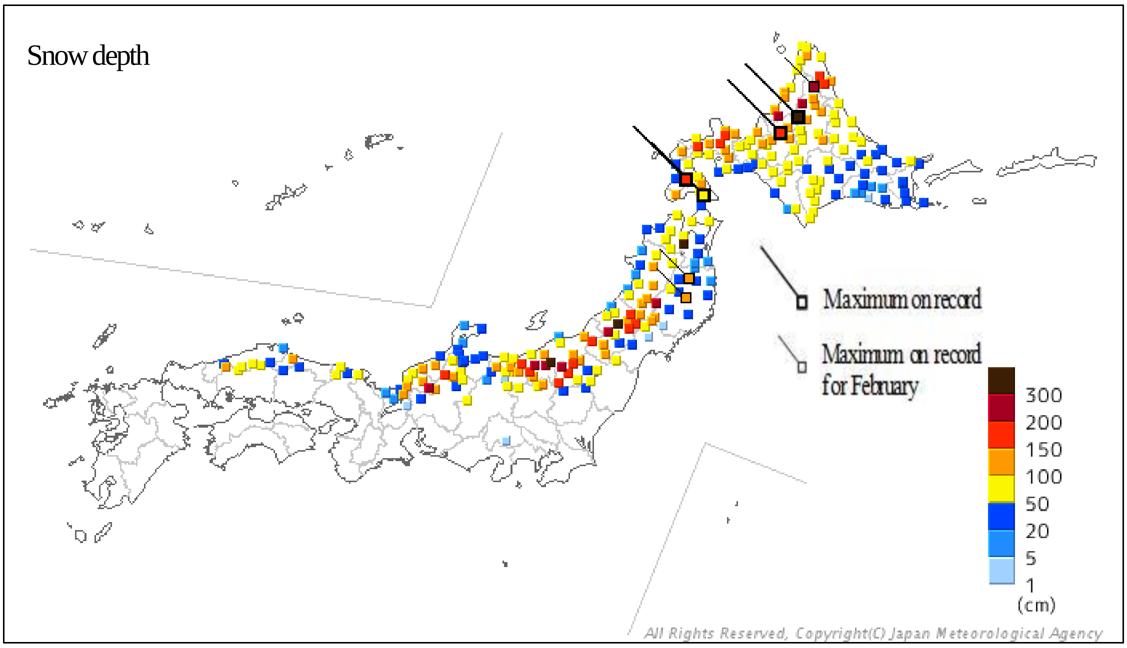

Figure 2. Snow depths [cm] (as of 8 a.m. 15 Feb. 2018)
The base period for the normal is 1981 – 2010.

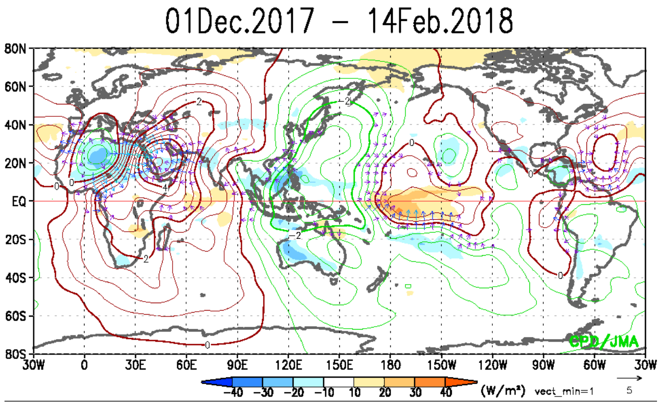

Figure 3. Velocity potential anomalies at 200 hPa (contours) and OLR anomalies (shading) averaged for the period from 1 December 2017 to 14 February 2018

Contour and shading intervals are 0.5 x 10^6 m^2/s and 10 W/m^2, respectively, with shading corresponding to 0 W/m^2 omitted. Vectors indicate divergent wind anomalies greater than 1 m/s. The base period for the normal is 1981 – 2010.

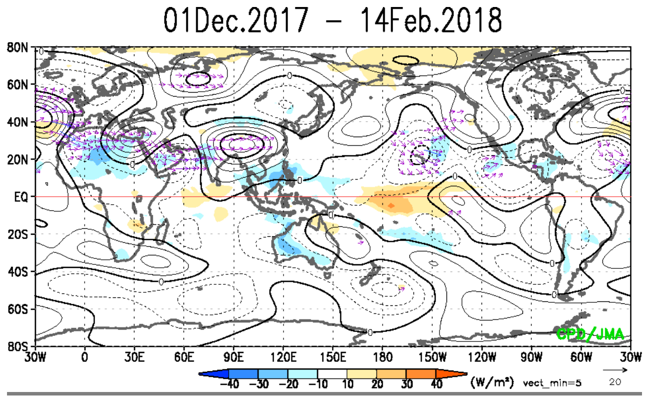

Figure 4. Stream function anomalies at 200 hPa (contours) and OLR anomalies (shading) averaged for the period from 1 December 2017 to 14 February 2018

Contour and shading intervals are 5 x 10^6 [m^2/s] and 10 W/m^2, respectively, with shading corresponding to 0 W/m^2 omitted. Vectors indicate wave activity flux (Takaya and Nakamura 2001) greater than 5 m^2/s^2. The base period for the normal is 1981 – 2010.

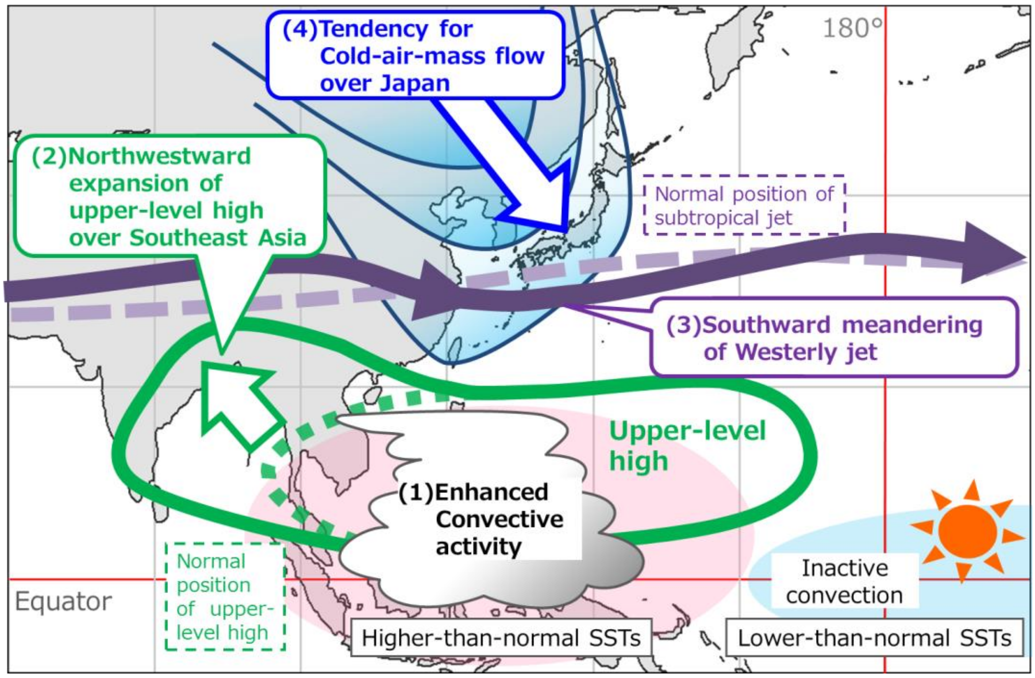

Figure 5. Primary factors contributing to the cold waves and heavy snow observed in Japan from December 2017 onward

The following numbers correspond to those in the above figure:

(1) Convective activity was enhanced over the Maritime Continent due to higher-than-normal SSTs in the tropical western Pacific region in association with the La Niña event observed from boreal autumn 2017 onward.

(2) The northwestern part of the upper-level high located over Southeast Asia strengthened in association with active convection (1).

(3) The subtropical jet stream meandered southward over Japan in association with the stronger-than-normal upper-level high (2).

(4) Cold air accumulating over eastern Siberia tended to flow over Japan in association with the southward meandering of the westerly jet over Japan (3).

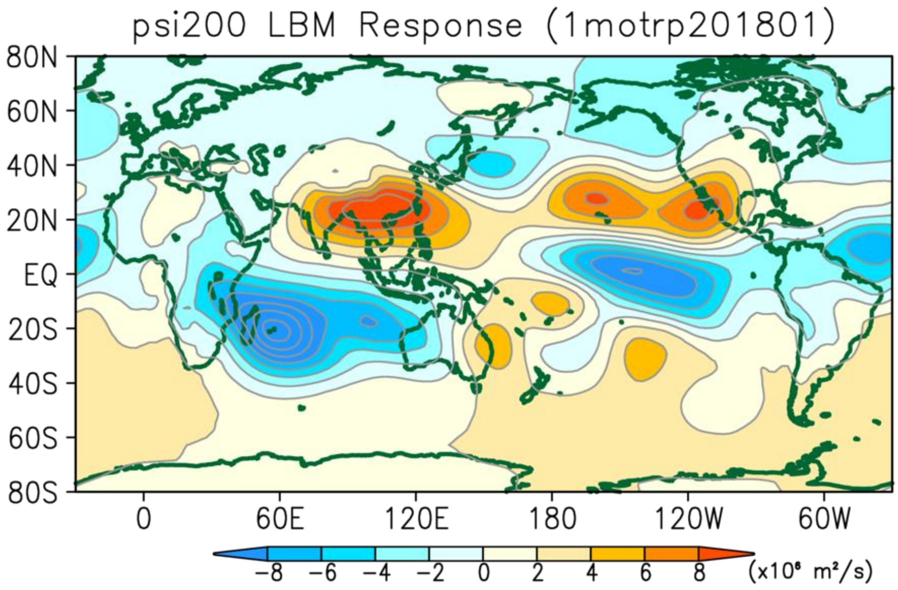

Figure 6. Atmospheric response (stream function at 200 hPa) in the LBM experiment using diabatic heating over the tropics for January 2018

Diabatic heating over the tropics was estimated from JRA-55.

Figure 7. Climatological regions of Japan

The country has four divisions (northern, eastern, western Japan and Okinawa/Amami) and eleven subdivisions (Hokkaido, Tohoku, Kanto-koshin, Hokuriku, Tokai, Kinki, Chugoku, Shikoku, northern Kyushu, southern Kyushu and Okinawa).