DOST-PAGASA ANNUAL REPORT ON PHILIPPINE TROPICAL CYCLONES

2017

An official publication of the

Weather Division
Philippine Atmospheric, Geophysical and
Astronomical Services Administration (PAGASA)
Department of Science and Technology

Quezon City, Philippines
March 2019

Administrator	**Vicente B. Malano, Ph.D.**
Deputy Administrator, Operations and Services	**Landrico U. Dalida, Jr., Ph.D.**
Chief, Weather Division	**Esperanza O. Cayanan, Ph.D.**
Chief, Marine Meteorological Services Section	**Renito B. Paciente**
Chief, Weather Forecasting Section	**Roberto S. Sawi**
Supervising Meteorologist, Tropical Cyclone Group	**Juanito S. Galang**
Meteorologists, Tropical Cyclone Group	**Samuel F. Duran**
	Robb P. Gile
	Sheilla Mae R. Reyes

Weather Division
Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)
Department of Science and Technology (DOST)
WFFC Bldg., BIR Road, Brgy. Pinyahan, Diliman, Quezon City 1100, Philippines

ISSN 2672-3190 (Print)

For more information on publications of DOST-PAGASA
visit our website at bagong.pagasa.dost.gov.ph

PRINTED IN THE REPUBLIC OF THE PHILIPPINES

The **Annual Report on Philippine Tropical Cyclones** is an annual technical report published by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). This Report aims to provide a compendium of official information about the tropical cyclone (TC) season of interest, the TCs within the Philippine Area of Responsibility (PAR) for the season, and the warning services provided by the agency in relation to each TC event. As such, this iteration of the Annual Report serves as the official source of information for Philippine TCs during the 2017 season, unless a superseding reanalysis report is released by the agency.

The first issue of an annual report of this kind, entitled "Tropical Cyclones of 1948", was published by the Climatological Division under the direction of Dr. Casimiro del Rosario, Director of the post-war Weather Bureau. More than 70 years later, the Annual Report on Philippine Tropical Cyclones for 2017 was prepared by tropical cyclone meteorologists of the Weather Division under the direction of Dr. Vicente B. Malano, Administrator of PAGASA.

EXECUTIVE SUMMARY

A total of 22 tropical cyclones (TCs) entered the Philippine Area of Responsibility (PAR) in 2017, all of which were subject to domestic and international warnings by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). This season was characterized by higher than average annual number of TCs within the PAR, higher than normal number of storms and depressions, and lower than normal number of typhoons. July and September were the most active months of the year, while August saw less TCs than normal. The season was also notable for having no TCs during the month of Southwest Monsoon onset (June) and having slightly higher than average number of late-season TCs. In total, the TC activity in 2017 lasted for 53 days and 6 hours. Typhoon PAOLO was the strongest Philippine TC in 2017.

The 2017 season made a record-high number of landfalling TCs since 2009. The annual figure for the year, 10 TCs, was higher than long-term average. The period of November and December 2017 saw the greatest number of landfalling TCs during the year, reaching a total of 5 TCs, was higher than the average number for this period. Most of the TCs that made landfall during the year were at tropical depression category at the time of initial landfall. Meanwhile, 3 TCs were considered to be close-approaching TCs or those that passed to within 100 km of the nearest Philippine coastline. Typhoon VINTA was the strongest TC to make landfall during the year.

The TC events of 2017 directly and indirectly resulted to the deaths of 258 individuals which was the highest since 2014. Furthermore, a total of 117 injured and 217 missing persons were also reported. Damages to agriculture and infrastructure across the country amounted to Php 6.639 billion which was lower than the figures from the 2016 season. The last 2 TCs of the season, Tropical Storm URDUJA and Typhoon VINTA, were considered to be the costliest and deadliest TCs in 2017 respectively, with both TCs accounting for the deaths of 220 individuals and damages of up to Php 6.043 billion in the affected areas.

PAGASA, through the Weather Division, issued 307 domestic and 234 international warnings for the 22 TCs. A total of 15 TCs necessitated the raising of Tropical Cyclone Warning Signals in the country. TCWS No. 2 was the highest level of warning signal raised in 2017.

CONTENTS

TROPICAL CYCLONE WARNING SERVICE IN THE PHILIPPINE ISLANDS

Tropical Cyclone Warning Service in the Philippine Islands

HISTORICAL BACKGROUND

The Inception of Typhoon Observation and Warning in the Philippines

With entries from Montalvan (2013) and Manila Observatory (2014)

Although the current national meteorological and hydrological service of the Philippines, the PAGASA, was only instituted on 8 December 1972, the provision of meteorological service in the Philippines, including the issuance of typhoon warnings, dates back to the 19^{th} century with the *Observatorio Meteorológico del Ateneo Municipal de Manila* – a Jesuit institution established in 1865. The Observatory was founded following an article published by Fr. Jaime Nonell describing the observations of a typhoon in September 1865 by Fr. Francisco Colina. Despite initial hesitations to continue systemic observations due to primitive equipment, the Jesuits proceeded to establish the Observatory after being promised of a Secchi universal meteorograph from the Holy See. This meteorograph arrived in the Observatory in 1869, which at that time, was one of 3 in existence in the world.

Based on the understanding about tropical cyclones (TCs) in other ocean basins (i.e. hurricanes in the Atlantic and cyclones in the Indian Ocean) at that time, Fr. Federico Faura, the founding director of the Observatory, hypothesized that the typhoons in the Far East come from the Pacific and were not essentially dissimilar from other TCs as far as their nature and precursory phenomena were concerned because the popular myth at that time was that typhoons in the Far East come from the mountains. His hypothesis was put into test when barometric readings fell and changes in wind direction were observed on 7 July 1879. From this observation, Fr. Faura announced that a typhoon has passed over Northern Luzon which was later confirmed. This was the first TC warning issued in the Philippines.

Following this feat, in November of the same year, the Observatory announced that a typhoon will be crossing Manila which was the first TC forecast in the country. Although the lack of telegraph communications prevented the information from being disseminated outside Manila (resulting in casualties and damages in these areas), the early warning helped mariners to secure their vessels ahead of the typhoon as well as prevented further sea travel in the Manila area.

After the 1884 promulgation of a royal decree formalizing the institution as the official state organ for the observation and prediction of weather, the Jesuit priests of the Observatory, now called the *Observatorio Meteorológico de Manila*, made further strides in improving TC forecasting and warning in the Far East. In 1886, a typhoon barometer was developed by Fr. Faura for use by mariners in the Philippine seas and the South China Sea. In 1897, Fr. José Maria Algué, the successor of Faura as director of the Observatory, invented the barocyclonometer. This improvement of Faura's aneroid barometer allowed the prediction of TCs throughout the entire Far East. The Algue barocyclonometer technology was so advanced that in 1911, the instrument was applied to the Atlantic basin and adopted for use in all Atlantic naval stations of the United States Navy. Lastly, Fr. Algué was also credited for publishing the *Baguios ó ciclones Filipinos: Estudio teórico-practico* (Typhoons or Filipino cyclones: A study in theory and practice) in 1894 which served as an important guide for mariners in understanding and dealing with TCs in the Far East.

Following the promulgation of Act No. 131 of the Philippine Commission in 1901, the Observatory was reorganized as the Philippine Weather Bureau under the Department of Interior, with Fr. Algué as its first director. In the same year, 72 meteorological stations were established by the Bureau, allowing the systematic observation of rainfall and temperature across the country. In the following years, aside from the production of weather maps from electronically transmitted data (Fig 1.1), the mystification of Far East TCs was finally ended when Fr. Algué finally categorized TCs from the Pacific Ocean into 11 types. By the end of 1923, a total of 159 stations comprised the Bureau's observation network, with 90 additional stations established by local volunteers the year after. By 1926, the Bureau was regularly exchanging TC warnings with other observatories in the Far East.

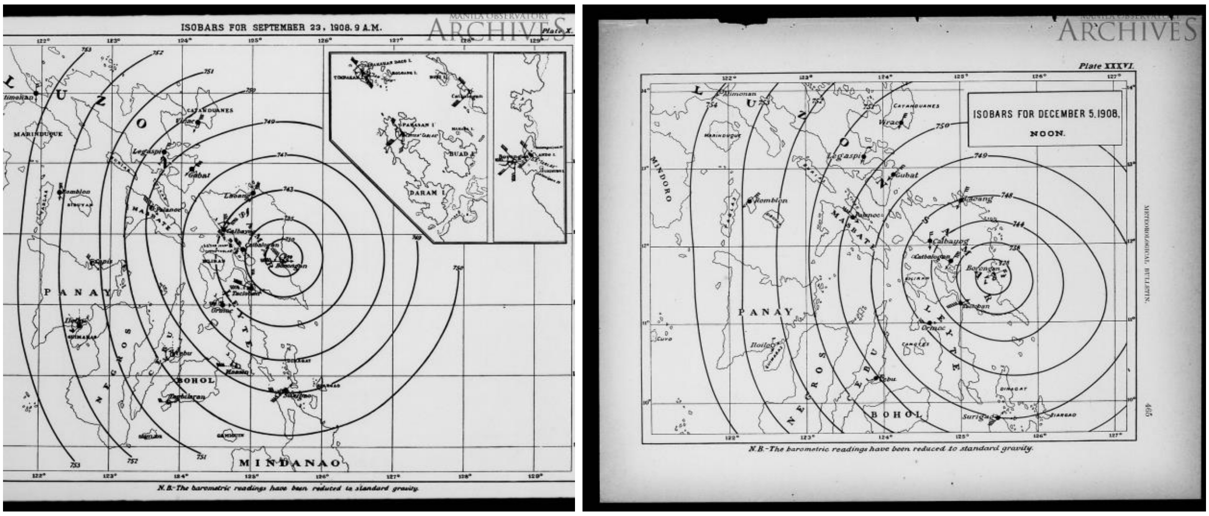


Fig. 1.1. Surface weather charts at (a) 9:00 AM on 23 September 1908 and (b) 12:00 PM on 5 December 1908 showing the isobar analysis of a TC making landfall in Eastern Samar. Images obtained from the website of the Manila Observatory Archives (http://archives.observatory.ph).

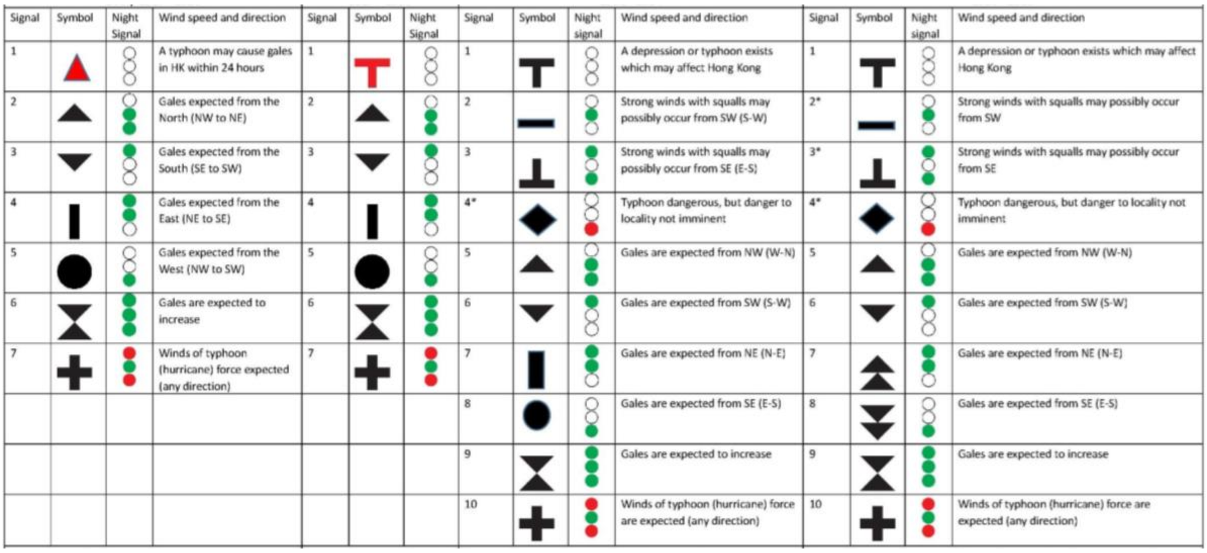
Origin of the Philippine Tropical Cyclone Warning Signals

With entries from Lui et al. (2018)

The origin of the tropical cyclone warning signal (TCWS) system of the Philippines can be traced back to the 1917 system of numbered storm signal codes developed by the Hong Kong Observatory (HKO). This system provided a standby signal, gale signals in four directions (N, S, E, W), an increasing gale signal, and a hurricane signal and was designed to warn the public of the impending threat of winds associated with an approaching TC in Hong Kong. Fig. 1.2 presents the evolution of the numbered storm signal system and the symbols associated with each signal that were hoisted in signal station masts.

Following a minor revision in 1927, the system was modified in 1930 after the recommendations at the Conference of Directors of Far Eastern Weather Services. The conference which was attended by Fr. Miguel P. Selga on behalf of the Philippine Weather Bureau aimed to introduce uniformity in local and non-local TC signals used by meteorological services in the Far East. Based on the recommendations, the 7-tier system was extended to 10 by introducing 2 signals for strong winds with squalls and a signal indicating the “presence of a dangerous typhoon, but danger to locality was not imminent”. The new system was adopted by the Bureau in 1931.

Amendments to the 1930 numbered storm signal system were made in 1935 following an agreement between the Bureau and the HKO. In the new system, Signals 2 to 4 were not used in Hong Kong, while Signal 9 was not implemented by the Bureau in the country. This is addition to changes in the symbols used for Signal Nos. 7 and 8. The 1935 version of the 10-tier system remained in effect until the demise of the *Observatorio Meteorologico de Manila* as the Philippine Weather Bureau following its destruction during the Battle of Manila in February 1945.



(a) (b) (c) (d)

Fig. 1.2. Evolution of the numbered storm signal system in the Far East: (a) 1917 HKO, (b) 1927 HKO, (c) 1931 Far East, and (d) 1935 Far East.

The current design of the TCWS system originated from the public storm warning signal (PSWS) system used by the post-war Philippine Weather Bureau, now a purely civilian agency of the government. Much simpler than the pre-war 10-tier numbered signal system where it was loosely based, the PSWS system consists of 3 storm signal levels wherein a higher signal number indicates stronger winds expected over a locality where it is raised. Unlike the current warning signal system, the original PSWS had a fixed lead time of 18 hours.

The post-war PSWS remained in use by the Bureau and its successor agency, PAGASA, until 1990, when it was deemed that the existing system failed to emphasize the threat posed by winds in excess of 185 km/h. In response, the PSWS was modified in 1991 to increase the lead time of lower storm signal levels to at most 36 hours and to include a Signal No. 4 to be raised in areas where TC winds of more than 185 km/h are expected. The new system, called the modified PSWS, was first tested when the first Signal No. 4 was raised during the passage of Typhoon TRINING in Luzon on 27 October 1991 and remained in use by PAGASA until 2015, when the system was amended in response to the public clamor for changes in the modified PSWS following the disaster of Super Typhoon YOLANDA in November 2013.

In order to address these demands, PAGASA introduced the TCWS in May 2015 to supersede the modified PSWS system. Aside from revising the range of wind speeds in Signal Nos. 2 to 4, the new TCWS introduced a Signal No. 5 in order to emphasize the threat posed by typhoon winds in excess of 220 km/h. Table 1 summarizes the changes from the original PSWS to the current TCWS.

Table 1.1. Evolution of post-war warning signals from the PSWS system to the TCWS system.

Warning Signal	Expected or prevailing wind speeds and longest available lead time from first issuance		
	PSWS (until 1990)	Modified PSWS (1991-2014)	TCWS (2015-Present)
Signal No. 1	30 to 60 km/h 18 hours	30 to 60 km/h 36 hours	30 to 60 km/h 36 hours
Signal No. 2	61 to 100 km/h 18 hours	61 to 100 km/h 24 hours	61 to 120 km/h 24 hours
Signal No. 3	In excess of 100 km/h 18 hours	101 to 185 km/h 18 hours	121 to 170 km/h 18 hours
Signal No. 4	-	In excess of 185 km/h 12 hours	171 to 220 km/h 12 hours
Signal No. 5	-	-	In excess of 220 km/h 12 hours

History of Tropical Cyclone Naming in the Western North Pacific basin

Domestic and International Names

Systematic naming of TCs within the Western North Pacific basin including the Philippine region began when in 1945, the United States Fleet Weather Central/Typhoon Tracking Center in Guam, now called the Joint Typhoon Warning Center (JTWC) started assigning female English names to TCs of at least tropical depression category in alphabetical order. This naming practice was updated in 1979 when JTWC introduced male names to be used alternately with female names. However, in 1963, the post-war Philippine Weather Bureau started naming TCs entering or developing within the Philippine Area of Responsibility (PAR) using female Filipino names ending in *-ng* in native alphabetical order, resulting in Western North Pacific TCs having 2 names when the system occurs within the PAR. In the Philippines, the names assigned by the JTWC (and later on, JMA) are referred to as *international names*, while the names assigned by the Bureau (and later on, PAGASA) are called *domestic names*.

Beginning in 2000, the World Meteorological Organization (WMO) transferred the TC monitoring duties in the Western North Pacific, including the assignment of international names, from the JTWC to the Japan Meteorological Agency (JMA) after the latter's Tokyo Typhoon Center's assignment as the Regional Specialized Meteorological Center (RSMC-Tokyo). In addition, a new scheme of international names was adopted to replace the alphabetical naming scheme used by the JTWC since 1945. In the new system, the 14 member-countries of the UNESCAP/WMO Typhoon Committee contributed a set of 10 names using their respective languages. Unlike the JTWC system, the rotation of names under the new scheme is based on the alphabetical order of the contributing nations.

Meanwhile, changes in the domestic naming scheme was also introduced by PAGASA (which assumed tropical cyclone services from the Bureau in 1972) in 2001 when the agency began using new sequential sets of TC names based on the English alphabet that do not just end in *-ing* and departed from the old practice of using only feminine names. The new PAGASA naming scheme remains in use today and is further discussed alongside the current scheme of international names in the subsequent sections of this report.

DOST-PAGASA EARLY WARNING SERVICES FOR TROPICAL CYCLONES IN THE PHILIPPINES

Monitoring Domains

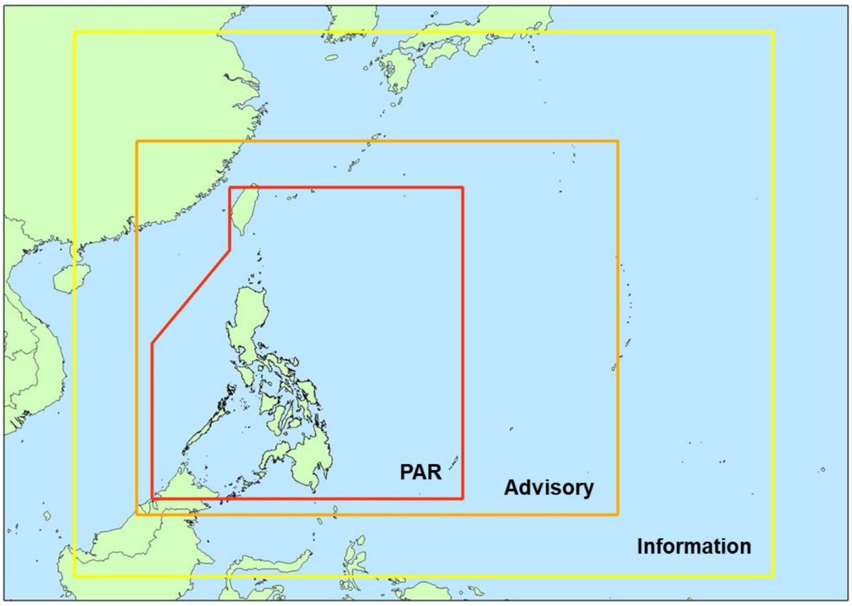


Fig. 1.3. Operational TC monitoring domains used by PAGASA.

As the mandated national meteorological and hydrological service of the Philippines, PAGASA, through the tropical cyclone meteorologists of the Weather Division, provides analysis, forecast and warning services to various end users when TCs develop or enter within any of the 3 operational TC monitoring domains of the agency as presented in Fig. 1.3.

Philippine Area of Responsibility (PAR)

The PAR, shown in Fig. 1.3 with domain bounded with red lines, is the official forecast and warning area of responsibility of PAGASA as designated by the WMO. As such, the PAR serves as the domain in which PAGASA has the responsibility for issuing domestic tropical cyclone warnings as well as warnings for exchange with other meteorological centers in the region. In addition, the domain also serves as the limit of high seas forecast areas of the agency. The PAR is the region in the Western North Pacific basin bounded by rhumb lines connecting 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 and encompasses nearly all of the land territory of the Philippines except for the southernmost portions of Tawi-Tawi and some of the country's claims in the Kalayaan Group of 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.

All Western North Pacific TCs entering the PAR are assigned a domestic name, whether or not they possess an international name from the RSMC-Tokyo. During TC occurrences within the PAR, PAGASA issues Tropical Cyclone Warnings for Shipping every 6 hours and Severe Weather Bulletins (Alert or Warning) every 12, 6 or 3 hours, depending on the degree of threat posed by the TC to coastal and inland areas of the country.

Tropical Cyclone Advisory Domain (TCAD)

The region in the Western North Pacific basin bounded by rhumb lines connecting the coordinates 4°N 114°E, 28°N 114°E, 28°N 145°E, and 4°N 145°E except the region within the PAR, is referred as the Tropical Cyclone Advisory Domain (TCAD) shown in Fig. 1.3 with domain bounded with orange lines. In 2016, the domain was created as a measure to address the public clamor for official information from PAGASA about TCs outside the PAR, whether or not the cyclone will pose any threat to the country.

Whenever a TC is monitored within the domain, PAGASA routinely analyzes its center position, intensity and movement every 6 hours and issues Tropical Cyclone Advisories (TCAs) once a day at 11:00 AM[1]. Updates in between these issuances are incorporated in the Public Weather Forecast at 4:00 AM and 4:00 PM.

Tropical Cyclone Information Domain (TCID)

The region in the Western North Pacific basin bounded by rhumb lines connecting the coordinates 0° 110°E, 35°N 110°E, 35°N 155°E, and 0° 155°E except the region within the PAR and the TCAD is referred as the Tropical Cyclone Information Domain (TCID), shown in Fig. 1.3 as the outermost domain. Like TCAD, this domain was also created in 2016 in response to the public demand for information on TCs outside the PAR.

Routine analysis of center position, intensity and movement are undertaken every 6 hours for TCs within the TCID. However, no standalone warning product is issued. Instead, PAGASA provides information on these TCs in the Public Weather Forecast at 4:00 AM and 4:00 PM.

Tropical Cyclone Classification

Western North Pacific TCs are classified by PAGASA according to their maximum sustained winds near their centers. The current scheme which was implemented since 2015 is a 5-tier scale with Tropical Depression as the weakest of the categories and Super Typhoon as the strongest. Table 1.2 presents the classification of TCs under the current scheme and their corresponding maximum

[1] Except on first and final issuance, in which TCAs can be issued at any time of the day

sustained winds near the center in kilometers per hour (km/h), nautical miles per hour or knot (kt) and in Beaufort scale number.

Table 1.4. Classification of TCs used by PAGASA since May 2015

Category of TC	Maximum sustained winds near the center		
	km/h	kt	Beaufort Scale
Tropical Depression (TD)	< 62	< 34	< 8
Tropical Storm (TS)	62 to 88	34 to 47	8 to 9
Severe Tropical Storm (STS)	89 to 117	48 to 63	10 to 11
Typhoon (TY)	118 to 220	64 to 120	12
Super Typhoon (STY)	> 220	> 120	12

The difference between the pre-2015 categories and the current scheme is the adoption of Severe Tropical Storm and Super Typhoon, thereby increasing the number of TC categories from 3 to 5. The change was part of operational improvements made by PAGASA following the disaster of Super Typhoon YOLANDA in 2013.

Provision of Warning Products and Services

Depending on the location of the TC within the monitoring domains, PAGASA issues different warning products to the end users. This subsection discusses each warning product issued by the agency during tropical cyclone events.

For TCs within the TCID

PAGASA does not issue any warning product for TCs within the TCID. However, the following information on the TCs within the domain are incorporated in the Public Weather Forecast issued at 4:00 AM and 4:00 PM based on observation data at 2:00 AM and 2:00 PM, respectively:

Analysis	Center position Maximum sustained winds (10-minute averaging) Maximum gust Direction and speed of movement

Tropical Cyclone Advisory (TCA)

For TCs within the TCAD, PAGASA issues Tropical Cyclone Advisory (TCA) to domestic end users at 11:00 AM based on observation data at 8:00 AM, except for initial and final issuance, which are issued within 3 hours after any standard observation time (8:00 AM, 2:00 PM, 8:00 PM and 2:00 AM). The TCA includes the following information regarding the TC of interest:

Analysis	Center Position Maximum sustained winds (10-minute averaging) Maximum gust Direction and speed of movement
24-, 48- , and 72-h Forecast	Center Position Category (i.e TD, TS, STS, TY or STY)

Aside from these, the TCA contains warning information such as a general statement of possible hazards that may affect the country, the areas where TCWS will be first raised if there are any, as well as other information such as date and time of expected entry to the PAR and etymology of the international name of the TC.

In between issuances, updates on the following information are also incorporated in the Public Weather Forecast issued at 4:00 AM and 4:00 PM based on observation data at 2:00 AM and 2:00 PM, respectively:

Analysis	Center position Maximum sustained winds (10-minute averaging) Maximum gust Direction and speed of movement

Severe Weather Bulletin – Tropical Cyclone Alert (SWB-Alert)

If a TC is within the PAR but the situation does not necessitate the raising of TCWS on any locality (or if all TCWS have been cancelled), PAGASA issues Severe Weather Bulletin – Alert (SWB-Alert) to domestic end users at 11:00 AM and 11:00 PM based on observation data at 8:00 AM and 8:00 PM, respectively. However, initial and final issuances are made within 3 hours after any standard observation time. The SWB-Alert includes the following information:

Analysis	Center position Maximum sustained winds (10-minute averaging) Maximum gust Direction and speed of movement
24-, 48- , 72-, 96-, and 120-h Forecast	Center Position Category (i.e TD, TS, STS, TY or STY)

Aside from these, the SWB-Alert contains warning information such as the expected hazards that may affect inland and coastal areas (including coastal waters) within the next 3 days and areas where TCWS will be raised (including earliest time of raising) if there are any, as well as other information such potential area/s of landfall and possible date and time of exit from the PAR.

In between issuances, updates on the following information are also incorporated in the Public Weather Forecast issued at 4:00 AM and 4:00 PM based on observation data at 2:00 AM and 2:00 PM, respectively:

Analysis	Center position Maximum sustained winds (10-minute averaging) Maximum gust Direction and speed of movement

Severe Weather Bulletin – Tropical Cyclone Warning (SWB-Warning)

If a TC is within the PAR and the situation necessitates the raising of TCWS over any locality, a Severe Weather Bulletin – Tropical Cyclone Warning (SWB-Warning) is issued to domestic end users at 11:00 AM, 5:00 PM, 11:00 PM, and 5:00 AM based on observation data at 8:00 AM, 2:00 PM, 8:00 PM, and 2:00 AM. The SWB-Warning includes the following information:

Analysis	Center position Maximum sustained winds (10-minute averaging) Maximum gust Direction and speed of movement
24-, 48- , 72-, 96-, and 120-h Forecast	Center Position Category (i.e TD, TS, STS, TY or STY)

Aside from these, the SWB-Warning identifies the areas where TCWS are currently in effect, areas where TCWS will be raised or cancelled (including earliest time of raising or cancelling), and other warning information such as the expected hazards that may affect inland and coastal areas (including coastal waters) within the next 3 days. Furthermore, additional information such as potential area/s of landfall and possible date and time of exit from the PAR are also provided.

If a TC is at most 24 hours before an expected landfall, additional issuances of SWB-Warnings are made at 2:00 PM, 8:00 PM, 2:00 AM and 8:00 AM based on observation data at 11:00 AM, 5:00 PM, 11:00 PM and 5:00 AM, respectively.

Tropical Cyclone Warning for Shipping (IWS)

If a TC is within the PAR irrespective of the threat posed in localities, a Tropical Cyclone Warning for Shipping (also known as International Warning for Shipping or IWS) is issued to mariners and shipmasters plying the coastal waters and high seas within the PAR at 11:00 AM, 5:00 PM, 11:00 PM, and 5:00 AM based on observation data at 8:00 AM, 2:00 PM, 8:00 PM, and 2:00 AM. The IWS contains the following information:

Analysis	Center position Maximum sustained winds (10-minute averaging) Central Pressure Direction and speed of movement Radius of wind areas above 30, 50, and 64 kt
24-, 48- , 72-, 96-, and 120-h Forecast	Center Position Category (i.e TD, TS, STS, TY or STY)

The IWS also serves as the official warning of PAGASA as the national meteorological and hydrological services for TCs within the PAR. As such, the IWS is disseminated to other TC warning centers via the WMO Global Telecommunications System (GTS) using the header WTPH20 RPMM.

Tropical Cyclone Warning Signal (TCWS) System

The Tropical Cyclone Warning Signal (TCWS) System is a 5-tier wind warning scheme used by PAGASA since 2015 in order to warn the localities of the expected severe wind conditions associated with an approaching TC inside the PAR. The warning signals raised over the localities are dependent on the maximum sustained wind, wind structure, and forecast track of the TC. Table 1.5 presents the various warning signals under the TCWS system, the expected prevailing wind speed over the area where it is in effect, and the lead time before the onset of such winds. Note that the lead time of each warning signal level is valid beginning only on the first instance the said warning signal is raised.

Table 1.5. Tropical Cyclone Warning Signal System

TCWS	Prevailing or expected meteorological condition
Signal No. 1	Winds of 30 to 60 km/h is prevailing or is expected to prevail within the next 36 hours from the time the signal was raised.
Signal No. 2	Winds of 61 to 120 km/h is prevailing or is expected to prevail within the next 24 hours from the time the signal was raised.
Signal No. 3	Winds of 121 to 170 km/h is prevailing or is expected to prevail within the next 18 hours from the time the signal was raised.
Signal No. 4	Winds of 171 to 220 km/h is prevailing or is expected to prevail within the next 12 hours from the time the signal was raised.
Signal No. 5	Winds in excess of 220 km/h is prevailing or is expected to prevail within the next 12 hours from the time the signal was raised.

As the name suggests, because it is a wind warning signal system, the level of warning signal in effect over a community has no relation to the expected amount of rainfall over the area during the entire passage of the TC. At the moment, the warning signals are raised on a provincial level, although depending on the wind structure of the TC, the size of the province, and the orientation of the province with respect to the forecast track, warning signals may be raised on a sub-provincial level.

PAGASA Tropical Cyclone Naming Scheme

The first TC of the year that enters or develops within the PAR is assigned the name beginning with letter A and so as one TC succeeds another. For the 2017 season, the first TC was named AURING, followed by BISING, and so on. If the total number of TCs within the year exceeds 25, an auxiliary list is used, and the 26th TC will be assigned the name beginning in letter A. In the case of 2017, the 26th TC would have used the name ALAMID. Note that Philippine TC names do not use names beginning with letter X.

Four sets of regular names from A to Z and auxiliary names from A to J are being rotated every year. Set 1 was used for 2017, while set 2 will be for 2018, and so on. Set 1 will be used again in 2021. The sets of TC names as of the 2017 season are presented in Table 1.6, while the sets of auxiliary names are in Table 1.7.

Table 1.6. Regular domestic names for Philippine TCs

Set 1	Set 2	Set 3	Set 4
2017, 2021, 2025, 2029	2018, 2022, 2026, 2030	2019, 2023, 2027, 2031	2020, 2024, 2028, 2032
AURING	AGATON	AMANG	AMBO
BISING	BASYANG	BETTY	BUTCHOY
CRISING	CALOY	CHEDENG	CARINA
DANTE	DOMENG	DODONG	DINDO
EMONG	ESTER	EGAY	ENTENG
FABIAN	FLORITA	FALCON	FERDIE
GORIO	GARDO	GORING	GENER
HUANING	HENRY	HANNA	HELEN
ISANG	INDAY	INENG	IGME
JOLINA	JOSIE	JENNY	JULIAN
KIKO	KARDING	KABAYAN	KRISTINE**
LANNIE	LUIS	LIWAYWAY	LEON**
MARING	MAYMAY	MARILYN	MARCE
NANDO	NENENG	NIMFA	NIKA**
ODETTE	OMPONG	ONYOK	OFEL
PAOLO	PAENG	PERLA	PEPITO
QUEDAN	QUEENIE	QUIEL	QUINTA
RAMIL	ROSITA	RAMON	ROLLY
SALOME	SAMUEL	SARAH	SIONY
TINO	TOMAS	TISOY	TONYO
URDUJA*	USMAN	URSULA	ULYSSES
VINTA*	VENUS	VIRING	VICKY
WILMA	WALDO	WENG	WARREN
YASMIN	YAYANG	YOYOY	YOYONG
ZORAIDA	ZENY	ZIGZAG	ZOSIMO

* To be replaced in early 2019.
** Replacement names for Karen, Lawin, and Nina following their decommissioning in 2016.

Table 1.7 Auxiliary domestic names for Philippine TCs.

Set 1	Set 2	Set 3	Set 4
2017, 2021, 2025, 2029	2018, 2022, 2026, 2030	2019, 2023, 2027, 2031	2020, 2024, 2028, 2032
ALAMID	AGILA	ABE	ALAKDAN
BRUNO	BAGWIS	BERTO	BALDO
CONCHING	CHITO	CHARO	CLARA
DOLOR	DIEGO	DADO	DENCIO
ERNIE	ELENA	ESTOY	ESTONG
FLORANTE	FELINO	FELION	FELIPE
GERARDO	GUNDING	GENING	GOMER
HERNAN	HARRIET	HERMAN	HELING
ISKO	INDANG	IRMA	ISMAEL
JEROME	JESSA	JAIME	JULIO

When the passage of a TC results in significant number of casualties and / or damages to personal and public properties, the name of the TC is decommissioned (i.e. removed) and replaced by the agency. For a TC name to be decommissioned, any of the following criteria must be satisfied:

Casualties	At least 300 deaths
Damages	Combined infrastructure and agricultural damage cost of at least Php 1 billion pesos

The statistics of casualties and damages to be used for decommissioning will come from the official reports of the National Disaster Risk Reduction and Management Council.

RSMC-Tokyo Tropical Cyclone Naming Scheme

If a TC within the area of responsibility of RSMC-Tokyo (region in the Western North Pacific basin bounded by rhumb lines connecting the coordinates 0° 100°E, 60°N 100°E, 60°N 180°E and 0° 180°E) intensifies into a TS with maximum winds of at least 62 km/h based on the analysis of RSMC-Tokyo, the TC will be assigned a 4-digit identification number and an identification name.

The RSMC identification number has the format YYNN, with YY signifying the last 2 digits of the year when the TC reached TS category based on RSMC-Tokyo analysis, and NN referring to the sequence number of the TC. For instance, 1721 refers to the 21st Western North Pacific TC of at least TS category in 2017. Meanwhile, the identification name is based on the list of international names contributed by member countries / territories of the ESCAP/WMO Typhoon Committee, as presented in Fig. 1.4. The names in the list are used sequentially and all names in a column must be exhausted first before the names of the next column is used. For instance, if TEMBIN was the last TC of at least TS category for the 2017, the first TC to satisfy the criteria in 2018 will be named BOLAVEN, followed by SANBA, JELAWAT, EWINIAR, and so on.

In this report, the letter "T" is appended before the 4-digit identification number and is written before the international name. The RSMC identification is then enclosed in parentheses and is written after the domestic name (e.g. Typhoon PAOLO (T1721 LAN)).

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

Fig. 1.4. International names of TCs used by RSMC-Tokyo. Figure adapted from the website of RSMC-Tokyo / JMA (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/tyname.html).

Similar to the domestic naming scheme, the international names used by the RSMC-Tokyo can be requested for decommissioning by the member countries and territories of the Typhoon Committee, especially if the TC resulted in significant number of casualties and / or damages to properties (although decommissioning may be requested for other reasons). The decommissioning is decided upon by the Typhoon Committee during its Annual Session. Once the name is removed from the list, the country that contributed the name shall submit a set of potential replacements.

TROPICAL CYCLONE SEASON 2017

Tropical Cyclone Season 2017

TROPICAL CYCLONES WITHIN THE PHILIPPINE AREA OF RESPONSIBILITY

A total of 22 tropical cyclones (TCs) were observed within the Philippine Area of Responsibility (PAR) during the 2017 season (Fig. 2.1). This is more than the long-term (1981-2010) annual average figure of 18 to 19 and more than the annual number of TCs for the last 3 years. Of these, 17 developed from low pressure areas (LPAs) inside the PAR, with 76% of them developing over the Philippine Sea. The rest either formed over the West Philippine Sea (1) or inland (3). Meanwhile, of the 5 that developed outside the PAR, one formed over the West Philippine Sea while the rest originated from the Philippine Sea region due east of 135°E. A list of the 22 TCs in 2017 is presented in Table 2.1.

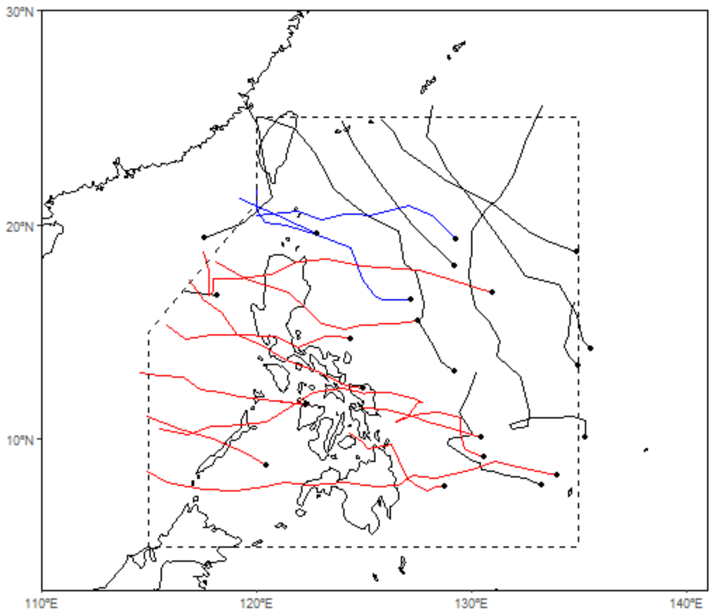


Fig. 2.1. PAGASA warning best track data of TCs within the PAR in 2017. The tracks of landfalling and close-approaching TCs are colored red and blue, respectively. Black dots mark the initial position of each best track.

The average duration of a TC within the PAR, measured by the length of its warning period for the 2017 TC season was 2 days and 10 hours. URDUJA was the longest-lasting TC within the PAR for this season with a duration of 6 days and 18 hours, while the shortest was NANDO, lasting for only 6 hours. In total, the TC activity within the PAR for this season lasted for 53 days and 6 hours.

Nearly 60% of the TCs in 2017 reached tropical storm (TS) or severe tropical storm (STS) category within the PAR which is more than the long-term average of 6 annually. The season also witnessed slightly higher-than-average number of TCs reaching at most tropical depression (TD) category and lower-than-average number of typhoons (TY) within PAR. No super typhoon (STY) occurred within the PAR during the year. Of the 22 TCs this year, the most intense was TY PAOLO, with a peak intensity within PAR of 926 hPa and 185 km/h. This typhoon with international name T1721 LAN was also the strongest named TC in the Western North Pacific (WNP) basin with a basin-wide peak intensity of 915 hPa and 185 km/h according to the best track data of the Regional Specialized Meteorological Center in Tokyo (RSMC-Tokyo).

Historical data shows that since 1981, a slightly decreasing trend was observed in the annual number of TCs within the PAR. Furthermore, the number of TD and TS/STS within PAR were found to be slightly increasing, while the annual TY cases were decreasing (Fig. 2.2) during the same period. These are all consistent with the findings of Cinco et al. (2016) using RSMC-Tokyo best track dataset.

Table 2.1. List of TCs within the PAR during the 2017 season

Domestic Name	International Name	Duration within the PAR (Warning Period) (PhST)	Peak Intensity*	
			hPa	km/h
TD AURING	-	01/07 8AM to 01/09 8AM	1000	55
TD BISING	-	02/03 2PM to 02/06 2PM	1004	45
TD CRISING	-	04/14 2PM to 04/15 8PM	1004	45
TS DANTE	T1701 MUIFA	04/26 8AM to 04/27 8PM	998	65
STS EMONG	T1703 NANMADOL	07/02 2AM to 07/03 2AM	987	95
TD FABIAN	T1707 ROKE	07/22 2AM to 07/22 2PM	1000	55
TY GORIO	T1709 NESAT	07/25 2PM to 07/30 2AM	957	145
TS HUANING	T1710 HAITANG	07/30 2AM to 07/31 5AM	990	85
STS ISANG	T1713 HATO	08/20 8AM to 08/22 2PM	977	110
TS JOLINA	T1714 PAKHAR	08/24 2PM to 08/26 2PM	993	80
TS KIKO	T1717 GUCHOL	09/04 2PM to 09/06 8PM	998	65
TY LANNIE	T1718 TALIM	09/11 2PM to 09/13 2PM	965	130
TS MARING	T1719 DOKSURI	09/11 2PM to 09/13 2PM	990	85
TD NANDO	-	09/23 2PM to 09/23 8PM	1004	45
STS ODETTE	T1720 KHANUN	10/11 8PM to 10/14 8PM	977	110
TY PAOLO	T1721 LAN	10/16 8AM to 10/22 2AM	926	185
STS QUEDAN	T1722 SAOLA	10/25 8AM to 10/28 8AM	981	105
STS RAMIL	T1723 DAMREY	11/01 2AM to 11/03 2AM	987	90
TS SALOME	T1724 HAIKUI	11/09 5AM to 11/11 2AM	995	75
TS TINO	T1725 KIROGI	11/17 8AM to 11/18 8AM	998	65
TS URDUJA	T1726 KAI-TAK	12/12 2PM to 12/19 8AM	993	80
TS VINTA	T1727 TEMBIN	12/20 2PM to 12/24 8AM	973	120

*Peak intensity within the PAR may be lower than the peak intensity of a TC throughout its lifespan.

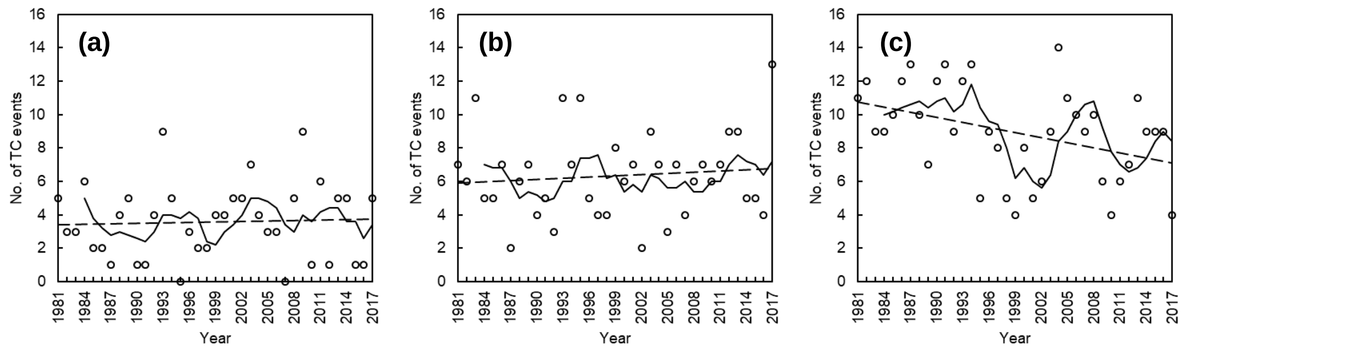


Fig. 2.2. Annual number of (a) depressions, (b) storms, and (c) typhoons within the PAR since 1981 (open dot) and their associated 5-year running means (solid line) and linear trends (dashed line).

Notable Months

Fig 2.3 presents the monthly number of TCs that developed within or entered the PAR for this season. July and September were the most active months of 2017 with each month having 4 TCs, although these were near the long-term average of 3 to 4 for July and 3 for September. The RSMC-Tokyo also noted that as many as 8 TCs of at least TS category developed within the Western North Pacific basin in July 2017 which is a record high (along with July 1971) for the basin since RSMC-Tokyo began record-keeping in 1951.

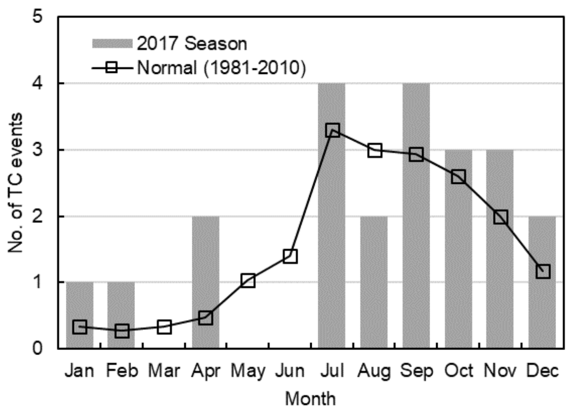


Fig. 2.3. Monthly number of TCs within the PAR for 2017 (bar) and the corresponding long-term (1981-2010) averages (line)

Figs. 2.4a and 2.4c presents the monthly mean streamlines at 850 hPa and outgoing longwave radiation (OLR) for July and their respective anomalies. The notable TC activity in July was attributed to the presence of a deep monsoon trough extending from northern Indochina towards the Philippines and the southern Philippine Sea at around 145°E. This resulted in enhanced convective activity in this region, especially over the West Philippine Sea region wherein an anomalous low-level cyclonic circulation was observed. Of the 8 TCs of at least TS category in the basin in July, 4 developed in the West Philippine Sea with 1 of them entering the PAR as TS HUANING – the only TC in 2017 to enter the PAR from northeastward heading.

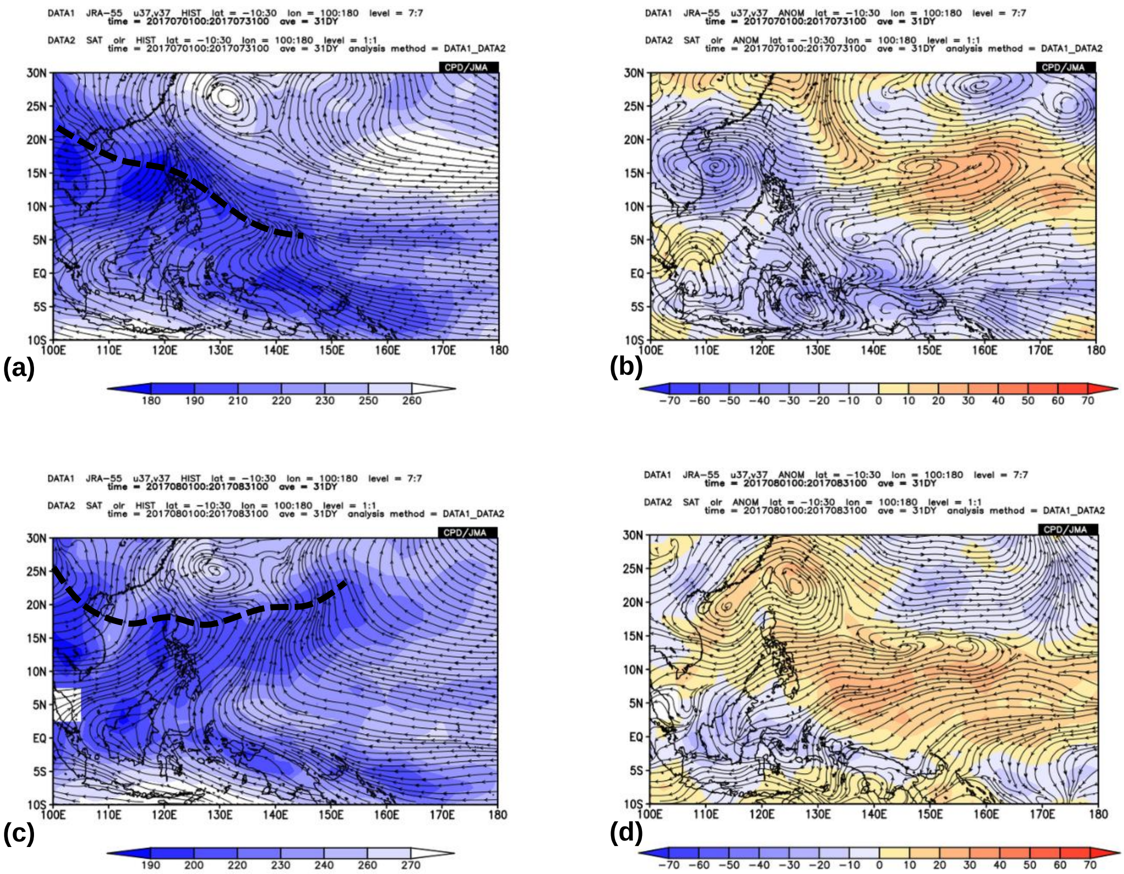


Fig. 2.4. JRA-55 reanalysis of (left) monthly mean streamlines at 850 hPa (lines with arrow) and OLR (shading) and (right) related anomalies (1981-2010 normal) for (a, b) July and (c, d) August 2017. The approximate axis of monsoon trough is marked by the dashed line. Figure derived from the JRA-55 reanalysis (Kobayashi et al. 2015; Harada et al. 2016) provided by the Climate Prediction Division / Japan Meteorological Agency (CPD/JMA).

Fig. 2.3 also shows that August 2017 had slightly below-average number of TCs, with only 2 entering or developing within the PAR. The mean synoptic pattern for August 2017 in Fig. 2.4c resembles that of a reverse-oriented monsoon trough (RMT) (Fig. 2.5a), with the axis extending southeastward from northern Indochina to the extreme northern Luzon and eastward to northeastward from Luzon to the Western North Pacific at around 150°E. Analysis of tropical cyclone movement in the presence of RMTs (Lander 1996) (Fig. 2.5b) suggests that tropical cyclones during this period were less likely to enter the PAR compared to when the axis was in its mean position. The presence of anomalous anticyclonic circulations over the northern Philippine Sea, the seas east of Taiwan and over the Pacific Ocean east of Northern Marianas at around 150 to 160°E in Fig 2.4d resulted in suppressed convection over much of the Philippine region and the surrounding waters compared to the climatological normal and slightly enhanced convective activity over the Western North Pacific region north of 20°N and east of 145°E.

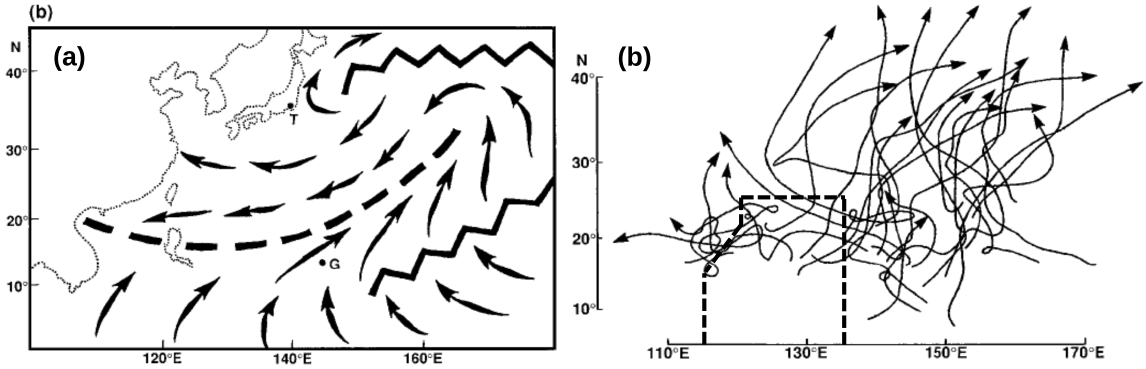


Fig. 2.5. (a) A schematic example of the low-level wind flow associated with an RMT, showing the position of the ridge axis (zigzag line) and the monsoon trough (dashed line) and (b) the tracks of 27 TCs that occurred in association with selected RMT episodes between 1981 and 1992 with the dashed line marking the boundaries of the PAR. Figures adapted from Lander (1996).

Another notable feature of the 2017 season was the absence of TC within the PAR in June, which is normally the month of onset of the Southwest Monsoon in the Philippines and the month with an average of 1 or 2 tropical cyclones based on 1981-2010 climatology. Mean 850 hPa streamlines and OLR revealed that while a monsoon trough was already present and was extending southeastward from northern Indochina to the southern Philippines, it was "relaxed" (Wang and Zhou 2008) and situated further south of its normal position (Lander 1996), resulting in suppressed convective activity over the region. The suppression of the monsoon trough was due to the presence of an anomalous anticyclonic circulation over the northern Philippines (Fig. 2.6b)

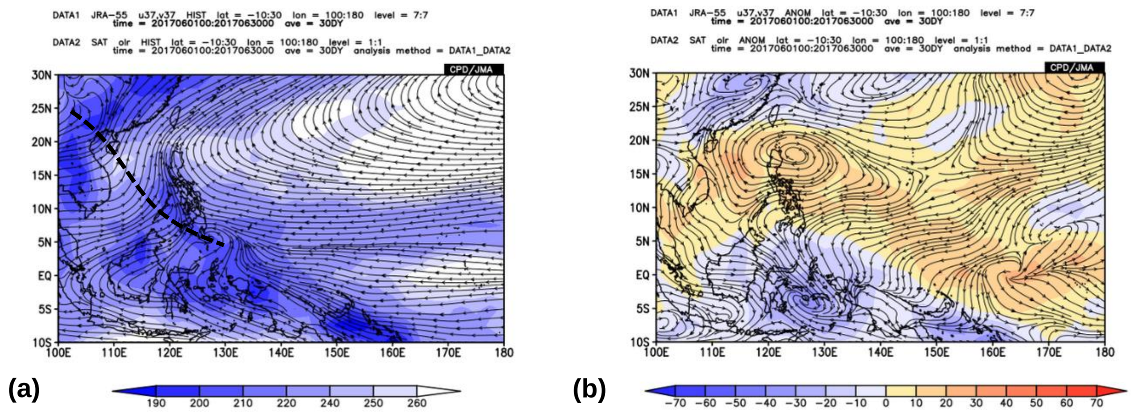


Fig. 2.6. Same as Fig. 2.4, but for June 2017.

Lastly, the slightly above (but near-normal) number of late-season (November-December) TCs in 2017 can be attributed to the developing La Niña over the central-eastern equatorial Pacific during the second half of 2017. During La Niña years, the westward displacement of the "warm pool" (closer to the Philippines) confines the TC genesis locations to the west of 160°E, thereby increasing the frequency of TCs entering the PAR and the number of landfalling TCs compared to neutral and El Niño years (Corporal-Lodangco et al. 2016). The Oceanic Niño Index (ONI) over the last 5 years and the mean sea surface temperature anomaly over the equatorial Pacific for November and December are presented in Fig. 2.7.

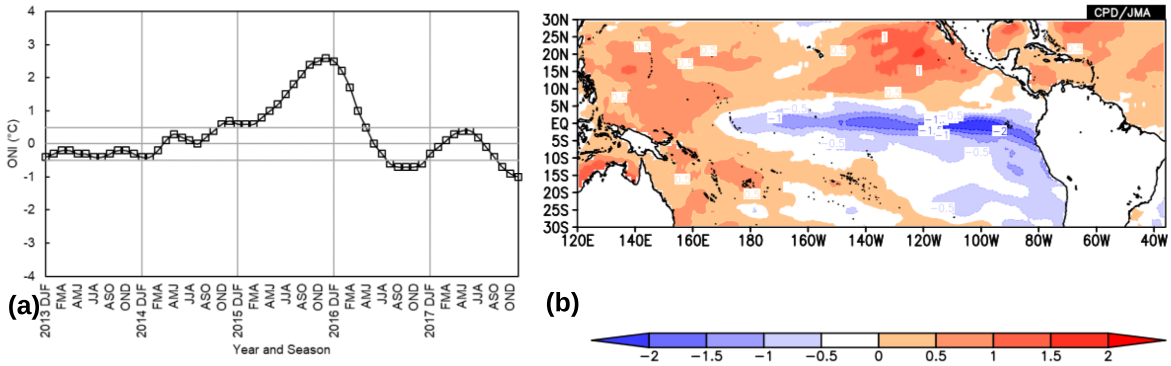


Fig. 2.7. La Niña episode of 2017-2018: (a) ONI values from DJF 2013 to NDJ 2017 and (b) mean sea surface temperature anomaly over the equatorial Pacific from November to December 2017. Data provided by the National Oceanic and Atmospheric Administration / National Weather Service / Climate Prediction Center and CPD/JMA.

LANDFALLING AND CLOSE-APPROACHING PHILIPPINE TROPICAL CYCLONES

The red tracks in Fig. 2.1 mark the path of landfalling TCs during the season. Of the 22 TCs for the 2017 season, 10 crossed the Philippine archipelago. Aside from having more landfalling TCs than the long-term average figure of 7 to 8 annually, this season had the highest number of landfalling TCs since the last record-high in 2009 (with 10 TCs). November and December registered the most number of landfalling TCs during the 2017 season. A total of 5 TCs crossed the country during these months, which were above the long-term average of 1 to 3. This was attributed to the developing La Niña which increased the frequency of TC occurrence within the PAR via the westward displacement of mean genesis region closer to the Philippines (Corporal-Lodangco et al. 2016).

Most of the TCs that made landfall during the year were at tropical depression category at the time of initial landfall. Of the 10 TCs that crossed the Philippine landmass in 2017, VINTA was the most intense, with a landfall intensity of 90 km/h and 987 hPa during its first landfall over eastern Mindanao, and 105 km/h and 981 hPa during its final landfall in southern Palawan.

Aside from landfalling TCs, 3 TCs in 2017 were classified as “close-approaching” TCs. A TC is said to be “close-approaching” if its center or eye passed within 100 km of the nearest coastline of any Philippine landmass but did not make landfall. For the 2017 season, all the close-approaching TCs, TD FABIAN, STS ISANG and TD KIKO crossed the Balintang Channel between the province of Batanes and the Babuyan Islands in northern Cagayan.

DESTRUCTIVE AND DECOMMISSIONED PHILIPPINE TROPICAL CYCLONES OF 2017

Based on information provided by the National Disaster Risk Reduction and Management Council, the 22 TCs of the 2017 season directly and indirectly (e.g. via enhancement of the Southwest Monsoon) affected 664,980 families or 2,930,764 persons across the country. A total of 258 were killed during the season, along with 117 injured and 217 missing individuals. Meanwhile, damages to infrastructure and agriculture amounted to Php 6.639 billion nationwide.

TS URDUJA was considered to be the costliest TC of the season, with damages to agriculture and infrastructure amounting to Php 1.910 billion and Php 2.032 billion, respectively. Meanwhile, TY VINTA was the deadliest TC this year, claiming the lives of 173 people, in addition to 18 injured and 169 missing individuals. With both TCs satisfying the cost of damage criterion, PAGASA formally decommissioned the names URDUJA and VINTA. The replacement names will be implemented in the 2021 season. Furthermore, the equivalent international names of these TCs, KAI-TAK and TEMBIN, were requested by the agency to be decommissioned by the United Nations Economic and Social

Commission for Asia and the Pacific / World Meteorological Organization Typhoon Committee from the list of names being used in the Western North Pacific basin.

SUMMARY OF TROPICAL CYCLONE WARNINGS FOR THE 2017 SEASON

A total of 307 domestic TC information products were issued by PAGASA during the 2017 season. These include 269 Severe Weather Bulletins (SWBs), 29 Weather Advisories (WxAs; for the precursory and remnant LPAs of these TCs) and 9 Tropical Cyclone Advisories (TCAs). Of the 269 SWBs, 187 were SWB-Warning, while the rest were SWB- Alert. Meanwhile, a total of 234 Tropical Cyclone Warnings for Shipping (IWS) were issued to the maritime end users and were sent to the WMO Global Telecommunications System (GTS). Table 2.2 lists down the products issued by PAGASA to various end users per TC event.

Table 2.2. Summary of warning products issued by PAGASA during the 2017 season.

Name of TC	SWB Alert	SWB Warning	IWS	TCA	WxA
TD AURING	1	14	9	0	1
TD BISING	8	0	13	0	1
TD CRISING	1	9	6	0	4
TS DANTE (T1701 MUIFA)	4	0	7	2	0
STS EMONG (T1703 NANMADOL)	5	0	5	0	2
TD FABIAN (T1707 ROKE)	1	3	3	0	0
TY GORIO (T1709 NESAT)	6	10	19	0	4
TS HUANING (T1710 HUANING)	2	5	6	1	0
STS ISANG (T1713 HATO)	1	13	10	0	1
TS JOLINA (T1714 PAKHAR)	2	13	9	0	1
TS KIKO (T1717 GUCHOL)	3	6	10	0	1
TY LANNIE (T1718 TALIM)	6	0	9	4	0
TS MARING (T1719 DOKSURI)	3	11	9	0	3
TD NANDO	2	0	2	0	3
STS ODETTE (T1720 KHANUN)	2	16	13	1	1
TY PAOLO (T1721 LAN)	13	0	24	0	0
STS QUEDAN (T1722 SAOLA)	7	0	13	1	0
STS RAMIL (1723 DAMREY)	4	7	9	0	1
TS SALOME (T1724 HAIKUI)	3	9	9	0	1
TS TINO (T1725 KIROGI)	2	4	5	0	2
TS URDUJA (T1726 KAI-TAK)	5	39	28	0	2
TY VINTA (T1727 TEMBIN)	1	28	16	0	1
Total Issuances	82	187	234	9	29

Of the 22 TCs this season, 15 necessitated the raising of Tropical Cyclone Warning Signals (TCWS) to localities for a total duration of 692 hours due to the potential occurrence of tropical cyclone winds in coastal and inland areas. The highest TCWS that was raised during the season was TCWS #2, which was raised during the passage of 6 TCs, namely, STS ISANG, TS JOLINA, STS ODETTE, TS SALOME, TS URDUJA and TY VINTA.

NOTABLE TROPICAL CYCLONES OF 2017

Tropical Storm URDUJA (T1726 KAI-TAK)

12 to 19 December 2017

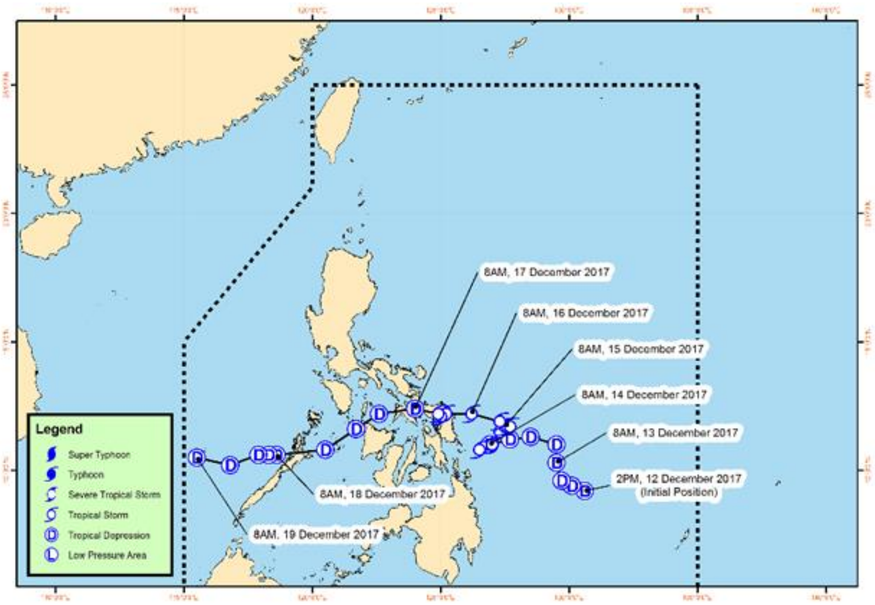


Fig. 3.1.1. DOST-PAGASA warning best track of Tropical Storm URDUJA

METEOROLOGICAL HISTORY

Tropical Storm (TS) URDUJA originated from a westward propagating low pressure area (LPA) over the Philippine Sea that entered the Philippine Area of Responsibility (PAR) at 8:00 AM on 11 December. A combination of favorable environmental conditions and constructive interference of Rossby and Kelvin waves over the Western North Pacific allowed the LPA to develop into a Tropical Depression (TD) at 2:00 PM on 12 December while approximately 480 km East Northeast of Hinatuan, Surigao del Sur (9.2°N, 130.6°E). PAGASA assigned the domestic name "URDUJA" to the system as the 21st tropical cyclone (TC) to enter or develop within the PAR for the 2017 season. At the time of formation, the TD had maximum winds of 55 km/h near the center and central pressure of 1002 hPa.

Despite initial favorable conditions, vertical wind shear within the vicinity of the LPA (as well as over the large expanse of the Philippine Sea) began to increase to unfavorable levels resulting from the progressing cold surge of the Northeast Monsoon, significantly disrupting the structure of URDUJA. The low-level circulation center (LLCC) became exposed as the convective clouds that was supposed to consolidate in the core of "URDUJA" and sheared off to the west of the LLCC. This disruption prevented the system to significantly intensify in a region of warm sea surface temperature and high tropical cyclone heat potential. From 12 to 14 December, the intensification rate was only 11 km/h (3 m/s). Nevertheless, URDUJA became a TS at 2:00 PM of 14 December – roughly 48 hours after it developed into a TD. The Regional Specialized Meteorological Center-Tokyo assigned the international name "KAI-TAK" to the system as it became a TS. "KAI-TAK", a name of an old airport was contributed by Hong Kong.

URDUJA was able to maintain its TS category in the presence of increasingly unfavorable vertical shear conditions due to other offsetting environmental factors, allowing the system to reach peak intensity of 80 km/h and 993 hPa while over the Philippine Sea at approximately 210 km East of Borongan City, Eastern Samar (11.9°N, 127.3°E). Despite the cold and dry air advection associated with the cold surge that suppress convective instability, eddy heat and moisture transport from the warm sea surface of the Philippine Sea and the convergence zone generated by the northeasterly surge flow and the easterly flow at the northern edge of the cyclonic circulation of URDUJA offset this suppression (Chen et al. 2012; Ogino et al. 2018; Yokoi and Matsumoto 2008). Additional convergence is provided by the presence of a shear line (also known as tail-end of a cold front) at the leading edge of the cold surge. All these contributed to the sustained, albeit sheared convection that sustained the intensity of URDUJA.

URDUJA made its first landfall in San Policarpio, Eastern Samar during peak intensity at 1:30 PM 16 December. Increasing frictional effects and vertical wind shear while over the northern portion of Samar island weakened the system into a TD at 8:00 AM 17 December. URDUJA maintained its strength (maximum winds of 55 km/h and central pressure of 1002 hPa) after 4 additional landfalls (Table 3.1.1) while traversing the Central Philippines. Further weakening (to 45 km/h) was observed after the cyclone made landfall over Taytay, Palawan at 6:00 AM 18 December.

Table 3.1.1 List of areas where TS "URDUJA" made landfall.

Landfall Area	Time of Landfall	Intensity at Landfall
San Policarpio, Eastern Samar	1:30 PM 16 December	Tropical Storm (80 km/h)
Mobo, Masbate	10:00 AM 17 December	Tropical Depression (55 km/h)
Sibuyan Island, Romblon	12:00 PM 17 December	Tropical Depression (55 km/h)
Malay, Aklan	6:00 PM 17 December	Tropical Depression (55 km/h)
Cuyo, Palawan	11:00 PM 17 December	Tropical Depression (55 km/h)
Taytay Palawan	6:00 AM 18 December	Tropical Depression (55 km/h)

After reemerging over the coastal waters of Northern Palawan, URDUJA continued moving generally westward. Between 10:00 AM and 11:00 AM 19 December, TD "URDUJA" left the PAR with maximum winds of 45 km/h near the center. The system was able the briefly re-intensify into a weak TS on 20 and 21 December as it moved west-southwestward over the South China Sea between southern Vietnam and insular Malaysia. URDUJA was last observed as a TD in the early hours of 24 December near the southern portion of peninsular Malaysia.

Throughout the entire duration of URDUJA inside the PAR, the most notable characteristic of its track was its erratic behavior during the period of 14 and 15 December while off to the east of Eastern Visayas. URDUJA exhibited a quasi-stationary loop-like tracking within the 2-day period. A revisit of deep-layer environmental steering winds revealed the lack of a dominant system dictating the movement of URDUJA beginning 14 December when the subtropical ridge to the northeast of the system retreated although strong westerly winds located south of the system allowed the system to drift in a looping manner while behaving quasi-stationary. The erratic movement only ended by 16 December when the subtropical ridge extending from mainland Asia began providing easterly to northeasterly steering flow.

HEAVY RAINFALL EVENT OF 13-16 DECEMBER 2017

Due to high vertical shear conditions, much of the convection of URDUJA were sheared to the west of the LLCC when the movement of the system became erratic and, at times, nearly stationary. This meant that well before its landfall over Eastern Visayas, much of the convection were over Eastern Visayas (especially Samar island) and portions of Bicol Region (Fig. 3.1.2, red cloud signature over the said areas) for a prolonged period of time, resulting to heavy rainfall over these areas during the period of 13 to 16 December 2017. The excessive rains were aggravated by the enhanced convection generated by the speed and directional convergence associated with a shear line (also known as tail-end of a cold front or surge front) on the leading edge of a cold surge wind flow, as well as the convergence zone between the wind flows of the cold surge (northeasterlies) and the cyclonic circulation of the TC (Chen et al. 2012; Ogino et al. 2018; Yokoi and Matsumoto 2008).

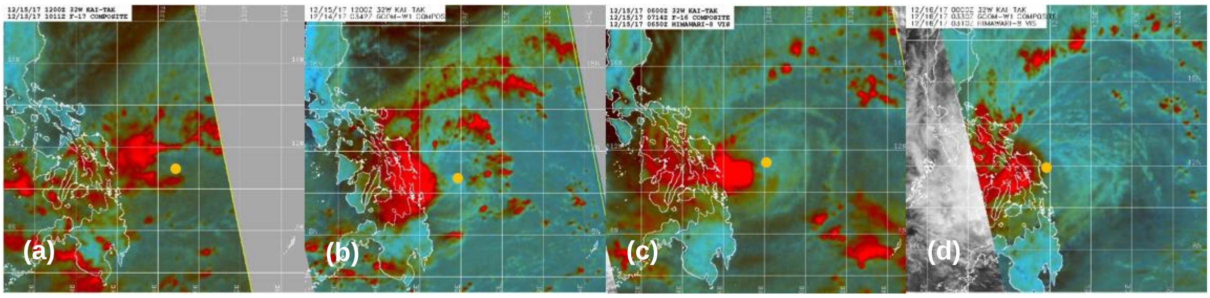


Fig. 3.1.2. High-frequency (89 and 91 GHz) microwave composite images of Tropical Storm "URDUJA" on 13 to 16 December 2017 (a-d). Cloud signatures in red indicate convective clouds, while those in blue green indicate low clouds. The low-level circulation center is marked by the orange dot. Images are from Naval Research Laboratory – Monterey.

Based on gauge-calibrated satellite estimates (Fig. 3.1.3) during the aforementioned 4-day period, widespread rainfall in excess of 100 mm per day were experienced over much of Visayas and southern Luzon as well as portions of northeastern Mindanao during the passage of URDUJA. Eastern Visayas and Dinagat Islands received the brunt of the heavy rains with daily accumulations above 250 mm especially on 14 and 15 December. Local disaster managers reported multiple landslides and flooding occurrences resulting from heavy rains, especially over MIMAROPA and Eastern Visayas, with the deadliest being in the province of Biliran wherein landslides in 4 municipalities (Biliran, Naval, Caibiran and Almeria) resulted to the deaths of 28 people.

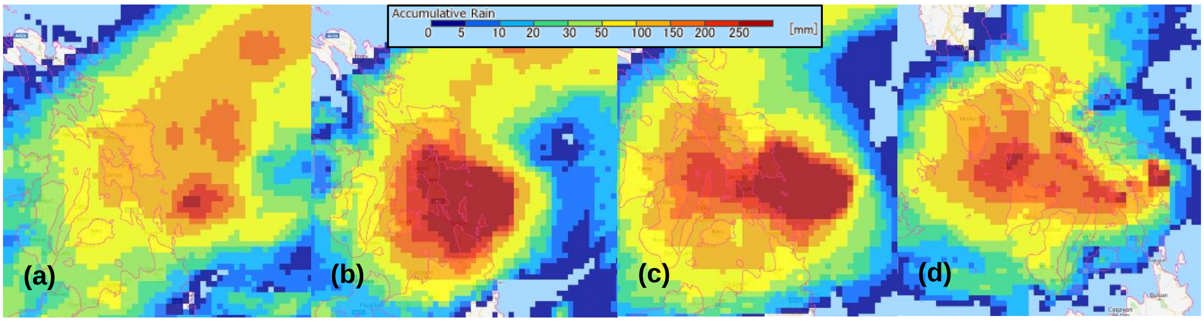


Fig 3.1.3. Global Satellite Mapping of Precipitation gauge-calibrated satellite rainfall estimates during the Heavy Rainfall Event of 13 to 16 December 2017. Images are from Japan Aerospace Exploration Agency / Earth Observation Research Center.

Observation reports from manned PAGASA synoptic stations in the country (Table 3.1.2) revealed that Eastern Visayas was the most hardly hit area by the heavy rains with 5 of 6 synoptic stations in the area receiving a 4-day accumulated rainfall in excess of 500 mm. Data also showed that 14 and 15 December were the wettest days of the event. It was during this period that the station in Guiuan, Eastern Samar reported the highest 24-hour rainfall throughout the passage, reaching 780.4 mm on 14 December or 73.5% of the total rainfall of the station during the event. Table 2 presents the stations with the 10 highest rainfall totals during the event. These stations, mostly located in Eastern Visayas and Bicol Region, reported 4-day accumulations that accounted for 71% (in Romblon) to 99% (in Tacloban City) of the rainfall observed by these stations throughout the passage of URDUJA (12-19 December).

Guiuan, Eastern Samar recorded the highest accumulated rainfall during the event, reaching 1,061.7 mm or roughly 95.9% of the total rainfall (1107.1 mm) recorded by the station during the passage (12-19 December). This was also equivalent to 241.2% of the December 1981-2010 normal rainfall for this area. This was followed by Borongan, Eastern Samar and Catbalogan City, Samar with 906.8 and 750.5 mm, respectively.

Table 3.1.2. PAGASA synoptic stations with the 10 highest rainfall accumulation during the Heavy Rainfall Event of 13-16 December 2017.

Name of synoptic station	12/13	12/14	12/15	12/16	Total	% HRE	%N
Guiuan, Eastern Samar	139.6	780.4	137.0	4.7	1061.7	95.9	241.2
Borongan City, Eastern Samar	265.2	343.6	155.0	143.0	906.8	94.4	134.4
Catbalogan City, Samar	96.1	215.0	331.2	108.2	750.5	91.2	232.6
Catarman, Northern Samar	102.3	66.9	347.4	20.5	537.1	83.2	85.5
Tacloban City, Leyte	88.6	192.4	109.6	109.7	500.3	99.2	129.6
Masbate City, Masbate	25.6	4.2	63.0	224.4	317.2	89.6	122.5
Juban, Sorsogon	48.5	0.0	162.0	71.6	282.1	80.7	-
Romblon, Romblon	1.4	0.0	4.0	207.6	213.0	71.4	100.6
Roxas City, Capiz	9.5	0.0	23.0	177.0	209.5	89.0	122.3
Maasin City, Southern Leyte	49.4	95.4	53.2	1.6	199.6	94.2	8.8

Note: %HRE – percentage of total rainfall during the passage (12-19 December) associated with the heavy rainfall event. %N – percentage of total rainfall during the Event against normal for December.

OTHER SIGNIFICANT METEOROLOGICAL OBSERVATIONS

Table 3.1.3 presents the lowest mean sea level pressure (MSLP) and peak gust observations during the passage of “URDUJA” based on tropical cyclone passage reports from 9 synoptic stations, as well as hourly observation reports from 6 other stations. The highest peak gust and lowest MSLP throughout the passage were both recorded in Borongan, Eastern Samar (94 km/h and 993.4 hPa), as “URDUJA” moved closer towards Eastern Samar.

Table 3.1.3. Extremes of mean sea level pressure (MSLP) and peak gust observations from selected PAGASA synoptic stations during the passage of URDUJA

Location of synoptic station	Mean sea level pressure (hPa)		Peak gust (km/h)	
	Date and time	Value	Date and time	Value
Borongan, Eastern Samar	2017.12.16, 10:04 AM	993.4	2017.12.16, 10:04 AM	94
Catbalogan City, Samar	2017.12.16, 12:00 PM	997.5	2017.12.16,10:52 AM	61
Catarman, Northern Samar	2017.12.16, 3:00 PM	1001.0	2017.12.15, 12:55 PM	65
Guiuan, Eastern Samar	2017.12.16, 3:00 PM	1000.9	2017.12.16, 12:50 PM	86
Masbate City, Masbate	2017.12.17, 4:00 PM	1001.6	2017.12.17, 9:24 AM	43
Romblon, Romblon	2017.12.17, 3:00 PM	1003.7	2017.12.17, 10:15 AM	50
Tacloban City	2017.12.16, 2:30 PM	998.0	2017.12.16, 11:09 AM	86
Legazpi City, Albay	2017.12.16, 4:00 PM	1001.6	2017.12.17, 3:25 AM	40
Virac, Catanduanes	2017.12.16, 3:00 PM	1002.2	2017.12.16, 7:00 AM	43
Juban, Sorsogon	2017.12.16, 6:00 PM	1002.1	-	-
San Jose, Occidental Mindoro	2017.12.17, 4:00 PM	1003.4	-	43
Puerto Princesa city	2017.12.18, 4:00 AM	1005.8	-	-
Roxas City, Capiz	2017.12.17, 3:00 PM	1003.5	-	58
Maasin City, Southern Leyte	2017.12.14, 3:00 PM	1005.2	-	50
Surigao City, Surigao del Norte	2017.12.13, 4:00 AM	1006.2	-	32

EARLY WARNING INFORMATION

The first official information released by PAGASA in relation to URDUJA was a Weather Advisory issued at 11:00 AM 11 December. The advisory noted the presence of the precursory LPA of USMAN within the PAR which was located to the east of Mindanao. It also indicated the potential of this disturbance to develop into a TD within 36 hours.

The first Severe Weather Bulletin (SWB) for URDUJA was issued at 5:00 PM on 12 December when the precursory LPA developed into a TD. Throughout the monitoring and warning period, a total of 44 SWBs were issued by the agency to the public, disaster managers, and other end-users. The final SWB was issued at 11:00 AM on 19 December when the center of URDUJA left the PAR.

Tropical Cyclone Warning Signals (TCWS) were first raised during the issuance of SWB #4 at 5:00 PM on 13 December, with Eastern Samar under TCWS 1. A total of 29 areas in southern Luzon, Visayas and northeastern Mindanao were placed under TCWS #1, 13 of which were under TCWS #2 and the rest under TCWS #1. All active TCWS were cancelled at 5:00 AM on 19 December in conjunction with the issuance of SWB #43 as USMAN moved further away from the Philippine landmass.

Supplementary to the issuance of SWBs by the Weather Division, local Heavy Rainfall Warnings and Thunderstorm Advisories were also issued by the agency through its PAGASA Regional Services Divisions. In addition, general flood advisories were also issued by the Main Operations Center of the Hydrometeorology Division to various affected regions.

CASUALTY AND DAMAGE STATISTICS

The National Disaster Risk Reduction and Management Council reported 435,220 families or 1,852,900 persons from MIMAROPA, Bicol Region, Visayas and CARAGA that were affected by URDUJA and the resulting Heavy Rainfall Event. A total of 47 dead, 78 injured, and 44 missing persons were reported by local disaster managers. The heavy rainfall associated with URDUJA flooded 484 areas and caused at least 20 landslide incidents in MIMAROPA, Western Visayas and Eastern Visayas. A total of 35,285 houses were reported to be damaged, of which 2,748 suffered total damage. Coast guard and disaster managers also reported 2 capsized or sunk sea crafts due to rough seas. The cost of damages to infrastructure and agriculture in the affected areas were estimated at Php 3,942,565,000.00.

Because of the extent of damages and number of casualties, a total of 18 local government units in MIMAROPA and Eastern Visayas regions were placed under state of calamity. As of 7 February 2018, the national government agencies and local government units have provided assistance amounting to Php 184,820,337.18 to the affected families in 6 regions.

Typhoon VINTA (T1727 TEMBIN)

20 to 24 December 2017

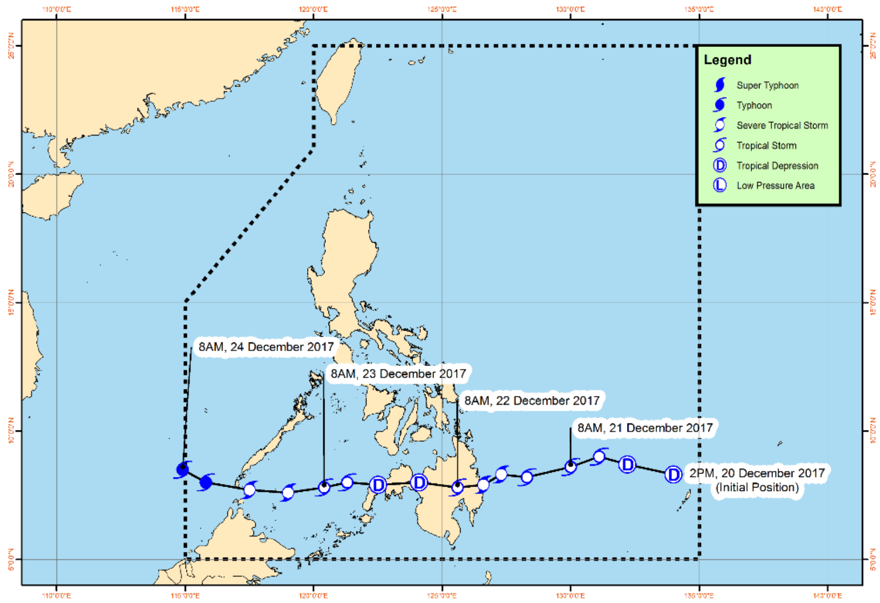


Fig. 3.2.1. DOST-PAGASA warning best track of Typhoon VINTA

METEOROLOGICAL HISTORY

The precursory low pressure area (LPA) of Typhoon (TY) VINTA was first noted on surface weather charts on the evening of 15 December over the Caroline Islands between the states of Yap and Chuuk. Embedded within an equatorial Rossby wave, this westward-moving LPA had entered the PAR after moving past north of Palau in the morning of 20 December. At 2:00 PM of the same day, the LPA developed into a tropical depression (TD) with an initial intensity of 45 km/h and 1004 hPa owing to favorable atmospheric and oceanic conditions. PAGASA assigned the named "VINTA" to the new TD as the 22nd tropical cyclone to develop or enter the PAR for the 2017 season. At the time of formation, the center of VINTA was approximately 845 km East of Hinatuan, Surigao del Sur (8.3°N, 134.0°E).

With persistent favorable conditions, VINTA underwent a near-rapid intensification of +35 km/h and -15 hPa within 24 hours as it tracked generally westward over the southern Philippine Sea. VINTA had reached tropical storm (TS) category with maximum winds of 65 km/h and central pressure of 998 hPa within 12 hours after it developed into a TD. The Regional Specialized Meteorological Center-Tokyo assigned the name "TEMBIN" to the system when it intensified into a TS. "TEMBIN", a Japanese word for Libra, was contributed by Japan.

At 8:00 PM on 21 December, as VINTA moved closer towards the Surigao del Sur – Davao Oriental area, it reached a peak intensity of 90 km/h and 987 hPa. During this time, the center of VINTA, now a Severe Tropical Storm (STS) was roughly 105 km East of Hinatuan, Surigao del Sur (8.3°N, 127.3°E). Radar images of VINTA taken roughly 5 hours after reaching peak intensity (Fig. 3.2.2a-c) revealed an eye-like feature resulting from inner convective banding, as well as the orographic enhancement of convection by the mountain ranges in eastern Mindanao. Furthermore, radar images (Fig. 3.2.2) revealed the asymmetric distribution of convection within VINTA with widespread convection concentrated on the western semicircle of the cyclone. The asymmetry was attributed to the low to moderate (20-25 km/h) easterly wind shear over the southern Philippine Sea.

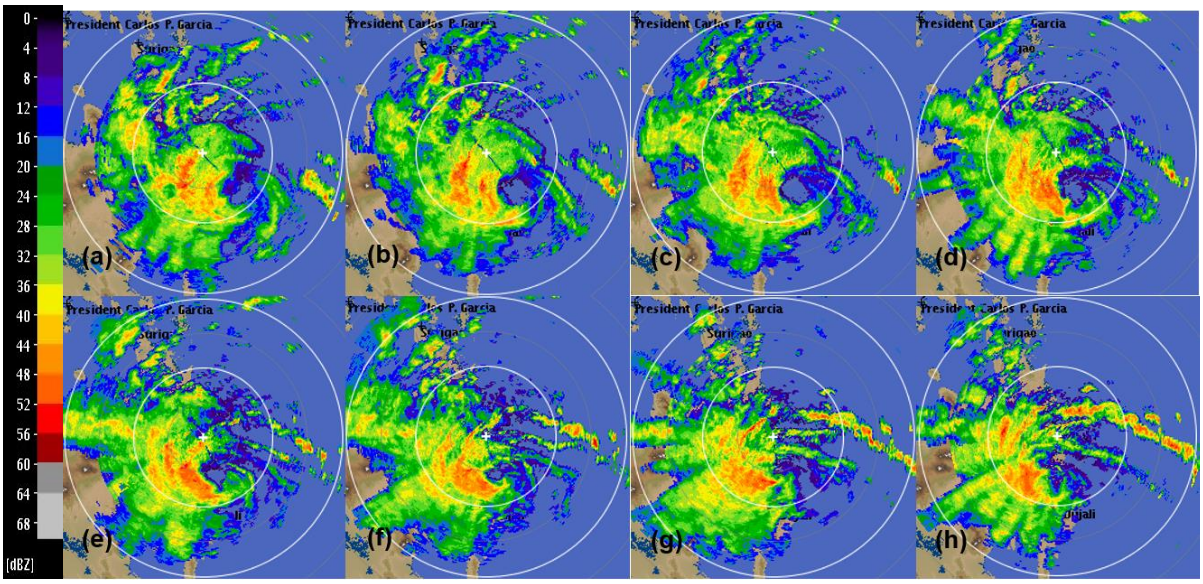


Fig 3.2.2. CAPPI 2 km reflectivity images of VINTA from PAGASA Hinatuan radar station on 22 December at (a) 12:45 AM, (b) 1:15 AM, (c) 1:45 AM (landfall), (d) 2:15 AM, (e) 2:45 AM, (f) 3:15 AM, (g) 3:45 AM and (h) 4:15 AM (left to right, top row first).

At 1:45 AM, VINTA made landfall at peak intensity over the coastal municipality of Cateel in Davao Oriental (Fig. 3.2.2c), making it the strongest tropical cyclone to directly hit Mindanao since TY Pablo (T1224 Bopha) in 2012. The center of VINTA passed within the 100-km radius of the PAGASA radar station in Hinatuan Surigao del Sur. Images from this station following landfall (Fig. 3.2.2d-h) showed the deterioration of the eye-like feature as the inner convective banding collapsed due to terrain interaction. However, the mountain ranges in eastern Mindanao continued to enhance the inner core convection of VINTA. Nevertheless, nearly 6 hours after landfall, VINTA weakened into a TS with maximum winds of 80 km/h and central pressure of 993 hPa. As the cyclone crossed the mountainous region of eastern and central Mindanao, it further weakened into a TD in the early afternoon of the same day. Maximum winds near the center of VINTA had already dropped by 30 km/h before it emerged over the Sulu Sea in the late evening of 22 December.

Another period of near-rapid intensification took place as VINTA moved westward over the Sulu Sea towards southern Palawan. Within 24 hours after crossing land, the TC exceeded its initial peak intensity with maximum winds of 105 km/h and central pressure of 981 hPa by 8:00 PM of 23 December. After two hours, VINTA made landfall over the remote island municipality of Balabac in Palawan and at 2:00 AM of the following day, it further intensified into a TY with maximum sustained winds and central pressure of 120 km/h and 973 hPa, respectively. At this point, the TC completed its near-rapid intensification of +45 km/h and -22 hPa over the last 24 hours, faster than the rate of intensification observed before its landfall over Mindanao (+35 km/h and -15 hPa).

Rapid or near-rapid intensification is not common over the Sulu Sea, especially the region south of 10°N, given that tropical cyclones are not common over this region. Based on PAGASA historical records from 1948 to 2016, of the TCs that crossed the Sulu Sea south of 10°N, VINTA was the first to exhibit this rate of intensification in this region. At the time the near-rapid intensification was observed, moderate to high easterly to southeasterly vertical wind shear was prevailing over the Sulu Sea (Fig. 3.2.3a). However, the impact of vertical shear was compensated by excellent radial divergent outflow aided by a mid to upper-level anticyclone centered offshore of Bicol Region (Fig. 3.2.3b) and warmer than normal sea surface temperature (+2 to +3°C anomaly) over the Sulu Sea (Fig. 3.2.3c).

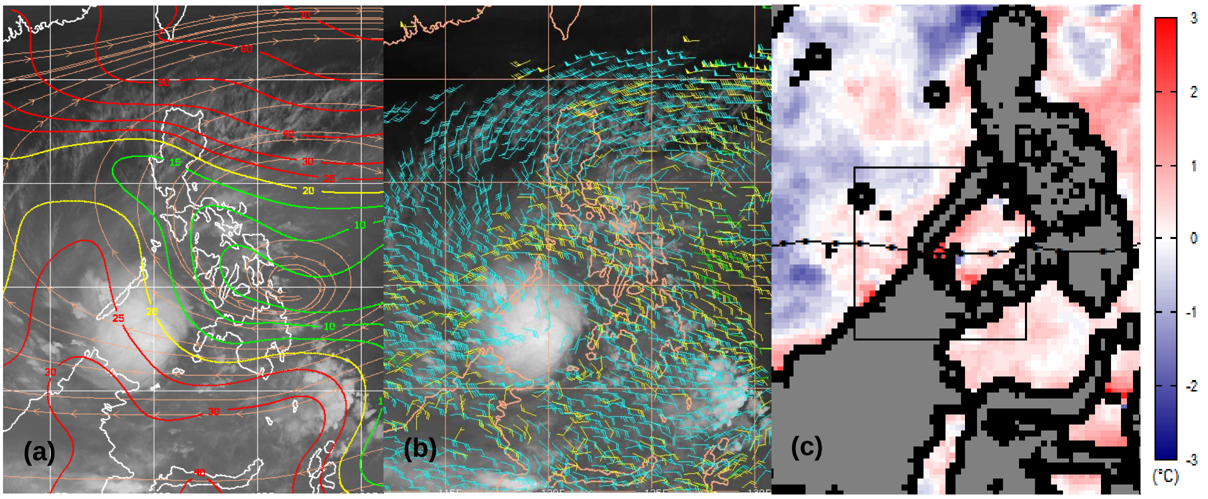


Fig 3.2.3. Environmental conditions on 23 December 2017 in the vicinity of VINTA: (a) vertical wind shear magnitude and direction at 8:00 AM, (b) mid to upper-level winds at 8:00 AM, and (c) sea surface temperature (SST) anomaly (microwave-based SST against Reynolds SST climatology). In Fig. 2a, the red, yellow and green isotachs indicate high, moderate, and low vertical wind shear, respectively, while the pink streamlines represent the wind shear direction. Meanwhile, in Fig. 2b, the blue, yellow and green wind barbs indicate winds at 100-250 hPa, 251-350 hPa, and 351-500 hPa, respectively. Figs. 2a and 2b are from Cooperative Institute for Meteorological Satellite Studies – University of Wisconsin at Madison, while Fig. 2c is from Remote Sensing Systems.

The eye of TY VINTA left the PAR at 8:00 AM on 24 December as it continued moving westward over the West Philippine Sea. At 2:00 PM of the same day, the cyclone reached a peak intensity of 130 km/h and 970 hPa. However, due to increasing vertical wind shear, rapid weakening ensued as VINTA moved closer towards southern Vietnam. Roughly 36 hours after reaching peak intensity, the TC was downgraded to a TD. On the evening of 26 December, VINTA weakened into an LPA off Mũi Cà Mau in southern Vietnam.

HEAVY RAINFALL OBSERVATIONS

During the period of 21-23 December, gauge-calibrated satellite estimates and actual gauge observations (Fig. 3.2.4) revealed that the areas within the rainfall swath of VINTA which includes most of Mindanao and southern Palawan, experienced widespread heavy rainfall especially in the upland and mountainous areas of Mindanao. Fig. 3.2.4 shows that the highest rainfall was both estimated and observed in the areas of Kitanglad and Pantaron ranges. An automatic rain gauge in Damilag, Bukidnon recorded a 3-day accumulation of 264.5 mm which was the highest observed nationwide. The site also recorded the highest daily rainfall throughout the passage, reaching 235.5 mm on 21 December. Meanwhile, satellite estimate of 3-day rainfall over the Damilag site was higher, reaching 382.1 mm.

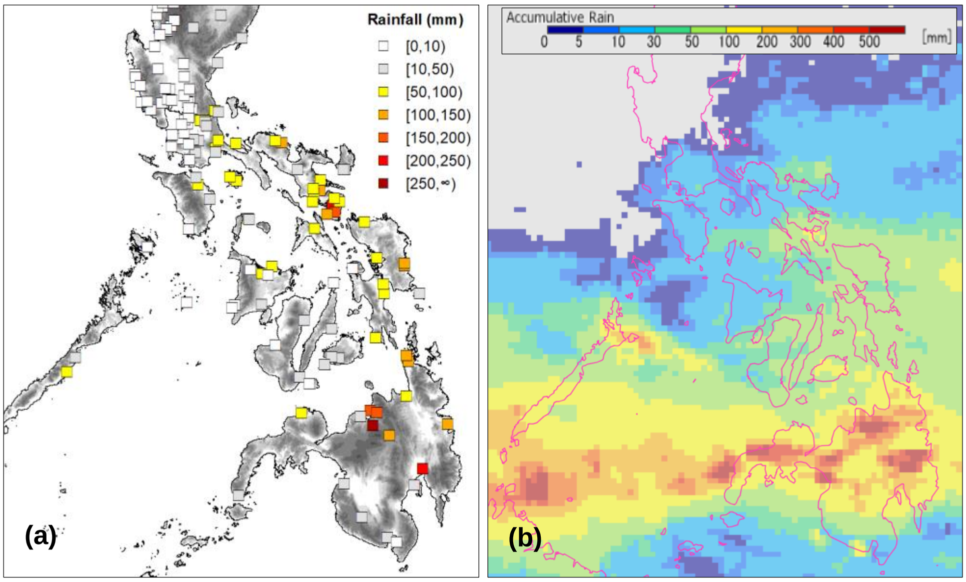


Fig. 3.2.4. (a) *In situ* observations and (b) GSMAP gauge-calibrated satellite estimates of accumulated rainfall during the passage of VINTA from 21 to 23 December. Fig. 3.2.4b is from Japan Aerospace Exploration Agency / Earth Observation Research Center.

Table 3.2.1 shows the 10 rain gauges in Mindanao with the highest 3-day accumulated rainfall and the corresponding satellite-derived estimates on these sites. Although the estimates were generally higher compared to their corresponding gauge data, the sparse observation network in Mindanao (only 17 operational sites) prevented the confirmation of possibly higher accumulated rainfall in the mountainous and other upland areas that were far from the rain gauges such as the vicinities of Piapayungan and Pantaron ranges where estimates reached more than 600 mm.

Table 3.2.1. Ten (10) highest *in-situ* rainfall observations in Mindanao and their corresponding gauge-calibrated satellite estimates.

Station Type	Location	Gauge observation (mm)	Satellite estimate (mm)
Automatic Rain Gauge	Damilag, Bukidnon	264.5	382.1
Automatic Rain Gauge	Tagum City, Davao del Norte	217.0	220.7
Automatic Rain Gauge	Jasaan, Misamis Oriental	161.0	444.2
Automatic Rain Gauge	Moscat, Misamis Oriental	156.0	508.9
Automatic Rain Gauge	Sison, Surigao del Norte	147.0	101.6
Synoptic Station	Malaybalay, Bukidnon	142.6	193.2
Synoptic Station	Hinatuan, Surigao del Norte	112.2	174.9
Synoptic Station	Surigao City, Surigao del Norte	112.1	111.8
Synoptic Station	Dipolog City, Zamboanga del Norte	87.6	88.4
Synoptic Station	Butuan City	81.7	238.1

Despite disagreements regarding the amount of 3-day rainfall in Mindanao, the data shows that the complex topography of Mindanao aggravated the intensity of observed rainfall over the islands especially in the upland regions, as well as influenced the spatial distribution of heavy rains, both via orographic lifting. In the Philippines, the impact of topography on the intensity and distribution of areas affected by heavy rainfall has been observed and studies in major mountain ranges in Luzon such as in the Cordillera Central, Sierra Madre and Zambales ranges (i.e. Cayanan et al. 2011; Lagmay et al. 2015; Racoma et al. 2016).

In the case of Mindanao, numerical experiments have been performed (Minamide and Yoshimura 2014) using TY Pablo as case event by modifying the model topography to estimate the orographic effect on the spatial distribution and intensity of rainfall. Results showed that while moisture flux from the surrounding oceans is important, heavy rainfall events, and the presence of complex topography play a critical role in enhancing the rainfall intensity and determining the spatial distribution of heavy rainfall. This is achieved through enhanced vertical moisture flux resulting from forced lifting and the altering the direction of horizontal moisture flux, forcing a convergence which also increases vertical moisture flux. Such mechanism can explain the heavy rainfall events near or at mountainous and other upland regions of Mindanao during the passage.

Table 3.2.2 presents the 10 rain gauges outside Mindanao with the highest 3-day accumulated rainfall and the corresponding satellite-derived estimates on these sites. Outside Mindanao, rainfall accumulations between 50 and 100 mm were recorded over several gauge stations on the eastern section of Southern Luzon and Visayas, with higher 3-day rainfall over some stations in Sorsogon, Albay, Camarines Norte and Eastern Visayas. However, this was not fully captured by satellite-based estimates in terms of spatial extent and intensity, with underestimations when compared against gauge data, especially from stations in Quezon, Marinduque and Camarines Norte.

Table 3.2.2. Same as Table 3.2.1, but for gauge stations outside Mindanao.

Station Type	Location	Gauge observation (mm)	Satellite estimate (mm)
Synoptic Station	Juban, Sorsogon	205.6	77.1
Automatic Rain Gauge	Irosin, Sorsogon	151.5	98.2
Synoptic Station	Legazpi City, Albay	135.0	39.1
Synoptic Station	Daet, Camarines Norte	113.4	30.4
Automatic Rain Gauge	Borongan City, Eastern Samar	105.0	50.0
Automatic Rain Gauge	Bulan, Sorsogon	102.0	99.3
Synoptic Station	Borongan City, Eastern Samar	101.2	50.0
Automatic Rain Gauge	Gubat, Sorsogon	95.5	73.3
Automatic Rain Gauge	Tolosa, Leyte	91.5	79.8
Automatic Rain Gauge	Torrijos, Marinduque	83.0	9.6

The rainfall observed on the eastern section of Southern Luzon and Visayas during the passage of VINTA was attributed to both the shear line (also known as tail-end of a cold front or surge front) on the leading edge of a cold surge wind flow during that period (Fig. 3.2.5) and the convergence zone between the wind flows of the cold surge (northeasterlies) and the cyclonic circulation of the TC (Chen et al. 2012; Ogino et al. 2018; Yokoi and Matsumoto 2008).

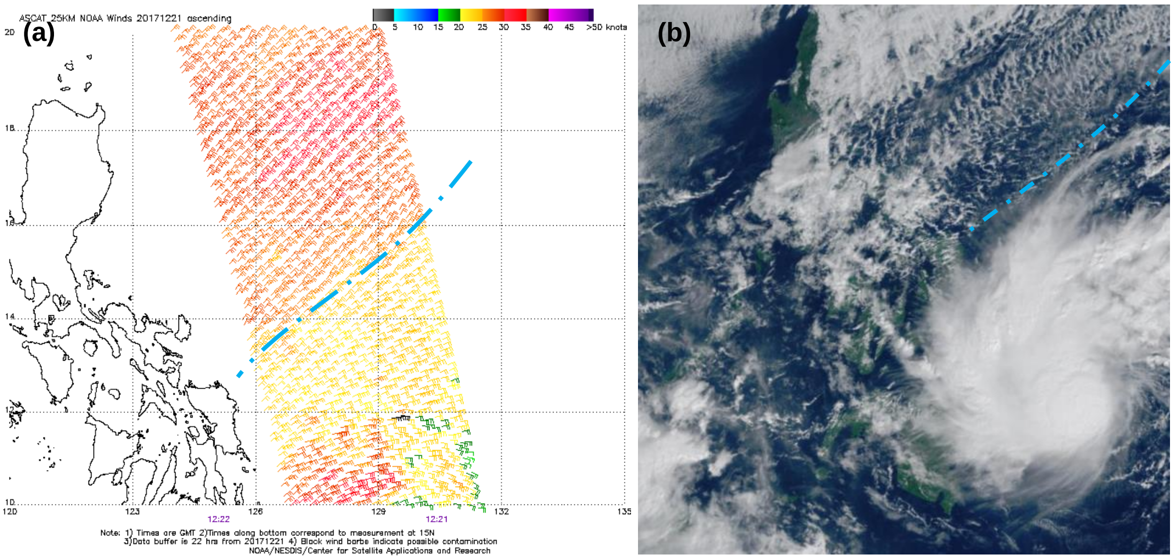


Fig. 3.2.5. A shear line (dotted-dashed line) marking the leading edge of a cold surge event at 8:00 PM on 20 December based on (a) ASCAT surface wind field estimates and (b) Himawari-8 visible imagery. Fig. 3.2.5a was provided by the Center for Satellite Application and Research (STAR) of NOAA/NESDIS, while Fig. 3.2.5b was made available by the National Institute of Informatics of Japan.

OTHER SIGNIFICANT METEOROLOGICAL OBSERVATIONS

Table 3.2.3 presents the lowest mean sea level pressure (MSLP) and peak gust observations during the passage of "VINTA" based on tropical cyclone passage reports from 10 synoptic stations in Visayas and Mindanao. As the nearest station to landfall area, the synoptic station in Hinatuan, Surigao del Sur reported the lowest MSLP throughout the passage, reaching 1000.4 hPa at 3:00 AM on 22 December, roughly 1 hour after the reported landfall at Cateel, Davao Oriental. Meanwhile, the synoptic station in Guiuan, Eastern Samar recorded the highest peak gust during the passage, reaching 86 km/h at 4:52 AM on 22 December.

Table 3.2.3. Extremes of mean sea level pressure (MSLP) and peak gust observations from selected PAGASA synoptic stations during the passage of VINTA

Name of synoptic station	Mean sea level pressure (hPa)		Peak gust (km/h)	
	Date and time	Value	Date and time	Value
Dauis, Bohol	2017.12.22, 3:00 PM	1002.4	2017.12.22, 9:15 AM	36
Guiuan, Eastern Samar	2017.12.22, 5:00 AM	1005.7	2017.12.22, 4:52 AM	86
Butuan City	2017.12.22, 4:00 AM	1003.1	2017.12.21, 9:10 PM	50
Cotabato City	2017.12.22, 4:00 PM	1002.9	2017.12.21, 8:02 AM	14
Davao City	2017.12.22, 4:00 AM	1001.9	2017.12.21, 3:00 PM	18
Dumaguete City, Negros Oriental	2017.12.22, 5:00 PM	1002.9	2017.12.22, 7:05 PM	40
Malaybalay City, Bukidnon	2017.12.22, 4:00 PM	1002.9	-	4
El Salvador City, Misamis Oriental	2017.12.22, 5:00 PM	1001.0	-	54
Hinatuan, Surigao del Sur	2017.12.22, 3:00 AM	1000.4	2017.12.21, 9:21 PM	54
Maasin City, Southern Leyte	2017.12.22, 5:00 AM	1005.0	2017.12.22, 7:11 AM	40

EARLY WARNING INFORMATION

PAGASA provided the first standalone information on the precursory LPA of VINTA in a Weather Advisory issued at 11:00 AM on 20 December. In this advisory, the agency noted that apart from scattered rain showers over portions of eastern Mindanao, the LPA may develop into a TD in the next 24 to 48 hours. After 6 hours, PAGASA issued its first Severe Weather Bulletin (SWB) for VINTA when the precursory LPA developed into a TD. Throughout the monitoring and warning period, a total of 29 SWBs were issued by the agency to the public, disaster managers, and other end-users. The final SWB was issued at 10:30 AM on 24 December when the eye of VINTA left the PAR.

Tropical Cyclone Warning Signals (TCWS) were immediately raised on the first SWB issuance because portions of eastern Mindanao (Surigao del Sur and Davao Oriental) were expected to experience tropical cyclone winds within 36 hours. TCWS #2 was the highest warning signal raised by PAGASA during the monitoring and warning period. A total of 34 areas in Mindanao, Palawan and portions of Visayas were placed under TCWS, with 21 areas under TCWS #2 and the rest under TCWS #1. All active TCWS were cancelled at 10:30 AM on 24 December in conjunction with the issuance of the final SWB.

Supplementary to the issuance of SWBs by the Weather Division, local Heavy Rainfall Warnings and Thunderstorm Advisories were also issued by the agency through its PAGASA Regional Services Divisions (PRSDs). In additional, general flood advisories were also issued by the Main Operations Center of the Hydrometeorology Division to various affected regions.

CASUALTY AND DAMAGE STATISTICS

The National Disaster Risk Reduction and Management Council reported 167,963 families or 797,337 persons from MIMAROPA, Central Visayas, Zamboanga Peninsula, Northern Mindanao, Davao Region, SOCCSKSARGEN, ARMM and Caraga Region that were affected by VINTA. A total of 173 dead, 18 injured, and 169 missing persons were reported by local disaster managers. The heavy rainfall associated with VINTA flooded 239 areas and caused multiple landslide incidents in MIMAROPA, Zamboanga Peninsula, Northern Mindanao and ARMM. A total of 9,361 houses were reported to be damaged, of which 4,179 suffered total damage. Coast guard and disaster managers also reported 2 capsized and 1 drifted sea crafts due to rough seas. Cost of damages to infrastructure and agriculture were estimated at Php 2,100,081,000.00.

Because of the extent of damages and number of casualties, a total of 14 local government units in Mindanao and Palawan were placed under state of calamity. As of 10 February 2018, the national government agencies and local government units have provided assistance amounting to Php 158,061,601.85 to the affected families in 5 regions.

OTHER TROPICAL CYCLONES OF 2017

Tropical Depression AURING

07 to 09 January 2017

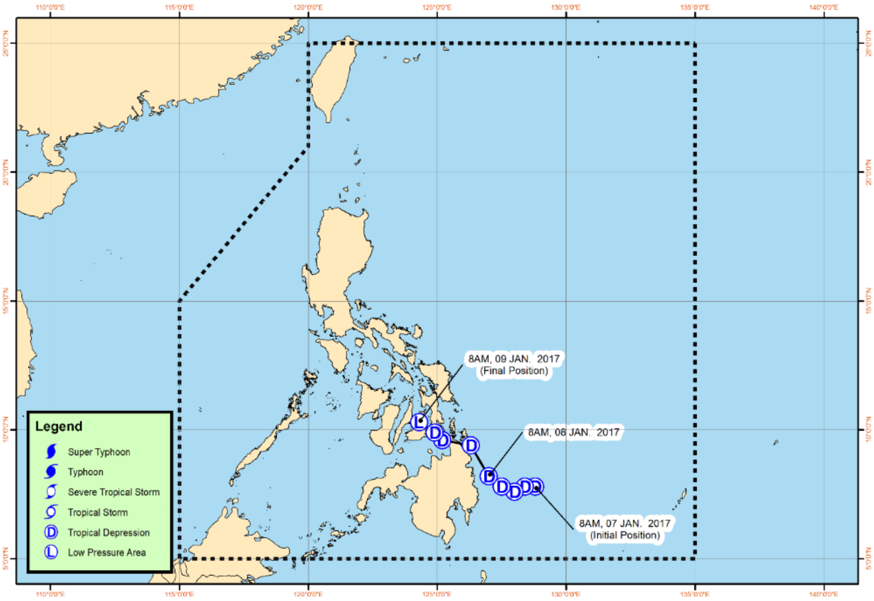


Fig. 4.1. DOST-PAGASA warning best track of Tropical Depression AURING

Tropical Depression (TD) AURING formed from an area of low pressure (LPA) at 8:00 AM on 07 January while centered over the Philippine Sea due east southeast of Hinatuan, Surigao del Sur. While tracking generally northwestward towards the Surigao Provinces, it slightly intensified to 55 km/h, which was its peak intensity throughout its lifespan. AURING made its first landfall over Siargao Island, Surigao del Norte at 3:00 PM on 08 January, followed by another over Dinagat Islands an hour after. It then crossed the southern tip of Panaon Island in Southern Leyte at 6:00 PM of the same day. After its 3rd landfall, AURING slightly weakened to 45 km/h. At 4:45 AM of the next day, AURING made its 4th landfall over Ubay, Bohol. It finally weakened into an LPA at 8:00 AM as it approached Mactan Island in Cebu.

The regions of Eastern Visayas and Caraga experienced heavy rains which resulted in multiple flooding and landslide events. No casualties were reported from the 38,882 people affected by AURING. However, cost of damages reached Php 38.639 million.

Tropical Depression BISING

03 to 06 February 2017

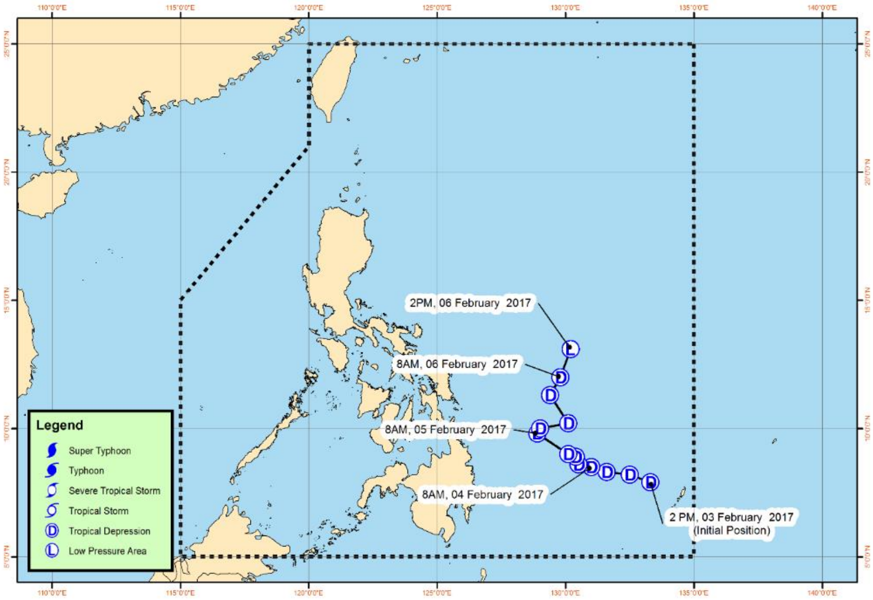


Fig. 4.2. DOST-PAGASA warning best track of Tropical Depression BISING

BISING was first noted as tropical depression (TD) at 2:00 PM on 03 February while located over the Philippine Sea due east southeast of Hinatuan, Surigao del Sur. Throughout its 3-day lifespan, it remained as a minimal TD with maximum winds of 45 km/h. It initially tracked west northwestward before shifting to a generally northward heading on 05 February. At 2:00 PM on 06 February, BISING weakened into a low pressure area.

BISING did not adversely affect any part of the country.

Tropical Depression CRISING
14 to 15 April 2017

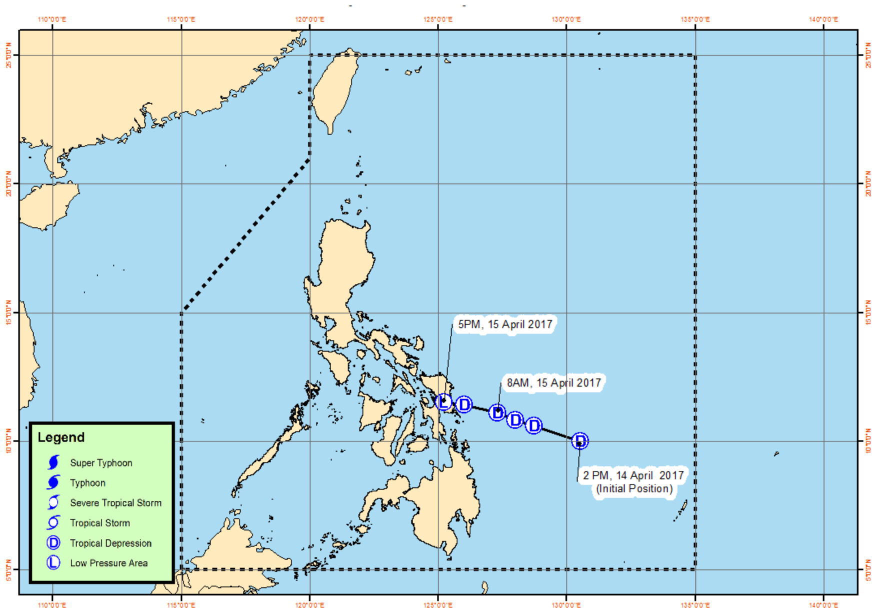


Fig. 4.3. DOST-PAGASA warning best track of Tropical Depression CRISING.

CRISING originated from a low pressure area (LPA) over the Philippine Sea due northwest of Palau. It was first noted as tropical depression (TD) at 2:00 PM of 14 April. While CRISING moved generally northwestward toward Eastern Samar, it slightly intensified and reached its peak intensity of 55 km/h at 8:00 AM on 15 April. However, the peak intensity was only momentary and after 6 hours, the TD slightly weakened to 45 km/h. At 6:30 PM later that day, CRISING made landfall over Hernani, Eastern Samar. Shortly after its landfall, it weakened into an LPA.

Scattered to widespread heavy rains occurred over Leyte, Southern Leyte, Surigao del Norte, Dinagat Islands and portions of Cebu and Bohol, especially on 15 April. Of the 427 people directly affected by CRISING, 10 were reported dead while 19 were injured. Meanwhile, the cost of damages to agriculture and infrastructure remains undetermined as of the time of writing.

Tropical Storm DANTE (T1701 MUIFA)

26 to 27 April 2017

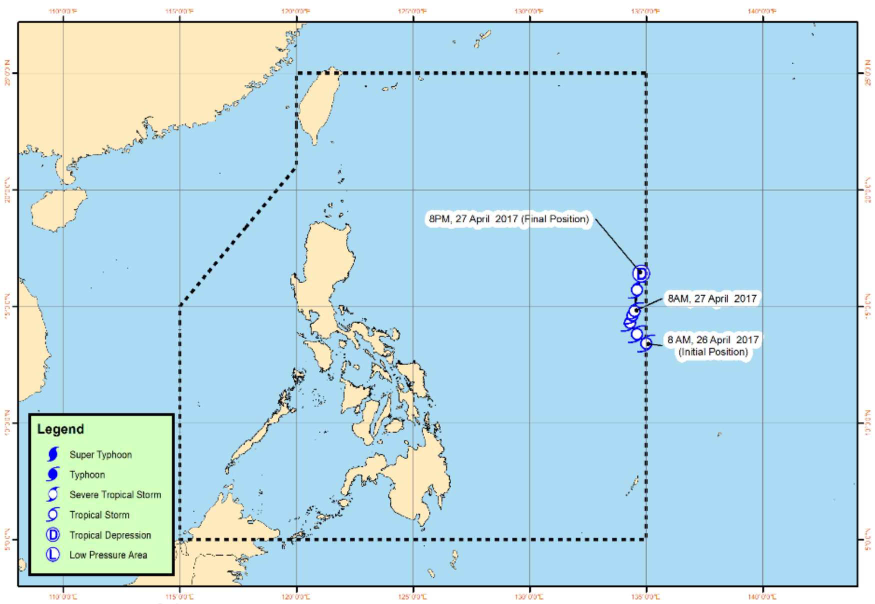


Fig. 4.4. DOST-PAGASA warning best track of Tropical Storm DANTE.

DANTE was first identified as a tropical depression (TD) at 2:00 AM on 23 April while centered due southwest of Guam. It steadily intensified into a tropical storm at 2:00 AM on 26 April with maximum sustained winds of 65 km/h. The TS entered the Philippine Area of Responsibility (PAR) at 8:00 AM of the same day and tracked slowly near the eastern boundary of the PAR throughout the day, gradually shifting its heading northwards. DANTE weakened into a TD at 8:00 PM of the following day and left the PAR hours after. The TD steadily weakened until it became a low pressure area in the evening of 29 April while located over the Ogasawara Islands, Japan.

DANTE did not adversely affect any part of the country.

Severe Tropical Storm EMONG (T1703 NANMADOL)

02 to 03 July 2017

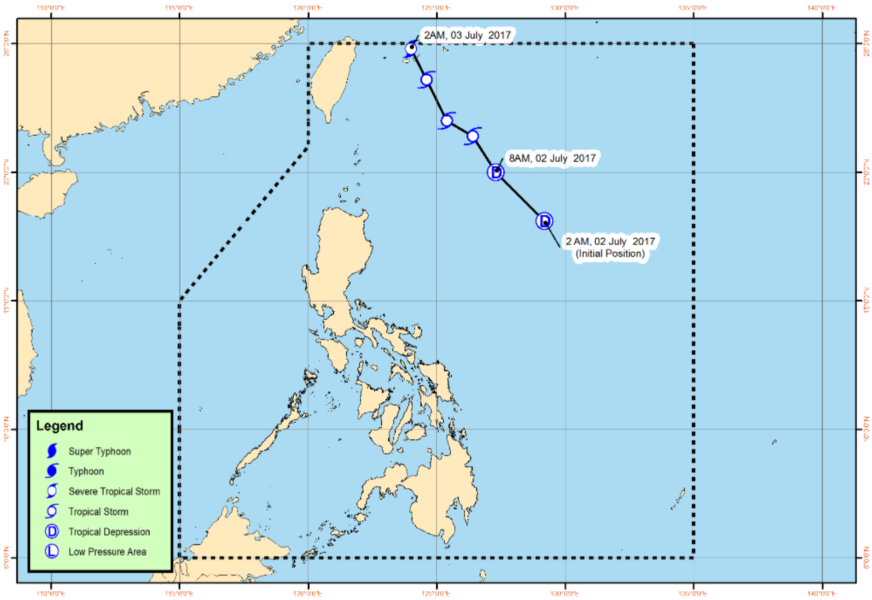


Fig. 4.5. DOST-PAGASA warning best track of Severe Tropical Storm EMONG.

EMONG was first noted as a tropical depression TD over the northern Philippine Sea at 2:00 AM on 2 July. While moving north northwestward towards the southern Ryukyus, it intensified into a tropical storm within 12 hours of becoming a TD. After passing over Ishigaki Island at 1:00 AM on 03 July, it intensified into a severe tropical storm with maximum sustained winds of 95 km/h. Shortly thereafter, EMONG left the Philippine Area of Responsibility and continued to track in a recurving fashion towards mainland Japan. It made landfall near Nagasaki City in Kyushu shortly before 7:00 AM on 4 July. Throughout the day, EMONG traversed Kyushu, Shikoku and southern Kansai regions before emerging over the seas south of Chubu and Kanto regions. At 8:00 AM of the following day, EMONG transitioned to an extratropical cyclone.

EMONG did not adversely affect any part of the country. However, scattered to widespread monsoon rains were observed over the western portion of the country due to the partly enhanced Southwest Monsoon.

Tropical Depression FABIAN (T1707 ROKE)

22 July 2017

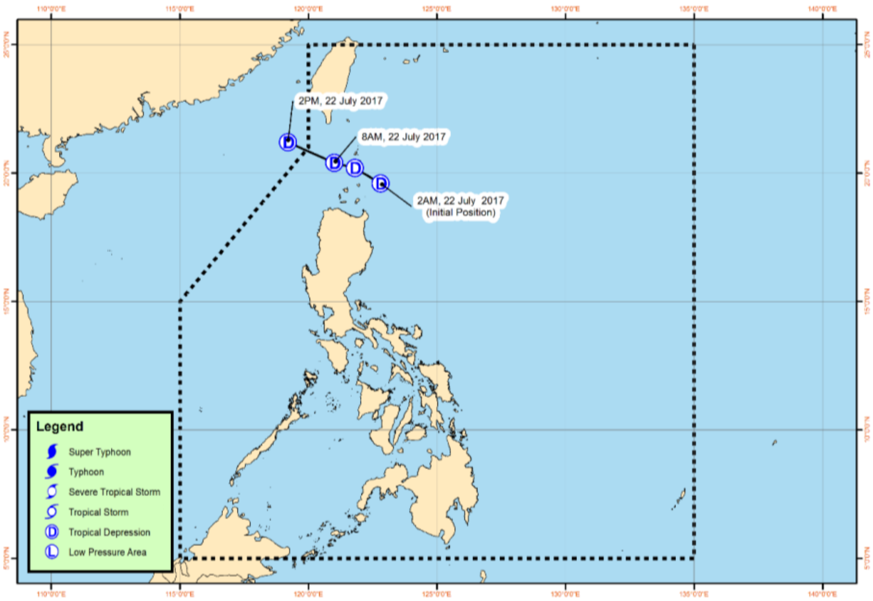


Fig. 4.6. DOST-PAGASA warning best track of Tropical Depression FABIAN.

FABIAN originated from an area of low pressure (LPA) near Extreme Northern Luzon that developed into a tropical depression (TD) at 2:00 AM on 22 July. In the succeeding hours, FABIAN traversed the Balintang Channel near Batanes in a west northwestward course until it left the PAR at 2:00 PM later that day. By late afternoon, FABIAN intensified into a tropical storm just outside the Philippine Area of Responsibility as it continued to track the same heading. In the early hours of 23 July, the TS swept past the northeastern portion of Hong Kong which resulted in its weakening into a TD roughly six hours later as it moved further inland. FABIAN finally weakened into an LPA in the early hours of 24 July.

Scattered to at times widespread rains were observed over Batanes and Babuyan Group of Islands during the passage of FABIAN. No casualties or significant damages were reported by local disaster managers over the affected areas.

Typhoon GORIO (T1709 NESAT)

22 July 2017

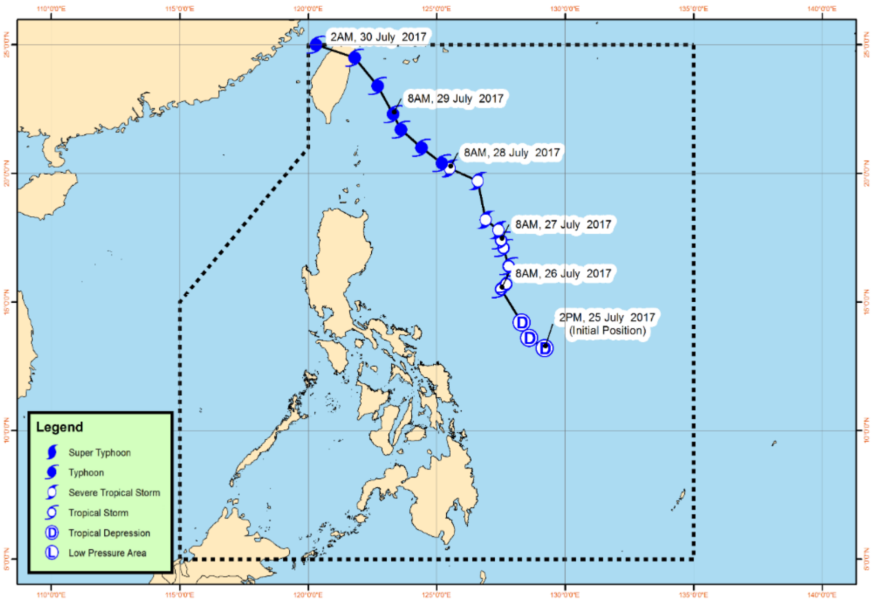


Fig. 4.7. DOST-PAGASA warning best track of Typhoon GORIO.

GORIO was first identified as a tropical depression (TD) over the Philippine Sea due east of Southern Luzon at 2:00 PM on 25 July. Moving generally north northwestward, it intensified into a tropical storm (TS) at 8:00 AM of the next day and severe tropical storm 36 hours after. As it continued to move towards the sea east of Taiwan, GORIO intensified into a typhoon in the early afternoon of 28 July. Within 12 hours, it reached its peak intensity of 145 km/h, which was maintained until it made landfall over Yilan County in northern Taiwan. After a slight weakening during the land crossing, GORIO had left the Philippine Area of Responsibility at 2:00 AM on July 30 before it made landfall over Fuzhuo City in Fujian, China hours after. GORIO was last noted as a TD in the early hours of 30 July.

Although GORIO remained over the Philippine Sea and far from any landmass of the country, it enhanced the southwest monsoon which brought widespread heavy rains over most of Luzon, especially on the western section. No casualties were reported from the 7,339 individuals affected by the monsoon rains. Meanwhile, damages to agriculture and infrastructure reached Php 8.819 million.

Tropical Storm HUANING (T1710 HAITANG)

30 to 31 July 2017

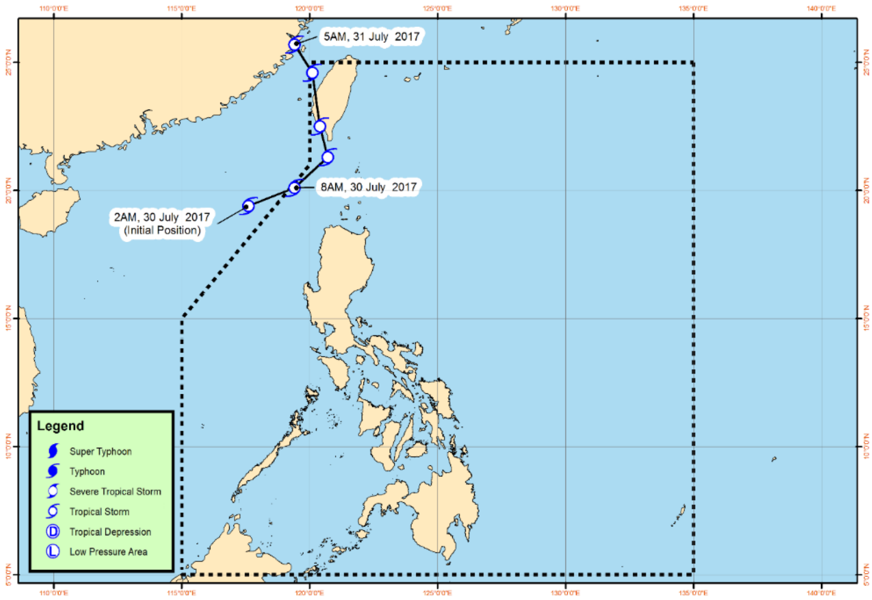


Fig. 4.8. DOST-PAGASA warning best track of Tropical Storm HUANING

The precursor of HUANING was associated with a low pressure area located over the northern West Philippine Sea due southeast of Hong Kong. Developing into a tropical depression (TD) on 28 July, it remained quasi-stationary at first due to the ambiguous steering environment. At 2:00 PM on 29 July, HUANING intensified into tropical storm (TS). As GORIO moved towards Taiwan, HUANING began to accelerate northeastward and by 8:00 AM on July 30, the TS entered the Philippine Area of Responsibility. HUANING moved over the Luzon Strait as it shifted to a more northward heading. It had reached its peak intensity of 85 km/h just before it hit the southwestern coast of Taiwan in the evening of 30 July. Slight weakening ensued due to land interaction and by the time HUANING emerged over the Taiwan Strait and left the PAR in the early hours of 31 July, it had already weakened into a minimal TS. The tropical cyclone eventually went on to make landfall nearly in the same area in Fujian, China where GORIO made landfall. HUANING was last noted as a TD in the morning of 1 August over inland southeastern China.

While it did not directly affect any part of the country, the southwest monsoon flow was enhanced by HUANING. However, the orientation of its path diverted the flow of the southwest monsoon away from western Luzon and into Taiwan, sparing the former from further monsoon rains it experienced during the period of GORIO's monsoon enhancement. Nevertheless, the weakening monsoon rains resulted in damages amounting to Php 49 thousand.

Severe Tropical Storm ISANG (T1713 HATO)

20 to 22 August 2017

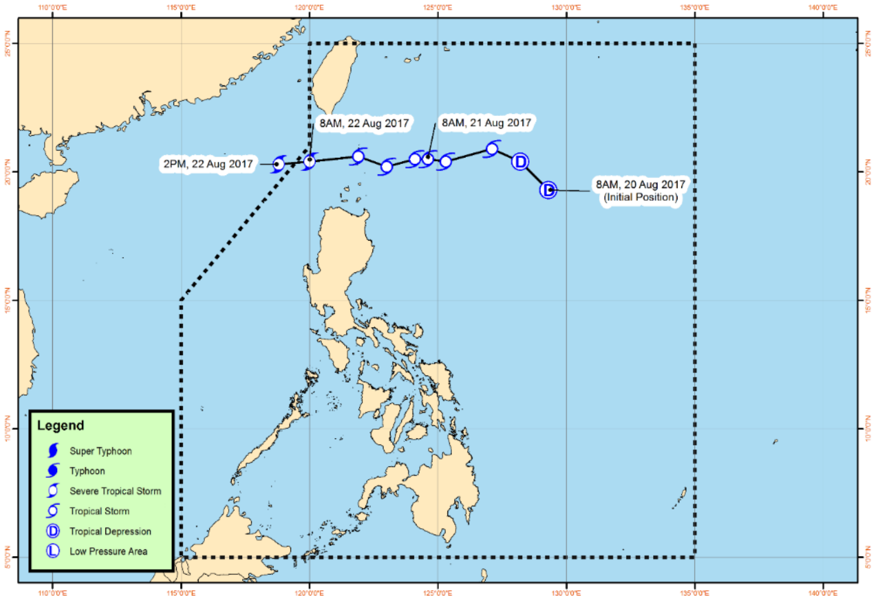


Fig. 4.9. DOST-PAGASA warning best track of Severe Tropical Storm ISANG.

A low pressure area over the Philippine Sea due east of Extreme Northern Luzon developed into a tropical depression (TD) at 8:00 AM on 20 August and was named ISANG. Within 12 hours of formation, ISANG intensified into a tropical storm, with gradual intensification observed as it approached Batanes. Generally moving westward, it traversed the municipal waters between Batan and Itbayat Islands in Batanes in the early hours of 22 August. At 8:00 AM of the same day, it intensified into a severe tropical storm and at 2:00 PM, it left the PAR as it tracked west northwestward towards the Hong Kong – Macau area. In the early morning of 23 August, ISANG intensified into a typhoon (TY) and at 12:50 PM of the same day, it made landfall over Zhuhai in Guangdong, China. Over the next 2 days, the TY continuously weakened and was last tracked as a TD near the Myanmar-China border in the morning of 25 August.

From 20 to 22 August, widespread heavy rains associated with ISANG prevailed over much of Northern Luzon, especially on 21 August over Ilocos Region, Cordillera Administrative Region, Batanes, Cagayan, and Isabela. Furthermore, scattered monsoon rains also were observed over the western section of Central and Southern Luzon, as well as the portions of Eastern Visayas, Northern Mindanao and Zamboanga Peninsula Regions. No casualties or significant damages to properties were reported by local disaster managers.

Tropical Storm JOLINA (T1714 PAKHAR)

24 to 26 August 2017

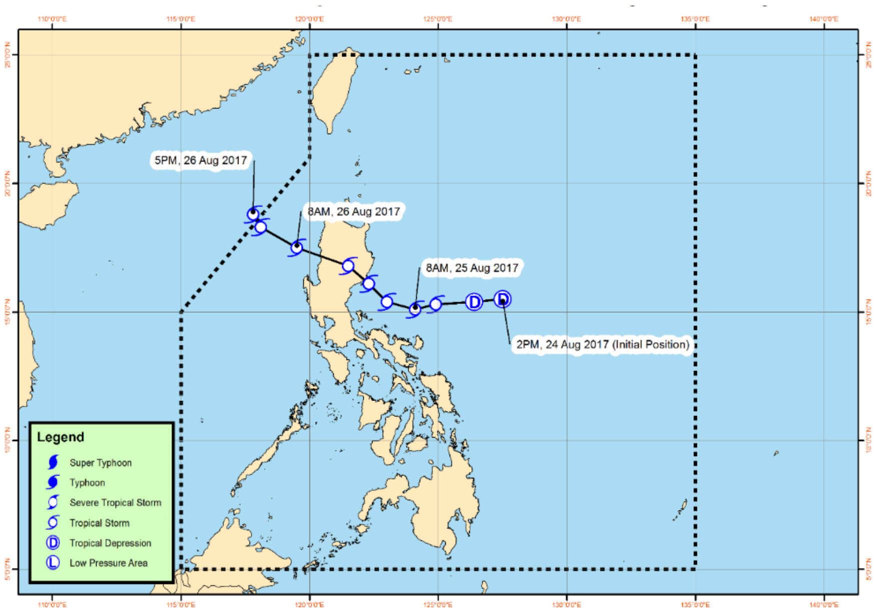


Fig. 4.10. DOST-PAGASA warning best track of Tropical Storm JOLINA.

JOLINA was first tracked as tropical depression (TD) at 2:00 PM on 24 August after developing from an area of low pressure due east northeast of Virac, Catanduanes. The TD steadily intensified as it moved westward, reaching tropical storm (TS) in the early hours of 25 August. After shifting to a more northwestward heading, JOLINA continued to intensify throughout the day, reaching a peak intensity of 80 km/h before making landfall over Casiguran, Aurora at 10:00 PM. Interaction with the rugged terrain of Northern Luzon caused it to slightly weaken but as it emerged over the West Philippine Sea due west of Ilocos Region, JOLINA managed to re-intensify. By the time it left the PAR in the afternoon of 26 August, it had maximum winds of 80 km/h. JOLINA continued to intensify, reaching severe tropical storm category (STS) in the early morning of 27 August while maintaining a northwestward heading towards southeastern China. At 8:00 AM of the same day, the STS made landfall over Taishan in Guangdong, China. Continuous weakening ensued as it moved further inland and by morning of the next day, JOLINA was last tracked as a TD.

Scattered to widespread heavy rains were experienced in most areas of Luzon, especially in Northern and Central Luzon due to JOLINA and the southwest monsoon it was interacting with, resulting in multiple flooding and landslide incidents over these areas. No casualties were reported from the 3,397 people directly affected by the storm.

Tropical Storm KIKO (T1717 GUCHOL)

04 to 06 September 2017

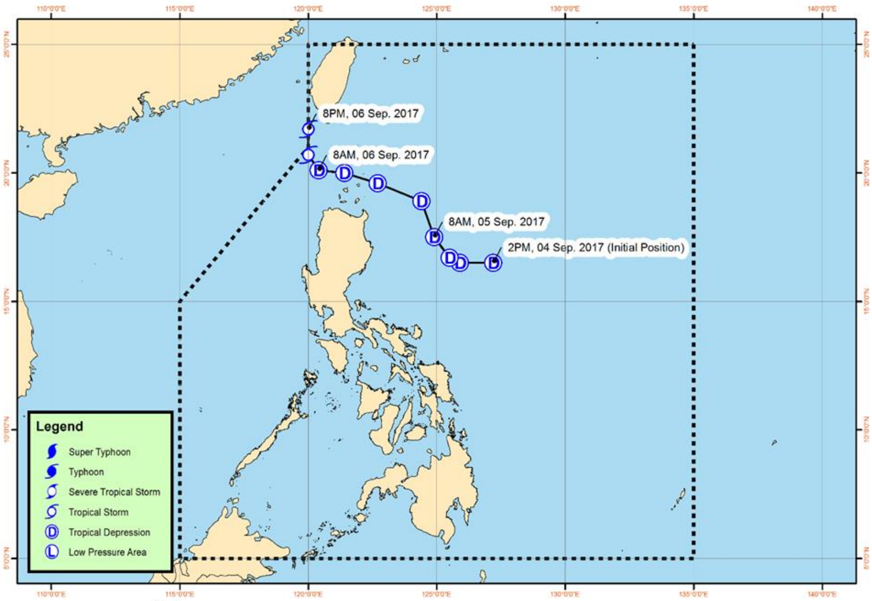


Fig. 4.11. DOST-PAGASA warning best track of Tropical Storm KIKO.

KIKO formed as a tropical depression (TD) over the Philippine Sea east of Central Luzon at 2:00 PM on 04 September. After initially moving northwestward, it shifted to a more west northwestward heading in the afternoon of 05 September and traversed the Balintang Channel hours later. The tropical cyclone intensified slowly throughout its lifespan, reaching tropical storm (TS) category 48 hours after formation as it veered northward. Hours after leaving the PAR at 8:00 PM on 6 September, KIKO weakened to a TD as it moved towards the Taiwan Strait where it was last tracked.

A significant portion of Northern Luzon, especially over Ilocos Norte, Apayao, and Cagayan experienced scattered to widespread heavy rains associated with KIKO. However, no casualties and damages to property due to KIKO were reported by local disaster managers.

Typhoon LANNIE (T1718 TALIM)

11 to 13 September 2017

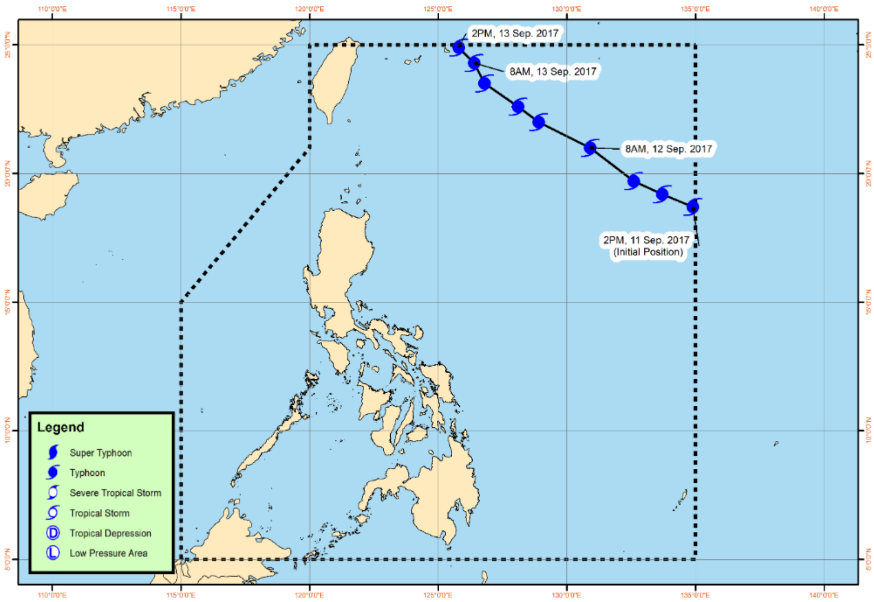


Fig. 4.12. DOST-PAGASA warning best track of Typhoon LANNIE.

Typhoon (TY) LANNIE was first noted as a tropical depression (TD) near the Northern Marianas in the evening of 8 September. Tracking generally west northwestward, LANNIE steadily intensified, eventually reaching typhoon category as it entered the PAR at 2:00 PM on 11 September. While over the northern Philippine Sea, the TY continued to intensify to its maximum intensity within the PAR of 130 km/h at 8:00 AM on 13 September. At 2:00 PM of the same day, it left the PAR as it began to slow down near Miyako Island in the southern Ryukyus. Over the next 3 days, it recurved while moving over the East China Sea and by 16 September, it was heading northeastward, albeit a weakening trend, towards mainland Japan. LANNIE made landfall as a severe tropical storm near Kagoshima City in southern Kyushu at noon on 17 September. Throughout the day, it traversed the regions of southern Kyushu, Shikoku, Kansai, and northwestern Chubu before emerging over the sea west of Tsubame City in Niigata Prefecture as an extratropical cyclone in the early hours of 18 September.

LANNIE did not adversely affect any part of the country.

Tropical Storm MARING (T1719 DOKSURI)

11 to 13 September 2017

Fig. 4.13. DOST-PAGASA warning best track of Tropical Storm MARING

MARING originated from an area of low pressure northeast of Bicol Region and was first noted as a tropical depression (TD) at 2:00 PM on 11 September at 2:00 PM. Centered east of Infanta, Quezon, it moved generally westward and made landfall in the vicinity of Mauban, Quezon at 10:00 AM of the following day. After crossing the landmass of Southern Luzon and emerging over the West Philippine Sea due west of Zambales, MARING intensified into a tropical storm at 8:00 PM of the same day. It had shifted to a west northwestward heading before it exited the PAR at 4:00 PM on 13 September. MARING gradually intensified as it traversed the West Philippine Sea. It had reached typhoon category with peak intensity of 150 km/h on 15 September before it hit the coast of Quang Binh, Vietnam around noon. Following a period of rapid weakening, MARING was last noted as a TD at 8:00 AM on 16 September.

Heavy rains were dumped over Metro Manila and the nearby provinces in Central and Southern Luzon during the passage of MARING. This resulted in multiple incidents of flooding and landslide over these areas. Of the 40,966 people affected by this tropical cyclone, a total of 25 dead and 4 missing individuals were reported. Meanwhile, damages to agriculture and infrastructure amounted to Php 267.039 million.

Tropical Depression NANDO

23 September 2017

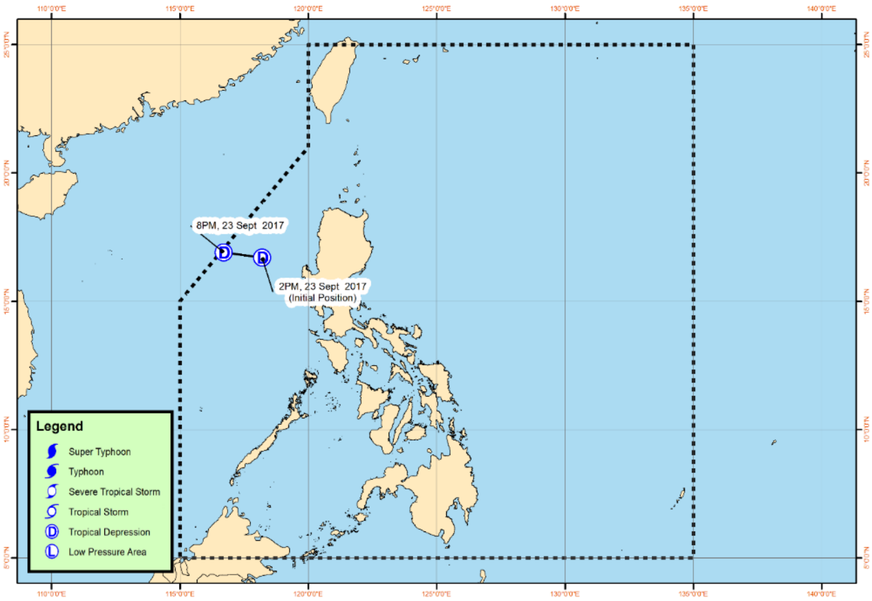


Fig. 4.14. DOST-PAGASA warning best track of Tropical Depression NANDO

NANDO originated from a low pressure area (LPA) that crossed Central Luzon in the evening of 22 September. As the LPA emerged over the West Philippine Sea, it developed into a weak tropical depression at 2:00 PM on 23 September. Moving west northwestward towards southern China, NANDO left the PAR at 8:00 PM of the same day. The TD made landfall over Hainan Island in the evening of 24 September and over Quang Ninh in northern Vietnam in the afternoon of the following day. NANDO was last tracked as a TD in the early hours of 26 September

NANDO did not adversely affect any part of the country.

Severe Tropical Storm ODETTE (T1720 KHANUN)

11 to 14 October 2017

Fig. 4.15. DOST-PAGASA warning best track of Severe Tropical Storm ODETTE.

ODETTE was first noted as tropical depression (TD) at 8:00 PM on 11 October while centered over the Philippine Sea due east of Tuguegarao City, Cagayan. It had intensified into tropical storm (TS) after 24 hours as it moved westward towards Northern Luzon. ODETTE made landfall over Santa Ana, Cagayan on 13 October at around 12:40 AM. It continued to intensify as it traversed Northern Luzon and was upgraded to a severe tropical storm when it emerged over the West Philippine Sea. After a period of erratic movement from the evening of 13 October to the morning of the following day, ODETTE left the PAR in the early evening of 14 October as it moved west-northwestward. The tropical cyclone eventually intensified into a typhoon in the early hours of 15 October, with peak intensity of 140 km/h reached after 6 hours. However, this intensification was short-lived. Within 24 hours after peak intensity, rapid weakening ensued. ODETTE made its final landfall in the early hours of 16 October at Xuwen County in Guangdong, China as a TS. It was last tracked as a TD at 8:00 AM of the same day as it headed towards Hainan Island.

Heavy rains associated with ODETTE were experienced over significant portions of Northern Luzon, particularly in Cagayan, Isabela, Kalinga, Apayao, Ilocos Norte, Ilocos Sur, La Union and Mountain Province. In addition, scattered to widespread monsoon rains enhanced by ODETTE were also observed over the western portions of Southern Luzon, Visayas, and Mindanao . Only 1 death was reported from the 4,721 individuals directly affected by ODETTE. However, damages to agriculture reached Php 4.446 million in the affected areas.

Typhoon PAOLO (T1721 LAN)

16 to 22 October 2017

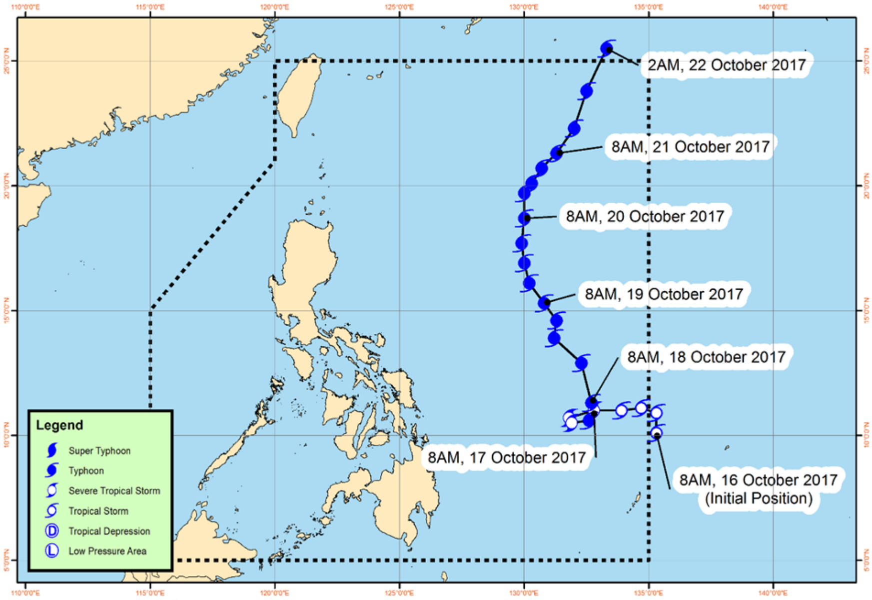


Fig. 4.16. DOST-PAGASA warning best track of Typhoon PAOLO.

The most intense tropical cyclone in 2017, PAOLO, developed from a low pressure area in the vicinity of Chuuk, Micronesia. Tracking generally northwestward, it was first noted as a tropical depression in the afternoon of 15 October. While centered over the Philippine Sea due northeast of Palau, it intensified into a tropical storm in the early hours of 16 October. PAOLO entered the PAR in the late afternoon of the same day as it shifted to a westward heading. As it further intensified into a severe tropical storm in the morning of 17 October, PAOLO exhibited a brief period of quasi-stationary motion. During this time, the TC continue to intensify and reached typhoon category in the early hours of 18 October. Over the next two days, PAOLO steadily intensified as it tracked north northwestward over the Philippine Sea. In the morning of 20 October, the TY began recurving to the northeast. In the early hours of 22 October, PAOLO exited the PAR as it reached its peak intensity of 185 km/h. The TY continued to track northeastward over the sea south of Japan until it made landfall over Omaezaki City in the southern coast of Chubu region of Japan. PAOLO fully transitioned into an extratropical cyclone in the morning of 23 October off the east coast of Fukushima Prefecture.

PAOLO did not adversely affect any part of the country.

Severe Tropical Storm QUEDAN (T1722 SAOLA)

25 to 28 October 2017

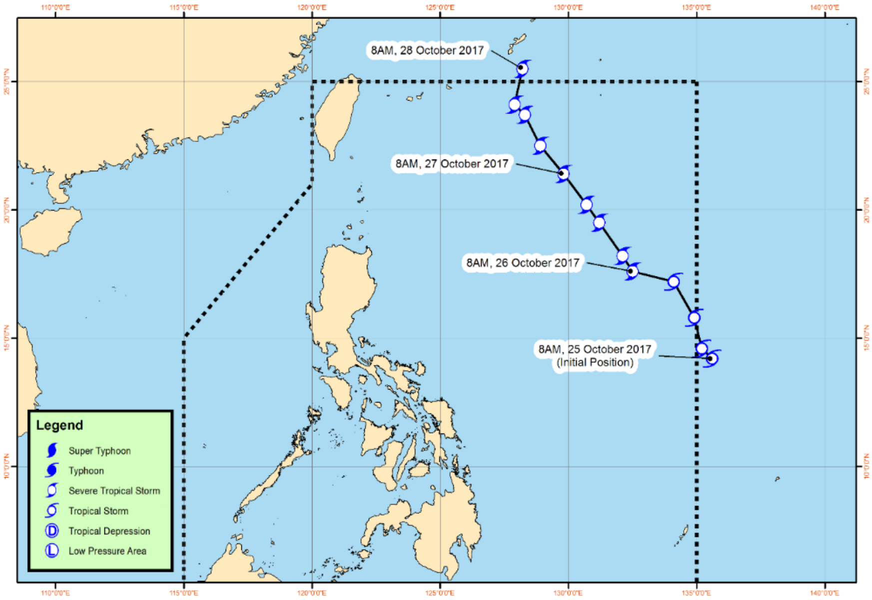


Fig. 4.17. DOST-PAGASA warning best track of Severe Tropical Storm QUEDAN.

QUEDAN was first tracked as a tropical depression at 2:00 PM on 22 October over the sea due west of Namonuito Islands in the Federated States of Micronesia. Moving northwestward, it intensified into a tropical storm in the evening of 24 October and entered the PAR after 24 hours. Over the next 2 days, QUEDAN maintained a northwestward heading as it slowly intensified. It was upgrade to a severe tropical storm (STS) at 8:00 AM on 26 October. In the early hours of 28 October, the STS began recurving as it approached the Ryukyu Islands. It eventually left the PAR before 8:00 AM of the same day. QUEDAN continued to track generally northeastward and made several landfalls and close approaches over the islands in the Ryukyu Arc. In the evening of 29 October, it transitioned into an extratropical cyclone while centered over the sea due southeast of Chiba Prefecture.

QUEDAN did not adversely affect any part of the country.

Severe Tropical Storm RAMIL (T1723 DAMREY)

01 to 03 November 2017

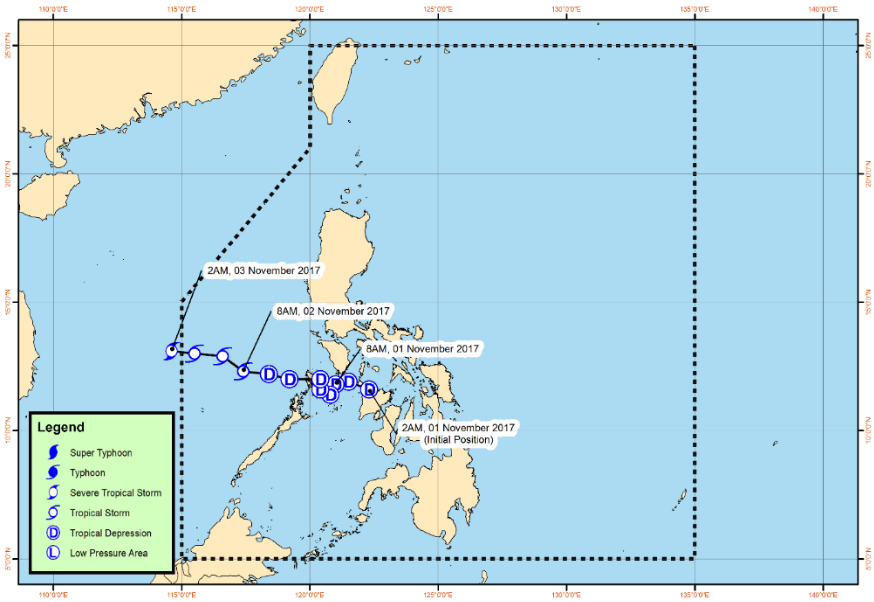


Fig. 4.18. DOST-PAGASA warning best track of STS RAMIL.

RAMIL originated from an area of low pressure that traversed Visayas which developed into a tropical depression (TD) at 2:00 AM on 01 November over the northwestern portion of Panay Island. After moving erratically over the Sulu Sea area between the Cuyo Archipelago and Mindoro Island, the TD crossed the Calamian Group of Islands in the late afternoon of the same day. After emerging over the West Philippine Sea, RAMIL intensified into a tropical storm in the morning of 02 November as it tracked generally westward towards the direction of Vietnam. A period of rapid intensification ensued as RAMIL moved outside the PAR. At 2:00 AM on 03 November, it intensified into a severe tropical storm and after 6 hours, it reached typhoon category. RAMIL eventually made landfall at peak intensity of 130 km/h in the vicinity of Ninh Hòa town in the South Central Vietnam. Following a period of rapid weakening, RAMIL was last tracked as a TD over Cambodia in the early hours of 4 November.

The interaction between the prevailing Northeast Monsoon, the cold surge shear line and the circulation of RAMIL resulted in rains in most portions of the country, with heavier rainfall observed over Metro Manila, Southern Tagalog Regions, Bicol Region, Eastern Visayas, and the eastern portions of Central Luzon and Cagayan Valley. Multiple flooding and landslide incidents were reported by local disaster managers. There were no casualties among the 305 people reported to be directly affected by RAMIL, although no damage statistics were available even as of this time.

Tropical Storm SALOME (T1724 HAIKUI)

09 to 11 November 2017

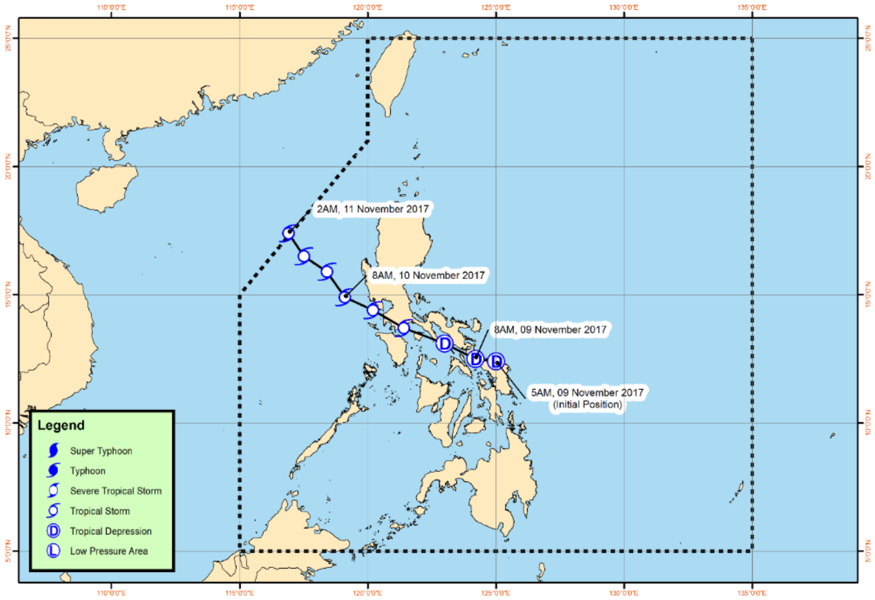


Fig. 4.19. DOST-PAGASA warning best track of TS SALOME.

SALOME developed into a tropical depression over the northern coast of Northern Samar in the early hours of 09 November. Over the next 12 hours, the TD made landfall over the southwestern coast of Albay and the southern tip of Bondoc Peninsula in Quezon as it maintained a generally northwestward course. As SALOME made its final landfall in the Philippines over San Juan, Batangas, it intensified into a tropical storm (TS) at around 8:00 PM. After emerging over the coastal waters of Cavite-Batangas area in the early hours of 10 November, SALOME continued to track northwestward consistently as it slowly intensified. It reached its peak intensity of 75 km/h in the afternoon of 10 November and after 12 hours, its circulation left the PAR. Over the next 2 days, SALOME shifted to a more westward course as it gradually weakened due to the surge of the Northeast Monsoon. It was last tracked as a TD at 8:00 AM on 13 November over the West Philippine Sea due south of Hainan Island, China.

Scattered to widespread rains were observed over most of Luzon due to TS SALOME, especially over portions of Southern Luzon mainland and Cagayan Valley. A total of 5,673 individuals were directly affected by SALOME, while total cost of damages was estimated at Php 277.277 million.

Tropical Storm TINO (T1725 KIROGI)
17 to 18 November 2017

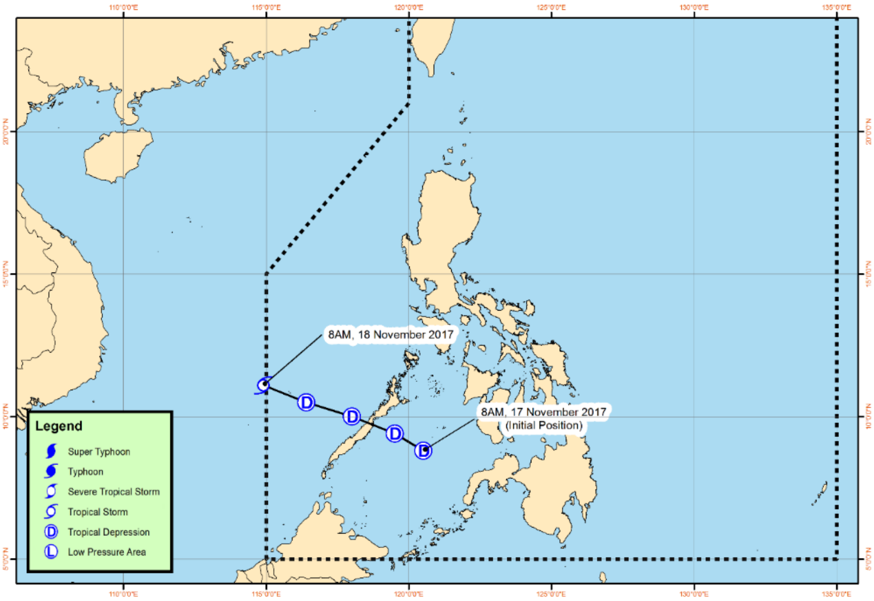


Fig. 4.20. DOST-PAGASA warning best track of TS TINO.

TINO originated from a low pressure area (LPA) that traversed Southern Mindanao on 16 November and was first noted as a tropical depression (TD) at 8:00 AM of the following day over the Sulu Sea due southwest of Cagayancillo, Palawan. Tracking west northwestward, the TD made landfall over the southern portion of Puerto Princesa City at 5:00 PM on 17 November. After emerging over the West Philippine Sea hours later, TINO continued moving west northwestward as it gradually intensified. At 8:00 AM of the following day, the TD was upgraded to a tropical storm as it left the PAR. TINO maintained its intensity over the next 18 hours as it shifted to a more westward heading. The Northeast Monsoon eventually weakened the tropical cyclone as it approached Vietnam. TINO weakened into an LPA at 8:00 PM on 19 November and dissipated off the south central coast of Vietnam hours later.

Scattered rains due to TINO were observed over Palawan. However, the prevailing Northeast Monsoon and the associated cold surge shear line brought isolated heavy rains in other parts of Southern Luzon, as well as in some areas in Samar Island. Of the 497 families directly affected, there were no reported dead, missing or injured individuals. However, no damage statistics were available for TINO as of the time of writing.

WARNING BEST TRACK DATA

Warning Best Track Data

The following information are the details of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) warning best track (WBST) of each tropical cyclone (TC) during the 2017 season. WBST consists of the following parameters:

- Date and time of analysis, in Philippine Standard Time;
- Latitude and longitude of the center position, rounded off to the nearest 0.1°N and 0.1°E, respectively;
- Central pressure of the TC, in hectopascal (hPa) and rounded off to the nearest even integer for estimates of at least 980 hPa and to the nearest 5 hPa for estimates below 980 hPa;
- Maximum sustained winds of 10-minute averaging, in kilometers per hour (km/h) and rounded off to the nearest 5 km/h; and,
- Category of the TC based on the PAGASA tropical cyclone classification scheme, for instance, tropical depression (TD), tropical storm (TS), severe tropical storm (STS), typhoon (TY), or super typhoon (STY).

Unlike the best track data from the Regional Specialized Meteorological Centers (RSMCs), WBEST is based on the information released by PAGASA during the warning period. Hence, these data are not obtained from the reanalysis of these TC events. A final best track (FBST) will be released by agency as soon as the reanalysis is complete.

Table 5.1. Details of the warning best track of TD AURING.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
07 January 8:00 AM	7.8	128.8	1004	45	Tropical Depression
07 January 2:00 PM	7.8	128.4	1000	55	Tropical Depression
07 January 8:00 PM	7.6	128.0	1000	55	Tropical Depression
08 January 2:00 AM	7.8	127.5	1000	55	Tropical Depression
08 January 8:00 AM	8.2	127.0	1000	55	Tropical Depression
08 January 2:00 PM	9.8	126.3	1000	55	Tropical Depression
08 January 8:00 PM	9.6	125.2	1004	45	Tropical Depression
09 January 2:00 AM	9.9	124.9	1004	45	Tropical Depression
09 January 8:00 AM	10.3	124.3	-	-	Low Pressure Area

Table 5.2. Details of the warning best track of TD BISING.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
03 February 2:00 PM	7.9	133.3	1004	45	Tropical Depression
03 February 8:00 PM	8.2	132.5	1004	45	Tropical Depression
04 February 2:00 AM	8.3	131.6	1004	45	Tropical Depression
04 February 8:00 AM	8.5	131.0	1004	45	Tropical Depression
04 February 2:00 PM	8.6	130.5	1004	45	Tropical Depression
04 February 8:00 PM	8.9	130.4	1004	45	Tropical Depression
05 February 2:00 AM	9.0	130.1	1004	45	Tropical Depression
05 February 8:00 AM	9.8	128.9	1004	45	Tropical Depression
05 February 2:00 PM	10.0	129.0	1004	45	Tropical Depression
05 February 8:00 PM	10.2	130.1	1004	45	Tropical Depression
06 February 2:00 AM	11.3	129.4	1004	45	Tropical Depression
06 February 8:00 AM	12.0	129.8	1004	45	Tropical Depression
06 February 2:00 PM	13.1	130.2	-	-	Low Pressure Area

Table 5.3. Details of the warning best track of TD CRISING.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
14 April 2:00 PM	10.1	130.5	1004	45	Tropical Depression
14 April 8:00 PM	10.6	128.7	1004	45	Tropical Depression
15 April 2:00 AM	10.8	128.0	1004	45	Tropical Depression
15 April 8:00 AM	11.1	127.3	1004	55	Tropical Depression
15 April 2:00 PM	11.4	126.0	1004	45	Tropical Depression
15 April 8:00 PM	11.5	125.0	-	-	Low Pressure Area

Table 5.4. Details of the warning best track of TS DANTE.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
26 April 8:00 AM	13.4	135.0	998	65	Tropical Storm
26 April 2:00 PM	13.8	134.6	998	65	Tropical Storm
26 April 8:00 PM	14.3	134.3	998	65	Tropical Storm
27 April 2:00 AM	14.6	134.4	998	65	Tropical Storm
27 April 8:00 AM	14.8	134.5	998	65	Tropical Storm
27 April 2:00 PM	15.7	134.6	998	65	Tropical Storm
27 April 8:00 PM	16.4	134.8	1002	55	Tropical Depression

Table 5.5. Details of the warning best track of STS EMONG.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
02 July 2:00 AM	18.1	129.2	1004	45	Tropical Depression
02 July 8:00 AM	20.0	127.3	1000	60	Tropical Depression
02 July 2:00 PM	22.0	125.7	993	80	Tropical Storm
02 July 8:00 PM	23.6	124.6	993	80	Tropical Storm
03 July 2:00 AM	24.8	124.0	987	95	Severe Tropical Storm

Table 5.6. Details of the warning best track of TD FABIAN.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
22 July 2:00 AM	19.6	122.8	1004	45	Tropical Depression
22 July 8:00 AM	20.4	121.0	1002	55	Tropical Depression
22 July 2:00 PM	21.2	119.2	1000	55	Tropical Depression

Table 5.7. Details of the warning best track of TY GORIO.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
25 July 2:00 PM	13.2	129.2	1002	55	Tropical Depression
25 July 8:00 PM	13.6	128.6	1002	55	Tropical Depression
26 July 2:00 AM	14.2	128.3	1000	60	Tropical Depression
26 July 8:00 AM	15.5	127.5	998	65	Tropical Storm
26 July 2:00 PM	15.7	127.7	995	70	Tropical Storm
26 July 8:00 PM	16.4	127.8	993	80	Tropical Storm
27 July 2:00 AM	17.1	127.6	990	85	Tropical Storm
27 July 8:00 AM	17.4	127.5	990	85	Tropical Storm
27 July 2:00 PM	17.8	127.4	987	90	Severe Tropical Storm
27 July 8:00 PM	18.2	126.9	987	90	Severe Tropical Storm
28 July 2:00 AM	19.7	126.6	981	105	Severe Tropical Storm
28 July 8:00 AM	20.2	125.5	981	105	Severe Tropical Storm
28 July 2:00 PM	20.4	125.2	973	120	Typhoon
28 July 8:00 PM	21.0	124.4	965	130	Typhoon
29 July 2:00 AM	21.7	123.6	957	145	Typhoon
29 July 8:00 AM	22.3	123.3	957	145	Typhoon
29 July 2:00 PM	23.4	122.7	957	145	Typhoon
29 July 8:00 PM	24.5	121.8	957	145	Typhoon
30 July 2:00 AM	25.0	120.3	960	140	Typhoon

Table 5.8. Details of the warning best track of TS HUANING

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
30 July 2:00 AM	19.4	117.6	998	65	Tropical Storm
30 July 8:00 AM	20.1	119.4	995	75	Tropical Storm
30 July 2:00 PM	21.3	120.7	993	80	Tropical Storm
30 July 8:00 PM	22.5	120.4	990	85	Tropical Storm
31 July 2:00 AM	24.6	120.1	998	65	Tropical Storm
31 July 5:00 AM	25.7	119.4	998	65	Tropical Storm

Table 5.9. Details of the warning best track of STS ISANG.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
20 August 8:00 AM	19.3	129.3	1002	55	Tropical Depression
20 August 2:00 PM	20.4	128.2	1002	55	Tropical Depression
20 August 8:00 PM	20.9	127.1	998	65	Tropical Storm
21 August 2:00 AM	20.4	125.3	998	65	Tropical Storm
21 August 8:00 AM	20.5	124.6	993	80	Tropical Storm
21 August 2:00 PM	20.5	124.1	993	80	Tropical Storm
21 August 8:00 PM	20.2	123.0	993	80	Tropical Storm
22 August 2:00 AM	20.6	121.9	993	80	Tropical Storm
22 August 8:00 AM	20.4	120.0	987	90	Severe Tropical Storm
22 August 2:00 PM	20.3	118.8	977	110	Severe Tropical Storm

Table 5.10. Details of the warning best track of TS JOLINA.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
24 August 2:00 PM	15.5	127.5	1004	45	Tropical Depression
24 August 8:00 PM	15.4	126.4	1002	55	Tropical Depression
25 August 2:00 AM	15.3	124.9	998	65	Tropical Storm
25 August 8:00 AM	15.1	124.1	993	80	Tropical Storm
25 August 2:00 PM	15.4	123.0	993	80	Tropical Storm
25 August 8:00 PM	16.1	122.3	993	80	Tropical Storm
26 August 2:00 AM	16.8	121.5	995	75	Tropical Storm
26 August 8:00 AM	17.5	119.5	993	80	Tropical Storm
26 August 2:00 PM	18.3	118.1	993	80	Tropical Storm

Table 5.11. Details of the warning best track of TS KIKO.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
04 September 2:00 PM	16.5	127.2	1002	55	Tropical Depression
04 September 8:00 PM	16.5	125.9	1002	55	Tropical Depression
05 September 2:00 AM	16.7	125.5	1002	55	Tropical Depression
05 September 8:00 AM	17.5	124.9	1002	55	Tropical Depression
05 September 2:00 PM	18.9	124.4	1002	55	Tropical Depression
05 September 8:00 PM	19.6	122.7	1002	55	Tropical Depression
06 September 2:00 AM	20.0	121.4	1002	55	Tropical Depression
06 September 8:00 AM	20.1	120.4	1000	60	Tropical Depression
06 September 2:00 PM	20.7	120.0	998	65	Tropical Storm
06 September 8:00 PM	21.7	120.0	998	65	Tropical Storm

Table 5.12. Details of the warning best track of TY LANNIE.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
11 September 2:00 PM	18.7	134.9	973	120	Typhoon
11 September 8:00 PM	19.2	133.7	973	120	Typhoon
12 September 2:00 AM	19.7	132.6	973	120	Typhoon
12 September 8:00 AM	21.0	130.9	973	120	Typhoon
12 September 2:00 PM	22.0	128.9	969	125	Typhoon
12 September 8:00 PM	22.6	128.1	969	125	Typhoon
13 September 2:00 AM	23.5	126.8	969	125	Typhoon
13 September 8:00 AM	24.3	126.4	965	130	Typhoon
13 September 2:00 PM	24.9	125.8	965	130	Typhoon

Table 5.13. Details of the warning best track of TS MARING.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
11 September 2:00 PM	14.7	124.4	1004	45	Tropical Depression
11 September 8:00 PM	14.8	123.8	1004	45	Tropical Depression
12 September 2:00 AM	14.8	123.2	1002	55	Tropical Depression
12 September 8:00 AM	14.3	121.9	1000	60	Tropical Depression
12 September 2:00 PM	14.8	120.9	1000	60	Tropical Depression
12 September 8:00 PM	14.9	119.0	995	75	Tropical Storm
13 September 2:00 AM	14.9	117.9	995	75	Tropical Storm
13 September 8:00 AM	14.7	116.7	990	85	Tropical Storm
13 September 2:00 PM	15.3	115.8	990	85	Tropical Storm

Table 5.14. Details of the warning best track of TD NANDO.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
23 September 2:00 PM	16.7	118.2	1004	45	Tropical Depression
23 September 8:00 PM	16.9	116.7	1004	45	Tropical Depression

Table 5.15. Details of the warning best track of STS ODETTE

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
11 October 8:00 PM	16.8	131.0	1004	45	Tropical Depression
12 October 2:00 AM	17.4	129.1	1002	55	Tropical Depression
12 October 8:00 AM	17.9	127.6	1002	55	Tropical Depression
12 October 2:00 PM	18.1	124.9	1002	55	Tropical Depression
12 October 8:00 PM	18.4	123.3	998	65	Tropical Storm
13 October 2:00 AM	18.3	121.9	995	75	Tropical Storm
13 October 8:00 AM	17.7	120.7	995	75	Tropical Storm
13 October 2:00 PM	17.5	119.1	987	90	Severe Tropical Storm
13 October 8:00 PM	17.5	118.0	987	90	Severe Tropical Storm
14 October 2:00 AM	16.9	118.0	987	90	Severe Tropical Storm
14 October 8:00 AM	16.7	117.8	987	90	Severe Tropical Storm
14 October 2:00 PM	17.9	117.8	981	105	Severe Tropical Storm
14 October 8:00 PM	18.7	117.5	977	110	Severe Tropical Storm

Table 5.16. Details of the warning best track of TY PAOLO.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
16 October 8:00 AM	10.1	135.3	998	65	Tropical Storm
16 October 2:00 PM	10.9	135.3	993	80	Tropical Storm
16 October 8:00 PM	11.1	134.7	993	80	Tropical Storm
17 October 2:00 AM	11.0	133.9	990	85	Tropical Storm
17 October 8:00 AM	11.0	132.8	987	90	Severe Tropical Storm
17 October 2:00 PM	10.7	131.8	987	90	Severe Tropical Storm
17 October 8:00 PM	10.5	131.9	981	105	Severe Tropical Storm
18 October 2:00 AM	10.6	132.6	973	120	Typhoon
18 October 8:00 AM	11.3	132.7	973	120	Typhoon
18 October 2:00 PM	12.9	132.3	973	120	Typhoon
18 October 8:00 PM	13.9	131.2	973	120	Typhoon
19 October 2:00 AM	14.6	131.3	973	120	Typhoon

19 October 8:00 AM	15.5	130.8	973	120	Typhoon
19 October 2:00 PM	16.1	130.2	965	130	Typhoon
19 October 8:00 PM	16.9	130.0	965	130	Typhoon
20 October 2:00 AM	17.7	129.9	965	130	Typhoon
20 October 8:00 AM	18.7	130.0	965	130	Typhoon
20 October 2:00 PM	19.7	130.0	957	145	Typhoon
20 October 8:00 PM	20.1	130.3	957	145	Typhoon
21 October 2:00 AM	20.7	130.7	947	160	Typhoon
21 October 8:00 AM	21.3	131.3	931	180	Typhoon
21 October 2:00 PM	22.3	132.0	926	185	Typhoon
21 October 8:00 PM	23.8	132.5	926	185	Typhoon
22 October 2:00 AM	25.5	133.3	926	185	Typhoon

Table 5.17. Details of the warning best track of STS QUEDAN

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
25 October 8:00 AM	14.2	135.6	993	80	Tropical Storm
25 October 2:00 PM	14.6	135.2	993	80	Tropical Storm
25 October 8:00 PM	15.8	134.9	993	80	Tropical Storm
26 October 2:00 AM	17.2	134.1	993	80	Tropical Storm
26 October 8:00 AM	17.6	132.5	987	90	Severe Tropical Storm
26 October 2:00 PM	18.2	132.1	987	90	Severe Tropical Storm
26 October 8:00 PM	19.5	131.2	987	90	Severe Tropical Storm
27 October 2:00 AM	20.2	130.7	987	90	Severe Tropical Storm
27 October 8:00 AM	21.4	129.8	987	90	Severe Tropical Storm
27 October 2:00 PM	22.5	128.9	987	90	Severe Tropical Storm
27 October 8:00 PM	23.7	128.3	987	90	Severe Tropical Storm
28 October 2:00 AM	24.1	127.9	984	100	Severe Tropical Storm
28 October 8:00 AM	25.5	128.2	981	105	Severe Tropical Storm

Table 5.18. Details of the warning best track of STS RAMIL.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
01 November 2:00 AM	11.6	122.3	1004	45	Tropical Depression
01 November 8:00 AM	11.8	121.0	1004	45	Tropical Depression
01 November 2:00 PM	11.6	122.4	1002	55	Tropical Depression
01 November 8:00 PM	12.0	119.2	1002	55	Tropical Depression
02 November 2:00 AM	12.2	118.4	1002	55	Tropical Depression
02 November 8:00 AM	12.3	117.4	998	65	Tropical Storm
02 November 2:00 PM	12.9	116.6	993	80	Tropical Storm
02 November 8:00 PM	13.0	115.5	993	80	Tropical Storm
03 November 2:00 AM	13.1	114.6	987	90	Severe Tropical Storm

Table 5.19. Details of the warning best track of TS SALOME.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
09 November 5:00 AM	12.4	125.0	1002	45	Tropical Depression
09 November 8:00 AM	12.5	124.2	1002	55	Tropical Depression
09 November 2:00 PM	13.1	123.0	1002	55	Tropical Depression
09 November 8:00 PM	13.7	121.4	998	65	Tropical Storm
10 November 2:00 AM	14.4	120.2	998	65	Tropical Storm
10 November 8:00 AM	14.9	119.1	998	65	Tropical Storm
10 November 2:00 PM	15.9	118.4	995	75	Tropical Storm
10 November 8:00 PM	16.5	117.5	995	75	Tropical Storm
11 November 2:00 AM	17.4	116.9	995	75	Tropical Storm

Table 5.20. Details of the warning best track of TS TINO.

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
17 November 8:00 AM	8.8	120.5	1002	55	Tropical Depression
17 November 2:00 PM	9.4	119.5	1002	55	Tropical Depression
17 November 8:00 PM	10.0	118.0	1002	55	Tropical Depression
18 November 2:00 AM	10.5	116.4	1002	55	Tropical Depression
18 November 8:00 AM	11.1	114.9	998	65	Tropical Storm

Table 5.21. Details of the warning best track of TS URDUJA

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
12 December 2:00 PM	9.2	130.6	1002	55	Tropical Depression
12 December 8:00 PM	9.4	130.1	1002	55	Tropical Depression
13 December 2:00 AM	9.6	129.7	1002	55	Tropical Depression
13 December 8:00 AM	10.3	129.5	1002	55	Tropical Depression
13 December 2:00 PM	11.0	129.5	1002	55	Tropical Depression
13 December 8:00 PM	11.3	128.5	1002	55	Tropical Depression
14 December 2:00 AM	11.2	127.7	1002	55	Tropical Depression
14 December 8:00 AM	11.0	126.9	1000	60	Tropical Depression
14 December 2:00 PM	10.8	126.5	998	65	Tropical Storm
14 December 8:00 PM	11.0	127.0	998	65	Tropical Storm
15 December 2:00 AM	11.4	127.3	995	75	Tropical Storm
15 December 8:00 AM	11.7	127.5	995	75	Tropical Storm
15 December 2:00 PM	11.7	127.6	995	75	Tropical Storm
15 December 8:00 PM	11.7	127.7	995	75	Tropical Storm
16 December 2:00 AM	11.9	127.3	993	80	Tropical Storm
16 December 8:00 AM	12.2	126.2	993	80	Tropical Storm
16 December 2:00 PM	12.2	125.2	995	75	Tropical Storm
16 December 8:00 PM	12.1	125.0	998	65	Tropical Storm
17 December 2:00 AM	12.2	124.9	998	65	Tropical Storm
17 December 8:00 AM	12.4	124.0	1002	55	Tropical Depression

17 December 2:00 PM	12.2	122.6	1002	55	Tropical Depression
17 December 8:00 PM	11.6	121.7	1002	55	Tropical Depression
18 December 2:00 AM	10.8	120.5	1002	55	Tropical Depression
18 December 8:00 AM	10.6	118.6	1004	45	Tropical Depression
18 December 2:00 PM	10.6	118.3	1004	45	Tropical Depression
18 December 8:00 PM	10.6	117.9	1004	45	Tropical Depression
19 December 2:00 AM	10.2	116.8	1004	45	Tropical Depression
19 December 8:00 AM	10.5	115.5	1004	45	Tropical Depression

Table 5.22. Details of the warning best track of TY VINTA

Date and Time (PhST)	Latitude (°N)	Longitude (°E)	Central Pressure (hPa)	Maximum Winds (km/h)	Category
20 December 2:00 PM	8.3	134.0	1004	45	Tropical Depression
20 December 8:00 PM	8.7	132.2	1002	55	Tropical Depression
21 December 2:00 AM	9.0	131.1	998	65	Tropical Storm
21 December 8:00 AM	8.6	130.0	998	65	Tropical Storm
21 December 2:00 PM	8.2	128.3	993	80	Tropical Storm
21 December 8:00 PM	8.3	127.3	987	90	Severe Tropical Storm
22 December 2:00 AM	7.9	126.6	987	90	Severe Tropical Storm
22 December 8:00 AM	7.8	125.6	993	80	Tropical Storm
22 December 2:00 PM	8.0	124.1	1000	60	Tropical Depression
22 December 8:00 PM	7.9	122.5	1000	60	Tropical Depression
23 December 2:00 AM	8.0	121.3	995	75	Tropical Storm
23 December 8:00 AM	7.8	120.4	993	80	Tropical Storm
23 December 2:00 PM	7.6	119.0	987	90	Severe Tropical Storm
23 December 8:00 PM	7.7	117.5	981	105	Severe Tropical Storm
24 December 2:00 AM	8.0	115.8	973	120	Typhoon
24 December 8:00 AM	8.5	114.9	973	120	Typhoon

REFERENCES

REFERENCES

Cayanan, E. O., T.-C. Chen, J. C. Argete, M.-C. Yen, and P. D. Nilo, 2011: The Effect of Tropical Cyclones on Southwest Monsoon Rainfall in the Philippines. *J. Meteorol. Soc. Japan*, **89A**, 123–139, doi:10.2151/jmsj.2011-A08.

Chen, T.-C., M.-C. Yen, J.-D. Tsay, N. T. Tan Thanh, and J. Alpert, 2012: Synoptic Development of the Hanoi Heavy Rainfall Event of 30–31 October 2008: Multiple-Scale Processes. *Mon. Weather Rev.*, **140**, 1219–1240, doi:10.1175/MWR-D-11-00111.1. http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-11-00111.1.

Cinco, T. A., and Coauthors, 2016: Observed trends and impacts of tropical cyclones in the Philippines. *Int. J. Climatol.*, **36**, 4638–4650, doi:10.1002/joc.4659.

Corporal-Lodangco, I. L., L. M. Leslie, and P. J. Lamb, 2016: Impacts of ENSO on Philippine Tropical Cyclone Activity. *J. Clim.*, **29**, 1877–1897, doi:10.1175/JCLI-D-14-00723.1. http://journals.ametsoc.org/doi/10.1175/JCLI-D-14-00723.1.

Harada, Y., and Coauthors, 2016: The JRA-55 Reanalysis: Representation of Atmospheric Circulation and Climate Variability. *J. Meteorol. Soc. Japan. Ser. II*, **94**, 269–302, doi:10.2151/jmsj.2016-015. https://www.jstage.jst.go.jp/article/jmsj/94/3/94_2016-015/_article.

Kobayashi, S., and Coauthors, 2015: The JRA-55 Reanalysis: General Specifications and Basic Characteristics. *J. Meteorol. Soc. Japan. Ser. II*, **93**, 5–48, doi:10.2151/jmsj.2015-001. https://www.jstage.jst.go.jp/article/jmsj/93/1/93_2015-001/_article.

Lagmay, A. M. F., G. Bagtasa, I. A. Crisologo, B. A. B. Racoma, and C. P. C. David, 2015: Volcanoes magnify Metro Manila’s southwest monsoon rains and lethal floods. *Front. Earth Sci.*, **2**, doi:10.3389/feart.2014.00036. http://journal.frontiersin.org/article/10.3389/feart.2014.00036/abstract.

Lander, M. A., 1996: Specific Tropical Cyclone Track Types and Unusual Tropical Cyclone Motions Associated with a Reverse-Oriented Monsoon Trough in the Western North Pacific. *Weather Forecast.*, doi:10.1175/1520-0434(1996)011<0170:STCTTA>2.0.CO;2.

Lui, W. H., T. C. Lee, and C. M. Shun, 2018: *Hong Kong Observatory Technical Note No. 109: Evolution of the Tropical Cyclone Warning Systems in Hong Kong since 1884*. 94 pp. http://www.hko.gov.hk/publica/tn/tn109.pdf.

Manila Observatory, 2014: History. http://www.observatory.ph/about/ (Accessed February 18, 2019).

Minamide, M., and K. Yoshimura, 2014: Orographic Effect on the Precipitation with Typhoon Washi in the Mindanao Island of the Philippines. *SOLA*, **10**, 67–71, doi:10.2151/sola.2014-014. http://jlc.jst.go.jp/DN/JST.JSTAGE/sola/2014-014?lang=en&from=CrossRef&type=abstract.

Montalvan, A. J., 2013: El Observatorio de Manila and the Specious Filipino Amnesia for Typhoons. *Kinaadman*, **35**, 42–65. http://www.xu.edu.ph/kinaadmanjournal-archives/101-kinaadmanjournal-archives/3071-volume-35.

Ogino, S.-Y., P. Wu, M. Hattori, N. Endo, H. Kubota, T. Inoue, and J. Matsumoto, 2018: Cold surge event observed by radiosonde observation from the research vessel “Hakuho-maru” over the Philippine Sea in December 2012. *Prog. Earth Planet. Sci.*, **5**, 9, doi:10.1186/s40645-017-0163-4. https://progearthplanetsci.springeropen.com/articles/10.1186/s40645-017-0163-4.

Racoma, B. A. B., C. P. C. David, I. A. Crisologo, and G. Bagtasa, 2016: The change in rainfall from tropical cyclones due to orographic effect of the Sierra Madre Mountain Range in Luzon, Philippines. *Philipp. J. Sci.*,.

Wang, B., and X. Zhou, 2008: Climate variation and prediction of rapid intensification in tropical cyclones in the western North Pacific. *Meteorol. Atmos. Phys.*, **99**, 1–16, doi:10.1007/s00703-006-0238-z. http://link.springer.com/10.1007/s00703-006-0238-z.

Yokoi, S., and J. Matsumoto, 2008: Collaborative Effects of Cold Surge and Tropical Depression–Type Disturbance on Heavy Rainfall in Central Vietnam. *Mon. Weather Rev.*, **136**, 3275–3287, doi:10.1175/2008MWR2456.1. http://journals.ametsoc.org/doi/abs/10.1175/2008MWR2456.1.