Extreme summer conditions in Japan in 2013

- Summary of analysis by the TCC Advisory Panel on Extreme Climatic Events -

2 September 2013

Tokyo Climate Center (TCC) , Japan Meteorological Agency
http://ds.data.jma.go.jp/tcc/tcc/index.html

The TCC Advisory Panel on Extreme Climatic Events[1], at its extraordinary session held at the Japan Meteorological Agency on 2 September, issued a statement on primary factors causing extreme summer (June – August) conditions in Japan in 2013.

- Japan experienced extreme weather in summer 2013 as shown below (area-averaged statistical data mentioned here began in 1946.).

<Temperatures>

- High temperatures: seasonal mean temperature anomalies were +1.2°C in western Japan (ranked 1st), +1.1°C in eastern Japan (ranked 3rd) and +0.7°C in Okinawa/Amami (ranked 2nd)
- New national record for daily maximum temperature of 41.0°C was marked at Ekawasaki in Shimanto City, Kochi Prefecture.
- A total of 143 observation stations broke or tied their daily high temperature records.

<Heavy precipitation>

- Heavy precipitation on the Sea of Japan side: precipitation ratio to the normal averaged over Tohoku region for July was 182% (ranked 1st) and that averaged over Hokuriku region for summer was 151% (ranked 4th)
- Some areas in Yamaguchi, Shimane, Akita and Iwate Prefectures were hit by such heavy rain as the respective areas had never experienced.

<Light precipitation>

- Light precipitation in parts of the Pacific side areas in eastern and western Japan and in some areas of Okinama/Amami: seasonal precipitation ratio to the normal averaged over Southern Kyushu and Amami for July was 11% (ranked 1st) and that averaged over Tokai region for summer was 64% (ranked 3rd).

- From July, Japan, particularly its western part, experienced extremely hot summer due to the enhanced Pacific High and the Tibetan High. Meanwhile, some areas on the Sea of Japan side often experienced heavy precipitation due to warm and moist flow around the periphery of the Pacific High, which expanded westward.

- Both the Pacific High and the Tibetan High were enhanced due mainly to significantly active Asian monsoon over a wide area which was caused by above-normal sea surface temperatures (SSTs) around Indonesia and the Philippines, and below-normal SSTs in the central and eastern equatorial Pacific.

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[1] JMA established the Advisory Panel on Extreme Climatic Events in 2009 to discuss extreme climatic events that are mainly caused by variations in the atmospheric general circulation and to timely issue a statement including causes and, if possible, outlooks of the event based on the advice of the Panel and other relevant information.

1. Climatic features

Japan experienced hot summer across the country in 2013. In particular, summer mean temperature averaged over western Japan was 1.2°C above normal (i.e. the 1981-2010 average), the highest since the area-averaged temperature records began in 1946.

Temperatures were significantly high on the Pacific side in eastern and western Japan around the 10th of August (Figure 1). In particular, 12th August saw the highest temperature ever recorded in Japan, 41.0˚C, at Ekawasaki station in Shimanto-city, Kochi Prefecture. As many as 143 observation stations recorded the highest daily maximum temperatures. Daily minimum temperatures were also quite high at many places and 93 stations recorded the highest daily minimum temperatures.

While seasonal total precipitation amounts were below normal in parts of the Pacific side areas in eastern and western Japan and in a part of Okinawa/Amami, they were above normal (i.e. the 1981-2010 average) in the Tohoku region and on the Sea of Japan side in the main island of Japan. In particular, the Tohoku region often experienced heavy precipitation and monthly precipitation ratio to the normal averaged over the region was the highest since the statistical records began in 1946. In some areas in Yamaguchi, Shimane, Akita and Iwate Prefectures, heavy precipitation that had never been experienced before in the respective areas occurred. The number of events with extreme precipitation exceeding 80 mm per hour observed during this summer[2] was the third highest since 1976.

Table 1 Ranking of regional average of seasonal temperature anomaly in summer (June – August)

	1st	2nd	3rd	This summer
Northern Japan	+2.2℃ (2010)	+1.9℃ (1978)	+1.5℃ (1999 etc.)	+1.0℃ Tie for 10th
Eastern Japan	+1.5℃ (2010)	+1.3℃ (1994)	+1.1℃ (2013etc.)	+1.1℃ Tie for 3rd
Western Japan	+1.2℃ (2013)	+1.1℃ (1994)	+0.9℃ (2004)	+1.2℃ 1st
Okinawa and Amami	+0.8℃ (1991)	+0.7℃ (2013 etc.)	–	+0.7℃ Tie for 2nd

※ Since 1946

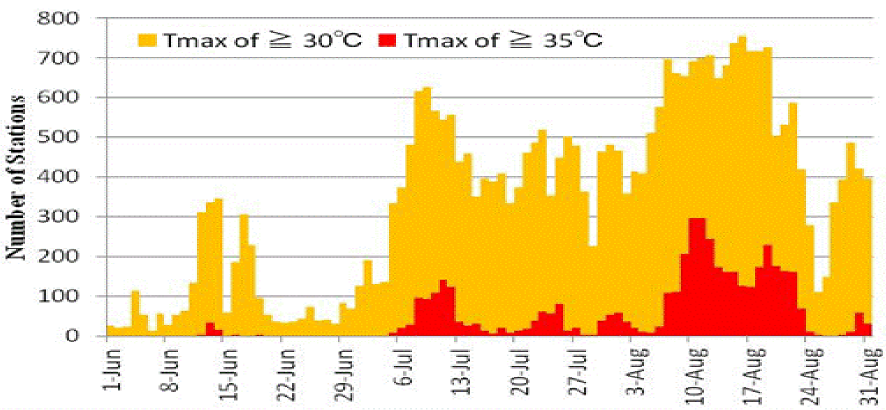


Figure 1 Time-series representations of number of stations with daily maximum temperatures of 30°C or above (Tmax of ≧ 30°C) and 35°C or above (Tmax of ≧ 35°C) in 2013

[2] The number of precipitation events is a per-1,000-station basis for precipitation per hour (every-hour-on-the-hour observations) since 1976 in order to use data obtained with the same observation methods.

Based on 927 surface meteorological stations in Japan.

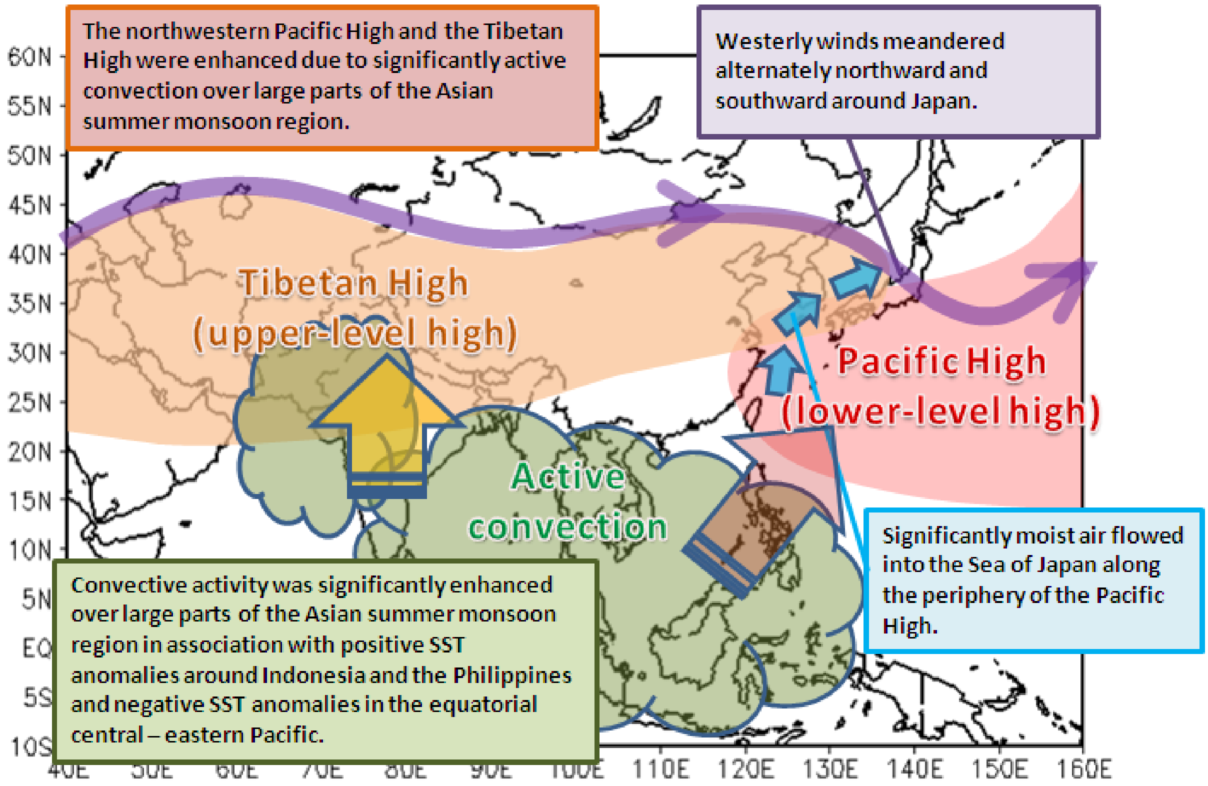


Figure 2 Primary factors contributing to the extreme summer conditions in Japan in July and August 2013

2. Characteristic atmospheric circulation causing Japan's extreme summer conditions

(1) General characteristics in July and August 2013 (Figure 2)

The northwestern Pacific High (a lower-level high pressure system) and the Tibetan High (an upper-level high pressure system), which govern Japan's summer climate, were enhanced during July and August 2013. In particular, the Pacific High continued to expand westward and predominantly developed over Okinawa/Amami (southwestern Japan) and western Japan. Japan experienced hot conditions nationwide, especially in its western part, due to both the enhanced high pressure systems. Sea surface temperatures (SSTs) around Japan in August were significantly higher than normal (i.e., the 1981 – 2010 average) due partly to predominant sunny conditions associated with the high pressure systems.

Convective activity was significantly enhanced over large parts of the Asian summer monsoon region (South and Southeast Asia) associated with SST anomaly patterns in the Pacific (above-normal SSTs around Indonesia and the Philippines, and below-normal SSTs in the equatorial central − eastern Pacific). The enhanced convective activity contributed to the enhancement of the Pacific High around Japan and the Tibetan High.

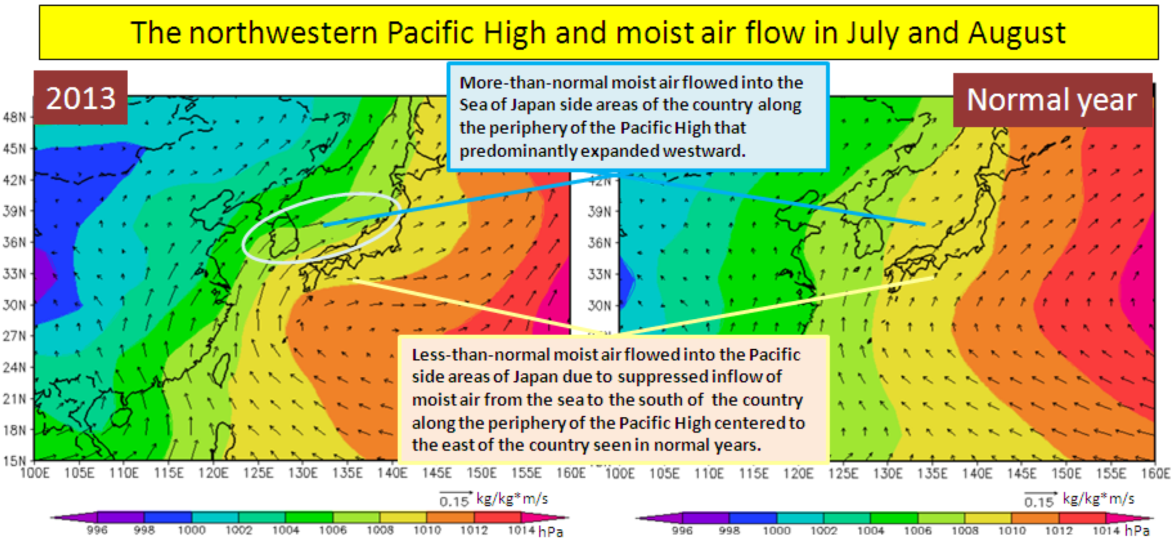


Figure 3 The Pacific High and moist air flow around Japan (1 July – 27 August)

Left and right panels show 2013 and normal year (i.e., the 1981 – 2010 average). The shading indicates sea level pressure, and arrows show 925-hPa water vapor flux.

(2) Primary factors contributing to heavy rains and dry conditions in July and August 2013

The northwestern Pacific High expanded northward to the Pacific side areas of western and eastern Japan in early July, and then the enhanced Pacific High remained centered over the areas to the south of Japan and Okinawa/Amami. Warm moist air continued to flow into the Sea of Japan along the western and northern periphery of the Pacific High, contributing to heavy rains in Tohoku (in northern Japan) and the Sea of Japan side areas of the country (Figure 3). Upper cold air sometimes flowed into Japan associated with southward meandering of westerly winds (the subtropical jet stream), contributed to heavy rains due to unstable atmospheric conditions. Significantly above-normal SSTs in the Sea of Japan may have contributed to that predominantly moist air masses were transported to Tokoku over the sea with little reduction of water vapor.

Dry conditions in Okinawa/Amami and on the Pacific side of western and eastern Japan persisted throughout July and August due to high pressure systems.

(3) Primary factors contributing to extremely hot conditions in mid-August 2013

The northwestern Pacific High was enhanced over Okinawa/Amami and western and eastern Japan, and the Tibetan High expanded to the main islands of the country in line with the northward meandering of upper-level westerly winds (the subtropical jet stream). Surface temperatures in Japan increased due to predominant sunny conditions and downward flow in association with the high pressure systems. In addition, extremely warmer-than-normal air over eastern China and the East China Sea was advected into the main islands of Japan along the northern periphery of the enhanced northwestern Pacific High. Furthermore, northerly winds prevailed over the Pacific side areas of western and eastern Japan, preventing sea winds from blowing into the areas. The weather conditions of long sunshine duration and weak sea winds that are prone to increase the effect of urbanization (i.e., heat island phenomenon) prevailed in urban areas on the Pacific side of Japan, contributing to preventing surface temperatures from decreasing in the night and dawn.

(4) Long-term trends of temperature

It is virtually certain that the summer (June-July-August) mean surface temperature over Japan has risen in the period from 1898 onward and the annual number of days with a maximum temperature of 35°C or above in the country has increased in the period from 1931 onward, analyzing observational records at stations considered to have been affected to a lesser extent by local urbanization. These long-term trends can be attributed in large part to global warming caused by increased concentrations of greenhouse gases such as CO_2.

3. Outlook

In the first half of September, temperatures are predicted to be normal or moderately above normal all over Japan. Extremely hot conditions with a daily maximum temperature of 35°C or above are not likely to persist for several days, although temperature will increase in sunny days.

Monthly precipitation amounts are predicted to be normal in Okinawa/Amami and be above normal in northern, eastern and western Japan due to inflow of moist air. It should be cautioned that heavy rains are likely to occur somewhere in Japan in the coming week (until 9 September) due to fronts and inflow of moist air.

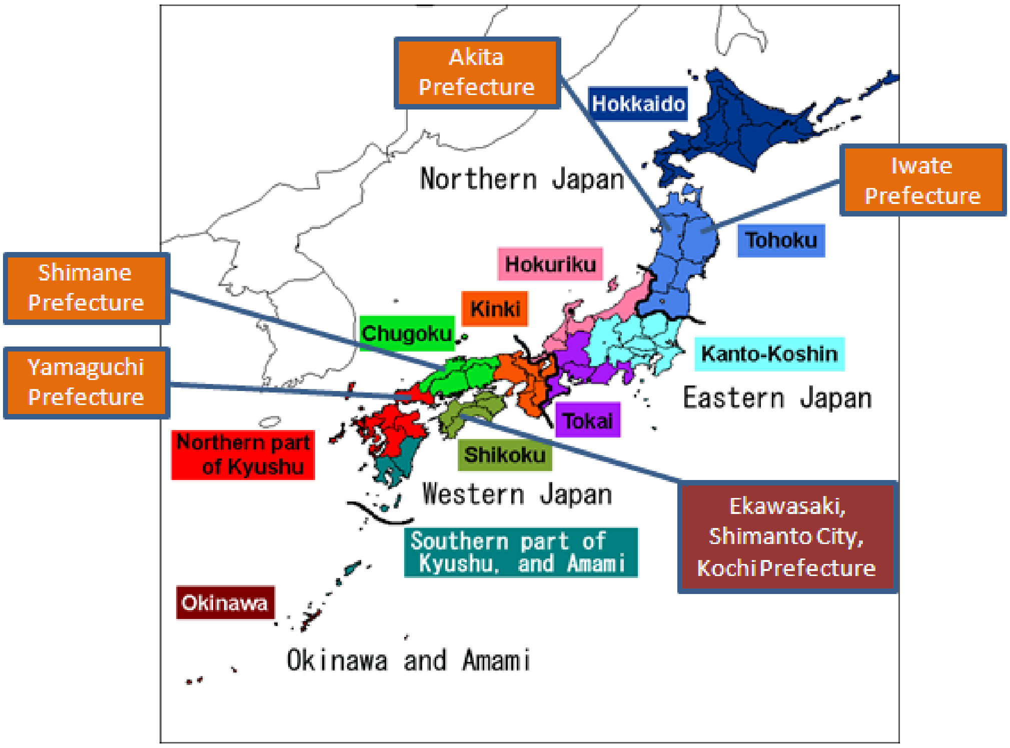


Figure A1 Names of Japanese regions

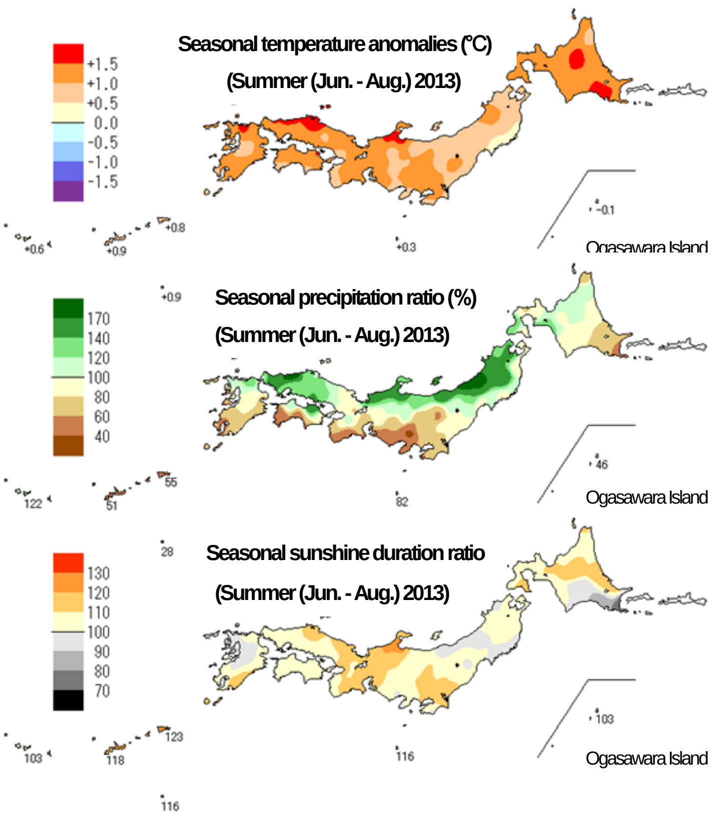


Figure A2 Seasonal temperature anomalies, precipitation ratios and sunshine duration ratios in summer (June – August) 2013

The base period for normal is 1981 – 2010.

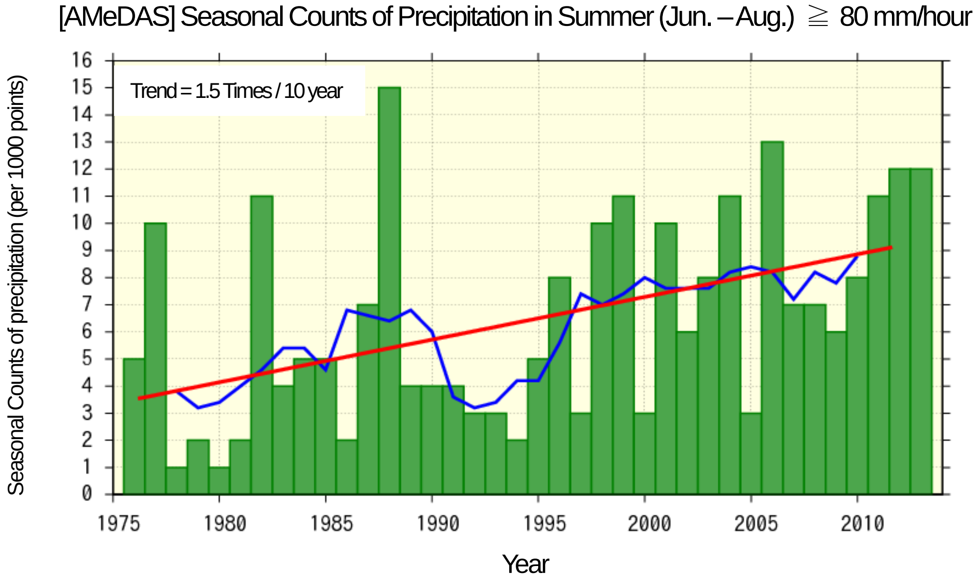


Figure A3 Seasonal number of events in summer (June – August) with precipitation exceeding 80 mm/hour from 1976 to 2013 (per 1,000 Automated Meteorological Data Acquisition System (AMeDAS) points)

The green bars indicate the values for each year. The blue line indicates the five-year running mean, and the straight red line indicates the long-term linear trend.

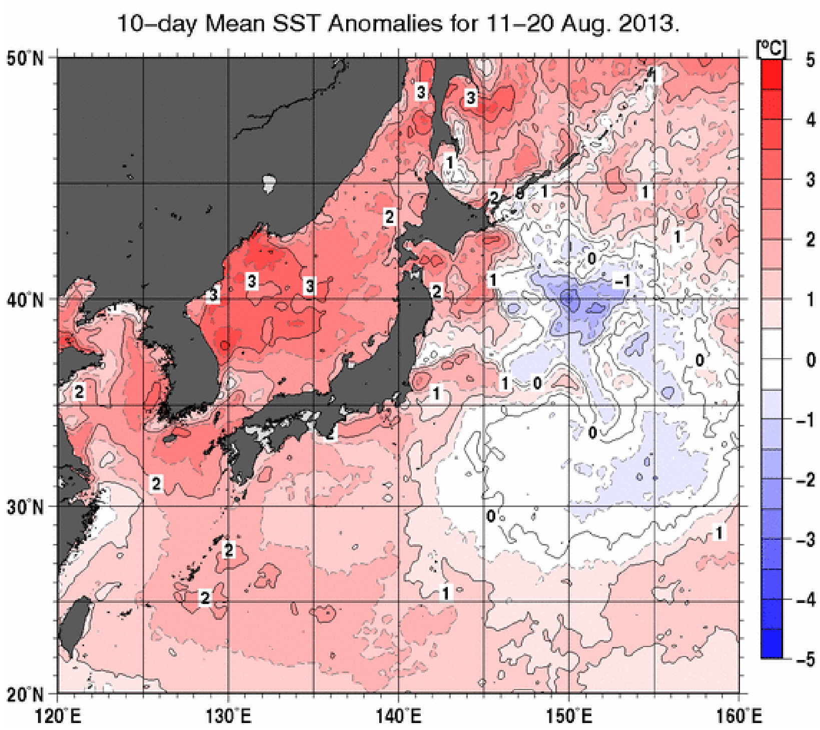
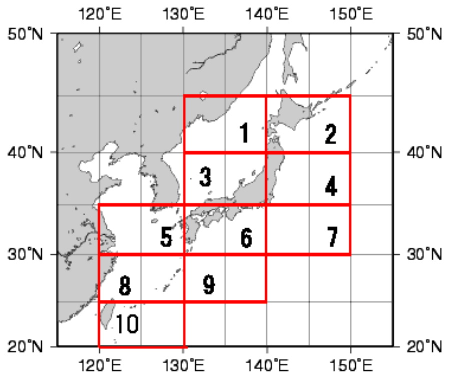


Figure A4 10-day mean sea surface temperature (SST) anomalies (11 – 20 August 2013)

The contour interval is 0.5°C. Light gray areas indicate inner bays. The values of SST anomalies are preliminary value. The base period for the normal is 1981 – 2010.

Table A1 **10-day mean sea surface temperature (SST) anomalies around Japan（11 – 20 August 2013）**



Area※2	SST(℃)	Anomaly(℃)	Ranking in mid-Aug. ※3
Area 1	24.7	2.7	1
Area 2	19.5	1.0	6
Area 3	28.1	2.5	1
Area 4	25.7	0.7	9
Area 5	29.6	2.0	1
Area 6	29.7	1.6	1
Area 7	28.1	0.3	11
Area 8	30.2	1.4	1
Area 9	30.2	1.6	2
Area 10	30.5	1.3	2

※1 The values in the table is preliminary value.
※2 The areas indicate areas in the left figure.
※3 Since 1985.

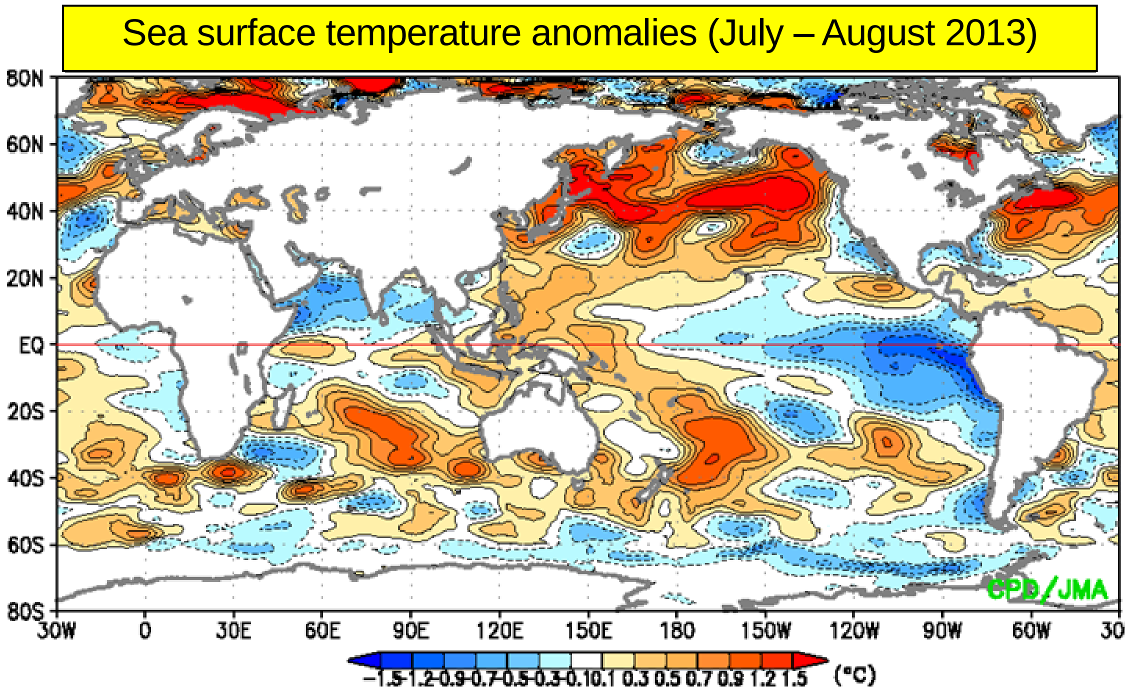


Figure A5 Two-month mean sea surface temperature (SST) anomalies (July – August 2013)
Warm (cold) color indicates positive (negative) SST anomalies. The base period for the normal is 1981 – 2010.

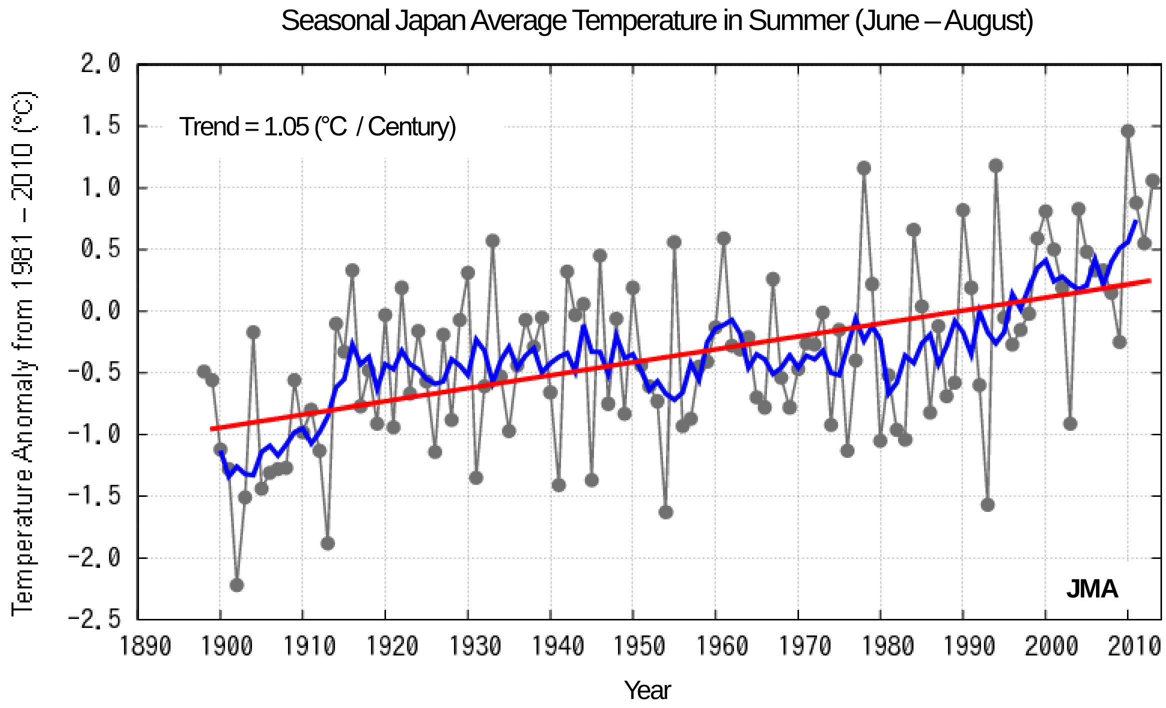


Figure A6 Seasonal surface temperature anomalies in summer (June – August) from 1898 to 2013 in Japan

The thin black line with dots indicates seasonal surface temperature anomalies at 17 stations considered to have been affected to a lesser extent by local urbanization for each year. The blue line indicates the five-year running mean, and the red line indicates the long-term linear trend. Anomalies are deviations from the baseline (the 1981 – 2010 average).

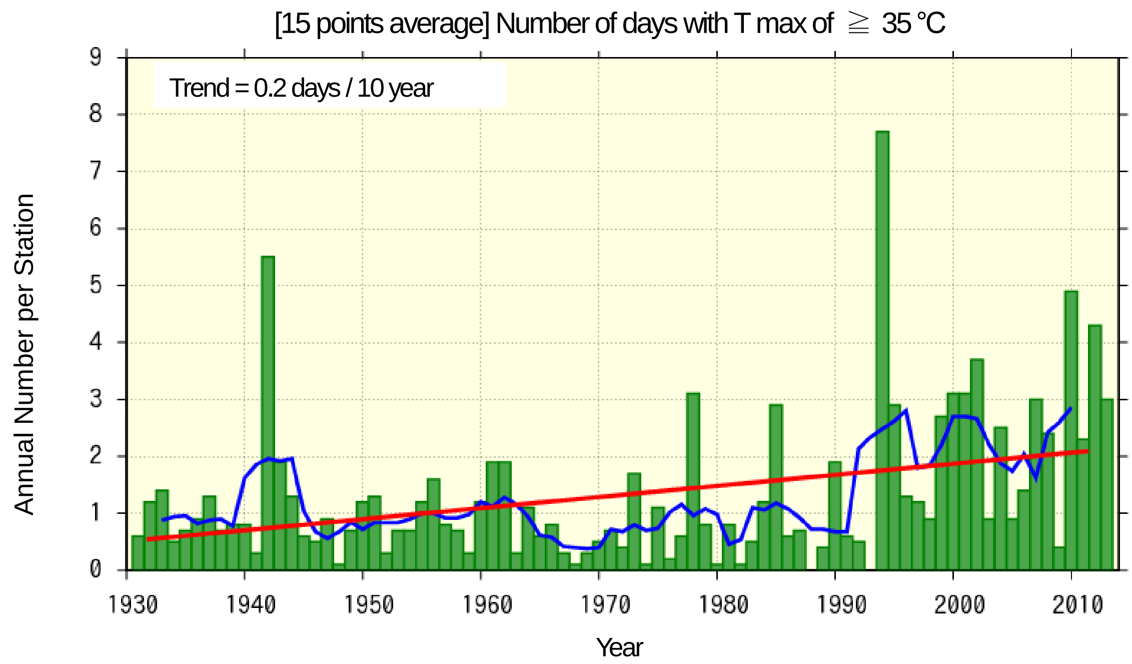


Figure A7 Annual number of days with maximum temperatures of 35°C or above from 1931 to 2013

The green bars indicate the values for each year. The blue line indicates the five-year running mean, and the straight red line indicates the long-term linear trend. JMA selected 15 stations considered to have been affected to a lesser extent by local urbanization. The value of 2013 is preliminary value as of 1 September 2013.