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TYPHOON COMMITTEE OPERATIONAL MANUAL

METEOROLOGICAL COMPONENT

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CONTENTS

Page

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APPENDICES

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CHAPTER 1 GENERAL

1.1 Introduction

Typhoons have always been a major threat to the Typhoon Committee region. As a result, they are a common target for meteorological services in the region to monitor, analyse, forecast and warn against.

Under the spirit of international co-operation, a regional programme to mitigate the damage due to tropical cyclones was launched by the Typhoon Committee which was established in 1968. Since its establishment under the auspices of ESCAP in co-operation with the World Meteorological Organization (WMO), the Typhoon Committee has developed its area of activities to consist of three components, i.e., meteorological, hydrological and disaster prevention and preparedness.

Of these components, the meteorological component aims at improving and upgrading the analysis and forecast used for the routine operation. For this purpose, the Typhoon Committee has arranged a variety of co-operation efforts. One of the epoch-making events in the history of the Committee was the Typhoon Operational Experiment (TOPEX), which was organized for all three components. The third component was specifically organized as Warning Dissemination and Information Exchange Component.

The Meteorological Component of TOPEX had a co-operation programme where concerted efforts were exerted to analyze and forecast specified typhoons using common technical procedures. The procedures were described in the TOPEX Operational Manual which had been utilized in meteorological services in the Typhoon Committee region during the operational phase of TOPEX.

Activities of the Meteorological Component of the Typhoon Committee - including execution of the meteorological component of TOPEX for three years (1981-1983) - had been planned and organized under the Tropical Cyclone Programme (TCP) of the WMO. The main long-term objective of the TCP is to assist Members in upgrading the capabilities of National Meteorological and Hydrological Services (NMHSs) to provide better tropical cyclone, related flood and storm surge forecasts and more effective warnings through regionally coordinated systems, and to encourage Members to establish national disaster prevention and preparedness measures.

As a result of international cooperation and coordination, and with the aid of meteorology and modern technology, such as satellites, weather radars and computers, all tropical cyclones around the globe are now being monitored from their early stages of formation and throughout their lifetime. Six centres designated by WMO as Regional Specialized Meteorological Centres (RSMCs) located in Honolulu, La Reunion, Miami, Nadi (Fiji), New Delhi and Tokyo, as well as other centres of National Meteorological Services (NMSs) carry out these activities. These centres also provide forecasts on the behaviour of tropical cyclones, their movements and changes in intensity and on associated phenomena - principally storm surges and flash floods.

The responsibility of the RSMC Tokyo - Typhoon Center is the provision of information on tropical cyclones for Members of the Typhoon Committee. Information should include formation, movement and development of tropical cyclones and associated meteorological phenomena. In addition, synoptic scale atmospheric situation which affects the behaviour of tropical cyclones should also be prepared by the RSMC Tokyo - Typhoon Center

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and disseminated to National Meteorological Centers (NMCs) in the appropriate format for operational processing. The RSMC Tokyo - Typhoon Center should be operational throughout the year and be manned round the clock when a tropical cyclone exists over the region concerned. The RSMC Tokyo - Typhoon Center should also carry out non-operational functions such as training.

In order to implement the RSMC Tokyo - Typhoon Center in the Typhoon Committee region, the Regional Co-operation Programme was discussed and adopted by the Typhoon Committee at its Extraordinary Session (Manila, March 1986). At the same time, the Committee approved a draft of the Typhoon Committee Operational Manual which specifies in more detail the extent and type of activity of the RSMC Tokyo - Typhoon Center and shows the direction of realizing the regional co-operation between Members.

The Operational Manual consists of the text and the appendices. Items included in the text relate to the Typhoon Committee agreement, in particular, basic information for executing meteorological operation, whilst the appendices contain national practices and procedures (it is felt that the Member concerned should have the right to be able to change without having to get prior formal agreement of the Typhoon Committee) together with detailed and technical information for meteorological operation. Information described in WMO official publications such as Manuals is only referred to and not included in this Manual.

Since March 1986, the draft of the Operational Manual has been revised and is still subject to further refinement and revision through experience gained in the use of the Operational Manual. It is also intended that the text of the Manual be updated or revised from time to time by the Typhoon Committee and that each item of information given in the appendices relating to the Manual be kept up to date by the Members concerned.

1.2 Terminology used in the region

1.2.1 General

Typhoon Committee Members

1.2.2 Classification of tropical cyclones[1]

(i)	Low pressure area	(L)
(ii)	Tropical depression	(TD)
(iii)	Tropical storm	(TS)
(iv)	Severe tropical storm	(STS)
(v)	Typhoon	(TY)

1.2.3 Tropical cyclone characteristics

(i) position of centre
(ii) confidence in the centre position
(iii) size and shape of eye, if any
(iv) central pressure
(v) direction of movement
(vi) speed of movement
(vii) maximum sustained wind
(viii) gusts

[1] Details are shown in 4.2.

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(ix) storm radius
(x) gale radius
(xi) storm surge potential for a particular coastal location
(xii) storm tide potential for a particular coastal location

1.2.4 Terms related to the warning and warning system

(i) typhoon season
(ii) tropical cyclone advisory
(iii) tropical cyclone information bulletin
(iv) gale warning
(v) storm warning
(vi) typhoon warning
(vii) visual storm signals
(viii) high sea bulletin
(ix) coastal weather bulletin
(x) bulletin or cyclone warning bulletin

1.3 Meaning of terms used for regional exchange

Astronomical tide: An Astronomical tide refers to the rise and fall of water due solely to gravitational interactions between the Earth, Moon, and Sun.

Average wind speed: Speed of the wind averaged over the previous 10 minutes (mean surface wind) as read from the anemogram or the 3 minutes mean determined with the non-recording anemometer or wind averaged over the previous 1 minute (mean surface wind) at 10 meter height or estimated wind at sea by mariners using the Beaufort scale.

Bulletin: Cyclone warning bulletin

Central pressure of a tropical cyclone: Surface pressure at the centre of the tropical cyclone as measured or estimated.

Centre fix of the tropical cyclone: The estimated location of the centre of a tropical cyclone.

Centre of the tropical cyclone: The centre of the cloud eye, or if not discernible, of the wind/pressure centre.

Confidence in the centre position: Degree of confidence in the centre position of a tropical cyclone expressed as the radius of the smallest circle within which the centre may be located by the analysis. "Position good" implies a radius of 30 nautical miles (55 kilometres) or less. "Position fair", a radius of 30 to 60 nautical miles (55 to 110 km) and "Position poor", a radius of greater than 60 nautical miles (110 km).

Cyclone: Tropical cyclone

Cyclone warning bulletin: A priority message for exchange of tropical cyclone information and advisories.

Direction of movement of the tropical cyclone: The direction towards which the centre of the tropical cyclone is moving.

Extra-tropical cyclone: A former tropical cyclone that has gone through extra-tropical transition and lost its initial tropical characteristics.

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Extra-tropical transition: is an evolutionary process by which a symmetric warm core tropical cyclone transforms to an asymmetric cold core extratropical cyclone. This process includes a change in the distribution of clouds, winds, and precipitation. Also, the primary energy source changes from latent heat release in deep convective clouds of the tropical cyclone to baroclinic conversion of available potential energy in the extratropical cyclone.

Eye of the tropical cyclone: The relatively clear and calm area inside the circular wall of convective clouds, the geometric centre of which is the centre of the tropical cyclone.

Gale force: Average wind speed in the range of 34 knots (17.2 m/s, 62 km/h) to 47 knots (24.4 m/s, 88 km/h), or wind force 8 or 9 in the Beaufort scale.

Gale-force wind warning: Meteorological message intended to warn those concerned of the occurrence or expected occurrence of gale force wind.

Gust: Instantaneous peak value of surface wind speed.

Hurricane force: Average wind speed of 64 knots (32.7 m/s, 118 km/h) and above, or wind force 12 in the Beaufort scale.

Hurricane-force wind warning: Meteorological message intended to warn those concerned of the occurrence or expected occurrence of hurricane-force wind.

Low pressure area: Region of the atmosphere in which the pressures are lower than those of the surrounding region at the same level. (On the weather map, the low pressure area is denoted with the capital L within the innermost isobar without showing the centre position.)

Maximum sustained wind[2]: Maximum value of the average wind speed at the surface.

Mean wind speed: Average wind speed.

Meteorological tide: A meteorological tide is the rise and fall of water due to wind and fluctuations in atmospheric pressure.

Reconnaissance aircraft centre fix of the tropical cyclone, vortex fix: The location of the centre of a tropical cyclone obtained by reconnaissance aircraft penetration.

Severe tropical storm: A tropical cyclone with the maximum sustained winds at storm force near the centre.

Speed of movement of the tropical cyclone: Speed of movement of the centre of the tropical cyclone.

Storm force: Average wind speed of 48 knots (24.5 m/s, 89 km/h) to 63 knots (32.6 m/s, 117 km/h), or wind force 10 or 11 in the Beaufort scale.

Storm-force wind warning: Meteorological message intended to warn those concerned of the occurrence or expected occurrence of storm force wind.

Storm surge: The difference between the actual water level under the influence of a tropical cyclone or developing disturbance (storm tide) and the level which would have been attained

[2] For converting the wind speeds of different averaging periods such as 1-min, 2-min, 3-min and 10-min, Tropical Cyclone Programme of WMO recommends to follow the guidelines as shown in the Appendix 1-A.

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in the absence of the meteorological disturbance (i.e. astronomical tide). (Storm surge results mainly from the shoreward movement of water under the action of wind stress. A minor contribution is also made by the hydrostatic rise of water resulting from the lowered barometric pressure.)

Storm tide: The actual sea level as influenced by a weather disturbance. The storm tide consists of the normal astronomical tide and the storm surge.

Sub-tropical cyclone: A low pressure system, developing over sub-tropical waters which initially contains few tropical characteristics. With time the sub-tropical cyclone can become tropical.

Sustained wind speed: Average wind speed. Average period of one, three or ten minutes is depending upon the regional practices.

Tropical cyclone: Generic term for a non-frontal synoptic scale cyclone originating over tropical or sub-tropical waters with organized convection and definite cyclonic surface wind circulation. (The term is also used for a storm in the South-West Indian Ocean in which the maximum of the sustained wind speed is estimated to be in the range of 64 to 90 knots and in the South Pacific and South-East Indian Ocean with the maximum of the sustained over 33 knots.)

Tropical cyclone advisory: A priority message for exchanging information, internationally, on tropical cyclones.

Tropical cyclone coastal crossing: Cyclone centre passage across the coast.

Tropical depression: A tropical cyclone with the maximum sustained winds of 33 knots (17.1 m/s, 61 km/h) or less near the centre.

Tropical disturbance: A non-frontal synoptic scale cyclone originating in the tropics or sub-tropics with enhanced convection and light surface winds.

Tropical cyclone impact: Evidence of damage or disruption caused by tropical cyclone-generated hazard(s) either direct or indirect. (includes damaging large swells from distant tropical cyclones).

Tropical cyclone island crossing: Cyclone centre passage across the island.

Tropical cyclone landfall: refer to tropical cyclone coastal crossing.

Tropical storm: A tropical cyclone with the maximum sustained winds at gale force near the centre.

Tropical wave: A trough or cyclonic curvature maximum in the trade wind easterlies or equatorial westerlies. The wave may reach maximum amplitude in the lower middle troposphere, or may be the reflection of an upper-troposphere cold low or equatorial extension of a mid-latitude trough.

Typhoon: A tropical cyclone with the maximum sustained winds at typhoon force near the centre.

Typhoon force: Average wind speed of 64 knots (32.7 m/s, 118 km/h) or more, or wind force 12 in the Beaufort scale.

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Typhoon warning: Meteorological message intended to warn those concerned of the occurrence or expected occurrence of typhoon force wind.

Visual storm signals: Visual signals displayed at coastal points to warn ships of squally winds, gales and tropical cyclones.

Weather warning: Meteorological message issued to provide appropriate warnings or hazardous weather conditions.

Zone of disturbed weather: A zone in which the pressure is low relative to the surrounding region and there are convective cloud masses which are not organized.

1.4 Units used for regional exchange

(a) The following units/indicators are used for marine (WWMIWS) purposes, in accordance with the WMO Manual on Marine Meteorological Services (WMO No.558):

(i) Distance in nautical miles, the unit (nm) being stated;

(ii) Location (position) by degrees and where possible tenths of degrees of latitude and longitude preferably expressed in numbers e.g."12.2S, 168.4E";

(iii) Direction of motion to the nearest sixteen points of the compass or in degree to the nearest ten, given in figures, e.g. "SOUTHSOUTHEAST" or "160 DEGREES";

(iv) Speed (wind speed and speed of movement of tropical cyclones) in knots, the unit (kt) being stated;

(v) Confidence in the centre position in nautical miles (nm) or in position good, fair or poor;

(vi) Pressure in hectopascals (hPa), the unit being stated;

(vii) Time in Coordinated Universal Time (UTC), the unit being stated.

(b) The following units/indicators are used in non-coded segments of exchanges, other than marine bulletins:

(i) Distance in kilometres (km) or nautical miles (nm);

(ii) Location (position) by degrees and tenths of degrees in figures of latitude and longitude and/or bearing on the sixteen point compass and distance from well-known fixed place(s);

(iii) Direction in sixteen points of compass given in figures;

(iv) Speed (wind speed and speed of movement of system) in knots (kt), metres per second (m/s) or kilometres per hour (km/h);

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(v) Confidence in the centre position in kilometres (km), nautical miles (nm) or in position good, fair or poor.

1.5 Identification of tropical cyclones

As soon as the wind speed in a tropical cyclone in the responsible area of the RSMC Tokyo - Typhoon Center (between 0°N and 60°N and between 100°E and 180°E) attains 34 knots, it will be given an identification name with a 4-digit number by the RSMC Tokyo - Typhoon Center. Each tropical cyclone should be identified by one of the names in Appendix 1-B, followed by the 4-digit number in brackets, whose number will consist of a year identification and a serial number identification (in two digits each). For example, the first tropical cyclone attaining the 34 knots threshold value in 2000 in the responsible area of the RSMC Tokyo - Typhoon Center was identified as Damrey (0001). If the life of a tropical cyclone spans across two calendar years, it will be accounted for in the year in which it has intensified to the stage where the wind speed has attained the 34 knots threshold value.

1.6 Acronyms

A list of acronyms used in this Operational Manual is shown in Appendix 1-C.

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CHAPTER 2 OBSERVING SYSTEM AND OBSERVING PROGRAMME

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2.1 Networks of synoptic land stations

The surface and upper-air stations in the regional basic synoptic network are those of the Typhoon Committee Members and are registered in OSCAR/Surface.

The RSMC Tokyo - Typhoon Center and all Typhoon Committee Members should initiate enhanced observation programmes for their stations in the area within 300 km of the centre of a tropical cyclone of TS intensity or higher. All the observations should be made available to the RSMC Tokyo - Typhoon Center and all Members. Enhanced observations should include:

(i) surface observations - hourly;
(ii) buoy observations - hourly;
(iii) radar observations - hourly;
(iv) upper-air observations - 6-hourly.

2.1.1 Surface observations

All surface stations included in the regional basic synoptic network should make surface observations at the four main standard times of observation, i.e., 0000, 0600, 1200 and 1800 UTC, and at the four intermediate standard times of observation, i.e., 0300, 0900, 1500 and 2100 UTC. Any surface station that cannot carry out the full observational programme should give priority to carrying out the observations at the main standard times. Additional surface observations at hourly intervals may be requested by any Member, whenever a tropical cyclone becomes an imminent threat to the Member, from the stations shown in Appendix 2-A.

2.1.2 Upper-air synoptic observations

All the upper-air stations included in the regional basic synoptic network should carry out radiosonde and radiowind observations at 0000 and 1200 UTC, and radiowind/wind profiler observations at 0600 and 1800 UTC. The radiosonde/radiowind observations carried out at 0000 and 1200 UTC should reach the 30 hPa level for more than 50 per cent of the ascents. The carrying out of the radiosonde/radiowind observations at 0000 and 1200 UTC should receive priority over the radiosonde/radiowind/wind profiler observations at 0600 and 1800 UTC.

Upper-air stations in the areas affected by tropical cyclones of TS intensity or higher should also make radiowind observations at 0600 and 1800 UTC which should aim at reaching the 70 hPa level.

Enhanced upper-air observations given in Appendix 2-B will be made as appropriate whenever a tropical cyclone of TS intensity or higher is centred within 300 km of the station. The minimum required is two observations per day, but for a better understanding of the ambient wind field three or even four ascents per day on some days should be made when possible. All data of these enhanced upper-air observations will be distributed among the Members.

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In addition to the upper-air synoptic observations, other upper air wind observations such as wind profiler observations should be carried out when possible and the data should be made available to the Members.

2.2 Ship and buoy observations

Hourly marine meteorological observations are made by the JMA research vessels (call signs of them are: JPBN and JGQH) in the seas adjacent to Japan and in the western North Pacific.

Upper-air observations are usually made twice a day (00, 12UTC) on board the JMA research vessels JPBN and JGQH. Enhanced upper-air observations are carried out six-hourly when the vessel is in the vicinity of a tropical cyclone of TS intensity or higher.

Marine meteorological observations are made by the Voluntary Observing Ships which are recruited by the Members in accordance with the Voluntary Observing Ship Scheme of the Global Ocean Observing System (GOOS). These are generally carried out every six hours and transmitted over the GTS. In addition, marine meteorological observations are reported hourly by on-board automatic weather stations on some of the Voluntary Observing Ships.

Marine meteorological observations, such as air pressure, sea surface temperature, significant wave height and period, are also made by the drifting ocean data buoys by the Members. All reports are coded in the BUFR code (FM-94) with drifting buoys Template (TM315009), and immediately put onto the GTS. A list of the drifting buoy observations by the Members is shown in Appendix 2-C.

2.3 Radar observations

It is essential that radar observations continue as long as a tropical cyclone of TS intensity or higher remains within the detection range of the radar. All meteorological centres should co-operate to ensure that the radar observations are transmitted through the GTS to the RSMC Tokyo - Typhoon Center and all Members. Reports will be coded in the BUFR code (FM-94) with RADOB Template (TM316050) and/or the RADOB code (FM 20-VIII).

In case the report is in plain language, the full range of information available at the radar station should be given. The message will therefore include, where available, the confirmation of the determination of the centre, the shape, definition, size and character tendency of the eye, the distance between the end of the outermost band and the centre of the cyclone and the direction and speed of movement with a statement of the interval of time over which the movement was calculated.

Distribution of the radar stations and detailed information on the radar equipment of the Typhoon Committee Members are given in Appendices 2-D and 2-E.

2.4 Meteorological satellite observations

2.4.1 Satellite imagery data and related products

Satellite imagery data and related products are essential for monitoring and analyzing tropical cyclones. Members which operate satellites are expected to provide those data and/or products to the Members. CMA, JMA and KMA currently operate geostationary meteorological satellites, and have been providing their imagery data and related products to

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the users of the western North Pacific and the South China Sea region to support their operations on tropical cyclones.

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Detailed information on the satellites operated by Typhoon Committee Members is given in Appendix 2-F.

A list of satellite imagery receiving facilities at meteorological centres of the Typhoon Committee Members is given in Appendix 2-G.

2.4.2 SAREP reports

SAREP reports (Part A) are disseminated eight times a day in the following cases from the RSMC Tokyo - Typhoon Center to Typhoon Committee Members through the GTS under the heading of IUCC10 RJTD in the BUFR code (FM 94):

(i) when a tropical cyclone of TS intensity or higher is located in the responsible area of the RSMC Tokyo - Typhoon Center;
(ii) when a tropical depression existing in the responsible area is forecasted to have an intensity of TS or higher within 24 hours; or
(iii) when an area of wind speed of 34 knots or higher caused by a tropical cyclone is forecasted to be in the responsible area within 24 hours.

SAREP reports are also issued by other Typhoon Committee Members. A list of SAREP reports issued by the RSMC Tokyo - Typhoon Center and other Typhoon Committee Members is shown in Appendix 2-H.

2.5 Aircraft observations

States within the ICAO Asia and Pacific Regions exchange reports from aircraft in flight prepared in conformity with ICAO requirements for meteorological reporting (known as air-reports or AIREPs) in accordance with the Regional OPMET Bulletin Exchange (ROBEX) scheme[3].

AIREPs in the north-east Pacific area are also collected by the centres at Honolulu, Washington, etc., and relayed to Tokyo.

AMDAR (Aircraft Meteorological Data Relay) reports are collected by the NMHSs involved in respective AMDAR Programmes and relayed via the GTS to the centre at Tokyo.

All reports will be disseminated in real-time to the RSMC Tokyo - Typhoon Center and to other Members through GTS and AFTN circuits.

The Members conduct reconnaissance flights for selected tropical cyclones. Detailed information of reconnaissance flights conducted by the Members is given in Appendix 2-I.

2.6 Tropical cyclone passage report

Each Member's tropical cyclone forecast center should compile reliable passage, landfall, near station passage, near-buoy passage and near-ship passage data, tabulate that data and send them to the Typhoon Committee Secretariat (TCS) within a week after cyclone

[3] The ICAO Asia Pacific Region ROBEX Handbook describes the ROBEX scheme, which consists of a number of Regional OPMET Centres (ROCs), Regional OPMET Data Banks (RODBs) and Inter-regional OPMET Gateways (IROGs) to deliver to the aviation users the required OPMET information in the form of predefined bulletins.

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passage for distribution to other Members. The task is assigned to the focal point for the meteorological component of each Member. A proposed tropical cyclone passage report form is shown in Appendix 2-J.

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CHAPTER 3 TROPICAL CYCLONE ANALYSIS AND FORECAST

3.1 Analysis at RSMC Tokyo - Typhoon Center

The RSMC Tokyo - Typhoon Center should produce analyses of various meteorological parameters in chart form and/or in grid point value depending on the facilities of NMCs to process these products. These analyses should include pressure distribution at the sea level and temperature, geo-potential height, humidity and wind at selected pressure levels.

The streamline analysis is indispensable over the tropical region for forecasting tropical cyclones. The RSMC Tokyo - Typhoon Center should produce streamline analyses of the upper and lower atmospheric levels utilizing cloud motion wind, aircraft reports, as well as upper-air observations. Furthermore, the RSMC Tokyo - Typhoon Center should issue analyses of ocean wave and sea surface temperature for the western North Pacific. A list of products provided by the RSMC Tokyo - Typhoon Center is given in Appendix 3-A.

The RSMC Tokyo - Typhoon Center should produce additional analyses of the tropical cyclone when it is in the responsible area, based on the enhanced observations. Such analyses should be disseminated in the form of additional bulletins consisting of information on:

(i) position of the tropical cyclone;

(ii) direction and speed of movement;

(iii) central pressure;

(iv) maximum wind and wind distribution.

Various analyses based on Himawari data other than cloud imagery itself should be produced by the RSMC Tokyo - Typhoon Center. Analysis of sea surface temperature combining satellite data and in-situ measurements should be prepared every day. These analyses are useful for the better understanding of the tropical atmosphere and medium-range assessment of forecasting tropical cyclones.

3.2 Forecast at RSMC Tokyo - Typhoon Center

The RSMC Tokyo - Typhoon Center should prepare the products for numerical weather prediction shown in the WMO Manual on the Global Data-Processing and Forecasting System (GDPFS) (WMO-No.485). These products should be made available to Members in real-time, and should include the following:

(i) deterministic forecast products of a high resolution global model to predict the change in large-scale atmospheric circulation patterns as well as the tropical cyclone movement and intensity

(ii) ensemble forecast products using a lower resolution version of the global model to enable estimation of uncertainties in tropical cyclone movement and intensity as

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well as to reduce forecast errors by using statistical methods such as ensemble mean.

The RSMC Tokyo - Typhoon Center should also prepare several statistical models for predicting the track of the tropical cyclone and apply the Dvorak method for the prediction of the intensity change of the tropical cyclone. Other relevant synoptic methods should also be applied for predicting the tropical cyclone.

The RSMC Tokyo - Typhoon Center should summarize in a consolidated form all available information and prepare the final forecasts of the tropical cyclone when it exists in the responsible area. These forecasts should include:

(i) 24, 48, 72, 96 and 120-hour forecast position;

(ii) 24, 48, 72, 96 and 120-hour forecast intensity and wind distribution;

(iii) prognostic reasoning;

(iv) tendency assessment if possible.

Furthermore, the RSMC Tokyo - Typhoon Center should prepare a 24-hour ocean wave forecast twice a day for the western North Pacific. Storm surge products suitable for the Typhoon Committee region should be provided by the RSMC Tokyo - Typhoon Center. A list of forecast products of the RSMC Tokyo - Typhoon Center, other than alphanumeric form, is shown in Appendix 3-A.

3.3 Operational analysis and forecast at centres of Typhoon Committee Members

The NMSs of Typhoon Committee Members are performing analysis and forecasting development and movement of tropical cyclones in the region. The analysis methods, the forecasting methods and NWP systems for forecasting currently used by the NMSs of Typhoon Committee Members are given in Appendix 3-B.

The final responsibility for the operational analysis and forecasting will be with the NMSs of each of the Members.

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CHAPTER 4 TROPICAL CYCLONE WARNINGS AND ADVISORIES

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4.1 General

The responsibility for warning the human settlements on land which are threatened by a tropical cyclone rests in all cases with the NMSs. These national responsibilities are not subject to regional agreement. Therefore, only the cyclone warning systems intended for international users and exchanges among the Typhoon Committee Members are described in this chapter.

4.2 Classification of tropical cyclones[4, 5]

Classifications of tropical cyclones for the exchange of messages among the Typhoon Committee Members are given below:

(i) Low pressure area	(L)	Central position cannot be accurately assessed.
(ii) Tropical depression	(TD)	Central position can be identified, but the maximum sustained wind is 33 kt or less.
(iii) Tropical storm	(TS)	Maximum sustained wind is between 34 and 47 kt.
(iv) Severe tropical storm	(STS)	Maximum sustained wind is between 48 and 63 kt.
(v) Typhoon	(TY)	Maximum sustained wind is 64 kt or more.

4.3 Tropical cyclone advisories

The RSMC Tokyo - Typhoon Center should disseminate six to three-hourly analyses and forecasts of tropical cyclones in the form of bulletins (tropical cyclone advisories - see examples in Appendix 4-B):

(i) analysis of the central position, intensity and wind distribution;

(ii) 24, 48, 72, 96 and 120-hour forecasts of the central position;

(iii) 24, 48, 72, 96 and 120-hour forecasts of intensity and wind distribution;

(iv) prognostic reasoning;

(v) tendency assessment if possible.

4.4 Tropical cyclone warnings for the high seas (WWMIWS)

The IMO/WMO Worldwide Met-Ocean Information and Warning Service (WWMIWS) is the internationally coordinated service for the promulgation of meteorological warnings and forecasts.

[4] "Tropical cyclone" is a generic term that includes tropical depression, tropical storm, severe tropical storm and typhoon.

[5] Classifications internally used by Members are shown in Appendix 4-A.

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The WWMIWS produces marine meteorological maritime safety information messages for issuance on Enhanced Group Call (EGC) satellite systems, NAVTEX and High-frequency Narrow-band Direct Printing (HF NBDP) communication systems covering the following areas:

- warnings and forecasts for the High Seas;
- warnings and forecasts for coastal, offshore and local waters (including ports, lakes and harbour areas).

Operational guidance for handling and formatting meteorological information is given in detail in the Annex VI of the WMO Technical Regulations (Manual on Marine Meteorological Services - WMO-No. 558).

The provision of warnings for weather systems that produce average wind speeds of 34 knots and greater is a mandatory requirement of the WWMIWS.

In relation to international marine requirements, the WWMIWS coordinates the broadcast of forecasts and warnings to vessels at sea through the Global Maritime Distress and Safety System (GMDSS), which includes EGC satellite communications.

As part of the WWMIWS coordination, there are the following types of Centres:

Issuing service means a National Meteorological Service which has accepted responsibility for ensuring that meteorological warnings and forecasts for shipping are disseminated through approved EGC satellite systems to the designated area (METAREA) for which the Service has accepted responsibility under the WWMIWS.

Preparation service means a National Meteorological Service which has accepted responsibility for the preparation of warnings and forecasts for parts of or an entire designated area (METAREA) in the WMO system for the dissemination of meteorological forecasts and warning to shipping under the WWMIWS and for their transfer to the relevant Issuing Service for broadcast.

The METAREA Coordinator is responsible for ensuring that Tropical Cyclone warnings for the WWMIWS in their METAREA are issued onto the appropriate GMDSS communication system.

Areas of responsibility

Members having official responsibility as an Issuing Service within the WWMIWS for issuing warnings on approved EGC satellite systems are Japan and China (METAREA XI).

The pre-assigned forecast areas of Typhoon Committee Members were agreed upon by Regional Associations II and V (Res. 17 (IV-RA II; WMO-181, 1966) and Res.10 (IV-RA V; WMO-187, 1966)). Weather forecast areas fixed nationally by individual Typhoon Committee Members are shown in WMO Publication No. 9, Weather Reporting Volume D - Information for Shipping.

Format and content of bulletins

The format and content of warnings issued for the WWMIWS, as outlined below, has been derived from guidance provided in the Manual on Marine Meteorological Services (WMO No.558).

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Tropical Cyclone warnings for the WWMIWS shall use the following wind warning category labels:

- Gale force wind warning (Beaufort force 8 or 9);
- Storm-force wind warning (Beaufort force 10 or 11);
- Typhoon-force/Hurricane-force wind warning (Beaufort force 12 or over).

Any Tropical Cyclone related wind warning issued for the WWMIWS should include the following content (excluding any relevant system metadata requirements):

(a) Header label for marine radio broadcast purposes ("SECURITE")
Note: This label needs to be visible on any product provided to mariners with the potential to be read out on marine radio systems.

(b) Type of wind warning (GALE-FORCE, STORM-FORCE, TYPHOON-FORCE/HURRICANE-FORCE WIND WARNING)

(c) Name of the issuing centre

(d) Name of the system and name of the basin

(e) Date and time of reference in UTC

(f) Type of disturbance (Tropical cyclone)

(g) Location of disturbance (latitude and longitude)

(h) Central pressure (hPa)

(i) Intensity (maximum 10-minute average winds in knots)

(j) Direction and speed of movement of the disturbance

(k) Extent of affected area in nautical miles

(l) Wind speed (knots) and direction in the affected areas

(m) Sea and swell condition in affected areas (in qualitative terms)

(n) Expected location and intensity at 12 or 24 hour time periods.

(o) Indication of when next warning will be issued.

When no more warnings are to be issued, that fact shall be stated in the bulletins.

The radio stations broadcasting tropical cyclone forecasts and warnings for the benefit of the ships on the high seas in the Typhoon Committee Members are listed in Appendix 4-C, where are shown the names of coastal radio stations with their call signs and the area covered by their bulletins. The details are shown in WMO Publication No. 9, Weather Reporting Volume D - Information for Shipping.

4.5 Tropical cyclone SIGMET and advisory information for international aviation

In accordance with the International Civil Aviation Organization (ICAO) Annex 3 - *Meteorological Service for International Air Navigation*/WMO Technical Regulations, Volume II: Meteorological Service for International Air Navigation (WMO-No. 49 Vol. 2), SIGMET is

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information issued by a (designated) meteorological watch office (MWO) concerning the occurrence or expected occurrence of specified en-route weather and other phenomena in the atmosphere (including tropical cyclone) that may affect the safety of aircraft operations and of the development of those phenomena in time and space.

Each designated MWO is required to maintain continuous watch over meteorological conditions affecting flight operations within one or more designated flight information regions (FIRs) and prepare, supply and disseminate SIGMET information (including for tropical cyclone as necessary) relating to its designated area of responsibility. Each designated MWO should coordinate SIGMET with neighbouring MWO(s), especially when the en-route weather phenomenon extends or is expected to extend beyond the MWO's specified area of responsibility, in order to ensure harmonized SIGMET provision. The ICAO Asia and Pacific Regions Air Navigation Plan (APAC ANP) describes the FIRs in the Asia and Pacific Regions and lists the designated MWOs and the requirements for the issuance of SIGMET information (including for tropical cyclone).

SIGMET information (for tropical cyclone) shall be prepared, formatted and disseminated in accordance with ICAO Annex 3/WMO-No. 49 Vol. 2 and should be based on advisory information provided by Tropical Cyclone Advisory Centres (TCACs) designated by regional air navigation agreement. The data type designator to be used in the WMO abbreviated heading of such messages shall be T1T2 = WC (WMO-No. 386, Manual on GTS refers).

In accordance with ICAO Annex 3/WMO-No. 49 Vol. 2 and the ICAO Asia and Pacific Regions Air Navigation Plan, the designated TCAC Tokyo shall:

a) monitor the development of tropical cyclones in its area of responsibility;

b) issue advisory information concerning the position of the cyclone centre, its direction and speed of movement, changes in intensity at time of observation, central pressure and maximum surface wind near the centre, in abbreviated plain language to:

   1) MWOs in its area of responsibility;

   2) other TCACs whose areas of responsibility may be affected; and

   3) World Area Forecast Centres (WAFCs) [London and Washington], and international OPMET databanks; and

c) issue updated advisory information to MWOs for each tropical cyclone, as necessary, but at least every six hours.

The tropical cyclone advisory information shall be prepared, formatted and disseminated in accordance with the technical specifications and detailed criteria in ICAO Annex 3/WMO-No. 49 Vol. 2. The data type designator to be used in the WMO abbreviated heading of such messages shall be T1T2 = FK (WMO-No. 386, Manual on GTS, refers).

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CHAPTER 5 TELECOMMUNICATIONS

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5.1 General

The basic meteorological telecommunication network for the exchange of forecasts, warnings and observational data will be the Global Telecommunication System (GTS).

Note: With respect to meteorological service for international air navigation (as described in sections 2.5 and 4.5), the telecommunications facilities used for the exchange of operational meteorological information should be the aeronautical fixed service (AFS)[6].

5.2 Dissemination of data and products

The RSMC Tokyo - Typhoon Center should have adequate telecommunication facilities for the real-time collection and dissemination of data and products. A large amount of grid point data produced at the RSMC Tokyo - Typhoon Center should be exchanged between the RSMC Tokyo - Typhoon Center and NMCs where adequate circuits for this purpose exist, such as GTS and Internet.

Conventional radio facsimile broadcasts are widely used in the region, though they have some disadvantages, i.e., it takes a long time to transmit a number of charts and received charts are sometimes distorted due to noises. Nevertheless, facsimile broadcasts and reception facilities shall be retained in full operation until telecommunications via satellite is introduced to transmit products both in chart and in grid point value form.

5.3 Schedule for exchange of cyclone advisories

Tropical cyclone advisories issued by the RSMC Tokyo - Typhoon Center shall be transmitted at intervals of six to three hours. These messages shall be given high priority.

5.4 Meteorological telecommunication network for the Typhoon Committee region

The network is shown in Appendix 5-A and its present status is summarized in Appendix 5-B.

5.5 Addresses, telex/cable and telephone numbers of the tropical cyclone warning centres

A list of addresses of the tropical cyclone warning centres of the Typhoon Committee Members, together with their telex/cable and telephone numbers and e-mail addresses, is given in Appendix 5-C.

5.6 Abbreviated headings of tropical cyclone advisories and warnings

The abbreviated headings of meteorological messages containing tropical cyclone advisories issued by the RSMC Tokyo - Typhoon Center shall be:

(i) prognostic reasoning - WTPQ30 RJTD through WTPQ35 RJTD;

[6] The AFS is comprised of a number of systems and applications that are used for ground-ground (i.e. point-to-point and/or point-to-multipoint) communications in the international aeronautical telecommunication service. In accordance with the ROBEX scheme, the (AFS) systems used to disseminate SIGMET/tropical cyclone advisory information and air-reports include the aeronautical fixed telecommunications network (AFTN) and the air traffic services message handling system (AMHS).

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(ii) analysis and five-day forecast - WTPQ50 RJTD through WTPQ55 RJTD;

(iii) numerical prediction by global deterministic model - FXPQ20 RJTD through FXPQ25 RJTD;

(iv) numerical prediction by global ensemble model - FXPQ30 RJTD through FXPQ35 RJTD.

The abbreviated headings of meteorological bulletins used for the exchange of tropical cyclone warnings by the Typhoon Committee Members are given in Appendix 5-D.

5.7 Exchange of information related to tropical cyclones

Collection and dissemination of observational and processed data plus warnings related to tropical cyclones at Regional Telecommunication Hubs (RTHs) and NMCs are summarized in Appendix 5-E.

The meanings of the symbols used in abbreviated headings in the meteorological messages transmitted to the GTS are listed in Appendix 5-F. The details are described in the Manual on the Global Telecommunication System (WMO Publication No. 386) and Weather Reporting Volume C - Transmissions, Chapter I Catalogue of Meteorological Bulletins (WMO Publication No. 9).

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CHAPTER 6 MONITORING AND QUALITY CONTROL OF DATA

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6.1 Quality control of observational data

NMCs will make additional efforts to ensure that all observational data disseminated during periods of cyclone threat to the area are specifically free from errors. Wherever appropriate, verification of reports or of elements of reports will be requested of the observing station and communication channels will be kept open to facilitate this, particularly in cases where an enhanced observing programme is being carried out.

In the exchange of data during periods of cyclone threat, queries concerning reports on which there is doubt should be addressed to the relevant NMC.

Examples of message format for inquiry on doubtful and garbled reports are shown in Appendix 6-A.

6.2 Monitoring of exchange of information

Monitoring will be carried out by the RSMC Tokyo - Typhoon Center and all Typhoon Committee Members in accordance with their standard procedures. Special attention will be given to identification of deficiencies during the cyclone season in the flow of observational data and processed information relating to cyclone analysis and forecast with a view to appropriate remedial action.

The Members will inform the RSMC Tokyo - Typhoon Center of any shortcomings in the flow of data (raw and processed) and also indicate any requirements over and above those already agreed upon for tropical cyclone warning purposes.

Regular monitoring at the RSMC Tokyo - Typhoon Center should be made twice a year for appropriate periods when enhanced observations are carried out. Special monitoring may be made depending on the situation.

The procedure of regular monitoring is shown in Appendix 6-B.

6.3 Verification

Immediately after the dissipation of a tropical cyclone of TS grade or stronger, the RSMC Tokyo - Typhoon Center should disseminate a report on the tropical cyclone in the form of bulletins to provide Members with data needed for verification, such as position and intensity of the tropical cyclone (see the example in Appendix 6-C):

After the end of each typhoon season, each Member will conduct the verification for its analyses and forecasts and send the report to the RSMC Tokyo - Typhoon Center in accordance with the standard procedure as shown in Appendix 6-D. Verification sheets for positioning of the centre, prediction of movement, and analysis and forecast of intensity of a tropical cyclone are shown in Appendix 6-E.

The RSMC Tokyo - Typhoon Center should summarize the reports issued in a year and the results of verification conducted by Members. It should publish an annual report with respect to tropical cyclones and activities of the RSMC Tokyo - Typhoon Center and Members. The report should also identify specific areas where further co-operative research needs to be carried out by Members.

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CHAPTER 7 ARCHIVAL OF DATA

7.1 Data to be archived by Typhoon Committee Members

Members should establish tropical cyclone data files and information services nationally, archiving all appropriate available data.

7.2 Data to be archived by RSMC Tokyo - Typhoon Center

The RSMC Tokyo - Typhoon Center should archive as far as possible tropical cyclone related data received at the centre. The data set should be produced during the period when tropical cyclone(s) is (are) in the range of 1,000 km around Typhoon Committee Members. Except for satellite imagery data, all data should be recorded by the RSMC Tokyo - Typhoon Center preferably on electronic media. A proposed list of data to be archived by the RSMC Tokyo - Typhoon Center is shown in Appendix 7-A.

7.3 Exchange of archived data

Whenever possible Members should supply the RSMC Tokyo - Typhoon Center with all additional data requested by the RSMC Tokyo - Typhoon Center. The RSMC Tokyo - Typhoon Center should make available the archived data to Members on request for use in research, studies, investigations and training. As to distribution, similar arrangements should be made as for the TOPEX data sets which were provided by the Japan Meteorological Agency to Typhoon Committee Members (one set each) with financial assistance from UNDP. The detailed arrangements for exchange of data should be agreed upon bilaterally. Request for data sets by non-Typhoon Committee Members should be made through the WMO Secretariat upon payment of net cost (for electronic media, copying, handling, postal fees, etc.) by the requesting WMO Members.

In accordance with the directive of the WMO Executive Council (EC-XLV), (Geneva, June 1993) an international format for the archiving of tropical cyclone data is to be used by all RSMCs with activity specialization in tropical cyclones.

Complete historical data using the international format given in Appendix 7-B will be made available for research applications. RSMC Tokyo - Typhoon Center will provide such data to the Director of the National Climatic Data Center (NCDC), USA.

The WMO Secretariat has the responsibility for the maintenance of the format, including assignment of the source codes to appropriate organizations, and authorizing additions and changes.

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CHAPTER 8 CAPACITY DEVELOPMENT

8.1 Tropical Cyclone Forecast Competency in the Typhoon Committee Region

Tropical Cyclone Forecast Competency in the Typhoon Committee Region is shown in Appendix 8-A.

8.2 Capacity development activities conducted by RSMC Tokyo - Typhoon Center

The RSMC Tokyo - Typhoon Center should carry out capacity development activities in accordance with the Tropical Cyclone Forecast Competency in the Typhoon Committee Region.

8.3 Capacity development activities conducted by Members

Members should establish and maintain capacity development strategy and conduct necessary training activities or give opportunities to participate in activities conducted by other centers, to develop, maintain and enhance capacity of staff members for tropical cyclone analysis, forecast and related activities, in accordance with the Tropical Cyclone Forecast Competency in the Typhoon Committee Region.

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APPENDICES

APPENDIX 1-A

GUIDELINES FOR CONVERTING BETWEEN VARIOUS WIND AVERAGING PERIODS IN TROPICAL CYCLONE CONDITIONS

This note is based on recommendations from Harper et al. (2010) and extracts from Knaff and Harper (2010), providing advice on why, when and how "wind averaging conversions" can be made.

a) Why Convert Wind Speeds?

From the observational perspective, the aim is to process measurements of the wind so as to extract an estimate of the **mean** wind at any time and its **turbulence** properties. From the forecasting viewpoint, the aim is, given a specific wind speed metric derived from a process or product, to usefully predict other metrics of the wind. Typically, these needs revolve around the concept of the mean wind speed and an associated peak gust wind speed; such that the statistical properties of the expected level of wind turbulence under **different exposures** can be used to permit useful conversions **between peak gust wind speed** estimates.

b) When to Convert Wind Speeds?

Wind speed conversions to account for varying averaging periods only apply in the context of a maximum (peak gust) wind speed of a given duration observed within some longer interval. Simply measuring the wind for a shorter period of time at random will not ensure that it is always higher than the mean wind (given that there are both lulls and gusts). It is important that all wind speed values be correctly identified as an estimate of the **mean wind** or an estimate of a **peak gust**.

Once the mean wind is reliably estimated, the random effects of turbulence in producing higher but shorter-acting wind gusts, typically of greater significance for causing damage, can be estimated using a "gust factor". In order for a gust factor to be representative, certain conditions must be met, many of which may not be exactly satisfied during a specific weather event or at a specific location:

- Wind flow is turbulent with a steady mean wind speed (**statistically stationary**);
- Constant surface features exist within the period of measurement, such that the boundary layer is in equilibrium with the underlying surface roughness (**exposure**);
- The conversion assumes the mean wind speed and the peak gust wind speed are at the same **height** (e.g. the WMO standard observation height +10 m) above the surface.

c) How to Convert Individual Point-Specific Wind Speeds

Firstly, the mean wind speed estimate V should be explicitly identified by its averaging period T_o in seconds, described here as V_{To}, e.g.

V_{600} is a 10-min averaged mean wind estimate;
V_{60} is a 1-min averaged mean wind estimate;
V_3 is a 3-sec averaged mean wind estimate.

Next, a peak gust wind speed should be additionally prefixed by the gust averaging period τ, and the time period over which it is observed (also termed the **reference period**), described here as $V_{\tau,To}$, e.g.

$V_{60,600}$ is the highest 1-min mean (peak 1-min gust) within a 10-min observation period;
$V_{3,60}$ is the highest 3-sec mean (peak 3-sec gust) within a 1-min observation period.

The "gust factor" $G_{\tau,To}$ then relates as follows to the mean and the peak gust:

$$V_{\tau,To} = G_{\tau,To} V ,$$

where the (true) mean wind V is estimated on the basis of a suitable sample, e.g. V_{600} or V_{3600}.

On this basis, Table 1 provides the recommended near-surface (+10 m) conversion factors $G_{\tau,To}$ between typical peak gust wind averaging periods, which are a strong function of the exposure class because the turbulence level

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varies depending on the surface roughness. Table 1 only provides a range of indicative exposures for typical forecasting environments and Harper et al. (2010) or WMO (2008) should be consulted for more specific advice regarding particular types of exposures - especially if it is intended to calibrate specific measurement sites to "standard exposure".

Table 1 Wind speed conversion factors for tropical cyclone conditions (after Harper et al. 2010).

Exposure at +10 m		Reference Period	Gust Factor $G_{\tau,To}$				
Class	Description		*Gust Duration* τ (s)				
		T_o (s)	*3*	*60*	*120*	*180*	*600*
In-Land	Roughly open terrain	3600	1.75	1.28	1.19	1.15	1.08
		600	1.66	1.21	1.12	1.09	1.00
		180	1.58	1.15	1.07	1.00	
		120	1.55	1.13	1.00		
		60	1.49	1.00			
Off-Land	Offshore winds at a coastline	3600	1.60	1.22	1.15	1.12	1.06
		600	1.52	1.16	1.09	1.06	1.00
		180	1.44	1.10	1.04	1.00	
		120	1.42	1.08	1.00		
		60	1.36	1.00			
Off-Sea	Onshore winds at a coastline	3600	1.45	1.17	1.11	1.09	1.05
		600	1.38	1.11	1.05	1.03	1.00
		180	1.31	1.05	1.00	1.00	
		120	1.28	1.03	1.00		
		60	1.23	1.00			
At-Sea	> 20 km offshore	3600	1.30	1.11	1.07	1.06	1.03
		600	1.23	1.05	1.02	1.00	1.00
		180	1.17	1.00	1.00	1.00	
		120	1.15	1.00	1.00		
		60	1.11	1.00			

Some example applications of the above recommendations are:

- To estimate the expected "off-land" 3-sec peak gust in a 1-min period, multiply the estimated "off-land" mean wind speed by 1.36
- To estimate the expected "off-sea" 3-sec peak gust in a 10-min period, multiply the estimated "off-sea" mean wind speed by 1.38
- To estimate an "at-sea" 1-min peak gust in a 10-min period, multiply the estimated "at-sea" mean wind speed by 1.05

Note that it is not possible to convert from a peak gust wind speed back to a **specific** time-averaged mean wind - only to the **estimated true mean** speed. Hence to estimate the "off-sea" mean wind speed given only a peak observed gust of 1-min duration (τ = 60 s) measured in a 10-min period (T_o = 600 s), multiply the observed 1-min peak gust by (1/1.11) = 0.90. This does not guarantee that the estimated mean wind will be the same as the 10-min averaged wind at that time but, because the 10-min average is normally a reliable estimate of the true mean wind, it will likely be similar. In all cases, measurement systems should aim to reliably measure the mean wind speed and the standard deviation using a sample duration of not less than 10-min (WMO 2008), i.e. V_{600}. Additional shorter averaging periods and the retaining of peak information should then be targeted at operational needs.

d) Converting Between Agency Estimates of Storm Maximum Wind Speed V_{max}

This is a slightly different situation from converting a point specific wind estimate because the concept of a storm-wide maximum wind speed V_{max} is a metric with an associated spatial context (i.e. anywhere within or associated with the storm) as well as a temporal fix context (at this moment in time or during a specific period of time). While it may be expressed in terms of any wind averaging period it remains important that it be unambiguous in terms of representing a mean wind or a peak gust. Agencies that apply the WMO standard 10-min averaged V_{max} wind have

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always applied a wind-averaging conversion to reduce the maximum "sustained" 1-min wind value (a 1-min peak gust) that has been traditionally associated with the Dvorak method (Dvorak 1984, Atkinson and Holliday 1977)[7]. As noted in the previous section, it is technically not possible to convert from a peak gust back to a specific time-averaged mean wind - only to the estimated true mean wind speed. However, in Harper et al. (2010) a practical argument is made for nominal conversion between $V_{max,60}$ and $V_{max,600}$ values via an hourly mean wind speed reference, and the recommendations are summarised in Table 2.

It can be noted that the recommended conversion for at-sea exposure is about 5% higher than the "traditional" value of 0.88 (WMO 1993), which is more appropriate to an off-land exposure. This has special implications for the Dvorak method because "at sea" is the typical exposure of interest where such conversions have been traditionally applied.

Table 2 Conversion factors between agency estimates of maximum 1-min and maximum 10-min averaged tropical cyclone wind speed V_{max}. (after Harper et al. 2010).

$V_{max,600}=K\ V_{max,60}$	At-Sea	Off-Sea	Off-land	In-Land
K	0.93	0.90	0.87	0.84

e) References

Atkinson, G.D., and C. R. Holliday, 1977: Tropical cyclone minimum sea level pressure/maximum sustained wind relationship for the Western North Pacific. *Mon. Wea. Rev.,* **105**, 421-427.

Dvorak, V.F., 1984: Tropical cyclone intensity analysis using satellite data. NOAA Tech. Rep. NESDIS 11, *National Oceanic and Atmospheric Administration*, Washington, DC, 47 pp.

Knaff, J.A. and B.A. Harper, 2010: Tropical cyclone surface wind structure and wind-pressure relationships. In: Proc. WMO IWTC-VII, *World Meteorological Organization*, Keynote 1, La Reunion, Nov.

Harper, B.A., J. D. Kepert, and J. D. Ginger, 2010: Guidelines for converting between various wind averaging periods in tropical cyclone conditions. *World Meteorological Organization*, TCP Sub-Project Report, WMO/TD-No. 1555.

WMO 1993: Global guide to tropical cyclone forecasting. Tropical Cyclone Programme Report No. TCP-31, *World Meteorological Organization*, WMO/TD - No. 560, Geneva.

WMO 2008: Guide to meteorological instruments and methods of observation. *World Meteorological Organization*, WMO-No. 8, 7th Ed, 681pp.

[7] As detailed in Harper et al. (2010), this traditional assumption is without a firm basis.

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APPENDIX 1-B

LIST OF NAMES FOR TROPICAL CYCLONES ADOPTED BY THE TYPHOON COMMITTEE FOR THE WESTERN NORTH PACIFIC OCEAN AND THE SOUTH CHINA SEA

(Valid as of 2022)

Contributed by	I	II	III	IV	V
	Name	Name	Name	Name	Name
Cambodia	Damrey	Kong-rey	Nakri	Krovanh	Trases
China	Haikui	Yinxing	Fengshen	Dujuan	Mulan
DPR Korea	Kirogi	Toraji	Kalmaegi	Surigae	Meari
Hong Kong, China	Yun-yeung	Man-yi	Fung-wong	Choi-wan	Ma-on
Japan	Koinu	Usagi	Koto	Koguma	Tokage
Lao PDR	Bolaven	Pabuk	Nokaen	Champi	Hinnamnor
Macao, China	Sanba	Wutip	Penha	In-fa	Muifa
Malaysia	Jelawat	Sepat	Nuri	Cempaka	Merbok
Micronesia	Ewiniar	Mun	Sinlaku	Nepartak	Nanmadol
Philippines	Maliksi	Danas	Hagupit	Lupit	Talas
RO Korea	Gaemi	Nari	Jangmi	Mirinae	Noru
Thailand	Prapiroon	Wipha	Mekkhala	Nida	Kulap
U.S.A.	Maria	Francisco	Higos	Omais	Roke
Viet Nam	Son-Tinh	Co-May	Bavi	Conson	Sonca
Cambodia	Ampil	Krosa	Maysak	Chanthu	Nesat
China	Wukong	Bailu	Haishen	Dianmu	Haitang
DPR Korea	Jongdari	Podul	Noul	Mindulle	Nalgae
Hong Kong, China	Shanshan	Lingling	Dolphin	Lionrock	Banyan
Japan	Yagi	Kajiki	Kujira	Kompasu	Yamaneko
Lao PDR	Leepi	Nongfa	Chan-hom	Namtheun	Pakhar
Macao, China	Bebinca	Peipah	Peilou	Malou	Sanvu
Malaysia	Pulasan	Tapah	Nangka	Nyatoh	Mawar
Micronesia	Soulik	Mitag	Saudel	Rai	Guchol
Philippines	Cimaron	Ragasa	Narra	Malakas	Talim
RO Korea	Jebi	Neoguri	Gaenari	Megi	Doksuri
Thailand	Krathon	Bualoi	Atsani	Chaba	Khanun
U.S.A.	Barijat	Matmo	Etau	Aere	Lan
Viet Nam	Trami	Halong	Bang-Lang	Songda	Saola

Replaced names

Aere	for	Kodo	(2002)	Atsani	for	Morakot	(2011)	Yamaneko	for	Hato	(2019)
Morakot	for	Hanuman	(2002)	Champi	for	Ketsana	(2011)	Yun-yeung	for	Kai-tak	(2019)
Matmo	for	Chataan	(2004)	In-fa	for	Parma	(2011)	Koinu	for	Tembin	(2019)
Nuri	for	Rusa	(2004)	Rai	for	Fanapi	(2012)	Pulasan	for	Rumbia	(2020)
Peipah	for	Vamei	(2004)	Hato	for	Washi	(2013)	Krathon	for	Mangkhut	(2020)
Molave	for	Imbudo	(2004)	Ampil	for	Bopha	(2014)	Yinxing	for	Yutu	(2021)
Noul	for	Pongsona	(2006)	Jongdari	for	Sonamu	(2015)	Co-May	for	Lekima	(2021)
Dolphin	for	Yanyan	(2006)	Barijat	for	Utor	(2015)	Nongfa	for	Faxai	(2021)
Mujigae	for	Maemi	(2006)	Mun	for	Fitow	(2015)	Ragasa	for	Hagibis	(2021)
Mirinae	for	Sudal	(2006)	Bailu	for	Haiyan	(2015)	Koto	for	Kammuri	(2021)
Lionrock	for	Tingting	(2006)	Lan	for	Vicente	(2015)	Nokaen	for	Phanfone	(2021)
Fanapi	for	Rananim	(2006)	Bualoi	for	Rammasun	(2016)	Penha	for	Vongfong	(2022)
Pakhar	for	Matsa	(2007)	Saudel	for	Soudelor	(2017)	Peilou	for	Linfa	(2022)
Doksuri	for	Nabi	(2007)	Surigae	for	Mujigae	(2017)	Narra	for	Molave	(2022)
Haikui	for	Longwang	(2007)	Koguma	for	Koppu	(2017)	Gaenari	for	Goni	(2022)
Sanba	for	Chanchu	(2008)	Cempaka	for	Melor	(2017)	Bang-Lang	for	Vamco	(2022)

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Maliksi	for	Bilis	(2008)	Nyatoh	for	Meranti	(2018)				
SonTinh	for	Saomai	(2008)	Trases	for	Sarika	(2018)				
Leepi	for	Xangsane	(2008)	Mulan	for	Haima	(2018)				
Mangkhut	for	Durian	(2008)	Hinnamnor	for	Nock-ten	(2018)				

Corrected spelling

Megkhla	to	Mekkhala	(2002)	Kaemi	to	Gaemi	(2008)	Koni	to	Goni	(2008)
Kularb	to	Kulap	(2002)	Chebi	to	Jebi	(2008)	SonTinh	to	Son-Tinh	(2008)
Ramasoon	to	Rammasun	(2002)	Noguri	to	Neoguri	(2008)				
Vipa	to	Wipha	(2002)	Changmi	to	Jangmi	(2008)				

OPERATIONAL PROCEDURES FOR THE ASSIGNMENT OF NAMES OF TROPICAL CYCLONES

(a) RSMC Tokyo - Typhoon Center will assign a name each time a 4-digit identification number is to be assigned. That is, names on the Typhoon Committee list will only be given to tropical cyclones of tropical storm strength or above. Each tropical cyclone should be identified by its name followed by the 4-digit number in brackets. The same names and numbers should also be used in bulletins issued by the Tokyo Tropical Cyclone Advisory Centre under the umbrella of the International Civil Aviation Organization (ICAO) as well as in bulletins for Meteorological Area (METAREA)-XI of the IMO/WMO Worldwide Met-Ocean Information and Warning Service (WWMIWS), issued by both China and Japan. This would contribute to the standardization of the usage of names of tropical cyclones as was desired by the Typhoon Committee.

(b) The exchange of observational data should be promoted as much as possible in addition to what is already exchanged among the warning centres and the meteorological services in the region, to ensure that RSMC Tokyo - Typhoon Center would benefit from the best possible data and information needed for it to carry out its work.

(c) On the operation of the name list, the names will be assigned following the pre-determined order. The name would remain unchanged throughout the life history of the tropical cyclone. To avoid confusion, tropical cyclones given a name before crossing the Date Line or 100°E and entering the western North Pacific should be assigned a number by RSMC Tokyo - Typhoon Center but should not be assigned a new name in the Typhoon Committee list. RSMC Honolulu Hurricane Center and RSMC New Delhi will continue the use of the tropical cyclone names assigned by RSMC Tokyo - Typhoon Center when tropical cyclones cross the Date Line from west to east or 100°E from east to west, respectively.

(d) The names and numbers assigned by RSMC Tokyo - Typhoon Center will be used by all Typhoon Committee Members when issuing warning bulletins intended for the international community including the press, aviation and shipping.

(e) The Typhoon Committee, as the authority to maintain the list, shall review the list of names and its operation regularly at its annual sessions as the need arises.

(f) Members may request the retirement of a name from the list particularly in case of tropical cyclones causing extensive destruction or for other reasons. Such notification shall be made preferably within a year of the event. The decision to retire names should be made at the regular review at annual sessions of the Typhoon Committee.

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APPENDIX 1-C

LIST OF ACRONYMS USED IN THE OPERATIONAL MANUAL
- METEOROLOGICAL COMPONENT -

AFTN	Aeronautical Fixed Telecommunication Network
AIREP	Air-report
AMV	Atmospheric Motion Vector
APT	Automatic Picture Transmission
ASCAT	Advanced SCATterometer
BoM	Bureau of Meteorology
BUFR	Binary Universal Form for the Representation of meteorological data
BUOY	Report of a buoy operation
CAPPI	Constant Altitude Plan Position Indicator
CMA	China Meteorological Administration
CMC	Canadian Meteorological Centre
CSR	Clear Sky Radiance
DDN	DataDirect Networks
DWD	Deutscher Wetterdienst
ECMWF	European Centre for Medium-Range Weather Forecasts
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EPS	Ensemble Prediction System
ESCAP	Economic and Social Commission for Asia and the Pacific
FAX	Facsimile
FTP	File Transfer Protocol
FY	Feng-Yun
FY-ESM	Feng-Yun Emergency Support Mechanism
GEO-KOMPSAT	Geostationary Korea Multi-Purpose Satellite
GEPS	Global EPS
GNSS	Global Navigation Satellite System
GOOS	Global Ocean Observing System
GRIB	General regularly distributed information in binary form
GSM	Global Spectral Model
GTS	Global Telecommunication System
HKO	Hong Kong Observatory
HRPT	High Resolution Picture Transmission
HWRF	Hurricane Weather Research and Forecast System
ICAO	International Civil Aviation Organization
IR	Infrared
JCSAT	Japan Communications Satellite
JMA	Japan Meteorological Agency
JTWC	Joint Typhoon Warning Center
KMA	Korea Meteorological Administration
METAR	Aerodrome/aviation routine meteorological report
MPLS	Multi-Protocol Label Switching
MSTP	Multiple Spanning Tree Protocol
MTI	Moving Target Indicator
MWO	Meteorological Watch Office
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite, Data and Information Service
NHM	Non-Hydrostatic Model
NMC	National Meteorological Centre
NMHS	National Meteorological and Hydrological Service

Field Code Changed

Deleted: AMeDAS→ Automated Meteorological Data Acquisition System¶

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NMS	National Meteorological Service
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Laboratory
NWP	Numerical Weather Prediction
OLR	Outgoing Longwave Radiation
OPMET	Operational Meteorological information
OSCAT	OceanSat Scatterometer
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PBL	Planetary Boundary Layer
PILOT	Upper-wind report from a fixed land station
PNG	Portable Network Graphics
PWV	Precipitable Water Vapour
R/A	Radar/raingauge-Analyzed precipitation
RADOB	Report of ground radar weather observations
RO	Radio Occultation
ROBEX	Regional OPMET Bulletin Exchange
RSMC	Regional Specialized Meteorological Centre
RTH	Regional Telecommunication Hub
S-VISSR	Stretched VISSR
SAREP	Report of synoptic interpretation of cloud data obtained by a meteorological satellite
SATAID	SATellite Animation and Interactive Diagnosis
SHIP	Report of surface observation from a sea station
SHIPS	Statistical Hurricane Intensity Prediction Scheme
SST	Sea Surface Temperature
SYNOP	Report of surface observation from a fixed land station
TAC	Traditional Alphanumeric Code Form
TC	Typhoon Committee
TCAC	Tropical Cyclone Advisory Centre
TCP	Tropical Cyclone Programme
TCP/IP	Transmission Control Protocol / Internet Protocol
TCS	Typhoon Committee Secretariat
TDCF	Table-Driven Code Form
TEMP	Upper-level pressure, temperature, humidity and wind report from a fixed land station
TIFS	Typhoon Intensity Forecast scheme based on SHIPS
TOPEX	Typhoon Operational Experiment
TRAMS	Tropical Regional Atmosphere Model for the South China Sea
TS	Tropical Storm
TWRF	Typhoon Weather Research and Forecast System
UKMO	United Kingdom Met Office
UNDP	United Nations Development Programme
UTC	Universal Time Coordinated
VIS	Visible
VISSR	Visible and Infrared Spin Scan Radiometer
VPN	Virtual Private Network
WMO	World Meteorological Organization
WV	Water Vapour
WWMIWS	IMO/WMO Worldwide Met-Ocean Information and Warning Service

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APPENDIX 2-A

Field Code Changed

LIST OF STATIONS FROM WHICH ENHANCED SURFACE OBSERVATIONS ARE AVAILABLE

The following stations will make hourly surface observations when they are within 300 km of the centre of a tropical cyclone of TS intensity or higher:

Cambodia

China

(54): 324, 337, 342, 346, 405, 423, 436, 471, 493, 497, 511, 534, 539, 602, 618, 662, 715, 751, 753, 776, 823, 826, 836, 843, 857, 863, 929, 945

(58): 040, 141, 150, 238, 251, 265, 345, 362, 457, 472, 477, 543, 556, 569, 646, 652, 666, 752, 754, 834, 847, 911, 921, 926, 931, 944

(59): 007, 023, 046, 058, 072, 082, 087, 096, 117, 134, 209, 211, 254, 278, 287, 293, 316, 417, 431, 456, 493, 501, 632, 644, 658, 663, 673, 758, 838, 845, 855, 948, 981

Democratic People's Republic of Korea

(47): 003, 005, 008, 014, 016, 020, 022, 025, 028, 031, 035, 037, 039, 041, 045, 050, 052, 055, 058, 060, 061, 065, 067, 068, 069

Hong Kong, China

(45): 007

Japan

(47): 401, 407, 409, 412, 418, 420, 421, 426, 430, 570, 575, 582, 584, 590, 600, 604, 605, 610, 624, 629, 636, 648, 651, 655, 662, 675, 678, 740, 741, 746, 750, 765, 772, 778, 800, 807, 815, 817, 827, 830, 843, 887, 891, 893, 895, 909, 918, 927, 936, 945, 971, 991

Lao People's Democratic Republic

Macao, China

(45): 011

Malaysia

(48): 601, 615, 620, 647, 650, 657, 665, 603, 604, 618, 679

(96): 413, 421, 441, 449, 465, 471, 481, 491, 420, 450, 467, 477

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Philippines

(98): 132, 134, 222, 223, 232, 233, 324, 325, 327, 328, 334, 336, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 440, 444, 446, 526, 531, 536, 538, 543, 546, 548, 553, 558, 618, 630, 642, 644, 646, 648, 653, 741, 746, 751, 752, 753, 755, 836, 851

Republic of Korea

(47): 090, 093, 095, 098, 099, 100, 101, 102, 105, 106, 108, 112, 114, 115, 119, 121, 127, 129, 130, 131, 133, 135, 136, 137, 138, 140, 143, 146, 152, 155, 156, 159, 162, 165, 168, 169, 170, 172, 174, 175, 177, 184, 185, 188, 189, 192, 201, 202, 203, 211, 212, 214, 216, 217, 221, 226, 232, 235, 236, 243, 244, 245, 247, 248, 251, 252, 253, 254, 255, 257, 258, 259, 260, 261, 262, 263, 264, 266, 268, 271, 272, 273, 276, 277, 278, 279, 281, 283, 284, 285, 288, 289, 294, 295

Thailand

(48): 303, 351, 352, 353, 357, 378, 383, 407, 432, 437, 462, 465, 480, 500, 501, 517, 551, 552, 560, 568, 580, 583

USA

(91): 203, 212, 258, 317, 324, 334, 339, 348, 353, 356, 366, 367, 369, 371, 376, 378, 408, 413, 425, 434

Viet Nam

(48): 820, 826, 839, 845, 848, 855, 870, 877, 900, 914, 917, 918, 920

Note: Name, latitude, longitude and elevation of these stations are included in OSCAR/Surface.

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APPENDIX 2-B

Field Code Changed

LIST OF STATIONS FROM WHICH ENHANCED UPPER-AIR OBSERVATIONS ARE AVAILABLE

The following stations will make 6-hourly upper-air observations when they are within 300 km of the centre of a tropical cyclone of TS intensity or higher:

Cambodia

China

(54): 511, 727, 857

(57): 083, 494, 972

(58): 150, 362, 457, 665, 847, 968

(59): 134, 316, 758, 981

Democratic People's Republic of Korea

(47): 041, 058

Hong Kong, China

(45): 004
upper-air observations are made by wind profiler at 06 and 18 UTC normally, but radiosondes will be launched when warranted by local wind conditions

Japan

(47): 418, 600, 646, 678, 741, 778, 807, 827, 909, 918, 945

Lao People's Democratic Republic

Macao, China

Malaysia

(48): 601, 615, 650, 657

(96): 413, 441, 471, 481

Philippines

(98): 223, 233, 328, 433, 444, 618, 646,747, 753

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Republic of Korea

(47): 102, 104, 122, 138, 158, 169, 186

Thailand

(48): 327, 378, 381, 407, 431, 453, 480, 500, 551, 565, 568

USA

(91): 212, 334, 348, 366, 376, 408, 413

Viet Nam

(48): 820, 855, 900

Note: Name, latitude, longitude and elevation of these stations are included in OSCAR/Surface.

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APPENDIX 2-C

LIST OF BUOY OBSERVATIONS BY TYPHOON COMMITTEE MEMBERS

Member	Area	Observation Elements	Frequency	Heading in the BUFR code (FM 94)
Hong Kong, China	South China Sea	Air pressure and sea surface temperature	Every hour during tropical cyclone seasons	IOBC01 VHHH for buoys operated solely by Hong Kong, China IOBX02 KWBC for buoys operated under the Barometer Upgrade Scheme of the Global Drifter Programme of Data Buoy Cooperation Panel of GOOS
Japan	Western North Pacific	Air pressure, sea surface temperature, significant wave height and period	Every 3 hours (Every hour when waves are higher than thresholds set beforehand)	IOBC11 RJTD

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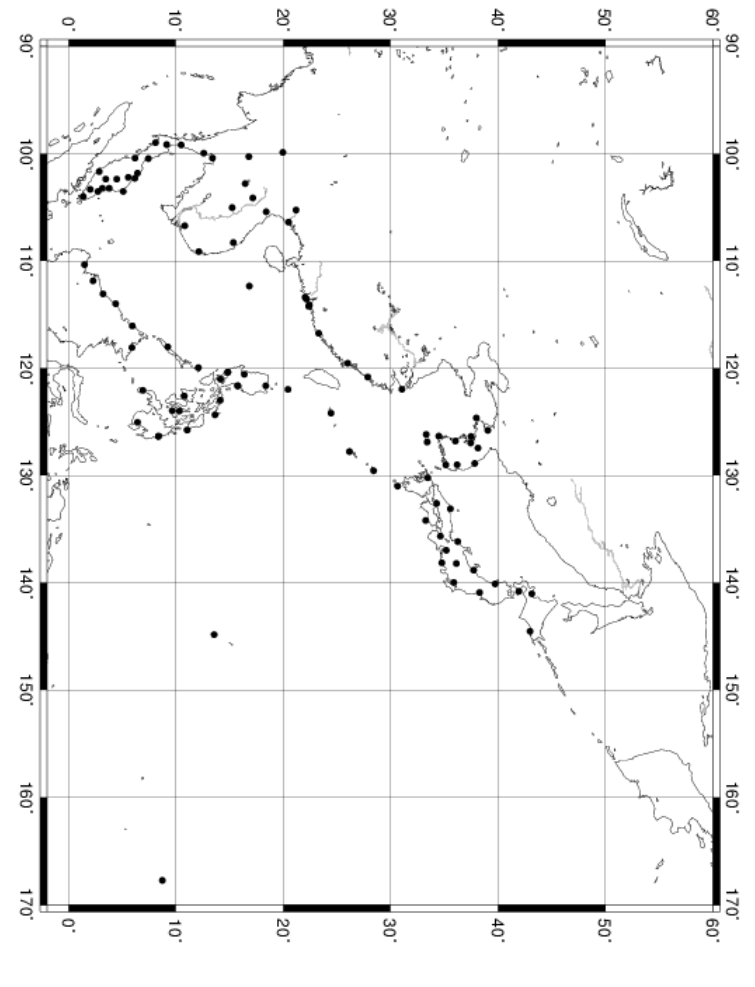
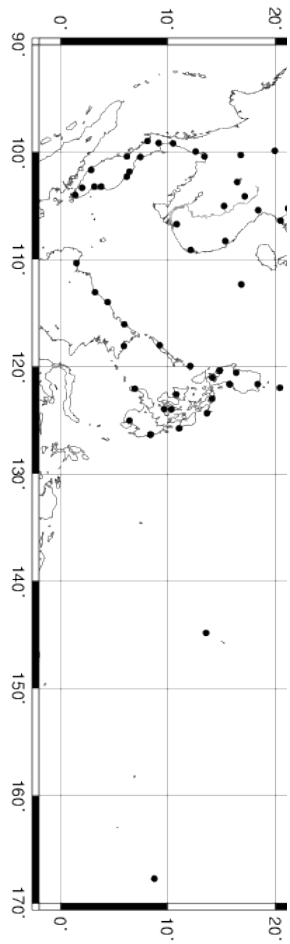
APPENDIX 2-D

DISTRIBUTION OF THE RADAR STATIONS OF TYPHOON COMMITTEE MEMBERS





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APPENDIX 2-E

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TECHNICAL SPECIFICATIONS OF RADARS OF TYPHOON COMMITTEE MEMBERS

Name of the Member **China**

NAME OF STATION		Shanghai	Wenzhou	Fuzhou	Shantou	Xishadao
SPECIFICATIONS	Unit					
Index number		58367	58659	58941	59316	59981
Location of station		31° 02′ N 121° 57′ E	27° 51′ N 120° 49′ E	25° 59′ N 119° 32′ E	23° 17′ N 116° 44′ E	16° 50′ N 112° 20′ E
Antenna elevation	m	68	294	652.5	196.7	8.5
Wave length	cm	10.6	10.6	10.4	10.4	10.6
Peak power of transmitter	kW	500	500	500	500	500
Pulse length	μs	1	3.0	1.0	1	3
Sensitivity minimum of receiver	dBm	-110	-110	-119	-109	-110
Beam width (Width of over -3dB antenna gain of maximum)	deg	2.0	2.0	2.0	1.2	2.0
Detection range	km	600	600			
Scan mode in observation						
1.Fixed elevation		1	1	1	1	
2.CAPPI		2	2	2	2	2
3.Manually controlled		3	3	3	3	
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2	2	2	2
Doppler processing 1. Yes, 2. No		2	2	1	1	2
Display 1. Digital, 2. Analog		1	1	1	1	2
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1	1	1	1	1
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Democratic People's Republic of Korea**

NAME OF STATION		Pyongyang				
SPECIFICATIONS	Unit					
Index number		47058				
Location of station		39° 02′ N 125° 47′ E				
Antenna elevation	m	90				
Wave length	cm	3.2				
Peak power of transmitter	kW	150				
Pulse length	μs	1, 2				
Sensitivity minimum of receiver	dBm	-132				
Beam width (Width of over -3dB antenna gain of maximum)	deg	44				
Detection range	km	300				
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1 2 3				
DATA PROCESSING						
MTI processing 1. Yes, 2.No		2				
Doppler processing 1.Yes, 2.No		2				
Display 1. Digital, 2. Analog		1				
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1				
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1				

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Name of the Member **Hong Kong, China**

NAME OF STATION		Tai Mo Shan	Tate's Cairn			
SPECIFICATIONS	Unit					
Index number		45009	45010			
Location of station		22° 25′ N 114° 07′ E	22° 21′ N 114° 13′ E			
Antenna elevation	m	968	586			
Wave length	cm	10.6	10.3			
Peak power of transmitter	kW	650	750			
Pulse length	μs	1.0/2.0	1.0/2.0			
Sensitivity minimum of receiver	dBm	-109/-112	-111/-114			
Beam width (Width of over -3dB antenna gain of maximum)	deg	0.9(H) 0.9(V)	0.9(H) 0.9(V)			
Detection range	km	500	500			
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2			
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2			
Doppler processing 1. Yes, 2. No		1	1			
Display 1. Digital, 2. Analog		1	1			
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (Continuous)	3 (Continuous)			
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1			

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Name of the Member **Japan - 1**

NAME OF STATION		Sapporo /Kenashiyama	Kushiro /Kombumori	Hakodate /Yokotsudake	Sendai	Akita
SPECIFICATIONS	Unit					
Index number		47415	47419	47432	47590	47582
Location of station		43° 08´ N 141° 01´ E	42° 58´ N 144° 31´ E	41° 56´ N 140° 47´ E	38° 16´ N 140° 54´ E	39° 43´ N 140° 06´E
Antenna elevation	m	749.0	121. 6	1141.7	98.0	55.3
Wave length	cm	5.61	5. 59	5.60	5.59	5.59
Peak power of transmitter	kW	250	4（H/V each）	250	3（H/V each）	250
Pulse length	μs	1.1/2.6	1.0 32/64/128	1.1/2.6	1.0 32/64/128	1.1/2.6
Sensitivity minimum of receiver	dBm	-109/-112	(H)-111/-113 (V)-111/-114 (short pulse / long pulse)	-108/-111	(H)-112/-114 (V)-112/-114 (short pulse / long pulse)	-108/-112
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.1(H) 1.1(V)	(H)0.9/0.9 (V)0.9/0.9 (H plane / V plane)	1.0(H) 1.0(V)	(H)1.0/1.0 (V)1.0/1.0 (H plane / V plane)	1.0(H) 0.9(V)
Detection range	km	400	400	400	400	400
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1	1	1	1	1
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Japan - 2**

NAME OF STATION		Tokyo /Kashiwa	Niigata /Yahikoyama	Fukui /Tojimbo	Nagano /Kurumayama	Shizuoka /Makinohara
SPECIFICATIONS	Unit					
Index number		47695	47572	47705	47611	47659
Location of station		35° 52´ N 139° 58´ E	37° 43´ N 138° 49´ E	36° 14´ N 136° 09´ E	36° 06´ N 138° 12´ E	34° 45´ N 138° 08´E
Antenna elevation	m	74.0	645.0	106.9	1937.1	186.0
Wave length	cm	5.60	5.61	5.60	5.64	5.66
Peak power of transmitter	kW	3（H/V each）	250	4（H/V each）	250	250
Pulse length	μs	1.0 32/64/128	1.0/2.5	1.0 32/64/128	1.0/2.6	1.1/2.6
Sensitivity minimum of receiver	dBm	(H)-112/-114 (V)-112/-114 (short pulse / long pulse)	-109/-113	(H)-111/-113 (V)-111/-113 (short pulse / long pulse)	-110/-114	-110/-113
Beam width (Width of over -3dB antenna gain of maximum)	deg	(H)1.0/1.0 (V)1.0/1.0 (H plane / V plane)	1.0(H) 1.0(V)	(H)0.9/0.9 (V)0.9/1.0 (H plane / V plane)	1.1(H) 1.0V)	1.1(H) 1.1(V)
Detection range	km	400	400	400	400	400
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1	1	1	1	1
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Japan - 3**

NAME OF STATION		Nagoya	Osaka /Takayasuyama	Matsue /Misakayama	Hiroshima /Haigamine	Murotomisaki
SPECIFICATIONS	Unit					
Index number		47636	47773	47791	47792	47899
Location of station		35° 10′ N 136° 58′ E	34° 37′ N 135° 39′ E	35° 33′ N 133° 06′ E	34° 16′ N 132° 36′ E	33° 15′ N 134° 11′E
Antenna elevation	m	73.1	497.5	553.0	751.5	207.0
Wave length	cm	5.59	5.60	5.61	5.59	5.60
Peak power of transmitter	kW	4（H/V each）	4（H/V each）	250	3（H/V each）	4（H/V each）
Pulse length	μs	1.0 32/64/128	1.0 32/64/128	1.1/2.6	1.0 32/64/128	1.0 32/64/128
Sensitivity minimum of receiver	dBm	(H)-111/-113 (V)-111/-113 (short pulse / long pulse)	(H)-111/-113 (V)-111/-113 (short pulse / long pulse)	-109/-112	(H)-112/-114 (V)-112/-113 (short pulse / long pulse)	(H)-111/-113 (V)-111/-113 (short pulse / long pulse)
Beam width (Width of over -3dB antenna gain of maximum)	deg	(H)1.0/0.9 (V)0.9/0.9 (H plane / V plane)	(H)0.9/0.9 (V)0.9/0.9 (H plane / V plane)	1.0(H) 1.1(V)	(H)1.0/0.9 (V)0.9/1.0 (H plane / V plane)	(H)0.9/1.0 (V)1.0/0.9 (H plane / V plane)
Detection range	km	400	400	400	400	400
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1	1	1	1	1
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Japan - 4**

NAME OF STATION		Fukuoka /Sefuriyama	Tanegashima /Nakatane	Naze /Funchatoge	Okinawa /Itokazu	Ishigakijima /Omotodake
SPECIFICATIONS	Unit					
Index number		47806	47869	47909	47937	47920
Location of station		33° 26′ N 130° 12′ E	30° 38′ N 130° 59′ E	28° 24′ N 129° 33′ E	26° 09′ N 127° 46′ E	24° 26′ N 124° 11′E
Antenna elevation	m	983.2	302.5	318.8	208.2	533.5
Wave length	cm	5.59	5.59	5.66	5.61	5.61
Peak power of transmitter	kW	3（H/V each）	4（H/V each）	250	250	250
Pulse length	μs	1.0 32/64/128	1.0 32/64/128	1.1/2.6	1.0/2.5	1.1/2.7
Sensitivity minimum of receiver	dBm	(H)-112/-114 (V)-112/-113 (short pulse / long pulse)	(H)-111/-113 (V)-111/-113 (short pulse / long pulse)	-109/-113	-109/-113	-107/-111
Beam width (Width of over -3dB antenna gain of maximum)	deg	(H)1.0/1.0 (V)0.9/1.0 (H plane / V plane)	(H)1.0/0.9 (V)0.9/0.9 (H plane / V plane)	1.1(H) 1.0(V)	1.0(H) 1.0(V)	1.1(H) 1.1(V)
Detection range	km	400	400	400	400	400
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1	1	1	1	1
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Macao, China**

NAME OF STATION		Taipa Grande	Zhuhai-Macao Radar			
SPECIFICATIONS	Unit					
Index number		45011				
Location of station		22.1599°N 113.5624°E	22.0240°N 113.3756°E			
Antenna elevation	m	183	250			
Wave length	cm	3.4	~10			
Peak power of transmitter	kW	200	> 800			
Pulse length	μs	0.4, 0.8, 1.0, 2.0	0.5, 1.57, 4.5			
Sensitivity minimum of receiver	dBm	-113	-114 for 4.5 μs -111 for 1.57 μs			
Beam width (Width of over -3dB antenna gain of maximum)	deg	1°	< +/- 0.01°			
Detection range	km	128	230/460			
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		3	3			
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2			
Doppler processing 1. Yes, 2. No		1	1			
Display 1. Digital, 2. Analog		1	1			
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3	3			
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		2	1			

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Name of the Member **Malaysia - 1**

NAME OF STATION		Alor Star	Kota Bharu	Kuala Lumpur (Sepang)	Kuala Lumpur (Subang)	Kluang
SPECIFICATIONS	Unit					
Index number		48603	48615	48650	48647	48672
Location of station		6° 11´ N 100° 24´ E	6° 10´ N 102° 17´ E	2° 51´ N 101° 40´ E	3° 09´ N 101° 34´ E	2° 01´ N 103° 19´E
Antenna elevation	m	33	33	12	117	133
Wave length	cm	10.71	10.71	10.44	10.71	10.71
Peak power of transmitter	kW	650	650	750	650	650
Pulse length	μs	0.8 and 2	0.8 and 1.9	0.5,1 and 2	0.8 and 2	0.8 and 2
Sensitivity minimum of receiver	dBm	-110	-110	-116	-110	-110
Beam width (Width of over -3dB antenna gain of maximum)	deg	2	2	1	1	2
Detection range	km	300	300	480	300	300
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2	2	2	2
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (every 10 mins)	3 (every 10 mins)	3 (every 10 mins)	3 (every 5 mins)	3 (every 10 mins)
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1 (from May 2005)	1 (from 1996)	1 (upgrade in 2016)	1 (upgrade in 2015)	1 (from Apr 2005)

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Name of the Member **Malaysia - 2**

NAME OF STATION		Kuantan	Kuching	Bintulu	Miri
SPECIFICATIONS	Unit				
Index number		48657	96413	96441	96449
Location of station		3° 47´ N 103° 13´ E	1° 29´ N 110° 20´ E	3° 13´ N 113° 04´ E	4° 23´ N 113° 59´ E
Antenna elevation	m	52	77	171	120
Wave length	cm	10.71	5.3	5.3	10.73
Peak power of transmitter	kW	650	220	250	540
Pulse length	μs	0.8 and 2	0.8 and 2	0.8 and 1.8	0.8 and 2
Sensitivity minimum of receiver	dBm	-110	-110	-110	-110
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.9	1.7	1.7	1.9
Detection range	km	300	300	300	300
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1	1	1	1
DATA PROCESSING					
MTI processing 1. Yes, 2. No		2	2	2	2
Doppler processing 1. Yes, 2. No		1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (every 10 mins)	3 (every 10 mins)	3 (every 10 mins)	3 (every 10 mins)
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1 (from 1996)	1 (from 2000)	1 (from 2001)	1 (from 2010)

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Name of the Member **Malaysia - 3**

NAME OF STATION		Kota Kinabalu	Sandakan	Temerloh	Kuala Krai	Cameron Highlands
SPECIFICATIONS	Unit					
Index number		96471	96491			
Location of station		5° 56´ N 116° 03´E	5° 54´ N 118° 04´ E	3° 28´ N 102° 22´ E	5° 34´ N 102° 12´ E	4° 29´ N 102° 22´ E
Antenna elevation	m	27	28	82	80	1602
Wave length	cm	5.3	5.3	3.2	3.2	3.2
Peak power of transmitter	kW	210	250	79	84	79
Pulse length	μs	0.8 and 1.8	0.8 and 1.8	0.5/1.0/2.0	0.5/1.0/2.0	0.5/1.0/2.0
Sensitivity minimum of receiver	dBm	-110	-110	-118	-118	-118
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.7	1.7	1.0	1.0	1.0
Detection range	km	300	300	100	100	100
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	1,2	1,2	1,2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2	2	2	2
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (every 10 mins)	3 (every 10 mins)	3 (every 5 mins)	3 (every 5 mins)	3 (every 5 mins)
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1 (from 2000)	1 (from 2001)	1 (from 2021)	1 (from 2021)	1 (from 2022)

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Name of the Member **Malaysia - 4**

NAME OF STATION		Marang	Rompin	Sibu		
SPECIFICATIONS	Unit					
Index number						
Location of station		5° 5´ N 103° 31´ E	2° 44´ N 103° 31´ E	2° 17´ N 111° 51´ E		
Antenna elevation	m	38	56.7	38		
Wave length	cm	10.60	11.1	10.95		
Peak power of transmitter	kW	910	910	910		
Pulse length	μs	0.5/1.0/2.0	0.5/1.0/2.0	0.5/1.0/2.0		
Sensitivity minimum of receiver	dBm	-118	-118	-118		
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.0	1.0	1.0		
Detection range	km	300	300	300		
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1,2	1,2	1,2		
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2	2		
Doppler processing 1. Yes, 2. No		1	1	1		
Display 1. Digital, 2. Analog		1	1	1		
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (every 10 mins)	3 (every 10 mins)	3 (every 10 mins)		
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1 (from 2022)	1 (from 2022)	1 (from 2022)		

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Name of the Member **Philippines - 1**

NAME OF STATION		Aparri	Virac	Guiuan	Subic (EEC)	Subic (SELEX)
SPECIFICATIONS	Unit					
Index number		98231	98447	98558		
Location of station		18° 21' 35'' N 121° 37' 48.50'' E	13° 37' 47.16'' N 124° 20' 02.59'' E	11° 02' 42.72'' N 125° 45' 20.56'' E	14° 49' 19.44'' N 120° 21' 49.68''E	14° 49' 19.44'' N 120° 21' 49.68''E
Antenna elevation	m	34	33.5	25	40	40
Wave length	cm	10.52	10.52	10.52	10.4	
Peak power of transmitter	kW	10	10	10	850	1000
Pulse length	μs	2 & 100 - intensity mode 1 @ 50 - Doppler mode	2 & 100 - intensity mode 1 @ 50 - Doppler mode	2 & 100 - intensity mode 1 @ 50 - Doppler mode	2.0, 1.0, 0.8, 0.4	2.0, 1.0, 0.5
Sensitivity minimum of receiver	dBm	-114	-114	-114	-114	-117
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.8	1.8	1.8	1.83	1
Detection range	km	440	440	440	480	480
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	2	1
Doppler processing 1. Yes, 2. No		2	2	2	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1 (Operational)	2 (damage by Typhoon "ROLLY")	2 (problem with BUC)	2 (defective RCU)	2 (defective switchboard over current)

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Name of the Member **Philippines - 2**

NAME OF STATION		Tagaytay	Mactan	Tampakan	Ilo-Ilo Iloilo	Bohol
SPECIFICATIONS	Unit					
Index number			98646		98637	
Location of station		14° 08' 31.70'' N 121° 01' 20.20'' E	10° 19' 21.80'' N 123° 58' 49.01'' E	06° 25' 03.30'' N 125° 01' 51.41'' E	10° 46' 22.30'' N 122° 34' 46.00'' E	09° 38' 48.72'' N 123° 57' 02.70'' E
Antenna elevation	m	30	21	23	21	30
Wave length	cm	5.34	5.33	10.4	10.44	10.7
Peak power of transmitter	kW	250	250	850	850	1000
Pulse length	μs	2.0, 1.0, 0.8, 0.4	2.0, 1.0, 0.8, 0.4	2.0, 1.0, 0.8, 0.4	2.0, 1.0, 0.8, 0.4	2.0, 1.0, 0.8, 0.4
Sensitivity minimum of receiver	dBm	-114	-114	-114	-114	-114
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.0	1.0	1.3	1.3	0.9
Detection range	km	250	480	480	480	480
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2	2	2	2
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1 (Operational)	1 (Operational)	2 (damaged building due to earthquake)	2 (for replacement of HVPS)	1

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Name of the Member **Philippines - 3**

NAME OF STATION		Hinatuan (EEC)	Hinatuan (SELEX)	Baguio	Daet	Baler
SPECIFICATIONS	Unit					
Index number		98755	98755			98334
Location of station		08° 22' 02.37'' N 126° 20' 18.73'' E	08° 22' 02.37'' N 126° 20' 18.73'' E	16° 21' 22.60'' N 120° 33' 32.60'' E	14° 07' 43.10'' N 122° 58' 58.46'' E	15° 44' 56.30'' N 121° 37' 55.62'' E
Antenna elevation	m	34	34	15	21	6
Wave length	cm	10.78	10.78			
Peak power of transmitter	kW	850	850	500	1000	1000
Pulse length	μs	2.0, 1.0, 0.8, 0.4	2.0, 1.0, 0.8, 0.4	2.0, 1.0, 0.5	2.0, 1.0, 0.5	2.0, 1.0, 0.5
Sensitivity minimum of receiver	dBm	-114	-114	-117	-117	-117
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.3	1.3	1	1	1
Detection range	km	480	480	480	480	480
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2	2	2	2
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		2 (Damaged by Earthquake)	1	1	1	1

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Name of the Member **Philippines - 4**

NAME OF STATION		Basco	Quezon Palawan	Busuanga Palawan	Zamboanga	
SPECIFICATIONS	Unit					
Index number		98134				
Location of station		20° 25' 40.21'' N 121° 58' 13.60'' E	09° 13' 50.10'' N 118° 00' 20.90'' E	12° 05' 20.11'' N 119° 56' 15.43'' E	06° 54' 55.10'' N 122° 02' 29.15'' E	
Antenna elevation	m	6	21	18.6	24.6	
Wave length	cm	5.35	5.35	5.35	5.35	
Peak power of transmitter	kW	250	250	250	250	
Pulse length	μs	2.0, 1.0, 0.8, 0.5	2.0, 1.0, 0.8, 0.5	2.0, 1.0, 0.8, 0.5	2.0, 1.0, 0.8, 0.5	
Sensitivity minimum of receiver	dBm	-115.8	-115.8	-115.8	-115.8	
Beam width (Width of over -3dB antenna gain of maximum)	deg	1	1	1	1	
Detection range	km	500	500	500	500	
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2	2	2	
DATA PROCESSING						
MTI processing 1. Yes, 2. No		2	2	2	2	
Doppler processing 1. Yes, 2. No		1	1	1	1	
Display 1. Digital, 2. Analog		1	1	1	1	
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)	3 (constantly tracking)	
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		2 (Destroyed by Typhoon "Ferdie", 2016)	2 (Maintenance	2 (Maintenance	2 (Defective IRIS Server/ Signal Processor)	

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Name of the Member **Republic of Korea - 1**

NAME OF STATION		Gosan	Seongsan	Gangneung	Oseongsan	Baengnyeong-do
SPECIFICATIONS	Unit					
Index number		47185	47188	47105	47144	47102
Location of station		33.294329°N 126.163073° E	33.387103°N 126.879986° E	37.817669°N 128.865647° E	36.012700°N 126.784168° E	37.967549°N 124.630307° E
Antenna elevation	m	103	68	99	234	185
Wave length	cm	10.61	10.88	10.50	10.96	10.45
Peak power of transmitter	kW	850	850	850	850	850
Pulse length	μs	0.5, 1.0 2.0, 4.5	0.5, 1.0 2.0, 4.5	0.5, 1.0 2.0, 4.5	0.5, 1.0 2.0, 4.5	0.5, 1.0 2.0, 4.5
Sensitivity minimum of receiver	dBm	-114	-114	-114	-114	-114
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.0	1.0	1.0	1.0	1.0
Detection range	km	240, 480	240, 480	240, 480	240, 480	240, 480
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1, 2	1, 2	1, 2	1, 2	1, 2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (5-minutely)	3 (5-minutely)	3 (5-minutely)	3 (5-minutely)	3 (5-minutely)
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Republic of Korea - 2**

NAME OF STATION		Jindo	Gwangdeok - san	Myeonbong - san	Gwanaksan	Gudeoksan
SPECIFICATIONS	Unit					
Index number		47175	47094	47148	47116	47160
Location of station		34.472553°N 126.323994° E	38.117316°N 127.433708° E	36.179323°N 128.997319° E	37.444119°N 126.963994° E	35.118694°N 128.999744° E
Antenna elevation	m	497	1066	1136	641	549
Wave length	cm	10.37	10.38	10.99	11.03	11.05
Peak power of transmitter	kW	850	850	850	850	850
Pulse length	μs	0.5, 1.0 2.0, 4.5	0.5, 1.0 2.0, 4.5	0.5, 1.0 2.0, 4.5	0.5, 1.0 2.0, 4.5	0.5, 1.0 2.0, 4.5
Sensitivity minimum of receiver	dBm	-114	-114	-114	-114	-114
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.0	1.0	1.0	1.0	1.0
Detection range	km	240, 480	240, 480	240, 480	240, 480	240, 480
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1, 2	1, 2	1, 2	1, 2	1, 2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (5-minutely)	3 (5-minutely)	3 (5-minutely)	3 (5-minutely)	3 (5-minutely)
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Republic of Korea - 3**

NAME OF STATION		Korean Aviation Meteorological Agency				
SPECIFICATIONS	Unit					
Index number		47113				
Location of station		37° 28´ N 126° 21´ E				
Antenna elevation	m	145				
Wave length	cm	5.32				
Peak power of transmitter	kW	250				
Pulse length	μs	1.0; 2.0				
Sensitivity minimum of receiver	dBm	-110				
Beam width (Width of over -3dB antenna gain of maximum)	deg	0.53				
Detection range	km	130, 428				
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1, 2				
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1				
Doppler processing 1. Yes, 2. No		1				
Display 1. Digital, 2. Analog		1				
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (continuous)				
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1				

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Name of the Member **Singapore**

NAME OF STATION		Changi				
SPECIFICATIONS	Unit					
Index number		48698				
Location of station		1° 22′ N 103° 59′ E				
Antenna elevation	m	35				
Wave length	cm	10				
Peak power of transmitter	kW	750				
Pulse length	μs	1 or 3				
Sensitivity minimum of receiver	dBm	-110				
Beam width (Width of over -3dB antenna gain of maximum)	deg	< 1				
Detection range	km	480				
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2				
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1				
Doppler processing 1. Yes, 2. No		1				
Display 1. Digital, 2. Analog		1				
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 (continuous)				
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1				

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Name of the Member **Thailand - 1**

NAME OF STATION		Chiang Rai	Sakol Nakon	Phitsanulok	Khon Khaen	Ubon Ratchathani
SPECIFICATIONS	Unit					
Index number		48303	48356	48378	48381	48407
Location of station		19° 57´ N 99° 52´ E	17° 09´ N 104° 07´ E	16° 47´ N 100° 16´ E	16° 27´ N 102° 47´ E	15° 14´ N 105° 01´ E
Antenna elevation	m	440	198	56	215	155
Wave length	cm	5	5	5	5	5
Peak power of transmitter	kW	350	350	350	350	350
Pulse length	μs	0.8&2	0.8&2	0.8&2	0.8&2	0.8&2
Sensitivity minimum of receiver	dBm	-110	-110	-110	-100	-100
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.0	1.0	1.0	1.0	1.0
Detection range	km	240	240	240	240	240
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1, 2	1, 2	1, 2	1, 2	1, 2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1, 3	1, 3	1, 3	1, 3	1, 3
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Thailand - 2**

NAME OF STATION		Samut Songkram	Hua Hin	Chumporn	Surat Thani	Krabi
SPECIFICATIONS	Unit					
Index number		48438	48475	48517	48551	48563
Location of station		13° 24´ N 100° 24´ E	12° 35´ N 99° 57´ E	10° 29´ N 99° 11´ E	9° 08´ N 99° 09´ E	8° 06´ N 98° 58´ E
Antenna elevation	m	29	30	28	33	51
Wave length	cm	5	10	5	5	5
Peak power of transmitter	kW	350	350	350	350	350
Pulse length	μs	0.8&2	0.8&2	0.8&2	0.8&2	0.8&2
Sensitivity minimum of receiver	dBm	-110	-115	-110	-110	-110
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.0	2.1	1.0	1.0	1.0
Detection range	km	240	240	240	240	240
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1, 2	1, 2	1, 2	1, 2	1, 2
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		1	1	1	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1, 3	1, 3	1, 3	1, 3	1, 3
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Thailand - 3**

NAME OF STATION		Sathing Pra (Songkla)	Narathiwat			
SPECIFICATIONS	Unit					
Index number		48568	48583			
Location of station		7° 26´ N 100° 27´ E	6° 25´ N 101° 49´ E			
Antenna elevation	m	30	29			
Wave length	cm	5	5			
Peak power of transmitter	kW	350	350			
Pulse length	μs	0.8&2	0.8&2			
Sensitivity minimum of receiver	dBm	-115	-110			
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.0	1.0			
Detection range	km	240	120			
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1, 2	1, 2			
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1			
Doppler processing 1. Yes, 2. No		1	1			
Display 1. Digital, 2. Analog		1	1			
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1, 3	1, 3			
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1			

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Name of the Member **USA**

NAME OF STATION		Guam	Kwajalein			
SPECIFICATIONS	Unit					
Index number		91217	91366			
Location of station		13° 33´ N 144° 50´ E	8° 44´ N 167° 44´ E			
Antenna elevation	m	110	30			
Wave length	cm	10.6	10.0			
Peak power of transmitter	kW	750	500			
Pulse length	μs	1.57/ 4.5	0.8			
Sensitivity minimum of receiver	dBm	-113	-107			
Beam width (Width of over -3dB antenna gain of maximum)	deg	0.96	1.0			
Detection range	km	399	250			
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		2	2			
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	2			
Doppler processing 1. Yes, 2. No		1	1			
Display 1. Digital, 2. Analog		1	1			
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		3 6-minute continuous	3 continuous			
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1			

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Name of the Member **Viet Nam - 1**

NAME OF STATION		Phu Lien	Viet Tri	Vinh	Tam Ky	Nha Trang
SPECIFICATIONS	Unit					
Index number		48826	48813	48845	48833	48877
Location of station		20.48 °N 106.38 °E	21.18 °N 105.25 °E	18.40 °N 105.41 °E	15.34 °N 108.28 °E	12.13 °N 109.12 °E
Antenna elevation	m	140	56	27	40	52
Wave length	cm	5.3	5.3	5.3	5.6	5.6
Peak power of transmitter	kW	250	250	250	250	250
Pulse length	μs	2	2	2	0.8;2.0	0.8;2.0
Sensitivity minimum of receiver	dBm	-110	-110	-110	-113	-113
Beam width (Width of over -3dB antenna gain of maximum)	deg	1.1	1.1	1.1	1	1
Detection range	km	384	384	384	480	480
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1, 3	1, 3	1, 3	1, 2, 3	1, 2, 3
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1	1	1	1	1
Doppler processing 1. Yes, 2. No		2	2	2	1	1
Display 1. Digital, 2. Analog		1	1	1	1	1
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1, 3	1, 3	1, 3	1, 3	1, 3
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1	1	1	1	1

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Name of the Member **Viet Nam - 2**

NAME OF STATION		Nha Be				
SPECIFICATIONS	Unit					
Index number						
Location of station		10° 49´ N 106° 43´ E				
Antenna elevation	m	25				
Wave length	cm	5.6				
Peak power of transmitter	kW	250				
Pulse length	μs	0.4; 0.8; 2.0				
Sensitivity minimum of receiver	dBm	-122				
Beam width (Width of over -3dB antenna gain of maximum)	deg	1				
Detection range	km	480				
Scan mode in observation 1. Fixed elevation 2. CAPPI 3. Manually controlled		1, 2, 3				
DATA PROCESSING						
MTI processing 1. Yes, 2. No		1				
Doppler processing 1. Yes, 2. No		1				
Display 1. Digital, 2. Analog		1				
OPERATION MODE (When tropical cyclone is within range of detection) 1. Hourly 2. 3-hourly 3. Others		1, 3				
PRESENT STATUS 1. Operational 2. Not operational (for research etc.)		1				

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APPENDIX 2-F

TECHNICAL SPECIFICATIONS OF SATELLITE OPERATED BY TYPHOON COMMITTEE MEMBERS

1. FY-2G (operational since 2015) / FY-2H (operational since 2019) [China]

(a) Observations

(i) Full-Disk Observations (FY-2G/H): Every hour

(ii) Regional Observations based on request (FY-ESM[8]): Every 6 minutes

(b) Products

(i) Full-Disk Observation Data (FY-2G/H): Every hour

(ii) Regional Observation Data based on request (FY-ESM[9]): Every 6 minutes

(iii) Full-Disk AMV Product:

(c) Dissemination ways

(i) Direct Broadcast Services

(ii) CMAcast (communication satellite dissemination service)

(iii) Internet Services

[National Satellite Meteorological Center Portal Site]
http://www.nsmc.gov.cn/en

[FengYun Satellite Data Center Site]
http://data.nsmc.org.cn

[Real-time imagery, FengYun Satellite Weather Application Platform(SWAP)]
http://rsapp.nsmc.org.cn/en

2. FY-4A (operational since 2018) [China]

(a) Observations

(i) Full-Disk Observations (FY-4A/B): Every 15 minutes

(ii) China Area Observations(FY-4A): Every 5 minutes

(iii) Regional Observations (FY-4B): 1 minute

(iv) Regional Observations based on request (FY-ESM[9]): Every 5 minutes

(b) Products

(i) Full-Disk Observation (FY-4A/B): Every 15 minutes

(ii) Asia region Observation (FY-4A): Every 5 minutes

[8] More information available on http://fy4.nsmc.org.cn/service/en/emergency/index.html

Field Code Changed

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Deleted: Full-Disk Observations (FY-2G/H): → → Every hour¶
Regional Observations (FY-2F): → → → → Every 6 minutes¶
Regional Observations based on request (FY-ESM[9]): → → → → Every 6 minutes

Deleted: <#>Regional Observation Data (FY-2F): → Every 6 minutes¶

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Deleted: Full-Disk Observations: → Every hour¶
China Area Observations: → Every 5 minutes¶
Regional Observations based on request (FY-ESM[8]): → → → → Every 5 minutes

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(iii) Regional Observations(FY-4B):1 minute

(iv) Regional Observations Data based on request (FY-ESM[9]): Every 5 minutes

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Deleted: Full-Disk Observation Data: → Every hour¶ China Area Observation Data: → Every 5 minutes¶ Regional Observations Data based on request (FY-ESM[8]): Every 5 minutes

(c) Dissemination ways

(i) Direct Broadcast Service

(ii) CMACast (communication satellite dissemination service)

(iii) Internet Services

[FTP-based Service]

http://fy4.nsmc.org.cn/data/en/data/realtime.html

[National Satellite Meteorological Center Portal Site]

http://www.nsmc.gov.cn/en

[FengYun Satellite Data Center Site]
http://data.nsmc.org.cn

[Real-time imagery, FengYun Satellite Weather Application Platform (SWAP)]
http://rsapp.nsmc.org.cn/en

3. Himawari-8(observation operational since 2015, backup operation since December 2022) / Himawari-9 (backup operational since 2017, observation operation since December 2022) [Japan]

Deleted: /9 (operational

Deleted: operational

(a) Observations

(i) Full-Disk Observations: Every 10 minutes

(ii) Japan Area Observations: Every 2.5 minutes

(iii) Target Area Observations including those Based on Request by NMHSs (HimawariRequest)[10]: Every 2.5 minutes

(b) Products

(i) Full-Disk Observation Data: Every 10 minutes

(ii) Japan Area Observation Data: Every 2.5 minutes

(iii) Target Area Observation Data: Every 2.5 minutes

(iv) Full-Disk AMV: Every hour

(v) Full-Disk Clear Sky Radiance (CSR): Every hour

(vi) AMV-based Sea-surface Wind data (ASWind) (Full-Disk) : Every 30 minutes

(vii) AMV-based Sea-surface Wind data (ASWind) (Target Area) : Every 10 minutes

[10] More information available on https://www.jma.go.jp/jma/jma-eng/satellite/HimawariRequest.html

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(c) Dissemination ways

(i) HimawariCloud (Internet Cloud Service)
Service which distributes full-spec imagery derived from the Himawari-series satellites
(https://www.data.jma.go.jp/mscweb/en/himawari89/cloud_service/cloud_service.html)

(ii) HimawariCast (communication satellite dissemination service)
Service which disseminates primary sets of imagery from the Himawari-series satellites via a communication satellite
(https://www.data.jma.go.jp/mscweb/en/himawari89/himawari_cast/himawari_cast.php)

(iii) Internet Services for National Meteorological and Hydrological Services (NMHSs)
[JMA real-time satellite imagery webpage]
https://www.jma.go.jp/bosai/map.html#contents=himawari&lang=en

[MSC (Meteorological Satellite Center) real-time satellite imagery webpage]
https://www.data.jma.go.jp/mscweb/data/himawari/

[SATAID (Satellite Animation and Interactive Diagnosis) Service]
https://www.wis-jma.go.jp/cms/sataid/

[JDDS (JMA Data Dissemination Service)]
https://www.jma.go.jp/jma/jma-eng/satellite/jdds.html

4. GEO-KOMPSAT-2A (operational since 2019) [Republic of Korea]

(a) Observations

(i) Full-Disk Observations: Every 10 minutes
(ii) Extended Local Area Observations: Every 2 minutes
(iii) Local Area Observations: Every 2 minutes

(b) Products

(i) Full-Disk Observation Data: Every 10 minutes
(ii) Extended Local Area Observation Data: Every 2 minutes
(iii) Local Area Observation Data: Every 2 minutes

(c) Dissemination ways

(i) Direct Broadcast Service
Request application form for receiving station
(http://datasvc.nmsc.kma.go.kr/datasvc/html/base/cmm/selectPage.do?page=stat

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ic.reqStation)

(ii) Internet Services

[FTP-based Service]

All sixteen channels data of full-disk image will be put on KMA's FTP server designated for GEO-KOMPSAT-2A data dissemination in every 10 minutes.

(Account policy: 1 account per 1 country)

Need personal contact (denver@korea.kr or lsm0918@korea.kr)

Deleted: hyunjong.oh@korea.kr

[National Meteorological Satellite Center website]

http://datasvc.nmsc.kma.go.kr/datasvc/html/main/main.do?lang=en

[Data Collection or Production Centre website]

http://dcpc.nmsc.kma.go.kr/openwis-user-portal/srv/en/main.home

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APPENDIX 2-G

Field Code Changed

SATELLITE IMAGERY RECEIVING FACILITIES AT TYPHOON COMMITTEE MEMBERS

Member	Station		FengYun-2	FengYun-3	FengYun-4	FengYun-2/3/4	Himawari-8/9		GEO-KOMPSAT-2A	NOAA/JPSS	AQUA/TERRA	METOP
			Direct Broadcast	Direct Broadcast	Direct Broadcast	CMAcast	HimawariCast	HimawariCloud	Direct Broadcast	Direct Broadcast	Direct Broadcast	Direct Broadcast
Cambodia							✔	✔				
China	Beijing	39.9°N, 116.4°E	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
DPR Korea	Pyongyang	39.0°N, 125.8°E								✔		
Hong Kong, China	Kowloon	22.3°N, 114.2°E		✔	✔	✔	✔	✔		✔	✔	✔
Japan	Kiyose	35.8°N, 139.5°E					✔	✔		✔		✔
Lao PDR							✔					
Macao, China	Macao	22.2°N, 113.5°E	✔		✔	✔	✔	✔		✔		
Malaysia	Petaling Jaya	3.1°N, 101.7°E					✔	✔		✔		
Philippines	Cebu City	0.3°N, 124.0°E					✔					
	Davao City	7.1°N, 125.6°E					✔					
	El Salvador City	8.5°N, 124.6°E					✔					
	Legaspi City	13.1°N, 123.7°E					✔					
	Quezon City	14.7°N, 121.0°E				✔	✔					
	Tacloban City	11.2°N, 125.0°E					✔					
	Tuguegarao City	17.6°N, 121.8°E					✔					
Republic of Korea	Jinchoen	36.7°N, 127.4°E					✔	✔		✔		
Singapore	Changi Airport	1.4°N, 104.0°E			✔		✔	✔		✔	✔	
Thailand	Bangkok	13.7°N, 100.6°E				✔	✔	✔				
USA	Guam	13.4°N, 144.6°E					✔			✔	✔	✔
	NCEP/College Park	39.0°N, 76.9°W						✔		✔	✔	✔
Viet Nam	Hanoi	21.0°N, 105.5°E					✔	✔				
	Ho Chi Ming City	10.5°N, 106.4°E								✔		

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APPENDIX 2-H

Field Code Changed

LIST OF SAREP REPORTS ISSUED BY TYPHOON COMMITTEE MEMBERS

Member	Frequency	Heading in the BUFR code (FM 94)	Issuance Condition
RSMC Tokyo - Typhoon Center	8 times/day	IUCC10 RJTD	(i) When a tropical cyclone of TS intensity or higher is located in the responsible area of the RSMC Tokyo - Typhoon Center; (ii) When a tropical depression existing in the responsible area is forecasted to have an intensity of TS or higher within 24 hours; or (iii) When an area of wind speed of 34 knots or higher caused by a tropical cyclone is forecasted to be in the responsible area within 24 hours.
Hong Kong, China	8 times/day	IUCC01 VHHH IUCC02 VHHH IUCC03 VHHH IUCC04 VHHH	When a tropical cyclone is located within 10°N to 30°N and 105°E to 125°E.
China	8 times/day	TCPQ40 BABJ	When a tropical cyclone is located within 0°N to 50°N and 105°E to 180°E.

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APPENDIX 2-I

RECONNAISSANCE FLIGHTS CONDUCTED BY TYPHOON COMMITTEE MEMBERS

HKO conducts dropsonde reconnaissance flights for selected tropical cyclones over the northern part of the South China Sea. Data are disseminated in real time to near real time in BUFR format through GTS circuit. Automatic data quality control algorithms are implemented to remove suspicious and erratic data from the dropsonde.

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APPENDIX 2-J

Field Code Changed

TROPICAL CYCLONE PASSAGE REPORT FORM

TC Name (RSMC No.) _____

Station/ buoy/ship Number	Minimum Sea Level Pressure		Maximum Sustained Wind		Peak Gust		Rainfall	
	hPa	Time Observed (UTC)	(10-min ave.) m/sec	Time Observed (UTC)	m/sec	Time Observed (UTC)	Amount mm	Date Observed

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APPENDIX 3-A

Field Code Changed

PRODUCTS PROVIDED BY RSMC TOKYO - TYPHOON CENTER

Chart-form products provided by RSMC Tokyo - Typhoon Center for regional purposes

Area	Contents and Level	Forecast hours	Initial time	Availability
A' (Far East)	500 hPa (Z, ζ)	Analysis	00, 12UTC	GTS
		24, 36	00, 12UTC	GTS, JMH
	500 hPa (T), 700 hPa (D)	24, 36	00, 12UTC	GTS, JMH
	700 hPa (ω), 850 hPa (T, A)	Analysis	00, 12UTC	GTS
		24, 36	00, 12UTC	GTS, JMH
	Surface (P, R, A)	24, 36	00, 12UTC	GTS, JMH
C (East Asia)	300 hPa (Z, T, W, A)	Analysis	00UTC	GTS
	500 hPa (Z, T, A)	Analysis	00, 12UTC	GTS, JMH
	500 hPa (Z, ζ)	48, 72	00, 12UTC	GTS
	700 hPa (Z, T, D, A)	Analysis	00, 12UTC	GTS
	700 hPa (ω), 850 hPa (T, A)	48, 72	12UTC	GTS
	850 hPa (Z, T, D, A)	Analysis	00, 12UTC	GTS, JMH
	Surface (P, R)	24	00, 12UTC	GTS
		48, 72	00, 12UTC	GTS, JMH
		96, 120	12UTC	GTS, JMH
O (Asia)	500 hPa (Z, ζ)	96, 120, 144, 168, 192	12UTC	GTS
	850 hPa (T), Surface (P)			
Q (Asia Pacific)	200 hPa (Z, T, W), Tropopause (Z)	Analysis	00, 12UTC	GTS
	250 hPa (Z, T, W)	Analysis, 24	00, 12UTC	
	500 hPa (Z, T, W)	24	00, 12UTC	
D (N.H.)	500 hPa (Z, T)	Analysis	12UTC	GTS
W (NW Pacific)	200 hPa (streamline)	Analysis, 24, 48	00, 12UTC	GTS
	850 hPa (streamline)		00, 12UTC	
X (Japan)	Ocean Wave (J, M, G and observation plots)	Analysis	00, 12UTC	GTS, JMH
	Ocean Wave (J, M, G, rough sea area and observation plots)	24		
C'' (NW Pacific)	Ocean Wave (J, M, G)	Analysis, 12, 24, 48, 72	00, 12UTC	GTS, JMH
	Ocean Wave (J, M, G and rough sea area)	24		
C''2 (NW Pacific)	Sea Surface Temperature	Daily analysis	-	GTS, JMH
C'2 (Asia Pacific)	Surface (P)	Analysis	00,06,12, 18UTC	GTS, JMH
		24	00, 12UTC	
		48		
	Surface (Typhoon Forecast)	12,24,48,72	00,06,12, 18UTC	
		24,48,72,96, 120		JMH

Notes:

(a) Area

A', C, O, Q, D, W, X, C'', C''2 and C'2 are illustrated in figure of the next page.

(b) Contents

Z: geopotential height	ζ: vorticity	T: temperature
D: dewpoint depression	ω: vertical velocity	W: wind speed by isotach
A: wind arrows	P: sea level pressure	R: rainfall
J: wave height	M: wave period	G: arrow for prevailing wave direction

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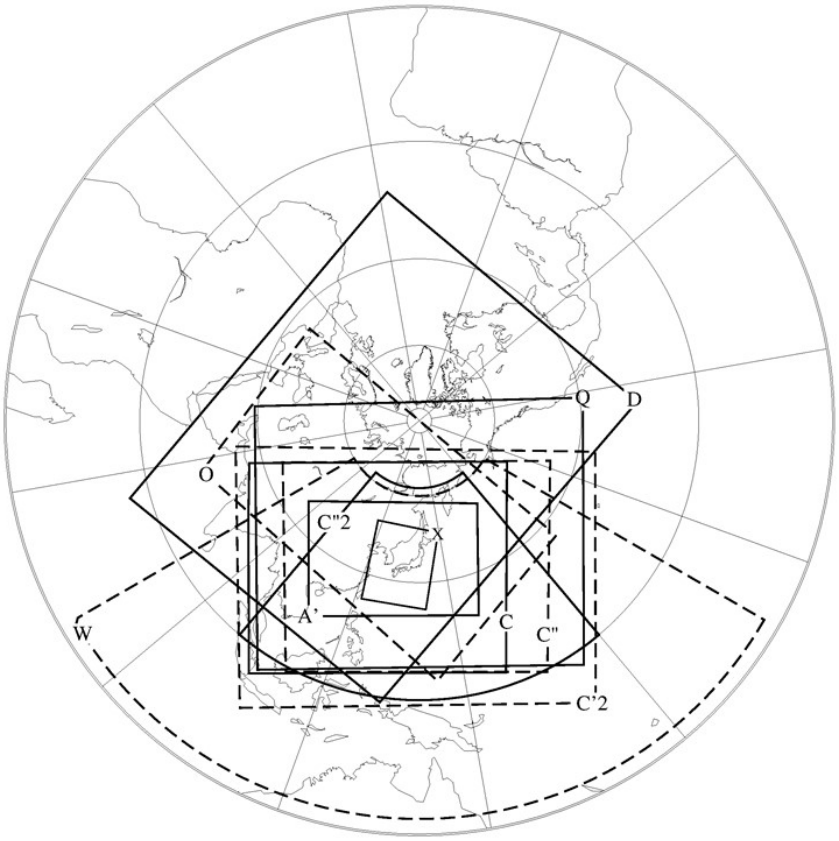

Output areas for facsimile charts transmitted through GTS and radio facsimile JMH

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NWP products (GSM and GEPS) provided by RSMC Tokyo - Typhoon Center
(Available at https://www.wis-jma.go.jp/cms/)

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**	**GEPS**
Area and resolution	Whole globe, 2.5°×2.5°	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	250 hPa: μU, σU, μV, σV, μW,σW 500 hPa: μZ, σZ 850 hPa: μU, σU, μV, σV, μT, σT, μW, σW ,Probability of temperature anomalies [±1, ±1.5, ±2σ] 1000 hPa: μZ, σZ Surface: μP, σP, Probability of 10 m sustained wind and gusts[10,15,25 m/s]†, Probability of precipitation [1,5,10,25,50,100 mm/24hour]†
Forecast hours	0 - 192 every 12 hours	0 - 264 every 12 hours † Except analysis
Initial times	00, 12UTC	00, 12 UTC

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Model	GSM	GSM	GSM
Area and resolution	5°S-90°N and 30°E-165°W, Whole globe 0.25° × 0.25°	5°S-90°N and 30°E-165°W, 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, Div 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, Div 850 hPa: Z, U, V, T, H, ω, ψ, χ 925 hPa: Z, U, V, T, H, ω, ζ, Div 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* and 12 UTC Initial † Except analysis * From Feb 17 2021	0 - 132 (every 3 hours) 138 - 264 (every 6 hours) are available for 00* and 12 UTC Initial † Except analysis * From Feb. 17 2021	0 - 132 every 6 hours and 144 - 264 every 12 hours for 00* and 12UTC initial † Except analysis * From Feb. 17 2021
Initial times	00, 06, 12, 18 UTC	00, 06, 12, 18 UTC	00, 06, 12, 18 UTC

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 P: sea level pressure Ps: pressure
R: rainfall Cla: total cloudiness Clh: cloudiness (upper layer)
Clm: cloudiness (middle layer) Cll: cloudiness (lower layer)
Div: divergence W:wind speed

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.

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List of other products provided by RSMC Tokyo - Typhoon Center
(Available at the Global Information System Center Tokyo server:
https://www.wis-jma.go.jp/cms/)

Data	Contents / frequency (initial time)
Satellite products	High density atmospheric motion vectors (BUFR) Himawari-8/9 (VIS, IR, WVx3: every hour), 60°S-60°N, 90°E-170°W Clear Sky Radiance (CSR) data (BUFR) Himawari-8/9 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 • peak 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-8/9 (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/)

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List of other products provided by RSMC Tokyo - Typhoon Center
(Available at the Numerical Typhoon Prediction Website:
https://tynwp-web.kishou.go.jp/)

Products	Frequency	Details
RSMC Advisories		
RSMC TC Advisory	At least 8 times/day	• RSMC Tokyo - Typhoon Center's TC analysis and forecasts up to 120-hours (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 equal to or above 50-kt 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 RSMC Tokyo – Typhoon Center *Information supplemental to RSMC advisories (may not be provided in certain situations; should not be considered as an official RSMC advisory or a replacement therefor)
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 at https://www.data.jma.go.jp/tca/data/index.html)
Remote Sensing		
Satellite Analysis	At least 4 times/day	• Results and historical logs of RSMC Tokyo – Typhoon Center's TC analysis conducted using satellite images (Conventional Dvorak analysis and Early-stage Dvorak analysis)
Satellite Imagery	Up to 142 times/day	• Satellite imagery of Himawari-8/9 (linked to the JMA website at https://www.jma.go.jp/bosai/map.html#elem=ir&lang=en&contents=himawari
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 at https://www.data.jma.go.jp/mscweb/en/product/product_ASWind.html)
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/bosai/weather_map/#lang=en)
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, 500 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

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Products	Frequency	Details
MJO phase diagram	Daily	• MJO phase and amplitude diagram and MJO Hovmöller diagram • (linked to the Tokyo Climate Center web site: • https://ds.data.jma.go.jp/tcc/tcc/products/clisys/mjo/monitor.html • https://ds.data.jma.go.jp/tcc/tcc/products/clisys/ASIA_TCC/mjo_cross.html)
Asian Monsoon Monitoring Indices	Daily, only during Apr. - Oct.	• Time series of vertical wind shear, OLR and other indices associated with SW Asian Monsoon (linked to the Tokyo Climate Center web site: https://ds.data.jma.go.jp/tcc/tcc/products/clisys/ASIA_TCC/monsoon_index.html)
Ocean Condition		
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 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 Intensity	4 times/day	• TC intensity forecast guidance based on the Statistical Hurricane Intensity Prediction Scheme (SHIPS)
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 forecast validation	4 times/day	• Real-time validation of TC track and intensity forecast of numerical forecast models and related products.
Marine Forecast		
Storm Surge Forecasts	4 times/day	• Distribution maps of deterministic storm surge forecast for RSMC Tokyo - Typhoon Center's TC track forecast and probabilistic forecasts using using GEPS ensemble prediction (up to 132 hours) • Time-series storm surge forecast charts for RSMC Tokyo - Typhoon Center's TC track forecast and TC track forecasts from GEPS ensemble prediction (up to 132 hours) • Time-series representations of sea levels, related anomalies, and wind and sea level pressure based on official forecasts for stations of Typhoon Committee Members (up to 132 hours) • Time-series storm surge forecast charts for RSMC Tokyo - Typhoon Center's ensemble TC track forecasts with box-and-whisker plots and probabilities of 1-, 2- and 3m-exceeding storm surges (up to 132 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)

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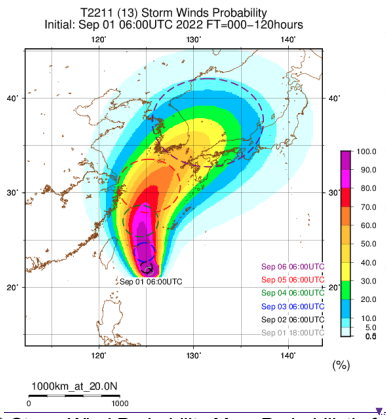
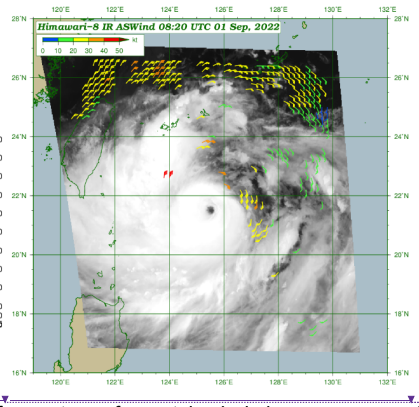
Example of the products provided by RSMC Tokyo - Typhoon Center





(Left) Storm Wind Probability Map: Probabilistic forecast map for sustained wind equal to or above 50-kt with forecast time of 1, 2, 3, 4 and 5 days, to grasp the possible impact for areas of interest. (Right) Sea-surface AMV: AMV-based sea-surface wind in the vicinity of TCs estimated from Himawari-8/9 low-level AMVs. Data are available every 30 minutes for full-disk observation and every 10 minutes for Target Area observation, respectively.

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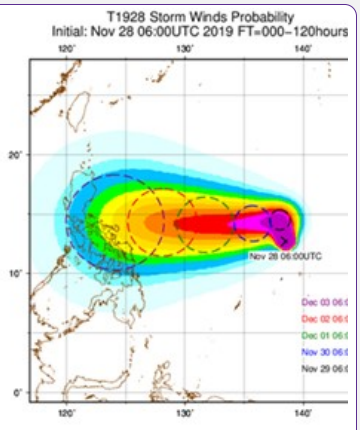

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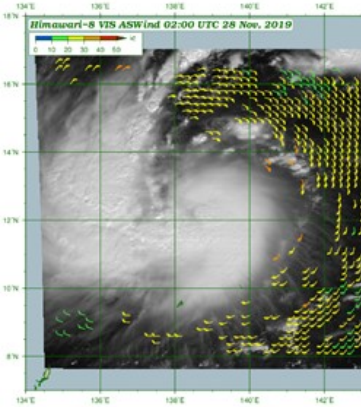

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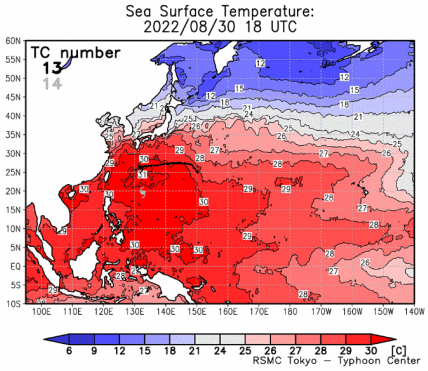

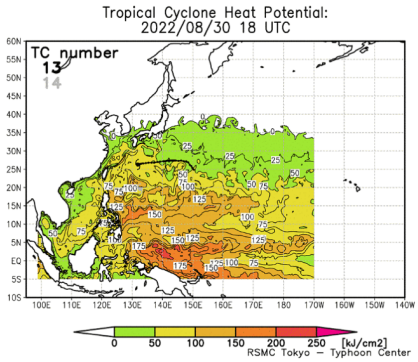

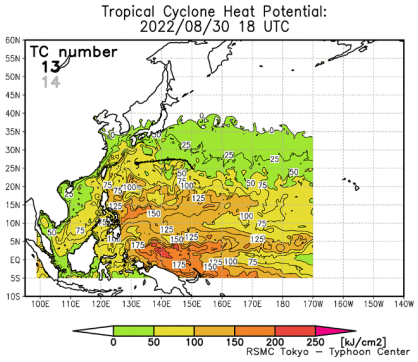

(Left) Sea Surface Temperature analysed with observation data of satellites, buoys, ships. "SST > 26°C to a depth of 60 m" is one of the necessary conditions for TC development and genesis. (Right) Tropical cyclone heat potential: Total heat contents from sea surface down to the depth of the 26°C isotherm, operationally used as TC intensity guidance. Minimum threshold for rapid intensification of TC in the western North Pacific is around 40 kJ/cm^2.

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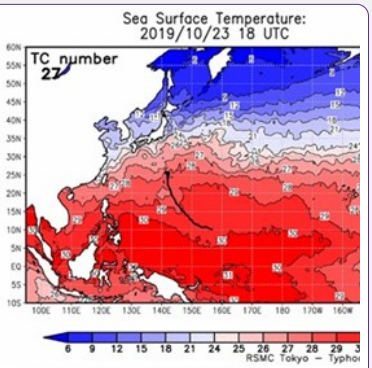

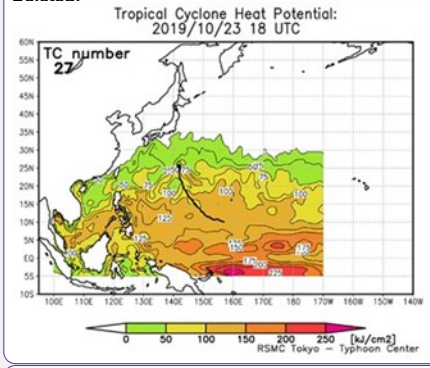

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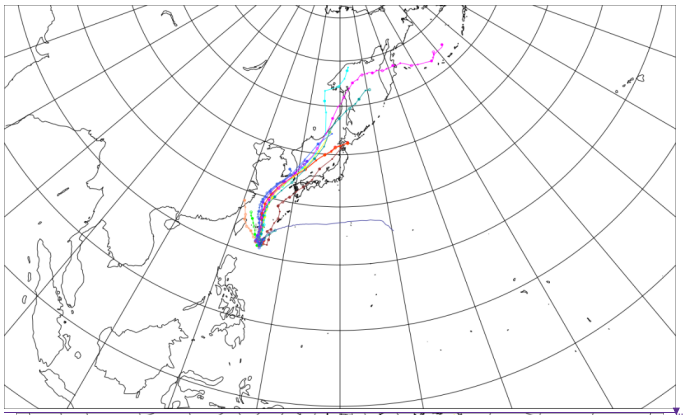
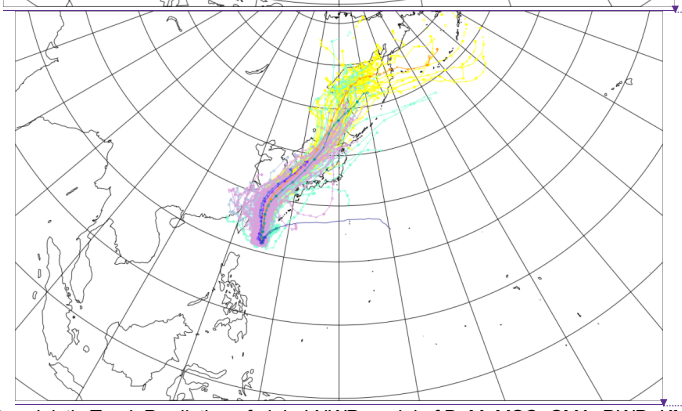
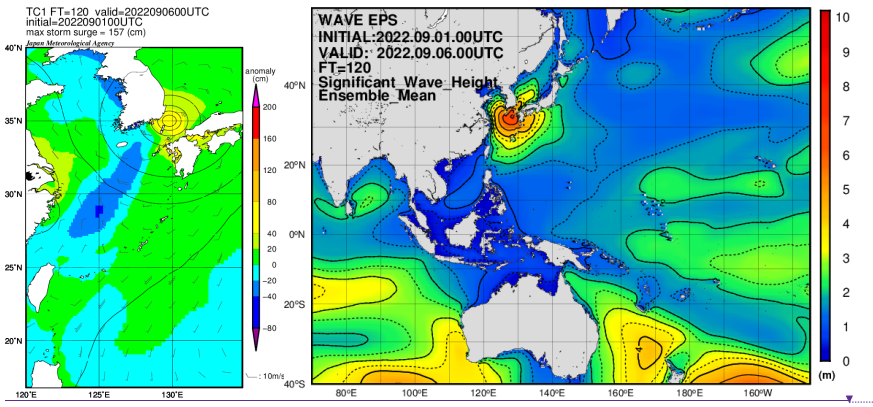




(Above) Deterministic Track Prediction of global NWP model of BoM, MSC, CMA, DWD, KMA, UKMO, NCEP, ECMWF and JMA. Track prediction of specific NWP models can be selected for display.
(Below) Ensemble Track Prediction of NCEP, UKMO, ECMWF and JMA.



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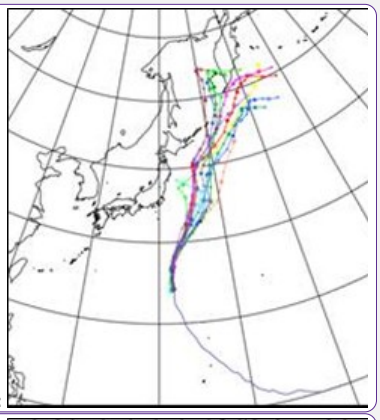

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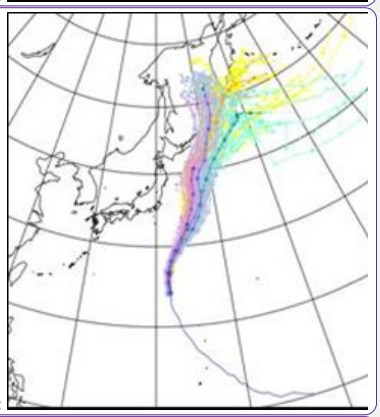

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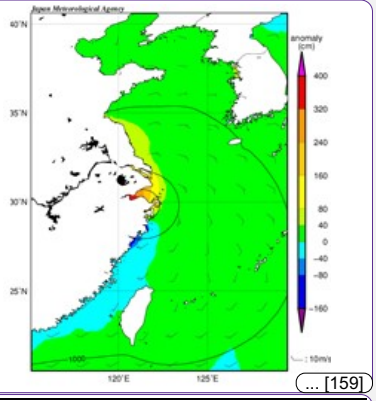

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(Left) Storm surge forecast for RSMC Tokyo - Typhoon Center's official track forecast, (Right) Ocean Wave Height produced by Wave Ensemble System of JMA.

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Deterministic NWP models used in the Numerical Typhoon Prediction website

System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Specification of (Model/Data)
JMA deterministic Global model (GSM)	Global	TL959 (~20 km)	128	132 hours (06, 18 UTC) 264 hours (00, 12 UTC)	Model
BoM deterministic Global model (ACCESS-G)	Global	Lon: 0.35° Lat: 0.23°	-	240 hours (00, 12UTC)	Data
CMA deterministic Global model (CMA GFS)	Global	0.25°	-	120 hours (00, 06,12,18 UTC)	Data
CMC deterministic Global model (GDPS)	Global	1.0°	-	144 hours (00, 12UTC)	Data
DWD deterministic Global model (ICON)	Global	0.25°	-	174 hours (00, 12UTC)	Data
ECMWF deterministic Global model (IFS-HRES)	Global	0.5°	-	240 hours (00, 12 UTC)	Data
KMA deterministic Global model (GDAPS)	Global	Lon: 0.23° Lat: 0.16°	-	168 hours (00, 12UTC),	Data
NCEP deterministic Global model (GFS)	Global	0.5°	-	192 hours (00, 06, 12, 18 UTC)	Data
UKMO deterministic Global model	Global	Lon: 0.83° Lat: 0.56°	-	120 hours (00, 12 UTC)	Data

EPS used in the Numerical Typhoon Prediction website

System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Number of Ensemble Members	Specification of (Model/ Data)
JMA Global EPS (GEPS)	Global	TQ479 (~27 km)	128	132 hours (06, 18 UTC) 264 hours (00, 12 UTC)	51	Model
ECMWF Global EPS	Global	Only track data	-	240 hours (00, 12 UTC)	51	Data
NCEP Global EPS	Global	0.5°	-	384 hours (00, 06, 12, 18 UTC)	31	Data
UKMO Global EPS	Global	Only track data	-	168 hours (00, 06, 12, 18 UTC)	36	Data

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APPENDIX 3-B

Analysis methods, forecasting methods and NWP for forecasting currently used by the NMSs of Typhoon Committee Members

Name of the Member: **[China]**

1 Tropical Cyclone Analysis

Parameter	Time	Methods	Other Sources
Dvorak Intensity (CI, T, DT, PT, MET number)	00, 06, 12, 18 UTC	Dvorak EIR method (Dvorak, 1984)	Satellite observational data from FY-4 (AGRI images, GHI images, GIIRS sounding data and LMI lightning data)) and FY-3 (Atmospheric vertical temperature profile), other available satellite microwave and sounding data
Center Position, Accuracy of center position, Direction and speed of movement	00, 03, 06, 09, 12, 15, 18, 21 UTC	Satellite images and other estimation methods which utilize surface observations	
Central Pressure (CP), Maximum Sustained Wind speed (MSW), Maximum Gust Wind speed (MGW), 50 kt radii (R50), 30 kt radii (R30)	00, 03, 06, 09, 12, 15, 18, 21 UTC	(1) Conversion from Dvorak method (Dvorak, 1984) (for CP, MSW and MGW) (2) Weather map analysis with full utilization of all observational data available (SYNOP, SHIP, BUOY, ASCAT, AMV including sea surface wind estimated from low-level AMV) (3) Statistical relationship between MSW and R50 selected by TC size	

2 Tropical Cyclone Forecasting

Parameter	Issuance Time	Lead Time	Methods
Likelihood of development of organized convective cloud systems into TSs	00, 06, 12, 18 UTC	24 hours	(1) Dvorak Intensity (2) 850 hPa and 200 hPa streamlines of deterministic Global NWP models and Ensemble Prediction Systems (EPSs) of major centers (e.g. GRAPES, ECMWF, NCEP and UKMO) (3) 850 hPa and 200 hPa streamlines of deterministic regional NWP models and EPS of GRAPES

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Parameter	Issuance Time	Lead Time	Methods
Center position, Direction and speed of movement, Radius of probability circle	00, 06, 12, 18 UTC	24, 48, 72, 96, 120 hours	Center position, Direction and speed of movement: (1) Simple consensus method using deterministic Global NWP models of GRAPES and other major centers such as ECMWF, NCEP and UKMO (2) Global EPSs of GRAPES, ECMWF, NCEP and UKMO as reference (3) Deterministic regional NWP models of GRAPES_TYM, Shanghai GRAPES Typhoon Model (SGTM), STI - Typhoon Ensemble Data Assimilation and Prediction System (STI-TEDAPS) as reference (4) OBEST method (a consensus method using EPSs of ECMWF, NCEP and UKMO (Dong and Zhang; 2016,Qi et al, 2014), STI Shanghai Selective Tropical Cyclone (STI-SSTC) , STI- western North Pacific tropical cyclone intensity prediction scheme (STI-WIPS) Radius of probability circle: Verification results of past TC track errors according to the ensemble spread of the Global EPSs of GRAPES, ECMWF, NCEP and UKMO (Chen et al, 2018).
CP, MSW, MGW, R50	00, 06, 12, 18 UTC	24, 48, 72, 96, 120 hours	CP, MSW and MGW: (1) Statistical and dynamical guidance (Chen et al, 2018) (2) Deterministic Global NWP models of GRAPES and other major centers such as ECMWF, NCEP and UKMO as reference (3) Deterministic Regional NWP models of GRAPES as reference R50: MSW-R50 development curve determined by TC size

3 NWP Systems in Operational Use

System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
CMA-GFS	Global	0.25°	87	240h (00,06,12,18 UTC)	_	Own
CMA-GEPS	Global	0.5°	87	360h (00,12UTC)	31	Own
CMA-TYM	40-180.°E; 15°S-60.0°N	0.09°	68	120h (00,06,12,18 UTC)	_	Own
CMA-REPS	70-145°E;15-65°N	0.1°	50	84h (00,12UTC)	15	Own
CMA-MESO	70-145°E 10-60°N	0.03°	50	72h (00,12UTC) 36h (03,06,09,15 ,18,21UTC)	_	Own
Shanghai GRAPES Typhoon Model (SGTM)	West Pacific Ocean and South China Sea	0.1°	50	up to 72h, interval is 6h	_	Own
STI - Typhoon Ensemble Data Assimilation and Prediction System (STI-TEDAPS)	West Pacific Ocean and South China Sea	27 km	35	up to 72h, interval is 6h	21	Own
CMA-TRAMS	Longitude: (70°E-160°E) Latitude: (0.8N-54.8°N)	0.09° (horizontal grids: 1001 x 601)	65	168hours (00,12 UTC) 72hours (06,18 UTC)	_	Own

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Reference

Chen G. M., Lei X T, Zhang X P, 2018. Verification of tropical cyclone operational forecast in 2017[R]. Ha Noi : UNESCAP/WMO Typhoon Committee:19.

Dong L and Zhang F Q, 2016. OBEST: an observation based ensemble sub-setting technique for tropical cyclone track prediction [J]. Wea Forecasting, 31(1): 57-70.

Dvorak V. F., 1984: Tropical cyclone intensity analysis using satellite data, NOAA Technical Report, 11.

Qi L b, Yu H and Chen P Y 2014. Selective ensemble-mean technique for tropical cyclone track forecast by using ensemble prediction systems [J]. Q. J. R. Meteorol. Soc.140, 805-813.

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Name of the Member: **[Hong Kong, China]**

1 Tropical Cyclone Analysis

Parameter	Time	Methods	Other Sources
1. Position, direction and speed of movement 2. Intensity (maximum sustained 10-minute mean wind near TC centre) 3. Central pressure, 4. Wind radii (of strong, gale, storm and hurricane force winds)	Synoptic hour in general (also subject to observation reception time)	1. Position, direction and speed of movement: • Satellite imagery • Radar imagery (reflectivity, zero-isodop on Doppler velocity) • Weather observation from synoptic stations, automatic weather stations, oil rigs and weather buoys 2. Intensity: • Dvorak analysis on satellite imagery • Radar imagery (Doppler wind) • Weather observation from synoptic stations, automatic weather stations, oil rigs and weather buoys • Dropsonde observations from reconnaissance flight 3. Central pressure: • Pressure observation from synoptic stations, automatic weather stations, oil rigs and weather buoys 4. Wind radii: • Weather observation from synoptic stations, automatic weather stations, oil rigs and weather buoys • Dropsonde observations from reconnaissance flight	(a) Scatterometer observations for analysing position, intensity and wind radii. (b) Microwave images for analysing position. (c) NOAA Multiplatform Tropical Cyclone Surface Winds Analysis for analysing intensity and wind radii.

2 Tropical Cyclone Forecasting

Parameter	Issuance Time	Lead Time	Methods
Track	Around 1 to 2 hour from the synoptic hour (T)	Forecast positions for: T + 24 h T + 48 h T + 72 h T + 96 h T + 120 h	Weighted ensemble forecast track is generated from 5 NWP guidance including JMA, UKMO, NCEP, ECMWF and ECMWF EPS. The ensemble forecast track forms the basis for formulating the operational TC forecast track. The operational TC forecast track may be slightly adjusted considering other NWP guidance (e.g. EPS products from CMC, KMA, JMA, NCEP and UKMO), real-time observations and past NWP performance.
Intensity (maximum sustained wind)	Around 1 to 2 hour from the synoptic hour (T)	Forecast intensity for: T + 24 h T + 48 h T + 72 h T + 96 h T + 120 h	The intensity forecast makes reference to the NWP intensity guidance products from ECMWF, JMA, NCEP, UKMO, NOAA HWRF, and AAMC-WRF of HKO. Factors such as rapid intensification chance deduced from statistical dynamical TC intensity forecast model, and environmental parameters such as sea surface temperature, wind shear, the ocean heat potential and land interactions are also considered in formulating the intensity forecast.

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3 NWP Systems in Operational Use

System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial time)	Number of Ensemble Members	Run by (own/other centers)
ECMWF deterministic global model	Global	0.1°	-	240 hours (00, 12 UTC) 90 hours (06, 18 UTC)	N. A.	Other
ECMWF global EPS	Global	Only TC track and intensity data	-	240 hours (00, 12 UTC) 144 hours (06, 18 UTC)	51	Other
ECMWF global EPS	Global	Ensemble member forecasts on surface and isobaric levels with horizontal resolution down to 0.2° covering selected domains	-	360 hours (00, 12 UTC) 90 hours (06, 18 UTC)	51	Other
NCEP deterministic global model	Global	0.25°	-	384 hours (00, 06, 12, 18 UTC)	N.A.	Other
NCEP global EPS	Global	Only TC track and intensity data	-	384 hours (00, 06, 12, 18 UTC)	31	Other
NCEP deterministic regional model (HWRF)	Domain based on the initial position of the TC	Only TC track and intensity data	-	Up to 126 hours (00, 06, 12, 18 UTC)	N.A.	Other
JMA deterministic global model (GSM)	Global	0.25°	-	264 hours (00, 12 UTC) 132 hours (06, 18 UTC)	N.A.	Other
JMA global EPS (GEPS)	Global	Only TC track and intensity data	-	132 hours (06, 18 UTC) 264 hours (00, 12 UTC)	51	Other
UKMO deterministic global model	Global	Lon: 0.23° Lat: 0.16°	-	144 hours (00, 12 UTC)	N.A.	Other
UKMO global EPS	Global	Only TC track and intensity data	-	192 hours (00, 06, 12, 18 UTC)	36	Other
CMA deterministic global model (GRAPES-GFS)	Global	0.25°	-	240 hours (00, 12 UTC)	N.A.	Other
CMA deterministic regional model (TRAMS)	0.8°N-54.8°N 70°E-160°E	0.09°	-	168 hours (00, 12 UTC) 72 hours (06, 18 UTC)	N.A.	Other
CMA regional EPS (REPS)	70-145°E 15-65°N	0.1°	-	84 hours (00, 12 UTC)	15	Other
CMC deterministic global model	Global	0.15°	-	240 hours (00, 12 UTC)	N.A.	Other

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System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial time)	Number of Ensemble Members	Run by (own/other centers)
CMC global EPS	Global	Only TC track data	-	240 hours (00, 12 UTC)	21	Other
DWD deterministic global model (ICON)	Global	13 km	-	180 hours (00, 12 UTC)	N.A.	Other
KMA deterministic global model	Global	0.35°	-	288 hours (00, 12 UTC)	N.A.	Other
AAMC-WRF	NW: 60ºN 45ºE NE: 60ºN 160ºE SW: 20ºS 45ºE SE: 20ºS 160ºE	10 km	42	84 hours	1	Own (Hon 2020)
RAPIDS-NHM	NW: 25.01°N 111.22°E NE: 25.01°N 117.13°E SW: 19.54°N 111.22°E SE: 19.54°N 117.13°E	2 km	60	15 hours	1	Own

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Name of the Member: **[Japan]**

1 Tropical Cyclone Analysis

Parameter	Time	Methods	Other Sources
Dvorak Intensity (CI, T, DT, PT, MET number)	00, 06, 12, 18 UTC	Dvorak EIR method (Dvorak, 1984, Koba et al., 1991) and Early Dvorak Analysis (EDA: Tsuchiya et al., 2001 and Kishimoto, 2008)	
Center Position, Accuracy of center position, Direction and speed of movement	00, 03, 06, 09, 12, 15, 18, 21 UTC	Satellite images and other estimation methods which utilize surface observations	
Central Pressure (CP), Maximum Sustained Wind speed (MSW), Maximum Gust Wind speed (MGW), 50 kt radii (R50), 30 kt radii (R30)	00, 03, 06, 09, 12, 15, 18, 21 UTC	(1) Conversion from Dvorak method (Koba et al., 1991) (for CP, MSW and MGW) (2) Weather map analysis with full utilization of all observational data available (SYNOP, SHIP, BUOY, ASCAT, AMV including sea surface wind estimated from low-level AMV (Nonaka et al., 2019), etc.) (3) Statistical relationship between MSW and R50 selected by TC size	CPs estimated from TC warm core intensities observed by the Advanced Microwave Sounding Unit-A (AMSU-A) (Oyama, 2014) and MSW estimated from multi-channel microwave imager data (Sakuragi et al., 2014, Hoshino and Nakazawa, 2007)

2 Tropical Cyclone Forecasting

Parameter	Issuance Time	Lead Time	Methods
Center position, Direction and speed of movement, Radius of probability circle (including for TDs expected to have TS intensity within 24 hours)	00, 06, 12, 18 UTC	24, 48, 72, 96, 120 hours	Center position, Direction and speed of movement: (1) Simple consensus method using deterministic Global NWP models of JMA and other major centers such as ECMWF, NCEP and UKMO (2) Global EPSs of JMA, ECMWF, NCEP and UKMO as reference (3) Deterministic regional NWP models of JMA and NCEP as reference Radius of probability circle: Verification results of past TC track errors according to the ensemble spread of the Global EPSs of JMA, ECMWF, NCEP and UKMO (Fukuda and Yamaguchi, 2019).
CP, MSW, MGW, R50	00, 06, 12, 18 UTC	24, 48, 72, 96, 120 hours	CP, MSW and MGW: (1) Statistical and dynamical guidance (TIFS: Yamaguchi et al., 2018) (2) Deterministic Global NWP models of JMA and other major centers such as ECMWF, NCEP and UKMO as reference (3) Deterministic Regional NWP models of JMA and NCEP as reference R50: MSW-R50 development curve determined by TC size

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3 NWP Systems in Operational Use

System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
JMA deterministic Global model (GSM)	Global	TL959 (~20 km)	128	132 hours (06, 18 UTC) 264 hours (00, 12 UTC)	-	Own
JMA Global EPS (GEPS)	Global	TQ479 (~27 km)	128	132 hours (06, 18 UTC) 264 hours (00, 12 UTC)	51	Own
JMA deterministic regional model (Meso-scale Model: MSM)	Japan and its surrounding areas	5 km (horizontal grids: 817 x 661)	96	39 hours (03, 06, 09, 15, 18, 21 UTC) 78 hours (00, 12 UTC)	-	Own
JMA regional EPS	Japan and its surrounding areas	5 km (horizontal grids: 817 x 661)	96	39 hours (00, 06, 12, 18 UTC)	21	Own
JMA deterministic regional model (Local Forecast Model: LFM)	Japan and its surrounding areas	2 km (horizontal grids: 1531 x 1301)	76	10 hours (Every hour)	-	Own
ECMWF deterministic Global model	Global	0.5°	-	240 hours (00, 12 UTC)	-	Other
ECMWF Global EPS	Global	Only track data	-	240 hours (00, 12 UTC)	51	Other
NCEP deterministic Global model	Global	0.5°	-	192 hours (00, 06, 12, 18 UTC)	-	Other
NCEP Global EPS	Global	0.5°	-	384 hours (00, 06, 12, 18 UTC)	31	Other
NCEP deterministic regional model (HWRF)	Domain based on the initial position of the TC	Only track and intensity data	-	Up to 126 hours (00, 06, 12, 18 UTC)	-	Other
UKMO deterministic Global model	Global	Lon: 0.83° Lat: 0.56°	-	120 hours (00, 12 UTC)	-	Other
UKMO Global EPS	Global	Only track data	-	168 hours (00, 06, 12, 18 UTC)	36	Other

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Name of the Member: **[Macao, China]**

1 Tropical Cyclone Analysis

Parameter	Time	Methods	Other Sources
Center Position, Direction and speed of movement	00, 06, 12, 18 UTC (increase to an hourly basis when TC enters the 800 km alert zone of Macao)	(1) Satellite imagery (2) Radar observations (3) Surface observation from synoptic stations, automatic weather stations, oil drills over the South China Sea	(a) ASCAT observations (b) NRL Microwave images (c) NOAA Multiplatform Tropical Cyclone Surface Winds Analysis / /
Intensity		Dvorak EIR method (Dvorak, 1984)	
Central Pressure (CP), Maximum Sustained Wind speed (MSW), Wind radii (strong wind and gale wind or above)		(1) Conversion from Dvorak method (Koba et al., 1991) (for CP and MSW) (2) Weather map analysis with full utilization of all observational data available (SYNOP, BUOY, oil drills)	

2 Tropical Cyclone Forecasting

Parameter	Issuance Time	Lead Time	Methods
Center position, Track and Intensity	00, 06, 12, 18 UTC (increase to an hourly basis when TC enters the 800 km alert zone of Macao)	24, 48, 72 hours	(1) Simple consensus method using deterministic NWP models of CMA, ECMWF, JMA, NCEP and UKMO (2) Global EPSs of ECMWF, JMA and NCEP as reference (3) Consider all environmental factors such as wind shear, sea surface temperature and upper/lower level divergence/convergence, which are favourable for intensification of TCs.

3 NWP Systems in Operational Use

System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
JMA deterministic Global model (GSM)	Global	TL959 (~50 km)	11	84 hours (00, 06, 18 UTC) 264 hours (12 UTC)	-	Other
ECMWF deterministic Global model	Global	0.25°	-	240 hours (00, 12 UTC)	-	Other
ECMWF Global EPS	Global	Only track data	-	240 hours (00, 12 UTC)	50 members 1 high resolution 1 control	Other
NCEP deterministic Global model	Global	0.25°	-	240 hours (00, 06, 12, 18 UTC)	-	Other
NCEP Global EPS	Global	Only track data	-	-	-	Other
UKMO deterministic Global model	Global	Lon: 0.23° Lat: 0.16°	-	144 hours (00, 12 UTC)	-	Other

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Name of the Member: **[Malaysia]**

1 Tropical Cyclone Analysis

Parameter	Time	Methods	Other Sources
Center Position, Accuracy of center position, Direction & speed of movement	00, 03, 06, 09, 12, 15, 18, 21 UTC	Satellite images, NWP products and other estimation methods which utilize surface observations	TC information such as central pressure, maximum sustained wind speed, maximum gust wind speed, R50 (50 kt radii), R30 (30 kt radii) from RSMC Tokyo

2 Tropical Cyclone Forecasting

Parameter	Issuance Time	Lead Time	Methods
Track (center position, distance from nearest town, direction and speed of movement)	01, 04, 07, 10, 13, 16, 19, 22 UTC	6, 12, 18, 24 hours	Track (center position, distance from nearest town, direction and speed of movement) refer to RSMC-Tokyo, Japan for South China Sea and Northwest Pacific region, and RSMC-New Delhi, India for Bay of Bengal region.

3 NWP Systems in Operational Use

System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
Mesoscale Deterministic Model: WRF driven by NCEP GFS model	**[9 km]:** Lon: 82.27 - 135.18°E Lat: 5.60°S - 31.34°N **[3 km]:** Lon: 97.15 - 121.03°E Lat: 3.45°S - 8.39°N **[1 km]:** Lon: 99.55 - 119.39 °E Lat: 0.53 – 7.44 °N	**[9 km]:** 655 x 479 **[3 km]:** 886 x 442 **[1 km]:** 2197 x 772	51	168 hours (00, 06, 12, 18UTC)	-	Own
Mesoscale Deterministic Model: WRF driven by UKMO model	**[9 km]:** Lon: 82.27 - 135.18°E Lat: 5.60°S - 31.34°N **[3 km]:** Lon: 97.15 - 121.03°E Lat: 3.45°S - 8.39°N **[1 km]:** Lon: 99.55 - 119.39°E Lat: 0.53 - 7.44 °N	**[9 km]:** 655 x 479 **[3 km]:** 886 x 442 **[1 km]:** 2197 x 772	51	60 (00, 06, 12, 18UTC)	-	Own
ECMWF deterministic Global model	Global	0.5°	-	240 hours (00, 12 UTC)	-	Other

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System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
NCEP deterministic Global model	Global	0.5°	-	192 hours (00, 06, 12, 18 UTC)	-	Other
JMA deterministic Global model (GSM)	Global	TL959 (~20 km)	100	132 hours (00, 06, 18 UTC) 264 hours (12 UTC)	-	Other

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Name of the Member: **[Philippines]**

1 Tropical Cyclone Analysis

Parameter	Time	Methods	Other Sources
Dvorak Intensity (DT, PT, MET, FT and CI numbers)	00, 06, 12, 18 UTC	▪ Dvorak EIR method (Dvorak 1984) ▪ Early-stage Dvorak Analysis (Tsuchiya et al. 2001; Kishimoto 2008)	▪ Satellite fix bulletins from other NMSs via Numerical Typhoon Prediction website or GTS ▪ CIMSS Advanced Dvorak Technique (ADT) (Olander and Velden 2007)
Center Position, Movement Speed and Direction	00, 06, 12, 18 UTC	Estimation of low-level circulation center using a combination of satellite images, weather radar scans, and surface observations (SYNOP, SHIP, BUOY).	▪ Satellite fix bulletins from other NMSs via Numerical Typhoon Prediction website or GTS ▪ CIMSS Automated Rotational Center Hurricane Eye Retrieval (ARCHER) (Wimmers and Velden 2010)
Central Pressure (PRES), Maximum Sustained Winds (MXWD), Maximum Gust (GUST),	00,06,12, 18 UTC	▪ Conversion of CI number to PRES and MXWD (Koba et al. 1991) ▪ Conversion of MXWD to GUST (Harper et al. 2010) ▪ Weather map analysis using all available observation data (SYNOP, SHIP, BUOY, ASCAT)	▪ PRES estimates from warm core intensity observations of Advanced Microwave Sounding Unit (AMSU) (Oyama 2014) via Numerical Typhoon Prediction website ▪ Weighted average of PRES analyses from Dvorak, AMSU and ATMS (Oyama et al. 2016) via Numerical Typhoon Prediction website ▪ CIMSS Satellite Consensus (SATCON) (Herndon and Velden 2018)
Radius of strong, gale-force, storm-force, and typhoon-force wind areas	00, 06, 12, 18 UTC	Weather map analysis using all available observation data (SYNOP, SHIP, BUOY, ASCAT)	▪ Sea surface winds estimated from low-level AMV (Nonaka et al. 2019) via Numerical Typhoon Prediction website ▪ NOAA/NESDIS Multiplatform Tropical Cyclone Surface Winds Analysis (MTCSWA) (Knaff and DeMaria 2010) ▪ CIMSS real-time wind radii estimates based on Knaff et al. (2016)

2 Tropical Cyclone Forecasting

Parameter	Issuance Time	Lead Time	Methods
PSTN, MOVE	00, 06, 12, 18 UTC	12, 24, 36, 48, 60, 72, 96, 120 hours	▪ Simple and selective (subjective) consensus method using global deterministic and EPS models of major centers via Numerical Typhoon Prediction website ▪ Global EPSs of NCEP, ECMWF, JMA and UKMO via Numerical Typhoon Prediction website as reference ▪ Regional deterministic NWP models of PAGASA, NCEP, and HKO as reference ▪ Analysis of environmental steering using actual 00 and 12 UTC upper-air charts (single layer approach) and CIMSS satellite AMV-derived deep-layer mean streamlines (Velden and Leslie 1991; Velden 1993)
Central Pressure (PRES), Maximum Sustained Winds (MXWD), Category (i.e., TD, TS, STS, TY, STY, LOW, XT)	00, 06, 12, 18 UTC	12, 24, 36, 48, 60, 72, 96, 120 hours	▪ Bias-corrected intensity prediction using weighted analog technique (Tsai and Elsberry 2014) ▪ Logistic Growth Equation Model (LGEM; DeMaria 2009) ▪ Typhoon Intensity Forecast Scheme based on SHIPS (TIFS; Yamaguchi et al. 2018; Ono et al. 2019) ▪ Global deterministic models from major NWP centers via GTS as reference ▪ Regional deterministic NWP models of PAGASA, NCEP, and HKO as reference
Radius of 70% Probability Circle	00, 06, 12, 18 UTC	24, 48, 72, 96, 120 hours	▪ Based on the direct positional error corresponding to cumulative ratio of 70% over the last 5 typhoon seasons.

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Note: Analyses and forecasts are made at 03, 09, 15, and 21 UTC for tropical cyclones that are landfalling or passing within 60 nmi of Philippine coastline. These additional analyses and forecasts commence within 24 hours of landfall or close approach and terminates once the cyclone leaves the 60-nmi coastal buffer.

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3 NWP Systems in Operational Use

System	Domain	Horizontal Resolution	Number of Vertical Level	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
PAGASA Regional Deterministic Model (WRF-ARW)	3°N-25°N 115°E-135°E	12 km (182 x 214 grids)	42	144 hours (00, 03, 06, 09, 12, 15, 18, 21 UTC)	-	Own
PAGASA Regional Deterministic Model (WRF-ARW)	5°N-21°N 116°E-127°E	3 km (361 x 593 grids)	42	48 hours (00, 03, 06, 09, 12, 15, 18, 21 UTC)	-	Own
JMA Global Deterministic Model (GSM)	Global	Track and intensity data only	-	132 hours (00, 06, 18 UTC) 264 hours (12 UTC)	-	Other
NCEP Global Deterministic Model	Global	Track data only	-	192 hours (00, 06, 12, 18 UTC)	-	Other
ECMWF Global Deterministic Model	Global	Track data only	-	240 hours (00, 12 UTC)	-	Other
UKMO Global Deterministic Model	Global	Track and intensity data only	-	120 hours (00, 12 UTC)	-	Other
KMA Global Deterministic Model	Global	Track and intensity data only	-	168 hours (00, 12 hours)	-	Other
BoM Global Deterministic Model	Global	Track and intensity data only	-	240 hours (00, 12 UTC)	-	Other
CMC Global Deterministic Model	Global	Track data only	-	144 hours (00, 12 UTC)	-	Other
CMA Global Deterministic Model	Global	Track data only	-	120 hours (00, 12 UTC)	-	Other
DWD Global Deterministic Model	Global	Track data only	-	84 hours (00, 12 UTC)	-	Other
JMA Global EPS (GEPS)	Global	Track and intensity data only	-	132 hours (06, 18 UTC) 264 hours (00, 12 UTC)	51	Other
NCEP Global EPS	Global	Track data only	-	384 hours (00, 06, 12, 18 UTC)	31	Other
ECMWF Global EPS	Global	Track data only	-	240 hours (00, 12 UTC)	51	Other
UKMO Global EPS	Global	Track data only	-	168 hours (00, 06, 12, 18 UTC)	36	Other
NCEP Regional Deterministic Model (HWRF)	Based on the initial position of the TC	Track and intensity data only	-	126 hours (00, 06, 12, 18 UTC)	-	Other

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System	Domain	Horizontal Resolution	Number of Vertical Level	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
HKO Regional Deterministic Model (NHM)	8°N-46.5°N 85°E-148°E	Track and intensity data only	-	72 hours (00, 06, 12, 18 UTC)	-	Other

Note: Apart from HWRF, deterministic and EPS model forecasts from other centers are made available via the JMA Numerical Typhoon Prediction website (https://tynwp-web.kishou.go.jp/) or the WMO Global Telecommunication System (GTS). HWRF forecasts are available via the HWRF Forecast Guidance website (https://www.emc.ncep.noaa.gov/gc_wmb/vxt/HWRF/index.php)

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Name of the Member: **[Republic of Korea]**

1 Tropical Cyclone Analysis

Parameter	Time	Methods	Other Sources
Center Position, Central pressure, Maximum sustained wind speed, Direction and speed of movement, 15 m/s radii, 25 m/s radii	00, 06, 12, 18 UTC	(1) Satellite images (ASCAT, OSCAT etc) and other estimation methods which utilize surface observations (SYNOP, SHIP, BUOY, AWS, Radar) (2) Dvorak technique for center pressure and maximum sustained wind speed estimates (Dvorak, 1984, Koba et al., 1991)	

2 Tropical Cyclone Forecasting

Parameter	Issuance Time	Lead Time	Methods
Likelihood of development of organized convective cloud systems into TSs	00, 06, 12, 18 UTC	24, 48, 72, 96, 120 hours	(1) EDA (2) Synoptic analysis covering all observations (3) Satellite imaginary (4) Consensus method using deterministic Global NWP model (GDAPS, ECMWF, NECP, JMA etc.) (5) 850 hPa and 200 hPa streamlines and steering flow, vertical wind shear of NWP models as reference
Center position, Direction and speed of movement, Radius of probability circle, Central pressure , Maximum sustained wind speed, 15 m/s radii, 25 m/s radii	00, 06, 12, 18 UTC	12, 24, 36, 48, 72, 96, 120 hours	Center position, direction and speed of movement : (1) Analysis of changes of circulation, organization of TC based on observations (SYNOP, SHIP, BUOY, AWS, Radar, Satellite) (2) Analysis of weather maps and comparison with NWP (3) Consensus method using KMA Global Data Assimilation and Prediction System (GDAPS) and other deterministic Global model (ECMWF, JMA, NCEP, etc.) (4) Global EPS (EPSG, ECMWF, JMA, NCEP, etc.) and OMME(Optimal multi model EPS) as reference Central pressure, maximum sustained wind speed: (1) Conversion with Dvorak technique and analysis of Satellite imaginary and observations(SYNOP, SHIP, BUOY, AWS) (2) KMA Global Data Assimilation and Prediction System (GDAPS) , other deterministic Global model (ECMWF, JMA, NCEP, etc.), Global EPS (EPSG, ECMWF, JMA, NCEP, etc.) and NCEP deterministic regional model (HWRF) as reference (3) Analysis of Sea Surface Temperature and Ocean heat content (4) Wind shear of NWP model Radius of probability circle: Expected TC locations with a probability of 70% at each lead time. Statistically measured by averaging forecast track errors for the latest 3 years

3 NWP Systems in Operational Use

System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
KMA Global Data Assimilation and Prediction System (GDAPS)	Global	~12 km	91	288 hours (00,12 UTC) 87 hours (06, 18 UTC)	-	Own
KMA Global EPS (EPSG)	Global	~32 km	91	288 hours (00,12 UTC)	26	Own
ECMWF deterministic Global model	Global	0.25°	137	240 hours (00, 12 UTC)	-	Other

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System	Domain	Horizontal Resolution	Number of Vertical Levels	Forecast Range (Initial Time)	Number of Ensemble Members	Run by (own/other centers)
ECMWF Global EPS	Global	0.25°	137	240 hours (00, 12 UTC)	51	Other
JMA deterministic Global model (GSM)	Global	track and intensity data	-	132 hours (00, 06, 18 UTC) 264 hours (12 UTC)	-	Other
JMA Global EPS (GEPS)	Global	track and intensity data	-	132 hours (06, 18 UTC) 264 hours (00, 12 UTC)	51	Other
NCEP deterministic Global model (GFS)	Global	track and intensity data	-	168 hours (00, 06, 12, 18 UTC)	-	Other
NCEP Global EPS	Global	track and intensity data	-	240 hours (00, 06, 12, 18 UTC)	80	Other
NCEP deterministic regional model (HWRF)	Regional	track and intensity data	-	Up to 126 hours (00, 06, 12, 18 UTC)	-	Other
Navy Global Environmental Model (NavGEM)	Global	track and intensity data		144 hours (00,12 UTC)		Other

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Name of the Member: **[Thailand]**

1 Tropical Cyclone Analysis

Parameter	Time	Methods	Other Sources
Dvorak Intensity (CI)	00, 06, 12, 18 UTC	Devorak Technique (Dvorak, 1984) And SATIAD Program from JMA for analysis	Satellite observational data from Himawari-8/9 from Japan and FY4A from China
Center Position, Accuracy of center position, Direction and speed of movement	00, 03, 06, 09, 12, 15, 18, 21 UTC and hourly from synoptic observation and AWS	Satellite images and Synoptic charts and other estimation methods which utilize surface observations	Observation and Weather Radar

2 Tropical Cyclone Forecasting

Parameter	Issuance Time	Lead Time	Methods	Other Sources
Center position, Direction and speed of movement, Radius of probability circle	00, 06, 12, 18 UTC	12, 24, 36, 48, 72, 96, 120 hours	Reference : RSMC TOKYO (Japan) in Pacific and South China sea region Reference : RSMC New Delhi (India) in Arabian and Andaman sea region - NWP products from TMD-HPC output	Center position, Direction and speed of movement: Simple consensus method using deterministic Global NWP models such as ECMWF, NCEP and JMA KMA and BOM (Australia)

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APPENDIX 4-A

CLASSIFICATIONS OF TROPICAL CYCLONES IN THE WESTERN NORTH PACIFIC INTERNALLY USED BY MEMBERS

Maximum sustained winds (knots)	≤33	34 - 47	48 - 63	≥ 64		
Typhoon Committee (10 min)	Tropical Depression (TD)	Tropical Storm (TS)	Severe Tropical Storm (STS)	Typhoon (TY)		
China (2 min)	TD	TS	STS	64 - 80 TY	81 - 99 Severe Typhoon (STY)	≥ 100 Super Typhoon (Super TY)
Hong Kong, China (10 min)	TD*	TS	STS	64 - 80 TY	81 - 99 Severe Typhoon (ST)	≥ 100 Super Typhoon (Super T)
Japan (10 min)	TD	TS	STS	64 - 84 TY	85 - 104 Very Strong TY	≥ 105 Violent TY
Macao, China (10 min)	TD	TS	STS	64 - 80 TY	81 - 99 Severe Typhoon (ST)	≥ 100 Super Typhoon (Super T)
Philippines (10 min)	TD	TS	STS	64 - 99 TY		≥ 100 Super TY
Republic of Korea (10min)	TD	TS	STS	64~84 TY	85~104 Very Strong TY	≥ 105 Super TY
U.S.A. (1 min)	TD	TS		64 - 129 TY		≥ 130 Super TY

*For Hong Kong, China, a Tropical Depression has maximum sustained winds of 22 – 33 knots.

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APPENDIX 4-B

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EXAMPLES OF ADVISORIES ISSUED FROM RSMC TOKYO - TYPHOON CENTER

RSMC Guidance for Forecast by GSM

FXPQ20 RJTD 231200
RSMC GUIDANCE FOR FORECAST
NAME TY 1826 YUTU (1826)
PSTN 231200UTC 12.0N 149.6E
PRES 965HPA
MXWD 75KT
FORECAST BY GLOBAL MODEL
TIME PSTN PRES MXWD
(CHANGE FROM T=0)
T=006 12.8N 149.0E -007HPA +007KT
T=012 13.5N 148.4E -012HPA +015KT
T=018 14.0N 147.5E -016HPA +011KT
T=024 14.5N 146.7E -018HPA +017KT
T=030 15.2N 145.8E -025HPA +023KT
T=036 15.7N 144.9E -025HPA +027KT
T=042 16.2N 144.0E -032HPA +028KT
T=048 16.3N 143.2E -032HPA +031KT
T=054 16.6N 142.4E -037HPA +035KT
T=060 16.7N 141.4E -035HPA +033KT
T=066 16.7N 140.3E -041HPA +033KT
T=072 16.8N 139.0E -039HPA +037KT
T=078 16.9N 137.7E -041HPA +035KT
T=084 16.9N 136.2E -040HPA +033KT
T=090 17.0N 135.0E -045HPA +036KT
T=096 17.0N 133.9E -043HPA +038KT
T=102 17.0N 132.8E -045HPA +038KT
T=108 16.8N 131.8E -047HPA +038KT
T=114 16.6N 130.9E -053HPA +041KT
T=120 16.5N 130.1E -054HPA +042KT
T=126 16.4N 129.2E -055HPA +042KT
T=132 16.4N 128.5E -051HPA +038KT=

RSMC Guidance for Forecast by GEPS

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

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T=012 13.2N 148.3E -001HPA +004KT
T=018 13.8N 147.6E -005HPA +004KT
T=024 14.3N 146.7E -005HPA +006KT
T=030 14.9N 145.9E -009HPA +009KT
T=036 15.4N 145.0E -009HPA +010KT
T=042 15.8N 144.2E -013HPA +010KT
T=048 16.1N 143.5E -012HPA +011KT
T=054 16.3N 142.7E -015HPA +012KT
T=060 16.5N 141.9E -014HPA +013KT
T=066 16.7N 141.0E -018HPA +017KT
T=072 16.9N 139.8E -017HPA +018KT
T=078 17.2N 138.6E -020HPA +018KT
T=084 17.4N 137.3E -020HPA +021KT
T=090 17.7N 136.0E -024HPA +021KT
T=096 17.8N 134.9E -023HPA +021KT
T=102 17.9N 133.9E -027HPA +023KT
T=108 17.9N 132.9E -026HPA +026KT
T=114 18.0N 132.1E -031HPA +028KT
T=120 17.9N 131.3E -031HPA +030KT
T=126 17.9N 130.6E -034HPA +030KT
T=132 18.0N 129.9E -033HPA +030KT=

RSMC Prognostic Reasoning

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

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THE INFLUENCE OF INTERACTION WITH HIGH SSTS, HIGH TCHP AND DRY AIR.
THE JMA INTENSITY FORECAST IS BASED ON GUIDANCE DATA. =

RSMC Tropical Cyclone Advisory for Five-day Forecast

WTPQ50 RJTD 231200
RSMC TROPICAL CYCLONE ADVISORY
NAME TY 1826 YUTU (1826)
ANALYSIS
PSTN 231200UTC 12.0N 149.6E GOOD
MOVE W 11KT
PRES 965HPA
MXWD 075KT
GUST 105KT
50KT 60NM
30KT 270NM NORTHEAST 210NM SOUTHWEST
FORECAST
24HF 241200UTC 14.4N 146.2E 50NM 70%
MOVE WNW 10KT
PRES 925HPA
MXWD 100KT
GUST 140KT
48HF 251200UTC 16.2N 143.2E 95NM 70%
MOVE WNW 09KT
PRES 915HPA
MXWD 105KT
GUST 150KT
72HF 261200UTC 17.4N 139.8E 130NM 70%
MOVE WNW 09KT
PRES 915HPA
MXWD 105KT
GUST 150KT
96HF 271200UTC 18.7N 135.6E 240NM 70%
MOVE WNW 11KT
PRES 935HPA
MXWD 95KT
GUST 135KT
120HF 281200UTC 19.6N 132.6E 375NM 70%
MOVE WNW 07KT
PRES 935HPA
MXWD 90KT
GUST 130KT =

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APPENDIX 4-C

Field Code Changed

STATIONS BROADCASTING CYCLONE WARNINGS FOR SHIPS ON THE HIGH SEAS

Station		Call sign of coastal radio station	Area covered
Member	Station		
China	Shanghai	XSG	Bohai Sea, Huanghai Sea, Donghai Sea, Shanghai Port, Taiwan Straits and sea around Taiwan province
	Tianjin	XSZ	North and Central Huanghai Sea and Bohai Sea
	Guangzhou	XSQ	Taiwan Straits, Bashi Channel, South China Sea and Beibu Wan Gulf
Hong Kong, China	Hong Kong	Broadcast via NAVTEX on 518 kHz[11]	Waters inside the boundary line: 30°N 105°E to 30°N 125°E to 10°N 125°E, to 10°N 105°E, to 30°N 105°E
Japan	Hokkaido	JNL	Hokkaido area
	Shiogama	JNN	Sendai area
	Yokohama	JGC	Tokyo area
	Nagoya	JNT	Nagoya area
	Kobe	JGD	Kobe area
	Hiroshima	JNE	Hiroshima area
	Niigata	JNV	Niigata area
	Maizuru	JNC	Maizuru area
	Moji	JNR	Fukuoka area
	Kagoshima	JNJ	Kagoshima area
	Okinawa	JNB	Okinawa area
Malaysia	Klang	SSB 5	Strait of Malacca
	Labuan	SSB 16	South China Sea
	Kuching	SSB 5	South China Sea
Philippines	Manila	DZR, DZG, DSP, DZD, DZF, DFH, DZO, DZN, DZS	Pacific waters inside the boundary line: 25°N 12°0E to 25°N 135°E, to 5°N 135°E, to 5°N 115°E, to 15°N 115°E, to 21°N 120°E, to 20°N 120°E
	San Miguel	NPO	North Pacific waters east of 160°E; Philippine Sea, Japan Sea, Yellow Sea, East China Sea, South China Sea
Republic of Korea	Seoul	HLL	East Sea, Yellow Sea, Jeju, Chusan, Nagasaki, and Kagoshima areas Waters inside the boundary line: 43°N 120°E to 43°N 132°E to 27°N 132°E, to 27°N 120°E, to 43°N 120°E
Thailand	Bangkok	HSA	Gulf of Thailand, West coast of Southern Thailand, Strait of Malacca and South China Sea
U.S.A.	Honolulu, Hawaii	KMV-99	Pacific Ocean
Viet Nam	Dannang	XVT 1-2	Basco Gulf, Blendong Sea and Gulf of Thailand
	Halphong	XVG 5, 9	*ditto*
	Ho Chi Minh Ville	XVS 1, 3, 8	*ditto*
	Nha Trang	XVN 1, 2	*ditto*

[11] Coast station VRX closed on 1 October 2006.

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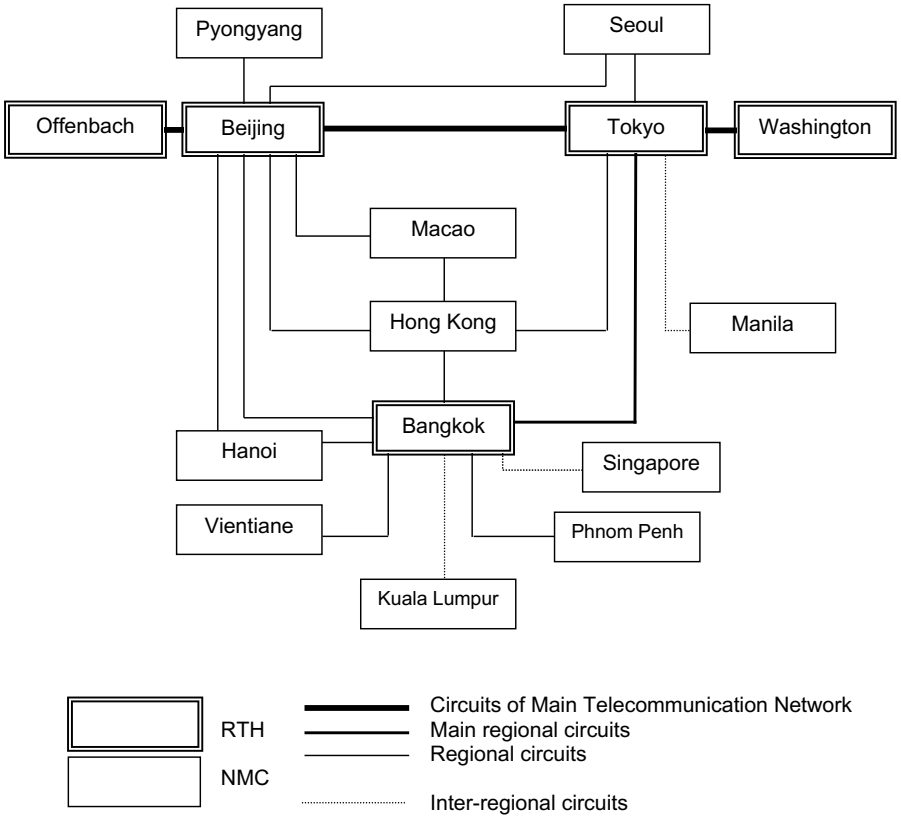
APPENDIX 5-A

Field Code Changed

METEOROLOGICAL TELECOMMUNICATION NETWORK FOR THE TYPHOON COMMITTEE



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APPENDIX 5-B

Field Code Changed

PRESENT OPERATIONAL STATUS OF THE METEOROLOGICAL TELECOMMUNICATION NETWORK FOR THE TYPHOON COMMITTEE REGION

1. Main Telecommunication Network	Present Operational Status
Beijing - Tokyo	Cable (MPLS), WMO FTP Beijing 30 Mbps/Tokyo 20 Mbps
Beijing - Offenbach	Cable (MPLS), TCP/IP Beijing 30 Mbps/Offenbach 50 Mbps
Washington - Tokyo	Internet, TCP/IP
2. Main regional circuit	
Tokyo - Bangkok	Cable (MPLS), TCP/IP Tokyo 6 Mbps/Bangkok 2 Mbps
3. Regional circuits	
Bangkok - Beijing	2 Mbps leased line, FTP protocol CMACast (Satellite broadcast)
Bangkok - Hanoi	64 kbps leased line, FTP protocol and Internet, FTP protocol
Bangkok - Hong Kong	Internet, FTP protocol
Bangkok - Phnom Penh	Internet (VPN), FTP protocol
Bangkok - Vientiane	Cable (DDN), 64 kbps, FTP protocol and Internet, FTP protocol
Beijing - Hanoi	64 kbps leased line, CMACast (Satellite broadcast)
Beijing - Hong Kong	Cable (MSTP), 20 Mbps TCP/IP CMACast (Satellite broadcast)
Beijing - Macao	20 Mbps leased line CMACast (Satellite broadcast)
Beijing - Pyongyang	64 kbps leased line, CMACast (Satellite broadcast)
Beijing - Seoul	Cable (MPLS), TCP/IP Beijing 30 Mbps/Seoul 4 Mbps
Beijing - Vientiane	CMACast (Satellite broadcast)

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Hong Kong - Macao	Internet (VPN) and Mobile leased line
Tokyo - Hong Kong	Cable (MPLS), WMO FTP Tokyo 6 Mbps/Hong Kong 1 Mbps
Tokyo - Seoul	Cable (MPLS), WMO FTP Tokyo 20 Mbps/Seoul 6 Mbps

4. Inter-regional circuits

Bangkok - Kuala Lumpur	Cable (MPLS), TCP/IP 64 kbps
Bangkok - Singapore	Cable (MPLS), TCP/IP 64 kbps
Tokyo - Manila	Cable (MPLS), TCP/IP Tokyo 6 Mbps/Manila 2 Mbps

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5. RTH radio broadcast

Bangkok	1 FAX, 1 VOICE
Tokyo	1 FAX

6. Satellite broadcast

Operated by China: CMACast	Operational observations, warnings, NWP products, satellite image and fax distribution
Operated by Japan: HimawariCast (JCSAT-2, 154°E)	Operational satellite image, NWP products, in-situ observation data and ASCAT ocean surface wind data distribution

7. Internet Cloud Service

Operated by Japan: HimawariCloud	Operational satellite image in full resolutions and bands

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APPENDIX 5-C

LIST OF ADDRESSES, TELEX/CABLE AND TELEPHONE NUMBERS OF THE TROPICAL CYCLONE WARNING CENTERS IN THE REGION

Centre	Mailing address	Telex/cable, Telephone, fax numbers
Cambodia		
Attn. Mr Ly Chana Deputy Director Department of Agricultural Hydraulics and Hydrometeorology	Norodom Boulevard	Tel.:(+855) 15 913081 Fax:(+855) 23 26345
Attn. Mr Hun Kim Hak Chief of Cambodian National	Pochentong	Tel/Fax:(+855) 23 66193 66192 NMC 66191 Airport
China		
National Meteorological Center China Meteorological Adm. (Director: Hao Liping)	No. 46 Zhongguancun Nandajie, Beijing 100081	Tel.:(+86) (10) 6840 6026 Cable:2894 Fax:(+86) (10) 6217 5928 E-mail: wmc-bj@cma.gov.cn
Democratic People's Republic of Korea		
Mr Ko Sang Bok Director Central Forecast Research Institute State Hydrometeorological Adm.	Oesong-dong Central District	Telex:38022 TCT KP Tel.:(+850) (2) 321 4539 Fax:(+850) (2) 381 4410
Hong Kong, China		
Central Forecasting Office Hong Kong Observatory (Attn. Mr. H.Y. Yeung)	134A Nathan Road Tsim Sha Tsui Kowloon Hong Kong, China	Tel.:(+852) 2926 8371 (Office hours) (+852) 2368 1944 (24 hours) Fax: (+852) 2311 9448 (Office hours) E-mail: hyyeung@hko.gov.hk
Japan		
Typhoon Center Weather Disaster Mitigation Division Atmosphere and Ocean Department Japan Meteorological Agency (Head: T. Hosomi)	3-6-9 Toranomon Minato-ku Tokyo 105-8431	Tel.: (+81) (3) 6758 3900 ext.4231 Fax: (+81) (3) 3434 9047 (Office hours)
Lao People's Democratic Republic		
Ministry of Agriculture and Forestry, Department of Meteorology and Hydrology, VIENTIANE	P.O. Box 811 Vientiane	Telex:4306 ONU VTELS Cable:UNDEVPRO
Macao, China		
Meteorological and Geophysical Bureau (Director: Leong Weng Kun)	Rampa do Observatório, Taipa Grande, Macau, China	Tel.:(+853) 88986173 Fax:(+853) 28850773 E-mail:meteo@smg.gov.mo
Malaysia		
National Weather & Geophysics Operation Centre, Malaysian Meteorological Department, (Director:	Jalan Sultan 46667 Petaling Jaya Selangor Malaysia	Tel.:(+60) (3) 7967 8118 (+60) (3) 7967 8119 Fax:(+60) (3) 7955 0964 E-mail: fariza@met.gov.my

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Dr. Fariza Yunus)		

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Centre	Mailing address	Telex/cable, Telephone, fax numbers
Philippines		
Mr. Juanito S. Galang Chief, Marine Meteorological Services Section Weather Division, DOST-PAGASA	PAGASA Weather and Flood Forecasting Center, BIR Road, Pinyahan, Quezon City 1100	Tel.:(+63) (2) 8284 0800 ext. 805 (24 hours) (+63) (2) 8284 0800 ext. 823 (Office hours) Fax.: (+63) (2) 892 (+63) (2) 892 Email: typhoon.ops@pagasa.dost.gov.ph junsgalang2313@gmail.com
Typhoon Committee Secretariat		
Secretary: Yu Jixin	Avenida de 5 de Outubro Coloane, Macau	Tel: (853) 8 8010531 Fax: (853) 8 8010530 E-mail: yujx@typhooncommittee.org
Republic of Korea		
National Typhoon Center Korea Meteorological Administration (Dong Jin KIM, Meteorologist in charge)	2 Seoseongro 810-gil, Namwon-eup, eogwipo, Jeju, 63614, Republic of Korea	Tel.:(+82) (70) 7850-6365 Fax:(+82) (64) 805-0368
Thailand		
Thai Meteorological Department (Director-General: Miss Chomparee Chompurat)	4353 Sukhumvit Road, Bangna, Bangkok 10260	Tel&FAX: (+66) (2) 398 9875 E-mail: tmd_inter@tmd.mail.go.th
Weather Forecast Division Thai Meteorological Department (Director: Miss Chalalai Jamphon)	4353 Sukhumvit Road, Bangna, Bangkok 10260	Tel&Fax: (+66) (2) 399 4001 E-mail: chalalaij@yahoo.com chalalaij@tmd.go.th weatherman@metnet.tmd.go.th tmd_inter@tmd.mail.go.th
South East Asia Meteorological Telecommunication Center Thai Meteorological Department (Director: Mrs. Wattana Singtuy)	4353 Sukhumvit Road, Bangna, Bangkok 10260	Tel.:(+66) (2) 399 4555 Fax:(+66) (2) 398 9861 E-mail: gtsbkk@metnet.tmd.go.th
USA		
National Weather Service (Genevieve Miller, Meteorologist in charge)	3232 Hueneme Road Barrigada Guam 96913	Tel.:(+1-671) 472 0944 Fax:(+1-671) 472 7405
RSMC Honolulu (Director: Mr. Christopher Brenchley)	2525 Correa Road Suite 250 Honolulu, HI 96822	Tel.:(+1-808) 973-5272 Fax:(+1-808) 973-5271
Viet Nam		
Forecast Division Forecast Department Hydro-Meteorological Service (Director: Nguyan Cong Thanh)	4 Dan Thai Than Hanoi	Tel.:(+84) (4) 264020 Fax:(+84) (4) 254278

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APPENDIX 5-D

Field Code Changed

ABBREVIATED HEADINGS FOR THE TROPICAL CYCLONE WARNINGS

Member	Abbreviated WMO Communication Headings
Cambodia	
China	WTPQ20 BABJ
Democratic People's Republic of Korea	
Hong Kong, China	WTPQ20 VHHH, WTSS20 VHHH
Japan	WTPQ50 - 55 RJTD
Lao People's Democratic Republic	
Macao, China	For domestic dissemination only and WTMU40 VMMC
Malaysia	For domestic dissemination only
Philippines	WTPH20 - 22 RPMM
Republic of Korea	WTKO20 RKSL
Singapore	WTSR20 WSSS
Thailand	For domestic dissemination only
USA	WTPQ31 - 35 PGUM
Viet Nam	WTVS20 VNNN

APPENDIX 5-E

Field Code Changed

COLLECTION AND DISTRIBUTION OF INFORMATION RELATED TO TROPICAL CYCLONES

Type of Data	Heading		Receiving station										
			TD	BJ	BB	HH	MM	SL	NN	KK	IV	PP	MC
Enhanced	SNCI30	BABJ	BJ	O	BJ	BJ	TD	TD	BJ	BB	BB	BB	
surface	SNHK20	VHHH	HH	HH	BJ	O		TD	BB	BB	BB	BB	HH
observation	SNJP20	RJTD	O	TD	TD	TD		TD	BB	BB	BB	BB	
	SNKO20	RKSL	SL	TD	TD	TD		O	BB	BB	BB	BB	
	SNLA20	VLIV	BB	BB	IV				BB	BB	O	BB	
	SNMS20	WMKK	BB	BB	KK	BJ			BB	O	BB	BB	
	SNMU40	VMMC		MC	BJ	BJ		TD	BB	BB	BB	BB	O
	SNPH20	RPMM	MM	TD	TD	TD	O	TD	BB	BB	BB	BB	
	SNTH20	VTBB	BB	BB	O	BB		TD	BB	BB	BB	BB	
	SNVS20	VNNN	BB		NN	BJ			O	BB	BB	BB	
Enhanced	USCI01	BABJ	BJ	O	BJ	BJ	TD	TD	BJ	BB	BB	BB	
upper-air	USCI03	BABJ	BJ	O	BJ	BJ	TD	TD	BJ	BB	BB	BB	
observation	USCI05	BABJ	BJ	O	BJ	BJ	TD	TD	BJ	BB	BB	BB	
	USCI07	BABJ	BJ	O	BJ	BJ	TD	TD	BJ	BB	BB	BB	
	USCI09	BABJ	BJ	O	BJ	BJ	TD	TD	BJ	BB	BB	BB	
	UKCI01	BABJ	BJ	O	BJ	BJ		TD	BJ	BB	BB	BB	
	ULCI01	BABJ	BJ	O	BJ	BJ		TD	BB	BB	BB	BB	
	ULCI03	BABJ	BJ	O	BJ	BJ		TD	BB	BB	BB	BB	
	ULCI05	BABJ	BJ	O	BJ	BJ		TD	BB	BB	BB	BB	
	ULCI07	BABJ	BJ	O	BJ	BJ		TD	BB	BB	BB	BB	
	ULCI09	BABJ	BJ	O	BJ	BJ		TD	BJ	BB	BB	BB	
	UECI01	BABJ	BJ	O	BJ	BJ		TD	BB	BB	BB	BB	
	USHK01	VHHH	HH	HH	BJ	O	TD	TD	BB	BB	BB	BB	HH
	UKHK01	VHHH	HH	HH	BJ	O		TD	BB	BB	BB	BB	HH
	ULHK01	VHHH	HH	HH	BJ	O		TD	BB	BB	BB	BB	HH
	UEHK01	VHHH	HH	HH	BJ	O		TD	BB	BB	BB	BB	HH
	USJP01	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	UKJP01	RJTD	O	TD	TD	TD		TD	BB	BB	BB	BB	
	ULJP01	RJTD	O	TD	TD	TD		TD	BB	BB	BB	BB	
	UEJP01	RJTD	O	TD	TD	TD		TD	BB	BB	BB	BB	
	USKO01	RKSL	SL	TD	TD	TD	TD	O	BB	BB	BB	BB	
	UKKO01	RKSL	SL	TD	TD	TD		O	BB	BB	BB	BB	
	ULKO01	RKSL	SL	TD	TD	TD		O	BB	BB	BB	BB	
	UEKO01	RKSL	SL	TD	TD	TD		O	BB	BB	BB	BB	
	USMS01	WMKK	BB	TD	KK	TD	TD	TD	BB	O	BB	BB	
	UKMS01	WMKK	BB	TD	KK	TD	TD	TD	BB	O	BB	BB	
	ULMS01	WMKK	BB	TD	KK	TD	TD	TD	BB	O	BB	BB	
	UEMS01	WMKK	BB	TD	KK	TD	TD	TD	BB	O	BB	BB	
	USPH01	RPMM	MM	TD	TD	TD	O	TD	BB		BB	BB	
	UKPH01	RPMM	MM	TD	TD	TD	O	TD	BB		BB	BB	
	ULPH01	RPMM	MM	TD	TD	TD	O	TD	BB		BB	BB	
Continued to	UEPH01	RPMM	MM	TD	TD	TD	O	TD	BB		BB	BB	

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the next page	USTH01	VTBB	BB	BB	O	BB	TD	TD	BB	BB	BB	BB	
			Receiving station										
Type of Data	Heading		TD	BJ	BB	HH	MM	SL	NN	KK	IV	PP	MC
Enhanced	UKTH01	VTBB	BB	BB	O	BB		TD	BB	BB	BB	BB	
Upper-air	ULTH01	VTBB	BB	BB	O	BB		TD	BB	BB	BB	BB	
observation	UETH01	VTBB	BB	BB	O	BB		TD	BB	BB	BB	BB	
	USVS01	VNNN	BB	TD	NN	TD	TD	TD	O	BB	BB	BB	
	UKVS01	VNNN	BB	TD	NN	TD		TD	O	BB	BB	BB	
	ULVS01	VNNN	BB	TD	NN	TD	TD	TD	O	BB	BB	BB	
	UEVS01	VNNN	BB	TD	NN	TD	TD	TD	O	BB	BB	BB	
	URPA10	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	URPA11	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	URPA12	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	URPA14	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	URPN10	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	UZPA13	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	UZPN13	KNHC	*		TD	TD		TD	BB	BB	BB	BB	
	UZPN13	KWBC	*	TD	TD	TD		TD	BB	BB	BB	BB	
	UZPN13	PGTW	*	TD	TD	TD		TD	BB	BB	BB	BB	
	IUDC01	VHHH	HH	HH	HH	O							
	IUDC02	VHHH	HH	HH	HH	O							
	IUDC03	VHHH	HH	HH	HH	O							
	IUDC04	VHHH	HH	HH	HH	O							
	IUDC05	VHHH	HH	HH	HH	O							
	IUDC06	VHHH	HH	HH	HH	O							
	IUDC07	VHHH	HH	HH	HH	O							
	IUDC08	VHHH	HH	HH	HH	O							
	IUDC09	VHHH	HH	HH	HH	O							
	IUDC10	VHHH	HH	HH	HH	O							
Enhanced	SNVB20	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
ship	SNVD20	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
observation	SNVE20	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	SNVX20	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	SNVB21	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	SNVD21	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	SNVE21	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	SNVX21	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	SNVX20	RPMM	MM	TD	TD	TD	O	TD	BB		BB	BB	
	SNVX20	VHHH	HH	HH	BJ	O	TD	TD	BB	BB	BB	BB	HH
	SNVX20	VNNN	BB	TD	NN	TD		TD	O	BB	BB	BB	
	SMVX01	VTBB	BB	BB	O	BB		TD	BB	BB	BB	BB	
	SIVX01	VTBB	BB	BB	O	BB		TD	BB	BB	BB	BB	
	SNVX20	VTBB	BB	BB	O	BB		TD	BB	BB	BB	BB	
Enhanced	SBCI30	BABJ	BJ	O	BJ	TD	TD	TD	BJ	BB	BB	BB	
radar	SCCI30	BABJ		O	BJ	BJ			BB	BB	BB	BB	
observation	SBCI60	BCGZ		O	BJ				BJ	BB	BB	BB	
Continued to	SCCI60	BCGZ	HH	O	BJ				BB	BB	BB	BB	
the next page	SBHK20	VHHH	HH	HH	BJ	O	TD		BB	BB	BB	BB	HH

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Type of Data	Heading		Receiving station TD	BJ	BB	HH	MM	SL	NN	KK	IV	PP	MC
Enhanced	ISBC01	VHHH	HH	HH	HH	O	TD	TD		BB	BB	BB	
radar	ISBC01	RJTD	O	TD	TD	TD	TD	TD		BB	BB	BB	
observation	SDKO20	RKSL						O					
	SDMS20	WMKK	BB	TD	KK	TD			BB	O	BB	BB	
	SDPH20	RPMM	MM	TD	TD			TD	BB		BB	BB	
	SDTH20	VTBB	BB	BB	O	BB			BB	BB	BB	BB	
	SDVS20	VNNN	BB	TD	NN	TD	TD		O	BB	BB	BB	
Satellite	TPPN10	PGTW			TD	TD			BB	BB	BB	BB	
guidance	TPPN10	PGUA	*		TD	TD			BB	BB	BB	BB	
	TPPA1	RJTY	*	TD	TD	TD	TD		BB	BB	BB	BB	
	TPPA1	RODN	*	TD	TD	TD	TD		BB	BB	BB	BB	
	IUCC10	RJTD	O	TD	TD	TD	TD	TD		BB	BB	BB	
	IUCC01	VHHH	HH	HH	HH	O							
	IUCC02	VHHH	HH	HH	HH	O							
	IUCC03	VHHH	HH	HH	HH	O							
	IUCC04	VHHH	HH	HH	HH	O							
Tropical	FXPQ01	VHHH	HH	HH	BJ	O			BB	BB	BB	BB	HH
Cyclone	FXPQ02	VHHH	HH	HH	BJ	O			BB	BB	BB	BB	HH
Forecast	FXPQ03	VHHH	HH	HH	BJ	O			BB	BB	BB	BB	HH
	FXPQ21	VHHH	HH	HH		O							
	FXPQ20	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ21	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ22	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ23	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ24	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ25	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ29	VTBB			O								
	FXPQ30	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ31	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ32	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ33	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ34	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPQ35	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	FXPH20	RPMM	MM	TD	TD	TD	O	TD	BB	BB	BB	BB	
	FXSS01	VHHH	HH	HH	BJ	O			BB	BB	BB	BB	HH
	FXSS02	VHHH	HH	HH	BJ	O			BB	BB	BB	BB	HH
	FXSS03	VHHH	HH	HH	BJ	O			BB	BB	BB	BB	HH
	FXSS21	VHHH	HH	HH		O							
	FXPN03	RKSL				TD		O					

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Deleted: FXPQ20
Deleted: VHHH
Deleted: HH
Deleted: HH
Deleted: BJ
Deleted: O
Deleted: TD
Deleted: TD
Deleted: BB
Deleted: BB
Deleted: BB
Deleted: BB
Deleted: HH
Deleted: FXSS20
Deleted: VHHH
Deleted: HH
Deleted: HH
Deleted: BJ
Deleted: O
Deleted: TD
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Type of Data	Heading		Receiving station TD	BJ	BB	HH	MM	SL	NN	KK	IV	PP	MC
Warning	WDPN31	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WDPN32	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WHCI28	BCGZ			BJ	BJ			BJ	BB	BB	BB	
	WHCI40	BABJ	BJ	O	BJ	BJ			BJ	BB	BB	BB	
	WSPH	RPMM	*	TD	TD	TD	O	TD	BB	BB	BB	BB	
	WTMU40	VMMC	BJ	MC	BJ	BJ			BB	BB	BB	BB	O
	WTPN21	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPN31	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPN32	PGTW	*	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPH20	RPMM	MM	TD	TD	TD	O		BB		BB	BB	
	WTPH21	RPMM	MM	TD	TD	TD	O		BB		BB	BB	
	WTPH22	RPMM	MM	TD	TD	TD	O		BB		BB	BB	
	WTPQ20	VHHH	HH	HH	BJ	O		TD	BB	BB	BB	BB	HH
	WTSS20	VHHH	HH	HH	BJ	O			BB	BB	BB	BB	HH
	WTVS20	VNNN			NN	BJ			O	BB	BB	BB	
	WTKO20	RKSL	SL	TD	TD	TD		O	BB	BB	BB	BB	
Prognostic Reasoning	WTPQ30	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ31	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ32	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ33	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ34	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ35	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
Five-day forecast	WTPQ50	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ51	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ52	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ53	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ54	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
	WTPQ55	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	
Others Best track	AXPQ20	RJTD	O	TD	TD	TD	TD	TD	BB	BB	BB	BB	

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Note: Meaning of abbreviation

O	:	Data originating centre
TD	:	Data transmitting centre - Tokyo
BJ	:	- Beijing
BB	:	- Bangkok
HH	:	- Hong Kong
MM	:	- Manila
SL	:	- Seoul
NN	:	- Hanoi
KK	:	- Kuala Lumpur
IV	:	- Vientiane
PP	:	- Phnom Penh
MC	:	- Macao
*	:	Places other than described above

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APPENDIX 5-F

TABLE of Abbreviated headings (TTAAii CCCC)

TT	Data designator
FK	Tropical cyclone advisories
FX	Miscellaneous forecasts
SB	Radar reports PART A
SC	Radar reports PART B
SD	Radar reports (PART A and PART B)
SN	Synoptic reports (non-standard hours)
TP	Satellite guidance
UA	Aircraft reports (AIREP)
UE	Upper-level observation, PART D
UK	Upper-level observation, PART B
UL	Upper-level observation, PART C
US	Upper-level observation, PART A
WD	Prognostic reasoning for typhoon
WH	Marine/Coastal flood warnings
WO	Other warnings
WC	Tropical cyclone (SIGMET)
WT	Tropical cyclone warnings
WW	Warning and weather summary

TABLE of Abbreviated Headings
(TTAAii CCCC) for BUFR

TTAAii CCCC	Data type
ISBC01 RJTD	Radar reports
ISBC01 VHHH	Radar reports
IUCC01-04 VHHH	SAREP reports
IUCC10 RJTD	SAREP reports
IUDC01-10 VHHH	Dropsonde reports

AA	Geographic designator
CI	China
HK	Hong Kong, China
JP	Japan
KO	Republic of Korea
KP	Cambodia
LA	Lao People's Democratic Republic
MS	Malaysia
MU	Macao, China
PA	Pacific area
PH	Philippines
PN	North Pacific area
PQ	Western North Pacific
PW	Western Pacific area
SS	South China Sea area
TH	Thailand
VS	Viet Nam

CCCC	Location indicator
BABJ	Beijing
BCGZ	Guangzhou
KWBC	Washington
PGFW	San Diego (Fleet Weather Central)
PGTW	Honolulu (JTWC)
PGUM	Guam (Agana)
RJTD	Tokyo
RJTY	Yokota
RKSL	Seoul
RKSO	Osan
RODN	Okinawa / Kadena AB
RPMK	Clark AB
RPMM	Manila / Intl.
VDPP	Phnom Penh
VHHH	Hong Kong
VLIV	Vientiane
VMMC	Macao
VNNN	Hanoi
VTBB	Bangkok
WMKK	Kuala Lumpur

Field Code Changed

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APPENDIX 6-A

Field Code Changed

EXAMPLE OF THE MESSAGE FORMAT FOR INQUIRY ON DOUBTFUL AND GARBLED REPORTS

Example 1. Inquiry on a doubtful report

BMBB01 VTBB 220245
RJTD
PLEASE CHECK THE FOLLOWING REPORT

BULLETIN	SNTH20 VTBB
DATE AND TIME	210200
LOCATION	48300
CONTENT	SECTION 1, 2ND GROUP: 80540

REGARDS
RSMC TOKYO =

Example 2. Inquiry on a garbled report

BMRR01 RPMM 210425
RJTD
AHD SNPH20 RPMM 210400 =

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APPENDIX 6-B

Field Code Changed

PROCEDURES OF REGULAR MONITORING AT RSMC TOKYO - TYPHOON CENTER

1. Monitoring period

The two appropriate periods are selected from the one year starting on 1st January and ending on 31st December. Each period will be up to five consecutive days.

2. Items of monitoring

The reception time of reports at RSMC Tokyo - Typhoon Center should be monitored. The types of reports to be monitored are:

(i) hourly surface observations (SYNOP code),

(ii) hourly ship and buoy observations (SHIP and BUOY codes),

(iii) 6-hourly upper-air observations (TEMP and PILOT codes),

(iv) hourly radar observations (BUFR and/or RADOB codes).

3. Format of monitoring results

Samples of format of monitoring results are shown in Fig. 6-B.1 to Fig 6-B.4.

4. Distribution of monitoring results

The monitoring results should be distributed once a year by RSMC Tokyo - Typhoon Center to Typhoon Committee Secretariat and its Members by the end of March every year. A copy will be forwarded to WMO Secretariat. Members can also retrieve the data from the Internet server of JMA (https://www.wis-jma.go.jp/monitoring/data/monitoring/) by using HTTPS.

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RECEPTION TIME OF SYNOP REPORTS

NOV. 07 2001 PAGE: 1

Location	00 UTC	01 UTC	02 UTC	03 UTC	04 UTC	05 UTC	06 UTC	07 UTC	08 UTC	09 UTC	10 UTC	11 UTC	12 UTC	13 UTC	14 QUTC	15 UTC	16 UTC	17 UTC	18 UTC	19 UTC	20 UTC	21 UTC	22 UTC	23 UTC
45007	0006			0307			0608			0909			1208			1507			1806			2111		
45011	0026						0646						1236						1833			2114		
47090	0012			0312			0612			0912			1212			1512			1812			2110		
47095	0012			0312			0612			0912			1212			1512			1812			2107		
47100	0012			0312			0612			0912			1212			1512			1812					
47101	0012			0312			0612			0912			1212			1512			1812					
47105	0012			0312			0612			0912			1212			1512			1812					
47108	0012			0312			0612			0912			1212			1512			1812					
47112	0012			0312			0612			0912			1212			1512			1812			2140		
47114	0012			0312			0612			0912			1212			1512			1812					
:																								
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Fig. 6-B.1 Format of monitoring results for SYNOP

RECEPTION TIME OF SHIP/BUOY REPORTS

NOV. 11 2001 PAGE: 5

Location	00 UTC	01 UTC	02 UTC	03 UTC	04 UTC	05 UTC	06 UTC	07 UTC	08 UTC	09 UTC	10 UTC	11 UTC	12 UTC	13 UTC	14 QUTC	15 UTC	16 UTC	17 UTC	18 UTC	19 UTC	20 UTC	21 UTC	22 UTC	23 UTC
JPBN																								
JCCX	0008	0105		0310	0404	0504	0609	0704	0804	0909	1005		1211	1307	1404	1516								
JDWX																								
JFDG																								
JGQH	0004	0101	0201	0304	0401	0501	0606	0701	0801	0904	1001	1101	1204	1301	1401	1505	1601	1701						
JMB																								
21002																								
21004																								
22001																								
:																								
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Fig. 6-B.2 Format of monitoring results for SHIP and BUOY

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RECEPTION TIME OF UPPER-AIR REPORTS

NOV. 07 2001 T: TEMP/TEMP SHIP P: PILOT/PILOT SHIP

Location	00 UTC PART	A	B	C	D	06 UTC PART	A	B	C	D	12 UTC PART	A	B	C	D	18 UTC PART	A	B	C	D
JPBN																				
JPBN																				
JCCX																				
JCCX																				
JDWX																				
JDWX																				
JGQH																				
JGQH																				
JIVB																				
JIVB																				
45004		T0044	T0044	T0044	T0044							T1238	T1238	T1238	T1238					
45004		P0044	P0044	P0044	P0044		P0710	P0710	P0710	P0710		P1238	P1238	P1238	P1238		P1850	P1850		
47122		T0127	T0127	T0127	T0127		T0727	T0727	T0734	T0734		T1327	T1327	T1327	T1327		T1927	T1927	T1927	T1927
47122																				
47138		T0127	T0127	T0127	T0127							T1327	T1327	T1327	T1327					
47138																				
47158		T0127	T0127	T0127	T0127							T1327	T1327	T1327	T1327					
47158																				
47185		T0127	T0127	T0127	T0127							T1327	T1327	T1327	T1327					
47185																				
47401		T0024	T0025	T0057	T0059							T1233	T1235	T1259	T1259					
47401							P0616	P0618									P1814	P1815		
47412		T0027	T0029	T0104	T0106							T1237	T1239	T1253	T1254					
47412							P0618	P0618									P1824	P1826		
:																				
:																				

Fig. 6-B.3 Format of monitoring results for TEMP and PILOT

RECEPTION TIME OF RADAR REPORTS

NOV. 07 2001 PAGE: 1

Location	00 UTC	01 UTC	02 UTC	03 UTC	04 UTC	05 UTC	06 UTC	07 UTC	08 UTC	09 UTC	10 UTC	11 UTC	12 UTC	13 UTC	14 QUTC	15 UTC	16 UTC	17 UTC	18 UTC	19 UTC	20 UTC	21 UTC	22 UTC	23 UTC
45009																								
45010																								
47106																								
47116																								
47144																								
47160																								
47185																								
47415																								
47418																								
47419																								
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Fig. 6-B.4 Format of monitoring results for Radar reports

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APPENDIX 6-C

Field Code Changed

EXAMPLE OF BEST TRACK REPORT

AXPQ20 RJTD 060400
RSMC TROPICAL CYCLONE BEST TRACK
NAME 9009 TASHA (9009)
PERIOD FROM JUL2612UTC TO AUG0100UTC
2612 20.0N 119.6E 1002HPA //KT 2618 19.6N 120.0E 1000HPA //KT
2700 19.2N 120.2E 1000HPA //KT 2706 18.8N 120.2E 1000HPA //KT
2712 18.6N 119.8E 1000HPA //KT 2718 18.6N 119.2E 1000HPA //KT
2800 18.6N 118.3E 996HPA 35KT 2806 18.6N 118.0E 992HPA 40KT
2812 18.7N 117.6E 990HPA 45KT 2818 18.8N 117.4E 990HPA 45KT
2900 18.9N 117.2E 990HPA 45KT 2906 18.8N 116.5E 985HPA 50KT
2912 18.8N 116.0E 985HPA 50KT 2918 19.0N 116.0E 985HPA 50KT
3000 19.4N 115.5E 980HPA 55KT 3006 20.1N 115.8E 980HPA 55KT
3012 21.4N 115.8E 980HPA 55KT 3018 22.0N 116.0E 980HPA 55KT
3100 23.6N 115.1E 985HPA 50KT 3106 25.0N 114.7E 990HPA 45KT
3112 25.5N 114.4E 996HPA 35KT 3118 25.8N 114.3E 998HPA //KT
0100 26.2N 114.6E 1000HPA //KT
REMARKS
TD FROMATION AT JUL2612UTC
FROM TD TO TS AT JUL2800UTC
FROM TS TO STS AT JUL2906UTC
FROM STS TO TS AT JUL3106UTC
FROM TS TO TD AT JUL3118UTC
DISSIPATION AT AUG0106UTC=

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APPENDIX 6-D

Field Code Changed

STANDARD PROCEDURES FOR THE VERIFICATION OF TROPICAL CYCLONE AND FORECAST AT NATIONAL METEOROLOGICAL CENTRES

1. General

Each Member will verify each tropical cyclone which affects it and summarize the verification made in a year

2. Basis for verification

The best initial tropical cyclone position, central pressure and maximum sustained wind as determined from a post-analysis conducted by the RSMC.

3. Points for verification

(1) Error statistics in each method (bias and standard deviation) by using common work sheets as shown in Appendix 6-E. Statistical computations involve positioning of the centre, prediction of movement, and analysis and forecast of intensity of a tropical cyclone.

(2) Discussion of following points;

(i) relative merits of each technique,

(ii) effects of inaccuracies on the forecast,

(iii) effects of meagreness of available relevant real-time observations,

(iv) variation from one geographical area to another,

(v) climatological factors in climatological and/or statistical method,

(vi) large-scale circulation pattern for giving rise to extremely poor prediction performance.

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APPENDIX 6-E

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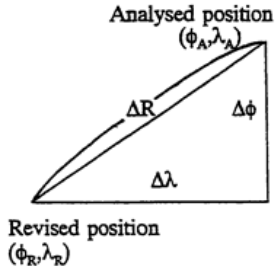
Verification sheet for positioning of the centre, prediction of movement, and analysis and forecast of intensity of tropical cyclones

Tropical Cyclone .....(.....)
Method .....

Date	Analysed position		Revised position		Error		
	ϕ_A	λ_A	ϕ_R	λ_R	$\Delta\phi$	$\Delta\lambda$	ΔR



$$\Delta R = a\sqrt{\left(\cos\phi_R \cdot \Delta\lambda \cdot \frac{\pi}{180}\right)^2 + \left(\Delta\phi \cdot \frac{\pi}{180}\right)^2} \quad \text{(km)}$$

ΔR ; Error in analysed position (km)
a ; Radius of the earth, 6371 km
ϕ, λ ; Latitude and longitude
ϕ, λ, $\Delta\phi$, $\Delta\lambda$ are measured in degree.

Remark ; For RADOB and RADAR position verification, interpolated position of reviced track at fixed observation time should be used.

Note; ΔR can also be measured directly on the verification map.

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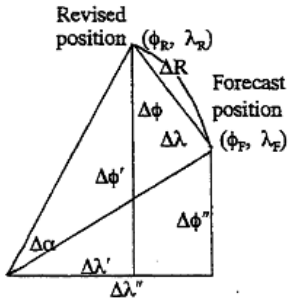
Verification sheet for positioning of the centre, prediction of movement, and analysis and forecast of intensity of tropical cyclones

Tropical Cyclone .....(.....)
Method .....

Forecast period 24-hour (check one)
48-hour

Initial Date	Initial position		Forecast position		Revised position		Error				
	ϕ_I	λ_I	ϕ_F	λ_F	ϕ_R	λ_R	$\Delta\phi$	$\Delta\lambda$	ΔR	$\Delta\alpha$	ΔSP



$$\Delta R = a\sqrt{(\cos\phi_I \cdot \Delta\lambda \cdot \frac{\pi}{180})^2 + (\Delta\phi \cdot \frac{\pi}{180})^2} \quad \text{(km)}$$

$$\Delta\alpha = \tan^{-1}\frac{\Delta\phi''}{\cos\phi_I \cdot \Delta\lambda''} - \tan^{-1}\frac{\Delta\phi'}{\cos\phi_I \cdot \Delta\lambda'}$$

$$\Delta SP = a\left\{\sqrt{(\cos\phi_I\cdot\Delta\lambda'')^2+(\Delta\phi'')^2} - \sqrt{(\cos\phi_I\cdot\Delta\lambda')^2+(\Delta\phi')^2}\right\}/\Delta t \quad \text{(km/hour)}$$

ΔR ; Error in prediction position (km)
$\Delta\alpha$; error in predicted direction of movement in degrees in azimuth angle
ΔSP ; Error in the speed of movement
$\Delta\phi'$, $\Delta\phi''$, $\Delta\lambda'$, $\Delta\lambda''$ are measured in degrees.
Δt ; forecast period (hour)
$\Delta\alpha$ is positive if forecast is to the right of the actual path.

$\Delta\lambda = \Delta\lambda'' - \Delta\lambda'$
$\Delta\phi = \Delta\phi' - \Delta\phi''$

Note ; ΔR, $\Delta\alpha$ and ΔSP can also be measured directly on the verification map.

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Verification sheet for positioning of the centre, prediction of movement, and analysis and forecast of intensity of tropical cyclones

Tropical Cyclone .....(.....)

	Analysis			24-hour forecast			48-hour forecast		
Method	.....			.....			.....		
Date	P_a	P_r	ΔP_a	P_f	P_r	ΔP_f	P_f	P_r	ΔP_f

Note :
P_r : Revised central pressure
P_a : Analysed central pressure, $\Delta P_a = P_a - P_r$
P_f : Predicted central pressure, $\Delta P_f = P_f - P_r$

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APPENDIX 7-A

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LIST OF DATA ARCHIVED BY RSMC TOKYO - TYPHOON CENTER

(a) Observation data (except for Himawari imagery data)

Kinds of data: SYNOP, METAR, SHIP, BUOY, TEMP, PILOT, Aircraft, Wind Profiler, AMV, Scatterometer, MW Sounder, MW Imager, CSR, Hyperspectral IR Sounder, GNSS-RO, Ground-based GNSS

(b) Himawari imagery data

Himawari Standard Data (HSD):

Kind of data: Himawari full-spec imagery data

Data format: Himawari Standard Format (https://www.data.jma.go.jp/mscweb/en/himawari89/space_segment/hsd_sample/HS_D_users_guide_en_v13.pdf)

Meteorological Satellite Center Monthly Report (DVD):

Kinds of data: Himawari images in SATAID and PNG formats. (https://www.data.jma.go.jp/mscweb/en/product/library_report.html)

Area coverage:
SATAID: 115°E ~ 150°E and 15°N ~ 50°N
PNG: Full earth disk as seen from 140°E

(c) Objective Analysis data

Global Surface/Atmospheric Analysis data

Kinds of data: Grid point data of the objective surface/atmospheric analysis

Area coverage: Global area covered by 1.25 X 1.25 latitude-longitude grid system.

Time of analysis: 00, 06, 12 and 18 UTC

Element and layer:

Surface: Sea surface pressure (Ps), temperature (Ts), Dew point depression (Ts - Tds), wind (Us, Vs);

Specific pressure levels (1000 - 0.4 hPa):

Geopotential height (Z), temperature (T), wind (U, V), Dew point depression (T-Td)

Western North Pacific Sea Surface Temperature Analysis data

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Kinds of data: Grid point data of the objective sea surface temperature analysis

Area coverage: Western North Pacific area (100°E ~ 180°E and 0° ~ 60°N) covered by 0.1 X 0.1 latitude-longitude grid system.

Time of analysis: 18 UTC

Element: SST, SST anomalies from the JMA climatology

(d) Others

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APPENDIX 7-B

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GLOBAL TROPICAL CYCLONE TRACK AND INTENSITY DATA SET - REPORT FORMAT

Position	Content
1-9	Cyclone Identification code composed by 2 digit numbers in order within the cyclone season, area code and year code. 01SWI2000 shows the 1st system observer in South-West Indian Ocean basin during the 2000/2001 season. Area codes are as follows: ARB = Arabian Sea ATL = Atlantic Ocean AUB = Australian Region (Brisbane) AUD = Australian Region (Darwin) AUP = Australian Region (Perth) BOB = Bay of Bengal CNP = Central North Pacific Ocean ENP = Eastern North Pacific Ocean ZEA = New Zealand Region SWI = South-West Indian Ocean SWP = South-West Pacific Ocean WNP = Western North Pacific Ocean and South China Sea
10-19	Storm Name
20-23	Year
24-25	Month (01-12)
26-27	Day (01-31)
28-29	Hour-universal time (at least every 6 hourly position -00Z, 06Z, 12Z and 18Z)
	Latitude indicator: 1 = North latitude; 2 = South latitude
31-33	Latitude (degrees and tenths)
34-35	Check sum (sum of all digits in the latitude)
36	Longitude indicator: 1 = West longitude; 2 = East longitude
37-40	Longitude (degrees and tenths)
41-42	Check sum (sum of all digits in the longitude)
43	Position confidence[12] 1 = good (< 30 nm; < 55 km) 2 = fair (30 - 60 nm; 55 - 110 km) 3 = poor (> 60 nm; > 110 km) 9 = unknown
44-45	Dvorak T-number (99 for no report)
46-47	Dvorak CI-number (99 for no report)
48-50	Maximum average wind speed (whole values) (999 for no report)
51	Units 1 = kt, 2 = m/s, 3 = km/h.
52-53	Time interval for averaging wind speed (minutes for measured or derived wind speed, 99 if unknown or estimated).
54-56	Maximum Wind Gust (999 for no report)
57	Gust Period (seconds, 9 for unknown)
58	Quality code for wind reports: 1 = Aircraft or Dropsonde observation 2 = Over water observation (e.g. buoy) 3 = Over land observation 4 = Dvorak estimate 5 = Other
59-62	Central pressure (nearest hectopascal) (9999 if unknown or unavailable)

[12] Confidence in the center position: Degree of confidence in the center position of a tropical cyclone expressed as the radius of the smallest circle within which the center may be located by the analysis. “position good” implies a radius of less than 30 nm, 55 km; “position fair”, a radius of 30 to 60 nm, 55 to 110 km; and “position poor”, radius of greater than 60 nm, 110 km.

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63	Quality code for pressure report (same code as for winds)
64	Units of length: 1 = nm, 2 = km
65-67	Radius of maximum winds (999 for no report)
68	Quality code for RMW: 1 = Aircraft observation 2 = Radar with well-defined eye 3 = Satellite with well-defined eye 4 = Radar or satellite, poorly-defined eye 5 = Other estimate
69-71	Threshold value for wind speed (gale force preferred, 999 for no report)
72-75	Radius in Sector 1: 315° - 45°
75-79	Radius in Sector 2: 45° - 135°
80-83	Radius in Sector 3: 135° - 225°
84-87	Radius in Sector 4: 225° - 315°
88	Quality code for wind threshold 1 = Aircraft observations 2 = Surface observations 3 = Estimate from outer closed isobar 4 = Other estimate
89-91	Second threshold value for wind speed (999 for no report)
92-95	Radius in Sector 1: 315° - 45°
95-99	Radius in Sector 2: 45° - 135°
100-103	Radius in Sector 3: 135° - 225°
104-107	Radius in Sector 4: 225° - 315°
108	Quality code for wind threshold (code as for row 88)
109-110	Cyclone type: 01 = tropics; disturbance (no closed isobars) 02 = < 34 knot winds, < 17 m/s winds and at least one closed isobar 03 = 34 - 63 knots, 17-32 m/s 04 = > 63 knots, > 32 m/s 05 = extratropical 06 = dissipating 07 = subtropical cyclone (nonfrontal, low pressure system that comprises initially baroclinic circulation developing over subtropical water) 08 = overland 09 = unknown
111-112	Source code (2 - digit code to represent the country or organization that provided the data to NCDC USA. WMO Secretariat is authorized to assign number to additional participating centers, organizations) 01 = RSMC Miami - Hurricane Center 02 = RSMC Tokyo - Typhoon Center 03 = RSMC-tropical cyclones New Delhi 04 = RSMC La Reunion - Tropical Cyclone Centre 05 = Australian Bureau of Meteorology 06 = Meteorological Service of New Zealand Ltd. 07 = RSMC Nadi - Tropical Cyclone Centre 08[13] = Joint Typhoon Warning Center, Honolulu 09[12]= Madagascar Meteorological Service 10[12] = Mauritius Meteorological Service 11[12] = Meteorological Service, New Caledonia 12 = Central Pacific Hurricane Center, Honolulu
Headings	1-19 Cyclone identification code and name; 20-29 Date time group; 30-43 Best track positions; 44-110 Intensity, Size and Type; 111-112 Source code.

[13] no longer used

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APPENDIX 8-A

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TROPICAL CYCLONE FORECAST COMPETENCY IN THE TYPHOON COMMITTEE REGION

Category 1
This competency unit is relevant to dedicated or specialized TC forecasters working in a TC office at an unsupervised level. It includes:
• analyzing broad-scale environment and determine TC position, intensity and structure;
• forecasting TC track, intensity and structure;
• determining potential TC-related hazards;
• formulating and issuing TC-related warning products;
• communicating relevant TC information to internal and external stakeholders.

Category 2
This competency unit is relevant to general forecasters who provide a range of TC forecast services based on information from the 'parent' RSMC or other agencies, and/or available data. It includes:
• accessing, interpreting, and adapting TC analysis and forecast;
• determining potential TC-related hazards;
• formulating and issuing TC-related warning products;
• communicating relevant TC information to internal and external stakeholders.

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Analyze broad-scale environment and determine TC position, intensity and structure (for Category 1)		
Description A range of observational information is analysed to interpret the synoptic scale environment, the position, intensity and structure of the tropical circulation		
Performance criteria		analyzes the synoptic scale environment to assess the likely influence on the disturbance in a range of situations
		determines TC centre location and current movement in accordance with standard operating procedures in a range of situations
		determines TC intensity in accordance with standard operating procedures in a range of situations
		determines TC structure in accordance with standard operating procedures in a range of situations
Back-ground	**Know-ledge**	standard operating procedures for TC analysis
		basic TC climatology and general impacts of ENSO on TC behaviors
		capabilities and limitations of different observational data types
		TC structure dynamics and conceptual models
		synoptic scale factors that affect the tropical cyclone intensity including shear, ocean temperatures, upper-level flow, stability, landfall, vorticity and low to mid-level moisture
		strengths and limitations of intensity analysis methods including Dvorak technique and other ones, such as ADT, CLOUD, AMSU intensity estimation and SATCON.
	Skills	uses data viewing software and other applications in the forecast process
		interprets observations, weather radar and satellite derived information such as scatterometry and cloud drift winds
		interprets satellite imagery including water vapor, visible, infra-red, and microwave for TC analysis
		uses Dvorak technique for TC centre location and intensity estimation.
		estimates the intensity from a number of inputs
		interprets wind shear from shear analyses and prognoses
		assesses the environment for motion and intensity changes
		interprets NWP guidance material

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Forecast TC track, intensity and structure (for Category 1)		
Description A range of information including numerical weather prediction (NWP) and objective aids in addition to an understanding of conceptual synoptic forecast approaches are used to forecast the track, intensity and structure in warning products that are issued in accordance with documented procedures.		
Performance criteria		interprets NWP-predicted synoptic scale environment to assess the likely influence on the disturbance in a range of situations
		determines TC forecast track in accordance with standard operating procedures in a range of situations
		determines TC forecast intensity in accordance with standard operating procedures in a range of situations
		determines TC forecast structure in accordance with standard operating procedures and timelines in a range of situations
Back-ground	**Know-ledge**	standard operating procedures for TC forecasts
		relative strengths and limitations of NWP in predicting cyclone movement, structure and intensity
		basic concept of rapid intensification/weakening, landfall process, and extra tropical transition
		verification results of official TC forecasts and NWP guidance
		basic theory of TC ensemble forecasts
		synoptic factors that affect TC genesis, motion, intensity, and structure
		track forecasting techniques including consensus and ensemble forecasts
		intensity forecasting methods
	Skills	evaluates model predictions against observed conditions to assess the most likely forecast environment for motion and intensity changes
		evaluates TC genesis potential using observations and NWP guidance including ensembles
		interprets NWP guidance material including ensemble output to determine forecast uncertainty
		uses software systems to determine forecast parameters

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Access, interpret, and adapt TC analysis and forecast (for Category 2)		
Description Guidance products from RSMC and other agencies are appropriately interpreted and assessed. Technical information including satellite and other observational information are interpreted taking into consideration the guidance products		
Performance criteria		evaluates and adapt TC analysis and forecast based on information from RSMCs or other TC forecast agencies, and/or available data
		interprets technical forecast guidance in order to assess impact potential upon forecast region of responsibility
		interprets observational and satellite information appropriately
Back-ground	**Know-ledge**	standard operating procedures for TC analysis and forecasts
		capabilities and limitations of different observational data types
		TC structure dynamics and conceptual models
		synoptic scale factors that affect the tropical cyclone intensity including shear, ocean temperatures, upper-level flow, stability, landfall, vorticity and low to mid-level moisture
		relative strengths and limitations of NWP in predicting cyclone movement, structure and intensity
		synoptic factors that affect TC genesis, motion, intensity, and structure
		track forecasting techniques including consensus and ensemble forecasts
		intensity forecasting methods
		strengths and limitations of Dvorak technique, and other intensity analysis guidance, such as ADT, CLOUD, AMSU intensity estimation, and SATCON
	Skills	uses data viewing software and other applications in the forecast process
		interprets observations, weather radar, satellite and satellite derived information at a general level
		assesses the environment for impact on the TC at a general level
		interprets NWP guidance material
		interprets official TC forecast products from official agencies

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Determine potential TC-related hazards (for Category 1 &2)		
Description Potential TC-related hazards such as high winds, rainfall, waves and storm surge are determined**,** taking also into consideration mesoscale weather phenomena, for key locations according to appropriate thresholds and including estimates of uncertainty.		
Performance criteria		forecasts extent of cyclonic winds (e.g. gales, storm force) and onset times for key locations using available guidance in a range of situations.
		forecasts rainfall using available guidance in a range of situations and liaise with relevant organizations to determine potential flooding and landslide.
		forecasts waves in accordance with standard operating procedures.
		forecasts storm tide potential considering various TC forecast scenarios and confidence levels (worst case, most likely, alternate TC forecast scenario).
Back-ground	**Know-ledge**	standard operating procedures for TC-related hazards including wave and storm surge associated with tropical cyclones.
		potential TC-related hazards in a range of synoptic and mesoscale situations
		basic theory of wave and storm surge
	Skills	interprets guidance material of NWP and/or other Centres such as RSMCs.
		assesses rainfall potential using probabilistic rainfall guidance, such as eTRaP and consensus model guidance (OCF, PME).
		determines onset, duration, coverage and associated uncertainties of weather phenomena
		interprets TC storm surge forecast guidance

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Formulate and issue TC-related warning products (for Category 1 &2)		
Description Forecast production systems are used to produce and disseminate a range of TC-related waning products according to operating procedures.		
Performance criteria		liaises effectively with internal staff in the development of TC forecast scenarios and impact on other services.
		formulates TC-related warning products, in consideration of potential impacts, in accordance with standard operating procedures in a range of situations.
		determines the appropriate key messages for general and technical audiences in a range of situations.
		issues the range of TC-related warning products in accordance with standard operating procedures and timelines in a range of situations.
Back-ground	**Know-ledge**	standard operating procedures for warning issuance and contingency plans of relevant DRR authorities such as local governments.
		local characteristics of potential impacts of tropical cyclones
		level of threat posed by storm tide
		user needs and significant impact thresholds
		product styles and standards
	Skills	uses appropriate software to determine range of potential impacts and produce warning products
		communicates with colleagues to formulate warning products
		compiles products and key messages for different audiences
		converts technical concepts into concise and easy to understand language

Communicate relevant TC information to internal and external stakeholders (for Category 1 &2)		
Description Forecasters are required to communicate information to internal and external users appropriate to their needs.		
Performance criteria		logically structures briefings and presentations to contain relevant, timely, and understandable information
		delivers briefings, presentations and interviews to suit the intended audience explaining technical information in concise, clear and easy to understand language
		communicate with related internal and external parties, such as DRR emergency managers, RSMCs, other TC forecast centres and weather services in neighboring areas
		responds to requests for information appropriately
Back-ground	**Know-ledge**	principles of effective communication, including presentation and interviews
		presentation and meeting formats and requirements
		legislation, regulations, policies, procedures and guidelines relating to workplace communication in the public sector such as privacy, confidentiality, freedom of information
	Skills	compiles products and key messages for different audiences
		converts technical concepts into concise and easy to understand language
		facilitates and engages in communication exchanges
		uses equipment for presentations

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