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ACTIVITIES OF THE RSMC TOKYO - TYPHOON CENTER IN 2012

(Submitted by the RSMC Tokyo - Typhoon Center)

Action Proposed

The Committee is invited to review the activities of the RSMC Tokyo - Typhoon Center in 2012.

Activities of the RSMC Tokyo - Typhoon Center in 2012

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 2012.

2. Track Forecasts

Operational track forecasts for 24 Tropical Cyclones (TCs) that reached Tropical Storm (TS) intensity or higher in 2012 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 106 km (109 km in 2011), 200 km (188 km), 291 km (289 km), 413 km (411 km) and 527 km (520 km) for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively (Table 2). Track forecasts were especially difficult for Kai-tak (1213) due to northward biases of track forecasts by numerical weather prediction (NWP). The mean hitting ratios of probability circles* for 24-, 48-, 72-, 96- and 120-hour forecasts are 76% (75% in 2011), 71% (75%), 75% (71%), 72% (71%) and 75% (75%), 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 and 5 give the mean errors and root mean square errors (RMSEs) of 24-, 48- and 72-hour central pressure (Table 4) and maximum sustained wind forecasts (Table 5) for 24 TCs of 2012. The annual mean RMSEs for central pressure forecasts are 12.8 hPa (11.7 hPa in 2011), 17.5 hPa (17.8 hPa) and 20.2 hPa (19.2 hPa) for 24-, 48- and 72-hour forecasts, respectively, while those of maximum wind speed forecasts for 24-, 48- and 72-hour forecasts are 5.7 m/s (5.6 m/s in 2011), 7.5 m/s (8.6 m/s) and 9.6 m/s (9.1 m/s), respectively. Intensity forecasts were particularly difficult for TCs that developed rapidly, such as Sanba (1216) whose central pressure decreased by 55 hPa in 24 hours.

4. Objective Tropical Cyclone Satellite Analysis

To improve operational tropical cyclone analysis, the Center is currently developing objective tropical cyclone satellite analysis using MTSAT called "Cloud grid information objective Dvorak analysis (CLOUD)" and plans to introduce it into operation in 2013. The unique points of CLOUD are that it enables to analyze tropical cyclones in TC's early (early-stage Dvorak analysis : EDA) through mature stages (Dvorak analysis) in a consistent and objective manner, and that it can be used with cloud grid information – an objective cloud product operationally prepared by the

Center since June 2005. The method has been verified and shown to have a level of accuracy comparable to those of manual EDA and Dvorak analysis. Objective microwave analyses for complementary intensity estimation are also to be introduced together with CLOUD. Information on the methods and systems including verification results is to be published in the Technical Review in 2013 (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/techrev.htm).

5. JMA Numerical Typhoon Prediction (NTP) website

Since October 2004, the Center has officially operated a Numerical Typhoon Prediction (NTP) website in cooperation with eight NWP centers: BoM (Australia), MSC (Canada), CMA (China), ECMWF, DWD (Germany), KMA (Republic of Korea), UKMO (UK) and NCEP (US). The NTP website provides predictions of tropical cyclone tracks derived from models of the major NWP centers and TC related products in order to assist the NMHSs of TYC Members in their tropical cyclone forecasting and warning services. Since 5 June 2012, storm surge time series charts have been provided in the website. The website is available only to registered organizations, including the NMHSs of TYC Members and participating NWP centers. Nine users other than Japan had accessed the website as of the end of 2012. The main contents of this site are as follows:

1) Predictions of tropical cyclone tracks, in table and chart format, from nine major NWP centers including JMA. Ensemble mean prediction with any combination of those centers is also available.
2) NWP model products, in chart format, from the NWP centers
3) Results of satellite image analysis (EDA and Dvorak analysis)
4) Storm surge distribution maps, storm surge time series charts of points for TYC Members

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

Following the recommendation at the TYC 41st session (Chiang Mai, 2009), the Center conducted a survey in June 2009, to collect information on the present status of TYC Members on using storm surge models in order to develop future plan for the establishment of a regional Storm Surge Watch Scheme (SSWS) suitable for the TYC region. 12 TYC Members responded by the end of 2009. After reviewing the survey responses, the Center decided to provide TYC Members with distribution maps and time-series charts of storm surges. For this purpose, 7 TYC Members provided the Center with bathymetric data of their surrounding areas together with past sea level data. With the provided data, the Center developed the storm surge model suitable for the TYC region and verified the results of the model. The Center started to provide storm surge distribution maps through its NTP website on 1 June 2011. Since 5 June 2012, it also has started provision of storm surge time series charts at one point for each Member upon request (forecasting points to be increased if so requested by TYC Members). Details on the storm surge model was shared with TYC Members through the annual TYC attachment training at the Center and 7th TCP/JCOMM Regional Workshop on Storm Surge and Wave Forecasting (Macao, China) in 2011. Verification results of the model were shown in the Technical Review published in 2012 (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/techrev/text14-2.pdf). The

Center plans to add 7 forecasting points (Thailand:1 and Republic of Korea:6) in storm surge time series charts and expand the targeted region in 2013.

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

Tropical Cyclone Ensemble Forecast Information 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 Home page (NWP-TCEFP Home page) provides deterministic and ensemble TC track forecasts, and strike probability maps based on ensemble TC track forecasts. Since 2011 typhoon season, new functions such as the display switch of all ensemble or deterministic data have been provided on the website. Questionnaire about effectiveness of EPS was sent to TYC Members from WMO in December 2011 for the further improvement of the NWP-TCEFP Home Page. The results of the first questionnaire by the WMO WWRP/TCP and of another questionnaire carried out by GIFS-TIGGE WG requested it to display more meteorological elements such as surface wind speeds and precipitation. These products could be implemented, should the product specification be considered and corresponding EPS data including the extended CXML be developed with the support of data providers. Further improvement of the website including addition of elements will be carried out based on the regular questionnaire survey by WMO circulated by the TCS on 14 December 2012. Progress report of the Project is submitted to the 45th session. Another feedback through the Severe Weather Forecasting Demonstration Project (SWFDP) in Southeast Asia will be also given to the NWP-TCEFP Home page. From 2013, the NWP-TCEFP plans to start evaluation of tropical cyclogenesis prediction over the western North Pacific on medium-range timescales using the TIGGE data and on intraseasonal timescales using the JMA 1-month EPS. In 2013, it starts with evaluation during the 2009 and 2010 seasons..

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

The SWFDP is designed as a series of sub-regional projects whose scope is to test the usefulness of NWP products produced by global and regional meteorological centers with the goal of improving severe weather forecasting and warning services in countries where sophisticated model outputs are currently not used. The Center 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. The Center input the information to the Regional Subproject Management Team (RSMT) meeting (Ha Noi, 2011) to contribute to the development of Regional Subproject Implementation Plan (RSIP). Besides, the Center provided the training materials on JMA ensemble prediction systems and the use of their products, including NWP-TCEFP products in the NWP-TCEFP Home page, to Training Workshop of SWFDP-SeA (Hong Kong, 2011). Feedbacks from NMHSs participating in SWFDP-SeA during the demonstration phase, especially in the Training Workshop of SWFDP to be held in 2013 will be reported.

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.

10. Tropical cyclone advisories in Common Alert Protocol (CAP)

The Common Alert Protocol (CAP) is an international standard format for emergency alerting and public warning. Sixteenth World Meteorological Congress (Geneva, June 2011) welcomed the implementation of the CAP as a joint collaborative effort between Public Weather Services Programme (PWSP) and the WIS. On the other hand, the TYC noted in the 44th session (Hangzhou, February 2012) that "Standardization and harmonization of Members' practices to promote effective warning, in particular communication of advisory and warning messages to the users". In this context, the Center started to develop experimental CAP profiles for TC advisories in 2012. The experimental CAP version of TC advisory was presented in the Seventh Tropical Cyclone RSMCs/TCWCs Technical coordination meeting (Chiteco, Indonesia, November 2012). The experimental CAP messages are served in an Atom feed (sometimes called as RSS). Recipient centers can retrieve updates by polling (periodically accessing) the feed at http://www.data.jma.go.jp/fcd/yoho/cap-rsmctk/atom.xml. The latest and sample tropical cyclone advisories in CAP format have been posted 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.

11. Radar composite map for the UFRM pilot city in Thailand

At the 43rd session of the TYC, Development of Regional Radar Network was endorsed as a project of the Working Group on Meteorology, and the project was planned to work on the establishment of radar composite map in Thailand as its first step. An expert mission by the team composed of Kyoto University, JMA, and TC Secretariat was undertaken in Thailand on 7 – 9 September 2012, in order to investigate the capacity of the Thailand Meteorological Department (TMD). It identified issues facing TMD in its radar hardware, software, communication, and human resource, and feasible steps for TMD to be taken were recommended. Following the recommendation, the 44th TC session requested TMD to submit progress reports and JMA, on its receipt, to hold attachment training for TMD experts. The progress after the expert mission was reported by TMD to TCS on February 29, 2012 reporting that TMD selected three radar sites covering the area of the UFRM pilot city (Hat Yai), Phuket, Krabi, and Sathing Pra whose data are available on a real time basis at TMD headquarter. It also stresses the need of training, particularly on creation of CAPPI and conversion of echo intensity to rainfall intensity. Based on the progress

report, JMA organized an attachment training course on radar composite techniques for TMD experts, from 19 to 22 November 2012, at the JMA Headquarters. At the end of the training, the participants recommended TMD works on acquiring techniques for creation of radar echo intensity at the lowest level at a radar site in 2013.

12. Tropical cyclone advisories for SIGMET in graphical format

As indicated in the Manual of Aeronautical Meteorological Practice (Doc 8896), the information on TCs in graphical format provided by TCAC Tokyo is shown in the JMA website (http://www.jma.go.jp/en/typh/). In addition to this, based on the techniques utilizing the cloud grid information for the analysis of existing CB areas, TCAC Tokyo plans to provide graphical Tropical cyclone advisories (TCAs) according to MODEL TCG in the Appendix 1 of ICAO Annex 3 in a few years.

13. Publications

The Center published two papers, "The Inactive Typhoon Season of 2010" and "JMA's Storm Surge Prediction for the WMO Storm Surge Watch Scheme (SSWS)" as its Technical Review No. 14 in March 2012, and Annual Report on the Activities of the RSMC Tokyo - Typhoon Center in 2011 in December 2012. 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.

14. Training

Two forecasters from Viet Nam and the Philippines visited the Center from 18 to 27 July 2012 to participate in the 12th TYC Attachment Training. The training covered the following subjects:

1. The Satellite analysis and viewer program (SATAID)
2. Tropical cyclone analysis (Dvorak technique)
3. Tropical cyclone forecasting
4. Storm surges
5. Quantitative precipitation estimation (QPE) and quantitative precipitation forecasting (QPF)
6. The Severe Weather Forecasting Demonstration Project (SWFDP)

15. Implementation Plans

Table 5 shows the implementation plans of the Center for the period from 2012 to 2016.

Table 1 Monthly and annual total numbers of products issued by the RSMC Tokyo - Typhoon Center in 2012

Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
IUCC10	0	13	26	9	52	161	96	214	140	197	44	97	1049
WTPQ20-25	0	26	30	9	57	190	154	361	224	292	56	102	1501
WTPQ30-35	0	7	7	2	4	46	38	91	51	75	14	26	361
WTPQ50-55	0	0	8	0	16	53	37	99	65	74	17	39	408
FXPQ20-25	0	26	29	8	56	184	152	354	220	286	56	100	1471
FKPQ30-35	0	13	15	4	28	93	76	177	111	143	28	50	738
AXPQ20	1	0	0	1	0	1	4	4	5	5	2	1	24

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 2012

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	Pakhar	(1201)	47	22	10	51	98	32	6	74	160	13	2	-	-	-	0	-	-	-	0	-
STS	Sanvu	(1202)	94	39	18	47	153	55	14	27	230	58	10	23	288	86	6	18	541	1	2	-
TY	Mawar	(1203)	105	94	14	41	229	178	10	38	383	180	6	32	827	66	2	-	-	-	0	-
TY	Guchol	(1204)	100	73	22	28	189	126	18	22	380	230	14	31	647	416	10	33	980	393	6	31
STS	Talim	(1205)	106	40	10	39	86	25	5	12	-	-	0	-	-	-	0	-	-	-	0	-
TS	Doksuri	(1206)	177	52	9	66	312	76	5	53	467	0	1	-	-	-	0	-	-	-	0	-
STS	Khanun	(1207)	125	28	7	34	155	78	3	23	-	-	0	-	-	-	0	-	-	-	0	-
TY	Vicente	(1208)	205	52	9	48	295	34	5	39	257	0	1	-	-	-	0	-	-	-	0	-
TY	Saola	(1209)	77	32	21	42	117	65	17	33	143	72	13	28	188	119	9	22	370	101	5	89
TY	Damrey	(1210)	114	53	20	42	228	85	16	35	317	123	12	27	611	90	8	29	872	31	4	43
TY	Haikui	(1211)	83	45	22	41	143	61	18	32	129	40	14	19	176	42	10	15	388	101	6	23
STS	Kirogi	(1212)	91	30	5	24	371	0	1	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Kai-tak	(1213)	163	86	17	84	371	121	13	85	662	77	9	79	998	60	5	67	1109	0	1	-
TY	Tembin	(1214)	74	42	41	33	129	104	37	25	218	195	33	25	304	202	29	25	480	302	25	35
TY	Bolaven	(1215)	91	43	32	49	169	92	28	39	236	134	24	38	356	160	20	46	383	156	16	31
TY	Sanba	(1216)	107	83	24	51	170	97	20	34	205	94	16	32	283	134	12	27	377	158	8	23
TY	Jelawat	(1217)	78	39	39	35	180	99	35	34	347	255	31	42	625	569	27	60	850	890	23	67
STS	Ewiniar	(1218)	110	47	18	27	157	86	14	20	195	99	10	28	180	77	6	20	202	73	2	-
STS	Maliksi	(1219)	110	43	8	24	459	120	4	51	-	-	0	-	-	-	0	-	-	-	0	-
STS	Gaemi	(1220)	125	59	16	54	182	61	12	31	196	61	8	20	240	63	4	29	-	-	0	-
TY	Prapiroo	(1221)	104	75	44	47	227	225	40	46	338	362	36	49	384	392	32	53	413	354	28	51
STS	Maria	(1222)	191	80	15	53	499	159	10	49	542	238	6	26	1038	479	2	23	-	-	0	-
TY	Son-tinh	(1223)	98	51	19	46	170	76	15	39	289	145	10	46	231	78	4	34	370	50	2	65
TY	Bopha	(1224)	114	44	46	65	230	92	42	55	328	156	38	46	414	196	34	41	470	184	30	41
TS	Wukong	(1225)	132	57	9	63	232	55	5	69	200	0	1	-	-	-	0	-	-	-	0	-

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 2012

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	Pakhar	(1201)	100	10	130	100	6	204	100	2	296	-	0	-	-	0	-
STS	Sanvu	(1202)	94	18	148	93	14	279	100	10	413	100	6	540	100	2	880
TY	Mawar	(1203)	71	14	157	80	10	322	67	6	444	0	2	648	-	0	-
TY	Guchol	(1204)	64	22	143	72	18	273	57	14	397	50	10	519	33	6	695
STS	Talim	(1205)	90	10	170	100	5	333	-	0	-	-	0	-	-	0	-
TS	Doksuri	(1206)	11	9	137	20	5	237	0	1	296	-	0	-	-	0	-
STS	Khanun	(1207)	71	7	139	100	3	259	-	0	-	-	0	-	-	0	-
TY	Vicente	(1208)	11	9	131	0	5	204	100	1	296	-	0	-	-	0	-
TY	Saola	(1209)	90	21	130	82	17	204	100	13	296	100	9	519	100	5	695
TY	Damrey	(1210)	70	20	136	63	16	245	75	12	373	63	8	583	25	4	833
TY	Haikui	(1211)	82	22	132	83	18	210	100	14	296	100	10	452	100	6	543
STS	Kirogi	(1212)	100	5	139	0	1	259	-	0	-	-	0	-	-	0	-
TY	Kai-tak	(1213)	35	17	138	15	13	246	0	9	358	0	5	544	0	1	695
TY	Tembin	(1214)	93	41	148	92	37	261	88	33	366	76	29	518	84	25	689
TY	Bolaven	(1215)	78	32	135	64	28	228	58	24	332	80	20	496	100	16	695
TY	Sanba	(1216)	83	24	139	85	20	240	100	16	368	83	12	463	75	8	556
TY	Jelawat	(1217)	97	39	153	77	35	278	68	31	378	67	27	638	65	23	829
STS	Ewiniar	(1218)	83	18	156	100	14	310	100	10	419	100	6	648	100	2	833
STS	Maliksi	(1219)	75	8	155	0	4	282	-	0	-	-	0	-	-	0	-
STS	Gaemi	(1220)	56	16	147	92	12	242	100	8	366	100	4	444	-	0	-
TY	Prapiroon	(1221)	75	44	137	80	40	241	81	36	345	81	32	440	79	28	550
STS	Maria	(1222)	40	15	154	0	10	309	33	6	426	0	2	482	-	0	-
TY	Son-tinh	(1223)	84	19	141	93	15	252	80	10	370	100	4	444	100	2	556
TY	Bopha	(1224)	74	46	134	45	42	220	55	38	306	50	34	405	60	30	516
TS	Wukong	(1225)	56	9	141	40	5	226	100	1	389	-	0	-	-	0	-
Annual Mean (Total)			76	495	142	71	393	250	75	295	355	72	220	501	75	158	647

Notes: Num. means numbers of forecasts.

Table 4 Root mean square errors and mean errors of central pressure (top) and maximum sustained wind (bottom) forecasts for the TCs in 2012

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	Pakhar	(1201)	-2.6	3.9	10	-4.7	5.2	6	-4.0	4.5	2
STS	Sanvu	(1202)	0.3	5.2	18	1.2	9.1	14	1.1	12.9	10
TY	Mawar	(1203)	-3.6	6.0	14	-1.5	7.9	10	-7.5	9.4	6
TY	Guchol	(1204)	0.5	13.1	22	-1.4	15.5	18	-2.1	19.5	14
STS	Talim	(1205)	1.3	3.1	10	-2.4	6.9	5	-	-	0
TS	Doksuri	(1206)	-1.8	3.0	9	-7.6	7.9	5	-11.0	11.0	1
STS	Khanun	(1207)	2.4	5.4	7	6.0	6.6	3	-	-	0
TY	Vicente	(1208)	4.4	9.1	9	9.0	16.6	5	-10.0	10.0	1
TY	Saola	(1209)	-9.9	14.2	21	-18.2	23.0	17	-18.8	22.7	13
TY	Damrey	(1210)	3.0	5.8	20	5.4	9.1	16	6.3	9.9	12
TY	Haikui	(1211)	-1.2	5.8	22	-4.4	10.1	18	-0.3	3.4	14
STS	Kirogi	(1212)	7.6	7.8	5	6.0	6.0	1	-	-	0
TY	Kai-tak	(1213)	3.4	7.2	17	7.8	10.3	13	17.4	19.3	9
TY	Tembin	(1214)	-1.2	15.8	41	0.5	17.7	37	2.6	15.0	33
TY	Bolaven	(1215)	-8.2	19.0	32	-12.5	22.4	28	-9.6	19.1	24
TY	Sanba	(1216)	8.3	27.2	24	14.0	39.7	20	10.6	40.1	16
TY	Jelawat	(1217)	-2.3	13.1	39	-0.3	17.1	35	-0.3	22.3	31
STS	Ewiniar	(1218)	-1.6	4.4	18	-6.9	8.3	14	-12.4	13.7	10
STS	Maliksi	(1219)	-5.5	5.9	8	-7.5	8.7	4	-	-	0
STS	Gaemi	(1220)	-4.1	6.3	16	-9.0	11.1	12	-12.1	12.6	8
TY	Prapiroon	(1221)	-7.8	11.2	44	-13.3	16.7	40	-17.6	21.4	36
STS	Maria	(1222)	-2.1	8.1	15	-5.0	7.7	10	-4.7	6.8	6
TY	Son-tinh	(1223)	3.7	8.3	19	11.5	16.4	15	21.3	25.4	10
TY	Bopha	(1224)	-1.4	16.8	46	-1.8	17.0	42	2.7	21.2	38
TS	Wukong	(1225)	-2.4	3.1	9	-2.8	3.0	5	-12.0	12.0	1
Annual Mean (Total)			-1.6	12.8	495	-2.6	17.5	393	-2.3	20.2	295

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	Pakhar	(1201)	2.1	2.8	10	3.0	3.5	6	2.6	3.6	2
STS	Sanvu	(1202)	0.6	2.6	18	0.6	3.3	14	1.3	4.8	10
TY	Mawar	(1203)	2.2	3.1	14	1.0	4.1	10	3.9	4.8	6
TY	Guchol	(1204)	0.7	7.6	22	0.9	9.6	18	-0.2	9.3	14
STS	Talim	(1205)	-0.3	2.7	10	1.5	5.5	5	-	-	0
TS	Doksuri	(1206)	2.6	2.8	9	5.1	5.4	5	5.1	5.1	1
STS	Khanun	(1207)	0.0	2.7	7	-0.9	2.6	3	-	-	0
TY	Vicente	(1208)	-1.4	3.9	9	-3.1	7.8	5	7.7	7.7	1
TY	Saola	(1209)	4.5	7.4	21	7.4	10.5	17	9.9	11.4	13
TY	Damrey	(1210)	-2.2	5.4	20	-2.1	4.5	16	-1.7	5.1	12
TY	Haikui	(1211)	1.4	2.7	22	3.4	4.9	18	2.8	3.3	14
STS	Kirogi	(1212)	-5.7	6.0	5	-5.1	5.1	1	-	-	0
TY	Kai-tak	(1213)	-1.4	3.8	17	-4.2	5.8	13	-10.0	11.0	9
TY	Tembin	(1214)	0.8	7.5	41	-0.1	8.4	37	-1.4	7.5	33
TY	Bolaven	(1215)	3.5	7.3	32	5.2	9.2	28	4.7	7.9	24
TY	Sanba	(1216)	-3.4	9.7	24	-4.1	14.5	20	-2.6	14.6	16
TY	Jelawat	(1217)	-0.1	4.4	39	-0.8	5.7	35	-0.2	8.1	31
STS	Ewiniar	(1218)	0.7	2.5	18	3.3	4.1	14	5.9	6.7	10
STS	Maliksi	(1219)	3.2	3.4	8	3.9	4.5	4	-	-	0
STS	Gaemi	(1220)	1.9	4.1	16	4.7	6.5	12	7.1	7.3	8
TY	Prapiroon	(1221)	2.3	4.2	44	3.9	5.7	40	5.7	7.6	36
STS	Maria	(1222)	0.7	3.5	15	0.8	2.4	10	0.9	2.1	6
TY	Son-tinh	(1223)	-3.8	6.2	19	-6.9	9.3	15	-22.4	25.8	10
TY	Bopha	(1224)	-0.5	7.5	46	-0.6	7.6	42	-2.4	9.7	38
TS	Wukong	(1225)	1.1	1.7	9	1.0	1.6	5	5.1	5.1	1
Annual Mean (Total)			0.5	5.7	495	0.9	7.5	393	0.5	9.6	295

Notes: Num. means numbers of forecasts.

Table 5 Implementation Plans of the RSMC Tokyo - Typhoon Center (2012-2016)

PRODUCT	2012	2013	2014	2015	2016	REMARKS
Satellite Observation						
MTSAT HRIT	———	———	———	———	———	All observed cloud images (full or half-disk)
MTSAT LRIT	———	———	———	———	———	24 times/day (full-disk) 24 times/day (polar-stereo East Asia)
Cloud motion wind (BUFR)	———	———	———	———	———	8 times/day (Northern Hemisphere) 4 times/day (Sorthern Hemisphere)
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)
Experimental CAP Tropical Cyclone Advisory		———	———	———	———	Storm surge time series charts have been provied since 2012
Others						
RSMC Tropical Cyclone Best Track	———	———	———	———	———	
Annual Report	———	———	———	———	———	Publication
Technical Review	·····	·····	·····	·····	·····	Publication (as necessary)
Tropical Cyclone Reanalysis		———	———	———	———	

SUPPORTING ACTIVITY	2012	2013	2014	2015	2016	REMARKS
Data archive	———	———	———	———	———	
Monitoring of data exchange	———	———	———	———	———	
Dissemination of products	———	———	———	———	———	Upgraded to WIS GISC Tokyo in 2011

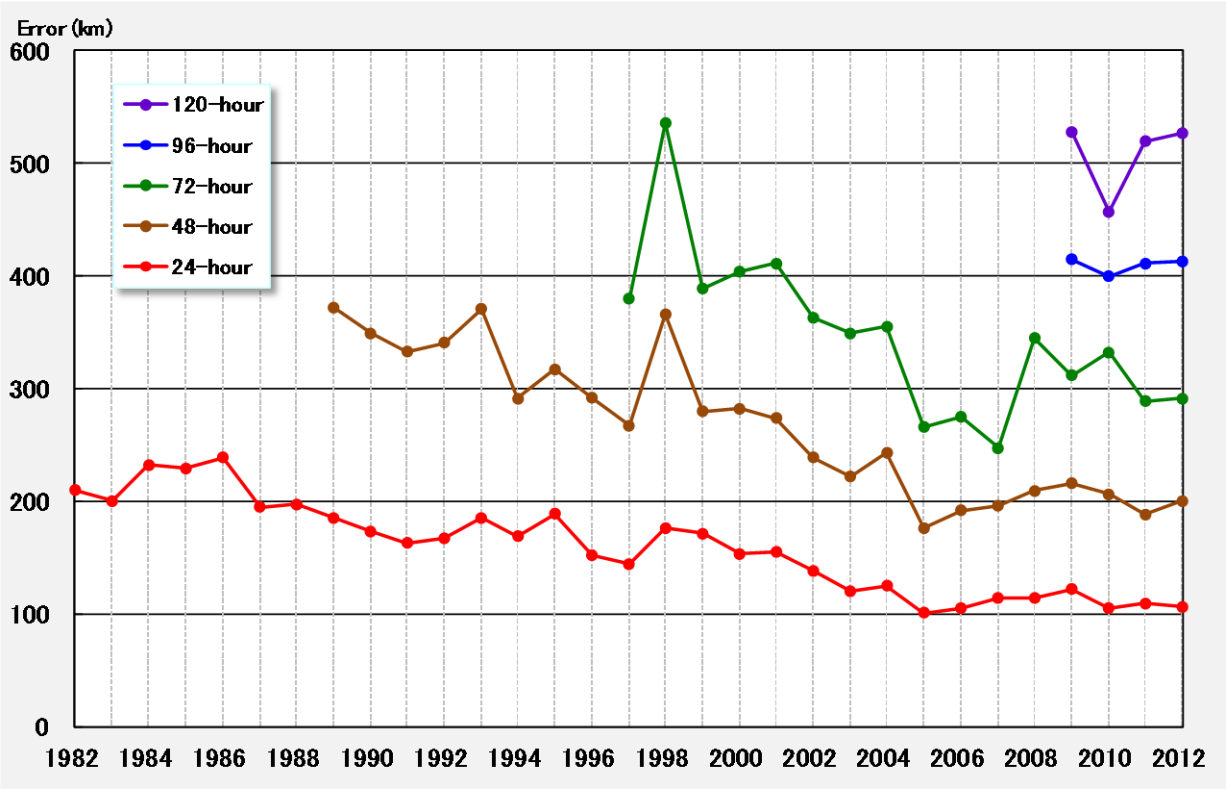

Figure 1 Annual mean position errors of track forecasts
Vertical axis: position error (km), Horizontal axis: year