ESCAP/WMO Typhoon Committee
Fifty fourth Session
7 – 9 March 2023
Macao, China

FOR PARTICIPANTS ONLY
WRD/TC.55/7.1
13 February 2023
ENGLISH ONLY

ACTIVITIES OF THE RSMC TOKYO - TYPHOON CENTER IN 2022

(Submitted by the RSMC Tokyo - Typhoon Center)

ACTION REQUIRED:

The Committee is invited to review the activities of the RSMC Tokyo - Typhoon Center in 2022 and future plans.

APPENDIXES:

A) DRAFT TEXT FOR INCLUSION IN SESSION REPORT

B) RSMC Tokyo - Typhoon Center Activity Report 2022 and future plans

APPENDIX A:
DRAFT TEXT FOR INCLUSION IN THE SESSION REPORT

x.x Review of the activities of the Regional Specialized Meteorological Center (RSMC) Tokyo in 2022

1. The Committee noted with appreciation the review of RSMC advisories, products and operational activities and changes made in 2022. It noted the forecast verification results for 25 TCs that reached TS intensity or higher formed in 2022: the forecast track errors of the year of 72 km (87 km in 2021), 124 km (157 km), 172 km (225 km), 195 km (261 km) and 267 km (264 km) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively, the annual mean Root Mean Squared Errors (RMSEs) for central pressure forecasts of 13.7 hPa (11.9 hPa), 19.4 hPa (15.9 hPa), 21.3 hPa (18.0 hPa), 19.4 hPa (19.0 hPa) and 15.5 hPa (17.9 hPa) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively, and those for maximum wind speed forecasts for 24-, 48-, 72-, 96- and 120-hour forecasts of 6.3 m/s (5.0 m/s), 8.7 m/s (6.5 m/s), 8.7 m/s (6.9 m/s), 7.7 m/s (7.6 m/s) and 6.0 m/s (8.2 m/s) respectively.

2. The Committee noted with appreciation the changes in RSMC advisories, products and operational/coordination activities made in 2022, especially the upgrades of tropical cyclone heat potential products and the Japan Meteorological Agency's (JMA's) global ensemble prediction system.

3. The Committee noted with appreciation the operation of RSMC Tokyo's Numerical Typhoon Prediction (NTP) website, and noted changes made in 2022 as well as those planned for the near future.

4. The Committee noted with appreciation RSMC Tokyo's maintenance of a dedicated platform for enhanced communication between operational forecasters and RSMC-Tokyo, as well as the sharing of advance-notice updates. In the 2022 typhoon season, more than 10 inquiries relating to tropical cyclones have been submitted, with related discussion helping to clarify TC status and forecasts.

5. The Committee noted with appreciation the contribution of RSMC Tokyo (which also serves as an International Civil Aviation Organization (ICAO) Tropical Cyclone Advisory Centre (TCAC Tokyo)) to compliance with ICAO Standards and Recommended Practices (SARPs), addressing the provision of TCA information in text, graphical and the ICAO Meteorological Information Exchange Model (IWXXM) 3.0 formats via multi-platform channels such as the TCAC Tokyo website.

6. The Committee was pleased to note the progress of the regional Storm Surge Watch Scheme (SSWS), which includes an upgrade of JMA's storm surge watch scheme model and an update of its products in August 2022. The Committee also noted with appreciation the ongoing contribution of RSMC Tokyo to the regional SSWS, especially the provision of various products including storm surge forecast distribution maps and time-series charts for selected stations, as well as week-range probabilistic wave forecasts for significant wave heights and peak wave periods. The Committee again encouraged Members to make their sea level observation data available in order to support verification activity.

7. The Committee noted with appreciation the efforts and progress made by RSMC Tokyo about development of tropical cyclone genesis guidance using early Dvorak Analysis and global ensemble. The Committee also welcomes RSMC Tokyo's efforts in seeking further approaches to increase the benefits of ensemble forecast utilization, including improvement of current operational products.

8. The Committee was pleased to note the progress of the regional radar network development project, under which experimental exchange of radar composite data among Japan, Thailand and Malaysia started in 2016. The project has been expanded, and three more Members (Lao PDR, the Philippines and Viet Nam) joined in 2018. The Committee noted with appreciation the progress made on regional radar data exchanges, especially the creation of a sample regional composite map based on Members' radar

data, and the Guide to Quantitative Precipitation Estimation (QPE) Program finalized by Thailand, Malaysia and Japan in July 2022.

9. The Committee was pleased to note the activities of the project for enhancing the utilization of Himawari-8/9 products, under which technical support for developing Rapidly Developing Cumulus Area (RDCA) identification using Himawari-8/9 data is provided. The Committee noted with appreciation the ongoing discussion, support and efforts contributed by project Members (Malaysia, Singapore, Thailand and Vietnam), including their presence at anonline technical meeting in 2022. The Committee also noted that HCAI (High-resolution Cloud Analysis Information) data and AMV-based Sea-surface Wind data are provided to NMHSs every 10 minutes.

10. The Committee noted with appreciation RSMC Tokyo's publication of its Technical Review No. 24 and the Annual Report on the Activities of the RSMC Tokyo Typhoon Center 2021 in April and October 2022, respectively.

11. The Committee was informed that RSMC Tokyo had started tropical cyclone satellite re-analysis in 2012 for the period from 1981 onward to enable evaluation and improvement regarding the quality of the Current Intensity (CI) number in satellite TC analysis. It also acknowledged that the Center has almost completed the reanalysis along with basic quality checking (QC) for the period from 1987 to 2016, and will share the whole dataset for the period from 1987 to 2016 with Members in 2023.

12. The Committee noted with appreciation that the operation of Himawari-8/9 geostationary meteorological satellites and further welcome the intention of RSMC Tokyo to continue providing Himawari products as well as technical support for using them. The Committee was informed that the switchover from Himawari-8 to -9 took place on December 13, 2022.

13. The Committee noted with appreciation RSMC Tokyo's virtual hosting of the 22nd Attachment Training session from 11 to 13 January 2023 with 51 attendees from eight Members (China, Hong Kong China, Macao China, Malaysia, the Philippines, the Republic of Korea, Thailand and the USA). The 2023 session included presentations on state-of-the-art TC motion by a distinguished invited lecturer and exercises on satellite image analysis. The course helped attendees to learn about basic understanding of TC monitoring and forecasting techniques and their application to operational services.

14. The Committee noted for RSMC-Tokyo's regular monitoring of observation data exchanges in 2022 as per the Typhoon Committee Operational Manual - Meteorological Component (TOM), with results to be provided by March 2023. The Committee expressed appreciation to all Members providing special observation data to Committee Members in 2022, and further encouraged all Members to conduct additional observation as requested by TOM.

15. The Committee noted with appreciation RSMC Tokyo's contribution to WMO Programmes and related activities, and its promotion of cooperation with other RSMCs for the Tropical Cyclone Programme. These included participation in the Advisory Group on Tropical Cyclones (AG-TC) under the Standing Committee on Disaster Risk Reduction and Public Services (SC-DRR), provision of real-time forecast guidance to Typhoon Committee Members, and contribution to capacity building within the framework of the Severe Weather Forecasting Programme – Southeast Asia (SWFP-SeA) and the Expert Team of Marine Services (ET-MS) under WMO Regional Association II. The Committee also noted with thanks the Center's coordination with adjacent RSMCs for ensuring consistent information delivery across basins.

APPENDIX B:
RSMC Tokyo - Typhoon Center Activity Report 2022 and future plans

1. RSMC advisories, products and operational/coordination activities

The RSMC Tokyo - Typhoon Center provides the Typhoon Committee Members with a range of products related to tropical cyclones in the western North Pacific and the South China Sea through the Global Telecommunication System (GTS) of World Meteorological Organization (WMO) and the Aeronautical Fixed Telecommunication Network (AFTN). This section reviews RSMC advisories, products and operational activities in 2022 and summarizes changes and future plans.

1.1 Review of RSMC advisories, products and operational activities in 2022

Table 1 shows the total number of RSMC Tropical Cyclone (TC) advisories and information issuances made via GTS in 2022.

✧ **Verification of track forecasts**

Operational track forecasts for 25 TCs that reached Tropical Storm (TS) intensity or higher in 2022 were verified against the Center's analysis data. Figure 1 shows the time series of the annual mean position errors of 24-hour (from 1982), 48-hour (from 1989), 72-hour (from 1997), 96-hour and 120-hour (from 2009) forecasts. The errors of the year are 72 km (87 km in 2021), 124 km (157 km), 172 km (225 km), 195 km (261 km) and 267 km (264 km) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively (Table 2).

✧ **Verification of track forecast probability circles**

RSMC Tokyo uses track forecast probability circles* to represent TC track forecast uncertainties. The mean hitting ratios of circles* for 24-, 48-, 72-, 96- and 120-hour forecasts throughout 2022 are 73% (67% in 2021), 72% (72%), 85% (74%), 95% (86%) and 94% (93%), respectively (Table 3).

* Track forecast probability circle: a circular area within which the center of a TC is expected to be located with a probability of 70% at each forecast time.

✧ **Verification of intensity forecasts**

Table 4a and 4b give the mean errors and root mean square errors (RMSEs) of 24-, 48-, 72-, 96- and 120-hour central pressure (Table 4a) and maximum sustained wind forecasts (Table 4b) for 25 TCs of 2022. The annual mean RMSEs for central pressure forecasts are 13.7 hPa (11.9 hPa in 2021), 19.4 hPa (15.9 hPa), 21.3 hPa (18.0 hPa), 19.4 hPa (19.0 hPa) and 15.5 hPa (17.9 hPa) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively, while those for maximum wind speed forecasts for 24-, 48-, 72-, 96- and 120-hour forecasts are 6.3 m/s (5.0 m/s in 2021), 8.7 m/s (6.5 m/s), 8.7 m/s (6.9 m/s), 7.7 m/s (7.6 m/s) and 6.0 m/s (8.2 m/s) respectively.

1.2 Changes in RSMC advisories, products and operational activities in 2022

✧ **Upgrade of tropical cyclone heat potential (TCHP) products**

In association with 2020 upgrades made to the ocean data assimilation (including higher resolution and adoption of four-dimensional variational data assimilation (4D-Var)), high-resolution TCHP products based on improved MOVE/MRI.COM-JPN data were made available on the NTP website in March 2022 (Figure 2).

✧ **End of WTPQ20-25 RJTD distribution**

RSMC Tokyo terminated provision of advisory for three-day forecasts with GTS headings of WTPQ20-25 RJTD in September 2022.

1.3 Future plans for changes in RSMC advisories, products and operational activities

✧ **Update of track forecast probability circles**

RSMC Tokyo considers updating track forecast probability circles as necessary based on verification results from recent years.

✧ **Update to the operational global model**

JMA plans to upgrade its operational Global Spectral Model (GSM) and Global Ensemble Prediction System (GEPS). One of the major revisions to the GSM involves horizontal resolution enhancement from 0.1875° to 0.125°.

2. Web-based RSMC TC Products

2.1 Numerical Typhoon Prediction (NTP) website

Since October 2004, RSMC Tokyo has operated the Numerical Typhoon Prediction (NTP) website as part of its contribution to the WMO/ESCAP Typhoon Committee. All the products of the NTP website are listed in Table 5. Changes made in 2022.

✧ **Upgrade of tropical cyclone heat potential (TCHP) products (Section 1.2)**

✧ **Upgrade of the storm surge watch scheme (SSWS) model and updating of related products**

In association with the SSWS model upgrade, SSWS products on the NTP website were updated in August 2022. The changes include higher resolution for coastal areas, expansion of the forecast area, extension of the forecast range and addition of probabilistic products based on comprehensive use of whole ensemble members (Section 3.1).

2.2 Tropical cyclone advisories for SIGMET in text, graphical and XML formats

As an International Civil Aviation Organization (ICAO) Tropical Cyclone Advisory Centre (TCAC Tokyo), RSMC Tokyo provides tropical cyclone advisories in text, graphical and XML formats, with ICAO Standards and Recommended Practices (SARPs) compliance. TCAs are issued when 1) a tropical cyclone with TS intensity or higher is present in TCAC Tokyo's area of responsibility, or 2) a tropical cyclone is expected to reach TS intensity in the area within 24 hours.

Message details include the following:

✧ Graphical TCAs
- In addition to official RSMC Tokyo TC advisories, TCAs describe areas of cumulonimbus (Cb) associated with tropical cyclones potentially affecting aviation safety as derived from Himawari geostationary satellite data. Graphical TCA information and related specifications are provided via the TCAC Tokyo web resource at https://www.data.jma.go.jp/tca/data/index.html. Graphical TCAs are sent to World Area Forecast Centres (WAFCs) so that they are transmitted through WAFS Internet File Service (WIFS) and Secure Aviation Data Information Service (SADIS) FTP.
- Gale force wind areas are not included for tropical cyclones lower than tropical storm intensity.

✧ ICAO Meteorological Information Exchange Model (IWXXM) 3.0-formatted TCA
- TCAs in a IWXXM form are transmitted via Air Traffic Services (ATS) Message Handling Services (AMHS) and on the TCAC Tokyo website.

TCAC Tokyo contributes to annual ICAO Asia and Pacific (APAC) SIGMET tests by issuing tropical cyclone advisory test messages.

2.3 Experimental version of TC advisory in CAP format

RSMC Tokyo has provided the experimental provision of TC advisory in CAP format at the website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/RSMC_HP.htm) since 12 November 2012.

3. RSMC Tokyo-led activities

3.1 Regional storm surge watch scheme suitable for the Typhoon Committee region

Since 2011, RSMC Tokyo has been providing products to support storm surge prediction, within the framework of the Storm Surge Watch Scheme (SSWS), in response to the results of the survey conducted in 2009 after the devastating storm surge disaster caused by Cyclone Nargis in 2008 (Hasegawa et al. 2017).

As described in 2.1, RSMC Tokyo provides Members with graphical SSWS products via the NTP website. These include storm surge forecast distribution maps and time-series charts for selected stations (Table 5). To predict storm surges for the regional SSWS, RSMC Tokyo runs a storm surge watch scheme model four times a day, even when no TCs exist in the area of responsibility, providing information on surges generated by monsoon winds or extra-tropical cyclones.

Stations for storm surge time-series predictions has been increased upon requests from the Committee Members. As of January 2023, time-series storm surge predictions are provided to 78 stations; USA (1), the Philippines (10), Viet Nam (20), Hong Kong, China (6), Macao, China (1), Republic of Korea (11), Thailand (2), Malaysia (17), Cambodia (4) and Singapore (6). Time series of storm surge predictions are provided on top of astronomical tides for stations calculated from hourly tidal observational data for a few years that are provided by Members. In addition, since February 2019, for stations where those observational data are not available, astronomical tides and storm tides have also become available by adopting a global ocean tide solution (FES2014).

Annual verification results of the storm surge products have been regularly published in Annual Report on Activities of the RSMC Tokyo since 2015. Statistical verification is conducted for stations where sea level observations are available in University of Hawaii Sea Level Center (UHSLC) data base. The verification continues to be enhanced with results for high-impact storm surge cases, in addition to the statistical verification.

As well as storm surge forecast products, RSMC Tokyo provides week-range wave forecast products based on the JMA Wave Ensemble System (WENS) via the NTP website (Table 5). WENS covers most of the global region (grid resolution: 0.5 degrees; ensemble members: 51), running at 00 and 12 UTC daily to predict conditions such as wave height and wave period up to 264 hours ahead.

In August 2022, RSMC Tokyo upgraded the storm surge watch scheme model and storm surge forecast products provided on the NTP website. The upgrade included (1) a new model framework based on the finite volume method (FVM) with an unstructured grid, (2) increased grid resolution in coastal regions from 2 minutes (approx. 4 km) to 1.5 km, (3) model domain expansion to cover most of the RSMC's area of responsibility, (4) forecast range extension from 72 to 132 hours, and (5) an improved typhoon bogusing scheme. The upgrade also resulted in a storm surge ensemble prediction system with 52 ensemble members, with 51 from JMA's GEPS and GSM deterministic forecasting for atmospheric forcing (as opposed to the six model runs driven by six different atmospheric forecast scenarios in the previous system). This 52-member ensemble prediction allows RSMC Tokyo to provide probabilistic storm surge products both in map format (ensemble mean, maximum, third quartile, spread and exceeding probabilities) and time-series chart format (box plots and exceeding probabilities).

3.2 Enhanced use of ensemble forecasts

RSMC Tokyo works to enhance operational use of ensemble forecasts by Committee Members. Such forecasts are currently used for:

- ✧ Provision of ensemble TC track guidance from ECMWF, NCEP, UKMO and JMA via the NTP website.
- ✧ Provision of two- and five-day tropical cyclone activity prediction (TCAP) maps displaying percentages of ensemble members in which TC-like vortices are represented within 300 km of a certain location during the relevant forecast time. Provision via the NTP website started in 2016, and accuracy improvement based on parameter-tuning was introduced in 2020 along with addition of climatological normal maps.
- ✧ Probability circles show the range into which the center of a TC is expected to move with 70% probability at each validation time. Since June 2019, the radius for all forecast times has been determined using the multiple ensemble method, which is solely premised on confidence levels based on cumulative ensemble spread calculated using ECMWF, NCEP and UKMO global EPSs in addition to GEPS.

GEPS upgrades were made in March 2022, with enhanced horizontal resolution of the model, improved sea surface temperature (SST) boundary conditions and updating of the initial perturbation amplitude (Section 5.3).

3.3 Development of Regional Radar Network

Development of Regional Radar Network is a project of the Typhoon Committee's Working Group on Meteorology. Technical assistance provided via the project includes development of a domestic radar network, radar data quality control and application of composite as well as quantitative precipitation estimation (QPE) techniques to the nationwide radar network. As a result of activities conducted in collaboration with Thailand and Malaysia (such as participation in technical meetings and workshops), an experimental radar data exchange involving these nations and Japan was initiated in 2016. Hourly regional radar composite imagery based on the exchange data is available on the RSMC Tokyo NTP website at https://tynwp-web.kishou.go.jp/Analysis/Radar/index.html.

In 2018, Lao PDR, the Philippines and Viet Nam joined the project, and technical meetings were held at JMA headquarters in 2018 and 2019. Based on the 2019 meeting, a sample regional composite map consisting of participating Members' radar data was produced in 2021 to demonstrate the usefulness of regional radar data exchange. Members at an online technical meeting held in November 2021 reviewed project achievements and highlighted their current situations along with challenges in radar. The discussions underlined the significance of data exchanges within the regional radar network and engagement in technical collaboration. Coordination for data exchanges between JMA and Members has been ongoing, with related status reviewed during a workshop in February 2023. The Guide to Quantitative Precipitation Estimation (QPE) Program was finalized by Thailand, Malaysia and Japan in July 2022.

3.4 Enhancement of utilization of Himawari-8/9

The Enhancement of Utilization of Himawari-8/9 is a project of the Working Group of Meteorology of the Typhoon Committee. Technical assistance provided through this project includes developing Rapidly Developing Cumulus Area (RDCA) detection technique using Himawari-8/9 products. A technical meeting was held with experts from Malaysia at JMA headquarters in October 2018 to exchange information on recent progress and ideas for advanced products in the field, and technical support and communication between Malaysia and RSMC Tokyo has conducted via e-mails.

An online technical meeting was also held with Members from Singapore, Thailand and Viet Nam in February 2020 to give an outline of RDCA detection, including technical aspects and the wide range of usage and verification methods implemented. Members also considered

potential RDCA applications and data suitable for verification. In 2021, Japan experts considered future initiatives, including another meeting in February 2022, to promote the adoption of RDCA detection techniques.
Since the 2022 meeting, JMA has provided source code for RDCA detection with Singapore, Thailand and Vietnam..

The High-resolution Cloud Analysis Information (HCAI) satellite-derived product based on data from the Advanced Himawari Imager (AHI) units on the Himawari-8/-9 satellites includes information on cloud mask (including dust mask), snow and ice mask, cloud top height, cloud type and quality control. HCAI data are provided to National Meteorological and Hydrological Services (NMHSs) via the JMA Data Dissemination System (JDDS) every 10 minutes in addition to AMV-based Sea-surface Wind data.

3.5 Cross-cutting activities with ICHARM

Enhancement of disaster risk reduction against heavy rain in collaboration with an Annual Operating Plan (AOP) of the Working Group on Hydrology (WGH), led by ICHARM, is undertaken by RSMC Tokyo for the Working Group on the Meteorology (WGM) side. RSMC Tokyo has currently been providing various data of JMA's NWP model to ICHARM so that ICHARM can test the effectiveness and figure out which data to use for the project. From 2021, RSMC Tokyo has provided one-month and three-month ensemble NWP model data.
In addition, a number of favorable practices related to effective public awareness were adopted in 2022. By way of example, during a prolonged period of heavy rain caused by a stationary front over wide areas of Japan in August, JMA (a meteorological body) and the country's Ministry of Land, Infrastructure and Transportation (a hydrological body) held a joint press conference to call for early evacuation due to the possibility of flooding from large rivers based on rainfall forecasts, thereby providing a united authoritative front to the public.

4. Publications

4.1 Technical review

RSMC Tokyo published "JMA's Wave Ensemble System and Related Development" as its Technical Review No. 24 in April 2022, which is available on the Center's website at:
https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/techrev.htm.

4.2 Annual report on the activities of the RSMC Tokyo - Typhoon Center

RSMC Tokyo published Annual Report on the Activities of the RSMC Tokyo - Typhoon Center 2021 in October 2022, which is available on the Center's website at:
https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/annualreport.html.

5. Other related activities

5.1 Tropical cyclone satellite re-analysis

Responding to the discussions of the Seventh WMO International Workshop on Tropical Cyclones (IWTC-VII La Reunion, France, 15-20, November 2010), and the 2nd international IBTrACS Workshop (Honolulu, Hawaii, 11-13 April 2011) held in conjunction with the WMO sponsored International Workshop on Satellite Analysis of Tropical Cyclones (IWSATC) (Honolulu, Hawaii, 13-16 April 2011), RSMC Tokyo started tropical cyclone satellite re-analysis in 2012 for the period from 1981 to confirm and improve the quality of the Current Intensity (CI) number in the satellite TC analysis. Re-analysis for the period from 1987 to 2016 has been completed, though it was figured out that the re-analysis from 1981 to 1986 is difficult to conduct with accuracy consistent with later events due to the inadequacy of available satellite imagery. Due to the need for additional quality checking and drafting a technical document, RSMC Tokyo plans to share the whole dataset for 1987 – 2016 with Members in 2023.

5.2 Himawari-8/9

The Himawari-8 geostationary meteorological satellite operated by JMA began operation at 02 UTC on 7 July 2015. Himawari-8 features significant improvements in terms of the number of observation bands, data capture periodicity and spatial resolution as compared to the previous generation. These enhancements are expected to support unprecedented prevention and mitigation of tropical cyclone-related disasters in the East Asia and Western Pacific regions. JMA runs two services for the provision of Himawari-8 imagery. One is the HimawariCast service, by which primary sets of imagery are disseminated for operational meteorological services via a communication satellite. The other is the HimawariCloud service, by which full sets of imagery are delivered to National Meteorological and Hydrological Services (NMHSs) via an Internet cloud service. In addition, JMA continuously provides Himawari-8 imagery in SATAID format via the WIS/GISC Tokyo server with its automatic downloader.

Himawari-9 was launched as the follow-on satellite to Himawari-8 on 2 November 2016, with a back-up period following a period of in-orbit testing until the actual switchover on December 13, 2022. Himawari-9 began observation after the switchover, with Himawari-8 taking over the back-up role. This dual combination of new-generation satellites will support JMA's stable provision of continuous satellite observation data for the Asia-Oceania region until 2029.

The Advanced Himawari Imager (AHI) on board Himawari-8/9 is capable of frequent and flexible observation, providing Full-Disk images of the earth every 10 minutes and regional images with shorter periodicity. In regional monitoring, Target Area observation provides imagery covering an area of approximately 1,000 km x 1,000 km every 2.5 minutes with flexibility for location changes. This rapid observation provides superior insight for extreme events such as tropical cyclones and volcanic eruptions. One example of the use for tropical cyclones is ASWind, as described in Chapter 2.1, which is used operationally by RSMC Tokyo for sea surface winds estimation in the vicinity of tropical cyclones.

Since January 2018, JMA has launched an international service called HimawariRequest service, allowing NMHSs to request Target Area observations, within a framework of a WMO RA II (Asia) regional project in collaboration with WMO RA V (South-West Pacific) Members. As of the end of December 2022, JMA had taken registrations from 22 NMHSs in RA II and RA V and opened the service to the 19 whose preparations for request submission were complete. The service has been introduced upon requests to monitor tropical cyclones, volcanic ash from eruptions and forest fire. Further information on HimawariRequest, including a service description and registration form, is available on the JMA website at https://www.jma.go.jp/jma/jma-eng/satellite/HimawariRequest.html. JMA expects the service to support disaster risk reduction activities in the region based on the monitoring of tropical cyclones and other extreme events.

5.3 Updates to the operational global model

JMA upgraded its GEPS in March 2022 to incorporate recent GSM developments, including enhanced horizontal resolution (40 to 27 km), improved sea surface temperature boundary conditions, and updating of the initial perturbation amplitude. The improved horizontal resolution enhances tropical cyclone central pressure prediction and reduces error tendency.

6. Typhoon Committee Attachment Training at RSMC Tokyo

The RSMC Tokyo – Typhoon Center has organized the ESCAP/WMO Typhoon Committee Attachment Training courses every year since 2001 with the support of the WMO Tropical Cyclone Programme and the Typhoon Committee in order to advance the tropical cyclone (TC) analysis and forecasting capacity of Committee Members. Forecasters from Member countries of the Panel on Tropical Cyclones have also been hosted since 2015. The course is set as a Category 2 Unit of the Tropical Cyclone Forecast Competency in the Typhoon Committee Region specifications.

Due to COVID-19, the 22nd course (11 – 13 January 2023) was held only online, with 51 attendees from eight Members (China, Hong Kong, China, Macao, China, Malaysia, the Philippines, the Republic of Korea, Thailand and the USA), with content including interactive exercises on satellite analysis techniques and Dvorak analysis. Dr. Ito Kosuke, a recognized expert in the field of tropical cyclones from the University of the Ryukyus, provided incisive input on recent progress in the understanding of tropical cyclone motion.

7. Regular monitoring of exchange information

In accordance with the ESCAP/WMO Typhoon Committee Operational Manual (TOM), RSMC Tokyo monitors observational data exchanges twice a year. The state of 2022 exchanges are currently being assessed, with final monitoring results to be circulated by March 2023.

8. Ties with WMO Programmes/activities and tropical cyclone RSMCs

The Advisory Group on Tropical Cyclones (AG-TC) under the Standing Committee on Disaster Risk Reduction and Public Services (SC-DRR) supports the delivery of globally consistent services on tropical cyclones. Representatives of RSMCs and TCWCs, including the RSMC Tokyo – Typhoon Center, attended three meetings held in 2022, and the Group's activities have included submitting recommendations to the second session of the WMO Services Commission (SERCOM-2). The Center also contributes to the Severe Weather Forecasting Programme – Southeast Asia (SWFP-SeA) as a participating organization, providing meteorological data for operational purposes and supporting capacity building, with representatives attending a Regional Sub-programme Management Team (RSMT) meeting in December 2022.

Expert Team on Marine Services (ET-MS) under the Working Group Services of the WMO Regional Association (RA) II was newly formed in September 2022 and started its activities. A lecture on storm surges and high waves was conducted at the ESCAP/WMO Typhoon Committee Attachment Training course in January 2023, as one of the ET activities for capacity building.

The third Joint Session of TC and PTC (February 2015) recommended establishing a cooperative mechanism to promote the transfer of technical expertise between TC and PTC Members. In this regard, a representative from the Center gave a presentation during a forecaster training course held online by RSMC New Delhi in April 2022.

Guidelines on responsibility transfer have been exchanged between RSMC Tokyo and RSMC New Delhi and between RSMC Tokyo and RSMC Honolulu to ensure information delivery when a named tropical cyclone crosses the boundary of each area of responsibility.

9. Implementation plan

Table 6 shows the implementation plan of the Center for the period from 2022 to 2026.

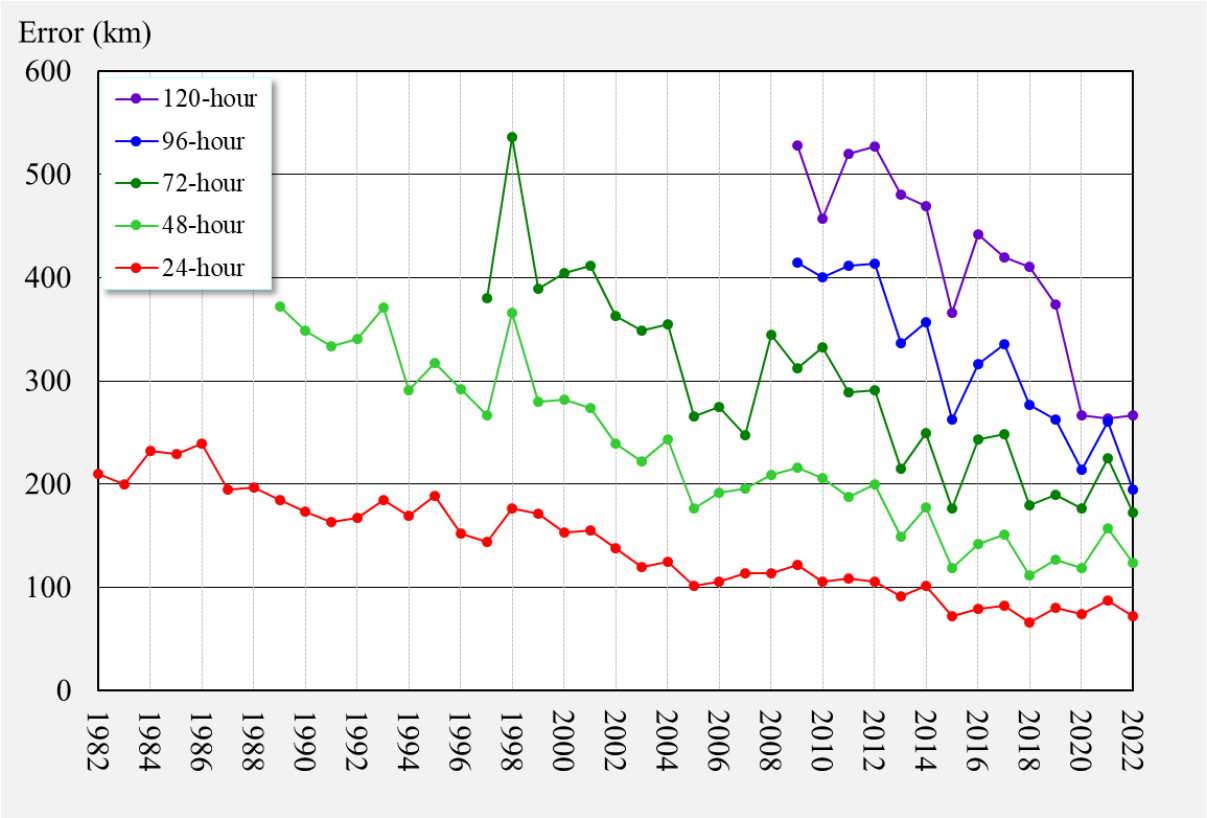

Figure 1 Annual mean position errors of track forecasts
Vertical axis: position error (km), Horizontal axis: year

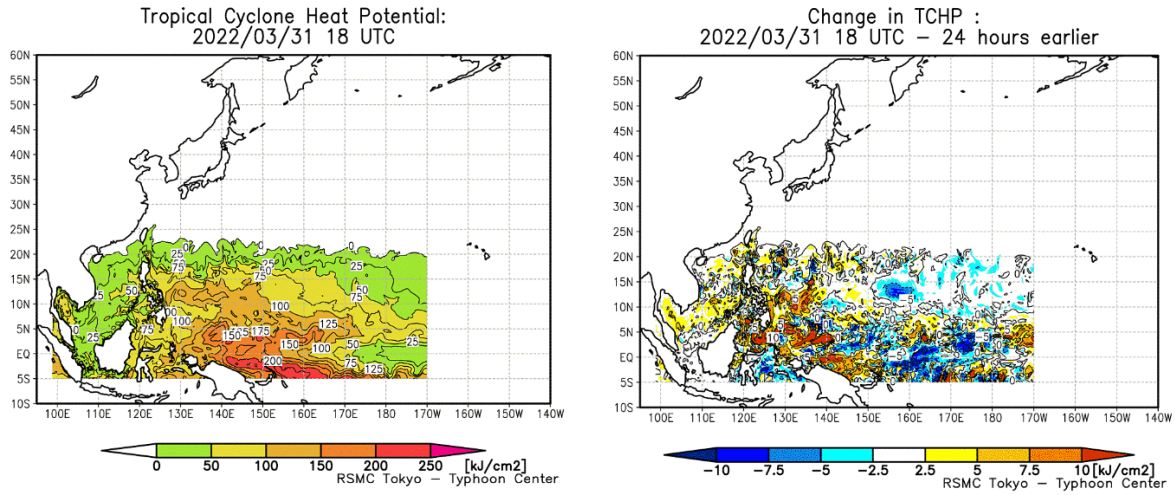

Figure 2 Tropical Cyclone Heat Potential (TCHP) product upgraded in March 2022
A sample image about TCHP (left) and its 24-hour changes on 31 March 2022

Table 1 Monthly and annual total numbers of products issued by the RSMC Tokyo - Typhoon Center in 2022

Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
IUCC10	0	0	0	91	0	11	92	152	305	122	35	16	824
WTPQ20-25	0	0	0	104	0	18	102	183	301	0	0	0	708
WTPQ30-35	0	0	0	51	0	9	49	91	165	70	18	11	464
WTPQ50-55	0	0	0	104	0	18	102	183	335	141	39	23	945
FXPQ20-25	0	0	0	51	0	9	49	89	164	68	18	11	459
FXPQ30-35	0	0	0	49	0	9	49	88	162	68	18	11	454
FKPQ30-35	0	0	0	51	0	9	49	89	164	68	18	11	459
AXPQ20	4	2	0	0	0	0	2	0	0	3	8	3	22

Notes:

IUCC10 RJTD	SAREP (BUFR format)
WTPQ20-25 RJTD	RSMC Tropical Cyclone Advisory for Three-day Forecasts
WTPQ30-35 RJTD	RSMC Prognostic Reasoning
WTPQ50-55 RJTD	RSMC Tropical Cyclone Advisory
FXPQ20-25 RJTD	RSMC Guidance for Forecast by Global Model
FXPQ30-35 RJTD	RSMC Guidance for Forecast by Global Ensemble Prediction System
FKPQ30-35 RJTD	Tropical Cyclone Advisory for SIGMET
AXPQ20 RJTD	RSMC Tropical Cyclone Best Track

Table 2 Mean position errors of track forecasts for the TCs in 2022

Tropical Cyclone			24-hour Forecast				48-hour Forecast				72-hour Forecast				96-hour Forecast				120-hour Forecast			
			Mean (km)	S.D. (km)	Num.	Impr. (%)	Mean (km)	S.D. (km)	Num.	Impr. (%)	Mean (km)	S.D. (km)	Num.	Impr. (%)	Mean (km)	S.D. (km)	Num.	Impr. (%)	Mean (km)	S.D. (km)	Num.	Impr. (%)
TY	Malakas	(2201)	59	28	26	67	79	52	22	76	107	45	18	79	141	60	14	80	156	99	10	83
TS	Megi	(2202)	99	0	1	43	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Chaba	(2203)	52	25	9	58	81	39	5	69	188	0	1	63	-	-	0	-	-	-	0	-
TS	Aere	(2204)	50	29	13	81	95	59	9	83	107	68	5	88	168	0	1		-	-	0	-
TS	Songda	(2205)	85	41	9	81	149	109	5	86	236	0	1	81	-	-	0	-	-	-	0	-
TS	Trases	(2206)	81	0	1	77	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Mulan	(2207)	152	38	3	51	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Meari	(2208)	42	17	8	84	56	31	4	92	-	-	0	-	-	-	0	-	-	-	0	-
STS	Ma-on	(2209)	102	37	13	57	220	31	9	57	362	51	5	56	616	0	1	33	-	-	0	-
TY	Tokage	(2210)	31	19	11	82	46	15	7	86	76	26	3	84	-	-	0	-	-	-	0	-
TY	Hinnamnor	(2211)	58	51	33	73	133	117	29	77	227	233	25	78	224	241	20	83	240	182	16	85
TY	Muifa	(2212)	69	70	29	54	123	118	25	64	155	90	21	67	213	84	17	62	296	135	13	50
TY	Merbok	(2213)	48	17	11	75	125	36	7	66	214	48	3	68	-	-	0	-	-	-	0	-
TY	Nanmadol	(2214)	75	19	20	45	119	27	16	65	116	46	12	82	89	60	8	90	203	92	4	84
TS	Talas	(2215)	97	9	2	50	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Noru	(2216)	90	44	19	35	144	78	15	54	164	91	11	69	189	115	7	80	378	32	3	73
STS	Kulap	(2217)	86	50	10	54	111	44	6	62	261	10	2	65	-	-	0	-	-	-	0	-
TY	Roke	(2218)	199	43	9	-39	527	53	5	-50	1061	0	1	-102	-	-	0	-	-	-	0	-
TS	Sonca	(2219)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Nesat	(2220)	37	22	15	72	54	40	11	84	91	51	7	85	120	57	3	87	-	-	0	-
TS	Haitang	(2221)	115	0	1	51	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
STS	Nalgae	(2222)	81	47	23	43	111	70	19	62	161	79	15	62	249	75	11	42	422	91	7	10
TS	Banyan	(2223)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Yamaneko	(2224)	105	53	3	19	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Pakhar	(2225)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
Annual Mean (Total)			72	52	269	61	124	108	194	69	172	155	130	73	195	152	82	77	267	158	53	74

Notes: S.D. means standard deviation of operational forecast errors.
Num. means numbers of forecasts.
Impr. indicates the ratios of position errors in operational forecasts to those in CLIPER predictions.

Table 3 Mean hitting ratios (%) and radii (km) of 70% probability circles issued for track forecasts for the TCs in 2022

Tropical Cyclone			24-hour Forecast			48-hour Forecast			72-hour Forecast			96-hour Forecast			120-hour Forecast		
			Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)
TY	Malakas	(2201)	92	26	86	95	22	165	100	18	265	100	14	390	100	10	556
TS	Megi	(2202)	100	1	148	-	0	-	-	0	-	-	0	-	-	0	-
TY	Chaba	(2203)	78	9	89	100	5	167	100	1	259	-	0	-	-	0	-
TS	Aere	(2204)	100	13	104	89	9	186	100	5	319	100	1	519	-	0	-
TS	Songda	(2205)	78	9	115	80	5	220	100	1	370	-	0	-	-	0	-
TS	Trases	(2206)	100	1	120	-	0	-	-	0	-	-	0	-	-	0	-
TS	Mulan	(2207)	0	3	93	-	0	-	-	0	-	-	0	-	-	0	-
TS	Meari	(2208)	100	8	100	100	4	185	-	0	-	-	0	-	-	0	-
STS	Ma-on	(2209)	54	13	95	22	9	179	0	5	304	0	1	519	-	0	-
TY	Tokage	(2210)	100	11	101	100	7	177	100	3	340	-	0	-	-	0	-
TY	Hinnamnor	(2211)	85	33	79	62	29	143	76	25	246	85	20	376	94	16	551
TY	Muifa	(2212)	79	29	87	80	25	152	86	21	249	100	17	373	92	13	534
TY	Merbok	(2213)	82	11	88	71	7	172	67	3	333	-	0	-	-	0	-
TY	Nanmadol	(2214)	35	20	68	56	16	125	100	12	213	100	8	350	100	4	519
TS	Talas	(2215)	100	2	148	-	0	-	-	0	-	-	0	-	-	0	-
TY	Noru	(2216)	58	19	88	47	15	160	100	11	263	100	7	389	100	3	654
STS	Kulap	(2217)	50	10	85	83	6	162	50	2	259	-	0	-	-	0	-
TY	Roke	(2218)	11	9	99	0	5	200	0	1	333	-	0	-	-	0	-
TS	Sonca	(2219)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
TY	Nesat	(2220)	100	15	69	100	11	121	100	7	201	100	3	315	-	0	-
TS	Haitang	(2221)	0	1	93	-	0	-	-	0	-	-	0	-	-	0	-
STS	Nalgae	(2222)	70	23	91	74	19	163	87	15	264	100	11	431	86	7	651
TS	Banyan	(2223)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
TS	Yamaneko	(2224)	33	3	106	-	0	-	-	0	-	-	0	-	-	0	-
TS	Pakhar	(2225)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
Annual Mean (Total)			73	269	89	72	194	159	85	130	258	95	82	385	94	53	564

Table 4a Root mean square errors and mean errors of central pressure forecasts for the TCs in 2022

Tropical Cyclone			24-hour Forecast				48-hour Forecast				72-hour Forecast				96-hour Forecast				120-hour Forecast			
			Error (hPa)	RMSE (hPa)	Num.	Impr. (%)	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)
TY	Malakas	(2201)	-3.3	9.1	26	21	-4.9	11.3	22	29	-3.9	13.2	18	29	3.6	7.8	14	42	9.5	11.3	10	-54
TS	Megi	(2202)	0.0	0.0	1	100	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Chaba	(2203)	2.8	6.5	9	53	7.8	11.3	5	22	0.0	0.0	1	100	-	-	0	-	-	-	0	-
TS	Aere	(2204)	-1.5	3.2	13	49	-3.1	4.2	9	74	-4.8	5.5	5	76	2.0	2.0	1		-	-	0	-
TS	Songda	(2205)	3.8	4.3	9	-23	4.8	5.1	5	52	4.0	4.0	1	83	-	-	0	-	-	-	0	-
TS	Trases	(2206)	0.0	0.0	1	100	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Mulan	(2207)	0.7	1.2	3	91	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Meari	(2208)	2.3	2.3	8	2	4.0	4.0	4	11	-	-	0	-	-	-	0	-	-	-	0	-
STS	Ma-on	(2209)	1.3	4.9	13	48	2.8	6.3	9	66	4.4	5.3	5	81	2.0	2.0	1	94	-	-	0	-
TY	Tokage	(2210)	6.4	11.6	11	-17	9.7	17.8	7	-73	8.0	10.7	3	31	-	-	0	-	-	-	0	-
TY	Hinnamnor	(2211)	-5.9	23.6	33	-29	-3.1	29.9	29	-9	-6.1	31.2	25	-7	-9.2	27.3	20	10	-9.9	20.4	16	34
TY	Muifa	(2212)	3.3	10.2	29	16	4.9	12.2	25	12	3.6	13.5	21	-42	2.7	10.5	17	0	3.9	14.0	13	-26
TY	Merbok	(2213)	3.5	6.8	11	-23	13.9	14.6	7	-112	21.7	22.2	3	-266	-	-	0	-	-	-	0	-
TY	Nanmadol	(2214)	2.5	25.9	20	-28	16.6	36.1	16	6	27.9	40.2	12	7	20.0	29.6	8	1	1.3	5.6	4	-9
TS	Talas	(2215)	0.0	0.0	2	100	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Noru	(2216)	6.4	18.1	19	39	15.6	27.5	15	-34	8.2	18.8	11	-11	23.7	26.8	7	-59	17.0	18.5	3	-27
STS	Kulap	(2217)	8.5	8.8	10	4	14.0	14.3	6	-5	22.5	22.6	2	-207	-	-	0	-	-	-	0	-
TY	Roke	(2218)	0.0	14.6	9	-20	-1.6	10.5	5	4	2.0	2.0	1	86	-	-	0	-	-	-	0	-
TS	Sonca	(2219)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Nesat	(2220)	-2.7	6.3	15	60	2.9	9.5	11	54	1.1	9.1	7	44	-12.0	12.5	3	48	-	-	0	-
TS	Haitang	(2221)	2.0	2.0	1	71	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
STS	Nalgae	(2222)	-3.9	7.3	23	37	-5.9	6.7	19	66	-5.6	6.6	15	68	-3.2	7.5	11	66	-7.9	12.9	7	51
TS	Banyan	(2223)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Yamaneko	(2224)	-2.7	2.8	3	75	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Pakhar	(2225)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
Annual Mean (Total)			0.5	13.7	269	7	3.4	19.4	194	7	2.6	21.3	130	9	2.1	19.4	82	12	-0.2	15.5	53	25

Impr. indicates the ratios of RMSEs of operational forecasts to those of SHIFOR predictions.

Table 4b Root mean square errors and mean errors of maximum sustained wind forecasts for the TCs in 2022

Tropical Cyclone			24-hour Forecast				48-hour Forecast				72-hour Forecast				96-hour Forecast				120-hour Forecast			
			Error (m/s)	RMSE (m/s)	Num.	Impr. (%)	Error (m/s)	RMSE (m/s)	Num.	Impr. (%)	Error (m/s)	RMSE (m/s)	Num.	Impr. (%)	Error (m/s)	RMSE (m/s)	Num.	Impr. (%)	Error (m/s)	RMSE (m/s)	Num.	Impr. (%)
TY	Malakas	(2201)	2.0	4.7	26	12	2.5	5.8	22	38	1.3	6.0	18	50	-1.5	3.5	14	74	-3.1	4.0	10	71
TS	Megi	(2202)	0.0	0.0	1	100	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Chaba	(2203)	-2.0	4.1	9	47	-3.1	7.6	5	12	2.6	2.6	1	63	-	-	0	-	-	-	0	-
TS	Aere	(2204)	1.2	3.0	13	2	3.1	3.7	9	26	4.1	4.6	5	20	-2.6	2.6	1		-	-	0	-
TS	Songda	(2205)	-0.6	1.2	9	43	-1.0	2.3	5	46	0.0	0.0	1	100	-	-	0	-	-	-	0	-
TS	Trases	(2206)	-2.6	2.6	1	-22	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Mulan	(2207)	0.0	0.0	3	100	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Meari	(2208)	-1.0	1.6	8	-1	-1.9	2.2	4	-30	-	-	0	-	-	-	0	-	-	-	0	-
STS	Ma-on	(2209)	-1.6	3.9	13	-6	-1.7	4.5	9	17	-3.1	4.0	5	53	0.0	0.0	1	100	-	-	0	-
TY	Tokage	(2210)	-4.2	7.7	11	-48	-6.2	11.5	7	-74	-6.9	8.1	3	-85	-	-	0	-	-	-	0	-
TY	Hinnamnor	(2211)	1.6	10.8	33	-35	1.3	12.9	29	2	2.7	13.4	25	11	5.0	10.7	20	34	4.8	7.6	16	54
TY	Muifa	(2212)	-1.4	3.9	29	28	-2.3	4.8	25	38	-1.3	5.5	21	33	-0.8	5.3	17	32	-0.4	5.8	13	34
TY	Merbok	(2213)	-2.6	5.1	11	-89	-6.2	7.7	7	-257	-7.7	8.5	3	-155	-	-	0	-	-	-	0	-
TY	Nanmadol	(2214)	-0.8	9.3	20	-27	-5.3	13.3	16	8	-9.2	14.0	12	18	-7.4	9.9	8	21	-0.6	2.9	4	43
TS	Talas	(2215)	0.0	0.0	2	100	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Noru	(2216)	-3.4	8.9	19	19	-7.7	13.8	15	-32	-3.7	9.2	11	-26	-8.8	10.7	7	3	-7.7	8.5	3	-30
STS	Kulap	(2217)	-0.5	3.0	10	12	-1.7	5.8	6	-46	-2.6	2.6	2	-139	-	-	0	-	-	-	0	-
TY	Roke	(2218)	-0.3	9.0	9	-28	0.5	7.4	5	-29	-2.6	2.6	1	-733	-	-	0	-	-	-	0	-
TS	Sonca	(2219)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Nesat	(2220)	0.7	3.3	15	53	-0.7	5.3	11	43	-0.7	4.8	7	32	6.0	6.5	3	4	-	-	0	-
TS	Haitang	(2221)	-2.6	2.6	1	33	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
STS	Nalgae	(2222)	1.0	3.2	23	29	1.2	2.3	19	64	0.7	2.1	15	58	-0.7	3.9	11	23	0.7	5.0	7	23
TS	Banyan	(2223)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Yamaneko	(2224)	1.7	2.1	3	58	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Pakhar	(2225)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
Annual Mean (Total)			-0.4	6.3	269	-3	-1.3	8.7	194	6	-1.0	8.7	130	19	-0.6	7.7	82	35	0.4	6.0	53	50

Impr. indicates the ratios of RMSEs of operational forecasts to those of SHIFOR predictions.

Table 5 Products of RSMC Tokyo via the NTP website

Products	Frequency	Details
RSMC Advisories		
RSMC TC Advisory	At least 8 times/day	• RSMC Tokyo – Typhoon Center's TC analysis and forecasts up to 120-hours (linked to the JMA website at https://www.jma.go.jp/bosai/map.html#contents=typhoon&lang=en)
Storm Wind Probability Map	4 times/day	• Probabilistic forecast map for sustained wind upward of 50-kt for 1, 2, 3, 4 and 5 days ahead
Prognostic Reasoning	4 times/day	• RSMC Tokyo Tropical Cyclone Prognostic Reasoning (WTPQ3X)
Advance Notice		• Advance notice on TC status change from RSMC Tokyo – Typhoon Center *Supplemental information to RSMC advisories (It may not be provided in certain situations and should not be considered as an official RSMC advisory and/or its replacement)
TC Advisory	4 times/day	• TC Advisory in text, graphical and xml formats including RSMC Tokyo – Typhoon Center's TC analysis, track and intensity forecasts up to 24-hours and horizontal extents of cumulonimbus cloud and cloud top height associated with TCs potentially affecting aviation safety (linked to the Tropical Cyclone Advisory Center Tokyo website at https://www.data.jma.go.jp/tca/data/index.html)
Remote Sensing		
Satellite Analysis	At least 4 times/day	• Results and historical logs of RSMC Tokyo – Typhoon Center's TC analysis conducted using satellite images (Conventional Dvorak analysis and Early-stage Dvorak analysis)
Satellite Imagery	Up to 142 times/day	• Satellite imagery of Himawari-8/9 (linked to the JMA website at https://www.jma.go.jp/bosai/map.html#contents=himawari&lang=en)
Satellite Microwave Products		• TC snapshot images • Warm-core-based TC intensity estimates • Weighted consensus TC intensity estimates made using Dvorak analysis and satellite microwave warm-core-based intensity estimates
Sea-surface AMV (ASWind)	Every 10 / 30 minutes	• AMV-based Sea-surface Wind in the vicinity of TC (linked to Meteorological Satellite Center's web site: https://www.jma.go.jp/jma/jma-eng/satellite/jdds.html)
Radar	Every hour	• Radar composite imagery of the Typhoon Committee Regional Radar Network
Atmospheric Circulation		
Weather Charts	4 times/day	• Weather maps for surface analysis, 24- and 48-hour forecasts (linked to the JMA website at https://www.jma.go.jp/bosai/weather_map/#lang=en)
NWP Multi Center Weather Charts	Twice/day	• Mean sea level pressure and 500 hPa Geopotential height (up to 168 hours) of deterministic NWP models from nine centers (BoM, CMA, CMC, DWD, ECMWF, KMA, NCEP, UKMO and JMA)
JMA GSM Analysis and Forecast	4 times/day	• Upper-air analysis and forecast data based on JMA-GSM - Streamlines at 850, 500 and 200 hPa - Divergence at 200 hPa - Velocity potential at 200 hPa - Vertical Velocity in Pressure Coordinate at 500 hPa - Dew Point Depression at 600 hPa - Curvature Vorticity at 850 hPa - Vertical wind shear between 200 and 850 hPa - Sea Level Pressure - Genesis Potential Index
MJO Phase Diagram	Daily	• MJO phase and amplitude diagram and MJO Hovmöller diagram (linked to the Tokyo Climate Center web site:

		https://ds.data.jma.go.jp/tcc/tcc/products/clisys/mjo/monitor.html https://ds.data.jma.go.jp/tcc/tcc/products/clisys/ASIA_TCC/mjo_cross.html)
Asian Monsoon Monitoring Indices	Daily, only during Apr. - Oct.	• Time series of vertical wind shear, OLR and other indices associated with SW Asian Monsoon (linked to the Tokyo Climate Center web site: https://ds.data.jma.go.jp/tcc/tcc/products/clisys/ASIA_TCC/monsoon_index.html)
Ocean Condition		
SST	Once/day	• Sea surface temperature and related differences from 24 hours ago
TCHP	Once/day	• Tropical cyclone heat potential and related differences from 24 hours ago
Numerical TC Prediction		
Track Bulletin	4 times/day	• RSMC Tokyo Tropical Cyclone Track Forecast Bulletin - Track forecast by GSM (FXPQ2X) - Track forecast by GEPS (FXPQ3X)
TC intensity (TIFS monitor)	4 times/day	• TIFS (Typhoon Intensity Forecast scheme based on SHIPS) Monitor
TC Track Prediction	4 times/day	• TC track prediction of deterministic NWP models from nine centers (BoM, CMA, CMC, DWD, ECMWF, KMA, NCEP, UKMO and JMA) and a related consensus • TC track prediction of EPS models from four centers (ECMWF, NCEP, UKMO and JMA)
TC Activity Prediction	Twice/day	• Two- and five-day TC activity prediction maps based on EPS models from four centers (ECMWF, NCEP, UKMO and JMA) and a related consensus
TC Verification	4 times/day	• Verification results of RSMC Tokyo's official forecasts as well as NWP model and guidance predictions
Marine Forecast		
Storm Surge Forecasts	4 times/day	• Distribution of storm surge for RSMC Tokyo – Typhoon Center TC track forecasts and probabilistic products (ensemble mean, maximum, third quartile, spread and exceeding probabilities) of storm surge EPS from GEPS ensemble members (up to 132 hours) • Time-series storm surge forecast charts (plume diagrams, box plots and exceeding probabilities) for RSMC Tokyo – Typhoon Center TC track forecasts and 51 TC track forecasts from GEPS ensemble members (up to 132 hours)
Ocean Wave Forecasts	Twice/day	• Distribution maps for ensemble mean, maximum, probability of exceeding various thresholds and ensemble spread of wave height and period based on Wave Ensemble System (WENS) (up to 264 hours) • Time-series representations with box plots for wave height/period and probability of exceeding various wave height/period thresholds based on WENS (up to 264 hours)

Table 6 Implementation Plans of the RSMC Tokyo - Typhoon Center (2022 - 2026)

PRODUCT	2022	2023	2024	2025	2026	REMARKS
Satellite Observation						
Himawari- 8/9						Every 10 minutes (Full-disk) Every 2.5 minutes (Target area)
Cloud motion wind (BUFR)						24 times/day
RSMC TC Advisories / Bulletins						
RSMC Tropical Cyclone Advisory						8 times/day
SAREP (for tropical cyclones, BUFR)						8 times/day Position of cloud sytem center, etc. 4 times/day Dvorak intensity
RSMC Prognostic Reasoning						4 times/day
RSMC Guidance for Forecast						4 times/day up to 132 hrs (GSM and GEPS)
Web-based RSMC Advisories / Products						
Numerical Typhoon Prediction Website						
Tropical Cyclone Advisory in text, graphical and XML formats						
Experimental CAP Tropical Cyclone Advisory						
Others						
RSMC Tropical Cyclone Best Track						
Annual Report						Publication
Technical Review						Publication (as necessary)
Tropical Cyclone Reanalysis						
TC Communication platform						

SUPPORTING ACTIVITY	2022	2023	2024	2025	2026	REMARKS
Attachment Training						The 23rd training course will be conducted in 2024 1Q.
Data archive						
Monitoring of data exchange						
Dissemination of products via GISC Tokyo						