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ACTIVITIES OF THE RSMC TOKYO - TYPHOON CENTER IN 2017

(Submitted by the RSMC Tokyo - Typhoon Center)

ACTION REQUIRED:

The Committee is invited to review the activities of the RSMC Tokyo - Typhoon Center in 2017 and future plans.

APPENDIXES:

A) DRAFT TEXT FOR INCLUSION IN SESSION REPORT

B) RSMC Tokyo - Typhoon Center Activity Report 2017 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 2017

1. The Committee noted with appreciation the review of RSMC advisories, products and operational activities and changes made in 2017. It noted the forecast verification results for 27 typhoons formed in 2017: the forecast track errors of the year of 82 km (79 km in 2016), 151 km (142 km), 248 km (243 km), 335 km (316 km) and 420 km (442 km) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively, the annual mean RMSEs for central pressure forecasts of 10.1 hPa (14.6 hPa), 14.9 hPa (21.5 hPa) and 16.9 hPa (23.4 hPa) for 24-, 48- and 72-hour forecasts, respectively, and those for maximum wind speed forecasts for 24-, 48- and 72-hour forecasts of 5.0 m/s (6.5 m/s), 6.8 m/s (8.9 m/s) and 7.8 m/s (10.0 m/s), respectively.

2. The Committee noted planned changes of RSMC advisories, products and operational activities, particularly the advance notice of upgrade to a tropical storm, intensity forecast for 96 and 120 hours and the extended RSMC Guidance for Forecast.

3. The Committee expressed its appreciation to the operation of RSMC Tokyo's Numerical Typhoon Prediction (NTP) website and noted changes made in 2017.

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. The Committee noted RSMC Tokyo's efforts to publish verification results of storm surge products in Annual Report on the Activities of the RSMC Tokyo and encouraged Members to make their tide observation available in University of Hawaii Sea Level Center (UHSLC) data base to contribute to the verification activity.

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

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 having made available the three Members' radar composite imagery on the NTP website since October 2017. It also noted with appreciation that a technical meeting for the experts of the three Members was held at the JMA headquarters in December 2017 to discuss technical issues to improve data quality of nationwide radar composite maps developed by TMD and MMD and to discuss challenges for the development and improvement of Quantitative Precipitation Estimation (QPE) techniques as well as the utilization of Doppler velocity data.

7. The Committee was informed that The Tropical Cyclone Forecaster Competency Task Team met in Guam 14 – 16 March 2017 and produced the final draft of the Competency, which included 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). The final draft was submitted to the Committee's 50th annual session for its approval and the inclusion in the Typhoon Committee Operational Manual - Meteorological Components (TOM).

8. The Committee noted with appreciation that RSMC Tokyo published the RSMC Tokyo Technical Review No.19 and the Annual Report on the Activities of the RSMC Tokyo Typhoon Center 2016 in March and December 2017 respectively.

9. 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 1995 has been completed. In addition, TC satellite analysis datasets for the period from 2004 to 2013 were investigated and the re-analysis was partially completed. RSMC Tokyo plans to complete re-analysis 1987 to 2013 by the end of 2018.

10. 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 technical supports for Members to utilize Himawari products. The Committee noted JMA's new international service for Target Area observation requests.

11. The Committee was pleased to note that RSMC Tokyo conducted the 17th Attachment Training from 11 to 21 December 2017, inviting three forecasters from Hong Kong, China; Thailand; and Viet Nam. 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 three forecasters from PTC Members: Bangladesh, Maldives and Myanmar.

12. The Committee noted the results of the annual observation exchange monitoring during the period of two typhoons in 2017: Hato (1713) and Doksuri (1719), which highlighted the special observation conducted by Hong Kong, China and the Philippines during the periods. It expressed its appreciation to the two 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 2017 and future plans

1. RSMC Advisories, Products and Operational Activities

The RSMC Tokyo - Typhoon Center provides the Typhoon Committee (TYC) 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 2017 and summarizes changes and future plans.

1.1 Review of RSMC advisories, products and operational activities in 2017

Table 1 shows the total number of products issued by the Center in 2017.

✧ **Verification of Track Forecasts**

Operational track forecasts for 27 Tropical Cyclones (TCs) that reached Tropical Storm (TS) intensity or higher in 2017 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 82 km (79 km in 2016), 151 km (142 km), 248 km (243 km), 335 km (316 km) and 420 km (442 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 2017 are 78% (78% in 2016), 79% (79%), 75% (79%), 68% (78%) and 75% (69%), 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 2017. The annual mean RMSEs for central pressure forecasts are 10.1 hPa (14.6 hPa in 2016), 14.9 hPa (21.5 hPa) and 16.9 hPa (23.4 hPa) for 24-, 48- and 72-hour forecasts, respectively, while those for maximum wind speed forecasts for 24-, 48- and 72-hour forecasts are 5.0 m/s (6.5 m/s in 2016), 6.8 m/s (8.9 m/s) and 7.8 m/s (10.0 m/s), respectively.

1.2 Changes in RSMC advisories, products and operational activities in 2017

✧ **Track Forecast Probability Circles**

In June 2017, track forecast probability circles for 96- and 120-hour forecasts were updated based on the latest forecast results using JMA's new Global EPS (GEPS), which was introduced in January 2017 as the replacement of Typhoon EPS and One-week EPS (WEPS). Verification results of the circles are shown in section 1.1.

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

✧ **RSMC Prognostic Reasoning**

On 1 January 2018, RSMC Tokyo started providing RSMC Prognostic Reasoning at 06 and 18UTC, in addition to 00 and 12UTC. It also changed the contents to include detailed

information, such as models and guidance used to produce forecasts and justification of forecaster's decision.

✧ **Advance notice of upgrade to TS**

RSMC Tokyo is in a test phase of operation and a system to provide advance notices to registered Committee Members through email and RSMC Tokyo's NTP website, when a tropical depression is upgraded to a tropical storm, as supplementary information of RSMC tropical cyclone advisory. An advanced notice is planned to be provided approximately an hour before to half an hour after the reference time of an official RSMC advisory, e.g. approximately from 23:00 to 00:30 in the case of an RSMC advisory with 00UTC reference time. This advanced notice may not be provided and should not be considered as an official RSMC advisory and/or its replacement.

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

RSMC Tokyo is planning to start providing intensity forecast for 96 and 120 hours in the first quarter of 2019, based on several tropical cyclone intensity forecast guidance products including the one based on the Statistical Hurricane Intensity Prediction Scheme (SHIPS). The new 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).

✧ **Extended RSMC Guidance for Forecast**

RSMC Tokyo is planning to extend the forecast time of RSMC Guidance for forecast to 132 hours in June 2018, based on the extended forecast time of the Global Spectral Model (GSM), JMA's deterministic global model. At the same time, a new abbreviated heading of GTS will be used for bulletins of RSMC Guidance for Forecast using JMA's ensemble model, which is being reported with the same heading of those using GSM (FXPQ20-25 RJTD). Details will be announced to the Members in due course. Model outputs of GSM, provided through GTS and the GISC Tokyo server will also be provided with the extended forecast time of 132 hours.

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. In the year of 2017, following changes were made to the site.

✧ **Vorticity at 850 hPa level and wind field divergence at 200 hPa level**

These products are used to identify lower-layer winds that could develop into tropical cyclones and upper-layer areas with divergence

✧ **Expansion of charts area**

Chart areas showing stream line content at 850 and 200 hPa, vertical wind shear, sea surface temperature (SST) and tropical cyclone heat potential (TCHP) were expanded to cover all Typhoon Committee Member areas.

✧ **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 UK Met Office (UKMO), and plans to add those of JMA and NCEP, and a multi-center grand ensemble of these four. (See paragraph 3.2).

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 TYC 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).

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). 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 Global Ensemble Prediction System (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 Typhoon Committee Members. As of November 2017, 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. At 27 stations out of the 78 stations, only storm surge is plotted, as astronomical tide data are not available. In 2018, RSMC Tokyo plans to provide astronomical tides estimated by an ocean tide model such as OTIS (OSU Tidal Inversion Software) at these 27 stations, in order for forecasters to estimate storm tide in time series charts, although it is less accurate than the estimated values from observed data.

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) (since 2016) consist of data on ensemble mean/3rd quantile/maximum wave heights, probability of wave heights exceeding 2, 3, 4, 5 and 6 m, and ensemble spread. Boxplot data and information on probabilities exceeding a certain level for selected stations are also provided on the site. WENS covers most of the global region and has a 1.25-degree grid resolution. It is run once a day at 12 UTC and enables prediction of ocean wave conditions up to 264 hours ahead with 27 members.

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 Typhoon 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 maps display potential tropical cyclone activity in consideration of the probability that a TC will be present 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 number of ensemble models used for consensus will be expanded to four in near future, by adding those of NCEP and JMA, and a multi-center grand ensemble (MCGE).

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. In December 2017, the Malaysia Meteorological Department (MMD), the Thai Meteorological Department (TMD) and JMA had a technical meeting to discuss technical issues to be addressed and future plans, including a further expansion of this project to other Members of interest such as Lao P.D.R., Viet Nam, and the Philippines in the future.

3.4 Tropical Cyclone Forecaster Competency

At the 66th World Meteorological Organization (WMO) Executive Council, the need for development of the tropical cyclone (TC) forecaster 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 RSMC Tokyo and Honolulu to develop draft TC forecaster 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. Since the latter originated from the first one, contents of these documents are quite similar, except that the latter has the competency requirement for non-forecast offices which primarily interprets provided forecasts for use in an advisory capacity to the emergency services, local media etc (Category 3). At the 10th Integrated Workshop of the Typhoon Committee (Malaysia, October 2015), RSMCs and Tokyo and Honolulu reported that both versions describe a list of requirements comprehensively enough to be used as a draft of the TC forecast competencies for the ESCAP/WMO Typhoon Committee. The RSMCs also indicated that all the Typhoon Committee Members have dedicated Meteorological Services, and thus a category for non-forecast offices, namely Category 3 of the Hurricane Committee version would not need to be included into the Typhoon Committee version. In addition, it should be considered that some Typhoon Committee Members still rely on TC forecasts of the RSMCs or other agencies to issue their TC information, TC competency requirements for such Members need to be included.

In October 2016, RSMC Honolulu and Tokyo circulated the draft version of TC forecast competency, which was developed largely based on the WMO International TC Competencies Regional Association (RA) V (version 1.3). Views of Members were collected. Also, for further discussion, focal points on this matter were set up. The Tropical Cyclone Forecaster Competency Task Team, which consists of the focal points and other experts, met in Guam from March 14 to 16 2017 to discuss 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 will be used as guidance in Typhoon Committee Attachment Training at RSMC Tokyo and other training activities. The final draft will be reported by the Working Group on Meteorology for the approval of this annual session of Typhoon Committee.

4. Publications

4.1 Technical Review

RSMC Tokyo published *Comparative Study of Dvorak Analysis in the western North Pacific* and *Upgrade of JMA's Storm Surge Prediction for the WMO Storm Surge Watch Scheme (SSWS)* as its Technical Review No. 19 in March 2017, which is available on the Center's website at http://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 2016 in December 2017, which is available on the Center's website at http://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 2016, re-analysis for the period from 1987 to 1995 was completed. In addition, satellite analysis datasets for the period from 2004 to 2013 were

investigated and the re-analysis was partially completed. RSMC Tokyo continues to work on the TC satellite re-analysis to complete re-analysis from 1987 to 2013 by the end of 2018.

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.

Himawari-8/9 are capable of frequent and flexible observation, providing Full-Disk images of the earth every 10 minutes and regional images with shorter intervals. In regional monitoring, Target Area observation provides imagery covering a 1,000 km x 1,000 km area every 2.5 minutes with flexibility for location changes to support JMA's national and international services. The observation is normally focused on an area of active volcanoes in the domain of the Tokyo Volcanic Ash Advisory Center (VAAC), and is adapted to encompass typhoons within the responsibility area of the Regional Specialized Meteorological Center (RSMC) Tokyo Typhoon Center.

Since February 2017, JMA has been developing an international 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. The service will be launched in January 2018.

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 17th ESCAP/WMO Typhoon Committee Attachment Training 2017 course was held at JMA Headquarters from 11 to 21 December 2017. The 2017 attendees were Ms. Sze-ning Chong from Hong Kong, China, Ms. Junjuda Pornsri from Thailand, Ms. Trang Quynh Tran from Vietnam, Mr. Md Omar Faruq from Bangladesh, Mr. Abdulla Hafiz Abdul Sattar Ali from Maldives and Dr. Tin Mar Htay from Myanmar. The training focused on practical knowledge and skills related to operational tropical cyclone analysis and forecasting via lectures and exercises using the Satellite Analysis and Viewer Program (SATAID). The course covered a range of subjects including Dvorak analysis, interpretation of microwave imagery, and storm surge 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, 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.

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 2017, two typhoons, Hato (1713) and Doksuri (1719), were selected for the regular monitoring. The target Members of the monitoring are China; Hong Kong, China; Macao, China and the Philippines (Hato, 1713) and the Philippines and Viet Nam (Doksuri, 1719). The result showed that Hong Kong (SYNOP, TEMP and RADOB) and the Philippines (SYNOP and TEMP) conducted additional 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 2017 to 2020.

Table 1 Monthly and annual total numbers of products issued by the RSMC Tokyo - Typhoon Center in 2017

Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
IUCC10	0	11	0	16	0	15	268	249	168	153	60	115	1055
WTPQ20-25	0	22	0	21	0	17	306	275	189	176	73	126	1205
WTPQ30-35	0	5	0	6	0	4	72	67	48	42	18	30	292
WTPQ50-55	0	0	0	0	0	0	64	64	35	47	5	28	243
FXPQ20-25	0	22	0	20	0	16	300	270	184	174	70	124	1180
FKPQ30-35	0	11	0	10	0	8	150	135	92	87	35	62	590
AXPQ20	1	0	0	0	0	1	1	2	8	4	3	6	26

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
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 2017

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	Muifa	(1701)	101	22	2	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
STS	Merbok	(1702)	116	59	4	53	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
STS	Nanmadol	(1703)	109	17	8	16	470	153	4	28	-	-	0	-	-	-	0	-	-	-	0	-
STS	Talas	(1704)	66	30	5	38	182	0	1	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Noru	(1705)	71	42	72	30	113	50	67	17	196	73	62	18	316	129	58	21	426	167	54	24
TS	Kulap	(1706)	127	101	14	34	231	111	10	34	430	132	6	31	651	119	2	-	-	-	0	-
TS	Roke	(1707)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Sonca	(1708)	107	17	6	53	145	23	2	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Nesat	(1709)	90	54	15	49	173	69	10	53	367	96	5	63	1038	0	1	148	-	-	0	-
TS	Haitang	(1710)	183	79	4	41	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Nalgae	(1711)	38	22	11	23	104	81	7	41	128	44	3	17	-	-	0	-	-	-	0	-
TY	Banyan	(1712)	99	45	19	31	221	137	15	30	424	304	11	32	242	66	3	18	-	-	0	-
TY	Hato	(1713)	69	44	12	41	125	71	8	21	144	39	4	11	-	-	0	-	-	-	0	-
STS	Pakhar	(1714)	110	85	8	49	211	103	4	35	-	-	0	-	-	-	0	-	-	-	0	-
TY	Sanvu	(1715)	99	43	21	21	170	82	17	15	248	67	13	15	306	136	9	15	303	64	5	53
STS	Mawar	(1716)	45	15	9	29	42	26	5	22	54	0	1	-	-	-	0	-	-	-	0	-
TS	Guchol	(1717)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Talim	(1718)	73	25	29	35	152	72	25	32	305	140	21	34	464	205	17	33	610	284	13	31
TY	Doksuri	(1719)	76	50	10	40	200	54	6	52	403	128	2	-	-	-	0	-	-	-	0	-
TY	Khanun	(1720)	91	38	10	20	149	37	6	14	198	47	2	-	-	-	0	-	-	-	0	-
TY	Lan	(1721)	85	32	25	27	121	58	21	20	193	112	17	21	276	237	13	23	285	258	9	16
STS	Saola	(1722)	74	32	16	22	188	130	12	28	269	146	8	23	168	112	4	3	-	-	0	-
TY	Damrey	(1723)	40	23	7	33	105	44	3	15	-	-	0	-	-	-	0	-	-	-	0	-
TS	Haikui	(1724)	65	16	5	21	46	0	1	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Kirogi	(1725)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Kai-tak	(1726)	67	51	8	23	67	11	2	-	-	-	0	-	186	17	2	19	254	44	6	15
TY	Tembin	(1727)	94	30	15	59	148	50	11	53	236	78	7	35	287	92	3	22	-	-	0	-
Annual Mean (Total)			82	50	335	30	151	98	237	24	248	148	162	22	335	187	112	22	420	216	87	24

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 2017

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	Muifa	(1701)	100	2	148	-	0	-	-	0	-	-	0	-	-	0	-
STS	Merbok	(1702)	75	4	130	-	0	-	-	0	-	-	0	-	-	0	-
STS	Nanmadol	(1703)	100	8	162	25	4	315	-	0	-	-	0	-	-	0	-
STS	Talas	(1704)	100	5	104	100	1	204	-	0	-	-	0	-	-	0	-
TY	Noru	(1705)	88	72	111	94	67	196	90	62	288	71	58	404	78	54	551
TS	Kulap	(1706)	57	14	105	30	10	176	17	6	241	0	2	296	-	0	-
TS	Roke	(1707)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
TS	Sonca	(1708)	50	6	111	100	2	264	-	0	-	-	0	-	-	0	-
TY	Nesat	(1709)	73	15	114	60	10	194	0	5	241	0	1	444	-	0	-
TS	Haitang	(1710)	25	4	148	-	0	-	-	0	-	-	0	-	-	0	-
TS	Nalgae	(1711)	100	11	101	86	7	188	100	3	247	-	0	-	-	0	-
TY	Banyan	(1712)	68	19	117	73	15	257	55	11	407	100	3	556	-	0	-
TY	Hato	(1713)	83	12	108	88	8	204	100	4	259	-	0	-	-	0	-
STS	Pakhar	(1714)	50	8	111	50	4	204	-	0	-	-	0	-	-	0	-
TY	Sanvu	(1715)	62	21	114	76	17	217	85	13	339	78	9	430	100	5	604
STS	Mawar	(1716)	100	9	95	100	5	176	100	1	241	-	0	-	-	0	-
TS	Guchol	(1717)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
TY	Talim	(1718)	90	29	115	72	25	214	52	21	300	41	17	411	38	13	554
TY	Doksuri	(1719)	70	10	104	83	6	199	0	2	250	-	0	-	-	0	-
TY	Khanun	(1720)	60	10	100	83	6	185	50	2	241	-	0	-	-	0	-
TY	Lan	(1721)	80	25	113	90	21	205	94	17	305	77	13	412	78	9	537
STS	Saola	(1722)	88	16	122	58	12	211	75	8	347	100	4	648	-	0	-
TY	Damrey	(1723)	100	7	103	100	3	185	-	0	-	-	0	-	-	0	-
TS	Haikui	(1724)	80	5	93	100	1	176	-	0	-	-	0	-	-	0	-
TS	Kirogi	(1725)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
TS	Kai-tak	(1726)	63	8	100	100	2	176	-	0	-	100	2	389	100	6	537
TY	Tembin	(1727)	60	15	106	73	11	201	86	7	257	67	3	370	-	0	-
Annual Mean (Total)			78	335	112	79	237	206	75	162	299	68	112	418	75	87	552

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 2017

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	Muifa	(1701)	-2.0	2.0	2	-	-	0	-	-	0
STS	Merbok	(1702)	9.3	9.6	4	-	-	0	-	-	0
STS	Nanmadol	(1703)	5.1	5.9	8	8.0	8.0	4	-	-	0
STS	Talas	(1704)	2.6	3.4	5	4.0	4.0	1	-	-	0
TY	Noru	(1705)	-1.9	11.0	72	-4.1	16.2	67	-5.4	18.5	62
TS	Kulap	(1706)	-0.6	3.6	14	-0.4	3.5	10	-1.3	5.2	6
TS	Roke	(1707)	-	-	0	-	-	0	-	-	0
TS	Sonca	(1708)	3.0	3.2	6	6.0	6.0	2	-	-	0
TY	Nesat	(1709)	5.5	9.6	15	9.1	11.3	10	-2.0	11.4	5
TS	Haitang	(1710)	6.8	7.0	4	-	-	0	-	-	0
TS	Nalgae	(1711)	0.4	2.3	11	-2.1	4.1	7	2.0	2.6	3
TY	Banyan	(1712)	6.5	15.8	19	5.1	17.8	15	6.6	22.0	11
TY	Hato	(1713)	0.3	6.9	12	8.1	11.6	8	6.3	6.9	4
STS	Pakhar	(1714)	-3.6	6.6	8	-8.0	10.7	4	-	-	0
TY	Sanvu	(1715)	-4.0	9.0	21	-5.3	9.5	17	-4.2	6.9	13
STS	Mawar	(1716)	-3.1	4.0	9	-6.4	6.7	5	-15.0	15.0	1
TS	Guchol	(1717)	-	-	0	-	-	0	-	-	0
TY	Talim	(1718)	-3.1	11.9	29	-4.8	17.9	25	8.3	16.0	21
TY	Doksuri	(1719)	12.1	16.5	10	16.7	20.4	6	-15.5	16.4	2
TY	Khanun	(1720)	4.2	10.1	10	4.2	13.4	6	-12.5	14.6	2
TY	Lan	(1721)	-3.7	12.9	25	-8.3	22.5	21	-14.1	23.9	17
STS	Saola	(1722)	1.9	7.9	16	1.8	9.2	12	-0.6	4.0	8
TY	Damrey	(1723)	6.6	8.4	7	-1.0	6.6	3	-	-	0
TS	Haikui	(1724)	-6.8	6.9	5	-17.0	17.0	1	-	-	0
TS	Kirogi	(1725)	-	-	0	-	-	0	-	-	0
TS	Kai-tak	(1726)	-0.5	2.6	8	-4.0	4.5	2	-	-	0
TY	Tembin	(1727)	5.3	9.8	15	8.2	12.1	11	8.9	15.7	7
Annual Mean (Total)			0.5	10.1	335	-1.1	14.9	237	-2.4	16.9	162

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	Muifa	(1701)	0.0	0.0	2	-	-	0	-	-	0
STS	Merbok	(1702)	-6.4	6.6	4	-	-	0	-	-	0
STS	Nanmadol	(1703)	-3.5	4.0	8	-5.8	5.9	4	-	-	0
STS	Talas	(1704)	-2.1	2.8	5	-5.1	5.1	1	-	-	0
TY	Noru	(1705)	2.0	4.7	72	2.9	7.3	67	3.7	8.4	62
TS	Kulap	(1706)	0.0	2.2	14	0.0	1.2	10	0.4	2.3	6
TS	Roke	(1707)	-	-	0	-	-	0	-	-	0
TS	Sonca	(1708)	0.0	0.0	6	0.0	0.0	2	-	-	0
TY	Nesat	(1709)	-3.3	6.1	15	-4.1	6.3	10	3.1	8.9	5
TS	Haitang	(1710)	-6.4	6.6	4	-	-	0	-	-	0
TS	Nalgae	(1711)	0.2	1.7	11	2.6	2.9	7	0.0	2.1	3
TY	Banyan	(1712)	-0.5	6.3	19	0.2	7.4	15	-2.8	11.7	11
TY	Hato	(1713)	0.6	6.1	12	-5.5	7.3	8	-6.4	6.6	4
STS	Pakhar	(1714)	3.2	4.8	8	5.8	8.2	4	-	-	0
TY	Sanvu	(1715)	2.6	4.7	21	2.9	4.5	17	1.4	2.6	13
STS	Mawar	(1716)	1.7	2.4	9	4.1	4.6	5	10.3	10.3	1
TS	Guchol	(1717)	-	-	0	-	-	0	-	-	0
TY	Talim	(1718)	2.8	6.1	29	4.1	8.3	25	-0.7	6.5	21
TY	Doksuri	(1719)	-5.7	7.8	10	-6.9	8.4	6	9.0	9.8	2
TY	Khanun	(1720)	-0.5	5.0	10	0.9	7.0	6	10.3	10.6	2
TY	Lan	(1721)	2.1	5.1	25	3.4	7.7	21	5.7	8.8	17
STS	Saola	(1722)	0.5	3.5	16	0.9	3.9	12	2.6	2.9	8
TY	Damrey	(1723)	-4.4	5.3	7	-1.7	5.1	3	-	-	0
TS	Haikui	(1724)	3.6	3.8	5	10.3	10.3	1	-	-	0
TS	Kirogi	(1725)	-	-	0	-	-	0	-	-	0
TS	Kai-tak	(1726)	1.9	3.4	8	3.9	4.1	2	-	-	0
TY	Tembin	(1727)	-1.4	6.2	15	-3.0	7.1	11	-3.7	8.4	7
Annual Mean (Total)			0.5	5.0	335	1.4	6.8	237	2.1	7.8	162

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
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
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 two centers (ECMWF and UKMO) 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)
Wave Height Forecasts	4 times/day	• Distribution maps of ensemble mean wave height, maximum wave height, probability of exceeding various wave heights and ensemble spread based on Wave EPS Model (up to 264 hours ahead) • Time-series charts of ensemble mean wave height with ensemble spread information and probability of exceeding various wave heights based on Wave EPS Model (up to 264 hours ahead)

Table 7 Implementation Plans of the RSMC Tokyo - Typhoon Center (2017 - 2020)

PRODUCT	2017	2018	2019	2020	2021	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 in Q1 of 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 84 hrs ahead (GSM), extended to 132 hrs in 2018 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						

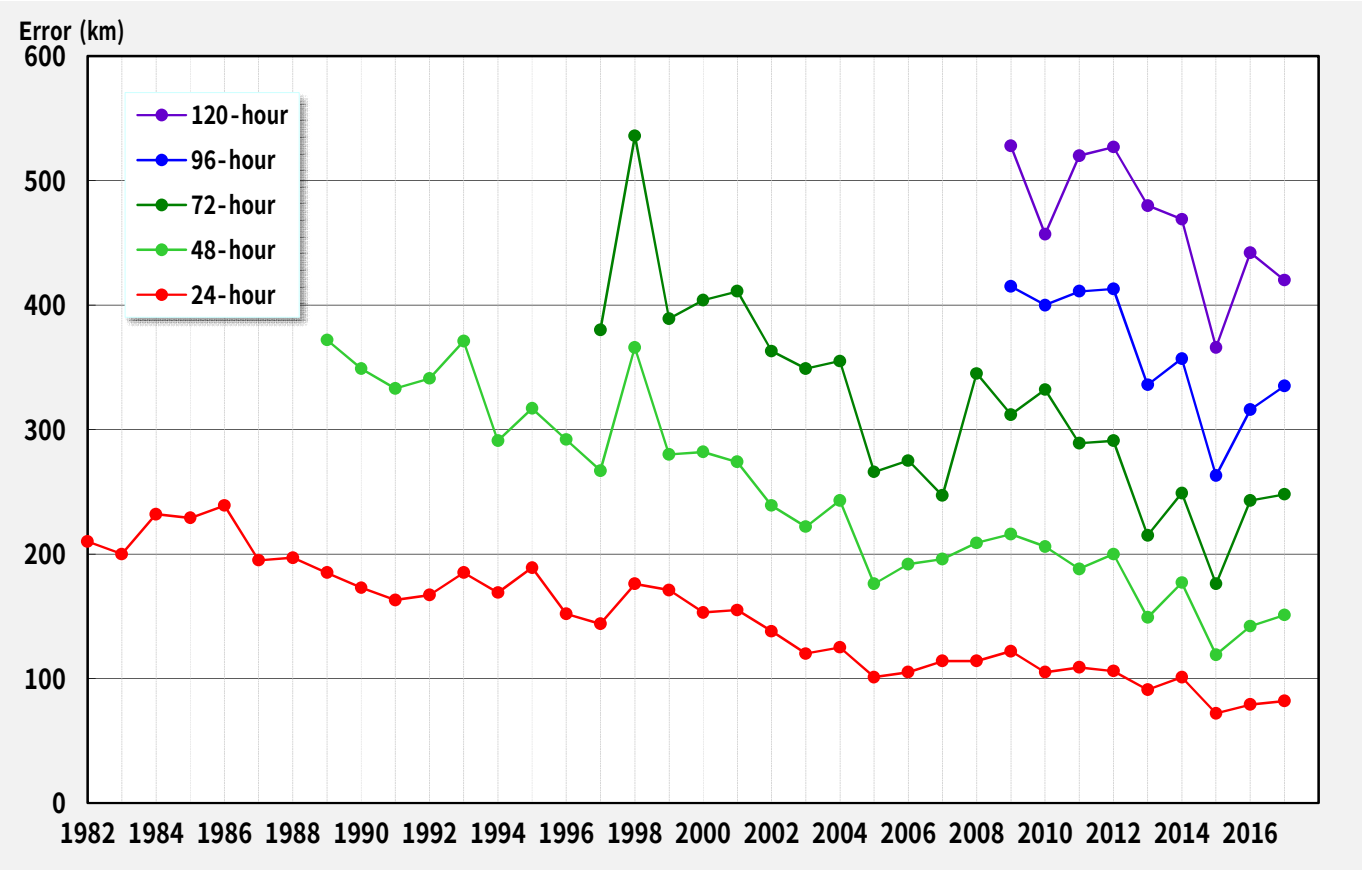

Figure 1 Annual mean position errors of track forecasts
Vertical axis: position error (km), Horizontal axis: year