Tokyo Climate Center, Japan Meteorological Agency

TCC News

No. 47 Winter 2017

Contents

Global temperature for 2016 was the highest since 1891

The annual anomaly of the global average surface temperature for the year 2016 (i.e. the combined average of the near-surface air temperature over land and the sea surface temperature) is estimated at +0.45°C above the 1981-2010 average, making it the warmest record for the 126-year period since 1891 (Figure 1). In 2016, the monthly average air temperatures for January, February, March, April, June and July, and the seasonal average air temperatures for the boreal winter, spring, and summer were also the highest recorded since 1891. Warm temperature deviations are especially seen over wide area of Eurasia, North America, the Indian Ocean, and the Tropical Pacific (Figure 2). On a longer time scale, the annual global average surface temperature has been rising at a rate of about 0.72°C per century.

Ten of the 11 warmest years on record since 1891 have occurred during this century. The recent high temperatures are thought to be affected by the global warming trend due to increase in anthropogenic greenhouse gas concentrations including carbon dioxide. Moreover the global averaged surface temperature is affected by inter-annual to decadal natural fluctuations intrinsic to the earth’s climate, and the highest temperature for 2016 is thought to be due to El Niño event which has persisted from the boreal summer 2014 to spring 2016.

JMA monitors monthly, seasonal and annual average anomalies of global surface temperature. Those results are routinely updated on the following TCC website:
http://ds.data.jma.go.jp/tcc/tcc/products/gwp/temp/ann_wld.html

(Koji Ishihara, Climate Prediction Division)

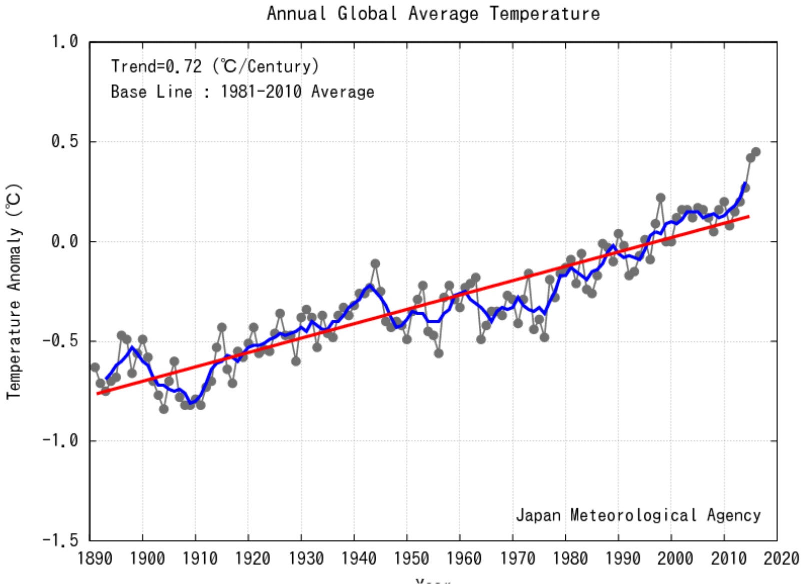


Figure 1
Long-term change in annual mean surface temperature anomalies over the globe
The black line with filled circles indicates anomalies of surface temperature in each year. The blue line indicates five-year running mean, and the red line indicates a long-term linear trend. Anomalies are represented as deviations from the 1981-2010 average.

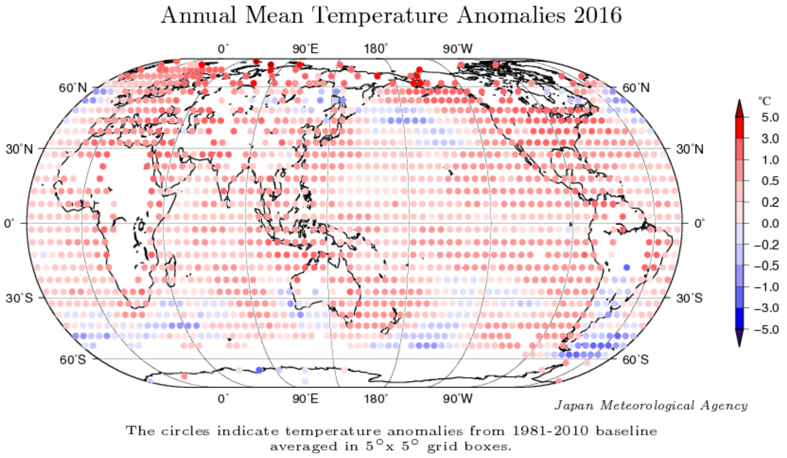


Figure 2 Annual mean temperature anomalies in 2016
The circles indicate anomalies of surface temperature averaged in 5° x 5° grid boxes. Anomalies are deviations from the 1981-2010 average.

Rank	Year	Temperature Anomaly w.r.t. 1981-2010 average
1	2016	+0.45
2	2015	+0.42
3	2014	+0.27
4	1998	+0.22
5	2013	+0.20
	2010	+0.20
7	2005	+0.17
8	2009	+0.16
	2006	+0.16
	2003	+0.16
	2002	+0.16

Table 1 Ranking of annual global average temperatures

Highlights of the Global Climate in 2016

Annual mean temperatures were above normal in many parts of the world and below normal in the southwestern part of Eastern Siberia and in northern Argentina (Figure 3). In particular, extremely high temperatures continued for most of the year in various places at low latitudes, and were also frequently observed from the northern part of Central Siberia to the Svalbard Islands, from the eastern part of Eastern Siberia to the western coast of Canada and from northern to southeastern Australia.

Annual precipitation amounts were above normal in eastern China, Mongolia, Central Asia, southeastern Europe, Indonesia and southern Argentina, and were below normal in eastern Brazil and southern Chile (Figure 4). Extremely high amounts were frequently observed in southeastern Europe, from the Midwest to the southern USA and in southeastern Australia, while extremely low amounts were frequently observed from southwestern France to northeastern Spain and in eastern Brazil.

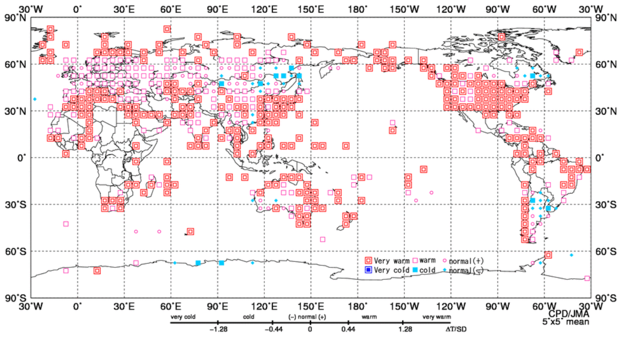


Figure 3 Annual mean temperature anomalies for 2016
Categories are defined by the annual mean temperature anomaly against the normal divided by its standard deviation and averaged in 5° × 5° grid boxes. The thresholds of each category are -1.28, -0.44, 0, +0.44 and +1.28. The normal values and standard deviations are calculated from 1981 – 2010 statistics. Land areas without graphics represent regions for which the observation data sample is insufficient or normal data are unavailable.

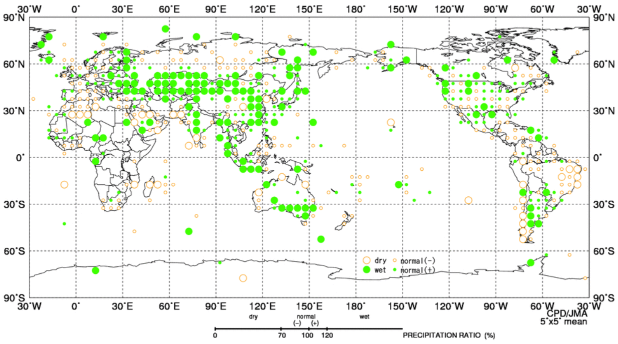


Figure 4 Annual total precipitation amount ratios for 2016
Categories are defined by the annual precipitation ratio to the normal averaged in 5° × 5° grid boxes. The thresholds of each category are 70, 100 and 120%. Land areas without graphics represent regions for which the observation data sample is insufficient or normal data are unavailable.

Major extreme climatic events and weather-related disasters occurring in 2016 are listed below (also see Figure 5).

(1) Heavy rain: the northeastern part of the Korean peninsula (August – September)
(2) Cold: in and around eastern Mongolia (January, October – November)
(3) Heavy rain: China (April – July)
(4) Warm: southern Kyushu region in Japan to southeastern China (April – June, October, December)
(5) Warm: Southeast Asia (January – May, July – November)
(6) Drought: Southeast Asia (January – May)
(7) Tropical storm: Sri Lanka, northeastern India and Bangladesh (May)
(8) Warm: southern India to Sri Lanka (January – April, July – August, October, December)
(9) Heat wave (March – May) and Wet (July – October): India
(10) Heavy rain: Pakistan (July – August)
(11) Heavy rain: northern Pakistan to Afghanistan (March – April)
(12) Warm: the northern part of Central Siberia to the Svalbard Islands (February, April – July, September)
(13) Wet: southeastern Europe (February – March, May – June, October)
(14) Dry: southwestern France to northeastern Spain (July – August, October, December)
(15) Warm: in and around northern Algeria (January – February, October)
(16) Warm: northeastern Saudi Arabia to the southern coast of the Red Sea (March, May – July)
(17) Warm: in the western part of Western Africa to the northwestern part of Middle Africa (April – June, August – December)
(18) Warm: Seychelles to the northeastern part of South Africa (January – April, October)
(19) Warm: the eastern part of Eastern Siberia to the western coast of Canada (April – August, October)
(20) Wet: the Midwest to the southern USA (March – April, July – August)
(21) Warm: the eastern to the southern USA (March, June – October)
(22) Warm: the southwestern USA to northwestern Mexico (February – March, October – December)
(23) Hurricane: Haiti and the southeastern USA (October)
(24) Warm: southern Mexico to Colombia (January – August, October)
(25) Warm (February – August) and Dry (February – May): eastern Brazil
(26) Warm: in and around central Chile (January – February, August – September, November)
(27) Warm: Micronesia (March – April, June, August)
(28) Warm: northern to southeastern Australia (March – July, September, November)
(29) Wet: southeastern Australia (January, June, September)
(30) Warm: in and around New Zealand (February, May, September)

(Kenji Kamiguchi, Tokyo Climate Center)

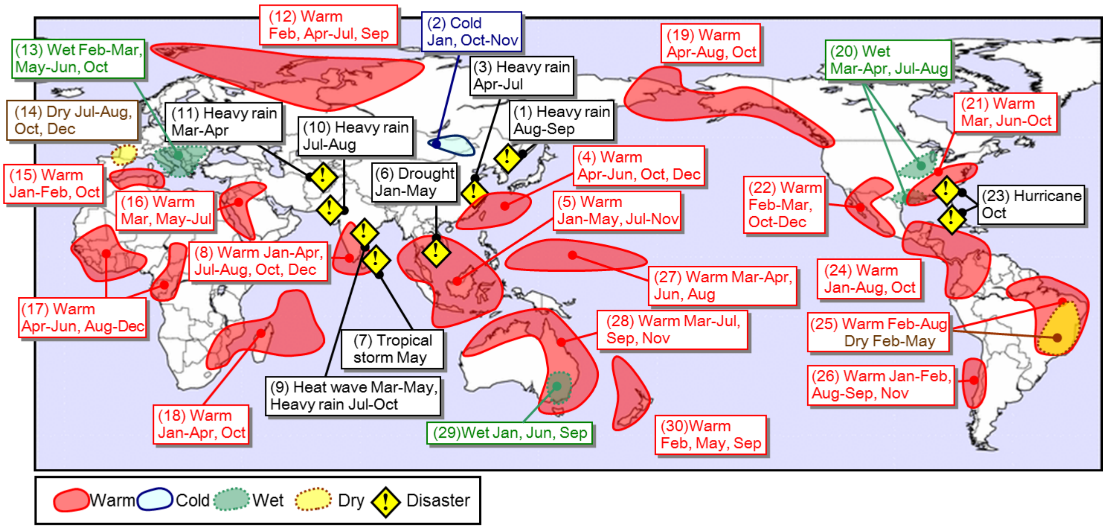


Figure 5 Major extreme climate events and weather-related disasters across the world in 2016
Schematic representation of major extreme climate events and weather-related disasters occurring during the year

Summary of Japan's Climatic Characteristics for 2016

- **Annual mean temperatures were significantly above normal in eastern Japan, western Japan and Okinawa/Amami.**
- **Annual precipitation amounts were significantly above normal on the Pacific side of northern Japan, in western Japan and in Okinawa/Amami.**
- **Four typhoons made landfall on northern Japan in August, bringing record heavy rainfall to Hokkaido and Iwate Prefecture.**
- **In autumn, western Japan experienced record-high seasonal precipitation amounts and the shortest autumn sunshine durations since 1946.**

1. Annual characteristics

In 2016, temperatures were generally above normal all over Japan except in autumn in northern Japan. Due to significant influence from low-pressure systems and fronts on western Japan and Okinawa/Amami in winter (2015/16) and autumn, and to the effects of numerous typhoons that approached northern Japan in August, annual precipitation amounts were significantly above normal on the Pacific side of northern Japan, in western Japan and in Okinawa/Amami. In addition, western Japan experienced record-high seasonal precipitation amounts and the shortest autumn sunshine durations since 1946. Meanwhile, annual precipitation amounts were above normal in northern Japan and on the Sea of Japan side of eastern Japan in association with frequent high-pressure systems covering these regions.

2. Seasonal characteristics

(a) Winter (December 2015 – February 2016)

In association with a weak winter monsoon, seasonal temperatures were above normal all over Japan, especially in eastern and western parts. Seasonal snowfall amounts were generally below normal for the Sea of Japan side and significantly above normal in northern Kyushu in association with significant cold air outbreaks at the end of January. Due to significant influence from low-pressure systems and fronts, seasonal precipitation amounts were above normal all over Japan, with the highest for winter since 1946/47 recorded in Okinawa/Amami.

(b) Spring (March – May)

Seasonal mean temperatures were significantly above normal due to warm southerly winds associated with dominant high-pressure systems to the east of Japan and the development of the subtropical high to the south of Japan. Seasonal sunshine durations were significantly above normal on the Sea of Japan side of eastern Japan and above normal in northern and western Japan due to the significant influence of the high-pressure systems. Seasonal precipitation amounts were significantly below normal on the Sea of Japan side of eastern Japan and below normal on the Pacific side of northern Japan. Meanwhile, seasonal precipitation amounts were above normal on the Pacific side of western Japan and in Okinawa/Amami due to the influence of low-pressure systems and fronts in April.

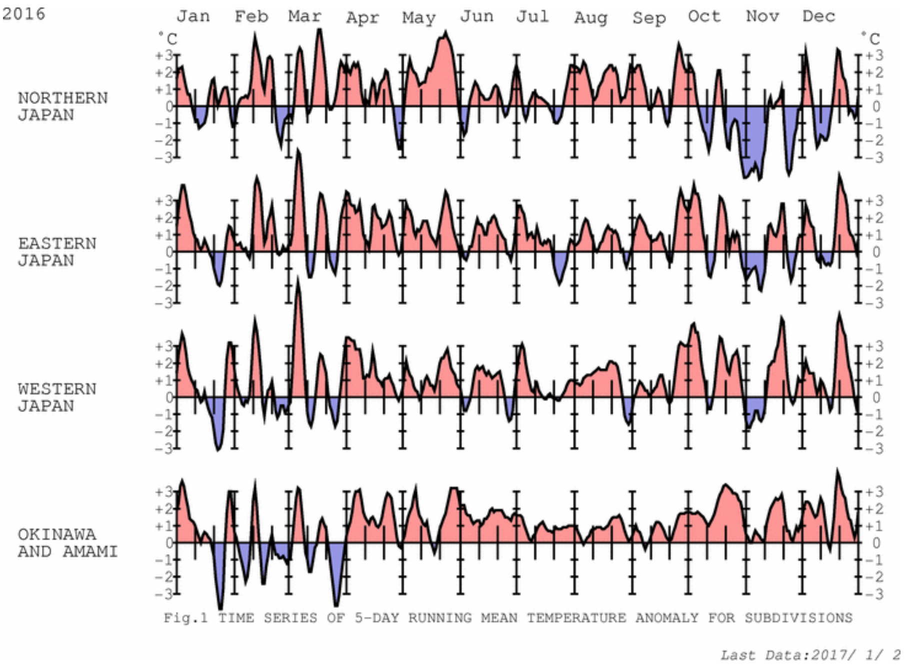


Figure 6 Time-series representation of five-day running mean temperature anomalies for subdivisions (January – December 2016). The normal is the 1981 – 2010 average.

(c) Summer (June – August)

Monthly mean temperatures and sunshine durations were above normal all over Japan. In Okinawa/Amami, monthly mean temperatures were the highest for summer since 1946 due to a combination of strong solar radiation and long sunshine durations. Meanwhile, in northern Japan, seasonal precipitation amounts were the highest for summer since 1946 due to the frequent passage of cyclones around the region in June and typhoons in August. In particular, the Pacific side of northern Japan experienced the highest precipitation amounts for summer since 1946. Four typhoons made landfall on Hokkaido and Iwate Prefecture, bringing storms and notably heavy rainfall to areas from northern to eastern Japan. In particular, Hokkaido and Iwate Prefecture experienced record heavy rainfall that caused serious damage from phenomena such as river overflows and landslides.

(d) Autumn (September – November)

Western Japan and Okinawa/Amami experienced the highest autumn mean temperatures since 1946 due to the presence of warm southerly winds. In association with significant influence from low-pressure systems and fronts, western Japan experienced the highest autumn precipitation amounts and the shortest autumn sunshine durations since 1946. In other regions, seasonal sunshine durations were also below normal. In northern Japan, seasonal mean temperatures were below normal for the first time since 2002 due to ongoing low temperatures after October.

(Masayuki Hirai, Climate Prediction Division)

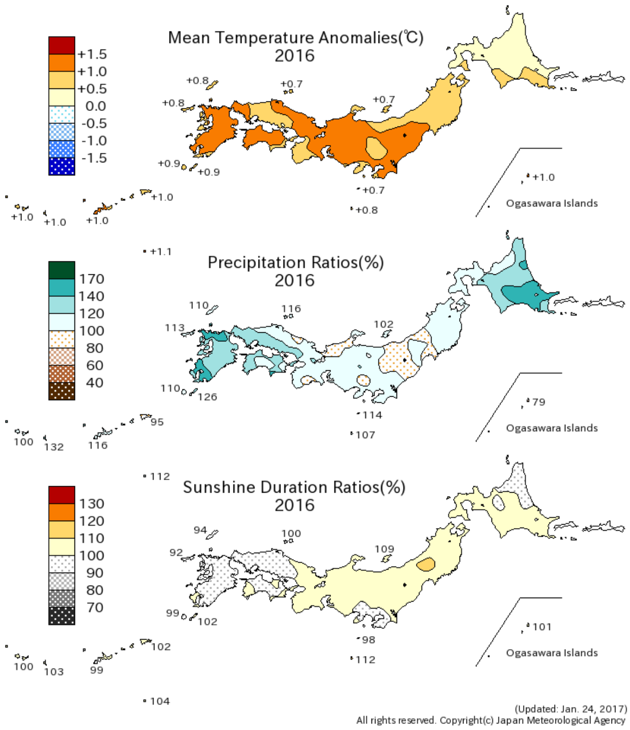


Figure 7 Annual climate anomalies/ratios for Japan in 2016

Development of new functions and analysis methods in TCC's Interactive Tool for Analysis of the Climate System

TCC's Interactive Tool for Analysis of the Climate System (iTacs) is a web-based application launched in 2009 to assist National Meteorological and Hydrological Services (NMHSs) in their analysis of extreme climate events and monitoring of climate conditions. Several improvements and version upgrades have been implemented, with the last upgrade being made in November 2015. TCC promotes iTacs usage through various opportunities for introduction of iTacs and annual training seminars. Consequently, there are currently more than 320 users by the end of February 2017 (Figure 8).

iTacs users have access to analysis and forecast datasets. The former consists of re-analysis and observational data such as the Japanese 55-year reanalysis (JRA-55) dataset, outgoing longwave radiation (OLR) provided by NOAA, sea surface temperature analysis (COBE-SST) from JMA's Climate Prediction Division, and world climate data from surface observation stations (CLIMAT reports). The forecast dataset consists of one-month prediction model products and JMA's re-forecast (hind-cast) dataset.

Since the last version upgrade, TCC has added new elements based on feedback and requests from iTacs users and JMA's Advisory Panel on Extreme Climate Events. Users can also now produce images expressing isentropic potential vorticity with levels from 270 to 850 K and constant fields such as altitude, land or sea masking (e.g., expressed with 0 for land and 1 for ocean) derived in the JRA-55 dataset (see the example shown in Figure 9). The latest comprehensive information on the datasets and related elements available on iTacs is provided at http://extreme.kishou.go.jp/tool/itacs-tcc2015/elements.html (Figure 10).

TCC welcomes user requests and feedback regarding iTacs toward the improvement of its functions and further assistance for the climate services of NMHSs, such as their formulation of analysis information on extreme climate events, climate monitoring and one-month forecasts.

(Kazuto Takemura, Tokyo Climate Center)

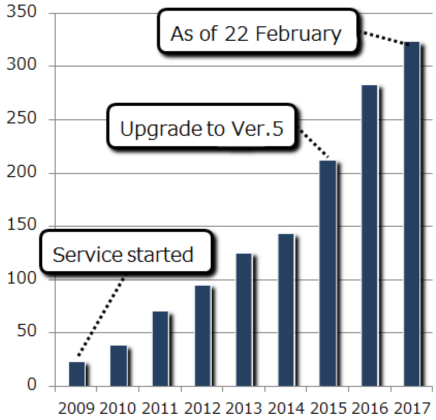


Figure 8 Annual change for the number of iTacs users

HOME > iTacs (Interactive Tool for Analysis of the Climate System) > List of datasets and elements available on iTacs

List of datasets and elements available on iTacs

Users can use two types of datasets, analysis dataset and forecast one on iTacs.

The analysis dataset consists of re-analysis and observational data such as the Japanese 55-year reanalysis (JRA-55) data, outgoing longwave radiation (OLR) provided by NOAA, sea surface temperature analysis (COBE-SST) data, world climate data from surface observation stations (CLIMAT reports). The forecast dataset consists of JMA's one-month prediction model products and re-forecast (hind-cast) dataset.

The datasets and its elements available on iTacs are listed as below.

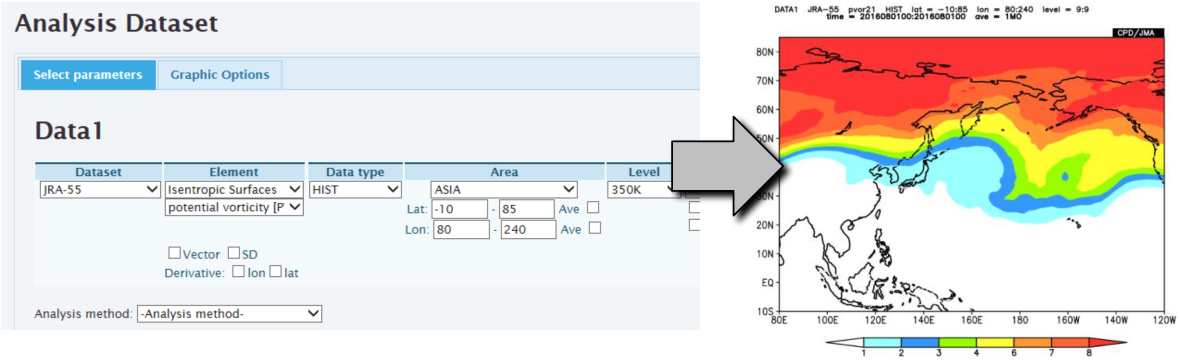
Analysis dataset
- JRA-55
- OLR
- COBE-SST
- MOVE-G2
- CLIMAT
- INDEX
- CONST

Forecast dataset
- 1-month forecast
- 1-month re-forecast(hindcast)

Analysis dataset

Dataset	Element		Unit
JRA-55	Pressure Levels	χ (Velocity potential)	10^6 m^2/s
		Div (Relative divergence)	1/s
		θe (Equivalent potential temperature)	K
		ω (Pressure vertical velocity)	Pa/s
		ψ (Stream function)	10^6 m^2/s
		θ (Potential temperature)	K
		q (Specific humidity)	kg/kg
		T (Temperature)	°C
		T-Td (Dew point depression)	°C
		U (Zonal wind)	m/s
		V (Meridional wind)	m/s
		Udiv (Zonal divergence wind)	m/s
		Vdiv (Meridional divergence wind)	m/s
		ζ (Relative vorticity)	1/s
		γ (Geopotential height)	m
		EGR (Maximum growth rate in the Eady problem)	1/day

Figure 10 Page layout for list of datasets and elements available on iTacs



Analysis Dataset

Data1

Dataset	Element	Data type	Area	Level
JRA-55	Isentropic Surfaces potential vorticity [P	HIST	ASIA Lat: -10 - 85 Ave ☐ Lon: 80 - 240 Ave ☐	350K

☐ Vector ☐ SD

Derivative: ☐ lon ☐ lat

Analysis method: -Analysis method-

Figure 9 Example of top page layout and charts of iTacs

The example shows parameter settings of monthly 350-K potential vorticity (units: PVU) in August 2016.

TCC Activity Report for 2016

In 2016, the Tokyo Climate Center (TCC) continued to support the climate services of NMHSs in Asia-Pacific countries by providing and enhancing data and products, holding training seminars, dispatching experts and hosting visitors.

1. Enhancement of data/products/tools on the TCC website

1.1 Renewed statistical products regarding the impacts of tropical SST variability on the global climate system

Sea surface temperature (SST) variability in the tropics can significantly impact on the global climate through atmospheric circulation. El Niño/La Niña events, which are identified by SST fluctuations from the central to the eastern equatorial Pacific (NINO.3), are widely-known examples of this. In addition, SST variability in the western tropical Pacific (NINO.WEST) and the tropical Indian Ocean (IOBW) may also have significantly affect climate conditions around the world. In January 2016, TCC has updated a part of its web pages that host investigation results on impacts of tropical sea surface temperature (SST) variability on the global climate and atmospheric circulation. The renewed products show statistical relationships between warmer/cooler SST events in the areas of NINO.3, NINO.WEST (i.e., El Niño/La Niña events) and the tropical Indian Ocean (IOBW) and the global climate system. The analysis is based on surface observation data, the COBE-SST analysis dataset produced by JMA, JMA's latest reanalysis dataset (JRA-55) and satellite observation data for outgoing longwave radiation (OLR). The period of the analysis was from 1958 through 2012 (55 years). See the web page of "Global climate" and "Atmospheric Circulation" for more details on data and methodology.

1.2 Incorporation of ENSO Forecast Probabilities into the El Niño Outlook

Forecast probabilities for the onset, persistence and end of ENSO events (El Niño, La Niña and ENSO-neutral periods) were incorporated into the TCC El Niño Outlook in August 2016 for added clarity.

Specifically, information on ENSO event outlooks contained in the lead part and the main body now includes probability values regarding ENSO event onset and other considerations. By way of example, the second lead part of the El Niño Outlook in July (before the update) was as follows:

- La Niña conditions are less likely to develop during boreal summer than in the previous month's prediction; La Niña onset is more likely to occur in boreal autumn.

With the new forecast probability information, the lead would be:

- The likelihood of La Niña conditions developing during boreal summer is 40%, which is lower than in the previous month's prediction.
- Despite a 40% likelihood that ENSO-neutral conditions will persist until boreal autumn, it is more likely that a La Niña event will begin to develop in autumn (60%).

Using probability values in the ENSO outlook supports expression of the likelihood of the onset, persistence and end of ENSO events with greater precision than simple expressions and users are also provided with information on probability changes or tendencies compared to the previous month's outlook.

These probabilities are based on output from the JMA's ENSO prediction model (JMA/MRI-CGCM2), which is also used for three-month prediction and warm-/cold-season prediction. The model is operated as a 51-member ensemble prediction system, and probabilities are essentially calculated as ratios of variables used to predict each event (El Niño, La Niña or ENSO-neutral conditions) before being calibrated using data from the 30-year (1981 – 2010) re-forecast experiment.

1.3 Revamp of TCC website

In March 2016, the Center revamped its website to improve user accessibility and operability. Users can now more easily access periodically updated products via the new Latest Update section on the left of the page. Positioning the mouse pointer over a window shows a key figure of each product and a related link. This upgrade provides users with convenient access to monthly, seasonally and annually updated products.

The update also provides brief introductions and links to major recommended products including iTacs (Interactive Tool for Analysis of the Climate System), long-range fore-cast products from the Global Producing Center (GPC Tokyo), Monthly Discussion on Seasonal Climate Outlook, El Niño Outlook, ClimatView (a worldwide CLIMAT viewer), and TCC News. TCC updates such as product launches and TCC News releases are also provided on the upper right of the screen.

2. Capacity development

TCC holds annual training seminars as part of capacity-development activities related to its role as an RCC in RA II. In addition to running annual training seminars, it also arranges expert visits to and hosts visitors from NMHSs to support exchanges of views on climate services and the effective transfer of technology.

2.1 Training seminar

TCC hold a training seminar in its each fiscal year from April to March. In 2016, TCC held a seminar in November, with primary mode of global climate variability and regional climate as the subject. Details of the event are reported in TCC News No. 46.

2.2 Expert visits and other follow-up activities

TCC experts visited the National Center of Hy-dro-Meteorological Forecasting (NCHMF) of Viet Nam in April and the Department of Meteorology (DOM) of Cambodia in August, to hold a follow-up seminar on one-month forecasts using the statistical downscaling technique and in the basic operation of TCC's Interactive Tool for Analysis of the Climate System (iTacs). The visits were planned as follow-up to the TCC training seminar held in

November 2015, and also provided an opportunity for NCHMF and DOM to discuss future co-operation with TCC (TCC News No. 44 and TCC News No. 45).

Other follow-up to previous TCC training seminars included hosting visiting experts at TCC and conducting teleconferences to provide technical support.

3. International meetings

3.1 Regional Climate Outlook Forums

RCCs are expected to actively contribute to discussions in Regional Climate Outlook Forums (RCOFs). In 2016, TCC experts participated in the following RCOFs in Asia:

- Twelfth session of the Forum on Regional Climate Monitoring, Assessment and Prediction for Regional Association II (FOCRA II) held in Guangzhou, China, from 7 to 9 April
- Eighth session of the South Asian Climate Outlook Forum (SASCOF-5) held in Colombo, Sri Lanka, from 25 to 26 April
- Ninth session of the South Asian Climate Outlook Forum (SASCOF-5) held in Nay Pyi Taw, Myanmar, from 27 to 28 September
- Fourth session of the East Asia winter Climate Outlook Forum (EASCOF) held in Ulaanbaatar, Mongolia, from 8 to 9 November

TCC attendees gave presentations on seasonal predictions based on JMA's numerical model and participated in discussions toward the formulation of a consensus statement on regional forecasts.

3.2 Other meetings

In 2016, TCC head Mr Kiyotoshi Takahashi and TCC expert Mr Atsushi Goto attended the fourth session of the Management Committee of the Intergovernmental Board on Climate Services held in Darmstadt, Germany, to contribute to the implementation and management of GFCS. Mr Goto also took part in the Developers' Meeting on GFCS-Relevant Climate Data, Products, and Tools held in Geneva, Switzerland, in December.

4. Publications

TCC has published its newsletter (TCC News) on a quarterly basis since 2005. The publication is intended to enhance communication and provide information to NMHSs and related communities about recent TCC developments, events and activities as well as details of the Center's reports on the state of the climate, monitoring results and outlooks. In 2015, TCC News Nos. 43 – 47 were issued and made available on the TCC website.

Other English-language publications related to the climate, such as Climate Change Monitoring Report 2015 and Annual Report on the Climate System 2015, were also published on the TCC website.

5. Staff changes

Dr Kazutoshi Onogi, who served as the head of TCC in 2015, transferred to the Planning Division of the Japan Meteorological Agency on 1st April to work as Senior Coordinator for Research and Development. He was succeeded by Mr Kiyotoshi Takahashi, who previously worked on the development of JMA's long-term reanalysis data and long-range forecast models.

6. Plans for 2017

Contribution to the Global Framework for Climate Services (GFCS)

RCCs are expected to play a major role in the implementation of the GFCS. TCC plans to further strengthen its activities and lead RA II's contribution to the Framework. Such activities include the provision of further assistance to NMHSs for better climate services, as well as maintenance and updating of the portal site for the Pilot Project on Information Sharing on Climate Services.

New/upgraded data, products and tool development

TCC plans to implement a major upgrade of its Seasonal Ensemble Prediction System for operational one-month forecasting by spring 2017.

To leverage the JRA-55 long-term reanalysis dataset, investigation on teleconnection indices (e.g., the Arctic Oscillation Index) is being conducted to enhance monitoring of atmospheric circulation. TCC plans to publish the investigation results and the indices on its website in 2017. In addition to its work on the above-listed products and tool, TCC is making efforts to develop information/products based on the Standard Precipitation Index (SPI) toward better monitoring of droughts worldwide.

Capacity development

In the last quarter of the year, TCC will hold its annual training seminar with a dozen invited experts as attendees. The Center will also continue to dispatch experts to NMHSs as necessary and host visitors from NMHSs upon request.

Hosting of EASCOF

In autumn, TCC will host the fifth session of the East Asia Winter Climate Outlook Forum (EASCOF) with the participation of experts engaged in climate services at NMHSs and researchers from China, Japan, Mongolia and the Republic of Korea. At the event, the climate conditions of the previous season will be reviewed, and the current status of the climate system as well as the seasonal Asian winter monsoon forecast for winter 2017/2018 will be discussed.

(Kiyotoshi Takahashi, Head, Tokyo Climate Center)

Any comments or inquiry on this newsletter and/or the TCC website would be much appreciated. Please e-mail to tcc@met.kishou.go.jp.
(Editors: Kiyotoshi Takahashi, Atsushi Goto and Yasushi Mochizuki)

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