Factors behind the heavy snowfall and low temperatures in Japan from mid-December 2020 onward and weather outlook

Summary

- From mid-December 2020 onward, a series of heavy snowfall events hit Japan, especially the Sea of Japan side of the country. The snowfall amounts were record-breaking in some places.
- One of the factors for these events is considered to be the southward meandering of both the polar front and subtropical jet streams around Japan, resulting in continuous cold air flow into the country. The meandering of these polar front and subtropical jet streams was likely to be linked to a blocking high over western Siberia and the ongoing La Niña condition, respectively.

1. Climate conditions

From mid-December 2020 onward, cold air from Siberia repeatedly flowed into the vicinity of Japan, associated with intensified East Asian winter monsoon. This cold air mass, supplied with a huge amount of moisture from the warmer-than-normal the Sea of Japan, caused heavy snowfall events mainly on the Sea of Japan side from northern to western Japan (Figures 1-1, 1-2, 1-3 and 1-4). In particular, previous records of 72-hour snowfall amount were broken at 19 observation stations in the Tohoku and Hokuriku region of the country (Figure 1-2). Even though it's still the middle of this winter, the maximum snow depths have already exceeded the climatological normal for winter in many places, mainly on the Sea of Japan side of the Japan's main island, and some places such as plains in Hokuriku region have experienced very high maximum snow depths more than double the normal (Figures 1-3 and 1-4).

Associated with cold-air inflow over Japan, temperatures were below normal nationwide in this period (Figures 1-5 and 1-6). In particular, the average temperatures in early January were the lowest in the last 36 years in northern Japan and in the last 35 years in western Japan (Figure 1-5).

2. Factors

The primary factors contributing the climate conditions detailed above are illustrated in

Figure 2-1.

One of the factors behind this heavy snowfall and low temperatures is thought to be the southward meandering of both the polar front jet stream (PFJ) and the subtropical jet stream (STJ) around Japan, resulting in continuous cold air flow into the vicinity of Japan. In association with the meandering of the PFJ, the polar vortex in the troposphere over the Arctic region split into two parts and one of them moved southward to the north of Japan, bringing with it intense cold air mass from the polar region to the vicinity of Japan. This repeated cold air outbreak hitting mainly northern Japan was so intense that the area-averaged temperature at 700hPa for about one month from 14 December 2020 was the second-lowest since 1958 (Figure 2-2).

The southward meandering of the PFJ around Japan was likely to be influenced by a blocking high over western Siberia and Rossby wave packet propagation from Europe.

The southward meandering of the STJ around Japan was likely to be caused by the enhanced convective activity over the Maritime Continent associated with the present La Niña condition.

3. **Outlook**

In many areas, the current snow depth has already exceeded the maximum depths of a normal winter. Please pay attention to the latest weather information.
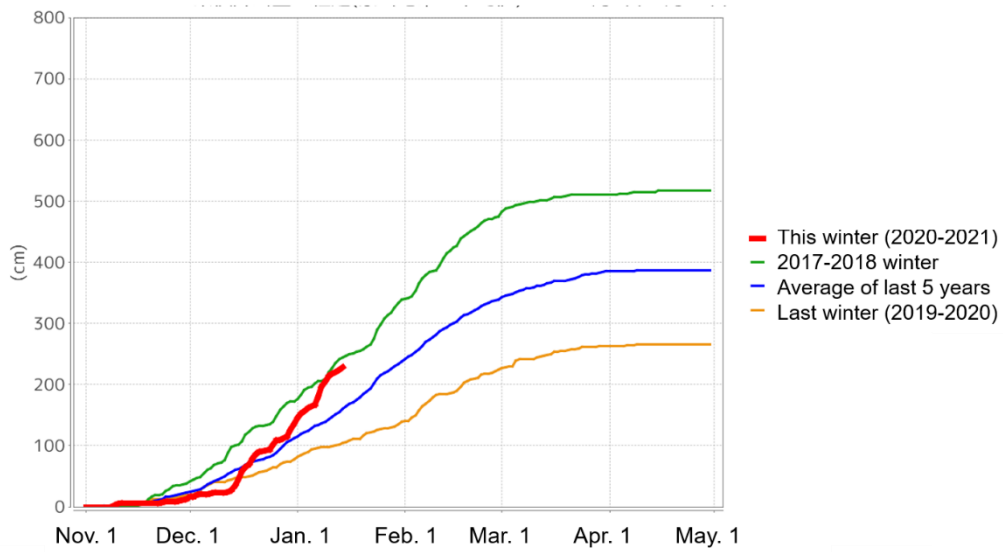
Figure 1-1. Cumulative snowfall [cm] averaged over snowy areas (the areas are designated under the Act on Special Measures for Heavy Snowfall Areas) (1 November 2020 - 14 January 2021).
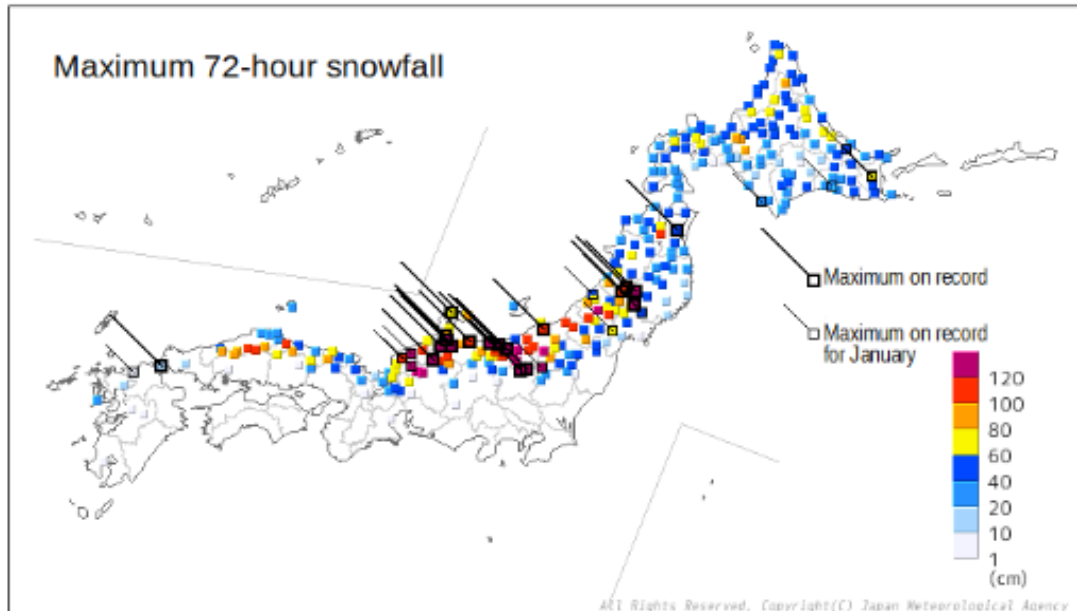

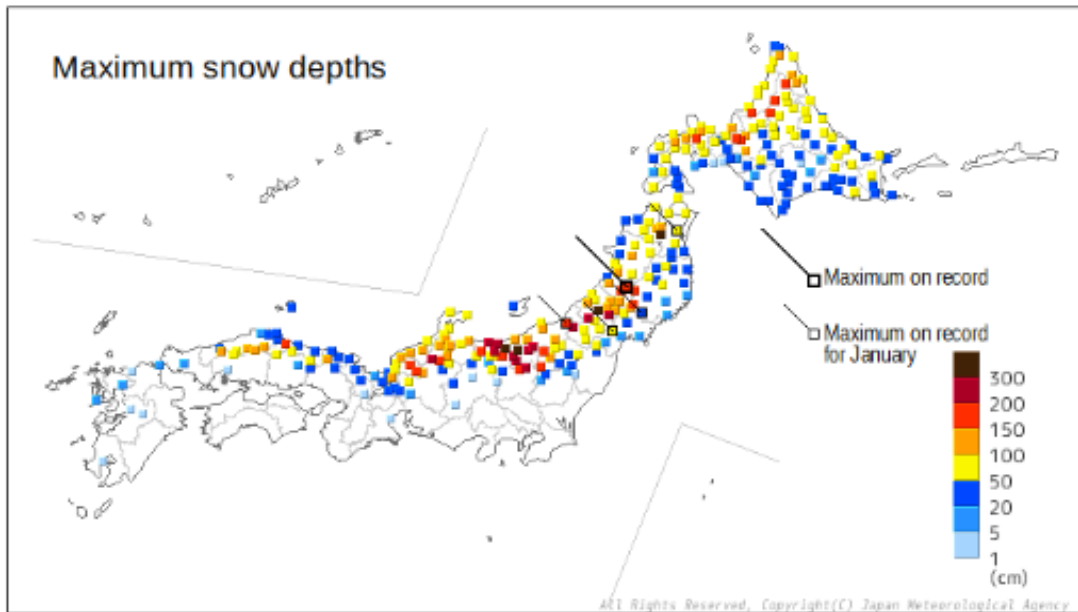**Figure 1-2. Maximum 72-hour snowfall [cm] during the period (14 December 2020 - 11 January 2021).**

Figure 1-3. Maximum snow depths [cm] for the period (14 December 2020 - 11 January 2021).
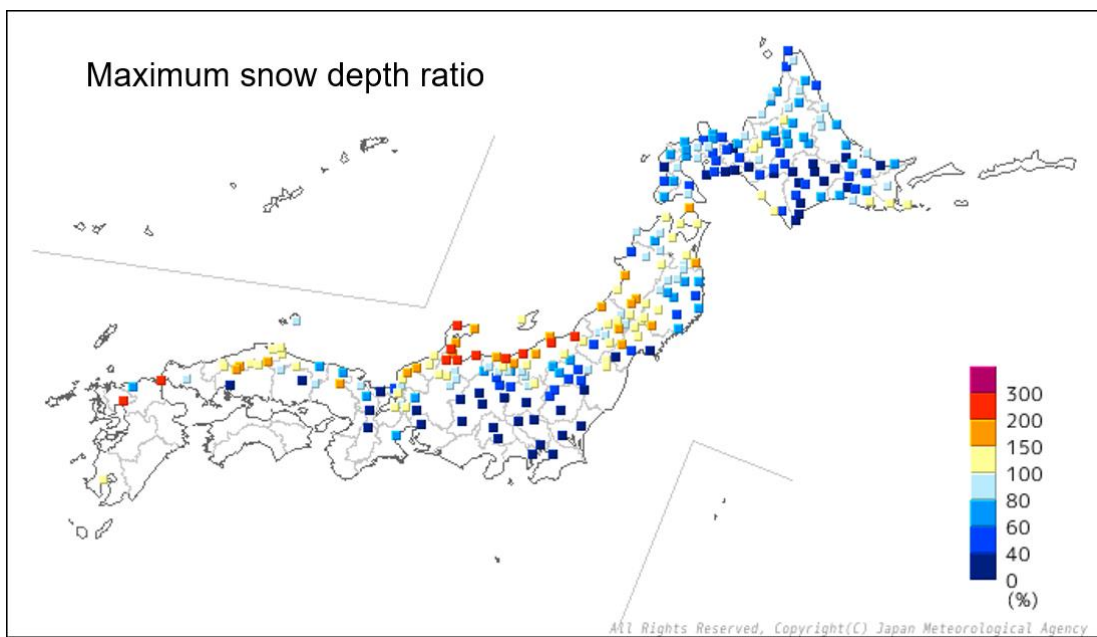

Figure 1-4. Maximum snow depth ratio during the period (14 December 2020 - 11 January 2021) to the normal of the annual maximum [%].
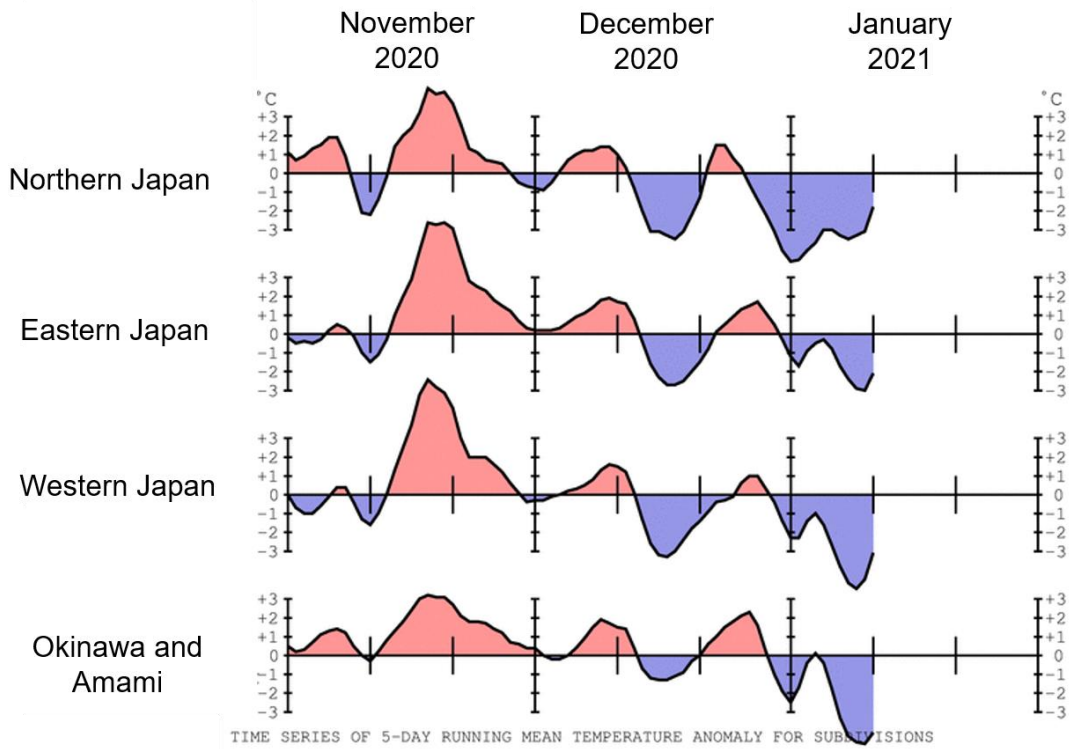
The base period for the normal is 1981 – 2010.

November
2020

December
2020

January
2021

Northern Japan

Eastern Japan

Western Japan

Okinawa and
Amami

TIME SERIES OF 5-DAY RUNNING MEAN TEMPERATURE ANOMALY FOR SUBDIVISIONS

Figure 1-5. Time-series representations of 5-day running mean temperature anomalies [℃] from November 2020 to January 2021.

The base period for the normal is 1981 − 2010.

Mean Temperature Anomalies (°C)
Dec. 14, 2020 − Jan. 11, 2021

+3.0
+2.0
+1.0
0.0
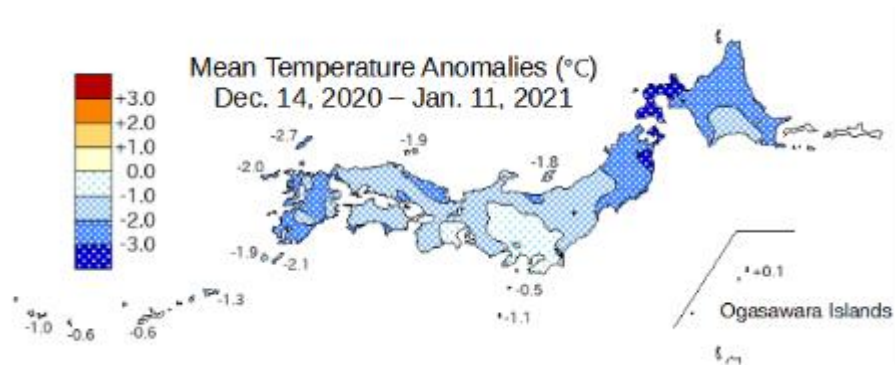-1.0
-2.0
-3.0

Ogasawara Islands

Figure 1-6. Distribution map of mean temperature anomaly [℃] (average from 14 December 2020 - 11 January 2021)
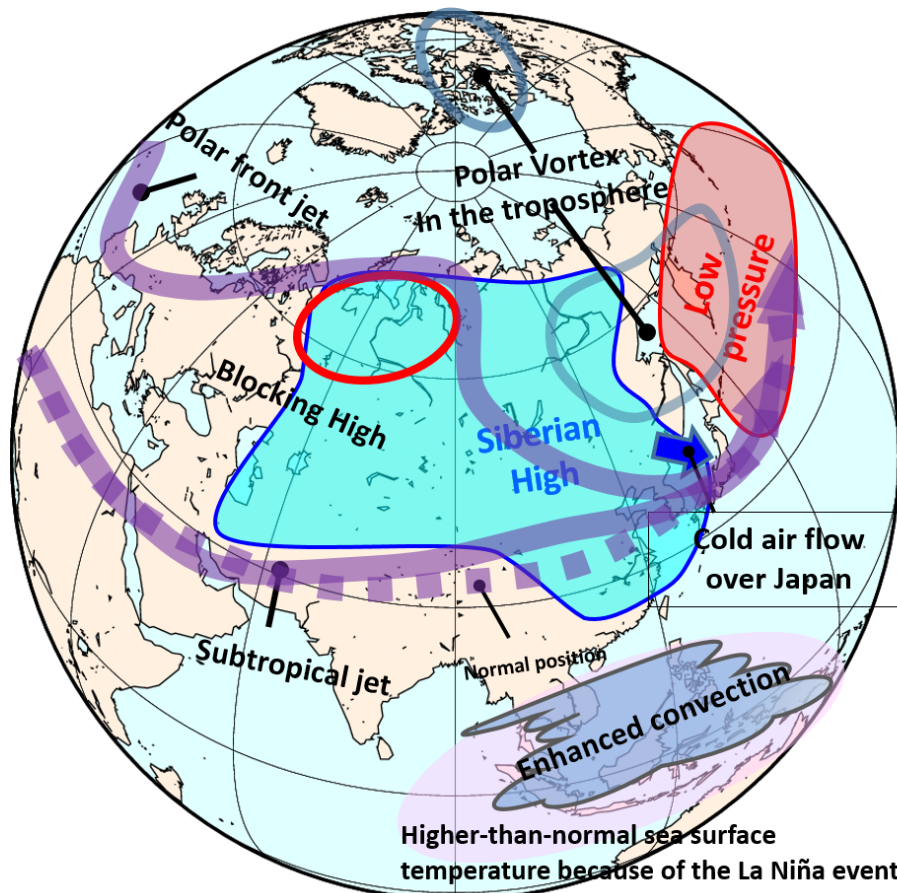
The base period for the normal is 1981 − 2010.

Figure 2-1. Characteristics of the atmospheric circulation that have brought heavy snowfall and low temperatures in Japan from mid-December 2020 onward
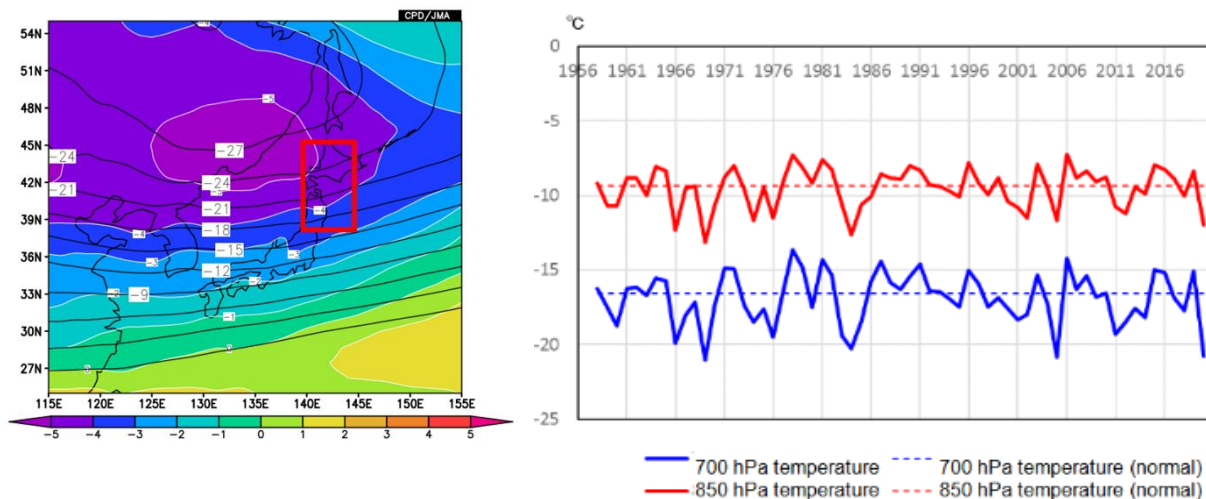

Figure 2-2. (Left) 700hPa-temperature (black line) and its anomaly (color) [°C] averaged over the period from 14 December 2020 to 11 January 2021. (Right) Area-averaged 700- hPa(blue) and 850hPa (red) temperatures over northern Japan for the period from 14 December to 11 January from 1958/59 to 2020/21.

Area-averages for northern Japan are calculated within the red box in the left figure. The anomaly is the difference from the mean for the period 1980/81 - 2009/10.
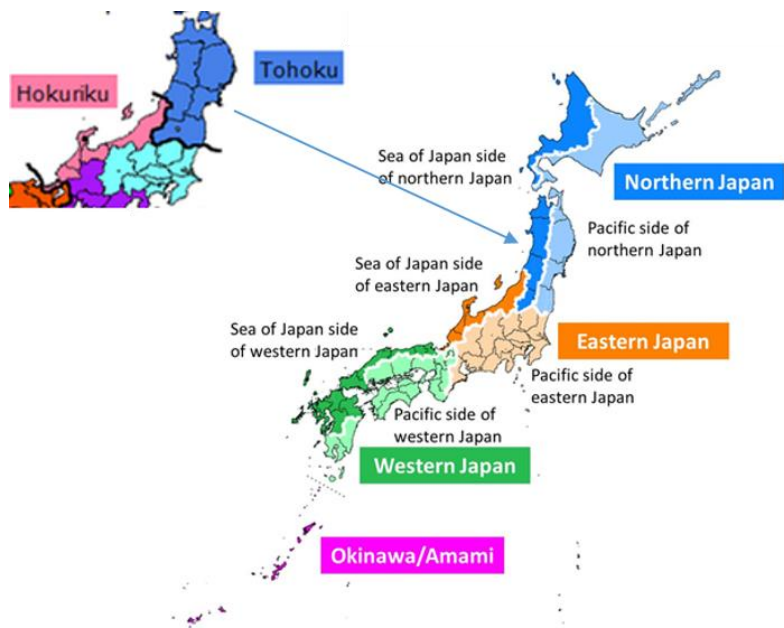
Figure A1. Climatological regions of Japan
The JMA defines seven regional divisions for climate monitoring and forecast (the Sea of Japan sides and the Pacific sides of northern, eastern, western Japan, and Okinawa/Amami).