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ACTIVITIES OF THE RSMC TOKYO - TYPHOON CENTER IN 2015

(Submitted by the RSMC Tokyo - Typhoon Center)

ACTION REQUIRED:

The Committee is invited to review the activities of the RSMC Tokyo - Typhoon Center in 2015.

APPENDIXES:

1) DRAFT TEXT FOR INCLUSION IN SESSION REPORT
2) RSMC Tokyo - Typhoon Center Activity Report 2015

APPENDIX A:
DRAFT TEXT FOR INCLUSION IN THE SESSION REPORT

x.x Review of the activities of the Regional Specialized Meteorological Center (RSMC) Tokyo 2015

1. The Committee was pleased that RSMC Tokyo is ready for provision of multi-scenario storm surge predictions as well as ensemble wave forecasts based on the JMA's Typhoon Ensemble Prediction System (TEPS) to the Committee Members. Verification results using tidal data available are to be included into RSMC Tokyo Annual Activity Report. Members were requested to provide tidal data for RSMC Tokyo to verify the storm surge forecasts for calculating astronomical tides and the further improvement of its storm surge model. The Committee expressed its gratitude to RSMC Tokyo for provision of storm surge forecasts to the TC Members and sharing information on storm surges through the annual TC attachment training.

2. The Committee was informed that the effectiveness of Ensemble Prediction Systems (EPS) for TC genesis forecasts was found through the work done under the joint project of World Weather Research Program (WWRP) and Tropical Cyclone Program (TCP), North Western Pacific Tropical Cyclone Ensemble Forecast Project (NWP-TCEFP). The verification identified the multi-center grand ensemble (MCGE) has better skills in TC genesis prediction than that of the best single ensemble, namely ECMWF ensemble. The Committee with appreciation noted the extension of NWP-TCEFP to 2016 for investigation of potential use of ensemble predictions for TC intensity forecasts and the planned provision of ensemble TC genesis prediction map in 2016 through the Numerical Typhoon Prediction (NTP) website if necessary data are provided.

3. The Committee reaffirmed that RSMC Tokyo participates in a sub-regional project in Southeast Asia (SWFDP-SeA) as the Regional Center for Tropical Cyclone / Typhoon Forecasting Support to provide typhoon related products, including NWP-TCEFP products at the NWP-TCEFP Home page. It noted that at the SWFDP-SeA regional Subproject Management Team Meeting, RSMC Tokyo and RFSC Hanoi agreed to work effectively, ensuring consistency of their products and avoiding duplication in accordance with the Regional Subproject Implementation Plan (RSIP).

4. 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 over the period from 1987 to 1993 has been completed. RSMC Tokyo plans to complete re-analysis up to 1998 by the end of 2016.

5. The Committee was informed that RSMC Tokyo is continuing experimental provision of TC advisory in CAP format at the JMA website (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/RSMC_HP.htm) since 12 November 2012.

6. The Committee was pleased that a technical meeting on radar composite techniques was held at TMD headquarters in December 2015 to discuss current issues on quality control of radar data, provide technical assistance for developments of QPE, and identify the way forward. Planned in 2016 are experimental test of radar data sharing among RSMC Tokyo, TMD and Malaysia Meteorological Department, technical assistance to TMD, and a technical meeting.

7. The Committee was informed that RSMC Tokyo, in cooperation with RSMC Honolulu, started drafting a Tropical Cyclone Forecaster Competency, responding to the discussion at the 66th WMO Executive Council. It noted that, in 2016, the draft is to be updated in accordance with feedbacks from the WGM Members.

8. The Committee was informed that based on the techniques utilizing the cloud grid information for the analysis of existing CB areas, RSMC Tokyo, as the TCAC Tokyo,

started providing graphical Tropical cyclone advisories (TCAs) according to MODEL TCG in the Appendix 1 of ICAO Annex 3 in August 2015.

9. The Committee was informed that Himawari-8 geostationary meteorological satellite began operation on 7 July 2015, replacing the previous MTSAT-2 operational satellite. Two new services, HimawariCast and HimawariCloud, have been established for provision of Himawari-8 data. JMA conducts training for NMHSs to enhance capacity for satellite data usage. In November 2015, a training course was held in conjunction with the 6th Asia/Oceania Meteorological Satellite Users' Conference in Tokyo, Japan.

10. The Committee was pleased that RSMC Tokyo conducted the 14th Attachment Training from 22 to 31 July 2015 inviting three forecasters from Cambodia, Thailand, and Vietnam. 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 agreed to invite three forecasters from PTC Members, i.e., Bangladesh, Maldives and Myanmar in 2015, Oman, Pakistan and Sri Lanka in 2016 on a trial basis with Japan Trust Fund. The Committee with pleasure noted that RSMC Tokyo plans to extend the training course by 2 days to provide lectures on TC warning developments with the financial supports of the WMO Secretariat.

APPENDIX B:
Activities of the RSMC Tokyo - Typhoon Center in 2015

1. Provision of RSMC Products

The RSMC Tokyo - Typhoon Center (hereinafter referred to as *the* Center) provides 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. Table 1 shows the total number of products issued by the Center in 2015.

2. Track Forecasts

Operational track forecasts for 27 Tropical Cyclones (TCs) that reached Tropical Storm (TS) intensity or higher in 2015 were verified against the Center's analysis data. Figure 1 shows the time series of the annual mean position errors of 24-hour (from 1982), 48-hour (from 1989), 72-hour (from 1997), 96-hour and 120-hour (from 2009) forecasts. The errors of the year are 72 km (101 km in 2014), 119 km (177km), 176 km (249 km), 263 km (357 km) and 366 km (469 km) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively (Table 2). The mean hitting ratios of probability circles*2 for 24-, 48-, 72-, 96- and 120-hour forecasts are 89% (78% in 2014), 93% (78%), 94% (75%), 88% (79%) and 83% (70%), respectively (Table 3).

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

3. 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 2015. The annual mean RMSEs for central pressure forecasts are 13.7 hPa (14.4hPa in 2014), 19.1 hPa (21.0 hPa) and 21.2 hPa (23.8 hPa) for 24-, 48- and 72-hour forecasts, respectively, while those of maximum wind speed forecasts for 24-, 48- and 72-hour forecasts are 5.9 m/s (6.1m/s in 2014), 8.2 m/s (8.9 m/s) and 9.0 m/s (10.4 m/s), respectively.

4. Tropical Cyclone Intensity Estimation Methods with Microwave Satellites and Radar

A new method for TC intensity estimation using single ground-based Doppler radar observations has been developed by the Centre. This method enables us to estimate TC intensity at five-minute intervals and its accuracy is comparable to or better than the accuracies of conventional methods such as Dvorak and satellite microwave-derived estimates. In addition, a weighted consensus method with TC intensity estimated based on the Dvorak technique and warm core intensity observed by the Advanced Microwave Sounding Unit-A (AMSU-A) of NOAA and MetOp series polar orbiting satellites were developed. This consensus estimate has higher accuracy than the Dvorak based TC intensity estimates. Details on these methods including their verification results are to be described in the Technical Review No. 18.

5. Numerical Typhoon Prediction (NTP) website

The Centre has been operating the NTP website since October 2004 as its contribution to the WMO/ESCAP Typhoon Committee. Products available at the website along with the planned product are listed in Table 5. On 26 May 2015, the website was re-launched with a completely new design for enriched content and improved user friendliness. The website is available only to registered organizations, including the Typhoon Committee Members and participating NWP centres. Further enhancement of the website, including real-time provision of ensemble TC genesis prediction maps, is planned next year.

6. Regional storm surge watch scheme suitable for the TYC region

In response to the results of the survey in 2009, the Center has been providing distribution maps since 1 June 2011 and time-series charts of storm surges since 5 June 2012 on the NTP website. Stations for storm surge time-series predictions have been increased on requests from the Members. As of the end of 2015, time-series storm surge predictions are provided to 51 stations; USA(1), the Philippines (10), Viet Nam (20), Hong Kong China (6), Macao China (1), Republic of Korea (11), and Thailand (2). In January 2016, 17 stations in Malaysia were added. 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 concerned. All products can be found on the NTP website. In addition to the enhancement of the storm surge prediction, RSMC Tokyo provides technical supports for Members to operationalize the JMA's storm surge model on requests of Members. In September 2015, a training workshop for operational use of JMA's marine model was held by Malaysia Meteorological Department (MMD). The storm surge forecasts have experimentally been available on a daily basis since 13 January 2016, for providing information on storm surges generated by monsoon winds or extra-tropical cyclones.

In 2016, RSMC Tokyo plans to provide multi-scenario storm surge predictions based on the JMA's Typhoon Ensemble System (TEPS). Also, ensemble wave forecasts based on Global EPS is under developments for their provision to the Typhoon Committee (incl. SWFDP SeA) at the NTP website. RSMC Tokyo verifies the storm surge model regularly whenever storm surge events occur in Japan. Verification results are to be included into annual activity reports of RSMC Tokyo from 2016. To further improve the storm surge model, verifications across the region are needed. To this end, whenever Members experience storm surge events, they are encouraged to provide hourly tidal observations during the events. RSMC Tokyo will verify the performance of the model and give feedbacks to the Members.

7. Contribution to the WMO North Western Pacific Tropical Cyclone Ensemble Forecast (NWP-TCEFP) Project

Tropical Cyclone Ensemble Forecast Information Home Page (NWP-TCEFP Home page) was launched by JMA in 2010 for the purpose of providing guidance of tropical cyclone forecasts in near real-time for TYC Members, using the TIGGE (THORPEX Interactive Grand Global Ensemble) Cyclone XML (CXML) data, under the joint project of World Weather Research Program (WWRP) and Tropical Cyclone Program (TCP), North Western Pacific Tropical Cyclone Ensemble Forecast Project (NWP-TCEFP). This web page provides deterministic and ensemble TC track forecasts, and strike probability maps based on ensemble TC track forecasts. The effectiveness of EPS for TC operational forecasts was confirmed by the questionnaire sent to TYC Members from WMO in December 2011 and 2012. To explore ways to provide those products in a more real-time basis responding to identified needs through the questionnaires, in 2014, RSMC Tokyo requested ECMWF, UKMO, and NWS to provide their ensemble NWP data on a real-time basis. Since October 2015, RSMC Tokyo has provided ensemble TC track guidance of ECMWF and NCEP to the Committee Members through the Numerical Typhoon Prediction website. RSMC Tokyo is still being under coordination with UKMO.

In addition, operational global medium-range ensemble predictions of TC genesis were systematically evaluated to further examine the skill of such forecasting and determine its potential for future operational use. The global ensembles used are ECMWF, JMA, NCEP and UKMO for the period from 2010 to 2013. It was found that operational global medium-range ensembles are capable of providing guidance on TC genesis predictions extending into the second week. Brier Skill Scores (BSS) for the western North Pacific, the Eastern and Central Pacific and the North Atlantic basins are higher than those for other basins, and ECMWF has the highest values in general. Meanwhile, BSS and reliability have been found to be sensitive to the choice of wind threshold values in the definition of model TCs. The multi-center grand ensemble (MCGE) has more skill (larger BSS) than the best single-model ensemble, namely the ECMWF ensemble for most time windows and in most TC basins.

NWP-TCEFP has been extended to 2016 to investigate potentials for operational use of ensemble predictions for TC intensity guidance. Considering that ensemble TC genesis prediction of the said four Centers and their MCGE are expected to be useful for TC genesis guidance in the region, RSMC Tokyo plans to provide ensemble TC genesis probability of these Centers to the Typhoon Committee Members through the NTP website in 2016, if necessary data are provided.

8. The Severe Weather Forecasting Demonstration Project (SWFDP) in South-east Asia

RSMC Tokyo has participated in a sub-regional project in Southeast Asia (SWFDP-SeA) as the Regional Center for Tropical Cyclone / Typhoon Forecasting Support since 2013. It has made contribution to the project through provision of typhoon related products, dispatch of experts to its training courses, developments of severe weather related products for SWFDP-SeA. The Regional Subproject Management Team Meeting of SWFDP in Southeast Asia was held in Hanoi, Viet Nam from 11 to 14 August 2015. RSMC Tokyo and RFSC Hanoi agreed, in accordance with the roles and responsibilities of RSMC Tokyo and RFSC Hanoi described in RSIP to ensure consistency between RSMC TC advisories and RFSC Hanoi guidance, and to coordinate their products to avoid duplication.

9. 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), the Center 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 over the period from 1987 to 1993 has been completed. RSMC Tokyo plans to complete re-analysis up to 1998 by the end of 2016.

10. Development of regional radar network

The Development of Regional Radar Network is one of the projects of the Working Group of Meteorology to develop a regional radar network in Southeast Asia. Toward this goal, as its first step, the Center has been providing technical assistance to the Thai Meteorological Department (TMD) for its development of the national radar network since 2011. From 2012 to 2014, TMD, with technical supports of RSMC Tokyo, worked on the application of the JMA's radar composite techniques to its nationwide radar network, as well as preliminary study on quantitative precipitation estimation (QPE) technique of its own. In December 2015, a follow-up technical meeting was held at TMD Headquarters to discuss current issues on quality control of radar data, provide technical assistance to develop QPE, and identify the way forward. In 2016, experimental testing of radar data sharing among the Centre, TMD, and Malaysia Meteorological Department are planned in addition to technical assistance to TMD.

11. Tropical Cyclone Forecaster Competency

At the 66th WMO Executive Council, the need for development of the tropical cyclone forecaster competencies by regional tropical cyclone committees under the initiative of the RSMCs was stressed, in order to ensure the quality of tropical cyclone forecasting services and to meet the 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 in 2015 of its Working Group on Meteorology.

RSMCs Honolulu and Tokyo reviewed 1) the TC Competency which was developed by BoM and submitted to the 7th RSMC/TCWC Technical Coordination Meeting (TCM) in 2012, and 2) TC Competency developed by the Hurricane Committee Task Team submitted to the RA IV Hurricane Committee in 2014 which originated from the BoM's version. At the 10th Integrated Workshop of the Typhoon Committee (Malaysia, October 2015), RSMCs Tokyo and Honolulu

reported the outcomes and their initial thoughts. In 2016, the draft is to be circulated to the Members and updated based on feedbacks from Members and discussion at the 8th TCM in 2015.

12. Tropical cyclone advisories for SIGMET in graphical format

RSMC Tokyo, as the ICAO TCAC, has developed graphical tropical cyclone advisories (hereinafter referred to as TCG) according to MODEL TCG in Appendix 1 of ICAO Annex 3. In August 2015, it started providing graphical tropical cyclone advisories including 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, Secure SADIS FTP and SADIS. WMO AHLs of the bulletin are PZXE (01-06) RJTD.

The extent of FRQ CB is automatically depicted using the technique called “Cloud Grid Information (CGI)” which utilizes JMA’s satellite images. CGI includes the information on the amount and type of clouds in a grid and enables prompt provision of the information on FRQ CB. In TCG, CBs which meet the following conditions are determined as FRQ CB associating a tropical cyclone; a) CBs existing within a gale force wind area, b) CBs existing out of a gale force wind area, but connect to CB grids within a gale force wind area; and c) CBs covering a wide area (about 100 km x 100km scale).

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.

13. Himawari-8 - Japan’s new geostationary meteorological satellite

The Himawari-8 geostationary meteorological satellite managed by JMA began operation on 7 July 2015, replacing the previous MTSAT-2 operational satellite.

Himawari-8 has 16 bands, which is more than three times the 5 bands of the previous MTSAT series. Three of these are visible bands corresponding to red, green and blue, enabling the creation of true-color images. Full-disk imagery is obtained every 10 minutes, and target-area observation is conducted at 2.5-minute intervals. The horizontal resolution is also double that of the MTSAT series. As a pioneer in the new generation of geostationary meteorological satellites, Himawari-8 is expected to show great capability for superior earth monitoring.

Prior to the start of Himawari-8’s operations, JMA established two new services known as HimawariCast (by which primary sets of imagery are provided via a communication satellite) and HimawariCloud (by which full sets of imagery are provided to National Meteorological and Hydrological Services (NMHSs) via an Internet cloud service). Most NMHSs in the Asia and the Pacific region currently incorporate Himawari-8 data from these services into their tropical cyclone monitoring and other activities.

To fully leverage the significant new capabilities of the satellite, Himawari-8 data utilization technology needs to be developed and shared with users in the Asia and the Pacific region. As a first step in this regard, JMA is conducting training for NMHS capacity development. Such events have included a training course held in conjunction with the 6th Asia/Oceania Meteorological Satellite Users’ Conference in Tokyo, Japan, in November 2015.

14. Harmonization of Tropical Cyclone Intensity Analysis

The Typhoon Committee published Assessment Report on Impacts of Climate Change on Tropical Cyclone Frequency and Intensity in the Typhoon Committee Region in 2010. The

report concluded that “For TC Intensity, differences in best track datasets available for WNP do not allow for a convincing detection of a long term trend in TC intensity change in this basin when compared with variability from natural causes.” Responding to the Report, Best-track Consolidation Meeting in Typhoon Committee was held in Hong Kong, China, December 2010. The meeting was attended by representatives from HKO, RSMC Tokyo, Joint Typhoon Warning Center (JTWC) and Shanghai Typhoon Institute (STI)/CMA. Through a case study on Typhoon Megi (1013), it was concluded that large differences of maximum sustained wind speed (MSW) among the centers was mainly caused by the different conversion from CI-number to MSW while there was no large difference in their CI-numbers. Also, it was found very difficult to verify MSW due to considerable uncertainty inherent in observational data and different wind-averaging period. The meeting recommended that the Centers were encouraged to exchange digitized CI numbers of historical TCs if they are available for CI number comparison.

In accordance with the recommendation, CI-number comparison was implemented as a WGM project, Harmonization of Tropical Cyclone Intensity Analysis under the Working Group on Meteorology. In 2014, after working for the digitization of CI numbers for the period from 2004-2014, CMA, HKO, JTWC, and RSMC Tokyo exchanged CI numbers. In 2015, cyclone-by-cyclone CI number comparison was made by RSMC Tokyo. Note here that CI-numbers of CMA until 2012 were based on the Simplified Dvorak technique, and thus those in 2013 were included into the CI number comparison analysis. Overall, most of Dvorak analysis of these four Centers are reasonably consistent (0.5 or less), proving the credibility of the Dvorak technique. Thus, detailed comparison analysis focused on 19 TCs with large discrepancies by 2.0 in CI number, which rarely come up but still existed. Preliminary findings for major reasons behind such large CI number discrepancies and suggestion toward more homogenous satellite TC analysis are shown as follows. A summary report is to be drafted and finalized based on feedbacks from the Members involved in 2016.

1. **Different interpretation during rapid intensification (Final T-number Constraints)**
- Operational reanalysis of Dvorak analysis should be done whenever the previous ones are questionable.
- Reanalysis of Dvorak analysis after TCs dissipates for best track analysis is also encouraged.
- Keep in mind that Final T-number Constraints are found appropriate for most Rapid Intensification/Weakening events.

2. **Erroneous Interpretation of Cloud Patterns (Embedded Center Pattern)**
- Microwave satellite imageries providing information on TC structures under dense overcasts should be used to understand TC development stages, and thus judge cloud patterns appropriately.

3. **Different interpretation of peak CI numbers before weakening and/or Landfall rules (CI-number Rules)**
- TC analysis near/over land relies on surface observations rather than satellite analysis. More surface observations should be shared among Members.

4. **Minor difference in Dvorak parameters of eye Patterns**
- Objective Dvorak techniques (e.g., ADT, CLOUD) providing good guidance for intense TCs (e.g., CDO pattern, eye patterns) should be referenced.
- AMSU-based TC intensity estimates and Satellite TC intensity consensus (e.g., SATCON) provide objective TC intensity guidance.

15. Coordination on the trans-boundary storms

Following the TCM-6 meeting which reaffirmed the intent for all the tropical cyclone forecasts in a basin should be completed by the RSMC/TCWC responsible for that basin, the Centre has operated the procedures to take over the responsibility for issuance of TC advisories for TCs crossing boundaries since 22 February 2010. In 2015, RSMC Tokyo took over the

responsibility of RSMC Honolulu for trans-boundary TCs (TC1512 (HALOLA) and TC1517 (KILO)) smoothly in accordance with the pre-agreed procedures between the two RSMCs Tokyo and Honolulu.

16. Publications

The Center published “Upgrade of JMA’s Typhoon Ensemble Prediction System”, “Probability Circles Representing the Uncertainty of Tropical Cyclone Track Forecasts”, and “Utilization of Tropical Cyclone Heat Potential for Improving Tropical Cyclone Intensity Forecasts” as its Technical Review No. 17 in March 2015 and Annual Report on the Activities of the RSMC Tokyo - Typhoon Center in 2014 in December 2015. They are available on the Center’s website at http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/RSMC_HP.htm.

17. Training

The Centre has organized 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 to enhance the capacity of Committee members in typhoon analysis and forecasting. The training focused on improving skills in tropical cyclone analysis and forecasting through practical training, including hands-on learning using the Satellite Analysis and Viewer Program (SATAID). It included presentations on a variety of subjects, including Dvorak analysis, interpretation of microwave imageries, quantitative precipitation estimation (QPE), quantitative precipitation forecasting (QPF) and storm surge forecasting.

At the third joint session of Panel on Tropical Cyclone (PTC) and Typhoon Committee (Bangkok, 2015), it was decided to pursue organizing the RSMC Tokyo attachment training by inviting two to three TC forecasters from the PTC Members for the enhancement of cooperation between the two committees. In accordance with this decision, it was agreed among RSMC Tokyo, ESCAP, WMO, and PTC secretariats that three TC forecasters from the PTC Members for the period, 2015-2016, i.e. Bangladesh, Maldives and Myanmar in 2015 and Oman, Pakistan and Sri Lanka in 2016, are to be invited on a trial basis with Japan Trust Fund. The 15th Training Attachment course was held at JMA Headquarters from 22 to 31 July 2015. According to the decision at the joint session, it was attended by six experts from the Typhoon Committee and the Panel on Tropical Cyclones: Mr. Soim Monichoth from Cambodia, Ms. Praphasri Udjai from Thailand, Mr. Tran Van Hung from Vietnam, Mr. Md. Azizur Rahman from Bangladesh, Mr. Hussain Afshal from the Maldives, and Mr. Hla Tun from Myanmar. The details of the training were posted at the JMA website (http://www.jma.go.jp/jma/en//photogallery/RSMC_training_201507.html).

From 2016, in accordance with the discussion between RSMC Tokyo and the WMO secretariat at the preparatory meeting of the regional subproject management team of the Severe Weather Forecasting Demonstration Project held in Hanoi, Viet Nam on 10 August 2015, RSMC Tokyo plans to extend the training course by 2 days to provide lectures on tropical cyclone warning developments during the attachment training with financial supports of the WMO Secretariat (additional financial supports for 2 day extension of the training, i.e. 2 days DSA for 3 trainees from the Committee Members are to be provided on a regular basis).

18. Implementation Plan

Table 6 shows the implementation plan of the Center for the period from 2015 to 2019.

Table 1 Monthly and annual total numbers of products issued by the RSMC Tokyo - Typhoon Center in 2015

Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
IUCC10	39	35	87	50	176	37	382	304	224	246	69	58	1707
WTPQ20-25	43	39	95	52	195	45	401	320	245	267	71	71	1884
WTPQ30-35	10	10	24	13	47	11	100	80	61	65	17	17	455
WTPQ50-55	8	10	35	15	63	2	157	109	67	88	29	20	603
FXPQ20-25	42	38	94	50	194	44	396	318	240	264	70	70	1822
FKPQ30-35	21	19	47	25	97	22	198	159	120	132	35	35	910
AXPQ20	2	1	1	1	2	2	1	4	2	5	6	0	27

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 2015

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 (%)
STS	Mekkhala	(1501)	52	39	17	23	114	63	12	22	145	57	6	24	262	59	2	34	-	-	0	-
TY	Higos	(1502)	65	23	11	46	80	16	7	25	149	34	3	48	-	-	0	-	-	-	0	-
TS	Bavi	(1503)	123	52	21	35	128	52	16	25	152	68	11	19	157	75	7	19	77	43	3	8
TY	Maysak	(1504)	57	33	30	44	78	37	26	31	130	55	22	33	188	50	18	33	239	65	14	34
TS	Haishen	(1505)	118	0	1	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Noul	(1506)	54	32	30	31	119	81	26	30	146	70	22	21	204	98	18	20	213	194	14	16
TY	Dolphin	(1507)	69	53	42	28	130	103	38	23	203	144	34	21	262	157	30	18	322	190	26	18
TS	Kujira	(1508)	123	60	11	65	227	45	7	53	322	19	3	69	-	-	0	-	-	-	0	-
TY	Chan-hom	(1509)	86	53	46	34	146	119	42	26	210	131	38	29	335	194	34	34	474	273	30	36
STS	Linfa	(1510)	107	59	26	47	187	47	22	52	312	106	18	46	428	154	14	47	527	228	10	50
TY	Nangka	(1511)	58	25	51	41	112	49	47	35	164	76	43	29	263	131	39	30	396	175	35	34
TY	Halola	(1512)	72	40	35	49	124	75	26	42	192	64	19	46	358	190	15	58	517	318	15	68
TY	Soudelor	(1513)	58	28	29	58	79	38	25	44	102	40	21	40	135	66	17	41	196	92	13	42
TS	Molave	(1514)	60	37	23	23	62	30	18	10	78	48	14	6	231	133	10	11	600	66	6	19
TY	Goni	(1515)	48	33	39	22	84	48	35	15	114	89	31	11	177	129	27	11	265	161	23	13
TY	Atsani	(1516)	59	29	38	37	98	49	34	23	162	58	30	22	263	91	26	24	388	190	22	27
TY	Kilo	(1517)	57	17	34	41	104	45	30	30	170	61	26	26	256	113	22	25	366	148	18	24
STS	Etau	(1518)	117	38	3	47	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Vamco	(1519)	82	0	1	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Krovanh	(1520)	64	46	17	33	117	82	13	20	177	80	9	15	270	43	5	14	356	0	1	-
TY	Dujuan	(1521)	69	70	24	24	89	62	20	14	147	55	15	15	342	126	11	23	643	272	7	28
TY	Mujigae	(1522)	52	26	10	31	154	51	6	51	276	0	1	-	-	-	0	-	-	-	0	-
STS	Choi-wan	(1523)	93	65	18	20	76	23	14	9	139	74	10	12	250	117	6	20	505	8	2	-
TY	Koppu	(1524)	81	42	27	44	104	53	23	30	117	41	19	18	141	29	15	15	152	44	11	9
TY	Champi	(1525)	83	57	42	44	138	64	38	32	211	64	34	28	335	118	30	29	442	194	26	28
TY	In-fa	(1526)	101	44	31	47	219	88	27	38	319	150	23	33	321	190	19	25	316	231	15	23
TY	Melor	(1527)	75	47	19	54	120	61	15	37	191	83	11	41	230	98	7	31	185	72	3	8
Annual Mean (Total)			72	48	676	36	119	77	567	27	176	105	463	24	263	150	372	25	366	228	294	26

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 2015

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)
STS	Mekkhala	(1501)	100	17	148	92	12	231	100	6	296	100	2	407	-	0	-
TY	Higos	(1502)	100	11	130	100	7	204	100	3	296	-	0	-	-	0	-
TS	Bavi	(1503)	62	21	147	100	16	266	100	11	389	100	7	519	100	3	695
TY	Maysak	(1504)	100	30	135	100	26	236	100	22	347	100	18	444	100	14	556
TS	Haishen	(1505)	100	1	130	-	0	-	-	0	-	-	0	-	-	0	-
TY	Noul	(1506)	97	30	138	96	26	223	100	22	347	94	18	399	93	14	513
TY	Dolphin	(1507)	81	42	145	79	38	256	88	34	380	87	30	457	85	26	577
TS	Kujira	(1508)	55	11	132	57	7	204	0	3	296	-	0	-	-	0	-
TY	Chan-hom	(1509)	78	46	137	81	42	231	82	38	344	85	34	455	77	30	574
STS	Linfa	(1510)	73	26	138	73	22	231	72	18	354	64	14	444	70	10	556
TY	Nangka	(1511)	100	51	138	98	47	227	98	43	336	82	39	454	80	35	578
TY	Halola	(1512)	91	35	138	96	26	238	100	19	321	73	15	484	67	15	648
TY	Soudelor	(1513)	100	29	137	100	25	228	100	21	340	100	17	444	100	13	556
TS	Molave	(1514)	96	23	153	100	18	295	100	14	431	100	10	519	83	6	695
TY	Goni	(1515)	97	39	142	97	35	257	97	31	373	96	27	447	100	23	555
TY	Atsani	(1516)	100	38	138	100	34	232	100	30	327	92	26	427	73	22	535
TY	Kilo	(1517)	100	34	140	100	30	252	100	26	378	95	22	444	89	18	556
STS	Etau	(1518)	67	3	145	-	0	-	-	0	-	-	0	-	-	0	-
TS	Vamco	(1519)	100	1	130	-	0	-	-	0	-	-	0	-	-	0	-
TY	Krovanh	(1520)	94	17	144	100	13	279	100	9	401	100	5	519	100	1	695
TY	Dujuan	(1521)	83	24	135	100	20	218	100	15	309	82	11	444	43	7	595
TY	Mujigae	(1522)	100	10	141	100	6	232	100	1	296	-	0	-	-	0	-
STS	Choi-wan	(1523)	83	18	135	100	14	254	100	10	359	100	6	494	100	2	695
TY	Koppu	(1524)	85	27	139	100	23	237	100	19	326	100	15	415	100	11	535
TY	Champi	(1525)	83	42	147	95	38	278	100	34	398	77	30	462	73	26	614
TY	In-fa	(1526)	84	31	141	63	27	248	70	23	375	79	19	448	80	15	556
TY	Melor	(1527)	84	19	134	100	15	210	82	11	306	100	7	370	100	3	482
Annual Mean (Total)			89	676	140	93	567	242	94	463	355	88	372	450	83	294	573

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 2015

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.
STS	Mekkhala	(1501)	1.8	9.5	17	3.4	8.3	12	-3.8	7.6	6
TY	Higos	(1502)	-0.7	21.5	11	13.7	19.8	7	-4.7	11.5	3
TS	Bavi	(1503)	-2.0	3.4	21	-2.9	3.7	16	-3.6	4.0	11
TY	Maysak	(1504)	6.7	13.9	30	11.2	19.4	26	14.0	23.9	22
TS	Haishen	(1505)	-8.0	8.0	1	-	-	0	-	-	0
TY	Noul	(1506)	-3.3	14.3	30	3.1	15.8	26	3.2	20.2	22
TY	Dolphin	(1507)	-4.7	14.0	42	-6.5	16.1	38	-6.0	17.8	34
TS	Kujira	(1508)	1.0	4.4	11	7.0	8.1	7	9.0	9.5	3
TY	Chan-hom	(1509)	-6.9	14.6	46	-11.4	20.6	42	-15.3	21.8	38
STS	Linfa	(1510)	-5.3	8.2	26	-5.2	11.9	22	-8.7	13.2	18
TY	Nangka	(1511)	-5.2	12.9	51	-8.6	21.1	47	-9.4	25.6	43
TY	Halola	(1512)	-5.8	16.0	35	-6.2	18.3	26	-4.7	16.8	19
TY	Soudelor	(1513)	2.2	19.3	29	1.6	29.7	25	-5.3	24.8	21
TS	Molave	(1514)	-2.2	4.5	23	-7.1	8.2	18	-8.8	11.6	14
TY	Goni	(1515)	-5.6	18.6	39	-7.4	21.8	35	-9.8	20.9	31
TY	Atsani	(1516)	-4.3	12.0	38	-7.1	16.6	34	-11.2	20.4	30
TY	Kilo	(1517)	-10.4	17.3	34	-22.3	26.5	30	-31.2	32.4	26
STS	Etau	(1518)	0.0	4.1	3	-	-	0	-	-	0
TS	Vamco	(1519)	-4.0	4.0	1	-	-	0	-	-	0
TY	Krovanh	(1520)	-3.1	16.2	17	-7.2	27.3	13	-11.0	21.8	9
TY	Dujuan	(1521)	4.7	11.3	24	11.1	20.8	20	17.1	29.1	15
TY	Mujigae	(1522)	6.0	9.2	10	14.8	20.9	6	-5.0	5.0	1
STS	Choi-wan	(1523)	-8.6	10.1	18	-10.0	12.1	14	-10.5	12.3	10
TY	Koppu	(1524)	-2.0	10.5	27	4.3	11.5	23	3.9	12.4	19
TY	Champi	(1525)	-3.5	11.6	42	-3.7	16.4	38	2.4	17.6	34
TY	In-fa	(1526)	-3.5	14.9	31	-5.6	19.4	27	-8.3	23.0	23
TY	Melor	(1527)	5.8	15.8	19	15.3	25.1	15	12.2	25.3	11
Annual Mean (Total)			-2.9	13.7	676	-3.6	19.1	567	-5.7	21.2	463

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.
STS	Mekkhala	(1501)	0.3	5.1	17	-0.6	4.1	12	3.0	5.0	6
TY	Higos	(1502)	0.2	10.2	11	-6.2	10.0	7	0.9	6.5	3
TS	Bavi	(1503)	1.5	2.4	21	2.3	2.9	16	2.6	2.6	11
TY	Maysak	(1504)	-1.2	4.6	30	-2.2	6.5	26	-3.0	7.6	22
TS	Haishen	(1505)	7.7	7.7	1	-	-	0	-	-	0
TY	Noul	(1506)	-1.2	5.4	30	-4.6	7.4	26	-5.0	8.2	22
TY	Dolphin	(1507)	0.7	4.9	42	0.9	5.8	38	0.8	7.5	34
TS	Kujira	(1508)	-0.2	2.6	11	-2.9	5.8	7	-7.7	8.0	3
TY	Chan-hom	(1509)	3.2	6.2	46	5.3	9.5	42	7.2	10.3	38
STS	Linfa	(1510)	3.7	5.1	26	4.6	7.6	22	6.7	8.8	18
TY	Nangka	(1511)	2.1	5.1	51	3.4	8.0	47	3.8	9.8	43
TY	Halola	(1512)	1.2	7.6	35	2.0	8.6	26	1.2	8.7	19
TY	Soudelor	(1513)	-1.1	6.8	29	0.0	9.9	25	2.6	8.5	21
TS	Molave	(1514)	3.5	4.0	23	6.0	6.3	18	7.2	8.1	14
TY	Goni	(1515)	0.9	7.0	39	1.0	7.7	35	2.4	7.3	31
TY	Atsani	(1516)	1.6	4.5	38	2.7	6.5	34	4.0	7.7	30
TY	Kilo	(1517)	4.4	6.8	34	8.7	10.1	30	11.4	11.9	26
STS	Etau	(1518)	0.0	2.1	3	-	-	0	-	-	0
TS	Vamco	(1519)	2.6	2.6	1	-	-	0	-	-	0
TY	Krovanh	(1520)	2.0	6.7	17	4.9	12.5	13	7.4	11.2	9
TY	Dujuan	(1521)	-4.7	7.0	24	-7.5	11.0	20	-9.8	14.8	15
TY	Mujigae	(1522)	-4.6	5.6	10	-8.6	10.7	6	2.6	2.6	1
STS	Choi-wan	(1523)	4.7	5.4	18	7.0	8.0	14	9.3	9.6	10
TY	Koppu	(1524)	1.9	5.7	27	-1.3	6.1	23	-0.5	6.3	19
TY	Champi	(1525)	0.8	4.9	42	1.1	6.5	38	-0.8	6.5	34
TY	In-fa	(1526)	1.9	6.8	31	3.6	9.2	27	5.0	11.1	23
TY	Melor	(1527)	-2.8	7.9	19	-7.2	12.1	15	-6.1	12.3	11
Annual Mean (Total)			1.1	5.9	676	1.4	8.2	567	2.4	9.0	463

Table 5 Products of RSMC Tokyo via NTP website

Products	Frequency	Contents
NWP Weather Map TC track guidance	Twice/day	Mean sea level pressure and 500 hPa Geopotential height (up to 72 hours at 00 TC, up to 168 hours at 12 UTC) of nine major NWP centers (BoM, MSC, CMA, DWD, KMA, UKMO, NCEP, ECMWF and JMA)
TC track guidance	Twice/day	TC track guidance of nine deterministic NWP models (BoM, MSC, CMA, DWD, KMA, UKMO, NCEP, ECMWF and JMA), ensemble TC track guidance of JMA's TEPS, ECMWF, and NCEP
EDA Analysis	4 times/day	Center position and its accuracy, T number
Sea Surface Temperature	once/day	Sea Surface Temperature in the area of responsibility
Tropical Cyclone Heat Potential	once/day	Tropical Cyclone Heat Potential in the area of responsibility
Vertical Wind Shear	4 times/day	Vertical Wind Shear of initial fields of the JMA's global model
Satellite Microwave Products		Microwave TC snapshot (37GHz(H,V,PCT), 89GHz(H,V,PCT), AMSU-based TC intensity(Central pressure, Maximum sustained wind)
Storm Surge Prediction	4 times/day	Storm surge distribution maps (up to 72 hours ahead), Time series storm surge forecasts (up to 72 hours ahead),
Stream line	4 times/day	Stream line (850 hPa, 200 hPa) based on initial fields of the JMA's global model
Graphical Tropical Cyclone Advisory for SIGMET	4 times/day	Center position, Maximum sustained wind speed, Direction and speed of movement, Central pressure, height and area of CB associated with a TC

Table 6 Implementation Plans of the RSMC Tokyo - Typhoon Center (2015 - 2019)

PRODUCT	2015	2016	2017	2018	2019	REMARKS
Satellite Observation						
MTSAT-2	———					Every 60 minutes (Full-disk) Every 30 minutes (Northern hemisphere)
Himawari-8		———	———	———	———	Every 10 minutes (Full-disk) Every 2.5 minutes (Target area)
Cloud motion wind (BUFR)	———	———	———	———	———	24 times/day
Analysis						
RSMC Tropical Cyclone Advisory	———	———	———	———	———	8 times/day
SAREP (for tropical cyclones, BUFR)	———	———	———	———	———	8 times/day Position of cloud sytem center, etc. 4 times/day Dvorak intensity
Numerical Typhoon Website satellite image analysis for tropical cyclones	———	———	———	———	———	4 times/day early stage Dvorak analysis & regular Dvorak analysis
Sea Surface Temperature	———	———	———	———	———	
Objective analysis pressure pattern, etc	———	———	———	———	———	
satellite Tropical Cyclone intensity	———	———	———	———	———	
Forecast						
RSMC Tropical Cyclone Advisory	———	———	———	———	———	4 times/day up to 120 hrs ahead 8 times/day up to 24 hrs ahead
RSMC Prognostic Reasoning	———	———	———	———	———	2 times/day
RSMC Guidance for Forecast	———	———	———	———	———	4 times/day up to 84 hrs ahead (GSM) 4 times/day up to 132 hrs ahead (TEPS)
NWP products pressure pattern, etc	———	———	———	———	———	
Numerical Typhoon Prediction Website tracks and prediction fields, etc	———	———	———	———	———	mostly updated 2 times/day 4 times/day up to 132 hrs ahead (TEPS) Time series charts at 41 stations have been provided anew since 2014
Experimental CAP Tropical Cyclone Advisory	———	———	———	———	———	
Others						
RSMC Tropical Cyclone Best Track	———	———	———	———	———	
Annual Report	———	———	———	———	———	Publication
Technical Review	·····	·····	·····	·····	·····	Publication (as necessary)
Tropical Cyclone Reanalysis	———	———	———	———	———	

SUPPORTING ACTIVITY	2014	2015	2016	2017	2018	REMARKS
Data archive	———	———	———	———	———	
Monitoring of data exchange	———	———	———	———	———	
Dissemination of products	———	———	———	———	———	Upgraded to WIS GISC Tokyo in 2011

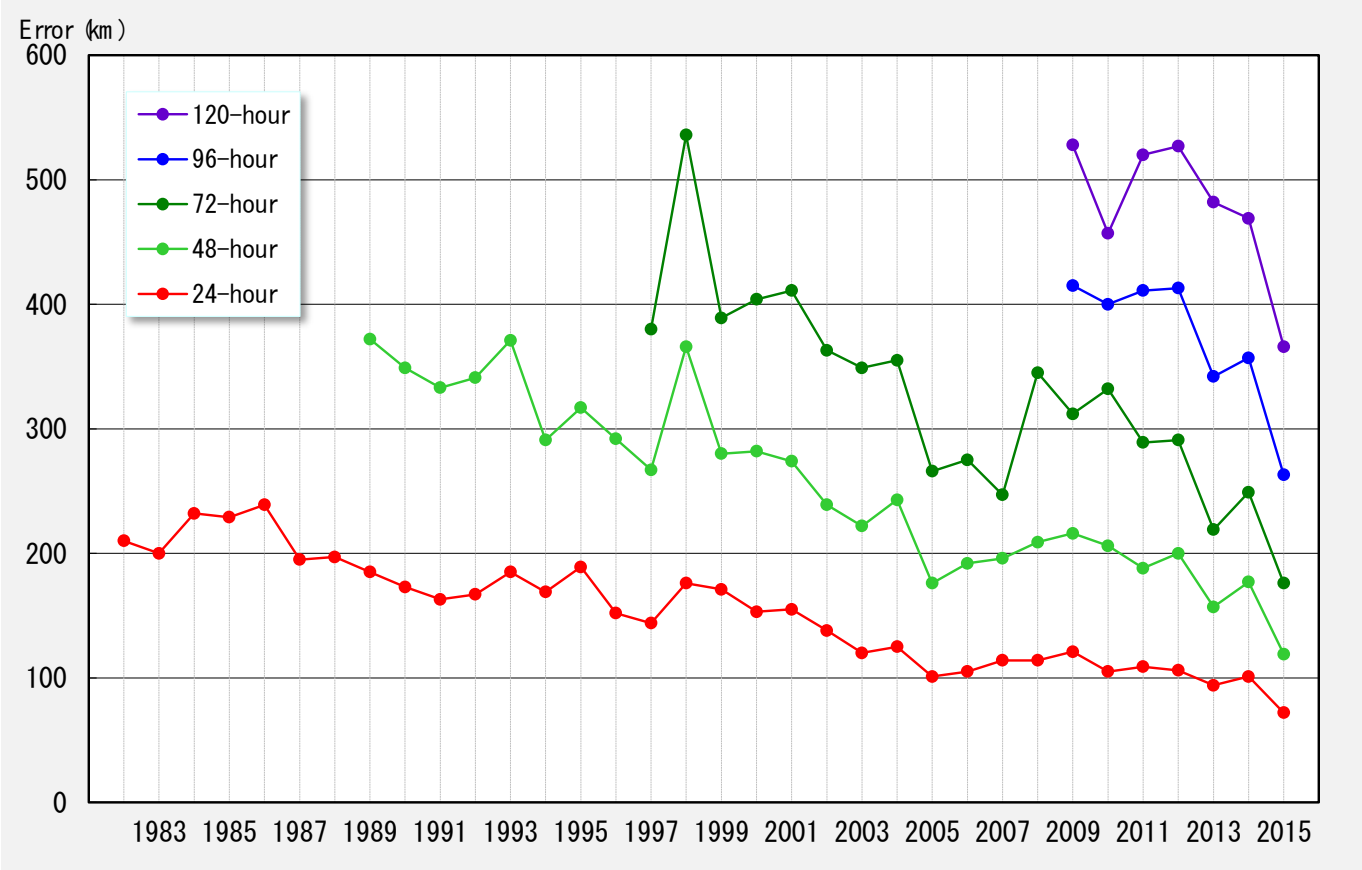

Figure 1 Annual mean position errors of track forecasts
Vertical axis: position error (km), Horizontal axis: year