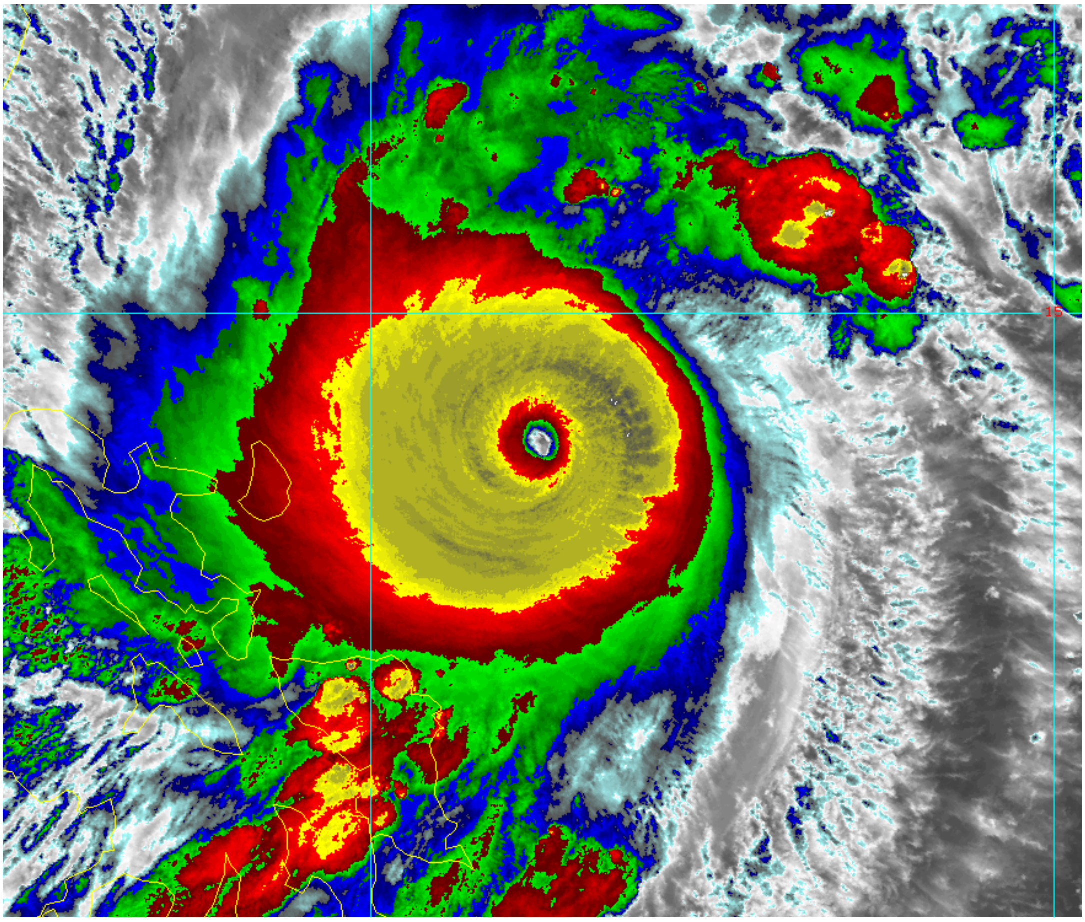
ANNUAL REPORT ON PHILIPPINE TROPICAL CYCLONES 2020



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The **Annual Report on Philippine Tropical Cyclones (ARTC)** is an annual technical report published by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) which serves as the yearly compendium of technical reviews of tropical cyclones that occurred within the Philippine Area of Responsibility based on the outputs of the post-season best track analysis conducted by the tropical cyclone meteorologists of the agency. The report also includes a summary of forecast and warning services provided by the agency for the entire season and each tropical cyclone.

Cover image: Enhanced infrared image of Super Typhoon Rolly (Goni) from the Himawari-8 satellite as it neared its lifetime peak intensity over the waters east of Catanduanes province. Figure courtesy of Regional and Mesoscale Meteorology Branch (RAMBB) of NOAA/NESDIS

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EXECUTIVE SUMMARY

The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) named 22 tropical cyclones (TCs) that occurred within the Philippine Area of Responsibility (PAR) during the 2020 Philippine TC season. Although slightly higher than the 1991-2020 climatological average, this value was near normal. The number of annual TC events within the PAR region for the past three decades was found to be more or less the same. With an emerging La Niña event over the tropical Pacific waters, the months of August and October reported the most active months of this TC season, with the number of TCs being considerably higher than climatological number. The month of July, which is usually the most active month within the PAR region, reported below normal activity in 2020.

Most of the 2020 Philippine TCs developed from tropical disturbances (i.e., low pressure areas) outside the PAR region, with a majority developing over the Philippine Sea area south of 20°N and east of 125°E. Majority of the TCs that occurred within the PAR region in 2020 had tracks that were generally oriented east-west or east southeast-west northwest that originated from the Philippine Sea and terminated over mainland Southeast Asia or the southern portion of China. This made the sub-region of the PAR south of 20°N the most frequented subregion within the PAR by TCs this season. The TCs that entered that PAR had an average lifespan of 5 days and 10.6 hours while the average duration of these TCs inside the PAR was 2 days and 16.9 hours.

The season is also characterized by above climatological average (albeit near normal) number of TCs peaking below typhoon category within PAR and below average (and around the lower limit of near normal values) number of TCs peaking at typhoon or super typhoon categories. Two of 22 TC events within the PAR region this season reached super typhoon category while inside the PAR region. Combined warning track and best track data from PAGASA since 1991 suggests that on average, weak TCs of depression category were slightly increasing within the PAR region while the number of those peaking as storms or typhoon remained more or less the same in the past three decades.

This season registered 11 landfalling TCs, half of the total number of TC cases for this season, nearly twice than the preceding season, and higher (albeit near normal) the climatological average. Most of the landfalling TCs during the season occurred during the last quarter of the year, which is consistent with the climatological nature of TC tracks within the PAR. Consolidated track data continues to show a notably decreasing trend in the number of TCs that cross the archipelago for the past three decades. Nearly all of these landfalling TCs tracked over Luzon and Samar Island. Nearly half of the landfalling TCs during the season were depressions at the time of initial landfall.

The total rainfall during TC days in the Philippines accounted for 30% to 50% of the total rainfall in 2020 over most areas in Luzon (with higher proportions in some localities over the northern and western sections of Luzon), 10% to 40% over Visayas (with higher proportions in Samar), and 10% to 30% for most areas in Mindanao. The observed rainfall during TC days were notably higher (at least 1,000 mm) for most of Luzon (aside from mainland Palawan) and the northern portion of Samar Island than in other parts of the country. In other parts of Visayas, the total rainfall during TC days was slightly higher in Western and Eastern Visayas (at least 750 mm). For Mindanao, portions of Zamboanga Peninsula, mainland Bangsamoro, and Caraga received higher rainfall amounts compared to other areas, although the values were up to 1,000 mm only.

As the operational arm responsible for the national TC forecasting and warning program, the Weather Division issued 472 public and 234 marine TC products during the season to its end users, in addition to the provision of expert advice and briefings to public and private sector partners. A total of 13 TCs necessitated the hoisting of Tropical Cyclone Wind Signals in all provincial or sub-provincial localities of the country except for Basilan, Sulu, Tawi-Tawi, the southern portion of Zamboanga Peninsula and Palawan, and most of SOCCSKSARGEN region. Wind signals were hoisted most frequently over Metro Manila, Bataan, Polillo Islands, Rizal, and portions of Quezon (General Nakar, Infanta, Real) and Camarines Norte (Paracale, Jose Panganiban, Capalonga, Vinzons) than in any other locality of the country. Owing to the passage of Super Typhoon Rolly, Wind Signal No. 5 was the highest level of wind signal hoisted during the 2020 season.

Despite disaster risk reduction and management activities, the National Disaster Risk Reduction and Management Council reported that the TC events of 2020 claimed the lives of 112 individuals, making 2020 the 41st deadliest TC season since 1970 and the 5th deadliest post-Yolanda season. Furthermore, a total of 610 injured and 11 missing persons were reported. Aggregate cost of damage across the country amounted to PHP 44.222 billion, making it the 12th costliest TC season since 1970 and the 3rd costliest post-Yolanda season. Damage to public infrastructure accounted for most of the total damage cost. Data since 1970 shows a generally downward trend in the number of casualties and proportion of deaths to total casualties, increasing proportion of injured persons to total casualties, and a steadily increasing trend in the total cost of damage due to TC events.

Verification statistics shows that over the past decade, PAGASA has been steadily improving in its operational TC track forecast, with higher forecast times (i.e., 48-hour and higher) seeing larger improvements. The mean DPE at all forecast times in 2020 were found to be the lowest since 2014 (and potentially in the history of PAGASA). Most of the typhoon and super typhoon cases during the season showed relatively small position errors across various forecast times. The four TCs that reported relatively large position errors for the season were caused by the inability of most guidance models to capture the translation speed and track orientation of these TCs, as well as the period of erratic motion resulting from the weakening of prevailing environmental steering that was not handled well in model predictions. Directional and speed biases were fairly small for forecast positions up to 72 hours.

TABLE OF CONTENTS

The Annual Report on Philippine Tropical Cyclone (ARTC) 2020 was made possible through the efforts of the following operational meteorologists of the Weather Division

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This edition of the ARTC was published under the supervision of **Mr. Juanito S. Galang,** Weather Services Chief of the Weather Division, and **Mr. Christopher F. Perez,** Assistant Weather Services Chief of the Marine Meteorological Services Section

NATIONAL TROPICAL CYCLONE FORECASTING AND WARNING PROGRAM

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National Tropical Cyclone Forecasting and Warning Program

Since 1879[1], the government meteorological service[2] of the Philippines has been providing tropical cyclone (TC) forecasts and warnings to ensure the safety, well-being, and economic security of the people, safeguard the environment, and promote national progress and sustainable development. Created by law[3] in 8 December 1972 as the successor to the Weather Bureau, the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) is a scientific and technological services institute of the Department of Science and Technology (DOST) mandated[4] to provide adequate, up-to-date, and timely information on atmospheric phenomena especially during high impact weather events such as TC occurrences. As the national meteorological and hydrological service (NMHS) of the Republic of the Philippines, PAGASA is responsible for the national TC forecasting and warning program of the country.

To ensure its effective and efficient implementation, the Weather Division, through the Marine Meteorological Services Section, is primarily responsible for the operational activities related to the national TC forecasting and warning program. The Marine Meteorological Services Section, through the Tropical Cyclone Group, implements the day-to-day activities related to TC operations of the agency.

Forecast Areas

On average, the Western North Pacific (WNP) basin accounts for one-third of the TC activity on the planet and sees activity all year round. With the Philippines receiving approximately 8 to 9 TC landfalls every year and with indirect wind and water impacts also likely in the presence of other weather systems (such as monsoons), the effective implementation of a TC forecasting and warning program is essential to protect lives and properties and mitigating the worsening impacts of these weather systems under a warming climate. To achieve this, PAGASA monitors TC activity across multiple forecast areas within the WNP basin. Appropriate forecasts, warnings, and expert advice are provided by the agency to the public and other stakeholders whenever a TC within these forecast areas may bring impacts to land or sea areas under PAGASA's responsibility.

For the 2020 season[5], PAGASA had the following TC forecast areas each of which are described in detail:

Philippine Area of Responsibility

Originating as a storm warning area for shipping forecasts from the Philippines as agreed upon with other member states of the Regional Association V of the World Meteorological Organization (WMO)[6], the Philippine Area of Responsibility (PAR) presently serves as the region in the WNP wherein PAGASA has the responsibility for issuing tropical cyclone analyses, forecasts, and warnings for both the public and maritime sectors. Domestic names are also provided for TCs that occur within the PAR region.

The PAR region is geographically defined as the land and sea areas within the WNP basin encompassed by rhumb lines that connect the coordinates 5°N 115°E, 15°N 115°E, 21°N 120°E, 25°N 120°E, 25°N 135°E, and 5°N 135°E. This encompasses nearly all the land territory of the Philippines except for the southernmost portions of Tawi-Tawi and some of the country's claims in the Kalayaan Islands. The area also includes the entire Palau archipelago, nearly all of Taiwan, as well as portions of the Malaysian state of Sabah and the Japanese prefecture of Okinawa. The

[1] The first typhoon warning of its kind in the Philippines was issued in 1879 indicating that a tropical cyclone was crossing northern Luzon.
[2] Observatorio Meteorológico de Manila (1865-1901), Weather Bureau (1901-1972), PAGASA (1972-present)
[3] Presidential Decree No. 78 s. 1972, as amended.
[4] Republic Act No. 10692 (PAGASA Modernization Act of 2015)
[5] PAGASA TC forecast areas have been updated on 23 March 2022.
[6] The extent of the PAR is based on Resolution 17 of the Fourth Session of WMO RA II (WMO-No. 181, 1966) and Resolution 10 of the Fourth Session of WMO RA V (WMO-No. 187, 1966).

bodies of water within the PAR include all archipelagic seas of the Philippines[7], West Philippine Sea[8], Luzon Strait, Mindanao Sea[9], Sulu Sea, and most of the Philippine Sea.

Extended Forecast Areas

In 2015, the Weather Division established the Extended Forecast Areas within the WNP basin to address the increasing demand from the public, disaster managers, news outlets, and other stakeholders for official information on TCs outside the PAR region. Larger than the PAR region, these forecast areas were created to define the region where PAGASA will provide additional public TC information.

The Tropical Cyclone Advisory Domain (TCAD) and the Tropical Cyclone Information Domain (TCID) constitute the Extended Forecast Areas of PAGASA. These regions are geographically defined as follows:

- The TCAD is the region in the WNP bounded by rhumb lines connecting the coordinates 4°N 114°E, 28°N 114°E, 28°N 145°E and 4°N 145°E, excluding the region identified as the PAR.
- The TCID is the region in the WNP bounded by rhumb lines connecting the coordinates 0° 110°E, 35°N 110°E, 35°N 155°E and 0°N 155°E, excluding the region identified as the PAR and TCAD.

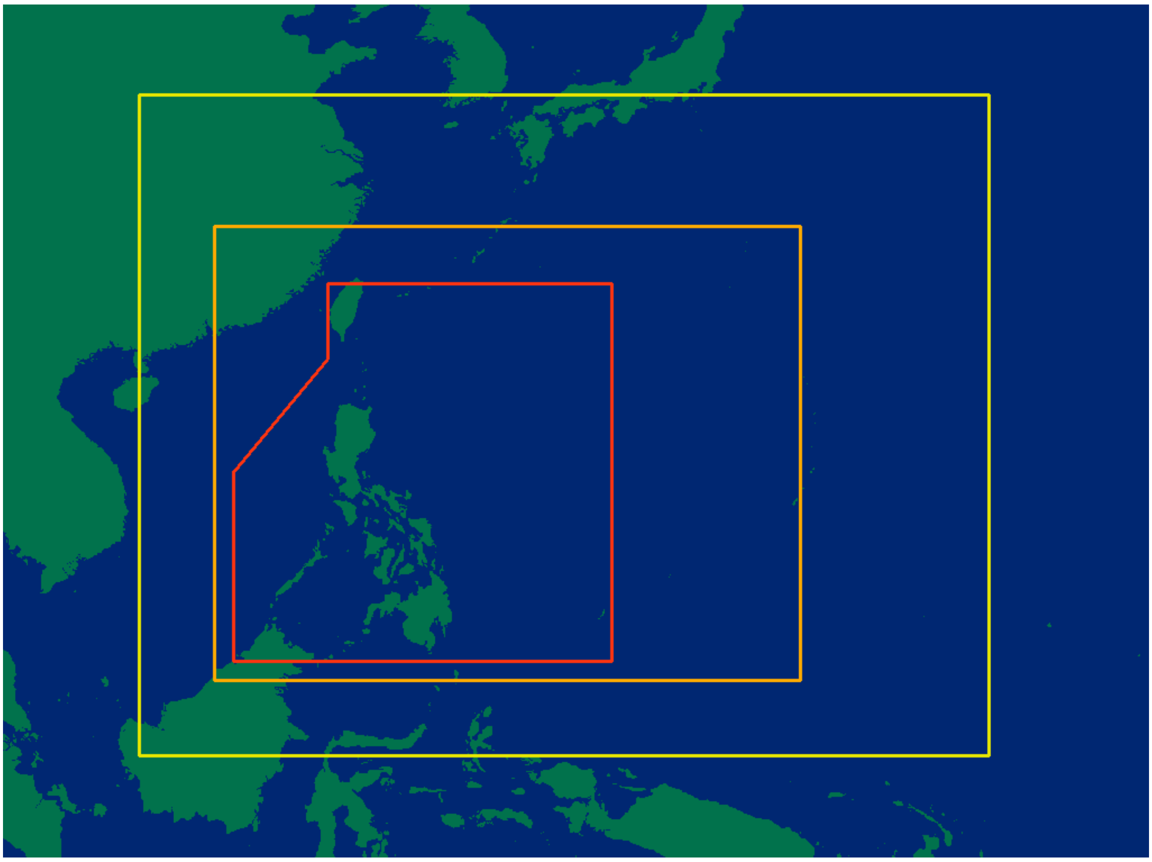

Fig. 1.1. TC forecast areas of PAGASA within the WNP basin (2015-2022).

[7] These archipelagic seas are the Sibuyan Sea, Visayan Sea, Camotes Sea, Samar Sea, and Bohol Sea.
[8] By virtue of Administrative Order No. 29 s. 2012, the West Philippine Sea is defined as the portion of the South China Sea within the exclusive economic zone (EEZ) of the Philippines. However, for ease of explanation, the entirety of the South China Sea will be referred to as the West Philippine Sea.
[9] The portion of the Celebes Sea that lies north of the boundary line delimiting the overlapping EEZs of the Philippines and Indonesia is referred to as the Mindanao Sea. This boundary line was agreed upon by both countries in 2014 was ratified by the Philippine Senate under Senate Resolution No. 1048 in 2019.

Classification of Tropical Cyclones

All TCs occurring within the WNP basin are categorized by PAGASA according to their maximum 10-minute winds near the center. The current classification system, which has since been updated[10] in March 2022, follows a five-tier scale with tropical depressions as the weakest of the categories and super typhoons as the strongest. The five-level system was originally introduced in 2015 following the onslaught of Super Typhoon Yolanda (Haiyan) in the Central Philippines in order to give emphasis to violent cases of typhoons, as well as to distinguish TCs possessing gale-force winds to those bearing storm-force winds (i.e., pre-2015 system classifies TCs with both gale-force and storm-force maximum winds as tropical storms)

Table 1.1 presents the TC categories in use under the current scheme and equivalent range of maximum winds near the center in Beaufort, knots (nautical miles per hour), kilometers per hour, and meters per second.

Table 1.1 Categories of TC used by PAGASA.

Category of TC	Maximum sustained winds near the center			
	Beaufort	kt	km/h	m/s
Tropical Depression (TD)	BF6 to BF7 (Strong winds)	22 to 33	39 to 61	10.8 to 17.1
Tropical Storm (TS)	BF8 to BF9 (Gale-force winds)	34 to 47	62 to 88	17.2 to 24.4
Severe Tropical Storm (STS)	BF10 to BF11 (Storm-force winds)	48 to 63	89 to 117	24.5 to 32.6
Typhoon (TY)	BF12 (Typhoon-force winds)	64 to 99	118 to 184	32.7 to 51.2
Super Typhoon (STY)	BF12 (Typhoon-force winds)	$\geq$ 100	$\geq$ 185	$\geq$ 51.3

Naming of Tropical Cyclones

Brief History

The practice of using names to identify TC events in the WNP goes back several centuries, with TCs being named after affected places, saints, or things they hit. Some of these TCs include the Kamikaze of 1274 and 1281, the 1881 Haiphong Typhoon, the 1906 Hong Kong Typhoon, the 1912 China Typhoon, the 1922 Swatow Typhoon, and the 1934 Muroto Typhoon. In 1944, while the world is in the midst of a global war, forecasters from the United States Army Air Forces based in the newly established weather center at Saipan (Northern Mariana Islands) informally named TCs after their wives and girlfriends. The practice reduced confusion when identifying these weather systems during map discussions.

With the growing popularity of this naming practice among military forecasters, the United States Armed Services began publicly assigning names for TCs within the WNP in 1945, thereby formalizing the practice. Eventually, in 1959, the Joint Typhoon Warning Center (JTWC) assumed the responsibility of assigning “international names” for TCs within the WNP. In 2000, Japan Meteorological Agency, acting as the WMO Regional Specialized Meteorological Center - Tokyo Typhoon Center (RSMC Tokyo), took over the naming responsibility from the JTWC.

Until 1962, the then-Weather Bureau has been relying on names assigned by the US military (JTWC). However, this changed in 1963 when the bureau decided to separately assign domestic names to TCs of at least TD category within the PAR region. One of the key reasons for the

[10] The five tropical cyclone categories used by PAGASA was updated in March 2022 to harmonize the domestic definition of Super Typhoon with equivalent peak categories used by other meteorological centers in the WNP basin. The new definition has been retroactively applied to all TCs pre-March 2022.

adoption of domestic naming is the absence of names for TCs that do not reach tropical storm category. These weather systems, despite their weaker winds, usually bring significant amount of heavy rainfall that causes widespread flooding and rain-induced landslides. PAGASA has since maintained this practice of assigning domestic names when it took over the functions of the Weather Bureau in 1972.

Domestic Naming Scheme

PAGASA assigns a domestic name to a TC of at least tropical depression category that enters or develops within the PAR region. Under the naming guidelines[11] which has been in effect since 2001, all domestic names do not exceed nine letters and three syllables and not bear any negative or offensive meaning. The names can be that of Filipino persons (male or female), places, animals, flowers, plants/trees, or traits reflecting Filipino culture or tradition and can come from any local language or dialects in the Philippines.

Four sets of regular names from A to Z of the English alphabet, excluding X, are being rotated every year. The first TC of the year that occurs within the PAR will be given the name beginning with letter A, the second B, the third C, and so on, until the 25th name is assigned. If the list is not exhausted within the year, the first TC of the succeeding year will be given the name from the set assigned for the succeeding year beginning with the letter A.

In addition, four sets of auxiliary names from A to J of the English alphabet are also rotated every year in the same manner as the regular names. As such, each set of auxiliary names is paired with a set of regular names. Auxiliary names are used in case the total number of TCs for the year exceeds 25. In such an event, the 26th TC will be given the name from the auxiliary set beginning with letter A, the 27th B, the 28th C, and so on, until auxiliary set is exhausted by the 35th TC of the year. To date, all auxiliary names remained unused.

Retiring Domestic Names

Under the present naming guidelines, the domestic name of a TC, whether regular or auxiliary, can be retired from the operational set through any of the two processes: decommissioning or delisting.

A domestic name is decommissioned by PAGASA if the TC directly caused either or both the deaths of at least 300 individuals or damage to infrastructure and agriculture amounting to at least PHP 1,000,000,000.00 based on the final report or, in its absence, the last situational report issued by the National Disaster Risk Reduction and Management Council (NDRRMC). The list of approved decommissioned names and their corresponding replacements is presented to the public within the first quarter of the year following the end of the TC season.

On the other hand, a domestic name is deemed delisted when there is a necessity for the name to be replaced without meeting the criteria for decommissioning. Delisting can happen at the start or the middle of the TC season (i.e., before the name is assigned to a TC) for various reasons. In such an event, a delisted name is immediately replaced. An example of delisted name is the case of Kanor, which was delisted prior to its supposed usage in September 2014 and was immediately replaced by Karding due to negative feedback from the public because a person involved in an infamous series of inappropriate videos with a minor at that time shares the same name (i.e., “Mang Kanor” scandal). Another example of delisted name was the case of Set III’s Nonoy in 2015, which was replaced by Nona even though the original name has already been used in three public TC products. Nonoy was delisted because of its perceived similarity with the nickname of then-President Benigno Aquino III (“Noynoy”).

Since 1963, PAGASA has decommissioned 68 names (44 from the new list of names) and delisted 38 names from the operational listing.

[11] A new naming protocol was introduced in 2001 following the decision of the agency to end the old domestic naming scheme which has been in effect since 1963. The old naming scheme also has four (4) sets of regular and auxiliary names but uses female Filipino names beginning with the letters of the Tagalog alphabet and ending with the suffix -ing.

Domestic names for the 2020 season

Table 1.2 presents the regular and auxiliary sets of names under Set IV, which was the set of names used during the 2020 season. Names under Set IV were last used during the 2016 season and is scheduled to be used again during the 2024 season (except for those that will be replaced in case of decommissioning). The names Kristine, Leon, Nika, Pepito, and Vicky were used for the first time in 2020 after the decommissioning of Karen, Lawin, and Nina in 2016, Pablo in 2012, and Violeta in 2004. Ambo, Quinta, Rolly, and Ulysses were eventually decommissioned by PAGASA after the end of the 2020 season.

Table 1.2. Regular and auxiliary domestic names during the 2020 season. Names in gray were unused during the season while those in bold were eventually decommissioned at the end of the season.

		Regular Set IV		
Ambo	Butchoy	Carina	Dindo	Enteng
Ferdie	Gener	Helen	Igme	Julian
Kristine	Leon	Marce	Nika	Ofel
Pepito	**Quinta**	**Rolly**	Siony	Tonyo
Ulysses	Vicky	Warren	Yoyong	Zosimo
		Auxiliary Set IV		
Alakdan	Baldo	Clara	Dencio	Estong
Felipe	Gomer	Heling	Ismael	Julio

Analysis and Forecast Process

Tropical Cyclone Analysis

The routine analysis of TCs begins with the determination of the center position. The estimation of the low-level circulation center is accomplished using a combination of satellite data (geostationary, microwave, scatterometer (SCAT)), Doppler weather radar scans, and surface meteorological observations[12]. In addition, satellite fix reports from other meteorological centers and objective tools from the Cooperative Institute for Meteorological Satellite Studies (CIMSS) (Wimmers and Velden 2010, 2016) are also routinely used as reference when finalizing the center position analysis. Information on the direction and speed of movement of TCs are derived from the six-hourly displacement vectors of the center position.

The intensity of a TC in terms of maximum sustained winds and central pressure is primarily estimated from the conversion of Dvorak Final T (FT) and Current Intensity (CI) numbers, unitless parameters derived from the subjective analysis of satellite images using the Dvorak (1984) method. These values are provided operationally by the PAGASA Meteorological Satellite Facility, as well as from satellite fix reports from other meteorological centers. The conversion from CI number to maximum sustained winds and central pressure is facilitated by a lookup table based on the relationship (Koba et al. 1991) between the reanalyzed (i.e., post-operational analysis) CI number and the corresponding best track intensities of WNP TCs during a six-year period in the 1980s when aircraft reconnaissance missions were still being flown by the United States in the basin. The estimates are then refined using wind fields from SCAT and microwave sensors, radial velocity analysis from Doppler weather radars, weather map analysis using available surface observations, and other objective tools from CIMSS (Olander and Velden 2007, Herndon and Velden 2018). Cyclone phase analyses (Hart 2003) are also consulted to diagnose extratropical transitions. The progression of eyewall replacement cycles (ERC) in mature typhoons and its impact on the intensity analysis is analyzed both subjectively using 85-82 GHz microwave images and objectively using ERC-relevant statistics derived from the same microwave images (Wimmers 2018)

[12] These observation data include reports of surface observation from fixed land stations (SYNOP or METAR), sea stations or marine vessels (SHIP), and meteorological buoys (moored or drifting; BUOY).

The maximum gust is derived from the maximum sustained wind estimate using a multiplier (gust factor) that varies depending on both the exposure conditions near the center of a TC (Harper et al. 2010) and the wind averaging period of the maximum sustained winds and maximum gust. For the case of PAGASA, maximum sustained winds and maximum gust are estimated using 10-minute and 3-second averaging.

The wind field of a TC is determined by estimating the spatial extent of strong winds[13], gale-force winds[14], storm-force winds[15], and typhoon-force winds[16] associated with the TC circulation. The extent of these TC winds is primarily estimated using the subjective analysis of SCAT and microwave-based wind fields, sea surface wind fields estimated from Himawari-8 low-level atmospheric motion vectors (AMV) (Nonaka et al. 2019), and weather map analysis using available surface observations. Objective wind field estimation tools (Knaff and DeMaria 2010; Knaff et al. 2016) are also being used as reference when refining the wind field analysis.

TC analysis is undertaken four (4) times daily at 00, 06, 12, and 18 UTC for all TCs situated within the PAR and the extended forecast areas. However, when a TC is forecast to make landfall or pass within 60 nmi of the Philippine coastline within 24 hours, additional analyses[17] are performed at 03, 09, 15, and 21 UTC. Moreover, as a requirement for public TC products, the center positions are also determined for the hour preceding the issuance time of the products.

Tropical Cyclone Forecast

PAGASA issues track and intensity (as category) forecasts out to 120 hours, as well as the radii of probability circles at each forecast time of the track forecast. Normally[18], these forecasts are issued up to four (4) times daily with initial times of 00, 06, 12, and 18 UTC, with additional forecasts[19] provided at initial times of 03, 09, 15, and 21 UTC when a TC is forecast to make landfall or pass within 60 nmi of the Philippine coastline within 24 hours.

The primary basis for the track forecasts is the track forecast guidance from global and regional deterministic models. Both simple and selective consensus methods are used to process these model guidance products to create the track forecast. Global ensemble prediction systems from major numerical weather prediction (NWP) centers are also employed as reference to refine the track forecast. The environmental steering of the TC is also analyzed either by using hand-analyzed upper-air charts (single layer approach) or satellite AMV-derived variable deep-layer mean streamlines (Velden and Leslie 1991; Velden 1993) to serve as another reference for diagnosing the forecast near-term motion of a TC.

Intensity forecasts are primarily based on several statistical and statistical-dynamical TC intensity guidance products. Dynamical intensity guidance from global and regional deterministic models are also used as reference when refining the intensity forecast, while cyclone phase forecast based on global deterministic models (Hart 2003) serve as primary reference for forecasting extratropical transitions. In addition, analysis of environmental parameters such as sea surface temperature, ocean heat content, vertical wind shear, and outflow characteristics along the forecast track are also considered. For near term intensity change of mature typhoons related to ERCs, a predictive model of ERC initiation based on the objectively-derived ERC-relevant eyewall statistics is also used (Wimmers 2018).

The track forecast issued by PAGASA incorporates the probability circles at each forecast time. The probability circle shows the range into which the TC center is forecast to move with 70% probability at each forecast time. The radii of these circles are statistically determined based on the result of the most recent five (5)-year track forecast verification.

[13] "Strong winds" is defined as near-surface winds of 22 to 33 kt or Beaufort Force 6 or 7.
[14] "Gale-force winds" is defined as near-surface winds of 34 to 47 kt or Beaufort Force 8 or 9.
[15] "Storm-force winds" is defined as near-surface winds of 48 to 63 kt or Beaufort Force 10 or 11.
[16] "Typhoon-force winds" is defined as near surface winds of at least 64 kt or Beaufort Force 12.
[17] Additional analyses are terminated once the TC has left the 60-nmi coastal buffer.
[18] The frequency of the forecasts depends on the public or marine TC product being issued.
[19] Additional forecasts are terminated once the TC has left the 60-nmi coastal buffer.

Tropical Cyclone Product Description

Depending on the location of the TC within the forecast areas and the threat posed by the TC to land and sea areas under PAGASA's responsibility, the Weather Division issues different TC products to the public, disaster managers, national government agencies, local government units, and other specialized end users. This section presents the description of public and marine TC products issued by the Weather Division during the 2020 season.

PAGASA also provides meteorological information to support domestic and international aviation in the form of WC SIGMET[20] when a TC of at least TS category enters the Manila Flight Information Region[21]. However, such product is not covered by this section or any section of this ARTC.

Tropical Cyclone Update

Although not a standalone product, the Tropical Cyclone Update (TCU) is a plain text message in the 24-Hour Public Weather Forecast that provides key updates on the location, intensity, and movement of all tropical cyclones of at least TD category within any of the TC forecast areas. The TCU includes the following elements in analysis:

Analysis	Center position Direction and speed of movement Maximum sustained winds Maximum gust

The 24-Hour Public Weather Forecast, where TCUs are incorporated, is issued twice daily at 4:00 AM PHT and 4:00 PM PHT.

Tropical Cyclone Advisory

The Tropical Cyclone Advisory (TCA) is a plain text product that provides information on the analysis, forecast, and warning for a TC of at least TD category inside the TCAD that is projected to enter the PAR within 120 hours. The TCA incorporates the following elements in the analysis and forecast:

Analysis	Center position Direction and speed of movement Maximum sustained winds Maximum gust
24-, 48-, 72-, 96- and 120-h forecasts	Center position Intensity (as category)

In addition, TCA may include any warning and non-warning information relevant to the subject TC such as the list of areas where tropical cyclone wind signals will be first hoisted, general statement of hazards which may affect land areas and coastal waters, and date and time of forecast entry to the PAR region.

TCAs are normally[22] issued once daily at 11:00 AM PHT.

Severe Weather Bulletins

The Severe Weather Bulletin (SWB) is a plain text product that provides information on the analysis, forecast, and warning for a TC that is either within the PAR (irrespective of threat to land

[20] A SIGMET provides concise information issued by the Meteorological Watch Office of a particular FIR (i.e., PAGASA for Manila FIR) concerning the occurrence or expected occurrence of specific en-route weather and other atmospheric phenomena that may affect the safety of aircraft operations. The WC SIGMET is the specific SIGMET for TC of at least TS category.
[21] An FIR is a specified region of airspace in which a flight information service and an alerting service are provided. These services provide information pertinent to the safe and efficient conduct of flights and alerting the different relevant authorities should an aircraft be in distress.
[22] The initial or final TCA may be issued at 5:00 AM, 11:00 AM, 5:00 PM, or 11:00 PM PHT.

areas) or still outside the PAR but the forecast scenario already necessitates the hoisting of tropical cyclone wind signals over land areas of the country. The SWB contains the following elements in the analysis and forecast:

Analysis	Center position Direction and speed of movement Maximum sustained winds Maximum gust
24-, 48-, 72-, 96- and 120-h forecasts	Center position Intensity (as category)

SWBs may include warning information such as the list of areas where wind signals are or will be in effect, forecast hazards that will affect land areas and coastal waters (i.e., heavy rainfall, severe winds, storm surge, high waves), landfall information, as well as non-warning information relevant to the TC such as expected date and time the TC will exit the PAR. In cases when a TC is at TY or STY category, the SWB may also include a warning statement related to areas affected and that will be affected in the next 3 hours by the violent conditions within the eyewall.

If no wind signals are in effect, SWBs are normally[23] every 12 hours at 11:00 AM PHT and 11:00 PM PHT. If wind warnings are in effect, SWBs are also issued at 5:00 AM PHT and 5:00 PM. If wind signals are in effect and the TC is forecast to make landfall or pass within 60 nmi of the Philippine coastline within 24 hours, additional issuances are also made at 2:00 AM PHT, 8:00 AM PHT, 2:00 PM PHT, and 8:00 PM PHT. The additional issuances shall cease to apply once the TC has left the 60-nmi coastal buffer.

Tropical Cyclone Warning for Shipping

A Tropical Cyclone Warning for Shipping or International Warning for Shipping (IWS) is a plain text product for marine vessels at sea that provides information on the analysis and forecast for a TC within the PAR region that may pose threat to safety of domestic or international maritime traffic. The provision of IWS is in accordance with the statutory obligation of the Philippines as a Contracting Government under the 1974 International Convention for the Safety of Life at Sea (SOLAS 1974) and the Worldwide Met-Ocean Information and Warning Service (WWMIWS)[24] mandatory requirement for the provision of warnings for weather systems that produce average wind speeds of 34 kt and greater.

The IWS incorporates the following elements in the analysis and forecast:

Analysis	Center position Direction and speed of movement Maximum sustained winds Maximum gust Central pressure Extent of strong, storm-force, and typhoon-force winds
24-, 48-, 72-, 96- and 120-h forecasts	Center position Category

In addition, IWS also contains a request to all marine vessels within the vicinity of the TC circulation to transmit shipborne meteorological observations every three (3) hours.

IWSs are normally[25] issued four (4) times daily at 5:00 AM PHT, 11:00 AM PHT, 5:00 PM PHT, and 11:00 PM PHT.

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[23] The initial or final SWB may be issued 5:00 AM, 11:00 AM, 5:00 PM, or 11:00 PM PHT.
[24] The WWMIWS is an internationally coordinated service established by the International Maritime Organization and the World Meteorological Organization for the promulgation of meteorological warnings and forecasts for the high seas, coastal waters, offshore waters, and local waters.
[25] The initial (final) IWS is done in conjunction with the issuance of the initial (final) SWB.

Tropical Cyclone Wind Signal System

The Tropical Cyclone Wind Signal (TCWS) System is a five-level land warning in plain text format used to warn land areas of TC winds of at least strong wind strength on the Beaufort Scale for at most 36 hours before the onset of such meteorological conditions. This wind signal system is numbered 1 to 5, with higher signal number associated with higher general wind strength and short warning lead time (i.e., hours before onset of wind threat).

The TCWS system has since been updated in March 2022 to harmonize the wind warning system with the existing typhoon damage scales for the Philippines, damage survey information, warning best practices from other tropical cyclone warning centers in the WNP basin, and the results of severe wind risk analysis projects undertaken by PAGASA researchers. However, for the purpose of this ARTC, this subsection presents the TCWS system as it was implemented during the 2020 season. Table 1.3 presents the wind signals of the TCWS system, the general wind strength associated with each wind signal, description of potential damage to structures and vegetation, and the associated color of each wind signal when presented on maps.

Table 1.3. PAGASA TCWS system as of the 2020 season

TCWS		General wind strength and description of potential damage to structures and vegetation
(cyan)	Wind Signal No. 1	Strong winds which may cause up to very light damage is prevailing or expected to prevail within 36 hours from the time the signal was raised
(yellow)	Wind Signal No. 2	Damaging gale- to storm-force winds[26] which may cause light to moderate damage is prevailing or expected to prevail within 24 hours from the time the signal was raised
(orange)	Wind Signal No. 3	Destructive[27] typhoon force winds which may cause moderate to heavy damage is prevailing or expected to prevail within 18 hours from the time the signal was raised.
(red)	Wind Signal No. 4	Very destructive[28] typhoon force winds which may cause heavy to very heavy damage is prevailing or expected to prevail within 12 hours from the time the signal was raised.
(magenta)	Wind Signal No. 5	Devastating[29] typhoon force winds which may cause very heavy to widespread damage is prevailing or expected to prevail within 12 hours from the time the signal was raised.

To ensure consistent interpretation, the generalized description of damage presented in Table 1.3 are defined below:

- Very light damage: Less than 5% of high-risk (HR) structures (and no damage to medium-risk (MR) and low-risk (LR) structures
- Light damage: 10% HR, 5% MR, and 0% LR
- Moderate damage: 25% HR, 10% MR, and 5% LR
- Heavy damage: 50% HR, 25% MR, and 10% LR
- Very Heavy damage: 80% HR, 50% MR, and 25% LR
- Widespread damage: Nearly 100% HR; more than 80% MR; more than 50% LR.

[26] If the TC is still at TS category, the statement for TCWS #2 changes from “Damaging gale- to storm-force winds…” to “Damaging gale-force winds…”
[27] Typhoon-force winds of up to 170 km/h.
[28] Typhoon-force winds of more than 170 km/h but not exceeding 220 km/h.
[29] Typhoon-force winds in excess of 220 km/h.

Moreover, the terms high-risk, medium-risk, and low-risk structures are defined as follows:

- High-risk structures: consist of old and densely built-up residential areas having light material structures and organic roof materials, squatter/slum areas, zone of mixed development, poor quality housing, warehouses, and old, dilapidated structures.
- Medium-risk structures: consist of older parts of city/town centers, timber structures/galvanized iron roofs and generally belong to the middle-income group.
- Low-risk structures: consist of concrete/framed structures, low-density population/housing, and usually the modern part of the city/town.

Although a general description of damage per wind signal is presented in Table 1.3, a more detailed description of potential damage to structures and vegetations resulting from the surface wind conditions associated with each wind signal are presented in Table 1.4.

Table 1.4. Potential damage to structures and vegetation associated with the surface wind conditions at each wind signal level.

Wind Signal	Damage to structures	Damage to vegetation
TCWS #1	• Very light or no damage to low-risk structures. • Light damage to medium- to high-risk structures • Slight damage to some houses of very light materials or makeshift structures in exposed communities.	• Some banana plants are tilted, a few downed and leaves are generally damaged. • Twigs of small trees may be broken. • Rice crops, however, may suffer significant damage when it is in its flowering stage.
TCWS #2	• Light to moderate damage to high-risk structures. • Very light to light damage to medium-risk structures. • No damage to very light damage to low-risk structures. • Unshielded, old, dilapidated schoolhouses, makeshift shanties, and other structures of light materials are partially damaged or unroofed. • A number of nipa and cogon houses may be partially or totally unroofed. • Some old, galvanized iron (G.I.) roofs may be peeled or blown off. • Some wooden, old electric posts are tilted or downed. • Some damage to poorly constructed signs/billboards. • In general, the winds may bring light to moderate damage to the exposed communities.	• Most banana plants, a few mango trees, ipil-ipil, and similar types of trees are downed or broken. • Some coconut trees may be tilted with few others broken. • Rice and corn may be adversely affected. • Considerable damage to shrubbery and trees with some heavy-foliaged trees blown down.

Table 1.4. *(Continuation)*

Wind Signal	Damage to structures	Damage to vegetation
TCWS #3	• Heavy damage to high–risk structures. • Moderate damage to medium-risk structures. • Light damage to low-risk structures. • Increasing damage (up to more than 50%) to old, dilapidated residential structures and houses of light materials. Majority of all nipa and cogon houses may be unroofed or destroyed. • Houses of medium strength materials (old, timber, or mixed timber-CHB structures, usually with G.I. roofing's) and some warehouses or bodega-type structures are unroofed. • There may be widespread disruption of electrical power and communication services.	• Almost all banana plants are downed. • Some big trees (acacia, mango, etc.) are broken or uprooted. • Dwarf-type or hybrid coconut trees are tilted or downed. • Rice and corn crops may suffer heavy losses. • Damage to shrubbery and trees with foliage blown off; some large trees blown down.
TCWS #4	• Very heavy damage to high–risk structures. • Heavy damage to medium-risk structures. • Moderate damage to low-risk structures. • Considerable damage to structures of light materials (up to 75% are totally and partially destroyed) with complete failure of roof structures. • Many houses of medium-built materials are unroofed with extensive damage to doors and windows; some with collapsed walls. • A few houses of first-class materials are partially damaged. • All signs/billboards are blown down.	• There is almost total damage to banana plantation. • Most mango trees, ipil-ipil, and similar types of large trees are downed or broken. • Coconut plantation may suffer extensive damage. • Rice and corn plantation may suffer severe losses.
TCWS #5	• Widespread damage to high-risk structures. • Heavy damage to medium risk structures. • Very heavy damage to low-risk structures. • Electrical power distribution and communication services severely disrupted. • All signs/billboards blown down.	• Total damage to banana plantation. • Most tall trees are broken, uprooted, or defoliated. • Coconut trees are stooped, broken or uprooted. • Few plants and trees survived.

Owing to the presence of natural and artificial obstructions such as local topography or nearby buildings, winds in a particular area (local winds) may be substantially stronger from the general wind strength (regional winds) over the provincial or sub-provincial locality implied by the wind signal. Compared to the prevailing regional winds, the local winds are generally stronger over offshore water, on high ground (e.g., mountainous areas), and in areas where channeling effect between obstructions occur. On the other hand, local winds are weaker in areas that are sheltered from the prevailing wind direction. In addition, the general wind strength associated with each wind signal is in terms of mean winds defined as the speed of the wind averaged over a 10-minute period at 10 meters above the ground. As such, a locality may experience gusts (instantaneous peak values of surface wind speed) that are higher than the range of wind speeds expressed by the highest TCWS raised during the passage of a TC.

The wind signals are meant to warn the public of the threat of TC winds over land areas and has nothing to do with the magnitude, intensity, extent, or duration of heavy rainfall or other hazards that may affect land areas. As such, the weather condition in the different parts of the Philippines cannot be simply inferred from the hoisted wind signal.

Product Dissemination

For Public Tropical Cyclone Products

Ensuring the effective and efficient dissemination of public TC products to end users is the shared responsibility of the Weather Division and the PAGASA Regional Services Divisions especially during periods of high impact weather events in the country. As such, public TC products are disseminated using both digital and paper-based platforms which include fax, electronic mail (email), short messaging service (SMS), official website, and social media in accordance with domestic requirements and quality standards. Moreover, the Weather Division continuously communicates with the NDRRMC to ensure timely dissemination of abbreviated versions of public TC products to the public through the Emergency Cell Broadcast System (ECBS)[30].

For Marine Tropical Cyclone Products

The fast, efficient, and effective dissemination of meteorological maritime safety information (MSI) to mariners of vessels within the waters under PAGASA's forecast responsibility is the shared responsibility of PAGASA (as the national meteorological service) and the designated authorities or centers for the broadcast of MSIs (e.g., METAREA XI Coordinator, Philippine Coast Guard). As such, constant coordination with these authorities or centers is in place to ensure that marine TC products are broadcasted through the applicable communication platforms[31] of the Global Maritime Distress Safety System (GMDSS) including scheduled broadcast of coastal radio stations situated in the Philippines. The dissemination of meteorological MSI is in accordance with the provisions of the SOLAS 1974, WWMIWS, and other applicable domestic and international maritime instruments and regulations.

Apart from GMDSS communications platforms, marine TC products are also available for distribution through the digital and paper-based platforms in use for the dissemination of public TC products, as well as through the WMO Global Telecommunications System as part of regional exchange of TC forecast and warning information. GTS-based dissemination of the IWS uses the abbreviated headings WTPH20 RPMM, WTPH21 RPMM, and WTPH22 RPMM.

Expert Advice and Briefings

Apart from the distribution of public and marine TC products through multiple digital and paper-based dissemination platforms, PAGASA performs expert advice and briefing to various end users and stakeholders using traditional and emerging media platforms to ensure that preparation, mitigation, and adaptation measures undertaken by the public, disaster managers, government agencies and institutions, and specialized sectors during TC events are risk-informed, scenario-driven, and evidence-based.

[30] The ECBS is an alert broadcast system in the Philippines designed to disseminate emergency alerts and warning to mobile devices via cell broadcast system. This system is being implemented by the NDRMMC and all telecommunications companies in the country in accordance with Republic Act No. 10639 (Free Mobile Disaster Alerts Act).

[31] These platforms include SafetyNET Enhanced Group Call (EGC) satellite communications, Digital Selective Calling (DSC), High-Frequency Narrow Band Direct Printing (HF NBDP), and Navigational Telex (NAVTEX)

PAGASA meteorologists at the national and local levels undertake regular public briefings and press conferences at regular intervals[32]. These are broadcasted via television, radio, and the internet via the official website, social media, and video streaming/sharing platforms. In addition, duty forecasters answer to interview requests[33] from news outlets and phone queries from the public and other interested parties and end users.

To support risk-informed, evidence-based decision making of the national government and local government units ahead of an impending TC passage, PAGASA meteorologists provide expert advice through detailed briefings and decision support to disaster managers at the national and local governments. These include pre-disaster risk assessment meetings of the NDRRMC Operations Center and local disaster risk reduction and management offices and phone briefings to heads of local governments. For the private sector, forecasters also give expert advice to business continuity planners and managers, especially when TCs (and other weather systems that are enhanced by them) will affect the economic centers of the country and likely cause significant disruption to their business activities.

These expert briefings and advices to the public and private sectors are supported by continuous information, education, and communication campaigns such as lectures, speaking engagements, and seminar-workshops to ensure that they effectively utilize the meteorological information that PAGASA provides them for their decision-making.

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[32] Regular public briefings during TC days are typically within 30 minutes of the issuance of SWBs (except during additional issuances of SWBs). However, special public briefings may be held during issuances of TCAs or when a significant change in the forecast scenario is present.
[33] These interviews may be on camera, through phone patch, or using a video conferencing platform.

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POST-SEASON BEST TRACK ANALYSIS OF PHILIPPINE TROPICAL CYCLONES

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Post-Season Best Track Analysis of Philippine Tropical Cyclones

A Forensic-like Investigation

The determination of analysis parameters such as center position, intensity, and motion of a tropical cyclone (TC) valid at a given synoptic time utilizes meteorological observation data from a wide array of platforms and formats, each having varying degrees of observation latency[1]. However, in an operational environment, the rigid time schedule of each forecast cycle[2] not only adds the element of time pressure to the conduct of TC analysis but also limits the amount and type of observation data that can be considered to those with relatively low latency. As such, the duty forecaster's exercise of professional judgment within time constraints based on the observation data that was available at that time heavily influences the determination of the analysis parameters in an operational setting. The best estimates of these parameters are referred to as an "operational track" and may incorporate (although minimized) short-term motions, especially when analysis parameters are estimated at three (3)-hour intervals, which may be unrepresentative of the overall motion of the TC.

After the termination of operational activities for a particular TC event, the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) collects all conventional and unconventional observation data not only from the domestic weather observation network but also those from other meteorological centers in the Western North Pacific (WNP) basin, including those that were not available to forecasters in both real and near real-time. Afterwards, the operational track is reviewed by performing a forensic-like analysis, which involves the re-construction of the motion and intensity change of TC throughout its lifespan using all the collected meteorological data and without the tight time constraints of the operational environment. This procedure is called a "best track analysis" and the final product of this investigation satisfies the basic components of the accepted definition[3] of "best track":

> *"A subjectively-smoothed representation of the motion and intensity change of a TC over its lifetime. The best track of a TC contains the latitude and longitude of the center position and the intensity in terms of maximum sustained winds[4] and central pressure at intervals of three (3) or six (6) hours. Best track positions and intensities, which are based on a post-event assessment of all collected meteorological data, may differ from values contained in operational advisories or bulletin and will also not generally reflect any short-term erratic motion."*

A fundamental component of this definition that differentiates operational track from a best track is that the latter provides three (3)- or six (6)-hourly representative estimates of the TC center position. Plotted center fixes derived from observation data often reveal a series of irregular movements, such include trochoidal motion or other wobbles, which do not generally persist for more than a few hours. These are unrepresentative of the overall motion. A subjectively-smoothed "best track" that does not focus on these short-period transient motions is ideal.

The subjective smoothing procedure means that center positions in the operational track may be re-positioned" in the best track and from a sampling perspective, this re-positioning is part of a filtering procedure that is administered to avoid aliasing small-scale noise. For a given time series with data points ΔT apart, the smallest wavelength which can be depicted accurately is about 4 x ΔT. Since the TC analysis times of PAGASA are at least three (3) hours apart, the smallest periods which can be adequately represented are on the order of 12 hours. Thus, the typhoon forecaster

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[1] Latency is the amount of time between the time of an observation and the time that the observation becomes available to forecasters in a form that they can assess and analyze.

[2] The forecast cycle is the 3-hour period beginning with a synoptic time (usually 00, 06, 12, and 18 UTC) where the (1) gathering, processing, and displaying of meteorological observation and forecast guidance, (2) determination of analysis information, (3) the formulation of forecast policy, and (4) preparation and issuance of relevant TC products and briefing materials are accomplished.

[3] PAGASA adopted the definition of "best track" from the National Hurricane Center.

[4] Both operational and best track intensities are estimated at 10-minute averaging periods.

in charge of best track analysis might try to avoid analyzing oscillations with a period less than 12 hours.

Best track analysis also allows the typhoon forecaster to adjust analysis parameters post real-time when, even in the absence of short-period transient motions, the re-constructed motion and intensity change of the TC based on all collected observation data do not agree with the values in the operational track. To better explain this, Fig. 2.1 shows both the operational and best track position and intensities of Tropical Storm Falcon (Danas) – one of the TCs of the 2019 season whose best track was strikingly different from its operational track. Although the operational and best tracks show similar motion in the initial and later phases of its existence within the PAR region, Fig. 2.1, clearly shows two clear differences that significantly changes the narrative of the storm:

- Tropical Storm Falcon developed into a tropical depression outside the PAR instead of inside it and much earlier than what the operational track shows. Moreover, the timing of intensification into a tropical storm was slightly later in the best track compared to its operational track counterpart.
- Best track analysis revealed that the storm did not make landfall over Cagayan Province during the late evening hours (local time) of 16 July 2019 compared to what was reported in the operational analysis. The analysis revealed the development of a remote low to the west of northern Luzon as Falcon's circulation neared Cagayan-Isabela area and interacted with the rugged northern Luzon landmass. Such finding was revealed by the use several meteorological data that were not available in a timely manner during the operational analysis.

A best track analysis may also result in an upward or downward revision of intensity estimates at each synoptic time. A good example of this is the case of Super Typhoon Rolly (Goni) which struck the island province of Catanduanes in the early hours of 1 November 2020 as one of the strongest landfalling WNP TCs on record. Radar data indicated that the center of the super typhoon directly passed over Virac Synoptic Station at around 5:00 AM (local time) on 1 November. Although real-time data transmission stopped hours prior to its passage due to violent weather condition, the station was able to observe a sea level pressure of 912.1 hPa at 5:14 AM – the lowest for the entire passage. This data was eventually transmitted to PAGASA Central Office as part of the station's passage report. Best track analysis revealed that by the time Rolly passed over Virac at around 21 UTC, the intensity had already dropped to 115 kt and 910 hPa (or 5 kt lower and 20 hPa higher compared to operational intensity). The same data was also used to revise the peak intensity of Rolly in the best track from 890 hPa to 905 hPa. Both of these revisions were consistent with reanalyzed Dvorak parameters and other post-real time remote sensing data (e.g., synthetic aperture radar-derived winds).

Through best track analysis, important statistics of the season (e.g., number of landfalling TCs for the year or month and the number of TCs that developed within or outside the PAR) or individual TCs (e.g., actual storm duration, peak intensity, landfall point and time), can be updated accordingly. While best track serves as the best available representation of the synoptic-scale development and movement of TCs, these are by no means perfect. In fact, best track data can be further revised or refined in the future to incorporate meteorological data that were not available during the initial post-season best track analysis, as well as other latest information and research results.

At the present, TC meteorologists from PAGASA perform both preliminary best track analysis in near-real time and post-season best track analysis after the season has ended to correct position and intensity estimates, with the latter benefitting from a larger set of real time, near-real time, and post-real time meteorological data and analyses.

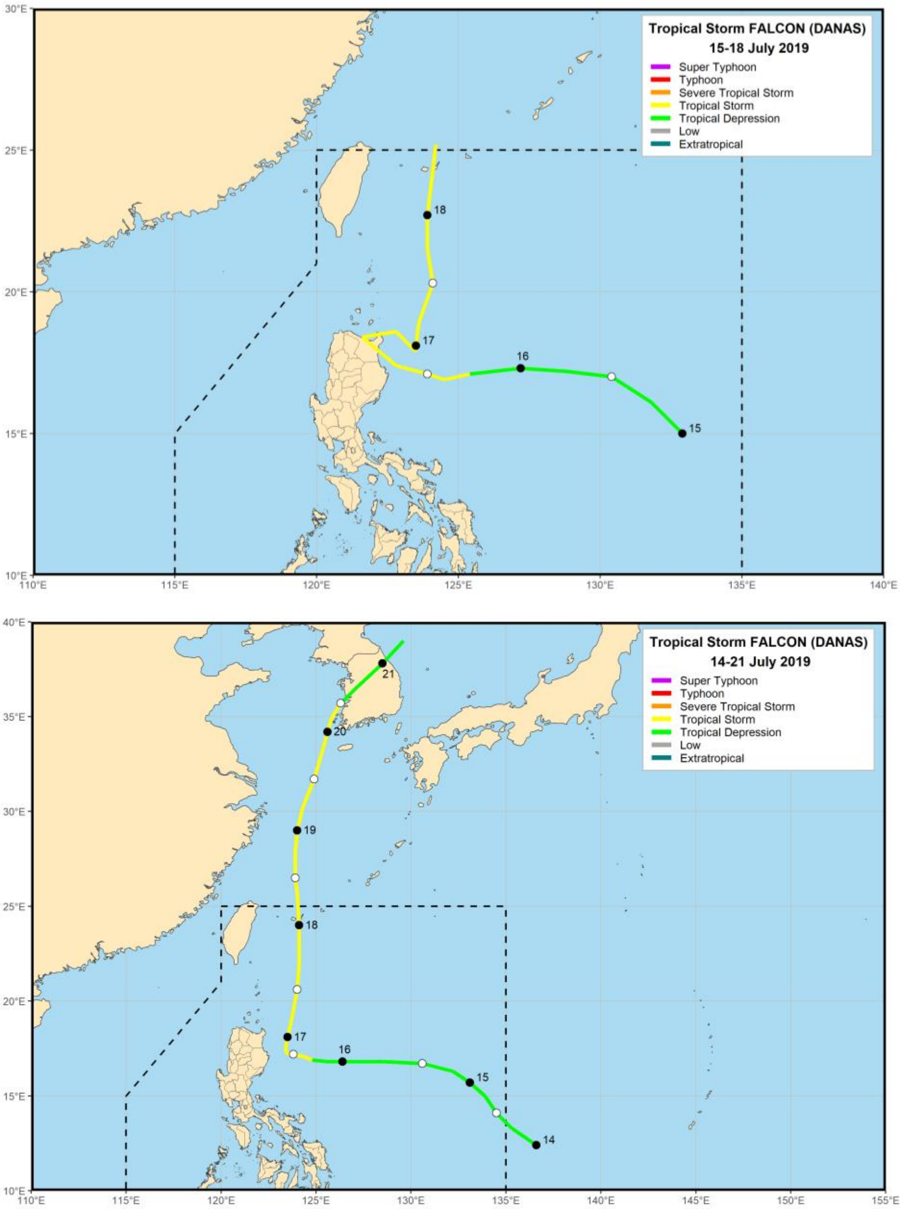

Fig 2.1. Operational (top) and best (bottom) track positions and intensities (as categories) of Tropical Storm Falcon (Danas). Line color indicates the category of TC. Shaded circles with date labels indicate 00 UTC positions while open circles indicate 12 UTC positions.

PAGASA Tropical Cyclone Publication Series

The TC meteorologists of the Marine Meteorological Services Section, Weather Division are responsible for the publication of the “Annual Report on Philippine Tropical Cyclones (ARTC)” every year. Published within two years after the termination of a particular TC season, the ARTC provides a yearly compendium of technical reviews of TCs that occurred within the Philippine Area of Responsibility (PAR) based on the outputs of the post- season best track analysis. Also included are the operational activities of PAGASA during the TC season and the summary of post-season verification of official forecasts against the best track data.

The first issue of an annual report of this kind was “Tropical Cyclones of 1948”, published by the Climatological Division under the direction of Dr. Casimiro del Rosario, Director of the then-Weather Bureau. The publication of this yearly compendium of best track information of each Philippine TC continued for decades and was eventually taken over by PAGASA (then under the Ministry of National Defense) when it was formed in 1972 after the Weather Bureau was abolished.

In December 1981, a new report series, the “Annual Tropical Cyclone Report” (ATCR) was issued by the Tropical Cyclone Division (TCD) of the National Weather Office (NWO), with its first issue covering the TC season of 1977. The old series under the Climatological Division continued, although the ATCR became the definitive technical report series of PAGASA due to its more comprehensive content.

The new series continued even after PAGASA was transferred to the National Science and Technology Authority (now the Department of Science and Technology) in 1984. However, with the dissolution of the Tropical Cyclone Division and the downsizing of the Weather Branch (WB; the successor to the NWO) in the succeeding years, the new publishing unit of the ARTC lacked the dedicated manpower to continue the best track analysis and the generation of these reports. In the early 1990s, the WB terminated both the best track analysis and the publication of the ARTC. The final issue of the ARTC covered the 1991 TC season.

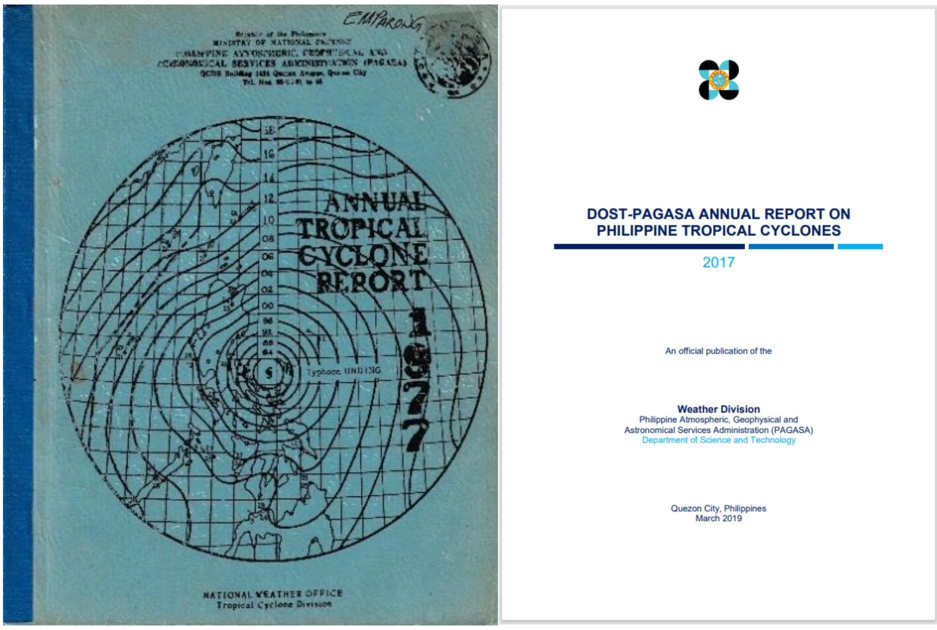

Fig. 2.2. Launch issues of the ATCR (1977 season, left) and ARTC (2017 season, right).

Several attempts were made to revive the publication of a TC technical report series. In March 2019, following creation of the Tropical Cyclone Group (TCG)[5] within the Weather Division (the successor to the WB), the publication of a TC report series resumed with the first issue of the “Annual Report on Philippine Tropical Cyclones” (ARTC). The launch issue covered the TC season of 2017 and was based on the operational track dataset of the season as the TCG was still in the process of finalizing the procedures for best track analysis. The first best track dataset in more than 25 years was released by the Weather Division in June 2020 as part of the 2018 ARTC.

The ARTC is available in both print (ISSN 2672-3190) and digital (ISSN 2799-0575) versions, the latter of which is available in the official website of PAGASA.

[5] The TCG is a unit of the Marine Meteorological Services Section responsible for the implementation of the tropical cyclone operational activities of the Weather Division.

PHILIPPINE TROPICAL CYCLONE SEASON OF 2020: AN OVERVIEW

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Philippine Tropical Cyclone Season of 2020: An Overview

General Statistics

The overview of the tracks of the tropical cyclones (TCs) that were observed within the Philippine Area of Responsibility (PAR) in 2020 is presented in Fig. 3.1. A total of 22 TCs were observed within the PAR region during the 2020 season. Although slightly higher than the climatological average of 20.2 for the past 30 years (1991-2020), the TC activity for the year within the PAR is deemed to be near normal[1] (Fig. 3.2). Seventeen of these TCs developed from tropical disturbance or areas of low pressure situated within the PAR region. Most of these formations occurred over the Philippine Sea area south of 20°N and east of 125°E. The rest developed over the Philippine Sea outside the PAR region, the Western North Pacific waters north of 20N, and the waters southwest of the Northern Mariana Islands. Most of the 2020 TCs degenerated into remnant lows, with only six transitioning into a post-tropical[2] low or cyclone at the end of their tropical lifespan.

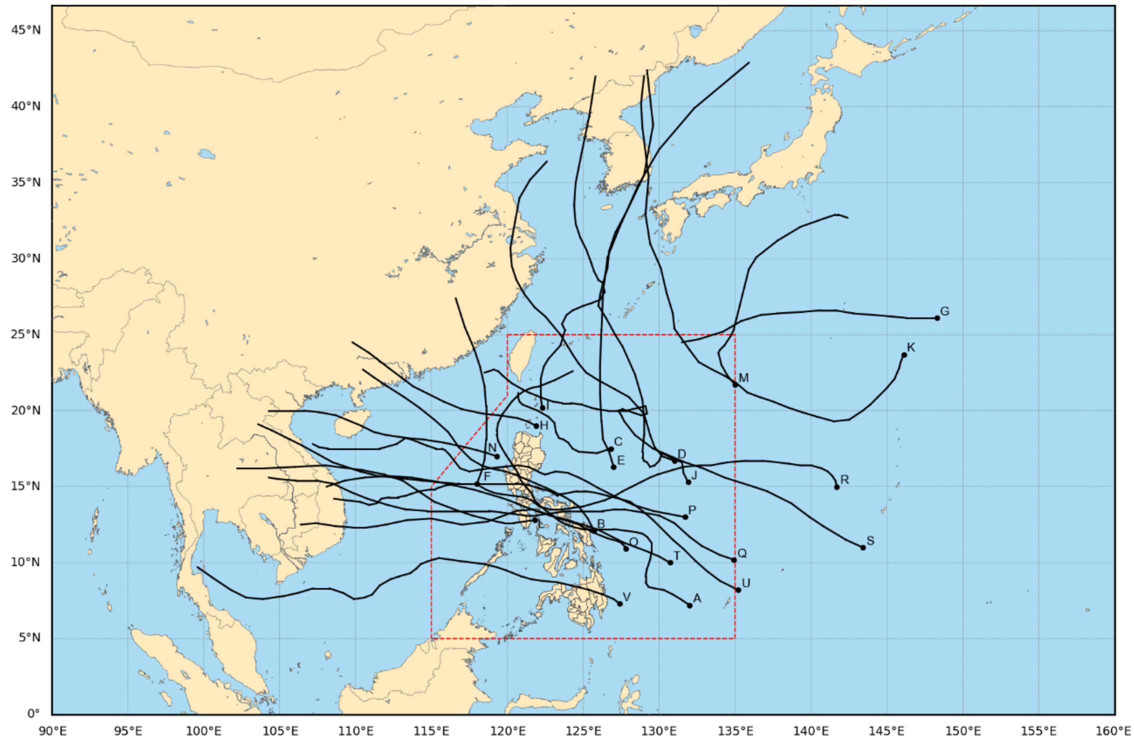

Fig. 3.1. PAGASA best track of TCs that occurred within the PAR in 2020. The filled circles in the tracks are the "genesis points" or locations where the TCs were first noted as a tropical depression on the best track data. The tracks are identified using the first letter of the domestic names of the TCs. The red dash line marks the limits of the PAR.

Fig. 3.1 shows that majority of the TCs that occurred within the PAR region in 2020 had tracks that were generally oriented east-west or east southeast-west northwest. These tracks were mostly originating from the Philippine Sea and terminating over mainland Southeast Asia or the southern portion of China. The second largest cluster of TC tracks during the season were mainly northward-oriented and had tracks terminating over the region north of 30°N (i.e., Korean Peninsula, Sea of Japan, Yellow Sea, sea area southeast of Japan). During the 2020 season, the sub-region of the PAR south of 20°N was the area within the PAR region that was most frequented by TCs.

[1] In this report, a value is deemed near normal if it lies within ±1 standard deviation of the normal value. Reference period for the 30-year normal is 1981-2010.
[2] Post-tropical lows or cyclones can be either subtropical or extratropical in nature.

The country also witnessed a total of 11 landfalling TCs, which is half of the total number of TCs that occurred within the PAR. Mostly occurring during the fourth quarter of the year, the number of landfalling TCs in 2020 was higher than the climatological average (8.4 TCs), although the number was considered to be near normal (Fig. 3.2). Nearly all of these landfalling TCs tracked over Luzon and Samar Island. Nearly half of the landfalling TCs of the season were at TD category at the time of initial landfall.

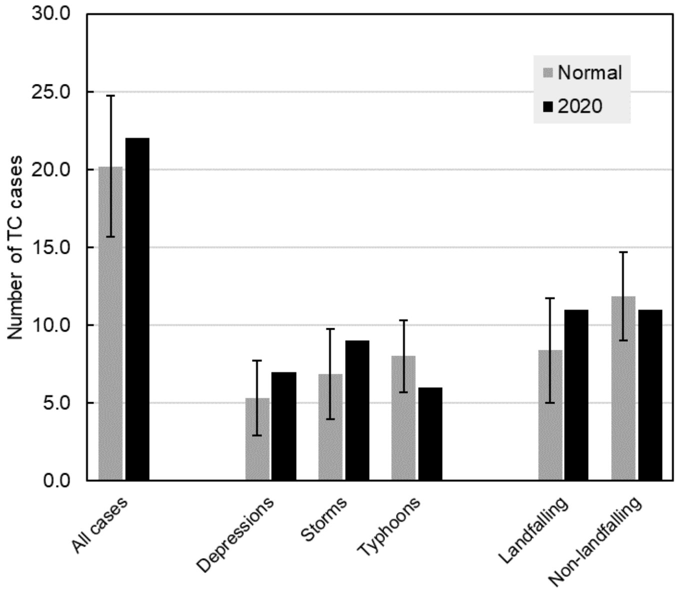

Fig. 3.2. The climatological normal of all TC occurrences within the PAR, depressions, storms (i.e., tropical storm and severe tropical storm categories), typhoons (i.e., typhoon and super typhoon categories), landfalling TCs, and non-landfalling TCs (grey bars) compared with those observed during the 2020 season (black bars). The errors bars on the normal values represent ±1 standard deviation from the climatological normal.

Table 3.1 lists down the duration of occurrence of each 2020 TC event from its genesis or formation to its weakening to an area of low pressure or transitioning into post-tropical low or cyclone, while Table 3.2 presents the duration of these TCs within the PAR. The TCs that occurred within the PAR in 2020 had an average lifespan[3] of 5 days and 10.6 hours. Super Typhoon Rolly was the longest-lasting TC of the season with a basin-wide duration of 10 days and 12 hours. Lasting only 2 days and 6 hours, Tropical Depression Carina had the shortest lifespan of the 2020 TCs. Within the PAR region, TCs lasted an average of 2 days and 16.9 hours. Lasting 8 days and 6 hours, Typhoon Ambo remained within the PAR longer than any other TC in 2020. On the other hand, Tropical Depression Gener only logged 10 hours within the PAR, making it the TC with the shortest period of occurrence within the PAR for the year.

Table 3.1 shows that during their lifespans in the Western North Pacific (WNP) basin, 11 of the 2020 TCs peaked at either typhoon (TY) or super typhoon (STY) category, while 7 reached tropical storm (TS) or severe tropical storm (STS) category. Two of the 2020 TCs, Rolly and Kristine reached STY category, with both TCs reaching their peak intensities within the PAR region. STY Rolly was the strongest TC to occur both within the WNP basin and the PAR region for the 2020 season, with a peak intensity reaching 120 kt and 905 hPa. On the other hand, TD Carina had the weakest basin peak intensity of the 2020 TCs. Table 3.2 shows that in terms of peak intensity within the PAR, 9 peaked at TS or STS category, 7 remained only as a TD within the PAR, while the rest reached TY or STY category. Fig. 3.2 shows that the number of TCs that peaked at TD and TS/STS categories was higher than the climatological average but within the range of near normal values. The number of TCs that peaked at TY or STY within the PAR was not only found to be lower than the climatological normal, but also around the lower limit of the range of near normal values.

[3] Lifespan is defined as the duration beginning with the synoptic time when the TC was first noted as TD and ending with the synoptic time when the TC either weakened into an area of low pressure or completed its post-tropical transition (without re-developing or re-transitioning into a TC at a later point).

Table 3.1. Key basin-wide parameters of each TC that occurred within the PAR region in 2020.

Domestic Name	International Name	Basin-wide tropical lifespan* (UTC)	Basin-wide peak intensity		
			Maximum Winds (kt)	Central Pressure (hPa)	Date and time of occurrence* (UTC)
Ambo	Vongfong (2001)	05/09 18 to 05/18 00	85	960	05/13 21
Butchoy	Nuri (2002)	06/11 00 to 06/14 12	40	996	06/13 00
Carina	*Unnamed*	07/12 06 to 07/14 12	25	1004	07/12 06
Dindo	Hagupit (2004)	07/31 00 to 08/05 12	70	975	08/03 12
Enteng	Jangmi (2005)	08/07 18 to 08/11 00	45	994	08/09 18
Ferdie	Mekkhala (2006)	08/09 00 to 08/11 12	65	975	08/11 00
Gener	*Unnamed*	08/09 00 to 08/13 00	30	1012	08/09 12
Helen	Higos (2007)	08/17 00 to 08/19 18	65	980	08/18 18
Igme	Bavi (2008)	08/21 00 to 08/27 06	85	945	08/25 18
Julian	Maysak (2009)	08/27 06 to 09/03 06	95	935	08/31 18
Kristine	Haishen (2010)	08/31 00 to 09/07 18	105	910	09/04 12
Leon	Noul (2011)	09/15 00 to 09/18 18	45	992	09/17 06
Marce	Dolphin (2012)	09/19 12 to 09/24 06	55	980	09/22 06
Nika	Nangka (2016)	10/11 06 to 10/14 18	45	990	10/13 12
Ofel	*Unnamed*	10/13 00 to 10/16 18	25	1002	10/15 06
Pepito	Saudel (2017)	10/18 18 to 10/25 18	65	975	10/22 12
Quinta	Molave (2018)	10/23 00 to 10/29 06	90	945	10/27 06
Rolly	Goni (2019)	10/26 18 to 11/06 06	120	905	10/31 18
Siony	Atsani (2020)	10/30 06 to 11/07 12	50	992	11/04 12
Tonyo	Etau (2021)	11/06 12 to 11/10 18	45	992	11/09 06
Ulysses	Vamco (2022)	11/08 00 to 11/16 00	85	955	11/14 00
Vicky	Krovanh (2023)	12/18 00 to 12/25 00	30	1002	12/20 00

* Provided as MM/DD HH.

Table 3.2. Period of occurrence and duration within the PAR, peak category within the PAR, and landfall occurrence of each TC that occurred within the PAR region in 2020.

Domestic Name	International Name	Period within the PAR		Peak category in PAR	Landfall
		Inclusive dates and times (UTC)	Duration		
Ambo	Vongfong (2001)	05/09 18 to 05/18 00	8d 6h	TY	Yes
Butchoy	Nuri (2002)	06/11 00 to 06/12 17	1d 17h	TS	Yes
Carina	*Unnamed*	07/12 06 to 07/14 12	2d 6h	TD	No
Dindo	Hagupit (2004)	07/31 00 to 08/03 01	3d 1h	STS	No
Enteng	Jangmi (2005)	08/07 18 to 08/09 06	1d 12h	TS	No
Ferdie	Mekkhala (2006)	08/09 00 to 08/10 02	1d 2h	TS	No
Gener	*Unnamed*	08/12 14 to 08/13 00	10h	TD	No
Helen	Higos (2007)	08/17 00 to 08/17 15	15h	TD	Yes
Igme	Bavi (2008)	08/21 00 to 08/22 11	1d 11h	TS	No
Julian	Maysak (2009)	08/27 06 to 08/31 13	4d 7h	TY	No
Kristine	Haishen (2010)	09/04 01 to 09/05 10	1d 9h	STY	No
Leon	Noul (2011)	09/15 00 to 09/16 20	1d 20h	TS	Yes
Marce	Dolphin (2012)	09/19 12 to 09/21 03	1d 15h	TS	No
Nika	Nangka (2016)	10/11 06 to 10/12 01	19h	TD	No
Ofel	*Unnamed*	10/13 00 to 10/15 13	2d 13h	TD	Yes
Pepito	Saudel (2017)	10/18 18 to 10/22 02	3d 8h	STS	Yes
Quinta	Molave (2018)	10/23 00 to 10/26 23	2d 23h	TY	Yes
Rolly	Goni (2019)	10/29 10 to 11/03 12	5d 2h	STY	Yes
Siony	Atsani (2020)	10/31 22 to 11/06 16	5d 18h	STS	No
Tonyo	Etau (2021)	11/06 12 to 11/08 19	2d 7h	TS	Yes
Ulysses	Vamco (2022)	11/08 01 to 11/13 02	5d 1h	TY	Yes
Vicky	Krovanh (2023)	12/18 00 to 12/20 05	2d 5h	TD	Yes

Observed Trends within the PAR

Fig. 3.3 presents the yearly number of TCs occurring within the PAR and its corresponding 5-year running mean and linear trend, as well as the 5-year running mean and linear trend of the number of TCs peaking as TD, TS/ STS, and TY/STY within the PAR, and the number of landfalling and non-landfalling TCs in Philippines over the past 30 years. The trend is based on a combined best track and warning track data from PAGASA.

It was observed that there is no perceptible increase or decrease in the number of TC occurrences within the PAR every year. The annual number of TCs peaking at TS/STS and TY/STY categories entering the area of responsibility was also found to be stable for the past 30 years, with the slightly decreasing trend deemed to be not significant. On the other hand, the number of TCs that remained as a TD within the PAR has been on a slightly increasing trend since 1991. The increased reliability of on-site and remote sensing observation platforms being utilized by PAGASA forecasters had been a factor in identifying more TD cases in recent years, potentially resulting in the slightly increasing trend that was noted. In terms of landfalling TCs, the past 30 years saw a notably decreasing trend in the number of TCs that cross the archipelago.

On average, it can be said that TCs occurring within the PAR remained the same in number in the past 3 decades, although weak TCs of depression category were slightly increasing. The observed trend in the annual number of TC occurrences within the PAR, the number of TCs peaking at TS/STS categories within the PAR, and the number of landfalling TCs in the Philippines remained consistent with those found by Cinco et al. (2016), although the same could not be said with the trends in terms of number of TCs peaking at TD and TY/STY categories. The investigation, which used data from 1971 to 2013, noted a stable number of TD cases and considerably decreasing trend in TCs peaking at TY/STY within the PAR.

Quarterly and Monthly Tropical Cyclone Activity

To make better sense of the progression of TC activity within the PAR region during the 2020 season, Figs. 3.4 presents the best track of TCs that occurred during April-June, July-September, and October-December 2020. In addition, the number of TC events per month within the PAR during the 2020 season and the corresponding monthly climatological averages are presented in Fig. 3.5. In both figures, the TCs were grouped in their corresponding quarter or month of occurrence based on the date and time (in UTC) it was first tracked in the PAR region.

The first quarter (January to March) of the 2020 season saw a period of relative quiescence within the PAR region. The first TC of the season, TY Ambo, developed over the Philippine Sea and crossed the archipelago during the second week of May. This was followed by TS Butchoy, which developed near the Bicol Peninsula, followed a generally northwestward path, and crossed Luzon in June. In total, the second quarter of the year produced only two landfalling TC events within the PAR. The activity during the second quarter (April to June) of 2020 was deemed to be near the climatological normal.

The third quarter (July to September) of the year is climatologically considered to be most active months of the year. For the 2020 season, the PAR had a near normal TC activity with the passage of 11 TCs within the region. Best track data indicates except for two TC events (Helen and Leon), the TCs during the third quarter of 2020 had predominantly northerly to northeasterly or recurving (northwesterly turning northeasterly) paths which brought these cyclones over the Philippine Sea region north of 15°N and 120°E. Although most of them were far from the archipelago, two of these non-landfalling cyclones of the quarter, Carina in July and Igme in August, made their close approach to Extreme Northern Luzon. Two of the 11 TCs, Helen in August and Leon in September, had a generally west northwestward path which made landfall in Extreme Northern Luzon and Southern Luzon after forming near land. Despite the non-landfalling nature of the tracks for most of these TCs, the general orientation of their tracks within the PAR region and the synoptic environments during their passages resulted in the enhancement of the Southwest Monsoon following the mechanism identified by Cayanan et al. (2011) and Bagtasa (2019).

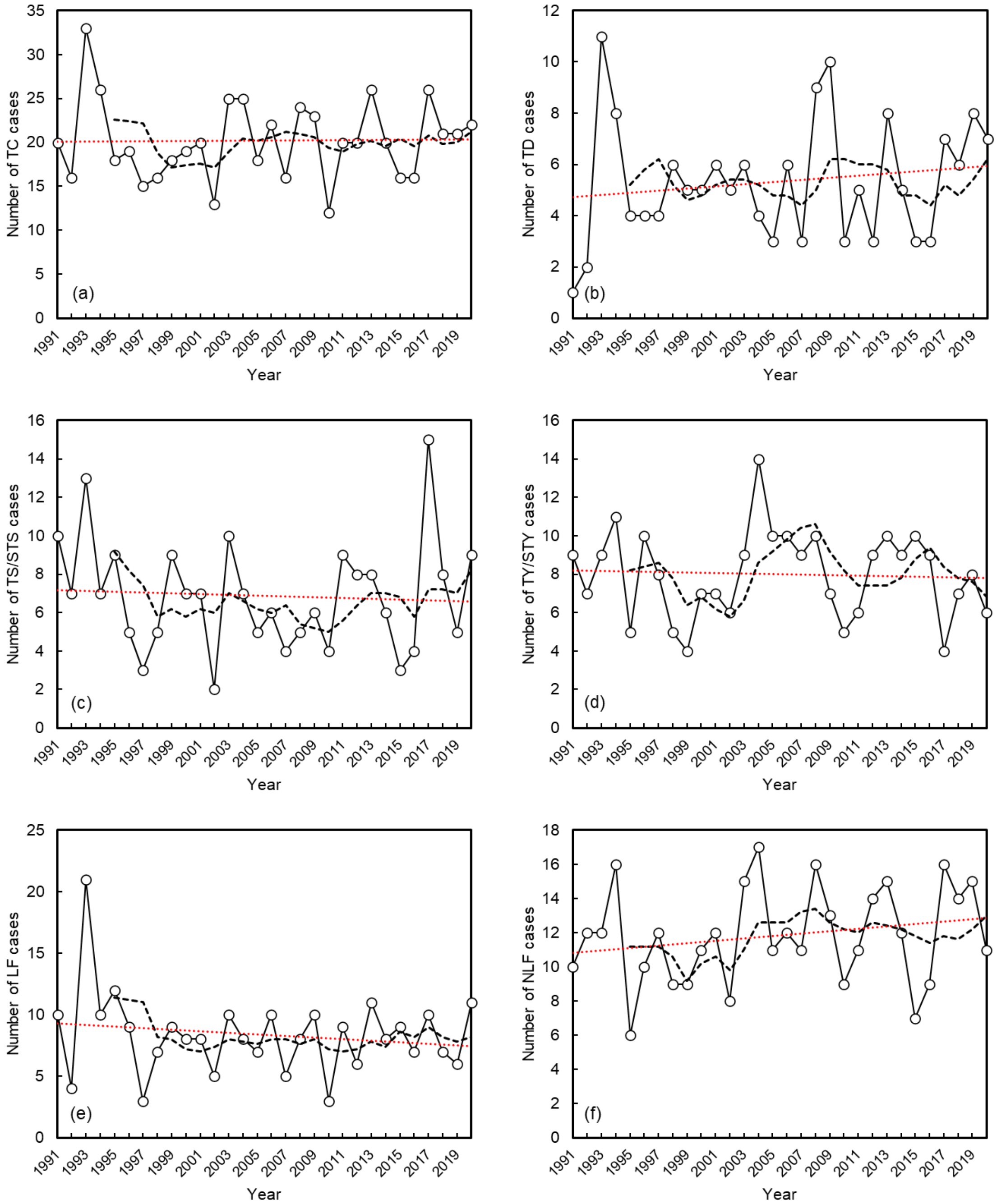

Fig. 3.3. Number of TCs that occurred in the PAR region per peak category within the PAR since 1991 – (a) all categories, (b) TD, (c) TS and STS, and (d) TY and STY; and TCs that (e) crossed (or made landfall; LF) and (f) did not cross the Philippines (including close approach cases; NLF) from 1991 to 2020. Dashed lines show five-year running mean and dotted red lines show linear trends.

Most of the TCs for the quarter peaked at TS or STS category within the PAR, although one, Kristine, reached STY category within the region and became the most intense TC to occur during the quarter. Six of the 11 TCs of the third quarter eventually peaked at TY or STY category outside the PAR.

Despite the near normal activity for the period, the third quarter of 2020 was characterized by a below normal July activity, an above normal August activity, and a nearly normal September activity. Best track data indicates that only two (non-landfalling) TCs occurred within the PAR in July. With six and three TC cases, respectively, the months of August and September had higher TC activity compared to July which is usually the most active month based on the monthly climatological normal. The below normal activity in July was attributed to high sea surface temperatures over the Indian Ocean basin and the resulting enhanced convective activity in the region (especially over the western Indian Ocean) following the positive phase of the Indian Ocean Dipole from summer to autumn of 2019. This resulted in suppressed convective activity of the Asian monsoon region, which delayed the northward migration of the subtropical jet stream over the Eurasian continent and induced a southwestward expansion of the North Pacific subtropical high. These conditions resulted in a reduced TC activity over the Philippine Sea and West Philippine Sea where TCs generally develop. On the other hand, August 2020 had an above normal TC Activity resulting due to an emerging La Niña event over the Central and Eastern Pacific (CEP) during the middle of boreal summer 2020 (JMA 2021) which enhanced convective activity over the Philippine Sea and West Philippine Sea.

A total of nine TCs developed or entered the PAR region during the fourth quarter (October to December) of 2020. All of these TC events followed generally westward or west-northwestward tracks. Except for two, these TCs crossed the archipelago, most of which made landfall over Southern Luzon and Samar Island. The non-landfalling cases of the quarter either made a close approach to Batanes (Siony) or developed over the waters west of Luzon following its passage over the island as a low pressure area (Nika). The orientation of these TC tracks was consistent with those of the climatological normal for the period.

The TCs during the period had equal proportions (i.e., three cases) of those that reached TS or STS category and those that peaked at TY or STY category within the PAR region. One of these TCs, Rolly, reached a peak intensity of 120 kt and 905 hPa and became the most intense TC to occur in the WNP basin for the year and one of the strongest landfalling TC in the country since modern records began in 1948. The quarter also witnessed the passage of TY Ulysses whose interaction with a shear line made it the deadliest and costliest TC event of the year.

The TC activity during the fourth quarter was found to be above normal when compared with the climatological average. Examination of monthly activity showed that while the TC activity during November and December was near normal, the TC activity for October was notably above normal. It had the same number of TC occurrences within the PAR as August despite the latter being more climatologically active. In boreal autumn of 2020, the prevailing La Niña over the CEP region resulted in enhanced tropical convection from the northern Indian Ocean and the Maritime Continent, tropical low-level circulation anomalies observed from the Indian Ocean to the Western Pacific, and increased sea surface temperature over the Philippine Sea associated with the westward displacement of the warm pool. These created favorable atmospheric and oceanic conditions for local TC formation.

Rainfall during Tropical Cyclone Days

Aside from the eyewall, immediate rain bands, or surface troughs of the TC, the country can also experience rainfall in the presence of the TC within the PAR through its interaction with the prevailing monsoon system. For instance, distant heavy rainfall events related to a TC occurrence within the PAR may be observed because of the TC enhancement of the Southwest Monsoon (Cayanan et al. 2011; Bagtasa 2019) or the enhanced moisture convergence in shear lines during strong Northeast Monsoon surges in the presence of a TC or other cyclonic disturbance (Yokoi and Matsumoto 2008; Ogino et al. 2018; Olaguera et al. 2020). To capture these distant precipitation events, instead of using a predetermined radius[4] from the TC center to delineate TC rainfall as suggested in existing literature (Jiang et al. 2008; Kubota and Wang 2009; Bagtasa 2017), this section presents the observed and estimated TC-related rainfall in the country using TC days[5] as delineating metric.

[4] Existing studies suggest using 10° radius (approximately 1100 km) from the TC center to delineate TC rainfall because rainfall amount decreases with a larger TC influence radius and becomes almost constant from around a 10° radius onward.

[5] TC days are meteorological days with at least one tropical cyclone within the PAR region irrespectively of its proximity to the Philippine archipelago

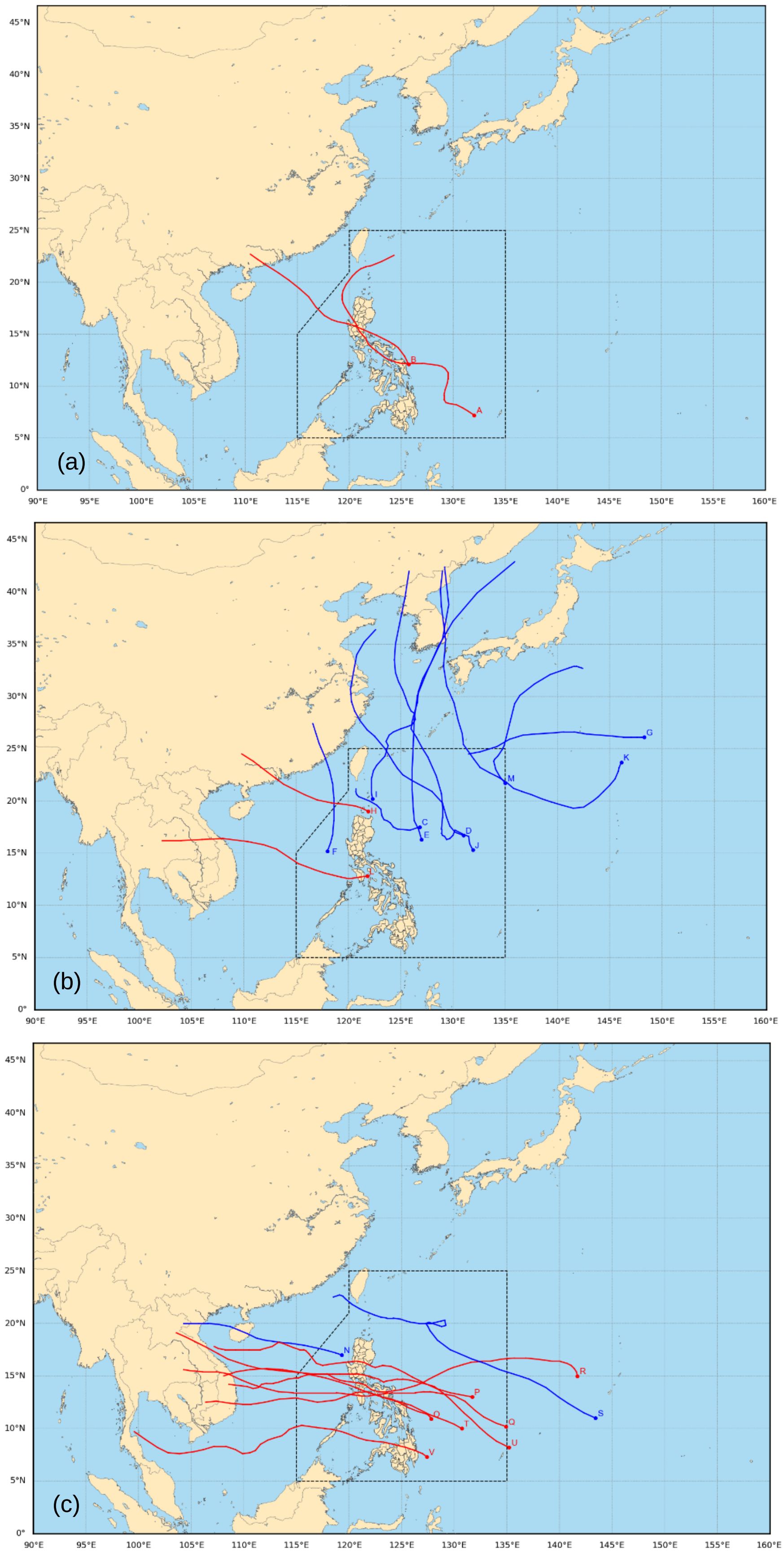

Fig 3.4. Best track of TCs that occurred within the PAR during (a) April to June, (b) July to September, and (c) October to December 2020. Red tracks are TCs that made landfall over the Philippine archipelago. The region enclosed by the black dash line is the PAR region

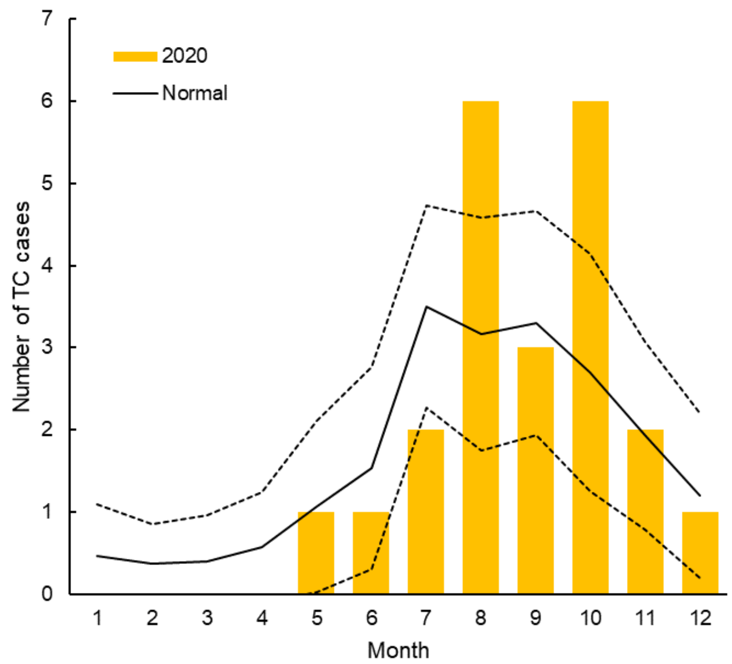

Fig. 3.5. Monthly number of TC occurrences within the PAR region for the 2020 season compared to the climatological normal (1991-2020). The dashed lines represent the range of near normal values based on ±1 standard deviation from the normal value.

Fig. 3.6a presents the total rainfall over the country during TC days based on gauge-adjusted satellite-based rainfall estimates (Mega et al. 2019) of the Global Satellite Mapping of Precipitation (Kubota et al. 2020). The total rainfall during TC days in the Philippines shows that the observed rainfall were notably higher (at least 1,000 mm) for most of Luzon (except mainland Palawan) and the northern portion of Samar Island than in other parts of the country. In other parts of Visayas, the total rainfall during TC days was slightly higher in Western and Eastern Visayas Regions (at least 750 mm). For Mindanao, portions of Zamboanga Peninsula, mainland Bangsamoro, and Caraga received higher rainfall amounts than in other areas, although the values were up to 1,000 mm only. The rainfall distribution presented a rainfall maximum region covering Northern Samar and the eastern portion of Luzon, with values generally exceeding 1,500 mm in most areas and with northern Aurora, southeastern Isabela (i.e., near the border with Aurora), and extreme northern Catanduanes receiving in excess of 2,000 mm.

When compared against the total rainfall for 2020 (Fig. 3.6b), the rainfall in most areas in Luzon during TC days accounted for 30 to 50% of the total rainfall for the year, with the higher proportions found over Cagayan Valley, Ilocos Norte, Abra, Bataan, and southern Zambales. For Visayas, the total rainfall during TC days in 2020 constituted 30% to 40% of the year-long rainfall in Samar Island and 10 to 40% over most areas. It was also observed that Palawan had similar observed proportions with those found in Visayas, which could be attributed to its geographic location. In most areas of Mindanao, TC-related rainfall was 10% to 30% of the total rainfall for the year.

To determine the extent of rainfall during TC days under the different monsoon regimes, the total rainfall during TC days were aggregated in terms of the approximate periods of each regime based on the discussion of Williams et al. (1993). For this report, the 2020 season was divided into four monsoon regimes. January to March were considered to be the mid and late phases of the Northeast Monsoon of 2019-2020 (NEM1) (although this regime was excluded in the report because no TC occurred during this period), while April and May were categorized as the inter-monsoon period or the trade winds regime (TWR). The months of June to October, the longest of the regimes, cover the onset, prevalence, and withdrawal of the Southwest Monsoon (SWM). Lastly, the period of November to December coincides with the early phase of the Northeast Monsoon of 2020-2021 (NEM2).

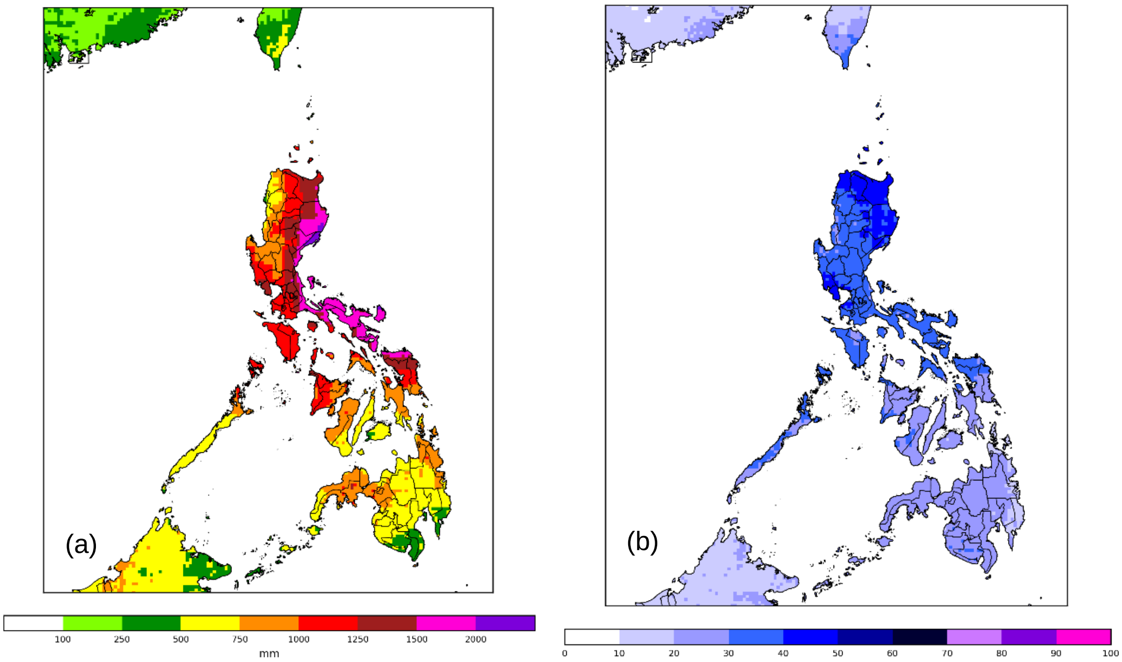

Fig. 3.6. GSMaP-Gauge nationwide estimates of (a) total rainfall (mm) during TC days and (b) its percentage contribution to the total rainfall in 2020.

The observed rainfall over the country during the TWR (Fig. 3.7a) was caused by a single TC event. Cumulative rainfall reaching 250-500 mm was estimated over Northern Samar and the northern portion of Aurora (including some municipalities in Quirino and Isabela bordering northern Aurora). Rainfall during the TC days of TWR for the southern portions of Cagayan Valley and Cordillera Administrative Region, most of Central Luzon provinces east of the Zambales Mountain Range (ZMR), Metro Manila, Laguna, Quezon, Bicol Region, Eastern Samar, Samar, and Biliran were also estimated between 100 and 250 mm. Fig. 3.7b shows that rainfall during TC days of TWR accounted for the following proportions of the total TWR rainfall of the following areas:

- Between 40 to 80% of total TWR rainfall over Bicol Region, Northern Samar, the northern half of Samar and Eastern Samar, and Biliran
- Between 20 to 70% for the southern portion of Cagayan Valley, most of Central Luzon provinces east of ZMR, Metro Manila, CALABARZON, and most of MIMAROPA (except for mainland Palawan)
- Up to 50% for Extreme Northern Luzon and the rest of mainland Luzon and Visayas
- Up to 40% over Mindanao.
- Less than 10% over most of mainland Palawan (except for extreme northern portion, up to 30%)

Due to the relatively shorter duration of the TWR compared with other monsoon regimes and with only one TC event during the period, the rainfall during TC days of the TWR accounted only for up to 20% off the total rainfall across the country for 2020, mostly over Luzon and portions of Eastern Visayas and Davao Region (Fig. 3.7c).

The SWM period accounted for the occurrence of 18 of the 22 TCs of the 2020 season. Rainfall estimates show that Eastern Visayas and most of Luzon (except for Ilocos Region and the central and southern portions of mainland Palawan) and Samar Island received rainfall of at least 500 mm during the period, while the rest of the country had rainfall ranging from 250 to 750 mm in most areas, with isolated areas reaching 750 to 1,000 mm of rainfall. Rainfall distribution show three distinct maximum areas: the eastern portion of Luzon and Northern Samar, the northern Sulu Sea and its neighboring provinces (i.e., southern Mindoro Island, Calamian and Cuyo Islands, western Panay Island), and the western portion of Central Luzon (i.e., Zambales, Bataan). The rainfall maximum regions had rainfall of at least 750 mm, with isolated areas receiving between 1,000 and 1,250 m (Fig. 3.7d).

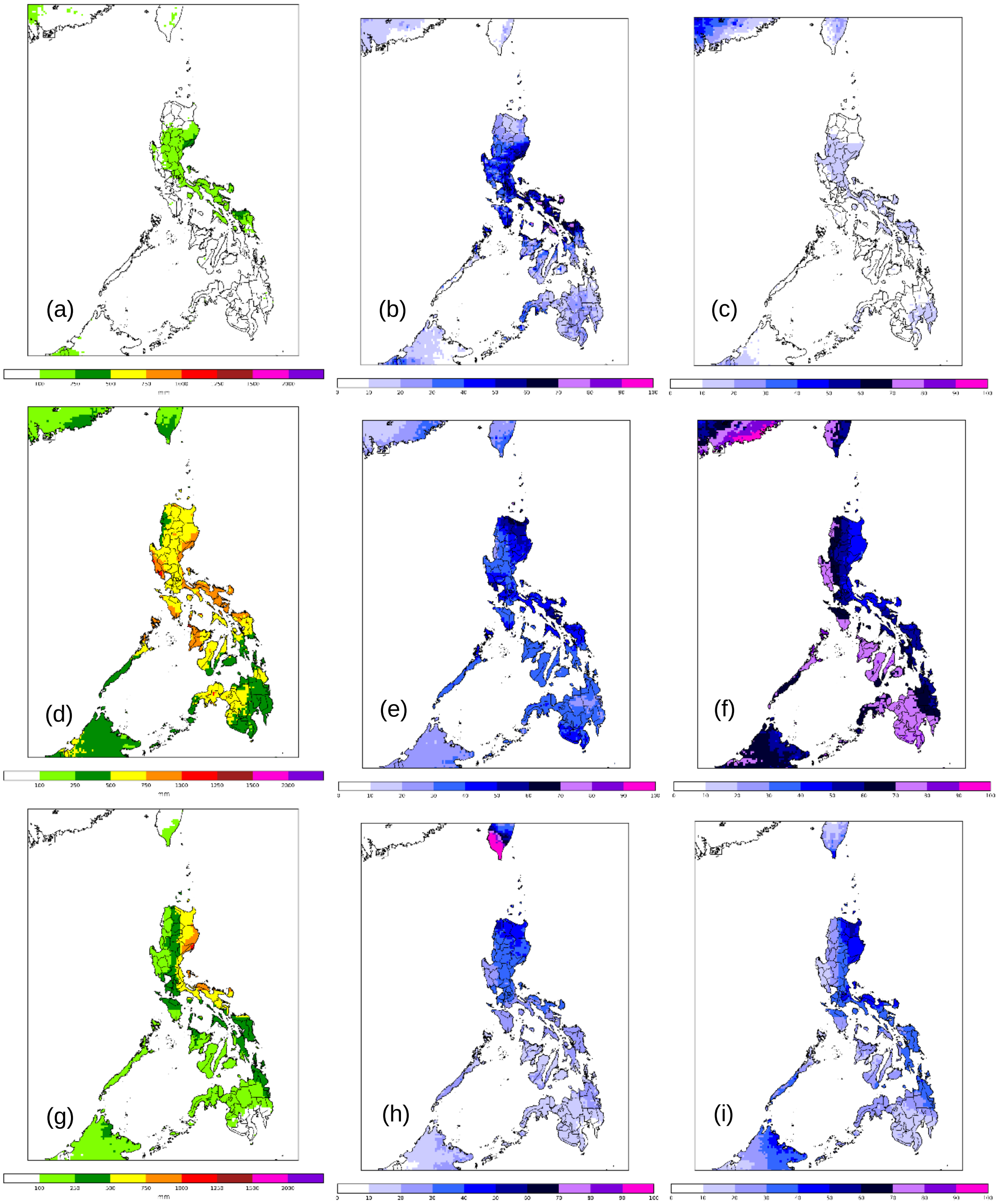

Fig 3.7. GSMaP-Gauge nationwide estimates of the (a) total rainfall (mm) during TC days of TWR and its corresponding percentage contribution to the (b) total rainfall observed during each regime and the (c) total rainfall of all TC days in 2020. Corresponding figures for the SWM and NEM2 regimes are (d) to (f) and (g) to (i), respectively.

As a proportion of the total rainfall during the SWM regime (Fig. 3.7e), TC days during the SWM account for at least 30% of the total rainfall nationwide, with higher proportions observed over Samar Island, Bicol Peninsula, and the northern and eastern portions of Northern Luzon. Rainfall during SWM TC days was of highest proportion of the total SWM rainfall over Extreme Northern Luzon and the northern portions of mainland Cagayan and Apayao (with approximately 50 to 80% of total SWM rainfall). Over Mindanao, rainfall during SWM TC days only constituted 20 to 50% of the total rainfall during the SWM period in most areas (the higher proportions were generally over the SOCCSKSARGEN Region) – generally lower than in any other portion of the country.

Fig. 3.7f shows that in terms of the share to the total rainfall for the year, the rainfall during TC days of the SWM accounted between 40 to 80%, with higher share for areas situated in the western portions of the country. This indicates that much of the total rainfall observed in 2020, especially over the western portion of the country, were generated, directly (during the landfall or close approach) or indirectly (through monsoon enhancement or interaction with other synoptic weather systems) during the TC days of the SWM. However, such large proportions could be attributed to the huge number of TC cases during the period of SWM that was used in this report, as well as the generally longer period of SWM (five months) compared to NEM1 (three months), TWR (two months), and NEM2 (two months).

A total of three landfalling TCs, including the deadliest TY of the season, occurred during the NEM2 period. The rainfall distribution map of cumulative rainfall during the TC days of NEM2 (Fig. 3.7g) indicates a shift in the maximum rainfall region to the eastern section of Luzon. Such change is consistent with the transition to the dominant monsoon regime. The eastern portion of the country generally received a total of 250 mm of rainfall or higher during the TC days of NEM2. The rainfall maximum region was found to be over mainland Cagayan Valley, Bicol Region, Aurora, and Quezon, with accumulated rainfall ranging from 500 to 1,000 mm in most areas and reaching 1,250 mm over extreme northern Aurora.

In terms of its share to the total NEM2 rainfall (Fig. 3.7h), the rainfall during TC days constituted generally higher proportions (40 to 60%) over the northern portion of Northern Luzon (i.e., Batanes, Cagayan, Ilocos Norte, Apayao). Rainfall during TC days accounted for 20 to 40% of total NEM2 rainfall over the rest of Luzon and up to 30% over the rest of the archipelago. Fig. 3.7i shows that the rainfall during the TC days of NEM2 accounted for the following proportions of the total rainfall of 2020:

- Between 30 and 60% over Cagayan Valley, CALABARZON, Bicol Region, and Aurora
- Between 20 and 40% over Caraga, Eastern Visayas, and most of mainland Palawan
- Up to 30% for the rest of the country

Extremes of Surface Meteorological Observations during Tropical Cyclone Days

Tables 3.3 and 3.4 present the extremes of rainfall, wind gust, and sea level pressure observations recorded by the network of manned surface weather stations (i.e., both synoptic and agrometeorological research stations) of PAGASA during the passage of landfalling (including close-approaching) and non-landfalling tropical cyclones. Compared to real-time reports, these data have undergone post-real time quality control from the Climatology and Agrometeorology Data Section of the Climatology and Agrometeorology Division.

Table 3.3. Extremes of land-based rainfall observations in the Philippines during TC days in 2020.

Parameter	Location	Value (mm)	Active TC and date / time of occurrence
Highest storm duration rainfall (landfalling or close-approaching TCs)	Aparri, Cagayan	504.4	TY Ulysses 11/08/2020 to 11/12/2020
Highest storm duration rainfall (other TCs)	Iba, Zambales	305.4	TS Nika 10/11/2020
Highest 24-hour accumulated rainfall (landfalling or close-approaching TCs)	Tanay, Rizal	356.2	TY Ulysses 11/11/2020
Highest 24-hour accumulated rainfall (other TCs)	Iba, Zambales	305.4	TS Nika 10/11/2020

Table 3.4. Extremes of land-based wind and sea level pressure observations in the Philippines during TC days for landfalling or close-approaching TCs in 2020.

Parameter	Location	Value	Active TC and date / time of occurrence
Lowest sea level pressure	Virac, Catanduanes	912.1 hPa	STY Rolly 2114 UTC, 10/31/2020
Highest peak gust	Legazpi City, Albay	SSW (210°) 106.9 kt (55 m/s)	STY Rolly 2217 and 2315 UTC, 10/31/2020

Tropical Cyclone Impacts: Casualties and Damage

Year-on-year statistics of dead, injured, and missing persons due to TC occurrences within the PAR region are presented in Fig. 3.8. Based on official report provided to PAGASA by the National Disaster Risk Reduction and Management Council (NDRRMC), the 2020 TC season in the Philippines resulted in 733 casualties – 112 dead, 610 injured, and 11 missing individuals. This makes the 2020 season both the 41st deadliest TC season since 1970 and the 5th deadliest post-Yolanda season. Moreover, 2020 was also the 25th worst season since 1970 and 3rd worst since 2013 in terms of the total casualty count. At 15.3%, the proportion of deaths to casualties during the 2020 season was the 3rd lowest both since 1970 and 2013. Since 1970, TC events have claimed the lives of 34,435 people and resulted to 75,034 injured individuals. No notable trends were observed in terms of casualty count and death toll since 1970. However, both the number of casualties and the proportion of deaths to total casualty count are on a generally downward trend for nearly two decades, while injured persons account for an increasing proportion of the total casualty count during the same period.

The combined nationwide cost of damage to agriculture and infrastructure due to TCs of 2020 (Fig. 3.9) amounted to PHP 44.222 billion. Damage to infrastructure accounted for the majority (63.6%) of the total cost. When adjusted for inflation using the published consumer price index (CPI) of the Philippine Statistics Authority, the 2020 season was the 12th costliest TC season since 1970 and the 3rd costliest post-Yolanda season. While there was no year-on-year trend, the aggregated cost of damage due to TC events has been steadily increasing since 1970.

Data from the NDRRMC (Table 3.5) also shows that the casualties and aggregated cost of damage reported for the 2020 season were attributed to Ambo, Ofel, Pepito, Quinta, Rolly, Ulysses, and Vicky. Statistics shows that TY Ulysses was the deadliest tropical cyclone of the season, killing 51 people. On the other hand, TY Ulysses yielded the highest number of casualties, with 430 people killed, injured, or missing. None of the 2020 TCs resulted in deaths that satisfied the decommissioning criteria of PAGASA[6]. In terms of damage cost, a total of four TCs (Ambo, Quinta, Rolly, and Ulysses) resulted in damage to agriculture and infrastructure with amounts exceeding the criteria[7] necessary for the decommissioning of their respective domestic names. Of these four, TY Ulysses was the costliest TC of the 2020 season. Traversing the populated areas of Central and Southern Luzon, this typhoon resulted in damage to properties amounting to PHP 20.229 billion, with roughly 64% attributed to infrastructure damage.

Following the termination of the 2020 season, the domestic names Ambo, Quinta, Rolly, and Ulysses were decommissioned by PAGASA from Set IV in 2021 and were subsequently replaced by Aghon, Querubin, Romina, and Upang, respectively. The replacements will be first introduced during the 2024 TC season. Furthermore, in its 53rd Session on 23-25 February 2021, the Typhoon Committee noted the request of PAGASA to retire the equivalent international names of Ambo (Vongfong), Quinta (Molave), Rolly (Goni) and Ulysses (Vamco). These international names were replaced by Penha (for Vongfong), Narra (for Molave), Gaenari (for Goni), and Bang-Lang (for Vamco) during the 54th Session of the Typhoon Committee on 23-25 March 2022.

[6] Deaths of at least 300 individuals as reported by the NDRRMC.
[7] Damage of at least PHP 1 billion as reported by the NDRRMC.

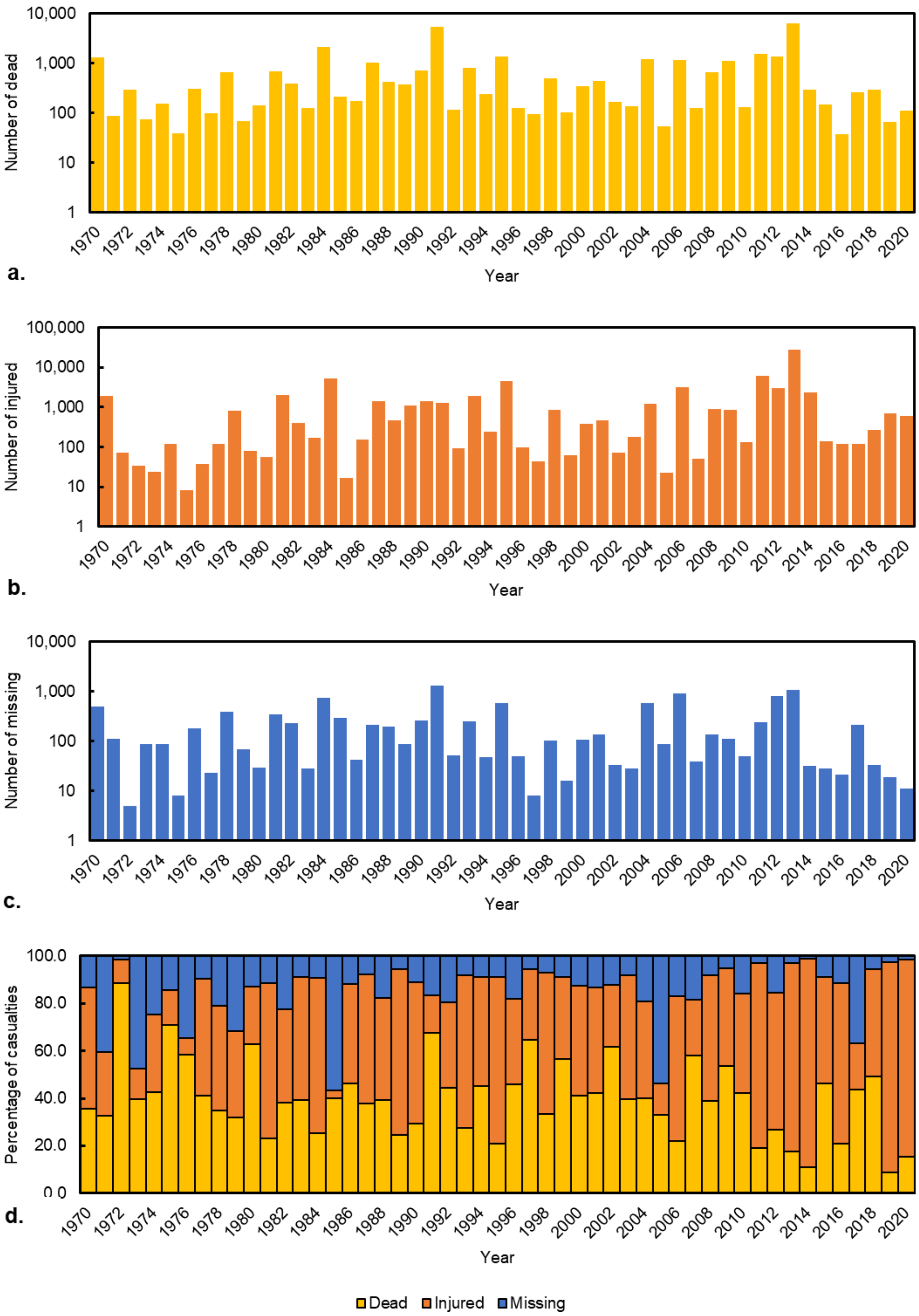

Fig. 3.8. Statistics of (a) dead, (b) injured, and (c) missing persons caused by tropical cyclones in the PAR region from 1970 to 2020. Actual number of persons are presented in (a) to (c), while (d) shows these numbers as a percentage of the total casualties. The y-axis in (a) to (c) uses a logarithmic (base 10) scale.

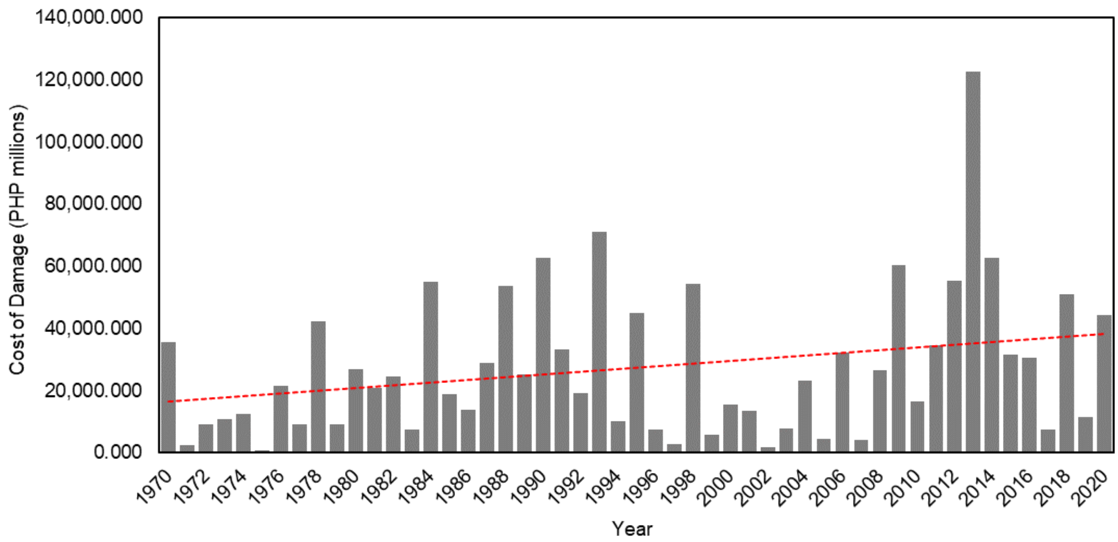

Fig. 3.9. Yearly total cost of damage (in PHP millions) caused by tropical cyclones in the PAR region from 1970 to 2020. The cost values are adjusted to 2020-equivalent values to account for inflation using the annual average CPIs published by the Philippine Statistics Authority. The red dash line presents the linear trend of the adjusted cost of damage.

Table 3.5. Casualty and cost of damage statistics caused by TCs that occurred within the PAR region in 2020. Note that other TCs were not included due to the absence of reported information from the NDRRMC.

Name of TC	Casualties				Cost of damage (PHP)		
	Dead	Injured	Missing	Total	Agriculture	Infrastructure	Total
Ambo	0	169	0	169	960.188	614.325	1,574.513
Ofel	0	0	0	0	1.346	0.000	1.346
Pepito	0	0	0	0	76.577	29.240	105.817
Quinta	27	40	4	71	2,660.731	1,561.635	4,222.366
Rolly	25	399	6	430	5,008.430	12,867.015	17,875.445
Ulysses	51	0	0	51	7,318.947	12,910.182	20,229.129
Vicky	9	2	1	12	51.141	162.482	213.623

Provision of Tropical Cyclone Products and Wind Signals

As the national meteorological and hydrological service of the Philippines, PAGASA issued 472 public TC products throughout the 2020 TC season. These included 193 Tropical Cyclone Updates (TCU), 7 Tropical Cyclone Advisories (TCA), and 272 Severe Weather Bulletins (SWB). For the maritime sector, a total of 234 marine TC products in the form of Tropical Cyclone Warnings for Shipping (IWS) were provided by PAGASA. Due to its length of occurrence within the PAR, TY Ambo warranted the issuance of 51 public TC products and 29 marine TC products – the highest of any TC in 2020. Table 3.5 presents the summary of issued TC products during the 2020 season.

Table 3.5 also shows that 13 of the 22 TCs in 2020 triggered the hoisting of Tropical Cyclone Wind Signals in the country due to the threat of strong to typhoon-force winds. During the season, wind signals were hoisted by PAGASA in all provincial or sub-provincial localities of the country except for Basilan, Sulu, Tawi-Tawi, the southern portion of Zamboanga Peninsula and Palawan, and most of SOCCSKSARGEN region. The passage of STY Rolly resulted in the hoisting of wind signals across 48 localities – the most for any TC during the season. Fig. 3.10a presents the map showing the frequency of hoisting wind signals during the 2020 season across the different localities of the country. Due to the nature of the observed TC events during the season, wind signals were most frequently hoisted over CALABARZON, Metro Manila, Bicol Region, nearly the entire Ilocos Region and Central Luzon, Mindoro, Marinduque, Romblon, Northern Samar, Calamian Islands, Semirara Islands, and the northern portions of Samar and Eastern Samar. In particular, these localities had wind signal levels of at least 1 hoisted at least five times during the

2020 season. Wind signals were hoisted most frequently (eight instances) over Metro Manila, Bataan, Polillo Islands, Rizal, and portions of Quezon (General Nakar, Infanta, Real) and Camarines Norte (Paracale, Jose Panganiban, Capalonga, Vinzons).

Fig. 3.10b shows the highest level of wind signal that was hoisted in each provincial or sub-provincial locality in the country during the 2020 season. With a landfalling STY during the fourth quarter of the year, Wind Signal No. 5 was the highest level of wind warning hoisted over any portion of the country during the year. The figure also shows an east-west oriented band of Wind Signal Nos. 3 to 5 over the central and southern portions of Luzon and the upper half of Eastern Visayas. Except for Eastern Visayas, the highest wind signal level hoisted for Visayas was only Wind Signal No. 2 (particular only over the northwestern Panay area). On the other hand, only Wind Signal No. 1 was hoisted for Mindanao localities throughout the typhoon season due to the absence of TCs which threatened gale to storm-force conditions over the areas.

Table 3.6. Summary of TC products and TCWS hoisted for each TC event of the 2020 season.

Name of TC	No. of public TC products issued				No. of IWS issued	No. of localities under TCWS	Highest wind signal level hoisted during the passage
	TCU	TCA	SWB	Total			
Ambo	14	0	37	51	29	46	Wind Signal No. 3
Butchoy	6	0	8	14	6	14	Wind Signal No. 1
Carina	4	0	12	16	8	2	Wind Signal No. 1
Dindo	9	0	7	16	11	0	-
Enteng	6	0	6	12	7	0	-
Ferdie	4	0	3	7	3	5	Wind Signal No. 1
Gener	7	0	2	9	2	0	-
Helen	4	0	2	6	2	0	-
Igme	9	0	4	13	5	0	-
Julian	12	0	11	23	15	0	-
Kristine	14	2	4	20	7	0	-
Leon	5	0	5	10	6	1	Wind Signal No. 1
Marce	8	0	3	11	4	0	-
Nika	3	0	3	6	4	23	-
Ofel	6	0	17	23	11	0	Wind Signal No. 1
Pepito	11	0	19	30	14	24	Wind Signal No. 2
Quinta	7	0	23	30	16	31	Wind Signal No. 3
Rolly	17	3	25	45	21	48	Wind Signal No. 5
Siony	23	2	24	49	24	4	Wind Signal No. 2
Tonyo	2	0	9	11	6	22	Wind Signal No. 1
Ulysses	12	0	26	38	19	37	Wind Signal No. 3
Vicky	10	0	22	32	14	34	Wind Signal No. 1

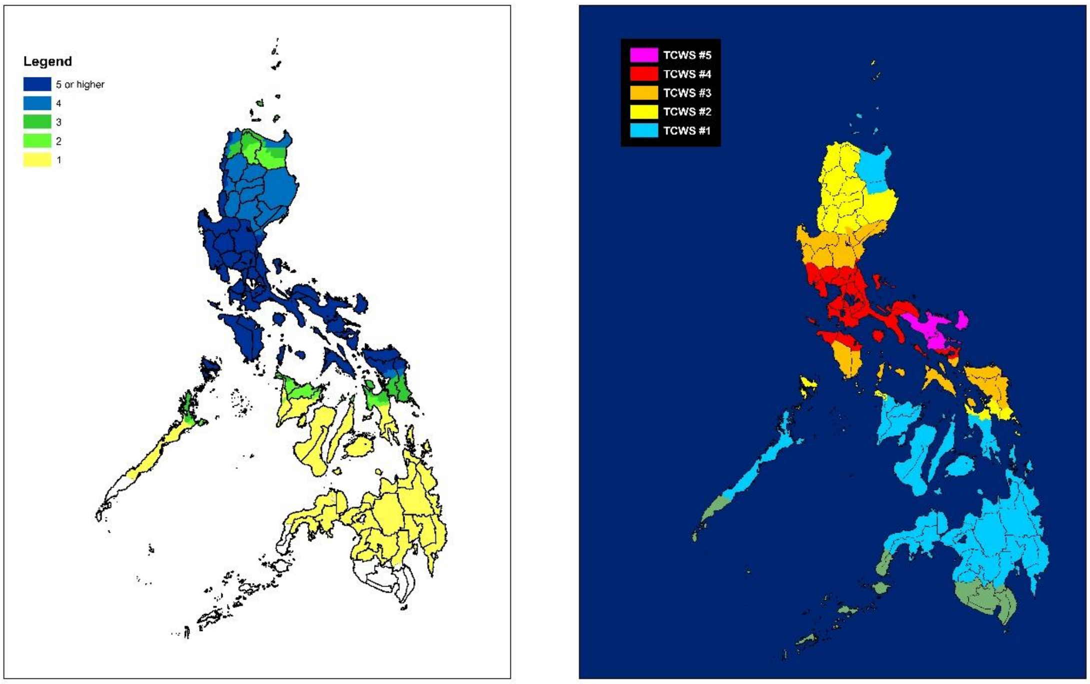

Fig. 3.10. (a) Frequency of hoisting TCWS per province or sub-provincial locality during the 2020 season and (b) the highest level of TCWS hoisted per locality.

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REVIEW OF THE PHILIPPINE TROPICAL CYCLONES OF 2020

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Review of the Philippine Tropical Cyclones of 2020

This section of the report contains the individual reviews of each Western North Pacific (WNP) tropical cyclone (TC) that occurred within the Philippine Area of Responsibility (PAR) during the 2020 season based on the result of post-season best track analysis of the Marine Meteorological Services Section, Weather Division. Each individual TC review includes the following information:

- A map showing the best track positions and intensities (as categories).
- A narrative of the meteorological history of the TC.
- The top station-observed extremes of the following surface weather observation over land during the occurrence of the TC within the PAR, including the corresponding dates and times of observation:
    - Highest storm duration[1] rainfall (in mm)
    - Highest 24-hour rainfall (in mm)
    - Highest peak 3-second gust speed (in kt and m/s) and direction (as cardinal direction and bearing)
    - Lowest sea level pressure (in hPa)

  The last two parameters are only provided for landfalling or close-approaching[2] TCs.
- A summary of public and marine TC products provided by the Weather Division during the occurrence of the TC within the PAR region, including the number of localities where TC Wind Signals (TCWS) were hoisted and the highest wind signal raised throughout the occurrence of the TC.
- A summary of casualties and damage statistics associated with the TC event based on aggregated reports and official communications from the National Disaster Risk Reduction and Management Council (NDRRMC) through the Disaster Statistics Unit, Operations Service of the Office of Civil Defense; and,
- A map showing the distribution of storm-duration rainfall over the land areas within the PAR region based on gauge-corrected satellite retrievals of the Global Satellite Mapping of Precipitation Project (GSMAP; Kubota et al. 2020) and reports from the PAGASA surface weather observation network. It must be noted that satellite retrievals may or may not be coherent with ground observations.

[1] Storm duration refers to the storm duration refers to the meteorological days the TC was inside the PAR region.
[2] Close-approaching TCs are those that moved less than 30 nmi from the Philippine coastline.

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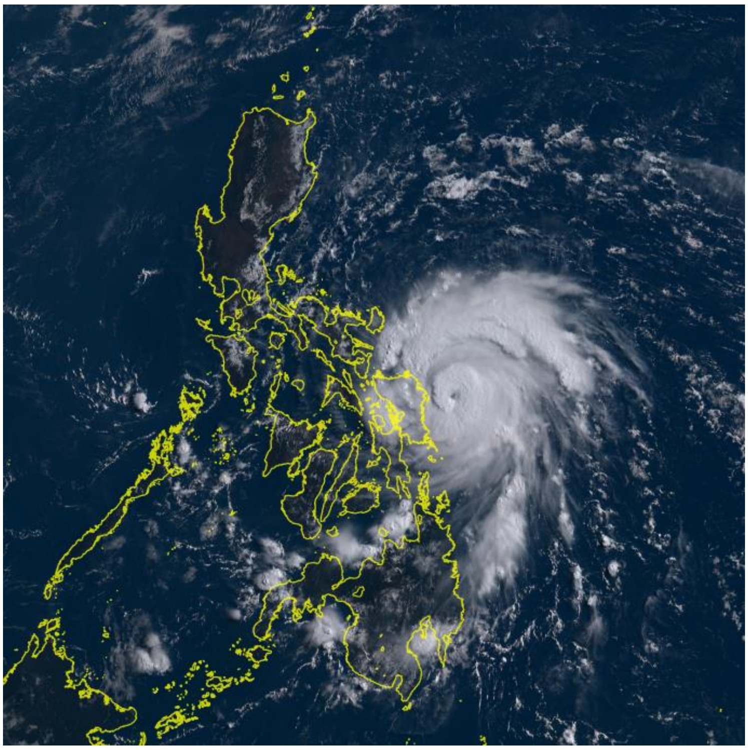
Typhoon Ambo
Vongfong (2001)

09 to 18 May 2020



Basin-wide peak intensity:
Typhoon
85 kt (155 km/h)
960 hPa

Developed:
18 UTC, 09 May 2020

Degenerated:
00 UTC, 18 May 2020

Duration within the PAR:
8 days and 6 hours

Peak category within the PAR:
Tropical Storm

Highest wind signal hoisted:
Wind Signal No. 3

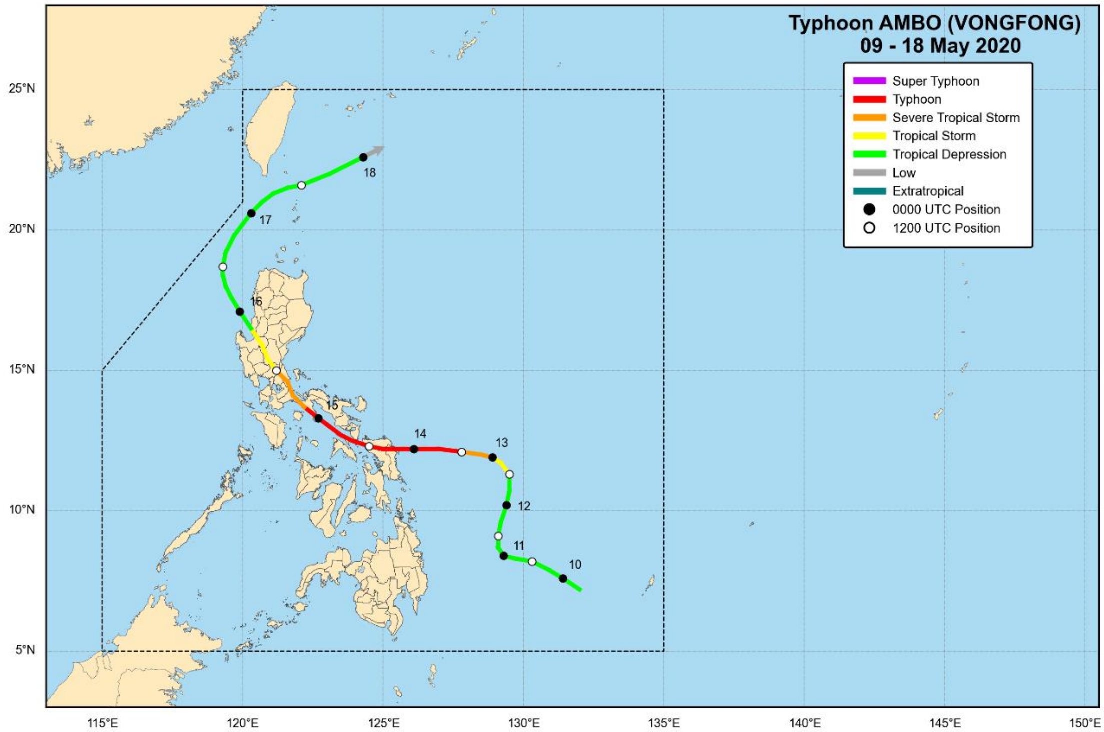


Fig. 4.1.1. Best track position and intensities of Typhoon Ambo.

Meteorological History

The first tropical cyclone of the 2020 season in the Philippines developed from an area of low pressure which first persisted over the sea southeast of Palau which tracked generally westward. It was upgraded into a tropical depression at 18 UTC on 09 May while over the Philippine Sea east of Mindanao. Ambo, as it was referred to, tracked generally west northwestward until 11 May when it started moving north northeastward under weak steering current. Intensification was initially slow, with Ambo reaching tropical storm category at 12 UTC on 12 May. At this time, the storm started turning northwestward.

Under the presence of favorable environmental conditions, Ambo underwent a period of extremely rapid intensification as it continued turning to a more westward track over the Philippine Sea east of Visayas. It was upgraded into a severe tropical storm at 00 UTC on 13 May and into a typhoon 12 hours later. Following an intensification rate of +40 kt over the past 24 hours, Ambo reached a peak intensity of 85 kt and 960 hPa at 21 UTC on 13 May.

At 0415 UTC of the following day, the center of the eye of the typhoon made its first landfall at peak intensity in the vicinity of San Policarpo, Eastern Samar. Its passage over the rugged terrain of Samar Island initiated a period of gradual weakening, although it remained a typhoon as it emerged over the waters west of Northern Samar and made additional landfalls in the vicinity of the following localities:

- San Antonio, Northern Samar (1415 UTC, 14 May)
- Capul, Northern Samar (1430 UTC)
- San Jacinto (Ticao Island), Masbate (1600 UTC)
- Claveria (Burias Island), Masbate: (1900 UTC)
- San Andres, Quezon (0000 UTC, 15 May)

Roughly 3 hours after its landfall over the Bondoc Peninsula in southern Quezon, Typhoon Ambo was downgraded to severe tropical storm category as it continued battling the frictional effects of the rugged landmass it was traversing. Over the next 9 hours, the storm tracked generally north northwestward while continuously weakening and skirted the west coast of Bondoc Peninsula and the east coast of northern Quezon. At 12 UTC of the same day, Ambo was further downgraded into a tropical storm while over the province of Bulacan. The storm continued its north northwestward movement over Central Luzon. It further weakened into a tropical depression at 21 UTC of the same day as it emerged over the Lingayen Gulf.

Ambo maintained its heading for the next 12 to 15 hours as it tracked over the waters west of Ilocos Provinces, then turned east northeastward as it moved over the Bashi Channel between Batanes and Taiwan. Ambo degenerated into a remnant low at 00 UTC on 18 May over the sea south of Yaeyama Islands.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (09 to 17 May 2020) rainfall over land:

- Catarman (Agromet), Northern Samar: 414.1 mm
- Casiguran, Aurora: 378.5 mm
- Catarman (Synoptic), Northern Samar: 368.0 mm
- Alabat, Quezon: 286.8 mm
- Juban, Sorsogon: 278.8 mm

Highest 24-hour rainfall over land:

- Catarman (Agromet), Northern Samar: 125.6 mm, 14 May 2020
- Catarman (Synoptic), Northern Samar: 306.0 mm, 14 May 2020
- Casiguran, Aurora: 282.7 mm, 15 May 2020
- Juban, Sorsogon: 260.8 mm, 14 May 2020
- Alabat, Quezon: 255.6 mm, 15 May 2020

Lowest sea level pressure over land:
- Infanta, Quezon: 990.9 hPa, 0945 UTC, 15 May 2020
- Catarman (Synoptic), Northern Samar: 991.2 hPa, 1100 UTC, 14 May 2020
- Alabat, Quezon: 994.6 hPa, 0600 UTC, 15 May 2020
- Tanay, Rizal: 994.7, 1000 UTC, 15 May 2020
- Masbate City, Masbate: 995.2 hPa, 1630 UTC, 14 May 2020

Highest peak gust over land:
- Catarman (Synoptic), Northern Samar:
  - NE (45°) at 68.0 kt (35 m/s), 0650 UTC, 14 May 2020
  - NE (40°) at 68.0 kt (35 m/s), 1050 UTC, 14 May 2020
- Infanta, Quezon: SE (130°) at 50.5 kt (26 m/s), 0953 UTC, 15 May 2020
- Juban, Sorsogon: NE (40°) at 42.8 kt (22 m/s), 1600 UTC, 14 May 2020
- Masbate City, Masbate: SSW (200°) at 40.8 kt (21 m/s), 1721 UTC, 14 May 2020
- Tayabas, Quezon: N (360°) at 38.9 kt (20 m/s), 0428 UTC, 15 May 2020
- Sangley Pt., Cavite City, Cavite: NW (320°) at 38.9 kt (20 m/s), 0428 UTC, 15 May 2020

Summary of Warning Information

Number of public TC products issued: **51**
- Severe Weather Bulletins: **37**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **14**

Number of TC Warning for Shipping issued: **29**

Reported Casualties and Cost of Damage
Source: Office of Civil Defense

Number of reported casualties: **169 injured and no reported dead or missing**
Combined cost of damage: **PHP 1,574,512,997.00**
- Damage to agriculture: **PHP 960,187,997.00**
- Damage to infrastructure: **PHP 614,325,000.00**

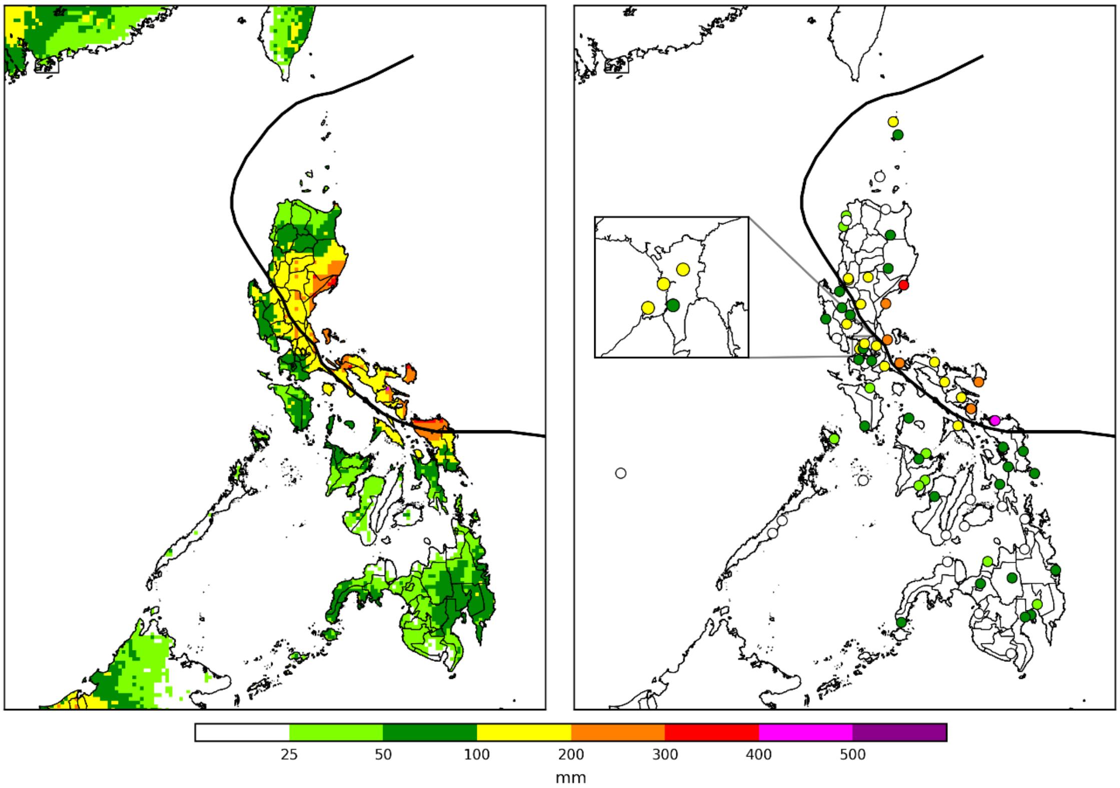


Fig. 4.1.2. Storm duration rainfall over land during the passage of Typhoon Ambo within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

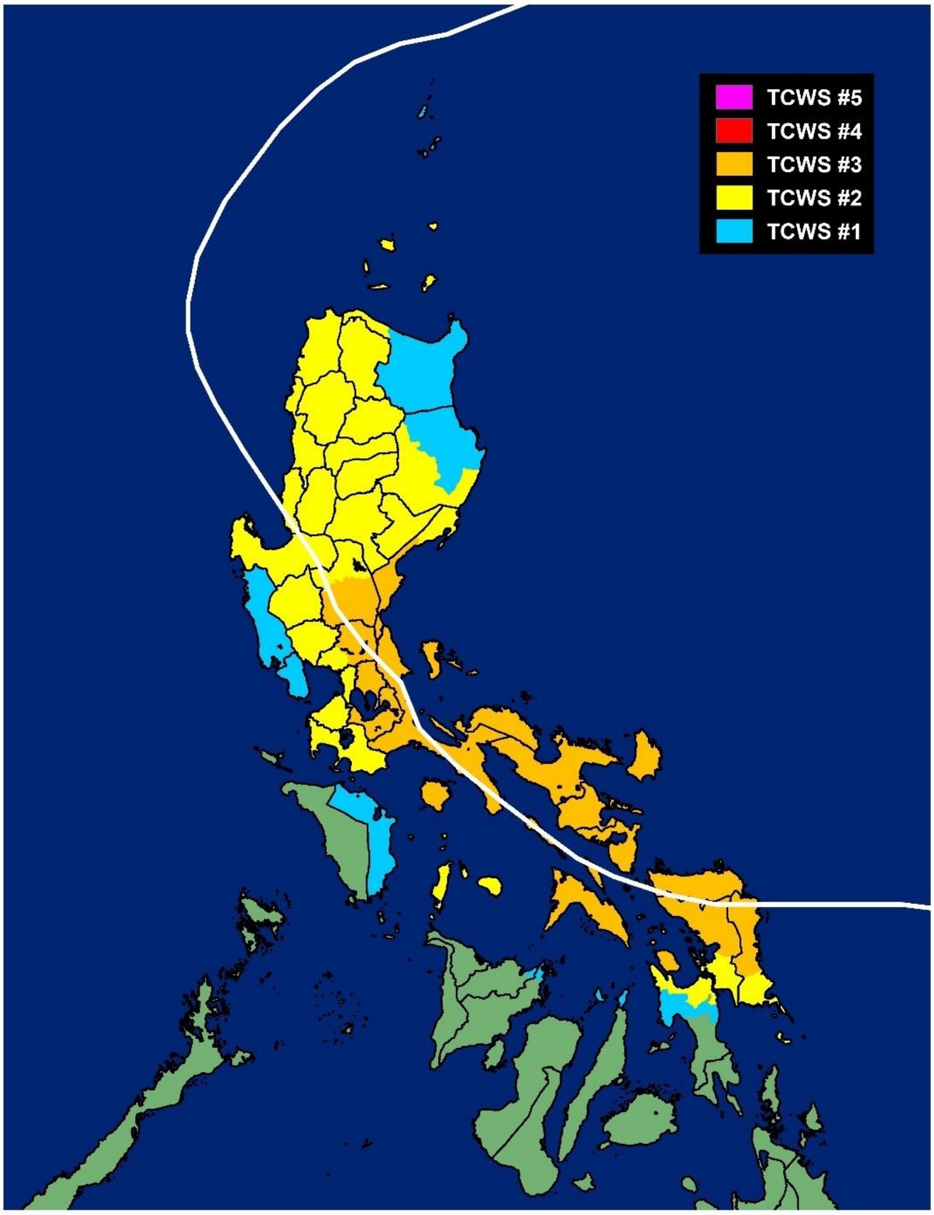
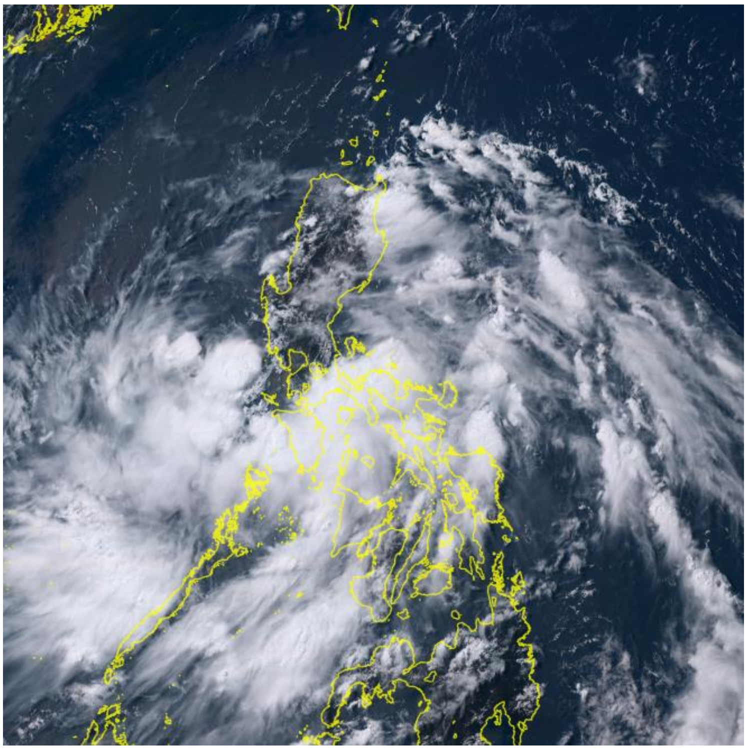


Fig. 4.1.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Typhoon Ambo. The best track is also overlaid as a solid thick white line.

Tropical Storm Butchoy
Nuri (2002)

11 to 14 June 2020



Basin-wide peak intensity:
Tropical Storm
40 kt (75 km/h)
996 hPa

Developed:
00 UTC, 11 June 2020

Degenerated:
12 UTC, 14 June 2020

Duration within the PAR:
1 day and 17 hours

Peak category within the PAR:
Tropical Storm

Highest wind signal hoisted:
Wind Signal No. 1

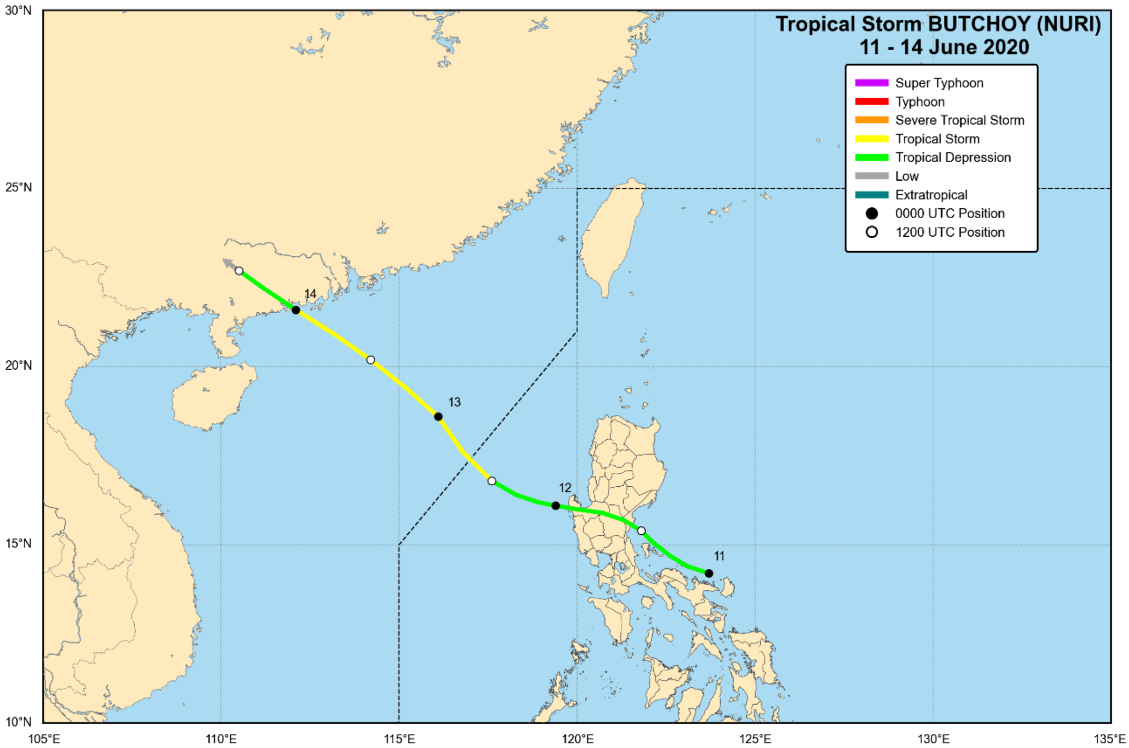


Fig. 4.2.1. Best track position and intensities of Tropical Storm Butchoy.

Meteorological History

The progenitor disturbance of what would become Tropical Storm Butchoy was first tracked over the Philippine Sea east of Eastern Visayas on 8 June. Over the next 3 days, the low pressure area tracked towards the Bicol Region-Eastern Visayas area and crossed the islands of Samar and Catanduanes. After emerging over the waters north of Camarines Sur, the disturbance developed into Tropical Depression Butchoy at 00 UTC on 11 June.

Butchoy struggled to consolidate initially as it tracked near the landmass of Luzon. As it moved initially west northwestward over the waters north of Bicol Peninsula, the depression crossed the Calaguas Archipelago at 04 UTC of the same day. Several hours later, it shifted to a more northwestward heading and tracked over the eastern coastal waters of Polillo Islands. It eventually made landfall at 14 UTC in the vicinity of San Luis, Aurora. For roughly 9 hours after reaching land, Butchoy traversed Pangasinan and northern portion of Central Luzon.

By 00 UTC of the following day, the tropical depression was already over the West Philippine Sea, where it gradually intensified as it tracked generally west northwestward. Butchoy reached tropical storm category at 12 UTC and exited the PAR region at 17 UTC of the same day. Outside the PAR region, the storm maintained its heading and reached a peak intensity of 40 kt and 996 hPa at 00 UTC on 13 June. However, this was only short-lived as the storm began weakening as it neared the coastal waters of southeastern China. At 00 UTC on 14 June, Butchoy was downgraded into a tropical depression. It eventually made landfall in the vicinity of Yangjiang City, Guangdong Province, China at 0050 UTC of the same day. PAGASA last noted Butchoy at 12 UTC when it finally degenerated into a remnant low over Guangxi Province.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (11 to 12 June 2020) rainfall over land:

- Iba, Zambales: 202.4 mm
- Subic Bay International Airport, Morong, Bataan: 165.0 mm
- South Harbor, City of Manila: 141.1 mm
- Sangley Pt., Cavite City, Cavite: 136.1 mm
- Coron, Palawan: 112.4 mm

Highest 24-hour rainfall over land:

- Iba, Zambales: 147.5 mm, 12 June 2020
- South Harbor, City of Manila: 141.1 mm, 11 June 2020
- Sangley Pt., Cavite City, Cavite: 135.5 mm, 11 June 2020
- Coron, Palawan: 111.4 mm, 11 June 2020
- Subic Bay International Airport, Morong, Bataan: 101.0 mm, 12 June 2020

Lowest sea level pressure over land:

- Muñoz City, Nueva Ecija: 1002.5 hPa, 0900 UTC, 11 June 2020
- Infanta, Quezon: 1002.6 hPa, 0800 UTC, 11 June 2020
- Dagupan City, Pangasinan: 1002.8 hPa, 0900 UTC, 11 June 2020
- Science Garden, Quezon City:
  - 1003.0 hPa, 0600 UTC, 11 June 2020
  - 1003.0 hPa, 0900 UTC, 11 June 2020
- Ninoy Aquino International Airport, Pasay City: 1003.0 hPa, 0700 UTC, 11 June 2020
- Clark International Airport, Mabalacat, Pampanga: 1003.1 hPa, 0600 UTC, 11 June 2020
- Iba, Zambales: 1003.1 hPa, 0600 UTC, 11 June 2020
- Tanay, Rizal: 1003.1 hPa, 0600 UTC, 11 June 2020

Highest peak gust over land:

- Clark International Airport, Mabalacat, Pampanga: NNW (340°) at 21.4 kt (11 m/s), 0748 UTC, 11 June 2020
- Infanta, Quezon: SSE (160°) at 19.4 kt (10 m/s), 0952 UTC, 11 June 2020
- Daet, Camarines Norte: 17.5 kt (9 m/s), between 1200 and 1300 UTC, 11 June 2020
- Iba, Zambales: NNW (330°) at 17.5 kt (9 m/s), 0547 UTC, 11 June 2020
- Masbate City, Masbate:
    - SW (220°) at 15.6 kt (8 m/s), 0233 UTC, 11 June 2020
    - SSW (200°) at 15.6 kt (8 m/s), 0318 UTC, 11 June 2020
- Sangley Pt., Cavite City, Cavite: SW (220°) at 9.7 kt (5 m/s), 1800 UTC, 11 June 2020

Summary of Warning Information

Number of public TC products issued: **14**

- Severe Weather Bulletins: **8**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **6**

Number of TC Warning for Shipping issued: **6**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

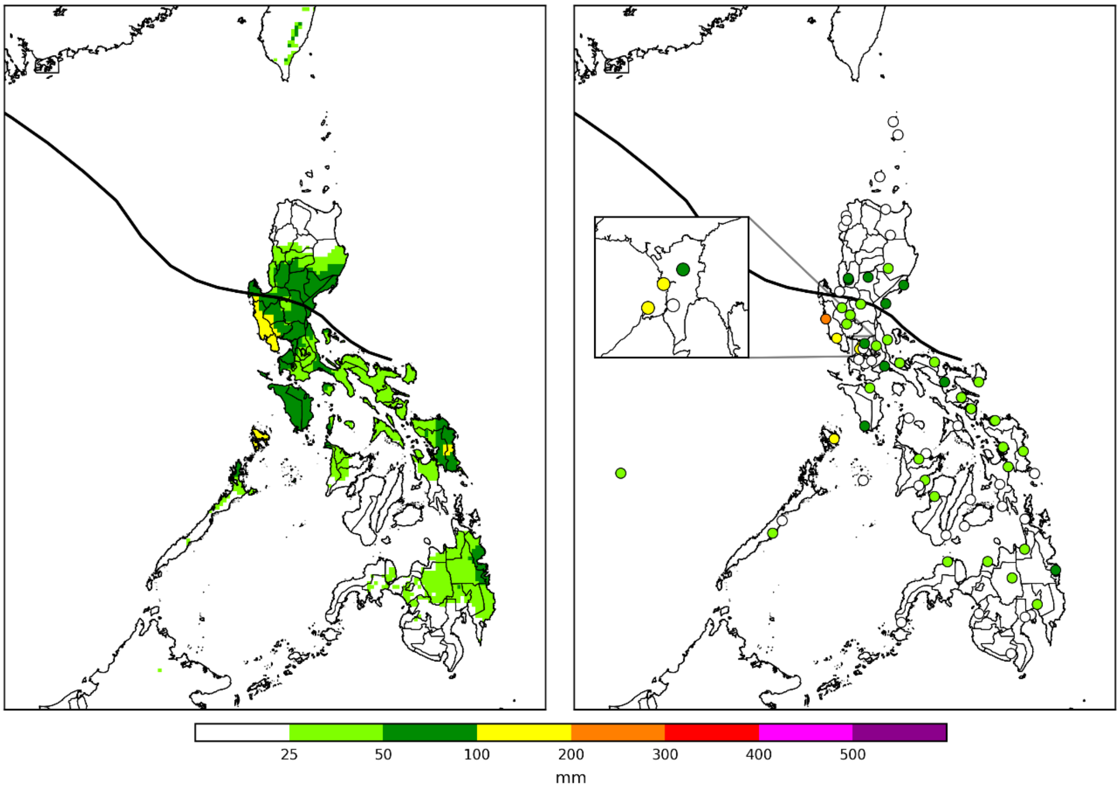


Fig. 4.2.2. Storm duration rainfall over land during the passage of Tropical Storm Butchoy within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

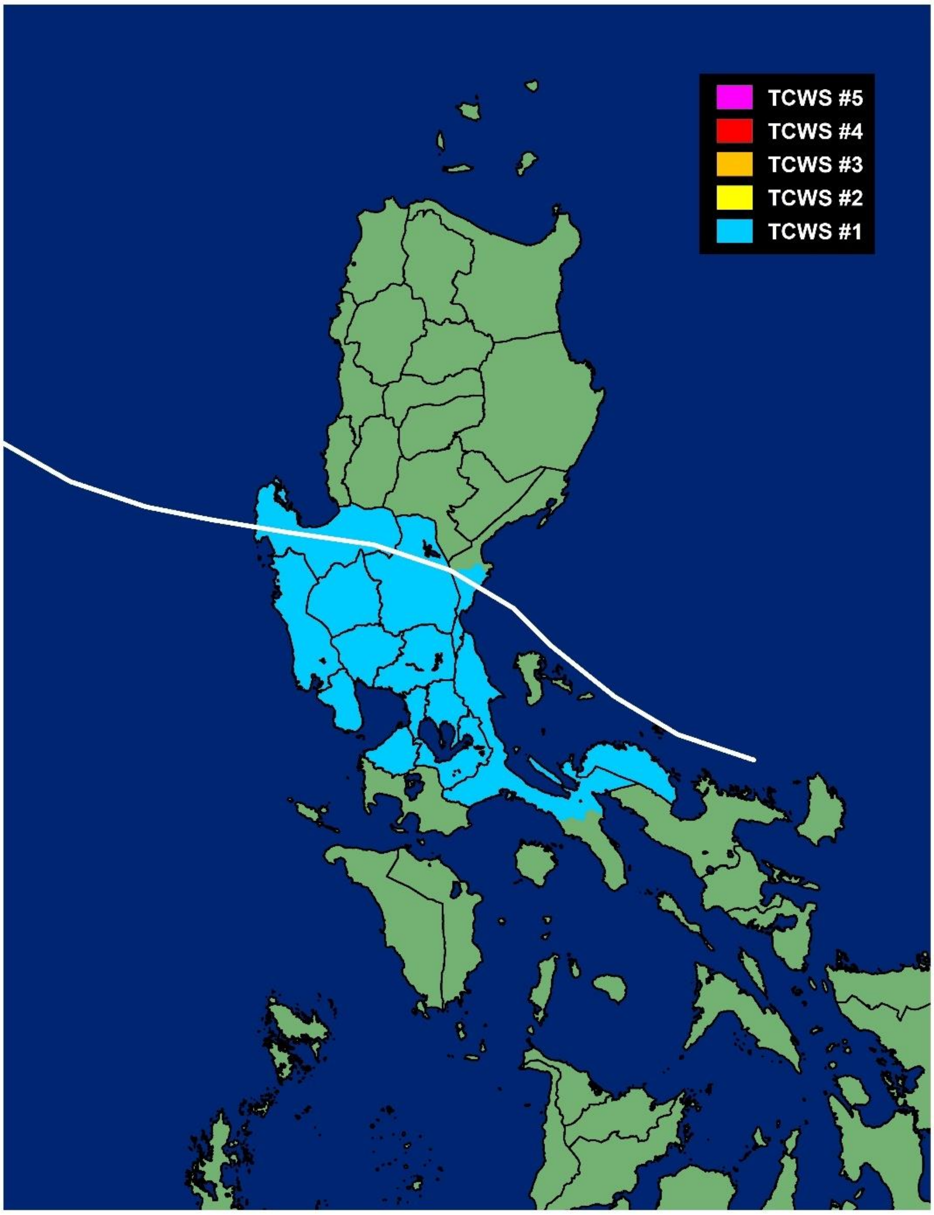
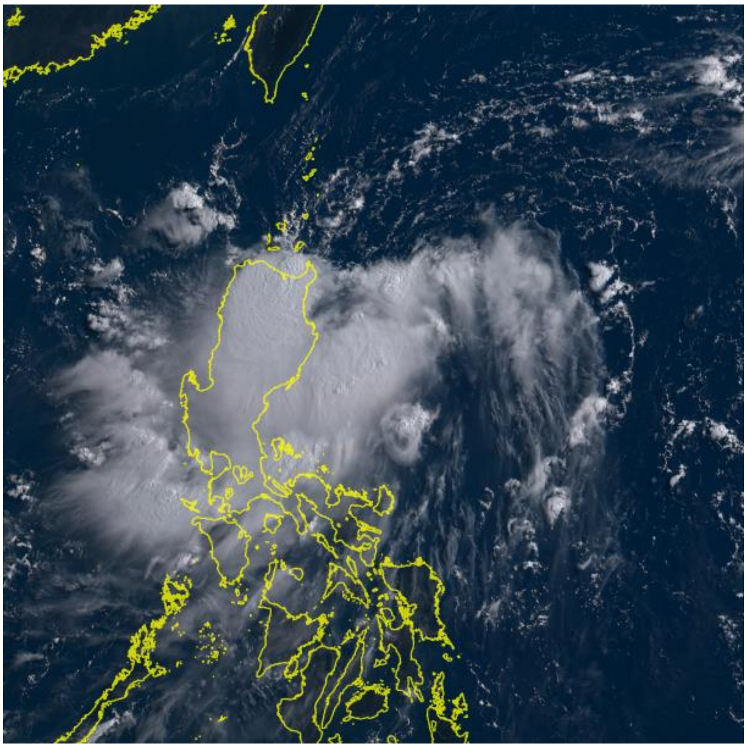


Fig. 4.2.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Tropical Storm Butchoy. The best track is also overlaid as a solid thick white line.

Tropical Depression Carina
(Unnamed by RSMC Tokyo)

12 to 14 July 2020



Basin-wide peak intensity:
Tropical Depression
25 kt (45 km/h)
1004 hPa

Developed:
06 UTC, 12 July 2020

Degenerated:
12 UTC, 14 July 2020

Duration within the PAR:
2 days and 6 hours

Peak category within the PAR:
Tropical Depression

Highest wind signal hoisted:
Wind Signal No. 1

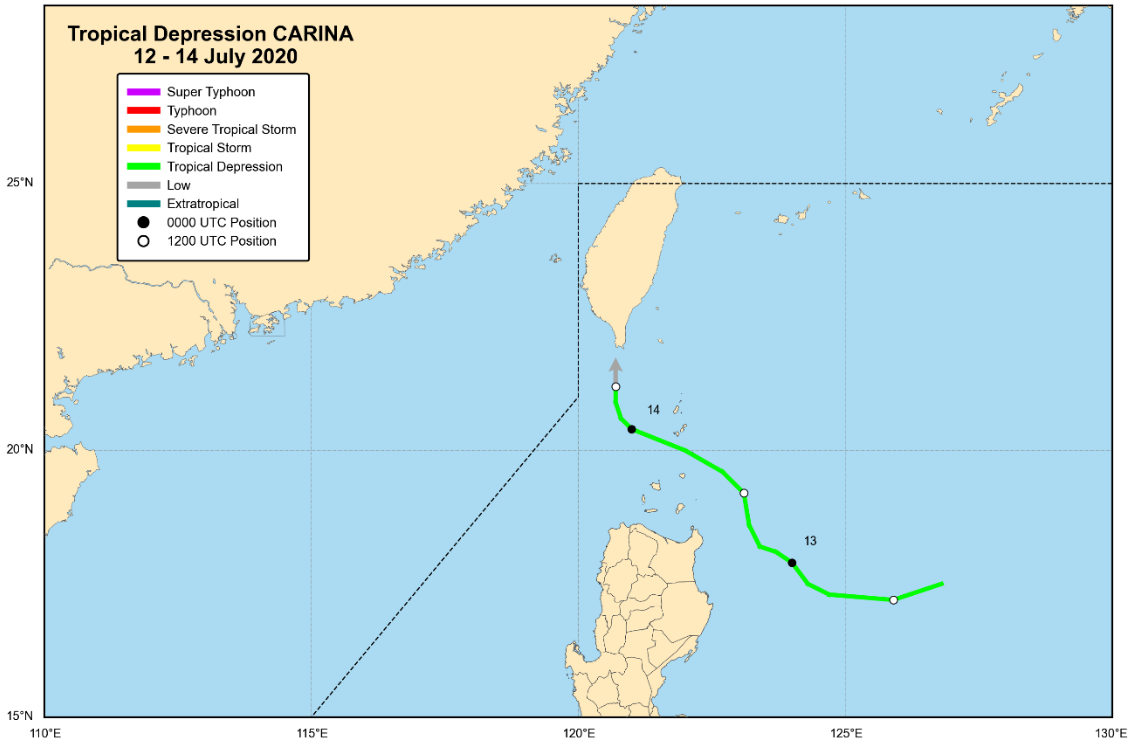


Fig. 4.3.1. Best track position and intensities of Tropical Depression Carina.

Meteorological History

An area of low pressure over the Philippine Sea east of Northern Luzon developed into Tropical Depression Carina at 06 UTC on 12 July. After initially tracking westward, the newly formed depression turned more northwestward and tracked over the Luzon Strait, particularly in the waters of Balintang Channel between Batanes and Babuyan Islands. During its passage over the channel, Carina tracked close to Batan and Sabtang islands between 18 UTC and 21 UTC on 13 July. Owing to generally unfavorable conditions, the depression struggled to intensify throughout its short lifetime. It eventually degenerated into a remnant low at 12 UTC on 14 July as it tracked towards the southern portion of Taiwan.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (12 to 14 July 2020) rainfall over land:

- Batac, Ilocos Norte: 190.6 mm
- Laoag City, Ilocos Norte: 189.1 mm
- Aparri, Cagayan: 153.8 mm
- PCA Bago-Oshiro, Davao City: 99.2 mm
- Sangley Pt., Cavite City, Cavite: 98.5 mm

Highest 24-hour rainfall over land:

- Batac, Ilocos Norte: 186.8 mm, 13 July 2020
- Laoag City, Ilocos Norte: 183.8 mm, 13 July 2020
- Aparri, Cagayan: 145.4 mm, 13 July 2020
- PCA Bago-Oshiro, Davao City: 95.8 mm, 14 July 2020
- Sangley Pt., Cavite City, Cavite: 88.4 mm, 12 July 2020

Lowest sea level pressure over land:

- Basco, Batanes: 1003.7 hPa, 2100 UTC, 13 July 2020
- Baguio City: 1003.8, 0600 UTC, 12 July 2020
- Calayan, Cagayan: 1004.2 hPa, 0700 UTC, 13 July 2020
- Aparri, Cagayan: 1005.1 hPa, 1800 UTC, 13 July 2020
- Casiguran, Aurora: 1005.4 hPa, 2300 UTC, 12 July 2020

Highest peak gust over land:

- Baler, Aurora: WNW (290°) at 35.0 kt (18 m/s), 0749 UTC, 12 July 2020
- Itbayat, Batanes:
    - S (180°) at 27.2 kt (14 m/s), 0552 UTC, 13 July 2020
    - SSE (160°) at 27.2 kt (14 m/s), 0825 UTC, 13 July 2020
- Iba, Zambales: WNW (290°) at 25.3 kt (13 m/s), 0114 UTC, 13 July 2020
- Subic Bay International Airport, Morong, Bataan: SW (220°) at 23.3 kt (12 m/s), 2330 UTC, 12 July 2020
- Aparri, Cagayan:
    - WNW (300°) at 19.4 kt (10 m/s), 2250 UTC, 12 July 2020
    - S (180°) at 19.4 kt (10 m/s), 1450 UTC, 13 July 2020
    - S (180°) at 19.4 kt (10 m/s), 1954 UTC, 13 July 2020
- Laoag City, Ilocos Norte: N (360°) at 19.4 kt (10 m/s), 0749 UTC, 12 July 2020

Summary of Warning Information

Number of public TC products issued: **16**

- Severe Weather Bulletins: **12**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **4**

Number of TC Warning for Shipping issued: **8**

Reported Casualties and Cost of Damage
Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

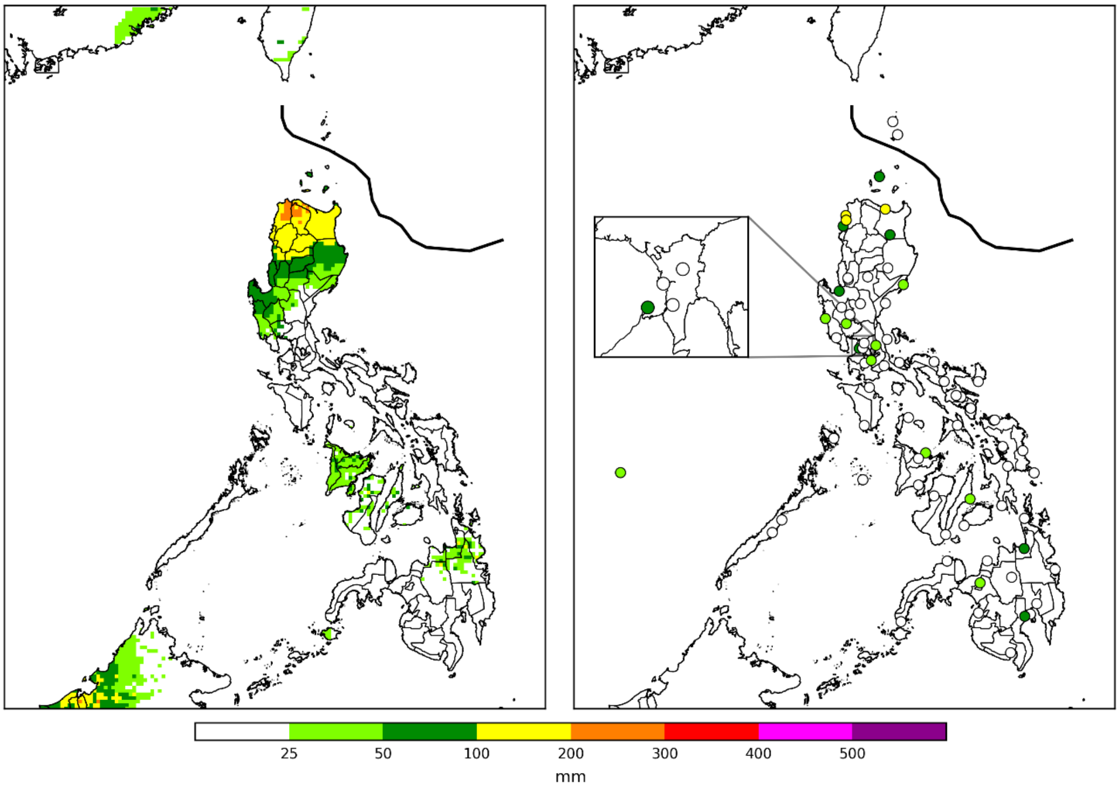


Fig. 4.3.2. Storm duration rainfall over land during the passage of Tropical Depression Carina within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

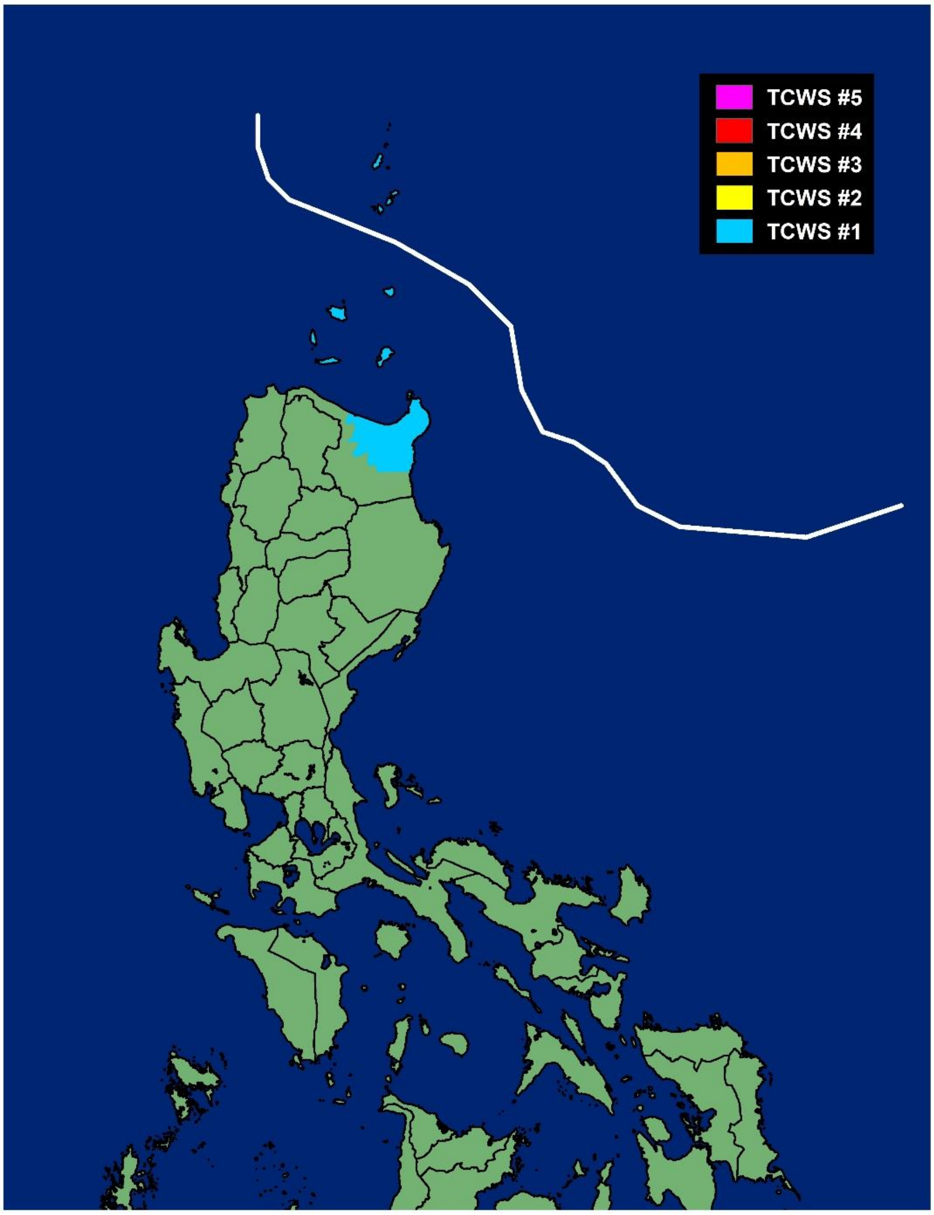
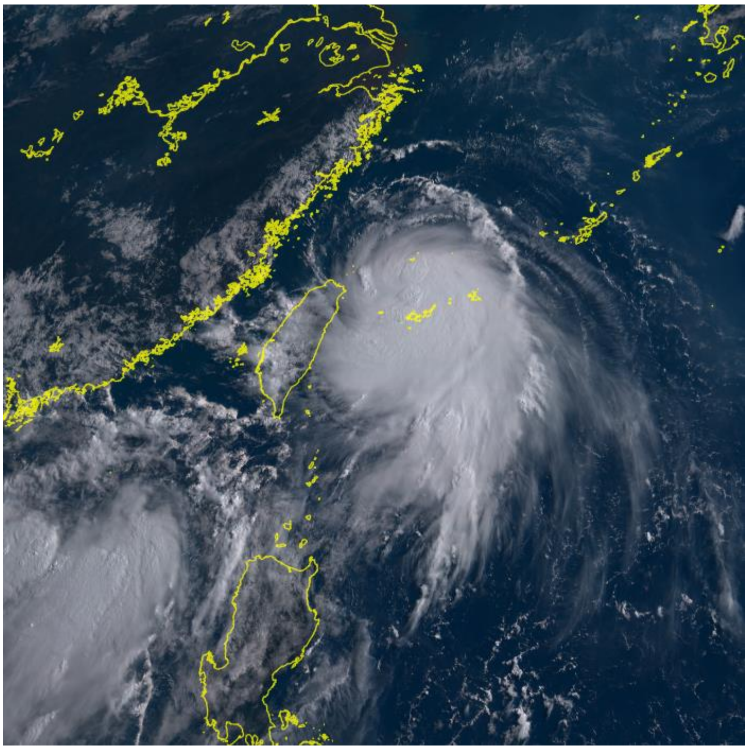


Fig. 4.3.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Tropical Depression Carina. The best track is also overlaid as a solid thick white line.

Typhoon Dindo
Hagupit (2004)

31 July to
05 August 2020



Basin-wide peak intensity:
Typhoon
70 kt (130 km/h)
975 hPa

Developed:
00 UTC, 31 July 2020

Transitioned:
12 UTC, 05 August 2020

Duration within the PAR:
3 days and 1 hour

Peak category within the PAR:
Severe Tropical Storm

Highest wind signal hoisted:
None

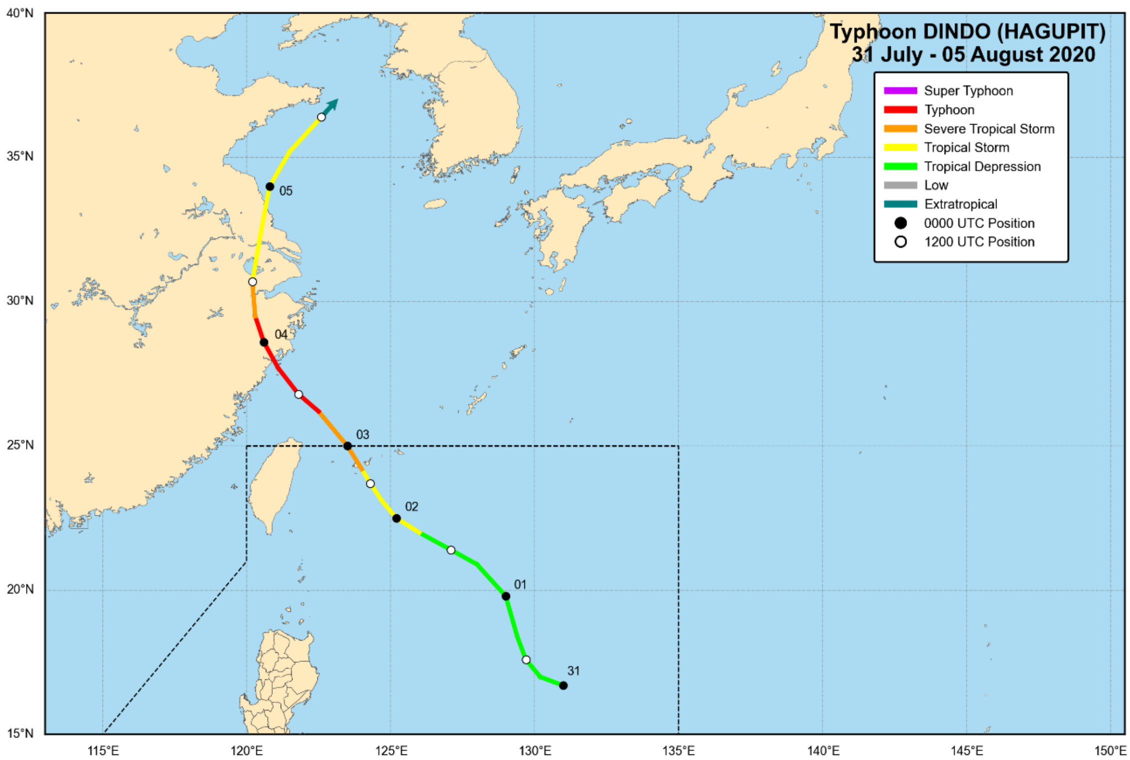


Fig. 4.4.1. Best track position and intensities of Typhoon Dindo.

Meteorological History

Typhoon Dindo developed from an area of low pressure on 31 July while over the Philippine Sea east of Luzon. Tracking generally northwestward far from the Philippine landmass, its development was rather slow during the first 2 days. Dindo eventually intensified into a tropical storm at 18 UTC on 01 August while approaching the Yaeyama Islands in the southern portion of the Ryukyu archipelago (Okinawa Prefecture, Japan).

On 02 August, the storm underwent a period of rapid intensification. As it made landfall in the vicinity of Taketomi (one of the towns comprising the Yaeyama Islands) at around 1800 UTC of the same day, Dindo was further upgraded into a severe tropical storm. Roughly five hours after leaving the PAR region at 01 UTC on 03 August, the tropical cyclone reached typhoon category while over the East China Sea.

Dindo continued intensifying as it approached the east coast of China and eventually attained a peak intensity of 70 kt and 975 hPa at 12 UTC on 03 August. At around 1930 UTC, Dindo made landfall in the vicinity of Wenzhou City, Zhejiang Province, China. A weakening trend ensued as the typhoon tracked inland over eastern China in a recurving manner. Dindo eventually emerged over the Yellow Sea as a tropical storm on 05 August as it began its post-tropical transition. PAGASA last tracked Dindo at 12 UTC of the same day as a post-tropical cyclone heading towards the west coast of the Korean Peninsula.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (31 July to 02 August 2020) rainfall over land:

- Mactan-Cebu International Airport, Lapu-Lapu City: 161.8 mm
- La Carlota City, Negros Occidental: 117.0 mm
- Tagum City, Davao del Norte: 103.0 mm
- Dumaguete City, Negros Oriental: 92.8 mm
- Iba, Zambales: 75.9 mm

Highest 24-hour rainfall over land:

- La Carlota City, Negros Occidental: 116.6 mm, 31 July 2020
- Mactan-Cebu International Airport, Lapu-Lapu City: 114.2 mm. 31 July 2020
- Dumaguete City, Negros Oriental: 79.4 mm: 31 July 2020
- Tagum City, Davao del Norte: 71.2 mm, 01 August 2020
- Sinait, Ilocos Sur: 55.6 mm, 31 July 2020

Summary of Warning Information

Number of public TC products issued: **16**

- Severe Weather Bulletins: **7**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **9**

Number of TC Warning for Shipping issued: **11**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

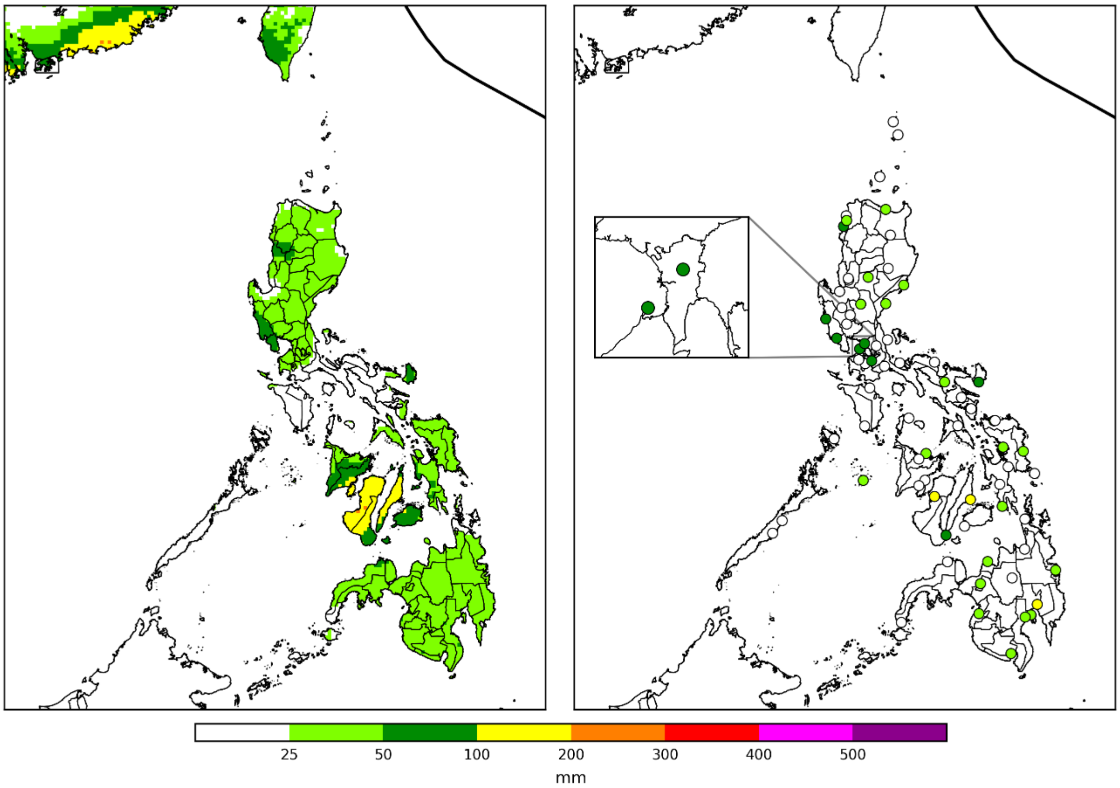
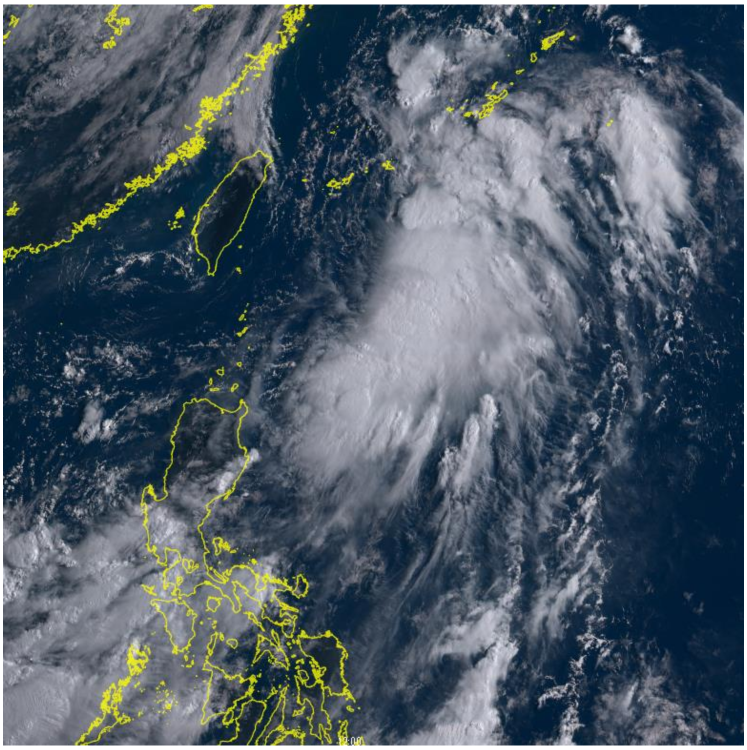


Fig. 4.4.2. Storm duration rainfall over land during the passage of Typhoon Dindo within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

Tropical Storm Enteng
Jangmi (2005)

07 to 11 August 2020



Basin-wide peak intensity:
Tropical Storm
45 kt (85 km/h)
994 hPa

Developed:
18 UTC, 07 August 2020

Transitioned:
00 UTC, 11 August 2020

Duration within the PAR:
1 day and 12 hours

Peak category within the PAR:
Tropical Storm

Highest wind signal hoisted:
None

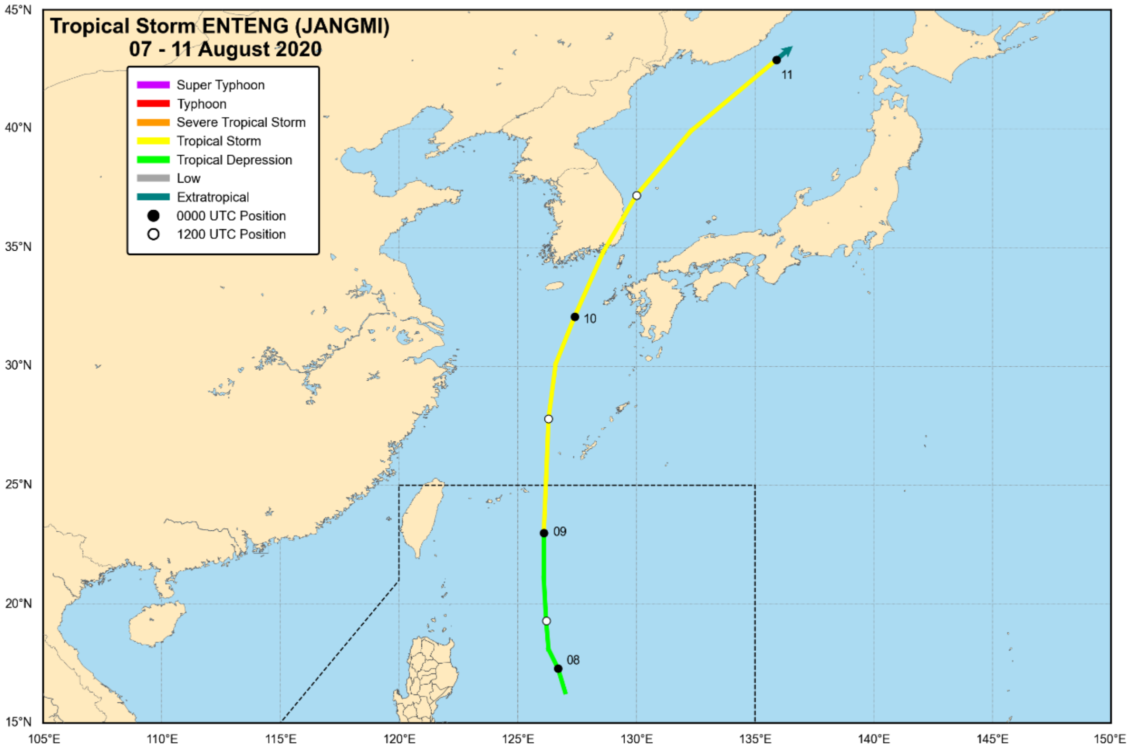


Fig. 4.5.1. Best track position and intensities of Tropical Storm Enteng.

Meteorological History

The progenitor disturbance of Tropical Storm Enteng was first noted over the Philippine Sea east of Bicol Region on 06 August as a brewing tropical low situated within an active monsoon trough. The low pressure area gradually consolidated despite having a broad circulation. It was eventually upgraded into a tropical depression at 18 UTC on 07 August, nearly 2 days after it was initially tracked. Over the next 2 days, Enteng moved generally northward at a considerably fast pace and remained far from the Philippine landmass. At 00 UTC on 09 August, the depression intensified into a tropical storm while over the sea southeast of Miyako Islands in Japan's Ryukyu archipelago. Enteng exited the PAR region 6 hours later.

Outside the PAR region, Enteng continued moving swiftly northward over the East China for the rest of 09 August before turning northeastward as it made its way towards the Korea Strait. Enteng made landfall as a tropical storm in the vicinity of Geoje Island in South Gyeongsang Province, South Korea at 0550 UTC on 10 August. The storm eventually reached the Sea of Japan, where it underwent post-tropical transition. Enteng became a post-tropical cyclone at 00 UTC on 11 August over the waters southeast of Primorsky Krai in the Russian Far East region.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (07 to 09 August 2020) rainfall over land:

- Subic Bay International Airport, Morong, Bataan: 255.5 mm
- Cuyo, Palawan: 165.4 mm
- Science Garden, Quezon City: 141.2 mm
- San Jose, Occidental Mindoro: 131.3 mm
- Iba, Zambales: 128.8 mm

Highest 24-hour rainfall over land:

- Subic Bay International Airport, Morong, Bataan: 173.0 mm, 09 August 2020
- Cuyo, Palawan: 115.4 mm, 08 August 2020
- San Jose, Occidental Mindoro: 100.7 mm, 08 August 2020
- Science Garden, Quezon City: 89.2 mm, 07 August 2020
- Malaybalay, Bukidnon: 85.4 mm, 07 August 2020

Summary of Warning Information

Number of public TC products issued: **12**

- Severe Weather Bulletins: **6**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **6**

Number of TC Warning for Shipping issued: **7**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

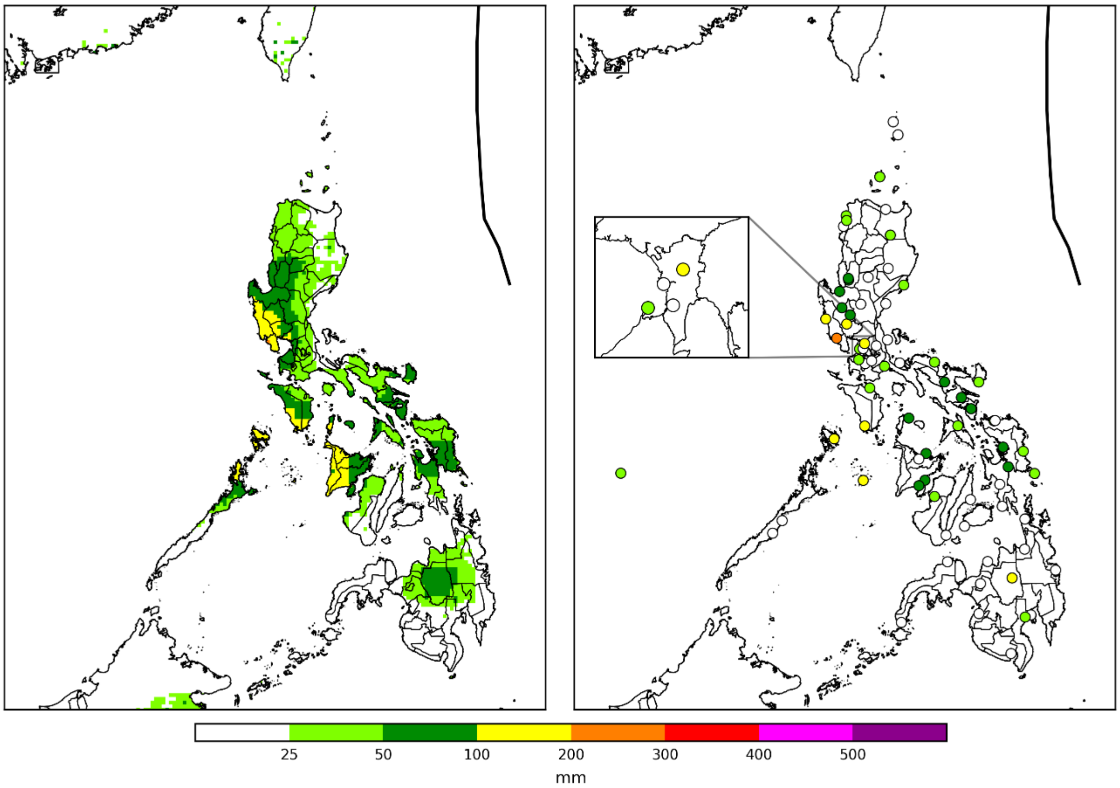
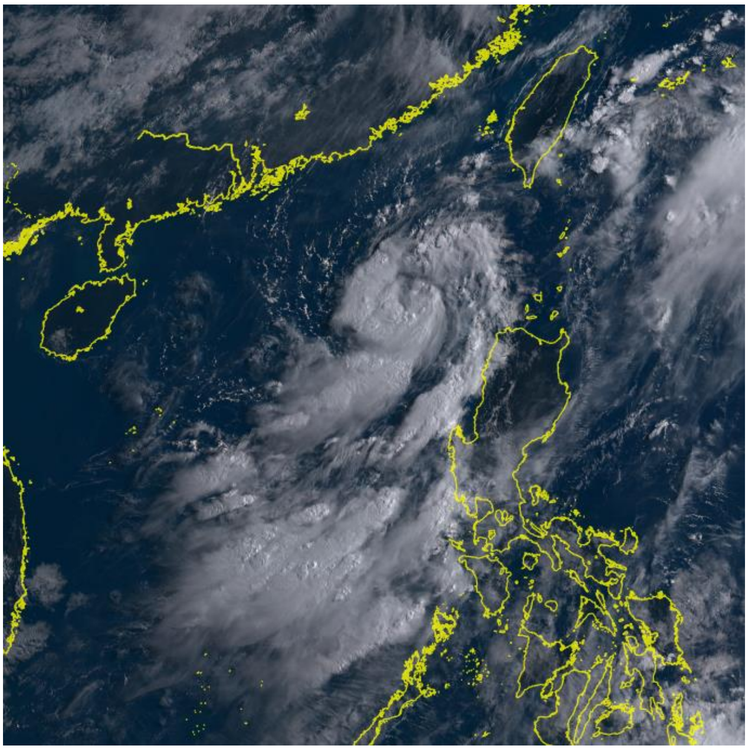


Fig. 4.5.2. Storm duration rainfall over land during the passage of Tropical Storm Enteng within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

Typhoon Ferdie
Mekkhala (2006)

09 to 11 August 2020



Basin-wide peak intensity:
Typhoon
65 kt (120 km/h)
975 hPa

Developed:
00 UTC, 09 August 2020

Degenerated:
12 UTC, 11 August 2020

Duration within the PAR:
1 day and 2 hours

Peak category within the PAR:
Tropical Storm

Highest wind signal hoisted:
Wind Signal No. 1

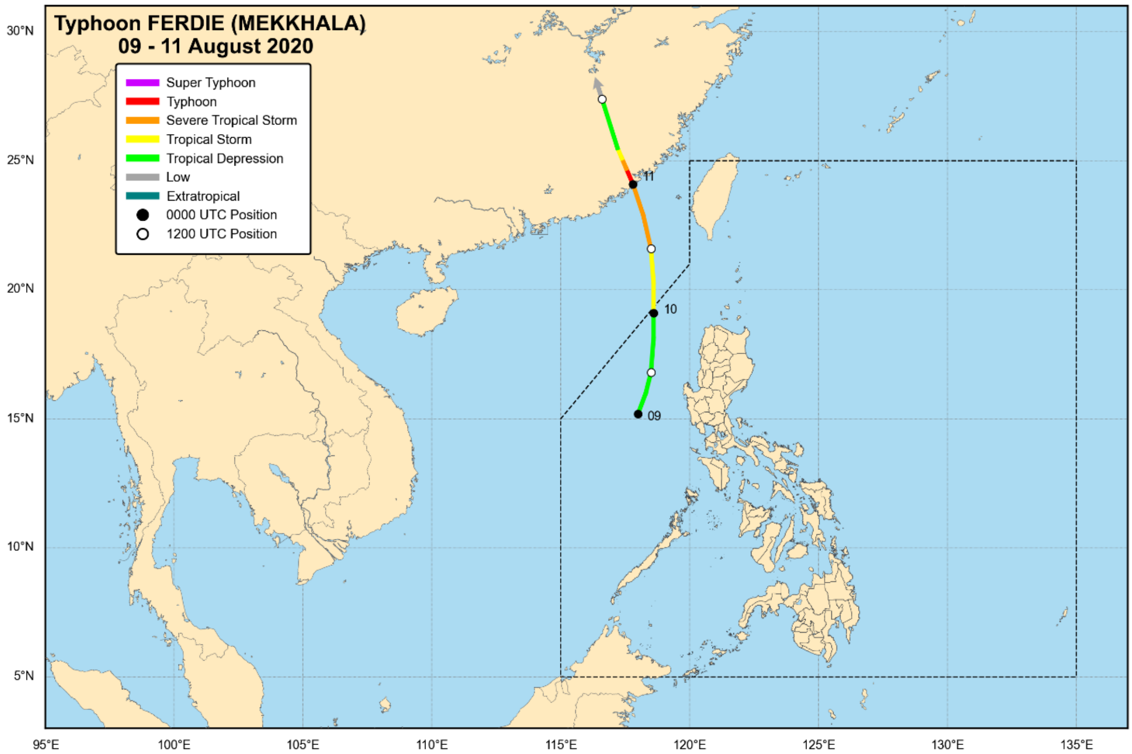


Fig. 4.6.1. Best track position and intensities of Typhoon Ferdie.

Meteorological History

Within the same active monsoon trough that spawned Tropical Storm Enteng, another area of low pressure persisted on 07 August over the West Philippine Sea west of Palawan. With Enteng being the dominant system within the monsoon trough, this disturbance remained disorganized until around 08 August when it started consolidating as Enteng tracked further north. The low pressure area was upgraded into Tropical Depression Ferdie at 00 UTC on 09 August while moving generally northward over waters west of Zambales. The depression further intensified into a tropical storm at 00 UTC of the following day and exited the northwestern limit of the PAR 2 hours later.

During the later portion of 09 August and into 10 August, Ferdie rapidly intensified as it tracked northward and north northwestward towards the coast of southeastern China. The cyclone reached typhoon category and peaked at 65 kt and 975 hPa shortly before making landfall at 2330 UTC on 10 August in the vicinity of Zhangpu County in Fujian Province, China. Rapid weakening ensued following its landfall as it moved north northwestward further inland. Ferdie weakened into a remnant low over Jiangxi Province in mainland China.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (09 August 2020) rainfall over land:

- Subic Bay International Airport, Morong, Bataan: 173.0 mm
- Clark International Airport, Mabalacat, Pampanga: 70.4 mm
- Iba, Zambales: 65.0 mm
- Science Garden, Quezon City: 50.8 mm
- Tarlac City, Tarlac: 42.2 mm

Highest 24-hour rainfall over land:
(Same as above)

Summary of Warning Information

Number of public TC products issued: **7**

- Severe Weather Bulletins: **3**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **4**

Number of TC Warning for Shipping issued: **3**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

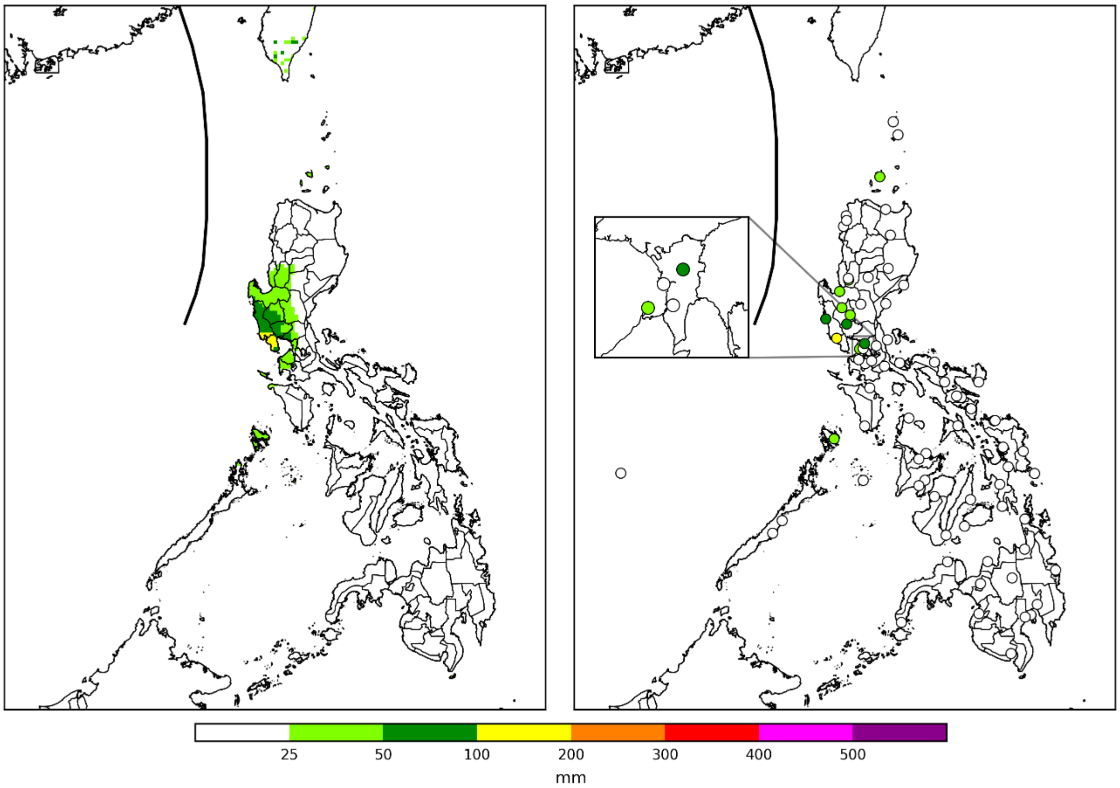


Fig. 4.6.2. Storm duration rainfall over land during the passage of Typhoon Ferdie within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

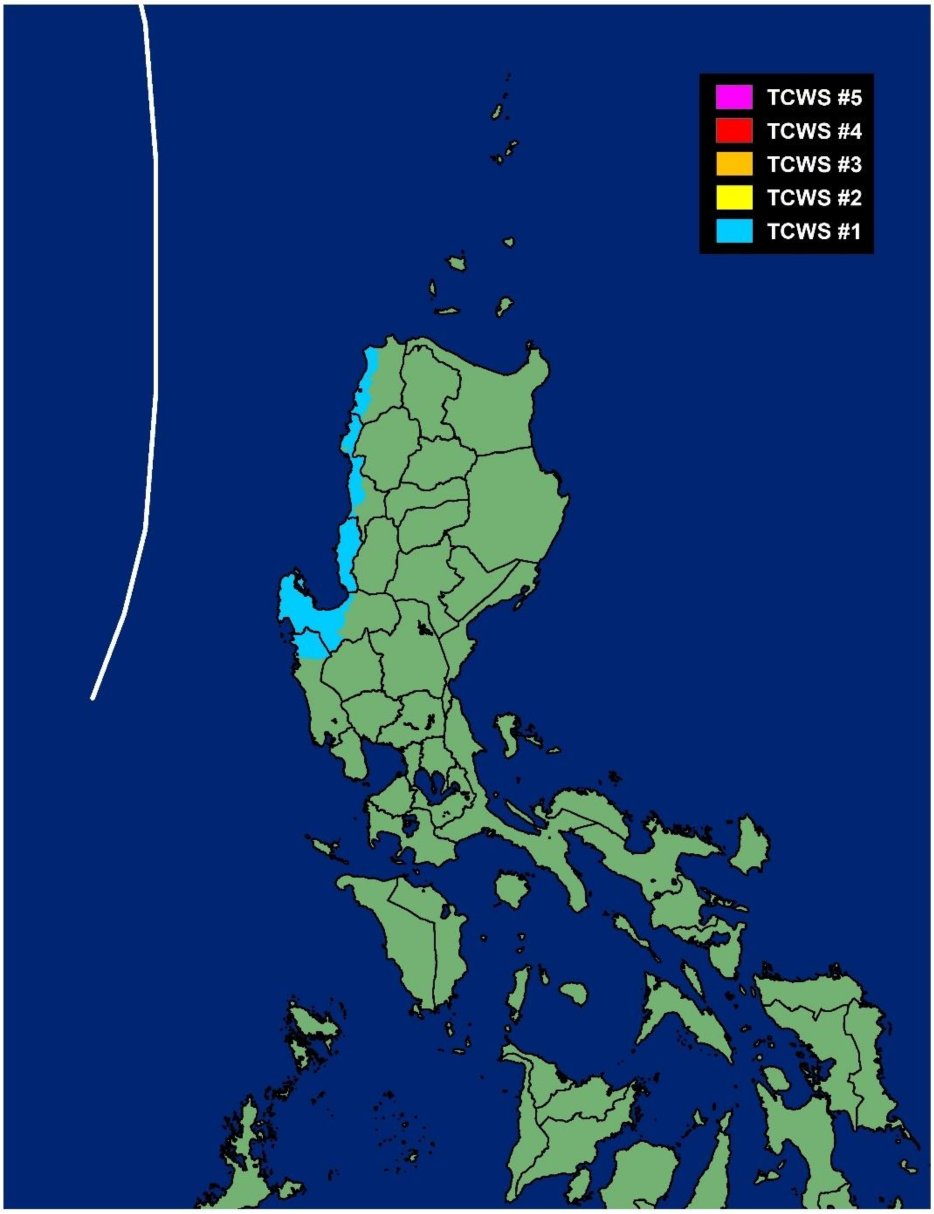
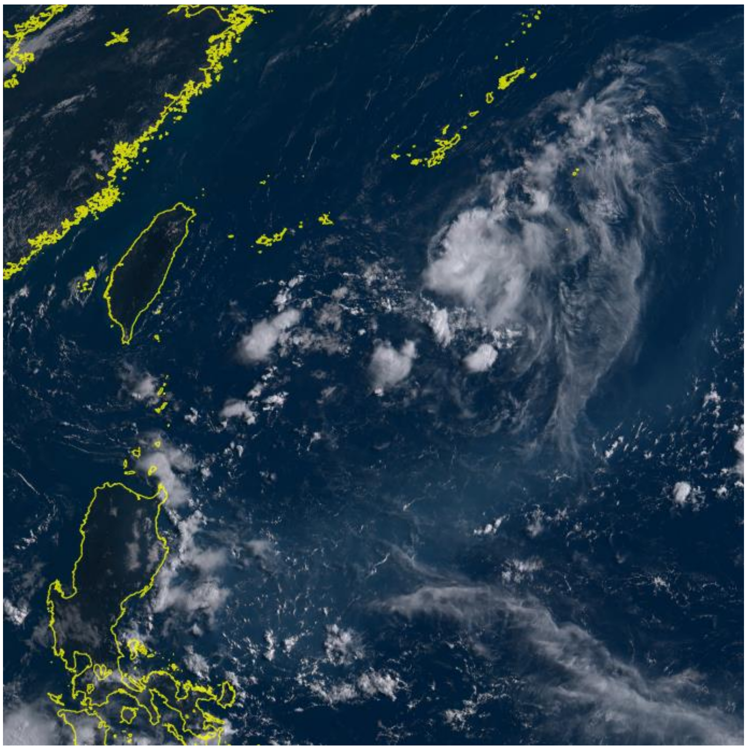


Fig. 4.6.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Typhoon Ferdie. The best track is also overlaid as a solid thick white line.

Tropical Depression Gener
(Unnamed by RSMC Tokyo)

09 to 13 August 2020



Basin-wide peak intensity:
Tropical Depression
30 kt (55 km/h)
1012 hPa

Developed:
00 UTC, 09 August 2020

Degenerated:
00 UTC, 13 August 2020

Duration within the PAR:
10 hours

Peak category within the PAR:
Tropical Depression

Highest wind signal hoisted:
None

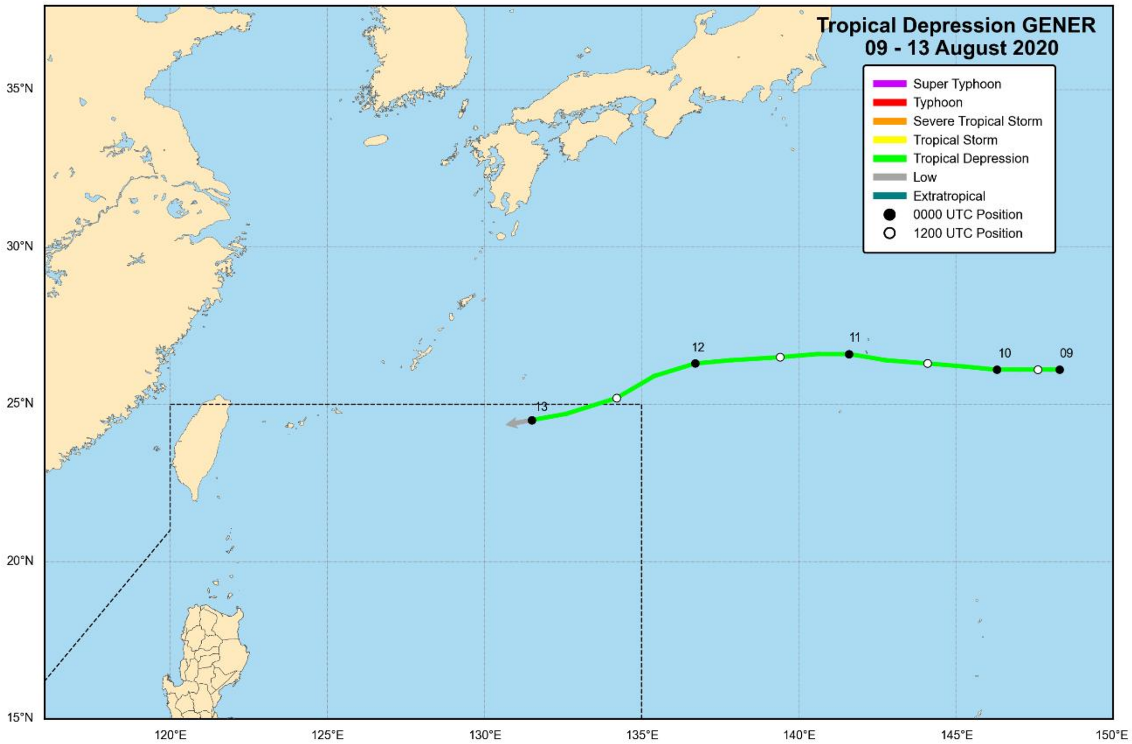


Fig. 4.7.1. Best track position and intensities of Tropical Depression Gener.

Meteorological History

While the monsoon trough remained active over the Philippine region, a westward-moving subtropical disturbance in the middle of the North Pacific and far east of Ogasawara archipelago (Japan) developed into a tropical depression at 00 UTC on 09 August. Tracking generally westward, the depression remained weak within an unusually high central pressure of 1012 to 1014 hPa, although there were periods when pockets of gale-force winds were estimated. The cyclone tracked over the waters south of Hahajima island in the Ogasawara archipelago between 18 UTC on 10 August and 00 UTC of the following day – its period of closest approach to any landmass throughout its lifetime. On 12 August, it turned west southwestward and entered the PAR region as Tropical Depression Gener at 14 UTC of the same day.

When it entered the PAR region, Gener was already close to dissipation due to the collapse of convective activity and unfavorable environmental conditions. At 00 UTC on 13 August, roughly 10 hours after entering the PAR, Gener degenerated into a remnant low. It eventually dissipated shortly after.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (12 August 2020) rainfall over land:

- Marawi City, Lanao del Sur: 80.5 mm
- Juban, Sorsogon: 44.0 mm
- Iba, Zambales: 38.8 mm
- PCA Bago-Oshiro, Davao City: 34.7 mm
- Echague, Isabela: 32.9 mm

Highest 24-hour rainfall over land:
(Same as above)

Summary of Warning Information

Number of public TC products issued: **9**

- Severe Weather Bulletins: **2**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **7**

Number of TC Warning for Shipping issued: **2**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

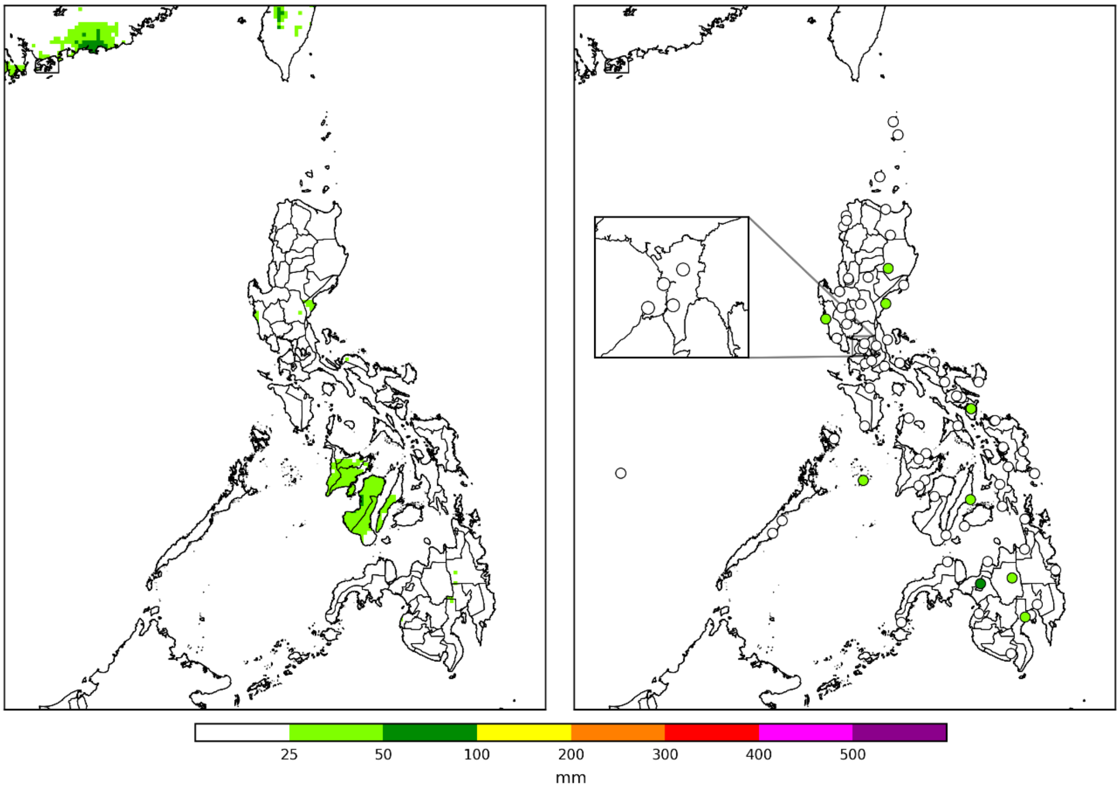
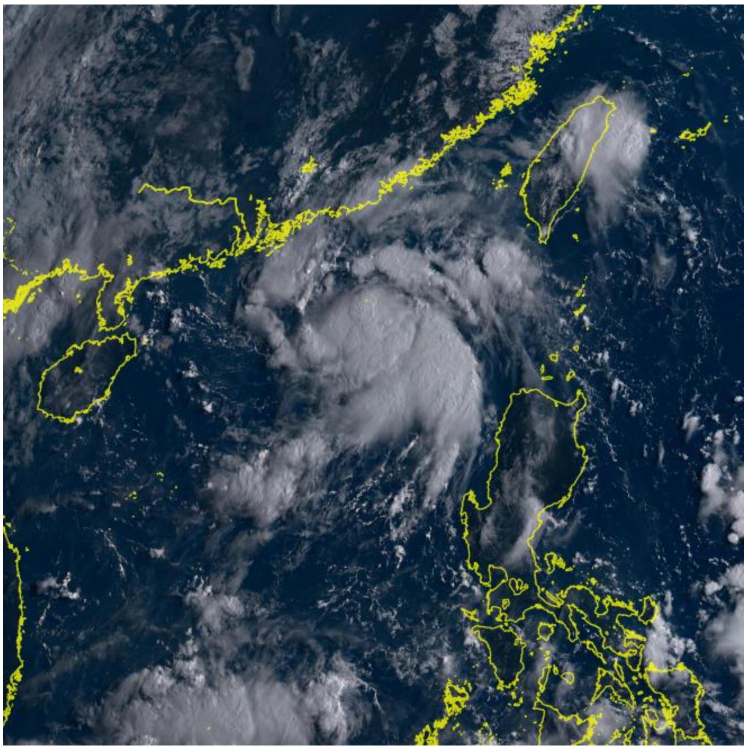


Fig. 4.7.2. Storm duration rainfall over land during the passage of Tropical Depression Gener within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is outside the domain of this figure.

Typhoon Helen
Higos (2007)

17 to 19 August 2020



Basin-wide peak intensity:
Typhoon
65 kt (120 km/h)
980 hPa

Developed:
00 UTC, 17 August 2020

Degenerated:
18 UTC, 19 August 2020

Duration within the PAR:
15 hours

Peak category within the PAR:
Tropical Depression

Highest wind signal hoisted:
None

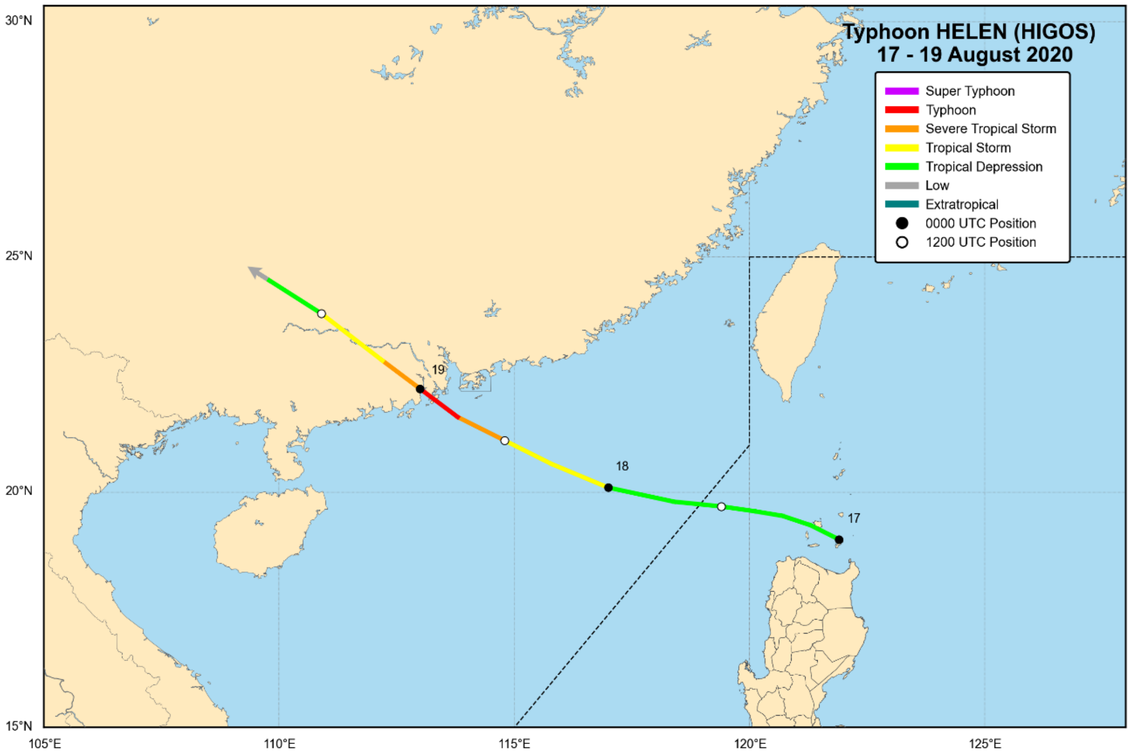


Fig. 4.8.1. Best track position and intensities of Typhoon Helen.

Meteorological History

A tropical low situated over the waters east of Northern Luzon developed into Tropical Depression Helen at 00 UTC on 17 August when it was over Camiguin Island in Calayan, Cagayan. Between 00 and 03 UTC, the newly formed depression tracked generally west northwestward as it passed very close between Calayan and Dalupiri Islands in the Babuyan archipelago. After a brief west northwestward movement, Helen left the PAR at 15 UTC of the same day it developed due to the proximity of the depression to the region's northwestern boundary.

Outside the PAR region, Helen tracked northwestward and began rapidly intensifying. At 00 UTC on 18 November, it was upgraded into a tropical storm. Roughly 18 hours later, Helen reached typhoon category with a peak intensity of 65 kt and 980 hPa as it moved over the waters south of the Pearl River Delta. It made landfall over Zhuhai City in China's Guangdong Province at 2200 UTC on 18 August. Helen quickly weakened soon after as it moved further inland and was downgraded into an area of low pressure at 18 UTC on 19 August over Guangxi Province. It eventually dissipated further north in Guizhou Province several hours later.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (17 August 2020) rainfall over land:

- El Salvador City, Misamis Oriental: 50.4 mm
- Mactan-Cebu International Airport, Lapu-Lapu City: 48.2 mm
- Tuguegarao City, Cagayan: 38.0 mm
- Calayan, Cagayan: 30.4 mm
- Guinobatan, Albay: 28.8 mm

Highest 24-hour rainfall over land:

(Same as above)

Lowest sea level pressure over land:

- Baguio City: 1004.4 hPa, 0600 UTC, 17 August 2020
- Tuguegarao City, Cagayan: 1005.5 hPa, 0600 UTC, 17 August 2020
- Muñoz City, Nueva Ecija: 1005.7 hPa, 0900 UTC, 17 August 2020
- Dagupan City, Pangasinan: 1005.8 hPa, 0900 UTC, 17 August 2020
- Clark International Airport, Mabalacat, Pampanga: 1005.9 hPa, 0900 UTC, 17 August 2020

Highest peak gust over land:

(No significant gust reported)

Summary of Warning Information

Number of public TC products issued: **6**

- Severe Weather Bulletins: **2**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **4**

Number of TC Warning for Shipping issued: **2**

Reported Casualties and Cost of Damage
Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

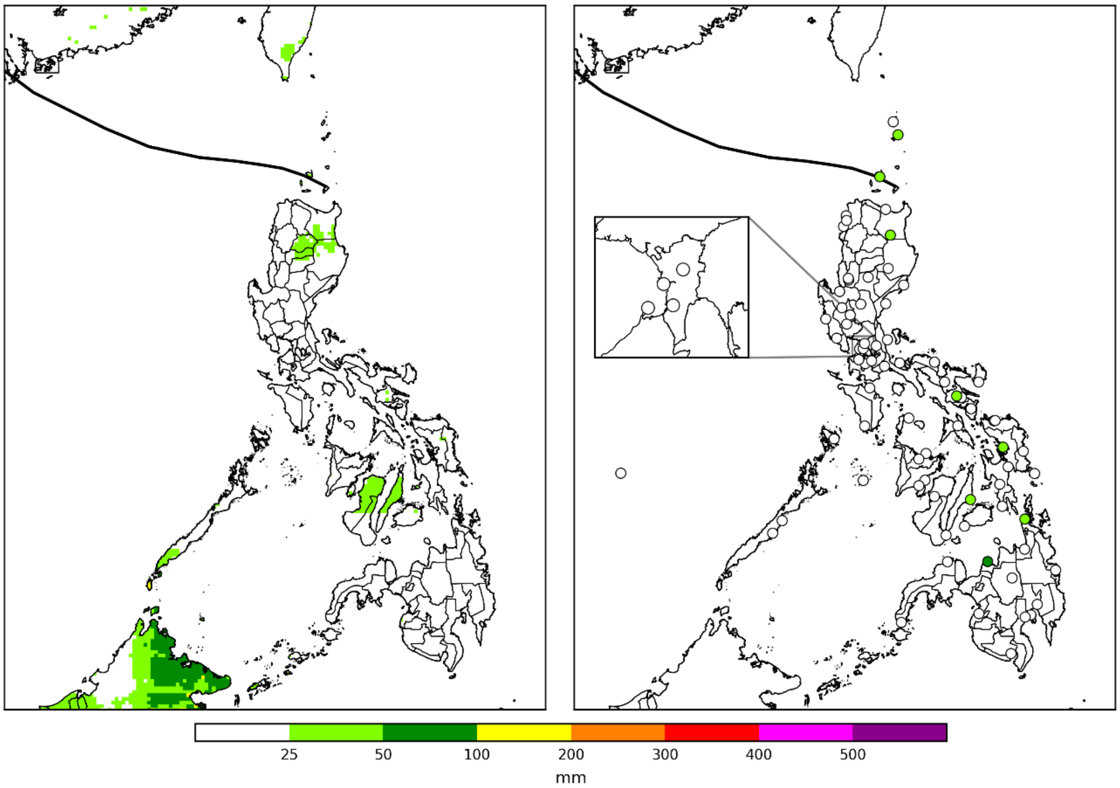
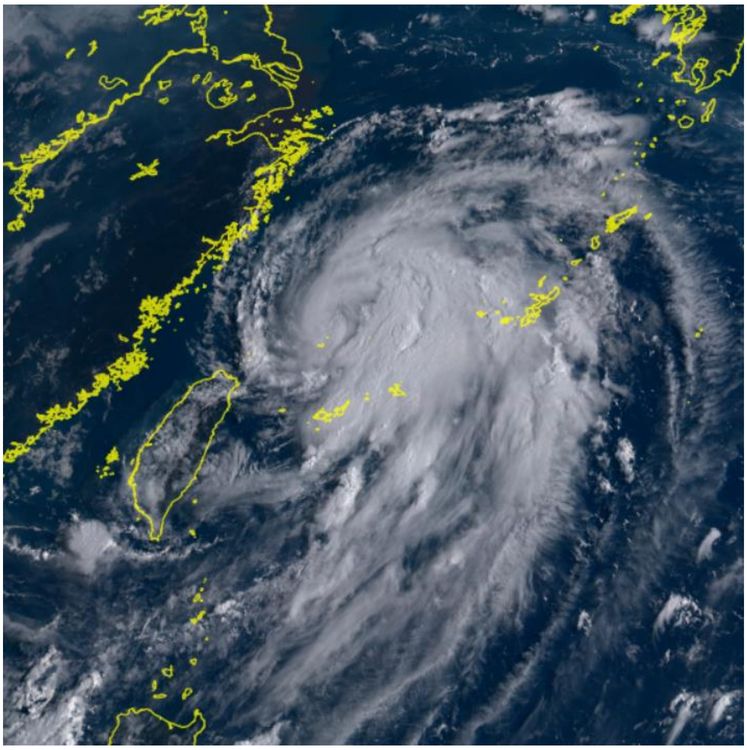


Fig. 4.8.2. Storm duration rainfall over land during the passage of Typhoon Helen within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

Typhoon Igme
Bavi (2008)

21 to 27 August 2020



Basin-wide peak intensity:
Typhoon
85 kt (155 km/h)
945 hPa

Developed:
00 UTC, 21 August 2020

Transitioned:
06 UTC, 27 August 2020

Duration within the PAR:
1 day and 11 hours

Peak category within the PAR:
Tropical Storm

Highest wind signal hoisted:
None

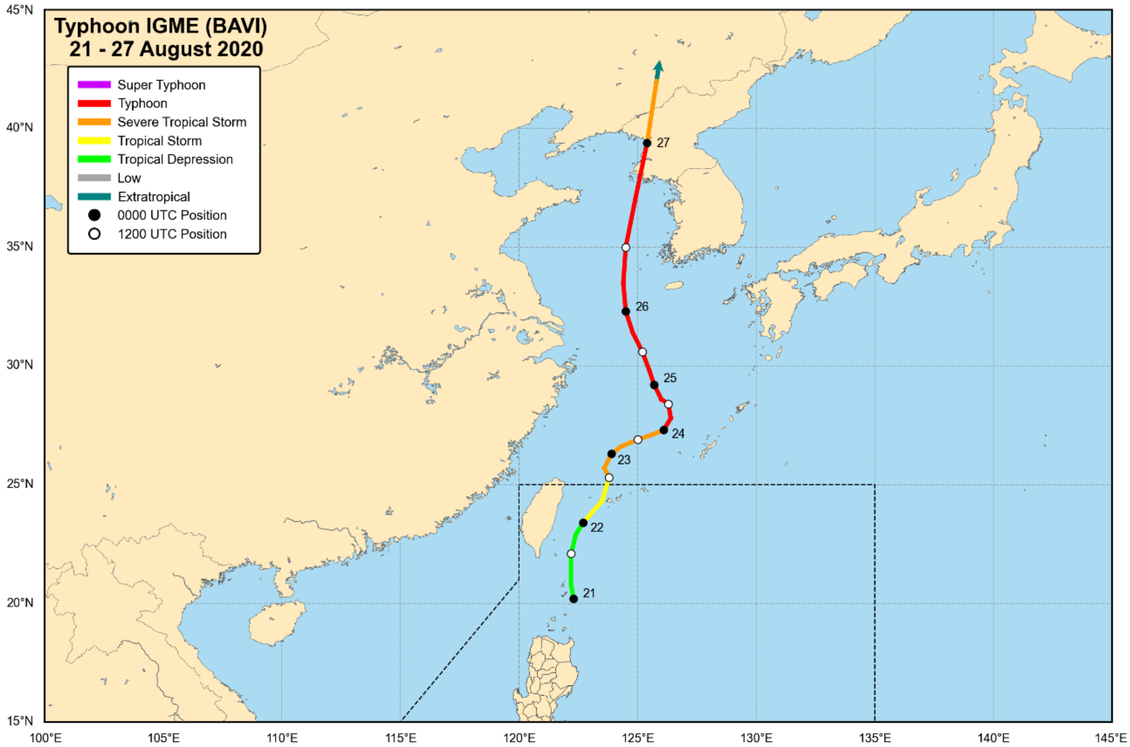


Fig. 4.9.1. Best track position and intensities of Typhoon Igme.

Meteorological History

Typhoon Igme developed from an area of low pressure which developed over the waters north of Chuuk in the Federated States of Micronesia on 15 August. This weather disturbance initially tracked westward for 4 days and generally northwestward thereafter as it neared the Philippine archipelago. At 00 UTC on 21 August, while over the waters east of Batanes, the low pressure area developed into Tropical Depression Igme. A period of rapid intensification ensued beginning 12 UTC of the same day in the presence of favorable conditions. Igme was upgraded into a tropical storm at 00 UTC on 22 August and into a severe tropical storm 12 hours later.

Initially tracking northward on 21 August, Igme turned more north northeastward the following day as it neared the Yaeyama Islands in the southern Ryukyu archipelago. At around 06 UTC on 22 August, Igme passed close to Taketomi Island, one of the islands in the Yaeyama group. The tropical cyclone exited the PAR region at 11 UTC on the same day.

On 23 August, Igme turned more east northeastward over the East China Sea. During the same period, its intensification also significantly slowed. The cyclone reached typhoon category at 00 UTC on 24 August as it began turning north northwestward. Further intensification still ensued, although at a modest pace, with Igme reaching a peak intensity of 85 kt and 945 hPa at 18 UTC on 25 August. The typhoon then started turning north northeastward the following day and at 12 UTC on 26 August, it entered the Yellow Sea. During the same period, the typhoon encountered very hostile environmental condition, triggering its post-tropical transition.

At around 2020 UTC on 26 August, Igme made landfall in the vicinity of Onggjin County in the South Hwanghae Province of North Korea. For the next several hours, the cyclone tracked further inland over the western portion of North Korea while undergoing post-tropical transition. PAGASA last tracked Igme at 06 UTC on 27 August when it became a post-tropical system.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (21 to 22 August 2020) rainfall over land:

- Basco, Batanes: 72.1 mm
- Francisco Bangoy International Airport, Davao City: 64.2 mm
- Laoag City, Ilocos Norte: 60.3 mm
- Itbayat, Batanes: 39.0 mm
- Los Baños, Laguna: 38.8 mm

Highest 24-hour rainfall over land:

- Francisco Bangoy International Airport, Davao City: 64.0 mm, 21 August 2020
- Basco, Batanes: 53.4 mm, 21 August 2020
- Laoag City, Ilocos Norte: 44.8 mm, 21 August 2020
- Los Baños, Laguna: 38.8 mm, 22 August 2020
- Cotabato City: 34.9 mm, 21 August 2020

Lowest sea level pressure over land:

- Baguio City: 1006.9 hPa, 0600 UTC, 21 August 2020
- Basco, Batanes: 1006.9 hPa, 0900 UTC, 21 August 2020
- Aparri, Cagayan: 1007.6 hPa, 0600 UTC, 21 August 2020
- Tuguegarao City, Cagayan: 1007.6 hPa, 0600 UTC, 21 August 2020
- Calayan, Cagayan: 1007.7 hPa, 0600 UTC, 21 August 2020
- Casiguran, Aurora, 1008.1 hPa, 0600 UTC, 21 August 2020
- Baler, Aurora: 1008.2 hPa, 0600 UTC, 21 August 2020

Highest peak gust over land:

Iba, Zambales: SE (130°) at 25.3 kt (13 m/s), 0326 UTC, 21 August 2020

Summary of Warning Information

Number of public TC products issued: **13**

- Severe Weather Bulletins: **4**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **9**

Number of TC Warning for Shipping issued: **5**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

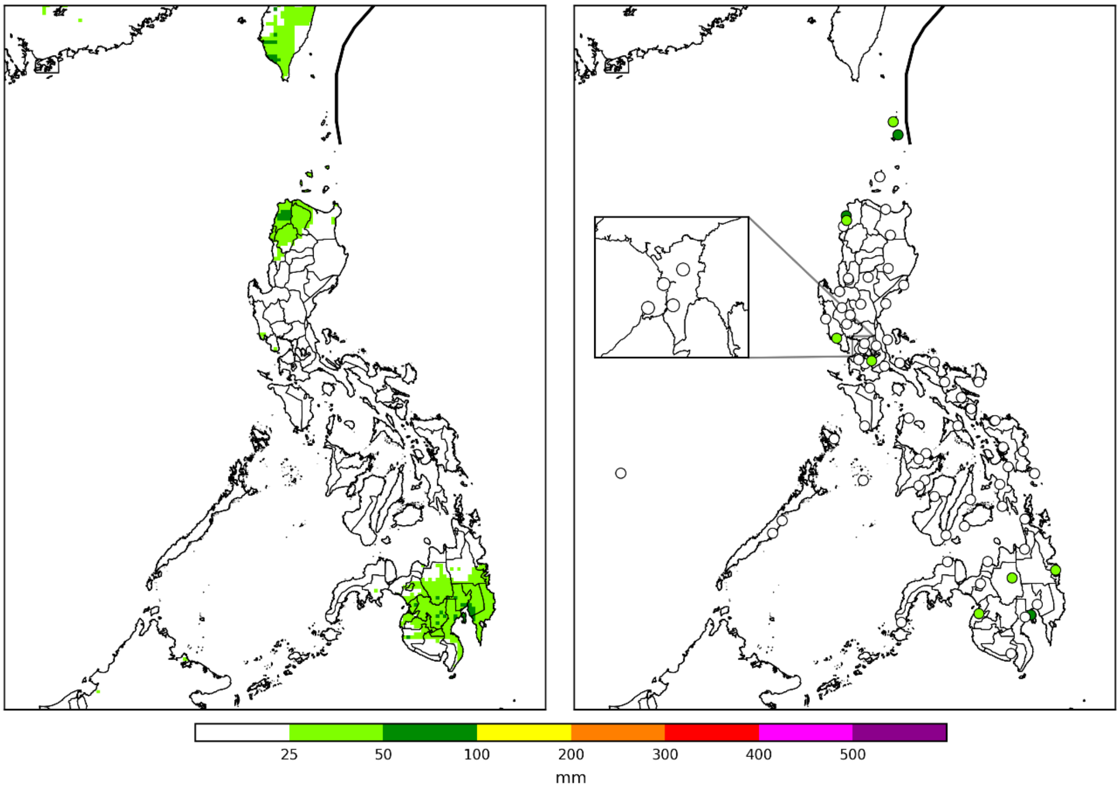
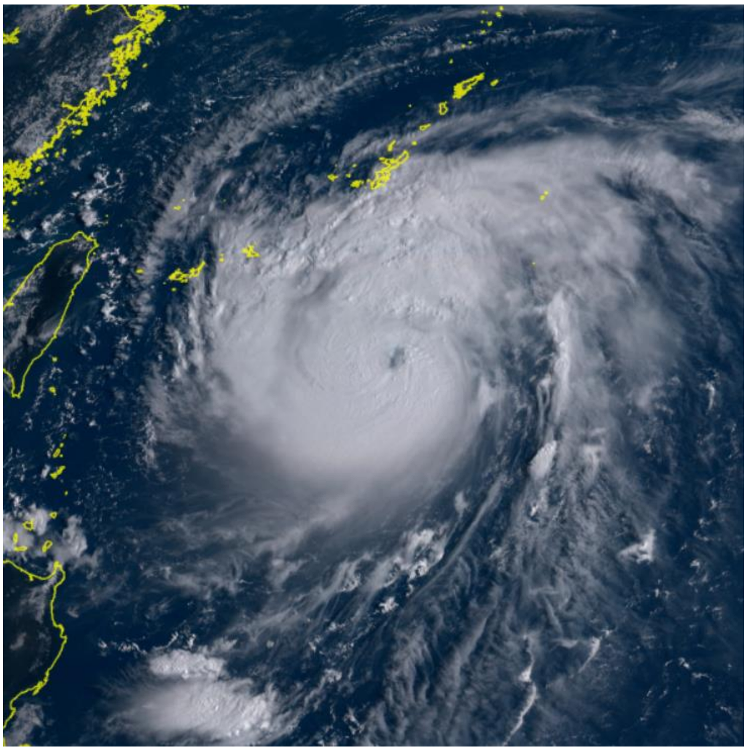


Fig. 4.9.2. Storm duration rainfall over land during the passage of Typhoon Igme within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

Typhoon Julian
Maysak (2009)

27 August to
03 September 2020



Basin-wide peak intensity:
Typhoon
95 kt (175 km/h)
935 hPa

Developed:
06 UTC, 27 August 2020

Transitioned:
06 UTC, 03 September 2020

Duration within the PAR:
4 days and 7 hours

Peak category within the PAR:
Typhoon

Highest wind signal hoisted:
None

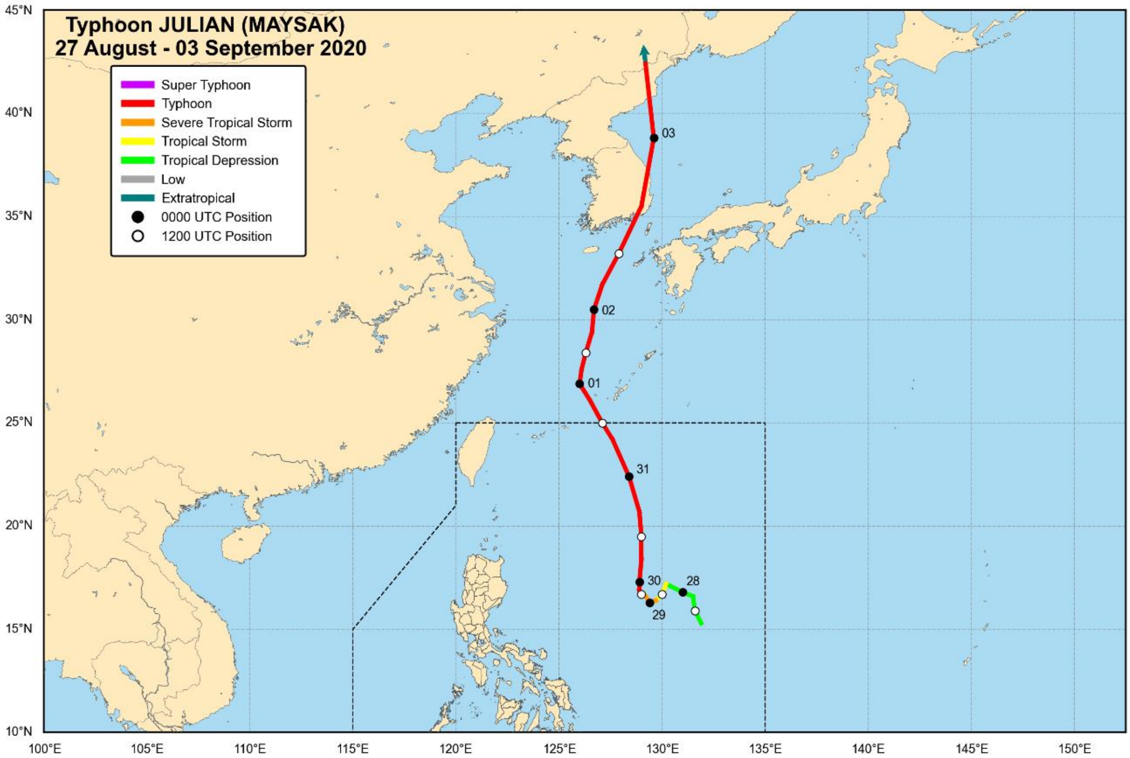


Fig. 4.10.1. Best track position and intensities of Typhoon Julian.

Meteorological History

The precursory disturbance of Typhoon Julian formed over the waters east of Northern Marianas on 23 August. This low pressure area entered the PAR region on 26 August and developed into a tropical depression at 06 UTC of the following day. Over the next 3 days, Julian tracked slowly and erratically (which was also accompanied by periods of being quasi-stationary) while substantially intensifying. On 28 August, the depression started to rapidly intensify in the presence of conducive environment. Julian reached tropical storm category at 06 UTC of the same day and severe tropical storm category 12 hours later. At 12 UTC on 12 August, the tropical cyclone was further upgraded to typhoon status.

On 30 August, Julian began accelerating northward in the presence of a subtropical ridge to its east. With warm waters and favorable atmospheric conditions on its path, the typhoon continued to intensify. Julian turned northwestward on 31 August as it tracked closer to the Ryukyu Islands, Japan. The typhoon exited the northern limit of the PAR region at 13 UTC of the same day and reached its peak intensity of 95 kt and 935 hPa roughly 5 hours later while passing close to Kume Island in the Ryukyu archipelago. Julian held its peak intensity onto the following day as it began turning north northeastward over the East China Sea.

Typhoon Julian entered a weakening trend by 02 September as it moved over less conducive environment near the Korean Peninsula. After passing over the waters east of Jeju, the eye of the typhoon made landfall near Busan City, South Korea at 1720 UTC of the same day. It briefly emerged over the Sea of Japan on 03 September, turned more northward, and made its final landfall in Hwadae County of North Korea's North Hamgyong Province. Julian transitioned into a post-tropical cyclone over Jilin Province in northeastern China at 06 UTC on 03 September.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (27 to 31 August 2020) rainfall over land:

- Calayan, Cagayan: 122.2 mm
- Baybay City, Leyte: 83.5 mm
- Iba, Zambales: 81.8 mm
- Laoag City, Ilocos Norte: 76.0 mm
- Malaybalay, Bukidnon: 75.6 mm

Highest 24-hour rainfall over land:

- Calayan, Cagayan: 83.6 mm, 31 August 2020
- Malaybalay, Bukidnon: 65.2 mm, 27 August 2020
- La Trinidad, Benguet: 63.2 mm, 30 August 2020
- Iba, Zambales: 61.2 mm, 30 August 2020
- Baybay City, Leyte: 52.2 mm, 27 August 2020

Summary of Warning Information

Number of public TC products issued: **23**

- Severe Weather Bulletins: **11**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **12**

Number of TC Warning for Shipping issued: **15**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**

Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

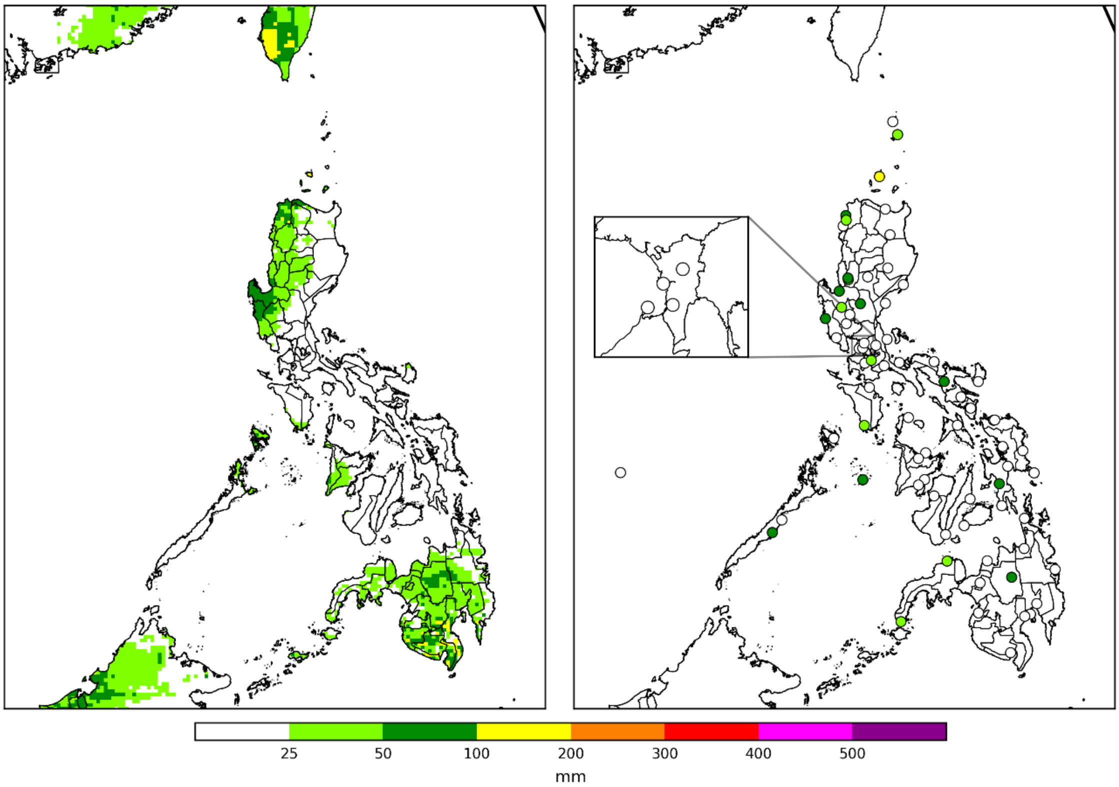
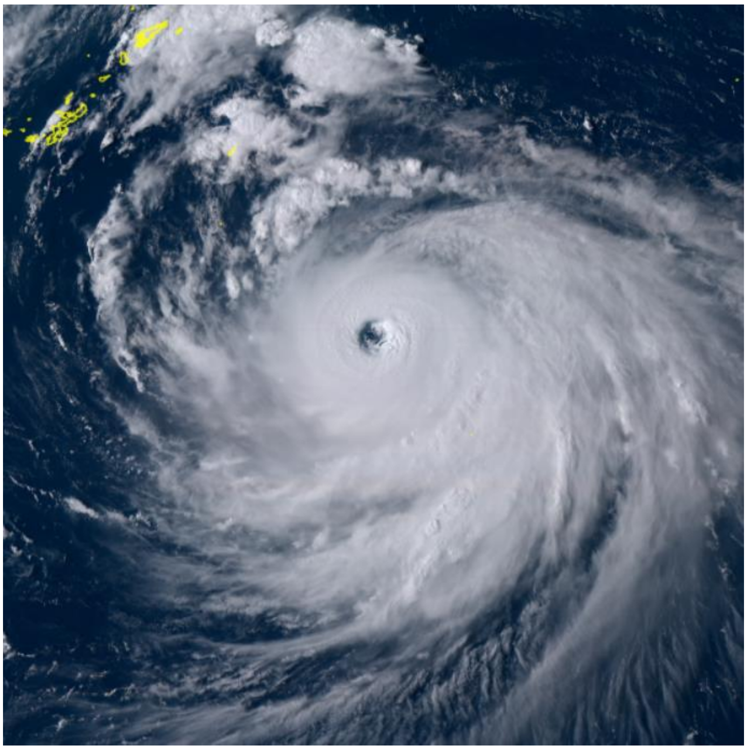


Fig. 4.10.2. Storm duration rainfall over land during the passage of Typhoon Julian within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line on the upper right corner of each panel.

Super Typhoon Kristine
Haishen (2010)

31 August to
07 September 2020



Basin-wide peak intensity:
Super Typhoon
105 kt (195 km/h)
910 hPa

Developed:
00 UTC, 31 August 2020

Transitioned:
18 UTC, 07 September 2020

Duration within the PAR:
1 day and 9 hours

Peak category within the PAR:
Super Typhoon

Highest wind signal hoisted:
None

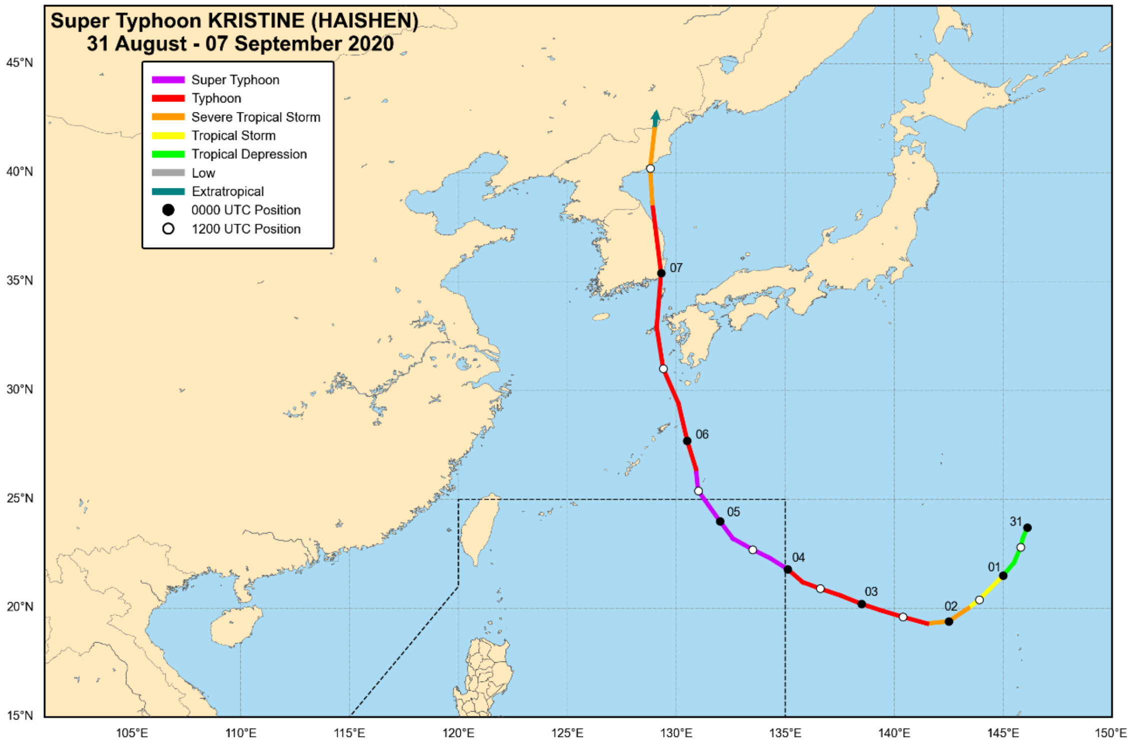


Fig. 4.11.1. Best track position and intensities of Super Typhoon Kristine.

Meteorological History

The origin of the second most intense tropical cyclone to occur within the PAR region can be traced as a tropical disturbance situated more than 500 km southeast of Ogasawara Islands. Tracking generally southwestward, the disturbance developed into a tropical depression at 00 UTC on 31 August and was further upgraded into tropical storm category 24 hours later. As it continued its southwestward motion, Haishen, as it was referred to prior to entry to the PAR region, began to rapidly intensify. It reached severe tropical storm category at 18 UTC on 01 September and became a typhoon at 06 UTC of the following day, just as it began turning west northwestward. On 03 September, after undergoing a short period of eyewall replacement which tapered off its intensification rate, the typhoon resumed its rapid intensification. Haishen reached super typhoon category at 00 UTC on 04 September and entered the PAR region an hour later – making it the first super typhoon with the PAR region for the 2020 season.

Within the PAR region, Kristine, as it was named by PAGASA, tracked generally northwestward and remained far from the Philippine landmass. At 12 UTC on 04 September, the super typhoon reached a peak intensity of 105 kt and 910 hPa. As the super typhoon moved over colder subtropical waters, it started to weaken, albeit slowly. Kristine left the PAR region at 10 UTC on 05 September just as it started turning north northwestward towards the northern Ryukyu archipelago of Japan.

Outside the PAR region, the super typhoon continued to weaken with the onset of another eyewall replacement cycle as it neared the Amami and Tokara Islands in the northern Ryukyus. At 18 UTC on 05 September, Kristine was downgraded to typhoon category. At around 0800 UTC of the following day, the center of the eye of the weakening typhoon crossed Kuchinoshima, an island in the Tokara group. Roughly 12 hours later, it made another landfall over Nakadōri Island (part of Gotō Islands) in Japan's Nagasaki Prefecture. At 2120 UTC of the same day, it made its third landfall in the vicinity of Tsushima Island after briefly crossing the Tsushima Strait.

At around 0000 UTC on 07 September, Kristine made another landfall in Ulsan City in South Korea as a 70-kt typhoon. After traversing the rugged terrain of the eastern Korean Peninsula, the tropical cyclone emerged over the Sea of Japan as a severe tropical storm. Kristine made its final landfall at around 1230 UTC on 07 September in the vicinity of Riwŏn County in the South Hamgyŏng Province, North Korea. PAGASA last tracked Kristine at 18 UTC of the same day as it transitioned into a post-tropical cyclone over the nearby North Hamgyŏng Province.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (04 to 05 September 2020) rainfall over land:

- Baler, Aurora: 51.5 mm
- Calayan, Cagayan: 38.8 mm
- Dagupan City, Pangasinan: 30.0 mm
- Infanta, Quezon: 21.3 mm
- Guiuan, Eastern Samar: 19.8 mm

Highest 24-hour rainfall over land:

- Baler, Aurora: 51.5 mm, 04 September 2020
- Calayan, Cagayan: 38.4 mm, 05 September 2020
- Dagupan City, Pangasinan: 30.0 mm, 05 September 2020
- Infanta, Quezon: 21.3 mm, 04 September 2020
- Guiuan, Eastern Samar: 19.8 mm, 05 September 2020

Summary of Warning Information

Number of public TC products issued: **20**

- Severe Weather Bulletins: **4**

- Tropical Cyclone Advisories: **2**
- Tropical Cyclone Updates: **14**

Number of TC Warning for Shipping issued: **7**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

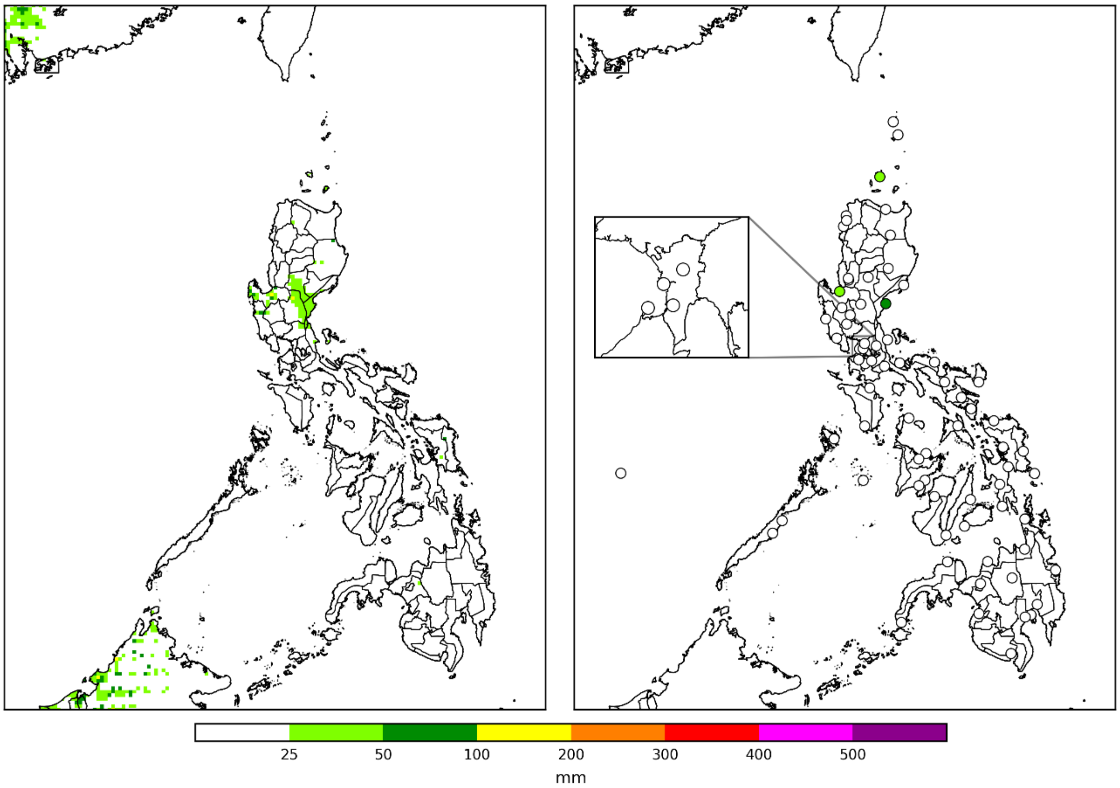
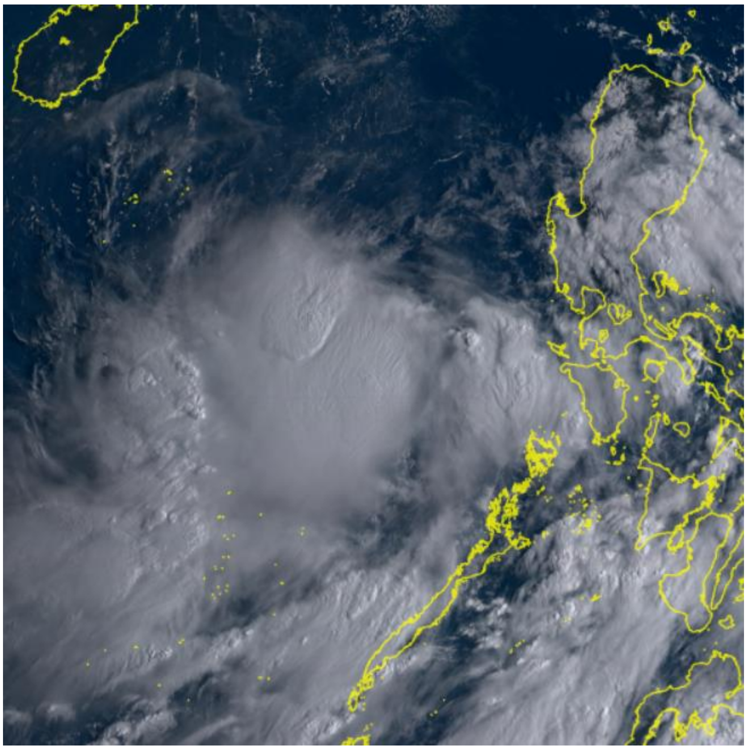


Fig. 4.11.2. Storm duration rainfall over land during the passage of Super Typhoon Kristine within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is outside the domain of this figure.

Tropical Storm Leon
Noul (2011)

15 to 18 September 2020



Basin-wide peak intensity:
Tropical Storm
45 kt (85 km/h)
992 hPa

Developed:
00 UTC, 15 September 2020

Degenerated:
18 UTC, 18 September 2020

Duration within the PAR:
1 day and 20 hours

Peak category within the PAR:
Tropical Storm

Highest wind signal hoisted:
Wind Signal No. 1

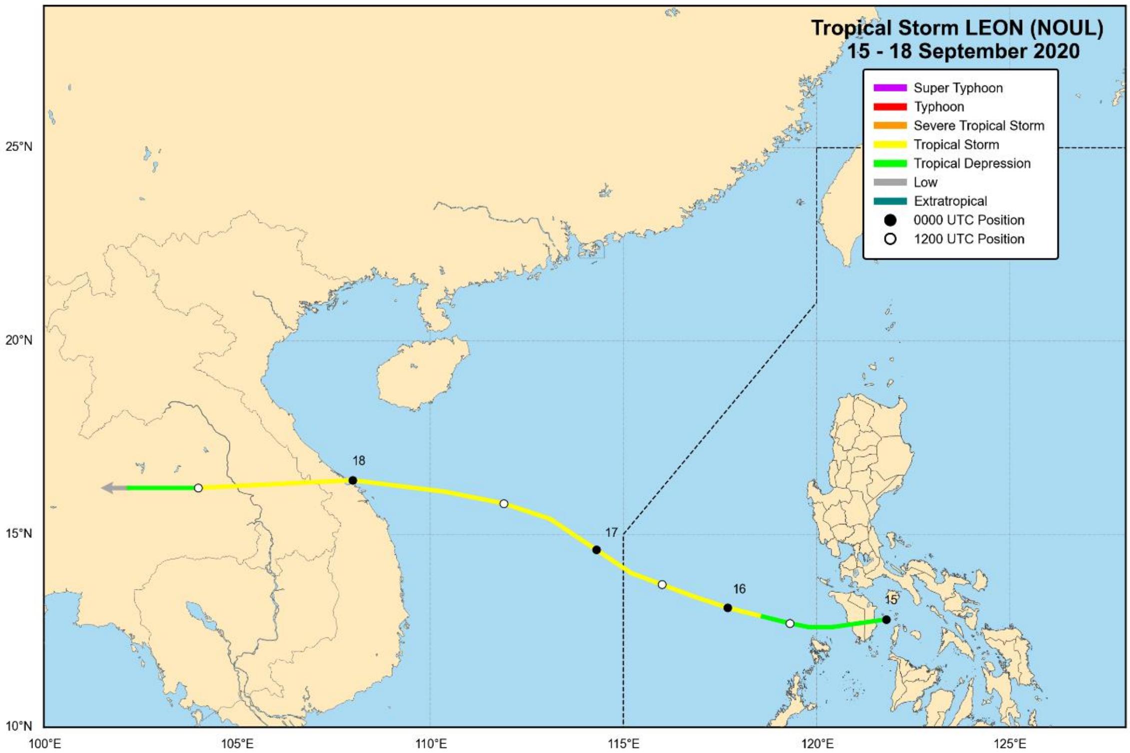


Fig. 4.12.1. Best track position and intensities of Tropical Storm Leon.

Meteorological History

Tropical Storm Leon originated from a tropical disturbance which was first tracked near Palau on 12 September and was first noted as a tropical depression over Tablas Strait between Tablas Island, Romblon and Oriental Mindoro at 00 UTC on 15 September after crossing the central portion of the Philippine archipelago. It shortly made landfall in the vicinity of Bongabong, Oriental Mindoro at 0130 UTC. At 06 UTC of the same day, the depression emerged over the Mindoro Strait. It eventually left the PAR region at around 20 UTC on 16 September.

Leon slowly organized and strengthened as it tracked generally west northwestward over West Philippine Sea. While still inside the PAR, it was upgraded into a tropical storm at 18 UTC on 15 September. It eventually reached a peak intensity of 45 kt and 992 hPa at 06 UTC on 17 September as it headed towards Vietnam. Leon made its final landfall in the vicinity of Thừa Thiên Huế Province in Vietnam at around 0030 UTC on 18 September. The tropical storm rapidly weakened thereafter as it moved westward. Leon was last tracked by PAGASA at 18 UTC on 18 September as it degenerated into a remnant low over Chaiyaphum Province, Thailand.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (15 to 16 September 2020) rainfall over land:

- San Jose, Occidental Mindoro: 203.3 mm
- Casiguran, Aurora: 160.6 mm
- Baler, Aurora: 132.4 mm
- Pag-asa Island, Kalayaan, Palawan: 111.0 mm
- Tacloban City, Leyte: 110.9 mm

Highest 24-hour rainfall over land:

- San Jose, Occidental Mindoro: 137.9 mm, 16 September 2020
- Calapan City, Oriental Mindoro: 103.2 mm, 15 September 2020
- Casiguran, Aurora: 98.0 mm, 15 September 2020
- Maasin City, Aurora: 97.0 mm, 15 September 2020
- Baler, Aurora: 77.0 mm, 15 September 2020

Lowest sea level pressure over land:

- San Jose, Occidental Mindoro:
  - 1003.4 hPa, 0600 UTC, 15 September 2020
  - 1003.4 hPa, 0700 UTC, 15 September 2020
  - 1003.4 hPa, 0800 UTC, 15 September 2020
  - 1003.4 hPa, 0900 UTC, 15 September 2020
- Iba, Zambales: 1004.0 hPa, 2100 UTC, 15 September 2020
- Calapan City, Oriental Mindoro: 1004.1 hPa, 0900 UTC, 15 September 2020
- Pag-asa Island, Kalayaan, Palawan: 1004.3 hPa, 1000 UTC, 15 September 2020
- Tanauan City, Batangas: 1004.3 hPa, 0900 UTC, 15 September
- Ninoy Aquino International Airport, Pasay City: 1004.3 hPa, 0900 UTC, 15 September 2020
- Romblon, Romblon: 1004.3 hPa, 0600 UTC, 15 September 2020
- Roxas City, Capiz: 1004.3 hPa, 0800 UTC, 15 September 2020
- Sangley Pt., Cavite City, Cavite: 1004.3 hPa, 0900 UTC, 15 September 2020
- Subic Bay International Airport, Morong, Bataan: 1004.4 hPa, 0900 UTC, 15 September 2020
- Science Garden, Quezon City: 1004.4 hPa, 0900 UTC, 15 September 2020

Highest peak gust over land:

- Daet, Camarines Norte: E (90°) at 23.3 kt (12 m/s), 0845 UTC, 15 September 2020
- San Jose, Occidental Mindoro:
    - S (170°) at 19.4 kt (10 m/s), 1430 UTC, 15 September 2020
    - E (80°) at 19.4 kt (10 m/s), 2008 UTC, 15 September 2020
- Calapan City, Oriental Mindoro: SE (130°) at 19.4 kt (10 m/s), 1300 UTC, 15 September 2020
- Romblon, Romblon:
    - SSE (160°) at 19.4 kt (10 m/s), 1750 UTC, 15 September 2020
    - S (180°) at 19.4 kt (10 m/s), 2050 UTC, 15 September 2020
- Roxas City, Capiz: SE (140°) at 19.4 kt (10 m/s), 0340 UTC, 15 September 2020
- Tanay, Rizal: NE (40°) at 19.4 kt (10 m/s), 1046 UTC, 15 September 2020
- Puerto Princesa City, Palawan: W (270°) at 19.4 kt (10 m/s), 0502 UTC, 15 September 2020
- Iba, Zambales: SE (130°) at 17.5 kt (9 m/s), 2116 UTC, 15 September 2020
- Subic Bay International Airport, Morong, Bataan: E (90°) at 15.6 kt (8 m/s), 0932 UTC, 15 September 2020

Summary of Warning Information

Number of public TC products issued: **10**

- Severe Weather Bulletins: **5**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **5**

Number of TC Warning for Shipping issued: **6**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

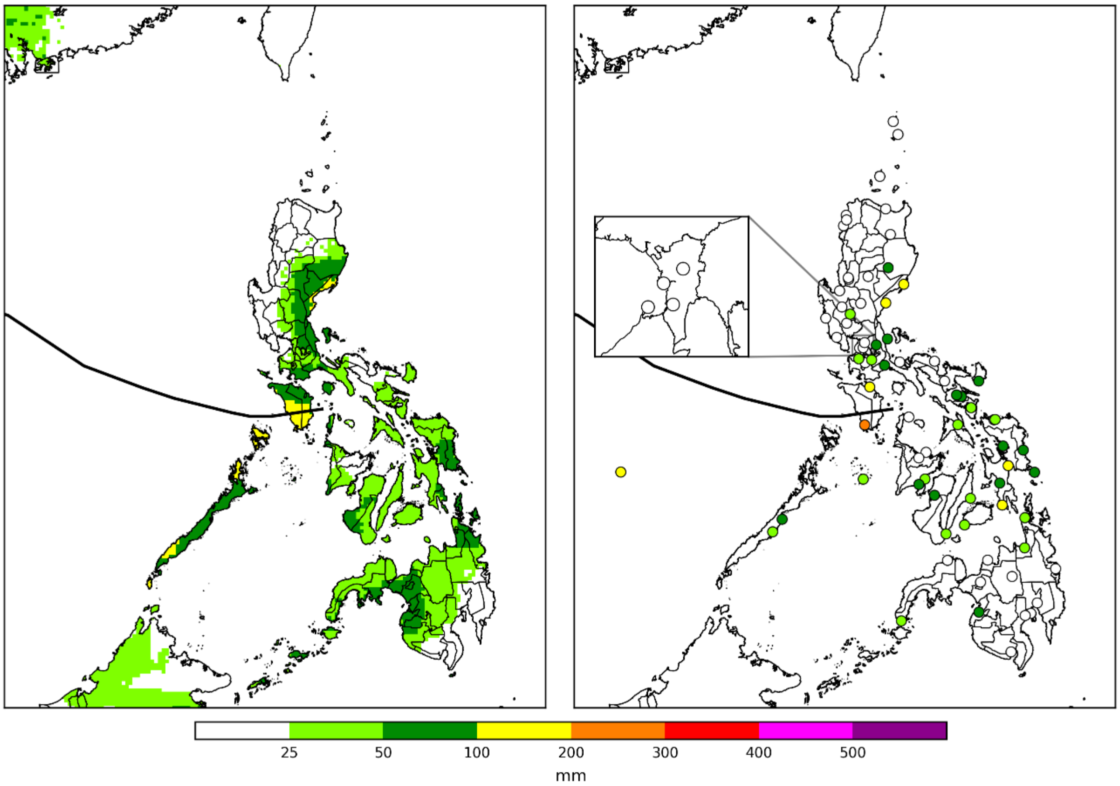


Fig. 4.12.2. Storm duration rainfall over land during the passage of Tropical Storm Leon within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

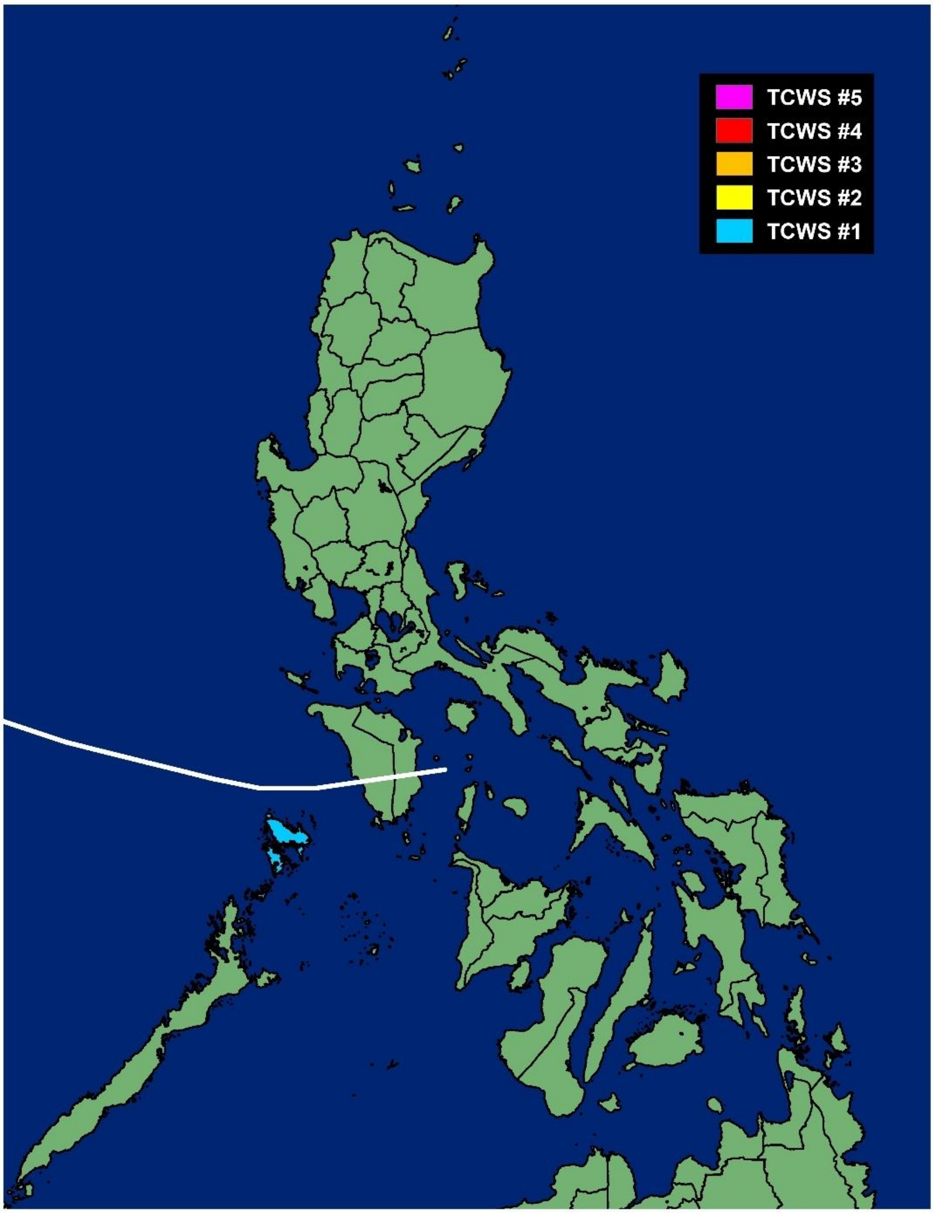
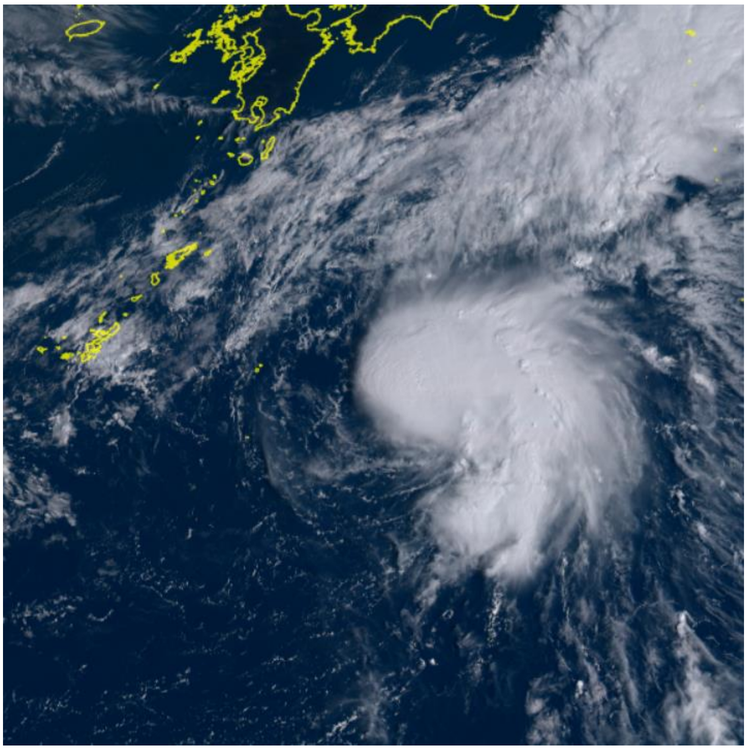


Fig. 4.12.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Tropical Storm Leon. The best track is also overlaid as a solid thick white line.

Severe Tropical Storm Marce
Dolphin (2012)

19 to 24 September 2020



Basin-wide peak intensity:
Severe Tropical Storm
55 kt (100 km/h)
980 hPa

Developed:
12 UTC, 19 September 2020

Degenerated:
06 UTC, 24 September 2020

Duration within the PAR:
1 day and 15 hours

Peak category within the PAR:
Tropical Storm

Highest wind signal hoisted:
None

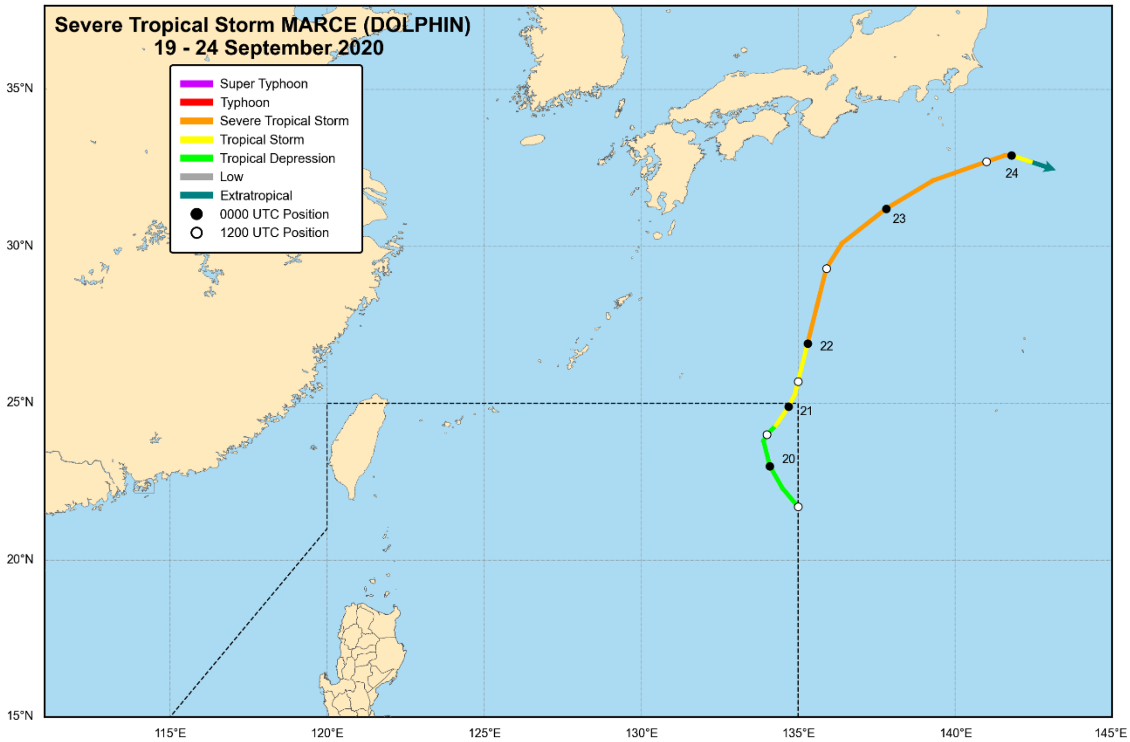


Fig. 4.13.1. Best track position and intensities of Severe Tropical Storm Marce.

Meteorological History

An area of low pressure situated over the far northeastern portion of the PAR region was first tracked as Tropical Depression Marce at 12 UTC on 19 September. Initially tracking north northwestward, the depression turned more north northeastward within 12 hours of formation as it made its way towards the waters south of mainland Japan. Marce was upgraded to tropical storm category at 18 UTC on 20 September and left the PAR region at 03 UTC of the following day.

Outside the PAR region, the tropical storm continued to modestly intensify. It was further upgraded into a severe tropical storm at 00 UTC on 22 September and reached a peak intensity of 55 kt and 980 hPa roughly 6 hours later. Marce eventually turned east northeastward over the waters south of Honshu, Japan and passed close to Aogashima (part of Izu Islands, Japan) between 07 and 08 UTC on 23 September. PAGASA last tracked this weather system at 06 UTC on 24 September as it became a post-tropical cyclone over the waters southeast of Kantō Plain in Honshu.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (19 to 21 September 2020) rainfall over land:

- Catarman (Synoptic), Northern Samar: 132.5 mm
- Catarman (Agromet), Northern Samar: 107.0 mm
- Roxas City, Capiz: 79.0 mm
- Tarlac City, Tarlac: 59.0 mm
- Romblon, Romblon: 56.9 mm

Highest 24-hour rainfall over land:

- Roxas City, Capiz: 75.0 mm, 20 September 2020
- Catarman (Agromet), Northern Samar: 60.5 mm, 20 September 2020
- Tarlac City, Tarlac: 59.0 mm, 20 September 2020
- Catarman (Synoptic), Northern Samar: 46.5 mm, 19 September 2020
- Mambusao, Capiz: 44.0 mm, 20 September 2020

Summary of Warning Information

Number of public TC products issued: **11**

- Severe Weather Bulletins: **3**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **8**

Number of TC Warning for Shipping issued: **4**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

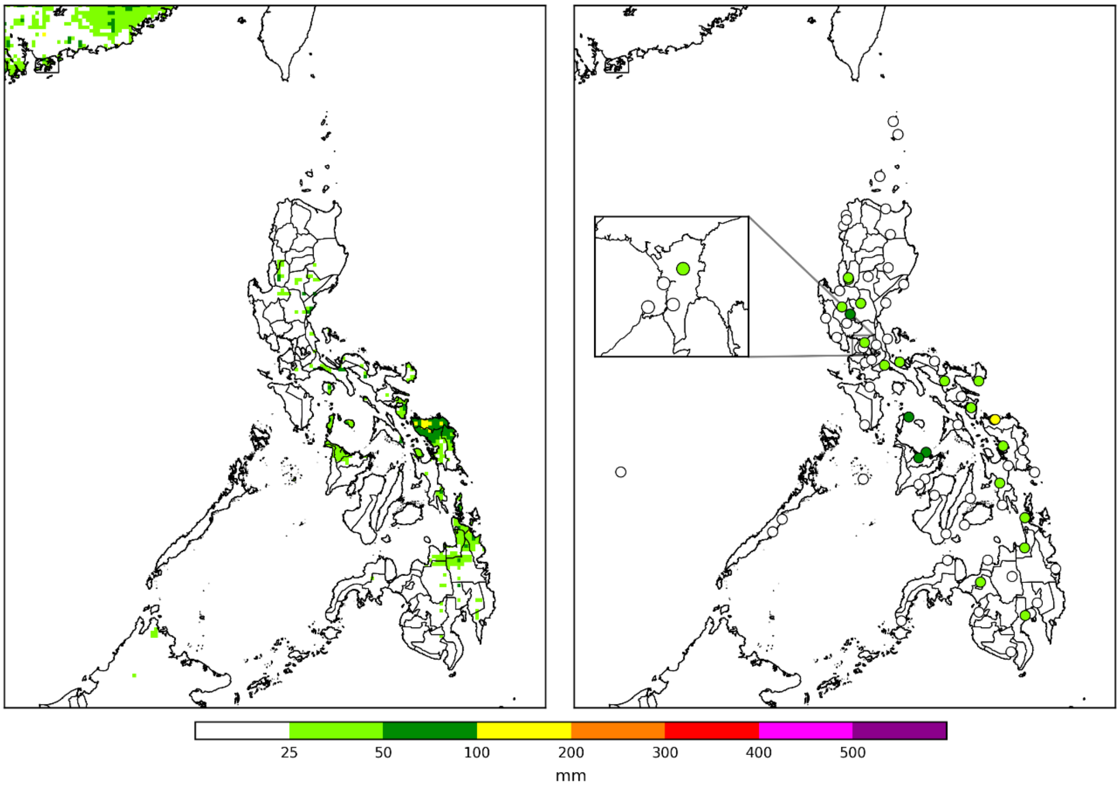
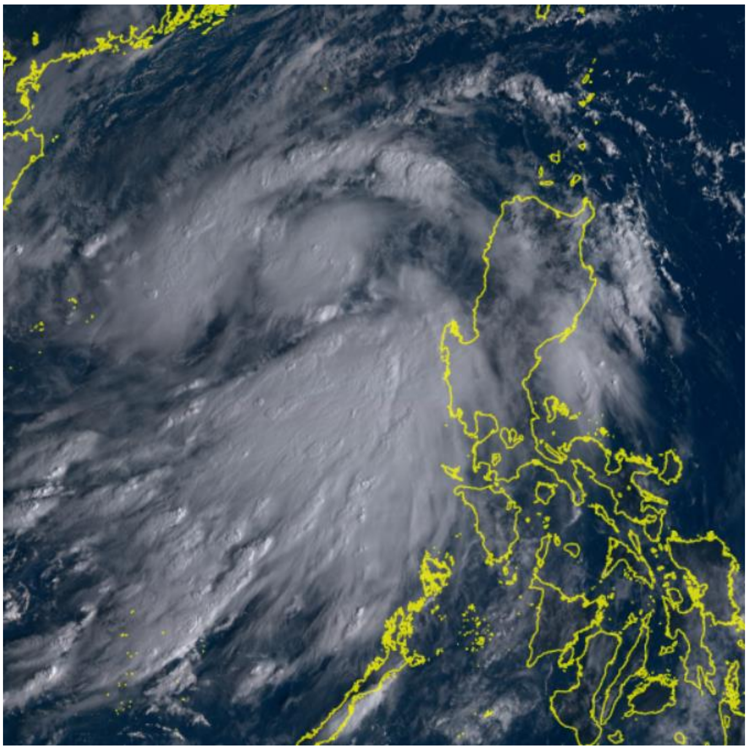


Fig. 4.13.2. Storm duration rainfall over land during the passage of Severe Tropical Storm Marce within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is outside the domain of this figure.

Tropical Storm Nika
Nangka (2016)

11 to 14 October 2020



Basin-wide peak intensity:
Tropical Storm
45 kt (85 km/h)
990 hPa

Developed:
06 UTC, 11 October 2020

Degenerated:
18 UTC, 14 October 2020

Duration within the PAR:
19 hours

Peak category within the PAR:
Tropical Depression

Highest wind signal hoisted:
None

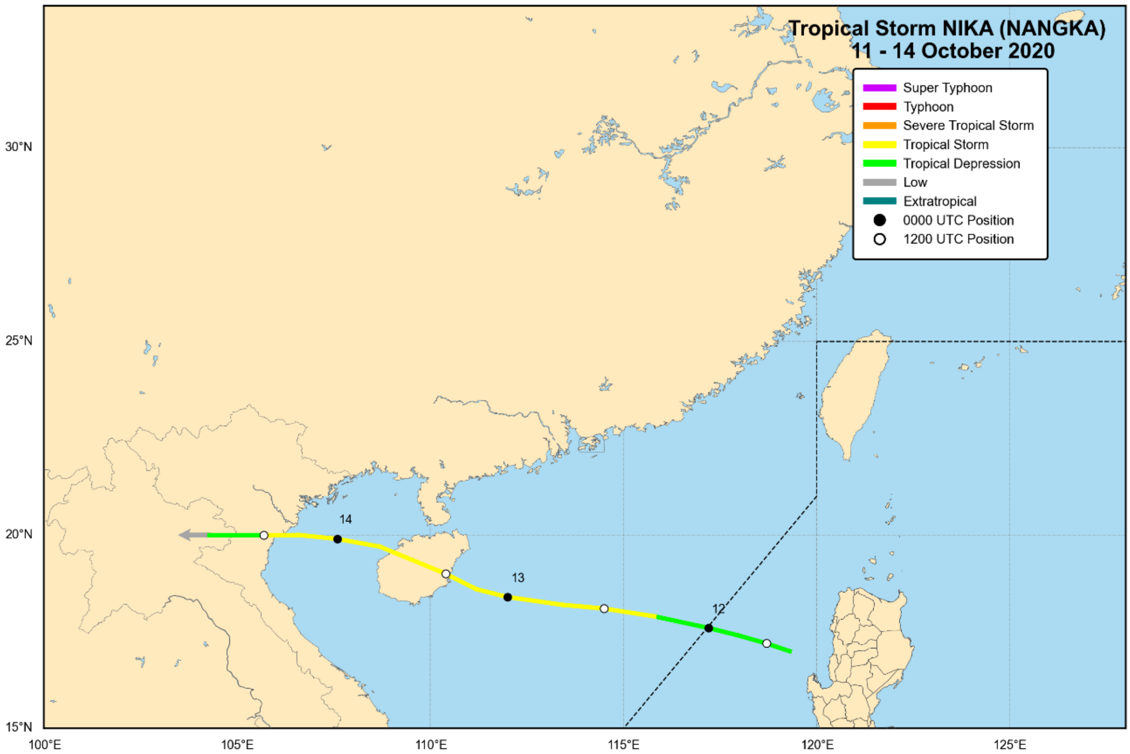


Fig. 4.14.1. Best track position and intensities of Tropical Storm Nika.

Meteorological History

Tropical Storm Nika originated from a tropical disturbance within the monsoon trough which developed over the waters east of Isabela-northern Aurora area on 10 October. After crossing the rugged terrain of Northern Luzon throughout the day, this weather disturbance developed into Tropical Depression Nika at 06 UTC on 11 October over the West Philippine Sea near Lingayen Gulf. Tracking generally west northwestward, the depression exited the PAR region at 01 UTC on 12 October.

Outside the PAR region, Nika continued tracking west northwestward while slowly consolidating. It was upgraded into a tropical storm at 06 UTC on 12 October and reached a peak intensity of 45 kt and 990 hPa shortly before making landfall between the cities of Wanning and Qionghai in Hainan, China at around 1120 UTC on 13 October. A period of gradual weakening ensued, which persisted even as the storm emerged over the Gulf of Tonkin. Nika made its final landfall in the vicinity of Nam Định Province in northern Vietnam at 0900 UTC on 14 October and degenerated into a remnant low while over Houaphanh Province in eastern Laos.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (11 October 2020) rainfall over land:

- Iba, Zambales: 305.4 mm
- Subic Bay International Airport, Mabalacat, Pampanga: 165.5 mm
- Casiguran, Aurora: 107.2 mm
- Camiling, Tarlac: 75.2 mm
- Mactan-Cebu International Airport, Lapu-Lapu City: 49.8 mm

Highest 24-hour rainfall over land:
(Same as above)

Summary of Warning Information

Number of public TC products issued: **6**

- Severe Weather Bulletins: **3**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **3**

Number of TC Warning for Shipping issued: **4**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

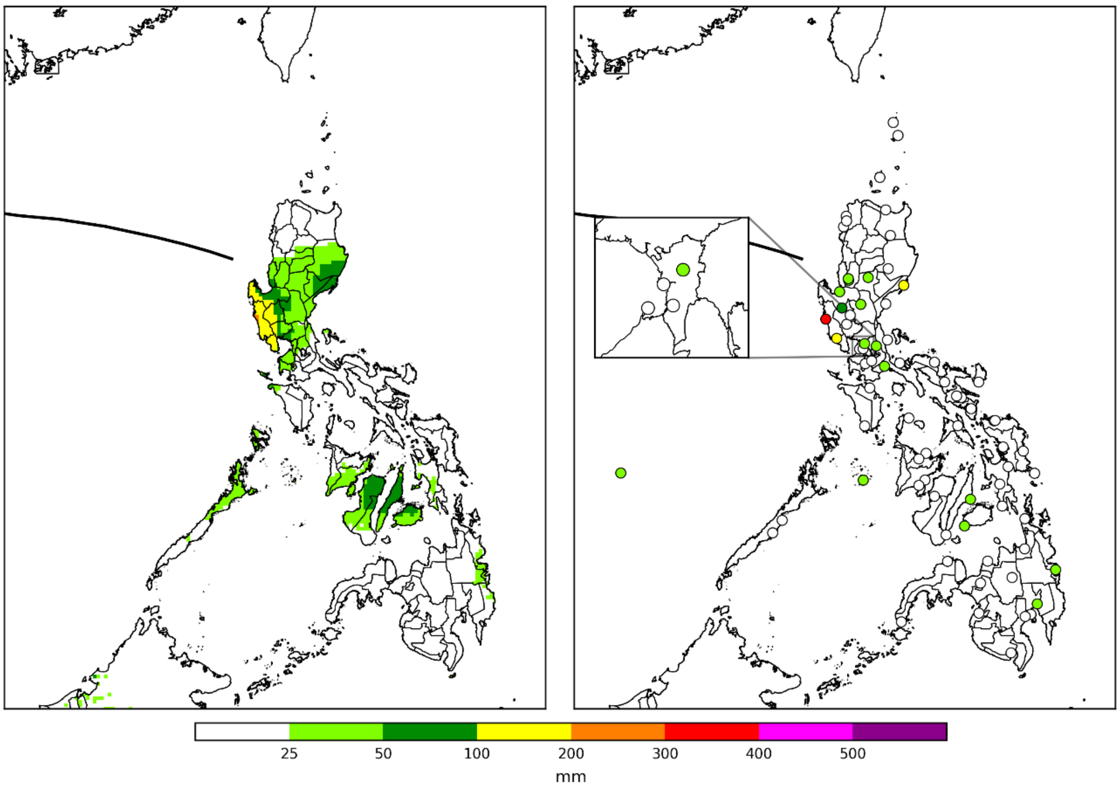
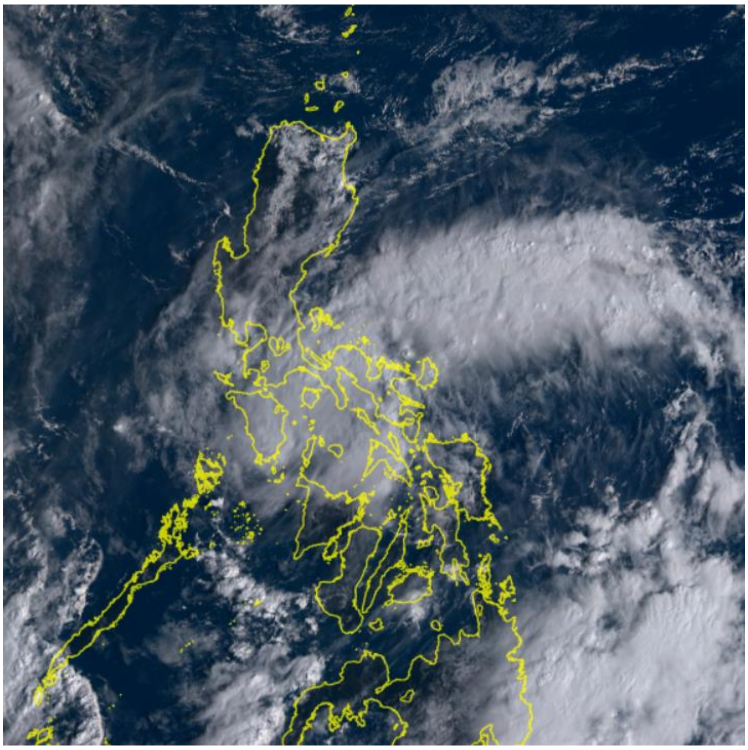


Fig. 4.14.2. Storm duration rainfall over land during the passage of Tropical Storm Nika within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

Tropical Depression Ofel
(Unnamed by RSMC Tokyo)

13 to 16 October 2020



Basin-wide peak intensity:
Tropical Depression
25 kt (45 km/h)
1002 hPa

Developed:
00 UTC, 13 October 2020

Degenerated:
18 UTC, 16 October 2020

Duration within the PAR:
2 days and 13 hours

Peak category within the PAR:
Tropical Depression

Highest wind signal hoisted:
Wind Signal No. 1

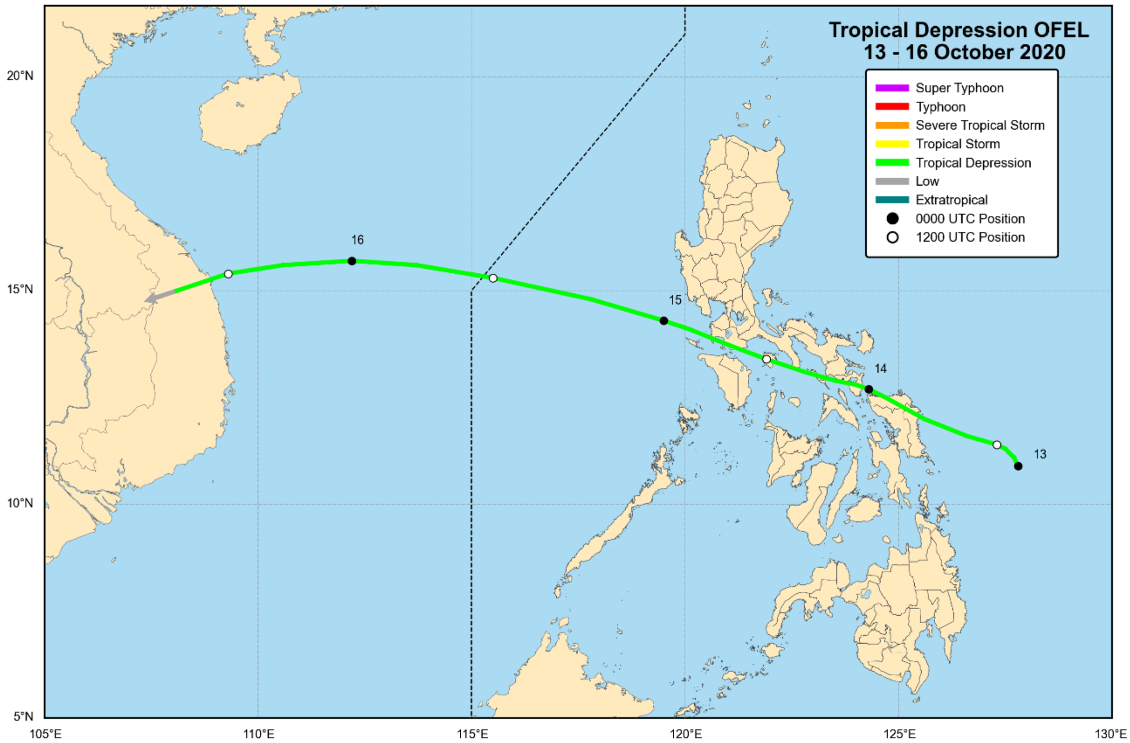


Fig. 4.15.1. Best track position and intensities of Tropical Depression Ofel.

Meteorological History

On 09 October, surface weather charts indicated the formation of a broad tropical disturbance in the middle of the Pacific near the Federated States of Micronesia. Over the next several days, this low pressure area tracked generally westward but remained disorganized. While over the waters east of Eastern Visayas, the disturbance developed into a weak tropical depression named Ofel at 00 UTC on 13 October.

Over the next 48 hours, Ofel tracked generally west northwestward across Eastern Visayas, Southern Luzon, and the inland waters surrounding them, making it the first of the series of four tropical cyclones that will cross the archipelago. It made landfall over the following localities as a weak tropical depression:

- Hilabaan Island, Dolores, Eastern Samar – 1810 UTC, 13 October
- Dolores (mainland), Eastern Samar – 1830 UTC, 13 October
- Biri, Northern Samar – 2300 UTC, 13 October
- Bulusan, Sorsogon – 0240 UTC, 14 October
- Burias Island, San Pascual, Masbate – 0730 UTC, 14 October
- San Francisco, Quezon – 0940 UTC, 14 October
- Torrijos, Marinduque – 1120 UTC, 14 October
- Lobo, Batangas – 1410 UTC, 14 October

At 18 UTC on 14 October, Ofel finally emerged over the Verde Island Passage west of Batangas. Despite the presence of considerable topography, it was able to maintain its circulation throughout its passage, although land interaction prevented it from further consolidating. Ofel continued tracking west northwestward until it left the PAR region at 13 UTC on 15 October.

Outside the PAR region, the tropical depression turned initially westward for the remainder of 15 October before turning more west southwestward the following day as it made its way towards central Vietnam. Ofel made its final landfall near Quảng Ngãi City in the vicinity of Quảng Ngãi Province, Vietnam at around 0300 UTC on 16 October. The depression quickly degenerated and became a remnant low 6 hours later.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (13 to 15 October 2020) rainfall over land:

- Legazpi City, Albay: 215.0 mm
- Pag-asa Island, Kalayaan, Palawan: 193.6 mm
- Daet, Camarines Norte: 190.2 mm
- Baler, Aurora: 187.1 mm
- Alabat, Quezon: 163.7 mm

Highest 24-hour rainfall over land:

- Catarman (Synoptic), Northern Samar: 135.0 mm, 13 October 2020
- Baler, Aurora: 131.3 mm, 14 October 2020
- Legazpi City, Albay: 126.9 mm, 15 October 2020
- Alabat, Quezon: 121.3 mm, 14 October 2020
- Juban, Sorsogon: 106.0 mm, 13 October 2020

Lowest sea level pressure over land:

- Alabat, Quezon: 1003.2 hPa, 0730 UTC, 14 October 2020
- Daet, Camarines Norte: 1003.5 hPa, 0600 UTC, 14 October 2020
- Legazpi City, Albay:
    - 1004.1 hPa, 0600 UTC, 14 October 2020
    - 1004.1 hPa, 0700 UTC, 14 October 2020
- Juban, Sorsogon: 1004.2 hPa, 0600 UTC, 14 October 2020
- Catarman (Synoptic), Northern Samar: 1004.4 hPa, 1900 UTC, 13 October 2020

Highest peak gust over land:

- Daet, Camarines Norte: NNE (20°) at 36.9 kt (19 m/s), 0239 UTC, 14 October 2020
- Iba, Zambales: SE (130°) at 29.2 kt (15 m/s), 0401 UTC, 15 October 2020
- Catarman (Synoptic), Northern Samar: NW (320°) at 27.2 kt (14 m/s), 1850 UTC, 13 October 2020
- Tanay, Rizal: NE (50°) at 25.3 kt (13 m/s), 1212 UTC, 14 October 2020
- Romblon, Romblon: SSW (210°) at 23.3 kt (12 m/s), 1759 UTC, 14 October 2020

Summary of Warning Information

Number of public TC products issued: **23**

- Severe Weather Bulletins: **17**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **6**

Number of TC Warning for Shipping issued: **11**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **PHP 1,346,097.90**

- Damage to agriculture: **PHP 1,346,097.90**
- Damage to infrastructure: **None reported**

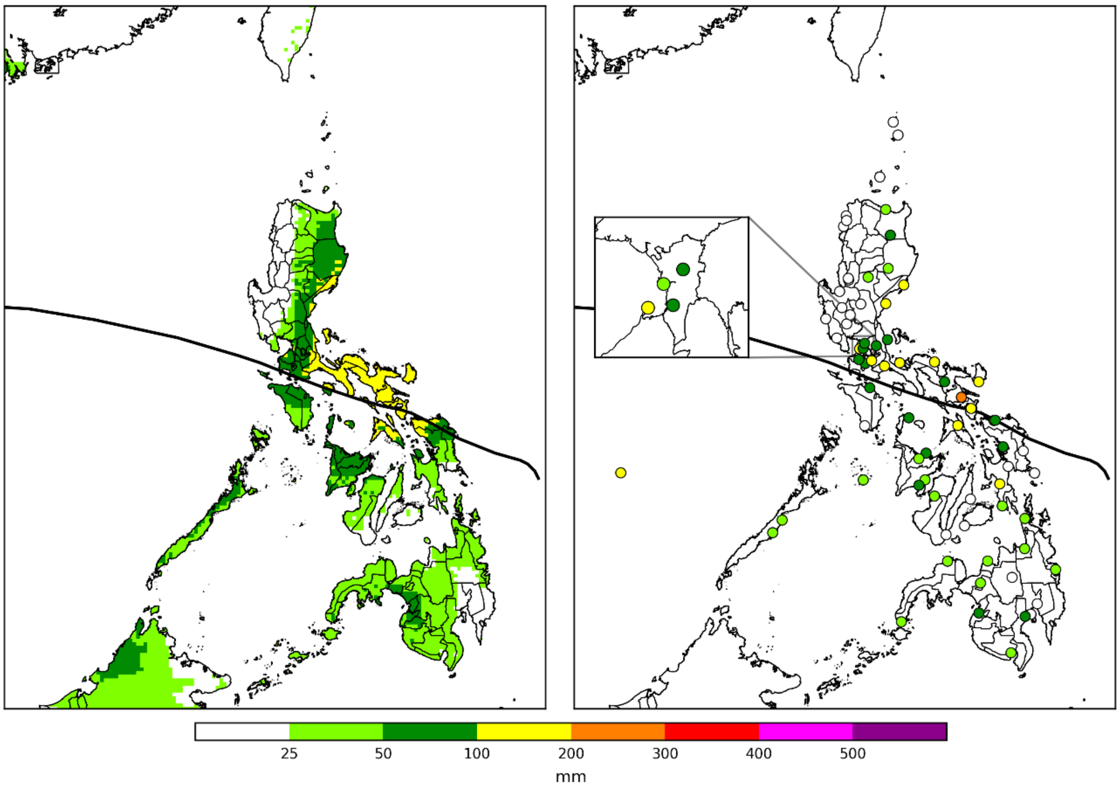


Fig. 4.15.2. Storm duration rainfall over land during the passage of Tropical Depression Ofel within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

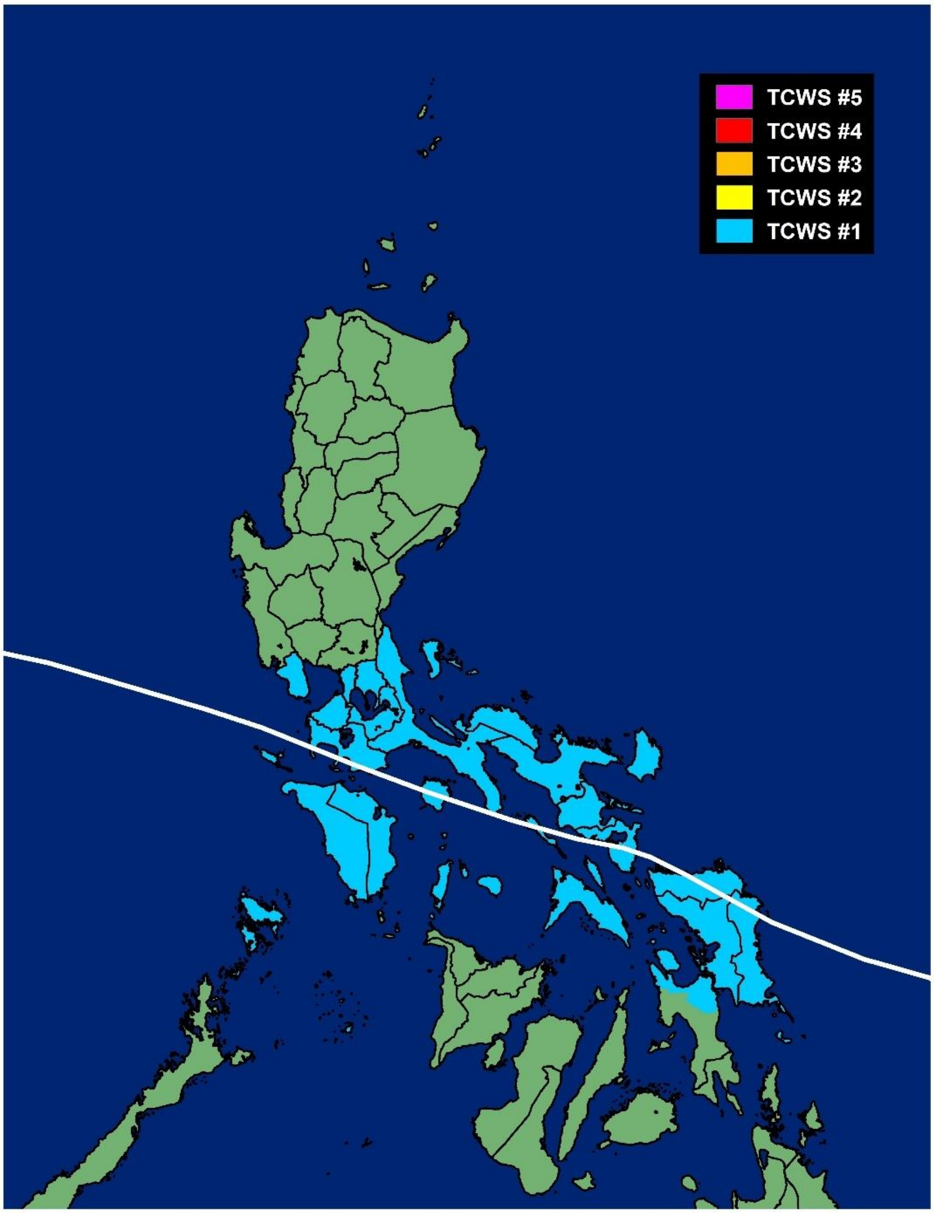
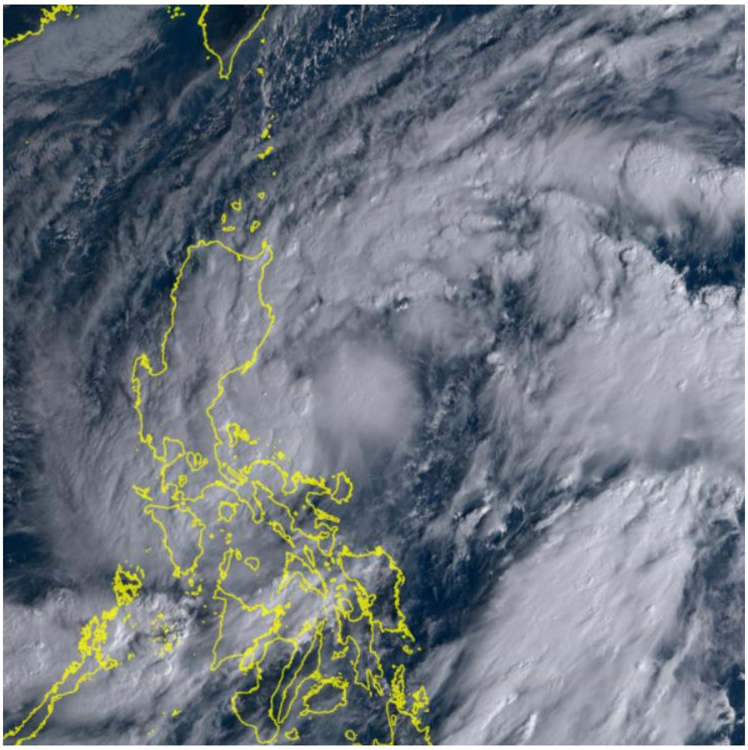


Fig. 4.15.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Tropical Depression Ofel. The best track is also overlaid as a solid thick white line.

Typhoon Pepito
Saudel (2017)

18 to 25 October 2020



Basin-wide peak intensity:
Typhoon
65 kt (120 km/h)
975 hPa

Developed:
18 UTC, 18 October 2020

Degenerated:
18 UTC, 25 October 2020

Duration within the PAR:
3 days and 8 hours

Peak category within the PAR:
Severe Tropical Storm

Highest wind signal hoisted:
Wind Signal No. 2

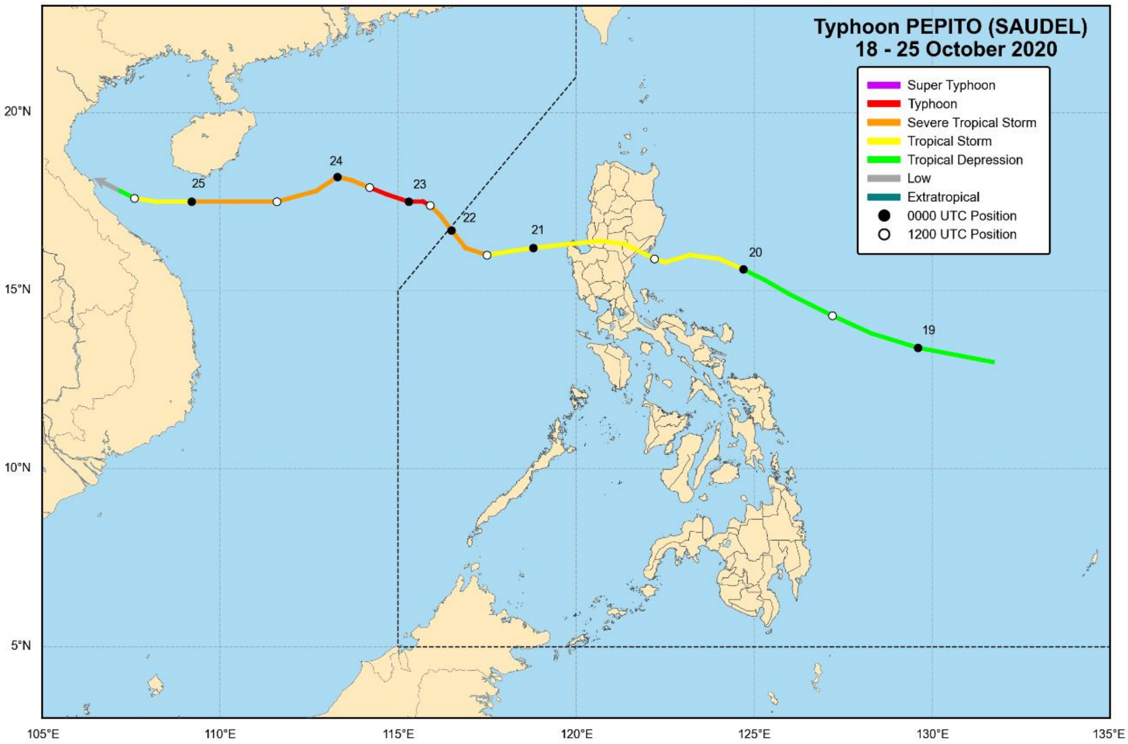


Fig. 4.16.1. Best track position and intensities of Typhoon Pepito

Meteorological History

Typhoon Pepito was first tracked on 14 October as an area of low pressure over the waters of Chuuk in the Federated States of Micronesia. This weather disturbance tracked generally westward over the Pacific waters for the next 5 days and entered the PAR region on 18 October. After gradually consolidating for the past several days, the low pressure area developed into Tropical Depression Pepito at 18 UTC on 18 October.

The newly formed cyclone tracked west northwestward initially as it moved over the Philippine Sea east of Luzon. It was eventually upgraded into a tropical storm at 00 UTC on 20 October as it continued to intensify while nearing Northern Luzon. Pepito crossed the southern tip of San Ildefonso Peninsula in Casiguran, Aurora at 1300 UTC on 20 October and made landfall in the vicinity of Dinalungan, Aurora at 1330 UTC. Over the next several hours, the storm traversed the mountainous terrain of Northern Luzon while maintaining its strength. After emerging over the Lingayen Gulf at around 1900 UTC of the same day, Pepito made its final landfall over Anda in the northwestern portion of Pangasinan at 2000 UTC. It eventually emerged over the waters west of Pangasinan roughly 1 hour later.

Now tracking almost west southwestward, Pepito resumed intensifying over the West Philippine Sea. As it turned northwestward, it was further upgraded into a severe tropical storm. Pepito exited the PAR region at 02 UTC on 22 October. Outside the PAR, the storm continued to gradually intensify while tracking generally northwestward. It reached typhoon category at 12 UTC on the same day and peaked at 65 kt and 975 hPa. It maintained its peak intensity for roughly 24 hours as it tracked towards the waters southeast of Hainan, China before starting to weaken, although it was able to remain as a severe tropical storm for 36 hours.

After a brief southwestward movement early on 24 October, Pepito tracked westward over the waters south of Hainan and the mouth of the Gulf of Tonkin. Increasingly unfavorable environment around the Gulf of Tonkin area caused the storm to rapidly weaken by 25 October. Pepito was further downgraded to tropical depression category at 12 UTC on 25 October and degenerated into a remnant low 6 hours later while still over the waters east of Quảng Bình Province in northern Vietnam.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (18 to 21 October 2020) rainfall over land:

- Alabat, Quezon: 216.5 mm
- Cuyo, Palawan: 211.2 mm
- Subic Bay International Airport, Morong, Bataan: 157.8 mm
- Pili, Camarines Sur: 142.7 mm
- Daet, Camarines Norte: 128.0 mm

Highest 24-hour rainfall over land:

- Cuyo, Palawan: 150.2 mm, 19 October 2020
- Pili, Camarines Sur: 101.6 mm, 19 October 2020
- Alabat, Quezon: 99.9 mm, 19 October 2020
- Baler, Aurora: 94.0 mm, 20 October 2020
- Roxas City, Capiz: 89.0 mm, 19 October 2020

Lowest sea level pressure over land:

- Baguio City: 996.4 hPa, 2000 UTC, 20 October 2020
- Baler, Aurora: 997.4 hPa, 1200 UTC, 20 October 2020
- Casiguran, Aurora: 997.7 hPa, 1100 UTC, 20 October 2020
- Sinait, Ilocos Sur: 997.8 hPa, 2000 UTC, 20 October 2020
- Laoag City, Ilocos Norte: 998.1 hPa, 2100 UTC, 20 October 2020

Highest peak gust over land:

- Subic Bay International Airport, Morong, Bataan: S (170°) at 44.7 kt (23 m/s), 0952 UTC, 21 October 2020
- Iba, Zambales: S (180°) at 42.8 kt (22 m/s), 0555 UTC, 21 October 2020
- Baler, Aurora: WNW (290°) at 38.9 kt (20 m/s), 0900 UTC, 20 October 2020
- Ninoy Aquino International Airport, Pasay City: E (90°) at 38.9 kt (20 m/s), 1744 UTC, 20 October 2020
- Baguio City: 36.9 kt (19 m/s), between 2200 and 2300 UTC, 20 October 2020
- Casiguran, Aurora: NE (40°) at 35.0 kt (18 m/s), 1345 UTC, 20 October 2020

Summary of Warning Information

Number of public TC products issued: **30**

- Severe Weather Bulletins: **19**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **11**

Number of TC Warning for Shipping issued: **14**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **PHP 105,817,126.00**

- Damage to agriculture: **PHP 76,577,126.00**
- Damage to infrastructure: **PHP 29,240,000.00**

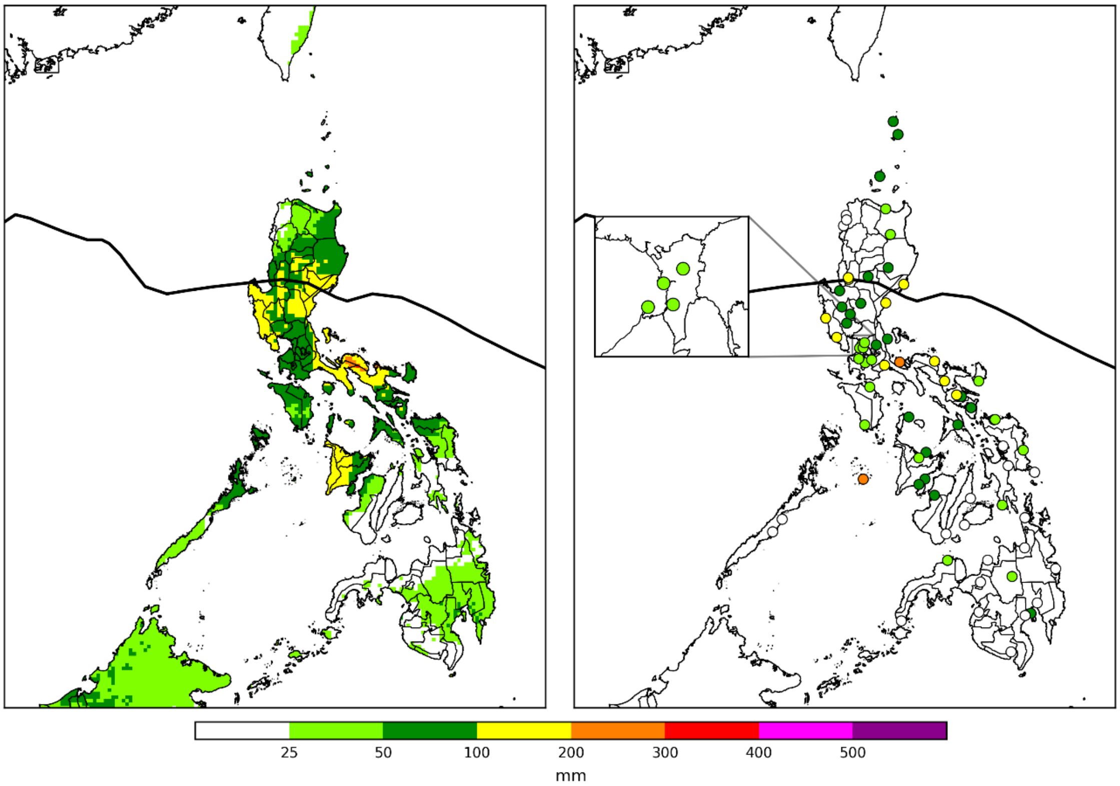


Fig. 4.16.2. Storm duration rainfall over land during the passage of Typhoon Pepito within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

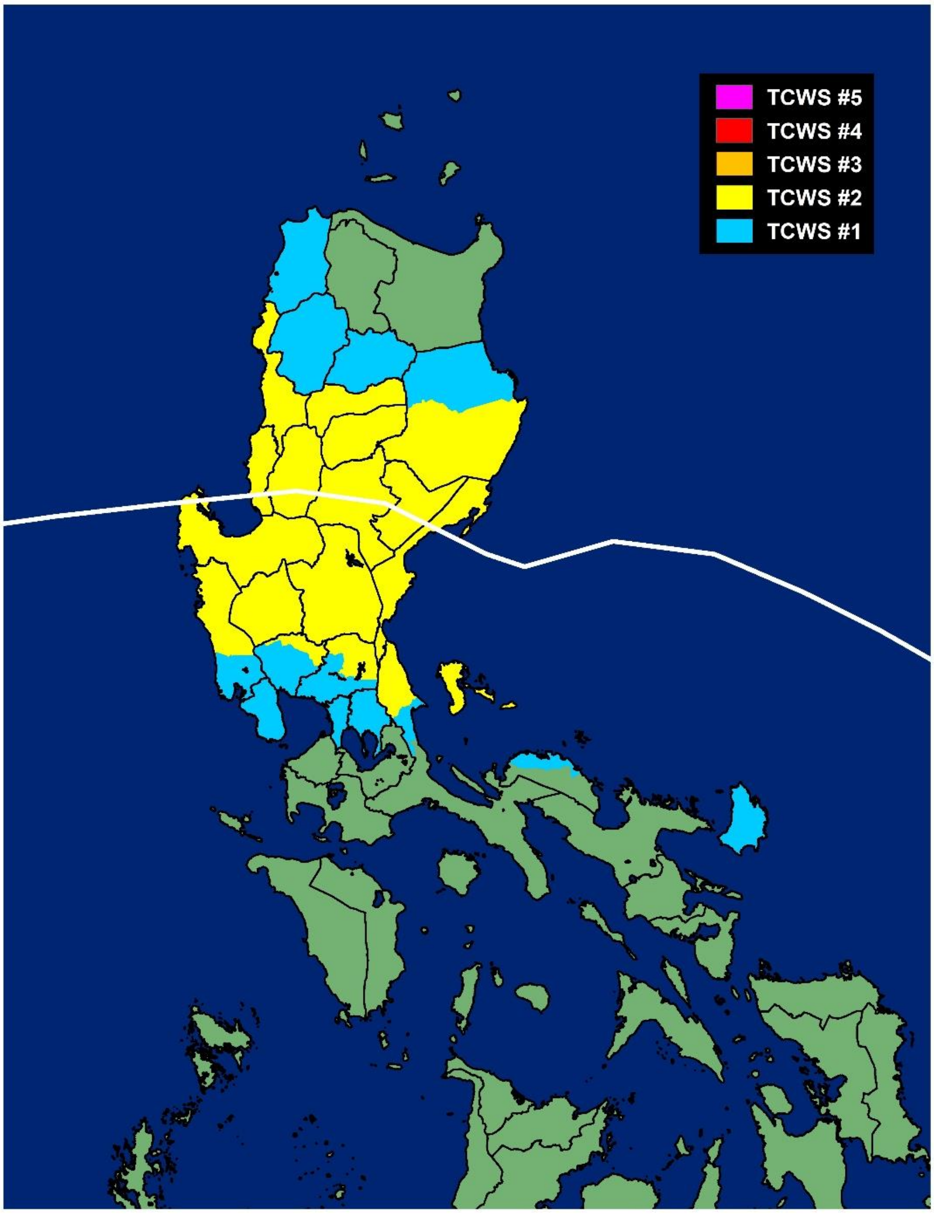
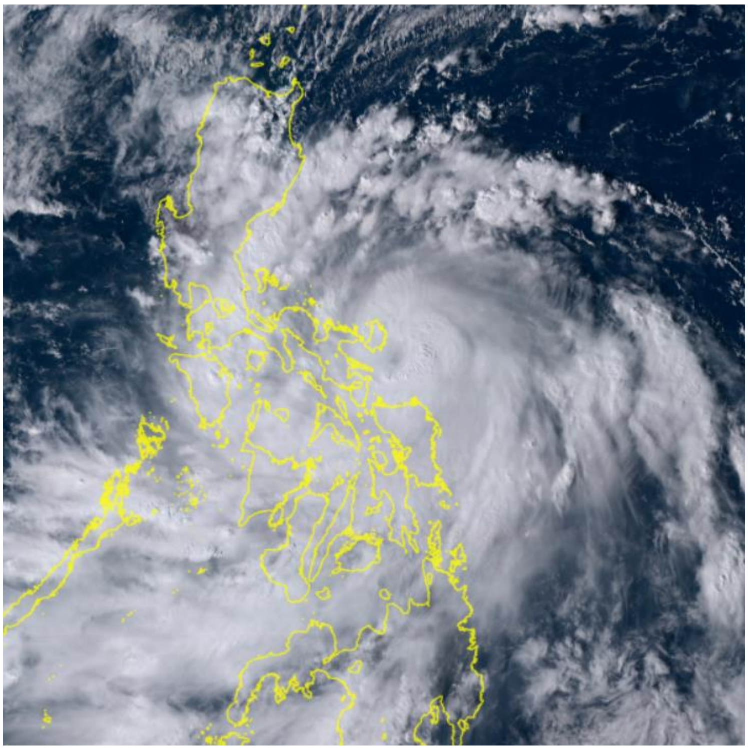


Fig. 4.16.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Typhoon Pepito. The best track is also overlaid as a solid thick white line.

Typhoon Quinta
Molave (2018)

23 to 29 October 2020



Basin-wide peak intensity:
Typhoon
90 kt (165 km/h)
945 hPa

Developed:
00 UTC, 23 October 2020

Degenerated:
06 UTC, 29 October 2020

Duration within the PAR:
2 days and 23 hours

Peak category within the PAR:
Typhoon

Highest wind signal hoisted:
Wind Signal No. 3

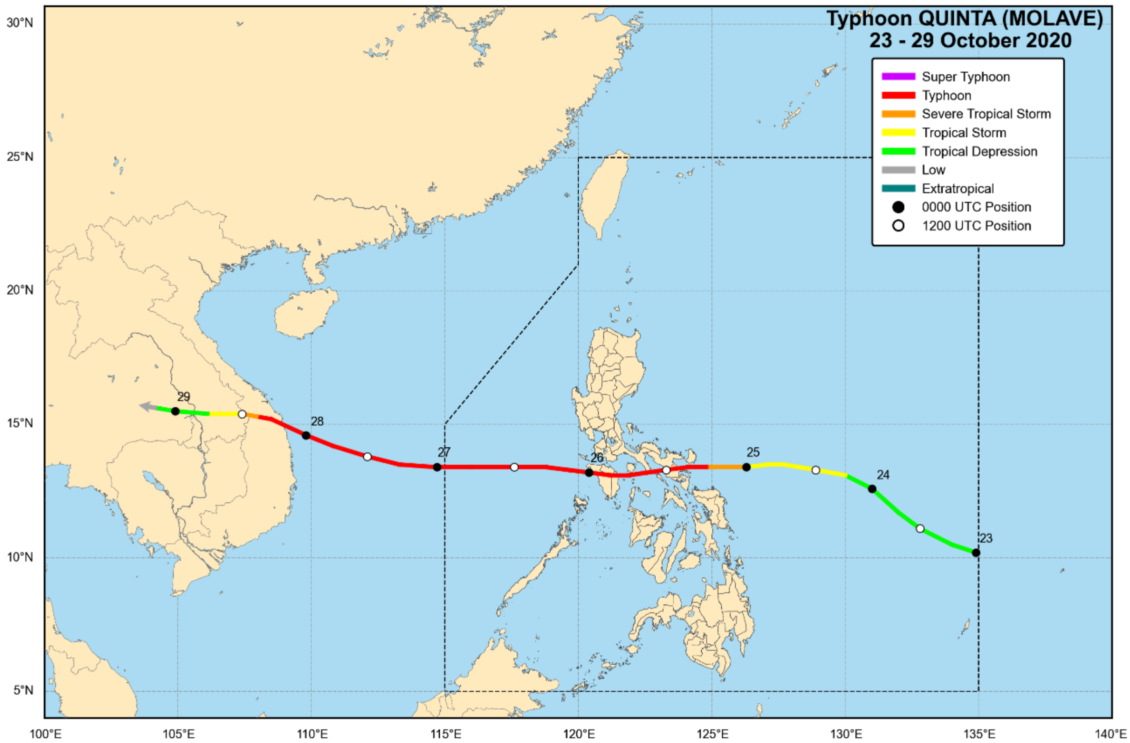


Fig. 4.17.1. Best track position and intensities of Typhoon Quinta.

Meteorological History

The precursory disturbance of what became Typhoon Quinta was first tracked on weather charts on 19 October over the waters of the Federated States of Micronesia. Tracking generally west northwestward, it entered the PAR region and reached tropical depression strength at 00 UTC on 23 October. Now bearing the name Quinta as the 17th tropical cyclone to occur within the PAR, the newly formed depression tracked northwestward over the Philippine Sea for the next 24 hours before turning westward.

At 06 UTC on 24 October, Quinta was upgraded into a tropical storm and started to rapidly intensify as it made its way towards the Bicol Region. It eventually reached severe tropical storm category at 00 UTC on 25 October and became a typhoon roughly 6 hours later as it was about to pass over the waters south of Catanduanes. The center of the eye of Quinta made its initial landfall in the vicinity of San Miguel Island in Tabaco City, Albay at 1010 UTC of the same day. This was followed by another landfall 40 minutes later in mainland Bicol Region near the border of Tabaco City and Malinao, Albay.

Throughout the rest of 25 October, the typhoon tracked generally westward over Southern Luzon and its surrounding waters. Succeeding landfalls were observed over San Andres, Quezon at 1430 UTC and near the border of Pola and Pinamalayan, Oriental Mindoro at 1930 UTC. Typhoon Quinta emerged over Mindoro Strait shortly past 23 UTC. After maintaining its strength following its traverse of Southern Luzon, Quinta resumed its intensification, albeit gradual, while moving westward over the West Philippine Sea away from the Philippine landmass.

Typhoon Quinta eventually exited the PAR region at 23 UTC on 26 October. Outside the PAR, the typhoon shifted to a more west northwestward heading as it made its way towards Vietnam. It reached a peak intensity of 90 kt and 945 hPa roughly 7 hours after exiting the PAR region. However, this peak only lasted for 6 hours as the typhoon began to gradually weaken as it neared the coast of central Vietnam. It made its final landfall as a weak typhoon at 1010 UTC on 28 October in the vicinity of Quảng Ngãi Province. The typhoon rapidly weakened as it moved further inland and was downgraded into a remnant low at 06 UTC on 29 October over Yasothon Province in northeastern Thailand.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (23 to 26 October 2020) rainfall over land:

- San Jose, Occidental Mindoro: 311.8 mm
- Legazpi City, Albay: 301.8 mm
- Tayabas, Quezon: 290.3 mm
- Juban, Sorsogon: 237.2 mm
- Calayan, Cagayan, 224.0 mm

Highest 24-hour rainfall over land:

- Legazpi City, Albay: 282.7 mm, 25 October 2020
- Juban, Sorsogon: 197.8 mm, 25 October 2020
- San Jose, Occidental Mindoro: 175.4 mm, 25 October 2020
- Infanta, Quezon: 163.4 mm, 26 October 2020
- Calapan City, Oriental Mindoro: 151.6 mm, 25 October 2020

Lowest sea level pressure over land:

- Virac, Catanduanes: 978.4 hPa, 0900 UTC, 25 October 2020
- Legazpi City, Albay: 981.6 hPa, 1100 UTC, 25 October 2020
- Calapan City, Oriental Mindoro: 987.1 hPa, 2100 UTC, 25 October 2020
- Daet, Camarines Norte: 989.0 hPa, 100 UTC, 25 October 2020
- San Jose, Occidental Mindoro: 991.4 hPa, 0700 UTC, 26 October 2020

Highest peak gust over land:

- Legazpi City, Albay: S (180°) at 70.0 kt (36 m/s), 1126 UTC, 25 October 2020
- Calapan City, Oriental Mindoro: ESE (120°) at 70.0 kt (36 m/s), 2252 UTC, 25 October 2020
- San Jose, Occidental Mindoro: W (280°) at 58.3 kt (30 m/s), 2240 UTC, 25 October 2020
- Virac, Catanduanes: 54.4 kt (28 m/s), between 0700 and 0800 UTC, 25 October 2020
- Romblon, Romblon: SSW (200°) at 52.5 kt (27 m/s), 2028 UTC, 25 October 2020
- Tayabas, Quezon:
    - NE (50°) at 46.7 kt (24 m/s), 0548 UTC, 25 October 2020
    - NE (40°) at 46.7 kt (24 m/s), 0605 UTC, 25 October 2020
    - NE (40°) at 46.7 kt (24 m/s), 1805 UTC, 25 October 2020

Summary of Warning Information

Number of public TC products issued: **30**

- Severe Weather Bulletins: **23**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **7**

Number of TC Warning for Shipping issued: **16**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **27 dead, 40 injured, and 4 missing**
Combined cost of damage: **PHP 105,817,126.00**

- Damage to agriculture: **PHP 76,577,126.00**
- Damage to infrastructure: **PHP 29,240,000.00**

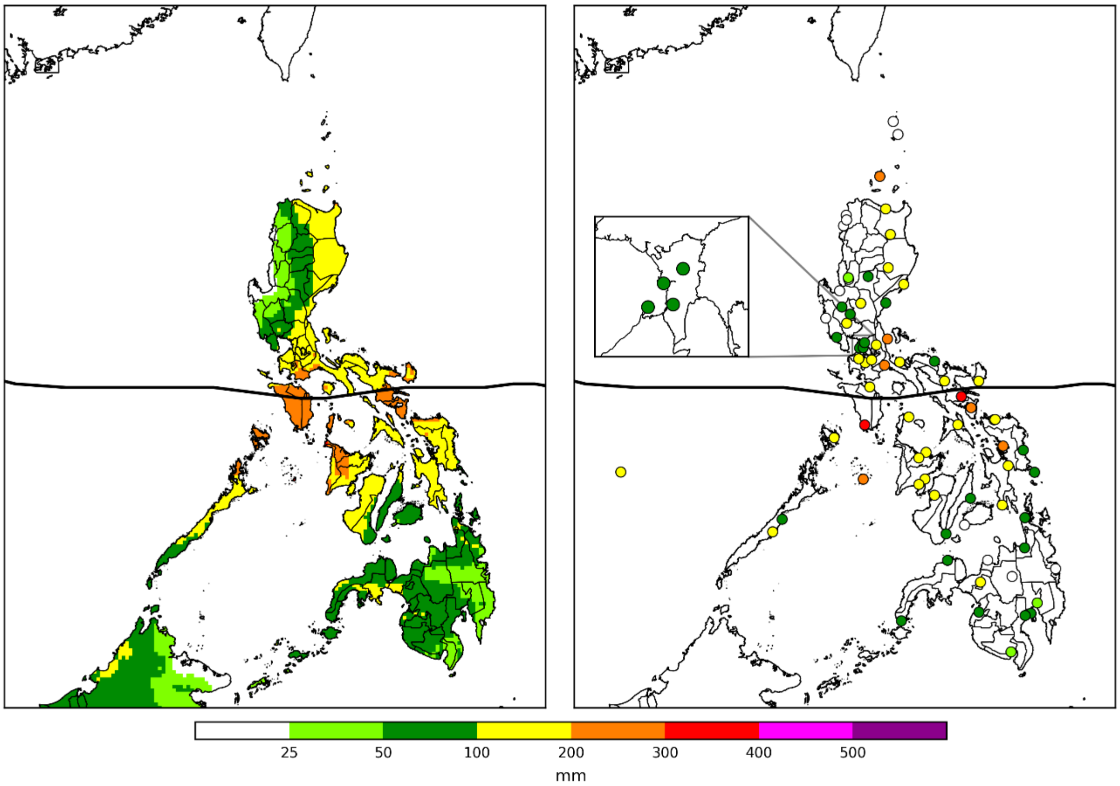


Fig. 4.17.2. Storm duration rainfall over land during the passage of Typhoon Quinta within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

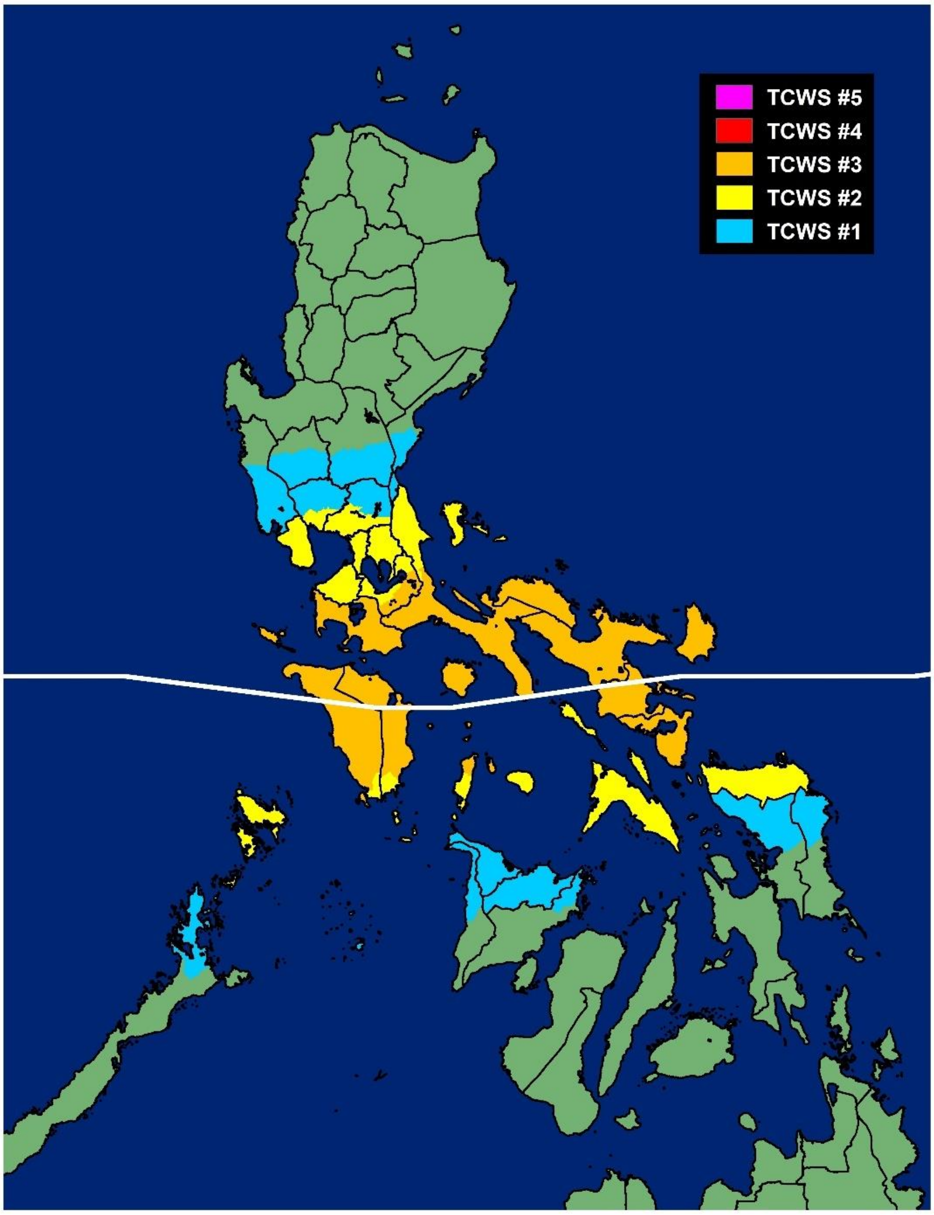
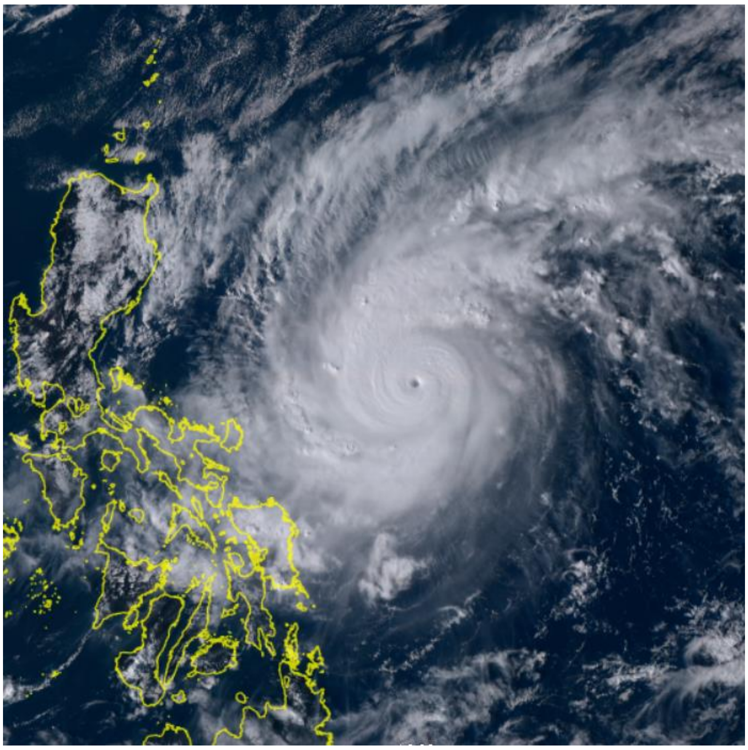


Fig. 4.17.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Typhoon Quinta. The best track is also overlaid as a solid thick white line.

Super Typhoon Rolly
Goni (2019)

26 October to
06 November 2020



Basin-wide peak intensity:
Super Typhoon
120 kt (220 km/h)
905 hPa

Developed:
18 UTC, 26 October 2020

Degenerated:
06 UTC, 06 November 2020

Duration within the PAR:
5 days and 2 hours

Peak category within the PAR:
Super Typhoon

Highest wind signal hoisted:
Wind Signal No. 5

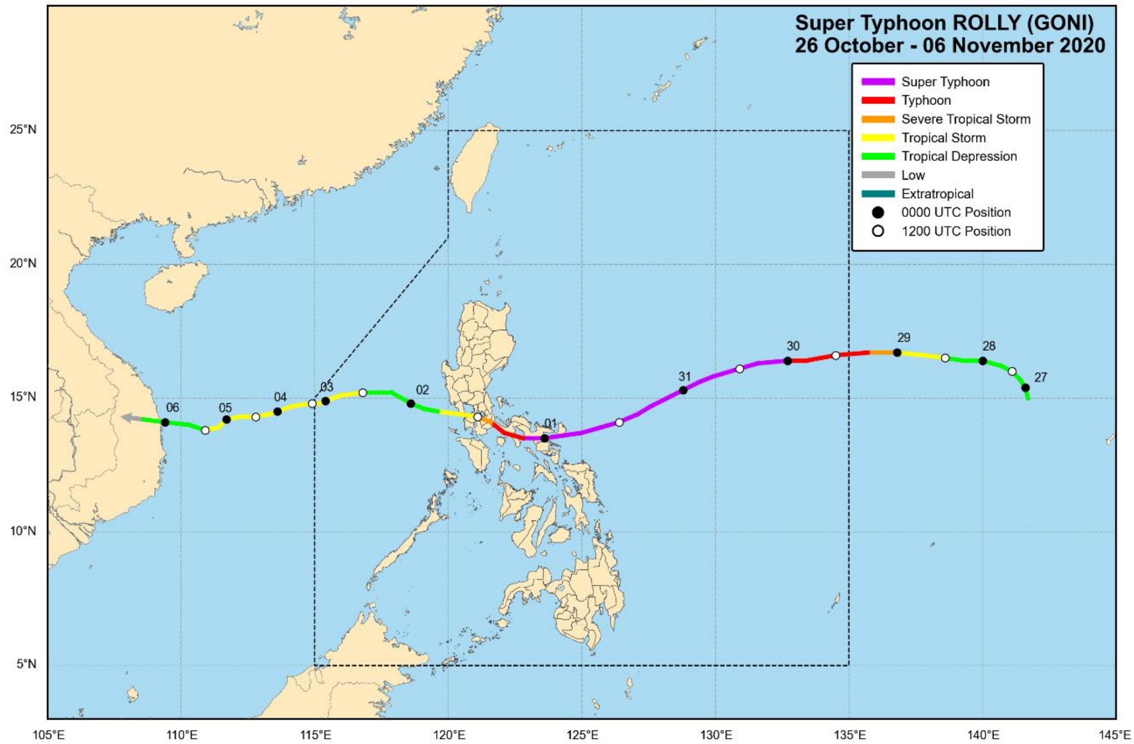


Fig. 4.18.1. Best track position and intensities of Super Typhoon Rolly.

Meteorological History

Super Typhoon Rolly developed from an area of low pressure which was first tracked over the waters of Pohnpei in the Federated States of Micronesia on 23 October. Over the next 5 days, the disturbance tracked generally northwestward towards the Philippine Sea, passing over the waters south and southwest of the Northern Mariana Islands. The disturbance was first tracked as a tropical depression at 18 UTC on 26 October. As the newly formed depression began tracking westward on 28 October, highly favorable environmental conditions allowed it to undergo a period of extremely rapid intensification. It reached tropical storm category at 12 UTC on 28 October and rapidly became a typhoon 18 hours later. At 10 UTC on 29 October, the tropical cyclone entered the PAR region as Typhoon Rolly, the 18th to occur within the PAR for the 2020 season.

Rolly continued tracking generally westward for the remainder of 29 October while explosively intensifying. At 18 UTC of the same day, the typhoon intensified by 55 kt over a 24-hour period. Roughly 6 hours later, Rolly reached super typhoon category – the 2nd to occur within the PAR region for the year. After nearly 4 days of westward movement, the super typhoon shifted to a west southwestward heading by 12 UTC on 30 October. At the same time, it reached 115 kt and 915 hPa – an intensity that it will maintain for nearly a day and a half. Rolly underwent a brief eyewall replacement cycle, a process common for typhoons and super typhoons, on 31 October as it neared the Bicol Region. This was followed by a brief period of intensification later into the day while over the waters east of Catanduanes. At 18 UTC of the same day, Super Typhoon Rolly attained its peak intensity of 120 kt and 905 hPa, making it the most intense tropical cyclone to occur during the year and one of the most intense tropical cyclones on record.

At 2050 UTC on 31 October, the center of the eye Super Typhoon Rolly made landfall in the vicinity of Bato, Catanduanes at peak intensity, making it one of the strongest tropical cyclones to make landfall. At 2320 UTC, the super typhoon made its second landfall over Tiwi Albay. Subsequent landfalls were also observed over San Narciso and Pagbilao in Quezon Province at 0400 and 0800 UTC of the following day as Rolly traversed Southern Luzon and its coastal waters. Increasing vertical wind shear and frictional effects associated with landfall initiated an extremely rapid weakening trend. Rolly was already a minimal tropical storm by the time it made its closest approach to southern Metro Manila between 12 and 13 UTC on 01 November. At around 14 UTC of the same day, it emerged over Manila Bay as a tropical depression and passed close to Corregidor Island and Bataan Peninsula.

Over the West Philippine Sea, Rolly continued tracking generally westward as it struggled to reconsolidate. Before exiting the PAR, it was upgraded back into a tropical storm, but further intensification was hampered by unfavorable conditions associated with a prevailing surge of the Northeast Monsoon. The tropical storm eventually left the PAR region at 12 UTC on 03 November.

Outside the PAR, Rolly continued moving slowly westward over the offshore waters east of Vietnam. In the presence of moderate to high wind shear, the storm failed to further intensify and at 12 UTC on 05 November, Rolly was downgraded into a tropical depression. It made its final landfall at around 0040 UTC on 06 November in the vicinity of Bình Định Province in central Vietnam and was last tracked as a remnant low at around 06 UTC of the same day in the nearby Gia Lai Province.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (29 October to 03 November 2020) rainfall over land:

- Guinobatan, Albay: 354.4 mm
- Legazpi City, Albay: 287.9 mm
- Virac, Catanduanes: 245.8 mm
- Catbalogan City, Samar: 198.2 mm
- Alabat, Quezon: 188.7 mm

Highest 24-hour rainfall over land:

- Virac, Catanduanes: 238.0 mm, 31 October 2020
- Guinobatan, Albay: 191.2 mm, 31 October 2020
- Legazpi City, Albay: 166.7 mm, 31 October 2020
- Juban, Sorsogon: 149.4 mm, 31 October 2020
- Indang, Cavite: 148.0 mm, 01 November 2020

Lowest sea level pressure over land:

- Virac, Catanduanes: 912.1 hPa, 2114 UTC, 31 October 2020
- Legazpi City, Albay: 978.4 hPa, 2317 UTC, 31 October 2020
- Alabat, Quezon: 985.9 hPa, 0600 UTC, 01 November 2020
- Tayabas, Quezon: 990.3 hPa, 0845 UTC, 01 November 2020
- Juban, Sorsogon: 994.4 hPa, 2200 UTC, 31 October 2020

Highest peak gust over land:

- Legazpi City, Albay:
  - SSW (210°) at 106.9 kt (55 m/s), 2217 UTC, 31 October 2020
  - SSW (210°) at 106.9 kt (55 m/s), 2315 UTC, 31 October 2020
- Virac, Catanduanes: SE (140°) at 73.9 kt (38 m/s) [3], 2150 UTC, 31 October 2020
- Daet, Camarines Norte: ESE (110°) at 68.0 kt (35 m/s), 0323 UTC, 01 November 2020
- Tanay, Rizal: NE (40°) at 54.4 kt (28 m/s), 0915 UTC, 01 November 2020
- Sangley Pt., Cavite City, Cavite: NNW (340°) at 52.5 kt (27 m/s), 0816 UTC, 01 November 2020

Summary of Warning Information

Number of public TC products issued: **45**

- Severe Weather Bulletins: **25**
- Tropical Cyclone Advisories: **3**
- Tropical Cyclone Updates: **17**

Number of TC Warning for Shipping issued: **21**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **25 dead, 399 injured, and 6 missing**
Combined cost of damage: **PHP 17,875,444,873.78**

- Damage to agriculture: **PHP 5,008,430,180.00**
- Damage to infrastructure: **PHP 12,867,014,693.78**

[3] The surface weather station at Virac, Catanduanes possibly experienced higher gusts than this value considering that the center of the eye of Rolly went over the station. However, the wind instrument of the station suffered from damage due to violent meteorological conditions which prevented higher gusts from being recorded.

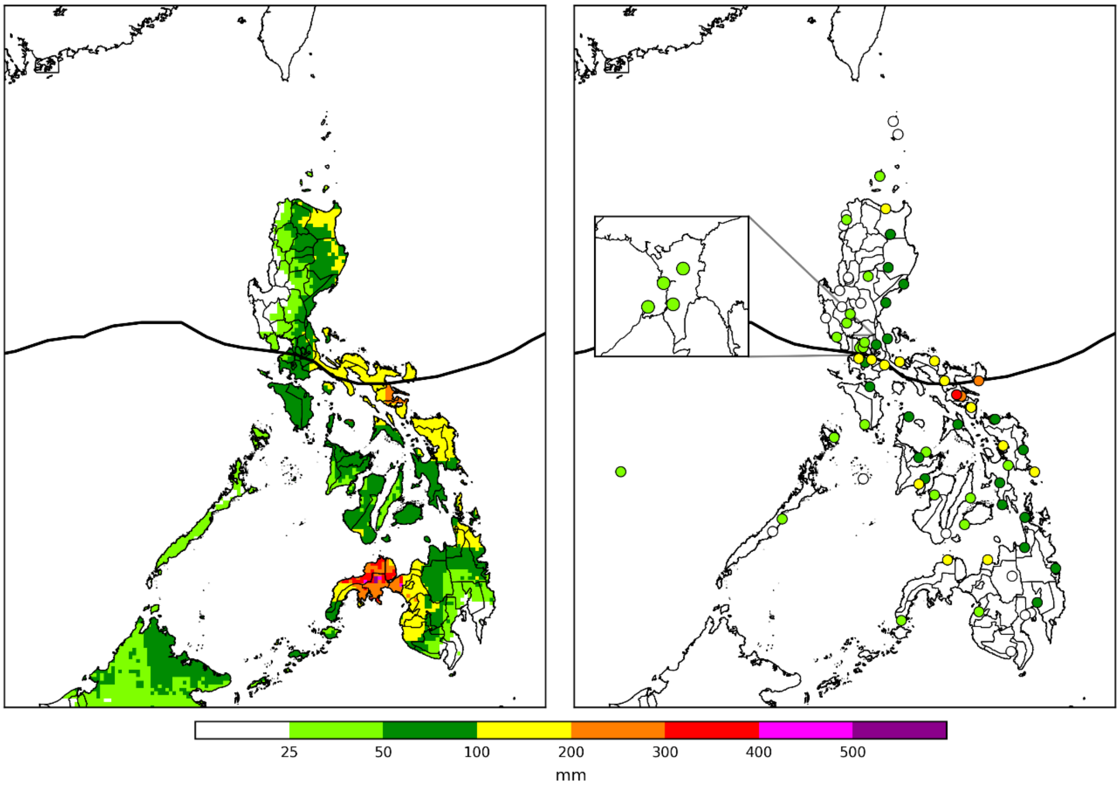


Fig. 4.18.2. Storm duration rainfall over land during the passage of Super Typhoon Rolly within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

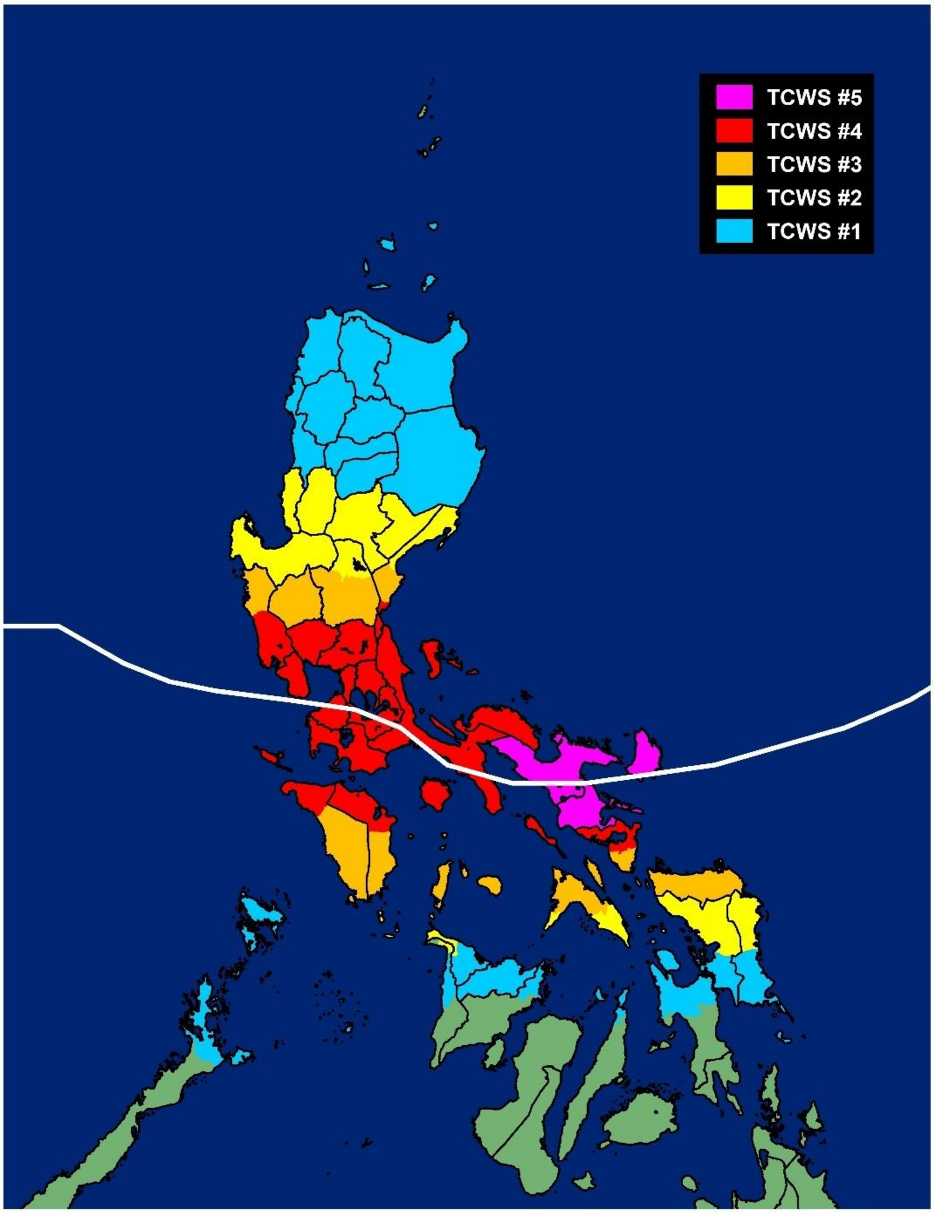
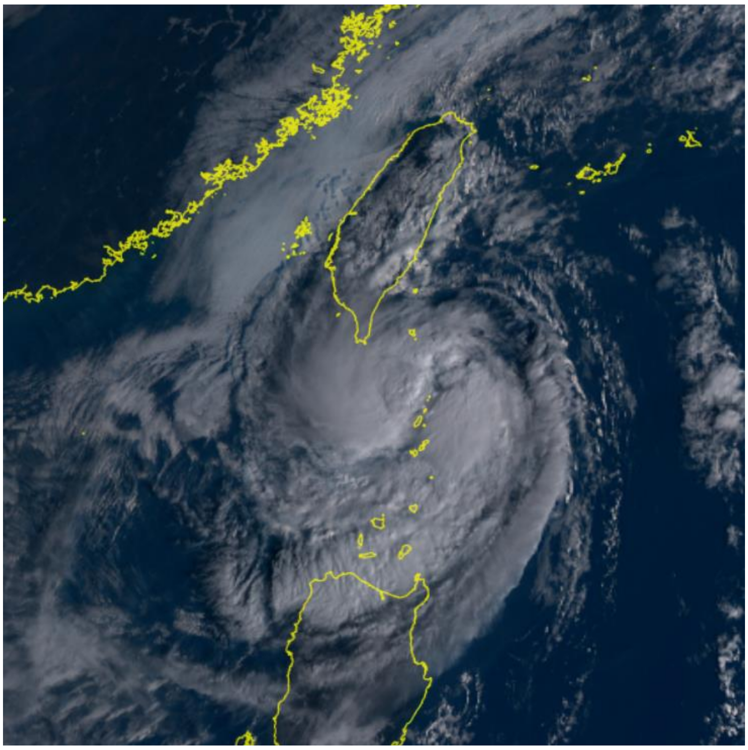


Fig. 4.18.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Super Typhoon Rolly. The best track is also overlaid as a solid thick white line.

Severe Tropical Storm Siony
Atsani (2020)

30 October to 07 November 2020



Basin-wide peak intensity:
Severe Tropical Storm
50 kt (95 km/h)
992 hPa

Developed:
06 UTC, 30 October 2020

Degenerated:
12 UTC, 07 November 2020

Duration within the PAR:
5 days and 18 hours

Peak category within the PAR:
Severe Tropical Storm

Highest wind signal hoisted:
Wind Signal No. 2

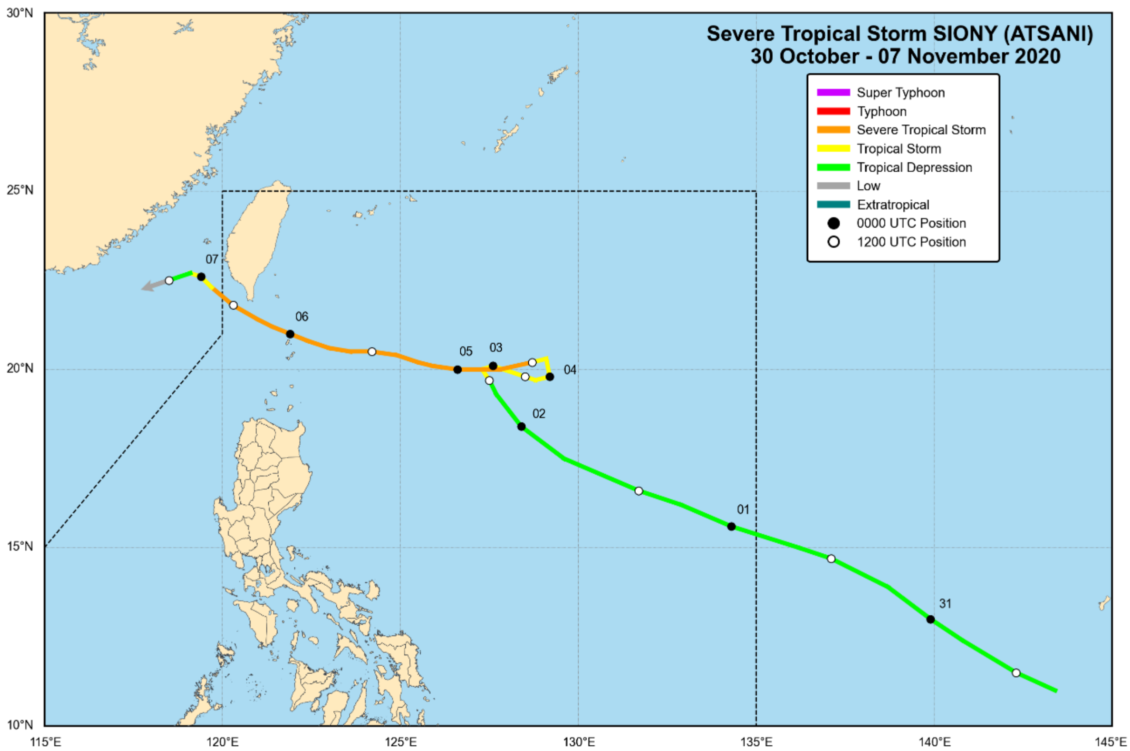


Fig. 4.19.1. Best track position and intensities of Severe Tropical Storm Siony.

Meteorological History

The precursory disturbance of Severe Tropical Storm Siony was first tracked near Pohnpei in the Federated States of Micronesia on 27 October. Tracking generally northwestward, this weather disturbance struggled to develop and consolidate, but eventually reached tropical depression category at 06 UTC on 30 October while over the waters southwest of Guam. The newly developed tropical cyclone entered the PAR region at 22 UTC on 31 October.

Tropical Depression Siony, as it was locally called, maintained its northwestward heading over the Philippine Sea for 2 days, although it began to slow down by 02 November as it entered a period of meandering motion in the absence of a robust steering environment. The tropical cyclone was also upgraded into a tropical storm at 12 UTC of the same day. The meandering motion of Siony lasted for 2 days. The storm eventually began tracking generally westward by 12 UTC on 04 November, just as it further intensified into a severe tropical storm.

Siony shifted to a more west northwestward heading on 05 November while slightly accelerating as it headed towards the Luzon Strait, although no further intensification was observed for the rest of its occurrence. Between 23 UTC of the same day and 01 UTC on 06 November, the severe tropical storm made its closest approach to Batanes when it passed over the waters separating Di'Tarem and Misanga Islands (Itbayat, Batanes). After passing over the waters south of Taiwan's Pingtung County, Siony exited the PAR region at 16 UTC on 06 November.

As it entered the Taiwan Strait after leaving the PAR, the severe tropical storm entered a rapid weakening phase due to increasingly hostile environmental conditions brought by an arriving Northeast Monsoon surge. After being downgraded into a tropical storm at 18 UTC on 06 November and into a tropical depression roughly 12 hours later, Siony degenerated into an area of low pressure at 12 UTC on 07 November. The remnant low eventually dissipated later that day.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (01 to 06 November 2020) rainfall over land:

- Alabat, Quezon: 235.7 mm
- Tayabas, Quezon: 165.6 mm
- Indang, Cavite: 153.4 mm
- Catarman (Synoptic), Northern Samar: 147.8 mm
- Pili, Camarines Sur: 142.5 mm

Highest 24-hour rainfall over land:

- Indang, Cavite: 148.0 mm, 01 November 2020
- Pili, Camarines Sur: 122.6 mm, 01 November 2020
- Alabat, Quezon: 108.8 mm, 03 November 2020
- Legazpi City, Albay: 106.2 mm, 01 November 2020
- Borongan City, Eastern Samar: 91.8 mm, 06 November 2020

Lowest sea level pressure over land:

- Basco, Batanes: 997.9 hPa, 2100 UTC, 05 November 2020
- Baguio City: 1007.6 hPa, 0600 UTC, 06 November 2020
- Clark International Airport, Mabalacat, Pampanga: 1009.5 hPa, 0900 UTC, 06 November 2020
- Muñoz City, Nueva Ecija: 1009.6 hPa, 0900 UTC, 06 November 2020
- Subic Bay International Airport, Morong, Bataan: 1009.6 hPa, 0900 UTC, 06 November 2020

Highest peak gust over land:

- Basco, Batanes:
  - 58.3 kt (30 m/s), between 1500 and 1800 UTC, 05 November 2020
  - 58.3 kt (30 m/s), between 0000 and 0300 UTC, 06 November 2020
- Itbayat, Batanes[4]: ESE (120°) at 42.8 kt (22 m/s), 0252 UTC, 06 November 2020
- Calayan, Cagayan: 31.1 kt (16 m/s), between 1500 and 1800 UTC, 01 November 2020
- Clark International Airport, Mabalacat, Pampanga: 27.2 kt (14 m/s), between 0900 and 1200 UTC, 01 November 2020
- Laoag City, Ilocos Norte:
  - 25.3 kt (13 m/s), between 0300 and 0600 UTC, 01 November 2020
  - 25.3 kt (13 m/s), between 1200 and 1500 UTC, 01 November 2020

Summary of Warning Information

Number of public TC products issued: **49**

- Severe Weather Bulletins: **24**
- Tropical Cyclone Advisories: **2**
- Tropical Cyclone Updates: **23**

Number of TC Warning for Shipping issued: **24**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

[4] Despite reporting the second highest peak gust and being situated very close to the observed track, Itbayat, Batanes was not included in the list of stations with the lowest sea level pressure observations due to the lack of operational barometer at the time of the passage.

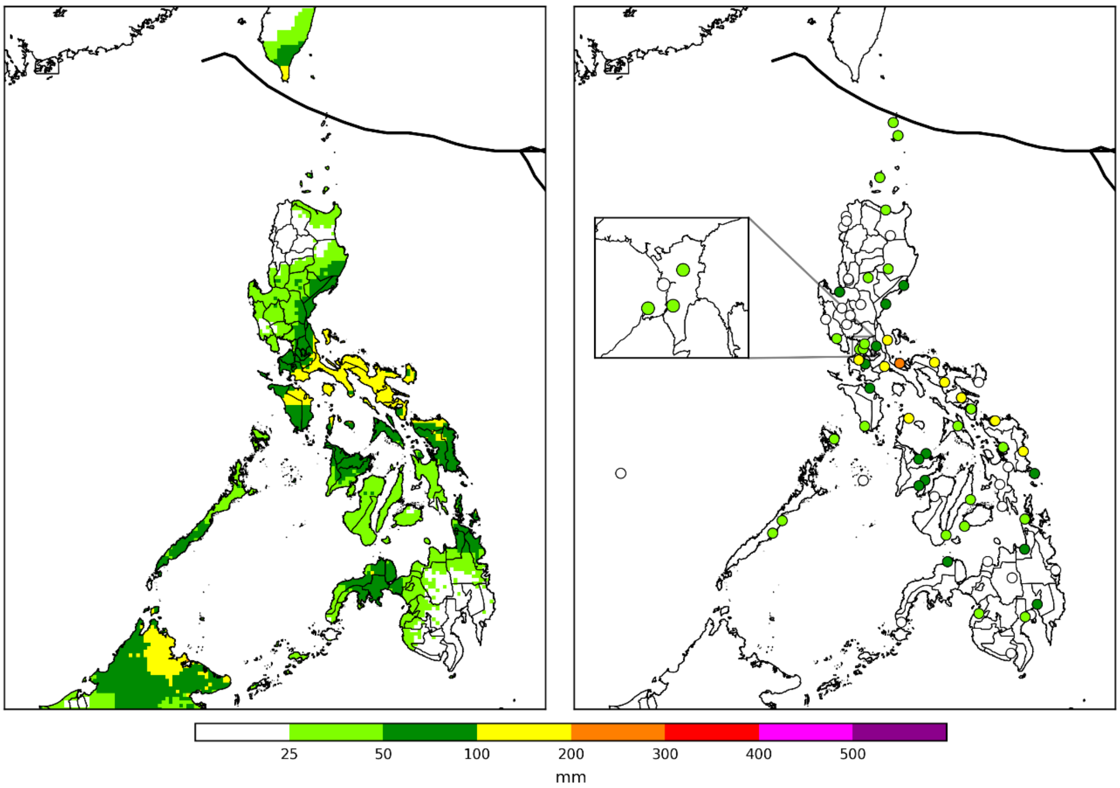


Fig. 4.19.2. Storm duration rainfall over land during the passage of Severe Tropical Storm Siony within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

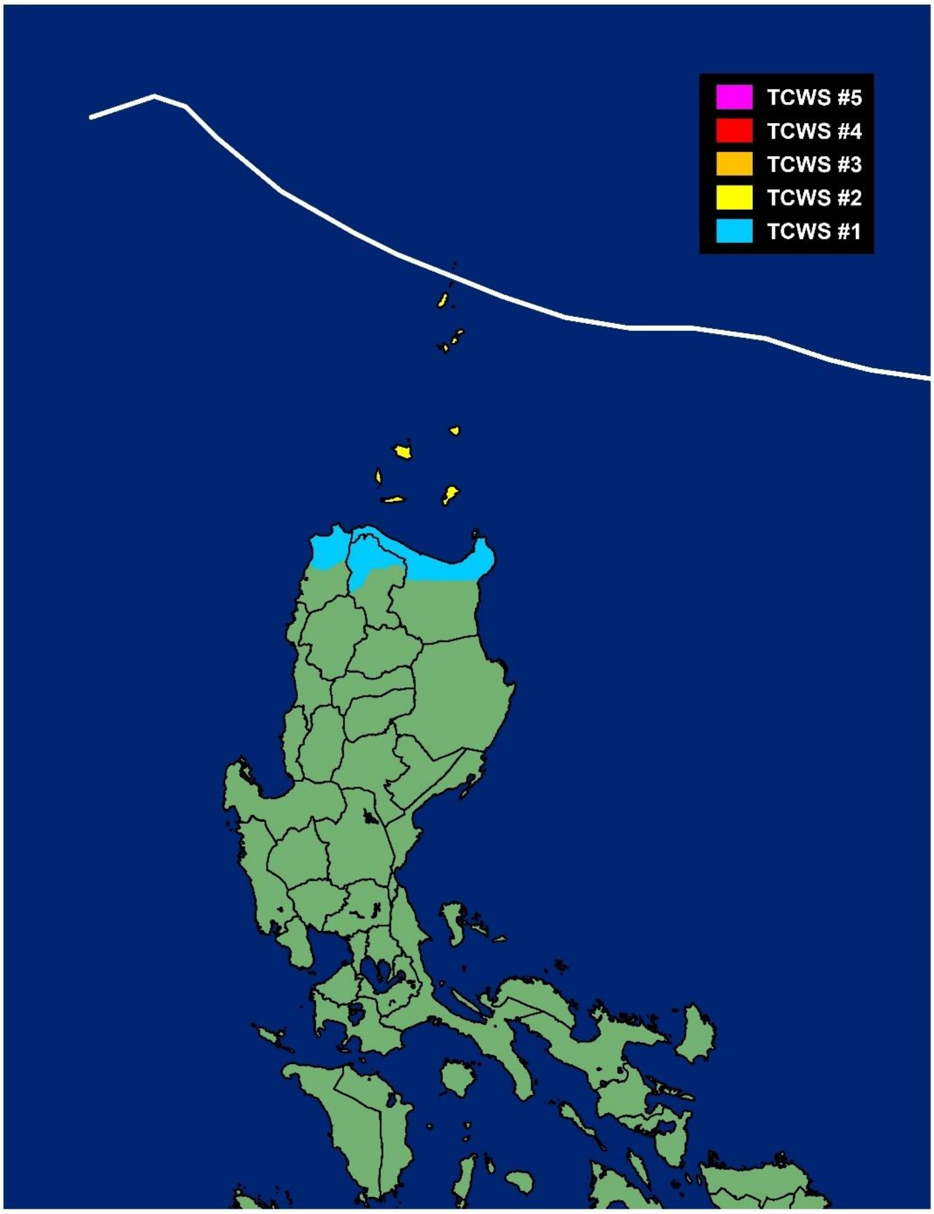
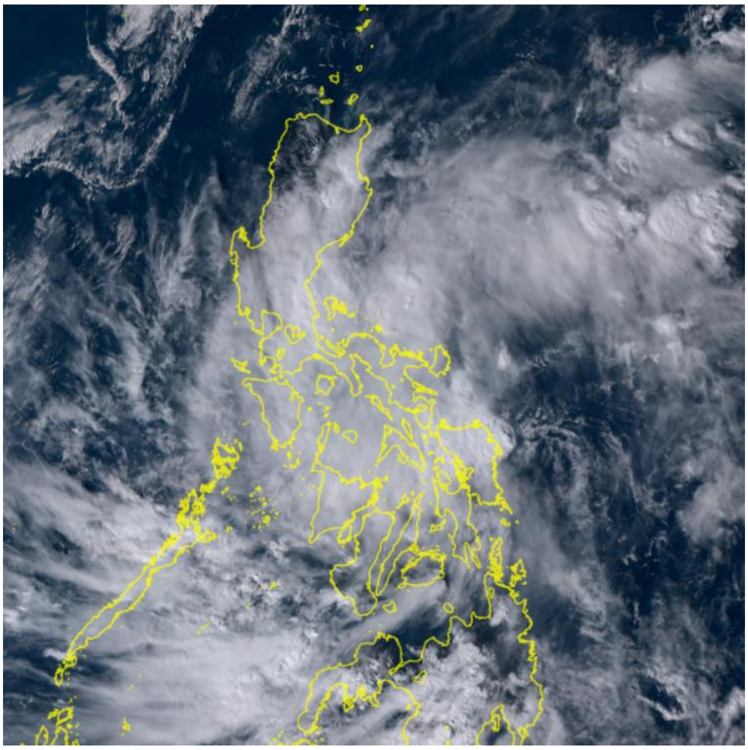


Fig. 4.19.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Severe Tropical Storm Siony. The best track is also overlaid as a solid thick white line.

Tropical Storm Tonyo
Etau (2021)

06 to 10 November 2020



Basin-wide peak intensity:
Severe Tropical Storm
45 kt (85 km/h)
992 hPa

Developed:
12 UTC, 06 November 2020

Degenerated:
18 UTC, 10 November 2020

Duration within the PAR:
2 days and 7 hours

Peak category within the PAR:
Tropical Storm

Highest wind signal hoisted:
Wind Signal No. 1

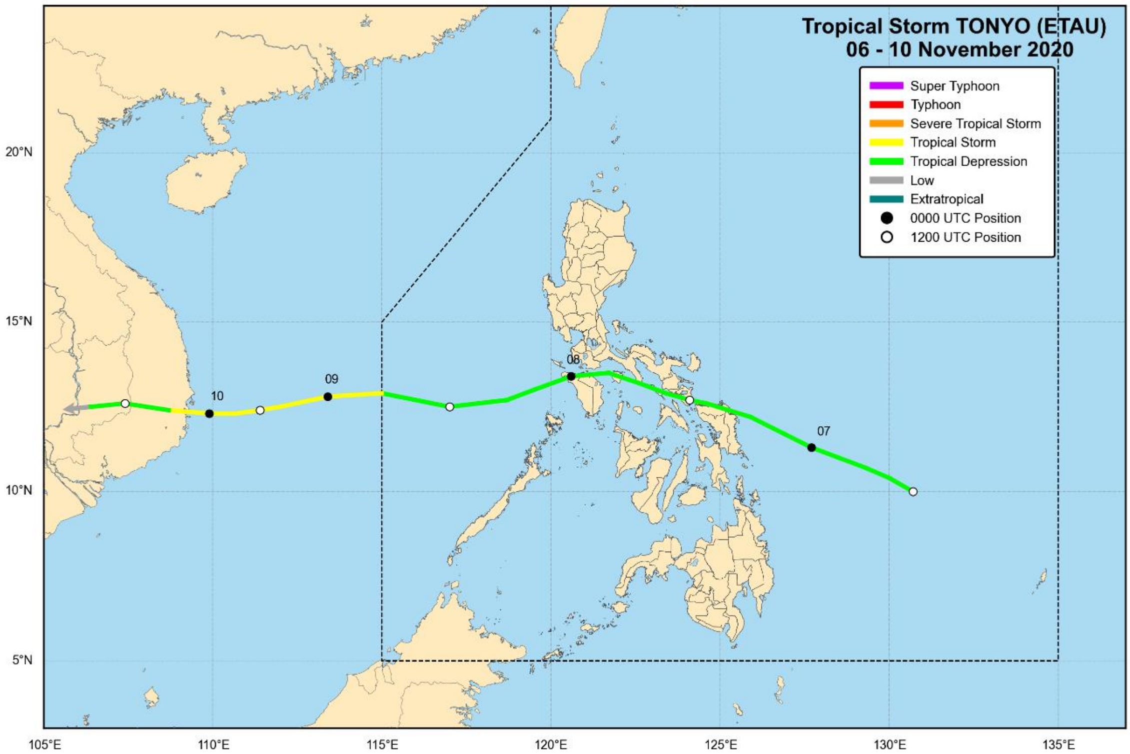


Fig. 4.20.1. Best track position and intensities of Tropical Storm Tonyo.

Meteorological History

Tropical Storm Tonyo developed over the Philippine Sea east of Caraga Region at 12 UTC on 06 November from a tropical disturbance which formed on 04 November over the waters off Chuuk in the Federated States of Micronesia. Tracking west northwestward, Tonyo remained a tropical depression for almost its entire duration within the PAR region. Throughout 07 November, while generally maintaining its heading, the depression traversed the northern part of Samar Island, portions of Southern Luzon, and their coastal waters. It made landfall over the following localities:

- Gamay, Northern Samar – 0730 UTC, 07 November
- Biri, Northern Samar – 1030 UTC, 07 November
- Border of Santa Magdalena and Bulusan, Sorsogon – 1150 UTC, 07 November
- San Pascual (Burias Island), Masbate – 1600 UTC, 07 November
- San Francisco, Quezon – 1750 UTC, 07 November
- Torrijos, Marinduque – 1940 UTC, 07 November
- San Teodoro, Oriental Mindoro, 2300, UTC 07 November

Tonyo eventually emerged over the West Philippine Sea at 01 UTC on 08 November. The depression maintained a generally westward or west southwestward heading as it moved away from the Philippine landmass. Tonyo eventually intensified into a tropical storm at 18 UTC on the same day and crossed the western limit of the PAR region 1 hour later.

Outside the PAR, the tropical storm continued tracking westward as it further intensified. It reached a peak intensity of 45 kt and 992 hPa at 06 UTC on 09 November. However, marginally unfavorable environment over the waters east of Vietnam due to the Northeast Monsoon surge triggered a weakening trend. At around 0300 UTC on 10 November, Tonyo made its final landfall as a minimal tropical storm over the town of Ninh Hòa in the coastal Khánh Hòa Province of Vietnam. The storm was downgraded into a tropical depression roughly 3 hours later and degenerated into an area of low pressure at 18 UTC on 10 November over Mondulkiri Province in Cambodia.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (06 to 08 November 2020) rainfall over land:

- Catarman (Synoptic), Northern Samar: 213.2 mm
- Catarman (Agromet), Northern Samar: 174.9 mm
- Casiguran, Aurora: 147.2 mm
- Aparri, Cagayan: 134.6 mm
- Tuguegarao City, Cagayan: 130.1 mm

Highest 24-hour rainfall over land:

- Catarman (Synoptic), Northern Samar: 155.4 mm, 07 November 2020
- Aparri, Cagayan: 128.7 mm, 08 November 2020
- Catarman (Agromet), Northern Samar: 127.6 mm, 07 November 2020
- Casiguran, Aurora: 123.0 mm, 08 November 2020
- Juban, Sorsogon: 101.4 mm, 07 November 2020

Lowest sea level pressure over land:

- Tayabas, Quezon: 1003.7 hPa, 1916 UTC, 07 November 2020
- Coron, Palawan:
    - 1004.0 hPa, 0600 UTC, 08 November 2020
    - 1004.0 hPa, 1800 UTC, 08 November 2020
- Legazpi City, Albay: 1004.0 hPa, 1100 UTC, 07 November 2020
- Alabat Quezon:
    - 1004.9 hPa, 2000 UTC, 07 November 2020
    - 1004.9 hPa, 2100 UTC, 07 November 2020
- Romblon, Romblon: 1005.0 hPa, 2110 UTC, 07 November 2020
- Subic Bay International Airport, Morong, Bataan: 1005.2 hPa, 0705 UTC, 08 November 2020

Highest peak gust over land:

- Legazpi City, Albay: NW (310°) at 35.0 kt (18 m/s), 1109 UTC, 07 November 2020
- Subic Bay International Airport, Morong, Bataan: ENE (70°) at 29.2 kt (15 m/s), 0547 UTC, 08 November 2020
- Calapan City, Oriental Mindoro:
    - E (90°) at 29.2 kt (15 m/s), 0315 UTC, 08 November 2020
    - E (90°) at 29.2 kt (15 m/s), 0412 UTC, 08 November 2020
- Tanay, Rizal: E (40°) at 27.2 kt (14 m/s), 2340 UTC, 07 November 2020
- Catarman (Synoptic), Northern Samar: ENE (70°) at 27.2 kt (14 m/s), 1943 UTC, 06 November 2020
- Sangley Pt. Cavite City, Cavite: NNW (340°) at 21.4 kt (11 m/s), 2213 UTC, 07 November 2020
- San Jose, Occidental Mindoro: E (90°) at 21.4 kt (11 m/s), 0605 UTC, 08 November 2020
- Masbate City, Masbate: SSW (200°) at 21.4 kt (11 m/s), 1043 UTC, 07 November 2020
- Romblon, Romblon: NNW (330°) at 19.4 kt (10 m/s), 1640 UTC, 07 November 2020
- Guiuan, Eastern Samar: NE (40°) at 19.4 kt (10 m/s), 0255 UTC, 08 November 2020

Summary of Warning Information

Number of public TC products issued: **11**

- Severe Weather Bulletins: **9**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **2**

Number of TC Warning for Shipping issued: **6**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **None reported**
Combined cost of damage: **None reported**

- Damage to agriculture: **None reported**
- Damage to infrastructure: **None reported**

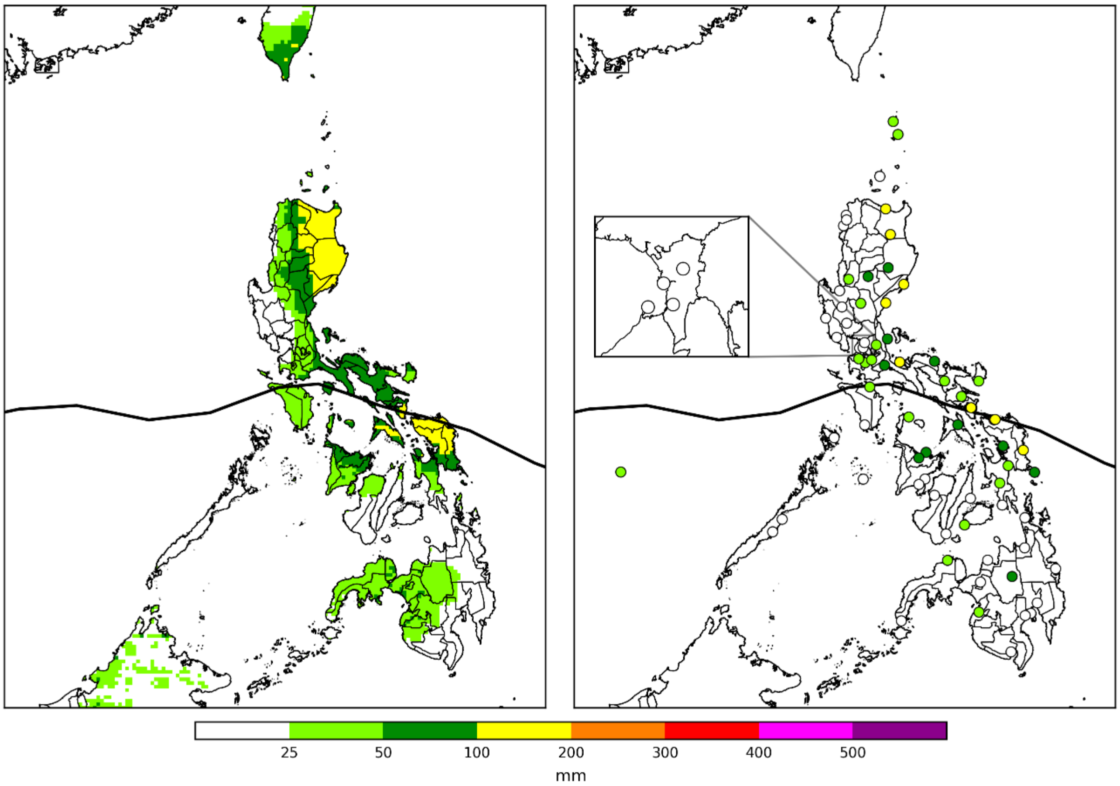


Fig. 4.19.2. Storm duration rainfall over land during the passage of Tropical Storm Tonyo within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

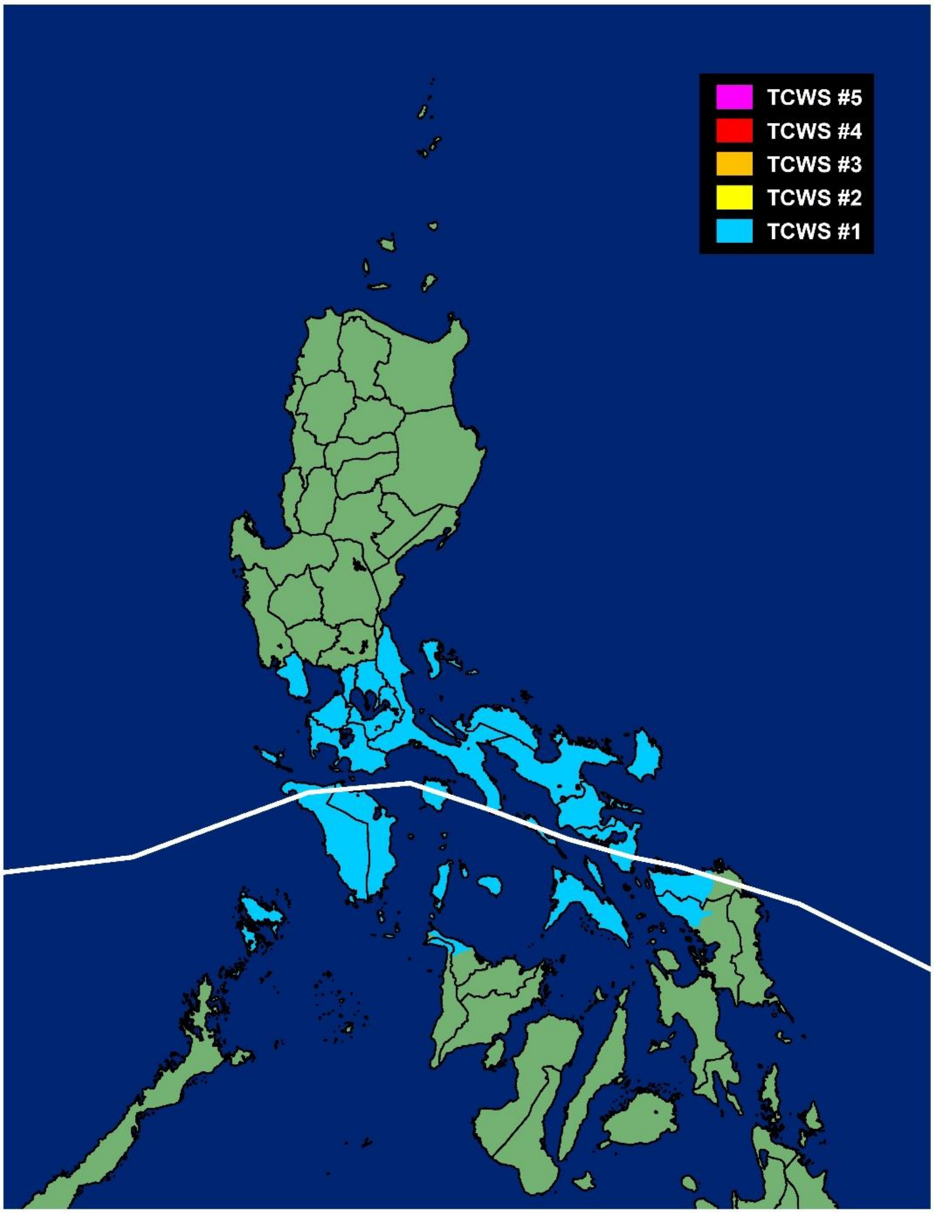
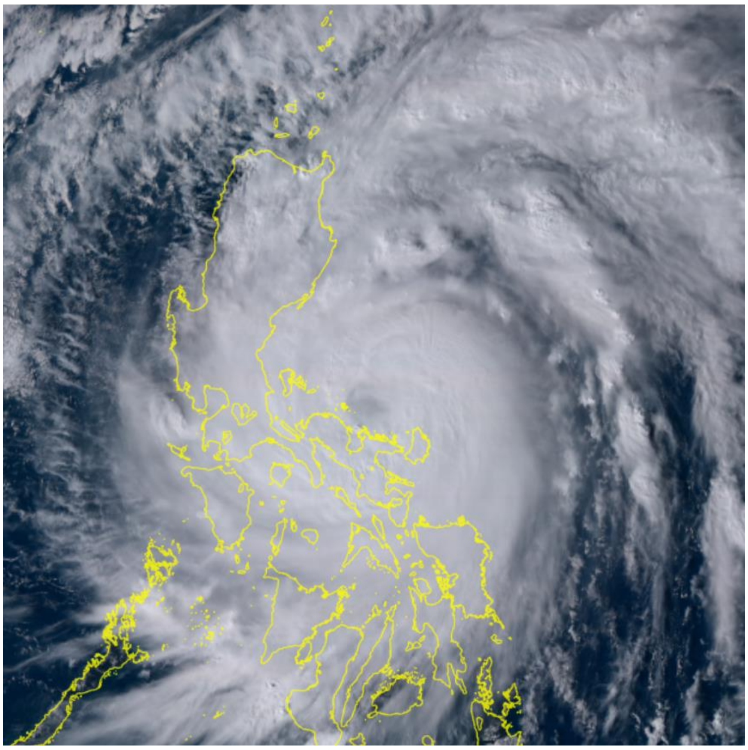


Fig. 4.19.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Tropical Storm Tonyo. The best track is also overlaid as a solid thick white line.

Typhoon Ulysses
Vamco (2022)

08 to 16 November 2020



Basin-wide peak intensity:
Typhoon
85 kt (155 km/h)
955 hPa

Developed:
00 UTC, 08 November 2020

Degenerated:
00 UTC, 16 November 2020

Duration within the PAR:
5 days and 1 hours

Peak category within the PAR:
Typhoon

Highest wind signal hoisted:
Wind Signal No. 3

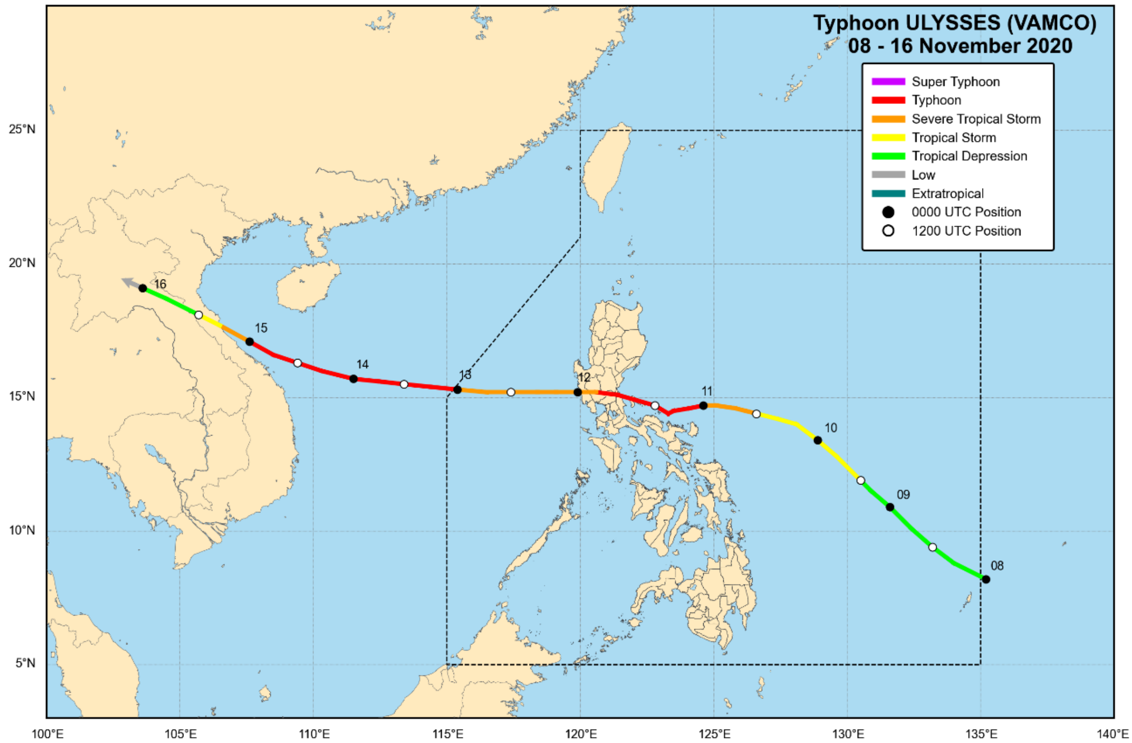


Fig. 4.20.1. Best track position and intensities of Typhoon Ulysses.

Meteorological History

The tropical disturbance that would become Typhoon Ulysses originated over the waters near Palau and was first identified on weather charts on 07 November. As it neared the Palau while tracking northwestward, it developed into a tropical depression at 00 UTC of the following day and entered the PAR region an hour later as Ulysses, the 20th tropical cyclone of the 2020 season.

For the next 48 hours, the newly formed depression moved generally westward over the Philippine Sea while gradually intensifying. At 12 UTC on 09 November, Ulysses was upgraded into a tropical storm. As it began tracking west northwestward on 10 November, the tropical storm started to rapidly intensify. It reached severe tropical storm category at 12 UTC of the same day and was further upgraded into a typhoon 12 hours later as it passed over the waters north of Catanduanes. On 11 November, Ulysses began to decelerate and turned west southwestward towards the waters north of Camarines Provinces. The typhoon eventually became almost stationary near the mouth of San Miguel Bay at around 09 UTC of the same day, although this only lasted for an hour as it resumed moving towards the direction of Polillo Islands. During this quasi-stationary phase, the eyewall of the typhoon battered the coastal towns of Camarines Provinces.

After making a close approach to Calaguas Islands, Ulysses reached its pre-landfall peak intensity of 75 kt and 965 hPa at 12 UTC on 11 November. The typhoon then passed over the islands of Pandanan and Malaguioan located just north of Patnanungan Island at 1440 and 1450 UTC, respectively, before making landfall in the vicinity of Burdeos (Poblacion) in Pollilo Island, Quezon at 1520 UTC. After briefly crossing Polillo Strait, the typhoon made its fourth landfall at peak intensity at 1740 UTC of the same day over General Nakar, Quezon, near its border with Dingalan, Aurora.

Ulysses subsequently crossed the Sierra Madre, the plains of Central Luzon, and the Zambales Mountains, resulting in its weakening to severe tropical storm category. It eventually emerged over the waters west of Cabangan, Zambales shortly before 00 UTC on 12 November. Ulysses maintained a westward heading for the next 2 days as it moved away from the landmass of Luzon. Close to the western boundary of the PAR, it re-intensified into a typhoon at 00 UTC on 13 November. It eventually left the PAR region an hour later.

Outside the PAR, the typhoon started to turn west northwestward for the remainder of its occurrence as it made its way towards Vietnam. At 00 UTC on 14 November, the typhoon reached its peak intensity of 85 kt and 955 hPa. However, a rapid weakening trend began 12 hours later as it neared the waters off the north central coast of Vietnam. At around 0610 UTC on 15 November, Ulysses, a minimal tropical storm by that time, made its final landfall north of Hoàn Lão township in Quang Binh Province. The tropical cyclone was last tracked as a remnant low at 00 UTC of the following day.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (08 to 12 November 2020) rainfall over land:

- Aparri, Cagayan: 504.4 mm
- Casiguran, Aurora: 426.5 mm
- Tanay, Rizal: 399.4 mm
- Daet, Camarines Norte: 380.3 mm
- Calayan, Cagayan: 357.6 mm

Highest 24-hour rainfall over land:

- Tanay, Rizal: 356.2 mm, 11 November 2020
- Daet, Camarines Norte: 270.6 mm, 11 November 2020
- Infanta, Quezon: 255.1 mm, 11 November 2020
- Casiguran, Aurora: 238.0 mm, 11 November 2020
- Aparri, Cagayan: 209.0 mm, 12 November 2020

Lowest sea level pressure over land:
- Infanta, Quezon: 977.0 hPa, 1700 UTC, 11 November 2020
- Daet, Camarines Norte: 981.3 hPa, 0900 UTC, 11 November 2020
- Clark International Airport, Mabalacat, Pampanga: 986.2 hPa, 2100 UTC, 11 November 2020
- Tanay, Rizal: 988.1 hPa, 1700 UTC, 11 November 2020
- Iba, Zambales: 989.0 hPa, 2300 UTC, 11 November 2020

Highest peak gust over land:
- Daet, Camarines Norte: WNW (300°) at 81.6 kt (42 m/s), 0456 UTC, 11 November 2020
- Infanta, Quezon: NW (320°) at 70.0 kt (36 m/s), 1447 UTC, 11 November 2020
- Baler, Aurora: SSE (160°) at 66.1 kt (34 m/s), 1750 UTC, 11 November 2020
- Tanay, Rizal: WNW (290°) at 54.4 kt (28 m/s), 1706 UTC, 11 November 2020
- Virac, Catanduanes: SW (220°) at 52.5 kt (27 m/s), 0207 UTC, 11 November 2020

Summary of Warning Information

Number of public TC products issued: **38**
- Severe Weather Bulletins: **26**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **12**

Number of TC Warning for Shipping issued: **19**

Reported Casualties and Cost of Damage
Source: Office of Civil Defense

Number of reported casualties: **51 dead and no reported injured or missing**
Combined cost of damage: **PHP 20,229,128,825.17**
- Damage to agriculture: **PHP 7,318,946,822.00**
- Damage to infrastructure: **PHP 12,910,182,003.17**

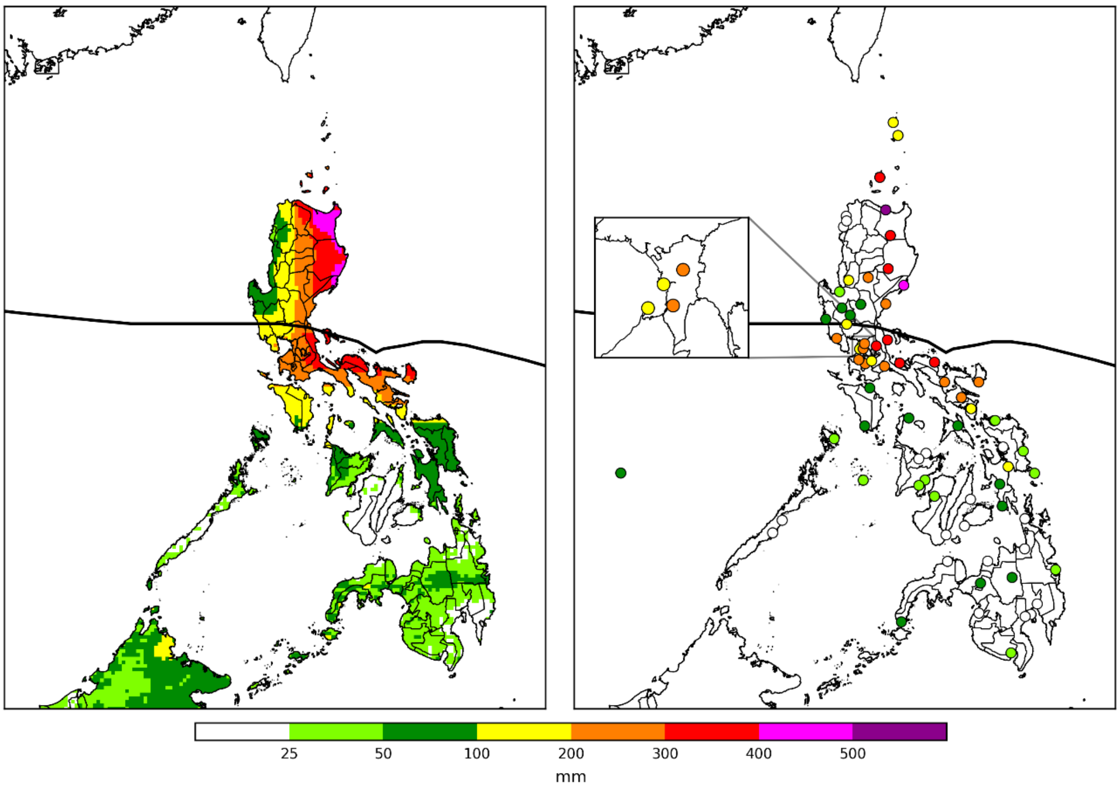


Fig. 4.20.2. Storm duration rainfall over land during the passage of Typhoon Ulysses within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

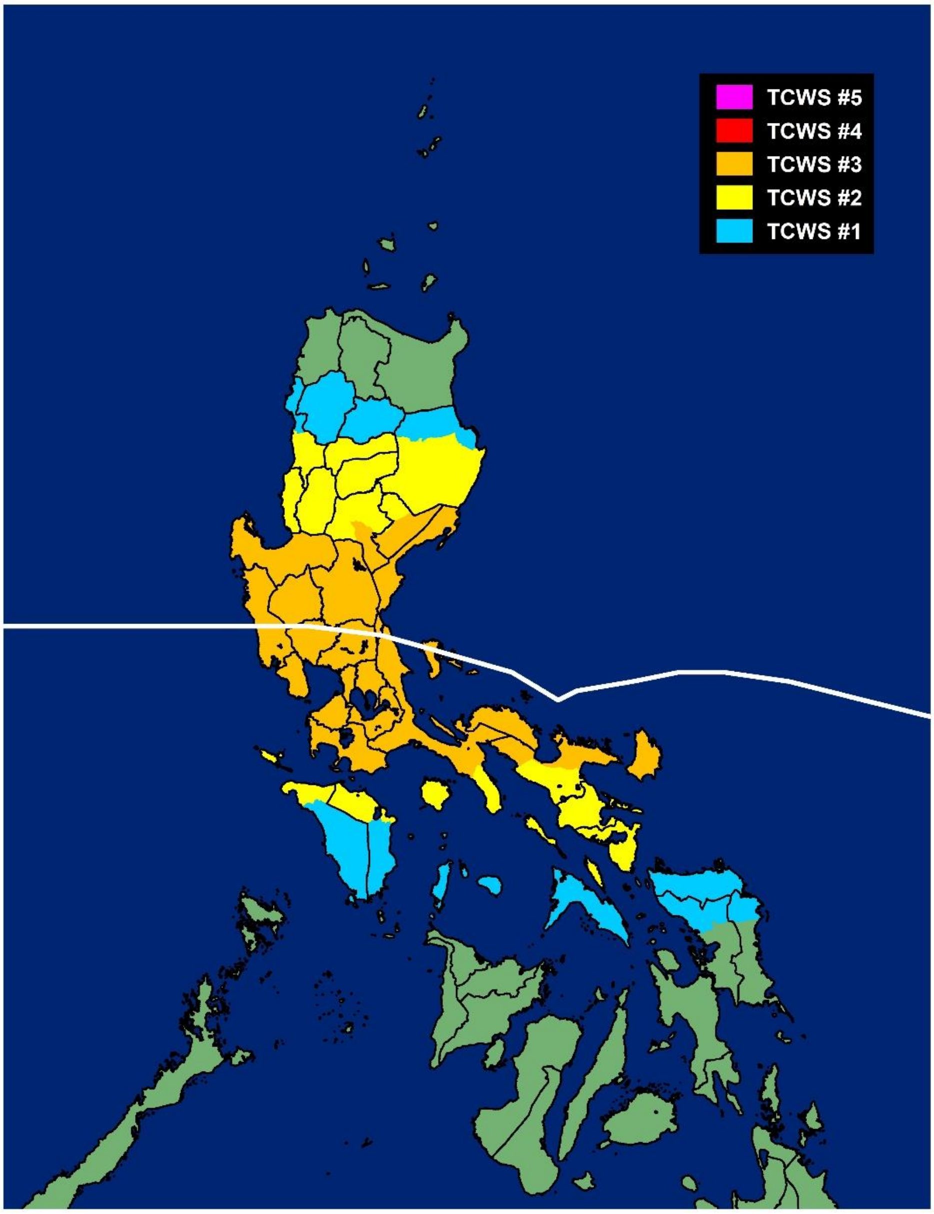
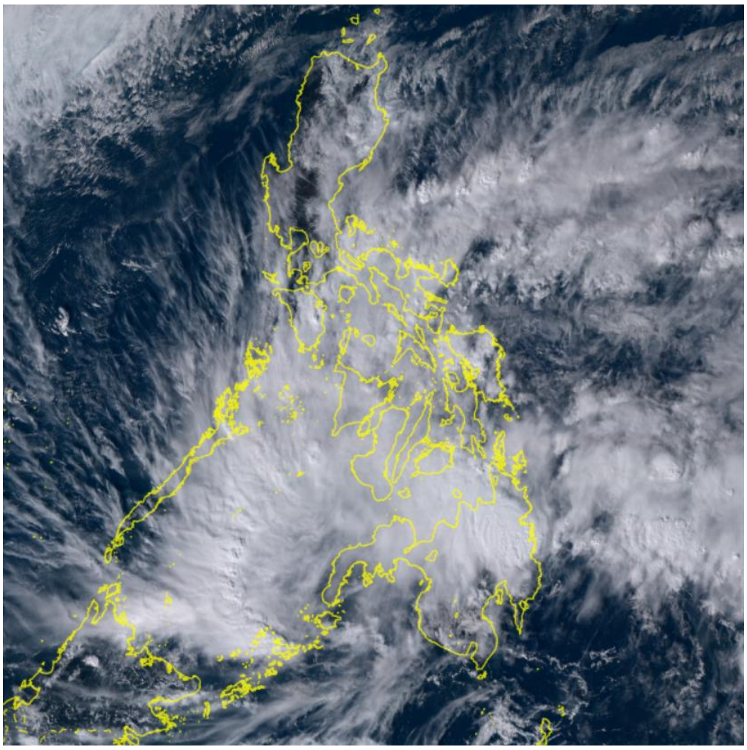


Fig. 4.20.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Typhoon Ulysses. The best track is also overlaid as a solid thick white line.

Tropical Depression Vicky
Vamco (2023)

18 to 25 December 2020



Basin-wide peak intensity:
Tropical Depression
30 kt (55 km/h)
1002 hPa

Developed:
00 UTC, 18 December 2020

Degenerated:
00 UTC, 25 December 2020

Duration within the PAR:
2 days and 5 hours

Peak category within the PAR:
Tropical Depression

Highest wind signal hoisted:
Wind Signal No. 1

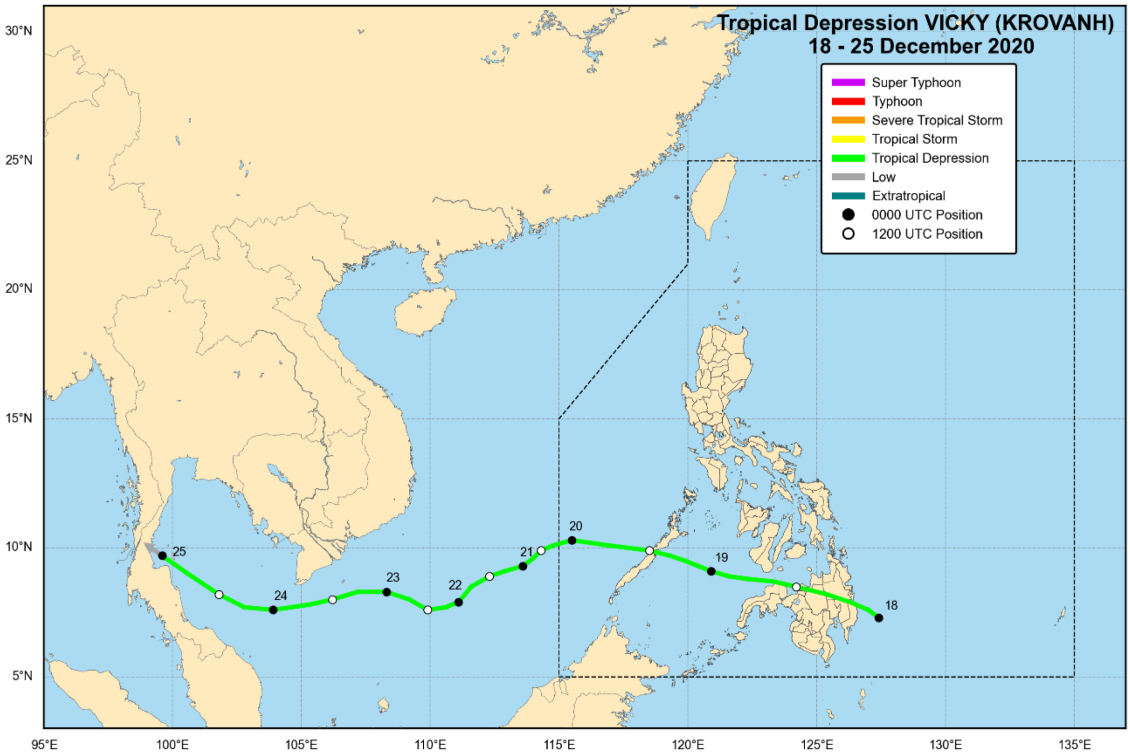


Fig. 4.21.1. Best track position and intensities of Tropical Depression Vicky.

Meteorological History

The last tropical cyclone within the PAR for the 2020 season was first tracked on 16 December as an area of low pressure situated over the waters south of Palau. Moving west northwestward over the Philippine Sea east of Mindanao, the disturbance entered the PAR region the following day. It developed into Tropical Depression Vicky at 00 UTC on 18 December while over the waters east of Davao Oriental. Due to its proximity to Mindanao at the time of formation, Vicky made landfall in the vicinity of Boston, Davao Oriental at around 0540 UTC of the same day. Due to the weak nature of its circulation, the newly formed depression rapidly crossed the landmass of Mindanao and was already over Iligan Bay at around 12 UTC of the same day. It briefly crossed the northern "hump" of Zamboanga Peninsula after making landfall at around 1340 UTC over the coastal town of Plaridel, Misamis Occidental. Vicky emerged over the waters between Mindanao and Negros Island at around 15 UTC and reached Sulu Sea a couple of hours later.

For the remainder of 18 December and onto the following day, Vicky tracked west northwestward over the Sulu Sea. Between 00 and 03 UTC on 19 December, the center of the depression passed between Tubbataha Reef area and mainland Cagayancillo, Palawan. At around 1100 UTC of the same day, Vicky made its third landfall in the vicinity of Puerto Princesa City, Palawan. The tropical depression emerged over the coastal waters west of the city shortly before 12 UTC. Over the West Philippine Sea, Vicky continued tracking west northwestward for the rest of 19 December before slowing down and turning generally southwestward the following day under the influence of a prevailing Northeast Monsoon cold surge. It exited the PAR region at 05 UTC on 20 December.

The tropical depression continued moving southwestward for roughly two and a half days over West Philippine Sea. During this period, it passed very close to the various islets and reefs in the Kalayaan Islands area. This was followed by a brief west northwestward turn at 12 UTC on 22 December. On 23 December, the depression shifted to a west southwestward heading as it tracked over the waters south of Vietnam. It again turned west northwestward on 24 December as it entered the Gulf of Thailand and headed towards the southern portion of Thailand. It made its final landfall as a weakening disturbance at around 22 UTC of the same day in the vicinity of Ko Samui Island in Surat Thani, Thailand before degenerating into a remnant low roughly 2 hours later over the waters west of Mu Ko Ang Thon in the same province.

Extremes of Surface Weather Observations during Tropical Cyclone Days

Highest storm duration (18 to 20 December 2020) rainfall over land:

- Casiguran, Aurora: 413.0 mm
- Baler, Aurora: 370.8 mm
- Hinatuan, Surigao del Sur: 250.6 mm
- Daet, Camarines Norte: 250.1 mm
- Virac, Catanduanes: 240.3 mm

Highest 24-hour rainfall over land:

- Casiguran, Aurora: 193.2 mm, 18 December 2020
- Hinatuan, Surigao del Sur: 182.2 mm, 18 December 2020
- Pag-asa Island, Kalayaan, Palawan: 177.8 mm, 19 December 2020
- Baybay City, Leyte: 164.4 mm, 18 December 2020
- Surigao City, Surigao del Norte: 163.6 mm, 18 December 2020

Lowest sea level pressure over land:

- Hinatuan, Surigao del Sur: 1002.5 hPa, 0700 UTC, 18 December 2020
- Francisco Bangoy International Airport, Davao City: 1003.3 hPa, 0600 UTC, 18 December 2020
- General Santos City: 1003.3 hPa, 0700 UTC, 18 December 2020
- Maasin City, Southern Leyte: 1003.4 hPa, 0700 UTC, 18 December 2020
- Dauis, Bohol: 1003.5 hPa, 0700 UTC, 18 December 2020
- Puerto Princesa City, Palawan: 1003.6 hPa, 0600 UTC, 19 December 2020

Highest peak gust over land:

- Guiuan, Eastern Samar: ENE (70°) at 44.7 kt (23 m/s), 1349 UTC, 18 December 2020
- Maasin City, Southern Leyte: ENE (60°) at 38.9 kt (20 m/s), 1049 UTC, 18 December 2020
- Hinatuan, Surigao del Sur: E (100°) at 33.0 kt (17 m/s), 0625 UTC, 18 December 2020
- Puerto Princesa City, Palawan: ENE (70°) at 31.1 kt (16 m/s), 1043 UTC, 18 December 2020
- Borongan City, Eastern Samar: NE (40°) at 29.2 kt (15 m/s), 0516 UTC, 18 December 2020

Summary of Warning Information

Number of public TC products issued: **32**

- Severe Weather Bulletins: **22**
- Tropical Cyclone Advisories: **0**
- Tropical Cyclone Updates: **10**

Number of TC Warning for Shipping issued: **14**

Reported Casualties and Cost of Damage

Source: Office of Civil Defense

Number of reported casualties: **9 dead, 2 injured, and 1 missing**
Combined cost of damage: **PHP 213,622,688.75**

- Damage to agriculture: **PHP 51,140,718.00**
- Damage to infrastructure: **PHP 162,481,970.75**

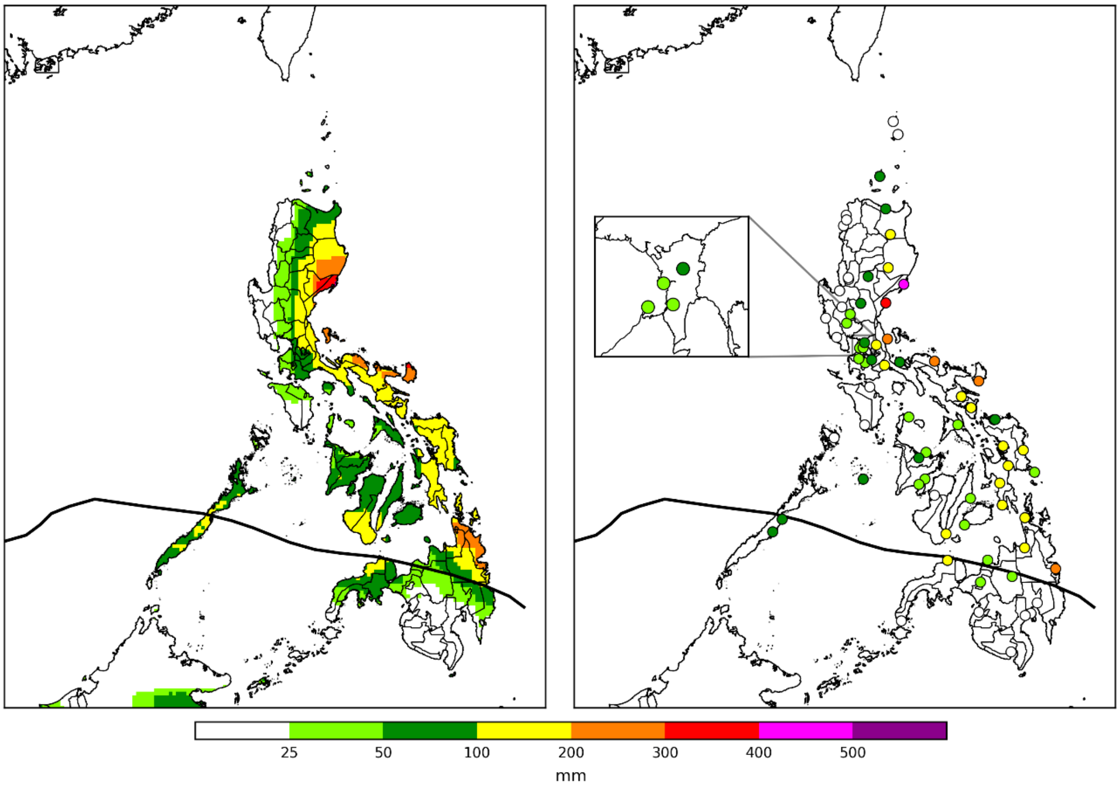


Fig. 4.21.2. Storm duration rainfall over land during the passage of Tropical Depression Vicky within the PAR based on GSMAP (left) and surface weather station reports (right). The best track is also overlaid as a solid thick black line.

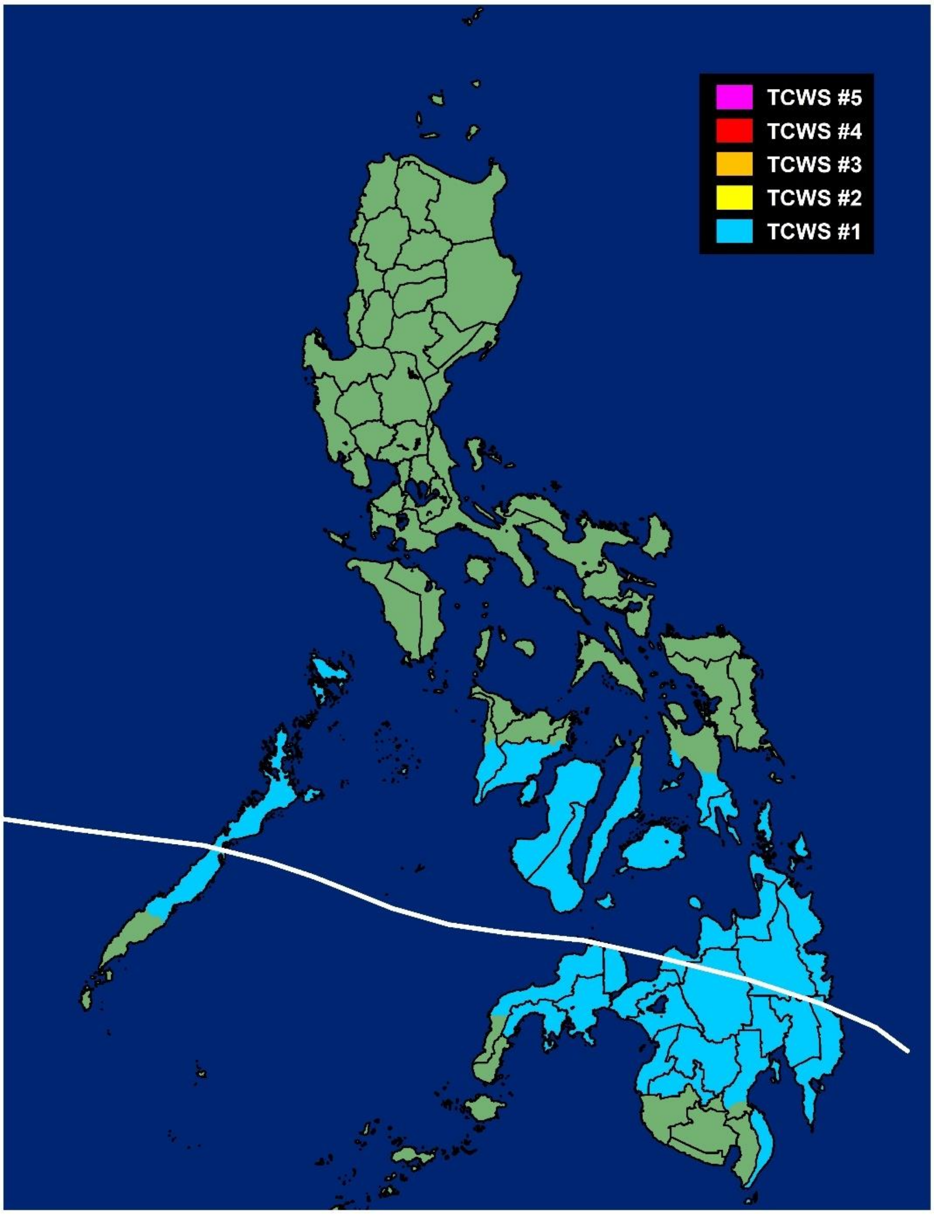


Fig. 4.21.3. Distribution of highest level of tropical cyclone wind signal level hoisted per province or sub-provincial locality during the passage of Tropical Depression Vicky. The best track is also overlaid as a solid thick white line.

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VERIFICATION OF OPERATIONAL TROPICAL CYCLONE FORECASTS FOR 2020

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Verification of Operational Tropical Cyclones Forecasts for 2020

This section reports the result of the verification of operational track forecasts for the 22 tropical cyclones (TCs) that occurred within the Philippine Area of Responsibility (PAR). These operational track forecasts (up to five days ahead) were verified against the TC best track data from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). Track forecasts with initial times at 00, 03, 06, 09, 12, 15, 18, and 21 UTC were evaluated, provided that the corresponding initial intensity is at least 34 kt (i.e., at least tropical storm (TS) category). The exclusion forecasts with initial intensity of less than 34 kt is based on the operational practice of the Regional Specialized Meteorological Center (RSMC) – Tokyo Typhoon Center. As such, 2020 TCs that did not reach TS category on the best track or those TCs whose initial intensities in all operational track forecasts were TD despite reaching TS category at some point in the best track were excluded from the verification. Based on these, no position errors were provided for Carina, Gener, Helen, and Ofel.

Metrics of Track Forecast Verification

To measure the performance of operational track forecasts, the direct positional error (DPE), along-track error (ATE), and cross-track error of the valid 24-, 48-h, 72-h, 96-, and 120-hour forecast positions were calculated using the verification subsystem of the PAGASA Integrated System for Typhoon Operations (PISTON)[1]. Heming (2016) defines DPE as the great circle distance between the observed position and forecast position at the same forecast validity time. The metric serves as a basic indication of the track forecast performance but does not provide information on the speed or directional bias of a forecast. Such information is provided by the specific forecast bias indicators called ATE and CTE.

To provide a visualized explanation of the ATE and CTE and their relationship with DPE, the metrics are diagrammatically presented in Fig. 5.1. The DPE can be represented as the hypotenuse of a right triangle whose sides comprise the component of the position error along the track (or the ATE) and the component across the track (or the CTE). ATE, the measure of forecast speed bias, is the component of the DPE along the direction[2] of the observed TC track. On the other hand, CTE, the measure of forecast directional bias, is the component of the DPE in the direction perpendicular to the aforementioned direction of the observed track.

Unlike the DPE, which is a non-negative number, ATE and CTE can be both positive and negative in value, with the sign being indicative of the nature of the bias of the track forecast. A positive ATE would indicate that the official track forecast has a fast bias while a negative ATE would indicate a slow bias in the forecast. Similarly, CTE is deemed positive if the forecast position lies to the right of the "extrapolated" observed track looking in the observed direction of motion of the TC in the northern hemisphere. This means that for a non-recurving TC moving east to west, a positive CTE would indicate a poleward bias in the track forecast of the TC.

[1] PISTON is a web-based graphical man-and-machine interactive application tool that integrates various subjective and objective guidance tools and provide other important information to facilitate typhoon forecast operations. This system aims to improve the efficiency of typhoon operations and reduce, but not eliminate, the forecasters' reliance on paper-based charts for forecast and warning preparation and issuance.

[2] The direction of the observed track at a particular ATE or CTE calculation is represented by the extrapolation of the line formed by connecting the observed position of the TC at forecast validity time and the observed position 6 hours before. The extrapolated line is also referred to in this document as the "extrapolated" observed track for the purpose of CTE calculation.

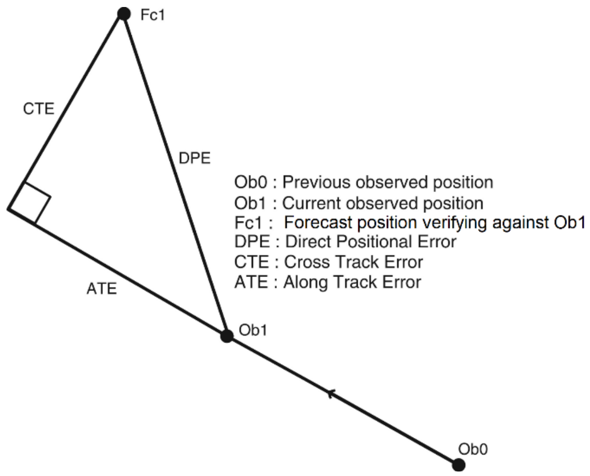

Fig. 5.1. Diagrammatic explanation of the metrics of operational track forecast performance. Figure adapted from Heming (2016).

Summary of 2020 Position Errors

For the 165 track forecasts issued by PAGASA during 2020 season, the mean DPEs were 59.9, 107.0, 143.7, 198.1, and 238.9 km for the 24-, 48-, 72-, 96-, and 12-hour forecast positions. The annual mean errors in the forecast of TC center position at the 12- to 120-hour forecast times since 2014 are shown in Fig. 5.2. It can be seen that the operational TC track forecasts of PAGASA have steadily improved within the last decade, although year-on-year fluctuations are also observed partly due to differences in the characteristics of TCs occurring within the PAR each year, the overall synoptic environment, and influences of seasonal to interannual climate variability. Higher forecast times (i.e., 48-hour and higher) have seen more improvements over the last decade. For instance, the 120-hour mean DPE in 2020 were similar to the mean DPE at 72 hours for the 2018 and 2019 seasons, while the 72-hour mean DPE of 2020 were similar to the mean DPE at 48-hour in 2016. Furthermore, the mean DPE at all forecast times in 2020 were found to be the lowest since 2014 (and potentially in the history of PAGASA). The improvements seen in the operational forecasts are partially attributed to the increased usage of multi-model consensus approach using the guidance information from a combination of global deterministic, regional deterministic, and global ensemble numerical weather prediction (NWP) models.

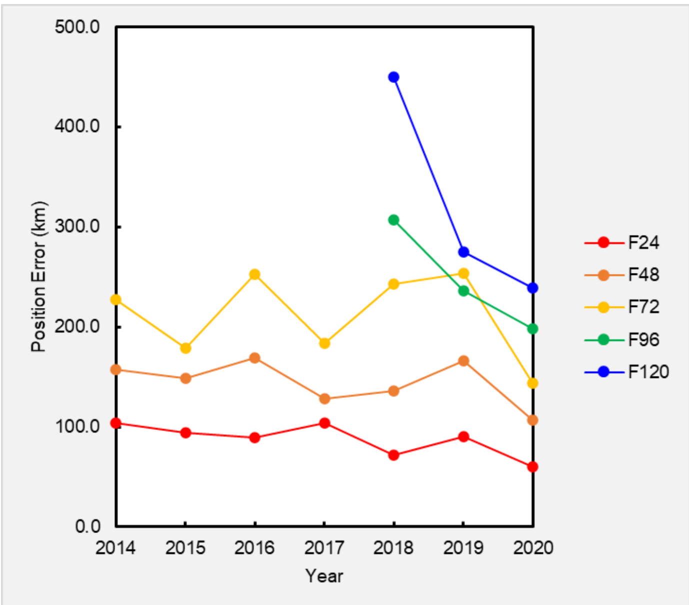

Fig. 5.2. Annual mean DPE of operational 24-, 48-, 72-, 96-, and 120-hour forecast positions from 2014 to 2020.

The details for position errors for each TC that occurred within the PAR region during the 2020 season are presented in Table 5.1. Track forecasts for Butchoy, Ferdie, Marce, and Siony were characterized by large position errors. For the case of Butchoy, Ferdie, and Marce, the large track errors were caused by the inability of most of the guidance models to fully capture the translation speed and track orientation of these TCs. Those in the track forecasts of Siony were caused by the period of erratic movement of the TC for two days in the absence of a dominant environmental steering that was not captured by the guidance models. Most of the typhoon (TY) and super typhoon cases during the season showed relatively small position errors across different forecast times, with TY Julian and TY Ulysses reporting mean errors not exceeding 200 km across the entire 5-day track forecast.

Table 5.1. Mean errors of operational 24-, 48-, 72-, 96-, and 120-hour forecasts for each of the TC that occurred within the PAR region. N represents the number of forecast positions that were verified against the PAGASA best track data.

TC Name	24-hour Forecast		48-hour Forecast		72-hour Forecast		96-hour Forecast		120-hour Forecast	
	Mean (km)	N	Mean (km)	N	Mean (km)	N	Mean (km)	N	Mean (km)	N
TY Ambo	75.3	22	107.4	22	120.8	15	252.1	7	370.8	3
TS Butchoy	53.4	1	221.5	1	-	0	-	0	-	0
TY Dindo	40.3	6	107.3	5	79.9	1	-	0	-	0
TS Enteng	68.9	2	-	0	-	0	-	0	-	0
TY Ferdie	135.8	1	-	0	-	0	-	0	-	0
TD Igme	32.1	3	25.2	3	113.5	3	-	0	-	0
TY Julian	58.6	14	69.7	13	62.7	10	70.8	6	161.5	2
STY Kristine	48.5	9	115.3	7	224.2	4	158.3	2	90.8	1
TS Leon	54.5	5	172.9	4	-	0	-	0	-	0
STS Marce	141.5	2	291.7	2	-	0	-	0	-	0
TS Nika	30.6	1	133.1	1	-	0	-	0	-	0
TY Pepito	42.2	9	75.8	9	84.7	9	113.6	6	-	0
TY Quinta	74.5	17	120.5	9	209.7	5	276.4	3	-	0
STY Rolly	46.3	24	106.1	18	177.8	13	218.7	9	176.6	4
STS Siony	83.8	18	167.6	13	287.2	9	413.7	5	531.7	1
TS Tonyo	76.9	1	-	0	-	0	-	0	-	0
TY Ulysses	37.9	19	55.2	14	83.1	9	110.7	6	170.8	2
Mean (N: total)	**59.9**	154	**107.0**	121	**143.7**	78	**198.1**	44	**238.9**	13

Fig. 5.3 shows the histogram of position errors of operational 24-, 48-, 72-, 96-, and 120-hour forecasts from PAGASA for the 2020 season. About 86.4% of 24-hour, 91.7% of 48-hour, 89.7% of 72-hour, 93.2% of 96-hour, and 84.6% of 120-hour forecasts had position errors not exceeding 100 km, 200 km, 300 km, 400 km, and 500 km, respectively.

For the speed and directional biases of the operational track forecast of the 2020 season, the scatter diagram of position errors of operational 24-, 48-, 72-, 96-, and 120-hour forecasts in the along- (ATE) and cross-track directions (CTE) are provided in Fig. 5.4. The mean directional and speed bias of the 24-, 48-, and 72-hour forecasts were found to be small. However, a considerable fast bias was noted on both the 96- and 12-hour forecast positions, with a more notable westward bias in the former.

Current Limits of Verification

The 2020 edition of the Annual Report on Philippine Tropical Cyclones (ARTC) was the first tropical cyclone report since the termination of the then-Annual Tropical Cyclone Report series in 1991 to feature best track-based track forecast verification statistics. However, the forecast position error statistics presented herein have the following limitations:

- The DPE, ATE, and CTE values from 2014 to 2017 are considered preliminary because of the absence of best track positions to serve as verifying dataset.
- Although the provision of five-day TC track forecasts commenced in 2015, Fig. 5.1 only included the verification scores for the 96- and 120-hour forecasts starting in 2018 due to the lack of an extended track data (either best track or warning track) from PAGASA for the years 2015 to 2017 which can be used to evaluate the performance at these forecast times (i.e., forecast positions at 96- and 120-hour usually lie outside the PAR region and observed track data up to the 2017 season are only limited to the PAR region).
- The provision of official forecast verification statistics ended in 1991 with the publication of the final annual tropical cyclone report of PAGASA. At the time of writing, efforts were underway to retrieve official track forecasts for the 1992 to 2013 seasons that were not yet digitized in order to facilitate its recalculation. Verification statistics using warning track as verifying dataset will be made available for these years in the 2021 or 2022 edition of the ARTC. In the absence of verification scores from 1992 to 2013, Fig. 5.2. did not incorporate the verification scores from 1991 and earlier seasons were not included.
- Other operational centers provide an operational forecast skill score and mean improvement ratios by comparing the official track forecast performance against a generally accepted benchmark, usually a climatological model. For track forecasts, the CLIPER model (Aberson 1998; Neumann 1972; Merrill 1980) serves as the benchmark prediction to assess operation skill. At this time, PAGASA track forecasts are not yet evaluated against these benchmarks, but such comparison is planned for the upcoming ARTCs once the model becomes available for operational use.

References

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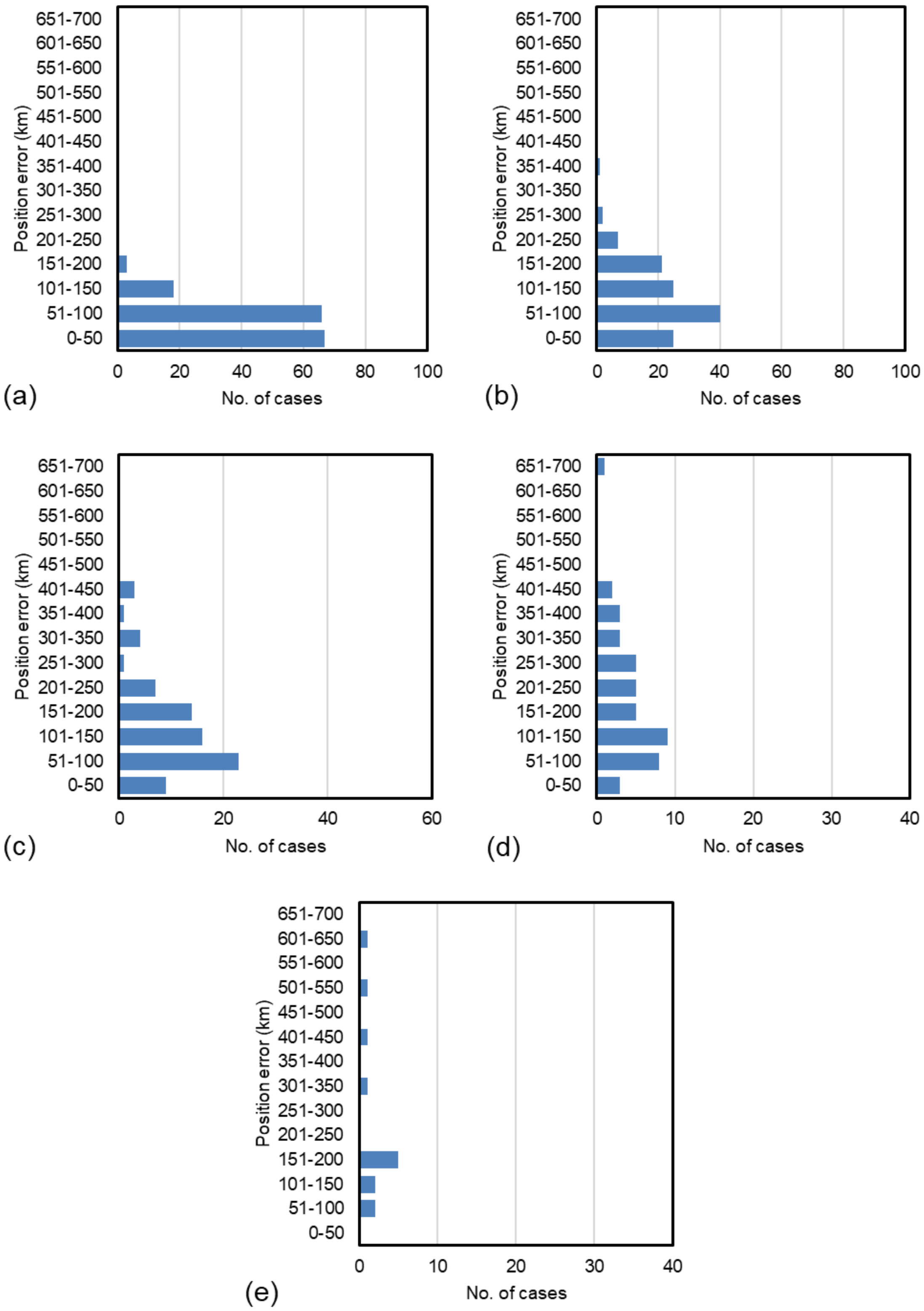

Fig. 5.3. Histogram of position errors of operational (a) 24-, (b) 48-, (c) 72-, (d) 96-, and (e) 120-hour forecasts from PAGASA for the 2020 season.

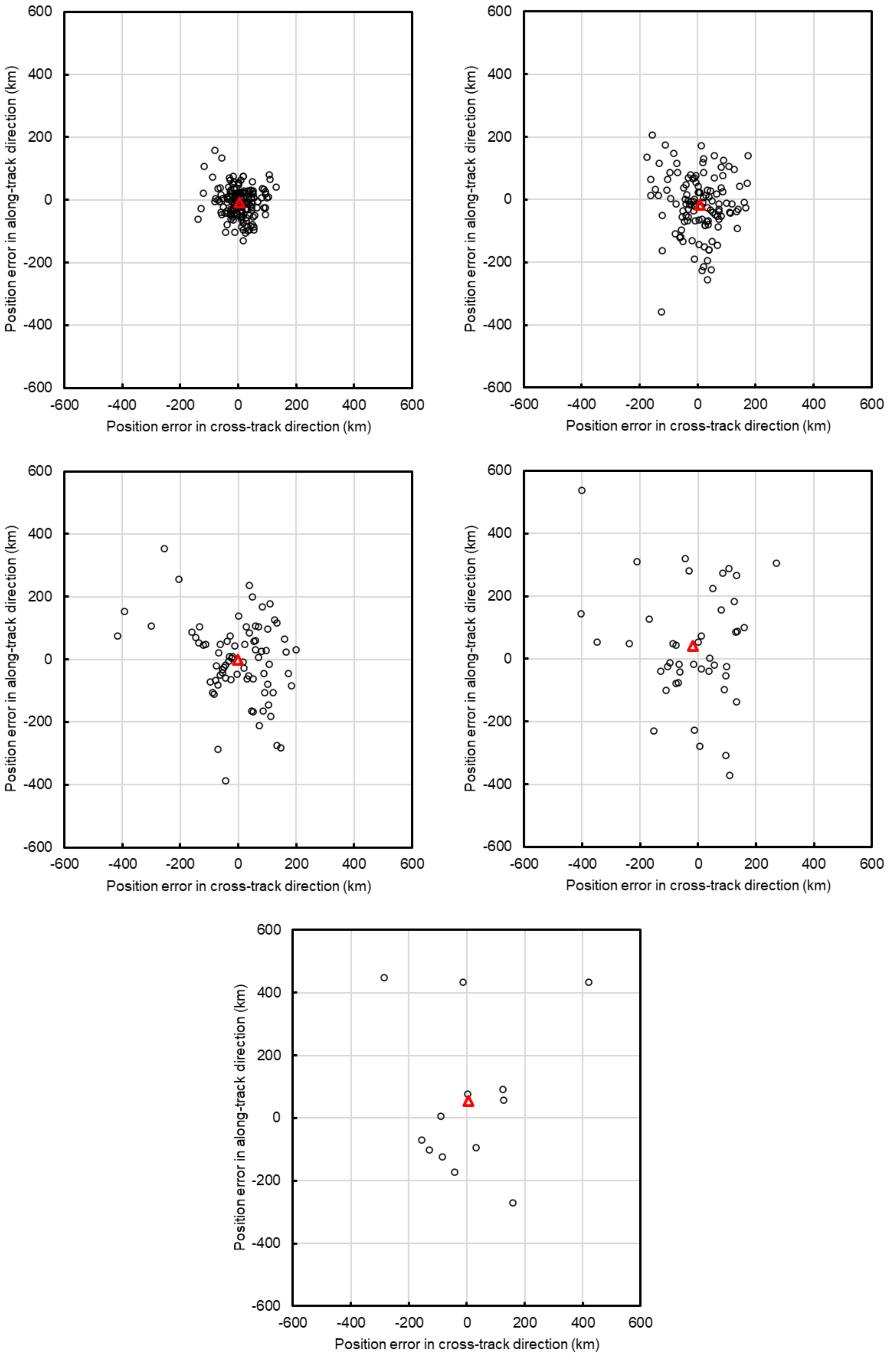

Fig. 5.4. Histogram of position errors of operational (a) 24-, (b) 48-, (c) 72-, (d) 96-, and (e) 120-hour forecasts from PAGASA for the 2020 season. The red triangle denotes the mean ATE and CTE for each forecast time.

PAGASA BEST TRACK DATA FOR 2020 TROPICAL CYCLONES

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PAGASA Best Track Data for 2020 Tropical Cyclones

The following information are the details of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) best track of each tropical cyclone (TC) during the 2020 season. Provided in a tabular format, each entry consists of the following information

- Date and time of analysis (DTG; Format: MM/DD HH) in Coordinated Universal Time (UTC);
- Latitude (CLAT) and longitude (CLON) coordinates of the center position rounded off to the nearest 0.1°N and 0.1°E respectively;
- Maximum sustained winds (MXWD) at 10-minute averaging in knots (kt) and rounded off to the nearest 5 kt; and,
- Sea level pressure at the estimated center position (PRES) in hectopascal (hPa) and rounded off to the nearest even integer for estimates of 990 hPa and higher or to the nearest 5 hPa for estimates below 990 hPa.

If the disturbance is classified as a low pressure area or post-tropical low/cyclone at a particular synoptic time, the indicator L or XT is written on the MXWD field, respectively.

The best track position and intensity information is always provided at standard synoptic times (00, 06, 12, and 18 UTC). In the case of a landfalling TC or a TC that passed within 30 nmi of the Philippine coastline, best track entries are provided at intermediate synoptic times as well (03, 09, 15, and 21 UTC) beginning at the point when the TC is 24 hours from landfall or its closest approach[1]. The best track data reverts to using standard synoptic times once the TC is more than 30 nmi from the Philippine coast line. The best track information covers the time the TC was first classified as a tropical depression to either its weakening into a low pressure area or transitioning into a post-tropical low/cyclone.

The best track positions and intensities in this report supersede the warning track[2] and the provisional track[3] that were issued by the Weather Division, PAGASA.

[1] This reference event is used for non-landfalling TCs that passed within 30 nmi of the Philippine coast line.
[2] Dataset containing the positions and intensities of a TC at standard (and if possible, intermediate) synoptic times that were issued in real time during the warning period.
[3] An initial version of the best track of a TC based on the revision of the operational track following a near-real time reanalysis of positions and intensities.

Table 6.1. Best track positions and intensities of Typhoon Ambo (Vongfong)

DTG	CLAT	CLON	MXWD	PRES
05/09 18	7.2	132.0	25	1006
05/10 00	7.6	131.4	25	1006
05/10 06	7.9	130.9	25	1006
05/10 12	8.2	130.3	25	1006
05/10 18	8.3	129.7	25	1006
05/11 00	8.4	129.3	25	1006
05/11 06	8.7	129.1	25	1006
05/11 12	9.1	129.1	30	1004
05/11 18	9.6	129.2	30	1004
05/12 00	10.2	129.4	30	1004
05/12 06	10.7	129.5	30	1002
05/12 12	11.3	129.5	35	1000
05/12 18	11.7	129.2	40	996
05/13 00	11.9	128.9	50	992
05/13 06	12.0	128.5	60	985
05/13 12	12.1	127.8	70	975
05/13 18	12.2	127.0	80	965
05/13 21	12.2	126.5	85	960
05/14 00	12.2	126.1	85	960
05/14 03	12.2	125.7	85	960
05/14 06	12.2	125.3	85	960
05/14 09	12.2	125.0	80	965
05/14 12	12.3	124.5	70	975
05/14 15	12.5	123.9	70	975
05/14 18	12.7	123.5	65	980
05/14 21	13.0	123.1	65	980
05/15 00	13.3	122.7	65	980
05/15 03	13.7	122.2	60	985
05/15 06	14.1	121.8	55	990
05/15 09	14.6	121.6	55	990
05/15 12	15.0	121.2	45	994
05/15 15	15.4	120.9	40	998
05/15 18	15.9	120.7	35	1000
05/15 21	16.5	120.3	30	1002
05/16 00	17.1	119.9	30	1004
05/16 03	17.6	119.6	30	1004
05/16 06	18.0	119.4	30	1002
05/16 09	18.4	119.3	30	1002
05/16 12	18.7	119.3	30	1002
05/16 15	19.2	119.4	30	1002
05/16 18	19.8	119.7	30	1002
05/16 21	20.2	120.0	30	1002
05/17 00	20.6	120.3	30	1004
05/17 03	21.0	120.7	30	1004
05/17 06	21.3	121.1	30	1002
05/17 09	21.5	121.6	30	1002
05/17 12	21.6	122.1	30	1004
05/17 15	21.8	122.6	30	1004
05/17 18	22.0	123.1	30	1002
05/18 00	22.6	124.3	L	1004

Table 6.2. Best track positions and intensities of Tropical Storm Butchoy (Nuri)

DTG	CLAT	CLON	MXWD	PRES
06/11 00	14.2	123.7	25	1004
06/11 03	14.4	123.1	25	1004
06/11 06	14.7	122.6	25	1002
06/11 09	15.1	122.1	25	1002
06/11 12	15.4	121.8	25	1004
06/11 15	15.7	121.3	25	1004
06/11 18	15.9	120.7	25	1002
06/11 21	16.0	120.0	25	1002
06/12 00	16.1	119.4	30	1000
06/12 03	16.2	118.9	30	1000
06/12 06	16.4	118.3	30	1000
06/12 12	16.8	117.6	35	998
06/12 18	17.6	116.8	35	998
06/13 00	18.6	116.1	40	996
06/13 06	19.4	115.2	40	996
06/13 12	20.2	114.2	35	998
06/13 18	20.9	113.2	35	998
06/14 00	21.6	112.1	30	1002
06/14 06	22.2	111.2	25	1004
06/14 12	22.7	110.5	L	1006

Table 6.3. Best track positions and intensities of Tropical Depression Carina

DTG	CLAT	CLON	MXWD	PRES
07/12 06	17.5	126.8	25	1004
07/12 12	17.2	125.9	25	1004
07/12 18	17.3	124.7	25	1004
07/12 21	17.5	124.3	25	1004
07/13 00	17.9	124.0	25	1004
07/13 03	18.1	123.7	25	1004
07/13 06	18.2	123.4	25	1004
07/13 09	18.6	123.2	25	1004
07/13 12	19.2	123.1	25	1004
07/13 15	19.6	122.7	25	1004
07/13 18	20.0	122.0	25	1004
07/13 21	20.2	121.5	25	1004
07/14 00	20.4	121.0	25	1004
07/14 03	20.6	120.8	25	1004
07/14 06	20.9	120.7	25	1004
07/14 12	21.2	120.7	L	1006

Table 6.4. Best track positions and intensities of Typhoon Dindo (Hagupit)

DTG	CLAT	CLON	MXWD	PRES
07/31 00	16.7	131.0	25	1006
07/31 06	17.0	130.2	25	1006
07/31 12	17.6	129.7	25	1006
07/31 18	18.4	129.4	25	1006
08/01 00	19.8	129.0	30	1004
08/01 06	20.9	128.0	30	1004
08/01 12	21.4	127.1	30	1002
08/01 18	22.0	126.0	35	1000
08/02 00	22.5	125.2	35	1000
08/02 06	23.1	124.7	40	998
08/02 12	23.7	124.3	45	996
08/02 18	24.2	124.0	55	990
08/03 00	25.0	123.5	60	985
08/03 06	26.2	122.5	65	980
08/03 12	26.8	121.8	70	975
08/03 18	27.7	121.1	70	975
08/04 00	28.6	120.6	65	980
08/04 06	29.5	120.3	50	992
08/04 12	30.7	120.2	40	998
08/04 18	32.4	120.5	35	1000
08/05 00	34.0	120.8	35	1000
08/05 06	35.2	121.5	35	1000
08/05 12	36.4	122.6	XT	1002

Table 6.5. Best track positions and intensities of Tropical Storm Enteng (Jangmi)

DTG	CLAT	CLON	MXWD	PRES
08/07 18	16.3	127.0	25	1002
08/08 00	17.3	126.7	25	1002
08/08 06	18.1	126.3	25	1002
08/08 12	19.3	126.2	25	1002
08/08 18	21.1	126.1	30	1000
08/09 00	23.0	126.1	35	998
08/09 06	25.3	126.2	40	996
08/09 12	27.8	126.3	40	996
08/09 18	30.1	126.6	45	994
08/10 00	32.1	127.4	40	996
08/10 06	34.8	128.6	40	996
08/10 12	37.2	130.0	35	998
08/10 18	39.9	132.3	35	998
08/11 00	42.9	135.9	XT	998

Table 6.6. Best track positions and intensities of Typhoon Ferdie (Mekkhala)

DTG	CLAT	CLON	MXWD	PRES
08/09 00	15.2	118.0	25	1004
08/09 06	16.0	118.3	25	1002
08/09 12	16.8	118.5	30	1000
08/09 18	18.1	118.6	30	1000
08/10 00	19.1	118.6	35	998
08/10 06	20.3	118.6	40	994
08/10 12	21.6	118.5	50	990
08/10 18	22.9	118.2	55	985
08/11 00	24.1	117.8	65	975
08/11 06	25.5	117.2	30	1002
08/11 12	27.4	116.6	L	1004

Table 6.7. Best track positions and intensities of Tropical Depression Gener

DTG	CLAT	CLON	MXWD	PRES
08/09 00	26.1	148.3	25	1014
08/09 06	26.1	148.0	25	1014
08/09 12	26.1	147.6	30	1012
08/09 18	26.1	147.0	30	1012
08/10 00	26.1	146.3	30	1012
08/10 06	26.2	145.3	30	1012
08/10 12	26.3	144.1	30	1012
08/10 18	26.4	142.8	25	1012
08/11 00	26.6	141.6	25	1012
08/11 06	26.6	140.6	25	1012
08/11 12	26.5	139.4	25	1012
08/11 18	26.4	137.8	25	1012
08/12 00	26.3	136.7	25	1012
08/12 06	25.9	135.4	25	1012
08/12 12	25.2	134.2	25	1012
08/12 18	24.7	132.6	25	1012
08/13 00	24.5	131.5	L	1012

Table 6.8. Best track positions and intensities of Typhoon Helen (Higos)

DTG	CLAT	CLON	MXWD	PRES
08/17 00	19.0	121.9	25	1006
08/17 03	19.3	121.3	25	1006
08/17 06	19.5	120.7	25	1006
08/17 09	19.6	120.1	25	1006
08/17 12	19.7	119.4	30	1004
08/17 18	19.8	118.4	30	1002
08/18 00	20.1	117.0	35	1000
08/18 06	20.6	115.8	40	996
08/18 12	21.1	114.8	55	990
08/18 18	21.6	113.8	65	980
08/19 00	22.2	113.0	60	985
08/19 06	22.8	112.2	40	996
08/19 12	23.8	110.9	30	1002
08/19 18	24.5	109.8	L	1004

Table 6.9. Best track positions and intensities of Typhoon Igme (Bavi)

DTG	CLAT	CLON	MXWD	PRES
08/21 00	20.2	122.3	25	1008
08/21 03	20.8	122.2	25	1008
08/21 06	21.3	122.2	25	1006
08/21 09	21.7	122.2	25	1006
08/21 12	22.1	122.2	30	1004
08/21 18	22.9	122.4	30	1004
08/22 00	23.4	122.7	35	1000
08/22 06	24.3	123.5	45	994
08/22 12	25.3	123.8	55	990
08/22 18	25.7	123.6	55	990
08/23 00	26.3	123.9	55	990
08/23 06	26.6	124.3	55	990
08/23 12	26.9	125.0	60	985
08/23 18	27.1	125.6	60	985
08/24 00	27.3	126.1	65	980
08/24 06	27.8	126.4	65	975
08/24 12	28.4	126.3	70	970
08/24 18	28.6	126.0	75	965
08/25 00	29.2	125.7	80	955
08/25 06	29.8	125.5	80	955
08/25 12	30.6	125.2	80	950
08/25 18	31.4	124.8	85	945
08/26 00	32.3	124.5	85	945
08/26 06	33.5	124.4	80	950
08/26 12	35.0	124.5	80	950
08/26 18	37.0	124.9	75	960
08/27 00	39.4	125.4	60	975
08/27 06	42.0	125.8	XT	990

Table 6.10. Best track positions and intensities of Typhoon Julian (Maysak)

DTG	CLAT	CLON	MXWD	PRES
08/27 06	15.3	131.9	25	1004
08/27 12	15.9	131.6	25	1004
08/27 18	16.6	131.5	30	1002
08/28 00	16.8	131.0	30	1000
08/28 06	17.2	130.2	35	998
08/28 12	16.7	130.0	40	996
08/28 18	16.4	129.7	50	990
08/29 00	16.3	129.4	55	985
08/29 06	16.6	129.2	55	985
08/29 12	16.7	129.0	65	975
08/29 18	16.9	128.9	70	970
08/30 00	17.3	128.9	75	965
08/30 06	18.4	129.0	75	965
08/30 12	19.5	129.0	80	960
08/30 18	20.7	128.9	80	955
08/31 00	22.4	128.4	80	955
08/31 06	24.2	127.6	85	945
08/31 12	25.0	127.1	90	940
08/31 18	26.1	126.5	95	935
09/01 00	26.9	126.0	95	930
09/01 06	27.6	126.1	95	930
09/01 12	28.4	126.3	95	935
09/01 18	29.4	126.6	90	940
09/02 00	30.5	126.7	85	945
09/02 06	31.7	127.1	80	950
09/02 12	33.2	127.9	80	950
09/02 18	35.5	129.0	75	960
09/03 00	38.8	129.6	65	970
09/03 06	42.4	129.2	XT	975

Table 6.11. Best track positions and intensities of Super Typhoon Kristine (Haishen)

DTG	CLAT	CLON	MXWD	PRES
08/31 00	23.7	146.1	25	1006
08/31 06	23.2	145.9	25	1004
08/31 12	22.8	145.8	25	1004
08/31 18	22.1	145.5	30	1002
09/01 00	21.5	145.0	35	1000
09/01 06	20.9	144.4	40	998
09/01 12	20.4	143.9	45	992
09/01 18	20.0	143.4	50	985
09/02 00	19.4	142.5	55	980
09/02 06	19.3	141.5	65	970
09/02 12	19.6	140.4	70	965
09/02 18	19.9	139.4	70	965
09/03 00	20.2	138.5	75	960
09/03 06	20.6	137.5	80	955
09/03 12	20.9	136.6	85	945
09/03 18	21.2	135.8	95	925
09/04 00	21.8	135.1	100	920
09/04 06	22.3	134.3	100	915
09/04 12	22.7	133.5	105	910
09/04 18	23.2	132.6	105	910
09/05 00	24.0	132.0	100	915
09/05 06	24.7	131.5	100	920
09/05 12	25.4	131.0	100	920
09/05 18	26.4	130.9	95	925
09/06 00	27.7	130.5	90	930
09/06 06	29.4	130.1	90	930
09/06 12	31.0	129.4	85	940
09/06 18	32.9	129.1	85	945
09/07 00	35.4	129.3	70	960
09/07 06	38.6	128.9	55	975
09/07 12	40.2	128.8	50	980
09/07 18	42.0	129.0	XT	990

Table 6.12. Best track positions and intensities of Tropical Storm Leon (Noul)

DTG	CLAT	CLON	MXWD	PRES
09/15 00	12.8	121.8	25	1006
09/15 03	12.7	121.1	25	1004
09/15 06	12.6	120.4	30	1002
09/15 09	12.6	119.8	30	1002
09/15 12	12.7	119.3	30	1000
09/15 15	12.8	118.9	30	1000
09/15 18	12.9	118.5	35	998
09/16 00	13.1	117.7	35	998
09/16 06	13.4	116.8	40	996
09/16 12	13.7	116.0	40	994
09/16 18	14.0	115.2	40	994
09/17 00	14.6	114.3	40	994
09/17 06	15.4	113.1	45	992
09/17 12	15.8	111.9	45	992
09/17 18	16.1	110.4	45	992
09/18 00	16.4	108.0	45	992
09/18 06	16.3	106.0	40	994
09/18 12	16.2	104.0	30	996
09/18 18	16.2	102.2	L	998

Table 6.13. Best track positions and intensities of Severe Tropical Storm Marce (Dolphin)

DTG	CLAT	CLON	MXWD	PRES
09/19 12	21.7	135.0	25	1010
09/19 18	22.3	134.5	25	1008
09/20 00	23.0	134.1	25	1006
09/20 06	23.8	133.9	25	1006
09/20 12	24.0	134.0	30	1004
09/20 18	24.3	134.3	35	1000
09/21 00	24.9	134.7	40	996
09/21 06	25.3	134.9	40	994
09/21 12	25.7	135.0	40	994
09/21 18	26.1	135.1	45	990
09/22 00	26.9	135.3	50	985
09/22 06	28.1	135.6	55	980
09/22 12	29.3	135.9	55	980
09/22 18	30.1	136.4	55	980
09/23 00	31.2	137.8	55	980
09/23 06	32.1	139.3	55	980
09/23 12	32.7	141.0	55	980
09/23 18	32.9	141.6	50	985
09/24 00	32.9	141.8	45	990
09/24 06	32.7	142.4	XT	992

Table 6.14. Best track positions and intensities of Tropical Storm Nika (Nangka)

DTG	CLAT	CLON	MXWD	PRES
10/11 06	17.0	119.3	25	1002
10/11 12	17.2	118.7	30	1000
10/11 18	17.4	118.0	30	1000
10/12 00	17.6	117.2	30	1000
10/12 06	17.9	115.8	35	998
10/12 12	18.1	114.5	40	996
10/12 18	18.2	113.4	45	992
10/13 00	18.4	112.0	45	992
10/13 06	18.6	111.2	45	992
10/13 12	19.0	110.4	45	990
10/13 18	19.7	108.7	45	990
10/14 00	19.9	107.6	40	996
10/14 06	20.0	106.6	35	998
10/14 12	20.0	105.7	30	1000
10/14 18	20.0	104.3	L	1004

Table 6.15. Best track positions and intensities of Tropical Depression Ofel

DTG	CLAT	CLON	MXWD	PRES
10/13 00	10.9	127.8	25	1004
10/13 03	11.1	127.7	25	1004
10/13 06	11.2	127.6	25	1004
10/13 09	11.3	127.5	25	1004
10/13 12	11.4	127.3	25	1004
10/13 15	11.6	126.6	25	1004
10/13 18	12.0	125.6	25	1004
10/13 21	12.5	124.7	25	1004
10/14 00	12.7	124.3	25	1004
10/14 03	12.8	124.0	25	1004
10/14 06	12.9	123.5	25	1004
10/14 09	13.1	122.8	25	1004
10/14 12	13.4	121.9	25	1004
10/14 15	13.7	121.1	25	1004
10/14 18	13.9	120.6	25	1004
10/14 21	14.1	120.1	25	1004
10/15 00	14.3	119.5	25	1004
10/15 06	14.8	117.8	25	1002
10/15 12	15.3	115.5	25	1002
10/15 18	15.6	113.7	25	1002
10/16 00	15.7	112.2	25	1002
10/16 06	15.6	110.6	25	1002
10/16 12	15.4	109.3	25	1002
10/16 18	15.0	108.1	L	1004

Table 6.16. Best track positions and intensities of Typhoon Pepito (Saudel)

DTG	CLAT	CLON	MXWD	PRES
10/18 18	13.0	131.7	25	1004
10/19 00	13.4	129.6	30	1002
10/19 06	13.8	128.3	30	1002
10/19 12	14.3	127.2	30	1002
10/19 15	14.6	126.6	30	1002
10/19 18	14.9	126.0	30	1002
10/19 21	15.3	125.3	30	1002
10/20 00	15.6	124.7	35	1000
10/20 03	15.9	124.0	35	998
10/20 06	16.0	123.2	40	996
10/20 09	15.8	122.5	40	996
10/20 12	15.9	122.2	40	996
10/20 15	16.3	121.4	40	996
10/20 18	16.4	120.7	40	996
10/20 21	16.3	119.7	40	996
10/21 00	16.2	118.8	40	996
10/21 06	16.1	118.1	45	992
10/21 12	16.0	117.5	55	985
10/21 18	16.2	116.9	55	985
10/22 00	16.7	116.5	60	980
10/22 06	17.1	116.2	60	980
10/22 12	17.4	115.9	65	975
10/22 18	17.5	115.7	65	975
10/23 00	17.5	115.3	65	975
10/23 06	17.7	114.7	65	975
10/23 12	17.9	114.2	60	980
10/23 18	18.1	113.7	55	985
10/24 00	18.2	113.3	55	985
10/24 06	17.8	112.7	55	985
10/24 12	17.5	111.6	50	990
10/24 18	17.5	110.5	50	990
10/25 00	17.5	109.2	45	992
10/25 06	17.5	108.2	35	998
10/25 12	17.6	107.6	25	1004
10/25 18	17.8	107.2	L	1006

Table 6.17. Best track positions and intensities of Typhoon Quinta (Molave)

DTG	CLAT	CLON	MXWD	PRES
10/23 00	10.2	134.9	25	1006
10/23 06	10.5	134.0	25	1006
10/23 12	11.1	132.8	25	1006
10/23 18	11.7	132.0	30	1004
10/24 00	12.6	131.0	30	1004
10/24 06	13.1	130.0	35	1000
10/24 12	13.3	128.9	40	998
10/24 15	13.4	128.3	40	998
10/24 18	13.5	127.7	45	994
10/24 21	13.5	127.1	45	994
10/25 00	13.4	126.3	50	992
10/25 03	13.4	125.6	55	990
10/25 06	13.4	124.8	65	980
10/25 09	13.4	124.1	70	975
10/25 12	13.3	123.3	70	975
10/25 15	13.2	122.6	70	975
10/25 18	13.1	121.9	70	975
10/25 21	13.1	121.2	70	975
10/26 00	13.2	120.4	70	975
10/26 03	13.3	119.6	70	975
10/26 06	13.4	118.8	75	965
10/26 12	13.4	117.6	80	955
10/26 18	13.4	116.0	80	955
10/27 00	13.4	114.7	85	950
10/27 06	13.5	113.3	90	945
10/27 12	13.8	112.1	90	945
10/27 18	14.2	110.8	85	950
10/28 00	14.6	109.8	80	955
10/28 06	15.2	108.5	70	970
10/28 12	15.4	107.4	45	992
10/28 18	15.4	106.1	30	1000
10/29 00	15.5	104.9	25	1004
10/29 06	15.6	104.3	L	1006

Table 6.18. Best track positions and intensities of Super Typhoon Rolly (Goni)

DTG	CLAT	CLON	MXWD	PRES
10/26 18	15.0	141.7	25	1008
10/27 00	15.4	141.6	25	1008
10/27 06	15.7	141.4	25	1008
10/27 12	16.0	141.1	30	1006
10/27 18	16.2	140.7	30	1006
10/28 00	16.4	140.0	30	1004
10/28 06	16.4	139.3	30	1004
10/28 12	16.5	138.6	35	1002
10/28 18	16.6	137.8	40	1000
10/29 00	16.7	136.8	55	994
10/29 06	16.7	135.7	65	985
10/29 12	16.6	134.5	75	975
10/29 18	16.4	133.4	95	945
10/30 00	16.4	132.7	100	935
10/30 06	16.3	131.6	105	925
10/30 12	16.1	130.9	115	915
10/30 18	15.8	129.9	115	915
10/30 21	15.6	129.4	115	915
10/31 00	15.3	128.8	115	915
10/31 03	15.0	128.2	115	915
10/31 06	14.7	127.6	115	915
10/31 09	14.4	127.1	115	915
10/31 12	14.1	126.4	115	915
10/31 15	13.9	125.7	115	915
10/31 18	13.7	125.0	120	905
10/31 21	13.6	124.3	115	910
11/01 00	13.5	123.6	100	925
11/01 03	13.5	122.8	80	965
11/01 06	13.7	122.1	65	980
11/01 09	14.1	121.6	50	992
11/01 12	14.3	121.1	40	998
11/01 15	14.4	120.4	35	1000
11/01 18	14.5	119.6	30	1002
11/01 21	14.6	119.1	30	1002
11/02 00	14.8	118.6	30	1002
11/02 06	15.2	117.9	30	1002
11/02 12	15.2	116.8	35	1000
11/02 18	15.1	116.0	35	1000
11/03 00	14.9	115.4	35	1000
11/03 06	14.8	115.2	35	1000
11/03 12	14.8	114.9	35	1000
11/03 18	14.7	114.2	35	1000
11/04 00	14.5	113.6	35	1000
11/04 06	14.4	113.3	40	998
11/04 12	14.3	112.8	40	998
11/04 18	14.3	112.2	40	998
11/05 00	14.2	111.7	40	998
11/05 06	13.9	111.4	35	1000
11/05 12	13.8	110.9	30	1002
11/05 18	14.0	110.3	30	1004
11/06 00	14.1	109.4	25	1008
11/06 06	14.2	108.6	L	1010

Table 6.19. Best track positions and intensities of Severe Tropical Storm Siony (Atsani)

DTG	CLAT	CLON	MXWD	PRES
10/30 06	11.0	143.4	25	1004
10/30 12	11.5	142.3	25	1004
10/30 18	12.4	140.8	25	1004
10/31 00	13.0	139.9	25	1004
10/31 06	13.9	138.7	25	1004
10/31 12	14.7	137.1	30	1002
10/31 18	15.0	136.2	30	1002
11/01 00	15.6	134.3	30	1002
11/01 06	16.2	132.9	30	1002
11/01 12	16.6	131.7	30	1002
11/01 18	17.5	129.6	30	1002
11/02 00	18.4	128.4	30	1002
11/02 06	19.3	127.7	30	1002
11/02 12	19.7	127.5	35	1000
11/02 18	20.0	127.3	35	1000
11/03 00	20.1	127.6	40	998
11/03 06	20.0	127.9	40	998
11/03 12	19.8	128.5	40	998
11/03 18	19.7	128.8	40	998
11/04 00	19.8	129.2	45	994
11/04 06	20.3	129.1	45	994
11/04 12	20.2	128.7	50	992
11/04 18	20.0	127.8	50	992
11/05 00	20.0	126.6	50	992
11/05 03	20.1	125.9	50	992
11/05 06	20.2	125.5	50	992
11/05 09	20.4	124.9	50	992
11/05 12	20.5	124.2	50	994
11/05 15	20.5	123.6	50	994
11/05 18	20.6	123.0	50	994
11/05 21	20.8	122.4	50	994
11/06 00	21.0	121.9	50	996
11/06 03	21.2	121.4	50	996
11/06 06	21.4	121.0	50	996
11/06 12	21.8	120.3	50	998
11/06 18	22.3	119.7	45	1000
11/07 00	22.6	119.4	35	1004
11/07 06	22.7	119.1	30	1008
11/07 12	22.5	118.5	L	1012

Table 6.20. Best track positions and intensities of Tropical Storm Tonyo (Etau)

DTG	CLAT	CLON	MXWD	PRES
11/06 12	10.0	130.7	25	1006
11/06 15	10.4	130.0	25	1006
11/06 18	10.7	129.3	25	1006
11/06 21	11.0	128.5	25	1006
11/07 00	11.3	127.7	25	1006
11/07 03	11.7	126.9	25	1006
11/07 06	12.2	125.9	25	1004
11/07 09	12.6	124.6	25	1004
11/07 12	12.7	124.1	25	1004
11/07 15	12.9	123.4	25	1004
11/07 18	13.2	122.6	25	1004
11/07 21	13.5	121.7	25	1004
11/08 00	13.4	120.6	25	1004
11/08 03	13.0	119.5	25	1004
11/08 06	12.7	118.7	25	1004
11/08 12	12.5	117.0	30	1002
11/08 18	12.9	115.0	35	998
11/09 00	12.8	113.4	40	996
11/09 06	12.5	122.0	45	992
11/09 12	12.4	111.4	40	996
11/09 18	12.3	110.7	40	996
11/10 00	12.3	109.9	35	998
11/10 06	12.4	108.7	30	1000
11/10 12	12.6	107.4	25	1004
11/10 18	12.5	106.4	L	1006

Table 6.21. Best track positions and intensities of Typhoon Ulysses (Vamco)

DTG	CLAT	CLON	MXWD	PRES
11/08 00	8.2	135.2	25	1006
11/08 06	8.8	134.0	25	1006
11/08 12	9.4	133.2	25	1006
11/08 18	10.1	132.4	25	1006
11/09 00	10.9	131.6	25	1006
11/09 06	11.5	130.9	30	1004
11/09 12	11.9	130.5	35	1002
11/09 18	12.8	129.6	35	1002
11/10 00	13.4	128.9	40	1000
11/10 06	14.0	128.1	45	994
11/10 09	14.2	127.4	45	994
11/10 12	14.4	126.6	50	990
11/10 15	14.5	126.2	50	990
11/10 18	14.6	125.8	55	985
11/10 21	14.7	125.1	60	980
11/11 00	14.7	124.6	65	975
11/11 03	14.6	124.1	70	970
11/11 06	14.5	123.5	70	970
11/11 09	14.4	123.3	70	970
11/11 12	14.7	122.8	75	965
11/11 15	14.9	122.1	75	965
11/11 18	15.1	121.4	75	965
11/11 21	15.2	120.6	60	980
11/12 00	15.2	119.9	55	985
11/12 03	15.2	119.1	55	985
11/12 06	15.2	118.4	60	980
11/12 12	15.2	117.4	60	980
11/12 18	15.2	116.5	60	980
11/13 00	15.3	115.4	65	975
11/13 06	15.4	114.4	70	970
11/13 12	15.5	113.4	75	965
11/13 18	15.6	112.5	80	960
11/14 00	15.7	111.5	85	955
11/14 06	16.0	110.3	85	955
11/14 12	16.3	109.4	80	960
11/14 18	16.6	108.5	70	970
11/15 00	17.1	107.6	55	985
11/15 06	17.7	106.5	35	1000
11/15 12	18.1	105.7	30	1008
11/15 18	18.7	104.5	25	1012
11/16 00	19.1	103.6	L	1014

Table 6.22. Best track positions and intensities of Tropical Depression Vicky (Krovanh)

DTG	CLAT	CLON	MXWD	PRES
12/18 00	7.3	127.4	25	1004
12/18 03	7.6	127.0	25	1002
12/18 06	7.9	126.3	25	1002
12/18 09	8.2	125.4	25	1004
12/18 12	8.5	124.2	25	1004
12/18 15	8.7	123.3	25	1004
12/18 18	8.8	122.3	25	1004
12/18 21	8.9	121.6	25	1004
12/19 00	9.1	120.9	25	1004
12/19 03	9.3	120.4	25	1004
12/19 06	9.5	119.9	25	1004
12/19 09	9.7	119.3	25	1004
12/19 12	9.9	118.5	25	1004
12/19 15	10.0	117.7	25	1004
12/19 18	10.1	116.9	25	1004
12/20 00	10.3	115.5	30	1002
12/20 06	10.1	114.8	30	1002
12/20 12	9.9	114.3	30	1002
12/20 18	9.6	114.0	30	1002
12/21 00	9.3	113.6	30	1002
12/21 06	9.1	112.9	30	1002
12/21 12	8.9	112.3	30	1002
12/21 18	8.5	111.6	30	1002
12/22 00	7.9	111.1	30	1002
12/22 06	7.7	110.6	25	1004
12/22 12	7.6	109.9	25	1004
12/22 18	8.0	109.2	25	1004
12/23 00	8.3	108.3	25	1006
12/23 06	8.3	107.2	25	1006
12/23 12	8.0	106.2	25	1006
12/23 18	7.8	105.3	25	1006
12/24 00	7.6	103.9	25	1006
12/24 06	7.7	102.8	25	1006
12/24 12	8.2	101.8	25	1006
12/24 18	9.0	100.6	25	1006
12/25 00	9.7	99.6	L	1008