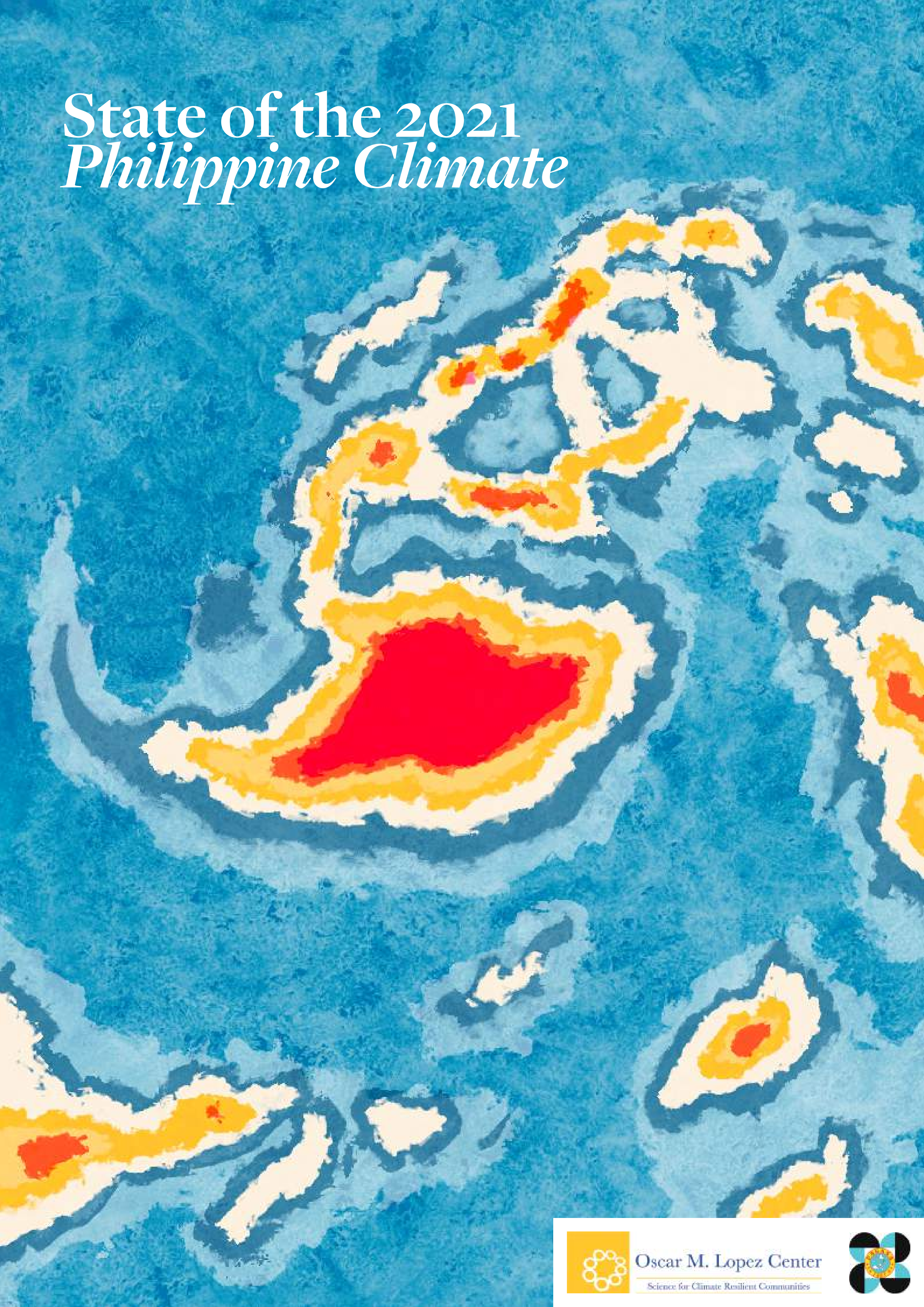
State of the 2021 *Philippine Climate*



Oscar M. Lopez Center
Science for Climate Resilient Communities

State of the 2021 Philippine Climate

This is the eighth of a series of annual reports titled State of the Philippine Climate. Available at: www.omlopezcenter.org/state-of-the-philippine-climate

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State of the 2021 *Philippine Climate*

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About the Publication

The *State of the Philippine Climate* (*SPC*) is an annual report that provides a summary of observations of the country's essential climate variables, as well as notable climatic and weather events. This publication is based on data provided by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), National Disaster Risk Reduction and Management Council (NDRRMC), and other national and international institutions. The primary goal of this annual climate report is to efficiently disseminate necessary climate information that can aid policy makers, local government units, and other stakeholders in their decision making processes toward science-based climate change adaptation and disaster risk management.

Effective communication of climate information to relevant stakeholders and the general public is one key step toward building a climate-resilient society. Such information allows the authorities to better visualize the implications and make informed decisions that could help the general public adapt to a changing climate.

This 2021 SPC report gives a brief but comprehensive overview of climate indicators (e.g. temperature, rainfall, ENSO, tropical cyclones) and the patterns, changes, and trends representing the country's climate in 2021. Several climatological records that have been broken or equaled, as well as climate anomalies and significant extreme events and their impacts are also presented.

About the Cover

The cover art is a digital illustration of Typhoon Maring (Kompasu 2021) by designer Enrico Cruz, with various textures used to represent the thalassic nature of the Philippines.

The cover derives from PAGASA's satellite image, taken October 21, 2021. Cool and warm colors helped visualize Typhoon Maring's heat signatures.

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Message from OML Center

In 2021, the global pandemic crippled the country, even as mass vaccination offered a glimmer of hope. The easing of restrictions allowed the economy to breathe in what we now call "the new normal". While all these are happening, climate change remains an ever-present danger to the Philippines. Its impacts send a message across classes, cultures, systems, and institutions—human driven global heating is part of the "new normal".

The State of the Climate 2021 highlights the weather and climate hazards the country has experienced during the past year. In addition, this publication shows how developing countries like the Philippines suffer from the consequences of missed opportunities to take climate action across the globe. Typhoon Odette (Rai), which affected at least 78% of the country's total population and left thousands of casualties, is only one event in the climate battle in 2021. Weather systems continue to change over time. For instance, Typhoon Maring (Kompasu) enhanced the southwest monsoon spawning unprecedented amount of rainfall which led to landslides and flooding in unsuspecting communities and causing at least P7 billion worth of damages.

The OML Center expresses its gratitude to our partners in the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the National Disaster Risk Reduction and Management Council (NDRRMC), and other institutions who tirelessly supported us in generating climate knowledge for the public. The Center hopes that this resource may not only be a reference for critical decision-making for climate change adaptation, but one of a thousand flickers that can spark various stakeholders to take action.

Rodel D. Lasco, PhD
Executive Director
Oscar M. Lopez Center

Message from PAGASA

Following the release of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), this report intends to provide an update on the status of weather and climate and relevant events in the Philippines for 2021.

As the global temperature continues to rise and the ocean accumulates more heat, more rapidly intensifying and destructive tropical cyclones were experienced by the country. Although less tropical cyclones (TCs) entered the PAR in 2021, the devastation incurred almost PHP 20 billion more than the previous year. With climate change, the exacerbation of these socio-economic impacts typical of climate-related hazards are expected and are even becoming more evident.

The daunting impacts of climate change call us to take evidence-based, climate-informed decisions and actions. With this report, we hope to equip local planners as well as the general public with the latest climate information to increase awareness and help in planning and developing climate change adaptation plans and mitigation strategies toward a sustainable future.

Vicente B. Malano, PhD
Administrator
PAGASA

Key Findings

What happened in 2021?

Temperature

Hotter-than-normal conditions prevailed throughout most of 2021. The annual daytime (maximum) temperature was warmer than normal by 0.01 °C, while the nighttime (minimum) temperature was warmer than normal by 0.4 °C.

The average temperature for 2021 in the country is 27.8 °C. This was 0.2 °C warmer than the 1991–2020 baseline temperature and 0.2 °C cooler than the country's average temperature in 2020.

Rainfall

2021 is the country's 11th wettest year since 1960. Throughout the year, Visayas and Mindanao experienced above-normal rainfall conditions while below- to near-normal rainfall conditions prevailed across Luzon.

The above-normal rainfall conditions are attributed to the active La Niña conditions in addition to monsoon surges, shear line and the passage of tropical cyclones.

Tropical Cyclones

Fifteen TCs entered the Philippine Area of Responsibility (PAR) in 2021, lower than the long-term average of 19–20 TCs per year. Eight TCs made landfall in the country, and five reached Typhoon category.

Among the 2021 TCs, STY Odette affected the most number of individuals and incurred the costliest damages of around PHP 52 billion to both agriculture and infrastructure.

ENSO

The La Niña conditions that began in 2020 persisted in 2021.

The prolonged cool phase of ENSO had a temporary cooling effect on the average mean temperature for 2021 and contributed to the above-normal rainfall received by most parts of the country.

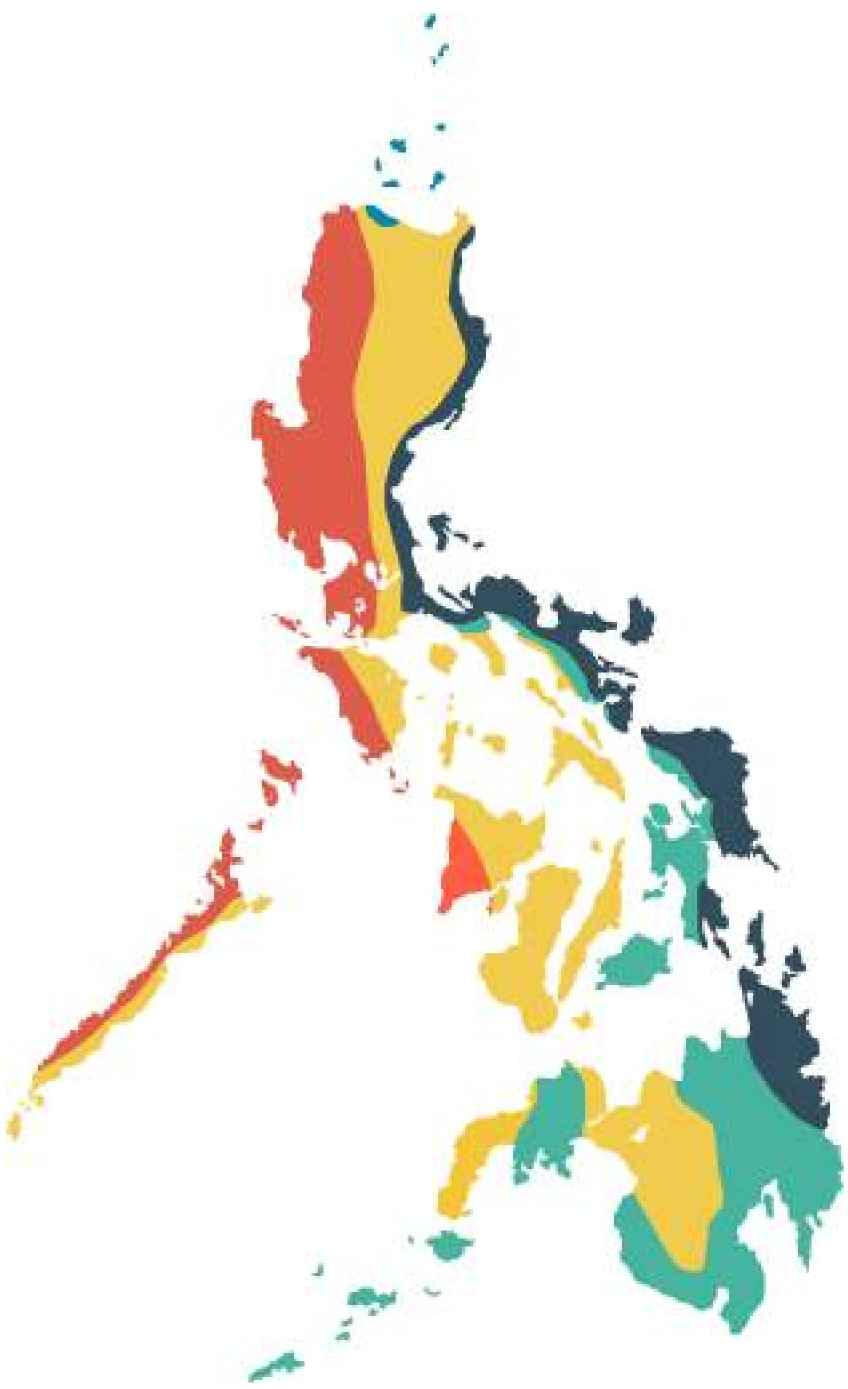
Climate Trends

Climate Types

The Philippine climate is characterized by relatively high temperatures, small temperature range, and abundant rainfall.

Due to its geographic location and archipelagic nature, the country receives an uneven distribution of rainfall throughout the year. In general, the country has four major climate types based on rainfall distribution as shown in Figure 1.

Figure 1
Four climate types of the Philippines based on Modified Coronas Classification System



Type I

Two pronounced seasons, dry from November to April and wet during the rest of the year.

Type II

No dry season with a pronounced rainfall from November to January.

Type III

Seasons are not very pronounced; relatively dry from November to April and wet during the rest of the year.

Type IV

Rainfall is more or less evenly distributed throughout the year.

PAGASA Synoptic Stations

The climate information used in this report were obtained from the PAGASA synoptic weather stations across the country.

The map in Figure 2 shows the location of these 54 operational stations. This map could be used as reference for the maps and figures in the next sections of this report.

Figure 2
Map of PAGASA Synoptic Stations

Climatological Normals

Climatological normals are 30-year averages of different climate variables.

These are routinely updated every ten years to provide the best estimates for the changing climate, including assessing climate events and establishing climate trends. These are used to assess anomalies or deviations in different variables.

Table 1 shows how the 2021 Philippine climate deviates from the 1991–2020 normal. The country-wide average temperature increased by 0.2 °C, and the average minimum temperature rose by 0.4 °C.

The country received more rainfall than the baseline records. Meanwhile, only 15 tropical cyclones entered PAR which is below the annual average.

The coldest month is January while the warmest month is May, both with a temperature that is 0.3 °C warmer than the average.

Table 1

A comparison of 2021 temperature, rainfall, and tropical cyclone observations with the climatological normals.

Climate Variables	1991 – 2020	2021
Annual Average Mean Temperature	27.6 °C	27.8 °C
Annual Average Minimum Temperature	23.8 °C	24.2 °C
Annual Average Maximum Temperature	31.4 °C	31.4 °C
Annual Average Rainfall	948 – 4,762 mm	980 – 6,865 mm
Annual Average number of TCs	19–20	15
Monthly Average Temperature	25.7 °C (January, coldest)	26.0 °C (January, coldest)
	28.6 °C (May, warmest)	28.9 °C (May, warmest)

Temperature

Temperature

The global average land and ocean surface temperatures for 2021 were 0.84 °C above the 20th-century average, making 2021 the **sixth warmest year** on record (NOAA, 2022). However, the **ocean heat content** (the amount of heat stored in the upper levels of the ocean) reached **a record high in 2021**, surpassing the previous record set in 2020 (NOAA, 2022). It is important to note that while land and ocean surface warming are the main manifestations of heating, more than 90% of heat accumulates in the ocean.

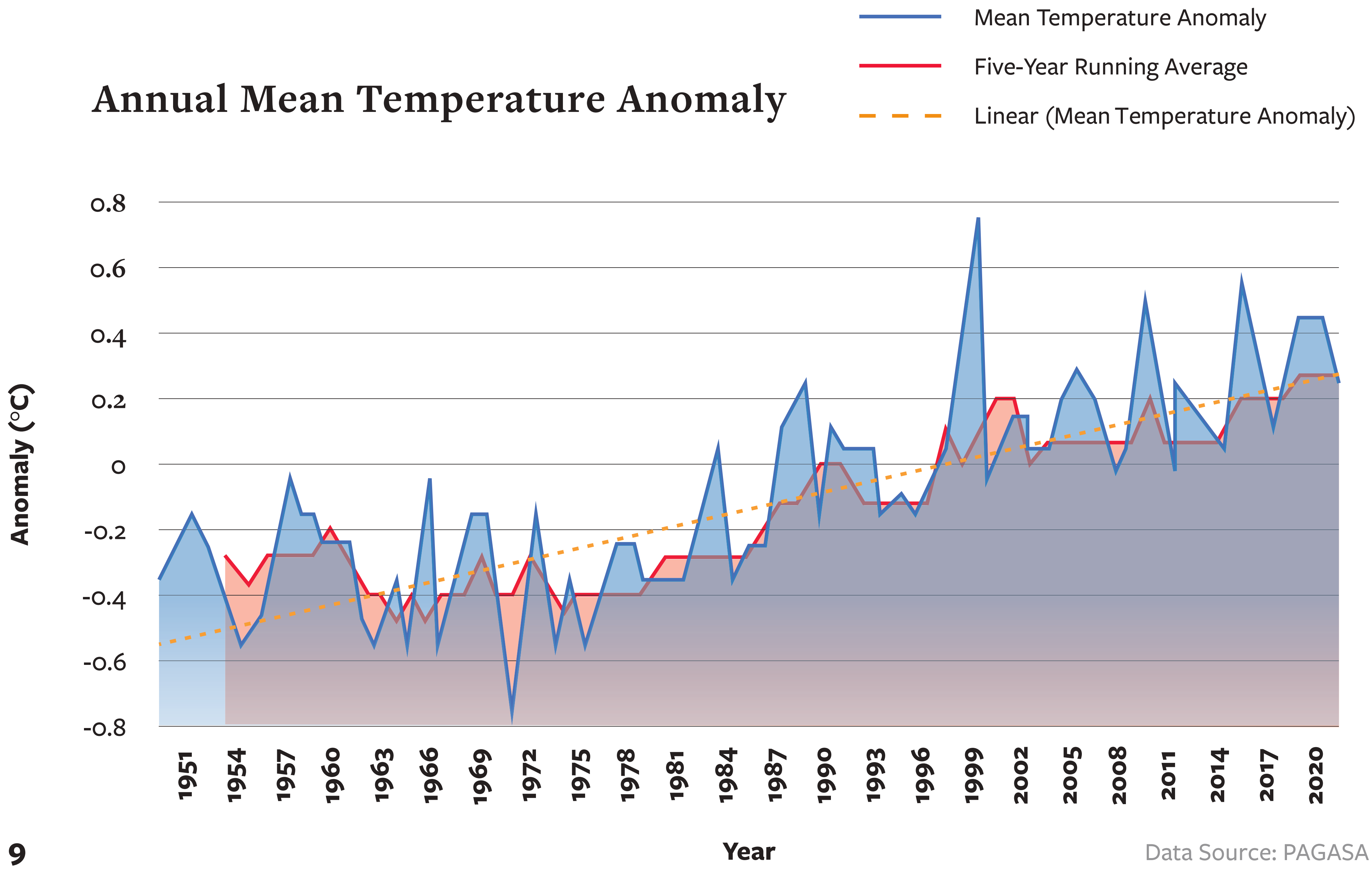
For Asia, 2021 marked the 34th consecutive year with above-average temperatures. With an anomaly of 1.6 °C (from the 1910-2000 base period), 2021 stands as Asia's **seventh warmest year** on record (NOAA, 2022).

The country's annual mean temperature anomaly showed interannual variability, but an increasing trend (of 0.1 °C per decade) is apparent.

To date, 2021 is the 8th warmest year, with an annual average temperature that is 0.2 °C warmer than the 1991-2020 normal. Both warmest and coldest temperatures also exceeded normal values by at least 0.01 °C (PAGASA, 2022).

Figure 3

National annual average mean temperature anomalies (relative to 1991–2020 normals) from 1951 to 2021.



Data Source: PAGASA

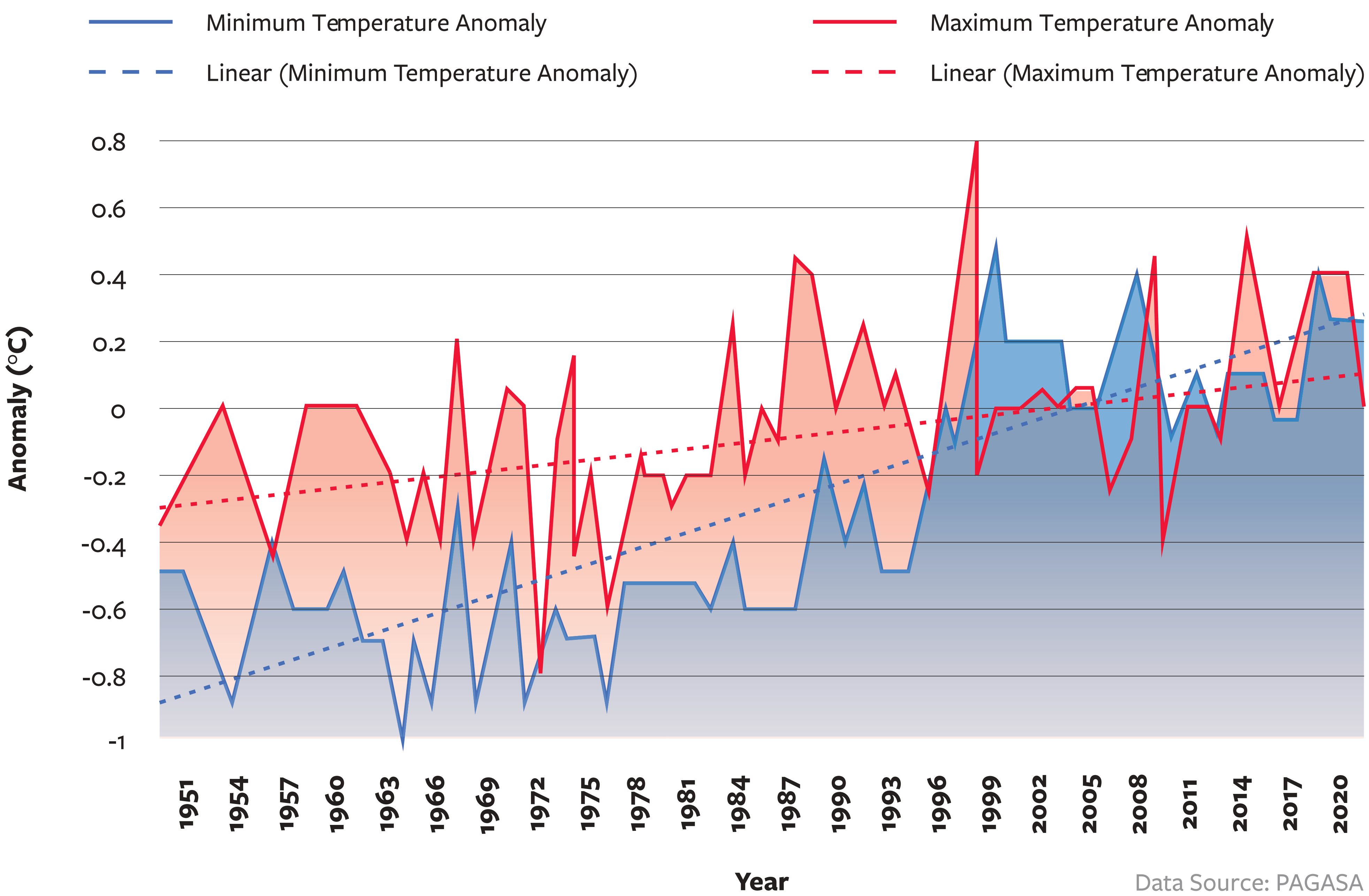
Maximum and Minimum Temperature Anomalies

Both daytime (maximum) and nighttime (minimum) temperature anomalies exhibit interannual variability, but the increasing trend is also evident. Nighttime temperatures have been hotter than normal since 1995.

For 2021, annual daytime and nighttime temperatures were both warmer than normal by 0.01 °C and 0.4 °C, respectively. The year 1998 still holds the record for the highest daytime (0.8 °C) and nighttime (0.5 °C) temperature anomalies.

Figure 4
National annual maximum and minimum temperature anomalies (relative to 1991–2020 normals) from 1951 to 2021.

Annual Temperature Anomaly



The maps show the distribution of daytime and nighttime temperature anomalies experienced in the country in 2021.

Among the 54 PAGASA synoptic stations, 16 recorded above-normal daytime temperatures while 17 recorded below-normal daytime temperatures. Stations in Zamboanga (Zamboanga del Sur) and Cotabato City (Maguindanao) exhibited the highest anomalies with 1.3 °C, and 1.1 °C increase above normal, respectively.

Two stations recorded a decrease of more than 1 °C in daytime temperature. The largest decrease was recorded by General Santos (South Cotabato) with 1.3 °C decrease.

Highest daytime temperature deviations from normal were mostly recorded in July, which coincided with the short break (June-August 2021) of the persisting La Niña conditions.

Twenty-six (26) stations recorded above-normal nighttime temperatures while seven recorded below-normal nighttime temperatures.

Iba (Zambales) station recorded the largest increase with 1.2 °C anomaly followed by Alabat (Quezon) with 1.1 °C warmer nighttime temperatures. Meanwhile, General Santos (South Cotabato) and Daet (Camarines Norte) stations recorded the largest decrease with temperature 0.6 °C lower than normal.

Figure 5
Annual daytime temperature anomalies for 2021 of selected PAGASA Stations.

Maximum Temperature Anomaly in °C

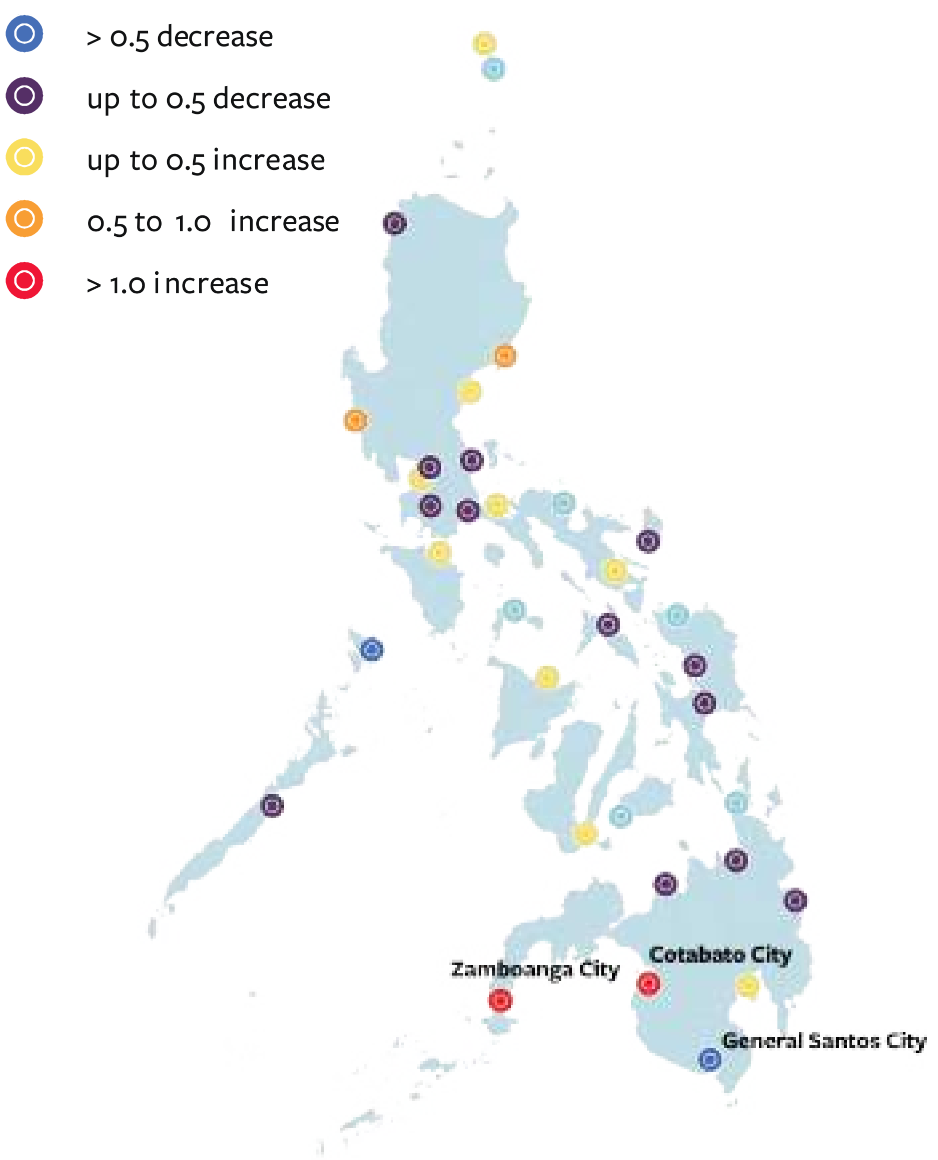
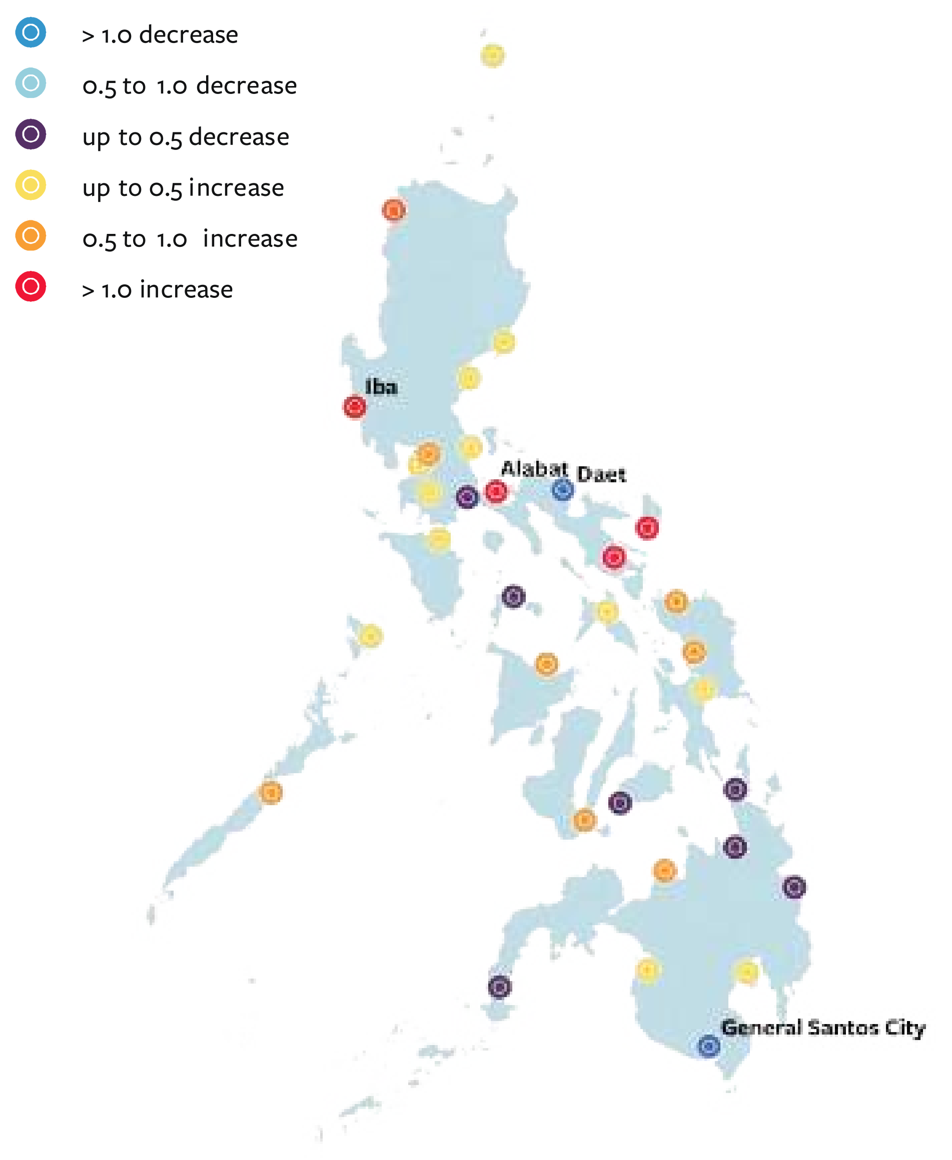


Figure 6
Annual nighttime temperature anomalies for 2021 of selected PAGASA Stations.

Minimum Temperature Anomaly in °C

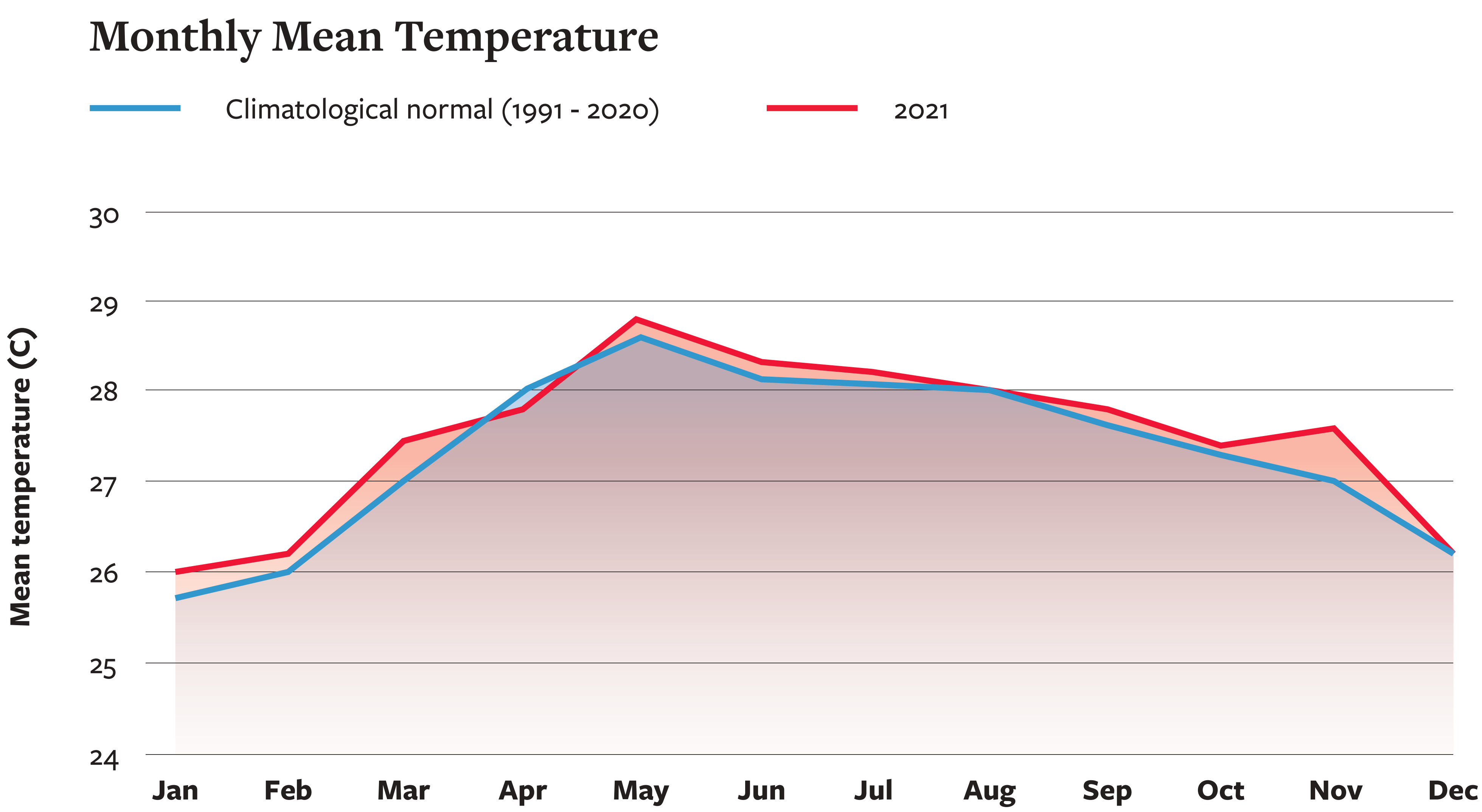


Monthly Average Temperature

Hotter-than-normal conditions were recorded in 2021. These warmer conditions are attributed to temperature increases ranging from 0.1 to 0.7 °C. December recorded a normal mean temperature while April was 0.3 °C cooler than its average.

May is the warmest month with a mean temperature of 28.9 °C, that is 0.3 °C warmer than its normal temperature. November recorded the largest departure from its average temperature with an increase of 0.6 °C. The coolest month of the year is January with 26.0 °C mean temperature (but 0.3 °C higher than its normal).

Figure 7
Monthly average temperature in 2021 relative to 1991–2020 baseline.



Data Source: PAGASA

Rainfall

Total Annual Rainfall

2021 is the country's 11th wettest year since 1960. With the ongoing La Niña state of the tropical Pacific since September 2020 (with a short break in June-August 2021), majority of PAGASA's synoptic stations in Visayas and Mindanao recorded above-normal rainfall.

Borongan (Eastern Samar) station recorded the highest rainfall amounting to more than 6,800 mm of rain. On the other hand, Zamboanga (Zamboanga del Sur) station received the least with 1,083 mm.

Rainfall Anomaly

Five stations recorded an increase of atleast 1,000 mm of rainfall. Borongan (Eastern Samar) and Virac (Catanduanes) stations, both located on the eastern side of the country, received the highest additional rainfall for the year. Majority of PAGASA's synoptic stations in Visayas and Mindanao recorded above-normal rainfall.

Meanwhile, Sangley Point (Cavite) station recorded the largest deficit of 736.8 mm of rainfall.

Figure 8

Total accumulated rainfall for 2021.

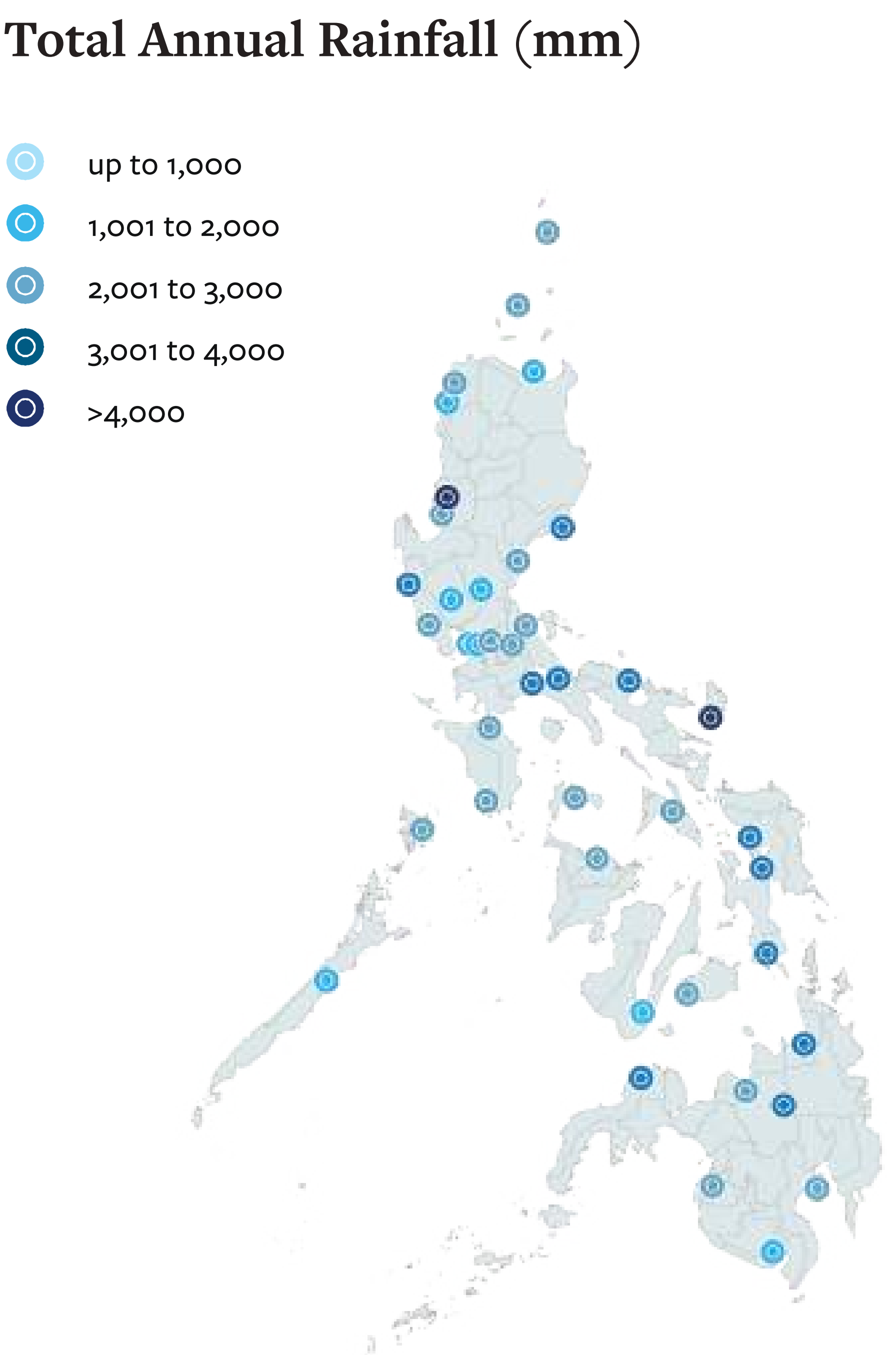
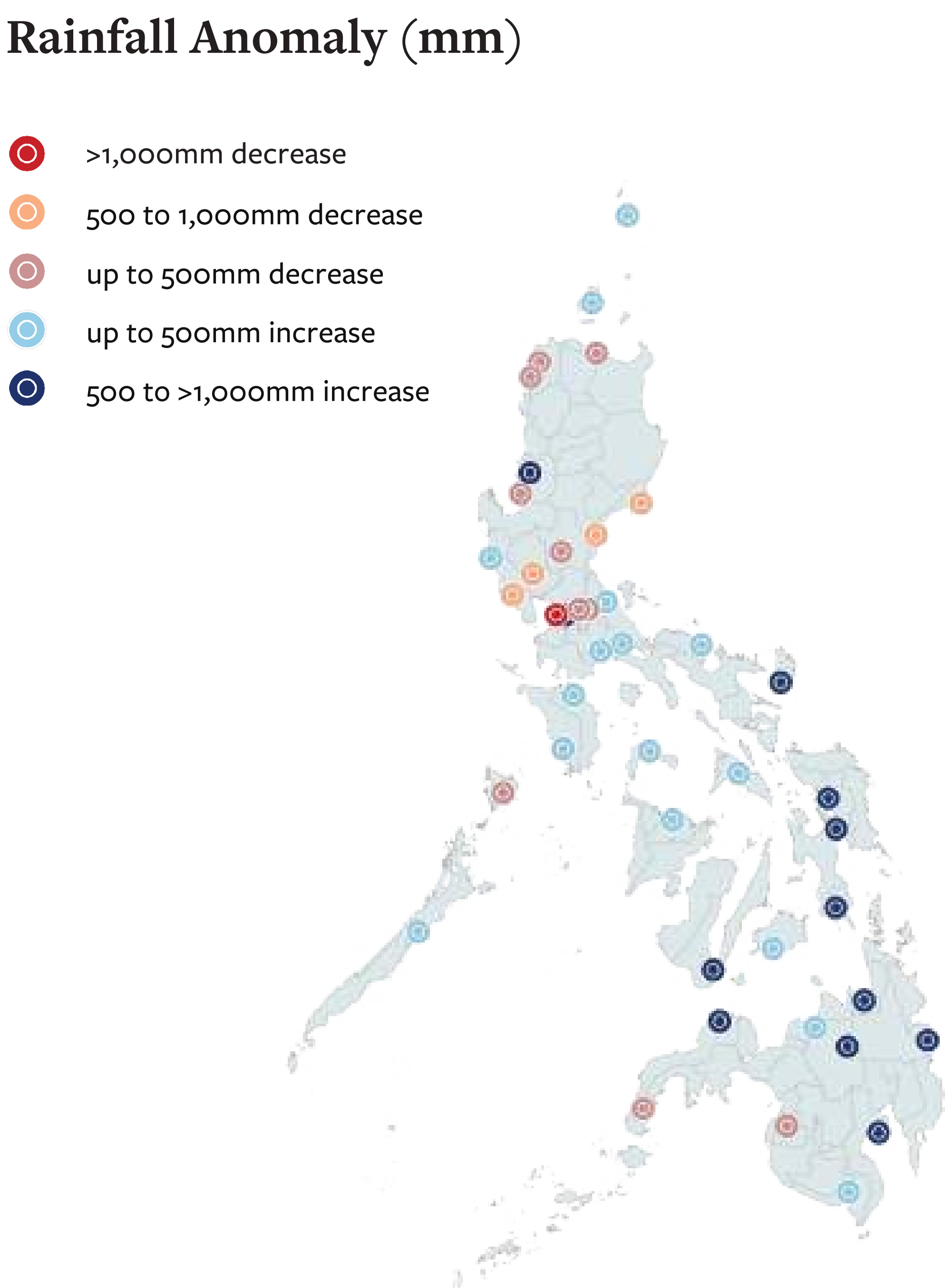


Figure 9

Annual rainfall anomaly (relative to 1991–2020 base period) for 2021.



Percent of Normal Rainfall

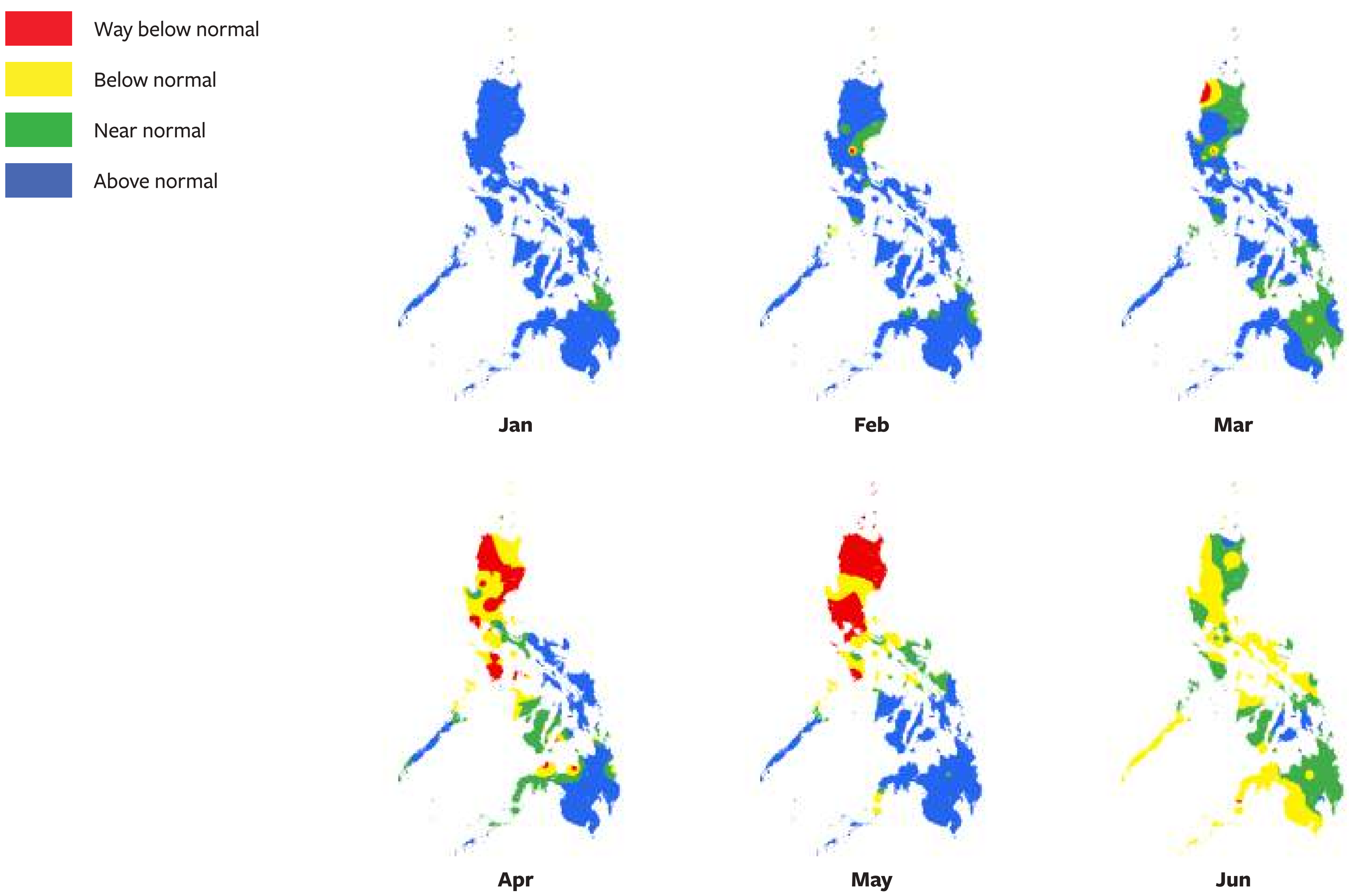
The Philippines experienced a near-normal to above-normal rainfall conditions in 2021.

Above-normal conditions (>120% of normal rainfall) were experienced during the first quarter as well as in July and October. Only August received below-normal (41-80%) rainfall while the remaining six months recorded near-normal conditions (81-120%).

The rain-bearing weather systems that prevailed during the first half of 2021 were the northeast (NE) monsoon, shear line, easterlies, low pressures areas (LPAs), localized thunderstorms, intertropical convergence zone (ITCZ), ridge of high pressure area (HPA), and 4 tropical cyclones (STS Auring, TY Bising, and TS Crising and Dante.)

Figure 10a

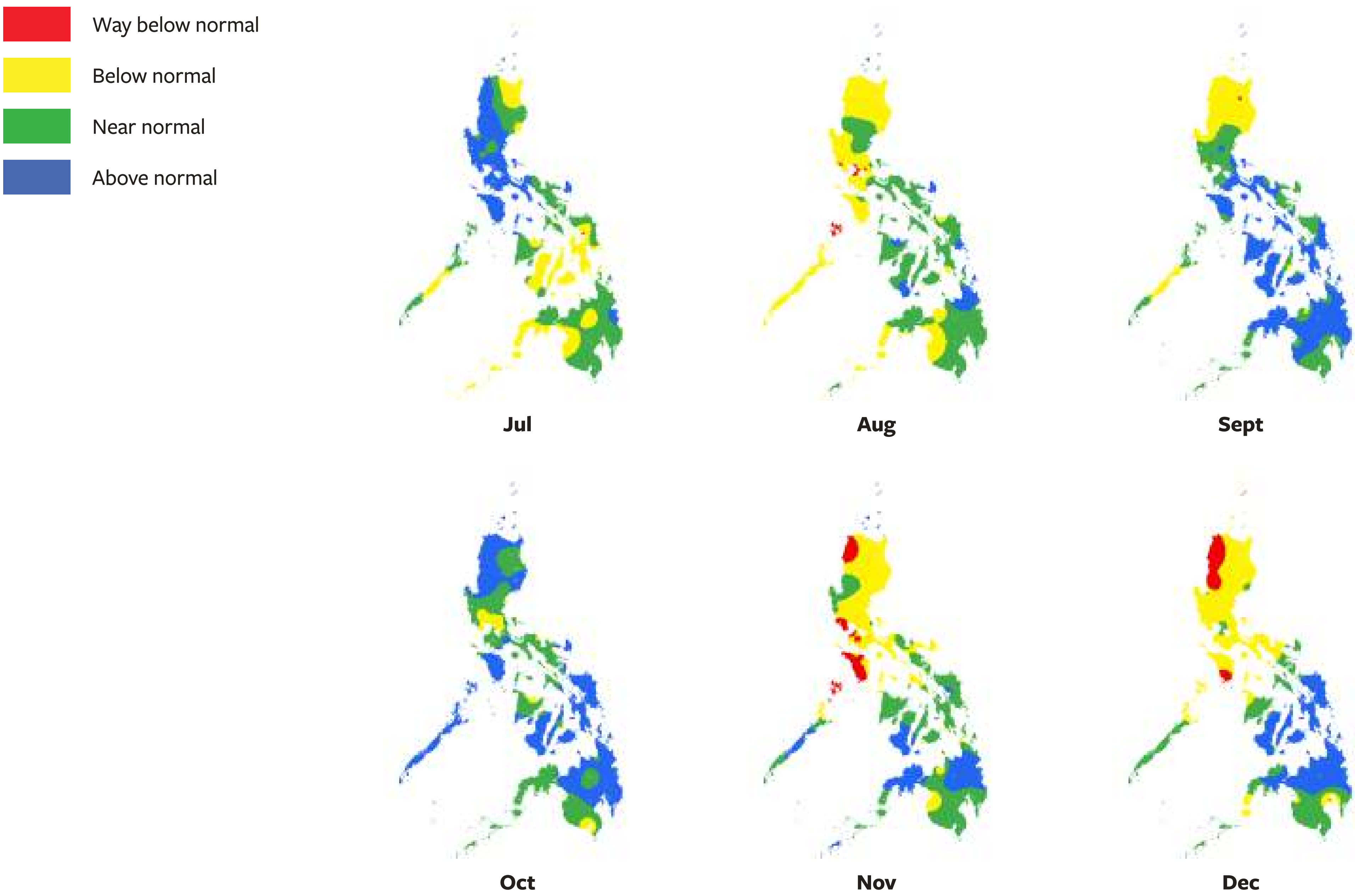
Percentage of observed total monthly rainfall relative to 1991–2020 reference period in 2021. Blue colors represent areas with above normal (>120%) rainfall conditions, while green colors depict near normal (81–120%) conditions. Areas with below normal (41-80%) conditions are in yellow, while areas under way below normal (≤40%) rainfall conditions are in red.



For the remaining six months, the active weather systems were the easterlies, SW monsoon, LPAs, ridge of HPAs, ITCZ, localized thunderstorms, and 11 TCs.

Figure 10b

Percentage of observed total monthly rainfall relative to 1991–2020 reference period in 2021. Blue colors represent areas with above normal (>120%) rainfall conditions, while green colors depict near normal (81–120%) conditions. Areas with below normal (41-80%) conditions are in yellow, while areas under way below normal (≤40%) rainfall conditions are in red.



Maximum 1-day Rainfall

Among the 54 PAGASA synoptic stations,Baguio (Benguet) received the highest maximum 1-day rainfall on October 11, 2021. This was during the passage of Severe Tropical Storm (STS) Maring (Kompasu) over the northern coasts of Luzon. A total of 625.3 mm of rain accumulated within 24 hours. This exceeded the monthly normal rainfall received by the station by almost 150 mm.

In addition to Baguio, six other stations exceeded their respective monthly normal rainfall: Itbayat and Basco (Batanes), Maasin (Southern Leyte), Surigao (Surigao del Norte), Virac (Catanduanes) and Dagupan City (Pangasinan) as shown in Table 2.

Except for Dagupan (Pangasinan) and Baguio (Benguet), the stations that recorded the highest maximum 1-day rainfall are all located on the eastern side of the country as shown on the map. This can be attributed to the tropical cyclones, northeast monsoon and other rain-bearing weather systems that are most active during the last two quarters of the year.

Table 2

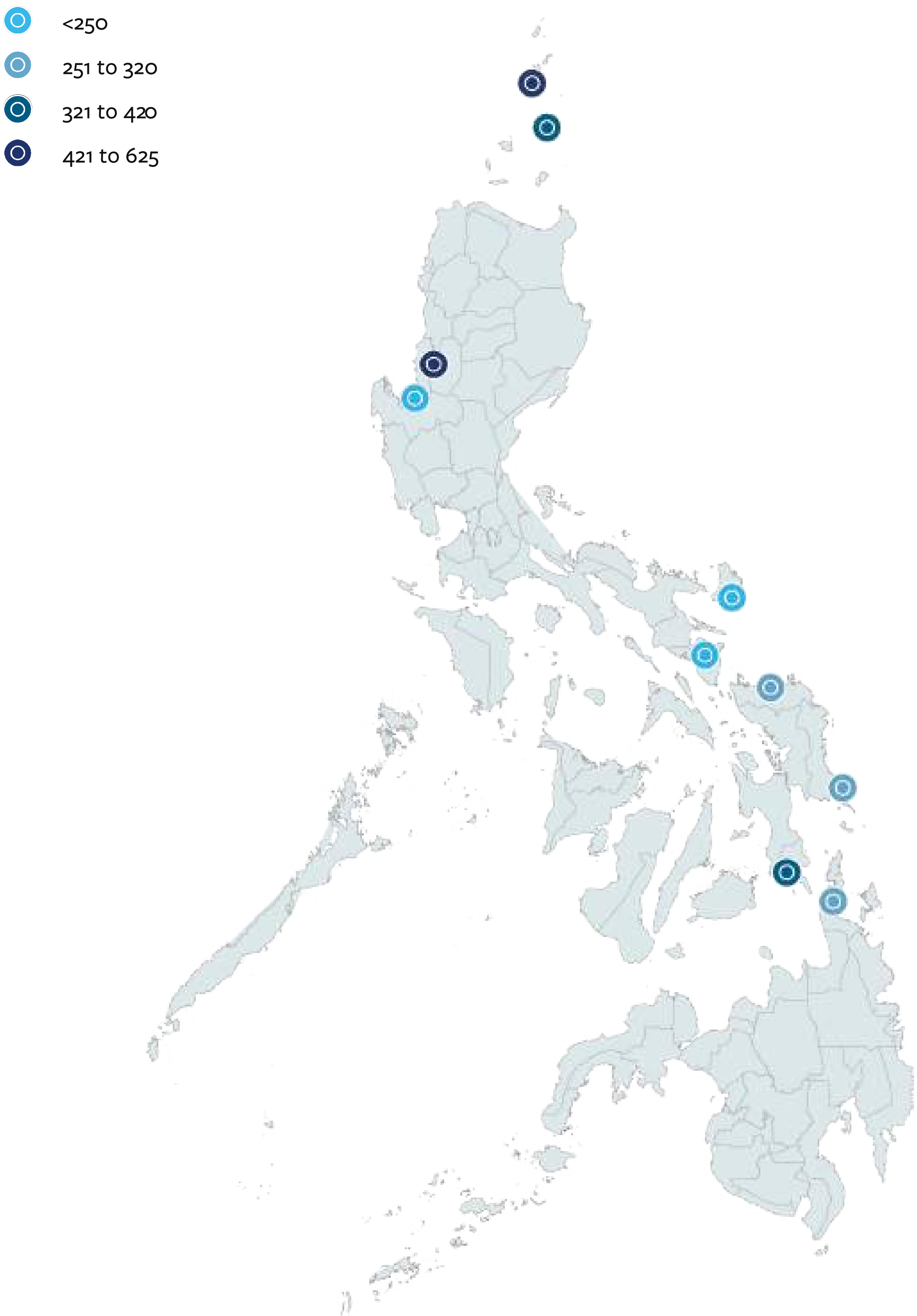
Top 10 PAGASA synoptic stations with highest maximum 1-day observed rainfall

Station	Date of Occurence	1-Day Observed Rainfall	Monthly Normal Average (mm)
Baguio, Benguet	October 11	625.3	477.3
Itbayat, Batanes	September 11	510.0	292.6
Basco, Batanes	September 11	420.7	343.3
Maasin, Southern Leyte	June 1	395.4	160.6
Surigao, Surigao del Norte	October 30	320.9	250.3
Catarman, Northern Samar	December 27	302.7	689.9
Guiuan, Eastern Samar	December 8	287.3	501.0
Virac, Catanduanes	April 19	252.2	140.5
Juban, Sorsogon	December 27	248.2	no record
Dagupan City, Pangasinan	October 11	241.3	226.6

Figure 11

Distribution of the maximum 1-Day Rainfall observed across the country in 2021.

Maximum 1-Day Rainfall (mm)



Climatological
Extremes

Climatological Extremes

Climatological records of daily temperature and rainfall were broken in 27 out of 54 stations in 2021.

Twelve of those stations registered at least one new record for highest daily temperature. Clark (Pampanga) had the most number of highest daily temperature records broken for a single station, with highest daily temperatures surpassed in March, June, September, and November.

Multiple records for highest daily temperature were also broken in Cotabato City (Maguindanao), Hinatuan (Surigao del Sur), El Salvador (Misamis Oriental), Malaybalay (Bukidnon), and Zamboanga (Zamboanga del Sur).

For lowest daily temperatures, Daet (Camarines Sur), San Jose (Occidental Mindoro) and Surigao (Surigao del Norte) stations broke their previous records. Among these stations, Surigao broke multiple records in July and October.

New records for greatest daily rainfall were set in sixteen stations (shown in Table 3). Of these, Basco (Batanes) had the highest amount, recording 420 mm in September.

Figure 12
PAGASA stations where climatological records were broken in 2021.

Temperature & Rainfall Extremes

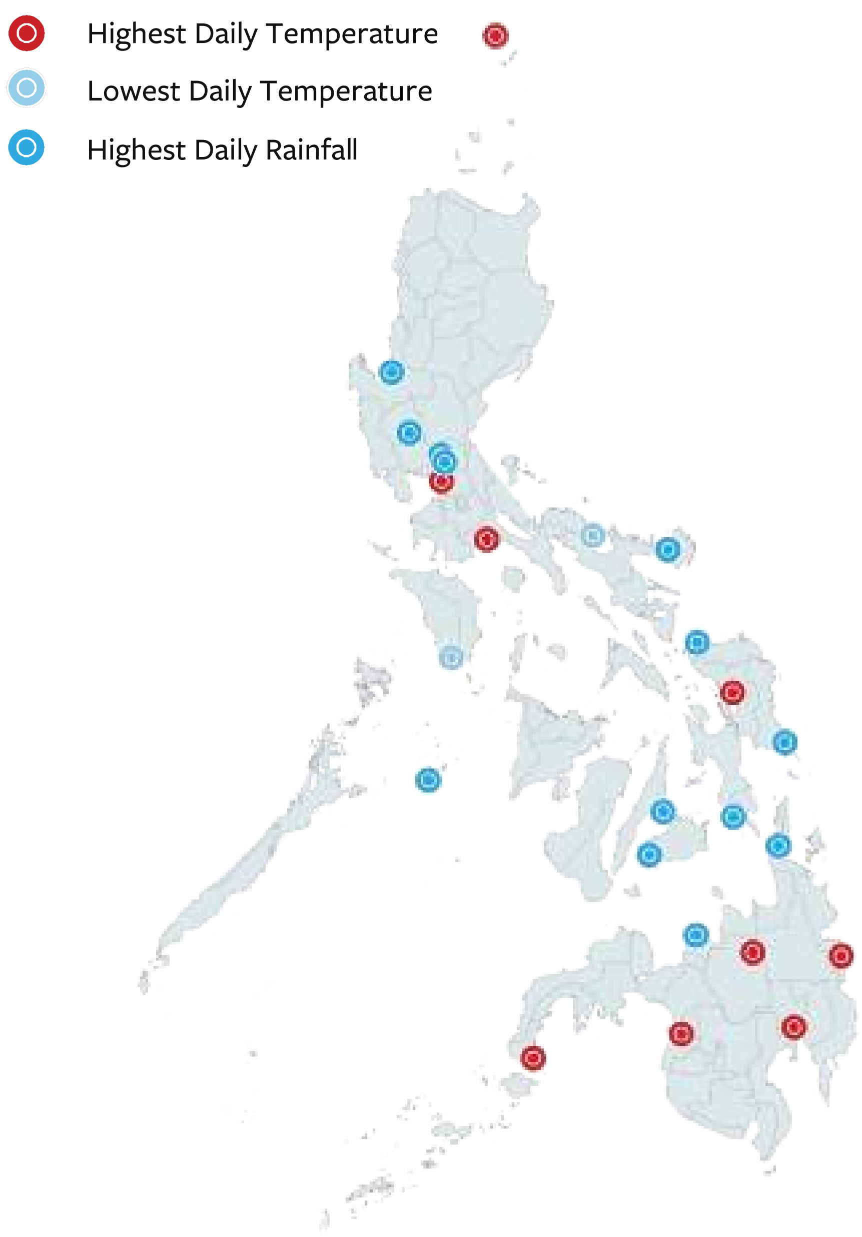


Table 3

Climatological extremes broken or equaled in 2021

Weather Station	Records Broken/ Equalled	Highest Daily Temperature (°C)	Date	Lowest Daily Temperature (°C)	Date	Greatest Daily Rainfall (mm)	Date
Basco Batanes	Previous					380.1	09-26-1974
	New					420.7	09-11-2021
Catarman Northern Samar	Previous					167.5	04-25-1996
	New					265.5	04-18-2021
Catbalogan Western Samar	Previous	36.0	08-24-2015				
	Previous	36.0	08-10-2019				
	New	36.0	08-06-2021				
Clark Pampanga	Previous	36.5	03-25-2010				
	New	36.7	03-30-2021				
	Previous	37.5	06-05-2020				
	New	38.3	06-01-2021				
	Previous	35.1	09-09-2020				
	New	35.4	09-26-2021				
	Previous	35.1	09-20-2020				
	Previous	34.0	11-20-2020				
	New	34.5	11-07-2021				
	Previous					36.8	02-07-2000
	New					63.4	02-13-2021
Cotabato City Maguindanao	Previous	36.5	07-18-2020				
	New	36.8	07-26-2021				
	Previous	35.5	08-11-2020				
	New	36.3	08-12-2021				
	Previous	36.4	10-20-2017				
	New	36.4	10-18-2021				

Weather Station	Records Broken/ Equalled	Highest Daily Temperature (°C)	Date	Lowest Daily Temperature (°C)	Date	Greatest Daily Rainfall (mm)	Date
Cuyo Palawan	Previous					85.8	03-01-1996
	New					90.0	03-13-2021
Daet Camarines Sur	Previous			20.0	08-13-1995		
	New			19.8	08-25-2021		
	New			19.8	08-26-2021		
Dagupan Pangasinan	Previous					78.0	01-25-2006
	New					83.0	01-22-2021
Davao Davao del Sur	Previous	35.6	07-16-1973				
	New	36.0	07-25-2021				
General Santos South Cotabato	Previous					115.2	05-10-2010
	New					151.8	05-18-2021
Guiuan Eastern Samar	Previous					108.2	09-30-1973
	New					150.1	09-06-2021
Itbayat Batanes	Previous	32.9	10-12-1997				
	New	32.9	10-01-2021				
	New	32.9	10-02-2021				
Hinatuan Surigao del Sur	Previous	36.2	07-25-2018				
	New	37.9	07-24-2021				
	New	37.9	07-25-2021				
	Previous	36.1	10-12-2013				
	Previous	36.1	10-12-2017				
	New	36.2	10-12-2021				
Subic Zambales	Previous					14.8	01-07-2006
	New					35.5	01-21-2021

Weather Station	Records Broken/ Equalled	Highest Daily Temperature (°C)	Date	Lowest Daily Temperature (°C)	Date	Greatest Daily Rainfall (mm)	Date
Lumbia-El Salvador Misamis Oriental	Previous	38.2	05-07-1998				
	New	38.7	05-05-2021				
	Previous	36.2	07-11-2002				
	New	38.6	07-25-2021				
	Previous	37.8	08-28-1990				
	New	37.8	08-02-2021				
	Previous					94.3	05-21-1990
	New					121.8	05-30-2021
Maasin Southern Leyte	Previous					126.0	06-12-2014
	New					395.4	06-01-2021
Mactan Cebu	Previous					88.0	06-05-2016
	New					102.7	06-01-2021
Malaybalay Bukidnon	Previous	33.0	07-15-2001				
	Previous	33.0	07-15-2016				
	New	33.4	07-12-2021				
	Previous	33.5	08-07-2000				
	New	34.0	08-31-2021				
NAIA Pasay City	Previous	38.2	05-18-2014				
	New	38.6	05-29-2021				
San Jose Occidental Mindoro	Previous	36.0	12-07-1991				
	New	36.0	12-24-2021				
	Previous			18.5	03-09-2019		
	Previous			18.5	03-11-2019		
	Previous			18.5	03-01-2020		
	New			18.5	03-01-2021		

Weather Station	Records Broken/ Equalled	Highest Daily Temperature (°C)	Date	Lowest Daily Temperature (°C)	Date	Greatest Daily Rainfall (mm)	Date
Science Garden Quezon City	Previous					55.8	01-16-1988
	New					72.4	01-20-2021
Surigao Surigao del Norte	Previous			20.0	07-06-1961		
	New			18.0	07-15-2021		
	New			18.0	07-19-2021		
	Previous			20.5	10-16-1906		
	New			20.0	10-30-2021		
	Previous					320.6	10-13-1919
	New					320.9	10-30-2021
Dauis-Tagbilaran Bohol	Previous					229.1	12-29-2014
	New					230.6	12-16-2021
Tanay Rizal	Previous					62.2	01-18-2015
	New					162.6	01-20-2021
Tayabas Quezon	Previous	32.0	01-23-2016				
	New	32.5	01-25-2021				
Virac Catanduanes	Previous					245.0	04-30-2009
	New					252.2	04-19-2021
Zamboanga Zamboanga del Sur	Previous	36.2	07-15-2020				
	New	36.2	07-24-2021				
	Previous	35.7	08-31-1992				
	New	35.8	08-06-2021				
	New	35.8	08-14-2021				

El Niño Southern Oscillation (ENSO)

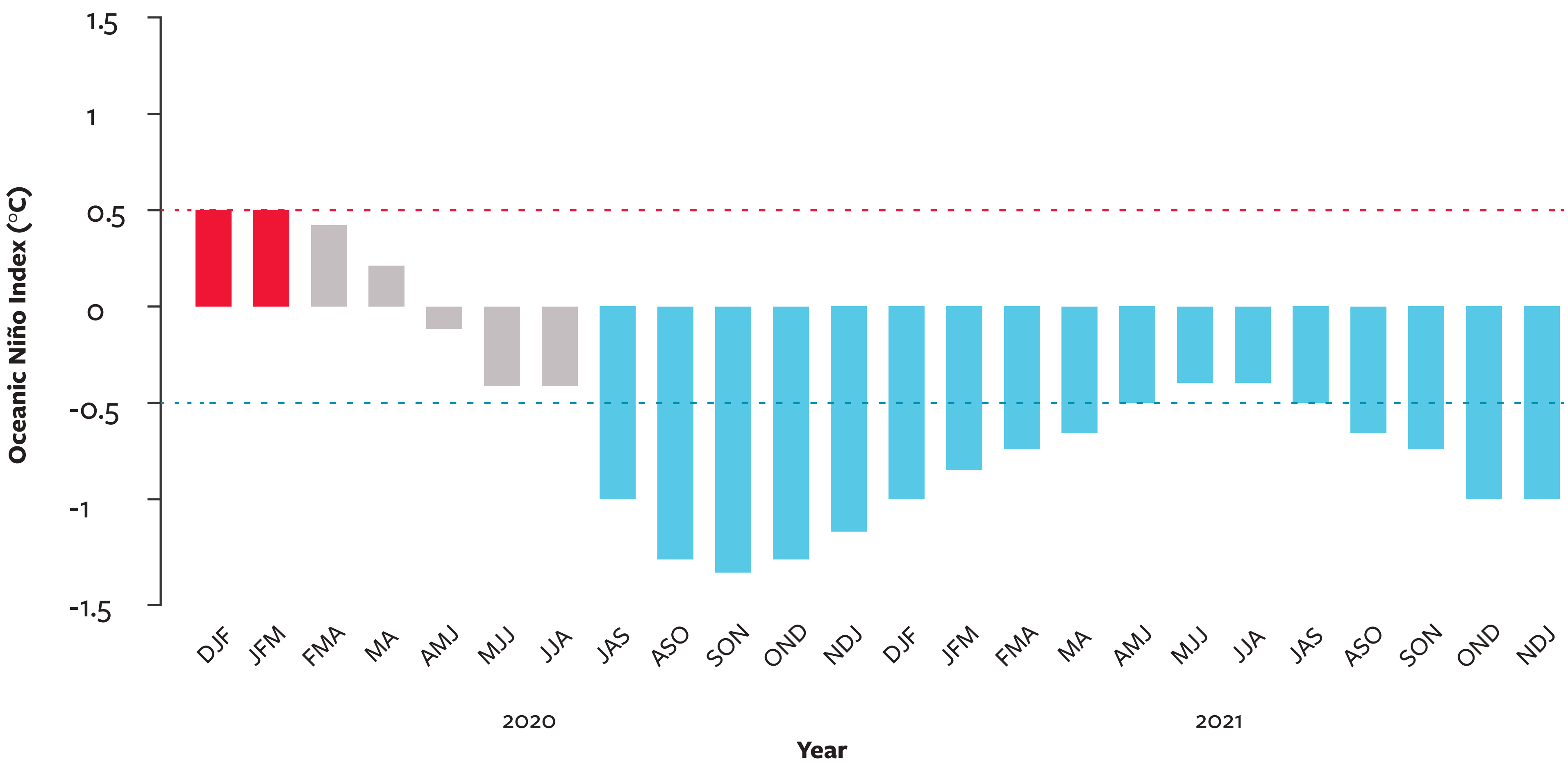
El Niño Southern Oscillation (ENSO)

The cool phase of ENSO prevailed throughout 2021. The La Niña conditions which began in September 2020 (with a short break in June- August 2021) persisted until the end of 2021. The Oceanic Niño Index (ONI) is used to identify El Niño and La Niña episodes in the central and eastern tropical Pacific region. ONI is based on the running three-month mean sea surface temperature anomaly for the Niño 3.4 region (shown in Figure 13).

Stronger trade winds (tropical easterlies) and below-average sea surface temperatures were observed in most parts of the Tropical Pacific Ocean. This resulted in La Niña conditions which contributed to the above-normal rainfall received by most parts of the country in January, February, March, September, and October of 2021.

Figure 13

Seasonal Oceanic Niño Index showing warm and cold phases in 2021



El Niño episodes happen when the ONI is at or above the +0.5 °C threshold for a minimum of five consecutive overlapping three-month periods. La Niña episodes occur when ONI is at or below the -0.5 °C threshold for the same amount of time.

Tropical Cyclones

Tropical Cyclones

In 2021, the Western North Pacific Ocean showed below-average activity with only 23 storms, 15 of which entered PAR. This number is below the long-term average of 19-20 tropical cyclones (TCs) per year. Eight of these TCs made landfall in the country and three reached Super typhoon category.

In March 2022, PAGASA revised the threshold intensities (maximum wind speed) for tropical cyclone categories to conform with regionally accepted standards and best practices of other meteorological centers within the Northwest Pacific region. The 2021 TCs listed below are classified according to the new category.

Table 4
List of TCs that entered the Philippine Area of Responsibility (PAR) in 2021.

TC#	TC Type	Local Name	Intl. Name	Date	Max Sustained Winds/ Gusts (kph)	Mean Sea Level Pressure over land (hPa)	Highest Recorded Peak Gust over land			Maximum Rainfall Accumulation per TC	
							Gust (m/s)	Station	Date, Time	RF (mm)	Station
1	STS	**Auring**	Dujuan	Feb 17-22	95/115	1006.4	15	Surigao	Feb 19, 7:17 PM	200.3	Daet
2	STY	**Bising**	Surigae	Apr 16-25	215/265	996.3	30	Virac	Apr 19, 7:00 AM	522.6	Virac
3	TS	**Crising**	--	May 13-14	65/80	1005.2	14		May 13, 6:00 PM	125.6	Surigao
4	TS	**Dante**	Choi-Wan	May 30 - Jun 5	75/90	997.4	22	Romblon	Jun 2, 11:00 AM	470.4	Maasin
5	TD	**Emong**	--	Jul 4-6	55/70	1002.4	18	Basco	Jul 5, 7:00 AM	165	Baler
6	TY	**Fabian**	In-Fa	Jul 16-24	150/185	None	None			834.6	Iba
7	TD	**Gorio**	Mirinae	Aug 4	55/70	None	None			147	Abucay
8	TS	**Huaning**	Lupit	Aug 7-8	65/80	None	None			92.8	Munoz
9	STS	**Isang**	Omais	Aug 19-22	95/115	None	None			98	Munoz

Table 4 (Cont.)

List of TCs that entered the Philippine Area of Responsibility (PAR) in 2021.

TC#	TC Type	Local Name	Intl. Name	Date	Max Sustained Winds/ Gusts (kph)	Mean Sea Level Pressure over land (hPa)	Highest Recorded Peak Gust over land			Maximum Rainfall Accumulation per TC	
							Gust (m/s)	Station	Date, Time	RF (mm)	Station
10	TY	**Jolina**	Conson	Sept 6-9	120/165	991.6	38	Guiuan	Sept 6, 8:30 PM	312.1	Tayabas
11	TY	**Kiko**	Chanthu	Sept 7-12	215/265	927.8	86	Basco	Sept 11, 7:50 AM	345.4	Iba
12	TD	**Lannie**	Lionrock	Oct 4-6	45/55	1004	22	Guiuan	Oct 4, 1:00 PM	186.4	Casiguran
13	STS	**Maring**	Kompasu	Oct 7-12	100/125	979.6	34	Basco	Oct 11, 2:06 PM	728.1	Baguio
14	TD	**Nando**	--	Oct 8-9	55/70	None	None			None	
15	STY	**Odette**	Rai	Dec 14-18	195/270	944.2	58	Surigao	Dec 16, 4:41 PM	428.6	Surigao

Legend

TC Category	Max Wind Speed	
	Old	Starting Mar. 2022
Tropical Depression (TD)	≤ 61 kph	≤ 61 kph
Tropical Storm (TS)	62-88 kph	62-88 kph
Severe Tropical Storm (STS)	89-117 kph	89-117 kph
Typhoon (TY)	118-220 kph	118-184 kph
Super Typhoon (STY)	> 220 kph	> 184 kph

Data Source: PAGASA

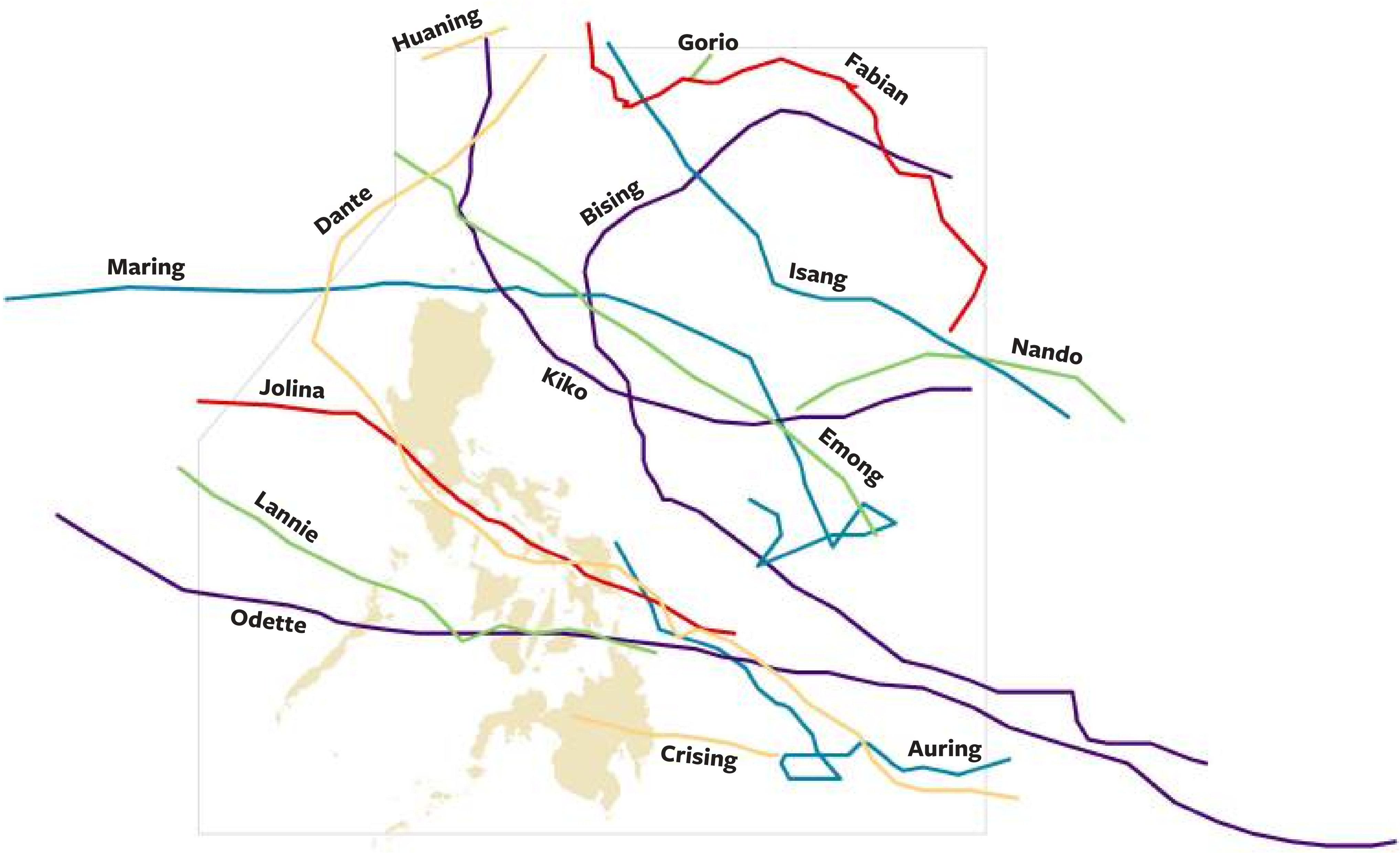
Figure 14

Track of tropical cyclones (TCs) that have entered the PAR (indicated by the grey line) in 2021

Legend

Typhoon Intensity

- Super Typhoon
- Typhoon
- Severe Tropical Storm
- Tropical Storm
- Tropical Depression
- PAR



Loss & Damage due to TCs and Associated Hazards

Among the 15 TCs that entered PAR, STY Odette (Rai) was considered the most devastating, accounting for 78% of the total population affected and 82% of the total cost of damage by 2021 TCs.

Almost 10.6 million individuals were affected with at least 405 casualties during the destructive passage of STY Odette across the country.

Overall, 13.5 million persons were affected by the TCs that entered PAR in 2021.

Region VII was the most affected with almost 4.4 million of its population affected by the TCs and associated hazards.

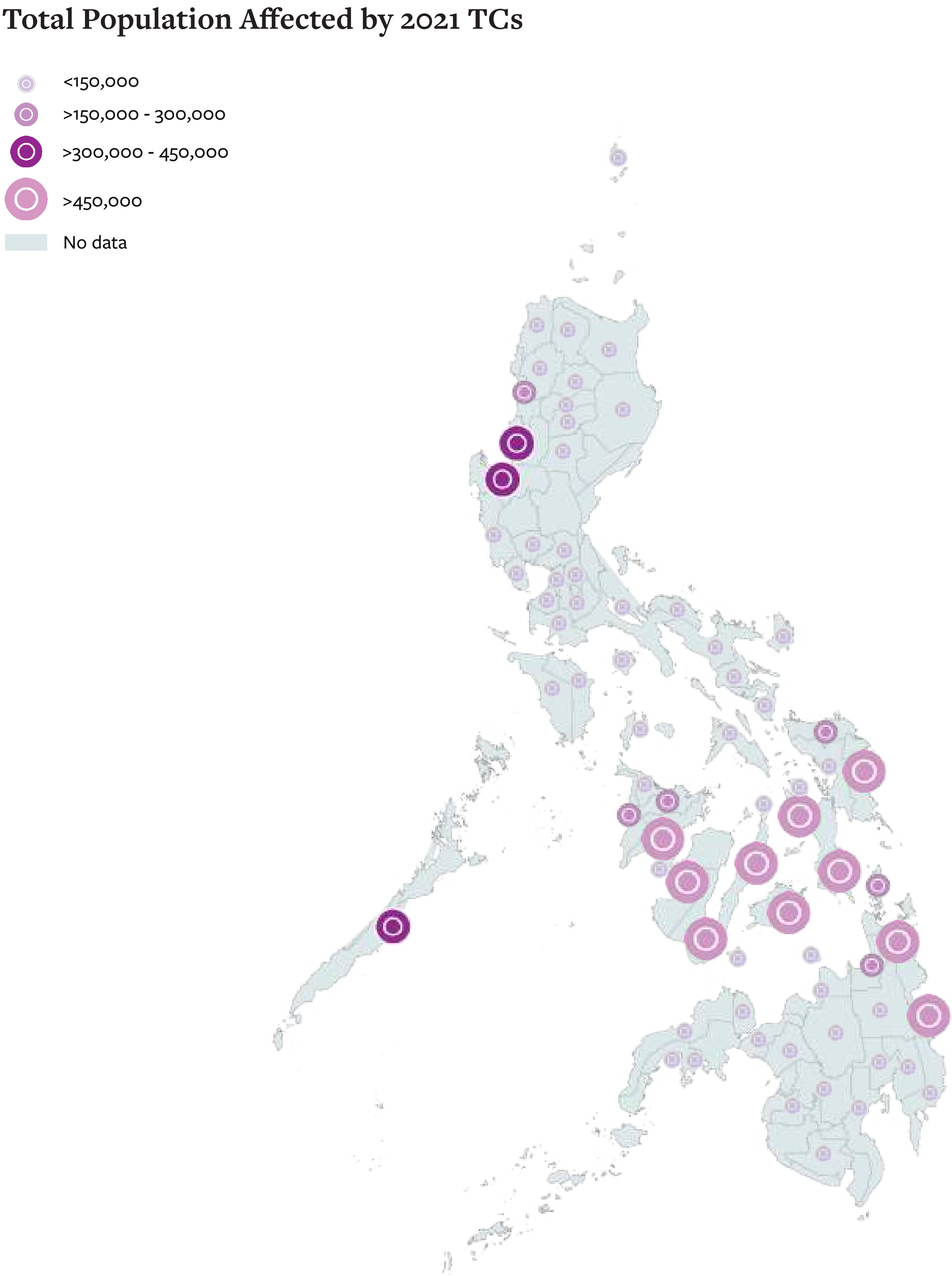
Table 5

2021 Tropical Cyclones ranked according to affected population

Tropical Cyclone	Date	No. of Individuals
STY Odette	Dec 14-18	10,607,625
STS Maring (Kompasu)	Oct 7-12	1,185,894
STY Bising (Surigae)	Apr 16-25	450,195
TY Jolina (Conson)	Sept 6-9	354,613
Southwest Monsoon enhanced by TY Fabian	Jul 16-24	331,422
STS Auring	Feb 17-22	272,451
TS Dante (Choi-Wan) and Intertropical Convergence Zone (ITCZ)	May 30 - Jun 5	137,918
TS Crising	May 13-14	59,597
STY Kiko (Chanthu)	Sept 7-12	46,678
TD Lannie	Oct 4-6	8,048
Grand Total		**13,454,441**

Data Source: NDRRMC Operations Center

Figure 15
Total affected population due to TCs and other associated hazards per province in 2021



Source: NDRRMC Operations Center

TCs in 2021 caused more damages to infrastructures than to the agricultural sector. The country's infrastructure suffered a total of PHP 34 billion in TC-related damages, while the agricultural sector sustained damages amounting to PHP 28 billion. Of these amounts, at least 79% was attributed to Super Typhoon (STY) Odette.

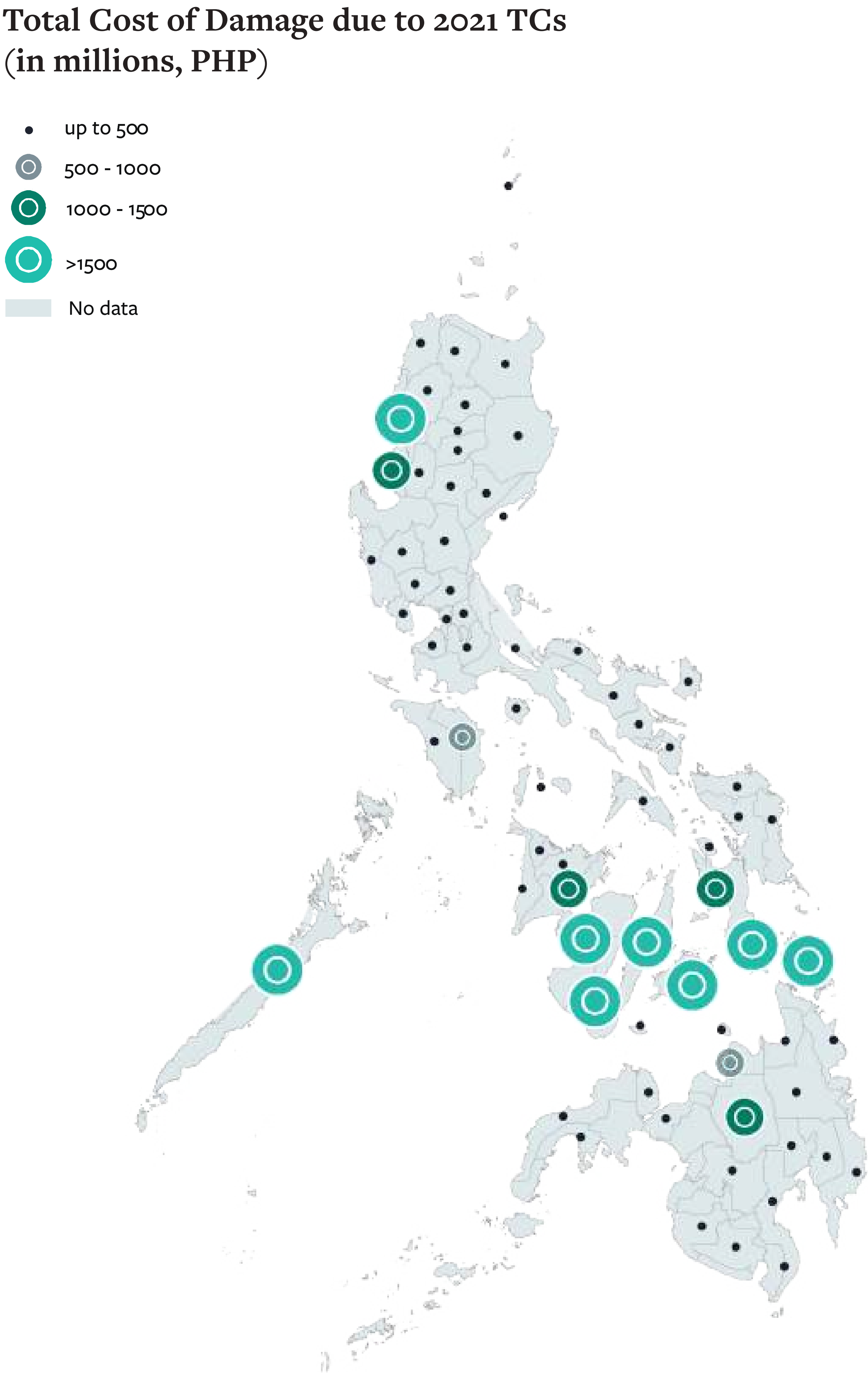
CARAGA region suffered the most damages with more than PHP 24 billion worth of damages to both infrastructure and agriculture. Among the provinces, Surigao del Norte reported PHP 19 billion in estimated total cost of damage.

Table 6

2021 Tropical Cyclones ranked according to cost of total damages (PHP)

Tropical Cyclone	Date	Agriculture (PHP)	Infrastructure (PHP)	Total Damages (PHP)
STY Odette	Dec 14-18	22,368,178,923	29,338,185,356	51,706,364,279
STS Maring (Kompasu)	Oct 7-12	3,321,718,527	4,066,475,133	7,388,193,661
TY Jolina (Conson)	Apr 16-25	1,349,221,036	63,676,053	1,412,897,089
Southwest Monsoon enhanced by TY Fabian	Sept 6-9	743,220,278	459,799,355	1,203,019,633
TS Dante (Choi-Wan) and Intertropical Convergence Zone (ITCZ)	Jul 16-24	152,110,102	157,638,000	309,748,102
STY Bising (Surigae)	Feb 17-22	261,911,000	10,870,000	272,781,000
STS Auring	May 30 - Jun 5	106,777,735	53,052,436	159,830,171
TY Kiko (Chanthu)	May 13-14	37, 354, 668		37,354,668
TS Crising	Sept 7-12	23,163,588		23,163,588
TD Lannie	Oct 4-6	12,225,109		12,225,109
Grand Total		**28,375,880,966**	**34,149,696,333**	**62,525,577,300**

Figure 16
Total cost of damages due to TCs and associated hazards reported per province in 2021.



Source: NDRRMC Operations Center

Jolina, Maring and Odette Retire in 2021

Typhoon Jolina (Conson)

TY Jolina (Conson) was the 10th TC that affected the country in 2021. It developed into a TD within PAR and underwent rapid intensification from a TD to a TY category within one day. **Jolina** made landfall over nine different locations across Eastern Visayas and southern Luzon. Its heavy rains caused flooding and landslides and triggered power outages across Eastern Visayas, Panay Island, Sorsogon, CALABARZON, and MIMAROPA.

Due to **Jolina's** passage, the fishing sector in Masbate suffered a loss of PHP 13.7 million. In addition, more than 300, 000 individuals were affected and and the combined damage to agriculture and infrastructure was estimated at PHP 1.4 billion.

Severe Tropical Storm Maring (Kompasu)

STS Maring (Kompasu) spawned from an LPA embedded in the ITCZ. It later assimilated with the remnants of a weaker system, TD Nando. With an initial position to the east of Bicol region, **Maring** erratically moved to the east then west northwestward towards Babuyan Island over the course of 5 days. It made landfall over Fuga Island, Aparri, Cagayan.

During **Maring**'s passage, the Baguio synoptic station recorded up to 732 mm rainfall. During the passage of **STS Maring**, most rains were accumulated in Benguet with up to 732 mm rainfall recorded by Baguio station. This led to catastrophic landslides and flooding in northern Luzon. **Maring**'s massive and large wind field enhanced the SW monsoon, which resulted in gusty conditions and intense rainfall over MIMAROPA and the western sections of Visayas.

Cost of damages due to **Maring** and the enhanced Habagat are estimated at PHP 7 billion, with 272,699 families affected.

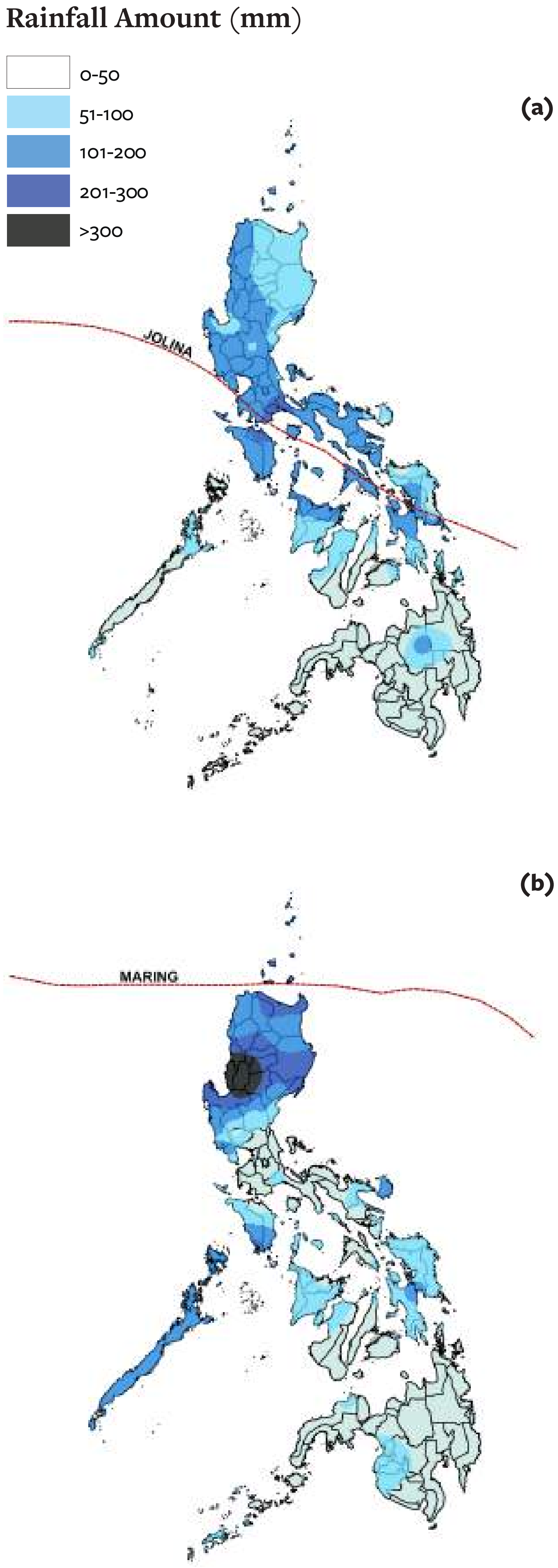


Figure 17
The accumulated rainfall associated with each TCs , (a) TY Jolina, (b) STS Maring, (c) STY Odette.

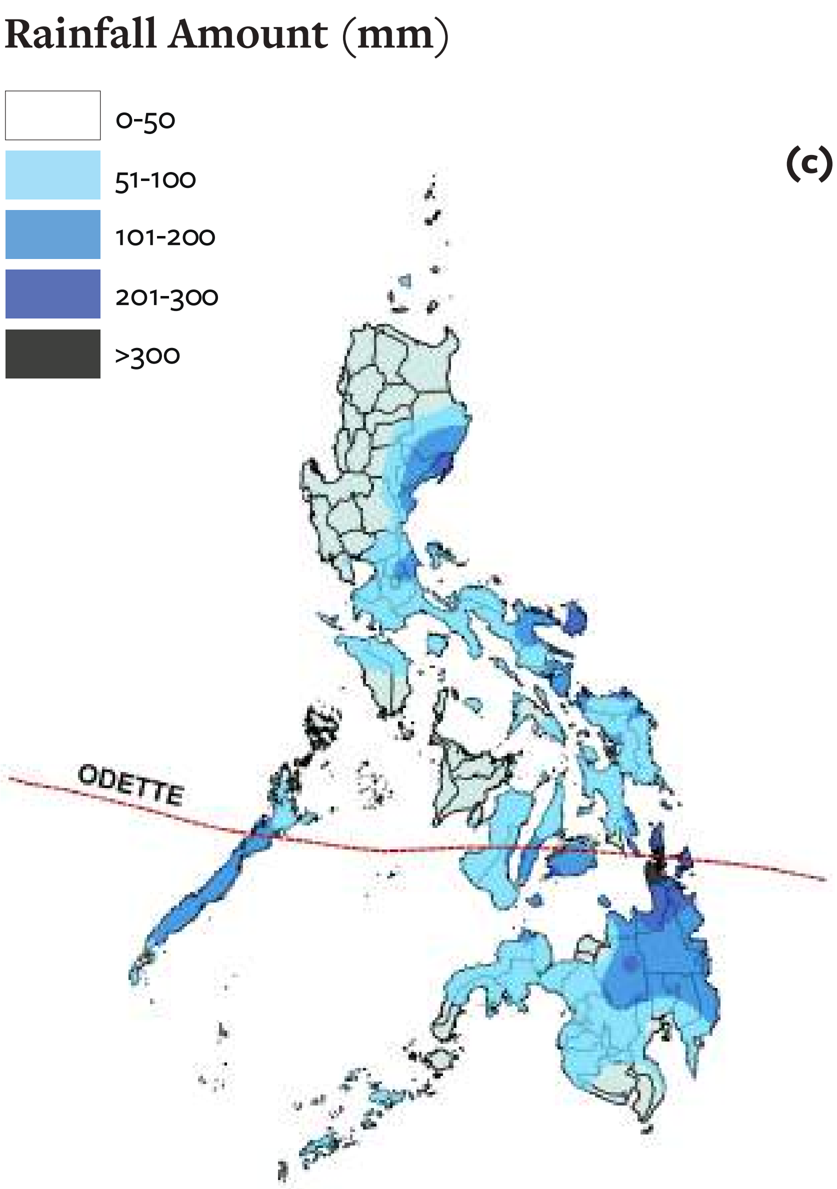
Super Typhoon Odette (Rai)

STY Odette (Rai) developed as a TD over the waters southeast of Palau. Favorable ocean conditions as it traversed towards the Philippine landmass allowed **Odette** to gather strength and bring with it highly destructive typhoon-force winds. It entered PAR as a Severe Tropical Storm on December 14 and rapidly intensified into a Typhoon on December 16 while on its west-northwest track.

The hardest hit region was Siargao Island, Surigao del Norte where **Odette** made its first landfall. It made eight more landfalls as it traversed northeastern Mindanao, Visayas, and Palawan.

Due to its destructive winds and intense to torrential rains, **Odette** caused widespread flooding and landslides, resulting in massive damages to agriculture and infrastructure amounting to about PHP 22 billion. A State of Calamity was declared in 12 cities and municipalities.

Figure 17 (cont.)
The accumulated rainfall associated with each TCs ,
(a) TY Jolina, (b) STS Maring, (c) STY Odette.



Notable Weather Events in 2021

and Major Modes of Climate Variability in the Philippines

Notable Weather Events in 2021

The most notable events in 2021 include a 53 °C heat index, consecutive typhoons in September, Habagat enhanced by STS Maring and the most destructive TC in 2021, STY Odette.

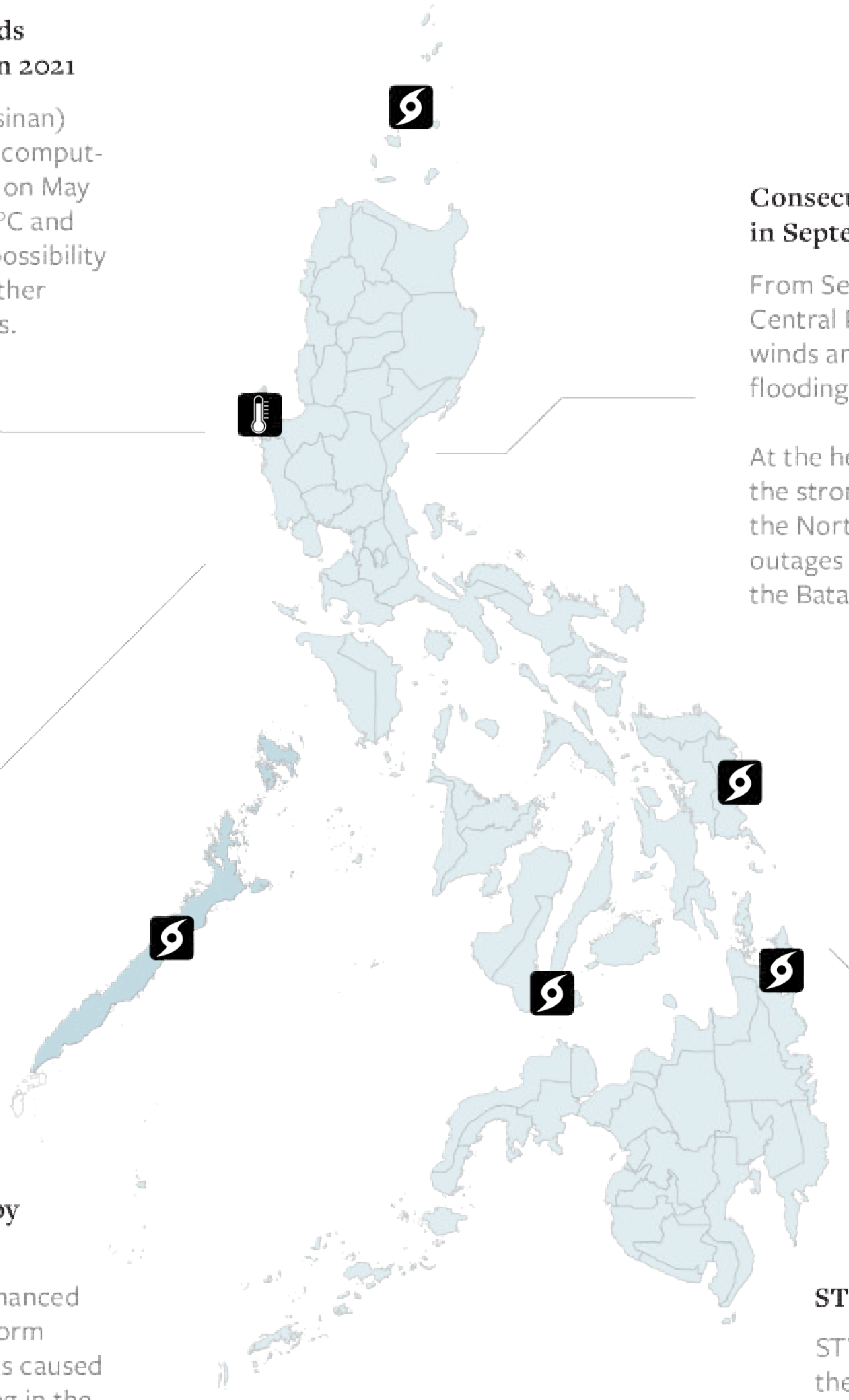
Dagupan City records highest heat index in 2021

Dagupan City (Pangasinan) recorded the highest computed heat index of 53°C on May 14. Heat indices of 52°C and above increases the possibility of heat strokes and other heat-related disorders.

Consecutive Typhoons in September

From Sept. 6 to 9, TY Jolina crossed Central Philippines bringing strong winds and heavy rainfall that caused, flooding in low-lying communities.

At the heels of Jolina, from Sept. 7 to 12. the stronger TY Kiko (Chanthu) crossed the Northern Philippines, causing power outages and infrastructure damage in the Batanes Islands.



Habagat enhanced by STS Maring

The SW monsoon enhanced by Severe Tropical Storm Maring (Kompasu) has caused landslides and flooding in the northern Philippines leaving casualties.

STY Odette

STY Odette (Rai) is on record as the costliest typhoon of 2021. Compared to TCs of previous years, it is second only to TY Yolanda (Haiyan) in terms of recorded loss and damage.

Odette brought torrential rains, violent winds, mudslides, floods and storm surges in the provinces of Surigao del Norte and Dinagat Islands in Mindanao, five provinces in Visayas,

Figure 18
Notable climate and weather-related events in 2021.

On top of the catastrophic impacts of tropical cyclones, other weather systems that prevailed in 2021 also caused millions in damages and affected thousands of individuals across different sectors.

Figure 19

Number of monitored incidents of natural hazards (other than TCs) in 2021.

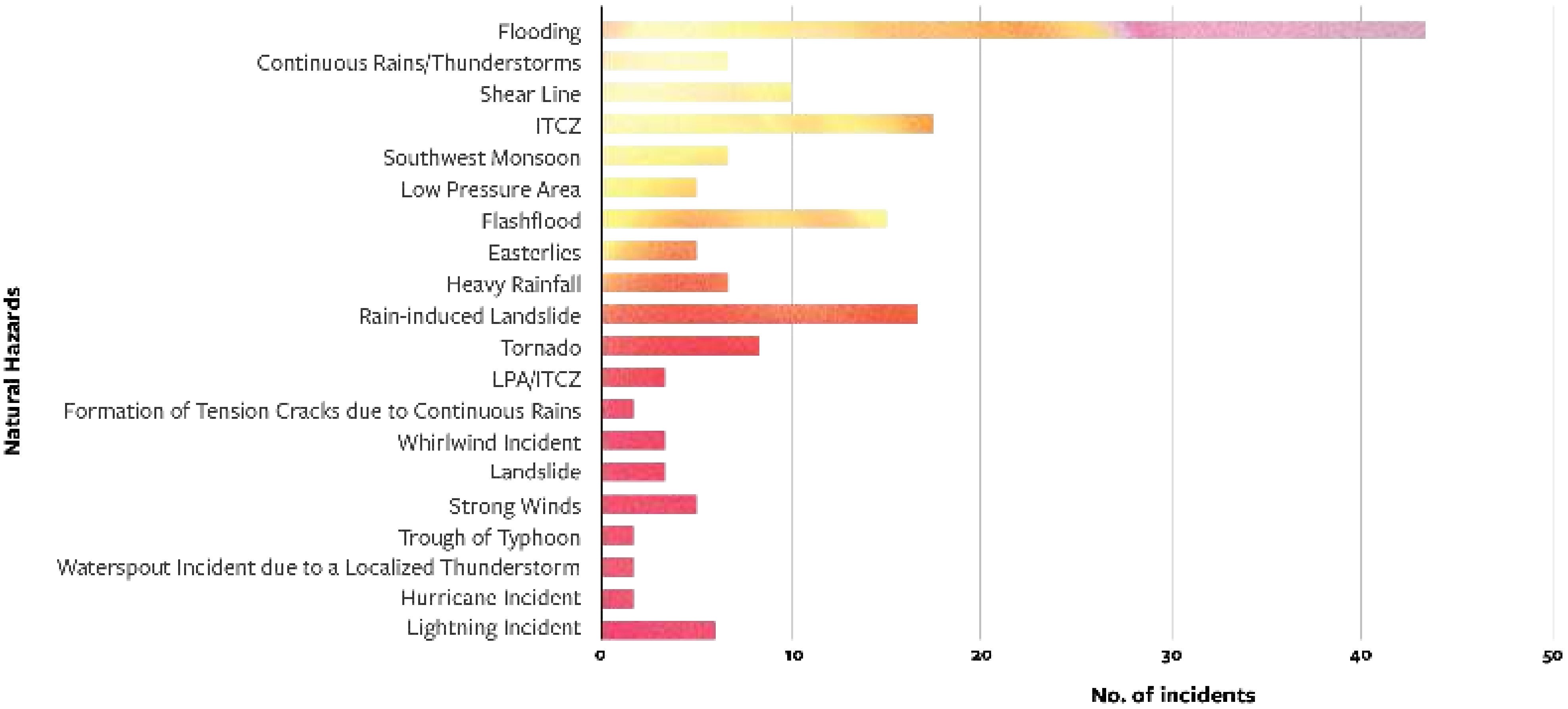
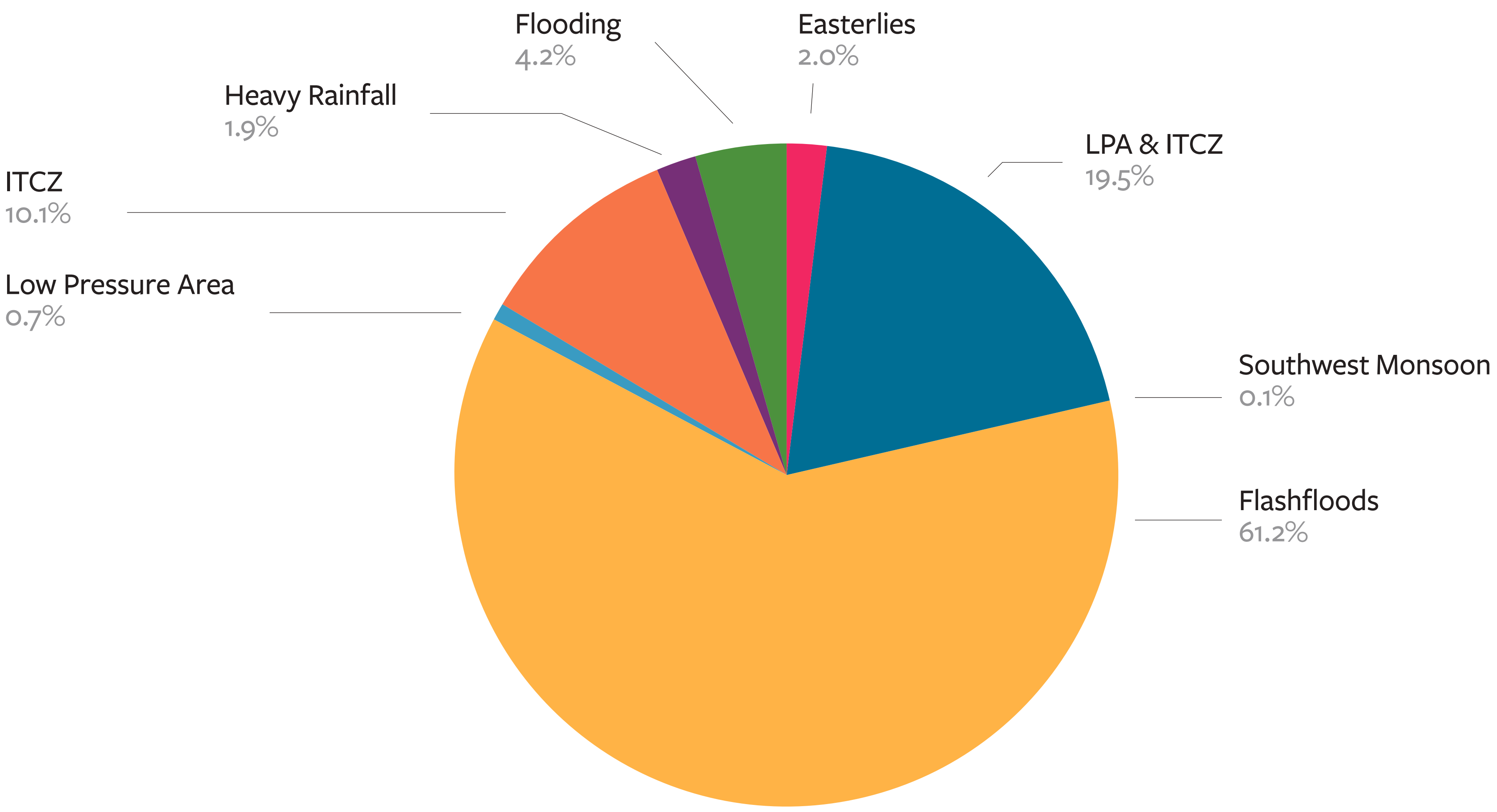


Figure 20

Cost of damage of monitored incidents of natural hazards (other than TCs) in 2021

Cost of Damage



Major Modes of Climate Variability in the Philippines

ITCZ

Rainfall is influenced by the location of the Inter-Tropical Convergence Zone (ITCZ), where the northeasterly winds in the Northern Hemisphere and the southeasterly winds in the Southern Hemisphere converge near the equator.

From December to February, the ITCZ is located near or close to the equator. It moves northward until it reaches north of the Philippines around August to September, and then moves southward before December.

Monsoons

A monsoon is a consistent seasonal wind pattern generated by a large weather and climate system that lasts for several months and affects large areas. There are two monsoon seasons in the country: Habagat (Southwest Monsoon) and Amihan (Northeast Monsoon).

Habagat usually means wet conditions in the western sections of the country from June to September. Habagat usually brings significant amount of rainfall that triggers flooding and landslides, and is sometimes further enhanced by the presence of tropical cyclones in PAR.

The Amihan (Northeast Monsoon) features cool and dry breeze with prolonged periods of successive cloudless days. It affects the eastern sections of the country from November to February.

ENSO

El Niño-Southern Oscillation (ENSO) refers to the ocean component (El Niño) and the atmospheric component (Southern Oscillation) of a naturally occurring coupled phenomenon that originates in the Pacific Ocean.

El Niño and La Niña generally refer to the pattern of above or below average sea surface temperatures and sea level pressure in the central and eastern Pacific that leads to a major shift in weather patterns across the Pacific. ENSO is the most important source of inter-annual variability of rainfall in the Philippines.

Tropical Cyclones

Tropical Cyclone (TC) is the general term for a cyclone that originates over tropical oceans. TCs are low pressure systems in which winds spin inward in a circularly symmetric spiral, bringing with it intense rain and winds. TCs are categorized further based on wind intensity. In March 2022, PAGASA revised the threshold intensities (maximum wind speed) for tropical cyclone categories.

The 2021 TCs are classified according to the new category released by PAGASA.

Other modes of variability include the Pacific Decadal Oscillation (PDO) which is characterized by patterns of sea surface temperature anomalies over the North Pacific. It has warm and cold phases that last for decades. During warm and cold phases of the PDO, the Madden-Julian Oscillation (MJO) is another tropical mode of variability that can influence the intra-seasonal variations in rainfall over the Philippines. The MJO is typically a 30- to 60-day (but may also range from 20 to 90 days) oscillation that moves eastward near the equator, and involves variations in wind, and rainfall.

For more information about these different modes of variability, visit the Philippine Climate Change Assessment WG1 at https://bit.ly/PhilCCAWG1

Data Sources

Climate and Agrometeorological Data Section and Impact Assessment and Applications Section - Philippine Atmospheric, Geophysical and Astronomical Services Administration.

National Disaster Risk Reduction and Management Council

NOAA's International Best Track Archive for Climate Stewardship (IBTrACS) data, accessed on [2022, January 13]

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About the Oscar M. Lopez Center

The Oscar M. Lopez Center is a non-profit organization born out of a private sector initiative to enhance support for research and innovative solutions towards climate change adaptation and disaster risk management. It is principled on the role that science must play in building the resilience of communities through actionable knowledge.

Founded in 2012, the OML Center was established as a response to an apparent research gap that was alarmingly disproportionate to the climate-related risks and vulnerabilities of the Philippines. The first of its kind in the country, it continues to be the only privately funded grant-giving NGO doing climate change research-based communications.

Propelled by its mandate to harness science in strengthening the climate resilience of the vulnerable, the Center consistently provides the scientific backbone to increase climate change awareness and action in the Philippines.

Other OML Center Projects

Mga Kwento ng Klima

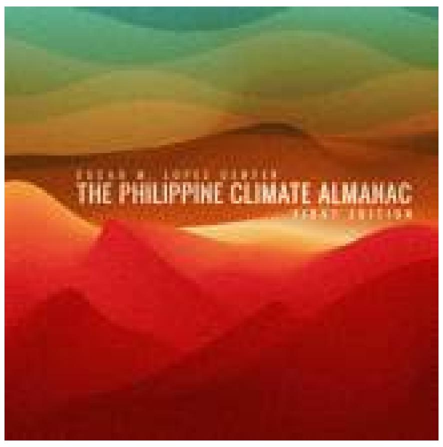
Co-produced with ABS-CBN DocuCentral, Mga Kwento ng Klima is an award-winning documentary chronicling the story of the changing climate in the context of the Filipino experience and how it has shaped the Filipino identity and culture.

Watch the documentary via ABS-CBN News' YouTube Channel or via iWant TFC.

Philippine Climate Change Assessment Reports (PHILCCA)

With the Climate Change Commission, we publish the Philippine Climate Change Assessment (PhilCCA) Reports, which contains comprehensive information on climate change science in the Philippines. Sectoral Snapshots highlighting climate vulnerabilities of Philippine forests and the public health sector were also developed to serve as quick visual reference guides for science-based planning and decision-making.

The PhilCCA Reports and Sectoral Snapshots can be downloaded at http://www.omlopezcenter.org/the-philippine-climate-change-assessment/.



The Philippine Climate Almanac

The first of its kind in the country, The Philippine Climate Almanac highlights record-breaking and other significant statistics of climate-related variables, extreme events and disasters across seven decades through data visualizations that we hope audiences outside the scientific and academic communites find compelling.

The Philippine Climate Almanac is available for download at http://www.omlopezcenter.org/the-philippine-climate-almanac.

Climate, Disaster and Development Journal (CDDJ)

CDDJ is an open access double-blind peer-reviewed journal on all aspects and intersections of climate, disaster, and development. The journal provides a forum for the presentation and sharing of recent research findings within and across these fields.

For more detailed information about the CDDJ, you may visit https://www.cddjournal.org.

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