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FOR PARTICIPANTS ONLY
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ACTIVITIES OF THE RSMC TOKYO - TYPHOON CENTER IN 2018

(Submitted by the RSMC Tokyo - Typhoon Center)

ACTION REQUIRED:

The Committee is invited to review the activities of the RSMC Tokyo - Typhoon Center in 2018 and future plans.

APPENDIXES:

A) DRAFT TEXT FOR INCLUSION IN SESSION REPORT

B) RSMC Tokyo - Typhoon Center Activity Report 2018 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 2018

1. The Committee noted with appreciation the review of RSMC advisories, products and operational activities and changes made in 2018. It noted the forecast verification results for 29 TCs that reached TS intensity or higher formed in 2018: the forecast track errors of the year of 66 km (82 km in 2017), 112 km (151 km), 179 km (248 km), 277 km (335 km) and 409 km (420 km) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively, the annual mean RMSEs for central pressure forecasts of 13.8 hPa (10.1 hPa), 18.7 hPa (14.9 hPa) and 20.4 hPa (16.9 hPa) for 24-, 48- and 72-hour forecasts, respectively, and those for maximum wind speed forecasts for 24-, 48- and 72-hour forecasts of 5.4 m/s (5.0 m/s), 6.9 m/s (6.8 m/s) and 7.3 m/s (7.8 m/s), respectively.

2. The Committee noted with appreciation to the changes of RSMC advisories, products and operational/coordination activities in 2018. It also noted the planned changes, that is, the commencement of 5-day tropical cyclone intensity forecasts, revision of probability circle and enhanced communication service on a trial basis.

3. The Committee expressed its appreciation to the operation of RSMC Tokyo's Numerical Typhoon Prediction (NTP) website and noted changes made in 2018 and those planned in the near future.

4. The Committee expressed its appreciation to the continuous contribution of RSMC Tokyo to the regional Storm Surge Watch Scheme (SSWS), especially the provision of various products including storm surge forecast distribution maps, time-series charts at selected stations and multi-scenario storm surge predictions as well as week-range wave forecasts which will newly include probability forecasts on peak wave period in addition to significant wave heights in January 2019. The Committee encouraged Members to make their sea level observation available to contribute to the verification activity. It also noted with appreciation for RSMC Tokyo's intention to start provision of astronomical tides estimated by a global ocean tide solution (FES2014)*[1] for 27 stations, where sea level observation data is not available, from 25 February 2019.

5. The Committee with appreciation noted the further development of RSMC Tokyo's Tropical Cyclone Activity Prediction maps using ensembles of ECMWF, NCEP, UKMO and JMA as well as a multi-center grand ensemble (MCGE) of them.

6. The Committee was pleased to note the progress of the regional radar network development project, whose experimental exchange of radar composite data among RSMC Tokyo, the Thai Meteorological Department (TMD) and the Malaysia Meteorological Department (MMD) started in 2016. The Committee expressed its appreciation to RSMC Tokyo for expanding this project by inviting three more Members, Lao P.D.R., the Philippines and Viet Nam, since 2018. It also noted with appreciation that a technical meeting for experts of the three Members and the new Members was held at the JMA headquarters in October 2018 to exchange information on experiences and challenges relating to regional radar data exchange and quality control, and to discuss future directions in the field.

7. The Committee was pleased to note the progress of the project on enhancing the utilization of Himawari-8/9 products, in which technical support for developing Rapidly Developing Cumulus Area (RDCA) identification using Himawari-8/9 data has been conducted. The committee noted with appreciation that a technical meeting was held with experts of MMD at the JMA headquarters in October 2018 to exchange information on recent progress and ideas for advanced products in the field.

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*[1] FES2014 was produced by NOVELTIS, LEGOS, CLS Space Oceanography Division and CNES. It is distributed by AVISO, with support from CNES (http://www.aviso.altimetry.fr/)

8. The Committee noted that the final draft of the TC Forecast Competency was submitted and approved at the Committee's 50th annual session and accordingly the Typhoon Committee Operational Manual - Meteorological Components (TOM) including the Competency was submitted for approval at the Committee's 51st annual session.

9. The Committee noted with appreciation that RSMC Tokyo published the RSMC Tokyo Technical Review No.20 and the Annual Report on the Activities of the RSMC Tokyo Typhoon Center 2017 in March and December 2018, respectively.

10. The Committee was informed that 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 1999 and from 2004 to 2013 has been completed. RSMC Tokyo has been working on the re-analysis for the rest (2000 - 2003 and 2014 - present).

11. The Committee noted with appreciation the operation of Himawari-8/9 geostationary meteorological satellites and further welcomed the intention of RSMC Tokyo to continue providing Himawari products as well as technical support for using them.

12. The Committee was pleased to note that RSMC Tokyo conducted the 18th Attachment Training from 15 to 26 October 2018, inviting three forecasters from Macao (China), Malaysia and the Philippines. In accordance with the decision of the third joint session of the Panel on Tropical Cyclone (PTC) and the Typhoon Committee, RSMC Tokyo, ESCAP, WMO, and PTC secretariats invited two forecasters from PTC Members: Oman and Sri Lanka. The committee noted with appreciation to RSMC Tokyo's intention to accept a few more (including self-funded) trainees of Typhoon Committee.

13. The Committee noted the results of the annual observation exchange monitoring during the period of two typhoons in 2018: Soulik (1819) and Mangkhut (1822), which highlighted the special observation conducted by China, Hong Kong (China), the Republic of Korea and the Philippines during the periods. It expressed its appreciation to the four Members, who provided special observation data to the Committee Members, and further encouraged all the Members to conduct additional observation, as requested by the Typhoon Committee Operational Manual - Meteorological Components (TOM)

APPENDIX B:
RSMC Tokyo - Typhoon Center Activity Report 2018 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 GTS and the AFTN. This section reviews RSMC advisories, products and operational activities in 2018 and summarizes changes and future plans.

1.1 Review of RSMC advisories, products and operational activities in 2018

Table 1 shows the total number of products issued by the Center in 2018.

✧ **Verification of Track Forecasts**

Operational track forecasts for 29 Tropical Cyclones (TCs) that reached Tropical Storm (TS) intensity or higher in 2018 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 66 km (82 km in 2017), 112 km (151 km), 179 km (248 km), 277 km (335 km) and 409 km (420 km) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively (Table 2).

✧ **Verification of Track Forecast Probability Circles**

RSMC Tokyo has used track forecast probability circles* to represent TC track forecast uncertainties. The radius of the circles for all forecast times is statistically determined according to the direction and speed of TC movement based on the results of recent TC track forecast verification. In addition, those for 96- and 120-hour forecasts are statistically determined according to the confidence level based on the cumulative ensemble spread calculated using the JMA's Ensemble Prediction System (EPS). The mean hitting ratios of circles* for 24-, 48-, 72-, 96- and 120-hour forecasts in 2018 are 82% (78% in 2017), 89% (79%), 82% (75%), 82% (68%) and 78% (75%), 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 4 gives the mean errors and root mean square errors (RMSEs) of 24-, 48- and 72-hour central pressure (Table 4a) and maximum sustained wind forecasts (Table 4b) for 27 TCs of 2018. The annual mean RMSEs for central pressure forecasts are 13.8 hPa (10.1 hPa in 2017), 18.7 hPa (14.9 hPa) and 20.4 hPa (16.9 hPa) for 24-, 48- and 72-hour forecasts, respectively, while those for maximum wind speed forecasts for 24-, 48- and 72-hour forecasts are 5.4 m/s (5.0 m/s in 2017), 6.9 m/s (6.8 m/s) and 7.3 m/s (7.8 m/s), respectively.

1.2 Changes in RSMC advisories, products and operational activities in 2018

✧ **RSMC Prognostic Reasoning**

On 1 January 2018, RSMC Tokyo started providing RSMC Prognostic Reasoning at 12 and 18 UTC, in addition to 00 and 06 UTC, with WMO header of WTPQ30-35 RJTD. It also changed the contents to include detailed information on synoptic situation, models and guidance used to produce forecasts and justification of forecaster's decision.

✧ **Advance notice of upgrade to TS**

RSMC Tokyo started providing advance notices to registered Committee Members via email and its NTP website, when TC status changes are likely. This is supplementary information to RSMC tropical cyclone advisories, and is provided in the event of:

1. an upgrade from a tropical depression (TD) to a tropical storm (TS)
2. a downgrade from a TS to a TD or extratropical transition
3. a TC crossing a border between RSMCs

An advanced notice is provided in principle from around an hour before to half an hour after the reference time of an official RSMC advisory (e.g., from 23:00 to 00:30 UTC for an RSMC advisory with a 00 UTC reference time). It should be noted that such notice may not be provided in certain situations and should not be considered as an official RSMC advisory and/or its replacement.

✧ **Extended RSMC Guidance for Forecast**

JMA began the operation of its new supercomputer system on 5 June 2018. The system has an effective peak performance 10 times faster than its predecessor and is capable of processing larger amounts of data with higher efficiency. JMA uses this power for a variety of numerical calculations in monitoring and prediction of weather and climate conditions over periods ranging from the short term to several months ahead, and utilizes the results to support the output of meteorological information for use in disaster prevention, daily life, socio-economic activity and a variety of other areas. The Agency plans to utilize the new supercomputer for precise early prediction of TCs and localized torrential rain and for improvements in various types of information, including ensemble prediction on scales ranging from weeks to months.

In the area of TC forecasts, the range of JMA's global spectral model (GSM) was extended on 5 June 2018 to cover periods up to 132 hours ahead for initial times of 00, 06 and 18 UTC in association with the supercomputer system upgrade. Leveraging this extension, RSMC Tokyo began providing track forecasts from a deterministic GSM with a header of FXPQ20-25 RJTD at 00 UTC on 1 August 2018 using the extended forecast range. Track forecasts based on data from JMA's global ensemble prediction system (GEPS), which were previously issued with the FXPQ20-25 header, are now provided with a header of FXPQ30-35 RJTD.

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

✧ **Intensity forecast for 96 and 120 hours**

RSMC Tokyo will start providing intensity forecast for 96 and 120 hours from 14 March 2019, based on several tropical cyclone intensity forecast guidance products including the one based on the Statistical Hurricane Intensity Prediction Scheme (SHIPS). The new scheme is known as TIFS (**T**yphoon **I**ntensity **F**orecasting scheme based on **S**HIPS), and the information will be added to existing RSMC Tropical Cyclone Advisory for five-day forecast with GTS headings of WTPQ 50-55 RJTD. An example of a bulletin including 96- and 120-hour intensity forecast is shown in Table 5 (subject to change).

✧ **Revision of probability circle**

RSMC Tokyo plans to revise probability circles by introducing categories by confidence level based on the cumulative ensemble spread calculated with multi-ensembles from four centers for all forecast times. This plan is based on the result that RSMC Tokyo compared characteristics of probability circles using statistical method, dynamical method consisting of single-ensemble and multi-ensemble use for 2016-2018 data. This improvement will be done in 2019 and verification of the new probability circle radii will also be conducted with tropical cyclone track data in 2019.

✧ **Enhanced communication**

RSMC Tokyo is planning to provide a platform in which the Committee Members can post inquiries or comments related to tropical cyclone analyses and forecasts. This will be operated on a trial basis in 2019 and gather feedback from the Members.

1.4 Review of RSMC coordination activities

In 2018, Hurricane Hector was formed in the Eastern Pacific, moved westward and crossed the boundary of the RSMCs Honolulu and Tokyo. Accordingly, RSMC Tokyo took over the responsibility for TC advisory issuances.
Procedures of taking over the responsibility for TC advisory issuances for TCs, which cross RSMCs' boundaries, were discussed and roughly coordinated between RSMCs Honolulu and Tokyo in 2015, and thorough investigation was ongoing in order to cover all possible cases when Hurricane Hector was formed. The operation of taking over the responsibility was done smoothly for this case in accordance with the pre-agreed procedures between the two RSMCs, and after minor modifications based on the actual operation, the procedures were finalized and documented as Standard Operating Procedures (SOP).

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 (https://tynwp-web.kishou.go.jp/) as part of its contribution to the WMO/ESCAP Typhoon Committee. All the products of the NTP website are listed in Table 6. Changes made in 2018 and those planned in 2019 are as follows.

✧ **Curvature vorticity and streamline map for the 850 hPa level**

Curvature vorticity and streamline map at 850 hPa has been provided in place of the previous total vorticity map.

✧ **Expansion of charts area and change in color tone**

The coverage of some maps were expanded as follows:

- Tropical cyclone heat potential (TCHP) map: 5 degrees expanded to the south and west
- Wave height prediction maps: 5 degrees expanded to the west
- Tropospheric circulation analysis maps: expanded to the east by 30 degrees to detect a precursor to tropical cyclogenesis at an earlier stage, and also expanded to the north by 10 degrees

In addition, color tone has been improved for some of these maps so as to highlight areas requiring heightened attention, e.g., from a basic two-color range (blue-red) or a GrADS rainbow palette to a multi-color range. Color of coast line in numerical weather maps has also been changed from black to brown for better visibility.

✧ **Bulletins**

RSMC Tokyo started provision of bulletins of RSMC Prognostic Reasoning (WTPQ30-35 RJTD) and numerical forecast typhoon track bulletins (FXPQ20-25 and FXPQ30-35 RJTD) described in 1.2 on its NTP website.

✧ **Tropical Cyclone Activity Prediction**

RSMC Tokyo provides two-day and five-day Tropical Cyclone Activity Prediction Maps covering its area of responsibility based on ensembles from the European Centre for Medium-Range Weather Forecasts (ECMWF), the National Centers for Environmental Prediction (NCEP), the UK Met Office (UKMO) and JMA, and a multi-center grand ensemble of these four. (See paragraph 3.2).

✧ **Probabilistic ocean wave period prediction**

In addition to the probabilistic forecasts for significant wave heights, probabilistic forecasts for peak wave period based on the Wave Ensemble System (WENS) will be available from 21 January 2019, considering that wave height is not the only factor that may cause damages to coastal regions; it is known that facilities in coastal regions are sometimes damaged by swells with longer periods. The new contents are forecast maps for ensemble

mean peak wave period, maximum peak wave period, probability of peak wave periods over 8, 10, 12 and 15 seconds, and ensemble spread with lead time of 24, 48, 72, 96, 120, 144, 168, 192, 216, 240 and 264 hours. EPSgrams at stations, the same as those for significant wave height products, are also available for wave period and probability of exceedance (probability of peak wave periods exceeding 10, 12 and 15 seconds).

✧ **Provision of storm tide prediction by utilizing an ocean tide solution**
RSMC Tokyo provides storm surge time-series charts to 78 stations in Member States. However, for 27 stations out of 78, where sea level observation data is not available, storm tide is not currently plotted in time-series charts. RSMC Tokyo will start provision of storm tide time-series charts for the 27 stations from 25 February 2019, by calculating astronomical tides and storm tides with a global ocean tide solution (FES2014)*[2].

✧ **Sea surface AMV (ASWind)**
The meteorological satellite center (MSC) of JMA has developed a method to estimate sea surface winds in the vicinity of tropical cyclones from Hiamwari-8/9. It is called ASWind (Atmospheric motion vector based Sea-surface Wind) which Himawari-8/9 provides every 30 minutes for full-disk observation and 10 minutes for Target Area observation, respectively, with high accuracy for surrounding areas of strong winds (30 kt or higher) due to TCs. RSMC Tokyo, using ASWinds operationally for TC analyses and forecasts since June 2018, plans to start providing ASWinds on its NTP website in 2019.

✧ **Probabilistic forecast maps for 50-kt winds**
RSMC Tokyo has developed 50-kt wind probability maps for western North Pacific region and plans to provide on the NTP website in the near future, after gathering the Member States' needs and preferences.

2.2 Tropical cyclone advisories for SIGMET in graphical format
In August 2015, RSMC Tokyo, as the ICAO TCAC, started providing graphical tropical cyclone advisories (hereinafter referred to as TCG) according to MODEL TCG in Appendix 1 of ICAO Annex 3. In March 2016, it started providing the graphical tropical cyclone advisories using a new Himawari product identifying Cb associated with tropical cyclones potentially affecting aviation safety. TCG is being provided through the website where the specifications and text format advisories are also available (http://www.data.jma.go.jp/fcd/tca/data/index.html). This website is linked to Numerical Typhoon Prediction website (https://tynwp-web.kishou.go.jp/). Also, TCG is sent to WAFCs, so that they are transmitted through WIFS and Secure SADIS FTP. WMO AHLs of the bulletin are PZXE (01-06) RJTD.

TCG is issued, together with text advisories, when 1) a tropical cyclone with Tropical Storm (TS) intensity or higher exists in the area of responsibility of RSMC Tokyo, or 2) a tropical cyclone is expected to reach TS intensity in the area within 24 hours. In the second case, gale force wind area is not to be presented in TCG.

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 (http://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,

*[2] FES2014 was produced by NOVELTIS, LEGOS, CLS Space Oceanography Division and CNES. It is distributed by AVISO, with support from CNES (http://www.aviso.altimetry.fr/)

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).

Products include storm surge forecast distribution maps (since June 2011), time-series charts at selected stations (since June 2012), multi-scenario storm surge predictions (since 2016) and week-range wave forecasts based on JMA Wave Ensemble system (WENS) (since 2016). JMA's storm surge model runs on a daily basis, even when no TCs exists in the area of responsibility, for providing information on storm surges generated by monsoon winds or extra-tropical cyclones (see Annex B Table 2 for specifications).

Multi-scenario storm surge predictions gives predictions based on RSMC Tokyo TC advisory and five additional TC scenarios extracted from the JMA's GEPS using cluster analysis. Maximum storm surges at each grid among the above 6 scenarios during the entire forecast period are also provided.

Stations for storm surge time-series predictions are increased upon requests from the Committee Members. As of December 2018, 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 where hourly tidal observational data for a few years are provided by Members.

Annual verification results of the storm surge products are regularly published in Annual Report on Activities of the RSMC Tokyo since 2015. Statistical verification is conducted for stations where tide 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 statistical verification.

Week-range wave forecasts created using its global Wave Ensemble System (WENS) are provided on the NTP website. WENS covers most of the global region and has a 1.25-degree grid resolution. It is run twice a day at 00 and 12 UTC and enables prediction of ocean wave conditions up to 264 hours ahead with 27 members.

RSMC Tokyo is working on upgrading the storm surge model; the new model uses finite volume method (FVM) with an unstructured (triangular) grid. As the new model can largely save the resources, RSMC Tokyo will increase the grid resolution around coastal regions from 2 minutes to 1 minute, expand the model domain to cover most of its area of responsibility, and increase the number of multi-scenario prediction using whole members of EPS.

3.2 Enhanced use of Ensemble Forecast

RSMC Tokyo has been working for enhancement of use of Ensemble Forecast as part of the World Weather Research Program (WWRP) and Tropical Cyclone Program (TCP), North Western Pacific Tropical Cyclone Ensemble Forecast Project (NWP-TCEFP) to enhance operational use of ensemble forecast by the Committee Members. Based on the assessment research using the TIGGE (THORPEX Interactive Grand Global Ensemble) datasets, RSMC Tokyo has provided ensemble TC track guidance of ECMWF and NCEP to the Committee Members on a real-time basis through the NTP website since October 2015.

Since 2016, RSMC Tokyo has been providing two-day and five-day Tropical Cyclone Activity Prediction Maps covering its area of responsibility based on ensembles from the ECMWF, UKMO and their consensus. The number of ensemble models used for consensus was expanded to four in 2018, by adding those of NCEP and JMA, and a multi-center grand ensemble (MCGE). The maps display potential tropical cyclone activity in terms of percentage of ensemble members in which TC-like vortices are represented within 300 km of a certain

location during the relevant forecast time. The products are intended to help forecasters identify and monitor areas in which tropical cyclones could form within two- and five-day periods.

The current probability circle radii for all forecast times are statistically determined according to the direction and speed of TC movement based on the results of recent TC track forecast verification. In addition, those for 96- and 120-hour forecasts are statistically determined according to the confidence level based on the cumulative ensemble spread from GEPS. RSMC Tokyo plans to revise probability circles by introducing categories by confidence level based on the cumulative ensemble spread calculated with multi-ensemble from the four centers for all forecast times. This is based on the result that RSMC Tokyo compared characteristics of probability circles using statistical method, dynamical method consisting of single-ensemble and multi-ensemble use for 2016-2018 data. The revised probability circle in TC track forecasts will be applied in 2019.

3.3 Development of regional radar network

The Development of Regional Radar Network is a project of the Working Group of Meteorology of the Typhoon Committee. Technical assistance provided through this project includes development of a national (domestic) radar network, radar data quality control, application of composite as well as quantitative precipitation estimation (QPE) techniques to the nationwide radar network. So far Thailand and Malaysia have been actively working on these items, through several technical meetings and workshops. As the latest achievement of this project, hourly radar composite imagery of Malaysia, Thailand and Japan is available on RSMC Tokyo NTP website since October 2017 at https://tynwp-web.kishou.go.jp/Analysis/Radar/index.html. This composite imagery is produced using radar composite data exchanged experimentally among three Members since 2016.

This project has been expanded and three more Members, Lao P.D.R., the Philippines and Viet Nam, have joined in 2018. Therefore, a technical meeting was held at the JMA headquarters in October 2018 for experts of the three and the new Members to exchange information on experiences and challenges relating to regional radar data exchange and quality control, and to discuss future directions in the field.

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 Himawari8/9 products. In 2018, a technical meeting was held with experts from Malaysia at JMA headquarters from in October 2018 to exchange information on recent progress and ideas for advanced products in the field. This support will be conducted also with other participants such as Singapore and Viet Nam in 2019.

3.5 Tropical Cyclone Forecast Competency

At the 66th World Meteorological Organization (WMO) Executive Council, the need for development of the tropical cyclone (TC) forecast competencies by regional tropical cyclone committees under the initiative of the Reginal Specialized Meteorological Centres (RSMCs) was stressed, in order to ensure the quality of tropical cyclone forecasting services and to meet users' requirements. The 47th session of the Typhoon Committee (Bangkok, 2015) requested RSMCs Tokyo and Honolulu to develop draft TC forecast competency as Annual Operating Plan of its Working Group on Meteorology.

RSMCs Honolulu and Tokyo reviewed 1) the WMO International TC Competencies Regional Association (RA) V (version 1.3), and 2) TC Competency developed by the Hurricane Committee Task Team submitted to the RA IV Hurricane Committee in 2014. After investigation, the two RSMCs created a draft version of TC forecast competency based on the

idea that, 1) both describe requirements comprehensively enough to be used as a draft of the TC forecast competencies for the ESCAP/WMO Typhoon Committee, 2) a category for non-forecast offices (Category 3 of the Hurricane Committee version) would not need to be included into the Typhoon Committee version and 3) TC competency requirements for Members, who still rely on RSMCs' or other agencies' TC forecasts to issue their TC information, need to be included. The draft was circulated in October 2016 and Members' views were collected. Also, for further discussion, focal points on this matter were set up. The Tropical Cyclone Forecaster Competency Task Team, consisting of the focal points and other experts, discussed how to use the competency framework and to produce the final draft. The competency framework includes requirements for dedicated and specialized TC forecasters at TC forecast agencies (Category 1) and those for general forecasters providing TC forecast services based on information provided by the parent RSMC or other agencies (Category 2). This framework is considered part of WMO's Competency Standards, which are a key element of a broader ambition to implement the WMO Quality Management System (QMS), and are/will be used as guidance in Typhoon Committee Attachment Training at RSMC Tokyo and other training activities.

The final draft was reported by the Working Group on Meteorology and approved at the 50th annual session of Typhoon Committee. Accordingly, the Typhoon Committee Operational Manual - Meteorological Components (TOM) including the Competency was composed and will be submitted to the 51st annual session for approval.

4. Publications

4.1 Technical Review

RSMC Tokyo published *Assimilation of Himawari-8 data into JMA's NWP systems*, *Introduction to JMA's new Global Ensemble Prediction System* and *2016 and 2017 Reviews of Probability-circle Radii in Tropical Cyclone Track Forecasts* as its Technical Review No. 20 in March 2018, 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 2017 in December 2018, 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. In 2018, re-analysis for the period from 1987 to 1999 was completed. In addition, satellite analysis datasets for the period from 2004 to 2013 were investigated and the re-analysis was completed. RSMC Tokyo continues to work on the TC satellite re-analysis to complete re-analysis for the rest of the period from 2000 to 2003 and from 2014 to present.

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 is the world's first new-generation satellite of its kind, featuring 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 typhoon -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.

On 2 November 2016, Himawari-9 was launched as the follow-on satellite to Himawari-8. After a period of in-orbit testing, Himawari-9 began serving as back-up to Himawari-8 on 10 March 2017 and will continue in this role until the planned switchover in or around 2022. 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.

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 December 2018, JMA had taken registrations from 15 NMHSs in RA II and RA V and opened the service to the 11 whose preparations for request submission were complete. In October 2018, the service was introduced to Australia for monitoring rapid developing cumulative clouds. The service was also subsequently extended to Australia for monitoring of bushfires in addition to tropical cyclones. 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.

6. Typhoon Committee Attachment Training at RSMC Tokyo

RSMC Tokyo has organized the ESCAP/WMO Typhoon Committee Attachment Training courses every year since 2001 with the support of the WMO Tropical Cyclone Programme (TCP) and the Typhoon Committee in order to advance the tropical cyclone forecasting capacity of Committee Members. Forecasters from the Member countries of the Panel on Tropical Cyclones (PTC) have also been invited since 2015 to enhance training collaboration between PTC and the Typhoon Committee.

The 18th ESCAP/WMO Typhoon Committee Attachment Training course was held at JMA Headquarters from 15 to 26 October 2018. The 2018 attendees were Mr. Kuok-Hou Ho from Macao (China), Mr. Mohd Afzainizam Bin Noordin from Malaysia, Mr. Jun Erza M. Bulquerin from the Philippines, Mr. Saif Al-Maqbali from Oman and Mr. Sujeewa Kanda Durage from Sri Lanka. The training focused on practical knowledge and skills related to operational tropical cyclone analysis and forecasting via lectures and exercises. The analysis course covered a range of subjects including interpretation of satellite imagery and Dvorak analysis techniques involving the use of the Satellite Analysis and Viewer Program (SATAID), and other analysis techniques based on microwave imagery, Doppler radar data and sea-surface Atmospheric Motion Vector data. The forecasting subject included techniques involving the use of various

types of guidance and information sources along with storm surge and wave forecasting. Presentations and exercises were also provided on public weather services, including the setting of warning criteria based on quantitative precipitation estimation and forecasting techniques, appropriate provision of disaster risk reduction information and forecast skill evaluation, to enhance capacity in the development and implementation of effective warning systems in collaboration with disaster risk reduction operators. All attendees gave presentations to help JMA staff understand the current status of their meteorological and hydrological services including tropical cyclone forecasting and warning services.

RSMC Tokyo plans to increase the number of Typhoon Committee trainees from three to four from the next training course, with the same cost-sharing scheme for WMO TCP and TCTF to cover the additional ticket and lump sum, respectively. RSMC Tokyo coordinated with the Training and Research Coordination Group (TRCG) to submit this proposal from TRCG side for the 51st annual session. In addition, RSMC Tokyo also plans to accept a few self-funded trainees of Typhoon Committee to meet the Committee Members' needs.

7. Regular Monitoring of the exchange information

In accordance with the ESCAP/WMO Typhoon Committee Operational Manual (TOM), RSMC Tokyo carried out regular monitoring of the exchange of observational data twice a year. For 2018, two typhoons, Soulik (1819) and Mangkhut (1822), were selected for the regular monitoring. The target Members of the monitoring are Hong Kong (China), Macao (China), China, Japan, Republic of Korea and Democratic People's Republic of Korea (Soulik, 1819) and the Philippines, Hong Kong (China), Macao (China), China and Viet Nam (Mangkhut, 1822). The result showed that China (TEMP), Hong Kong (SYNOP, TEMP and RADOB), Japan (SYNOP, SHIP and TEMP), Republic of Korea (TEMP) and the Philippines (SYNOP and TEMP) conducted frequent observation during the period and shared data with the Committee Members through GTS. Results of the monitoring are available on the GISC Tokyo Server at: http://www.wis-jma.go.jp/monitoring/data/monitoring/.

8. Implementation Plan

Table 7 shows the implementation plan of the Center for the period from 2018 to 2022.

Table 1 Monthly and annual total numbers of products issued by the RSMC Tokyo - Typhoon Center in 2018

Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
IUCC10	14	24	54	7	0	115	250	375	232	132	114	19	1336
WTPQ20-25	21	27	64	7	0	149	281	400	251	135	141	40	1516
WTPQ30-35	10	13	32	4	0	74	140	197	124	67	68	21	750
WTPQ50-55	0	10	27	1	0	11	56	92	75	53	21	0	346
FXPQ20-25	20	26	64	6	4	144	274	195	120	67	68	20	1008
FXPQ30-35	0	0	0	0	0	0	0	195	120	67	68	20	470
FKPQ30-35	10	13	32	3	0	73	138	195	124	67	68	20	743
AXPQ20	2	1	2	1	0	0	2	4	4	9	1	4	30

Notes:

IUCC10 RJTD	SAREP (BUFR format)
WTPQ20-25 RJTD	RSMC Tropical Cyclone Advisory
WTPQ30-35 RJTD	RSMC Prognostic Reasoning
WTPQ50-55 RJTD	RSMC Tropical Cyclone Advisory for five-day track forecast
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 2018

Tropical Cyclone			24-hour Forecast				48-hour Forecast				72-hour Forecast				96-hour Forecast				120-hour Forecast			
			Mean (km)	S.D. (km)	Num.	EO/EP (%)	Mean (km)	S.D. (km)	Num.	EO/EP (%)	Mean (km)	S.D. (km)	Num	EO/EP (%)	Mean (km)	S.D. (km)	Num	EO/EP (%)	Mean (km)	S.D. (km)	Num	EO/EP (%)
TS	Bolaven	(1801)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Sanba	(1802)	120	51	4	42	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Jelawat	(1803)	90	40	23	34	141	65	19	25	247	89	15	27	339	90	11	28	344	26	7	16
TS	Ewiniar	(1804)	60	31	11	21	122	64	5	23	-	-	0	-	-	-	0	-	-	-	0	-
STS	Maliksi	(1805)	67	51	12	14	92	31	8	7	153	39	4	8	-	-	0	-	-	-	0	-
TS	Gaemi	(1806)	141	73	4	98	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Prapiroon	(1807)	77	35	17	32	248	90	13	43	560	197	9	51	867	43	4	47	898	0	1	-
TY	Maria	(1808)	60	31	25	34	107	31	21	25	173	43	17	21	276	52	13	25	418	118	9	38
TS	Son-tinh	(1809)	45	27	4	13	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
STS	Ampil	(1810)	82	29	16	31	110	36	12	18	208	48	8	16	344	9	4	13	-	-	0	-
STS	Wukong	(1811)	55	15	10	29	104	28	6	20	160	48	2	-	-	-	0	-	-	-	0	-
TY	Jongdari	(1812)	83	41	30	15	128	101	26	11	243	132	21	13	448	181	15	21	636	183	11	21
TY	Shanshan	(1813)	54	33	25	31	99	44	21	31	117	64	17	34	194	137	13	53	201	106	9	38
TS	Yagi	(1814)	109	39	16	44	235	53	12	41	400	50	7	37	425	67	3	21	-	-	0	-
STS	Leepi	(1815)	178	56	9	153	340	59	5	127	-	-	0	-	-	-	0	-	-	-	0	-
TS	Bebinca	(1816)	110	58	13	65	100	45	9	22	96	26	5	9	120	0	1	-	-	-	0	-
TS	Hector	(1817)	45	23	2	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Rumbia	(1818)	39	23	7	14	111	67	3	4	-	-	0	-	-	-	0	-	-	-	0	-
TY	Soulik	(1819)	28	17	31	12	79	54	27	14	174	120	23	19	323	175	19	25	538	227	15	34
TY	Cimaron	(1820)	67	38	20	27	89	47	16	17	109	94	12	16	169	63	8	16	243	81	4	24
TY	Jebi	(1821)	43	21	29	21	86	70	24	19	121	50	20	15	219	151	16	19	388	256	12	29
TY	Mangkhut	(1822)	53	29	35	33	95	43	31	27	151	71	27	23	226	104	23	23	311	163	19	23
TS	Barijat	(1823)	51	32	5	35	103	0	1	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Trami	(1824)	48	32	35	20	58	26	30	12	95	35	26	13	184	100	22	19	426	244	18	30
TY	Kong-rey	(1825)	50	28	25	28	107	55	21	29	202	121	17	35	336	196	13	41	556	252	9	49
TY	Yutu	(1826)	44	38	41	25	71	47	37	19	136	80	33	25	236	125	29	33	343	179	25	35
TS	Toraji	(1827)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Man-yi	(1828)	119	57	19	27	185	68	15	18	209	75	11	11	213	96	7	7	467	108	3	22
STS	Usagi	(1829)	64	31	12	37	77	34	7	17	91	11	2	8	-	-	0	-	-	-	0	-
Annual Mean (Total)			66	46	480	27	112	77	369	20	179	128	276	20	277	172	201	24	409	226	142	29

Notes: S.D. means standard deviation of operational forecast errors.
Num. means numbers of forecasts.
EO/EP indicates the ratio of EO (mean position error of operational forecasts) to EP (mean position error of forecasts by the persistency forecast).

Table 3 Mean hitting ratios (%) and radii (km) of 70% probability circles issued for track forecasts for the TCs in 2018

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)
TS	Bolaven	(1801)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
TS	Sanba	(1802)	25	4	111	-	0	-	-	0	-	-	0	-	-	0	-
TY	Jelawat	(1803)	61	23	106	79	19	198	73	15	310	100	11	450	100	7	601
TS	Ewiniar	(1804)	91	11	145	100	5	263	-	0	-	-	0	-	-	0	-
STS	Maliksi	(1805)	83	12	136	100	8	269	100	4	407	-	0	-	-	0	-
TS	Gaemi	(1806)	50	4	148	-	0	-	-	0	-	-	0	-	-	0	-
TY	Prapiroon	(1807)	82	17	127	46	13	244	33	9	391	0	4	556	0	1	787
TY	Maria	(1808)	96	25	101	100	21	192	100	17	254	100	13	370	78	9	537
TS	Son-tinh	(1809)	100	4	106	-	0	-	-	0	-	-	0	-	-	0	-
STS	Ampil	(1810)	75	16	109	100	12	201	88	8	259	100	4	370	-	0	-
STS	Wukong	(1811)	100	10	111	100	6	204	100	2	259	-	0	-	-	0	-
TY	Jongdari	(1812)	83	30	120	81	26	217	71	21	325	40	15	456	55	11	643
TY	Shanshan	(1813)	84	25	101	95	21	188	94	17	282	92	13	501	100	9	787
TS	Yagi	(1814)	50	16	112	25	12	204	0	7	254	33	3	370	-	0	-
STS	Leepi	(1815)	11	9	111	0	5	204	-	0	-	-	0	-	-	0	-
TS	Bebinca	(1816)	38	13	98	100	9	176	100	5	274	100	1	389	-	0	-
TS	Hector	(1817)	100	2	111	-	0	-	-	0	-	-	0	-	-	0	-
TS	Rumbia	(1818)	100	7	103	67	3	185	-	0	-	-	0	-	-	0	-
TY	Soulik	(1819)	100	31	107	100	27	198	83	23	278	74	19	443	60	15	673
TY	Cimaron	(1820)	80	20	114	100	16	213	83	12	272	100	8	444	100	4	695
TY	Jebi	(1821)	100	29	116	96	24	208	100	20	282	88	16	391	83	12	546
TY	Mangkhut	(1822)	97	35	111	100	31	203	85	27	259	87	23	370	79	19	537
TS	Barijat	(1823)	80	5	100	100	1	176	-	0	-	-	0	-	-	0	-
TY	Trami	(1824)	94	35	111	100	30	204	100	26	276	91	22	411	72	18	578
TY	Kong-rey	(1825)	92	25	104	90	21	193	59	17	254	62	13	385	56	9	537
TY	Yutu	(1826)	90	41	99	100	37	187	88	33	253	90	29	398	92	25	618
TS	Toraji	(1827)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
TY	Man-yi	(1828)	42	19	101	53	15	187	64	11	263	100	7	508	100	3	756
STS	Usagi	(1829)	75	12	113	100	7	201	100	2	241	-	0	-	-	0	-
Annual Mean (Total)			82	480	110	89	369	203	82	276	279	82	201	419	78	142	610

Table 4 Root mean square errors and mean errors of central pressure (4a: left) and maximum sustained wind (4b: right) forecasts for the TCs in 2018

Tropical Cyclone			24-hour Forecast			48-hour Forecast			72-hour Forecast		
			Error (hPa)	RMSE (hPa)	Num.	Error (hPa)	RMSE (hPa)	Num.	Error (hPa)	RMSE (hPa)	Num.
TS	Bolaven	(1801)	-	-	0	-	-	0	-	-	0
TS	Sanba	(1802)	-2.5	2.6	4	-	-	0	-	-	0
TY	Jelawat	(1803)	14.4	27.5	23	20.7	33.0	19	24.5	36.3	15
TS	Ewiniar	(1804)	1.8	2.1	11	2.0	2.0	5	-	-	0
STS	Maliksi	(1805)	0.3	3.3	12	2.5	5.0	8	-2.5	3.5	4
TS	Gaemi	(1806)	0.0	1.4	4	-	-	0	-	-	0
TY	Prapiroon	(1807)	7.0	9.7	17	13.2	16.5	13	24.7	26.1	9
TY	Maria	(1808)	1.2	20.3	25	-1.0	21.5	21	-4.5	17.0	17
TS	Son-tinh	(1809)	-0.5	1.0	4	-	-	0	-	-	0
STS	Ampil	(1810)	-2.0	6.0	16	-5.8	7.4	12	-1.1	7.2	8
STS	Wukong	(1811)	-1.8	2.6	10	-1.0	3.9	6	-4.0	4.0	2
TY	Jongdari	(1812)	-1.4	7.0	30	2.2	9.1	26	4.4	9.6	21
TY	Shanshan	(1813)	-4.4	10.4	25	-4.6	10.3	21	-4.2	5.8	17
TS	Yagi	(1814)	-1.3	2.3	16	-1.1	3.0	12	1.4	2.3	7
STS	Leepi	(1815)	4.2	4.9	9	10.4	11.0	5	-	-	0
TS	Bebinca	(1816)	-1.2	4.1	13	2.7	3.6	9	3.6	4.6	5
TS	Hector	(1817)	-4.0	4.0	2	-	-	0	-	-	0
TS	Rumbia	(1818)	7.7	8.2	7	7.0	7.1	3	-	-	0
TY	Soulik	(1819)	0.3	7.9	31	1.5	9.5	27	4.7	8.7	23
TY	Cimaron	(1820)	3.2	6.9	20	8.7	12.3	16	10.5	17.7	12
TY	Jebi	(1821)	1.6	11.6	29	4.2	21.7	24	5.8	23.7	20
TY	Mangkhut	(1822)	1.7	10.5	35	0.1	12.6	31	-1.2	16.3	27
TS	Barijat	(1823)	-5.2	5.9	5	-10.0	10.0	1	-	-	0
TY	Trami	(1824)	-7.4	14.5	35	-12.3	20.0	30	-12.1	22.0	26
TY	Kong-rey	(1825)	0.2	27.1	25	-2.1	38.0	21	-13.8	35.2	17
TY	Yutu	(1826)	-3.3	18.6	41	-5.1	23.1	37	-15.1	24.6	33
TS	Toraji	(1827)	-	-	0	-	-	0	-	-	0
TY	Man-yi	(1828)	-4.4	14.8	19	-0.7	18.0	15	-2.3	16.4	11
STS	Usagi	(1829)	-6.7	9.4	12	-0.9	1.3	7	1.0	1.4	2
Annual Mean (Total)			-0.1	13.8	480	0.5	18.7	369	-0.8	20.4	276

Tropical Cyclone			24-hour Forecast			48-hour Forecast			72-hour Forecast		
			Error (m/s)	RMSE (m/s)	Num.	Error (m/s)	RMSE (m/s)	Num.	Error (m/s)	RMSE (m/s)	Num.
TS	Bolaven	(1801)	-	-	0	-	-	0	-	-	0
TS	Sanba	(1802)	2.6	2.6	4	-	-	0	-	-	0
TY	Jelawat	(1803)	-5.5	11.1	23	-8.4	13.8	19	-10.3	15.1	15
TS	Ewiniar	(1804)	-1.4	2.2	11	-1.0	1.6	5	-	-	0
STS	Maliksi	(1805)	1.1	1.7	12	1.0	2.0	8	3.2	3.4	4
TS	Gaemi	(1806)	-1.3	1.8	4	-	-	0	-	-	0
TY	Prapiroon	(1807)	-0.6	2.3	17	-2.4	4.3	13	-9.1	9.9	9
TY	Maria	(1808)	-0.7	7.1	25	0.1	7.3	21	1.7	5.6	17
TS	Son-tinh	(1809)	1.3	1.8	4	-	-	0	-	-	0
STS	Ampil	(1810)	1.6	3.6	16	3.4	4.8	12	2.3	4.4	8
STS	Wukong	(1811)	1.0	1.6	10	0.4	2.8	6	0.0	0.0	2
TY	Jongdari	(1812)	2.1	4.8	30	1.4	5.2	26	-0.5	5.1	21
TY	Shanshan	(1813)	1.5	4.4	25	1.7	4.2	21	1.1	2.4	17
TS	Yagi	(1814)	0.8	1.4	16	0.9	2.1	12	0.0	1.9	7
STS	Leepi	(1815)	-4.3	5.5	9	-11.8	12.0	5	-	-	0
TS	Bebinca	(1816)	0.2	2.4	13	-2.6	3.1	9	-4.1	4.3	5
TS	Hector	(1817)	2.6	2.6	2	-	-	0	-	-	0
TS	Rumbia	(1818)	-1.8	2.6	7	0.0	0.0	3	-	-	0
TY	Soulik	(1819)	0.6	3.4	31	0.5	4.4	27	-1.1	3.7	23
TY	Cimaron	(1820)	-1.4	3.3	20	-2.4	3.6	16	-2.4	5.2	12
TY	Jebi	(1821)	-1.0	3.7	29	-1.0	5.4	24	-0.4	5.0	20
TY	Mangkhut	(1822)	-0.5	3.4	35	0.1	4.6	31	0.5	5.2	27
TS	Barijat	(1823)	4.1	4.6	5	7.7	7.7	1	-	-	0
TY	Trami	(1824)	2.0	4.7	35	3.9	6.0	30	3.9	6.2	26
TY	Kong-rey	(1825)	-0.3	9.5	25	1.7	13.4	21	6.4	13.1	17
TY	Yutu	(1826)	1.3	6.6	41	2.2	7.5	37	5.9	8.7	33
TS	Toraji	(1827)	-	-	0	-	-	0	-	-	0
TY	Man-yi	(1828)	1.5	7.5	19	-0.7	8.3	15	0.5	7.7	11
STS	Usagi	(1829)	0.2	4.8	12	-1.1	2.2	7	-5.1	5.1	2
Annual Mean (Total)			0.1	5.4	480	0.1	6.9	369	0.6	7.3	276

Table 5 Example of RSMC Tropical Cyclone Advisory including 96 and 120 hour intensity forecast
(Subject to change)

Example of a new bulletin with 96- and 120-hour intensity forecast	Example of an existing WTPQ5x bulletin
WTPQ52 RJTD 160000 RSMC TROPICAL CYCLONE ADVISORY NAME TS 1721 LAN (1721) UPGRADED FROM TD ANALYSIS PSTN 160000UTC 10.1N 135.3E FAIR MOVE WNW 08KT PRES 996HPA MXWD 040KT GUST 060KT 30KT 120NM FORECAST 24HF 170000UTC 10.2N 132.9E 50NM 70% MOVE W 06KT PRES 985HPA MXWD 050KT GUST 070KT 48HF 180000UTC 11.4N 132.5E 95NM 70% MOVE NNW SLOWLY PRES 970HPA MXWD 065KT GUST 095KT 72HF 190000UTC 15.5N 130.4E 130NM 70% MOVE NNW 11KT PRES 970HPA MXWD 065KT GUST 095KT 96HF 200000UTC 18.8N 130.0E 200NM 70% MOVE N 08KT PRES 965HPA MXWD 070KT GUST 100KT 120HF 210000UTC 21.3N 131.2E 280NM 70% MOVE NNE 07KT PRES 925HPA MXWD 095KT GUST 135KT =	WTPQ52 RJTD 160000 RSMC TROPICAL CYCLONE ADVISORY NAME TS 1721 LAN (1721) UPGRADED FROM TD ANALYSIS PSTN 160000UTC 10.1N 135.3E FAIR MOVE WNW 08KT PRES 996HPA MXWD 040KT GUST 060KT 30KT 120NM FORECAST 24HF 170000UTC 10.2N 132.9E 50NM 70% MOVE W 06KT PRES 985HPA MXWD 050KT GUST 070KT 48HF 180000UTC 11.4N 132.5E 95NM 70% MOVE NNW SLOWLY PRES 970HPA MXWD 065KT GUST 095KT 72HF 190000UTC 15.5N 130.4E 130NM 70% MOVE NNW 11KT PRES 970HPA MXWD 065KT GUST 095KT 96HF 200000UTC 18.8N 130.0E 200NM 70% MOVE N 08KT 120HF 210000UTC 21.3N 131.2E 280NM 70% MOVE NNE 07KT =

Table 6 Products of RSMC Tokyo via NTP website

Products	Frequency	Details
Advisories		
Prognostic Reasoning	4 times/day	• RSMC Tokyo Tropical Cyclone Prognostic Reasoning (WTPQ)
RSMC TC Advisory	At least 8 times/day	• RSMC Tokyo – Typhoon Center's TC analysis, track forecast up to 120-hours and intensity forecast up to 72-hours (linked to JMA's website: https://www.jma.go.jp/en/typh/)
Graphical TC Advisory	4 times/day	• Graphical TC Advisory including RSMC Tokyo – Typhoon Center's TC analysis, track and intensity forecast up to 24-hours and horizontal extent of cumulonimbus cloud and cloud top height associated with TCs potentially affecting aviation safety (linked to Tropical Cyclone Advisory Center Tokyo Website: https://www.data.jma.go.jp/fcd/tca/data/index.html)
Operational Remarks		• Advance notice on TC status change from RSMC Tokyo – Typhoon Center
Track Bulletin	4 times/day	• RSMC Tokyo Tropical Cyclone Track Forecast Bulletin - Track forecast by deterministic GSM (FXPQ2X) - Track forecast by GEPS (FXPQ3X)
Observation/Analysis		
TC 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 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
Radar	Every hour	• Radar composite imagery of the Typhoon Committee Regional Radar Network
Weather Maps	4 times/day	• Weather maps for surface analysis, 24- and 48-hour forecast (linked to JMA's website: https://www.jma.go.jp/en/g3/)
Upper-Air Analysis	4 times/day	• Upper-air analysis based on GSM initial field data - Streamlines at 850 and 200 hPa - Vertical wind shear between 200 and 850 hPa - Divergence at 200 hPa - Vorticity at 850 hPa
Ocean Analysis	Once/day	• Sea surface temperature and difference from 24 hours ago • Tropical cyclone heat potential and difference from 24 hours ago
Forecasting/NWP		
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 ensemble NWP models from four centers (ECMWF, NCEP, UKMO and JMA)
NWP Weather Maps	Twice/day	• Mean sea level pressure and 500 hPa Geopotential height (up to 72 hours at 00 UTC, up to 168 hours at 12 UTC) of deterministic NWP models from nine centers (BoM, CMA, CMC, DWD, ECMWF, KMA, NCEP, UKMO and JMA)
TC Activity Prediction	Twice/day	• Two- and five-day TC activity prediction maps based on ensemble NWP models from four centers (ECMWF, NCEP, UKMO and JMA) and a related consensus

Storm Surge/Waves		
Storm Surge Forecasts	4times/day	• Distribution maps of storm surge for RSMC Tokyo – Typhoon Center's TC track forecast and each of five TC track forecasts selected from GEPS ensemble members and maximum storm surge among these six TC track forecasts (up to 72 hours ahead) • Time-series storm surge forecast charts for RSMC Tokyo – Typhoon Center's TC track forecast and each of five TC track forecasts selected from GEPS ensemble members (up to 72 hours ahead)
Ocean Wave Forecasts	Twice/day	• Distribution maps of 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 ahead) • Time-series of box-and-whisker plots of wave height and period, and probability of exceeding various thresholds of wave height and period based on Wave Ensemble System (WENS) (up to 264 hours ahead)

Table 7 Implementation Plans of the RSMC Tokyo - Typhoon Center (2018 - 2022)

PRODUCT	2018	2019	2020	2021	2022	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 Advisory						
RSMC Tropical Cyclone Advisory						8 times/day Intensity forecast for 96 and 120 hrs will start on 14 March 2019
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 ahead (GSM) 4 times/day up to 132 hrs ahead (GEPS)
Web-based RSMC Advisories / Products						
Numerical Typhoon Prediction Website						
Graphical Tropical Cyclone Advisory						
Experimental CAP Tropical Cyclone Advisory						
Others						
RSMC Tropical Cyclone Best Track						
Annual Report						Publication
Technical Review						Publication (as necessary)
Tropical Cyclone Reanalysis						

SUPPORTING ACTIVITY	2016	2017	2018	2019	2020	REMARKS
Attachment Training						
Data archive						
Monitoring of data exchange						
Dissemination of products via GISC Tokyo						

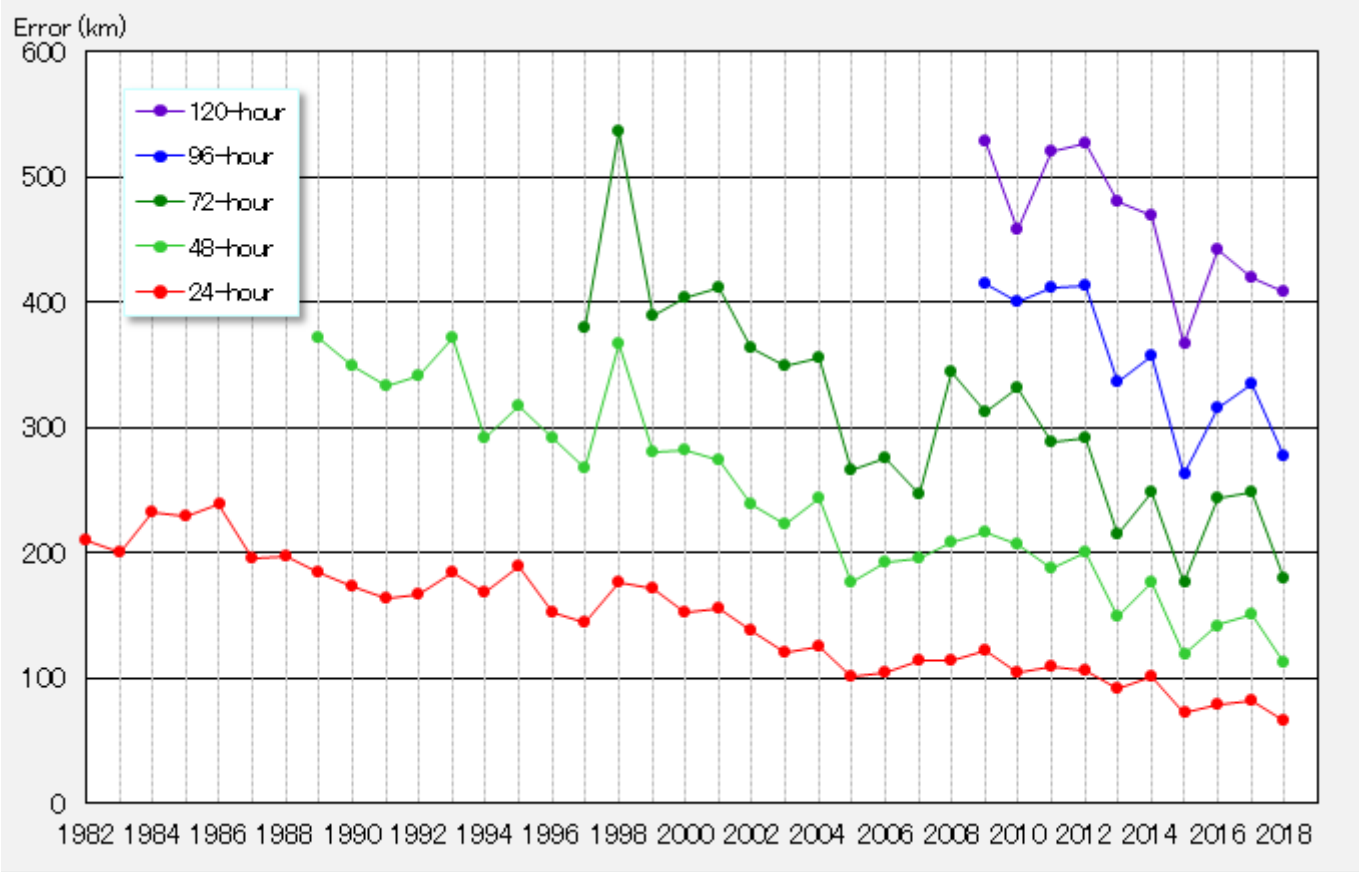

Figure 1 Annual mean position errors of track forecasts
Vertical axis: position error (km), Horizontal axis: year