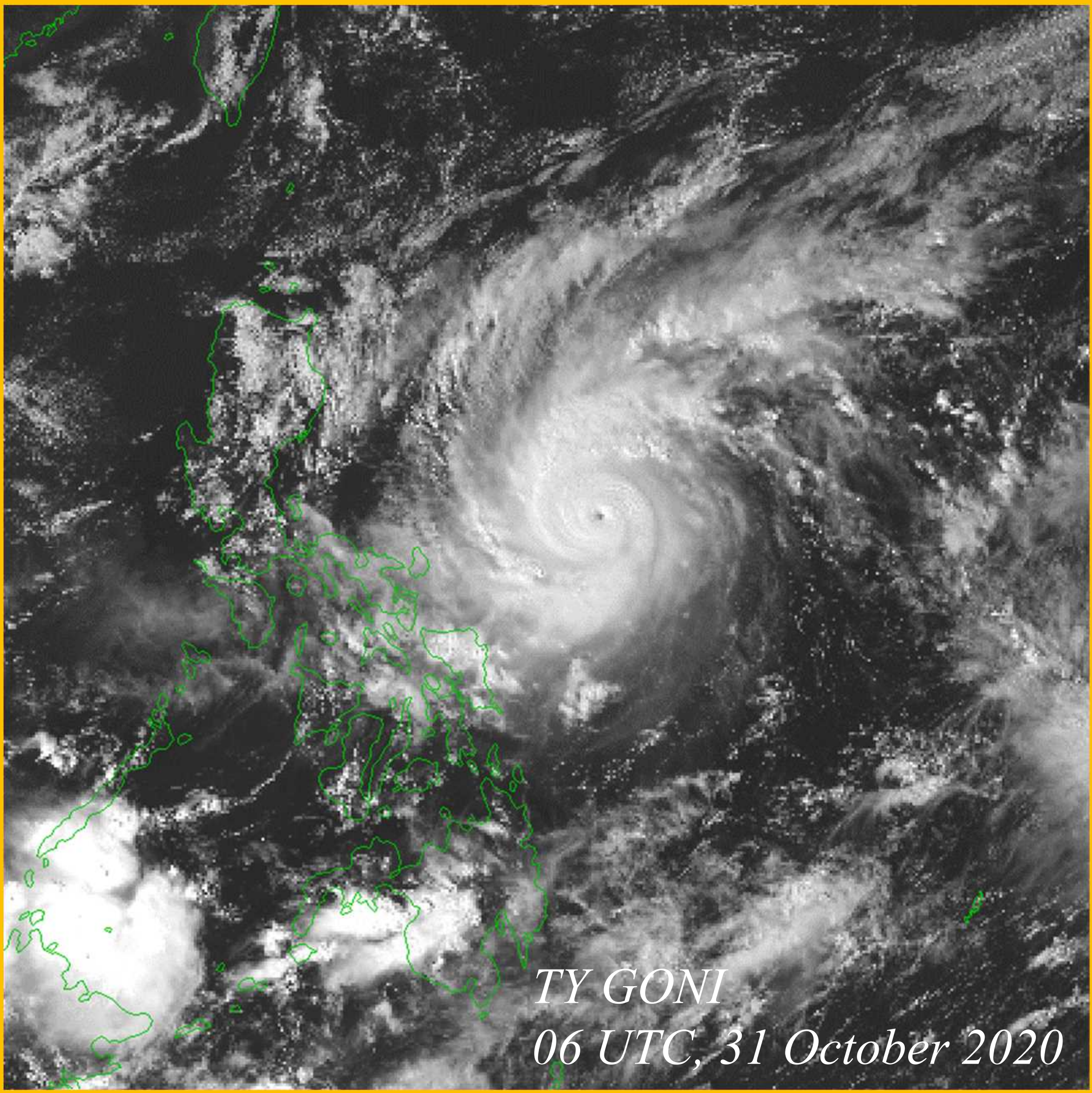
Annual Report on the Activities of the RSMC Tokyo - Typhoon Center 2020



Japan Meteorological Agency

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2020

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Introduction

The RSMC Tokyo - Typhoon Center (referred to here as *the Center*) is a Regional Specialized Meteorological Centre (RSMC) that carries out specialized activities in analysis, tracking and forecasting of western North Pacific tropical cyclones (TCs) within the framework of the World Weather Watch (WWW) Programme of the World Meteorological Organization (WMO). The Center was established at the headquarters of the Japan Meteorological Agency (JMA) in July 1989 following a designation by the WMO Executive Council at its 40th session (Geneva, June 1988).

The Center conducts the following operations on a routine basis:

(1) Preparation of information on the formation, movement and development of TCs and associated meteorological phenomena
(2) Preparation of information on synoptic-scale atmospheric situations that affect the behavior of TCs
(3) Provision of the above information to National Meteorological Services (NMSs), and in particular to United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)/WMO Typhoon Committee Members, in appropriate formats for operational processing

In addition to the routine services outlined above, the Center distributes a series of reports entitled *Annual Report on the Activities of the RSMC Tokyo - Typhoon Center* as operational references for the NMSs concerned. The reports summarize the activities of the Center and review the TCs of the preceding year.

In this issue covering 2020, Chapter 1 outlines routine operations performed at the Center and its operational products, while Chapter 2 reports on its major activities in 2020. Chapter 3 describes atmospheric and oceanic conditions in the tropics and notes the highlights of TC activity in 2020. Chapter 4 presents verification statistics relating to operational forecasts (i.e., official forecasts), results from JMA's numerical weather prediction (NWP) models and other guidance models, Atmospheric Motion Vector (AMV) based Sea-surface Wind (ASWind) data, TC central pressure estimates based on satellite microwave observations and storm surge predictions. Best-track data for 2020 TCs of tropical storm (TS) intensity or higher are shown in table and chart form in the appendices.

Chapter 1

Operations at the RSMC Tokyo - Typhoon Center in 2020

The Center's area of responsibility covers the western North Pacific and the South China Sea (0° – 60°N, 100° – 180°E) including marginal seas and adjacent land areas (Figure 1.1). The Center carries out analysis and forecasting in relation to TCs in the area and also provides the relevant NMSs with RSMC products via the Global Telecommunication System (GTS), the Aeronautical Fixed Telecommunication Network (AFTN), the Internet and other media.

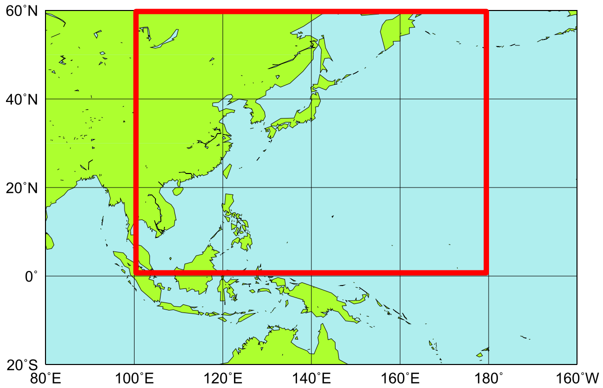

Figure 1.1
Area of responsibility of the RSMC Tokyo - Typhoon Center

1.1 Analysis

TC analysis is performed eight times a day at 00, 03, 06, 09, 12, 15, 18 and 21 UTC, and begins with determination of the TC's center position. Cloud imagery from Himawari-8 and microwave imagery from various polar orbiting satellites are the principal sources for this determination, especially for TCs migrating over data-sparse ocean areas. Information on the TC's direction and speed of movement is extracted primarily from six-hourly displacement vectors of the center position.

The maximum sustained wind speed in the vicinity of the TC's center is determined mainly from the Current Intensity (CI) number, which is derived from satellite imagery using the Dvorak method. The central pressure of the TC is then determined from the maximum sustained wind speed with the assumption of a certain pressure profile around the TC. The radii of circles representing winds with speeds exceeding 30 and 50 knots are determined mainly from surface observation, Advanced Scatterometer (ASCAT) observation and ASWind data derived from satellite images in the vicinity of the TC. The size of the central dense overcast area of the TC as observed in satellite imagery is also referenced to determine the radius of 50-knot wind speed circles.

1.2 Forecasts

The Center issues TC track forecasts with probability circle and intensity forecasts up to 120 hours ahead. In September 2020, the Center extended the forecast range from one to five days for tropical depressions (TDs) expected to reach TS intensity within 24 hours.

As a primary basis for TC track forecasts, JMA implements NWP using the Global Spectral Model (GSM) and the Global Ensemble Prediction System (GEPS). The GSM (TL959L100; upgraded on 18 March, 2014) has a horizontal resolution of approximately 20 km and 100 vertical layers, while GEPS (TL479L100;

operational as of 19 January 2017) has 27 members with a horizontal resolution of approximately 40 km and 100 vertical layers. Further details and recent model improvements are detailed in Appendix 6. Since 2015 the Center has mainly employed a consensus method for TC track forecasts. This approach involves taking the mean of predicted TC positions from multiple deterministic models, including the GSM and other NWP centers' models.

A probability circle shows the range into which the center of a TC is expected to move with 70% probability at each validation time. The radius for all forecast times up to 120 hours is determined by the multiple ensemble method, which is solely according to the confidence level based on the cumulative ensemble spread calculated using multiple ensemble prediction systems (EPSs) consisting of European Centre for Medium-Range Weather Forecasts (ECMWF), National Centers for Environmental Prediction (NCEP) and United Kingdom Met Office (UKMO) global EPSs in addition to GEPS.

In relation to TC intensity, the Center began providing TC intensity forecasts with extended lead times of up to 120 hours in March 2019, based on several tropical cyclone intensity forecast guidance products including the one based on the Statistical Hurricane Intensity Prediction Scheme (SHIPS). The new scheme was developed by JMA and Meteorological Research Institute (MRI) of JMA and is known as TIFS (Typhoon Intensity Forecasting scheme based on SHIPS).

1.3 Provision of RSMC Products

The Center prepares and distributes the RSMC bulletins listed below via the GTS or the AFTN when:

- a TC of TS intensity or higher exists in the Center's area of responsibility
- a TC is expected to reach or exceed TS intensity in the area within 24 hours

RSMC products are issued while any TC of TS intensity or higher or any TD expected to reach or exceed TS intensity within 24 hours exists in the Center's area of responsibility. Appendix 5 denotes the code forms of the bulletins.

(1) RSMC Tropical Cyclone Advisory for Three-day Forecasts (WTPQ20-25 RJTD: via GTS)

The RSMC Tropical Cyclone Advisory for Three-day Forecasts is issued eight times a day after observations made at 00, 03, 06, 09, 12, 15, 18 and 21 UTC, and reports the following elements in analysis, and in 24-, 48- and 72-hour forecasts for TCs:

Analysis	Center position Accuracy of center position determination Direction and speed of movement Central pressure Maximum sustained wind speed (10-minute average) Maximum gust wind speed Radii of wind areas over 50 and 30 knots
24-, 48- and 72-hour forecasts	Center position and radius of probability circle Direction and speed of movement Central pressure Maximum sustained wind speed (10-minute average) Maximum gust wind speed

*This Advisory is scheduled for termination shortly.

RSMC Tropical Cyclone Advisory (WTPQ50-55 RJTD: via GTS)

The RSMC Tropical Cyclone Advisory is issued eight times a day after observations made at 00, 03 06, 09, 12, 15, 18 and 21 UTC, and reports the following elements in analysis and in 24-, 48-, 72-, 96- and 120-hour forecasts[1] for TCs:

Analysis	Center position Accuracy of center position determination Direction and speed of movement Central pressure Maximum sustained wind speed (10-minute average) Maximum gust wind speed Radii of wind areas over 50 and 30 knots
24-, 48- 72-, 96- and 120-hour Forecasts[1]	Center position and radius of probability circle Direction and speed of movement Central pressure Maximum sustained wind speed (10-minute average) Maximum gust wind speed

(2) RSMC Guidance for Forecast by GSM (FXPQ20-25 RJTD: via GTS)

The RSMC Guidance for Forecast by GSM reports the results of predictions made by the GSM; which is run four times a day with initial analyses at 00, 06, 12 and 18 UTC. The guidance presents six-hourly GSM predictions for TCs up to 132 hours ahead and reports the following elements:

NWP prediction (T = 006 to 132)
Center position
Central pressure*
Maximum sustained wind speed*

** Predictions of these parameters are given as deviations from those at the initial time.*

(3) RSMC Guidance for Forecast by GEPS (FXPQ30-35 RJTD: via GTS)

The RSMC Guidance for Forecast by GEPS reports the results of predictions made by the GEPS; which is run four times a day with initial analyses at 00, 06, 12 and 18 UTC. The guidance presents the ensemble mean of GEPS six-hourly predictions up to 132 hours ahead and reports the following elements:

NWP prediction (T = 006 to 132)
Center position
Central pressure*
Maximum sustained wind speed*

** Predictions of these parameters are given as deviations from those at the initial time.*

[1] At 03, 09, 15 and 21 UTC, 24-, 45-, 69-, 93- and 117-hour forecasts for TCs are reported.

(4) SAREP (IUCC10 RJTD: via GTS)

The SAREP in BUFR format reports the results of TC analysis including intensity information (i.e., the CI number) based on the Dvorak method. It is issued shortly after observations made for TCs with TS intensity or higher at 00, 03, 06, 09, 12, 15, 18 and 21 UTC (TDs expected to reach TS intensity or higher within 24 hours at 00, 06, 12 and 18), and reports the following elements:

Himawari-8 imagery analysis	Center position Accuracy of center position determination Direction and speed of movement Mean diameter of overcast cloud Apparent past 24-hour change in intensity** Dvorak Intensity (CI, T, DT, MET, PT number) ** Cloud pattern type of the DT number** Trend of past 24-hour change** Cloud pattern type of the PT number** Type of the final T-number**

*** Reported only at 00, 06, 12 and 18 UTC*

BUFR/CREX templates for translation into table-driven code forms are provided on the WMO website at https://community.wmo.int/activity-areas/wis/wis-manuals. The SAREP is provided in text format on the Numerical Typhoon Prediction (NTP) website (see 1.7).

(5) RSMC Prognostic Reasoning (WTPQ30-35 RJTD: via GTS)

The RSMC Prognostic Reasoning report provides brief reasoning for TC analysis and forecasts, and is issued at 00, 06, 12 and 18 UTC following the issuance of the RSMC Tropical Cyclone Advisory. The bulletin provides general comments on current positioning, intensity and related changes, synoptic situations such as those of the subtropical high and atmospheric/oceanographic fields, reasoning behind TC track and intensity forecasts (including details of methodology and guidance models), and relevant remarks in plain language.

(6) RSMC Tropical Cyclone Best Track (AXPQ20 RJTD: via GTS)

The RSMC Tropical Cyclone Best Track report provides post-analysis data on TCs of TS intensity or higher. It reports the center position, the central pressure and the maximum sustained wind speed. The best track for each TC is usually finalized three months after the termination of related issuance of the above RSMC bulletins.

(7) Tropical Cyclone Advisory for SIGMET (FKPQ30-35 RJTD: via AFTN)

As a Tropical Cyclone Advisory Centre (TCAC) within the framework of the International Civil Aviation Organization (ICAO), the Center provides Tropical Cyclone Advisory (TCA) for SIGMET to Meteorological Watch Offices (MWOs) in order to support their preparations of SIGMET information on TCs. These advisories include the following elements in analysis and in 6-, 12-, 18- and 24-hour forecasts:

Analysis	Center position Observed CB cloud

	Direction and speed of movement Changes in intensity Central pressure Maximum sustained wind speed (10-minute average)
Forecast	Center position Maximum sustained wind speed (10-minute average)

1.4 Tropical Cyclone Advisory for SIGMET

The Center provides text-format and graphical TCAs in its role as the ICAO TCAC. These include the horizontal extent of cumulonimbus cloud and cloud top height associated with TCs potentially affecting aviation safety, in addition to text-format TCA information. Both text-format and graphical TCAs and related specifications are provided online for users via linkage from the NTP website (see 1.7), and graphical TCAs are also provided to World Area Forecast Centres (WAFCs).

In November 2020, the IWXXM GML format (Annex 3, Amendment 78, Appendix 2, para. 5.1.3) was introduced and certain element changes (Amendments 78 and 79, Table A2-2) were made, along with the commencement of tropical cyclone advisory messages in IWXXM 3.0 format on the TCAC Tokyo website.

1.5 WIS Global Information System Center Tokyo Server

As designated at the Sixteenth WMO Congress in June 2011, the Center introduced Data Collection or Production Centre (DCPC) service under the Global Information System Centre (GISC) Tokyo for the WMO Information System (WIS) in August 2011. It provides NWP products such as data on predicted fields in grid-point-value (GPV) form and observational values through WIS Data Discovery, Access and Retrieval (DAR) via a new GISC Tokyo server (https://www.wis-jma.go.jp/). GSM products with resolution of 0.5 and 0.25 degrees (surface layer) and JMA SATAID (SATellite Animation and Interactive Diagnosis; https://www.wis-jma.go.jp/cms/sataid/) Service are also available from the server through WIS DAR. All products available via the new server are listed in Appendix 7.

1.6 RSMC Tokyo - Typhoon Center Website

The RSMC Tokyo - Typhoon Center Website provides TC advisories on a real-time basis and a wide variety of products including TC analysis archives, technical reviews and annual reports on the Center's activities at https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/RSMC_HP.htm. Since 12 November 2012, the website provides experimental TC advisory information in Common Alert Protocol (CAP) format.

1.7 Numerical Typhoon Prediction Website

Since 1 October 2004, the Center has operated the Numerical Typhoon Prediction (NTP) website to assist the NMSs of Typhoon Committee Members in improving their TC forecasting and warning services. The site provides TC track predictions and weather maps of deterministic global NWP models from nine centers (Bureau of Meteorology (BoM, Australia), China Meteorological Administration (CMA, China), Canadian Meteorological Centre (CMC, Canada), Deutscher Wetterdienst (DWD, Germany), ECMWF, Korea Meteorological Administration (KMA, Republic of Korea), NCEP (USA), UKMO (UK) and JMA), ensemble TC track predictions of global EPSs from four centers (ECMWF, NCEP, UKMO and JMA) and a wide variety of products including the results of the Center's TC analysis, upper-air analysis, ocean analysis, storm surge and ocean wave forecasting. All products available on the website are listed in Appendix 8.

Chapter 2

Major Activities of the RSMC Tokyo - Typhoon Center in 2020

2.1 Provision of RSMC Products

The Center provides operational products for TC forecasting to NMSs via the GTS, the AFTN and other networks. Monthly and annual totals of products issued in 2020 are listed in Table 2.1.

Table 2.1 Monthly and annual totals of products issued by the RSMC Tokyo - Typhoon Center in 2020

Product	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
IUCC10	0	0	0	0	38	16	3	182	152	232	50	13	686
WTPQ20-25	0	0	0	0	43	21	8	213	164	263	170	21	903
WTPQ30-35	0	0	0	0	21	10	4	103	79	129	84	10	440
WTPQ50-55	0	0	0	0	43	21	8	213	164	263	170	21	903
FXPQ20-25	0	0	0	0	21	10	4	103	79	129	84	10	440
FXPQ30-35	0	0	0	0	21	10	4	103	79	129	84	10	440
FKPQ30-35	0	0	0	0	21	10	4	104	80	129	84	10	442
AXPQ20	6	0	0	0	0	0	0	2	0	1	2	8	19

Notes:

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

*WTPQ20-25 is scheduled for termination shortly.

2.2 Publications

In April 2020, the 22nd issue of the *RSMC Technical Review* was issued with the following areas of focus:

1. Implementation of All-sky Microwave Radiance Assimilation in JMA's Global NWP System
2. Introduction of a New Hybrid Data Assimilation System for the JMA Global Spectral Model

In December 2020, the Center published the *Annual Report on the Activities of the RSMC Tokyo - Typhoon Center 2019*. Both publications are available on the Center's website at https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/RSMC_HP.htm.

2.3 Typhoon Committee Attachment Training

The Center has organized ESCAP/WMO Typhoon Committee Attachment Training courses every fiscal year since 2001 with the support of the WMO Tropical Cyclone Programme and the Typhoon Committee in order to advance the TC analysis and forecasting capacity of Committee Members.

In 2020, preparations were made for the 20th event to be held from 9 to 11 March 2021. Amid the COVID-19 pandemic, the course was held virtually with attendees from seven Typhoon Committee Members (Hong Kong China, Macao China, Malaysia, the Philippines, the Republic of Korea, Singapore and Thailand), along with senior forecaster Ms. Sunitha Devi of RSMC New Delhi.

The course was intended to provide a solid understanding of monitoring, analysis and forecasting for tropical cyclones based on RSMC Tokyo products, and to raise awareness of up-to-date public weather services and information design based on the concept of the 10-year Vision to Protect Life and Property from Tropical Cyclones, as delineated in the Tokyo Statement from the High-level Dialogues on Tropical Cyclones held in Tokyo, Japan, in October 2019. Content also addressed the promotion of information sharing on recent tropical cyclone activities conducted by contributing services.

RSMC-Tokyo is committed to improving forecasting competence, and thereby the capacity of Meteorological Services in the Typhoon Committee region, via training to meet various regional needs, including basic application, state-of-the-art tropical cyclone forecasting and monitoring techniques/methodologies.

2.4 Monitoring of Observational Data Availability

The Center carried out regular monitoring of information exchanges for enhanced TC observation in accordance with the standard procedures stipulated in Section 6.2, Chapter 6 of *The Typhoon Committee Operational Manual (TOM) - Meteorological Component (WMO/TD-No. 196)*. Monitoring for the period from 1 January to 31 December 2020, was conducted for two TCs:

1. Tropical Storm (TS) Nuri (2002), from 00 UTC 10 June to 00 UTC 14 June 2020
2. Typhoon (TY) Vamco (2022), from 12 UTC 11 November to 12 UTC 15 November 2020

The results were distributed to all Typhoon Committee Members in March 2021, and are also available on the WIS GISC Tokyo server at https://www.wis-jma.go.jp/monitoring/data/monitoring/.

2.5 Other Activities in 2020

2.5.1 Services Introduced in 2020

The Center introduced the services detailed below in 2020.

(1) 5-day tropical cyclone forecasts for TDs expected to reach TS intensity within 24 hours

On 9 September 2020, the Center began to provide five-day forecasts for TDs expected to reach TS intensity within 24 hours toward accelerated disaster prevention support.

(2) Enhanced communication service

The Center maintains its own dedicated platform via which Committee Members can post inquiries and comments on tropical cyclone analysis and forecasts, with commencement of Advance Notice provision in July 2020. The first 18 months of trial basis operation saw active discussions and hundreds of accesses during the 2020 typhoon season, highlighting the platform's core role in maintaining communication among Members and the Center. Based on this success, the trial phase will be transitioned to full-fledged operation to further enhance related interaction.

2.5.2 Upgrades of Numerical Typhoon Prediction Website

The changes outlined below were made to the NTP website in July 2020.

(1) TIFS Monitor (TC intensity guidance monitor)

The Center began providing tropical cyclone intensity forecast guidance products, including TIFS data.

(2) Real-time verification results

The Center shares internal real-time verification results with Members via the NTP website under "Verification" on the "Numerical TC Prediction" global menu. The contents include the verification of Center's official forecasts, prediction results from global models on the site, and results from certain intensity guidance schemes for prediction of tracks and intensities (central pressure and maximum wind speed), along with a usage guide.

(3) TC Activity Prediction with higher accuracy

The Center provides two- and five-day Tropical Cyclone Activity Prediction Maps covering its area of responsibility based on ensembles from ECMWF, NCEP, UKMO and JMA, along with a grand ensemble for these four centers. The maps display potential tropical cyclone activity in terms of the percentage of ensemble members in which TC-like vortices are represented within 300 km of a certain location during the relevant forecast time. In 2020, the Center conducted parameter tuning with cumulative data and improved accuracy, and began provision of improved maps. Maps based on climatological normal values (1989 –2018) were also added for reference.

(4) Additional points for time-series charts representing ocean wave prediction

Five points were added to time-series charts representing ocean wave prediction responding to a request from Malaysia Meteorological Department.

(5) Introduction of NOAA-20 data to microwave TC intensity estimation

To further improve TC intensity estimation, the Center added a TC central pressure estimate based on satellite microwave observation data from the Advanced Technology Microwave Sounder (ATMS) on the NOAA-20 polar-orbiting satellite to time-series charts.

Chapter 3

Summary of the 2020 Typhoon Season

In 2020, 23 TCs of TS intensity or higher formed over the western North Pacific and the South China Sea. This total is below the climatological normal* frequency of 25.6. Among these 23 TCs, 10 reached TY intensity, 5 reached severe tropical storm (STS) intensity and 8 reached TS intensity (Table 3.1).

** Climatological normal is based on data for the period from 1981 to 2010.*

Table 3.1 List of tropical cyclones reaching TS intensity or higher in 2020

Tropical Cyclone			Duration (UTC) (TS or higher)			Minimum Central Pressure				Max Wind
						(UTC)	lat(N)	lon(E)	(hPa)	(kt)
TY	Vongfong	(2001)	121200 May	-	161200 May	140000	12.1	126.2	960	85
TS	Nuri	(2002)	121200 Jun	-	140000 Jun	130000	18.4	115.6	996	40
TS	Sinlaku	(2003)	010000 Aug	-	021800 Aug	020600	19.4	106.2	985	40
TY	Hagupit	(2004)	010600 Aug	-	051200 Aug	031200	26.8	121.8	975	70
TS	Jangmi	(2005)	081800 Aug	-	110600 Aug	091200	27.8	126.3	994	45
STS	Mekkhala	(2006)	100000 Aug	-	110600 Aug	101800	22.9	118.3	992	50
STS	Higos	(2007)	180000 Aug	-	191800 Aug	190000	22.2	113.0	992	55
TY	Bavi	(2008)	220000 Aug	-	270600 Aug	260000	32.4	124.5	950	85
TY	Maysak	(2009)	280600 Aug	-	030600 Sep	010000	26.9	126.0	935	95
TY	Haishen	(2010)	311200 Aug	-	071800 Sep	041200	22.7	133.5	910	105
TS	Noul	(2011)	151800 Sep	-	181800 Sep	170600	15.5	113.1	992	45
STS	Dolphin	(2012)	210000 Sep	-	240600 Sep	220600	28.1	135.8	975	60
STS	Kujira	(2013)	261800 Sep	-	300600 Sep	290000	32.6	153.8	980	60
TY	Chan-hom	(2014)	050000 Oct	-	111800 Oct	081200	29.4	133.3	965	70
TS	Linfa	(2015)	101800 Oct	-	111200 Oct	110000	14.9	109.4	994	45
TS	Nangka	(2016)	120600 Oct	-	141200 Oct	131200	19.0	110.4	990	45
TY	Saudel	(2017)	200000 Oct	-	251200 Oct	221200	17.1	115.9	975	65
TY	Molave	(2018)	240600 Oct	-	281800 Oct	270600	13.5	113.2	940	90
TY	Goni	(2019)	281800 Oct	-	051200 Nov	311800	13.8	125.0	905	120
STS	Atsani	(2020)	021800 Nov	-	070600 Nov	041200	20.2	128.7	992	50
TS	Etau	(2021)	081800 Nov	-	101200 Nov	090600	12.5	112.0	992	45
TY	Vamco	(2022)	091200 Nov	-	151200 Nov	140000	15.8	111.4	955	85
TS	Krovanh	(2023)	200000 Dec	-	220600 Dec	200600	10.0	115.2	1000	35

3.1 Atmospheric and Oceanographic Conditions in the Tropics

Subsequent to a positive Indian Ocean Dipole event from summer to autumn 2019, sea surface temperatures (SSTs) in the Indian Ocean were higher than normal throughout 2020. In association, convective activity was generally enhanced over the Indian Ocean until July 2020, but was relatively suppressed over the South China Sea and the sea east of the Philippines, where a large number of named TCs form in normal years (Figure 3.1). During July 2020 in particular, tropical convection was enhanced over the western Indian Ocean and suppressed in the Asian monsoon region, which delayed northward migration of the subtropical jet stream over Eurasia and induced southwestward expansion of the North Pacific Subtropical High, resulting in reduced named-TC genesis during the month (see 3.2).

A La Niña event emerged and developed from boreal summer to autumn 2020 onward in association with remarkably positive SST anomalies in the western equatorial Pacific and remarkably negative anomalies from central to eastern parts. In boreal autumn 2020, tropical convection was enhanced from the northern Indian Ocean to the Maritime Continent, and the tropical lower-tropospheric circulation anomalies observed from the Indian Ocean to the Pacific were associated with the prevailing La Niña conditions.

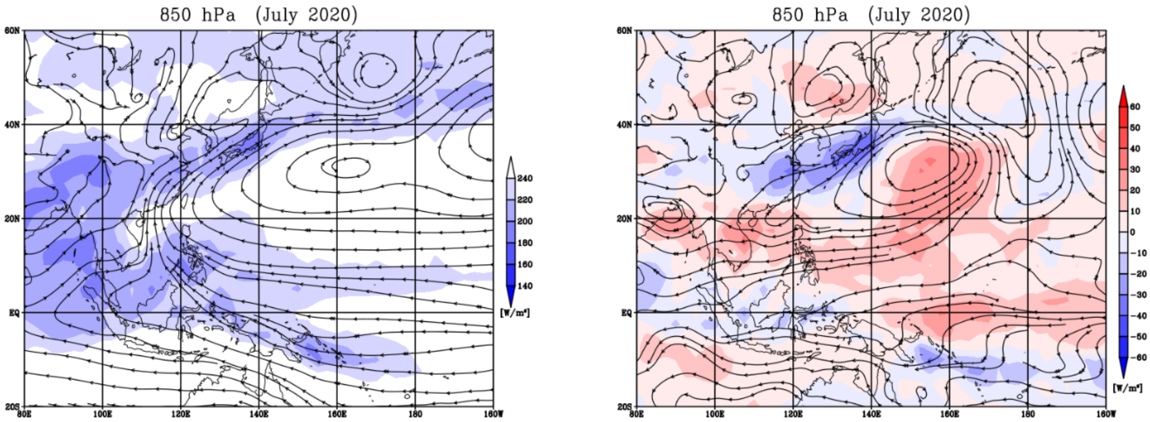

Figure 3.1 Monthly mean streamlines (lines with arrows) and OLR* (shading) (left) and related anomalies (right) at 850 hPa for July 2020.

To highlight atmospheric and oceanographic conditions, charts showing monthly mean SST anomalies for the western North Pacific and the South China Sea, monthly mean streamlines at 850 and 200 hPa, and OLRs* along with related anomalies for the months from January to December are available on the Center's website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html).

** OLR data were calculated using information provided by the Climate Prediction Center/NOAA at https://www.cpc.ncep.noaa.gov/products/global_precip/html/wpage.olr.html.*

3.2 Tropical Cyclones in 2020

A total of 23 named TCs formed over the western North Pacific and the South China Sea in 2020, which was below the 30-year average. Monthly and the climatological normal* numbers of named TC formation are shown in Figure 3.2, and the tracks of the 23 TCs are shown in Figure 3.3. Figure 3.4 shows the genesis points of the 23 TCs (dots) and related frequency distribution for past years (1951 - 2019).

** Climatological normal is based on data for the period from 1981 to 2010.*

The 2020 typhoon season started in May with Vongfong (2001), which originally formed as a TD around the Palau Islands and hit the Philippines with TY intensity early on 14 May. Notably, two named TCs had formed by July, which is far below the 30-year normal of 7.7. The third named TC formed at 00 UTC on 1 August, which is the second latest since related statistics began in 1951. This is attributed to high sea surface temperatures over the Indian Ocean and related convective activity in the region until July, which led to convective inactivity over the South China Sea and seas east of the Philippines where TCs generally form.

The total of six named TCs forming in October was the second highest since statistics began. Analysis shows significantly enhanced convective activity from the South China Sea to the area east of the Philippines, which created favorable atmospheric and oceanic conditions for local TC formation. This is attributed to an active Madden-Julian Oscillation (MJO) phase in the area in addition to the emergence of the La Niña event.

The mean genesis point of named TCs was 17.5˚N and 126.3˚E, which deviated west-northwestward from that of the 30-year average** (16.2˚N and 136.7˚E) (see Figure 3.4), probably affected by the La Niña conditions. The mean genesis point of named TCs formed in summer (June to August) was 19.9˚N and 124.1˚E, with west-northwestward deviation from that of the 30-year summer average** (18.4˚N and 134.9˚E), and that of named TCs formed in autumn (September to November) was 16.8˚N and 128.6˚E, with west-northwestward deviation from that of the 30-year autumn average** (15.9˚N and 137.8˚E).

The mean duration of TCs sustaining TS intensity or higher was 3.8 days, shorter than that of the 30-year average** (5.3 days). The mean duration of TCs sustaining TS intensity or higher formed in summer was 3.5 days, shorter than that of the 30-year average** (5.1 days), and the mean duration of TCs sustaining TS intensity or higher formed in autumn was 4.1 days, shorter than that of the 30-year average** (5.6 days).

*** The 30-year averaging period is from 1981 to 2010*

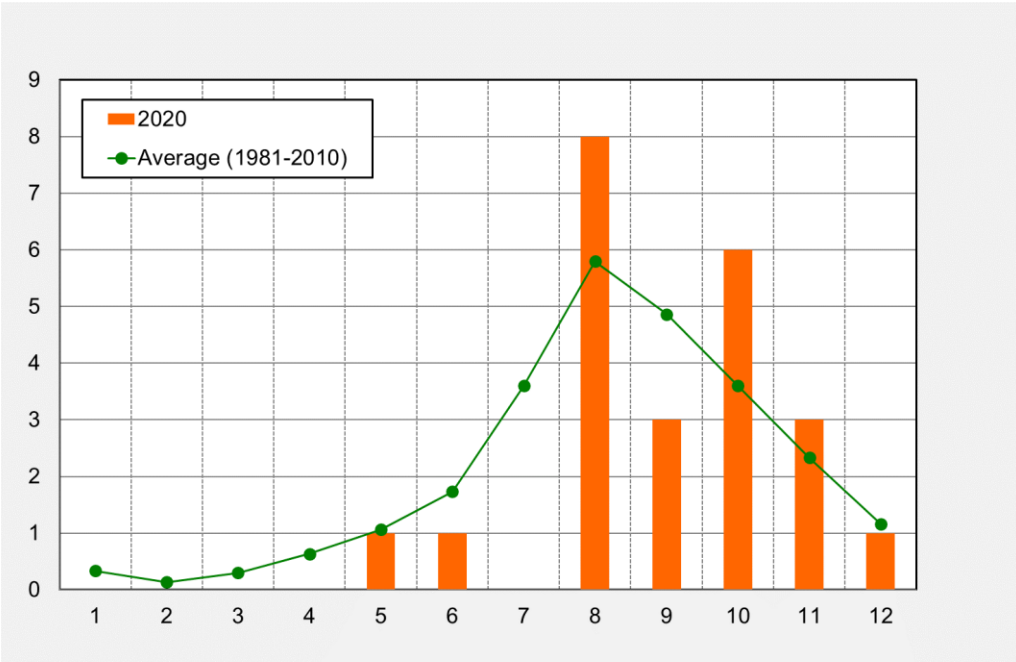

Figure 3.2 Monthly number of named TC formation for 2020 compared to the climatological normal

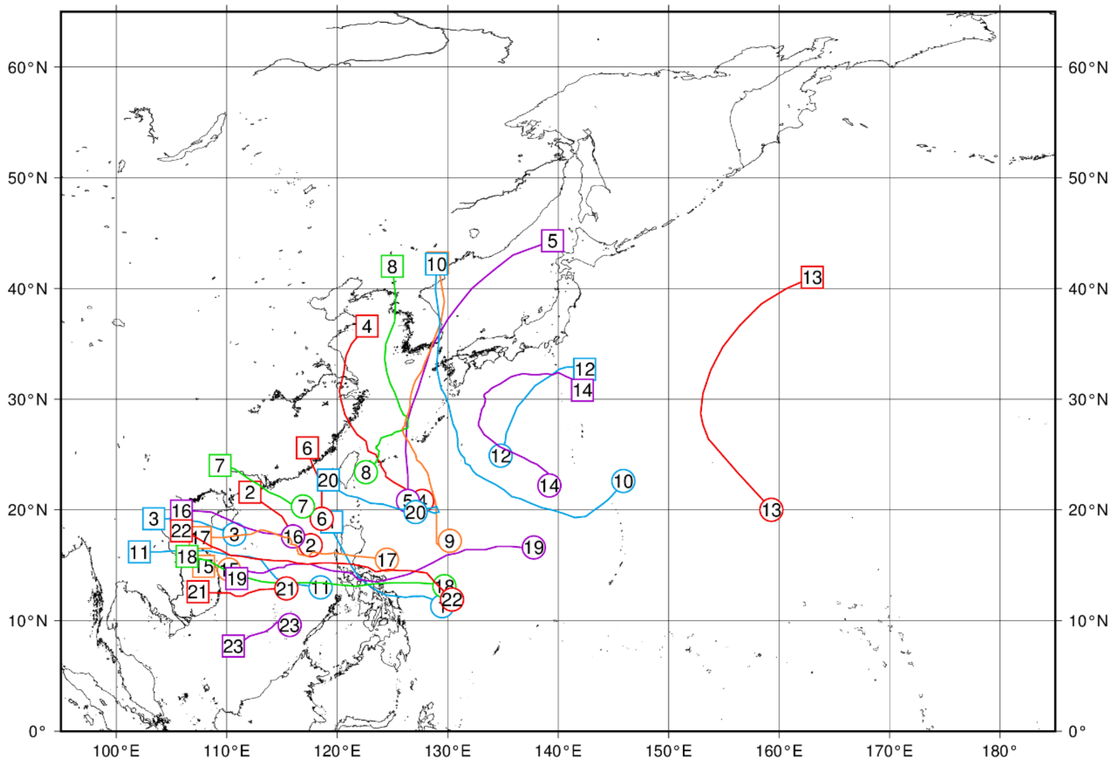

Figure 3.3 Tracks of the 23 named TCs that formed in 2020. TC tracks for those with an intensity of TS or higher are shown.

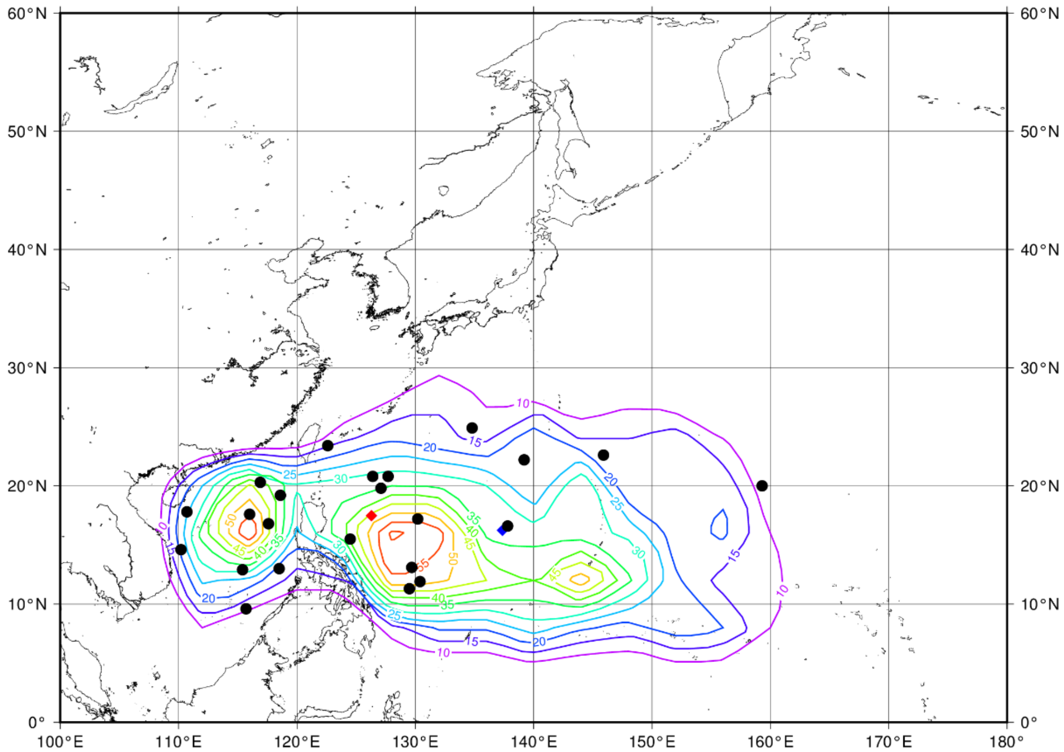

Figure 3.4 Genesis points of the 23 named TCs forming in 2020 (dots) and related frequency distribution for 1951 - 2019 (lines). Red and blue diamonds show the mean genesis points of TCs forming in 2020 and the 30-year average period (1981 – 2010), respectively.

Chapter 4

Verification of Forecasts and Other Products in 2020

4.1 Verification of Operational Forecasts for TCs with TS Intensity or Higher

Operational forecasts for the 23 TCs of TS intensity or higher that formed in 2020 were verified using RSMC TC best track data[2]. The verified elements were forecasts of the center position, central pressure and maximum sustained wind speed (up to five days ahead). In addition to forecast errors, improvement ratios of forecast errors to climatological model were also evaluated to assess operational forecast skill. Forecasts issued at 00, 06, 12 and 18 UTC were included in verification for TCs classified in best-track data as TS, STS or TY at both initial and forecast valid times. The position and intensity errors of such operational forecasts are shown in bold face in Appendix 3. (Those for TD before upgrading into TS intensity or higher are indicated in italic face in Appendix 3.)

4.1.1 Center Position

Figure 4.1 shows annual mean errors in TC track forecasts covering periods of 24 hours (since 1982), 48 hours (since 1989), 72 hours (since 1997), 96 hours and 120 hours (since 2009). It can be seen that operational TC track forecasts have steadily improved since 1982, although year-to-year fluctuations are seen due in part to differences in TC characteristics. The improvement observed since 2015 is partially attributed to the introduction of the consensus method using four global numerical models of ECMWF, JMA, NCEP and UKMO for operational forecasts in that year. The errors in 2020 were 74, 119, 176, 214 and 267 km for 24-, 48-, 72-, 96- and 120-hour forecasts, respectively. 120-hour forecast errors in 2020 were the lowest on record, and those for 72-hours matched the record-low of 2015.

The annual mean improvement ratios in relation to the climatology and persistence model (CLIPER)[3] for TC track prediction since 2011 are shown in Figure 4.2 to support evaluation of the net improvement of operational forecasting performance less affected by the year-to-year fluctuations seen in Figure 4.1. The values are defined as

$$\frac{\text{Mean Position Error (CLIPER)} - \text{Mean Position Error (Operational)}}{\text{Mean Position Error (CLIPER)}}$$

and positive/negative values indicate that the operational forecasts were better/worse than the CLIPER predictions. Although there are year-to-year fluctuations, it can be seen that operational forecasts have

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[2] Maximum sustained wind of TD is not described in best track data or operational forecast. Therefore, maximum sustained wind of TD was treated as 30 kt for convenience in verification in 4.1.

[3] The Center operates the CLIPER model based on Aberson (1998), Neumann (1972) and Merrill (1980). The model outputs no information on current atmospheric status, but best-track data such as TC center position/central pressure/movement and dates are referenced. Multiple regression coefficients for the model were generated from best-track data between 1980 and 2010.

steadily improved in the long run. The annual mean improvement ratios for 24-, 48-, 72-, 96- and 120-hour forecasts in 2020 were 59% (49% in 2019), 71% (66%), 73% (65%), 76% (61%) and 78% (56%), respectively.

The details of errors including improvement ratios to CLIPER for each named TC that formed in 2020 are summarized in Table 4.1. Forecasts for Dolphin (2012) and Chan-hom (2014) were characterized by large errors. Those in forecasts for Dolphin (2012) were attributed to the fact that guidance models predict a weaker North Pacific Subtropical High, which resulted in large track errors. Those in forecasts for Chan-hom (2014) were attributed to the fact that guidance models did not properly predict direction changes in movement associated with the North Pacific Subtropical High and an upper cold low. Meanwhile, forecasts for Maysak (2009), Saudel (2017) and Vamco (2022) showed relatively small errors.

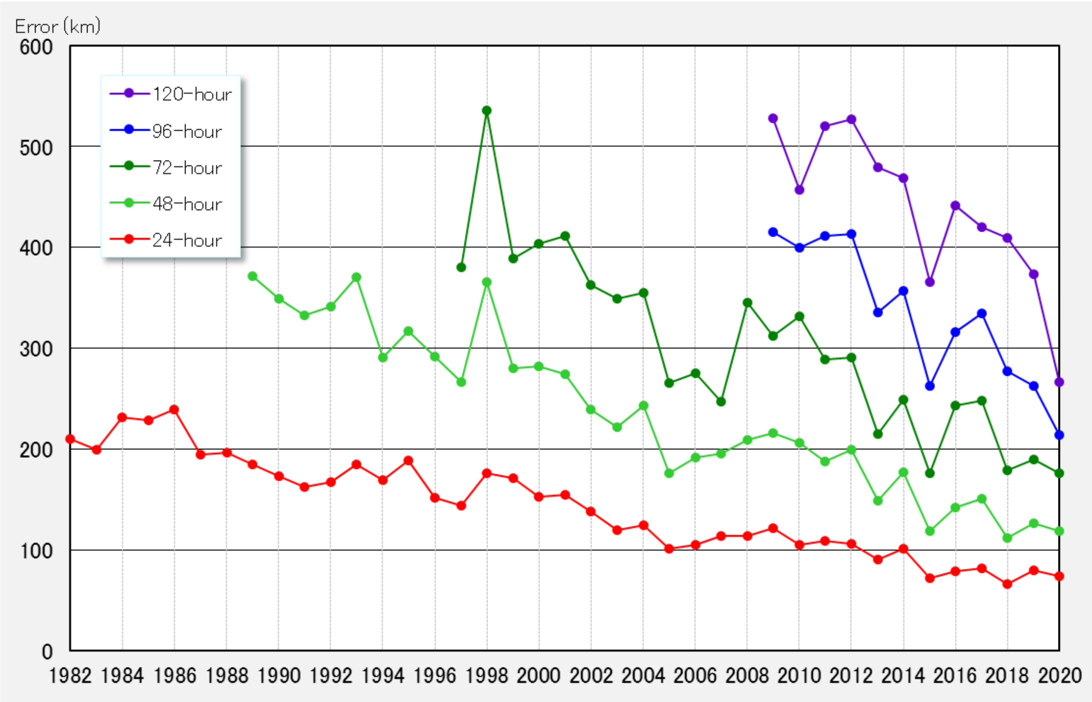

Figure 4.1 Annual mean position errors in 24-, 48-, 72-, 96- and 120-hour operational track forecasts

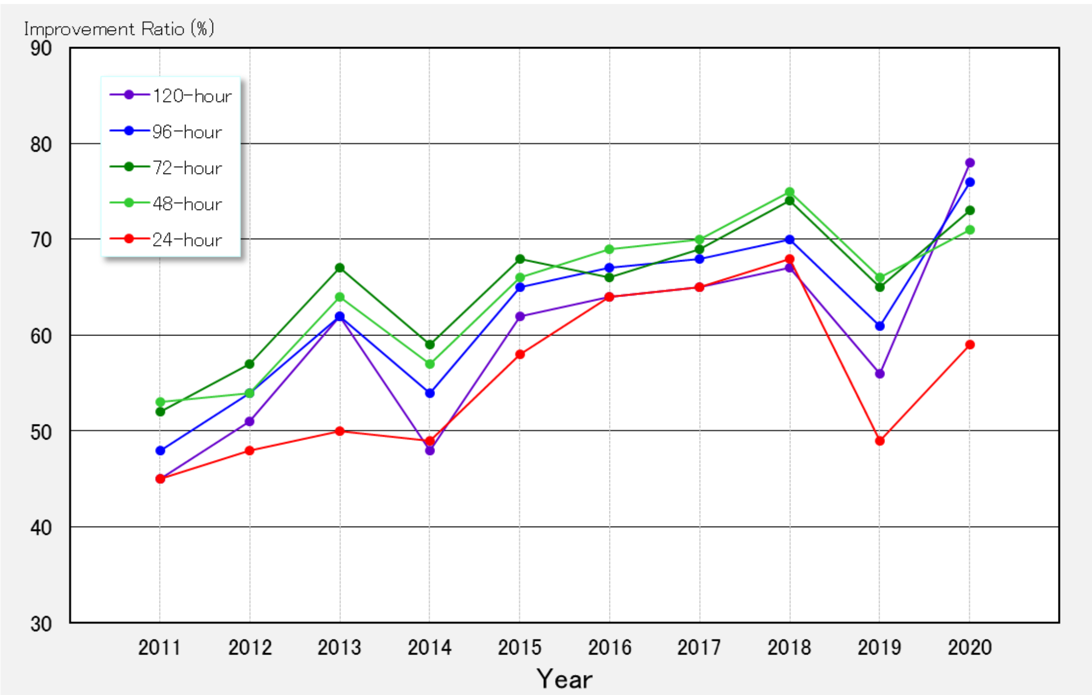

Figure 4.2 Annual mean improvement ratios in 24-, 48-, 72-, 96- and 120-hour operational track forecasts.

Table 4.1 Mean position errors of 24-, 48-, 72-, 96- and 120-hour operational forecasts for each named TC that formed in 2020. S.D., Impr. and Num. represent the standard deviation of operational forecast position errors, improvement ratio (see the equation in 4.1.1 for detail) and number of samples, respectively.

Tropical Cyclone			24-hour Forecast				48-hour Forecast				72-hour Forecast				96-hour Forecast				120-hour Forecast			
			Mean (km)	S.D. (km)	Num.	Impr. (%)	Mean (km)	S.D. (km)	Num.	Impr. (%)	Mean (km)	S.D. (km)	Num.	Impr. (%)	Mean (km)	S.D. (km)	Num.	Impr. (%)	Mean (km)	S.D. (km)	Num.	Impr. (%)
TY	Vongfong	(2001)	82	30	12	46	136	39	8	67	126	41	4	83	-	-	0	-	-	-	0	-
TS	Nuri	(2002)	38	5	2	80	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Sinlaku	(2003)	64	49	3	78	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Hagupit	(2004)	45	32	13	67	108	44	8	64	240	39	4	61	-	-	0	-	-	-	0	-
TS	Jangmi	(2005)	71	32	6	83	102	1	2	91	-	-	0	-	-	-	0	-	-	-	0	-
STS	Mekkhala	(2006)	157	0	1	33	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
STS	Higos	(2007)	130	12	3	-21	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Bavi	(2008)	44	22	17	76	46	29	13	89	103	42	9	82	166	100	5	73	332	0	1	68
TY	Maysak	(2009)	63	31	20	70	87	54	16	83	100	38	12	87	102	53	8	92	166	70	4	90
TY	Haishen	(2010)	91	89	25	37	133	107	19	54	153	93	13	62	177	96	9	72	237	76	5	78
TS	Noul	(2011)	115	65	8	58	190	66	4	65	-	-	0	-	-	-	0	-	-	-	0	-
STS	Dolphin	(2012)	236	68	9	-15	498	67	5	-115	579	0	1	-186	-	-	0	-	-	-	0	-
STS	Kujira	(2013)	75	51	10	67	96	38	6	84	231	10	2	77	-	-	0	-	-	-	0	-
TY	Chan-hom	(2014)	72	38	23	67	158	97	19	75	353	154	15	69	419	181	11	67	374	96	7	72
TS	Linfa	(2015)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS	Nangka	(2016)	79	45	5	43	100	0	1	72	-	-	0	-	-	-	0	-	-	-	0	-
TY	Saudel	(2017)	56	24	18	63	54	27	14	82	90	51	10	74	136	86	6	45	192	9	2	36
TY	Molave	(2018)	82	42	14	35	126	68	10	57	140	73	6	74	201	84	2	78	-	-	0	-
TY	Goni	(2019)	51	23	27	58	120	54	23	59	195	59	19	63	238	93	15	69	316	188	11	72
STS	Atsani	(2020)	77	46	14	60	145	27	10	76	265	116	6	77	336	22	2	80	-	-	0	-
TS	Etau	(2021)	53	19	3	87	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY	Vamco	(2022)	49	38	20	63	56	34	16	80	77	34	12	84	99	24	8	88	102	29	4	92
TS	Krovanh	(2023)	81	24	4	56	145	0	1	72	-	-	0	-	-	-	0	-	-	-	0	-
Annual Mean (total)			74	58	257	59	119	98	175	71	176	125	113	73	214	150	66	76	267	151	34	78

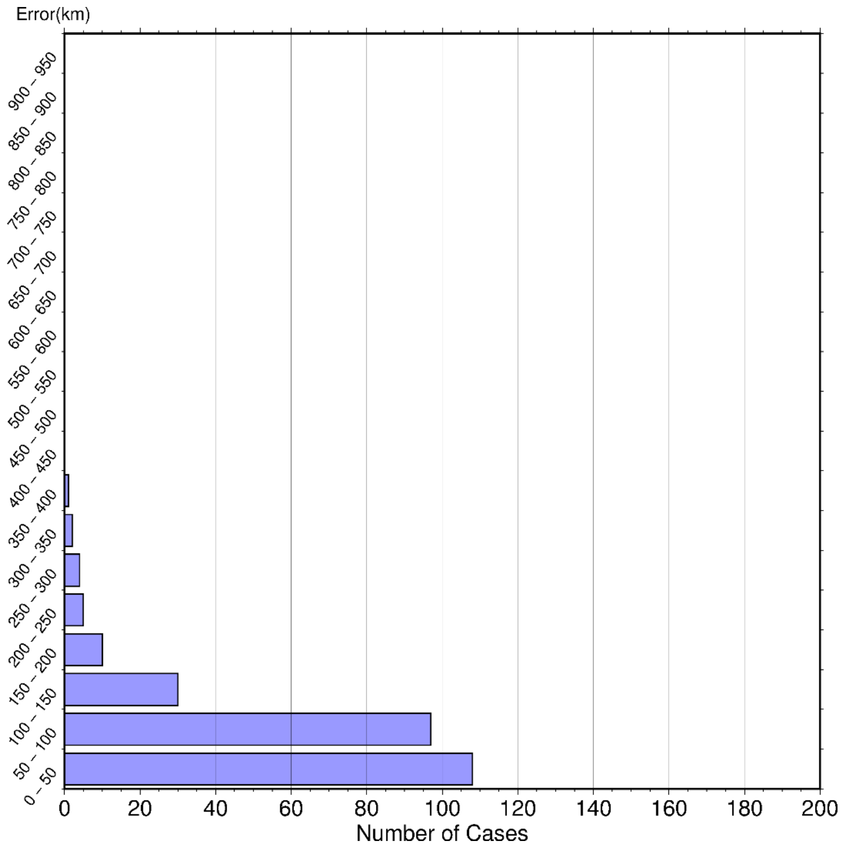

Figure 4.3 Histogram of 24-hour forecast position errors in 2020. (Histograms for 48-, 72-, 96- and 120-hour forecasts are available on the Center's website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html)).

Figure 4.3 shows a histogram of 24-hour forecast position errors. About 91% (91% in 2019) of 24-hour forecasts, 95% (94%) of 48-hour forecasts, 96% (97%) of 72-hour forecasts, 95% (92%) of 96-hour forecasts and 100% (90%) of 120-hour forecasts had errors of less than 150, 300, 450, 500 and 600 km, respectively.

Figure 4.4 shows frequency distributions of 24-hour forecast position errors in longitudinal/latitudinal direction and cross-track/along-track direction. While the bias of errors in 24-, 48- and 72-hour forecasts is small, westward bias is seen in those of 120-hour forecasts. This may be attributed to operational track forecasting for Goni (2019) that indicated overly fast movement, especially in the decline stage.

Table 4.2 presents the mean hitting ratios and radii of 70% probability circles* provided in operational forecasts for each named TC that formed in 2020. The term *hitting ratio* here is used to describe the ratio of the number of 70% probability circles within which the actual TC center fell to the total number of circles. The annual mean radius of circles provided in 24-hour position forecasts was 93 km (93 km in 2019), and their hitting ratio was 74% (69%). The corresponding values for 48-hour forecasts were 163 km (162 km in 2019) and 77% (72%), those for 72-hour forecasts were 256 km (249 km in 2019) and 83% (75%), those for 96-hour forecasts were 362 km (363 km in 2019) and 89% (72%), and those for 120-hour forecasts were 505 km (509 km in 2019) and 100% (80%).

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

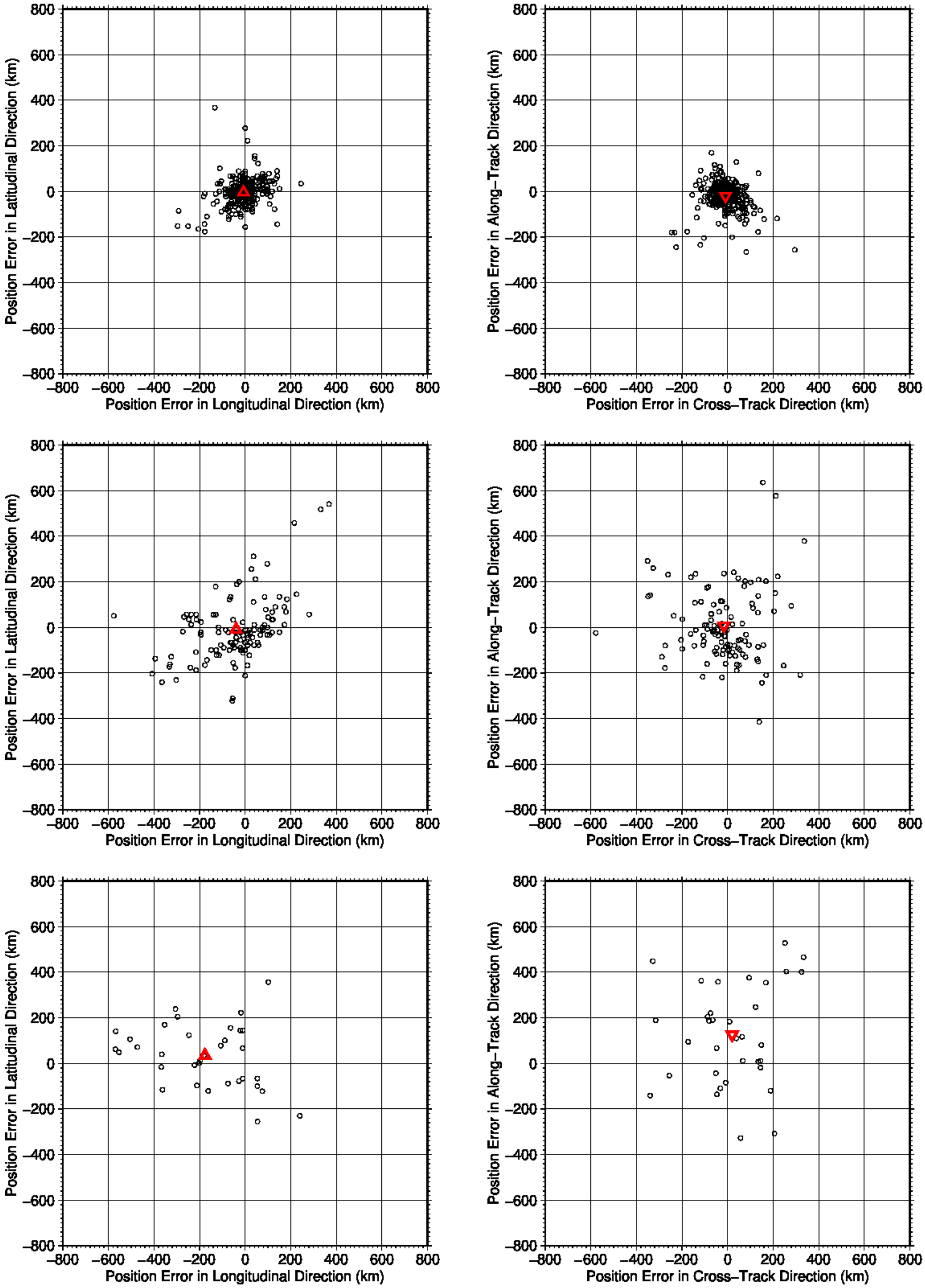

Figure 4.4 Scatter diagrams of 24- (top), 72- (middle) and 120-hour (bottom) forecast position errors in longitudinal/latitudinal direction (left) and cross-/along-track direction (right) in 2020. (Scatter diagrams of 48-, 96-hour forecasts are available on the Center's website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html)). Direction of TC track is determined from movement in 6 hours prior to the initial time. Red triangles denote annual means of position forecast errors.

Table 4.2 Mean hitting ratios (%) and radii (km) of 70% probability circles provided in 24-, 48-, 72-, 96- and 120-hour operational forecasts for each named TC that formed in 2020. Num. represents number of samples.

Tropical Cyclone			24-hour Forecast			48-hour Forecast			72-hour Forecast			96-hour Forecast			120-hour Forecast		
			Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)	Ratio (%)	Num.	Radius (km)
TY	Vongfong	(2001)	75	12	94	75	8	167	100	4	259	-	0	-	-	0	-
TS	Nuri	(2002)	100	2	93	-	0	-	-	0	-	-	0	-	-	0	-
TS	Sinlaku	(2003)	67	3	109	-	0	-	-	0	-	-	0	-	-	0	-
TY	Hagupit	(2004)	85	13	94	100	8	181	100	4	278	-	0	-	-	0	-
TS	Jangmi	(2005)	50	6	99	100	2	167	-	0	-	-	0	-	-	0	-
STS	Mekkhala	(2006)	0	1	148	-	0	-	-	0	-	-	0	-	-	0	-
STS	Higos	(2007)	0	3	105	-	0	-	-	0	-	-	0	-	-	0	-
TY	Bavi	(2008)	88	17	79	100	13	128	100	9	230	100	5	326	100	1	519
TY	Maysak	(2009)	80	20	85	88	16	146	100	12	210	100	8	287	100	4	389
TY	Haishen	(2010)	60	25	82	47	19	131	69	13	185	78	9	259	100	5	370
TS	Noul	(2011)	38	8	91	50	4	160	-	0	-	-	0	-	-	0	-
STS	Dolphin	(2012)	0	9	102	0	5	200	0	1	482	-	0	-	-	0	-
STS	Kujira	(2013)	90	10	105	100	6	173	100	2	287	-	0	-	-	0	-
TY	Chan-hom	(2014)	70	23	94	63	19	180	40	15	294	64	11	471	100	7	656
TS	Linfa	(2015)	-	0	-	-	0	-	-	0	-	-	0	-	-	0	-
TS	Nangka	(2016)	60	5	90	100	1	139	-	0	-	-	0	-	-	0	-
TY	Saudel	(2017)	94	18	101	100	14	198	100	10	322	100	6	426	100	2	556
TY	Molave	(2018)	71	14	98	80	10	170	100	6	284	100	2	519	-	0	-
TY	Goni	(2019)	93	27	95	78	23	175	89	19	271	93	15	393	100	11	546
STS	Atsani	(2020)	79	14	90	70	10	164	50	6	259	100	2	370	-	0	-
TS	Etau	(2021)	100	3	120	-	0	-	-	0	-	-	0	-	-	0	-
TY	Vamco	(2022)	80	20	88	88	16	141	100	12	219	100	8	280	100	4	389
TS	Krovanh	(2023)	100	4	120	100	1	241	-	0	-	-	0	-	-	0	-
Annual Mean (total)			74	257	93	77	175	163	83	113	256	89	66	362	100	34	505

4.1.2 Central Pressure and Maximum Wind Speed

Figure 4.5 shows annual means of root mean square errors (RMSEs) for TC central pressure forecasts covering periods of 24 hours, 48 hours (since 2001), 72 hours (since 2003) 96 hours and 120 hours (since 2019). The values for maximum wind speed forecasts are available on the Center's website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html).

Operational TC intensity forecasts have improved recently after a long period with no notable enhancement, although year-to-year fluctuations exist, as seen in the higher accuracy observed in 2020 compared to 2019 for 72-, 96- and 120-hour forecasts. The annual mean RMSEs of central pressure for 24-, 48-, 72- 96- and 120-hour forecasts were 11.6 hPa (11.2 hPa in 2019), 15.0 hPa (15.1 hPa), 14.6 hPa (17.6 hPa), 13.9 hPa (18.2 hPa) and 13.0 hPa (20.3 hPa), respectively. The corresponding values for maximum wind speed were 5.8 m/s (5.1 m/s in 2019), 7.0 m/s (7.1 m/s), 7.3 m/s (8.0 m/s), 7.2 m/s (8.4 m/s) and 6.8 m/s (9.3 m/s), respectively.

Figure 4.6 shows annual mean improvement ratios for a guidance model based on climatology and persistence (Statistical Hurricane Intensity Forecast; SHIFOR[4]) to highlight the net improvement of operational central pressure forecast performance less affected by the year-to-year fluctuations seen in Figure 4.4. The values are defined as

$$\left(\mathrm{RMSE(SHIFOR)} - \mathrm{RMSE(Operational)}\right)\ /\ \mathrm{RMSE(SHIFOR)},$$

with positive/negative values indicating better/worse operational forecasts than SHIFOR predictions. The values for maximum wind speed forecasts are available on the Center's website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html). It can be seen that operational TC intensity forecasts have improved recently, with minimal year-to-year fluctuations. The annual mean improvement ratios of central pressure for 24-, 48-, 72-, 96- and 120-hour forecasts were 28% (20% in 2019), 36% (21%), 44% (14%), 44% (2%) and 43% (-15%), respectively. The corresponding values of maximum wind were 19% (17% in 2019), 31% (17%), 30% (16%), 28% (-1%) and 15% (-31%), respectively.

The details of errors in operational central pressure forecasts, including improvement ratios to SHIFOR for each named TC that formed in 2020, are summarized in Table 4.3. The data for maximum wind speed forecasts are available on the Center's website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html). Forecasts for Vongfong (2001) and Goni (2019) were characterized by large errors. Those in forecasts for both Vongfong (2001) and Goni (2019) were attributed to the fact that guidance models did not predict rapid intensification in the early or middle stages.

Figure 4.7 shows a histogram of maximum wind speed errors for 24-hour forecasts. Approximately 61% (56% in 2019) of 24-hour forecasts had errors of less than ±3.75 m/s, with figures of ±6.25 m/s for 69%

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[4] The Center operates the SHIFOR model based on Jarvinen and Neumann (1979). The explanatory variables include TC analysis data (center position, central pressure and maximum sustained wind, and related temporal variation from best-track data) and date. Multiple regression coefficients for the model were generated from best-track data for named TCs forming between 1977 and 2010.

(66%) of 48-hour forecasts, ±6.25 m/s for 69% (58%) of 72-hour forecasts, ±8.75 m/s for 85% (66%) of 96-hour forecasts and ±8.75 m/s for 88% (57%) of 120-hour forecasts.

[Reference]

Aberson, S. D., 1998. Five-Day Tropical Cyclone Track Forecasts in the North Atlantic Basin, *Weather and Forecasting*, **13**, 1005-1015.

Jarvinen, B. R. and C. J. Neumann, 1979: Statistical forecasts of tropical cyclone intensity, *NOAA Tech. Memo. NWS NHC-10*, 22 pp.

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Merrill, R. T., 1980: A statistical tropical cyclone motion forecasting system for the Gulf of Mexico. *NOAA Tech. Memo. NWS NHC 14*, 21 pp.

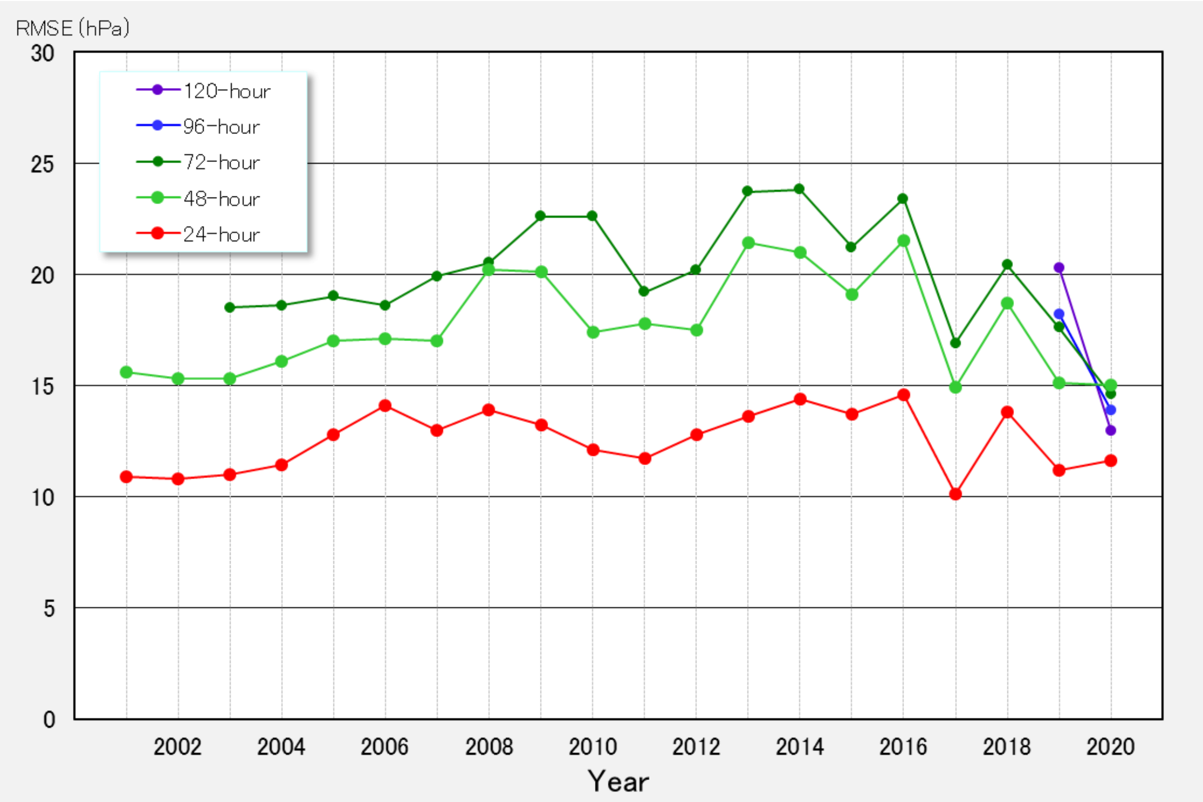


Figure 4.5 Annual RMSEs in 24-, 48, 72-, 96- and 120-hour operational central pressure forecasts

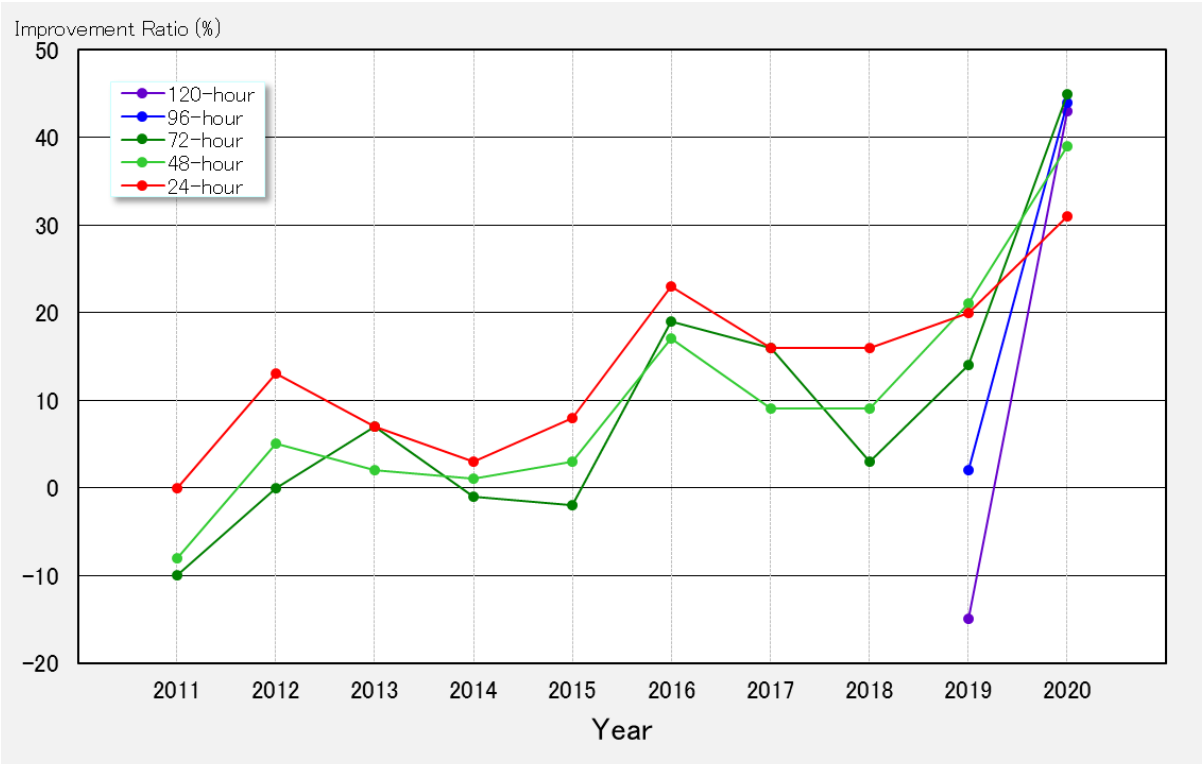


Figure 4.6 Annual mean improvement ratios in 24-, 48, 72-, 96- and 120-hour operational central pressure forecasts

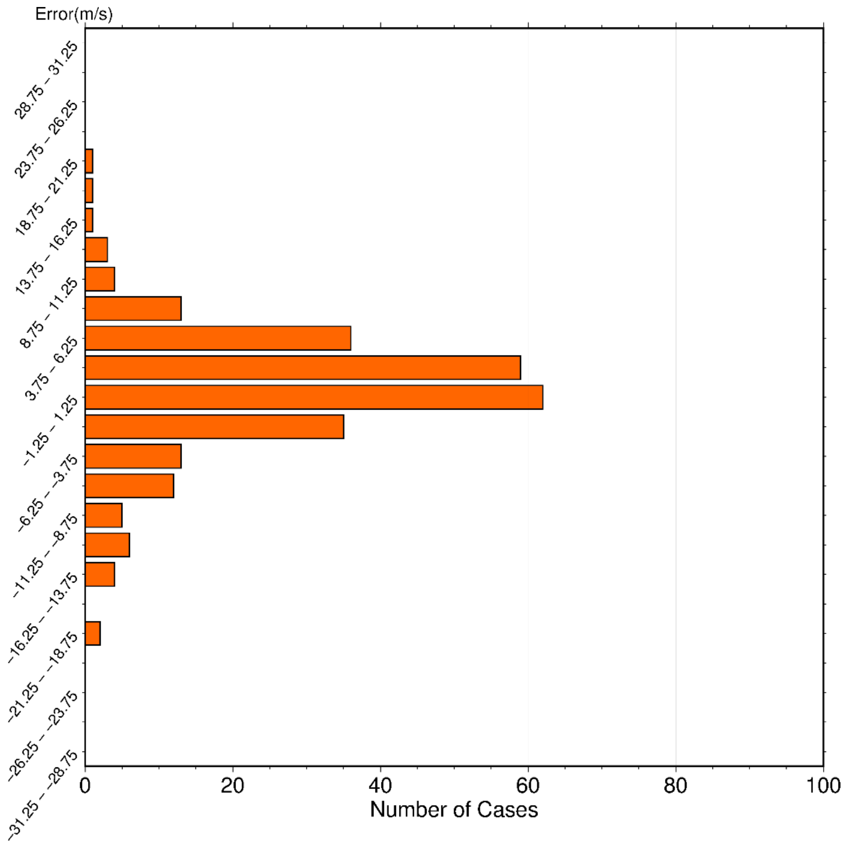


Figure 4.7 Histogram of 24-hour forecast maximum wind speed errors in 2020. (Histograms for 48-, 72-, 96- and 120-hour forecasts are also available on the Center's website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html)).

Table 4.3 Mean errors of 24-, 48-, 72-, 96- and 120-hour operational central pressure forecasts for each named TC that formed in 2020. Impr. and Num. represent improvement ratio of RMSEs (see the equation in 4.1.2 for detail) and number of samples, respectively.

Tropical Cyclone	24-hour Forecast				48-hour Forecast				72-hour Forecast				96-hour Forecast				120-hour Forecast			
	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)	Error (hPa)	RMSE (hPa)	Num.	Impr. (%)
TY Vongfong (2001)	-2.8	18.2	12	11	-14.4	23.1	8	32	-12.5	14.6	4	62	-	-	0	-	-	-	0	-
TS Nuri (2002)	-6.0	6.0	2	47	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS Sinlaku (2003)	5.0	5.8	3	-19	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY Hagupit (2004)	2.9	7.7	13	41	2.9	3.8	8	78	-5.2	7.2	4	70	-	-	0	-	-	-	0	-
TS Jangmi (2005)	-3.3	4.6	6	12	-1.0	1.4	2	92	-	-	0	-	-	-	0	-	-	-	0	-
STS Mekkhala (2006)	2.0	2.0	1	78	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
STS Higos (2007)	-2.0	3.5	3	59	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY Bavi (2008)	-4.0	12.4	17	4	-2.3	9.6	13	56	-3.3	8.2	9	71	-5.0	9.7	5	61	0.0	0.0	1	100
TY Maysak (2009)	-5.0	9.2	20	4	-11.6	15.7	16	-15	-8.8	11.1	12	29	-2.5	10.3	8	43	-7.5	11.2	4	5
TY Haishen (2010)	6.4	14.4	25	27	2.7	16.7	19	49	-5.4	18.9	13	44	-6.7	16.5	9	39	5.0	8.7	5	43
TS Noul (2011)	-2.8	4.7	8	60	-13.0	14.1	4	43	-	-	0	-	-	-	0	-	-	-	0	-
STS Dolphin (2012)	1.7	8.7	9	17	1.4	10.4	5	-44	8.0	8.0	1	8	-	-	0	-	-	-	0	-
STS Kujira (2013)	3.3	5.1	10	20	-0.5	5.5	6	40	-12.5	12.7	2	52	-	-	0	-	-	-	0	-
TY Chan-hom (2014)	-4.8	6.8	23	19	-7.8	9.7	19	-42	-10.7	12.0	15	-70	-10.1	12.1	11	-42	-8.7	10.0	7	17
TS Linfa (2015)	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TS Nangka (2016)	-1.2	3.5	5	62	-6.0	6.0	1	70	-	-	0	-	-	-	0	-	-	-	0	-
TY Saudel (2017)	-2.2	6.5	18	47	1.5	5.6	14	69	-0.7	3.8	10	79	-6.8	7.2	6	64	-1.0	1.4	2	95
TY Molave (2018)	9.4	11.7	14	39	19.4	21.3	10	-23	19.2	23.2	6	-7	-8.5	12.0	2	43	-	-	0	-
TY Goni (2019)	6.6	20.9	27	34	4.2	24.1	23	46	-8.5	20.3	19	51	-13.1	19.1	15	49	-10.0	19.2	11	41
STS Atsani (2020)	-5.6	8.0	14	-40	-11.1	12.8	10	14	-14.7	14.9	6	24	-19.5	19.5	2	10	-	-	0	-
TS Etau (2021)	-6.0	6.2	3	64	-	-	0	-	-	-	0	-	-	-	0	-	-	-	0	-
TY Vamco (2022)	1.3	10.3	20	53	2.4	9.0	16	43	4.9	9.3	12	28	6.0	8.3	8	52	-4.2	5.7	4	75
TS Krovanh (2023)	-3.0	3.5	4	65	-2.0	2.0	1	90	-	-	0	-	-	-	0	-	-	-	0	-
Annual Mean (total)	0.3	11.6	257	31	-1.3	15.0	175	39	-4.8	14.6	113	45	-7.0	13.9	66	44	-5.7	13.0	34	43

4.2 Verification of Timing of First-issued Operational Forecasts for Individual Named TCs

The Center issues TC track forecasts with probability circles and intensity values when a TC of TS intensity or higher is present or expected within 24 hours in its area of responsibility. Accordingly, initial forecasts for individual TCs are also used as 24-hour genesis forecasts in addition to track and intensity forecasts.

Table 4.4 shows differences between initial times of initial forecasts and upgrade times in best-track data/real-time provisional analysis data for individual named TCs. Differences tend to be less than the ideal of 24 hours.

Tropical Cyclone			First Forecast	Upgrade (Best)	Upgrade (Prov.)	Lead Time (Best)	Lead Time (Prov.)
TY	Vongfong	(2001)	111200 May	121200 May	121200 May	24 h	24 h
TS	Nuri	(2002)	111200 Jun	121200 Jun	121200 Jun	24 h	24 h
TS	Sinlaku	(2003)	310000 Jul	010000 Aug	010600 Aug	24 h	30 h
TY	Hagupit	(2004)	010000 Aug	010600 Aug	011200 Aug	6 h	12 h
TS	Jangmi	(2005)	071800 Aug	081800 Aug	081800 Aug	24 h	24 h
STS	Mekkhala	(2006)	091800 Aug	100000 Aug	100300 Aug	6 h	9 h
STS	Higos	(2007)	171200 Aug	180000 Aug	180000 Aug	12 h	12 h
TY	Bavi	(2008)	211200 Aug	220000 Aug	220000 Aug	12 h	12 h
TY	Maysak	(2009)	271800 Aug	280600 Aug	280600 Aug	12 h	12 h
TY	Haishen	(2010)	310600 Aug	311200 Aug	011200 Sep	6 h	30 h
TS	Noul	(2011)	150600 Sep	151800 Sep	151800 Sep	12 h	12 h
STS	Dolphin	(2012)	210000 Sep	210000 Sep	210300 Sep	0 h	3 h
STS	Kujira	(2013)	260600 Sep	261800 Sep	270000 Sep	12 h	18 h
TY	Chan-hom	(2014)	041200 Oct	050000 Oct	050000 Oct	12 h	12 h
TS	Linfa	(2015)	100000 Oct	101800 Oct	101800 Oct	18 h	18 h
TS	Nangka	(2016)	110600 Oct	120600 Oct	120600 Oct	24 h	24 h
TY	Saudel	(2017)	190000 Oct	200000 Oct	200000 Oct	24 h	24 h
TY	Molave	(2018)	231200 Oct	240600 Oct	241800 Oct	18 h	30 h
TY	Goni	(2019)	271200 Oct	281800 Oct	281800 Oct	30 h	30 h
STS	Atsani	(2020)	290000 Oct	021800 Nov	291200 Oct	114 h	12 h
TS	Etau	(2021)	080000 Nov	081800 Nov	081800 Nov	18 h	18 h
TY	Vamco	(2022)	081200 Nov	091200 Nov	090600 Nov	24 h	18 h
TS	Krovanh	(2023)	181200 Dec	200000 Dec	200600 Dec	36 h	42 h

Table 4.4 Lead times of operational forecasting for upgrade to TS intensity or higher. "First forecast," "Upgrade (Best/Prov.)" and "Lead time (Best/Prov.)" are the initial time of the first forecast for individual named TCs, the time when the TC was upgraded to TS intensity or higher in best-track data/provisional analysis, and the time difference between the two, respectively.

4.3 Verification of Numerical Models (GSM, GEPS)

GSM and GEPS provide primary information for use by JMA forecasters in making operational TC track and intensity forecasts. The details of GSM and GEPS and information on recent related improvements are given in Appendix 6. GSM and GEPS predictions were verified with RSMC TC best track data and predictions using the persistency (PER) method. All TC forecast verifications were conducted for both systems.

4.3.1 GSM Prediction

1) Center Position

GSM annual mean position errors observed since 1997 are presented in Figure 4.8. In 2020, the annual mean errors for 30-, 54-, 78-, 102- and 126-hour* predictions were 98 km (115 km in 2019), 172 km (180 km), 250 km (268 km), 300 km (385 km) and 357 km (510 km) , respectively. The mean position errors of 18-, 30-, 42-, 54-, 66-, 78-, 90-, 102-, 114- and 126-hour predictions for each named TC are given in Table 4.5.

** 30-, 54-, 78-, 102- and 126-hour GSM predictions are used as primary information by forecasters creating 24-, 48-, 72-, 96- and 120-hour operational forecasts, respectively.*

Table 4.6 shows relative GSM performance compared with results obtained using the PER method*. In this comparison, TCs were classified into the three life stages of before, during and after recurvature. The definition of the stages is based on the direction of movement of each TC at individual prediction times (Figure 4.9). The table indicates that GSM results outperformed those of the PER method throughout the forecast period beyond 18 hours from the initial time, and that the ratios of error reduction for the GSM compared to the PER method were about 51% (47% in 2019), 64% (58%), 69% (68%), 71% (69%), 74% (70%) and 75% (70%) for 18-, 30-, 54-, 78-, 102- and 126-hour predictions, respectively.

About 82% (75% in 2019) of 30-hour predictions had errors of less than 150 km, while 89% (85%) of 54-hour predictions had errors of less than 300 km, and 86% (85%) of 78-hour predictions had errors of less than 450 km. Histograms showing the position errors of 30-, 54-, 78-, 102- and 126-hour predictions are available at
https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html.

** The PER method is based on the assumption that a TC holds the same movement throughout the forecast period, and linear extrapolation for the latest 12-hour track of the TC is applied to create TC track forecasts. Position errors with the PER method are used to evaluate the relative performance of operational forecasts and model predictions.*

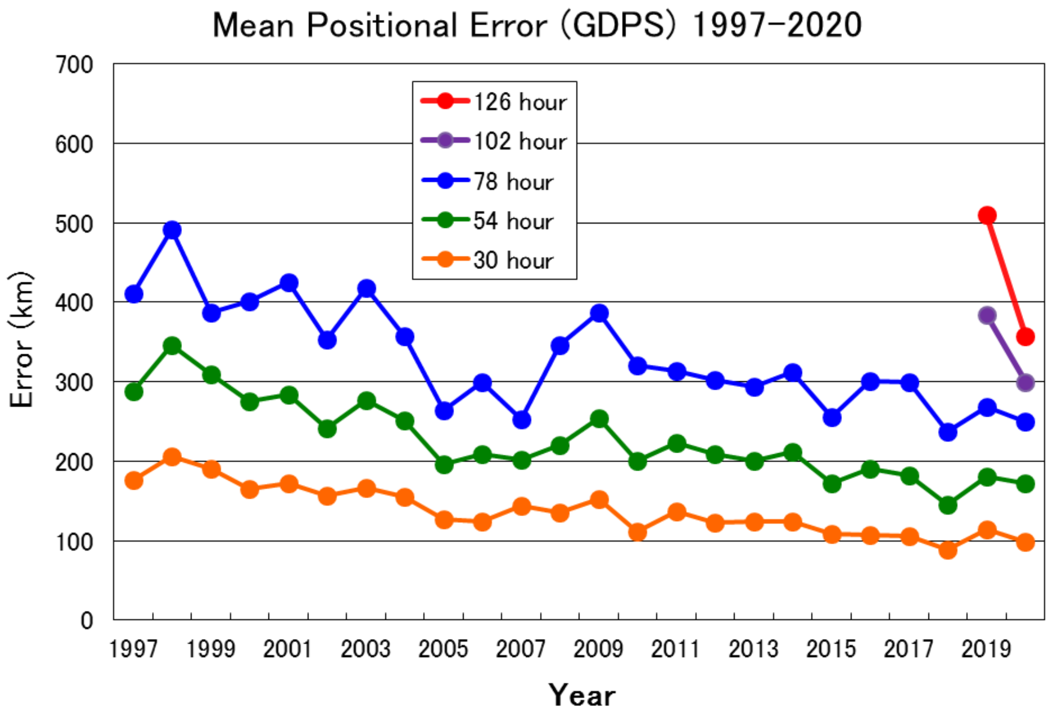


Figure 4.8 GSM annual mean position errors since 1997

Table 4.5 GSM mean position errors (km) for each named TC that formed in 2020. The number of samples is given in parentheses.

Tropical Cyclone			T=18		T=30		T=42		T=54		T=66		T=78		T=90		T=102		T=114		T=126	
TY	2001	VONGFONG	69.4	(22)	91.4	(20)	107.6	(17)	110.9	(17)	117.9	(15)	143.3	(13)	138.5	(9)	141.9	(7)	164.6	(7)	188.9	(5)
TS	2002	NURI	50.0	(7)	42.4	(5)	27.3	(3)	-	(1)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
TS	2003	SINLAKU	79.5	(7)	87.1	(5)	84.2	(3)	86.8	(1)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
TY	2004	HAGUPIT	54.2	(17)	84.0	(14)	122.8	(11)	141.4	(9)	135.1	(8)	102.4	(7)	65.6	(5)	111.0	(3)	284.0	(1)	-	(-)
TS	2005	JANGMI	76.3	(10)	84.2	(7)	101.8	(2)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
STS	2006	MEKKHALA	38.5	(3)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
STS	2007	HIGOS	56.0	(5)	133.7	(3)	259.4	(1)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
TY	2008	BAVI	47.2	(20)	45.3	(18)	51.5	(16)	70.5	(14)	101.6	(12)	142.3	(10)	200.0	(8)	273.2	(6)	365.8	(4)	571.6	(2)
TY	2009	MAYSAK	47.2	(23)	76.4	(21)	88.7	(19)	103.5	(17)	124.2	(15)	119.8	(13)	136.3	(11)	154.8	(9)	202.2	(7)	294.8	(5)
TY	2010	HAISHEN	82.2	(27)	110.3	(25)	156.6	(23)	204.6	(21)	246.2	(19)	279.9	(17)	293.5	(15)	297.0	(13)	297.7	(11)	362.6	(9)
TS	2011	NOUL	135.4	(11)	193.9	(9)	243.8	(7)	298.3	(5)	383.1	(3)	500.2	(1)	-	(-)	-	(-)	-	(-)	-	(-)
STS	2012	DOLPHIN	169.4	(13)	269.4	(11)	415.4	(9)	589.3	(7)	776.4	(5)	902.4	(3)	938.9	(1)	-	(-)	-	(-)	-	(-)
STS	2013	KUJIRA	49.7	(13)	55.7	(11)	85.3	(9)	155.1	(7)	227.7	(5)	335.0	(3)	612.8	(1)	-	(-)	-	(-)	-	(-)
TY	2014	CHAN-HOM	51.6	(27)	75.5	(25)	111.3	(23)	162.2	(21)	235.5	(19)	382.7	(17)	542.7	(15)	641.5	(13)	617.5	(11)	609.6	(9)
TS	2015	LINFA	120.1	(4)	108.5	(2)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
TS	2016	NANGKA	54.9	(10)	75.2	(8)	101.2	(6)	139.1	(4)	231.6	(2)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
TY	2017	SAUDEL	53.9	(23)	67.1	(21)	82.6	(17)	111.2	(15)	141.7	(13)	210.9	(11)	210.9	(9)	235.0	(7)	200.7	(5)	224.9	(3)
TY	2018	MOLAVE	98.3	(19)	130.1	(17)	170.7	(15)	229.8	(13)	293.2	(11)	344.9	(9)	396.2	(7)	453.3	(5)	514.8	(3)	757.0	(1)
TY	2019	GONI	71.0	(34)	93.1	(32)	120.8	(30)	153.4	(28)	158.8	(25)	172.5	(23)	177.2	(20)	218.1	(19)	250.6	(17)	232.3	(13)
STS	2020	ATSANI	93.3	(29)	127.9	(27)	170.2	(25)	235.5	(23)	306.5	(21)	353.0	(19)	368.8	(17)	361.5	(15)	369.7	(13)	434.5	(11)
TS	2021	ETAU	121.1	(7)	134.6	(5)	110.2	(3)	196.7	(1)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
TY	2022	VAMCO	58.0	(25)	75.3	(22)	116.1	(21)	143.4	(18)	181.1	(15)	200.8	(13)	202.2	(11)	191.7	(9)	217.4	(8)	221.7	(6)
TS	2023	KROVANH	142.7	(6)	87.1	(4)	88.2	(2)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
All	Annual	Mean	74.3	(362)	98.0	(312)	130.8	(262)	171.6	(222)	212.3	(188)	250.0	(159)	275.0	(129)	299.6	(106)	318.8	(87)	357.4	(64)

Table 4.6 Mean position errors (km) of GSM and PER method predictions for the 23 named TCs that formed in 2020 in the stages before, during and after recurvature. The number of samples is given in parentheses. IMPROV is the ratio of error reductions in GSM results to those observed using the PER method.

TIME	MODEL	Before		During		After		All	
T=18	GSM	81.0	(220)	55.4	(78)	74.3	(64)	74.3	(362)
	PER	141.6	(220)	160.8	(78)	181.8	(64)	152.8	(362)
	IMPROV	42.8	%	65.5	%	59.1	%	51.4	%
T=30	GSM	104.0	(185)	71.2	(68)	110.2	(59)	98.0	(312)
	PER	226.8	(185)	318.9	(68)	346.9	(59)	269.6	(312)
	IMPROV	54.2	%	77.7	%	68.2	%	63.6	%
T=42	GSM	136.7	(151)	99.2	(59)	149.5	(52)	130.8	(262)
	PER	325.3	(151)	460.7	(59)	548.9	(52)	400.2	(262)
	IMPROV	58.0	%	78.5	%	72.8	%	67.3	%
T=54	GSM	169.1	(124)	144.5	(54)	212.0	(44)	171.6	(222)
	PER	466.9	(124)	604.3	(54)	706.2	(44)	547.7	(222)
	IMPROV	63.8	%	76.1	%	70.0	%	68.7	%
T=66	GSM	203.1	(100)	175.8	(47)	276.5	(41)	212.3	(188)
	PER	610.4	(100)	732.4	(47)	877.1	(41)	699.1	(188)
	IMPROV	66.7	%	76.0	%	68.5	%	69.6	%
T=78	GSM	235.8	(81)	211.6	(42)	326.7	(36)	250.0	(159)
	PER	742.5	(81)	903.7	(42)	1041.5	(36)	852.8	(159)
	IMPROV	68.2	%	76.6	%	68.6	%	70.7	%
T=90	GSM	252.7	(67)	226.8	(32)	376.2	(30)	275.0	(129)
	PER	854.5	(67)	1045.5	(32)	1272.3	(30)	999.1	(129)
	IMPROV	70.4	%	78.3	%	70.4	%	72.5	%
T=102	GSM	273.9	(56)	275.5	(27)	390.5	(23)	299.6	(106)
	PER	1003.8	(56)	1168.9	(27)	1457.0	(23)	1144.2	(106)
	IMPROV	72.7	%	76.4	%	73.2	%	73.8	%
T=114	GSM	275.5	(45)	295.8	(23)	449.0	(19)	318.8	(87)
	PER	1137.1	(45)	1339.8	(23)	1331.3	(19)	1233.1	(87)
	IMPROV	75.8	%	77.9	%	66.3	%	74.1	%
T=126	GSM	283.2	(32)	366.3	(18)	515.4	(14)	357.4	(64)
	PER	1336.3	(32)	1549.8	(18)	1404.5	(14)	1411.3	(64)
	IMPROV	78.8	%	76.4	%	63.3	%	74.7	%

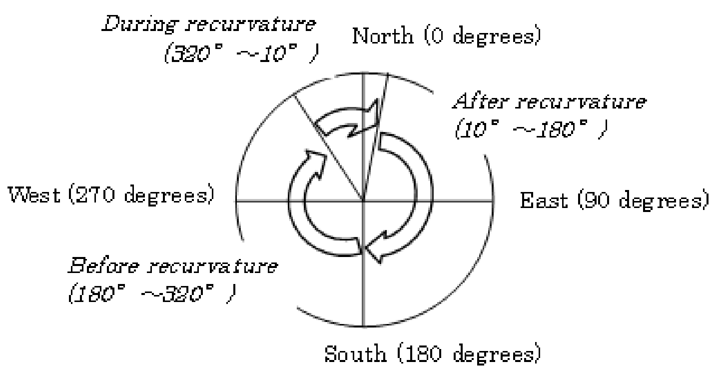


Figure 4.9 Definition of the stages before, during and after recurvature based on the direction of TC movement.

2) Central Pressure and Maximum Wind Speed

The mean errors of 30-, 54-, 78-, 102- and 126-hour GSM central pressure predictions in 2020 were +8.0 hPa (+7.6 hPa in 2019), +9.5 hPa (+9.2 hPa), +8.1 hPa (+11.3 hPa), +2.0 hPa (+7.6 hPa) and -3.0 hPa (+4.5 hPa), respectively. Their root mean square errors (RMSEs) were 15.9 hPa (16.1 hPa in 2019) for 30-hour predictions, 20.9 hPa (20.3 hPa) for 54-hour predictions, 24.8 hPa (24.0 hPa) for 78-hour predictions, 21.8 hPa (22.7 hPa) for 102-hour predictions and 14.3 hPa (19.7 hPa) for 126-hour predictions. The biases in 30-, 54-, 78-, 102- and 126-hour maximum wind speed predictions were -7.1 m/s (-6.6 m/s in 2019) with an RMSE of 10.1 m/s (9.5 m/s), -7.4 m/s (-7.2 m/s) with a RMSE of 12.5 m/s (11.7 m/s), -6.4 m/s (-8.3 m/s) with a RMSE of 13.8 m/s (13.6 m/s), -3.5 m/s (-6.8 m/s) with a RMSE of 11.4 m/s (13.1 m/s) and -1.3 m/s (-5.4 m/s) with a RMSE of 7.2 m/s (11.4 m/s), respectively.

Figure 4.10 shows histograms of central pressure errors and maximum wind speed errors in 30-hour GSM predictions. It can be seen that the GSM has a small positive bias in central pressure prediction (left) and tends to underestimate the wind speed of TCs (right). This underestimation occurs because the model's current horizontal resolution (about 20 km) is not fine enough to produce the TC core structure, especially when the TC is intense and small.

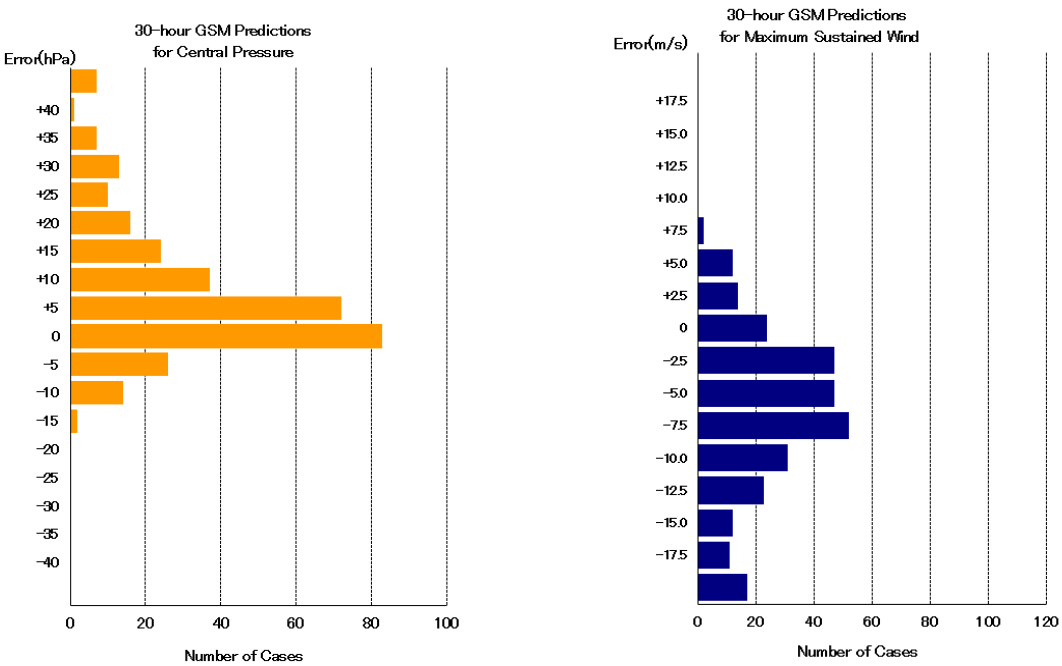


Figure 4.10 Error distribution of GSM 30-hour intensity predictions in 2020. The figure on the left shows error distribution for central pressure, while the one on the right shows that for maximum wind speed (the error distributions of 54-, 78-, 102- and 126-hour predictions are available at https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html).

4.3.2 GEPS Prediction

1) Ensemble Mean Center Position

GEPS took over the role of the Typhoon Ensemble Prediction System (TEPS), and has been providing ensemble forecasts for TCs since January 2017. GEPS and TEPS annual mean position errors observed since 2008 are presented in Figure 4.11. In 2020, the mean position errors of GEPS ensemble mean forecasts for

30-, 54-, 78-, 102- and 126-hour predictions for each named TC are given in Table 4.7. The annual means of ensemble mean position errors for 30-, 54-, 78-, 102- and 126-hour predictions were 108 km (98 km with the GSM), 177 km (172 km), 250 km (250 km), 292 km (300 km) and 352 km (357 km), respectively.

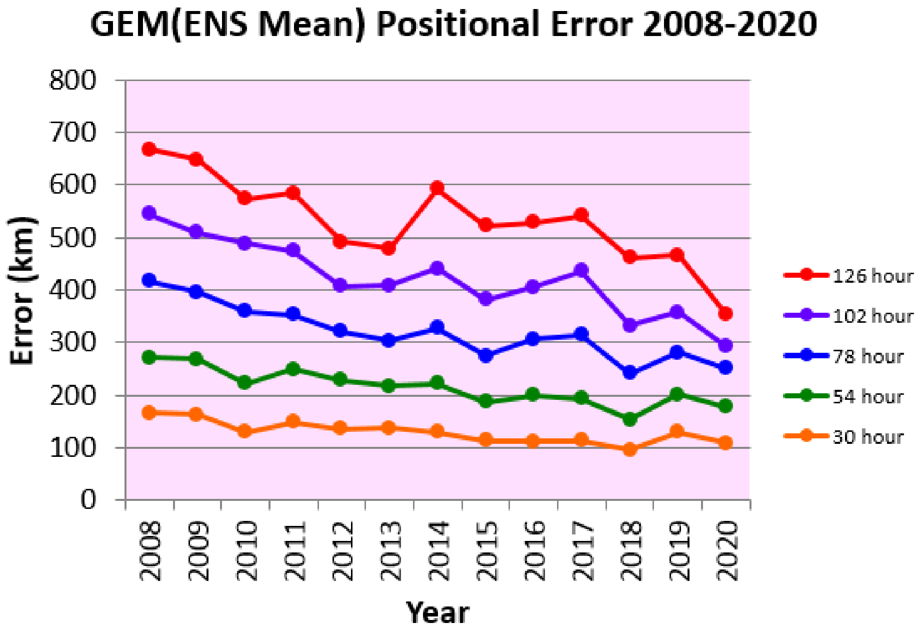


Figure 4.11 GEPS and TEPS annual mean position errors since 2008

2) Spread-Skill Relationship

Although position errors of GEPS ensemble mean forecasts were larger than those of the GSM in short-range forecasts, GEPS provides useful information on the reliability of TC track forecasts with its ensemble spread. Figure 4.12 shows the relationship between 6-hourly cumulative ensemble spreads in TC position forecasts and ensemble mean forecast position errors in 126-hour prediction. In an ideal EPS with a large number of samples, significant positional errors are observed when the ensemble spread is large. The figure shows that significant errors were seen in 2020 only when GEPS predicted large spreads.

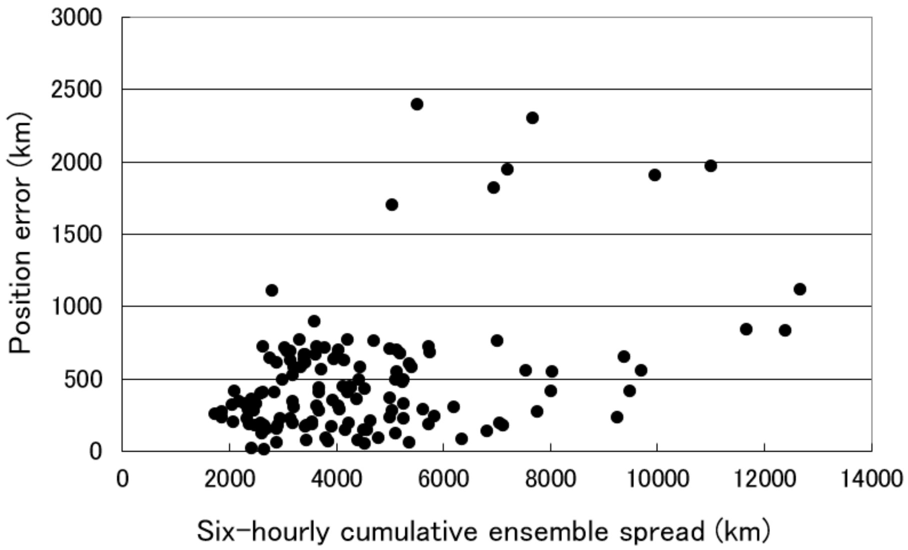


Figure 4.12 Relationship between six-hourly cumulative ensemble spread in TC position forecasts (km) and ensemble mean forecast position errors (km) in 126-hour predictions in 2020.

Table 4.7 Mean position errors (km) of GEPS ensemble mean forecasts for each named TC that formed in 2020. The number of samples is given in parentheses.

Tropical Cyclone			**T=18**		**T=30**		**T=42**		**T=54**		**T=66**		**T=78**		**T=90**		**T=102**		**T=114**		**T=126**	
TY	**2001**	**VONGFONG**	**64.7**	**(22)**	**90.6**	**(19)**	**107.2**	**(18)**	**121.7**	**(17)**	**130.7**	**(15)**	**174.3**	**(11)**	**184.8**	**(9)**	**172.0**	**(7)**	**152.0**	**(5)**	**128.3**	**(3)**
TS	**2002**	**NURI**	**28.3**	**(7)**	**34.9**	**(5)**	**33.8**	**(3)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
TS	**2003**	**SINLAKU**	**81.2**	**(7)**	**97.4**	**(5)**	**107.7**	**(3)**	**140.2**	**(1)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
TY	**2004**	**HAGUPIT**	**54.1**	**(17)**	**79.6**	**(13)**	**100.8**	**(9)**	**133.9**	**(4)**	**195.2**	**(2)**	**390.3**	**(1)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
TS	**2005**	**JANGMI**	**71.5**	**(7)**	**84.3**	**(3)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
STS	**2006**	**MEKKHALA**	**31.3**	**(3)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
STS	**2007**	**HIGOS**	**73.1**	**(5)**	**164.6**	**(2)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
TY	**2008**	**BAVI**	**58.0**	**(20)**	**57.1**	**(18)**	**63.1**	**(16)**	**67.4**	**(14)**	**91.3**	**(12)**	**131.7**	**(10)**	**210.3**	**(8)**	**283.3**	**(6)**	**410.3**	**(4)**	**482.6**	**(2)**
TY	**2009**	**MAYSAK**	**47.9**	**(23)**	**71.5**	**(21)**	**84.7**	**(19)**	**97.9**	**(17)**	**112.8**	**(15)**	**115.0**	**(13)**	**134.2**	**(11)**	**150.8**	**(9)**	**204.5**	**(7)**	**273.7**	**(5)**
TY	**2010**	**HAISHEN**	**79.3**	**(27)**	**119.5**	**(25)**	**162.8**	**(23)**	**187.0**	**(21)**	**215.7**	**(19)**	**216.4**	**(16)**	**232.5**	**(14)**	**262.4**	**(12)**	**304.5**	**(10)**	**329.6**	**(8)**
TS	**2011**	**NOUL**	**165.2**	**(10)**	**216.3**	**(8)**	**261.3**	**(6)**	**337.5**	**(4)**	**492.3**	**(2)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
STS	**2012**	**DOLPHIN**	**198.8**	**(13)**	**317.4**	**(11)**	**477.3**	**(9)**	**650.6**	**(7)**	**842.1**	**(5)**	**988.2**	**(3)**	**1033.9**	**(1)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
STS	**2013**	**KUJIRA**	**54.8**	**(13)**	**65.0**	**(11)**	**94.3**	**(9)**	**134.9**	**(7)**	**188.7**	**(5)**	**273.6**	**(3)**	**511.8**	**(1)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
TY	**2014**	**CHAN-HOM**	**58.7**	**(27)**	**82.3**	**(25)**	**114.6**	**(23)**	**149.3**	**(21)**	**232.4**	**(19)**	**369.2**	**(17)**	**498.5**	**(15)**	**574.0**	**(13)**	**562.2**	**(11)**	**579.3**	**(9)**
TS	**2015**	**LINFA**	**143.0**	**(4)**	**148.2**	**(2)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
TS	**2016**	**NANGKA**	**55.6**	**(10)**	**77.4**	**(8)**	**112.5**	**(6)**	**157.0**	**(4)**	**249.7**	**(2)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
TY	**2017**	**SAUDEL**	**58.3**	**(24)**	**61.0**	**(22)**	**91.7**	**(20)**	**121.1**	**(18)**	**142.5**	**(16)**	**178.1**	**(14)**	**178.5**	**(12)**	**180.2**	**(10)**	**157.0**	**(8)**	**175.2**	**(6)**
TY	**2018**	**MOLAVE**	**109.4**	**(19)**	**144.2**	**(17)**	**189.8**	**(15)**	**245.6**	**(13)**	**307.2**	**(11)**	**376.7**	**(9)**	**437.4**	**(7)**	**492.8**	**(5)**	**591.7**	**(3)**	**764.9**	**(1)**
TY	**2019**	**GONI**	**78.6**	**(34)**	**108.5**	**(32)**	**142.0**	**(30)**	**175.4**	**(28)**	**191.2**	**(26)**	**195.6**	**(24)**	**199.8**	**(22)**	**234.0**	**(20)**	**253.8**	**(18)**	**257.4**	**(16)**
STS	**2020**	**ATSANI**	**100.2**	**(28)**	**141.2**	**(26)**	**181.0**	**(24)**	**233.5**	**(23)**	**291.6**	**(21)**	**325.8**	**(19)**	**339.4**	**(17)**	**343.2**	**(15)**	**367.9**	**(13)**	**490.2**	**(11)**
TS	**2021**	**ETAU**	**137.2**	**(7)**	**156.0**	**(5)**	**150.3**	**(3)**	**249.9**	**(1)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
TY	**2022**	**VAMCO**	**66.3**	**(23)**	**92.0**	**(21)**	**123.3**	**(18)**	**152.3**	**(17)**	**198.3**	**(14)**	**215.6**	**(12)**	**213.4**	**(10)**	**213.7**	**(8)**	**262.4**	**(7)**	**268.6**	**(5)**
TS	**2023**	**KROVANH**	**171.2**	**(6)**	**150.0**	**(3)**	**147.5**	**(1)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**	**-**	**(-)**
All	**Annual**	**Mean**	**80.3**	**(356)**	**107.7**	**(302)**	**140.2**	**(255)**	**176.9**	**(217)**	**216.4**	**(184)**	**250.0**	**(152)**	**272.4**	**(127)**	**292.1**	**(105)**	**317.2**	**(86)**	**352.1**	**(66)**

To add reliability information to TC track forecasts, JMA has introduced a reliability index in which the categories A, B and C represent the highest, middle and lowest levels of reliability, respectively. The index is based on the six-hourly cumulative ensemble spread at each forecast time. The category levels were set from the results of the pre-operational running of GEPS so that the category frequencies are 40%, 40% and 20%, respectively. Table 4.8 shows ensemble mean forecast errors classified with the reliability index. Theoretically, mean position errors with higher reliability should be smaller than those with lower reliability throughout forecast times with sufficient samples in an ideal EPS. The table shows that GEPS provides appropriate reliability information on 2020 TC track forecasts.

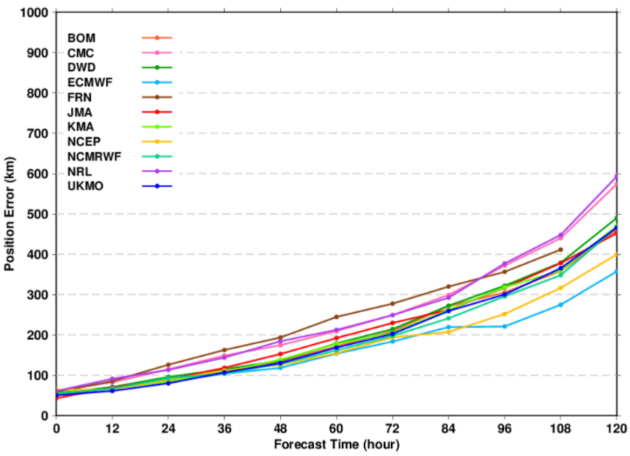
Table 4.8 Ensemble mean forecast position errors (km) in 2020 classified with six-hourly cumulative ensemble spread at each forecast time. The number of samples is given in parentheses.

Time	Reliability Index					
	A		B		C	
T=30	86	(145)	112	(146)	159	(73)
T=54	146	(119)	196	(120)	222	(60)
T=78	185	(95)	279	(95)	301	(48)
T=102	236	(72)	398	(73)	435	(38)
T=126	369	(53)	431	(55)	802	(28)

4.4 Verification for Other Guidance Models

4.4.1 Verification by WGNE

The Center utilizes other guidance models in addition to JMA's NWP models for operational TC track and intensity forecasting, including global deterministic NWP models from seven other centers (BoM, CMC, DWD, ECMWF, KMA, NCEP and UKMO). These models (as well as the Meteo France (FRN) model, the Naval Research Laboratory (NRL) model and National Centre for Medium Range Weather Forecasting (NCMRWF) model) are verified under the framework of WGNE (the Working Group on Numerical Experimentation), which is a collaborative working group for development of Earth system models (design, implementation, error diagnosis and model revision) across the full range of temporal and spatial scales. JMA works on inter-comparison of these models under the framework. Figures 4.13 and 4.14 show the results of the verification for center positions and 72-hour intensity forecasts by WGNE.



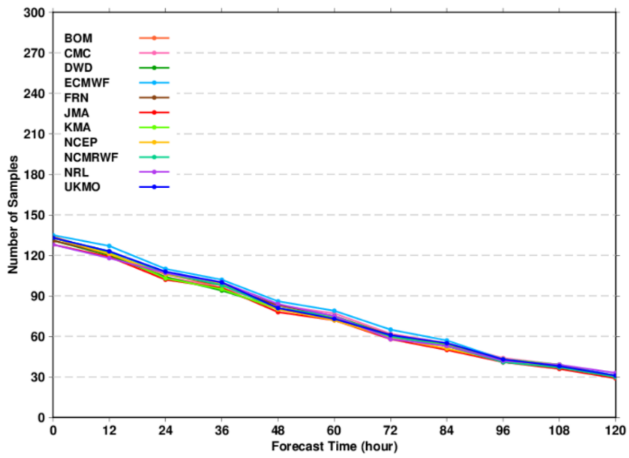


Figure 4.13 (Left) Positional errors for 2020 named TCs. The tropical depression (TD) stage of targeted TCs is also included in this verification. (Right) Sample numbers.

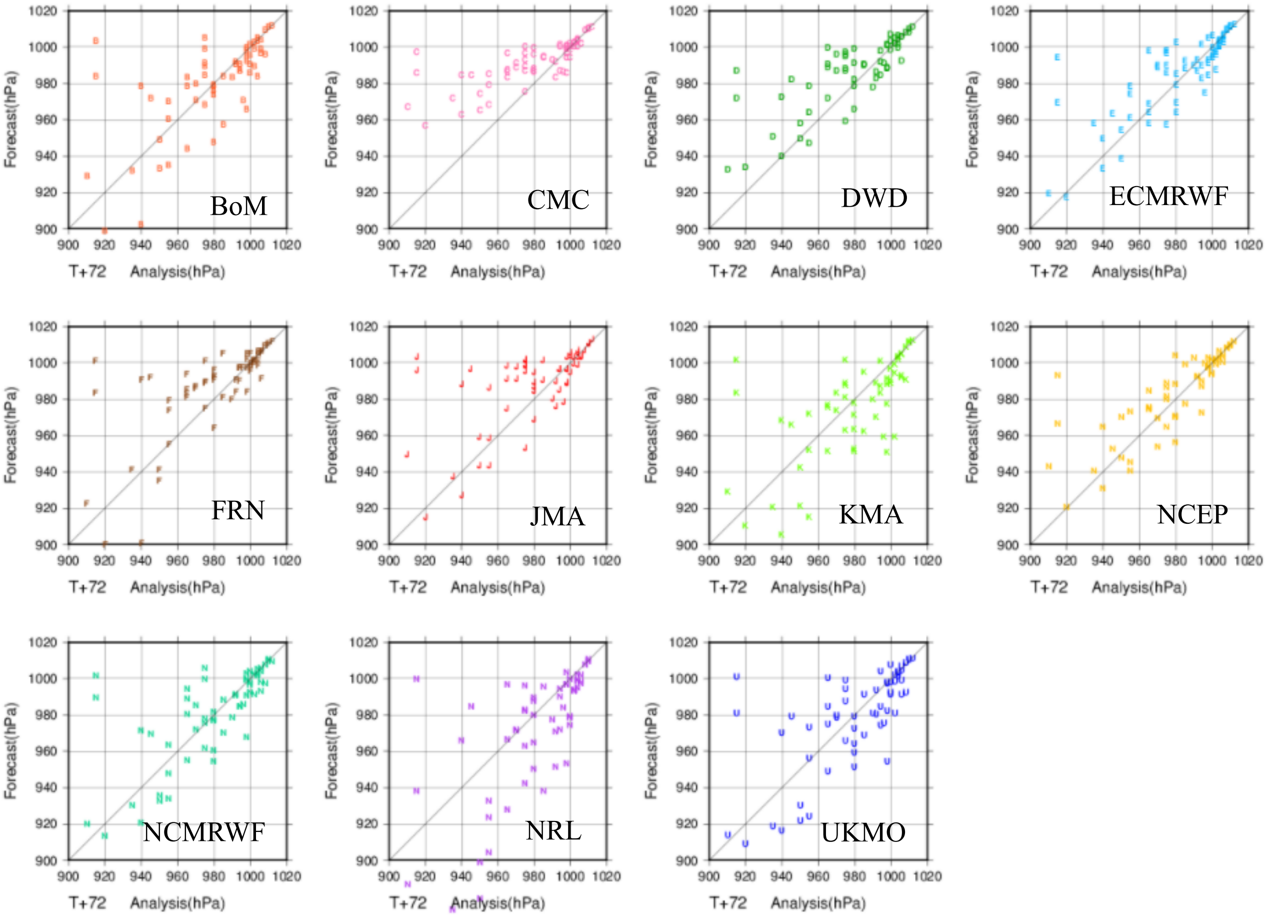


Figure 4.14 Scatter diagrams of 72-hour TC center pressure forecasts from 11 deterministic models for 2020. The tropical depression (TD) stage of targeted TCs is also included in this verification.

4.4.2 Verification of Intensity Guidance Models

Table 4.9 shows mean central pressure errors in TIFS and LGEM (Logistic Growth Equation Model) intensity guidance and related consensus. This section describes verification of the latest guidance data available for each initial time of real-time operation conducted for RSMC operational forecasting. Values for maximum wind speed forecasts are available on the Center's website (https://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/AnnualReport/2020/index.html).

Table 4.9 Mean error and RMSE of central pressure forecasts from intensity guidance models produced by the Center in 2020. Num. represents number of samples.

Prediction		24-hour Forecast			48-hour Forecast			72-hour Forecast			96-hour Forecast			120-hour Forecast		
		Error (hPa)	RMSE (hPa)	Num.	Error (hPa)	RMSE (hPa)	Num.	Error (hPa)	RMSE (hPa)	Num.	Error (hPa)	RMSE (hPa)	Num.	Error (hPa)	RMSE (hPa)	Num.
Intensity guidance model	TIFS	-1.0	12.4	255	-4.2	15.9	176	-8.4	18.6	116	-11.1	19.7	69	-9.9	17.2	36
	LGEM	2.0	14.9	255	-0.0	19.1	176	-4.5	19.5	116	-10.3	18.2	69	-	-	0
Consensus method	TIFS&LGEM	0.5	13.2	255	-2.1	16.8	176	-6.4	18.4	116	-10.7	18.1	69	-	-	0

4.5 Verification of AMV-based Sea-surface Winds (ASWinds)

JMA produces Atmospheric Motion Vectors (AMVs) using successive satellite imagery from the Himawari-8 geostationary satellite. These are derived from the Full-disk observation conducted every 10 minutes and Region 3 tropical cyclone observation conducted over an area of 1,000 square kilometers every 2.5 – 5 minutes. Since July 2017, JMA has used the AMV-based Sea-surface Winds (ASWinds) product based on low-level AMVs (assigned below 700 hPa level) to estimate sea-surface winds in the vicinity of TCs. The ASWinds are derived at intervals of 10 – 30 minutes with frequent and wide-ranging wind distribution information. Figure 4.15 shows the distributions of ASWind derived using the Full-disk and Region 3 observations by Himawari-8 for Typhoon Saudel (2017). The wide-area coverage and high temporal resolution of ASWinds data are also expected to support real-time determination of 30-kt wind radii for TC areas where low-level clouds appear in Himawari-8 imagery together with surface wind observations from satellite microwave scatterometers such as the ASCAT units on board MetOp polar-orbiting satellites (referred to here as "ASCAT winds").

JMA verifies the quality of ASWinds data from Visible (B03: 0.64 μm), Short-wave Infrared (B07: 3.9 μm), and Infrared (B13: 10.4 μm) with respect to ASCAT wind data in the vicinity of 23 TCs occurring in 2020 (Table 4.10). Wind speed biases in ASWinds data from full-disk and Region 3 observation are small at -0.7 to -0.6 m/s, and -0.9 to -0.7 m/s, respectively. Vector differences in ASWinds from Region 3 observation are slightly larger than those from full-disk observation, which suggests that the use of high-frequency Region-3 observation data supports tracking to determine the movement of low-level cloud associated with mesoscale phenomena.

The mean distribution of ASWinds data from full-disk and Region-3 observation (Figure 4.16) for 2020 suggests that the representation of Region-3 ASWinds is higher than that of full-disk ASWinds, particularly near TC centers. This is attributed to the higher temporal frequency of Region-3 imagery.

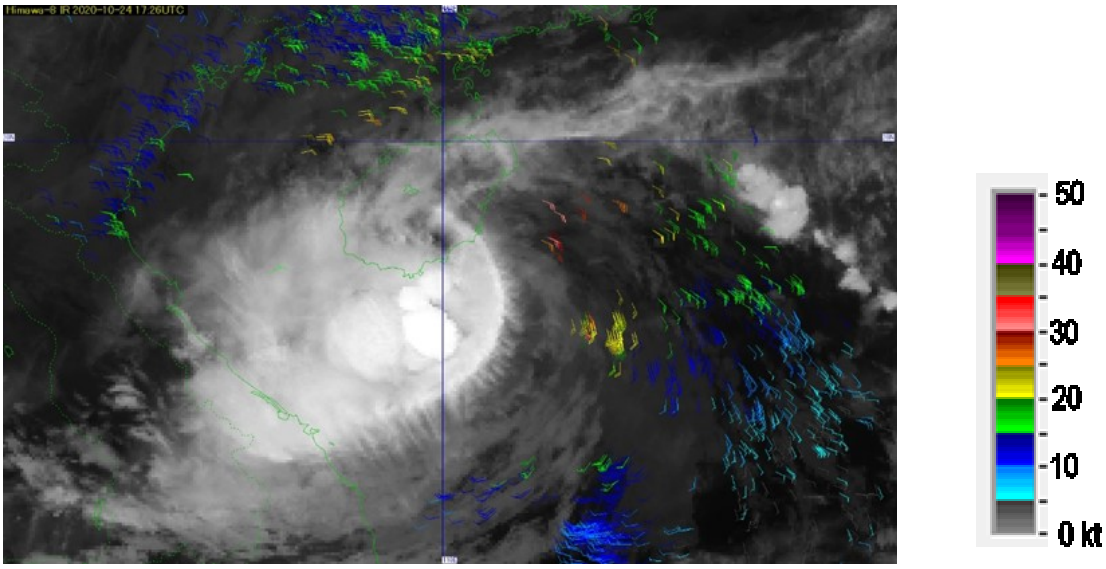


Figure 4.15: ASWinds derived from a series of Himawari-8 full-disk and Region 3 Infrared (B13) and Short-wave Infrared (B07) images for TY Saudel (2017) at 1726 UTC on 24 October 2020.

Table 4.10 Vector Differences (VDs) and biases of ASWinds (0.85 < QI) with reference to ASCAT winds within a square of 20 degrees centered at the TC center for 23 TCs in 2020.

(a) ASWind (Full-Disk)

	Number of collocations	Vector Difference [m/s]	Bias [m/s]
B03（VIS）	395,977	1.7	-0.6
B07（SWIR）	345,527	2.0	-0.7
B13（IR）	359,696	1.8	-0.7

(b) ASWind (Region 3)

	Number of collocations	Vector Difference [m/s]	Bias [m/s]
B03（VIS）	796,136	2.5	-0.7
B07（SWIR）	880,535	2.8	-0.8
B13（IR）	685368	2.7	-0.9

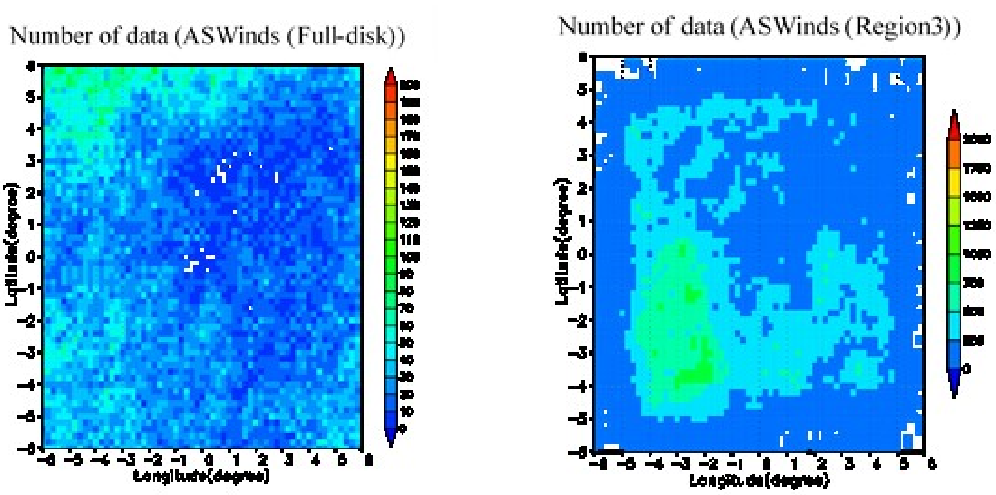


Figure 4.16: Spatial distributions of full-disk and Region 3 ASWind data within a square of 12 degrees centered at TC center for 23 TCs in 2020.

4.6 Verification of TC Central Pressure Estimates Based on Satellite Microwave Observations

JMA uses TC central pressure (Minimum Sea Level Pressure, or MSLP) estimates based on TC warm core intensity (i.e., the maximum temperature anomaly near the TC center) from microwave sounders on board polar-orbiting satellites as reference for JMA operational TC analysis. The Advanced Microwave Sounding Unit-A (AMSU-A) of the NOAA and MetOp series of polar-orbiting satellites has been used for MSLP estimation since 2013. JMA also began to use data from the Advanced Technology Microwave Sounder (ATMS) on board the Suomi-NPP and JPSS-1 (NOAA-20) satellites in 2015. The higher spatial resolution of ATMS observation (32 km at the sub-satellite point) as compared to AMSU-A (48 km) enables more accurate determination of warm core intensity. Figure 4.17 shows the MSLP estimates based on AMSU-A and ATMS observations (referred to here as AMSU/ATMS estimates) together with MSLP estimates based on the Dvorak technique (Dvorak estimates) and a product based on consensus between AMSU/ATMS MSLP estimates and Dvorak MSLP estimates (CONSENSUS) for TY Maysak (2009).

Table 4.11 shows the results of AMSU and ATMS estimate verification with respect to JMA best-track data for 2015 - 2020 together with Dvorak TC intensity estimates and CONSENSUS. The biases and root mean square errors (RMSEs) of AMSU estimates are -5.5 to 2.7 hPa and 10.0 to 14.0 hPa, respectively (Table 4.11a). It should be noted that the RMSE of CONSENSUS between AMSU estimates and Dvorak estimates is consistently smaller than that for AMSU and Dvorak estimates over a period of six years, which is attributed to the benefits of independent information from the satellite microwave observation. The RMSE for ATMS estimates is smaller than that for AMSU (Table 4.11b), which indicates that the higher resolution of ATMS observation as compared to AMSU leads to more accurate determination of TC warm core intensity. As with the AMSU estimate result, the RMSEs of CONSENSUS between ATMS and Dvorak estimates are smaller than those of ATMS and Dvorak estimates. The superiority of CONSENSUS to individual estimates is seen in bias comparison.

Use of AMSU/ATMS estimates via CONSENSUS is expected to support JMA's operational TC intensity analysis, particularly when in-situ observation data are scarce and operational TC intensity analysis depends largely on the Dvorak estimates. JMA began using data from the AMSU-A unit on the MetOp-C polar-orbiting satellite for TC intensity estimation during the 2020 TC season.

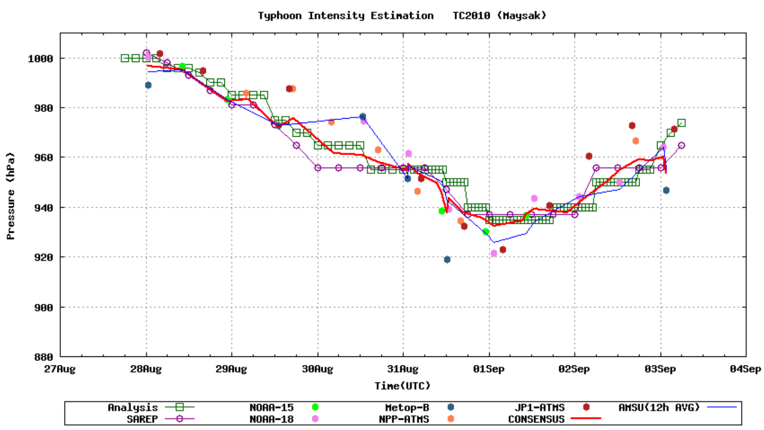


Figure 4.17 Time-series representation of Dvorak MSLP estimates, microwave-based MSLP estimates (AMSU and ATMS), CONSENSUS between Dvorak and AMSU/ATMS estimates and JMA analysis for TY Maysak (2009) on the Numerical Typhoon Prediction (NTP) website

Table 4.11 (a) Bias and RMSE of Dvorak MSLP estimates, AMSU MSLP estimates and CONSENSUS between Dvorak and AMSU estimates with respect to the best-track data for the previous six years (2015 - 2020); (b) as per (a) but for ATMS estimates

(a) BIAS and RMSE of central pressure estimates to BstTrack for AMSU

Year		2015	2016	2017	2018	2019	2020
BIAS	AMSU	1.3	2.7	-2.9	-3.1	-2.5	-5.5
	Dvorak	0.1	-2.1	-2.0	-0.4	-2.9	-2.8
	Consensus	**0.3**	**-0.8**	**-2.6**	**-1.5**	**-3.2**	**-4.0**
RMSE (hPa)	AMSU	12.8	13.8	10.0	12.4	11.7	14.0
	Dvorak	7.5	9.6	7.2	7.0	9.2	8.4
	Consensus	**6.8**	**8.2**	**6.7**	**6.7**	**7.6**	**7.9**
Number of Data		819	595	569	680	645	478

(b) BIAS and RMSE of central pressure estimates to BstTrack for ATMS

Year		2015	2016	2017	2018	2019	2020
BIAS	ATMS	3.0	4.1	1.8	0.9	1.9	0.9
	Dvorak	-0.5	-1.4	-2.0	-0.9	-3.7	-3.6
	Consensus	**0.8**	**0.3**	**-0.7**	**-0.3**	**-1.9**	**-1.8**
RMSE (hPa)	ATMS	11.9	13.0	8.7	11.4	9.9	9.0
	Dvorak	7.8	8.5	7.9	7.9	9.7	9.6
	Consensus	**6.1**	**7.1**	**6.3**	**7.0**	**7.1**	**6.0**
Number of Data		229	190	193	224	244	148

4.7 Verification of Storm Surge Prediction

Storm surge predictions have been provided since 2011 via the Numerical Typhoon Prediction website to Typhoon Committee Members within the framework of the Storm Surge Watch Scheme (SSWS). For details of the storm surge model, refer to Hasegawa et al. (2012) on the Center's website. Verification of deterministic storm surge prediction was conducted on data from eight stations (Table 4.12) for which sea level observation information is provided on the University of Hawaii Sea Level Center (UHSLC) database website (http://uhslc.soest.hawaii.edu/data/?fd) for all named TCs in 2020. Hourly hindcast data (from FT = -5 to FT = 0) and forecast data (from FT = 1 to FT = 72) were compared with observation data.

In addition, a multi-scenario prediction method was incorporated into the model in June 2016 to support the provision of more useful risk management information (Hasegawa et al., 2017). Verification of multi-scenario predictions was conducted on data from a station in Manila South Harbor (Philippines) for TY Vamco (2022).

Table 4.12 Stations used for verification

	Station	Abbreviation	Member
1	Quarry Bay	QB	Hong Kong
2	Langkawi	LK	Malaysia
3	Legaspi Port	LG	Philippines
4	Manila South Harbor	ML	Philippines
5	Subic Bay	SB	Philippines
6	Apra Harbor	AP	U.S.A.
7	Qui Nhon	QN	Viet Nam
8	Vung Tau	VT	Viet Nam

Table 4.13 Storm surges exceeding 0.5 m observed at the eight stations for each named TC that formed in 2020 (unit: m).

Station	Named TC	Storm surge [m]
QB	NANGKA (2016)	0.63
QB	SAUDEL (2017)	0.56
ML	VAMCO (2022)	0.63

4.7.1 Deterministic Prediction

Storm surges exceeding a meter in height were not observed at any of eight stations in 2020 (Table 4.13). Figure 4.18 shows scatter diagrams of modeled storm surges (hindcast and forecast) against observation data. Verification results (Figure 4.18, right) indicate that the model overestimated storm surges for some cases in 2020, mainly because of TC track errors and typhoon bogus, which expresses wind and pressure fields based on simple parametric TC modeling without changes in TC structure and wind reduction caused by land topography.

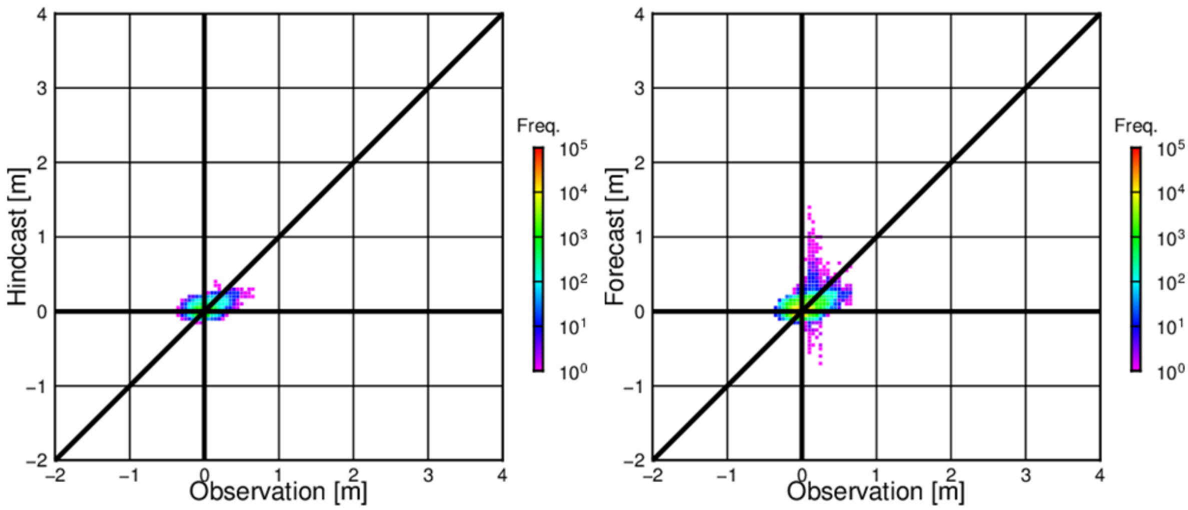


Figure 4.18 Scatter diagrams of modeled storm surges against observation data from eight stations for all named TCs that formed in 2020 (left: hindcast; right: forecast)

The verification shown above is insufficient to evaluate model accuracy for TCs, because the number of available observations is limited and remarkable storm surges were not observed in most stations. Accordingly, additional verification was conducted using data from stations in Japan, where sufficient observation data are available and TCs frequently approach or make landfall. Although the characteristics of model forecasts may vary by region, the storm surge model is considered to have comparable accuracy at storm surge watch scheme stations.

Figure 4.19 shows scatter diagrams of modeled storm surges (forecast) against observation data from 207 stations (operated by JMA, the Ports and Harbours Bureau, the Japan Coast Guard and the Geospatial Information Authority of Japan) in Japan. The verification period is 2020, and cases of TCs are extracted. Seven named TCs approached the country, with none making landfall. The three panels indicate that forecasts for Japan tend to overestimate storm surges, as seen from storm surge watch scheme stations. Naturally, errors increase with lead time. For the third day in particular, the figure shows extreme overestimation attributed mainly to TC track errors.

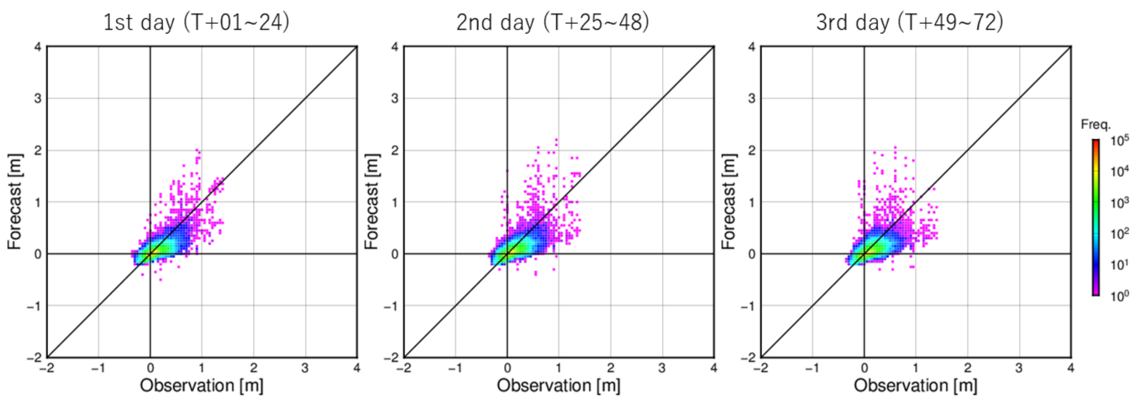


Figure 4.19 Scatter diagrams of modeled storm surges (forecast) against observation data from 207 stations (operated by JMA, the Port Authority, the Japan Coast Guard and the Geospatial Information Authority of Japan) in Japan for TCs in 2020. All plots are three-hourly maximum values.

4.7.2 Multi-Scenario Prediction

TY Vamco (2022) hit Luzon Island with a maximum wind speed of 40 m/s and a minimum pressure of 965 hPa in November 2020. Figure 4.20 shows the analysis track and predicted tracks (official and five selected instances) covering the 24-hour period before the peak of a storm surge in Manila South Harbor. TY Vamco made landfall along the eastern coast of Luzon Island and passed westward with a track similar to that of the official forecast. The maximum storm tide for Manila South Harbor in the official forecast scenario was 0.60 m (Figure 4.21), while the corresponding maximum storm surge was 0.39 m. The predicted peak of the storm surge was around 0.2 m lower than actually observed (observed maximum storm tide: 0.63 m above mean sea level; maximum storm surge: 0.63 m), and was delayed by about an hour. The underestimation of the peak surge may be attributed to the observed sea level anomaly (approx. 0.2 m) seen during this period. The anomaly is associated with factors other than the tropical cyclone, as it was seen both before and after tropical cyclone passage.

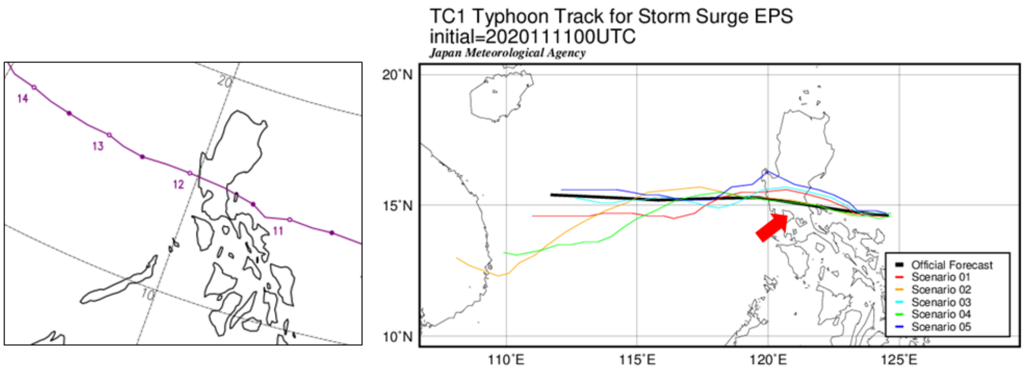


Figure 4.20 Analysis track (left) and predicted tracks (right) for TY Vamco. In the figure on the right, colored lines show the five selected tracks and the bold black line shows the official JMA forecast. The red arrow shows Manila South Harbor.

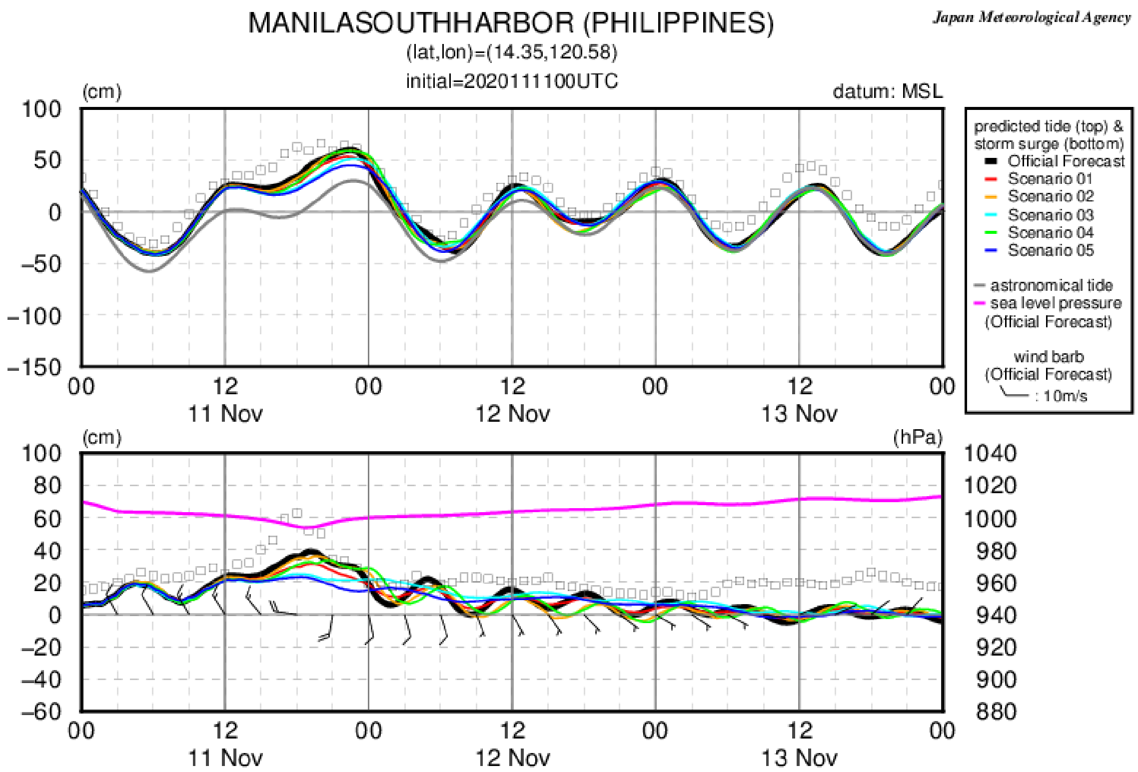


Figure 4.21 Time-series representation of storm tide and astronomical tide (top), storm surge, sea level pressure and surface wind (bottom) for Manila South Harbor (Philippines). Squares show hourly observation values.

[Reference]

Hasegawa. H., N. Kohno, and H. Hayashibara, 2012: JMA's Storm Surge Prediction for the WMO Storm Surge Watch Scheme (SSWS). *RSMC Tokyo-Typhoon Center Technical Review*, **14**, 13-24.

Hasegawa. H., N. Kohno, M. Higaki, and M. Itoh, 2017: Upgrade of JMA's Storm Surge Prediction for WMO Storm Surge Watch Scheme (SSWS). *RSMC Tokyo-Typhoon Center Technical Review*, **19**, 26-34.

Appendices

RSMC Tropical Cyclone Best Track Data in 2020

Vongfong (2001)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
May 08/06	6.8	134.0	1006	-	0.0	TD
08/12	6.4	133.4	1008	-	0.5	TD
08/18	6.3	132.9	1006	-	0.5	TD
09/00	6.5	132.7	1008	-	0.5	TD
09/06	6.7	132.5	1006	-	0.5	TD
09/12	7.0	132.2	1008	-	1.0	TD
09/18	7.2	132.0	1006	-	1.0	TD
10/00	7.6	131.4	1006	-	1.0	TD
10/06	7.9	130.9	1004	-	1.0	TD
10/12	8.2	130.3	1006	-	1.0	TD
10/18	8.3	129.7	1004	-	1.0	TD
11/00	8.3	129.2	1006	-	1.0	TD
11/06	8.7	129.0	1004	-	1.0	TD
11/12	9.1	129.1	1006	-	1.5	TD
11/18	9.6	129.2	1004	-	1.5	TD
12/00	10.2	129.4	1006	-	2.0	TD
12/06	10.7	129.5	1004	-	2.0	TD
12/12	11.3	129.5	1000	35	2.5	TS
12/18	11.6	129.2	998	40	3.0	TS
13/00	11.8	128.9	992	50	3.5	STS
13/06	12.0	128.4	985	60	4.0	STS
13/12	12.2	127.8	975	70	5.0	TY
13/18	12.2	127.0	965	80	5.0	TY
14/00	12.1	126.2	960	85	5.5	TY
14/06	12.2	125.3	960	85	5.5	TY
14/12	12.3	124.4	975	70	4.5	TY
14/18	12.7	123.6	980	65	4.0	TY
15/00	13.3	122.7	980	65	4.0	TY
15/06	14.0	121.9	992	50	3.5	STS
15/12	14.9	121.3	994	45	3.0	TS
15/18	16.2	120.6	1000	35	2.5	TS
16/00	17.3	120.0	1000	35	2.0	TS
16/06	18.1	119.6	1000	35	1.5	TS
16/12	18.9	119.5	1002	-	1.5	TD
16/18	19.7	119.5	1004	-	1.0	TD
17/00	20.6	120.0	1004	-	1.0	TD
17/06	21.3	121.1	1004	-	1.5	TD
17/12	21.6	122.1	1004	-	1.5	TD
17/18	22.0	123.1	1002	-	1.5	TD
18/00	22.6	124.3	1004	-	1.5	TD
18/06	24.4	127.0	1002	-	1.5	TD
18/12						Dissip.

Nuri (2002)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Jun. 10/00	11.3	126.4	1008	-	0.5	TD
10/06	12.1	125.9	1006	-	0.0	TD
10/12	12.9	125.4	1006	-	0.0	TD
10/18	13.7	124.7	1006	-	0.0	TD
11/00	14.3	123.9	1006	-	0.0	TD
11/06	14.7	122.9	1004	-	0.5	TD
11/12	15.1	121.8	1004	-	1.0	TD
11/18	15.8	120.5	1002	-	1.0	TD
12/00	16.1	119.4	1002	-	1.5	TD
12/06	16.4	118.3	1000	-	1.5	TD
12/12	16.8	117.6	998	35	2.0	TS
12/18	17.5	116.7	998	35	2.0	TS
13/00	18.4	115.6	996	40	2.0	TS
13/06	19.4	115.0	996	40	2.0	TS
13/12	20.1	114.0	998	35	2.0	TS
13/18	20.8	113.0	998	35	2.0	TS
14/00	21.6	112.1	1002	-	1.5	TD
14/06	22.6	111.0	1004	-	-	TD
14/12						Dissip.

Sinlaku (2003)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Jul. 31/00	16.6	114.0	998	-	1.5	TD
31/06	17.0	113.1	998	-	1.5	TD
31/12	17.5	111.8	996	-	2.0	TD
31/18	17.7	111.1	996	-	2.0	TD
Aug. 01/00	17.8	110.7	994	35	2.5	TS
01/06	18.5	108.6	994	35	2.0	TS
01/12	18.9	107.6	992	35	2.0	TS
01/18	19.0	106.9	992	35	2.0	TS
02/00	19.2	106.5	990	35	2.0	TS
02/06	19.4	106.2	985	40	2.0	TS
02/12	19.2	104.7	992	35	1.5	TS
02/18	19.2	103.4	994	-	1.0	TD
03/00	20.2	102.2	996	-	1.0	TD
03/06						Dissip.

Hagupit (2004)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Jul. 30/18	15.2	131.2	1006	-	0.0	TD
31/00	16.2	130.8	1008	-	0.0	TD
31/06	17.2	130.2	1006	-	0.0	TD
31/12	17.7	129.7	1008	-	0.5	TD
31/18	18.9	129.4	1008	-	1.0	TD
Aug. 01/00	20.2	128.8	1004	-	1.5	TD
01/06	20.8	127.7	1002	35	1.5	TS
01/12	21.3	127.1	1002	35	2.0	TS
01/18	22.0	126.0	1002	35	2.0	TS
02/00	22.5	125.1	1000	35	2.5	TS
02/06	23.0	124.4	998	40	3.0	TS
02/09	23.3	124.4	998	40	-	TS
02/12	23.6	124.2	996	45	3.5	TS
02/15	23.9	124.0	992	50	-	STS
02/18	24.3	123.9	990	55	3.5	STS
02/21	24.5	123.7	985	60	-	STS
03/00	25.0	123.5	985	60	3.5	STS
03/03	25.3	122.8	985	60	-	STS
03/06	26.2	122.6	980	65	4.0	TY
03/12	26.8	121.8	975	70	5.0	TY
03/18	27.7	121.2	975	70	5.0	TY
04/00	28.6	120.7	985	55	4.5	STS
04/06	29.7	120.4	992	45	4.0	TS
04/12	30.7	120.2	998	40	3.0	TS
04/18	32.4	120.6	1000	35	2.5	TS
05/00	33.9	120.8	1000	35	2.0	TS
05/06	35.0	121.3	1000	35	2.0	TS
05/12	36.6	122.7	1002	-	1.5	L
05/18	38.1	125.4	1002	-	1.5	L
06/00	39.0	128.0	1000	-	1.5	L
06/06	41.0	132.1	992	-	-	L
06/12	42.0	134.9	988	-	-	L
06/18	43.0	136.7	984	-	-	L
07/00	44.2	139.9	984	-	-	L
07/06	45.5	143.0	988	-	-	L
07/12	47.2	145.9	986	-	-	L
07/18	47.8	147.8	988	-	-	L
08/00	48.5	150.6	986	-	-	L
08/06	49.3	154.0	984	-	-	L
08/12	51.0	155.6	986	-	-	L
08/18	51.0	158.2	986	-	-	L
09/00	50.8	160.7	988	-	-	L
09/06	50.9	162.4	988	-	-	L
09/12	50.8	164.5	992	-	-	L
09/18	50.7	167.0	994	-	-	L
10/00	50.8	169.3	994	-	-	L
10/06	50.8	171.0	996	-	-	L
10/12	51.0	172.6	996	-	-	L
10/18	51.3	174.2	996	-	-	L
11/00	51.6	175.7	996	-	-	L
11/06	52.0	177.0	998	-	-	L
11/12	52.2	178.2	1000	-	-	L
11/18	52.4	179.3	1000	-	-	L
12/00	52.4	179.8	1000	-	-	L
12/06	52.3	180.7	1002	-	-	Out

Jangmi (2005)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Aug. 06/18	14.2	127.5	1006	-	0.5	TD
07/00	14.7	127.3	1006	-	0.5	TD
07/06	15.2	127.2	1006	-	0.5	TD
07/12	15.7	127.0	1004	-	0.5	TD
07/18	16.3	127.0	1002	-	0.5	TD
08/00	17.0	126.9	1002	-	1.0	TD
08/06	18.1	126.6	1000	-	1.5	TD
08/12	19.4	126.4	1002	-	1.5	TD
08/18	20.8	126.4	998	35	2.0	TS
09/00	23.0	126.4	996	40	2.5	TS
09/06	25.3	126.2	996	40	2.5	TS
09/12	27.8	126.3	994	45	2.5	TS
09/18	29.5	126.8	994	45	2.5	TS
09/21	30.8	127.3	994	45	-	TS
10/00	32.1	127.7	996	40	2.5	TS
10/03	33.3	128.1	996	40	-	TS
10/06	34.6	128.5	996	40	2.5	TS
10/09	35.8	129.2	998	35	-	TS
10/12	37.2	130.0	998	35	2.5	TS
10/18	40.0	132.2	998	35	2.5	TS
11/00	43.0	135.9	998	35	2.5	TS
11/06	44.3	139.5	998	-	-	L
11/12	45.9	143.4	996	-	-	L
11/18	47.0	147.6	996	-	-	L
12/00	47.8	151.5	994	-	-	L
12/06	48.3	153.6	992	-	-	L
12/12	48.8	155.3	992	-	-	L
12/18	49.0	157.6	990	-	-	L
13/00	49.4	158.7	990	-	-	L
13/06	49.5	159.6	990	-	-	L
13/12	49.4	160.1	990	-	-	L
13/18	49.4	161.1	992	-	-	L
14/00	49.3	162.1	992	-	-	L
14/06	49.7	162.1	996	-	-	L
14/12	49.3	162.5	998	-	-	L
14/18	49.1	162.7	998	-	-	L
15/00						Dissip.

Mekkhala (2006)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Aug. 09/00	15.1	118.2	1002	-	0.5	TD
09/06	16.0	118.3	1000	-	1.0	TD
09/12	17.0	118.4	1002	-	1.5	TD
09/18	18.1	118.5	1002	-	1.5	TD
10/00	19.2	118.6	1000	35	2.0	TS
10/06	20.4	118.6	998	40	2.5	TS
10/12	21.6	118.6	996	45	2.5	TS
10/18	22.9	118.3	992	50	3.0	STS
11/00	24.2	117.7	996	45	3.0	TS
11/06	25.6	117.3	1004	-	2.5	TD
11/12						Dissip.

Higos (2007)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Aug. 16/06	17.6	123.4	1006	-	0.5	TD
16/12	17.7	123.2	1006	-	0.0	TD
16/18	18.5	122.9	1006	-	0.5	TD
17/00	19.1	121.9	1006	-	0.5	TD
17/06	19.5	120.7	1006	-	1.0	TD
17/12	19.7	119.6	1004	-	1.5	TD
17/18	19.8	118.4	1002	-	2.0	TD
18/00	20.3	116.9	1000	35	2.0	TS
18/06	20.5	115.9	1000	35	2.5	TS
18/12	21.2	114.8	998	40	2.5	TS
18/18	21.6	113.8	996	50	3.0	STS
19/00	22.2	113.0	992	55	3.5	STS
19/06	22.8	112.0	998	40	3.0	TS
19/12	23.7	110.7	1004	35	2.5	TS
19/18	24.0	109.4	1006	-	2.0	TD
20/00	25.1	109.0	1006	-	2.0	TD
20/06	26.0	108.7	1006	-	1.5	TD
20/12						Dissip.

Date/Time (UTC)	Center position Lat (N)	Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Bavi (2008)						
Aug. 20/18	18.7	122.8	1006	-	1.0	TD
21/00	20.2	123.1	1008	-	1.0	TD
21/06	21.3	123.2	1006	-	1.0	TD
21/12	22.1	123.1	1006	-	1.5	TD
21/18	22.9	123.0	1004	-	1.5	TD
22/00	23.4	122.6	1000	35	2.0	TS
22/06	24.3	123.5	994	45	2.5	TS
22/09	24.7	123.7	990	55	-	STS
22/12	25.3	123.8	990	55	3.0	STS
22/15	25.6	123.5	990	55	-	STS
22/18	25.7	123.6	990	55	3.0	STS
22/21	26.0	123.8	990	55	-	STS
23/00	26.3	123.9	990	55	3.0	STS
23/03	26.5	124.0	990	55	-	STS
23/06	26.6	124.3	990	55	3.0	STS
23/09	26.7	124.6	990	55	-	STS
23/12	26.8	125.0	985	60	3.5	STS
23/15	27.0	125.2	985	60	-	STS
23/18	27.1	125.6	985	60	3.5	STS
23/21	27.2	125.9	985	60	-	STS
24/00	27.3	126.1	980	65	4.0	TY
24/03	27.4	126.4	975	65	-	TY
24/06	27.8	126.4	975	65	4.0	TY
24/09	28.2	126.4	975	65	-	TY
24/12	28.4	126.3	970	70	4.5	TY
24/18	28.6	126.0	965	75	4.5	TY
25/00	29.2	125.7	955	80	4.5	TY
25/06	29.8	125.5	955	80	5.0	TY
25/12	30.6	125.2	955	80	5.0	TY
25/18	31.4	124.8	955	80	5.0	TY
26/00	32.4	124.5	950	85	5.0	TY
26/06	33.6	124.3	950	85	5.0	TY
26/12	35.0	124.4	955	80	5.0	TY
26/18	37.0	125.2	965	70	4.5	TY
27/00	39.1	125.3	980	55	4.0	STS
27/06	42.0	125.0	992	-	3.5	L
27/12	43.8	126.2	996	-	-	L
27/18	45.4	127.0	998	-	-	L
28/00	45.0	126.1	1002	-	-	L
28/06	44.7	125.6	1002	-	-	L
28/12	44.6	125.9	1004	-	-	L
28/18	45.3	125.2	1006	-	-	L
29/00	46.4	124.6	1006	-	-	L
29/06	46.8	123.6	1008	-	-	L
29/12	46.6	123.8	1010	-	-	L
29/18	46.6	124.4	1012	-	-	L
30/00						Dissip.

Date/Time (UTC)	Center position Lat (N)	Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Maysak (2009)						
Aug. 27/00	14.8	132.3	1004	-	0.5	TD
27/06	15.4	132.1	1002	-	0.5	TD
27/12	16.1	131.9	1002	-	0.5	TD
27/18	16.8	131.8	1000	-	1.0	TD
28/00	17.4	131.1	1000	-	1.5	TD
28/06	17.2	130.2	996	35	2.0	TS
28/12	16.7	130.0	994	40	2.5	TS
28/18	16.5	129.7	990	50	3.0	STS
29/00	16.5	129.6	985	55	3.5	STS
29/06	16.7	129.3	985	55	3.5	STS
29/12	17.0	129.0	975	65	4.0	TY
29/18	17.0	129.0	970	70	4.5	TY
30/00	17.2	129.0	965	75	5.0	TY
30/06	18.4	129.0	965	75	5.0	TY
30/12	19.3	129.0	955	80	5.0	TY
30/18	20.7	128.9	955	80	5.0	TY
31/00	22.4	128.4	955	80	5.0	TY
31/03	23.3	128.2	955	80	-	TY
31/06	24.2	127.6	955	80	5.0	TY
31/09	24.5	127.2	955	80	-	TY
31/12	25.0	127.1	950	85	5.5	TY
31/15	25.5	126.8	950	85	-	TY
31/18	26.1	126.5	940	90	6.0	TY
31/21	26.5	126.2	940	90	-	TY
Sep. 01/00	26.9	126.0	935	95	6.0	TY
01/03	27.3	125.9	935	95	-	TY
01/06	27.6	126.1	935	95	6.0	TY
01/09	28.1	126.2	935	95	-	TY
01/12	28.4	126.3	935	95	6.0	TY
01/15	28.9	126.5	940	90	-	TY
01/18	29.4	126.6	940	90	5.5	TY
01/21	30.0	126.6	945	85	-	TY
02/00	30.5	126.7	945	85	5.0	TY
02/03	31.2	126.9	945	85	-	TY
02/06	31.7	127.1	950	80	4.5	TY
02/09	32.6	127.7	950	80	-	TY
02/12	33.2	127.9	950	80	4.5	TY
02/15	34.1	128.3	950	80	-	TY
02/18	35.5	128.8	955	75	4.5	TY
02/21	37.0	129.4	960	70	-	TY
03/00	38.8	129.7	965	65	4.5	TY
03/06	42.3	129.1	976	-	3.5	L
03/12	45.6	127.4	976	-	-	L
03/18	47.0	125.3	976	-	-	L
04/00	48.1	124.1	976	-	-	L
04/06	48.9	123.4	978	-	-	L
04/12	48.9	123.1	982	-	-	L
04/18	49.5	123.3	988	-	-	L
05/00	50.6	124.0	992	-	-	L
05/06	51.6	124.8	996	-	-	L
05/12	52.4	125.7	1000	-	-	L
05/18	52.9	126.4	1002	-	-	L
06/00	53.1	126.9	1004	-	-	L
06/06	53.0	127.3	1006	-	-	L
06/12	52.6	128.6	1008	-	-	L
06/18	52.0	130.1	1010	-	-	L
07/00	51.9	132.1	1012	-	-	L
07/06						Dissip.

Date/Time (UTC)	Center position Lat (N)	Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Haishen (2010)						
Aug. 30/12	24.9	145.5	1008	-	0.5	TD
30/18	24.5	145.9	1008	-	1.0	TD
31/00	23.9	146.1	1006	-	1.0	TD
31/06	23.2	146.1	1004	-	1.5	TD
31/12	22.6	145.9	1002	35	2.0	TS
31/18	22.1	145.6	1000	35	2.0	TS
Sep. 01/00	21.2	144.8	1000	35	2.0	TS
01/06	20.9	144.5	996	40	2.5	TS
01/12	20.5	144.0	992	45	3.0	TS
01/18	20.0	143.3	985	50	3.5	STS
02/00	19.4	142.5	980	55	3.5	STS
02/06	19.3	141.5	970	65	4.0	TY
02/12	19.7	140.4	965	70	4.5	TY
02/18	20.0	139.4	965	70	4.5	TY
03/00	20.2	138.5	960	75	5.0	TY
03/06	20.6	137.5	950	80	5.0	TY
03/12	21.0	136.6	945	85	5.5	TY
03/18	21.2	135.8	925	95	6.0	TY
04/00	21.8	135.1	920	100	6.5	TY
04/06	22.3	134.3	915	100	6.5	TY
04/12	22.7	133.5	910	105	6.5	TY
04/18	23.2	132.6	910	105	6.5	TY
04/21	23.5	132.3	910	105	-	TY
05/00	24.0	132.0	915	100	6.5	TY
05/03	24.2	131.6	915	100	-	TY
05/06	24.7	131.5	920	100	6.5	TY
05/09	25.0	131.2	920	100	-	TY
05/12	25.4	131.0	920	100	6.5	TY
05/15	25.8	130.9	920	100	-	TY
05/18	26.4	130.9	925	95	6.0	TY
05/21	27.1	130.8	925	95	-	TY
06/00	27.7	130.5	930	90	5.5	TY
06/03	28.5	130.3	930	90	-	TY
06/06	29.4	130.1	930	90	5.5	TY
06/09	30.3	129.8	935	90	-	TY
06/12	31.0	129.4	940	85	5.5	TY
06/15	31.9	129.2	945	85	-	TY
06/18	32.9	129.0	945	85	5.0	TY
06/21	34.1	129.1	950	80	-	TY
07/00	35.5	129.2	960	70	4.5	TY
07/03	36.9	129.3	970	60	-	STS
07/06	38.4	129.1	970	55	4.0	STS
07/12	39.8	128.9	975	45	3.5	TS
07/18	42.2	129.0	986	-	3.0	L
08/00	44.0	128.3	990	-	-	L
08/06	45.3	127.9	990	-	-	L
08/12	45.8	127.1	992	-	-	L
08/18	45.8	127.1	994	-	-	L
09/00	45.6	126.9	998	-	-	L
09/06	45.4	126.8	1000	-	-	L
09/12	44.7	125.5	1002	-	-	L
09/18	43.6	125.1	1002	-	-	L
10/00	42.9	124.4	1004	-	-	L
10/06	42.0	124.0	1006	-	-	L
10/12						Dissip.

Date/Time (UTC)	Center position Lat (N)	Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Noul (2011)						
Sep. 15/00	12.8	121.8	1006	-	0.5	TD
15/06	12.6	120.4	1002	-	1.0	TD
15/12	12.7	119.1	1000	-	1.5	TD
15/18	13.0	118.5	998	35	2.0	TS
16/00	13.1	117.7	998	35	2.0	TS
16/06	13.2	116.8	996	40	2.0	TS
16/12	13.4	115.7	994	40	2.5	TS
16/18	13.8	114.5	994	40	2.5	TS
17/00	14.6	113.8	994	40	2.5	TS
17/06	15.5	113.1	992	45	2.5	TS
17/12	15.8	111.9	992	45	2.5	TS
17/18	15.9	110.3	992	45	2.5	TS
18/00	16.3	108.3	992	45	2.5	TS
18/06	16.3	105.2	994	40	2.5	TS
18/12	16.2	104.0	994	35	2.0	TS
18/18	16.2	102.1	998	-	1.5	TD
19/00						Dissip.

Dolphin (2012)

Date/Time (UTC)		Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Sep.	19/12	21.6	135.0	1010	-	0.5	TD
	19/18	22.3	134.5	1008	-	0.5	TD
	20/00	22.9	134.2	1008	-	1.0	TD
	20/06	23.6	134.0	1006	-	1.0	TD
	20/12	24.0	134.3	1004	-	1.5	TD
	20/18	24.2	134.7	1002	-	2.0	TD
	21/00	24.9	134.8	996	40	2.5	TS
	21/06	25.3	135.0	996	40	2.5	TS
	21/12	25.7	135.0	996	40	3.0	TS
	21/18	26.1	135.2	992	45	3.0	TS
	22/00	26.9	135.3	985	50	3.0	STS
	22/06	28.1	135.8	975	60	3.5	STS
	22/12	29.3	136.3	975	60	3.5	STS
	22/18	30.1	137.0	975	60	3.5	STS
	23/00	31.2	137.9	975	60	3.5	STS
	23/06	32.1	139.3	980	55	3.5	STS
	23/09	32.7	140.1	985	50	-	STS
	23/12	32.9	140.8	985	50	3.5	STS
	23/15	32.9	141.1	985	50	-	STS
	23/18	32.9	141.3	985	50	3.5	STS
	23/21	32.9	141.5	985	50	-	STS
	24/00	32.9	141.8	990	45	3.0	TS
	24/03	32.7	142.0	992	45	-	TS
	24/06	32.7	142.4	992	-	2.5	L
	24/12	33.2	142.5	996	-	-	L
	24/18	33.7	142.5	996	-	-	L
	25/00	34.0	141.7	1000	-	-	L
	25/06	35.5	142.1	1000	-	-	L
	25/12	37.2	142.8	1000	-	-	L
	25/18	38.9	144.0	996	-	-	L
	26/00	40.2	145.4	998	-	-	L
	26/06	40.9	146.0	1004	-	-	L
	26/12	41.6	146.8	1004	-	-	L
	26/18	42.0	147.1	1004	-	-	L
	27/00	42.7	147.4	1000	-	-	L
	27/06	43.5	147.9	1000	-	-	L
	27/12	44.6	148.4	998	-	-	L
	27/18	45.5	149.7	994	-	-	L
	28/00	47.3	151.7	990	-	-	L
	28/06	48.8	152.9	986	-	-	L
	28/12	49.5	154.1	986	-	-	L
	28/18	50.1	157.9	990	-	-	L
	29/00	50.7	161.9	996	-	-	L
	29/06	50.6	165.8	998	-	-	L
	29/12	50.2	167.5	1004	-	-	L
	29/18	49.9	168.9	1008	-	-	L
	30/00						Dissip.

Kujira (2013)

Date/Time (UTC)		Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Sep.	25/12	16.6	158.7	1008	-	0.5	TD
	25/18	17.2	158.6	1006	-	1.0	TD
	26/00	17.9	158.9	1008	-	1.0	TD
	26/06	18.6	159.3	1006	-	1.5	TD
	26/12	19.3	159.5	1004	-	1.5	TD
	26/18	20.0	159.3	1002	35	1.5	TS
	27/00	20.7	158.7	1002	35	1.5	TS
	27/06	21.9	157.6	1000	35	2.0	TS
	27/12	23.3	156.3	998	40	2.0	TS
	27/18	24.9	154.9	996	40	2.5	TS
	28/00	26.4	153.6	992	45	3.0	TS
	28/06	27.7	153.1	990	50	3.0	STS
	28/12	28.7	152.9	985	55	3.5	STS
	28/18	30.5	153.1	985	55	3.5	STS
	29/00	32.6	153.8	980	60	3.5	STS
	29/06	34.7	154.9	980	60	3.5	STS
	29/12	36.6	156.4	980	60	3.5	STS
	29/18	38.6	158.4	985	55	3.5	STS
	30/00	40.0	160.7	990	50	3.5	STS
	30/06	41.0	163.0	996	-	3.0	L
	30/12	41.2	166.2	1000	-	-	L
	30/18	41.1	169.2	1000	-	-	L
Oct.	01/00	40.4	172.1	1004	-	-	L
	01/06	39.6	175.4	1004	-	-	L
	01/12	38.4	177.8	1006	-	-	L
	01/18	37.1	180.4	1006	-	-	Out

Chan-hom (2014)

Date/Time (UTC)		Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Oct.	04/00	21.4	140.0	1004	-	0.5	TD
	04/06	21.8	140.0	1000	-	1.0	TD
	04/12	22.1	139.7	1002	-	1.0	TD
	04/18	22.2	139.3	1000	-	1.5	TD
	05/00	22.2	139.2	998	35	2.0	TS
	05/06	22.4	139.1	996	35	2.0	TS
	05/12	22.9	139.3	998	35	2.0	TS
	05/18	23.3	139.1	996	40	2.5	TS
	06/00	23.7	138.6	992	45	2.5	TS
	06/06	24.1	138.1	992	45	2.5	TS
	06/12	24.3	137.6	990	50	2.5	STS
	06/18	24.7	136.9	980	55	3.0	STS
	07/00	25.2	135.8	975	60	3.0	STS
	07/06	25.7	134.7	970	65	3.5	TY
	07/12	26.5	133.7	970	65	4.0	TY
	07/15	26.8	133.3	970	65	-	TY
	07/18	27.3	133.0	970	65	4.0	TY
	07/21	27.6	132.8	970	65	-	TY
	08/00	27.9	132.8	970	65	4.0	TY
	08/03	28.2	132.9	970	65	-	TY
	08/06	28.7	133.0	970	65	4.5	TY
	08/09	29.1	133.1	970	65	-	TY
	08/12	29.4	133.3	965	70	4.5	TY
	08/15	29.8	133.4	965	70	-	TY
	08/18	30.0	133.4	965	70	4.5	TY
	08/21	30.1	133.4	965	70	-	TY
	09/00	30.2	133.3	970	70	4.5	TY
	09/03	30.4	133.3	970	70	-	TY
	09/06	30.5	133.4	970	70	4.5	TY
	09/09	30.7	133.7	975	65	-	TY
	09/12	31.0	134.0	980	60	4.0	STS
	09/15	31.2	134.4	980	60	-	STS
	09/18	31.4	134.8	985	55	3.5	STS
	09/21	31.8	135.4	985	55	-	STS
	10/00	32.0	135.7	985	55	3.5	STS
	10/03	32.1	136.0	985	55	-	STS
	10/06	32.3	136.8	985	55	3.5	STS
	10/09	32.2	137.7	985	55	-	STS
	10/12	32.2	138.2	985	55	3.5	STS
	10/15	32.3	138.9	990	50	-	STS
	10/18	32.2	139.5	990	50	3.0	STS
	10/21	32.4	140.0	990	50	-	STS
	11/00	32.1	140.6	992	45	3.0	TS
	11/06	31.8	141.3	996	40	3.0	TS
	11/12	31.4	142.0	998	35	2.5	TS
	11/18	30.8	142.2	1002	-	2.5	TD
	12/00	30.3	142.3	1004	-	2.5	TD
	12/06	29.6	142.5	1002	-	2.0	TD
	12/12	29.1	142.7	1004	-	2.0	TD
	12/18	28.9	143.2	1004	-	2.0	TD
	13/00	28.6	144.1	1008	-	2.0	TD
	13/06	28.6	144.6	1006	-	2.0	TD
	13/12	28.6	144.8	1008	-	2.0	TD
	13/18	28.6	144.5	1008	-	2.0	TD
	14/00	28.5	144.4	1008	-	2.0	TD
	14/06	28.7	144.5	1008	-	2.0	TD
	14/12	28.8	144.2	1010	-	2.0	TD
	14/18	28.9	144.1	1010	-	2.0	TD
	15/00	29.4	144.0	1010	-	2.0	TD
	15/06	29.7	143.8	1010	-	2.0	TD
	15/12	30.0	144.1	1010	-	2.0	TD
	15/18	30.5	144.3	1012	-	2.0	TD
	16/00	31.1	145.5	1012	-	2.0	TD
	16/06	32.0	146.5	1010	-	2.0	TD
	16/12	33.1	147.4	1012	-	2.0	TD
	16/18	34.7	149.5	1012	-	2.0	TD
	17/00	36.4	152.9	1012	-	2.0	L
	17/06	37.2	155.9	1010	-	-	L
	17/12	38.1	159.0	1012	-	-	L
	17/18	39.0	161.9	1014	-	-	L
	18/00	39.0	164.4	1016	-	-	L
	18/06	38.7	166.7	1016	-	-	L
	18/12	38.5	168.9	1018	-	-	L
	18/18	38.4	170.0	1018	-	-	L
	19/00	38.2	171.3	1018	-	-	L
	19/06	38.2	171.8	1016	-	-	L
	19/12						Dissip.

Linfa (2015)

Date/Time (UTC)		Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Oct.	06/18	13.8	125.9	1004	-	0.0	TD
	07/00	13.8	125.4	1006	-	0.5	TD
	07/06	13.8	124.8	1004	-	0.5	TD
	07/12	13.8	124.3	1006	-	0.0	TD
	07/18	13.7	123.9	1006	-	0.0	TD
	08/00	13.2	122.6	1008	-	0.0	TD
	08/06	12.9	121.2	1006	-	0.0	TD
	08/12	12.8	119.1	1008	-	0.0	TD
	08/18	12.7	118.0	1006	-	0.0	TD
	09/00	12.8	116.8	1006	-	0.0	TD
	09/06	13.2	115.7	1004	-	0.0	TD
	09/12	13.4	115.2	1006	-	0.0	TD
	09/18	13.5	114.7	1004	-	0.5	TD
	10/00	13.7	114.2	1004	-	1.0	TD
	10/06	14.3	113.1	1002	-	1.5	TD
	10/12	14.5	111.7	1002	-	2.0	TD
	10/18	14.6	110.2	998	35	2.0	TS
	11/00	14.9	109.4	994	45	2.5	TS
	11/06	15.2	108.5	998	35	2.0	TS
	11/12	14.9	107.9	1002	-	1.5	TD
	11/18	14.6	107.3	1002	-	1.5	TD
	12/00	14.4	106.9	1004	-	1.0	TD
	12/06	14.2	106.7	1002	-	1.0	TD
	12/12						Dissip.

Nangka (2016)

Date/Time (UTC)		Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Oct.	11/00	16.7	119.9	1004	-	-	TD
	11/06	16.8	119.4	1002	-	0.0	TD
	11/12	17.0	118.7	1002	-	0.5	TD
	11/18	17.2	118.0	1000	-	1.0	TD
	12/00	17.6	117.2	1000	-	1.5	TD
	12/06	17.6	116.0	998	35	2.0	TS
	12/12	17.8	114.5	996	40	2.5	TS
	12/18	17.9	113.4	996	40	2.5	TS
	13/00	18.3	112.0	992	45	2.5	TS
	13/06	18.6	111.2	992	45	2.5	TS
	13/12	19.0	110.4	990	45	2.5	TS
	13/18	19.8	108.6	990	45	2.5	TS
	14/00	19.9	107.2	996	40	2.0	TS
	14/06	19.9	106.6	998	35	2.0	TS
	14/12	19.9	105.9	1000	-	1.5	TD
	14/18						Dissip.

Saudel (2017)

Date/Time (UTC)		Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Oct.	18/18	13.1	130.3	1004	-	1.0	TD
	19/00	13.3	129.4	1004	-	1.0	TD
	19/06	13.9	128.1	1002	-	1.5	TD
	19/12	14.2	127.3	1002	-	2.0	TD
	19/18	15.0	126.0	1002	-	2.5	TD
	20/00	15.5	124.5	1000	35	2.5	TS
	20/06	15.7	123.0	996	35	2.5	TS
	20/12	15.8	121.8	996	35	2.5	TS
	20/18	16.1	119.8	996	35	2.5	TS
	21/00	16.0	118.8	996	35	2.5	TS
	21/06	16.2	117.8	990	45	3.0	TS
	21/12	15.8	117.4	985	55	3.5	STS
	21/18	16.0	116.5	985	55	3.5	STS
	22/00	16.8	116.3	980	60	3.5	STS
	22/06	16.9	115.8	980	60	4.0	STS
	22/12	17.1	115.9	975	65	4.0	TY
	22/18	17.5	115.7	975	65	4.0	TY
	23/00	17.5	115.3	975	65	4.0	TY
	23/06	17.7	114.7	975	65	4.0	TY
	23/12	17.9	114.2	980	60	4.0	STS
	23/18	18.1	113.6	985	55	4.0	STS
	24/00	18.2	113.1	985	55	4.0	STS
	24/06	17.8	112.2	985	55	4.0	STS
	24/12	17.7	111.1	990	50	4.0	STS
	24/18	17.5	109.7	990	50	3.5	STS
	25/00	17.5	109.0	992	45	3.5	TS
	25/06	17.5	108.2	1000	35	3.0	TS
	25/12	17.5	107.6	1006	-	2.5	TD
	25/18						Dissip.

Molave (2018)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Oct. 22/00	9.4	137.5	1008	-	0.0	TD
22/06	9.6	137.1	1004	-	0.0	TD
22/12	9.8	136.5	1006	-	0.5	TD
22/18	10.0	135.5	1004	-	1.0	TD
23/00	10.0	134.8	1006	-	1.0	TD
23/06	10.5	134.2	1004	-	0.5	TD
23/12	11.1	133.6	1006	-	1.0	TD
23/18	12.0	132.3	1004	-	1.5	TD
24/00	12.6	131.1	1004	-	1.5	TD
24/06	13.1	129.7	1000	35	2.0	TS
24/12	13.3	128.8	998	40	2.5	TS
24/18	13.4	127.4	994	45	3.0	TS
25/00	13.4	126.4	992	50	3.5	STS
25/06	13.4	124.7	985	60	4.0	STS
25/12	13.3	123.2	975	70	4.5	TY
25/18	13.1	121.8	975	70	4.5	TY
26/00	13.2	120.4	975	70	4.5	TY
26/06	13.4	118.8	975	65	4.0	TY
26/12	13.4	117.5	965	75	5.0	TY
26/18	13.4	116.0	955	80	5.0	TY
27/00	13.4	114.4	950	85	5.5	TY
27/06	13.5	113.2	940	90	6.0	TY
27/12	13.8	112.1	940	90	6.0	TY
27/18	14.2	110.9	945	85	6.0	TY
28/00	14.6	109.8	955	80	5.5	TY
28/06	15.2	108.7	970	70	5.0	TY
28/12	15.4	108.4	992	45	4.0	TS
28/18	15.8	106.4	1000	-	3.0	TD
29/00	15.0	105.0	1004	-	2.0	TD
29/06						Dissip.

Goni (2019)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Oct. 26/12	14.1	141.7	1008	-	0.5	TD
26/18	14.6	141.7	1006	-	0.5	TD
27/00	15.1	141.6	1008	-	1.0	TD
27/06	15.7	141.5	1006	-	1.5	TD
27/12	16.0	141.1	1008	-	1.5	TD
27/18	16.2	140.7	1006	-	1.5	TD
28/00	16.4	140.0	1008	-	1.5	TD
28/06	16.4	139.3	1006	-	2.0	TD
28/12	16.5	138.6	1008	-	2.0	TD
28/18	16.6	137.8	1002	35	2.5	TS
29/00	16.6	136.7	998	45	3.0	TS
29/06	16.7	135.7	996	50	3.5	STS
29/12	16.7	134.5	985	65	4.5	TY
29/18	16.4	133.4	975	75	5.0	TY
30/00	16.4	132.7	965	85	5.5	TY
30/06	16.4	131.6	945	100	7.0	TY
30/12	16.1	130.9	915	115	7.5	TY
30/18	15.9	129.9	915	115	7.5	TY
31/00	15.3	128.8	915	115	7.5	TY
31/06	14.7	127.6	915	115	7.5	TY
31/12	14.2	126.5	915	115	7.5	TY
31/18	13.8	125.0	905	120	8.0	TY
Nov. 01/00	13.5	123.6	945	100	6.0	TY
01/06	13.7	121.9	980	60	4.5	STS
01/12	14.3	121.3	996	45	3.0	TS
01/18	14.5	119.5	1000	35	2.0	TS
02/00	14.8	118.4	1000	35	2.0	TS
02/06	15.1	117.6	1000	35	2.0	TS
02/12	15.1	116.8	1000	35	2.0	TS
02/18	15.1	116.0	1002	35	2.5	TS
03/00	15.0	115.4	1002	35	2.5	TS
03/06	14.8	115.2	1002	35	2.5	TS
03/12	14.8	114.7	1002	35	2.5	TS
03/18	14.6	114.0	1002	35	2.5	TS
04/00	14.4	113.6	1002	35	2.5	TS
04/06	14.3	113.3	1000	40	2.5	TS
04/12	14.3	112.8	1000	40	2.5	TS
04/18	14.4	112.2	1000	40	2.5	TS
05/00	14.5	111.7	1000	40	2.5	TS
05/06	13.9	111.4	1002	35	2.5	TS
05/12	13.8	110.9	1006	-	2.5	TD
05/18	14.0	110.1	1008	-	2.5	TD
06/00	14.1	109.4	1008	-	-	TD
06/06	14.7	107.2	1008	-	-	TD
06/12						Dissip.

Atsani (2020)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Oct. 30/12	11.5	142.9	1004	-	1.5	TD
30/18	12.5	141.9	1002	-	1.5	TD
31/00	13.3	140.1	1004	-	1.5	TD
31/06	13.9	138.8	1002	-	1.5	TD
31/12	14.5	137.4	1002	-	2.0	TD
31/18	14.9	136.0	1002	-	2.0	TD
Nov. 01/00	15.6	134.3	1002	-	2.0	TD
01/06	16.0	132.5	1002	-	2.0	TD
01/12	16.6	130.6	1002	-	2.0	TD
01/18	17.9	129.1	1002	-	2.0	TD
02/00	19.2	128.1	1004	-	2.0	TD
02/06	19.6	127.0	1002	-	2.0	TD
02/12	19.6	126.7	1002	-	2.0	TD
02/18	19.8	127.1	1000	35	2.5	TS
03/00	20.1	127.6	998	40	2.5	TS
03/06	20.0	127.9	998	40	2.5	TS
03/12	19.8	128.5	998	40	2.5	TS
03/18	19.7	128.8	998	40	2.5	TS
04/00	19.8	129.2	994	45	2.5	TS
04/06	20.3	129.0	994	45	3.0	TS
04/12	20.2	128.7	992	50	3.0	STS
04/18	20.0	127.7	992	50	3.0	STS
05/00	19.9	126.7	992	50	3.0	STS
05/06	20.1	125.5	992	50	3.0	STS
05/12	20.5	124.2	994	50	3.0	STS
05/18	20.6	123.0	994	50	3.0	STS
06/00	21.1	121.9	996	50	3.0	STS
06/06	21.3	120.9	996	50	3.0	STS
06/12	21.7	120.2	998	50	3.0	STS
06/18	22.3	119.7	1000	45	3.0	TS
07/00	22.6	119.5	1004	35	2.5	TS
07/06	22.7	119.2	1008	-	2.0	TD
07/12						Dissip.

Etau (2021)

Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Nov. 06/12	10.0	130.7	1008	-	0.5	TD
06/18	10.7	129.3	1006	-	0.5	TD
07/00	11.3	127.8	1008	-	0.0	TD
07/06	12.2	125.9	1006	-	0.5	TD
07/12	13.0	123.7	1004	-	1.0	TD
07/18	13.0	122.6	1004	-	0.5	TD
08/00	12.8	121.5	1006	-	1.0	TD
08/06	12.7	120.0	1004	-	1.5	TD
08/12	12.7	118.2	1002	-	2.0	TD
08/18	12.9	115.4	998	35	2.0	TS
09/00	12.8	113.0	996	40	2.0	TS
09/06	12.5	112.0	992	45	2.0	TS
09/12	12.2	111.4	996	40	2.0	TS
09/18	12.2	110.8	996	40	2.0	TS
10/00	12.5	110.3	998	35	2.0	TS
10/06	12.5	108.7	1000	35	2.0	TS
10/12	12.6	107.4	1004	-	1.5	TD
10/18	12.4	106.4	1006	-	2.0	TD
11/00						Dissip.

Vamco (2022)

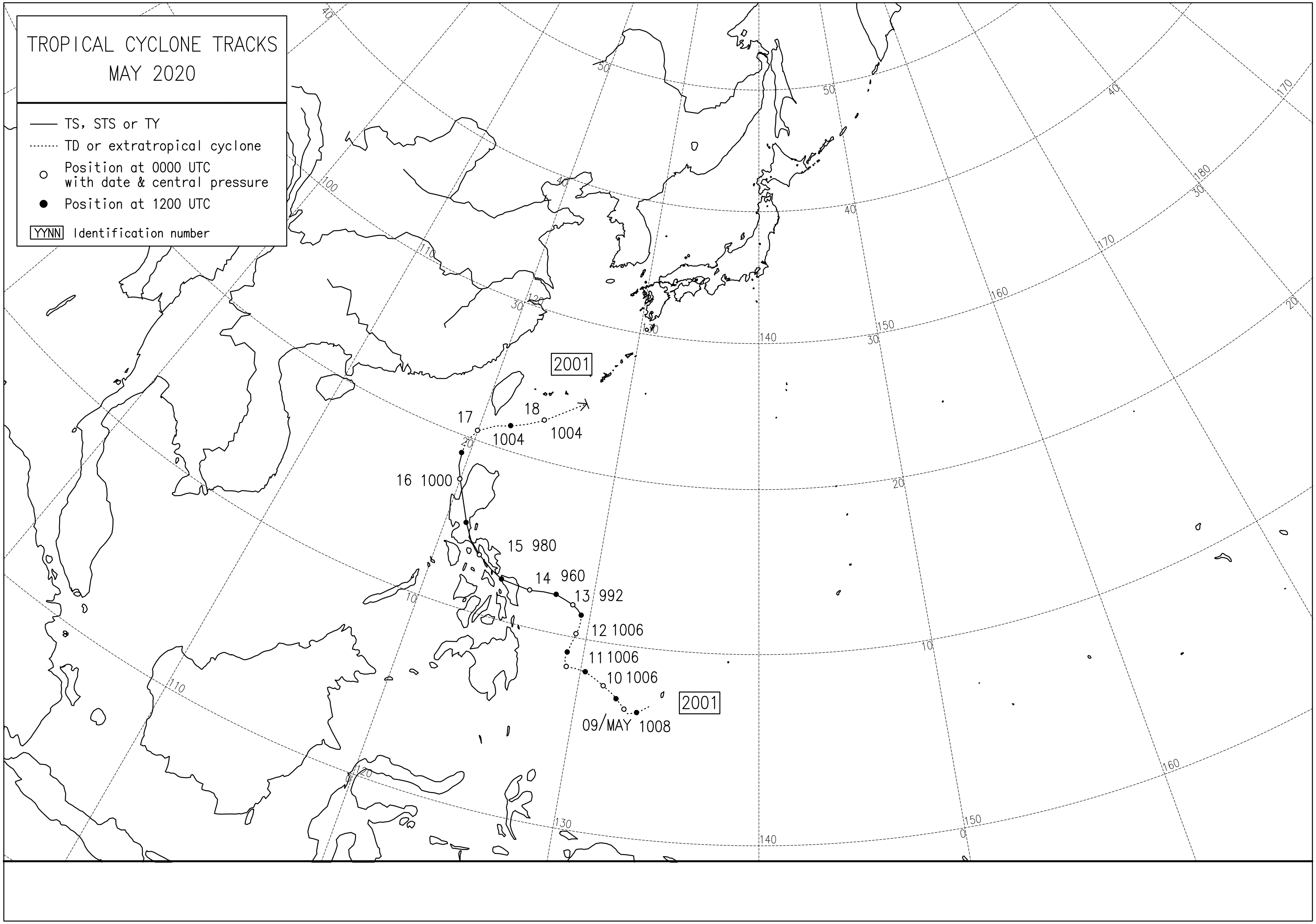
Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Nov. 08/00	8.2	135.2	1008	-	0.0	TD
08/06	8.8	133.9	1006	-	0.0	TD
08/12	9.4	133.2	1008	-	0.0	TD
08/18	10.0	132.6	1006	-	0.5	TD
09/00	10.9	131.6	1006	-	1.0	TD
09/06	11.5	130.9	1004	-	1.5	TD
09/12	11.9	130.4	1004	35	2.0	TS
09/18	12.3	130.0	1002	35	2.0	TS
10/00	13.4	128.9	1000	40	2.5	TS
10/06	14.3	128.1	994	45	3.0	TS
10/12	14.5	126.6	992	50	3.0	STS
10/18	14.5	125.7	990	55	3.5	STS
11/00	14.6	124.6	975	65	4.0	TY
11/06	14.4	123.5	970	70	4.5	TY
11/12	14.8	122.8	965	75	5.0	TY
11/18	15.1	121.3	970	70	4.5	TY
12/00	15.2	119.6	985	55	4.0	STS
12/06	15.2	118.5	980	60	3.5	STS
12/12	15.1	117.3	980	60	3.0	STS
12/18	15.2	116.3	980	60	4.0	STS
13/00	15.4	115.5	980	60	4.0	STS
13/06	15.4	114.4	980	60	4.0	STS
13/12	15.5	113.4	965	75	5.0	TY
13/18	15.6	112.4	960	80	5.0	TY
14/00	15.8	111.4	955	85	5.5	TY
14/06	15.9	110.3	975	70	5.5	TY
14/12	16.4	109.4	980	65	5.0	TY
14/18	16.7	108.6	980	65	5.0	TY
15/00	17.1	107.9	990	55	4.5	STS
15/06	17.9	106.6	1000	35	4.0	TS
15/12	18.1	105.9	1008	-	3.5	TD
15/18	18.7	104.3	1012	-	-	TD
16/00	19.2	103.6	1014	-	-	TD
16/06	20.1	103.0	1014	-	-	TD
16/12						Dissip.

Krovanh (2023)

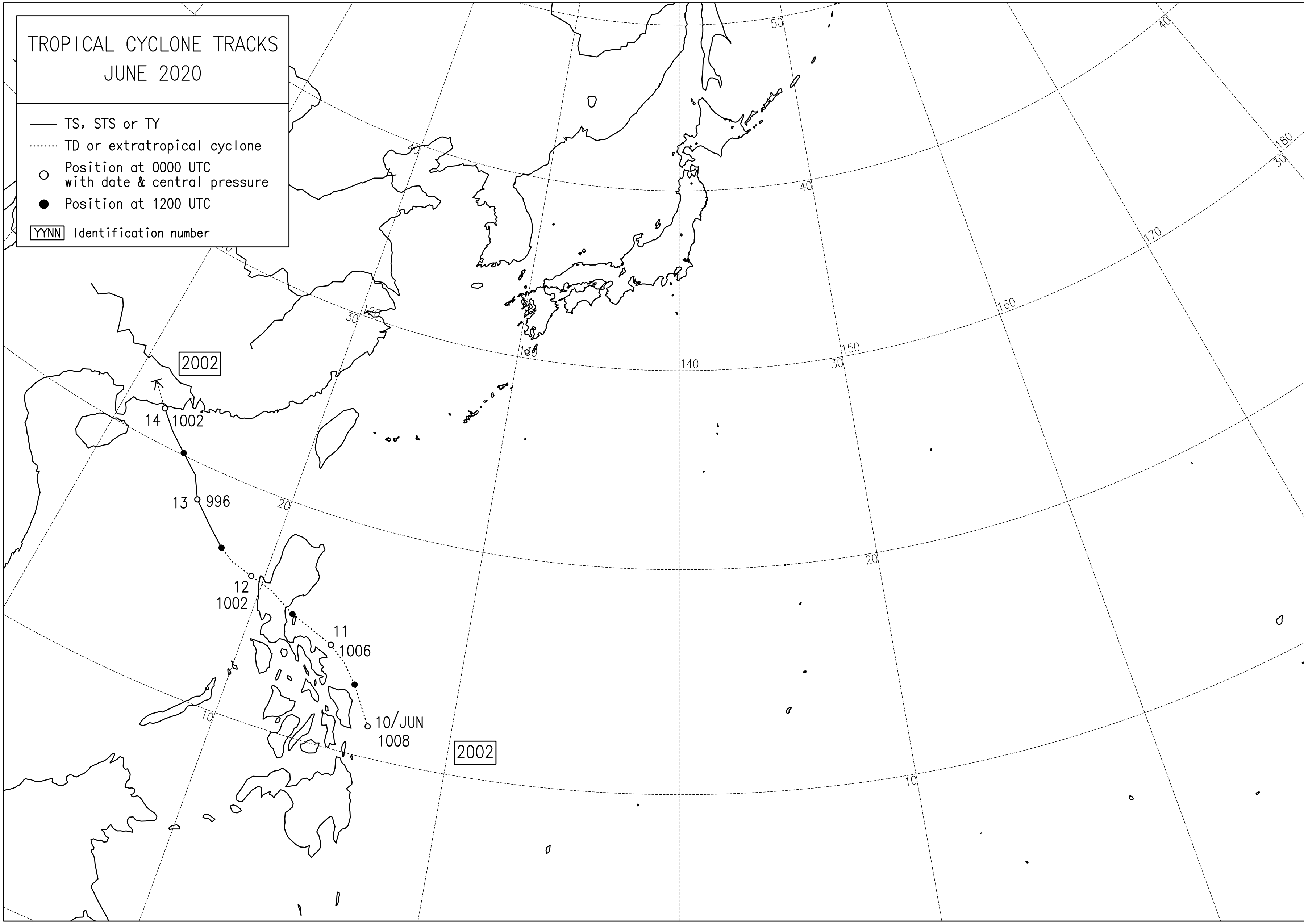
Date/Time (UTC)	Center position Lat (N)	Center position Lon (E)	Central pressure (hPa)	Max wind (kt)	CI num.	Grade
Dec. 18/00	7.2	127.2	1004	-	1.0	TD
18/06	8.2	126.1	1002	-	1.0	TD
18/12	9.4	124.2	1004	-	1.5	TD
18/18	8.6	122.3	1004	-	1.0	TD
19/00	8.6	120.9	1004	-	1.0	TD
19/06	9.2	119.3	1004	-	1.5	TD
19/12	9.9	117.7	1004	-	2.0	TD
19/18	9.2	116.1	1004	-	2.0	TD
20/00	9.6	115.7	1002	35	2.0	TS
20/06	10.0	115.2	1000	35	2.0	TS
20/12	9.8	114.5	1002	35	2.0	TS
20/18	9.4	114.1	1002	35	2.0	TS
21/00	9.0	113.5	1002	35	2.0	TS
21/06	8.8	112.8	1002	35	2.0	TS
21/12	8.6	112.1	1002	35	2.0	TS
21/18	8.1	111.4	1002	35	2.0	TS
22/00	7.3	111.1	1002	35	2.0	TS
22/06	7.7	110.6	1004	-	2.0	TD
22/12	8.1	110.2	1004	-	2.0	TD
22/18	8.0	109.4	1004	-	2.0	TD
23/00	8.1	109.1	1006	-	2.0	TD
23/06	8.6	107.8	1006	-	2.0	TD
23/12	8.0	106.2	1006	-	2.0	TD
23/18	7.7	105.2	1006	-	1.5	TD
24/00	7.5	103.9	1006	-	1.0	TD
24/06	7.6	102.8	1004	-	0.5	TD
24/12	8.2	101.7	1006	-	1.0	TD
24/18	9.0	100.6	1008	-	1.5	TD
25/00	9.9	99.6	1008	-	-	Out

Appendix 2

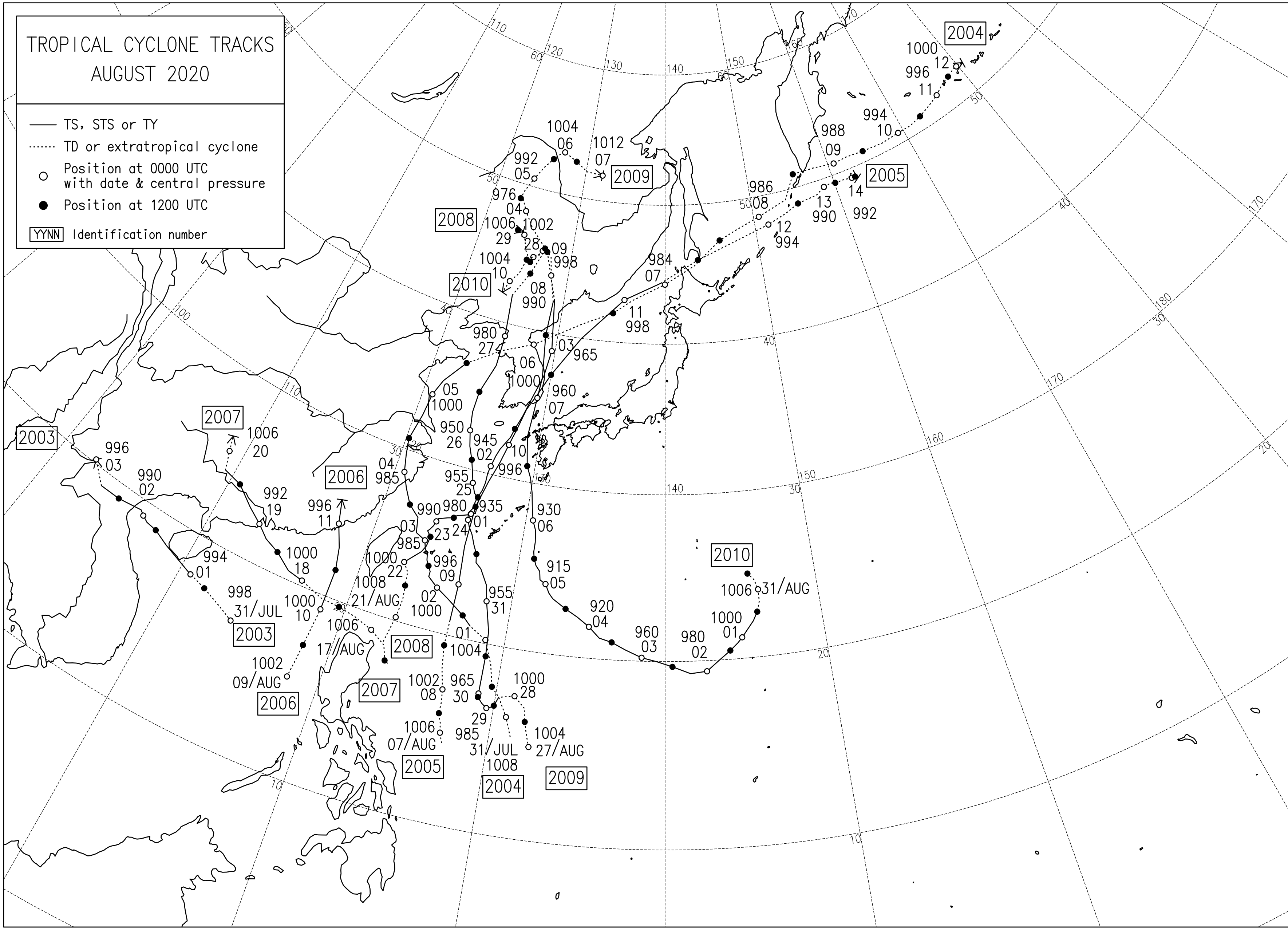
Monthly Tracks of Tropical Cyclones in 2020

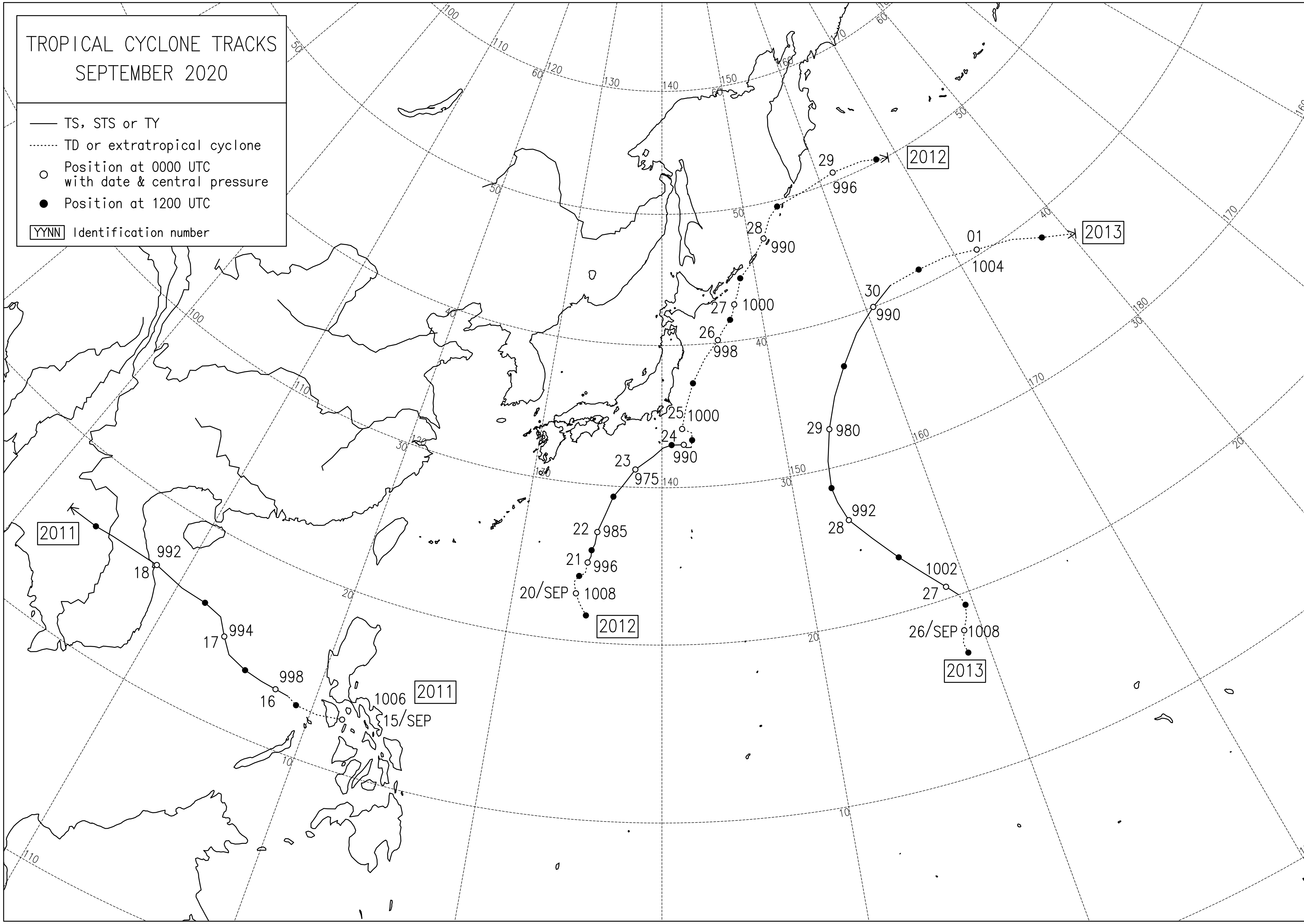


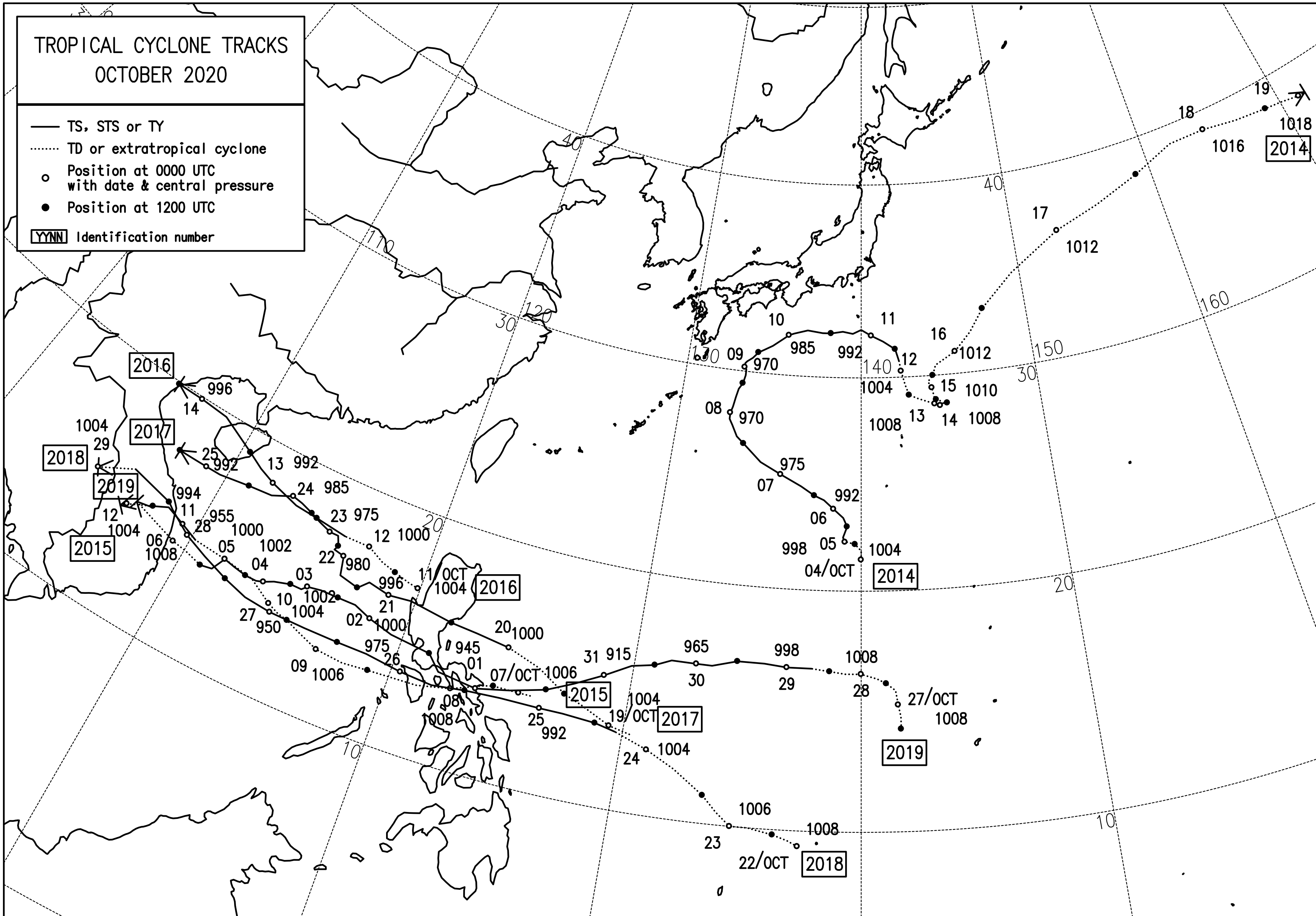
TROPICAL CYCLONE TRACKS
MAY 2020
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC with date & central pressure
Position at 1200 UTC
YYNN Identification number
2001
17
18
1004
1004
16 1000
15 980
14 960
13 992
12 1006
11 1006
10 1006
09/MAY 1008
2001

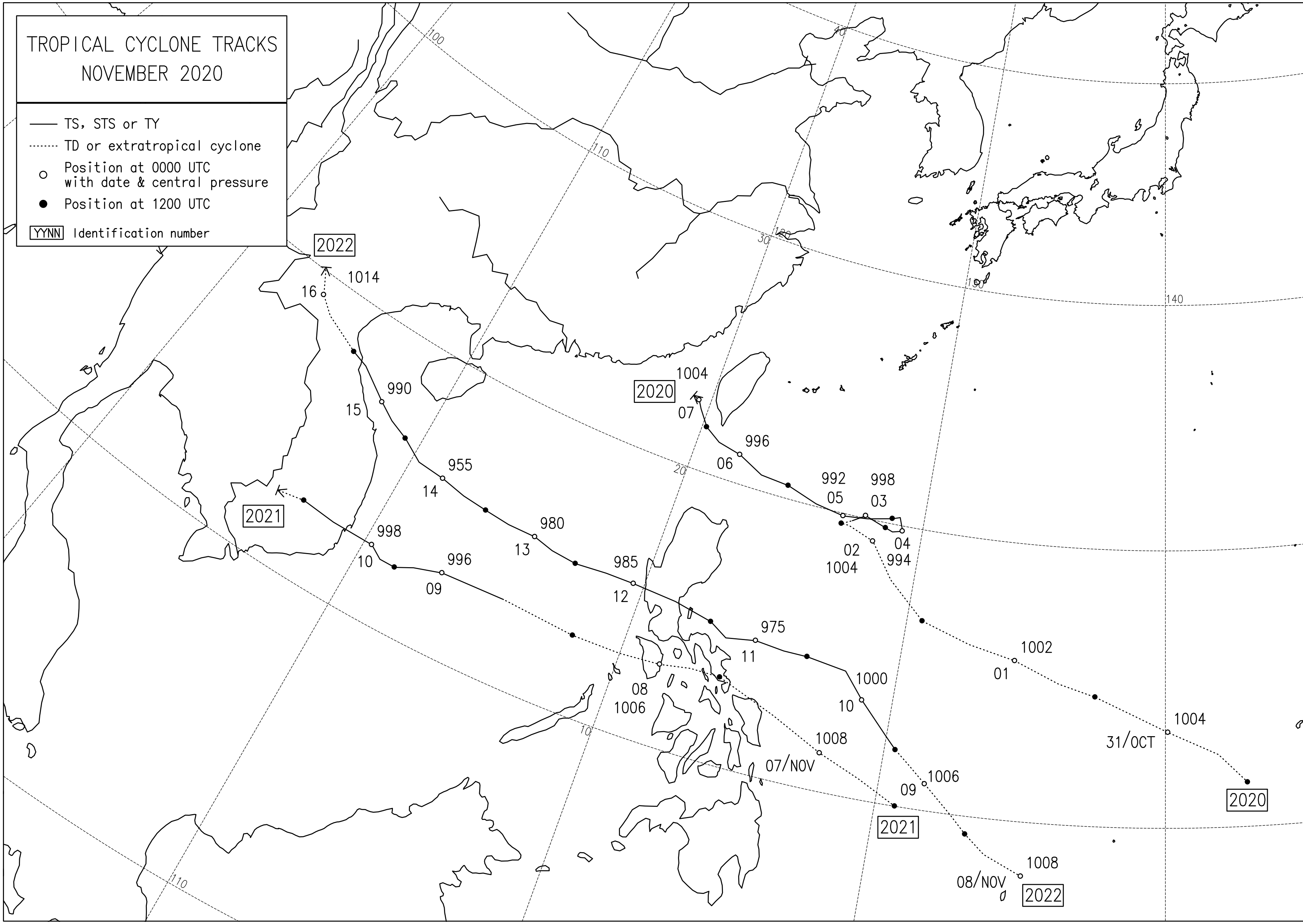


TROPICAL CYCLONE TRACKS
JUNE 2020
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
YYNN Identification number
2002
14 1002
13 996
12
1002
11
1006
10/JUN
1008
2002

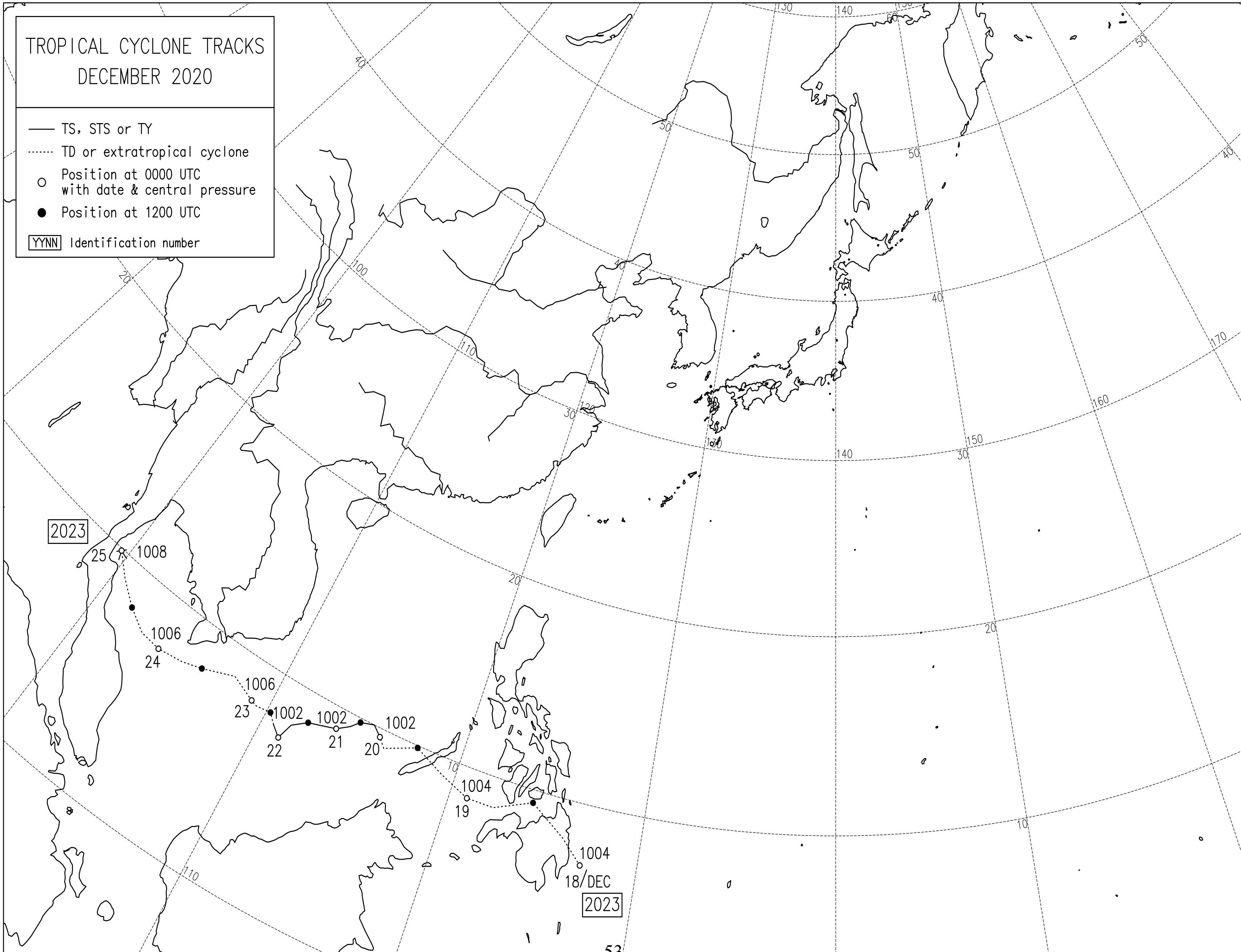

TROPICAL CYCLONE TRACKS
AUGUST 2020
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
YYNN Identification number
2003
2004
2005
2006
2007
2008
2009
2010


TROPICAL CYCLONE TRACKS
SEPTEMBER 2020
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
YYNN Identification number
2011
15/SEP
1006
16
998
17
994
18
992
2011
2012
20/SEP
1008
21
996
22
985
23
975
24
990
25
1000
26
998
27
1000
28
990
29
996
2012
2013
26/SEP
1008
27
1002
28
992
29
980
30
990
01
1004
2013


TROPICAL CYCLONE TRACKS
OCTOBER 2020
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
YYNN Identification number
2014
2015
2016
2017
2018
2019
04/OCT
07/OCT
11/OCT
19/OCT
22/OCT
27/OCT
110
120
130
140
150
160
10
20
30
40



TROPICAL CYCLONE TRACKS
NOVEMBER 2020
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC with date & central pressure
Position at 1200 UTC
YYNN Identification number
2020
2021
2022
31/OCT
1004
01
1002
02
1004
03
998
04
994
05
992
06
996
07
1004
07/NOV
1008
08
1006
09
996
10
998
08/NOV
1008
09
1006
10
1000
11
975
12
985
13
980
14
955
15
990
16
1014


TROPICAL CYCLONE TRACKS
DECEMBER 2020
TS, STS or TY
TD or extratropical cyclone
Position at 0000 UTC
with date & central pressure
Position at 1200 UTC
YYNN Identification number
2023
25
1008
1006
24
1006
23
1002
1002
1002
22
21
20
1004
19
1004
18/DEC
2023

Errors of Track and Intensity Forecasts for Each Tropical Cyclone in 2020

Date/Time	(UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TY Vongfong(2001)																			
May.	11/12	TD	TD	*68*	*117*	*25*				*-2*	*15*				*0*	*-20*			
	11/18	TD	TD	*70*	*60*					*0*					*-5*				
	12/00	TD	TD	*70*	*47*	*64*				*6*	*32*				*-15*	*-40*			
	12/06	TD	TD	*92*	*34*					*13*					*-25*				
	12/12	TS	TS	**65**	**33**	**93**	**79**			**19**	**15**	**0**			**-25**	**-15**	**0**		
	12/18	TS	TS	**22**	**56**	**105**	**112**			**25**	**0**	**-15**			**-25**	**0**	**25**		
	13/00	STS	TS	**0**	**86**	**112**	**121**			**25**	**-10**	**-15**			**-25**	**10**	**25**		
	13/06	STS	STS	**11**	**109**	**124**	**191**			**10**	**-27**	**-20**			**-15**	**25**	**25**		
	13/12	TY	TY	**16**	**88**	**102**				**-15**	**-39**				**10**	**40**			
	13/18	TY	TY	**0**	**77**	**185**				**-30**	**-40**				**25**	**45**			
	14/00	TY	TY	**11**	**87**	**202**				**-10**	**-8**				**10**	**15**			
	14/06	TY	TY	**0**	**87**	**163**				**-17**	**-6**				**20**	**10**			
	14/12	TY	TY	**24**	**97**					**-19**					**30**				
	14/18	TY	TY	**16**	**150**					**-20**					**35**				
	15/00	TY	TY	**11**	**70**					**0**					**5**				
	15/06	STS	STS	**11**	**39**					**-2**					**5**				
	15/12	TS	STS	**15**															
	15/18	TS	TS	**24**															
	16/00	TS	TS	**67**															
	16/06	TS	TS	**79**															
	16/12	TD	TS																
	16/18	TD	TD																
Initial: TS/STS/TY			mean	**23**	**82**	**136**	**126**	–	–	**-3**	**-14**	**-13**	–	–	**4**	**16**	**19**	–	–
Valid: TS/STS/TY			sample	**16**	**12**	**8**	**4**	**0**	**0**	**12**	**8**	**4**	**0**	**0**	**12**	**8**	**4**	**0**	**0**
Initial: TD(before upg.)			mean	*75*	*64*	*45*	–	–	–	*4*	*24*	–	–	–	*-11*	*-30*	–	–	–
Valid: TD/TS/STS/TY			sample	*4*	*4*	*2*	*0*	*0*	*0*	*4*	*2*	*0*	*0*	*0*	*4*	*2*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)	Grade Best	Grade Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TS Nuri(2002)																		
Jun. 11/12	TD	TD	*0*	*85*	*115*				*0*	*-6*				*0*	*10*			
11/18	TD	TD	*0*	*55*					*-2*					*5*				
12/00	TD	TD	*33*	*64*	*47*				*-4*	*-10*				*5*	*15*			
12/06	TD	TD	*43*	*24*					*-4*					*5*				
12/12	TS	TS	**43**	**43**					**-6**					**10**				
12/18	TS	TS	**54**	**33**					**-6**					**10**				
13/00	TS	TS	**21**															
13/06	TS	TS	**22**															
13/12	TS	TS	**42**															
13/18	TS	TS	**21**															
14/00	TD	TD																
Initial: TS/STS/TY		mean	**34**	**38**	–	–	–	–	**-6**	–	–	–	–	**10**	–	–	–	–
Valid: TS/STS/TY		sample	**6**	**2**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**
Initial: TD(before upg.)		mean	*19*	*57*	*81*	–	–	–	*-3*	*-8*	–	–	–	*4*	*13*	–	–	–
Valid: TD/TS/STS/TY		sample	*4*	*4*	*2*	*0*	*0*	*0*	*4*	*2*	*0*	*0*	*0*	*4*	*2*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time		Grade		Center Position Error(km)						Central Pressure Error(hPa)					Max. Wind Error(kt)[1]				
	(UTC)	Best	Prov.	T=00[2]	=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120
TS Sinlaku(2003)																			
Jul.	31/00	TD	TD	*101*	*11*	*54*				*0*	*2*				*0*	*5*			
	31/06	TD	TD	*75*	*106*					*0*					*0*				
	31/12	TD	TD	*25*	*124*	*138*				*2*	*2*				*0*	*0*			
	31/18	TD	TD	*15*	*55*					*2*					*0*				
Aug.	01/00	TS	TD	**22**	**48**					**4**					**0**				
	01/06	TS	TS	**0**	**15**					**9**					**-5**				
	01/12	TS	TS	**62**	**131**					**2**					**0**				
	01/18	TS	TS	**76**															
	02/00	TS	TS	**42**															
	02/06	TS	TS	**64**															
	02/12	TS	TD	**94**															
Initial: TS/STS/TY			mean	**52**	**64**	–	–	–	–	**5**	–	–	–	–	**-2**	–	–	–	–
Valid: TS/STS/TY			sample	**7**	**3**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**
Initial: TD(before upg.)			mean	*54*	*74*	*96*	–	–	–	*1*	*2*	–	–	–	*0*	*3*	–	–	–
Valid: TD/TS/STS/TY			sample	*4*	*4*	*2*	*0*	*0*	*0*	*4*	*2*	*0*	*0*	*0*	*4*	*2*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)	Grade Best	Grade Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
					TY Hagupit(2004)													
Aug. 01/00	TD	TD	*54*	*64*	*129*				*2*	*13*				*0*	*-20*			
01/06	TS	TD	**21**	**41**					**0**					**5**				
01/12	TS	TS	**0**	**24**	**59**	**257**			**-4**	**5**	**-13**			**10**	**-5**	**20**		
01/18	TS	TS	**25**	**23**	**56**	**193**			**0**	**5**	**-6**			**0**	**-5**	**10**		
02/00	TS	TS	**11**	**52**	**121**	**216**			**-5**	**5**	**-2**			**5**	**0**	**5**		
02/06	TS	TS	**15**	**32**	**97**	**295**			**0**	**6**	**0**			**0**	**-5**	**0**		
02/12	TS	TS	**15**	**35**	**134**				**15**	**2**				**-15**	**-5**			
02/18	STS	STS	**15**	**32**	**160**				**17**	**0**				**-20**	**-5**			
03/00	STS	STS	**23**	**10**	**64**				**13**	**0**				**-15**	**-5**			
03/06	TY	TY	**44**	**37**	**177**				**6**	**0**				**-5**	**0**			
03/12	TY	TY	**0**	**114**					**0**					**0**				
03/18	TY	TY	**0**	**113**					**-2**					**5**				
04/00	STS	TY	**15**	**60**					**-2**					**5**				
04/06	TS	STS	**49**	**11**					**0**					**0**				
04/12	TS	TS	**0**															
04/18	TS	TS	**0**															
05/00	TS	TS	**0**															
05/06	TS	TS	**38**															
Initial: TS/STS/TY		mean	**16**	**45**	**108**	**240**	–	–	**3**	**3**	**-5**	–	–	**-2**	**-4**	**9**	–	–
Valid: TS/STS/TY		sample	**17**	**13**	**8**	**4**	**0**	**0**	**13**	**8**	**4**	**0**	**0**	**13**	**8**	**4**	**0**	**0**
Initial: TD(before upg.)		mean	*54*	*64*	*129*	–	–	–	*2*	*13*	–	–	–	*0*	*-20*	–	–	–
Valid: TD/TS/STS/TY		sample	*1*	*1*	*1*	*0*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*1*	*1*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)	Grade Best	Grade Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TS Jangmi(2005)																		
Aug. 07/18	TD	TD	*76*	*133*					*0*					*0*				
08/00	TD	TD	*11*	*108*	*126*				*2*	*0*				*-5*	*0*			
08/06	TD	TD	*35*	*82*					*2*					*-5*				
08/12	TD	TD	*42*	*59*	*49*				*4*	*0*				*-10*	*0*			
08/18	TS	TS	**38**	**94**	**103**				**2**	**0**				**-5**	**0**			
09/00	TS	TS	**10**	**94**	**101**				**-4**	**-2**				**5**	**5**			
09/06	TS	TS	**39**	**72**					**-6**					**10**				
09/12	TS	TS	**56**	**29**					**-8**					**15**				
09/18	TS	TS	**31**	**28**					**-2**					**5**				
10/00	TS	TS	**11**	**108**					**-2**					**5**				
10/06	TS	TS	**11**															
10/12	TS	TS	**24**															
10/18	TS	TS	**11**															
11/00	TS	LOW	**8**															
Initial: TS/STS/TY		mean	**24**	**71**	**102**	–	–	–	**-3**	**-1**	–	–	–	**6**	**3**	–	–	–
Valid: TS/STS/TY		sample	**10**	**6**	**2**	**0**	**0**	**0**	**6**	**2**	**0**	**0**	**0**	**6**	**2**	**0**	**0**	**0**
Initial: TD(before upg.)		mean	*41*	*96*	*87*	–	–	–	*2*	*0*	–	–	–	*-5*	*0*	–	–	–
Valid: TD/TS/STS/TY		sample	*4*	*4*	*2*	*0*	*0*	*0*	*4*	*2*	*0*	*0*	*0*	*4*	*2*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)		Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
STS Mekkhala(2006)																			
Aug.	09/18	TD	TD	*39*	*39*					*6*					*-15*				
	10/00	TS	TD	**11**	**157**					**2**					**-10**				
	10/06	TS	TS	**11**															
	10/12	TS	TS	**0**															
	10/18	STS	STS	**0**															
	11/00	TS	TS	**10**															
	11/06	TD	TS																
Initial: TS/STS/TY			mean	**6**	**157**	–	–	–	–	**2**	–	–	–	–	**-10**	–	–	–	–
Valid: TS/STS/TY			sample	**5**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**
Initial: TD(before upg.)			mean	*39*	*39*	–	–	–	–	*6*	–	–	–	–	*-15*	–	–	–	–
Valid: TD/TS/STS/TY			sample	*1*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time	(UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
STS Higos(2007)																			
Aug.	17/12	TD	TD	*31*	*192*	*334*				*2*	*-6*				*-5*	*5*			
	17/18	TD	TD	*0*	*163*					*4*					*-15*				
	18/00	TS	TS	**30**	**142**					**2**					**-10**				
	18/06	TS	TS	**0**	**132**					**-4**					**5**				
	18/12	TS	TS	**10**	**114**					**-4**					**0**				
	18/18	STS	STS	**0**															
	19/00	STS	STS	**0**															
	19/06	TS	TS	**0**															
	19/12	TS	TS	**45**															
	19/18	TD	TD																
Initial: TS/STS/TY			mean	**12**	**130**	–	–	–	–	**-2**	–	–	–	–	**-2**	–	–	–	–
Valid: TS/STS/TY			sample	**7**	**3**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**
Initial: TD(before upg.)			mean	*16*	*178*	*334*	–	–	–	*3*	*-6*	–	–	–	*-10*	*5*	–	–	–
Valid: TD/TS/STS/TY			sample	*2*	*2*	*1*	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)	Grade Best	Grade Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TY Bavi(2008)																		
Aug. 21/12	TD	TD	*76*	*45*	*40*				*2*	*-10*				*-10*	*5*			
21/18	TD	TD	*84*	*15*					*2*					*-10*				
22/00	TS	TS	**22**	**22**	**39**	**78**	**226**	**332**	**2**	**0**	**10**	**5**	**0**	**-10**	**-5**	**-5**	**-5**	**5**
22/06	TS	TS	**0**	**37**	**22**	**87**	**266**		**-5**	**0**	**0**	**0**		**0**	**0**	**0**	**0**	
22/12	STS	STS	**11**	**51**	**22**	**97**	**243**		**-35**	**-30**	**-15**	**0**		**25**	**20**	**10**	**0**	
22/18	STS	STS	**11**	**30**	**22**	**74**	**86**		**-20**	**-15**	**-10**	**-15**		**20**	**10**	**10**	**10**	
23/00	STS	STS	**0**	**44**	**19**	**67**	**11**		**-15**	**0**	**-10**	**-15**		**10**	**5**	**5**	**10**	
23/06	STS	STS	**0**	**68**	**89**	**117**			**-5**	**0**	**-5**			**5**	**0**	**0**		
23/12	STS	STS	**24**	**67**	**80**	**202**			**0**	**0**	**-5**			**0**	**0**	**5**		
23/18	STS	STS	**0**	**39**	**15**	**63**			**5**	**0**	**5**			**-5**	**0**	**0**		
24/00	TY	STS	**15**	**29**	**61**	**140**			**15**	**5**	**0**			**-10**	**-5**	**5**		
24/06	TY	TY	**10**	**22**	**28**				**10**	**5**				**-5**	**-5**			
24/12	TY	TY	**0**	**22**	**35**				**10**	**0**				**-5**	**0**			
24/18	TY	TY	**0**	**24**	**66**				**-5**	**5**				**5**	**0**			
25/00	TY	TY	**15**	**24**	**105**				**0**	**0**				**0**	**0**			
25/06	TY	TY	**0**	**50**					**0**					**0**				
25/12	TY	TY	**0**	**43**					**-5**					**5**				
25/18	TY	TY	**0**	**90**					**-10**					**10**				
26/00	TY	TY	**11**	**87**					**-10**					**15**				
26/06	TY	TY	**11**															
26/12	TY	TY	**18**															
26/18	TY	TY	**14**															
27/00	STS	STS	**14**															
Initial: TS/STS/TY		mean	**8**	**44**	**46**	**103**	**166**	**332**	**-4**	**-2**	**-3**	**-5**	**0**	**4**	**2**	**3**	**3**	**5**
Valid: TS/STS/TY		sample	**21**	**17**	**13**	**9**	**5**	**1**	**17**	**13**	**9**	**5**	**1**	**17**	**13**	**9**	**5**	**1**
Initial: TD(before upg.)		mean	*80*	*30*	*40*	–	–	–	*2*	*-10*	–	–	–	*-10*	*5*	–	–	–
Valid: TD/TS/STS/TY		sample	*2*	*2*	*1*	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time	(UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
									TY Maysak(2009)										
Aug.	27/18	TD	TD	*0*	*97*					*6*					*-15*				
	28/00	TD	TD	*0*	*92*	*207*				*9*	*10*				*-15*	*-15*			
	28/06	TS	TS	**0**	**64**	**173**	**111**	**60**	**203**	**9**	**10**	**-5**	**15**	**5**	**-15**	**-15**	**5**	**-10**	**0**
	28/12	TS	TS	**0**	**98**	**229**	**119**	**31**	**116**	**-5**	**-10**	**-25**	**0**	**-5**	**-5**	**5**	**10**	**-5**	**5**
	28/18	STS	STS	**15**	**96**	**148**	**41**	**53**	**82**	**0**	**-20**	**-15**	**-10**	**-15**	**0**	**10**	**10**	**5**	**10**
	29/00	STS	STS	**0**	**85**	**53**	**41**	**73**	**261**	**-10**	**-30**	**-10**	**-10**	**-15**	**5**	**20**	**5**	**10**	**20**
	29/06	STS	STS	**15**	**34**	**63**	**59**	**124**		**-10**	**-30**	**-10**	**-15**		**5**	**20**	**5**	**15**	
	29/12	TY	TY	**0**	**56**	**44**	**89**	**125**		**-5**	**-25**	**-10**	**-10**		**5**	**15**	**5**	**10**	
	29/18	TY	TY	**11**	**57**	**88**	**132**	**144**		**-20**	**-15**	**-5**	**10**		**15**	**10**	**5**	**0**	
	30/00	TY	TY	**0**	**64**	**59**	**101**	**202**		**-20**	**-10**	**-5**	**0**		**15**	**5**	**5**	**-5**	
	30/06	TY	TY	**11**	**78**	**39**	**102**			**-15**	**0**	**-10**			**10**	**0**	**10**		
	30/12	TY	TY	**22**	**84**	**49**	**100**			**-10**	**0**	**-10**			**5**	**0**	**10**		
	30/18	TY	TY	**0**	**24**	**66**	**124**			**-5**	**-5**	**-5**			**5**	**5**	**10**		
	31/00	TY	TY	**0**	**24**	**69**	**183**			**0**	**-10**	**5**			**0**	**10**	**5**		
	31/06	TY	TY	**0**	**37**	**62**				**0**	**-10**				**0**	**10**			
	31/12	TY	TY	**10**	**59**	**58**				**0**	**-10**				**0**	**10**			
	31/18	TY	TY	**11**	**50**	**43**				**-5**	**-15**				**5**	**15**			
Sep.	01/00	TY	TY	**10**	**53**	**145**				**-10**	**-5**				**10**	**-5**			
	01/06	TY	TY	**0**	**11**					**0**					**5**				
	01/12	TY	TY	**0**	**43**					**5**					**0**				
	01/18	TY	TY	**0**	**86**					**5**					**-5**				
	02/00	TY	TY	**0**	**150**					**-5**					**0**				
	02/06	TY	TY	**48**															
	02/12	TY	TY	**0**															
	02/18	TY	TY	**0**															
	03/00	TY	TY	**0**															
Initial: TS/STS/TY			mean	**6**	**63**	**87**	**100**	**102**	**166**	**-5**	**-12**	**-9**	**-3**	**-8**	**3**	**7**	**7**	**3**	**9**
Valid: TS/STS/TY			sample	**24**	**20**	**16**	**12**	**8**	**4**	**20**	**16**	**12**	**8**	**4**	**20**	**16**	**12**	**8**	**4**
Initial: TD(before upg.)			mean	*0*	*94*	*207*	–	–	–	*8*	*10*	–	–	–	*-15*	*-15*	–	–	–
Valid: TD/TS/STS/TY			sample	*2*	*2*	*1*	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*0*	*2*	*1*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TY Haishen(2010)																		
Aug. 31/06	TD	TD	*105*	*278*					*0*					*-5*				
31/12	TS	TD	**39**	**278**	**470**				**6**	**31**				**-10**	**-30**			
31/18	TS	TD	**39**	**391**					**13**					**-15**				
Sep. 01/00	TS	TD	**64**	**223**	**265**				**16**	**20**				**-15**	**-15**			
01/06	TS	TD	**35**	**161**					**26**					**-25**				
01/12	TS	TS	**15**	**150**	**190**	**221**	**268**	**370**	**20**	**20**	**30**	**20**	**10**	**-15**	**-10**	**-15**	**-10**	**0**
01/18	STS	TS	**24**	**100**	**159**	**160**	**166**	**223**	**10**	**25**	**30**	**15**	**5**	**-5**	**-10**	**-15**	**-5**	**0**
02/00	STS	STS	**22**	**146**	**132**	**126**	**107**	**135**	**15**	**25**	**15**	**0**	**0**	**-10**	**-10**	**0**	**10**	**0**
02/06	TY	STS	**10**	**47**	**31**	**23**	**31**	**233**	**15**	**15**	**0**	**0**	**-5**	**-5**	**0**	**5**	**10**	**20**
02/12	TY	STS	**24**	**24**	**11**	**35**	**63**	**223**	**10**	**15**	**-5**	**-15**	**15**	**-5**	**-5**	**5**	**15**	**5**
02/18	TY	TY	**0**	**25**	**33**	**67**	**147**		**30**	**10**	**-10**	**-20**		**-10**	**0**	**15**	**15**	
03/00	TY	TY	**0**	**15**	**35**	**67**	**245**		**20**	**5**	**-15**	**-20**		**-5**	**5**	**20**	**20**	
03/06	TY	TY	**10**	**11**	**35**	**112**	**339**		**15**	**-5**	**-15**	**-20**		**0**	**10**	**20**	**25**	
03/12	TY	TY	**0**	**15**	**46**	**167**	**228**		**15**	**-5**	**-20**	**-20**		**-5**	**10**	**20**	**25**	
03/18	TY	TY	**0**	**11**	**78**	**211**			**15**	**-10**	**-20**			**-5**	**15**	**15**		
04/00	TY	TY	**0**	**57**	**94**	**327**			**5**	**-15**	**-20**			**5**	**20**	**20**		
04/06	TY	TY	**0**	**57**	**126**	**316**			**-5**	**-15**	**-25**			**10**	**20**	**30**		
04/12	TY	TY	**0**	**49**	**122**	**164**			**-5**	**-20**	**-15**			**10**	**20**	**20**		
04/18	TY	TY	**0**	**46**	**169**				**-10**	**-10**				**15**	**10**			
05/00	TY	TY	**0**	**56**	**234**				**-15**	**-20**				**20**	**20**			
05/06	TY	TY	**0**	**83**	**189**				**-10**	**-15**				**10**	**15**			
05/12	TY	TY	**11**	**56**	**104**				**-20**	**0**				**15**	**0**			
05/18	TY	TY	**10**	**67**					**-10**					**5**				
06/00	TY	TY	**11**	**81**					**0**					**5**				
06/06	TY	TY	**0**	**76**					**0**					**-5**				
06/12	TY	TY	**0**	**60**					**5**					**0**				
06/18	TY	TY	**0**															
07/00	TY	TY	**33**															
07/06	STS	TY	**17**															
07/12	TS	STS	**56**															
Initial: TS/STS/TY		mean	**15**	**91**	**133**	**153**	**177**	**237**	**6**	**3**	**-5**	**-7**	**5**	**-2**	**3**	**11**	**12**	**5**
Valid: TS/STS/TY		sample	**29**	**25**	**19**	**13**	**9**	**5**	**25**	**19**	**13**	**9**	**5**	**25**	**19**	**13**	**9**	**5**
Initial: TD(before upg.)		mean	*105*	*278*	–	–	–	–	*0*	–	–	–	–	*-5*	–	–	–	–
Valid: TD/TS/STS/TY		sample	*1*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time		Grade		Center Position Error(km)						Central Pressure Error(hPa)					Max. Wind Error(kt)[1]				
	(UTC)	Best	Prov.	T=00[2]	=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120
TS Noul(2011)																			
Sep.	15/06	TD	TD	*33*	*142*					*2*					*-5*				
	15/12	TD	TD	*0*	*151*	*109*	*402*			*2*	*-2*	*-14*			*0*	*5*	*25*		
	15/18	TS	TS	**0**	**166**	**109**				**-4**	**-17**				**10**	**20**			
	16/00	TS	TS	**16**	**109**	**146**				**-9**	**-17**				**10**	**20**			
	16/06	TS	TS	**11**	**55**	**279**				**-2**	**-14**				**5**	**20**			
	16/12	TS	TS	**24**	**46**	**224**				**-7**	**-4**				**10**	**15**			
	16/18	TS	TS	**34**	**46**					**-2**					**5**				
	17/00	TS	TS	**31**	**120**					**0**					**0**				
	17/06	TS	TS	**22**	**248**					**-2**					**5**				
	17/12	TS	TS	**15**	**132**					**4**					**0**				
	17/18	TS	TS	**0**															
	18/00	TS	TS	**24**															
	18/06	TS	TS	**32**															
	18/12	TS	TS	**11**															
	18/18	TD	TD																
Initial: TS/STS/TY			mean	**18**	**115**	**190**	–	–	–	**-3**	**-13**	–	–	–	**6**	**19**	–	–	–
Valid: TS/STS/TY			sample	**12**	**8**	**4**	**0**	**0**	**0**	**8**	**4**	**0**	**0**	**0**	**8**	**4**	**0**	**0**	**0**
Initial: TD(before upg.)			mean	*17*	*147*	*109*	*402*	–	–	*2*	*-2*	*-14*	–	–	*-3*	*5*	*25*	–	–
Valid: TD/TS/STS/TY			sample	*2*	*2*	*1*	*1*	*0*	*0*	*2*	*1*	*1*	*0*	*0*	*2*	*1*	*1*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time	Grade		Center Position Error(km)						Central Pressure Error(hPa)					Max. Wind Error(kt)[1]				
(UTC)	Best	Prov.	T=00[2]	=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120
STS Dolphin(2012)																		
Sep. 21/00	TS	TD	**61**	**150**	**409**	**579**			**13**	**17**	**8**			**-15**	**-15**	**-10**		
21/06	TS	TS	**30**	**229**	**569**				**17**	**10**				**-15**	**-5**			
21/12	TS	TS	**0**	**250**	**578**				**5**	**-10**				**-5**	**10**			
21/18	TS	TS	**0**	**263**	**494**				**5**	**-5**				**-5**	**5**			
22/00	STS	STS	**0**	**294**	**439**				**0**	**-5**				**0**	**5**			
22/06	STS	STS	**39**	**333**					**-5**					**5**				
22/12	STS	STS	**19**	**304**					**-10**					**10**				
22/18	STS	STS	**58**	**178**					**-5**					**5**				
23/00	STS	STS	**0**	**126**					**-5**					**5**				
23/06	STS	STS	**0**															
23/12	STS	STS	**43**															
23/18	STS	STS	**143**															
24/00	TS	TS	**100**															
Initial: TS/STS/TY		mean	**38**	**236**	**498**	**579**	–	–	**2**	**1**	**8**	–	–	**-2**	**0**	**-10**	–	–
Valid: TS/STS/TY		sample	**13**	**9**	**5**	**1**	**0**	**0**	**9**	**5**	**1**	**0**	**0**	**9**	**5**	**1**	**0**	**0**
Initial: TD(before upg.)		mean	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Valid: TD/TS/STS/TY		sample	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time		Grade		Center Position Error(km)						Central Pressure Error(hPa)					Max. Wind Error(kt)[1]				
	(UTC)	Best	Prov.	T=00[2]	=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120
STS Kujira(2013)																			
Sep.	26/06	TD	TD	*100*	*25*	*156*	*356*			*-2*	*-5*	*-5*			*0*	*5*	*5*		
	26/12	TD	TD	*77*	*65*	*157*	*420*			*-8*	*-10*	*-30*			*5*	*5*	*20*		
	26/18	TS	TD	**53**	**113**	**91**	**221**			**-4**	**-10**	**-15**			**5**	**10**	**15**		
	27/00	TS	TS	**66**	**201**	**156**	**242**			**0**	**0**	**-10**			**0**	**0**	**10**		
	27/06	TS	TS	**33**	**30**	**86**				**0**	**-5**				**0**	**5**			
	27/12	TS	TS	**95**	**98**	**66**				**7**	**5**				**-10**	**-5**			
	27/18	TS	TS	**42**	**56**	**42**				**5**	**5**				**-5**	**-5**			
	28/00	TS	TS	**37**	**28**	**132**				**5**	**2**				**-5**	**0**			
	28/06	STS	TS	**11**	**43**					**5**					**-5**				
	28/12	STS	STS	**15**	**50**					**10**					**-10**				
	28/18	STS	STS	**22**	**89**					**5**					**-5**				
	29/00	STS	STS	**29**	**42**					**0**					**0**				
	29/06	STS	STS	**18**															
	29/12	STS	STS	**14**															
	29/18	STS	STS	**44**															
	30/00	STS	STS	**22**															
Initial: TS/STS/TY			mean	**36**	**75**	**96**	**231**	–	–	**3**	**-1**	**-13**	–	–	**-4**	**1**	**13**	–	–
Valid: TS/STS/TY			sample	**14**	**10**	**6**	**2**	**0**	**0**	**10**	**6**	**2**	**0**	**0**	**10**	**6**	**2**	**0**	**0**
Initial: TD(before upg.)			mean	*88*	*45*	*156*	*388*	–	–	*-5*	*-8*	*-18*	–	–	*3*	*5*	*13*	–	–
Valid: TD/TS/STS/TY			sample	*2*	*2*	*2*	*2*	*0*	*0*	*2*	*2*	*2*	*0*	*0*	*2*	*2*	*2*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time	(UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TY Chan-hom(2014)																			
Oct.	04/12	TD	TD	*33*	*137*	*10*	*153*	*593*	*1064*	*-2*	*-10*	*-5*	*0*	*-25*	*5*	*10*	*10*	*5*	*20*
	04/18	TD	TD	*0*	*108*	*35*	*100*	*323*	*467*	*0*	*0*	*0*	*5*	*-15*	*0*	*5*	*5*	*0*	*15*
	05/00	TS	TS	**21**	**24**	**37**	**101**	**256**	**381**	**0**	**5**	**0**	**0**	**-15**	**0**	**0**	**5**	**0**	**15**
	05/06	TS	TS	**15**	**23**	**23**	**121**	**191**	**198**	**-2**	**0**	**-5**	**5**	**0**	**5**	**5**	**10**	**-5**	**0**
	05/12	TS	TS	**57**	**35**	**89**	**242**	**322**	**368**	**-5**	**-5**	**-5**	**-10**	**-5**	**0**	**5**	**5**	**5**	**0**
	05/18	TS	TS	**15**	**15**	**104**	**285**	**392**	**368**	**5**	**-5**	**-5**	**-15**	**-10**	**-5**	**5**	**5**	**10**	**5**
	06/00	TS	TS	**45**	**64**	**190**	**374**	**536**	**556**	**0**	**-5**	**-10**	**-15**	**-12**	**0**	**5**	**5**	**10**	**10**
	06/06	TS	TS	**15**	**75**	**261**	**368**	**488**	**360**	**0**	**-10**	**-5**	**-10**	**-6**	**0**	**10**	**0**	**5**	**5**
	06/12	STS	STS	**0**	**102**	**354**	**456**	**525**	**388**	**0**	**-5**	**-15**	**-10**	**-13**	**0**	**5**	**10**	**5**	**15**
	06/18	STS	STS	**0**	**113**	**322**	**418**	**397**		**-10**	**-5**	**-20**	**-10**		**10**	**5**	**15**	**5**	
	07/00	STS	STS	**46**	**116**	**241**	**349**	**258**		**-10**	**-10**	**-15**	**-12**		**10**	**5**	**10**	**10**	
	07/06	TY	TY	**30**	**110**	**159**	**274**	**369**		**-10**	**-5**	**-15**	**-16**		**15**	**5**	**10**	**15**	
	07/12	TY	TY	**20**	**117**	**138**	**221**	**880**		**-5**	**-15**	**-10**	**-18**		**5**	**10**	**5**	**20**	
	07/18	TY	TY	**11**	**80**	**79**	**314**			**-5**	**-20**	**-15**			**5**	**15**	**10**		
	08/00	TY	TY	**10**	**31**	**89**	**507**			**-5**	**-15**	**-12**			**0**	**10**	**10**		
	08/06	TY	TY	**10**	**44**	**121**	**614**			**-5**	**-15**	**-16**			**0**	**10**	**15**		
	08/12	TY	TY	**15**	**89**	**204**	**654**			**-15**	**-10**	**-13**			**10**	**5**	**15**		
	08/18	TY	TY	**15**	**135**	**293**				**-15**	**-5**				**10**	**5**			
	09/00	TY	TY	**59**	**86**	**187**				**-10**	**-7**				**10**	**10**			
	09/06	TY	TY	**58**	**36**	**79**				**-5**	**-11**				**5**	**15**			
	09/12	STS	STS	**0**	**22**	**33**				**0**	**-6**				**0**	**10**			
	09/18	STS	STS	**15**	**48**					**-5**					**5**				
	10/00	STS	STS	**0**	**76**					**-2**					**5**				
	10/06	STS	STS	**15**	**88**					**-4**					**5**				
	10/12	STS	STS	**22**	**131**					**-2**					**5**				
	10/18	STS	STS	**29**															
	11/00	TS	TS	**0**															
	11/06	TS	TS	**0**															
	11/12	TS	TS	**15**															
	11/18	TD	TS																
	12/00	TD	TD																
Initial: TS/STS/TY			mean	**20**	**72**	**158**	**353**	**419**	**374**	**-5**	**-8**	**-11**	**-10**	**-9**	**4**	**7**	**9**	**7**	**7**
Valid: TS/STS/TY			sample	**27**	**23**	**19**	**15**	**11**	**7**	**23**	**19**	**15**	**11**	**7**	**23**	**19**	**15**	**11**	**7**
Initial: TD(before upg.)			mean	*16*	*122*	*22*	*127*	*458*	*765*	*-1*	*-5*	*-3*	*3*	*-20*	*3*	*8*	*8*	*3*	*18*
Valid: TD/TS/STS/TY			sample	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TS Linfa(2015)																		
Oct. 10/00	TD	TD	*25*	*87*	*138*				*4*	*-2*				*-10*	*0*			
10/06	TD	TD	*31*	*58*	*70*				*0*	*2*				*0*	*0*			
10/12	TD	TD	*87*	*58*					*-4*					*5*				
10/18	TS	TS	**108**															
11/00	TS	TS	**25**															
11/06	TS	TS	**0**															
11/12	TD	TS																
11/18	TD	TD																
Initial: TS/STS/TY		mean	**44**	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Valid: TS/STS/TY		sample	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Initial: TD(before upg.)		mean	*48*	*68*	*104*	–	–	–	*0*	*0*	–	–	–	*-2*	*0*	–	–	–
Valid: TD/TS/STS/TY		sample	*3*	*3*	*2*	*0*	*0*	*0*	*3*	*2*	*0*	*0*	*0*	*3*	*2*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TS Nangka(2016)																		
Oct. 11/06	TD	TD	*15*	*77*	*86*	*237*			*0*	*0*	*-6*			*0*	*0*	*10*		
11/12	TD	TD	*0*	*85*	*138*	*266*			*2*	*0*	*-8*			*-5*	*5*	*20*		
11/18	TD	TD	*35*	*87*	*214*				*0*	*0*				*0*	*5*			
12/00	TD	TD	*35*	*34*	*163*				*-2*	*-4*				*5*	*5*			
12/06	TS	TS	**32**	**31**	**100**				**0**	**-6**				**0**	**10**			
12/12	TS	TS	**22**	**39**					**2**					**0**				
12/18	TS	TS	**11**	**156**					**2**					**0**				
13/00	TS	TS	**0**	**94**					**-4**					**5**				
13/06	TS	TS	**25**	**78**					**-6**					**10**				
13/12	TS	TS	**11**															
13/18	TS	TS	**10**															
14/00	TS	TS	**11**															
14/06	TS	TS	**43**															
14/12	TD	TD																
Initial: TS/STS/TY		mean	**18**	**79**	**100**	–	–	–	**-1**	**-6**	–	–	–	**3**	**10**	–	–	–
Valid: TS/STS/TY		sample	**9**	**5**	**1**	**0**	**0**	**0**	**5**	**1**	**0**	**0**	**0**	**5**	**1**	**0**	**0**	**0**
Initial: TD(before upg.)		mean	*21*	*71*	*150*	*252*	–	–	*0*	*-1*	*-7*	–	–	*0*	*4*	*15*	–	–
Valid: TD/TS/STS/TY		sample	*4*	*4*	*4*	*2*	*0*	*0*	*4*	*4*	*2*	*0*	*0*	*4*	*4*	*2*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time	(UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TY Saudel(2017)																			
Oct.	19/00	TD	TD	*0*	*46*	*57*	*170*	*323*	*373*	*-2*	*-2*	*12*	*15*	*0*	*0*	*5*	*-15*	*-15*	*0*
	19/06	TD	TD	*34*	*92*	*15*	*84*	*207*	*225*	*2*	*4*	*10*	*10*	*-5*	*0*	*-5*	*-10*	*-10*	*5*
	19/12	TD	TD	*0*	*34*	*46*	*78*	*201*	*286*	*2*	*5*	*5*	*0*	*-5*	*0*	*-5*	*-5*	*0*	*5*
	19/18	TD	TD	*0*	*99*	*35*	*197*	*293*	*294*	*2*	*5*	*5*	*-5*	*0*	*0*	*-5*	*-5*	*5*	*0*
	20/00	TS	TS	**24**	**21**	**79**	**179**	**257**	**201**	**2**	**10**	**5**	**-5**	**0**	**0**	**-10**	**-5**	**5**	**0**
	20/06	TS	TS	**21**	**33**	**31**	**162**	**232**	**183**	**4**	**5**	**5**	**-5**	**-2**	**-5**	**-10**	**-5**	**5**	**0**
	20/12	TS	TS	**21**	**56**	**0**	**92**	**152**		**5**	**10**	**0**	**-10**		**-10**	**-10**	**0**	**10**	
	20/18	TS	TS	**25**	**62**	**11**	**79**	**65**		**5**	**10**	**-5**	**-10**		**-10**	**-10**	**5**	**10**	
	21/00	TS	TS	**0**	**75**	**63**	**94**	**86**		**10**	**5**	**-5**	**-7**		**-10**	**-5**	**5**	**10**	
	21/06	TS	STS	**25**	**78**	**91**	**31**	**22**		**0**	**0**	**-5**	**-4**		**0**	**0**	**5**	**5**	
	21/12	STS	STS	**0**	**85**	**44**	**48**			**0**	**0**	**0**			**0**	**0**	**0**		
	21/18	STS	STS	**79**	**81**	**75**	**86**			**0**	**-5**	**2**			**0**	**5**	**-5**		
	22/00	STS	TY	**46**	**57**	**46**	**11**			**0**	**0**	**0**			**0**	**0**	**0**		
	22/06	STS	TY	**11**	**34**	**98**	**117**			**0**	**0**	**-4**			**0**	**0**	**5**		
	22/12	TY	TY	**11**	**49**	**55**				**-10**	**-5**				**10**	**5**			
	22/18	TY	TY	**11**	**59**	**48**				**-10**	**-5**				**10**	**0**			
	23/00	TY	TY	**0**	**100**	**54**				**-10**	**0**				**10**	**0**			
	23/06	TY	TY	**25**	**88**	**65**				**-10**	**-4**				**10**	**5**			
	23/12	STS	TY	**0**	**57**					**-10**					**10**				
	23/18	STS	TY	**34**	**39**					**-5**					**5**				
	24/00	STS	STS	**21**	**11**					**-2**					**5**				
	24/06	STS	STS	**42**	**32**					**-8**					**10**				
	24/12	STS	STS	**42**															
	24/18	STS	STS	**75**															
	25/00	TS	TS	**42**															
	25/06	TS	TS	**0**															
	25/12	TD	TS																
Initial: TS/STS/TY			mean	**25**	**56**	**54**	**90**	**136**	**192**	**-2**	**2**	**-1**	**-7**	**-1**	**2**	**-2**	**1**	**8**	**0**
Valid: TS/STS/TY			sample	**22**	**18**	**14**	**10**	**6**	**2**	**18**	**14**	**10**	**6**	**2**	**18**	**14**	**10**	**6**	**2**
Initial: TD(before upg.)			mean	*9*	*68*	*38*	*132*	*256*	*294*	*1*	*3*	*8*	*5*	*-3*	*0*	*-3*	*-9*	*-5*	*3*
Valid: TD/TS/STS/TY			sample	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time	(UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
								TY Molave(2018)											
Oct.	23/12	TD	TD	50	133	240	335	400	252	0	15	25	35	-2	-5	-20	-25	-25	5
	23/18	TD	TD	81	163	266	337	313	351	4	10	30	25	-30	-10	-15	-25	-15	40
	24/00	TD	TD	95	120	253	369	302	452	6	10	35	15	-29	-15	-15	-30	-10	35
	24/06	TS	TD	43	127	217	286	285		11	15	40	0		-20	-15	-30	0	
	24/12	TS	TD	0	117	173	173	117		17	20	30	-17		-25	-20	-20	20	
	24/18	TS	TS	43	101	155	97			15	25	20			-20	-20	-10		
	25/00	STS	TS	11	100	168	120			10	20	15			-15	-15	-10		
	25/06	STS	STS	0	97	131	75			10	35	10			-5	-20	-5		
	25/12	TY	TY	22	77	70	87			10	30	0			-5	-15	0		
	25/18	TY	TY	25	66	58				5	15				0	-5			
	26/00	TY	TY	0	69	22				10	10				-5	-5			
	26/06	TY	TY	11	68	44				25	20				-15	-20			
	26/12	TY	TY	0	35	216				10	4				-5	-5			
	26/18	TY	TY	0	22					10					-5				
	27/00	TY	TY	45	46					0					0				
	27/06	TY	TY	31	34					-5					5				
	27/12	TY	TY	22	184					4					-5				
	27/18	TY	TY	35															
	28/00	TY	TY	11															
	28/06	TY	TY	0															
	28/12	TS	STS	131															
	28/18	TD	TS																
	29/00	TD	TD																
Initial: TS/STS/TY			mean	24	82	126	140	201	–	9	19	19	-9	–	-9	-14	-13	10	–
Valid: TS/STS/TY			sample	18	14	10	6	2	0	14	10	6	2	0	14	10	6	2	0
Initial: TD(before upg.)			mean	75	139	253	347	338	352	3	12	30	25	-20	-10	-17	-27	-17	27
Valid: TD/TS/STS/TY			sample	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time	(UTC)	Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TY Goni(2019)																			
Oct.	27/12	TD	TD	15	228	317	452	531	467	-8	5	65	60	-21	5	-10	-50	-50	20
	27/18	TD	TD	0	186	278	433	339	194	-2	15	60	65	-30	0	-20	-45	-50	35
	28/00	TD	TD	0	236	271	281	146	99	2	25	60	30	-30	-10	-30	-45	-30	40
	28/06	TD	TD	32	217	247	201	25	125	4	45	60	-5	-30	-15	-45	-45	10	40
	28/12	TD	TD	15	89	185	101	34	70	15	75	60	-21	-30	-30	-60	-45	25	40
	28/18	TS	TS	34	24	79	25	101	132	19	60	45	-50	-52	-30	-50	-35	50	50
	29/00	TS	TS	21	68	35	136	119	68	25	45	10	-45	-32	-30	-35	-15	45	35
	29/06	STS	TS	44	24	141	268	173	168	40	45	-25	-15	-10	-40	-35	25	20	10
	29/12	TY	STS	11	46	218	201	193	145	55	40	-46	-10	-8	-40	-30	45	20	10
	29/18	TY	TY	0	24	170	194	147	146	40	45	-45	-10	-8	-30	-30	50	15	10
	30/00	TY	TY	11	11	132	159	131	276	35	5	-6	-8	-8	-25	-10	10	10	10
	30/06	TY	TY	0	57	129	148	286	392	10	-30	-2	-4	-2	-5	35	10	10	5
	30/12	TY	TY	0	70	74	150	337	478	10	-16	-6	-8	-2	-5	20	10	10	0
	30/18	TY	TY	0	78	79	217	386	585	40	-10	-8	-8	4	-20	20	10	10	-10
	31/00	TY	TY	0	35	15	140	285	573	5	-8	-8	-8	4	-5	15	10	10	-10
	31/06	TY	TY	11	55	92	264	378	516	-10	-8	-8	0	4	20	15	10	-5	-5
	31/12	TY	TY	0	70	68	249	358		-16	-8	-12	-6		25	15	20	5	
	31/18	TY	TY	11	55	92	195	207		-30	-17	-17	-6		40	25	25	5	
Nov.	01/00	TY	TY	0	44	129	222	237		-6	-8	-10	-10		10	10	15	15	
	01/06	STS	TY	16	31	173	243	236		-8	-10	-8	-8		15	15	10	10	
	01/12	TS	STS	22	65	215	273			-8	-10	-8			15	15	10		
	01/18	TS	TS	108	46	184	237			-4	-8	-6			5	10	5		
	02/00	TS	TS	40	75	183	197			-2	-4	0			0	5	-5		
	02/06	TS	TS	55	130	153	196			-2	-2	-2			0	0	0		
	02/12	TS	TS	11	39	73				-2	0				0	-5			
	02/18	TS	TS	11	39	95				-4	-2				5	0			
	03/00	TS	TS	15	48	134				-4	-2				5	0			
	03/06	TS	TS	11	58	85				0	0				0	0			
	03/12	TS	TS	0	64					-2					0				
	03/18	TS	TS	11	46					-2					0				
	04/00	TS	TS	31	55					2					-5				
	04/06	TS	TS	24	31					-2					0				
	04/12	TS	TS	25															
	04/18	TS	TS	15															
	05/00	TS	TS	0															
	05/06	TS	TS	62															
	05/12	TD	TS																
	05/18	TD	TD																
Initial: TS/STS/TY			mean	19	51	120	195	238	316	7	4	-9	-13	-10	-4	0	11	15	10
Valid: TS/STS/TY			sample	31	27	23	19	15	11	27	23	19	15	11	27	23	19	15	11
Initial: TD(before upg.)			mean	13	191	260	294	215	191	2	33	61	26	-28	-10	-33	-46	-19	35
Valid: TD/TS/STS/TY			sample	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time		Grade		Center Position Error(km)						Central Pressure Error(hPa)					Max. Wind Error(kt)[1]				
	(UTC)	Best	Prov.	T=00[2]	=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120	T=24	=48	=72	=96	=120
STS Atsani(2020)																			
Oct.	30/12	TD	TS	131	86	366	418	218	478	-10	-22	-32	-43	-42	15	30	40	40	35
	30/18	TD	TS	141	133	340	277	178	337	-10	-22	-30	-43	-42	15	30	35	40	35
	31/00	TD	TS	0	154	271	184	173	314	-10	-24	-28	-39	-37	15	30	30	35	30
	31/06	TD	TS	25	225	304	176	167	181	-10	-12	-13	-14	-12	15	20	15	15	10
	31/12	TD	TS	24	222	377	290	83	123	-2	-4	-2	-2	-9	5	5	0	0	5
	31/18	TD	TS	11	219	209	70	283	379	-10	-20	-18	-17	-9	20	25	20	15	5
Nov.	01/00	TD	TS	11	218	194	123	251	330	-19	-23	-24	-37	-16	30	25	25	30	10
	01/06	TD	TS	0	261	181	175	226	351	-10	-6	-4	-7	-6	15	5	5	15	0
	01/12	TD	TS	119	229	49	261	315	492	-4	-2	-2	-19	-8	5	0	0	15	0
	01/18	TD	TS	238	195	76	194	309	585	-2	-2	-2	-19	-10	0	0	0	15	5
	02/00	TD	TS	154	159	280	179	290	626	-2	2	-7	-21	-19	0	-5	5	15	20
	02/06	TD	TS	151	43	163	224	327	684	-2	-2	-12	-21	-28	0	0	10	15	30
	02/12	TD	TS	105	53	184	182	289		-2	0	-14	-18		0	-5	10	10	
	02/18	TS	TS	**0**	**84**	**92**	**129**	**314**		**-6**	**-2**	**-14**	**-20**		**5**	**0**	**10**	**15**	
	03/00	TS	TS	**24**	**73**	**124**	**168**	**357**		**4**	**0**	**-16**	**-19**		**0**	**0**	**10**	**20**	
	03/06	TS	TS	**24**	**137**	**122**	**175**			**-2**	**-7**	**-11**			**5**	**10**	**10**		
	03/12	TS	TS	**33**	**201**	**161**	**298**			**0**	**-9**	**-13**			**0**	**10**	**10**		
	03/18	TS	TS	**25**	**92**	**161**	**381**			**0**	**-9**	**-15**			**0**	**10**	**15**		
	04/00	TS	TS	**0**	**84**	**175**	**437**			**-2**	**-16**	**-19**			**5**	**15**	**25**		
	04/06	TS	TS	**0**	**84**	**183**				**0**	**-16**				**0**	**15**			
	04/12	STS	STS	**0**	**59**	**144**				**-9**	**-18**				**10**	**15**			
	04/18	STS	STS	**52**	**64**	**129**				**-9**	**-20**				**10**	**20**			
	05/00	STS	STS	**0**	**67**	**159**				**-16**	**-14**				**15**	**20**			
	05/06	STS	STS	**11**	**22**					**-16**					**15**				
	05/12	STS	STS	**22**	**15**					**-8**					**5**				
	05/18	STS	STS	**0**	**22**					**-6**					**0**				
	06/00	STS	STS	**0**	**69**					**-8**					**15**				
	06/06	STS	STS	**0**															
	06/12	STS	TS	**11**															
	06/18	TS	TS	**0**															
	07/00	TS	TS	**0**															
	07/06	TD	TS																
Initial: TS/STS/TY			mean	**11**	**77**	**145**	**265**	**336**	–	**-6**	**-11**	**-15**	**-20**	–	**6**	**12**	**13**	**18**	–
Valid: TS/STS/TY			sample	**18**	**14**	**10**	**6**	**2**	**0**	**14**	**10**	**6**	**2**	**0**	**14**	**10**	**6**	**2**	**0**
Initial: TD(before upg.)			mean	85	169	230	212	239	407	-7	-11	-15	-23	-20	10	12	15	20	15
Valid: TD/TS/STS/TY			sample	13	13	13	13	13	12	13	13	13	13	12	13	13	13	13	12

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)	Grade Best	Grade Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TS Etau(2021)																		
Nov. 08/00	TD	TD	*0*	*177*	*34*				*4*	*-2*				*-5*	*5*			
08/06	TD	TD	*100*	*117*	*88*				*8*	*-4*				*-10*	*5*			
08/12	TD	TD	*0*	*145*	*131*				*-4*	*-6*				*5*	*5*			
08/18	TS	TS	**11**	**79**					**-4**					**5**				
09/00	TS	TS	**93**	**33**					**-6**					**10**				
09/06	TS	TS	**71**	**49**					**-8**					**10**				
09/12	TS	TS	**24**															
09/18	TS	TS	**55**															
10/00	TS	TS	**33**															
10/06	TS	TS	**45**															
Initial: TS/STS/TY		mean	**47**	**53**	–	–	–	–	**-6**	–	–	–	–	**8**	–	–	–	–
Valid: TS/STS/TY		sample	**7**	**3**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**0**
Initial: TD(before upg.)		mean	*33*	*146*	*84*	–	–	–	*3*	*-4*	–	–	–	*-3*	*5*	–	–	–
Valid: TD/TS/STS/TY		sample	*3*	*3*	*3*	*0*	*0*	*0*	*3*	*3*	*0*	*0*	*0*	*3*	*3*	*0*	*0*	*0*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)		Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TY Vamco(2022)																			
Nov.	08/12	TD	TD	94	92	137	185	194	173	-6	-2	10	5	10	0	0	-10	-5	-10
	08/18	TD	TD	25	130	131	208	187	134	-4	0	5	5	15	0	-5	-5	-5	-15
	09/00	TD	TD	93	47	162	212	121	163	-2	10	-10	-5	20	0	-5	15	10	-15
	09/06	TD	TS	66	15	141	131	95	144	0	0	-5	-10	0	0	5	5	10	-5
	09/12	TS	TS	16	118	87	152	119	143	0	-5	-5	5	-5	0	5	5	-5	0
	09/18	TS	TS	11	151	126	102	119	113	0	-10	-5	10	0	0	10	5	-10	-5
	10/00	TS	TS	0	98	140	86	108	85	5	-5	-5	15	-10	0	5	5	-15	5
	10/06	TS	TS	35	98	63	70	84	68	0	5	0	0	-2	0	-5	0	-5	0
	10/12	STS	STS	55	49	48	92	113		10	0	5	10		-5	0	-5	-15	
	10/18	STS	STS	15	63	34	46	57		0	-5	15	10		5	5	-15	-15	
	11/00	TY	TY	0	11	39	55	68		0	-5	15	0		0	5	-15	-5	
	11/06	TY	TY	0	35	15	31	122		-5	-5	5	-2		5	5	-10	0	
	11/12	TY	TY	15	44	57	60			-5	10	12			5	-10	-20		
	11/18	TY	TY	0	15	49	78			-5	20	16			5	-20	-25		
	12/00	STS	STS	11	39	54	119			-10	20	8			10	-20	-20		
	12/06	STS	STS	0	31	24	35			-10	5	-2			10	-10	0		
	12/12	STS	STS	11	0	15				10	5				-10	-10			
	12/18	STS	STS	11	15	34				20	5				-20	-10			
	13/00	STS	STS	44	25	53				30	8				-30	-10			
	13/06	STS	STS	0	15	57				10	-4				-15	5			
	13/12	TY	TY	0	46					-10					5				
	13/18	TY	TY	0	31					0					-5				
	14/00	TY	TY	11	43					-10					5				
	14/06	TY	TY	0	56					-4					15				
	14/12	TY	TY	0															
	14/18	TY	TY	15															
	15/00	STS	TY	15															
	15/06	TS	STS	0															
	15/12	TD	TS																
Initial: TS/STS/TY			mean	11	49	56	77	99	102	1	2	5	6	-4	-1	-3	-8	-9	0
Valid: TS/STS/TY			sample	24	20	16	12	8	4	20	16	12	8	4	20	16	12	8	4
Initial: TD(before upg.)			mean	70	71	143	184	149	153	-3	2	0	-1	11	0	-1	1	3	-11
Valid: TD/TS/STS/TY			sample	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Date/Time (UTC)		Grade Best	Prov.	Center Position Error(km) T=00[2]	=24	=48	=72	=96	=120	Central Pressure Error(hPa) T=24	=48	=72	=96	=120	Max. Wind Error(kt)[1] T=24	=48	=72	=96	=120
TS Krovanh(2023)																			
Dec.	18/12	TD	TD	*122*	*177*	*47*	*16*	*125*	*78*	*-4*	*-4*	*-8*	*-6*	*-6*	*5*	*5*	*10*	*10*	*5*
	18/18	TD	TD	*35*	*164*	*71*	*70*	*111*	*31*	*-4*	*-8*	*-8*	*-6*	*-2*	*5*	*10*	*10*	*10*	*0*
	19/00	TD	TD	*35*	*89*	*104*	*80*	*104*	*60*	*-2*	*-8*	*-4*	*-6*	*0*	*0*	*10*	*5*	*5*	*0*
	19/06	TD	TD	*91*	*95*	*121*	*67*	*100*	*87*	*0*	*-8*	*-6*	*-6*	*2*	*0*	*10*	*10*	*5*	*0*
	19/12	TD	TD	*178*	*90*	*84*	*110*	*55*		*-2*	*-8*	*-4*	*0*		*0*	*10*	*5*	*0*	
	19/18	TD	TD	*219*	*108*	*35*	*111*	*118*		*-2*	*-8*	*-4*	*0*		*0*	*10*	*5*	*0*	
	20/00	TS	TD	**114**	**115**	**145**				**-4**	**-2**				**5**	**0**			
	20/06	TS	TS	**62**	**89**					**-4**					**5**				
	20/12	TS	TS	**104**	**49**					**-4**					**5**				
	20/18	TS	TS	**40**	**70**					**0**					**0**				
	21/00	TS	TD	**55**															
Initial: TS/STS/TY			mean	**75**	**81**	**145**	–	–	–	**-3**	**-2**	–	–	–	**4**	**0**	–	–	–
Valid: TS/STS/TY			sample	**5**	**4**	**1**	**0**	**0**	**0**	**4**	**1**	**0**	**0**	**0**	**4**	**1**	**0**	**0**	**0**
Initial: TD(before upg.)			mean	*113*	*120*	*77*	*75*	*102*	*64*	*-2*	*-7*	*-6*	*-4*	*-2*	*2*	*9*	*8*	*5*	*1*
Valid: TD/TS/STS/TY			sample	*6*	*6*	*6*	*6*	*6*	*4*	*6*	*6*	*6*	*6*	*4*	*6*	*6*	*6*	*6*	*4*

1 Max. wind for TDs are treated as 30 kt in this validation
2 Position error of provisional analysis

Monthly and Annual Frequencies of Tropical Cyclones

Monthly and annual frequencies of tropical cyclones that attained TS intensity or higher in the western North Pacific and the South China Sea for 1951 - 2020

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1951		1	1	2	1	1	3	3	2	4	1	2	21
1952						3	3	5	3	6	3	4	27
1953		1			1	2	1	6	3	5	3	1	23
1954			1		1		1	5	5	4	3	1	21
1955	1	1	1	1		2	7	6	4	3	1	1	28
1956			1	2		1	2	5	6	1	4	1	23
1957	2			1	1	1	1	4	5	4	3		22
1958	1			1	1	4	7	5	5	3	2	2	31
1959		1	1	1			2	5	5	4	2	2	23
1960				1	1	3	3	10	3	4	1	1	27
1961	1		1		2	3	4	6	6	4	1	1	29
1962		1		1	2		5	8	4	5	3	1	30
1963				1		4	4	3	5	4		3	24
1964					2	2	7	5	6	5	6	1	34
1965	2	1	1	1	2	3	5	6	7	2	2		32
1966				1	2	1	4	10	9	5	2	1	35
1967		1	2	1	1	1	7	9	9	4	3	1	39
1968				1	1	1	3	8	3	5	5		27
1969	1		1	1			3	4	3	3	2	1	19
1970		1				2	3	6	5	5	4		26
1971	1		1	3	4	2	8	5	6	4	2		36
1972	1				1	3	7	5	4	5	3	2	31
1973							7	5	2	4	3		21
1974	1		1	1	1	4	4	5	5	4	4	2	32
1975	1						2	4	5	5	3	1	21
1976	1	1		2	2	2	4	4	5	1	1	2	25
1977			1			1	3	3	5	5	1	2	21
1978	1			1		3	4	8	5	4	4		30
1979	1		1	1	2		4	2	6	3	2	2	24
1980				1	4	1	4	2	6	4	1	1	24
1981			1	2		3	4	8	4	2	3	2	29
1982			3		1	3	3	5	5	3	1	1	25
1983						1	3	5	2	5	5	2	23
1984						2	5	5	4	7	3	1	27
1985	2				1	3	1	8	5	4	1	2	27
1986		1		1	2	2	4	4	3	5	4	3	29
1987	1			1		2	4	4	6	2	2	1	23
1988	1				1	3	2	8	8	5	2	1	31
1989	1			1	2	2	7	5	6	4	3	1	32
1990	1			1	1	3	4	6	4	4	4	1	29
1991			2	1	1	1	4	5	6	3	6		29
1992	1	1				2	4	8	5	7	3		31
1993			1			1	4	7	6	4	2	3	28
1994				1	1	2	7	9	8	6		2	36
1995				1		1	2	6	5	6	1	1	23
1996		1		1	2		6	5	6	2	2	1	26
1997				2	3	3	4	6	4	3	2	1	28
1998							1	3	5	2	3	2	16
1999				2		1	4	6	6	2	1		22
2000					2		5	6	5	2	2	1	23
2001					1	2	5	6	5	3	1	3	26
2002	1	1			1	3	5	6	4	2	2	1	26
2003	1			1	2	2	2	5	3	3	2		21
2004				1	2	5	2	8	3	3	3	2	29
2005	1		1	1	1		5	5	5	2	2		23
2006					1	2	2	7	3	4	2	2	23
2007				1	1		3	4	5	6	4		24
2008				1	4	1	2	4	4	2	3	1	22
2009					2	2	2	5	7	3	1		22
2010			1				2	5	4	2			14
2011					2	3	4	3	7	1		1	21
2012			1		1	4	4	5	3	5	1	1	25
2013	1	1				4	3	6	8	6	2		31
2014	2	1		2		2	5	1	5	2	1	2	23
2015	1	1	2	1	2	2	3	4	5	4	1	1	27
2016							4	7	7	4	3	1	26
2017				1		1	8	6	3	3	3	2	27
2018	1	1	1			4	5	9	4	1	3		29
2019	1	1				1	4	5	6	4	6	1	29
2020					1	1		8	3	6	3	1	23
Normal 1981-2010	0.3	0.1	0.3	0.6	1.1	1.7	3.6	5.8	4.9	3.6	2.3	1.2	25.6

Appendix 5

Code Forms of RSMC Products

(1) RSMC Tropical Cyclone Advisory for Three-day Forecasts (WTPQ20-25 RJTD)

WTPQ i i RJTD YYGGgg
RSMC TROPICAL CYCLONE ADVISORY
NAME class ty-No. name (common-No.)
ANALYSIS
PSTN YYGGgg UTC LaLa.La N LoLoLo.Lo E (or W) confidence
MOVE direction SpSpSp KT
PRES PPPP HPA
MXWD VmVmVm KT
GUST VgVgVg KT
50KT RdRdRd NM (or 50KT RdRdRd NM octant RdRdRd NM octant)
30KT RdRdRd NM (or 30KT RdRdRd NM octant RdRdRd NM octant)
FORECAST
24HF YYGGggF UTC LaLa.LaF N LoLoLo.LoF E (or W) FrFrFr NM 70%
MOVE direction SpSpSp KT
PRES PPPP HPA
MXWD VmVmVm KT
GUST VgVgVg KT
Ft1Ft1HF YYGGggF UTC LaLa.LaF N LoLoLo.LoF E (or W) FrFrFr NM 70%
MOVE direction SpSpSp KT
PRES PPPP HPA
GUST VgVgVg KT
MXWD VmVmVm KT
Ft2Ft2HF YYGGggF UTC LaLa.LaF N LoLoLo.LoF E (or W) FrFrFr NM 70%
MOVE direction SpSpSp KT
PRES PPPP HPA
MXWD VmVmVm KT
GUST VgVgVg KT =

Notes:

a. Underlined parts are fixed.

b. Abbreviations

PSTN	:	Position
MOVE	:	Movement
PRES	:	Pressure
MXWD	:	Maximum wind
HF	:	Hour forecast

c. Symbolic letters

i i	:	'20', '21', '22', '23', '24' or '25'
YYGGgg	:	Time of observation submitting the data for analysis in UTC
class	:	Intensity classification of the tropical cyclone 'TY', 'STS', 'TS' or 'TD'
ty-No.	:	Domestic identification number of the tropical cyclone adopted in Japan given in four digits (same as the international identification number)
name	:	Name assigned to the tropical cyclone from the name list prepared by the Typhoon Committee
common-No.	:	International identification number of the tropical cyclones given in four digits
LaLa.La	:	Latitude of the center position in "ANALYSIS" part
LoLoLo.Lo	:	Longitude of the center position in "ANALYSIS" part
confidence	:	Confidence of the center position. 'GOOD', 'FAIR' or 'POOR'
direction	:	Direction of movement given in 16 azimuthal direction such as 'N', 'NNE', 'NE' and 'ENE'
SpSpSp	:	Speed of movement
PPPP	:	Central pressure
VmVmVm	:	Maximum sustained wind

VgVgVg	:	Maximum gust wind
RdRdRd	:	Radii of 30knots and 50knots wind
octant	:	Eccentric distribution of wind given in 8 azimuthal direction such as 'NORTH', 'NORTHEAST' and 'EAST'
Ft1Ft1	:	48 (00, 06, 12 and 18 UTC) or 45 (03, 09, 15 and 21 UTC)
Ft2Ft2	:	72 (00, 06, 12 and 18 UTC) or 69 (03, 09, 15 and 21 UTC)
$YYGGgg_F$	:	Time in UTC on which the forecast is valid
$LaLa.La_F$	:	Latitude of the center of 70% probability circle in "FORECAST" part
$LoLoLo.Lo_F$	:	Longitude of the center of 70% probability circle in "FORECAST" part
FrFrFr	:	Radius of 70% probability circle

d. MOVE is optionally described as 'ALMOST STATIONARY' or '(direction) SLOWLY', depending on the speed of movement.

Example:

WTPQ20 RJTD 150000
RSMC TROPICAL CYCLONE ADVISORY
NAME STS 0320 NEPARTAK (0320)
ANALYSIS
PSTN 150000UTC 12.6N 117.8E FAIR
MOVE WNW 13KT
PRES 980HPA
MXWD 055KT
GUST 080KT
50KT 40NM
30KT 240NM NORTHEAST 160NM SOUTHWEST
FORECAST
24HF 160000UTC 14.7N 113.7E 110NM 70%
MOVE WNW 11KT
PRES 965HPA
MXWD 070KT
GUST 100KT
48HF 170000UTC 16.0N 111.0E 170NM 70%
MOVE WNW 07KT
PRES 970HPA
MXWD 065KT
GUST 095KT
72HF 180000UTC 19.5N 110.0E 250NM 70%
MOVE NNW 09KT
PRES 985HPA
MXWD 050KT
GUST 070KT =

(2) RSMC Tropical Cyclone Advisory (WTPQ50-55 RJTD)

WTPQii RJTD YYGGgg
RSMC TROPICAL CYCLONE ADVISORY
NAME class ty-No. name (common-No.)
ANALYSIS
PSTN YYGGgg UTC LaLa.La N LoLoLo.Lo E (or W) confidence
MOVE direction SpSpSp KT
PRES PPPP HPA
MXWD VmVmVm KT
GUST VgVgVg KT
50KT RdRdRd NM (or 50KT RdRdRd NM octant RdRdRd NM octant)
30KT RdRdRd NM (or 30KT RdRdRd NM octant RdRdRd NM octant)
FORECAST
24HF $YYGGgg_F$ UTC $LaLa.La_F$ N $LoLoLo.Lo_F$ E (or W) FrFrFr NM 70%
MOVE direction SpSpSp KT
PRES PPPP HPA
MXWD VmVmVm KT
GUST VgVgVg KT
Ft1Ft1HF $YYGGgg_F$ UTC $LaLa.La_F$ N $LoLoLo.Lo_F$ E (or W) FrFrFr NM 70%
MOVE direction SpSpSp KT
PRES PPPP HPA
GUST VgVgVg KT
MXWD VmVmVm KT
Ft2Ft2HF $YYGGgg_F$ UTC $LaLa.La_F$ N $LoLoLo.Lo_F$ E (or W) FrFrFr NM 70%

MOVE direction SpSpSp KT
PRES PPPP HPA
MXWD VmVmVm KT
GUST VgVgVg KT
Ft3Ft3HF YYGGgg$_F$ UTC LaLa.La$_F$ N LoLoLo.Lo$_F$ E (or W) FrFrFr NM 70%
MOVE direction SpSpSp KT
PRES PPPP HPA
MXWD VmVmVm KT
GUST VgVgVg KT
Ft4Ft4Ft4HF YYGGgg$_F$ UTC LaLa.La$_F$ N LoLoLo.Lo$_F$ E (or W) FrFrFr NM 70%
MOVE direction SpSpSp KT
PRES PPPP HPA
MXWD VmVmVm KT
GUST VgVgVg KT=

Notes:

a. Underlined parts are fixed.

b. Abbreviations and symbols are as per the RSMC Tropical Cyclone Advisory for Three-day Forecasts (WTPQ20-25 RJTD) except:

Ft3Ft3	:	96 (00, 06, 12 and 18 UTC) or 93 (03, 09, 15 and 21 UTC)
Ft4Ft4 Ft4	:	120 (00, 06, 12 and 18 UTC) or 117 (03, 09, 15 and 21 UTC)

Example:

```
WTPQ50 RJTD 080000
RSMC TROPICAL CYCLONE ADVISORY
NAME    TY 1919 HAGIBIS (1919)
ANALYSIS
PSTN    080000UTC 16.9N 143.8E GOOD
MOVE    WNW 13KT
PRES    915HPA
MXWD    105KT
GUST    150KT
50KT    100NM
30KT    350NM EAST 240NM WEST
FORECAST
24HF    090000UTC 19.8N 140.0E 60NM 70%
MOVE    NW 10KT
PRES    915HPA
MXWD    105KT
GUST    150KT
48HF    100000UTC 22.8N 138.4E 90NM 70%
MOVE    NNW 08KT
PRES    915HPA
MXWD    105KT
GUST    150KT
72HF    110000UTC 26.5N 136.3E 120NM 70%
MOVE    NNW 10KT
PRES    925HPA
MXWD    100KT
GUST    140KT
96HF    120000UTC 31.6N 135.9E 170NM 70%
MOVE    N 13KT
PRES    940HPA
MXWD    090KT
GUST    130KT
120HF 130000UTC 37.5N 142.5E 240NM 70%
MOVE    NE 20KT
PRES    980HPA
MXWD    060KT
GUST    085KT =
```

(3) RSMC Guidance for Forecast by GSM (FXPQ20-25 RJTD)

FXPQ i i RJTD YYGGgg
RSMC GUIDANCE FOR FORECAST
NAME class ty-No. name (common-No.)
PSTN YYGGgg UTC LaLa.La N LoLoLo.Lo E (or W)

PRES PPPP HPA
MXWD WWW KT
FORECAST BY GLOBAL MODEL
TIME PSTN PRES MXWD
(CHANGE FROM T=0)
T=006 LaLa.La N LoLoLo.Lo E (or W) appp HPA awww KT
T=012 LaLa.La N LoLoLo.Lo E (or W) appp HPA awww KT
T=018 LaLa.La N LoLoLo.Lo E (or W) appp HPA awww KT
:
T=132 LaLa.La N LoLoLo.Lo E (or W) appp HPA awww KT=

Notes:

a. Underlined parts are fixed.

b. Symbolic letters

i i	:	'20', '21', '22', '23', '24' or '25'
YYGGgg	:	Initial time of the model in UTC
class	:	Intensity classification of the tropical cyclone 'T', 'STS', 'TS' or 'TD'
PPPP	:	Central pressure in hPa
WWW	:	Maximum wind speed in knots
a	:	Sign of ppp and www (+, - or blank)
ppp	:	Absolute value of change in central pressure from T=0, in hPa
www	:	Absolute value of change in maximum wind speed from T=0, in knots

Example:

```
FXPQ20 RJTD 180600
RSMC GUIDANCE FOR FORECAST
NAME TY 0001DAMREY (0001)
PSTN 180000UTC 15.2N 126.3E
PRES    905HPA
MXWD    105KT
FORECAST BY GLOBAL MODEL
TIME       PSTN       PRES       MXWD
                   (CHANGE FROM T=0)
T=006 15.4N 125.8E +018HPA -008KT
T=012 15.5N 125.6E +011HPA -011KT
T=018 15.8N 125.7E +027HPA -028KT
                  :
                  :
T=132 20.7N 128.8E +021HPA -022KT=
```

(4) RSMC Guidance for Forecast by GEPS (FXPQ30-35 RJTD)

FXPQii RJTD YYGGgg
RSMC GUIDANCE FOR FORECAST
NAME class ty-No. name (common-No.)
PSTN YYGGgg UTC LaLa.La N LoLoLo.Lo E (or W)
PRES PPPP HPA
MXWD WWW KT
FORECAST BY GLOBAL ENSEMBLE PREDICTION SYSTEM
TIME PSTN PRES MXWD
(CHANGE FROM T=0)
T=006 LaLa.La N LoLoLo.Lo E (or W) appp HPA awww KT
T=012 LaLa.La N LoLoLo.Lo E (or W) appp HPA awww KT
T=018 LaLa.La N LoLoLo.Lo E (or W) appp HPA awww KT
:
T=132 LaLa.La N LoLoLo.Lo E (or W) appp HPA awww KT=

Notes:

a. Underlined parts are fixed.

b. Symbolic letters

ii	:	'30', '31', '32', '33', '34' or '35'
YYGGgg	:	Initial time of the model in UTC
class	:	Intensity classification of the tropical cyclone 'T', 'STS', 'TS' or 'TD'
PPPP	:	Central pressure in hPa
WWW	:	Maximum wind speed in knots
a	:	Sign of ppp and www (+, - or blank)
ppp	:	Absolute value of change in central pressure from T=0, in hPa
www	:	Absolute value of change in maximum wind speed from T=0, in knots

Example:

```
FXPQ30 RJTD 231200
RSMC GUIDANCE FOR FORECAST
NAME TY 1826 YUTU (1826)
PSTN 231200UTC 12.0N 149.6E
PRES    965HPA
MXWD    75KT
FORECAST BY GLOBAL ENSEMBLE PREDICTION SYSTEM
TIME       PSTN       PRES      MXWD
                    (CHANGE FROM T=0)
T=006 12.7N 149.1E -002HPA +001KT
T=012 13.2N 148.3E -001HPA +004KT
T=018 13.8N 147.6E -005HPA +004KT
                  :
                  :
T=132 18.0N 129.9E -033HPA +030KT=
```

(5) RSMC Prognostic Reasoning (WTPQ30-35 RJTD)

Example:

WTPQ30 RJTD 231200
RSMC TROPICAL CYCLONE PROGNOSTIC REASONING
REASONING NO.10 FOR TY 1826 YUTU (1826)
1.GENERAL COMMENTS
TY YUTU IS LOCATED AT 12.0N, 149.6E. INFORMATION ON THE CURRENT POSITION IS BASED ON ANIMATED MSI. POSITIONAL ACCURACY IS GOOD. THE SYSTEM IS IN A FAVORABLE ENVIRONMENT FOR DEVELOPMENT UNDER THE INFLUENCE OF HIGH SSTS, HIGH TCHP AND WEAK VWS. THIS HAS CAUSED THE SYSTEM TO DEVELOP OVER THE LAST SIX HOURS. HOWEVER, THE INFLUENCE OF DRY AIR IS UNFAVORABLE FOR SYSTEM DEVELOPMENT. INFORMATION ON CURRENT INTENSITY IS BASED ON DVORAK INTENSITY ANALYSES.
2.SYNOPTIC SITUATION
THE SYSTEM IS MOVING WESTWARD ALONG THE SOUTHERN PERIPHERY OF A MID-LEVEL SUB-TROPICAL HIGH. ANIMATED MSI SHOWS THE APPEARANCE OF AN EYE. WATER VAPOR IMAGERY SHOWS DRY AIR IN THE DIRECTION OF THE MOVEMENT. DMSP-F18/SSMIS 89 GHZ MICROWAVE IMAGERY SHOWS THE SYSTEM HAS A BAND WITH CURVATURE INDICATING THE CSC.
3.TRACK FORECAST
THE SYSTEM WILL MOVE NORTHWESTWARD ALONG THE PERIPHERY OF A MID-LEVEL SUB-TROPICAL HIGH UNTIL FT12. THE SYSTEM WILL THEN MOVE WEST-NORTHWESTWARD ALONG THE PERIPHERY OF A MID-LEVEL SUB-TROPICAL HIGH UNTIL FT120. THE JMA TRACK FORECAST IS BASED ON GSM PREDICTIONS, AND REFERENCE TO OTHER NWP MODELS. JMA TRACK FORECAST CONFIDENCE IS FAIR UNTIL FT48 BUT LOW THEREAFTER DUE TO SIGNIFICANT DIFFERENCES AMONG NUMERICAL MODEL OUTPUTS.
4.INTENSITY FORECAST
THE SYSTEM WILL DEVELOP UNTIL FT48 DUE TO THE INFLUENCE OF INTERACTION WITH HIGH SSTS, HIGH TCHP, WEAK VWS AND GOOD UPPER LEVEL OUTFLOW. THE SYSTEM WILL THEN MAINTAIN ITS INTENSITY UNTIL FT72 DUE TO THE INFLUENCE OF INTERACTION WITH HIGH SSTS, HIGH TCHP AND DRY AIR. THE JMA INTENSITY FORECAST IS BASED ON GUIDANCE DATA. =

(6) RSMC Tropical Cyclone Best Track (AXPQ20 RJTD)

AXPQ20 RJTD YYGGgg
RSMC TROPICAL CYCLONE BEST TRACK
NAME ty-No. name (common-No.)
PERIOD FROM MMMDDTTUTC TO MMMDDTTUTC
DDTT LaLa.LaN LoLoLo.LoE PPPHPA WWWKT   DDTT LaLa.LaN LoLoLo.LoE PPPHPA WWWKT
DDTT LaLa.LaN LoLoLo.LoE PPPHPA WWWKT   DDTT LaLa.LaN LoLoLo.LoE PPPHPA WWWKT

:

:

DDTT LaLa.LaN LoLoLo.LoE PPPHPA WWWKT DDTT LaLa.LaN LoLoLo.LoE PPPHPA WWWKT
REMARKS[1)]
TD FORMATION AT MMMDDTTUTC
FROM TD TO TS AT MMMDDTTUTC

:

:

DISSIPATION AT MMMDDTTUTC=

Notes:

a. Underlined parts are fixed.

b. [1)] REMARKS is given optionally.

c. Symbolic letters

MMM	:	Month in UTC given such as 'JAN' and 'FEB'
DD	:	Date in UTC
TT	:	Hour in UTC
PPP	:	Central pressure
WWW	:	Maximum wind speed

Example:

```
AXPQ20 RJTD 020600

RSMC TROPICAL CYCLONE BEST TRACK
NAME 0001 DAMREY (0001)
PERIOD FROM OCT1300UTC TO OCT2618UTC
1300 10.8N 155.5E 1008HPA   //KT   1306 10.9N 153.6E 1006HPA   //KT
1312 11.1N 151.5E 1004HPA   //KT   1318 11.5N 149.8E 1002HPA   //KT
1400 11.9N 148.5E 1000HPA   //KT   1406 12.0N 146.8E   998HPA   35KT
                               :
                               :
1712 14.6N 129.5E   905HPA 105KT   1718 14.7N 128.3E   905HPA 105KT
                               :
                               :
2612 32.6N 154.0E 1000HPA   //KT   2618 33.8N 157.4E 1010HPA   //KT
REMARKS
TD      FORMATION       AT OCT1300UTC
FROM  TD     TO  TS     AT OCT1406UTC
FROM  TS     TO  STS    AT OCT1512UTC
FROM  STS    TO  TY     AT OCT1600UTC
FROM  TY     TO  STS    AT OCT2100UTC
FROM  STS    TO  TS     AT OCT2112UTC
FROM  TS     TO  L      AT OCT2506UTC
DISSIPATION             AT OCT2700UTC=
```

(7) Tropical Cyclone Advisory for SIGMET (FKPQ30-35 RJTD)

FKPQ i i RJTD YYGGgg
TC ADVISORY

DTG:	yyyymmdd/time Z
TCAC:	TOKYO
TC:	name
NR:	number
PSN:	N LaLa.LaLa E LoLoLo.LoLo
MOV:	direction SpSpSp KT
C:	PPPP HPA
MAX WIND:	WWW KT
FCST PSN +6HR:	YY/GGgg Z NLaLa.LaLa ELoLoLo.LoLo*
FCST MAX WIND +6HR:	WWW KT*
FCST PSN +12HR:	YY/GGgg Z NLaLa.LaLa ELoLoLo.LoLo
FCST MAX WIND +12HR:	WWW KT
FCST PSN +18HR:	YY/GGgg Z NLaLa.LaLa ELoLoLo.LoLo*

FCST MAX WIND +18HR:	YY/GGgg Z NLaLa.LaLa ELoLoLo.LoLo*
FCST PSN +24HR:	YY/GGgg Z N LaLa.LaLa E LoLoLo.LoLo
FCST MAX WIND +24HR:	WWW KT
RMK:	NIL =
NXT MSG:	yyyymmdd/time Z

* 6 hour and 18 hour forecasts are added from 22 May 2008.

Notes:

a. Underlined parts are fixed.

b. Abbreviations

DTG	:	Date and time
TCAC	:	Tropical Cyclone Advisory Centre
TC	:	Tropical Cyclone
NR	:	Number
PSN	:	Position
MOV	:	Movement
C	:	Central pressure
MAX WIND	:	Maximum wind
FCST	:	Forecast
RMK	:	Remarks
NXT MSG	:	Next message

c. Symbolic letters

i i	:	'30', '31', '32', '33', '34' or '35'
YYGGgg	:	Date(YY), hour(GG) and minute(gg) in UTC (Using "Z")
yyyymmdd/time	:	Year(yyyy), month(mm), date(dd), hour and minute (time) in UTC (Using "Z")
name	:	Name assigned to the tropical cyclone by RSMC Tokyo-Typhoon Center
Number	:	Advisory number (starting with "01" for each cyclone)
LaLa.LaLa	:	Latitude of the center position
LoLoLo.LoLo	:	Longitude of the center position
direction	:	Direction of movement given in 16 azimuthal direction such as 'N', 'NNE', 'NE' and 'ENE'
SpSpSp	:	Speed of movement. "SLW" for less than 3 kt "STNR" for less than 1 kt.
PPPP	:	Central pressure
WWW	:	Maximum sustained wind

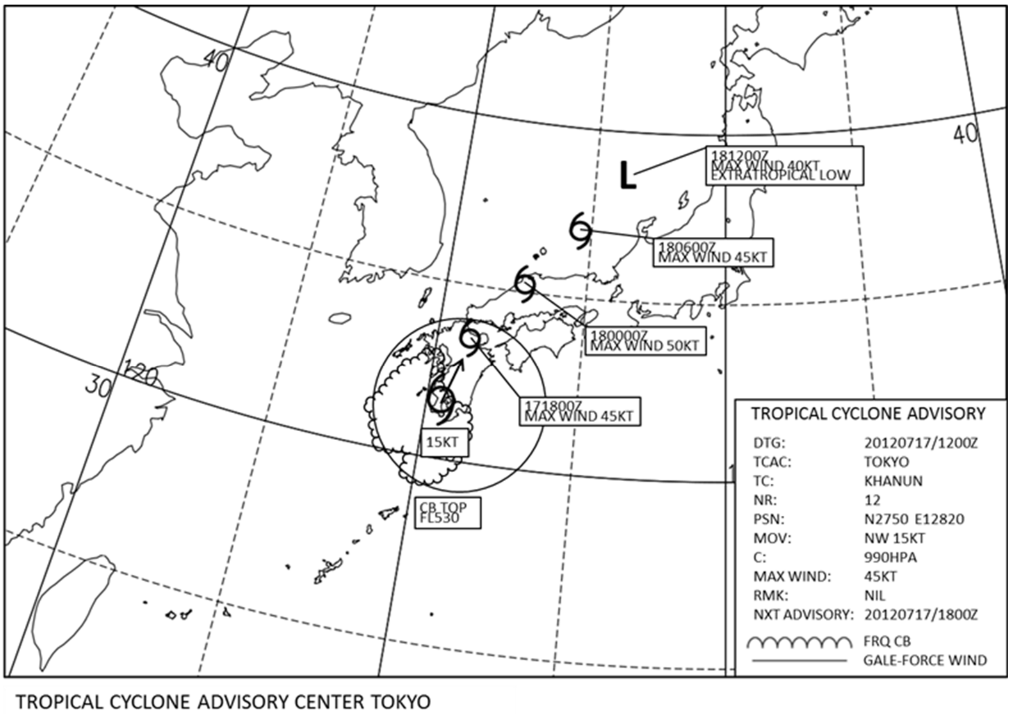
Example:

FKPQ30 RJTD 271200
TC ADVISORY

DTG:	20080927/1200Z
TCAC:	TOKYO
TC:	JANGMI
NR:	15
PSN:	N2120 E12425
MOV:	NW 13KT
C:	910HPA
MAX WIND:	115KT
FCST PSN +6HR:	27/1800Z N2200 E12330
FCST MAX WIND +6HR:	115KT
FCST PSN +12HR:	28/0000Z N2240 E12250
FCST MAX WIND +12HR:	115KT
FCST PSN +18HR:	28/0600Z N2340 E12205
FCST MAX WIND +18HR:	95KT
FCST PSN +24HR:	28/1200Z N2440 E12105
FCST MAX WIND +24HR:	80KT
RMK:	NIL
NXT MSG:	20080927/1800Z =

(8) Graphical Tropical Cyclone Advisory for SIGMET

Example:



Appendix 6

Specifications of JMA's NWP Models (GSM, GEPS)

The Global Spectral Model (GSM) and the Global Ensemble Prediction System (GEPS) are used in JMA as a primary basis for TC forecasts. The general specifications of GSM and GEPS are summarized in Table A6.1.

Table A6.1 Specifications of GSM and GEPS

NWP Models	GSM (Global Spectral Model), TL959L100	GEPS (Global Ensemble Prediction System), TL479L100
Resolution	20 km, 100 layers (Top: 0.01hPa)	40 km, 100 layers (Top: 0.01hPa)
Area	Global	Global
Method for initial value	Global Data Assimilation System (Hybrid-4DVAR) Outer resolution: TL959L100 Inner resolution: TL319L100 Window: Init-3h to Init + 3h	Unperturbed condition: Truncated GSM initial condition Initial perturbation: LETKF-based perturbation and SV-based perturbation Ensemble size: 27 (26 perturbed members and 1 control member) SV target areas: Northern Hemisphere (30 – 90°N), Tropics (30°S – 30°N), Southern Hemisphere (90 – 30°S)
Forecast length (initial times)	264 hours (00, 12 UTC) 132 hours (06, 18 UTC)	264 hours (00, 12 UTC) 132 hours (06, 18 UTC)
Operational as from	25 May 2017	19 January 2017

GSM (TL959L100) has a horizontal resolution of approximately 20 km and 100 vertical layers. Details of the model can be found in JMA (2019) and Yonehara et al. (2020).

GEPS (TL479L100) is an ensemble prediction system used for TC track forecasts up to five days ahead, one-week forecasts, early warning information on extreme weather, and one-month forecasts. It has 27 members and a horizontal resolution of approximately 40 km along with 100 vertical layers for the first 11 days of forecasts. Details of the system can be found in JMA (2019) and Yamaguchi et al. (2020). A combination of a Local Ensemble Transform Kalman Filter (LETKF; Hunt et al. 2007) and a singular vector (SV) method (Buizza and Palmer 1995) is employed for the initial perturbation setup. In addition, a stochastically perturbed physics tendency scheme (Buizza et al. 1999) is incorporated in consideration of model uncertainties associated with physical parameterizations, and a perturbation technique for sea surface temperature (SST) is incorporated to represent uncertainty in the prescribed SST.

[Recent upgrades to GSM, Global Data Assimilation System and GEPS]

GSM:

- Revision of parameterization schemes such as gravity wave and boundary layer (March 2020).
- Improvement of land surface process (March 2020).
- Adjustment of sea ice albedo and cloud processes in Polar Regions (March 2020).
- The forecast period was extended to 264 hours at 00UTC (March 2020).

Global Data Assimilation System:

Assimilation of ScatSat-1/OSCAT and GOES-16 AMV data was started (July 2020).GEPS:

- Incorporation of recent GSM development (March 2020).
- Direct application of initial perturbations from JMA's new hybrid data assimilation system (March 2020).

[References]

Buizza, R., M. Miller, and T. N. Palmer, 1999: Stochastic representation of model uncertainties in the ECMWF Ensemble Prediction System. Quart. J. Roy. Meteor. Soc., 125, 2887–2908.

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Hunt, B. R., E. J. Kostelich and I. Szunyogh, 2007: Efficient data assimilation for spatiotemporal chaos: a local ensemble transform Kalman filter. Physica. D., 230, 112 – 126.

Japan Meteorological Agency, 2019: Outline of Operational Numerical Weather Prediction at JMA. Appendix to WMO Technical Progress Report on the Global Data-processing and Forecasting System (GDPFS) and Numerical Weather Prediction (NWP) Research. Japan Meteorological Agency, Tokyo, Japan.

Yamaguchi, H., M. Ikegami, K. Ochi, Y. Ota, R. Sekiguchi, T. Takakura, 2020: Upgrade of JMA's Global Ensemble Prediction System, WGNE Res. Activ. Earth system Modell., 50, 06.17-18.

Yonehara, H., C. Matsukawa, T. Nabetani, T. Kanehama, T. Tokuhiro, K. Yamada, R. Nagasawa, Y. Adachi, R. Sekiguchi, 2020: Upgrade of JMA's Operational Global Model, WGNE Res. Activ. Earth system Modell., 50, 06.18-19.

Products on WIS GISC Tokyo Server

(Available at https://www.wis-jma.go.jp/cms/)

NWP products (GSM and GEPS with GRIB formatted data)

Model	GSM	GSM	GSM
Area and resolution	Whole globe, 1.25°×1.25°	20°S–60°N, 60°E–160°W 1.25°×1.25°	Whole globe, 2.5°×2.5°
Levels and elements	10 hPa: Z, U, V, T 20 hPa: Z, U, V, T 30 hPa: Z, U, V, T 50 hPa: Z, U, V, T 70 hPa: Z, U, V, T 100 hPa: Z, U, V, T 150 hPa: Z, U, V, T 200 hPa: Z, U, V, T, ψ, χ 250 hPa: Z, U, V, T 300 hPa: Z, U, V, T, H, ω 400 hPa: Z, U, V, T, H, ω 500 hPa: Z, U, V, T, H, ω, ζ 600 hPa: Z, U, V, T, H, ω 700 hPa: Z, U, V, T, H, ω 850 hPa: Z, U, V, T, H, ω, ψ, χ 925 hPa: Z, U, V, T, H, ω 1000 hPa: Z, U, V, T, H, ω Surface: P, U, V, T, H, R†	10 hPa: Z, U, V, T 20 hPa: Z, U, V, T 30 hPa: Z, U, V, T 50 hPa: Z, U, V, T 70 hPa: Z, U, V, T 100 hPa: Z, U, V, T 150 hPa: Z, U, V, T 200 hPa: Z§, U§, V§, T§, ψ, χ 250 hPa: Z, U, V, T 300 hPa: Z, U, V, T, D 400 hPa: Z, U, V, T, D 500 hPa: Z§, U§, V§, T§, D§, ζ 700 hPa: Z§, U§, V§, T§, D§, ω 850 hPa: Z§, U§, V§, T§, D§, ω, ψ, χ 925 hPa: Z, U, V, T, D, ω 1000 hPa: Z, U, V, T, D Surface: P¶, U¶, V¶, T¶, D¶, R¶	10 hPa: Z*, U*, V*, T* 20 hPa: Z*, U*, V*, T* 30 hPa: Z°, U°, V°, T° 50 hPa: Z°, U°, V°, T° 70 hPa: Z°, U°, V°, T° 100 hPa: Z°, U°, V°, T° 150 hPa: Z*, U*, V*, T* 200 hPa: Z, U, V, T 250 hPa: Z°, U°, V°, T° 300 hPa: Z, U, V, T, D*‡ 400 hPa: Z*, U*, V*, T*, D*‡ 500 hPa: Z, U, V, T, D*‡ 700 hPa: Z, U, V, T, D 850 hPa: Z, U, V, T, D 1000 hPa: Z, U*, V*, T*, D*‡ Surface: P, U, V, T, D*‡, R†
Forecast hours	0–84 every 6 hours and 96–192 every 12 hours for 12UTC initial † Except analysis	0–84 (every 6 hours) § 96–192 (every 24 hours) for 12UTC initial ¶ 90–192 (every 6 hours) for 12UTC initial	0–72 every 24 hours and 96–192 every 24 hours for 12UTC ° 0–120 for 12UTC † Except analysis * Analysis only
Initial times	00, 06, 12, 18UTC	00, 06, 12, 18UTC	00UTC and 12UTC ‡ 00UTC only

Model	GEPS
Area and resolution	Whole globe, 2.5°×2.5°
Levels and elements	250 hPa: μU, σU, μV, σV 500 hPa: μZ, σZ 850 hPa: μU, σU, μV, σV, μT, σT 1000 hPa: μZ, σZ Surface: μP, σP
Forecast hours	0–192 every 12 hours
Initial times	00, 12UTC

NWP products (GSM and GEPS with GRIB2 formatted data)

Model	GSM	GSM	GSM
Area and resolution	5S-90N and 30E-165W, Whole globe 0.25° × 0.25°	5S-90N and 30E-165W, Whole globe 0.5° × 0.5°	Whole globe 1.25° × 1.25°
Levels and elements	Surface: U, V, T, H, P, Ps, R, Cla, Clh, Clm, Cll	10 hPa: Z, U, V, T, H, ω 20 hPa: Z, U, V, T, H, ω 30 hPa: Z, U, V, T, H, ω 50 hPa: Z, U, V, T, H, ω 70 hPa: Z, U, V, T, H, ω 100 hPa: Z, U, V, T, H, ω 150 hPa: Z, U, V, T, H, ω 200 hPa: Z, U, V, T, H, ω, ψ, χ 250 hPa: Z, U, V, T, H, ω 300 hPa: Z, U, V, T, H, ω 400 hPa: Z, U, V, T, H, ω 500 hPa: Z, U, V, T, H, ω, ζ 600 hPa: Z, U, V, T, H, ω 700 hPa: Z, U, V, T, H, ω 800 hPa: Z, U, V, T, H, ω 850 hPa: Z, U, V, T, H, ω, ψ, χ 900 hPa: Z, U, V, T, H, ω 925 hPa: Z, U, V, T, H, ω 950 hPa: Z, U, V, T, H, ω 975 hPa: Z, U, V, T, H, ω 1000 hPa: Z, U, V, T, H, ω Surface: U, V, T, H, P, Ps, R, Cla, Clh, Clm, Cll	10 hPa: Z, U, V, T 20 hPa: Z, U, V, T 30 hPa: Z, U, V, T 50 hPa: Z, U, V, T 70 hPa: Z, U, V, T 100 hPa: Z, U, V, T 150 hPa: Z, U, V, T 200 hPa: Z, U, V, T, ψ, χ 250 hPa: Z, U, V, T, ζ, ∇ 300 hPa: Z, U, V, T, H, ω 400 hPa: Z, U, V, T, H, ω 500 hPa: Z, U, V, T, H, ω, ζ 600 hPa: Z, U, V, T, H, ω 700 hPa: Z, U, V, T, H, ω, ζ, ∇ 850 hPa: Z, U, V, T, H, ω, ψ, χ 925 hPa: Z, U, V, T, H, ω, ζ, ∇ 1000 hPa: Z, U, V, T, H, ω Surface: P, U, V, T, H, R
Forecast hours	0–132 (every 3 hours) 138–264 (every 6 hours) are available for 00 UTC and 12 UTC initial	0–132 (every 3 hours) 138–264 (every 6 hours) are available for 00 UTC and 12 UTC initial	0–132 (every 3 hours) 138–264 (every 6 hours) are available for 00 UTC and 12 UTC initial
Initial times	00, 06, 12 and 18 UTC	00, 06, 12 and 18 UTC	00, 06, 12 and 18 UTC

Model	GEPS
Area and resolution	Whole globe, 1.25°×1.25°
Levels and elements	250 hPa: μU, σU, μV, σV 500 hPa: μZ, σZ 850 hPa: μU, σU, μV, σV, μT, σT 1000 hPa: μZ, σZ Surface: μP, σP Probability of precipitation [1,5,10,25,50,100 mm/24hour], Probability of 10m sustained wind and gusts[10,15,25 m/s], Probability of temperature anomalies [±1, ±1.5, ±2σ]
Forecast hours	0-264 every 12 hours
Initial times	00UTC and 12UTC

Notes:

Z: geopotential height	U: eastward wind	V: northward wind
T: temperature	D: dewpoint depression	H: relative humidity
ω: vertical velocity	ζ: vorticity	ψ: stream function
χ: velocity potential	∇: divergence	P: sea level pressure
Ps: pressure	R: rainfall	Cla: total cloudiness
Clh: cloudiness (upper layer)	Clm: cloudiness (middle layer)	
Cll: cloudiness (lower layer)		

The prefixes μ and σ represent the average and standard deviation of ensemble prediction results respectively.
The symbols °, *, ¶, §, ‡ and † indicate limitations on forecast hours or initial time as shown in the tables.

Other products

Data	Contents / frequency (initial time)
Satellite products	High density atmospheric motion vectors (BUFR) Himawari-8 (VIS, IR, WVx3: every hour), 60S-60N, 90E-170W Clear Sky Radiance (CSR) data (BUFR) Himawari-8 radiances and brightness temperatures averaged over cloud-free pixels: every hour
Tropical cyclone Information	Tropical cyclone related information (BUFR) • tropical cyclone analysis data (00, 06, 12 and 18 UTC)
Wave data	Global Wave Model (GRIB2) • significant wave height • prevailing wave period • wave direction Forecast hours: 0–84 every 6 hours (00, 06 and 18UTC) 0–84 every 6 hours and 96-192 every 12 hours (12 UTC)
Observational data	(a) Surface data (TAC/TDCF) SYNOP, SHIP, BUOY: Mostly 4 times a day (b) Upper-air data (TAC/TDCF) TEMP (parts A-D), PILOT (parts A-D): Mostly twice a day
SATAID service	(a) Satellite imagery (SATAID) Himawari-8 (b) Observation data (SATAID) SYNOP, SHIP, METAR, TEMP (A, B) and ASCAT sea-surface wind (c) NWP products (SATAID) GSM (Available at https://www.wis-jma.go.jp/cms/sataid/)

Appendix 8

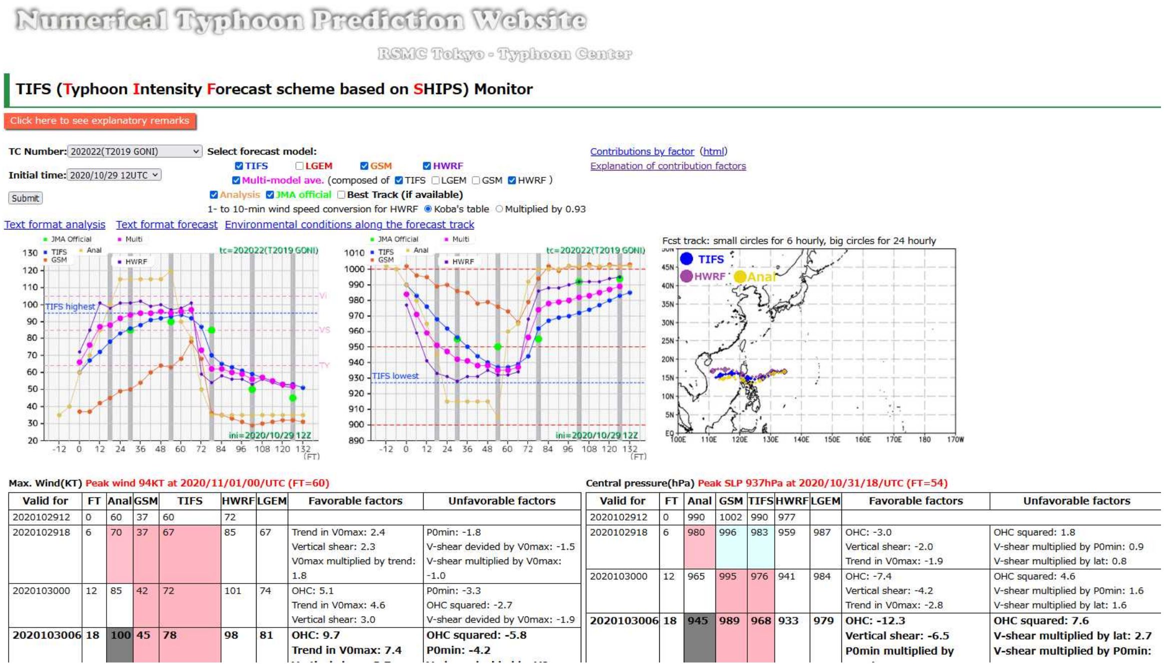
Products on NTP Website

List of products provided on the Numerical Typhoon Prediction (NTP) website

Products	Frequency	Details
RSMC Advisories		
RSMC TC Advisory	At least 8 times/day	• The Center's TC analysis and forecasts up to 120 hours ahead (linked to the JMA website at https://www.jma.go.jp/en/typh/)
Storm Wind Probability Map	4 times/day	• Probabilistic forecast map for sustained wind of 50-kt or more for 1, 2, 3, 4 and 5 days ahead
Prognostic Reasoning	4 times/day	• RSMC Tokyo Tropical Cyclone Prognostic Reasoning (WTPQ3X)
Advance notice		• Advance notice on TC status change from the Center
Graphical TC Advisory	4 times/day	• Graphical TC Advisory including RSMC Tokyo - Typhoon Center's TC analysis, track and intensity forecasts up to 24-hours and horizontal extents of cumulonimbus cloud and cloud top height associated with TCs potentially affecting aviation safety (linked to the Tropical Cyclone Advisory Center Tokyo Website)
Remote Sensing		
Satellite Analysis	At least 4 times/day	• Results and historical logs of the Center's TC analysis conducted using satellite images (Conventional Dvorak analysis and Early-stage Dvorak analysis)
Satellite Imagery	Up to 142 times/day	• Satellite imagery of Himawari-8/9 (linked to the JMA website at https://www.jma.go.jp/en/gms/smallc.html?area=6&element=0&mode=UTC)
Satellite Microwave Products		• TC snapshot images • Warm-core-based TC intensity estimates • Weighted consensus TC intensity estimates made using Dvorak analysis and satellite microwave warm-core-based intensity estimates
Sea-surface AMV (ASWind)	Every 10 / 30 minutes	• AMV-based Sea-surface Wind in the vicinity of TC (linked to the Meteorological Satellite Center web site)
Radar Composite Imagery	Every hour	• Radar composite imagery of the Typhoon Committee Regional Radar Network
Atmospheric Circulation		
Weather Charts	4 times/day	• Weather maps for surface analysis, 24- and 48-hour forecasts (linked to the JMA website at https://www.jma.go.jp/en/g3/)
NWP Multi Center Weather Charts	Twice/day	• Mean sea level pressure and 500 hPa Geopotential height (up to 168 hours) of deterministic NWP models from nine centers (BoM, CMA, CMC, DWD, ECMWF, KMA, NCEP, UKMO and JMA)
JMA GSM Analysis and Forecast	4 times/day	• Upper-air analysis and forecast data based on JMA-GSM - Streamlines at 850 and 200 hPa - Divergence at 200 hPa - Velocity potential at 200 hPa - Vertical Velocity in Pressure Coordinate at 500 hPa - Dew Point Depression at 600 hPa - Curvature Vorticity at 850 hPa - Vertical wind shear between 200 and 850 hPa - Sea Level Pressure - Genesis Potential Index
MJO Phase Diagram	Once/day	MJO phase and amplitude diagram and MJO Hovmöller diagram (linked to the Tokyo Climate Center web site)
Ocean Condition		

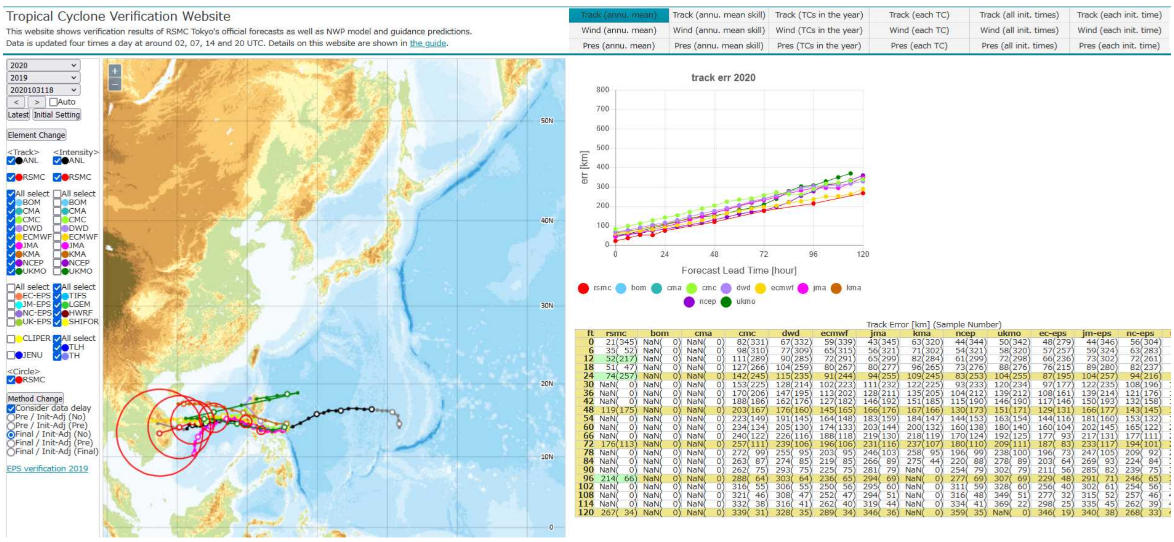
Products	Frequency	Details
SST	Once/day	• Sea surface temperature and related differences from 24 hours ago
TCHP	Once/day	• Tropical cyclone heat potential and related differences from 24 hours ago
Numerical TC Prediction		
Track Bulletin	4 times/day	• RSMC Tokyo Tropical Cyclone Track Forecast Bulletin - Track forecast by GSM (FXPQ2X) - Track forecast by GEPS (FXPQ3X)
TC intensity (TIFS monitor)	4 times/day	• TIFS (Typhoon Intensity Forecast scheme based on SHIPS) Monitor
TC Track Prediction	4 times/day	• TC track prediction of deterministic NWP models from nine centers (BoM, CMA, CMC, DWD, ECMWF, KMA, NCEP, UKMO and JMA) and a related consensus • TC track prediction of EPS models from four centers (ECMWF, NCEP, UKMO and JMA)
TC Activity Prediction	Twice/day	• Two- and five-day TC activity prediction maps based on EPS models from four centers (ECMWF, UKMO, NCEP and JMA) and a related consensus
TC Verification	4 times/day	• Verification results of RSMC Tokyo's official forecasts as well as NWP model and guidance predictions
Marine Forecast		
Storm Surge Forecasts	4 times/day	• Distribution 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) • 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)
Ocean Wave Forecasts	Twice/day	• Distribution maps for ensemble mean, maximum, probability of exceeding various thresholds and ensemble spread of wave height and period based on the Wave Ensemble System (WENS) (up to 264 hours) • Time-series representations with box-and-whisker plots for wave height/period and probability of exceeding various wave height/period thresholds based on the WENS (up to 264 hours)

RSMC Tokyo - Typhoon Center product examples



Website on the TIFS (Typhoon Intensity Forecast scheme based on SHIPS) monitor

The upper figure shows TIFS and GSM intensity prediction values at each initial time for individual TCs with analysis data in line graphs as well as a map of tracks. In the lower tables, the pink-colored and light blue-colored cells represent development and weakening from 12 hours before, respectively.



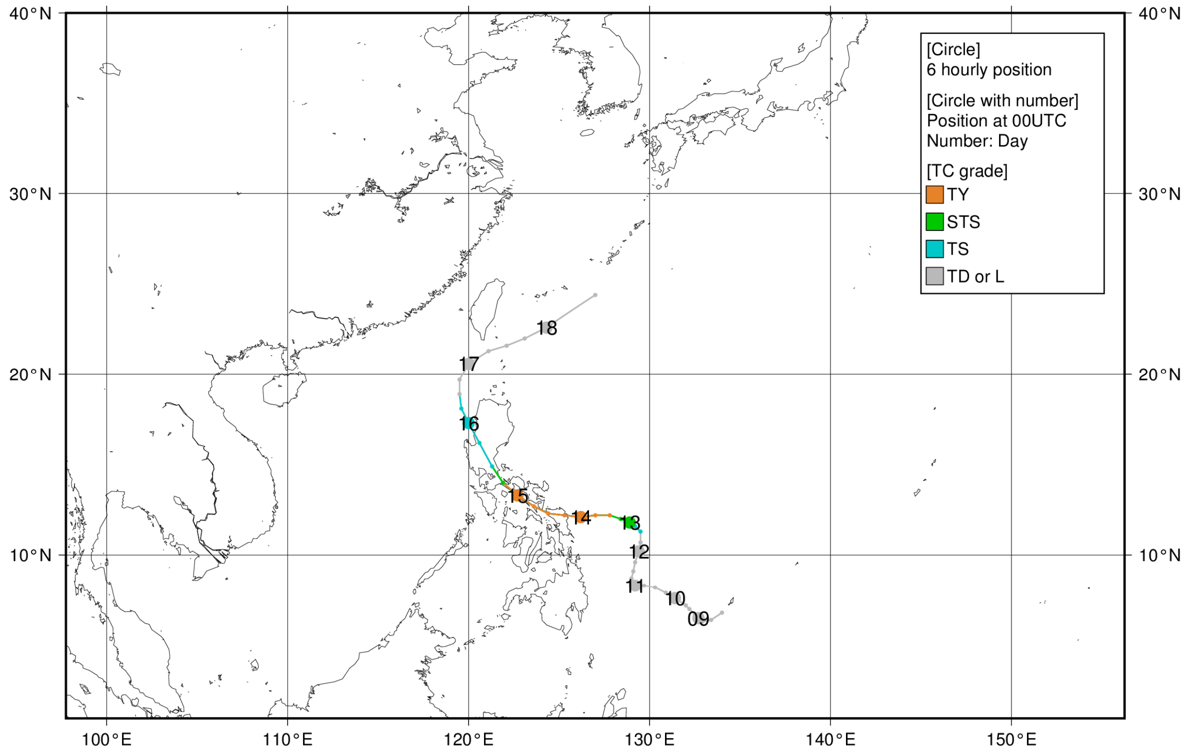
Website on the tropical cyclone verification

Left map shows the various forecast track data with forecast circles. In the right-hand-side, verification items (upper-right) and verification results (graphs and tables; middle-right and lower-right) are indicated.

Tropical Cyclones in 2020

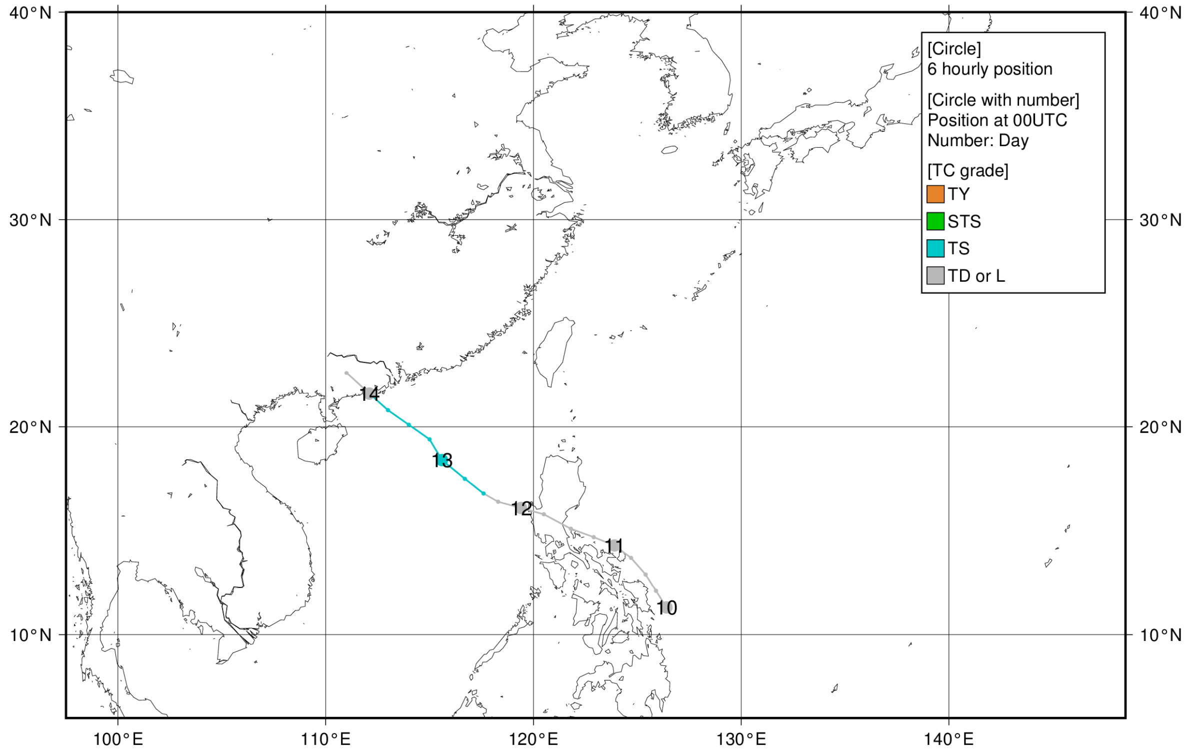
VONGFONG (2001)

VONGFONG formed as a tropical depression (TD) around the Palau Islands at 06 UTC on 8 May 2020. It initially moved westward and then northwestward. VONGFONG turned northward on 11 May and was upgraded to tropical storm (TS) intensity over the sea east of the Philippines at 12 UTC on 12 May. Moving westward, it was upgraded to typhoon (TY) intensity over the same waters at 12 UTC on 13 May. VONGFONG reached its peak intensity with maximum sustained winds of 85 kt and a central pressure of 960 hPa at 00 UTC on 14 May before hitting the Philippines. VONGFONG moved northwestward and crossed the Philippines from early on 14 May to the next day. It started to weaken on 14 May and entered the South China Sea on 16 May. VONGFONG weakened to TD intensity over the same waters at 12 UTC on 16 May and then gradually turned northeastward. It dissipated over the sea east of Okinawa Island at 12 UTC on 18 May.



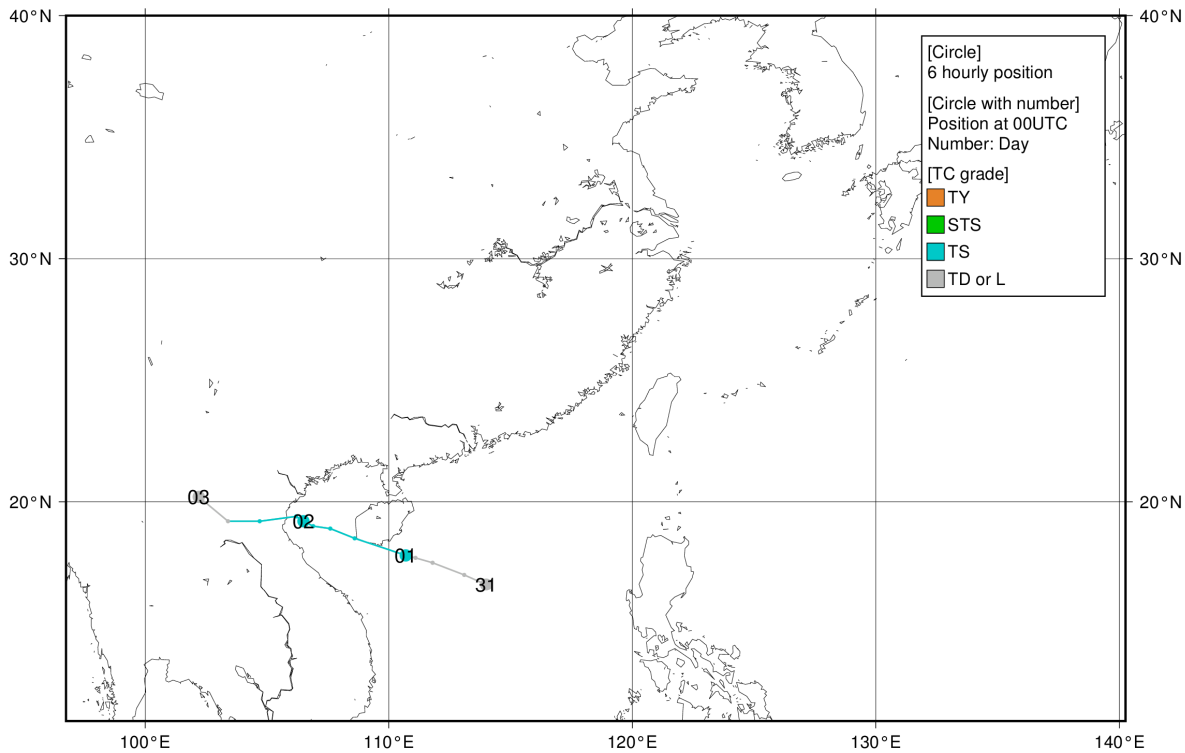
NURI (2002)

NURI formed as a tropical depression (TD) east of the Philippines at 00 UTC on 10 June 2020 and moved northwestward. After crossing Luzon Island, it was upgraded to tropical storm (TS) intensity over the South China Sea at 12 UTC on 12 June. NURI reached its peak intensity over the same water 12 hours later with maximum sustained winds of 40 kt and a central pressure of 996 hPa. After moving northwestward, NURI weakened to TD intensity near the coast of southern China at 00 UTC on 14 June and dissipated in southern China 12 hours later.



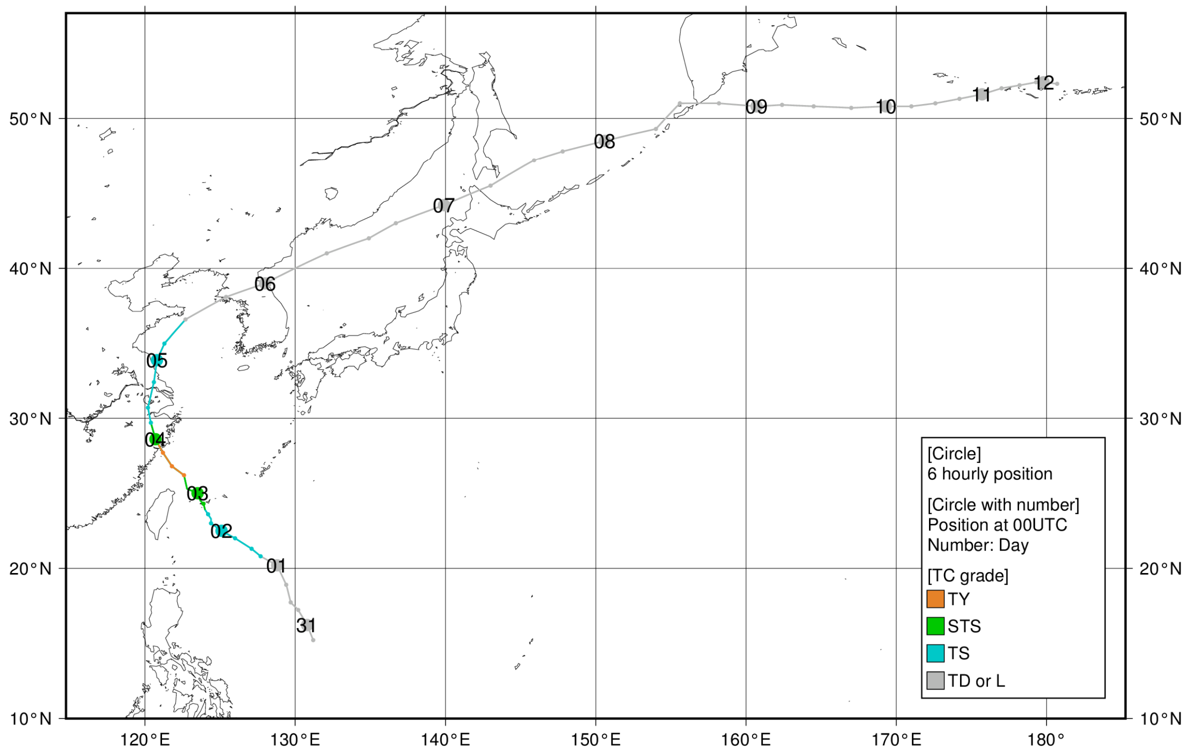
SINLAKU (2003)

SINLAKU formed as a tropical depression (TD) over the South China Sea at 00 UTC on 31 July 2020 and moved west-northwestward. It was upgraded to tropical storm (TS) intensity southeast of Hainan Island at 00 UTC on 1 August and kept its west-northwestward track off the southern coast of the island. SINLAKU reached its peak intensity with maximum sustained winds of 40 kt and a central pressure of 985 hPa over the westernmost part of the Gulf of Tonkin at 06 UTC on 2 August. After crossing the coast line of Viet Nam, it moved westward and weakened to TD intensity in northern Laos at 18 UTC on 2 August. It dissipated in the same country 12 hours later.



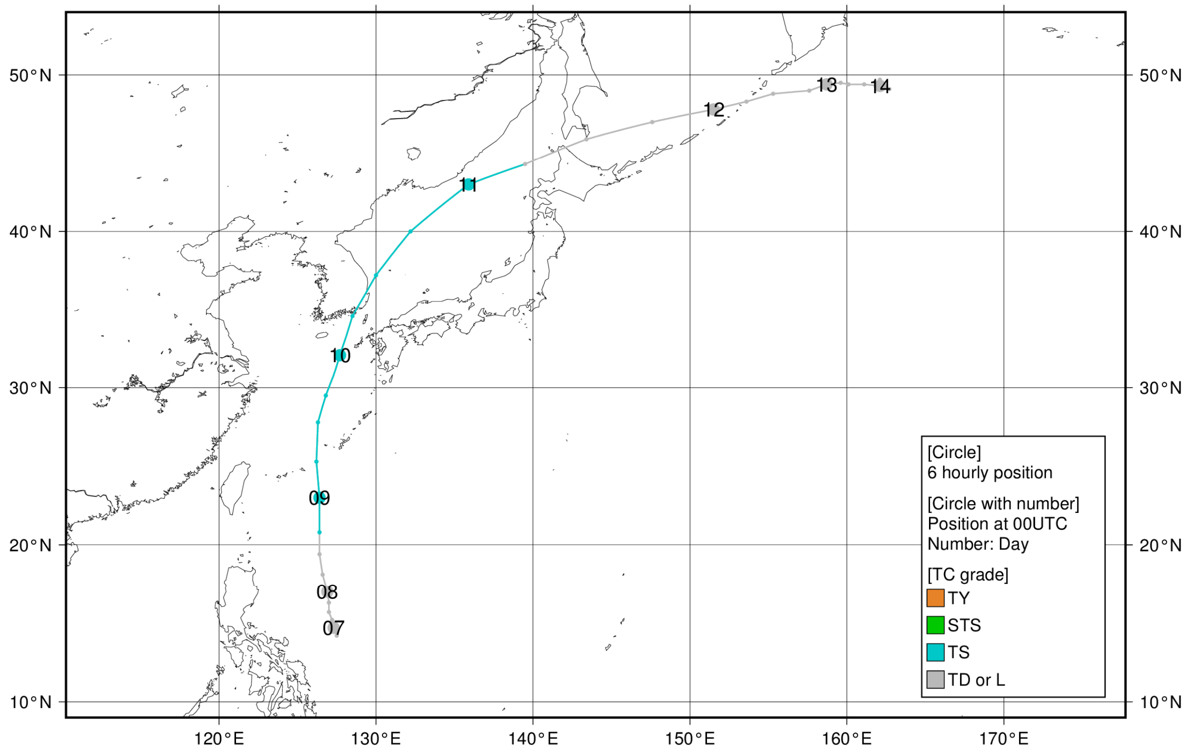
HAGUPIT (2004)

HAGUPIT formed as a tropical depression (TD) east of the Philippines at 18 UTC on 30 July 2020. It moved initially north-northwestward and turned northwestward around one day later. Keeping its northwestward track, HAGUPIT was upgraded to tropical storm (TS) intensity south of Okinawa Island at 06 UTC on 1 August. After entering the East China Sea, it was upgraded to typhoon (TY) intensity northeast of Taiwan Island at 06 UTC on 3 August. HAGUPIT reached its peak intensity with maximum sustained winds of 70 kt and a central pressure of 975 hPa north of Taiwan Island six hours later. HAGUPIT hit the coast of central China before 00 UTC on 4 August and turned northward. Gradually turning northeastward, HAGUPIT entered the Yellow Sea and transformed into an extratropical cyclone at 12 UTC on 5 August. After crossing the Korean Peninsula and northern Hokkaido, it turned eastward near the Kamchatka Peninsula, and finally crossed longitude 180 degrees east before 06UTC on 12 August.



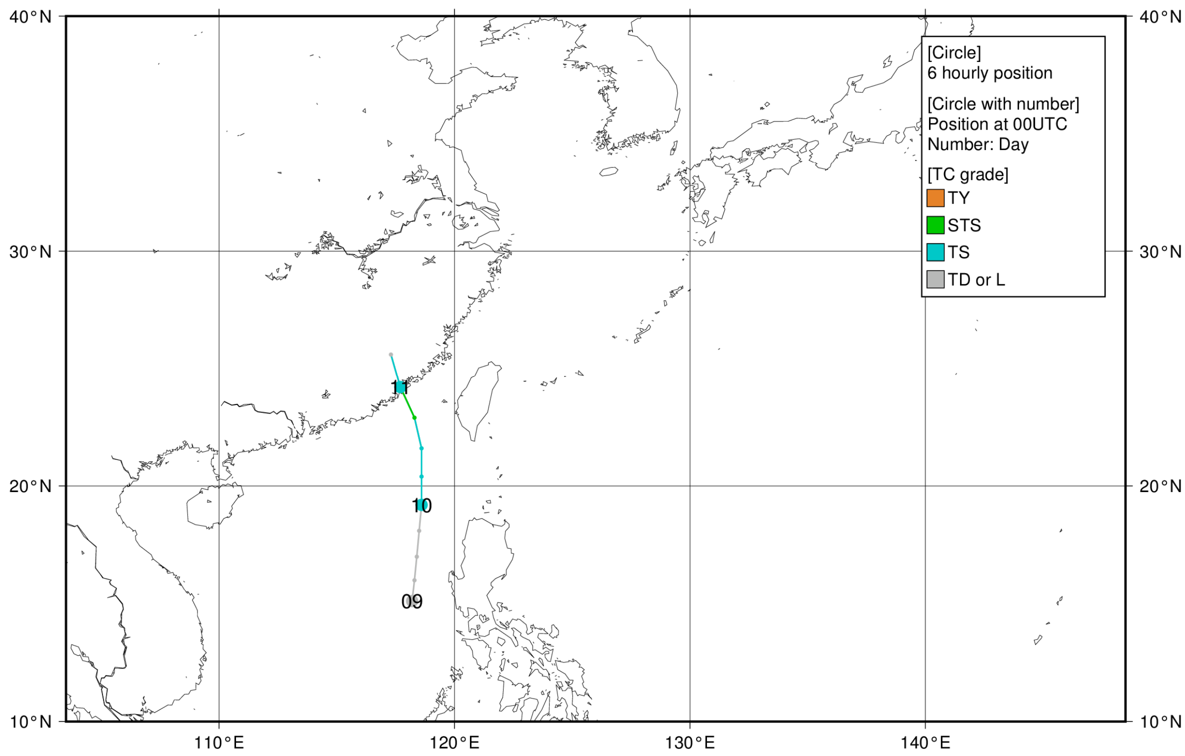
JANGMI (2005)

JANGMI formed as a tropical depression (TD) over the sea east of the Philippines at 18 UTC on 06 August 2020 and moved northward. It was upgraded to tropical storm (TS) intensity south of Okinawa at 18 UTC on 08 August and reached its peak intensity with maximum sustained winds of 45 kt and a central pressure of 994 hPa over the East China Sea at 12 UTC on the next day. JANGMI gradually turned northeastward and transitioned into an extratropical cyclone over the northern part of the Sea of Japan by 06 UTC on 11 August. It dissipated over the sea east of the Chishima Islands at 00 UTC on 15 August.



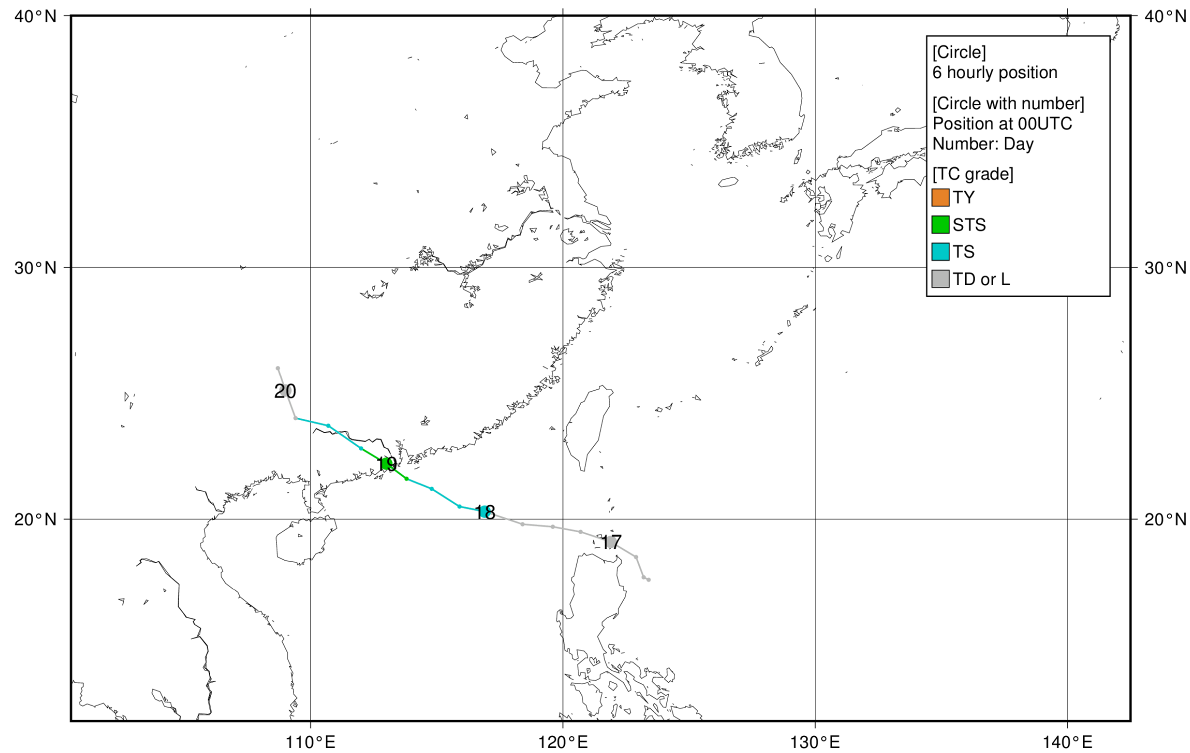
MEKKHALA (2006)

MEKKHALA formed as a tropical depression (TD) over the sea west of Luzon Island at 00 UTC on 9 August 2020 and moved northward. It was upgraded to tropical storm (TS) intensity over the same waters at 00 UTC the next day. MEKKHALA was upgraded to severe tropical storm (STS) intensity and reached its peak intensity with maximum sustained winds of 50 kt and a central pressure of 992 hPa at 18 UTC on 10 August. Keeping its northward track, MEKKHALA hit the coast of southeastern China around six hours later. MEKKHALA weakened to TD intensity at 06 UTC on 11 August and dissipated six hours later.



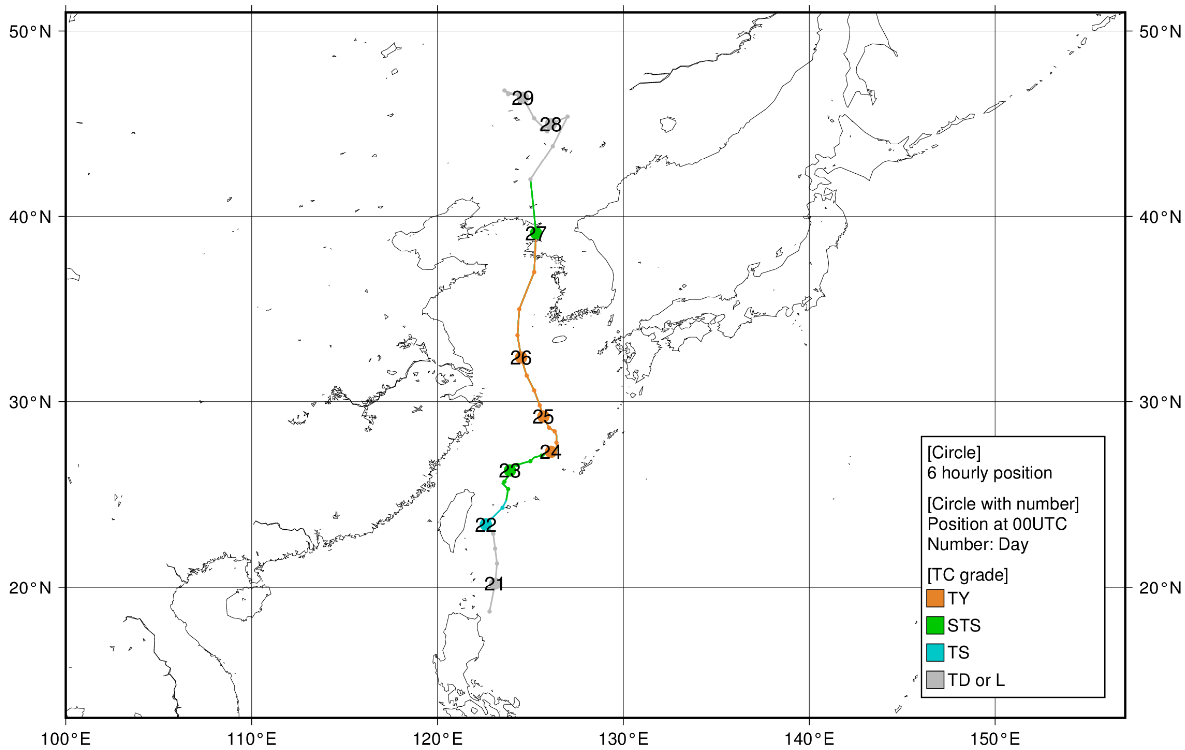
HIGOS (2007)

HIGOS formed as a tropical depression (TD) east of Luzon Island in the Philippines at 06 UTC on 16 August 2020. It initially moved north-northwestward and soon turned to the west-northwest around at 00 UTC on 17 August. After passing the Bashi Channel, HIGOS was upgraded to tropical storm (TS) intensity over the South China Sea at 00 UTC on 18 August. After moving over the same waters, HIGOS reached its peak intensity with maximum sustained winds of 55 kt and a central pressure of 992 hPa near the coast of southern China at 00 UTC on 19 August and weakened to TD intensity 18 hours later. It dissipated in southern China at 12 UTC on 20 August.



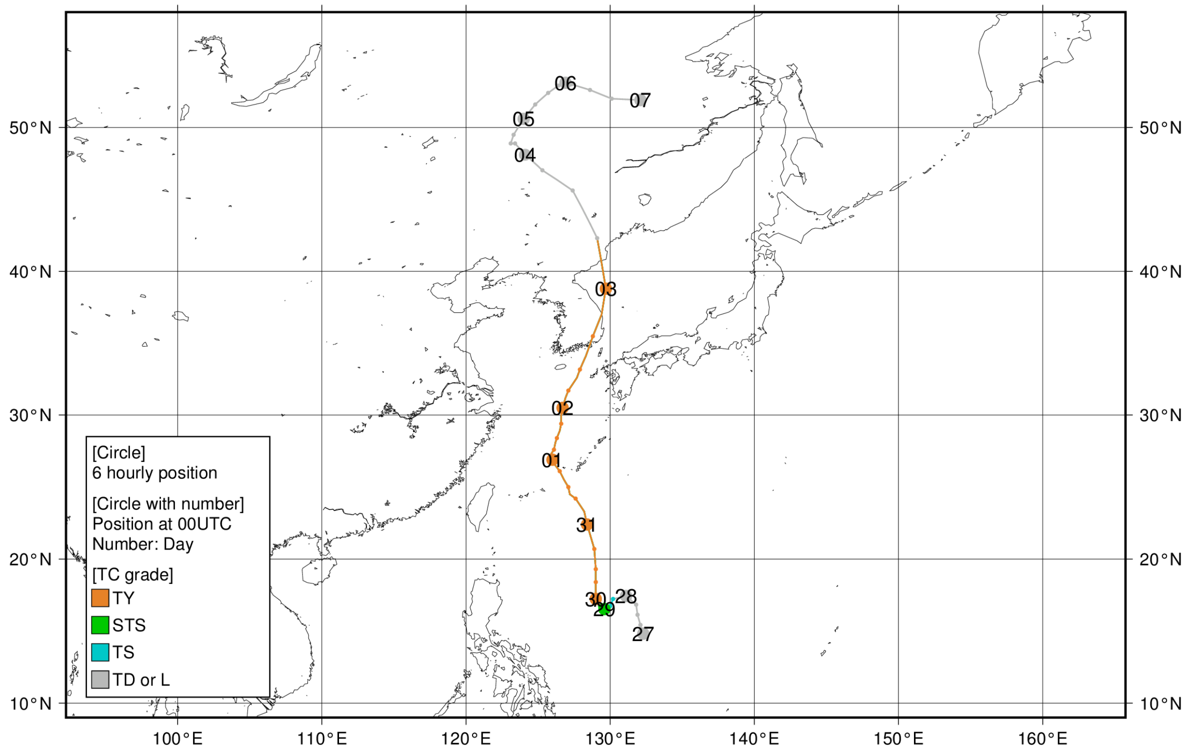
BAVI (2008)

BAVI formed as a tropical depression (TD) over the sea north of the Philippines at 18 UTC on 20 August 2020 and moved northward. It was upgraded to tropical storm (TS) intensity over the sea south of Okinawa at 00 UTC on 22 August and gradually turned northeastward. It was upgraded to typhoon (TY) intensity west of Okinawa at 00 UTC on 24 August and gradually turned northward. It reached its peak intensity with maximum sustained winds of 85 kt and a central pressure of 950 hPa over the northern part of the East China Sea at 00 UTC on 26 August. BAVI hit the Korean Peninsula with TY intensity late on 26 August and transitioned into an extratropical cyclone at 06 UTC on 27 August. It moved north-northeastward slowly and dissipated in Northeast China at 00 UTC on 30 August.



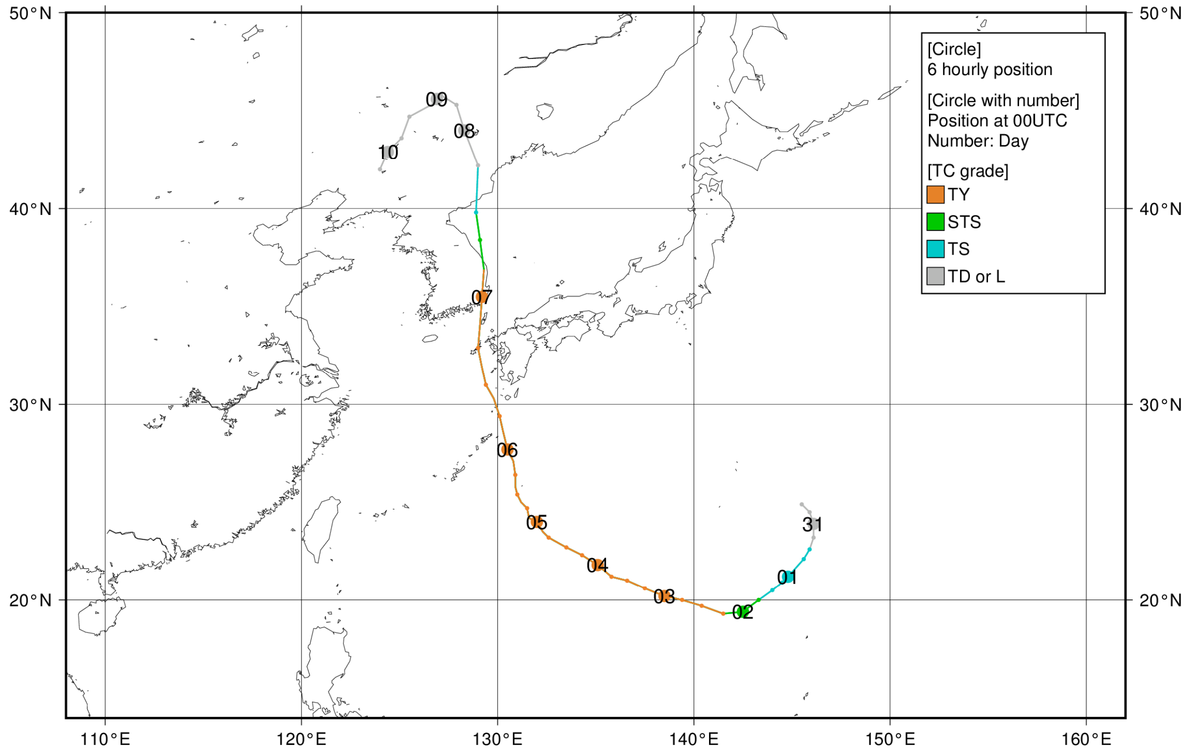
MAYSAK (2009)

MAYSAK formed as a tropical depression (TD) over the sea east of the Philippines at 00 UTC on 27 August 2020. It initially moved northward and then gradually turned westward later. MAYSAK was upgraded to tropical storm (TS) intensity over the same waters at 06 UTC on 28 August. Turning in a clockwise direction along semicircle, MAYSAK was upgraded to Typhoon (TY) intensity over the same waters at 12 UTC on 29 August. After moving northward, it gradually turned north-northwestward around 00 UTC on 31 August. It reached its peak intensity with maximum sustained winds of 95 kt and a central pressure of 935 hPa over the East China Sea at 00 UTC on 1 September, and then it gradually accelerated north-northeastward. MAYSAK crossed the Korean Peninsula with TY intensity late on 2 September and entered the Sea of Japan. It hit the northern part of the Korean Peninsula early on 3 September and transitioned into an extratropical cyclone there at 06 UTC on the same day. It dissipated over the lower Amur River basin at 06 UTC on 7 September.



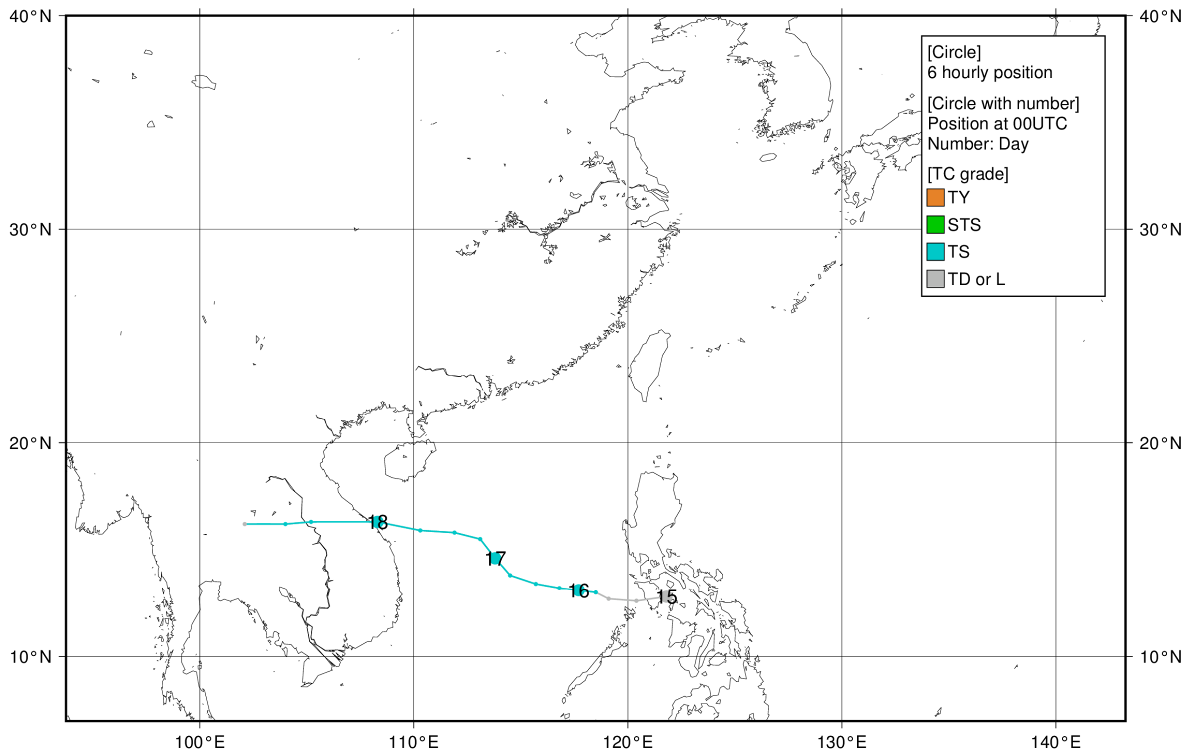
HAISHEN (2010)

HAISHEN formed as a tropical depression (TD) over the sea east of Iwoto Island at 12 UTC on 30 August 2020 and initially moved south-southeastward. Turning in a clockwise direction, it was upgraded to tropical storm (TS) intensity over the same waters 24 hours later. HAISHEN was upgraded to typhoon (TY) intensity over the sea northwest of the Mariana Islands at 06 UTC on 2 September and then moved northwestward. Keeping its northwestward track, it reached its peak intensity with maximum sustained winds of 105 kt and a central pressure of 910 hPa over the sea southeast of Minamidaitojima Island at 12 UTC on 4 September. HAISHEN subsequently turned and accelerated north-northwestward, and then entered the East China Sea early on 6 September. After moving northward off the west of Kyushu Island, it crossed the Korean Peninsula with TY intensity early on 7 September and entered the Sea of Japan. It transitioned into an extratropical cyclone in the northern part of the Korean Peninsula at 18 UTC on 7 September and dissipated over northeastern China at 12 UTC on 10 September.



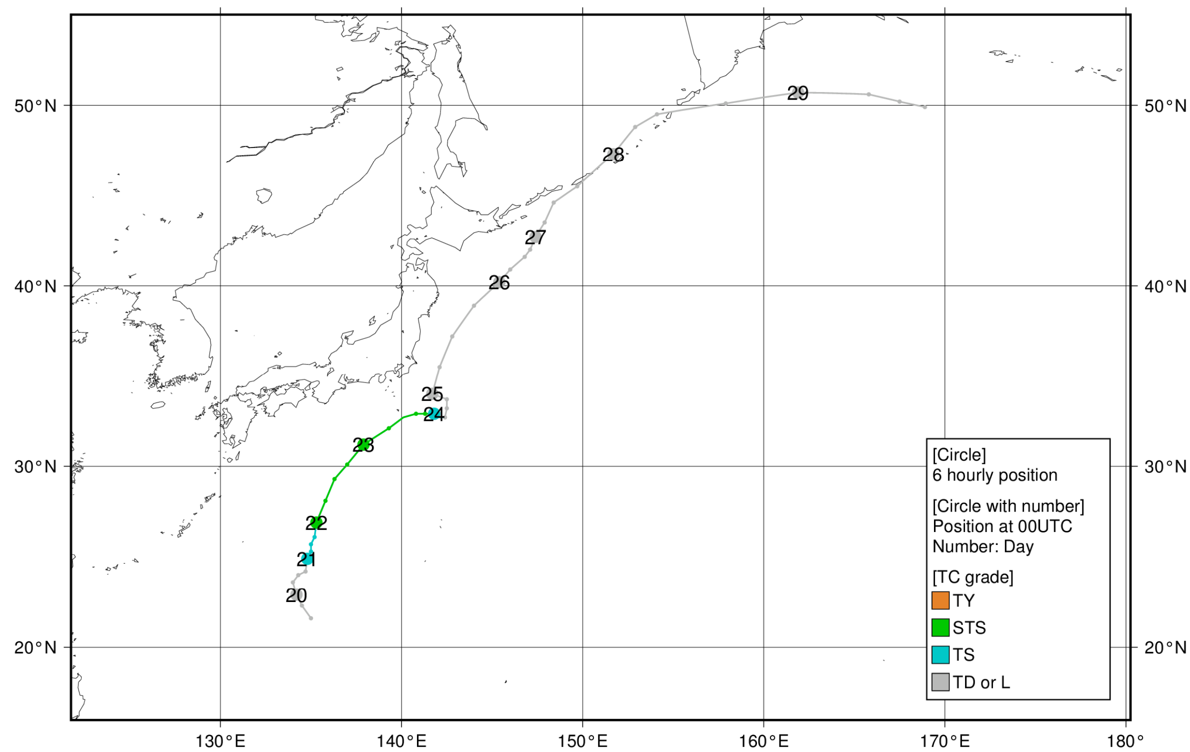
NOUL (2011)

NOUL formed as a tropical depression (TD) over the Philippines at 00 UTC on 15 September 2020. It initially moved westward and was upgraded to tropical storm (TS) intensity over the South China Sea at 18 UTC on 15 September. After moving westward, NOUL turned to the northwest around 00 UTC on 17 September, and reached its peak intensity with maximum sustained winds of 45 kt and a central pressure of 992 hPa over the same waters at 06 UTC on 17 September. After that, NOUL turned to the west at 12 UTC on 17 September and weakened to TD intensity around Thailand at 18 UTC on 18 September. It dissipated at 00 UTC on 19 September.



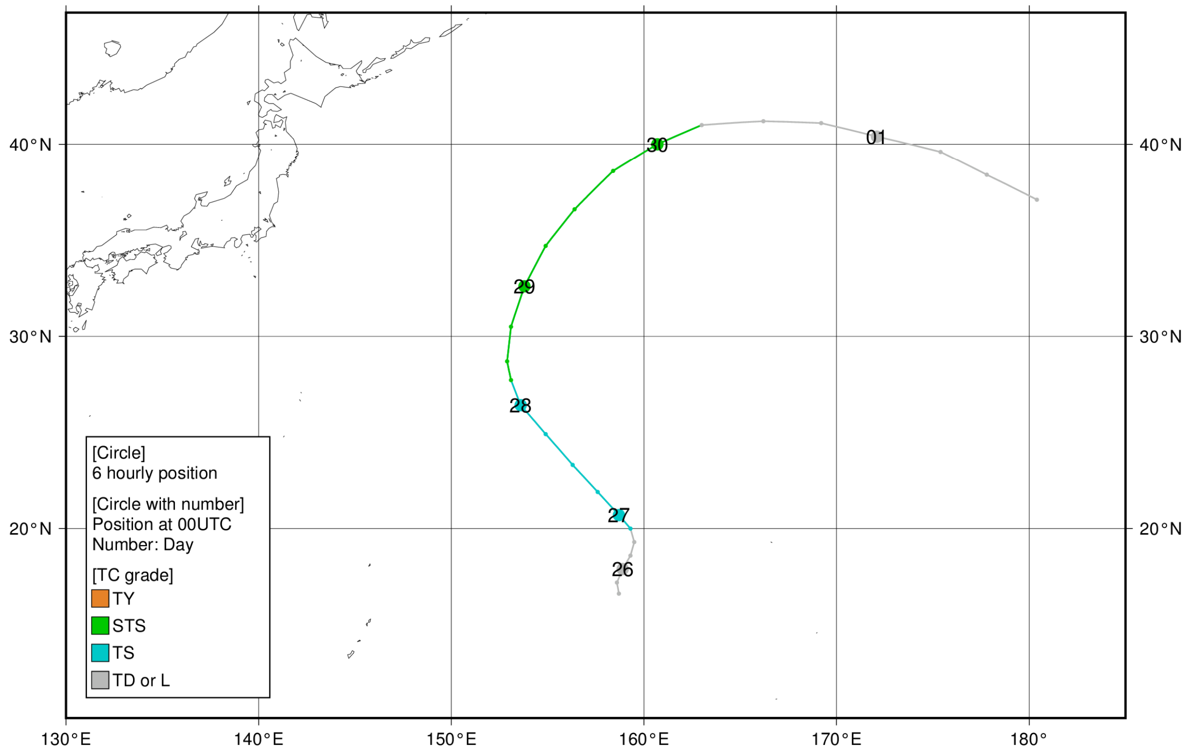
DOLPHIN (2012)

DOLPHIN formed as a tropical depression (TD) over the sea north of Okinotorishima Island at 12 UTC on 19 September 2020 and moved northward. It was upgraded to tropical storm (TS) intensity over the same waters at 00 UTC on 21 September. The next day, it was upgraded to severe tropical storm (STS) over the sea south of Japan at 00 UTC and reached its peak intensity with maximum sustained winds of 60 kt and a central pressure of 975 hPa over the same waters at 06 UTC. DOLPHIN gradually turned northeastward and transitioned into an extratropical cyclone east-southeast of Hachijojima Island by 06 UTC on 24 September. Afterwards it moved northeastward over the sea east of Japan and turned eastward at the northern part of the Chishima Islands. It dissipated over the sea east of the Chishima Islands at 00 UTC on 30 September.



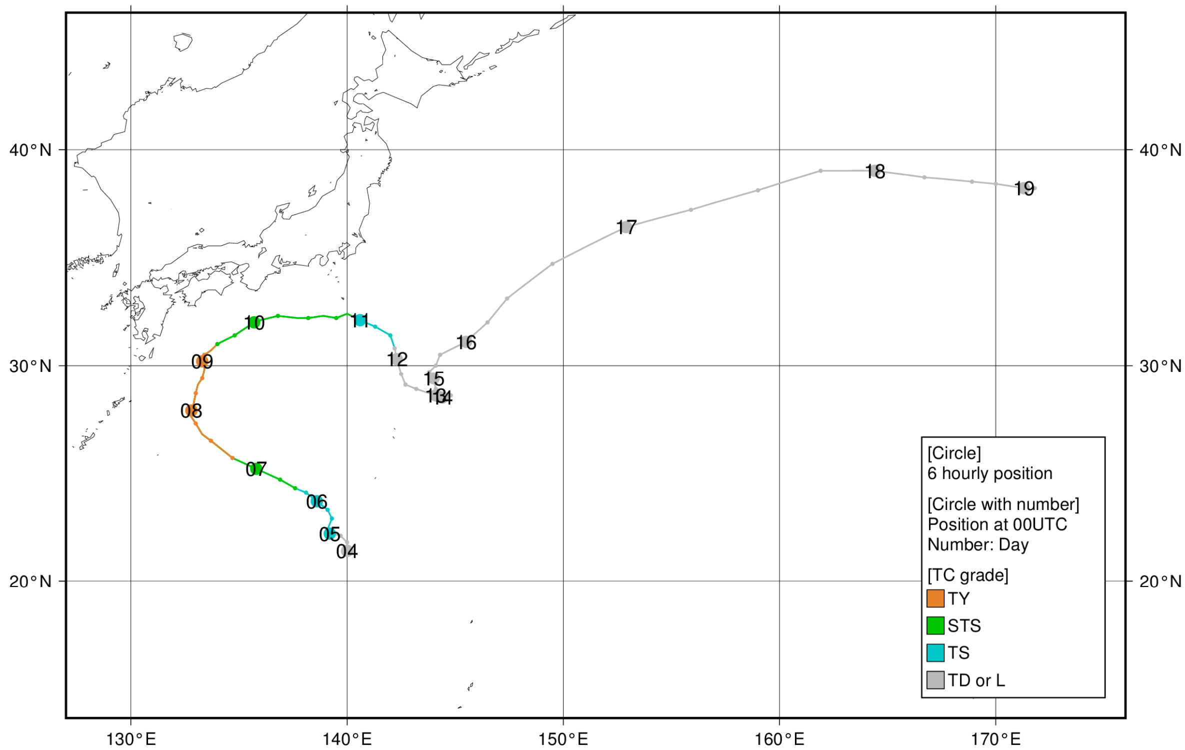
KUJIRA (2013)

KUJIRA formed as a tropical depression (TD) over the sea west of Wake Island at 12 UTC on 25 September 2020 and initially moved northward. Gradually turning northwestward, it was upgraded to tropical storm (TS) intensity over the sea southeast of Minamitorishima Island at 18 UTC on 26 September. Turning in a clockwise direction, KUJIRA reached its peak intensity with maximum sustained winds of 60 kt and a central pressure of 980 hPa over the sea east of Japan at 00 UTC on 29 September. Keeping its clockwise direction, it transformed into an extratropical cyclone over the sea far off east of Japan at 06 UTC on 30 September, and crossed longitude 180 degrees east at 18 UTC on 2 October.



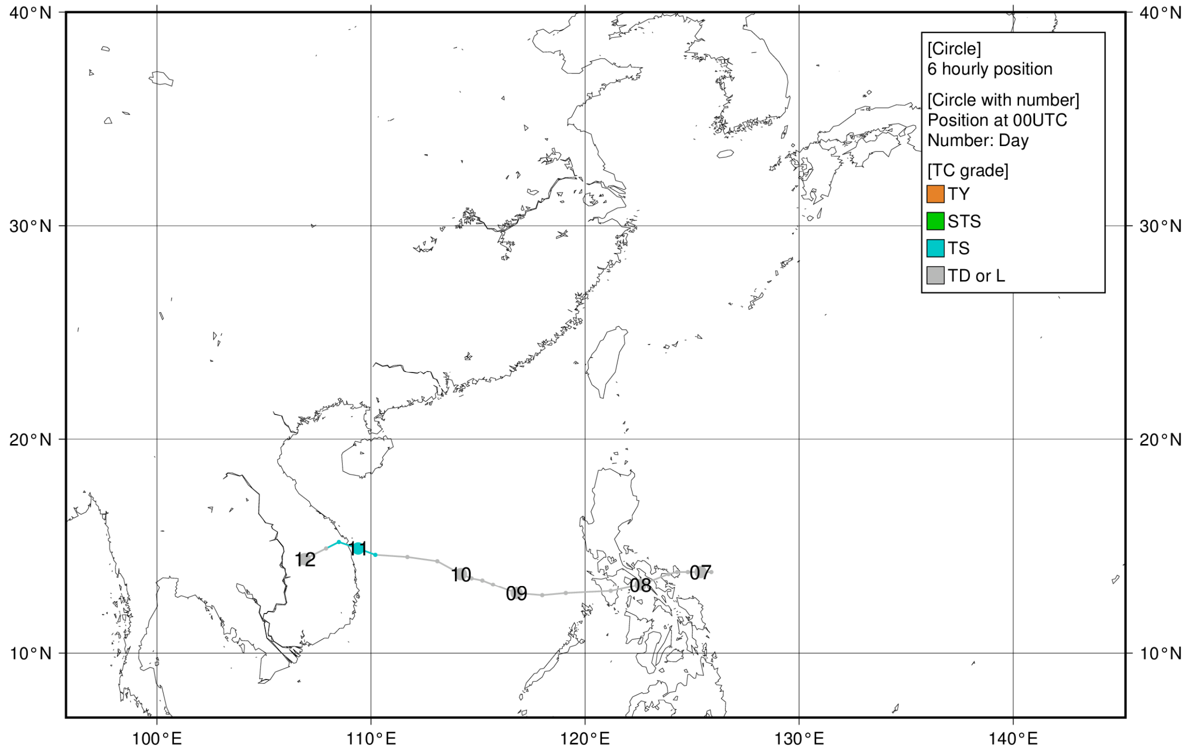
CHAN-HOM (2014)

CHAN-HOM formed as a tropical depression (TD) south of Japan at 00 UTC on 4 October 2020, and it initially moved northward. It gradually turned west-northwestward and was upgraded to tropical storm (TS) intensity over the same waters at 00 UTC on the next day. Keeping its west-northwestward track, CHAN-HOM was upgraded to typhoon (TY) intensity over the same waters at 06 UTC on 7 October. After turning northward, it reached its peak intensity with maximum sustained winds of 70 kt and a central pressure of 965 hPa southeast of Kyushu Island at 12 UTC on 8 October. After moving eastward over the sea south of Honshu Island, CHAN-HOM moved southeastward and weakened to TD intensity southeast of Hachijojima Island at 18 UTC on 11 October. CHAN-HOM moved southward before remaining almost stationary around 13 October, and it started moving northward early on 14 October. After turning northeastward, it accelerated and transformed into an extratropical cyclone east of Japan by 00 UTC on 17 October. It further moved eastward and finally dissipated south of Aleutians at 12 UTC on 19 October.



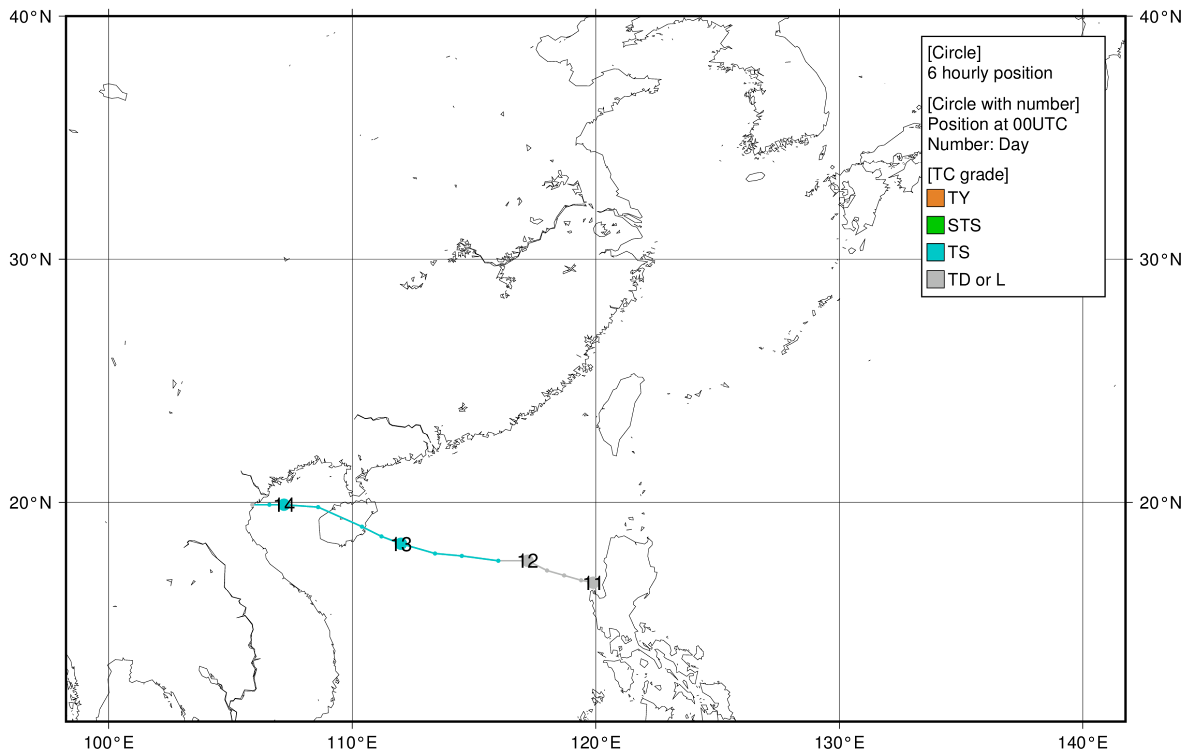
LINFA (2015)

LINFA formed as a tropical depression (TD) east of the Philippines at 18 UTC on 6 October 2020 and moved westward with keeping its intensity for four days. It was upgraded to tropical storm (TS) intensity at 18 UTC on 10 October and reached its peak intensity with maximum sustained winds of 45 kt and a central pressure of 994 hPa off the coast of Viet Nam six hours later. After hitting Viet Nam, LINFA weakened to TD intensity at 12 UTC on 11 October. It dissipated in Cambodia at 12UTC the next day.



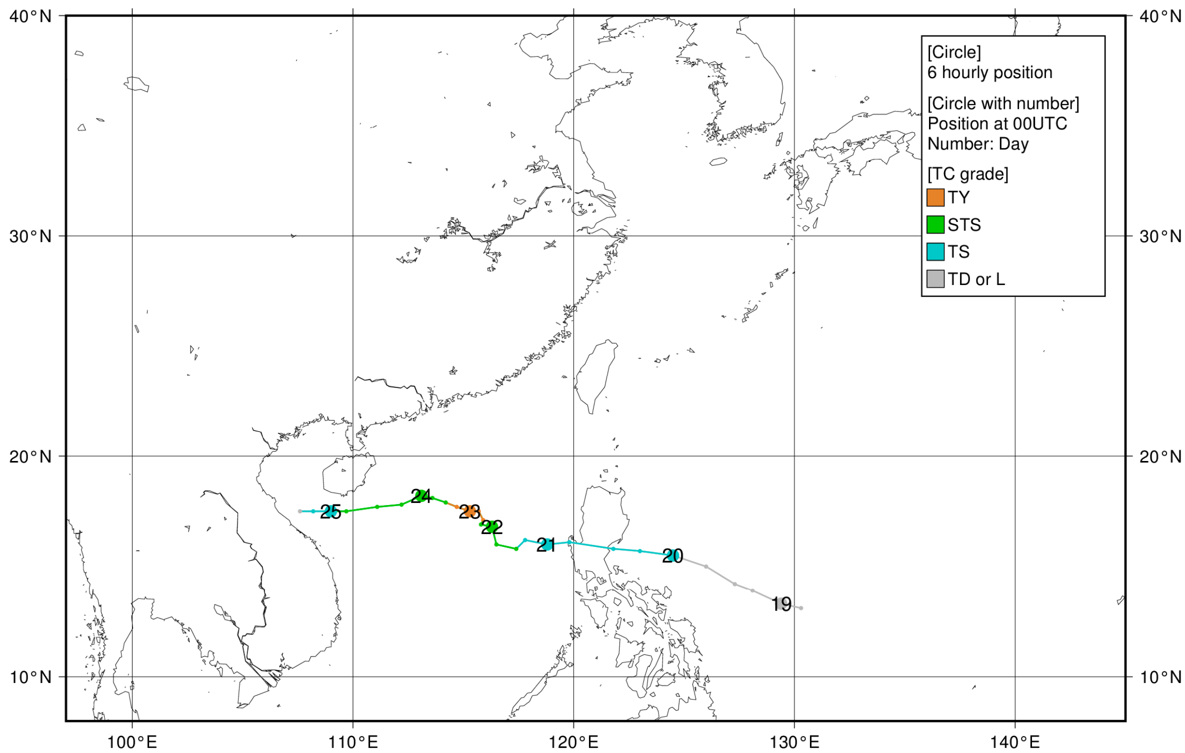
NANGKA (2016)

NANGKA formed as a tropical depression (TD) west of the Philippines at 00 UTC on 11 October 2020. It moved westward and was upgraded to tropical storm (TS) intensity over the South China Sea at 06 UTC on 12 October. NANGKA reached its peak intensity with maximum sustained winds of 45 kt over the same waters at 00 UTC on 13 October. Its central pressure was 992 hPa at 00 UTC on 13 October and lowered to 990 hPa at 12 UTC the same day when it crossed Hainan Island. NANGKA hit Vietnam and weakened to TD intensity at 12 UTC on 14 October and dissipated six hours later.



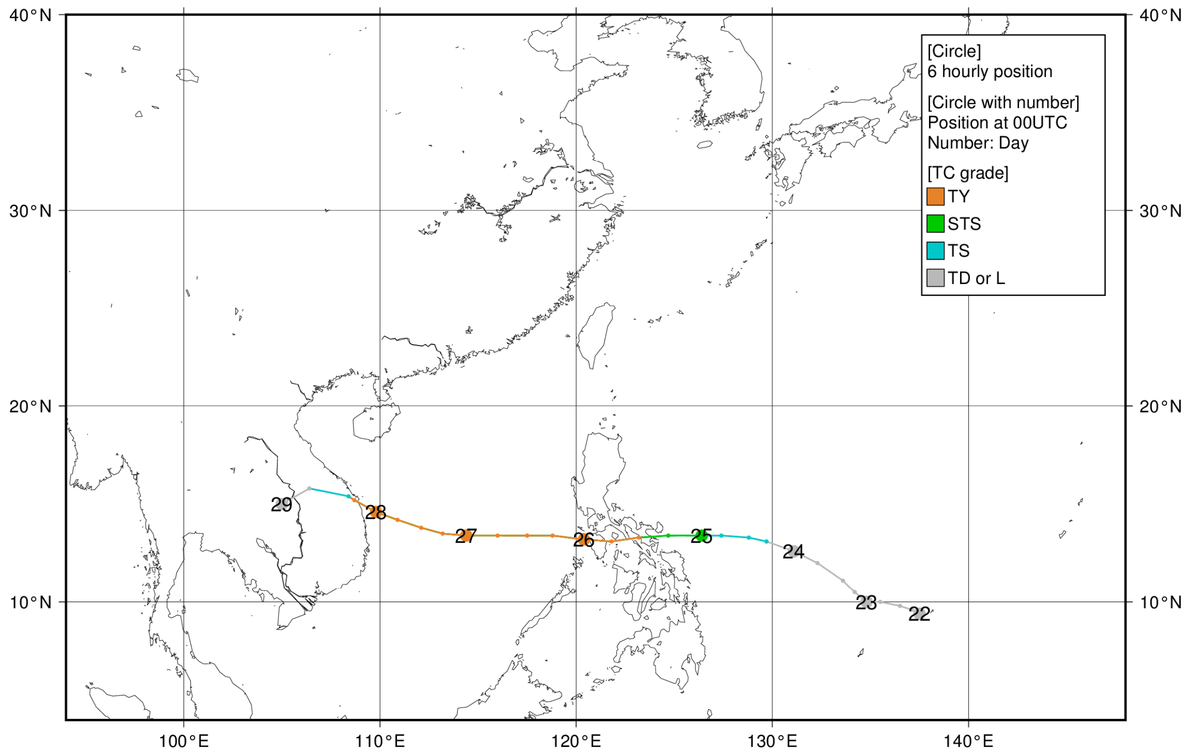
SAUDEL (2017)

SAUDEL formed as a tropical depression (TD) east of the Philippines at 18 UTC on 18 October 2020. It initially moved west-northwestward and was upgraded to tropical storm (TS) intensity at 00 UTC on 20 October. After crossing Luzon Island late on the same day, SAUDEL moved westward and intensified over the South China Sea. It reached its peak intensity with maximum sustained winds of 65 kt and a central pressure of 975 hPa over the same waters at 12 UTC on 22 October. SAUDEL continued to move westward and gradually weakened over the South China Sea. It weakened to TD intensity over the Gulf of Tonkin at 12 UTC on 25 October and dissipated six hours later.



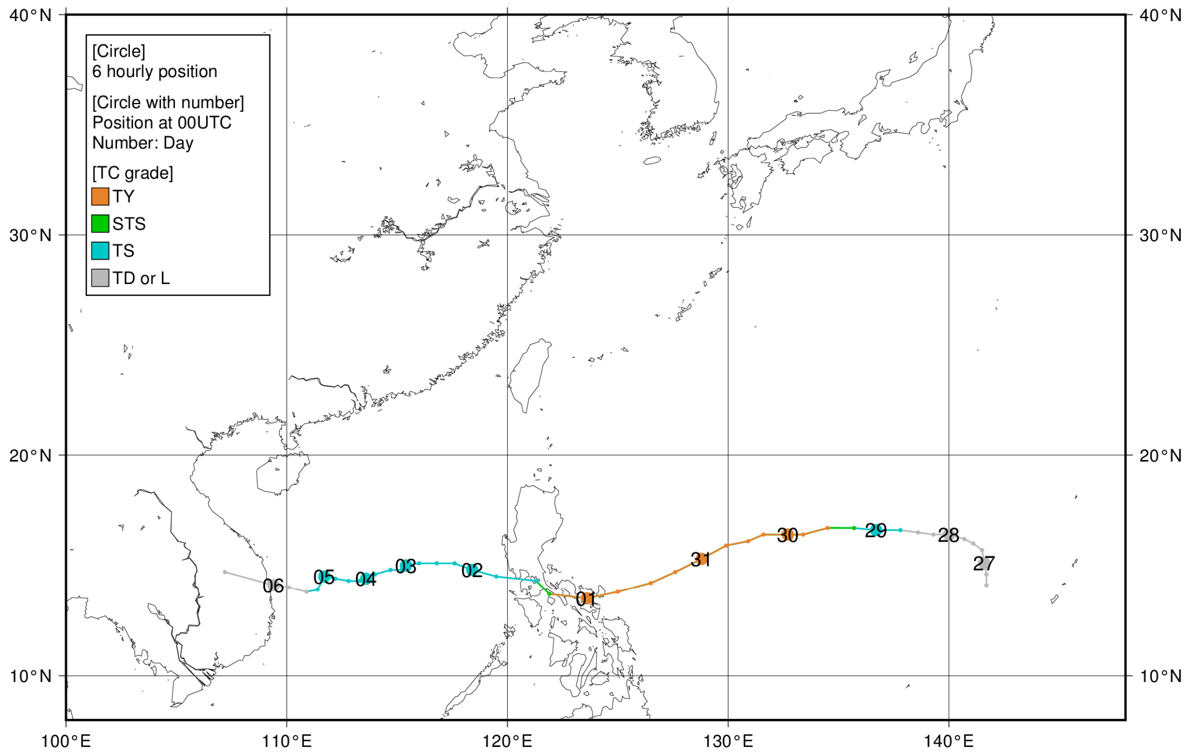
MOLAVE (2018)

MOLAVE formed as a tropical depression (TD) over the sea west of Yap Island at 00 UTC on 22 October 2020, and moved west-northwestward. It was upgraded to tropical storm (TS) intensity east of the Philippines at 06 UTC on 24 October, and turned westward. MOLAVE was upgraded to typhoon (TY) intensity at 12 UTC on 25 October when it was crossing the Philippines. Keeping its westward track, MOLAVE reached its peak intensity with maximum sustained winds of 90 kt and a central pressure of 940 hPa over the South China Sea at 06 UTC on 27 October. Gradually turning west-northwestward, it crossed the coast line of Viet Nam with TY intensity early on 28 October. MOLAVE weakened to TD intensity in Laos at 18 UTC the same day, and dissipated in eastern Thailand 12 hours later.



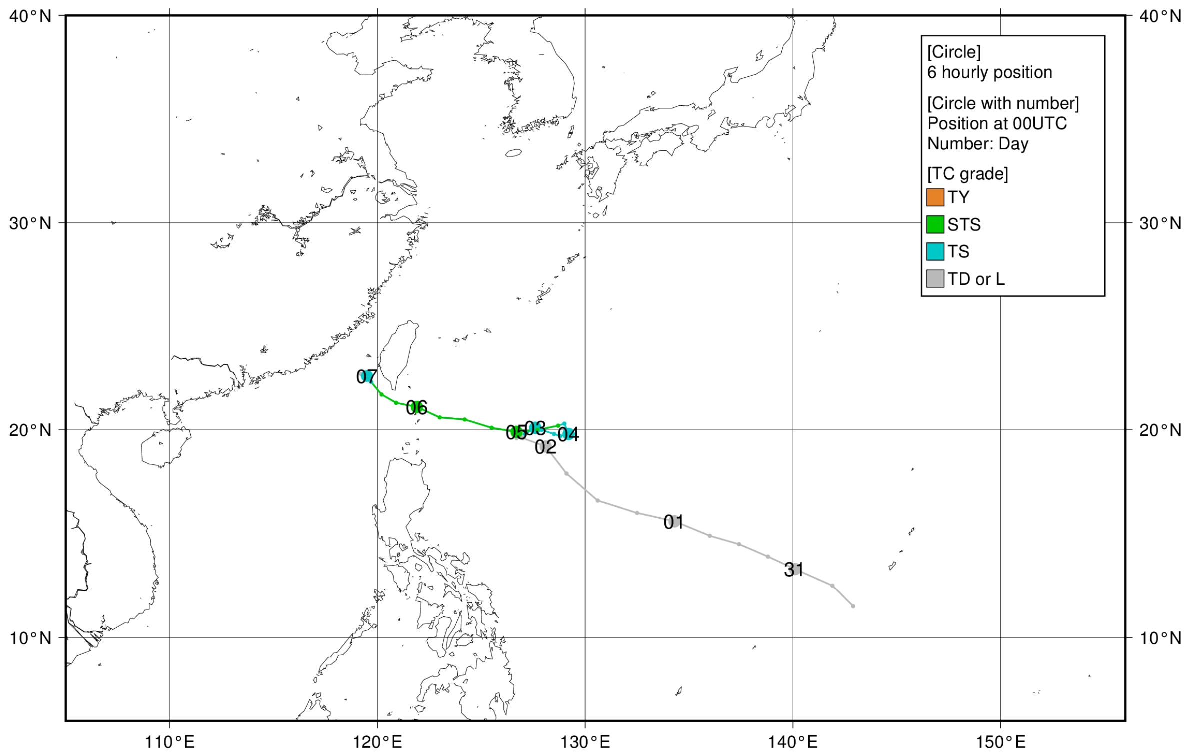
GONI (2019)

GONI formed as a tropical depression (TD) over the sea west of Guam Island at 12 UTC on 26 October 2020 and initially moved northward. After turning westward, it was upgraded to tropical storm (TS) intensity at 18 UTC on 28 October over the sea east of the Philippines and accelerated westward. GONI was upgraded to typhoon (TY) intensity over the same waters at 12 UTC on 29 October. It reached its peak intensity with maximum sustained winds of 120 kt and a central pressure of 905 hPa east of Luzon Island at 18 UTC on 31 October and subsequently crossed the Philippines. Keeping its westward track, GONI weakened to TD intensity over the South China Sea at 12 UTC on 5 November and dissipated in southern Laos at 12 UTC on 6 November.



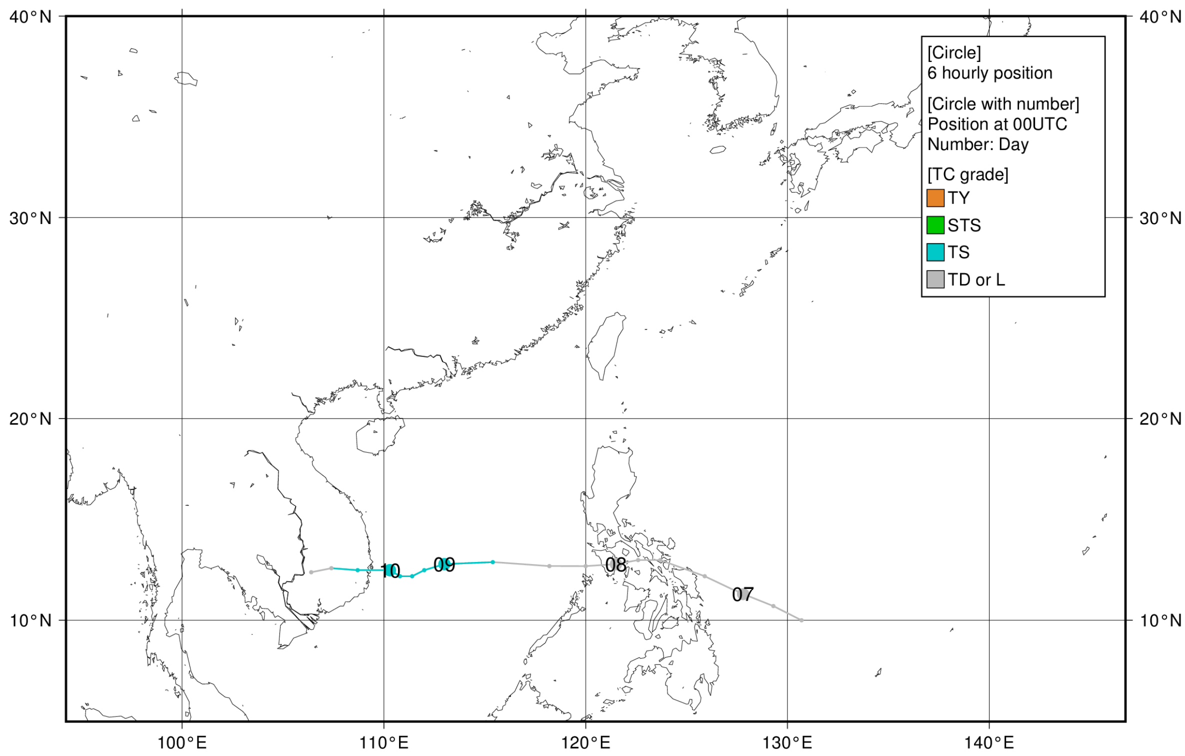
ATSANI (2020)

ATSANI formed as a tropical depression (TD) over the sea southwest of Guam Island at 12 UTC on 30 October 2020 and moved northwestward. On 2 November, it turned sharply east-northeastward over the sea east of the Philippines at 12 UTC and was upgraded to tropical storm (TS) intensity at 18 UTC. The next day, it started to turn in a counterclockwise direction to circle and reached its peak intensity with maximum sustained winds of 50 kt and a central pressure of 992 hPa at 12 UTC on 4 November. After that, ATSANI moved west-northwestward at 12 UTC on 5 November and weakened to TD intensity southwest of Taiwan Island at 06 UTC on 7 November. It dissipated over the same water six hours later.



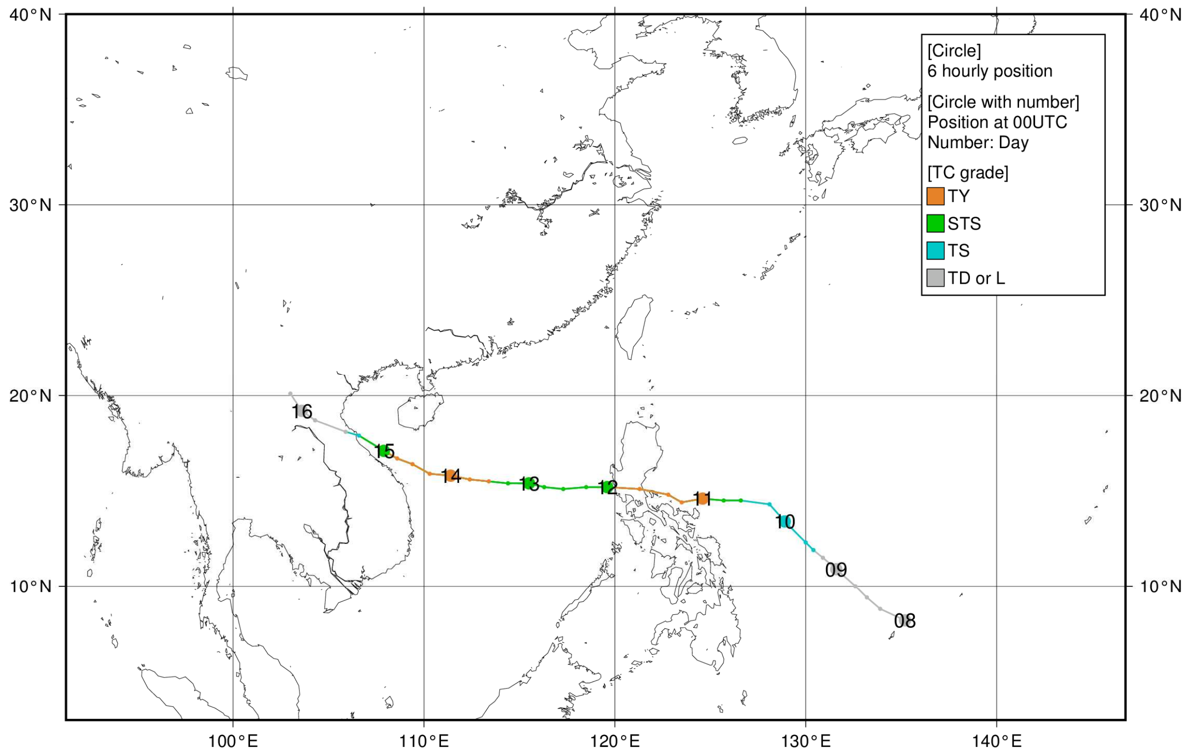
ETAU (2021)

ETAU formed as a tropical depression (TD) east of the Philippines at 12 UTC on 6 November 2020 and moved west-northwestward. After crossing the Philippines, it moved westward and was upgraded to tropical storm (TS) intensity over the South China Sea at 18 UTC on 8 November. ETAU reached its peak intensity with maximum sustained winds of 45 kt and a central pressure of 992 hPa over the same waters at 06 UTC the next day. Keeping its westward track, it hit Viet Nam with TS intensity and weakened to TD intensity at 12 UTC on 10 November. ETAU dissipated in Cambodia at 00 UTC the next day.



VAMCO (2022)

VAMCO formed as a tropical depression (TD) over the western part of the Caroline Islands at 00 UTC on 8 November 2020 and moved northwestward. It was upgraded to tropical storm (TS) intensity east of the Philippines at 12 UTC on 9 November and gradually turned westward. It was upgraded to typhoon (TY) intensity east of Luzon Island at 00 UTC on 11 November and hit the island with TY Intensity late on 11 November. After crossing the island, VAMCO developed again over the South China Sea. It reached its peak intensity with maximum sustained winds of 85 kt and a central pressure of 955 hPa over the same waters at 00 UTC on 14 November. It gradually turned northwestward and rapidly weakened. It hit northern Viet Nam with TS intensity and weakened to TD intensity at 12 UTC on 15 November. It dissipated in Laos at 12 UTC on 16 November.



KROVANH (2023)

KROVANH formed as a tropical depression (TD) off the east coast of Mindanao Island at 00 UTC on 18 December 2020. After crossing the island, it entered the Sulu Sea 18 hours later, and moved westward. After entering the South China Sea, KROVANH was upgraded to tropical storm (TS) intensity west of Palawan Island at 00 UTC on 20 December. It moved west-southwestward while keeping its peak intensity with maximum sustained winds of 35 kt. Its central pressure was 1002 hPa while maintaining TS intensity, except at 06 UTC on 20 December when the pressure temporarily dropped to 1000 hPa. KROVANH weakened to TD intensity south of Viet Nam at 06 UTC on 22 December, and moved further westward. It crossed longitude 100 degree east at 00 UTC on 25 December.