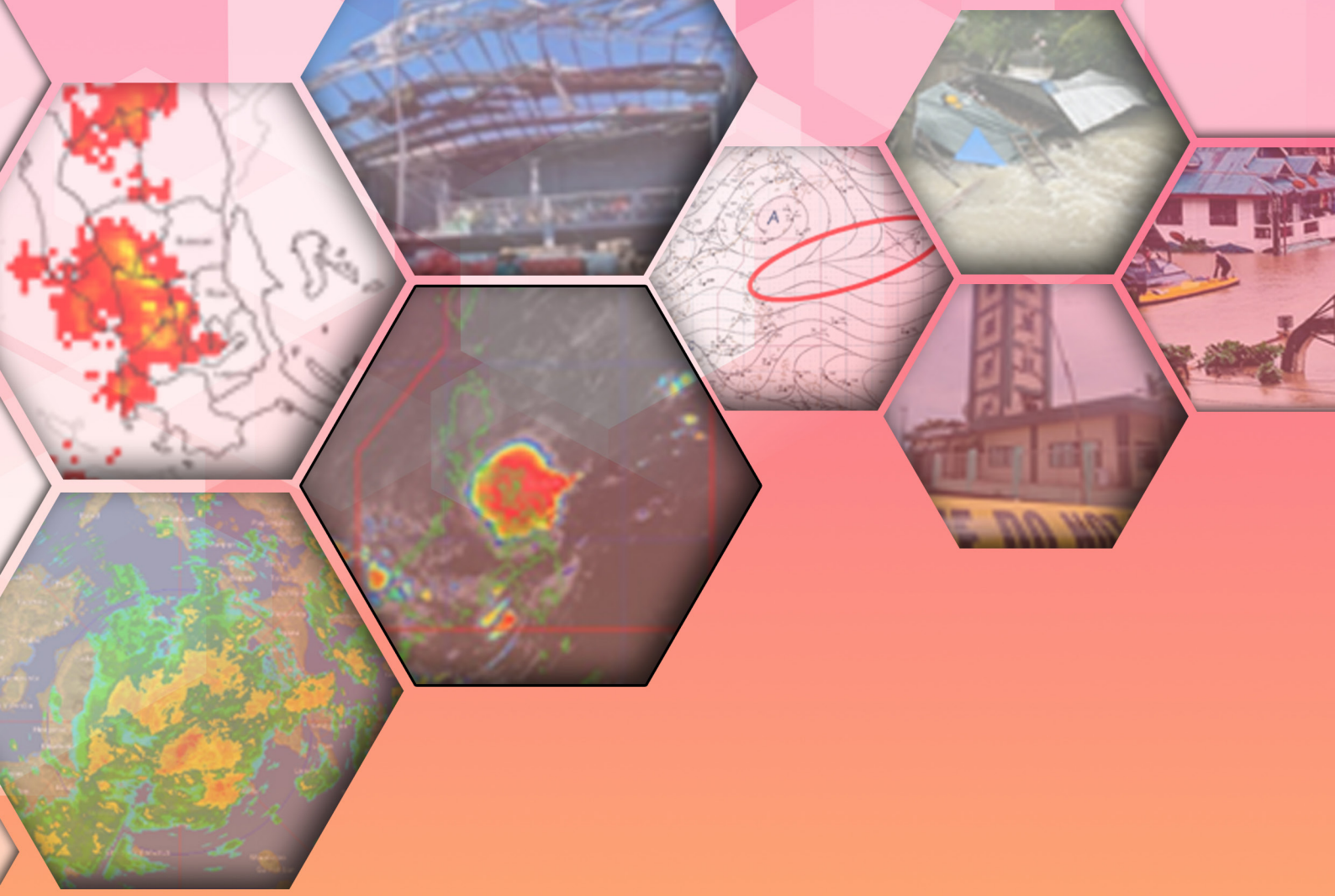

2023 ANNUAL CLIMATE BULLETIN

PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND ASTRONOMICAL SERVICES ADMINISTRATION
CLIMATOLOGY AND AGROMETEOROLOGY DIVISION
CLIMATE AND AGROMETEOROLOGICAL DATA SECTION

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ISSN: 3027-9577

PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND ASTRONOMICAL SERVICES ADMINISTRATION

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Language:
English

Published by:
Philippine Atmospheric, Geophysical and Astronomical Services Administration

PRINTED IN THE REPUBLIC OF THE PHILIPPINES
http://dx.doi.org/10.13140/RG.2.2.27167.57768

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HIGHLIGHTS

The triple-dip ***La Niña event*** that began in ***2020*** ended in ***early 2023***.

The El Niño conditions in April - June 2023 eventually reached an ***El Niño episode in August - October 2023***.

Despite the cooling effect of the La Niña in early 2023, ***global near-surface temperature reached its warmest year on record***.

The last ten years (2014-2023) were the ***warmest years on record***.

In the Philippines, the annual mean temperature in ***2023*** was above average making it the ***2nd warmest year*** since 1991.

The October-December 2023 reached its warmest record (***3.11 °C***) since 1991.

The frequency of tropical cyclones in the country was below to average while their intensity is above average;

The strongest TCs in 2023 are Super Typhoons ***(STY) Betty (Mawar) and Goring (Saola)*** - both with maximum sustained winds of ***195 kph.***

The ***onset and termination*** dates of the Southwest Monsoon and Northeast Monsoon are considered ***normal***, respectively.

The ***mean annual rainfall*** is ***slightly above average*** or near normal making it the ***14th wettest year since 1991***.

Several extremes were observed in rainfall and maximum temperature that broke as old as 70-year historical records.

There is ***no broken record*** for ***monthly minimum temperature*** in all PAGASA stations in 2023.

MESSAGE

The publication of the 2023 Annual Climate Bulletin provides a summary of the notable climate events and extreme records in the Philippines. I am pleased to inform you that this edition includes the insights of our personnel from different DOST-PAGASA Regional Services Divisions (PRSDs) and technical divisions on notable extreme events in 2023 that occurred in their respective areas including information on meteorological history, climatology, associated cost of damages, and course of actions taken by various concerned stakeholders.

The year 2023 is marked by the end of the La Niña that has persisted since 2020 but it is also interestingly highlighted by the commencement of an ongoing El Niño. Despite the cooling influence from the La Niña in early 2023, the year 2023 became the second warmest year on record in the country since 1991. Such a warming is also accompanied by near normal rainfall – the 14th wettest year since 1991. The frequency of tropical cyclones in the Philippine Area of Responsibility was one of the lowest on record while their intensity was above average.

I would like to take this opportunity to thank the production team behind this publication, particularly the contributors from various PRSDs and technical divisions, and the Climate and Agrometeorological Data Section - Climatology and Agrometeorology Division, for leading the efforts and authorship of this timely report. Lastly, I hope that everyone will enjoy reading the 2023 Annual Climate Bulletin.

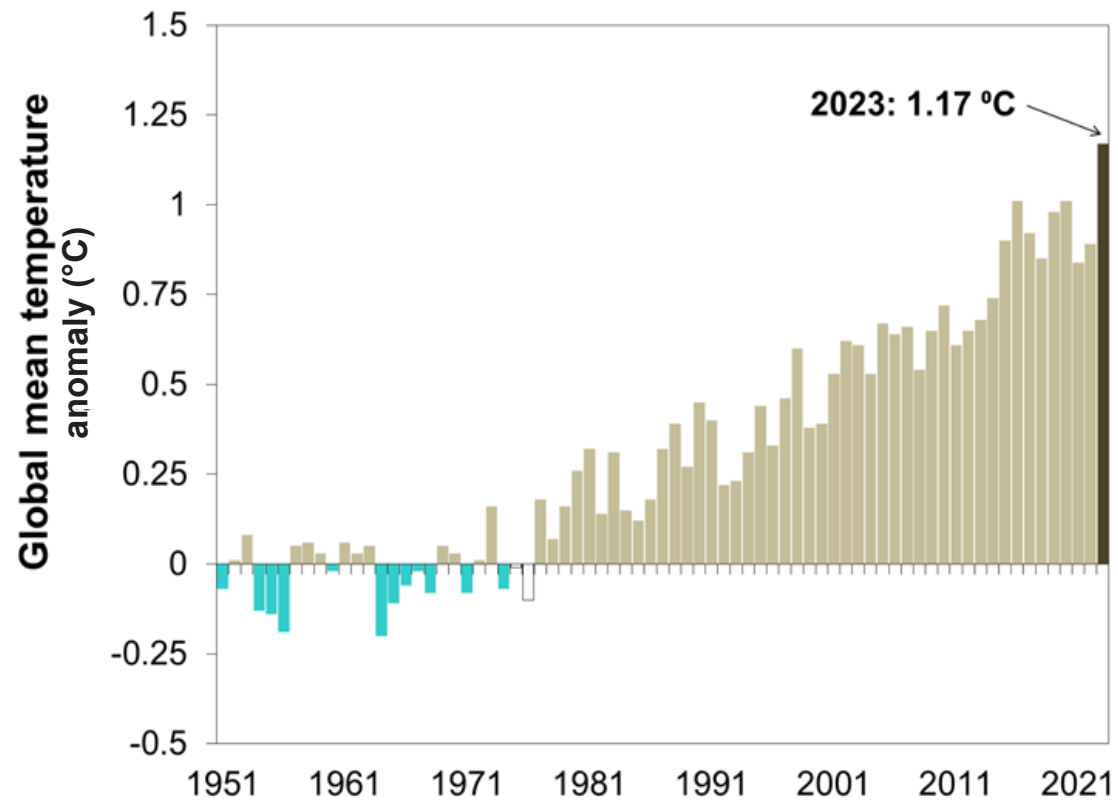
NATHANIEL T. SERVANDO, Ph.D.
Administrator

CHAPTER 1: GENERAL CLIMATE CONTEXT

The global mean annual near-surface temperature anomaly reached its **warmest year on record in 2023 at 1.17 °C warmer than the 1951-1980 base period** (NASA 2024). Various temperature dataset has also observed the same record-breaking global mean annual near-surface temperature anomaly in 2023 suggesting a robust warming detected in the same year (WMO 2023). Moreover, the observed temperature from **2014-2023 are the ten warmest years on record** across different datasets (NASA 2023), which makes the last ten years the warmest decade on record.

Record-warmest global monthly temperature anomalies in 2023 were observed from June to December, respectively. **The year 2023 has also observed the warmest seasonal temperature anomaly in July-September (JAS, 1.28 °C), and October-December (OND, 1.37 °C) since 1951, respectively (NASA 2023).** It is noteworthy that such a warm temperature record in 2022 was observed despite the cooling effect of the La Niña, which ended in early 2023.

Meanwhile, the annual ocean heat content in 2023 was the highest on record since 1958 (NOAA 2024) while the Antarctic sea ice extent was also the lowest on record (NOAA 2024). However, there remains a limited observation over the open ocean, which necessitates revisiting these records over time. Atmospheric carbon dioxide and other greenhouse gases also increased in 2023 (Copernicus 2024).



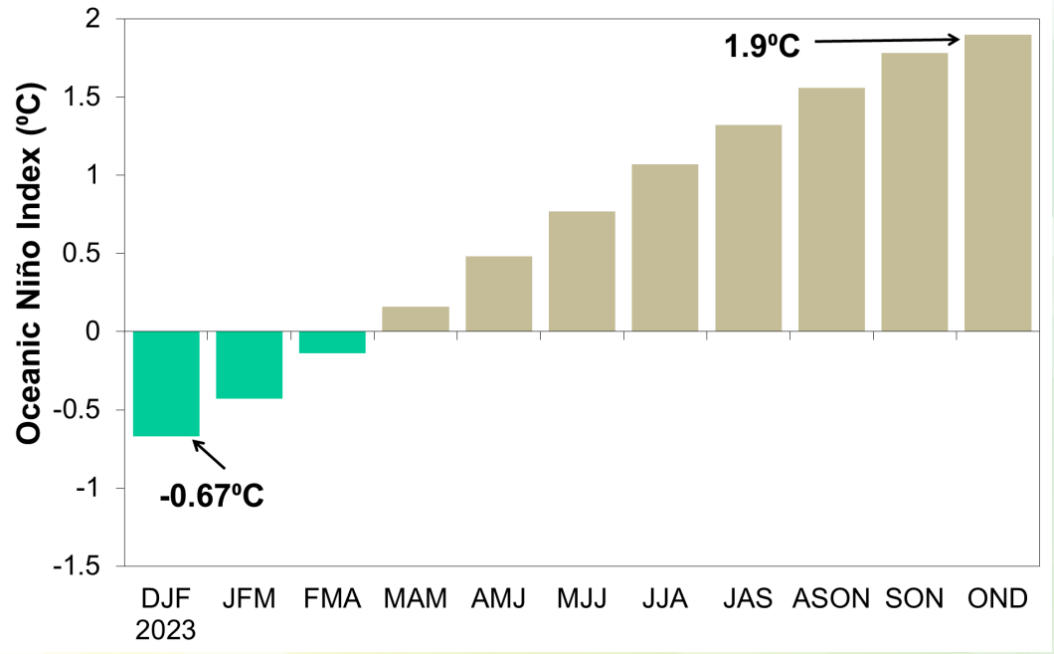
Global mean annual temperature anomaly from 1951-2023

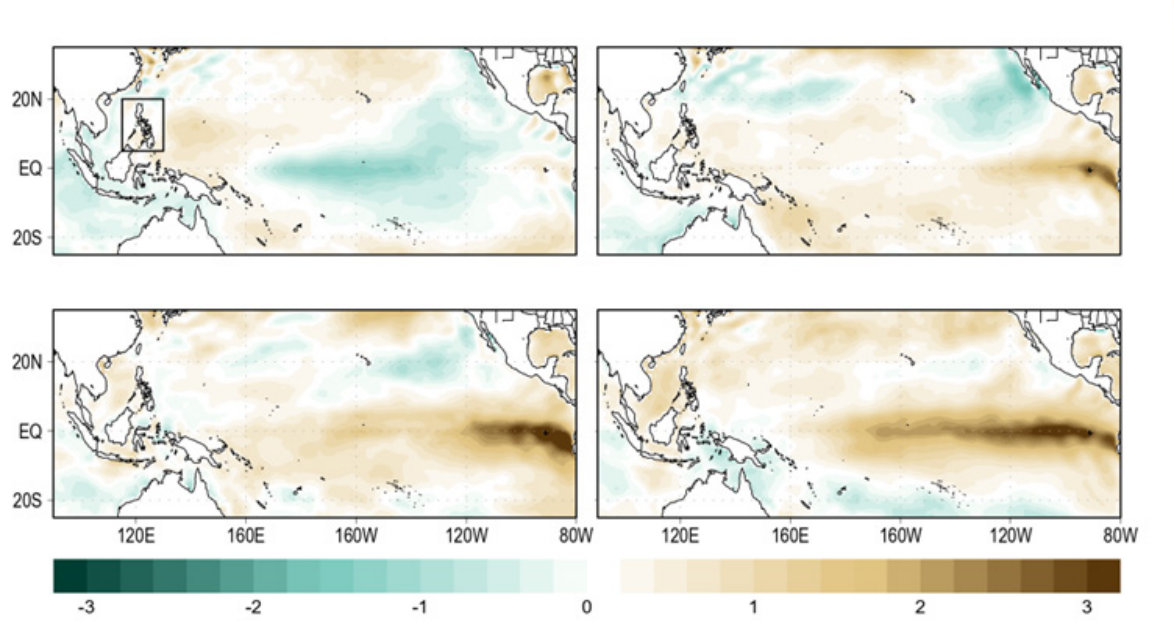
MAJOR CLIMATE DRIVERS

The climate variability of the Philippines is influenced by its geography and topography (Basconcillo et al. 2022). Due to its location in the tropical Pacific, the Philippine climate is characterized by a humid maritime environment, which, in turn, is influenced by various climate drivers across different temporal scales (e.g. interannual, subseasonal) including the El Niño Southern Oscillation (ENSO) and the Madden-Julian Oscillation (MJO). The ENSO, through the Walker Circulation largely regulates the interannual variability of wind, cloudiness and rainfall, air pressure pattern, and marine environment in the Philippines. Meanwhile, the MJO influences the intraseasonal climate variability in the Philippines (Phases 4-6) parallel to the propagation of its active and inactive phases, respectively, where an active phase generally refers to increased chances in rainfall and convective activities over maritime continent and Western Pacific.

The triple-dip La Niña that began in 2020 ended in early 2023 (CPC 2024). After a brief neutral condition, the El Niño Southern Oscillation transitioned to El Niño condition in April-May-June (AMJ) then eventually reached an El Niño episode in August-October (ASO) 2023. Based on the Oceanic Niño Index (ONI), the coolest SST anomaly was -0.67 °C observed in DJF 2022-2023 (which was within La Niña threshold) while the warmest SST anomaly was 1.9 °C observed in October-November-December (OND) 2023.

Cold SST anomalies were prominent in early 2023 but evidence of SST warming was observed beginning in AMJ 2023 near the Pacific coast of South America. Atypical of the asymmetric SST anomaly patterns associated with the El Niño episode, warm SST anomalies were observed in the marginal seas of the Philippines across during the second semester of 2023 simultaneous with warm tongue of SST anomalies that were prominent in the tropical Pacific.

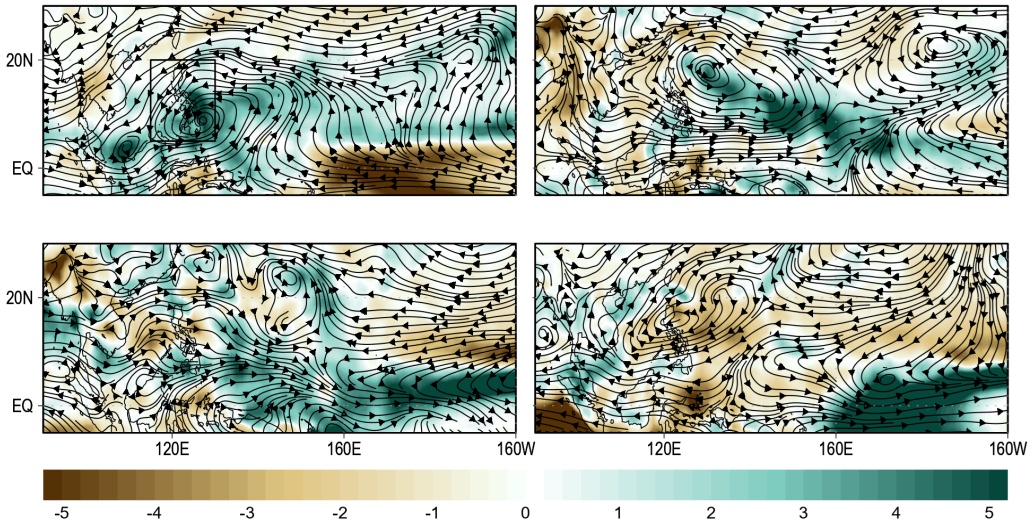




Seasonal sea surface temperature anomalies (clockwise) for 2023: January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively.

Above normal rainfall anomalies were observed over the Philippines and the maritime continent in JFM 2023 while generally below to near normal rainfall anomalies were experienced over the rest of Southeast Asia. Such rainfall anomalies coincided with an anomalous anticyclonic circulation over the Philippines and southern South China Sea. In AMJ 2023, most parts of Southeast Asia received below normal rainfall while above to near rainfall conditions were experienced in the Philippines, which can be attributed with an anomalous anticyclonic circulation observed in the northern Philippine Sea.

In JAS 2023, the southern half of the Philippines and Southeast Asia generally received near to above normal rainfall conditions while the remaining northern half experienced below to near normal rainfall conditions. Meanwhile, below normal rainfall anomalies were experienced in the open ocean to the east of the Philippines in July-August-September (JAS), which can be related to the anomalous anticyclonic circulation over the Philippines. A cyclonic circulation is related to enhanced convective activities (i.e. rainfall) while an anticyclonic circulation is related to suppressed convection. As expected in an El Niño condition, **anomalies westerlies over the tropical Pacific began to manifest in AMJ and persisted through the remaining months of 2023.**

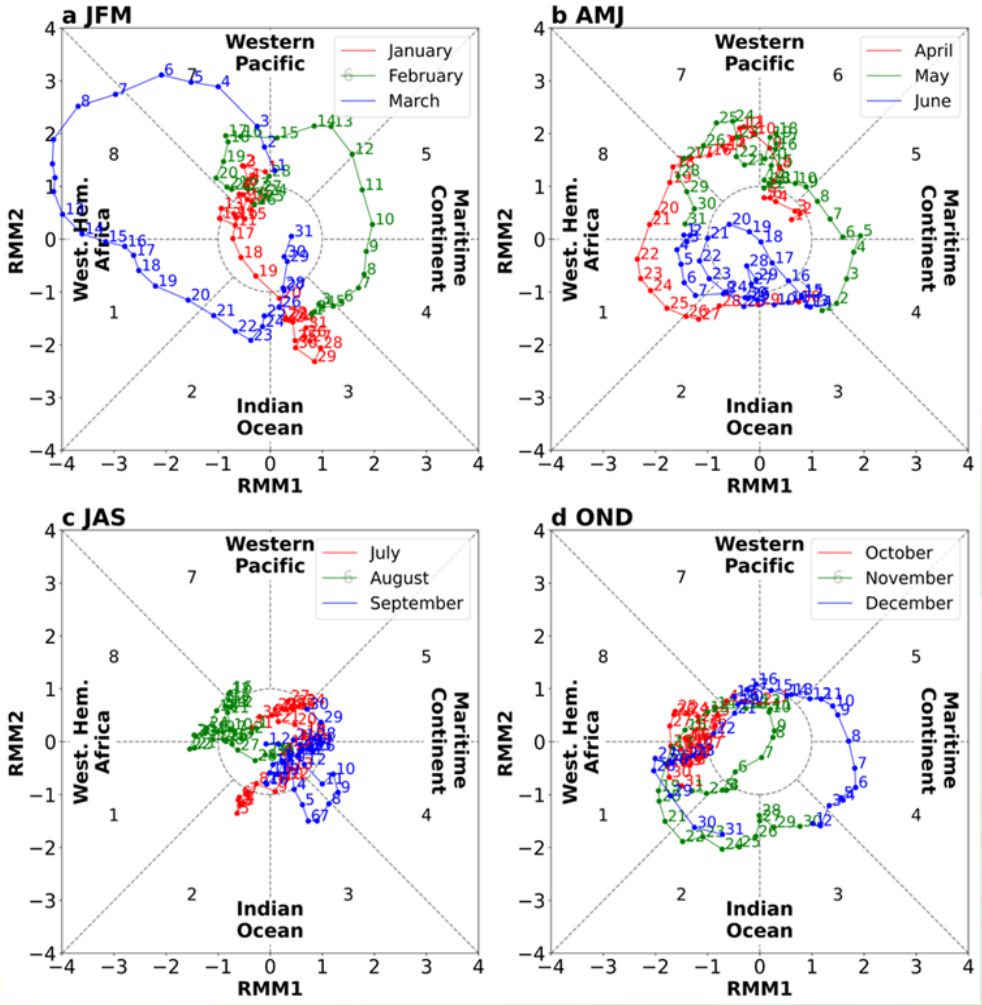


Seasonal streamline and rainfall anomalies (clockwise) for 2023:January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively.

During its active phase, the MJO is known to enhance the Philippine rainfall when it is found in Phases 4, 5, and 6 (i.e., convective centers are located in the Maritime Continent and Western Pacific. Conversely, when the convective centers of the MJO (Phases 8,1, and 2) are found in the Western Hemisphere and Africa and the Indian Ocean the Philippine rainfall becomes suppressed. Such an eastward-propagating intraseasonal system follows a 30- to 60-day cycle on the average making the MJO particularly useful in predicting the intraseasonal rainfall activity over the Philippines.

MJO was weak at the start of January. In February, the MJO center was located over the Maritime Continent, bringing favorable conditions for convection in the Philippines. The MJO continued its westward motion, reaching its peak magnitude at Western Hemisphere and Africa by March. **By April, the Maritime Continent experienced unfavorable conditions for convection due to MJO convective centers in the Western Pacific and Western Hemisphere and Africa.** The Philippines experienced enhanced convection in May for the MJO convective center at the Maritime Continent, and by June, weak MJO was observed. **Throughout the JAS season, the MJO was mostly weak or nonexistent.** At the start of the OND season, the MJO convective center is in the Western Hemisphere and Africa and the Indian Ocean. Later in December, enhanced convective activity was experienced in the Philippines due to the MJO convective center in the MC.

The other climate drivers and their influence on Philippine climate such as Indian Ocean Basin SST, the Western North Pacific Subtropical High, and IntertropicaL Convergence Zone are discussed in a separate knowledge material.



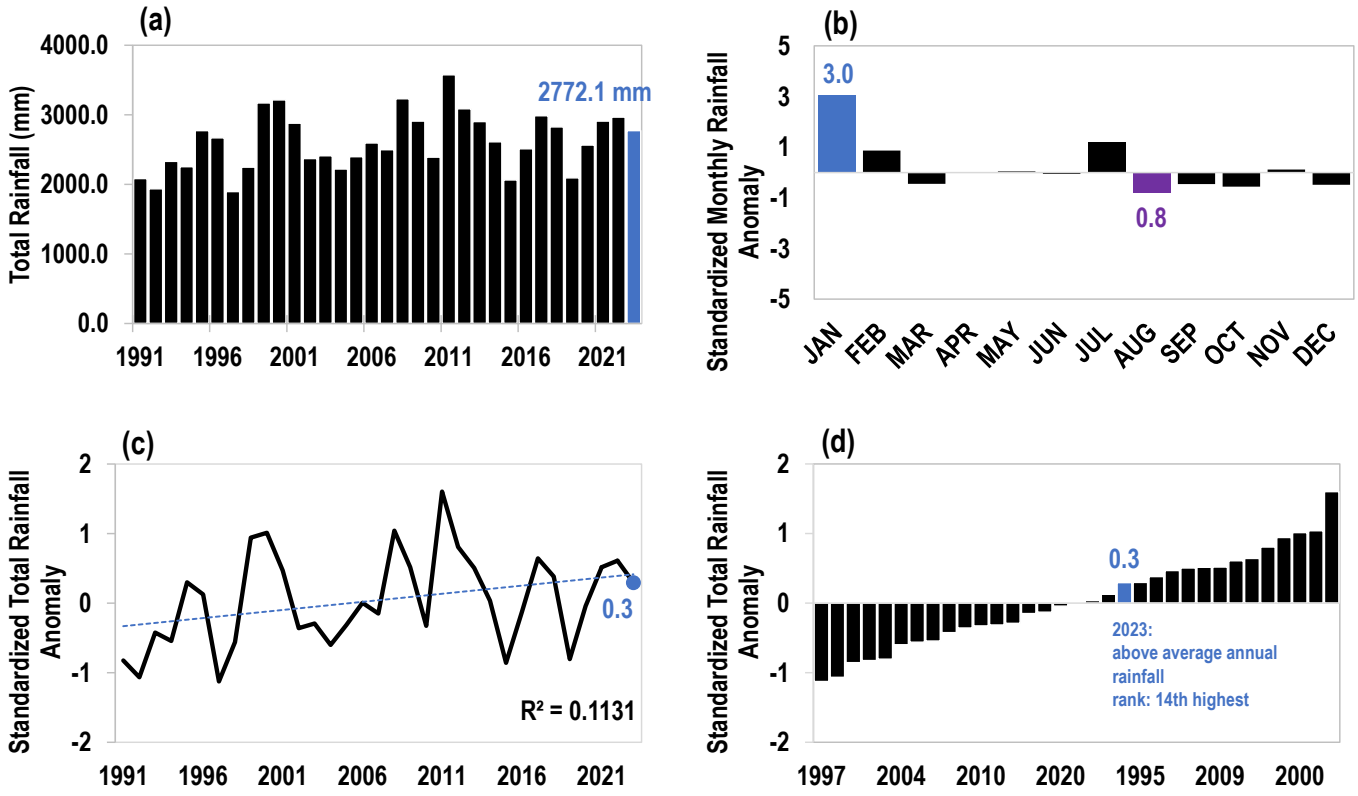
Phase-space diagram of the Real-time Multivariate MJO index (counter-clockwise) for 2023: January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively. Dots represent the daily MJO activity wherein dots inside the circle denote weak or no MJO. Colors indicate the corresponding months for each season.

CHAPTER 2:
RAINFALL

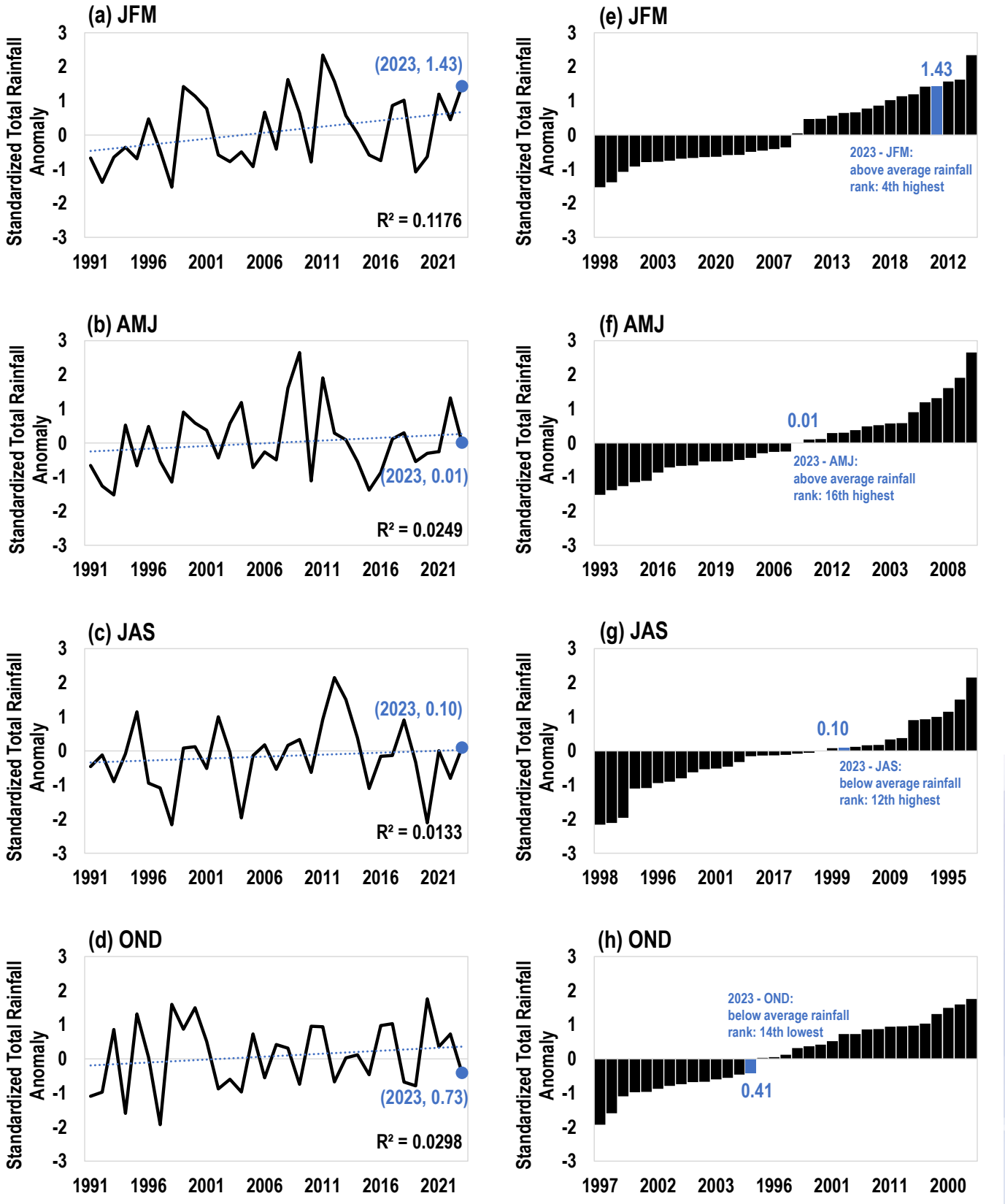
The nationwide rainfall was obtained by getting the average rainfall from more than 50 PAGASA Synoptic Stations, while the calculation of the standardized anomaly was similarly based on the 1991-2020 climatological standard normal.

In 2023, the Philippines recorded a **mean annual rainfall of 2,772.1 mm**, surpassing the 1991-2020 base period by **0.3 mm**. This places it as the **14th wettest year since 1991**. Notably, January in 2023 saw an above-average monthly rainfall of 3.0 mm, contributing to the **JFM season ranking as the 4th wettest since 1991**.

Slightly above average rainfall in the country was observed in JAS in 2023. Conversely, below-average rainfall was noted in OND in 2023. This pattern seems to correspond with the seasonal reversal of rainfall described by Lyon et al. (2006) during an El Niño event, wherein certain regions of the country may experience above average rainfall in JAS and below average rainfall in OND.



Timeseries of mean rainfall from 1991-2023 indicating (clockwise) the total annual rainfall, standardized monthly rainfall anomaly in 2023, standardized total annual rainfall anomaly, and ranked standardized total annual rainfall anomaly, respectively.

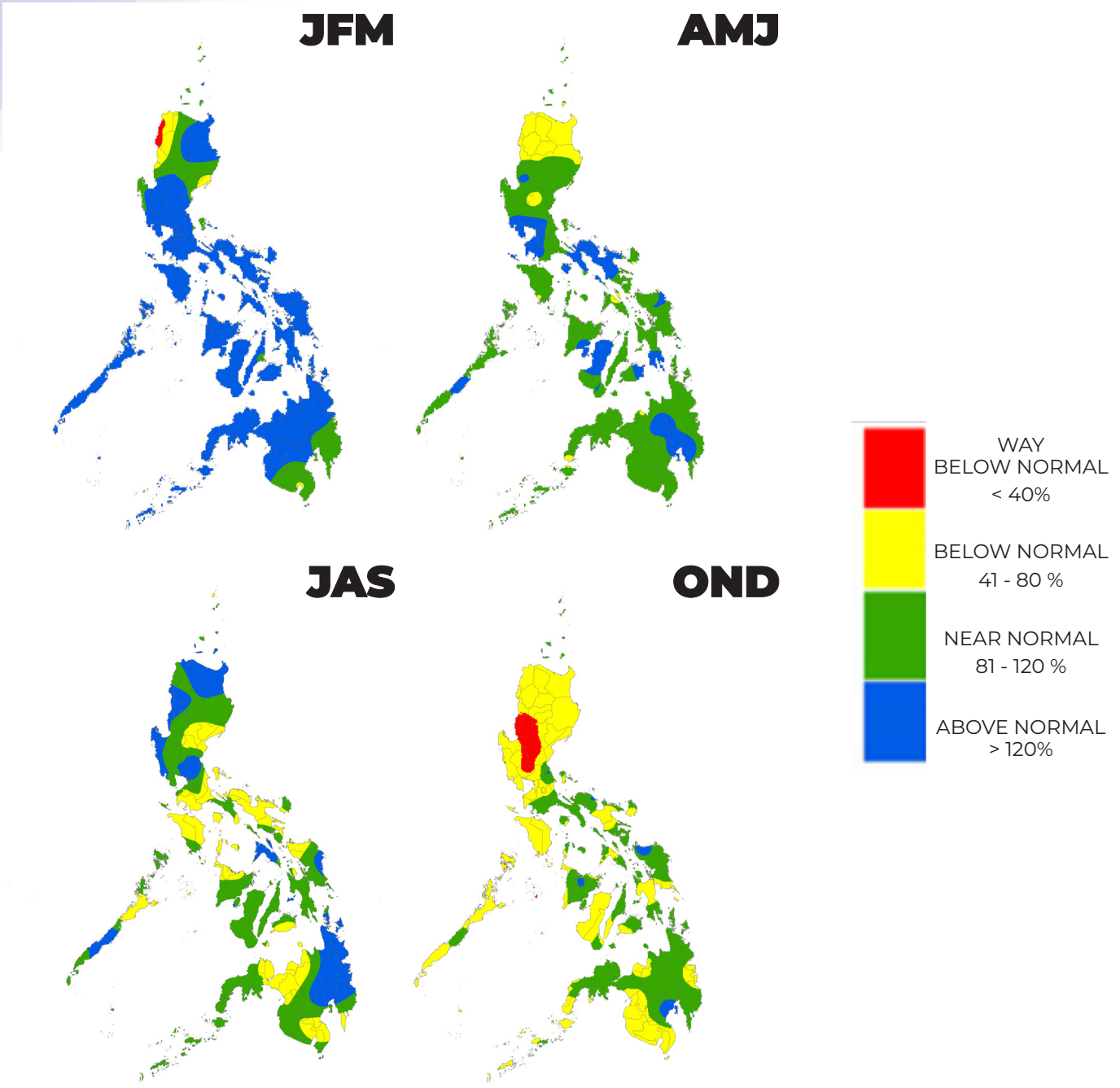


Timeseries of mean seasonal rainfall during January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively, expressed in standardized anomaly (left) and ranked standardized anomaly (right).

Above normal rainfall conditions were observed in most parts of the country, with patches of below normal to way below normal conditions over the Ilocos Region in the JFM season. In the AMJ season, generally near to above normal rainfall was observed across the country, except in northern Luzon, where below normal rainfall conditions were experienced.

Near to above normal rainfall conditions were still experienced in most parts of the country during the JAS season. However, portions of the country still experienced below normal rainfall conditions, such as in eastern parts of Central Luzon and parts of Southern Luzon, including Palawan and Cagayan de Oro.

Finally, in OND, way below to below normal rainfall conditions were observed in most of Luzon, and Visayas while near to above normal conditions were observed over eastern Visayas and Mindanao .



MONSOONS

The onset of the Southwest Monsoon (locally known as Habagat) was declared on 02 June 2023 after meeting the rainfall and wind pattern criteria used by PAGASA on the declaration of the rainy season in most stations along the western section of the country. In converse, the termination of the Southwest Monsoon was declared on 12 October 2023. Based on available records, both the onset and termination dates of the Southwest Monsoon are considered normal, respectively.

Meanwhile, the Northeast Monsoon (locally known as Amihan) typically begins in the latter part of the year and terminates in the following year. The termination of Northeast Monsoon 2022-2023 was declared on 21 March 2023 while the onset of the Northeast Monsoon 2022-2023 was announced on 20 October 2023. Based on available records, the termination and onset dates of the Northeast Monsoon in 2022-2023 and 2023-2024 are both normal, respectively.

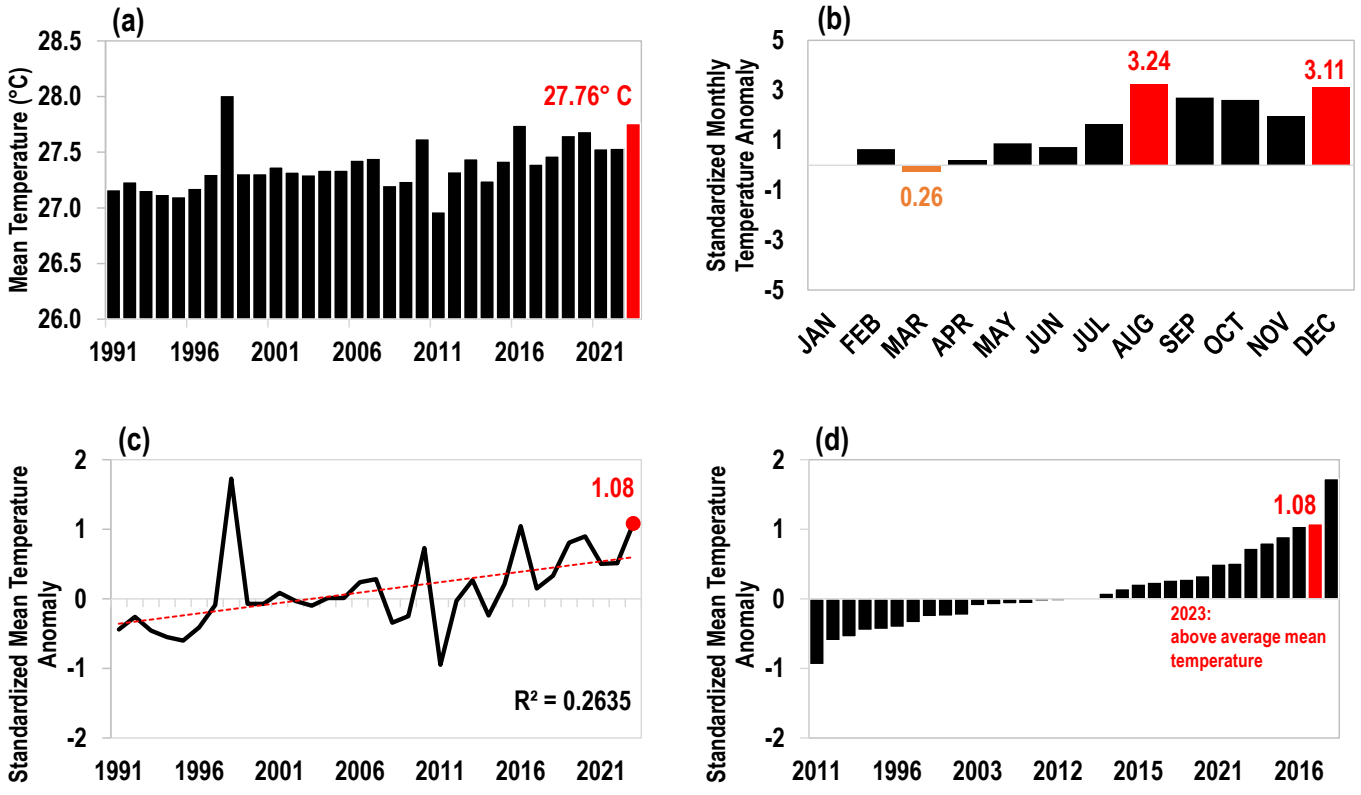
Monsoon system	Normal Onset*	Declared onset	Normal Termination*	Declared termination
Northeast Monsoon 2022-2023			3rd week of March to 1st week of April*	21 March 2023/ Normal
Southwest Monsoon 2023	2nd half of May to 1st half of June*	02 June 2023/ Normal	2nd to 3rd week of October*	12 October 2023/Normal
Northeast Monsoon 2023-2024	3rd week of October to 1st week of November*	20 October 2023/Normal		

**Based on latest available data*

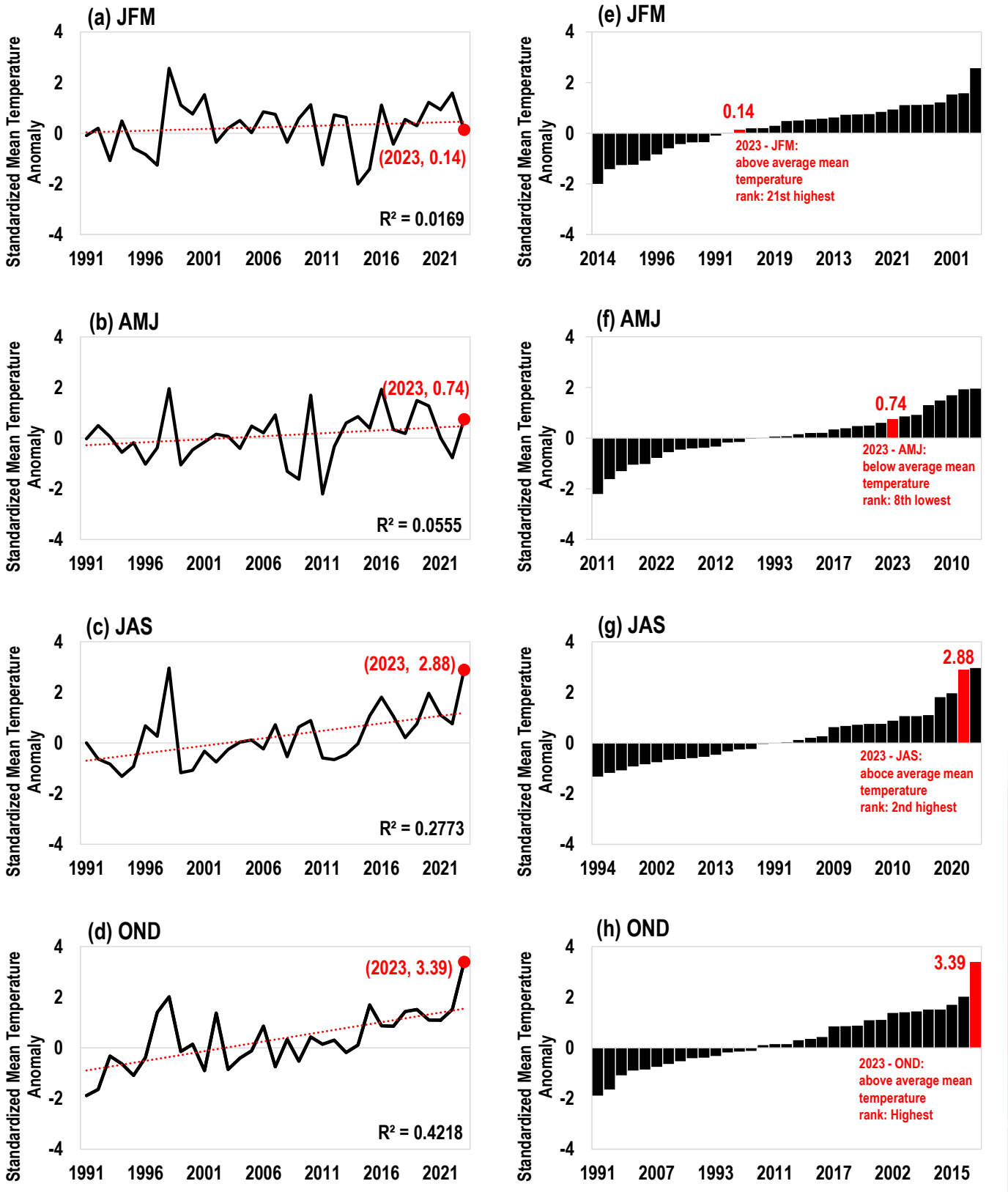
CHAPTER 3: TEMPERATURE

In 2023, the Philippines experienced a **mean annual temperature of 27.76°C,** marking an **increase of 1.08°C** compared to the 1991-2020 base period. This temperature anomaly places **the year 2023 as the second warmest year since 1991.** It is noteworthy that six out of the eight warmest years (1998, 2016, 2020, 2010, 2022, and 2021) coincided with La Niña episodes during the latter half of those years, while 2019 (the fifth warmest) experienced neutral conditions and 2023 observed an El Niño episode, respectively.

Throughout 2023, the country experienced consistently warmer monthly mean temperatures, which are particularly notable in the latter half of the year. The month of August, in particular, stood out, surpassing its monthly normal by 3.24 °C, ranking **the JAS in 2023 as the second warmest since 1991.** Additionally, the month of December recorded a deviation of 3.11 °C, marking **the OND in 2023 as the warmest since 1991,** surpassing the previous record set in 1998. All seasons, notably JAS and OND, experienced temperatures above average, a trend likely influenced by the presence of the El Niño event.



Timeseries of mean temperature from 1991-2023 indicating (clockwise) the mean annual temperature, standardized monthly temperature anomaly in 2023 standardized mean annual temperature anomaly, and ranked mean annual temperature standardized anomaly, respectively

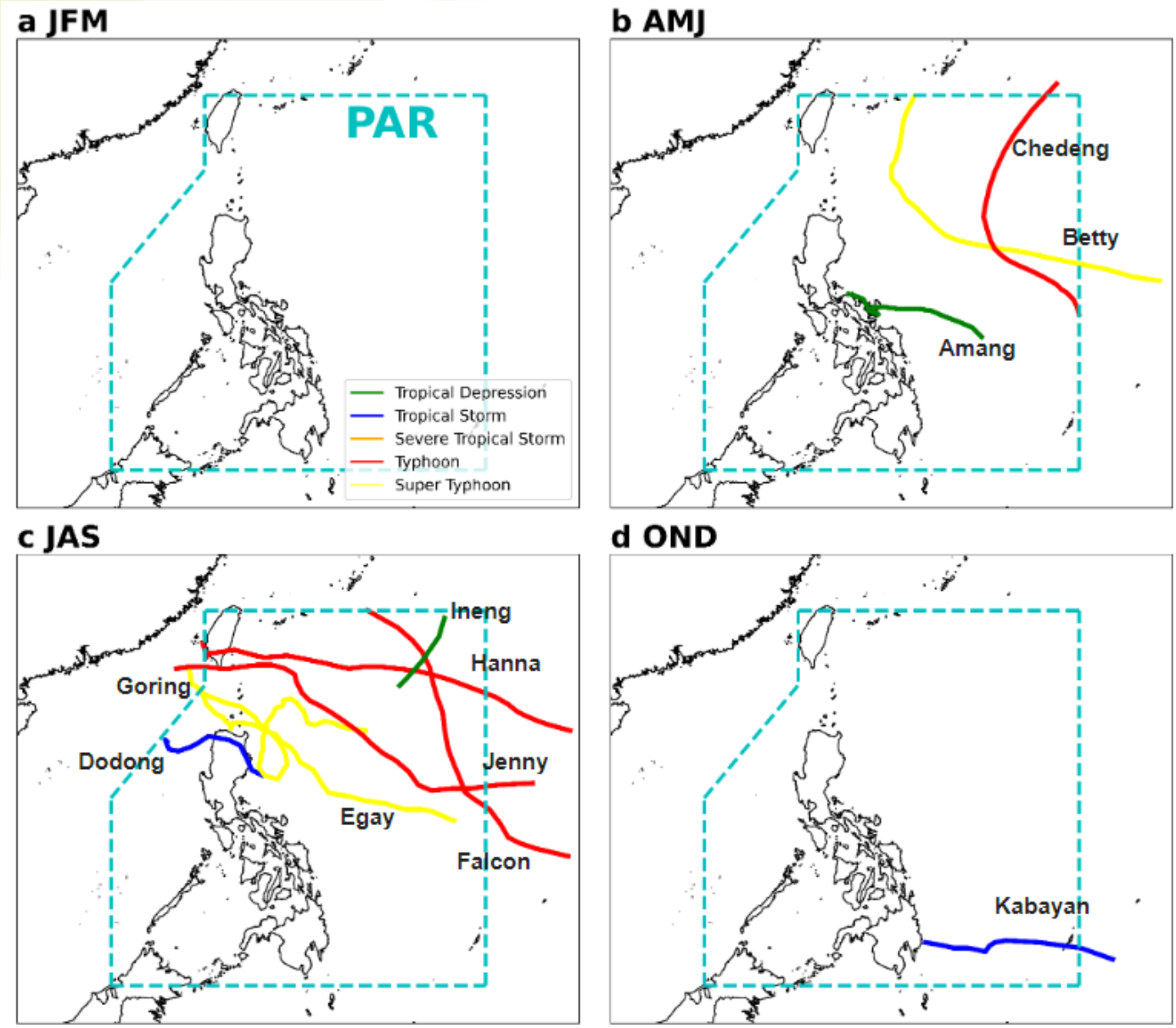


Timeseries of seasonal mean temperature during January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively, expressed in standardized anomaly (left) and ranked standardized anomaly (right).

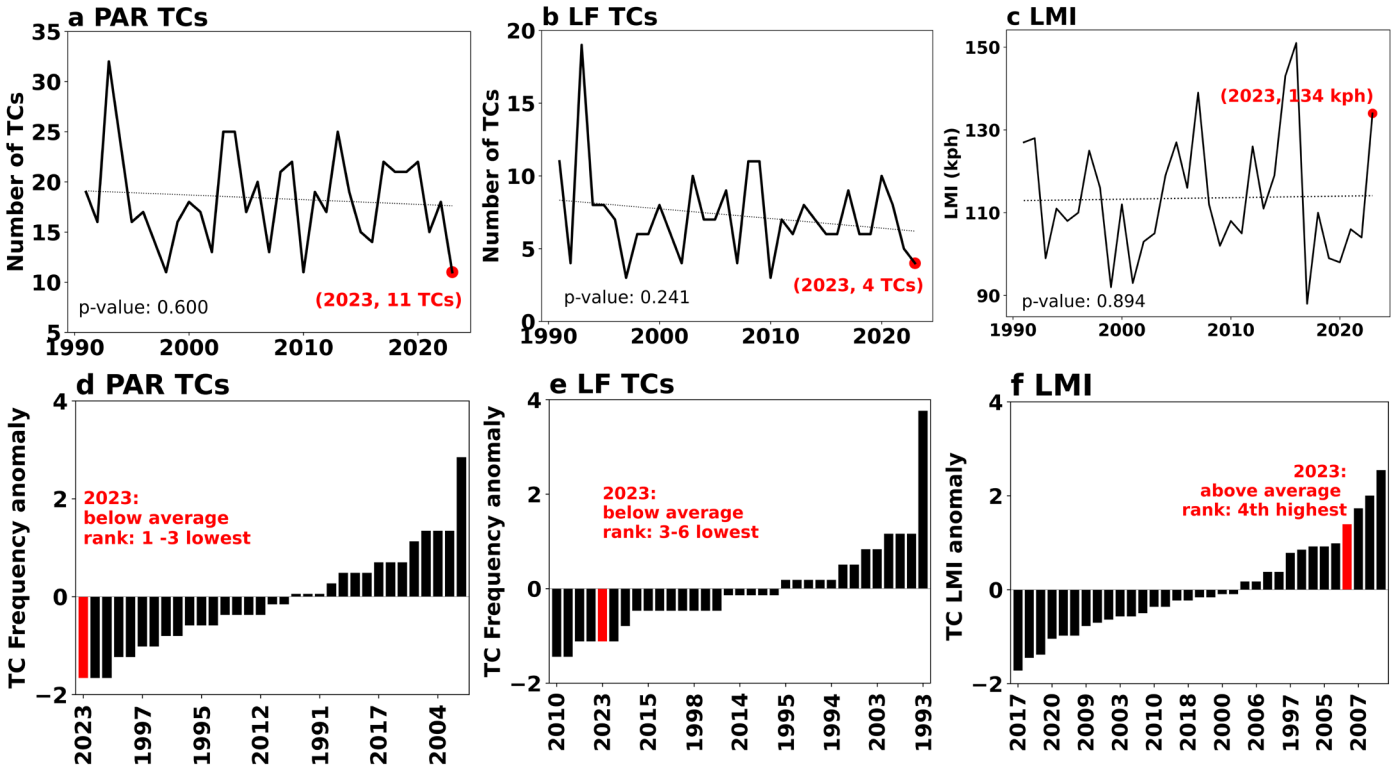
CHAPTER 4: TROPICAL CYCLONES

In 2023, **11 tropical cyclones** (TC) entered and/or formed within the Philippine Area of Responsibility (PAR) with **four making landfall**. No TC was recorded in JFM, while one out of the three TCs observed in AMJ made landfall. More than half these PAR TCs occurred in JAS with two landfalls, and only one in OND which also made landfall.

Of these TCs in 2023, the majority are of Typhoon category (four), while three intensified to reach Super Typhoon strength.



Seasonal tropical cyclone track map for 2023: January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively.



Timeseries of annual passage frequency of PAR TCs and landfalling (LF) TCs, and annual TC LMI for 1991-2023 expressed in absolute frequency (top) and ranked standardized anomaly (bottom).

The frequency of TC Passages in the PAR in 2023 was notably **below average**, marking it as **one the lowest occurrences** since 1991 alongside 2010 and 1998, ranking **1st to 3rd**. Similarly, the number of landfalls was **below average**, ranking among the **3rd to 6th lowest occurrences** since 1991 next to 2010 and 1997. Meanwhile, the **observed lifetime maximum intensity** of TCs in 2023 is **above average**, ranking **4th highest** since 1991.

The **strongest TCs** in 2023 are Super Typhoons (STY) **Betty (Mawar)** and **Goring (Saola)** both with maximum sustained winds of 195 kph within the PAR. STY Betty, however, obtained its lifetime maximum intensity of 215 kph outside the PAR.

Betty and Goring both indirectly affected the Philippines by intensifying the Habagat (southwest monsoon) which resulted in widespread rains over Luzon and western Visayas. **STY Egay (Doksuri)** and **TY Falcon (Khanun)**, though slightly less intense than Betty and Goring, incurred the **highest combined cost of damage** to agriculture, infrastructure and housing. This was primarily because as Egay exited the PAR after significantly enhancing Habagat, Falcon entered further intensifying the prevailing wind system. **The sustained strengthening of the Habagat resulted in cumulative damages amounting to no less than Php 14.8 billion leaving 30 dead, 171 injured and 9 missing persons**. (PAGASA, 2023)

CHAPTER 5:
EXTREMES

There were **four new monthly extreme rainfall records observed in 2023 in four different PAGASA Synoptic Stations**. Out of all the new extremes, the highest rainfall extreme in 2023 was recorded at PAGASA Catarman Synoptic Station on 20 November with a value of 618.8 mm, which broke the previous record that stood for 70 years. The extreme records at PAGASA Calayan and NAIA Synoptic Stations also broke records, which stood for 47 and 32 years, respectively.

STATION	New Rainfall Record (mm)	Date	Previous Rainfall Record (mm)	Date
BUTUAN	194.2	2/17/2023	160.4	2/8/2027
CALAYAN	373.1	7/25/2023	346.7	7/23/1977
CATARMAN	618.8	11/20/2023	346.5	11/28/1953
NAIA	66.5	4/13/2023	63.0	4/4/1992

For monthly maximum temperature (TMAX), **11 PAGASA Synoptic Stations broke their extreme records in 2023**. Out of these stations, PAGASA Zamboanga Synoptic Station observed the most number of new extreme records where new extreme records were set for the months of May, July, August, October, November, and December. This is followed by PAGASA Clark Synoptic station with three new TMAX records in July, November and December. Both PAGASA Daet and Malaybalay Synoptic stations also recorded two new TMAX extreme records. Of these new extreme records of TMAX, the highest record in 2023 was 37.9°C observed at PAGASA Daet Synoptic Station on September 7, 2023, which broke a record that stood for 56 years.

Meanwhile, there is no broken record for monthly minimum temperature in all PAGASA stations in 2023.

STATION	New TMAX Record (°C)	Date	Previous TMAX Record (°C)	Date
BORONGAN	36.6	10/3/2023	36.5	10/8/1986
CLARK	36.1	7/5/2023	36.0	7/9/2020
	34.8	11/6/2023	34.6	11/30/2022
	34.2	12/13/2023	34.0	12/8/2012
DAET	36.5	7/6/2023	36.0	7/5/1992
	37.9	9/7/2023	36.1	9/6/1968
HINATUAN	36.6	5/30/2023	36.0	5/24/1986
INFANTA	37.7	8/17/2023	37.0	8/27/1989

STATION	New TMAX Record (°C)	Date	Previous TMAX Record (°C)	Date
MALAYBALAY	33.5	7/7/2023	33.4	7/12/2021
	35.0	11/14/2023	34.8	11/29/1968
NAIA	34.6	12/10/2023	34.4	12/29/2020
PORT AREA	37.0	7/5/2023	36.5	7/2/1973
SAN JOSE	36.6	12/28/2023	36.0	12/24/2021
SANGLEY POINT	36.4	7/6/2023	36.3	7/25/2007
ZAMBOANGA	37.4	5/11/2023	37.0	5/5/2020
	36.3	7/6/2023	36.2	7/24/2021
	36.2	8/2/2023	35.8	8/14/2021
	36.4	10/20/2023	36.0	10/1/1999
	37.4	11/1/2023	36.4	11/13/2022
	36.4	12/2023	35.8	12/15/2014

CHAPTER 6: INSIGHTS

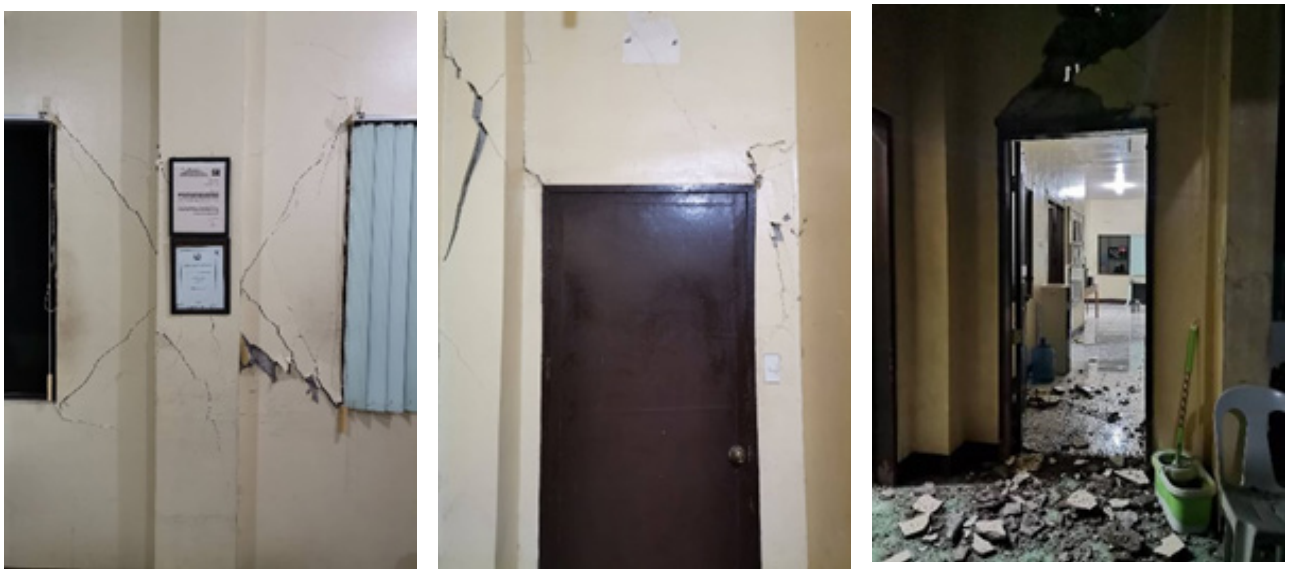
IMPACTS OF THE HINATUAN EARTHQUAKE ON THE OPERATIONS OF MPRSD

Prince Wilson P. Au
Mindanao - PAGASA Regional Services Division

Weather radar plays a crucial role in formulating heavy rainfall and thunderstorm warnings and advisories. It serves as a valuable tool for monitoring and visualizing actual atmospheric conditions in near real-time and weather events. In Mindanao, strategically located S-band and X-band radars cover most parts of the region. One S-band radar is installed in Hinatuan, Surigao del Sur, primarily for the purpose of monitoring the eastern part of Mindanao, for tropical cyclone occurrences and other weather systems like the Northeast Monsoon (Amihan) and Intertropical Convergence Zone (ITCZ), which can affect the local socioeconomic activities due to its geographical location. The municipality of Hinatuan is complemented with complex meteorological facilities, which include manned synoptic observations and automatic weather station (AWS). Through this data gathering scheme from various weather monitoring platforms, we are able to conduct weather and climate analyses as well as for research studies and weather certification issuances. Thus, the PAGASA Hinatuan Radar and Synoptic Station play a vital role in the operations of the Mindanao PAGASA Regional Services Division (MPRSD).

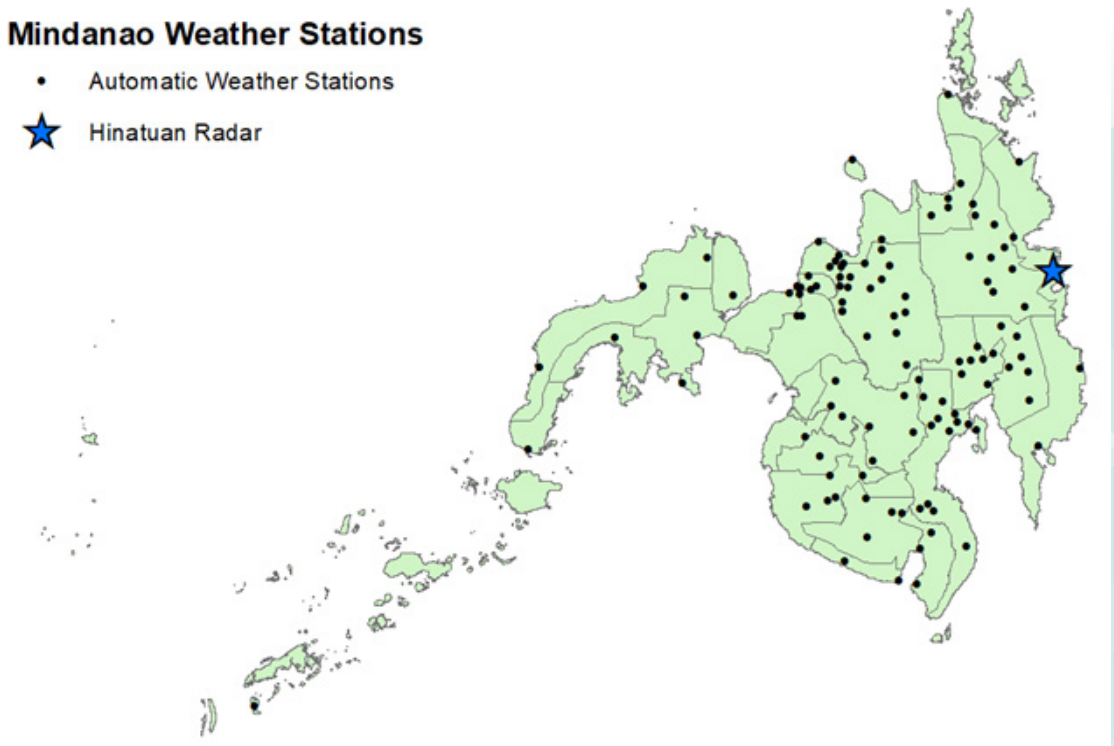
On **02 December 02, 2023, a 7.4 magnitude earthquake struck Hinatuan, causing extensive damage to infrastructures, including the PAGASA Hinatuan Radar and Synoptic Station building**. Fortunately, no PAGASA station personnel were harmed during the event. Damage assessment was conducted by the Department of Public Works and Highways (DPWH) and the Structural Engineers Association of Davao (SEAD) Incorporated. It was deemed that **the building is structurally unsafe due to significant damage during the earthquake**. To ensure the safety of PAGASA Hinatuan Station personnel, PAGASA management decided to suspend the operations of the Hinatuan Radar and Synoptic Station. Its personnel were temporarily assigned to the Agusan River Basin Flood Forecasting and Warning Center located in Patin-ay Prosperidad, Agusan del Sur, the nearest station to Hinatuan. Consequently, Hinatuan radar images and synoptic observations were discontinued.

Hinatuan Synoptic and Radar Station after the earthquake



Impact of the Hinatuan earthquake to Hinatuan Station

The discontinuation of synoptic observations implies gaps in the observation data, potentially affecting the accuracy and reliability of weather forecasts and atmospheric models, especially in the affected region. Local weather forecasters depend on real-time and historical synoptic data to generate accurate weather forecasts. However,automatic weather stations (AWS) were utilized to fill these gaps and address these issues. These AWSs are installed all-over Mindanao and are regularly maintained to provide reliable and near-real-time weather data such as rainfall, maximum temperature, minimum temperature, relative humidity, wind speed, wind direction, among others. Hence, despite the suspension of Hinatuan synoptic observation, MPRSD continues to provide reliable weather and climate information.



Automated Weather Stations installed in Mindanao

Weather data certification is one of the products of MPRSD used for project time suspension or extension by clients. For projects located in Hinatuan or nearby areas, synoptic data, especially rainfall, is necessary for issuing such certifications. This may pose an issue, but with other synoptic stations in the eastern part of Mindanao, they can represent the client's respective areas as well. Observation data from PAGASA Butuan and Surigao synoptic stations, respectively, are used for weather certification requests for Hinatuan and nearby areas, depending on the nature of request. To date, MPRSD handles such requests in a timely manner.

The Hinatuan radar captures real-time atmospheric conditions in the eastern portion of Mindanao, aiding weather forecasters in decision-making during the formulation of weather advisories and warnings. Although the Hinatuan radar has been shut down due to the earthquake's impact, weather forecasters use various available tools to fill in such data gaps. Example of such a tool is the satellite images captured by SATAID of the Japan Meteorological Agency, providing real-time atmospheric condition images not only for the eastern portion of Mindanao but for the entire Philippines. Weather forecasters utilize this tool to ensure that, even with the current absence of radar images from the Hinatuan radar, credible, correct, and timely advisories are issued every time.

Despite all that has happened, **the Mindanao PAGASA Regional Services Division still stands and provides the people with reliable, accurate, and timely weather and climate information.**

TAIL-END OF A COLD FRONT TO SHEAR LINE: A TALE OF TRANSITION

Robert B. Badrina
Weather Division

In November 2012, during our visit to the National Central University of Taiwan, we experienced a heavy downpour and thunderstorms. I thought that the rest of our visit would have the same weather - that is soaking wet. However, I was surprised that some of the days during our visit were cold, dry, and gusty. Apparently, what I experienced first-hand was what I used to read in textbooks - the cold front.

CHANGE FROM TAIL-END OF A COLD FRONT TO SHEAR LINE

Fronts are generally associated with mid-latitude weather systems where there is a distinct difference between the temperature of two air masses. Mid-latitude zones refer to areas located beyond the Tropic of Cancer (around 30° – 60° North). Since there are considerable differences between the temperature of two air masses in such zones, thunderstorm clouds can be formed in the boundary. In general, there are four types of fronts namely, warm, cold, stationary, and occluded depending on the movement of the dominant air mass.

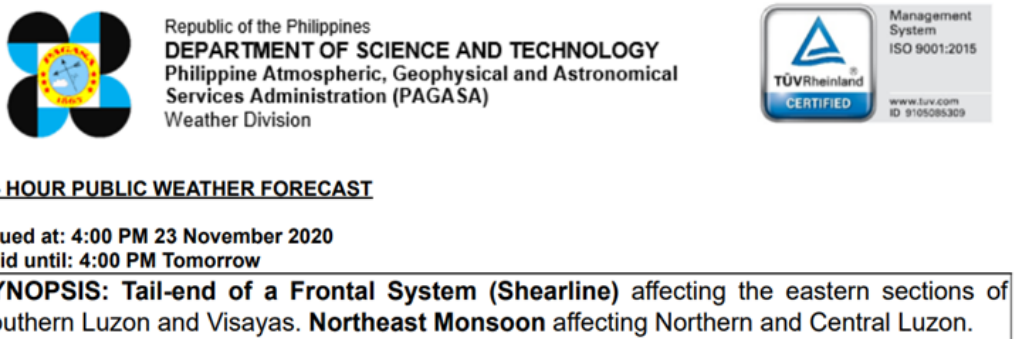
When I began my career as an operational weather forecaster of PAGASA in 2015, I encountered the term Tail End of a Cold Front (TECF) to describe the weather system associated with the Northeast Monsoon, which may cause thunderstorms and heavy rains, particularly in the eastern part of the country. In general, Northeast Monsoon with its stratified clouds usually cause light rains which are not convective in nature. According to our senior forecasters, the TECF was already in use as early as the 1980s and has been the practice since then. There were some instances that other seasoned forecasters also used the term “diffuse cold front.” The US National Weather Service described a “diffuse front” as an area where the wind shift and temperature change are weakly defined. Strictly speaking, this is also a characteristic of the TECF, the temperature difference in this area did not meet the criteria of the fronts in the mid-latitude. However, the question whether to continue using this term remains, considering that it is not a formal meteorological term and was not in use in other countries.

In 2017, Mr. Robb P. Gile, a fellow weather forecaster, was tasked to review the TECF using available literature. The result of the review pointed to a possibly more appropriate term which is called “shear line.” One of the articles mentioned in the review is from the forecasting manual published by the Naval Research Laboratory (NRL) wherein it states that shear lines or equatorward moving front are identified alongside cold fronts occurring during northeast monsoon season. The manual described the weak cold fronts which identified also as shear lines with associated cloudiness and light showers. The shear lines according to the manual may move south, even into the Visayas, and then return to Luzon with the persistent broken cloudiness before dissipating.

Pielke (2013) also mentioned the conversion of a frontal boundary into a convergence zone (also known as shear line due to directional difference across the boundary) frequently occurs during winter in the tropics. Another input from the Weather Prediction Center states that "Shear lines lie in troughs, but as surface data over the subtropical/tropical ocean is sparse, the trough may not be recognized in the available surface observation field. Using streamline analysis, a shear line is denoted by a confluence of streamlines equatorward and west of the col area where a cold front divides the subtropical ridge."

With the accompanying literature and the need to ensure a consistency with the scientific community the term "shear line" was recommended to be a more appropriate term to describe this system. The TECF is not actually a system but rather an area where the system is located. In addition, the TECF as the name suggests is typically connected with the cold front itself but technically synoptic charts show that shear lines can also be associated with the stationary fronts.

The **transition of using the term "shear line" started on November 23, 2020** at the 4PM Public Weather Forecast (see the figure below). As part of such transition, these two terms are still present in the synopsis in the next few months to familiarize the public with the changes on the term.



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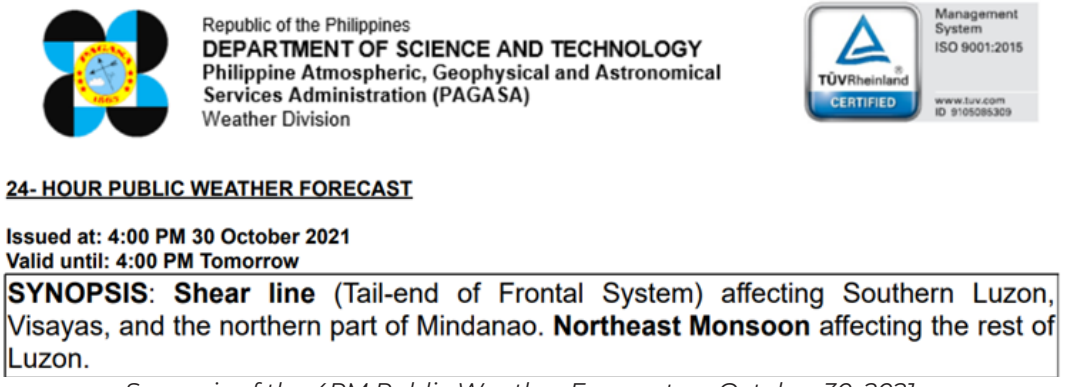
24- HOUR PUBLIC WEATHER FORECAST

Issued at: 4:00 PM 23 November 2020
Valid until: 4:00 PM Tomorrow

SYNOPSIS: Tail-end of a Frontal System (Shearline) affecting the eastern sections of Southern Luzon and Visayas. **Northeast Monsoon** affecting Northern and Central Luzon.

Synopsis of the 4PM Public Weather Forecast on November 23, 2020

On October 30, 2021 at the 4PM Public Weather Forecast, almost a year since Shear Line was first introduced in the public, the Tail End of Frontal System was now put inside the parenthesis and the term "shear line" became the main term for the weather system as shown in next figure:



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24- HOUR PUBLIC WEATHER FORECAST

Issued at: 4:00 PM 30 October 2021
Valid until: 4:00 PM Tomorrow

SYNOPSIS: **Shear line** (Tail-end of Frontal System) affecting Southern Luzon, Visayas, and the northern part of Mindanao. **Northeast Monsoon** affecting the rest of Luzon.

Synopsis of the 4PM Public Weather Forecast on October 30, 2021

The term Tail-end of Frontal System was finally removed in the synopsis and list of weather systems in the Philippines on November 16, 2021 at the 4PM Public Weather Forecast shown in the next figure. The last time the term Tail end of a Cold Front was used as a weather system term in the synopsis.

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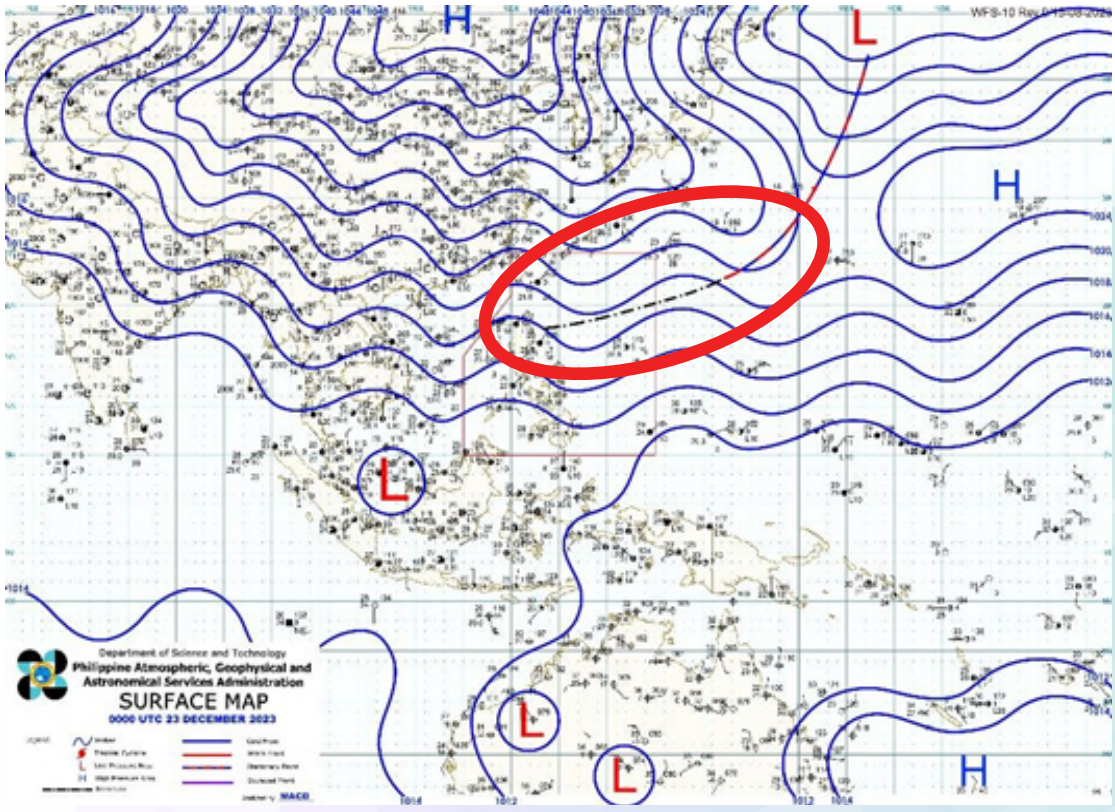
24- HOUR PUBLIC WEATHER FORECAST

Issued at: 4:00 PM 16 November 2021
Valid until: 4:00 PM Tomorrow

SYNOPSIS: **Intertropical Convergence Zone (ITCZ)** affecting Palawan and Mindanao. **Shear Line** affecting the eastern section of Northern Luzon.

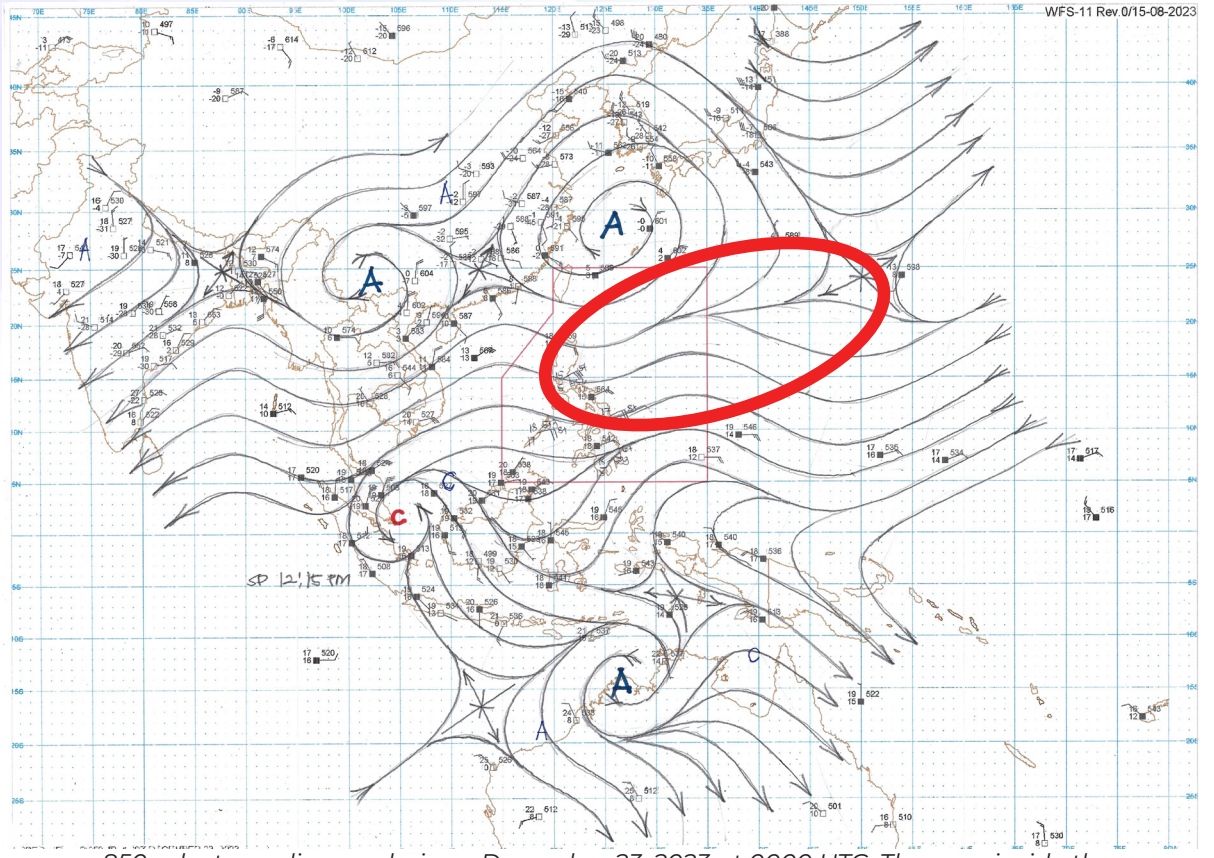
IDENTIFICATION OF SHEAR LINE

Synopsis is used to describe the present condition of the atmosphere of a particular area. The prevailing weather system identified in the synopsis is the basis for the formulation of the weather forecast. There are different data used to determine the "synopsis" in a particular place at a particular time. Some of this data are shown in the following figures where the "shear line" can be identified with its recognizable features.



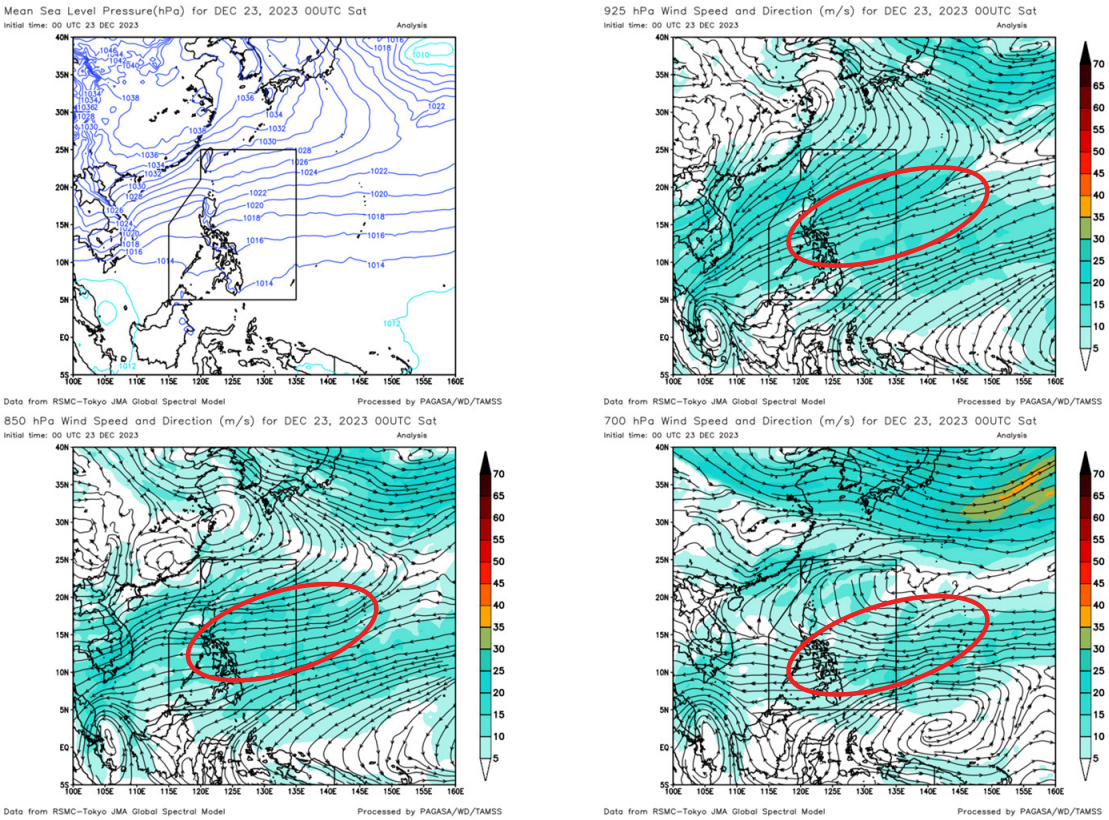
Synoptic Chart at 0000 UTC (8:00 AM local time) on December 23, 2023

The figure on the previous page shows the synoptic chart where different meteorological variables are plotted altogether in the map. An isobaric analysis (lines of equal pressure) is performed to determine the areas with high and low pressure systems. Additionally, the temperature differences between stations can help in the identification of the frontal system as shown in the figure. However, since the “shear line” is usually located over the eastern section of the country where there are limited numbers of stations, identifying it is quite a challenge. Other sources of data are needed to support and formulate the synopsis.



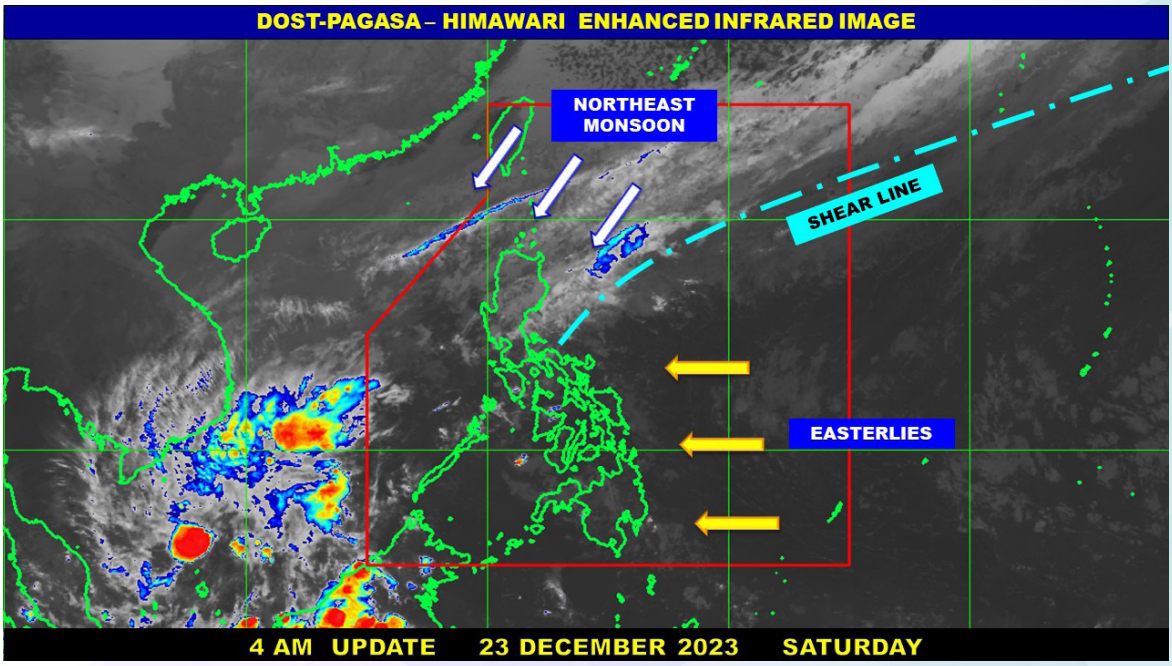
850 mb streamline analysis on December 23, 2023 at 0000 UTC. The area inside the red shape is the line of convergence between the cold Northeasterly wind and warm Easterly wind.

The figure above shows the streamline analysis of the meteorological data collected at the 850mb (around 5,000 feet or 1,170 meters). The streamline analysis is a technique to visualize the flow of air by converting point data (wind direction) and transforming it into lines with the same direction. The figure shows an area of convergence located at the northeastern part of Luzon (inside the red polygon) which is similar to the feature of a shearline. In particular, the convergence is usually located west of the col area as described by the Weather Prediction Center, which then is connected to a frontal system (not shown in the map) east of Japan.



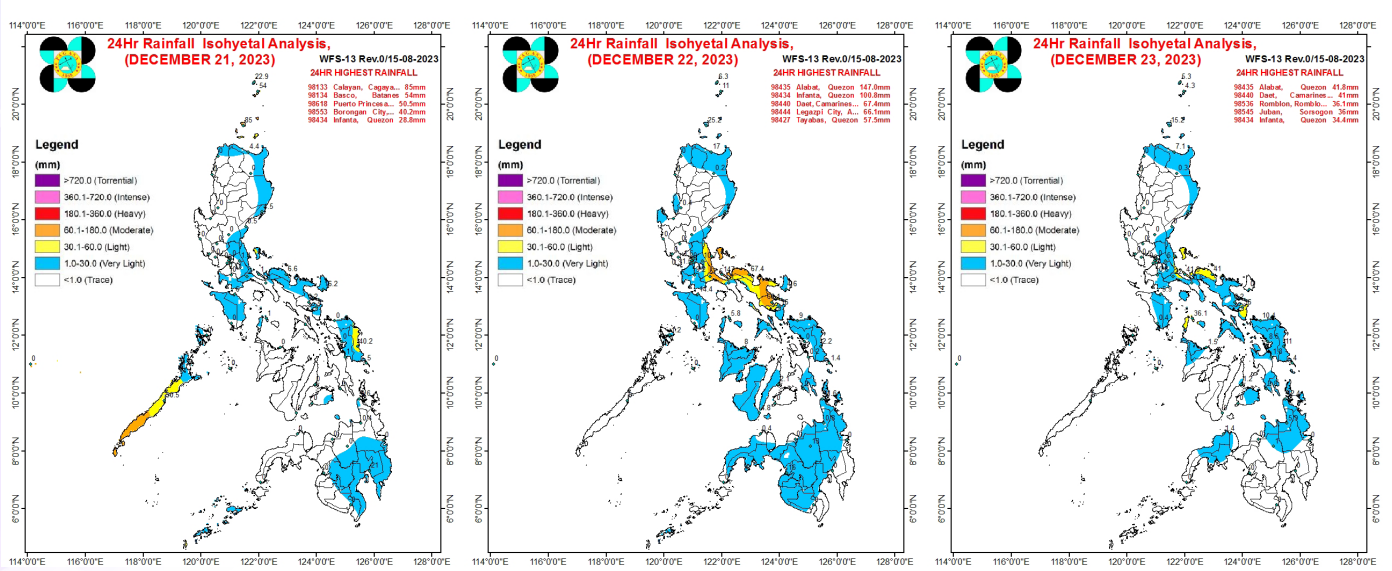
Numerical Weather Prediction Output based on Global Spectral Model (GSM) of Sea Level Pressure, Wind Speed and Direction at 925 mb (2498 feet), 850 mb (5,000 feet), and 700 mb (10,000 feet) on December 23, 2023 at 0000 UTC.

The Numerical Weather Prediction (NWP) outputs also serve as a guide in the identification of the prevailing weather system. The NWP can also produce forecast outputs of the future atmospheric conditions using dynamical assumptions and computations. In Figure 6, the point of convergence is almost similar to the manually analyzed weather chart for the 850 mb shown in Figure 5. The 700 mb output does not show this point of convergence which provides an idea that the convergence does not reach to the upper atmospheric level. Additionally, it can provide information that the identified shear line may not persist in the coming days.



Satellite Image on December 23, 2023

The satellite imagery can be very helpful particularly in the identification of features in the atmosphere. In the figure on the previous page, the satellite image on December 23, 2023 using the Enhanced Infrared Channel shows the boundary between the cold Northeast Monsoon and the warm Easterlies. This is the area where the Shear Line can be located.



Isohyetal Analysis using the data of DOST PAGASA Synoptic Stations on December 21-23, 2023

The Three(3)-day Isohyetal Analysis in the figure above shows the area with the same amount of rainfall. This is done using an interpolation technique with the data from DOST-PAGASA Synoptic Stations as input. The moderate rainfall captured particularly on December 22, 2023 in Quezon province and Bicol areas is an indicator of the possible impact of the prevailing shear line. The guidance of the NWP which shows an already shallow convergence in the northeastern part of the country is an indication of lessening impact of shear line. This can be observed in the very light to light rains on December 23, 2023 in the same areas of Quezon and Bicol.

DISCUSSION

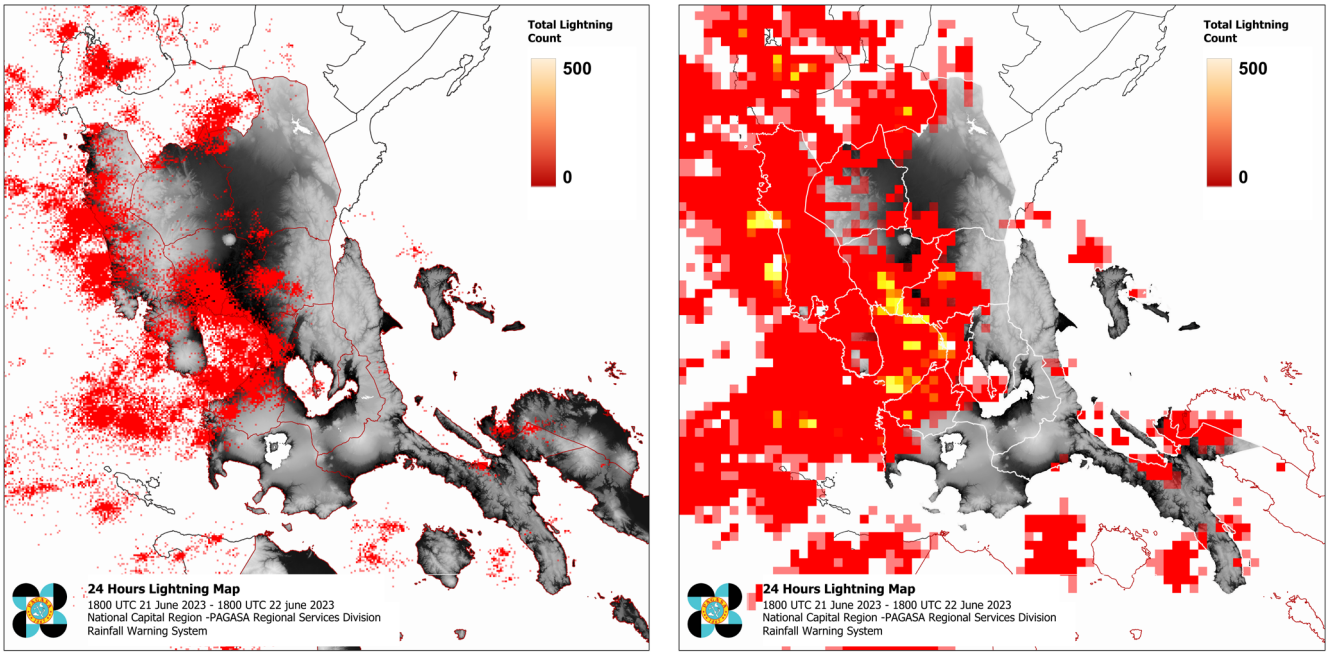
"Nothing in science has any value to society if it is not communicated." This is a quote from Anne Roe who is a noted twentieth century American psychologist and writer. As a weather forecaster, our job does not end by providing a reliable and timely weather forecast, the other part of the work is informing especially the general public. The information must be helpful for them to make the necessary actions to mitigate the possible impact particularly of severe weather events. The transition from Tail End of a Cold Front to Shear Line is not only about the use of a more appropriate term, but also in communicating effectively to the public on what to expect when this system is prevailing. Hopefully, the continued information dissemination to familiarize with the various weather terms can also improve the response of the people particularly those who are highly at risk. I used to end my broadcasting of the Weather Forecast with this reminder: "Maghanda para sa isang ligtas na Pilipinas."

***The author would like to thank Mr. Robb P. Gile, Mr. Raymond C. Ordinario, and the late former chief of the Weather Forecasting Section, +Mr. Roberto S. Sawi for the invaluable insights and inputs to this article.

TORNADO ACTIVITY IN BACOLOR, PAMPANGA

Munir J. Baldomero
National Capital Region - PAGASA Regional Services Division

On 22 June 2023, the municipalities of Bacolor and Macabebe in the Province of Pampanga reported the occurrence of a tornado accompanied by heavy rain showers and thunderstorms. According to the PAGASA total lightning detection network, such an occurrence was embedded in a severe thunderstorm system that occurred over the southern region of Pampanga on the same date. Wind convergence causes the formation of severe thunderstorms over the southern part of Central Luzon.



24-hour and 3-hourly lightning detection count on 22 of June 2023 based on the recorded lightning data from the PAGASA lightning detection network. (PAGASA-NCRPRSD, 2023)

The figure above presents the observed lightning activity over the forecast areas of the National Capital Region - PAGASA Regional Services Division. The 24-hour lightning map on the left depicts recorded lightning events associated with thunderstorm activity, which are largely concentrated in the western sector of the forecast zone. Throughout the day, there was a significant surge in lightning activity over southern Pampanga, particularly in the municipalities of Masantol, Macabebe, Sasmuan, Minalin, Lubao, Guagua, Santa Rita, and Bacolor. The 3-hourly lightning map on the right shows that between 5 PM and 8 PM, there was a noticeable surge in lightning incidents during a three-hour period. This rise in lightning activity coincided with the strengthening of severe thunderstorms, resulting in atmospheric conditions favorable to the creation of a tornado over Pampanga. The tornado, with its tremendous spinning winds and catastrophic potential, developed as a notable meteorological phenomenon in the area during that period. The lightning events wereas captured by PAGASA total lightning detection network.

The PAGASA lightning detection network encompasses 28 strategically positioned lightning sensors across the Philippines, stationed within PAGASA observing stations. Additionally, it incorporates 2 supplementary sensors sourced from the West Point Engineering headquarters in Bulacan and Brent International School in Laguna province. This cutting-edge lightning network represents the pinnacle of modern lightning detection technology, boasting unparalleled reliability and detection capabilities that capture both In-cloud and cloud-to-ground lightning strikes. Through its real-time lightning tracking and warning functionalities, along with a suite of lightning-derived products, the system facilitates early detection of thunderstorms across extensive geographical areas. Commencing in 2018 and concluding in 2019, this project stands as a testament to PAGASA's commitment to advancing meteorological monitoring and public safety.

Philippines lightning network under DOST-PAGASA (Earth Networks, 2019)

IMPACT ASSESSMENT

According to a report from the Bacolor Municipal Disaster Risk Reduction and Management Office, powerful winds blew away portions of roofing materials in certain residential areas, while other residential areas reported more significant damages in their properties. Thirty-eight partially damaged buildings or structures and seven completely destroyed houses and structures were reported, with an estimated cost of Php. 142,000.00. Fallen trees and other debris have impeded major roads, but officials have prioritized road-clearing efforts. It is fortunate that such an event resulted in no documented fatalities. Moreover, there were reports of minor injuries from flying debris, including bruises, scrapes, and abrasions among residents. Following the occurrence of the aforementioned event, 184 people were reported to have been impacted. According to the provincial social work and development office, the impacted people received a total of 347,430.00 pesos in support. Several electricity lines and posts, and communication links were damaged, in various sections of San Fernando City and Bacolor, and across McArthur Highway in Bacolor, respectively. Power distribution and communication lines were restored eventually once the debris, and power and communication lines had been cleared.

INSIGHTS / DISCUSSION

The effectiveness of the PAGASA total lightning detection network emphasizes its critical role in improving the operational capabilities of the NCRPRSD forecasting unit. By providing real-time data on lightning activity, this network allows meteorologists and emergency responders to swiftly assess and respond to changing weather conditions, such as thunderstorm development and the potential formation of severe weather events such as severe thunderstorms, hailstorms, and tornadoes. This proactive method not only improves public safety by allowing for early warning and advisories, but it also helps to mitigate the potential hazards posed by severe weather events. As such, the integration of advanced lightning detection technology within the NCRPRSD's forecasting framework highlights its commitment to safeguarding communities and promoting resilience in the face of adverse weather phenomena.

Summary of Final Report from the Pampanga Provincial Disaster Risk Reduction and Management Council on the impact of reported thunderstorms and tornado incidents on 29 June 2023.

DAMAGED HOUSES AND STRUCTURES			
City/ Municipality	**No. of Partially-damaged Houses/ Structures**	**No. of Totally-damaged Houses/ Structures**	**Estimated Cost of Damage (Pesos)**
Bacolor	33	7	**142,000.00**
Macabebe	5	-	
TOTAL	**38**	**7**	

OTHER INCIDENTS MONITORED			
Affected City/ Municipality	**Incident/Activity**	**Status**	**Remarks**
Bacolor	Collapsed main entrance and stained glass of Cabalantian Church	Cleared	No reported casualty.
	Slight Injuries	Treated at home	Minor injuries such as bruises, cuts and abrasions due to flying debris
Masantol	Fallen trees and debris along PDDP Dike	Cleared	No reported casualty.

AFFECTED POPULATION		
City/ Municipality	**Affected Families**	**Affected Individuals**
Bacolor	40	163
Macabebe	5	21
TOTAL	45	184

OTHER INCIDENTS MONITORED			
Agency/ Office	**In-kind Assistance Extended**	**Remarks**	**Remarks**
Bacolor		Brgy. Cabalantian, Magliman and San Isidro	311,000.00
Macabebe			36,430.00
TOTAL			**347,430.00**

Damage infrastructure at Baytra Supermarket along San Fernando – Lubao Road., Sitio Banlic, Bacolor Pampanga. (MDRRMO Bacolor)

Damage properties at Pasig San Rafael, Macabebe, Pampanga after the onslaught of tornado over Pampanga. (MDRRMO, Macabebe)

THE ONSLAUGHT OF SUPER TYPHOON EGAY (*DOKSURI*), JULY 2023

Romeo B. Ganal, Jr.
Northern Luzon - PAGASA Regional Services Division

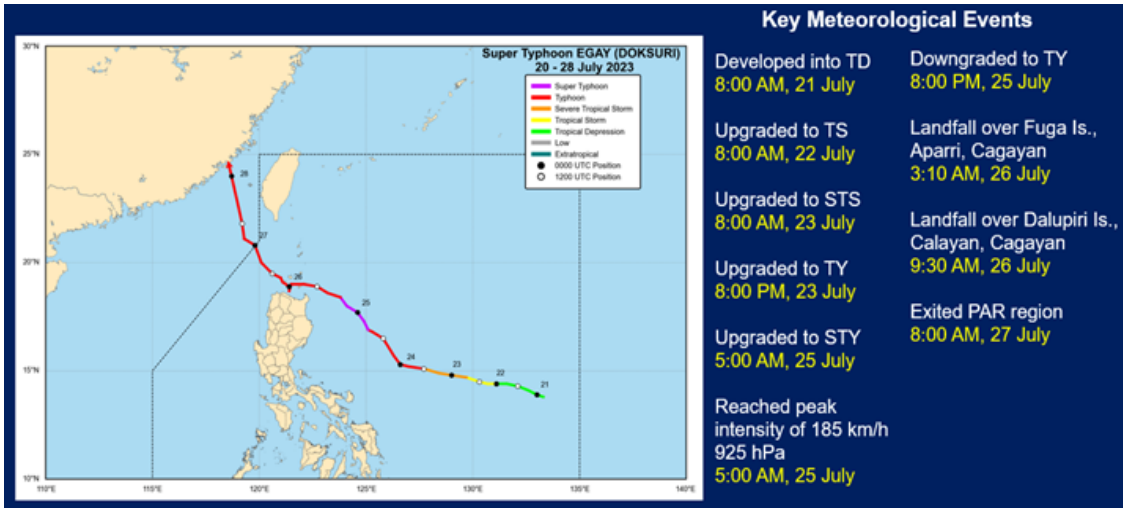
METEOROLOGICAL HISTORY

On 21 July 2023, a Low Pressure Area (LPA) located east of southeastern Luzon developed into Tropical Depression category and was given the local name "EGAY (International Name: Doksuri)". In the subsequent days, EGAY intensified into a Tropical Storm after category a day from its development, then into a Severe Tropical Storm category the following day, and further strengthened into a Typhoon category on the evening of 23 July as it moved westward over the Philippine Sea, posing a significant to severe threat to Northern Luzon. By 24 July, EGAY underwent rapid intensification and into a Super Typhoon category and was expected to cause extreme damages in the northern portions of Cagayan Valley, Cordillera, and Ilocos Regions.

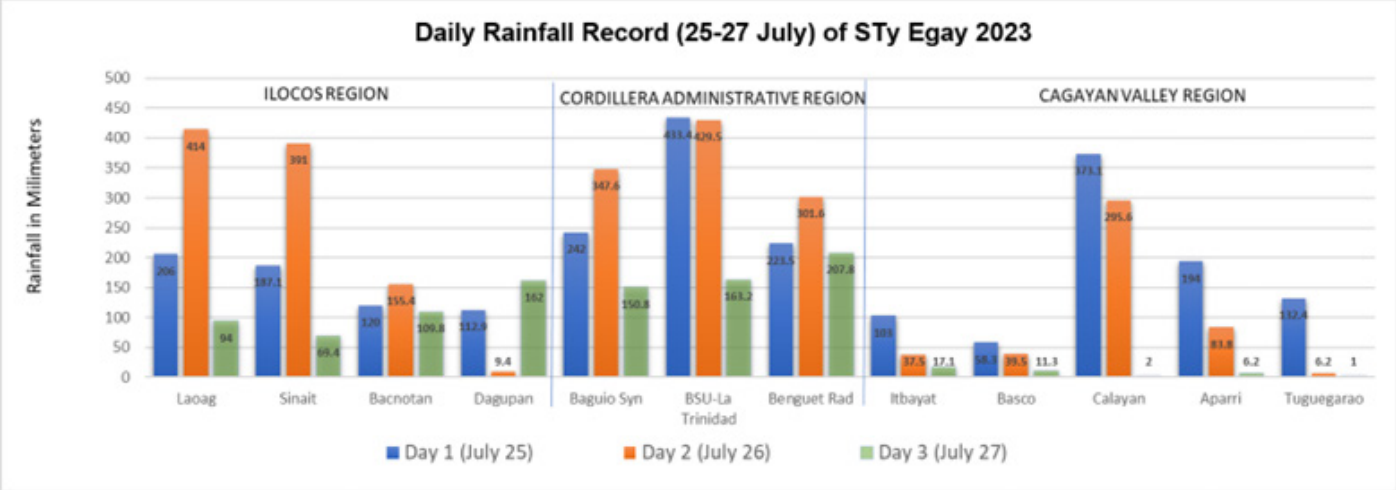
Tropical Cyclone Wind Signals (TCWS) were raised over the affected regions, with the highest TCWS No. 5 hoisted over the eastern portion of Babuyan Islands, indicating a potential extreme threat to the small islands in extreme Northern Luzon.

Additionally, as EGAY approached the Northern Luzon area, it simultaneously enhanced the prevailing Southwest Monsoon that brought monsoon rains over the western portions of the country. On 25 July, heavy rains brought by the enhanced monsoon began to batter Ilocos Provinces and Benguet, persisting throughout the following day. The intense downpour resulted in widespread flooding and flash floods across these areas.

At 3:10 AM of 26 July, EGAY made landfall in the vicinity of Fuga Island, Aparri, Cagayan, and later over Dalupiri Island, bringing severe winds and heavy rainfall. Stormy weather persisted over the Babuyan Group of Islands as EGAY traversed between the islands and the northern portion of mainland Luzon on the same day.



EGAY moved west northwestward, it weakened over the Luzon Strait and eventually exited the Philippine Area of Responsibility (PAR) on 27 July. All Tropical Cyclone Wind Signals were lifted as EGAY entered the Taiwan Strait.



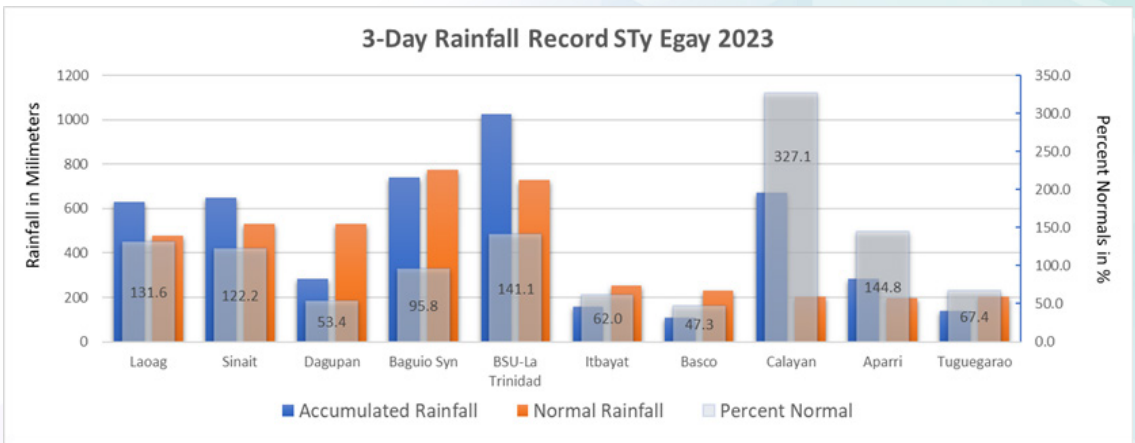
The graph illustrates the daily accumulated rainfall records of the PAGASA manned stations in Northern Luzon spanning from 25-27 July, 2023.

ASSOCIATED RAINFALL

On Day 1, the PAGASA stations situated on the eastern side of Luzon were directly affected by the rainbands associated with Super Typhoon EGAY. Particularly noteworthy is the Calayan station, which lay directly along EGAY's path. A remarkable 24-hour accumulated rainfall of 373.1 mm was recorded, which surpassed the monthly normal rainfall accumulation of 205 mm of the said station. Additionally, a substantial 24-hour accumulated rainfall was also observed in Aparri Station with a total of 144.8 mm during the same period.

In the Ilocos and Cordillera regions, most of the rainfall on Day 1 is attributed to monsoon rains, while on Day 2, the precipitation is influenced by both the southwest monsoon and Tropical Storm EGAY.

Two of the highest 24-hour accumulated rainfall associated with Super Typhoon EGAY were recorded on 25 July and 26 July in BSU-La Trinidad Station, with 433.4 mm and 429.5 mm, respectively. In just two days, such rainfall values surpassed the monthly normal rainfall accumulation of 727.1 mm of the said station. Additionally, significant 24-hour accumulated rainfall was also observed in other stations on 26 July, including Laoag (414.0 mm), Sinait (391.0 mm), Baguio (347.6 mm), Benguet Radar (301.6 mm), and DMMMSU-Bacnotan (155.4 mm).



Considering the cumulative rainfall over three days (25-27 July) directly associated with the passage of Super Typhoon EGAY, Calayan Station received 327.1% or over three times the amount of rainfall it normally experienced in July. Additionally, Aparri Station received 144.8% of its monthly average normal rainfall, BSU-La Trinidad Station received 141.1%, Laoag Station received 131.6%, and Sinait Station received 122.2% respectively. These indicate significant Super Typhoon EGAY-associated rainfall surpassing the typical July averages for these locations.

WARNING ISSUANCES AND ASSOCIATED DAMAGES

The Northern Luzon PRSD implemented a Rainfall Warning System, progressing from Yellow to Orange and Red warnings, beginning on 25 July. These warnings were issued to various provinces based on rainfall monitoring and forecasts. In the evening of the same date, the first Red Heavy Rainfall Warning was issued for Cagayan. The following day, similar warnings were issued for the provinces of Batanes, Apayao, Ilocos Norte, Ilocos Sur, and Abra, signaling a very high likelihood of serious flooding and rain-induced landslides in these regions, respectively. Moreover, the adjacent provinces situated around these areas were subject to an escalation in their rainfall warnings, with some being upgraded to Orange warning, indicating threatening impacts, while others were raised to Yellow warnings, signifying possible occurrences of flood and landslides.

SUMMARY OF HEAVY WARNING (HRWS) ISSUANCES OVER NORTHERN LUZON AOR DURING SUPER TYPHOON EGAY (JULY 25-28, 2023)			
BATANES	4	6	3
CAGAYAN	9	11	8
ISABELA	9	0	0
QUIRINO	0	0	0
NUEVA VIZCAYA	3	0	0
ILOCOS NORTE	4	4	9
ILOCOS SUR	6	3	7
LA UNION	6	1	7
PANGASINAN	8	2	0
APAYAO	2	5	8
ABRA	6	5	8
KALINGA	1	6	5
MT. PROVINCE	5	7	0
IFUGAO	6	6	0
BENGUET	5	1	7

On the early morning of 26 July, severe winds from Super Typhoon EGAY caused widespread damage in Sanchez Mira, Cagayan, resulting in reports of roofs being blown off and buildings being damaged. The area experienced significant destruction to both infrastructure and agriculture, prompting local authorities to declare a state of calamity. (photo source PIA Region 2)

On 26 July, reports emerged of rockslides and mudslides along Bokod Road in Baguio City, disrupting transportation in the area. These incidents were attributed to the persistent heavy rainfall resulting from the combined impact of SW Monsoon and STy Egay. On the same day, there was an incident reported in Brgy. Bakekang Central, Baguio City, who was tragically buried during the landslide incident.
(photo source: PIA Cordillera)

Rockslides also occurred in Camp 6 along Kennon Road, causing extensive damage to parked vehicles along the roadside and breaking electrical posts, resulting in a temporary power outage in the area. Additionally, the debris from the rockslides blocked the road, further complicating the situation and impeding traffic flow.
(photo source: PIA Cordillera)

Due to the escalating threat of flooding to low-lying areas in Poblacion East, San Ildefonso, Ilocos Sur, local authorities, including the Philippine National Police (PNP), Bureau of Fire Protection (BFP), and Municipal Disaster Risk Reduction and Management Office (MDRRMO), initiated emergency evacuation procedures. This urgent action was deemed necessary due to the continuous rise of rivers and the accumulation of trapped waters in low-lying areas. Similar situations were observed across almost the entire province, including the nearby provinces of La Union and Ilocos Norte, exacerbating the need for coordinated emergency response efforts by the local authorities.
(photo source: LGU San Ildefonso)

According to the latest report from the National Disaster Risk Reduction and Management Council (NDRRMC), a total of 1,377,169 families, comprising 5,385,066 individuals, were affected by the STy Egay and the enhanced SW Monsoon. Among these, 156,572 families, equivalent to 610,184 individuals, were from Regions 1, 2, and the Cordillera Administrative Region (CAR). Unfortunately, the event resulted in 30 fatalities, 171 injuries, and 9 individuals reported missing.

The event also inflicted extensive damage on infrastructure, with estimated costs amounting to Php 8,651,899,908.54. Moreover, the agricultural sector suffered immense losses, with estimated damages totaling Php 6,373,029,177.5645. Livestock, poultry, and fisheries were also significantly affected, incurring estimated losses amounting to Php 898,658,064.87. Additionally, various other assets and properties sustained damage, with an estimated cost of Php 9,977,216.22. (Source: NDRRMC SitRep 36, 24 Aug 2023)

SHEARLINE AND LPA TRIGGERS FLOODING IN THE EAST AND WEST

Vhan Therese Sabellano
Visayas - PAGASA Regional Services Division

Last November 2023, provinces in Northern Samar, Eastern Samar, Samar, Aklan and Capiz were submerged under floodwaters due to the impact of shear line. Early on the 14th of November, a shear line was affecting the eastern section of Visayas. On the 17th of November at 8 AM, a low-pressure area (LPA) located 935 km East of northeastern Mindanao entered the Philippine Area of Responsibility. The combination of both these weather systems brought rains over the Eastern Visayas. The LPA dissipated on 19 November 2023 at around 2:00 PM at the East of Surigao City, Surigao del Norte. From then on, the shear line continued to bring rains over MIMAROPA, Bicol Region, and Western & Eastern Visayas. This resulted in adverse weather conditions that led to heavy rainfall, subsequent flooding and landslides in these areas that claimed lives.

Various provinces in Eastern Visayas were submerged in flood. Photos from Rappler & Inquirer.

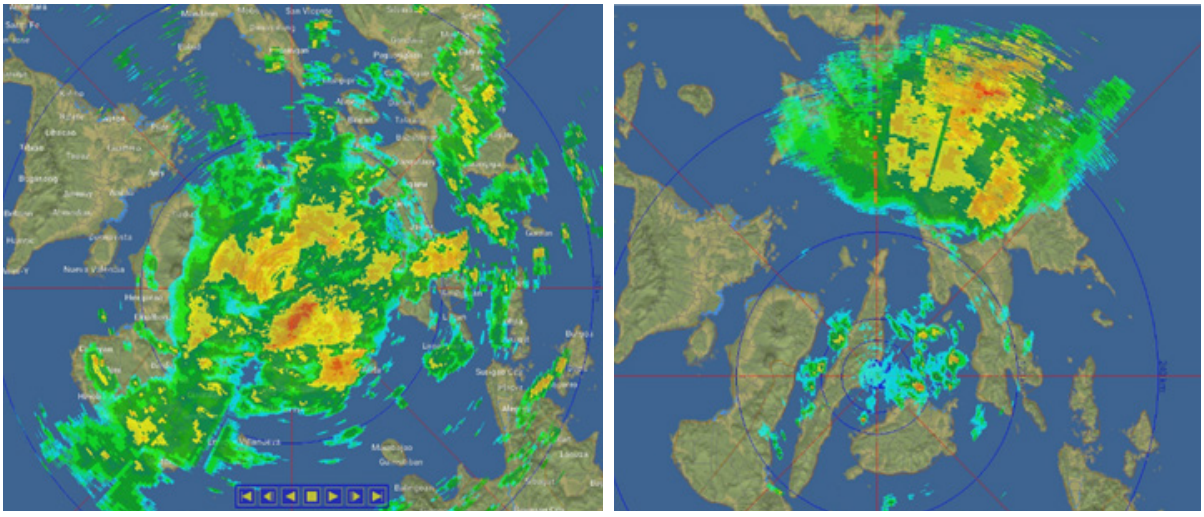
The forecasted weather condition for that period indicated cloudy skies with scattered rain showers and thunderstorms, primarily caused by the shear line. PAGASA warned the public of possible flash floods or landslides due to moderate to heavy rains in the affected regions.

These affected areas experienced continuous rainfall, which is attributed to the combined effects of the shear line and Low-Pressure Area. The impact of the continuous rainfall was evident in the recorded precipitation measurement in the affected areas. Stations in Catbalogan, Borongan, Kalibo, and Mambusao reported substantial rainfall since November 15, 2023 as seen in the table below, intensifying the flooding situation.

Recorded Rainfall in Visayas PRSD Stations

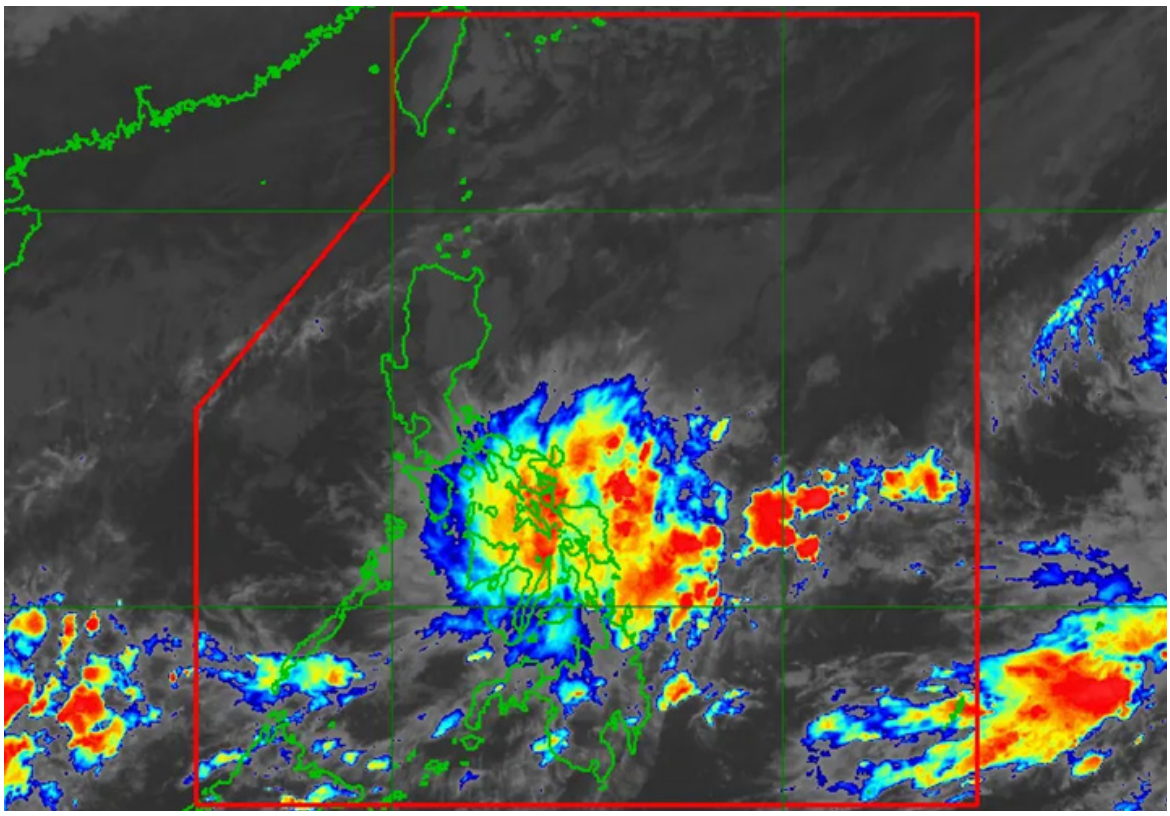
DATE	RAINFALL (mm)			
	Catbalogan	Borongan	Kalibo	Mambusao
11/15		16.0	12.0	55.5
11/16	11.2	48.0	4.8	39.3
11/17	22.0	46.4	18.6	7.2
11/18	84.6	109.6	11.8	26.6
11/19	63.8	109.0	31.3	177.2
11/20	67.6	24.4	4.1	15.4
11/21	2.9	8.0	0.2	14.9
11/22	19.0	30.2	14.2	0.5
TOTAL	**271.1**	**391.6**	**97.0**	**336.6**

Coupling the observed rainfall of various stations with different tools such as Radar, Satellite and Automatic Weather Stations, Visayas PRSD,the regional arm of PAGASA, issued several Heavy Rainfall Warnings to alert residents about the severity of the weather conditions. Thirty-seven counts of Yellow Heavy Rainfall Warnings were issued in several areas in Visayas. These warnings indicated expected rainfall amounts between 7.5 mm and 15 mm within one hour, with the possibility of flooding in low-lying areas.

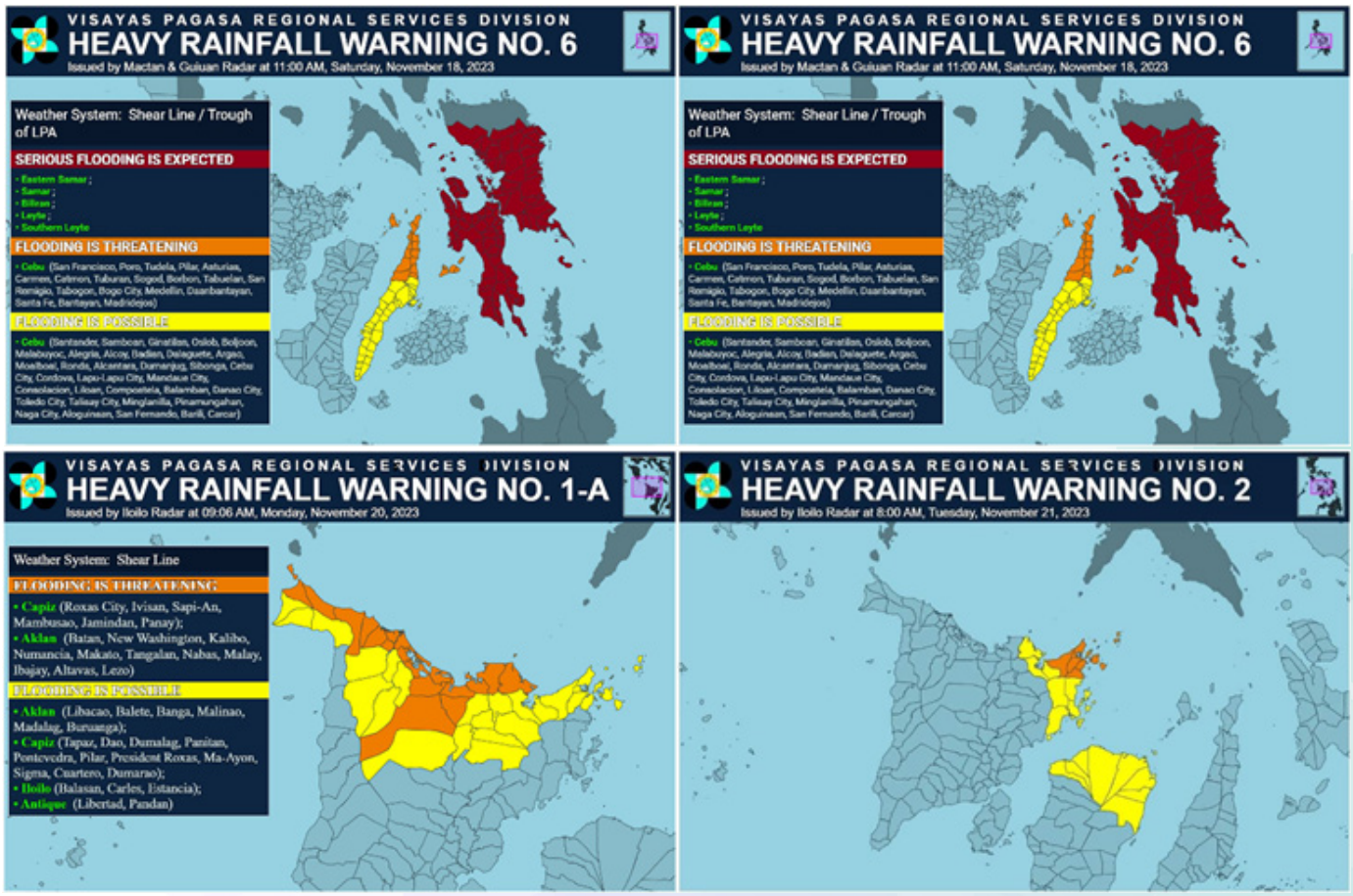


Radar images taken from Mactan Station.

As the intensity of rainfall increased, PAGASA escalated the warnings. Orange Heavy Rainfall Advisories were raised in areas experiencing rainfall between 15 mm and 30 mm within one hour, signifying an imminent threat of flooding. Locations in Samar, Eastern Samar, Biliran, Cebu, Iloilo, and Capiz were among those under the orange alert. A total of 27 Orange Heavy Rainfall Warning was issued during this period.



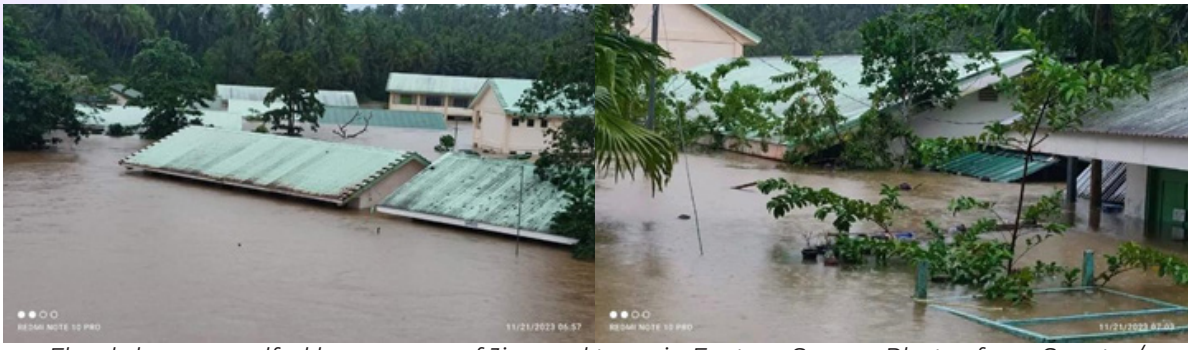
Satellite imagery of the Shear line affecting Visayas.



Sample Color-coded Heavy Rainfall Warning issued in Visayas.

The situation reached a critical point on 19 November 2023 with the issuance of a fourteen (14) Red Heavy Rainfall Warning in Samar and Eastern Samar. This warning signaled an emergency, indicating observed rainfall exceeding 30 mm within one hour or continuous heavy rainfall exceeding 65 mm over three hours. Communities are urged to take immediate action, as serious flooding can pose a significant risk to life and property.

Local news sources reported severe flooding affecting tens of thousands of residents in Panay Islands and Samar provinces. The aftermath of the flooding revealed widespread devastation, with roads submerged, houses inundated, power outages, water supply and internet service interrupted and agricultural lands ravaged. The non-stop rains have also triggered landslides in Liloan and Bontoc in Southern Leyte, Catbalogan City and Tagapul-an in Samar, Jipapad and Oras in Eastern Samar, and Babatngon, Leyte which also claimed 2 lives. Emergency response teams were deployed to assist affected communities, while local authorities urged residents to evacuate to safer areas.



Floods have engulfed large areas of Jipapad town in Eastern Samar. Photos from Sunstar/ Jipapad Pulis/Proceso Lopez Mengote

Floods have engulfed large areas of Jipapad town in Eastern Samar. Photos from Sunstar/ Jipapad Pulis/Proceso Lopez Mengote

The province of Capiz submerged in flood. Photos from PIA/PNA/MDRRMO

INSIGHTS

The issuance of Heavy Rainfall Warnings by the Visayas PAGASA Regional Services Division played a pivotal role in guiding decision-making processes, particularly concerning preemptive evacuation and other preparedness measures. The timely dissemination of warnings was able to aid local authorities in their decision making. They were capable of anticipating the extremity of the impending disaster and were able to take appropriate measures to safeguard lives and property.

Due to the effective communication between PAGASA and the stakeholders, the local government units were able to enact preemptive evacuation protocols and activate emergency response mechanisms ahead of the flooding event. This proactive approach helped minimize loss of life and property damage by ensuring that vulnerable populations were evacuated to safer areas before the onset of extreme weather conditions.

BREAKING RAINFALL RECORDS: SURPASSING PREVIOUS EXTREMES

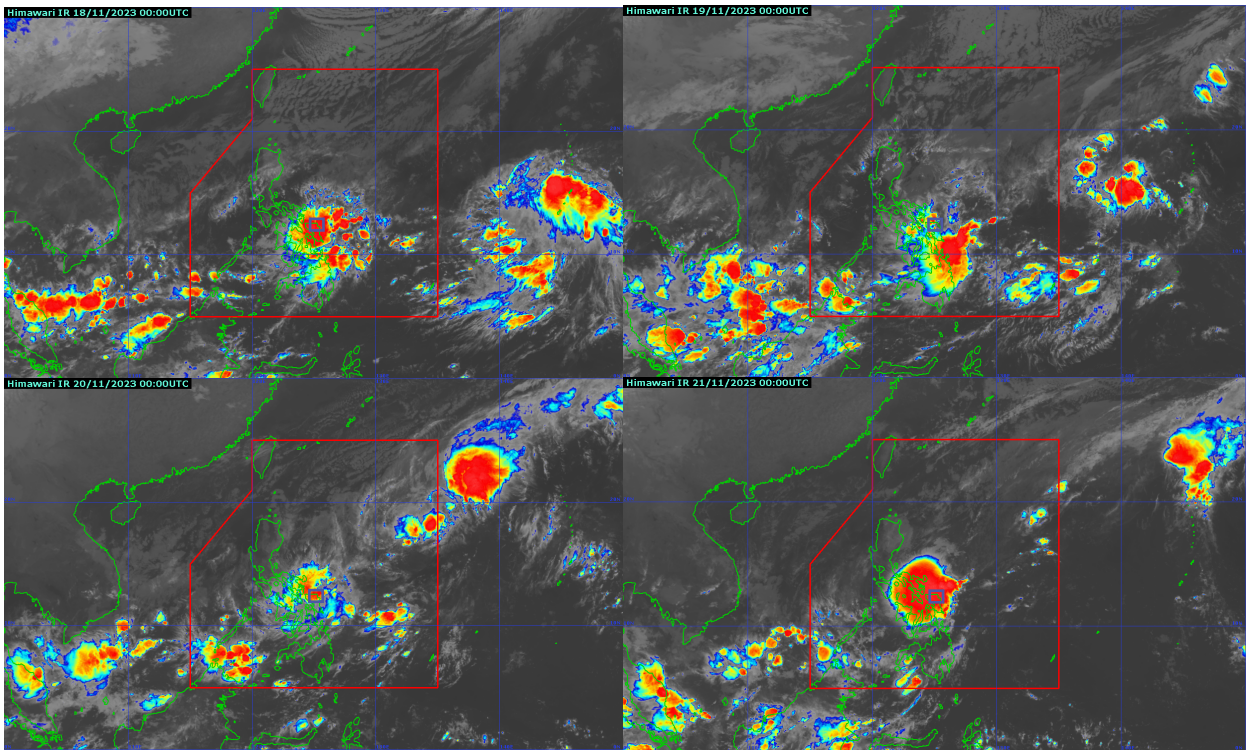
Neil John A. Miranda
Southern Luzon - PAGASA Regional Services Division

On 21 November 2023, various news media organizations reported on the widespread flooding in Northern Samar and the others asked for any assistance to be extended to the affected residents.

Reports say that the “Floods reached the second floor of some houses in Catarman, Lope de Vega and Catubig in Northern Samar as well as in Jipapad in Eastern Samar”.

WEATHER SITUATION

From 18 to 19 November 2023, Shearline/Trough of Low-Pressure Area caused cloudy skies with scattered rain showers and thunderstorms while on 20-22 November 2023 only Shearline brought cloudy skies with scattered rain showers and thunderstorms in Northern Samar.



Infrared Satellite imagery on 18-21 November 2023

The above figure displays infrared satellite images taken from 18 to 21 November 2023 at 0000 UTC. Noticeably, that there is high reflectivity in certain areas, indicating the possibility of heavy precipitation. The above dates recorded a significant amount of rainfall at PAGASA Catarman Synoptic Station signifying that the heavy precipitation observed in the satellite images indeed corresponded to the rainfall at the ground level. The small blue box in the images shows the location of Catarman, Northern Samar.

SIGNIFICANCE OF RAINFALL WARNING SYSTEM OF PAGASA

For countries like the Philippines, varying rainfall amounts could bring less or excessive rainfall that leads to inconveniences or even disasters. PAGASA's Rainfall Warning Systems (RWS) play a vital role in promoting the safety of its communities and economic sectors. The RWS is designed to alert concerned communities and emergency managers on heavy rainfall events that would cause flooding and disruption of activities. It is a nowcasting technique that bridges the gap of the 24-hour Local Weather Forecast issued every 5 AM and 5 PM daily.

There are two types of warnings under RWS, the Thunderstorm Warning System (TSTM-RWS) for short duration rainfall and the Heavy Rainfall Warning System (HR-RWS) for long duration rainfall. Rainfall warnings are three warning levels: Yellow, Orange and Red. Below is the current PAGASA HR-RWS warning levels and its description:

LEVELS	MEANING
Be Alert	Community AWARENESS FLOODING is POSSIBLE in low-lying areas and near river channels.
Be Prepared	Community PREPAREDNESS FLOODING is THREATENING in low-lying areas and near river channels.
Take Action	Community RESPONSE SEVERE FLOODING is EXPECTED in low-lying areas and near river channels.

In connection with the November 2023 Northern Samar flooding, Southern Luzon PRSD Forecasting issued an initial Yellow Warning Level of Heavy Rainfall Warning System on 18 November 2023 at 11:30 am in Northern Samar. A total of **ten Yellow, seven Orange, and eight Red Warning levels** were issued to Northern Samar from 18-22 November 2023. These advisories are vital to the concerned disaster managers and the public for their preparedness efforts and response.

According to Ms. Emerald E. Guevara, LDRRM Officer of Catarman, Northern Samar, "our office has been so grateful to Southern Luzon PAGASA for the weather updates and advisories you provide. We rely mostly on your data for our operations & warning". This is a testament that PAGASA products and services are vital to them and this aligns with the agency's mandate to provide adequate, up-to-date data, and timely information on weather-related phenomena to help government and the people prepare for calamities to afford greater protection to the people.

EFFECTS OF SHEARLINE RESULTED IN SIGNIFICANT CHANGES IN THE EXTREMES IN NORTHERN SAMAR

Situational Report No. 8 of the Municipal Disaster Risk Reduction and Management Office of Catarman on 21 November 2023, 2000H, states that the Shear Line caused widespread flooding in the municipality. Fifty-five barangays are affected with flood water ranging from one to three meters. Prior to 21 November 2023 flooding, some barangays were already flooded (Situational Report No. 2) starting 18 November 2023.

Governor Edwin Ongchuan placed the entire Province of Northern Samar under a state of calamity, on 21 November 2023.

Below is the detailed rainfall recorded at PAGASA Catarman Synoptic Station in November.

Day	24-hr Rainfall (mm)	Day	24-hr Rainfall (mm)
11/13	24.8	11/18	136.0
11/14	59.3	**11/19**	**185.9**
11/15	8.7	**11/20**	**618.8**
11/16	25.8	**11/21**	**77.7**
11/17	19.2	11/22	88.9

The table on the left gives us information that prior to 20 November 2023, there were already significant rainfall amounts received in the area before the widespread flooding happened.

19 November		**20 November**		**21 November**	
Time (UTC)	*Rainfall Amount (mm)*	*Time (UTC)*	*Rainfall Amount (mm)*	*Time (UTC)*	*Rainfall Amount (mm)*
0000z - 0600z	9.8	0000z - 0600z	50.9	0000z - 0600z	73.7
0600z - 1200z	50.3	0600z - 1200z	10.2	0600z - 1200z	0.6
1200z - 1800z	56.6	1200z - 1800z	182.6	1200z - 1800z	3.4
1800z - 2400z	69.2	1800z - 2400z	375.5	1800z - 2400z	Trace
TOTAL	**185.9**		**618.8**		**77.7**

The table above shows the 6-hourly rainfall amount on 19-21 November 2023. Continuous significant amount of rainfall was recorded. The 6-hourly rainfall (1800z-2400z) amount received on 20 November 2023 is 375.5 mm. It is more than 80% of the November monthly rainfall (457.8 mm). The total amount of rainfall on that day is 618.8 mm, exceeding the monthly normal for the whole month. Further, the 618.8 mm recorded daily rainfall is now the greatest rainfall recorded in Catarman Synoptic Station since the start of rainfall recordings in 1919. It surpasses the 605.5 mm (02 December 2019) rainfall which was the greatest rainfall from 1919 to 2022.

Below are some of the pictures from the DRRMO-Catarman on the effects of the widespread flooding in the area.

Sudden rise of the water level of Catarman River, Catarman, Northern Samar. Photos from DRRMO Catarman.

Flooding caused by continous and heavy downpour of rainfall in Catarman, Northern Samar. Photos from DRRMO Catarman.

Rescue operation to the stranded residents of Catarman, Northern Samar. Photos from DRRMO Catarman.

CHAPTER 7:
METHODOLOGY

REANALYSIS AND OTHER DATASET PRODUCTS

The atmospheric reanalysis is obtained and downloaded from the Japanese Reanalysis 55-year data product from https://rda.ucar.edu/datasets/ds628.1/.

The sea surface temperature data are obtained and downloaded from Centennial in situ Observation-Based Estimates SST version 2 dataset product (https://psl.noaa.gov/data/gridded/data.cobe2.html) while the Oceanic Nino Index is based on the Climate Prediction Prediction of the National Oceanic and Atmospheric Administration (https://origin.cpc.ncep.noaa.gov/products/).

The global mean temperature is based on the downloaded data from the National Aeronautical and Space Administration (https://data.giss.nasa.gov/gistemp/).

The Real-time Multivariate MJO index was obtained and downloaded from the Australian Bureau of Meteorology via http://www.bom.gov.au/climate/mjo/.

The tropical cyclone data are from the Climate and Agrometeorological Data Section (CADS), Climatology and Agrometeorology Division (CAD) of the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), Department of Science and Technology (DOST) (https://www.pagasa.dost.gov.ph/).

OBSERVED DATA, SCALE OF ANALYSIS AND STATISTICAL TESTS

The observed monthly rainfall and temperature data are obtained from 56 PAGASA Synoptic Stations from 1991-2023. The scale of analysis used the annual and seasonal terms defined as January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively. Unless otherwise stated, the observed data and its indicated standardized anomalies presented in this report are based on the climatological standard normal period 1991-2020. Similarly, the ranked historical data begins in 1991 to account for the new climatological standard normal as well as the increase in the number of observations at the same time.

REFERENCES

Bagtasa G. Influence of Madden–Julian Oscillation on the Intraseasonal Variability of Summer and Winter Monsoon Rainfall in the Philippines. J. Clim. (2020)

Basconcillo, J. et al. Influence of multiyear variability on the observed regime shifts in Philippine climatology. Asia-Pac. J. Atmos. Sci. (2022).

Copernicus Climate Change Service. Global Climate Highlights 2023: Copernicus: 2023 is the hottest year on record, with global temperatures close to the 1.5°C limit. https://climate.copernicus.eu/copernicus-2023-hottest-year-record Accessed 12 February 2024.
Earth Networks. Earth Networks Total Lightning Solution Philippines. (2019).

Kobayashi, S. et al. The JRA-55 Reanalysis: General specifications and basic characteristics. J. Meteorol. Soc. Japan (2015).

Lyon, B. et al. Seasonal reversal of the ENSO rainfall signal in the Philippines. Geophys. Res. Lett. (2006)

Madden, R. & Julian, P. Description of global-scale circulation cells in tropics with a 40–50 day period. J. Atmos. Sci. (1972).

National Aeronautical and Space Administration. Global Mean Land/Ocean Temperature. https://data.giss.nasa.gov/gistemp/tabledata_v3/GLB.Ts+dSST.txt Accessed 12 February 2024.

National Oceanic and Atmospheric Administration. 2023 was the world's warmest year on record, by far. https://www.noaa.gov/news/2023-was-worlds-warmest-year-on-record-by-far. Accessed 12 February 2024.

National Oceanic and Atmospheric Administration. Oceanic Nino Index. https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php Accessed 12 February 2024.

Pampanga Provincial Disaster Risk Reduction and Management Council. Final Report RE: Effect of Localized Thunderstorm and Reported Tornado Incident in Bacolor, Pampanga. (2023).

Philippine Atmospheric, Geophysical and Astronomical Services Administration. Tropical Cyclone Preliminary Report. https://www.pagasa.dost.gov.ph/tropical-cyclone/publications/preliminary-report
Accessed 28 February 2024.

Wheeler, M. & Hendon, H. An all-season real-time multivariate MJO index: Development of an index for monitoring and prediction. Mon. Weather Rev. (2004)

World Meteorological Organization. State of the Climate in South-West Pacific 2022. WMO No. 1324. https://reliefweb.int/report/world/state-climate-south-west-pacific-2022

https://mb.com.ph/2023/11/21/1-killed-370-000-individuals-displaced-by-flooding-in-n-samar

https://www.philstar.com/nation/2023/11/22/2313259/thousands-displaced-floods-hit-eastern-visayas

PDRRMO, Pampanga (2023): Final Report Re: Effects of Localized Thunderstorm and Reported Tornado Incident in Bacolor, Pampanga, Dated 29 June 2023

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Suggested citation: Basconcillo, J., Aquino, K., Ison C., et al. 2023 Annual Climate Bulletin. Philippine Atmospheric, Geophysical and Astronomical Services Administration (2024). http://dx.doi.org/10.13140/RG.2.2.27167.57768