Tokyo Climate Center, Japan Meteorological Agency

TCC News

Summer 2025

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Climate Change in Japan 2025

Following the 2015 adoption of the Paris Agreement against a background of global and regional climate change, Japan's Climate Change Adaptation Plan (based on the Climate Change Adaptation Act) was approved by the nation's Cabinet in 2018.

In March 2025, the Japan Meteorological Agency (JMA) and Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) published the Climate Change in Japan 2025 report to support related action by providing information with a physical science basis to the public, commercial enterprises and local/national government bodies (https://www.data.jma.go.jp/tcc/tcc/products/gwp/gwp.html).

This series of reports provides information on the status of atmospheric greenhouse gases and observed/projected changes in climate variables in and around Japan. The 2025 edition includes high-resolution climate projection updates and information on how the frequency and intensity of extreme heavy rainfall and high temperatures are projected to change with global warming.

Projections are based on the 2/4°C Warming Scenarios (RCP2.6 and RCP8.5 as referenced in the IPCC Fifth Assessment Report, respectively).

- 2°C Warming Scenario: potential climatic conditions with achievement of the Paris Agreement's 2°C goal.
- 4°C Warming Scenario: potential climatic conditions with no future additional mitigation measures.

The information in the reports is used for risk assessment, policy formation, infrastructural development and disaster mitigation.

1. Temperature

Annual surface temperature is virtually certain to have risen at a rate of 1.40°C per century between 1898 and 2024. Since 1910, the annual numbers of days with maximum temperatures (T_{max}) of ≥ 30°C and ≥ 35°C have increased (and since 1929 for days with minimum temperatures (T_{min}) of ≥ 25°C), while the number of T_{min} < 0°C days has decreased. Figure 1-1 shows changes in annual surface temperature as of the end of the 21st century relative to the end of the 20th century. Under both IPCC scenarios, annual surface temperature is projected to rise, with more T_{max} ≥ 35°C / T_{min} ≥ 25°C days and fewer T_{min} < 0°C days projected in many regions.

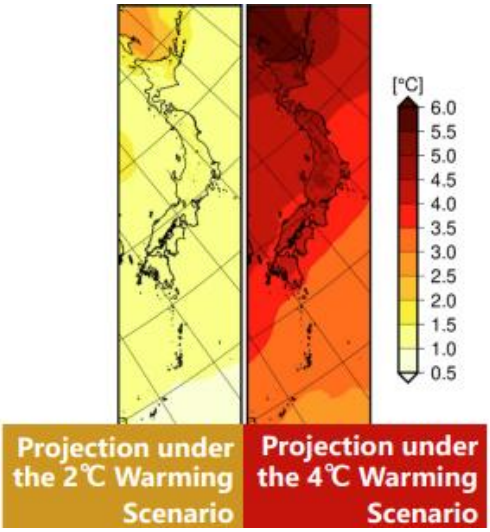

Figure 1-1 Annual surface temperature

2. Precipitation

The frequency of heavy rainfall events has risen overall (Figure 1-2), with heavier instances showing a particularly high rate of increase. It is extremely likely that annual maximum daily precipitation has increased. Under both IPCC scenarios, the national average frequency of heavy rainfall events is projected to increase, along with annual maximum daily precipitation (i.e., increased frequency and intensity of extreme rainfall). In conditions with a 4°C rise, centennial extreme precipitation (daily) compared with pre-industrial conditions is projected to occur approximately 5.3 times, and centennial daily precipitation amounts are projected to increase by approximately 32%.

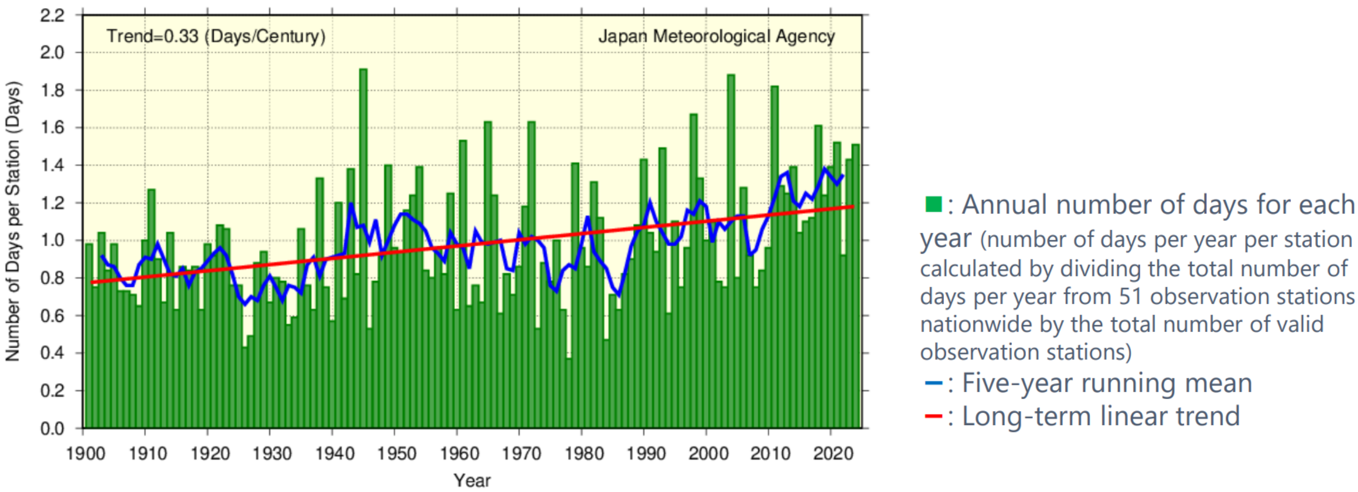

Figure 1-2 Annual number of days with precipitation ≥ 100 mm (1901 – 2024)

3. Snowfall

The annual maximum snow depth is extremely likely to have decreased in each region on the country's Sea of

Japan side since 1962. While annual maximum snow depth and snowfall are projected to decrease under the 4°C Warming Scenario, actual snowfall may increase during extreme events in some areas, such as mountainous regions of Honshu.

4. Sea surface temperature

The average sea surface temperature (SST) around Japan is virtually certain to have risen by +1.33°C per century until 2024; this is more than twice the global average. Figure 1-3 shows that SST around Japan is projected to increase under both IPCC scenarios.

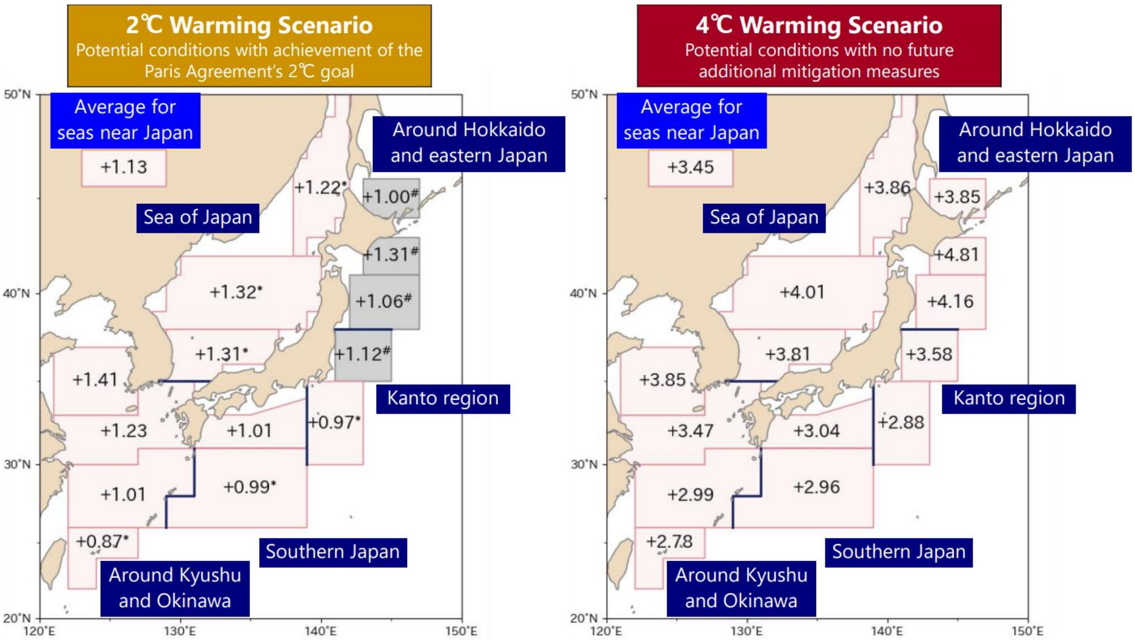

Figure 1-3 Changes in area-averaged SSTs around Japan at the end of the 21st century relative to the end of the 20th century (°C/century)

Areas with no symbols, those marked with [*], and those marked with [#] have virtually certain trends, extremely likely trends, and no discernible trend, respectively.

5. Sea levels

It is extremely likely that a rising trend in mean sea level (MSL) has occurred since the 1980s along the coast of Japan, although some long-period variability (assumed to be natural) is predominant over the whole period (Figure 1-4). MSL is also projected to continue rising during the 21st century along the coast of Japan.

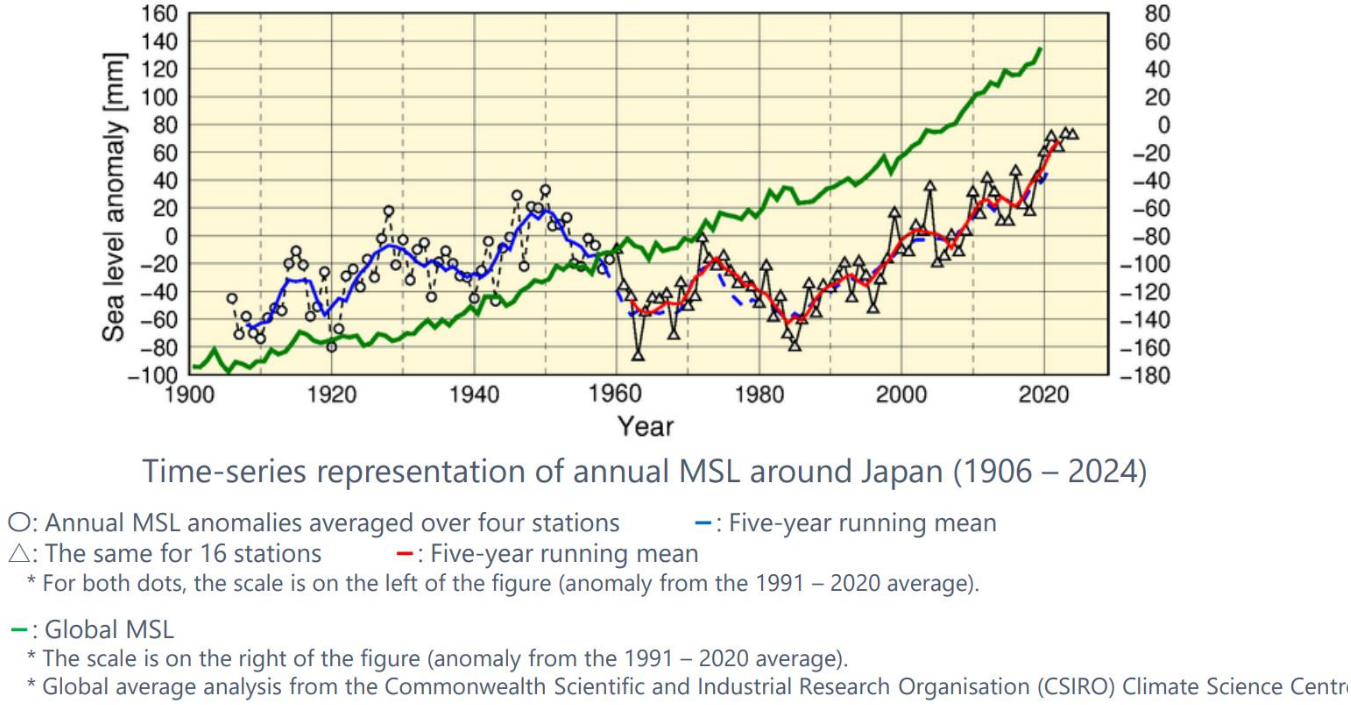

Figure 1-4 Time-series representation of annual MSL around Japan

(NAGASAWA Kyoka, Office of Climate Change)

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Upgrade of Reports on Global Extreme Climate Events

TCC monitors the global climate with CLIMAT and SYNOP reports from NMHSs and collects quality-checked data on temperature and precipitation, using the information to monitor extreme climate events around the world. Based on the data obtained, the Center issues weekly, monthly and seasonal monitoring reports on extreme climate conditions with overviews of disastrous events.

On 14th March 2025, TCC upgraded these products as follows to enhance usability and support workflow in users' data analysis:

- Revised maps of extreme climate events for weekly, monthly and seasonal reports to improve clarity and readability (Figure 2-1).
  The revision reduces ambiguity and helps to highlight critical points more efficiently.
- New data on weather stations recording extreme climate conditions in HTML and CSV format as part of monthly and seasonal reports (Figure 2-2).
  The data format is the same as that of weekly reports and provides granular data access, thereby clarifying the details of observation data and anomalies.

These updates are part TCC's ongoing efforts to optimize product accessibility. User feedback is warmly welcomed.

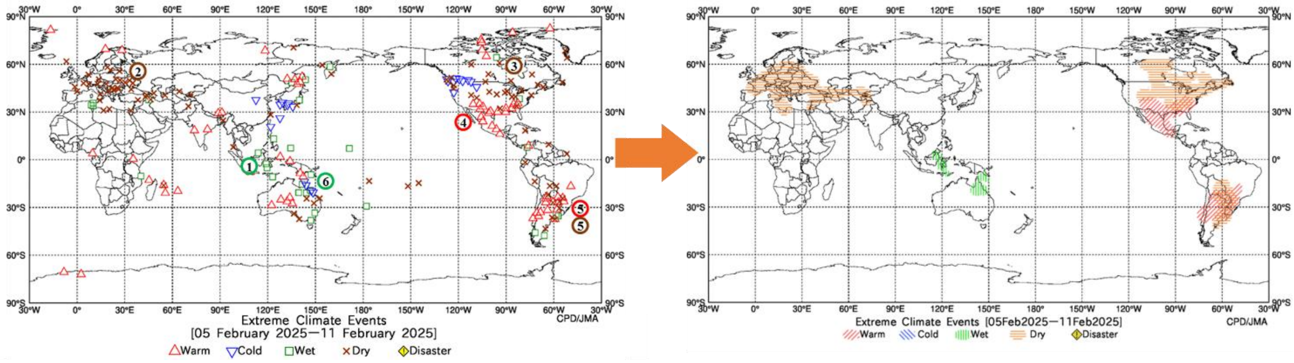

Figure 2-1 Revised map of extreme climate events

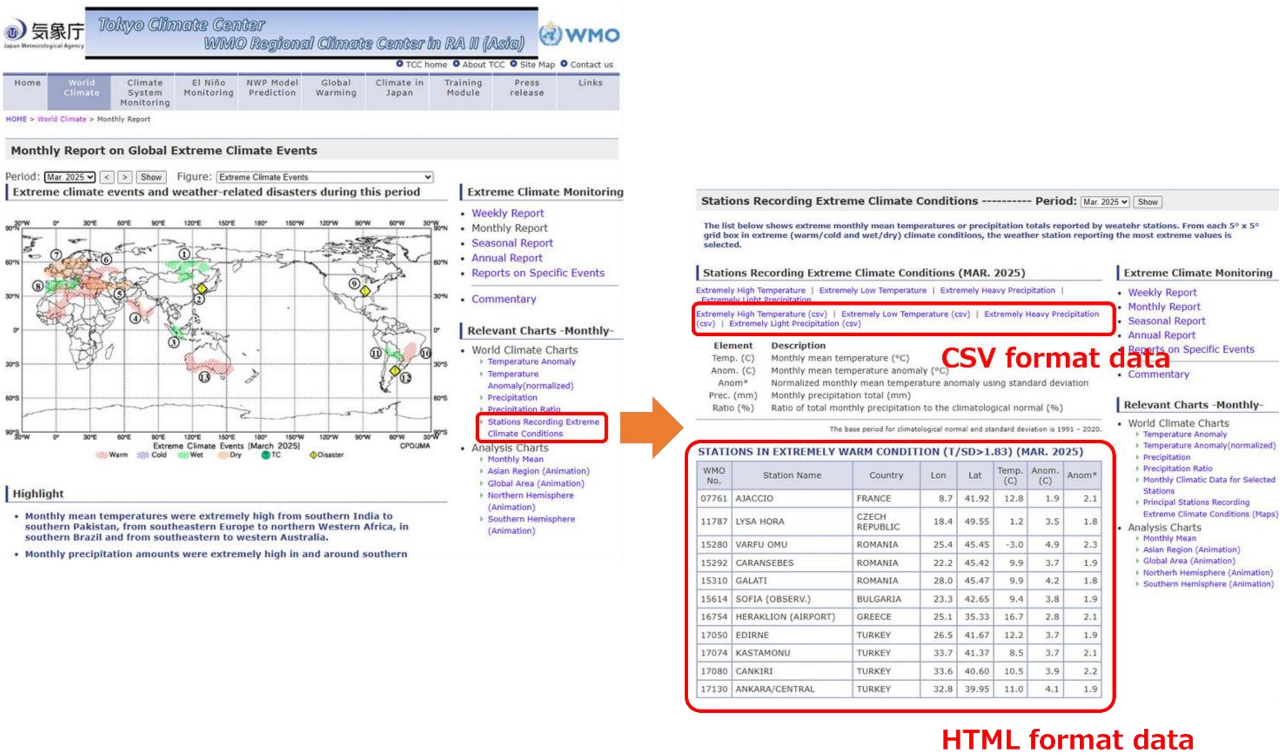

Figure 2-2 HTML/CSV data on weather stations recording extreme climate conditions

(YAMADA Ken, Tokyo Climate Center)

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HTML Upgrade for Monthly and Seasonal Highlights on the Climate System

The Japan Meteorological Agency monitors global atmospheric, oceanic and terrestrial climate systems using numerical objective analysis data (the Japanese Reanalysis for Three Quarters of a Century; JRA-3Q) and satellite observation data. The results provide useful information for interpretation of current climate conditions, including extreme events and long-term trends, and for long-range forecasts and scientific research. TCC has issued Monthly Highlights on the Climate System and Seasonal Highlights on the Climate System since March 2007 to highlight monitoring results.

For enhanced accessibility, these products were upgraded from PDF to HTML format in May 2025 (Figure 3-1). The following optimizations have also been actioned:

- To leverage the web format, hypertext references to text citations have been added for easier access to source materials.
- A figure for 850-hPa stream function in the tropics, in addition to that at 200 hPa, has been added (Figure 3-2) to facilitate comparison of upper- and lower-tropospheric circulation and interpretation of atmospheric circulation conditions.
- To match monthly highlight reporting, world climate monitoring maps in seasonal highlights now show stations recording extreme conditions, rather than the previous three-month mean normalized temperature anomalies. This helps to clarify areas with extremely high and low precipitation during the season in addition to those with extremely high and low temperatures worldwide (Figure 3-3).

TCC warmly welcomes feedback from NMHS toward further optimization of bulletins on climate system monitoring results.

Monthly Highlights on the Climate System

'Monthly Highlights on the Climate System' has been issued since March 2007 as a monthly bulletin focusing on the monthly highlights of the monitoring results.

Notice: Products have been upgraded from PDF to HTML format starting from the issue of May 2025 for improved accessibility.

Highlights in May 2025

- Significant positive sea surface temperature (SST) anomalies were seen around the Maritime Continent, and negative SST anomalies were observed in the eastern equatorial Pacific. Positive SST anomalies also prevailed over the southern tropical Indian Ocean. The NINO.3 index was -0.2°C.
- Convective activity was enhanced from India to around the Maritime Continent, while suppressed in the western North Pacific and from Africa to the western Indian Ocean. The onset of the Indian monsoon was earlier than normal (India Meteorological Department).
- In the upper troposphere, anti-cyclonic circulation anomalies straddling the equator were seen over the Indian Ocean. In the lower troposphere, cyclonic and anti-cyclonic circulation anomalies straddling the equator were seen from the Indian Ocean to the western Maritime Continent and over the Pacific, respectively.
- In the 500-hPa height field of the Northern Hemisphere, a stronger-than-normal polar vortex was located in the northern Canada. Positive and negative anomalies were seen over the western Europe and the eastern Europe, respectively. Positive and negative anomalies were seen over the northern Far East and the southern Far East, respectively. Positive anomalies were dominant over the Central Asia and the mid-latitudes of the North Pacific.
- The subtropical jet stream meandered over East Asia, resulting in a southward shift over China and a northward shift over the east of Japan. In the sea level pressure field, a pressure trough formed along the main island of Japan.
- Monthly mean temperatures were above normal in northern Japan. On the Pacific sides of eastern and western Japan, monthly sunshine durations and monthly precipitation amounts were below and above normal, respectively, especially significant for the Pacific side of eastern Japan.

Climate in Japan (Fig. 1):

- Monthly mean temperatures were above normal in northern Japan, because the region was likely to be affected by warm air. The monthly anomaly of the average surface temperature over Japan was +0.51°C. On a longer time scale, the average surface temperatures have risen at a rate of about 1.73°C per century in May.
- Monthly precipitation amounts were significantly above normal on the Pacific side of eastern Japan and were above normal on the Sea of Japan side of western Japan, on the Pacific side of western Japan and in Okinawa/Amami. Monthly sunshine durations were significantly below normal on the Pacific side of eastern Japan and were below normal on the Pacific side of western Japan. The regions were well-affected by low-pressure systems and fronts.

World Climate:

- The monthly anomaly of the global average surface temperature (i.e., the combined average of the near-surface air temperature over land and the SST) was +0.43°C (2nd warmest for May since 1891) (preliminary value) (Fig. 2). On a longer time scale, global average surface temperatures have risen at a rate of about 0.77°C per century in May (preliminary value).
- Extreme climate events were as follows (Fig. 3).
  - Monthly mean temperatures were extremely high from western China to Central Asia and from southern Mexico to Colombia via Caribbean countries.
  - Monthly mean temperatures were extremely low from central to southern India.
  - Monthly precipitation amounts were extremely high from eastern to western Japan, from Viet Nam to Thailand, from Bangladesh to India and from Paraguay to northeastern Argentina.

Oceanographic Conditions:

- In the equatorial Pacific, negative SST anomalies were observed in the eastern part, and remarkably positive SST anomalies were observed around Indonesia (Fig. 4). The monthly mean SST anomaly averaged over the NINO.3 region was -0.3°C and the SST deviation from the latest sliding 30-year mean over the region was -0.2°C (Fig. 5).
- In the North Pacific, remarkably positive SST anomalies were observed from the seas east of the Philippines to the south of Japan and around the dateline in the tropics and the mid-latitudes, and remarkably negative SST anomalies were observed to the southwest of California.
- In the South Pacific, remarkably positive SST anomalies were observed in the western part from the tropics to the mid-latitudes, the eastern part of the subtropics and the central part of the mid-latitudes.
- In the Indian Ocean, remarkably positive SST anomalies were observed in the Bay of Bengal and on the Southern Hemisphere side.
- In the North Atlantic, remarkably positive SST anomalies were observed in the western part of the subtropics and to the west of Europe.

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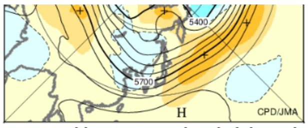

Fig.10 Monthly mean 500-hPa height and anomaly in the Northern Hemisphere (May 2025)
The contours show 500-hPa height at intervals of 60 m. The shading indicates its anomalies. The base period for the normal is 1991-2020.

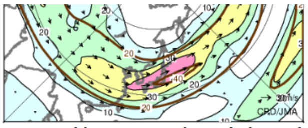

Fig.11 Monthly mean 200-hPa wind speed and vectors in the Northern Hemisphere (May 2025)
The black lines show wind speed at intervals of 10 m/s. The brown lines show its normal at intervals of 20 m/s. The base period for the normal is 1991-2020.

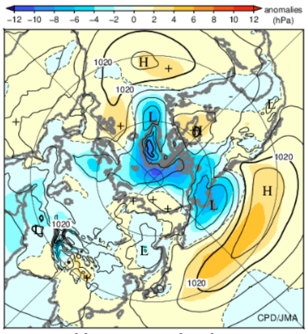

Fig.12 Monthly mean sea level pressure and anomaly in the Northern Hemisphere (May 2025)
The contours show sea level pressure at intervals of 4 hPa. The shading indicates its anomalies. The base period for the normal is 1991-2020.

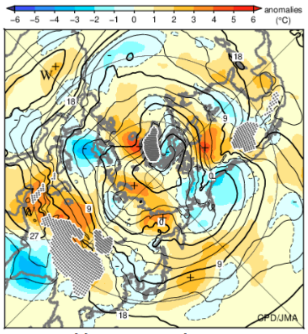

Fig.13 Monthly mean 850-hPa temperature and anomaly in the Northern Hemisphere (May 2025)
The contours show 850-hPa temperature at intervals of 3 degree C. The shading indicates its anomalies. The base period for the normal is 1991-2020.

Figure 3-1 Layout of May 2025 Monthly Highlights on the Climate System in HTML format

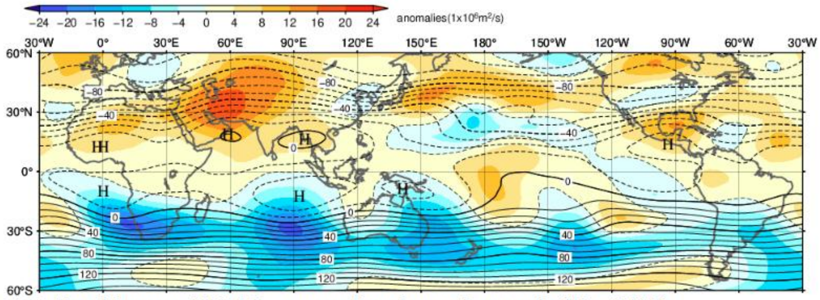

Fig.8 Monthly mean 200-hPa stream function and anomaly (May 2025)
The contour interval is 10×10^6 m^2/s. The base period for the normal is 1991-2020.

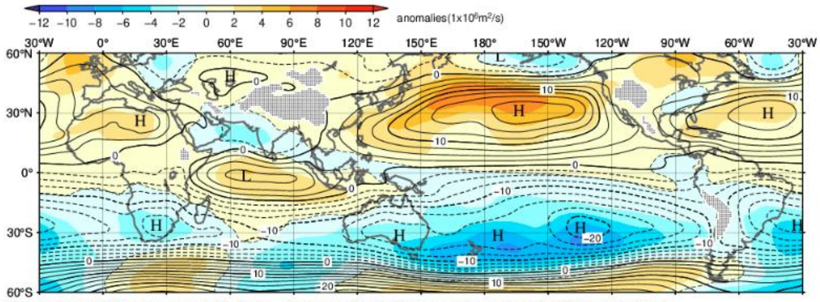

Fig.9 Monthly mean 850-hPa stream function and anomaly (May 2025)
The contour interval is 2.5×10^6 m^2/s. The base period for the normal is 1991-2020.

Figure 3-2 New figure for 850-hPa stream function in the tropics (bottom) in addition to that at 200 hPa (top) in HTML format

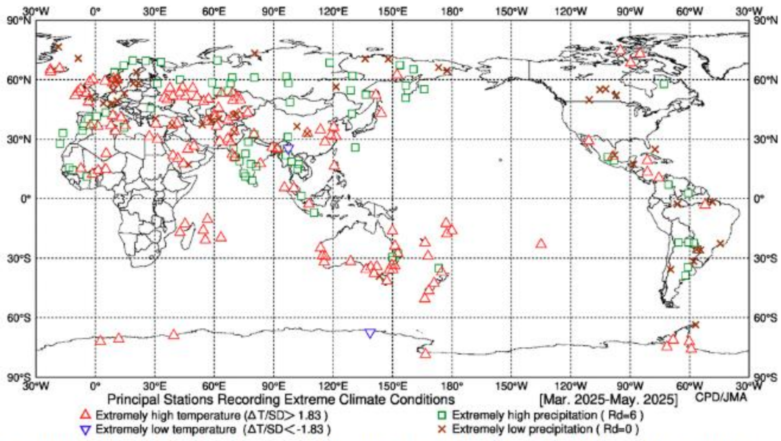

Fig.S2 Distribution of extreme climate stations (March 2025 - May 2025)

Figure 3-3 Worldwide map changed to show stations recording seasonal extreme climate conditions in HTML format

(TAKEMURA Kazuto, Tokyo Climate Center)

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TCC contributions to the Report on the States of the Climate in Asia 2024

WMO's State of the Climate in Asia 2024 report (published on 23 June 2025) summarizes climatic conditions and extreme weather events observed in 2024 and associated socio-economic impacts in the Asian region (RA II). The report is intended for widespread reference in various fields relating to climate change.

The contributions of National Meteorological and Hydrological Services (NMHSs) and WMO Regional Climate Centers (RCCs) were essential in compiling the report. TCC again made a significant contribution with its drafting of input on regional temperatures/extreme events in RA II and tropical cyclones over the western North Pacific Ocean and the South China Sea. Among extreme events in 2024, prolonged heatwaves reportedly affected much of East Asia, with a series of monthly average temperature records set in Japan, South Korea and China. Reporting shows unprecedented heatwaves throughout much of Japan in the summer and autumn. Ongoing collaboration among Members and RCCs in RA II is expected to support future reporting in this field for the Asian region.

URL: https://library.wmo.int/records/item/69575-

(KURAMOCHI Masaya, Tokyo Climate Center)

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Upgrade Plan of the JMA's Seasonal Ensemble Prediction System

The Japan Meteorological Agency (JMA) plans to upgrade its seasonal Ensemble Prediction System (EPS) from JMA/MRI-CPS3 (CPS3) to JMA/MRI-CPS4 (CPS4) around January 2026 (see Table 5-1). The seasonal EPS is based on an atmosphere-ocean coupled model developed jointly by JMA and the Meteorological Research Institute (MRI).

The new seasonal EPS will improve both the atmospheric and ocean models and increase the number of atmospheric vertical layers from 100 to 128. The introduction of a linear ozone scheme will contribute to a realistic representation of ozone variation compared to the monthly climatology used in CPS3. The initial atmospheric perturbation method will be changed from Breeding of Growing Modes to singular vectors and the Local Ensemble Transform Kalman Filter method. For atmospheric model perturbations, the stochastic humidity profile for convective parametrization method will be used in addition to the stochastic perturbation of physics tendency method. These perturbations provide better representation of uncertainty prediction.

In concurrence with this upgrade, one-month prediction will also be implemented using CPS4 rather than the Global Ensemble Prediction System (GEPS) via the WMC Tokyo website. Ensemble size and running frequency will remain at 5 members per day for operational six-month prediction and 50 members per week for one-month prediction. Ensemble size for statistical implementation in six-month prediction will be increased from 51 to 85 based on the Lagged Average Forecast method with 17 initial dates.

Table 5-1 Comparison of the new seasonal EPS and the current seasonal EPS

Model	JMA/MRI-CPS4 (Next model planned around January 2026)	JMA/MRI-CPS3 (Current model since February 2022)
Horizontal Resolution	Atmosphere: TL319 (approx. 55km) Ocean：0.25° (lon) × 0.25° (lat)	Atmosphere: TL319 (approx. 55km) Ocean：0.25° (lon) × 0.25° (lat)
Vertical Layers	Atmosphere: **128 levels** (up to 0.01hPa) Ocean: 60 levels	Atmosphere: 100 levels (up to 0.01hPa) Ocean: 60 levels
Initial Condition	Atmosphere: Global Analysis (GA) + **Ozone Analysis** (Re-forecast: JRA-3Q + **Ozone Analysis**) Land: Offline Land Analysis (*) Ocean: 4DVAR(coarse res) + IAU(eddy permitting res), daily (*) Sea Ice: 3DVAR, daily (*) * Forcing is given from GA (Re-forecast: JRA-3Q)	Atmosphere: GA (Re-forecast: JRA-3Q) Land: Offline Land Analysis (*) Ocean: 4DVAR(coarse res) + IAU(eddy permitting res), daily (*) Sea Ice: 3DVAR, daily (*) * Forcing is given from GA (Re-forecast: JRA-3Q)
Initial Perturbation	Atmosphere: **Singular Vectors** + **Local Ensemble Transform Kalman Filter** Ocean: Analysis uncertainty pattern	Atmosphere: Breeding of Growing Modes Ocean: Analysis uncertainty pattern
Model Perturbation	Atmosphere: Stochastic Perturbation of Physics Tendency (SPPT) + **Stochastic Humidity Profile for Convective parametrization**	Atmosphere: SPPT
Forecast Range	7 months	7 months
Ensemble Size	6-month prediction: 5 members per day (**85 members** are used for statistical forecasts by a Lagged Average Forecast (LAF) method) **1-month prediction: 50 members per week**	6-month prediction: 5 members per day (51 members are used for statistical forecasts by a LAF method)
Re-forecast	6-month prediction: 24 initials × 5 members × 30 years **1-month prediction:** **24 initials × 13 members × 30 years**	6-month prediction: 24 initials × 5 members × 30 years

(SATO Hitoshi, World Meteorological Centre Tokyo)

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Any comments or inquiry on this newsletter and/or the TCC website would be much appreciated.
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