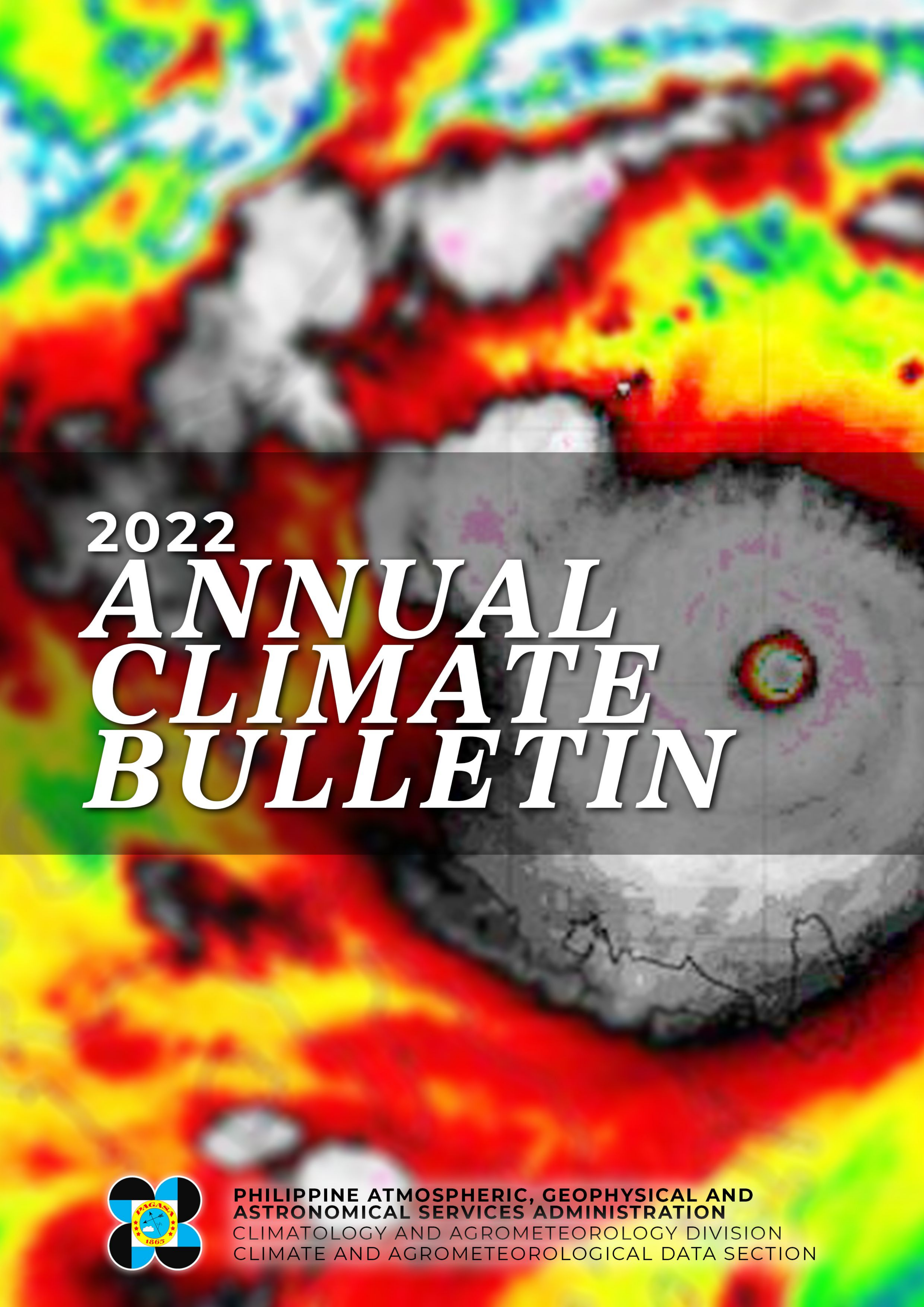

2022

ANNUAL CLIMATE BULLETIN

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

2022

ANNUAL CLIMATE BULLETIN

ABOUT THE COVER:
Satellite image of Super Typhoon Karding (International Name: Noru), retrieved from Himawari-8 Channel 13 (IR) at 18:00Z on 24 September 2022.

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PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND ASTRONOMICAL SERVICES ADMINISTRATION

Climatology and Agrometeorology Division (CAD)
Climate and Agrometeorological Data Section (CADS)
Senator Miriam P. Defensor-Santiago Ave., Brgy. Central, Quezon City 1100, Philippines
Email: cadpagasa@gmail.com

Contributing Authors:
Joseph Q. Basconcillo, Kimberli Anne M. Aquino, Lean Michael A. Malabanan, Vicki Ann A. Bagulbagul, Noel G. Bangquiao, Rosalina G. De Guzman, Christian Mark A. Ison, Ma. Elena V. Tan, Kristel Anne Valerie M. Villasica

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HIGHLIGHTS

The La Niña episode was in its third consecutive year and persisted throughout the year 2022 marking the rare occurrence of a ***triple-dip La Niña***.

Despite the cooling effect of the La Niña, global near-surface temperature remains ***warmer than the average***.

In the Philippines, the annual mean temperature was ***above average*** making the year ***2022 as the 6th warmest since 1991***.

The mean annual rainfall in 2022 was the ***7th wettest since 1991***.

The frequency and intensity of tropical cyclones in the country was ***below to near average***.

The strongest tropical cyclone in the Philippines to make a landfall in 2022 was ***Super Typhoon Karding (Noru)*** with a lifetime maximum intensity of ***195 kph***.

Higher number of extreme records were observed in ***maximum temperature than in minimum temperature***.

Several extremes were observed in rainfall, maximum, and minimum temperatures that broke as old as ***42-year historical records***.

MESSAGE

With the aim of reaching and informing a wider audience and more end-users of PAGASA Climate Products and Services, the 2022 Annual Climate Bulletin provides a summary of the notable climate events and extreme records in the Philippines. I am also pleased to inform you that this report is one of the first publications of PAGASA to use the climate normals based on the new climatological standard normal period of 1991-2020.

The year 2022 is marked by a La Niña event that persisted in the previous years. As expected in a La Niña condition, several parts of the country experienced above normal rainfall, making it the 7th wettest year since 1991. Despite the cooling influence from the La Niña and enhanced rainfall activity in the Philippines, 2022 remains one of the warmest years on record - the 6th since 1991. The intensity and frequency of tropical cyclones in the Philippine Area of Responsibility were generally below average as well.

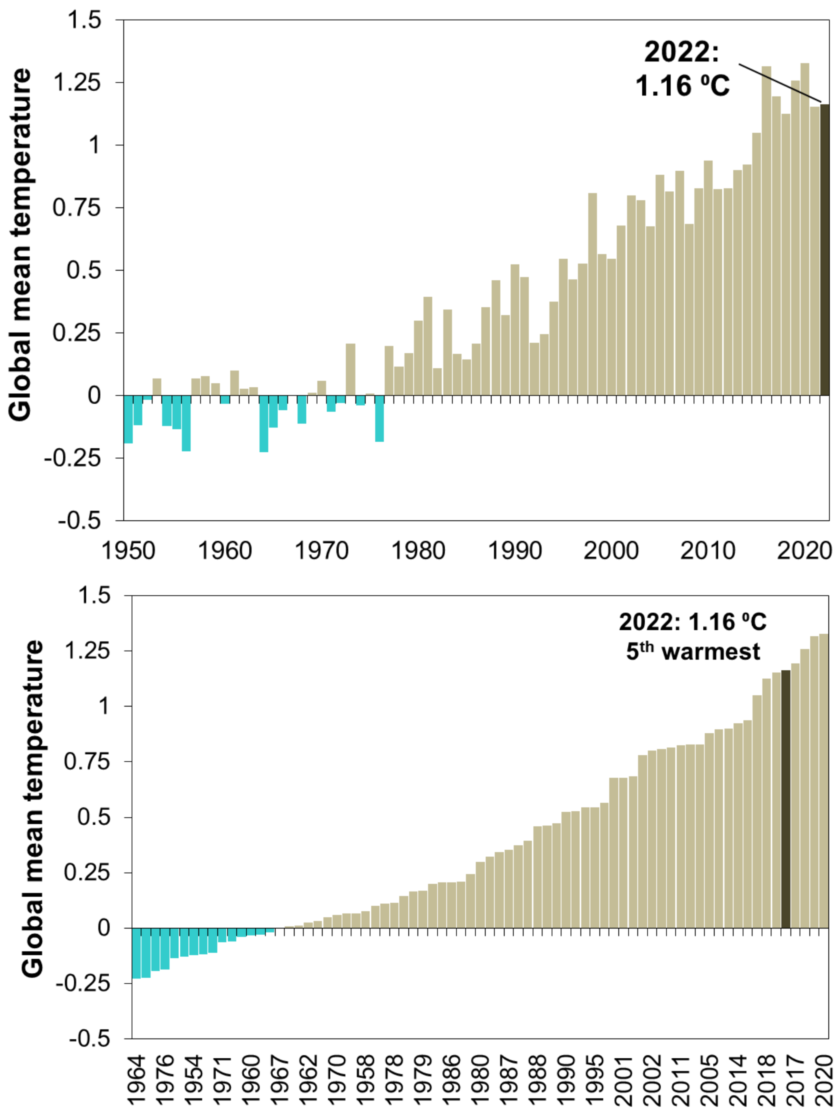
I would like to take this opportunity to thank the production team behind this publication, particularly the Climate and Agrometeorological Data Section - Climatology and Agrometeorology Division, for leading the efforts and authorship of this timely report. Lastly, I hope that everyone will enjoy reading the 2022 Annual Climate Bulletin.

NATHANIEL T. SERVANDO, Ph.D.
Administrator

Global Climate
Context

In 2022, the global mean annual near-surface temperature anomaly was **1.16 °C warmer than the 1951-1980 base period**, which makes it the fifth warmest year on record (NASA 2023). Based on various temperature dataset, the observed global mean annual near-surface temperature anomaly in 2022 ranges from **1.02 to 1.28°C** suggesting a robust warming detected in the same year (WMO 2023). Moreover, the observed temperature from **2015-2022 are eight warmest years on record** across different datasets (WMO 2023). It is noteworthy that such a warm temperature record in 2022 was observed despite the cooling effect of the ongoing La Niña.

Meanwhile, the **annual ocean heat content in 2022 was the highest on record** while the **ocean warming rate has continued to increase** (WMO 2023). An accelerated rise in sea level was detected from 2013-2022 that reached a new record high in 2022. However, there remains limited observations over the open ocean, which necessitates revisiting these records over time.

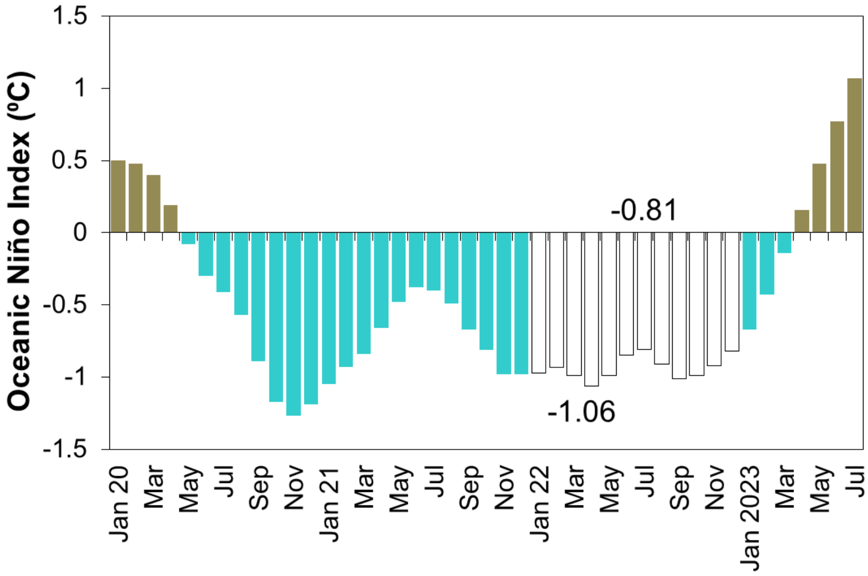


Global mean annual temperature anomaly and ranked anomaly (top-bottom) from 1950-2022

MAJOR CLIMATE DRIVERS

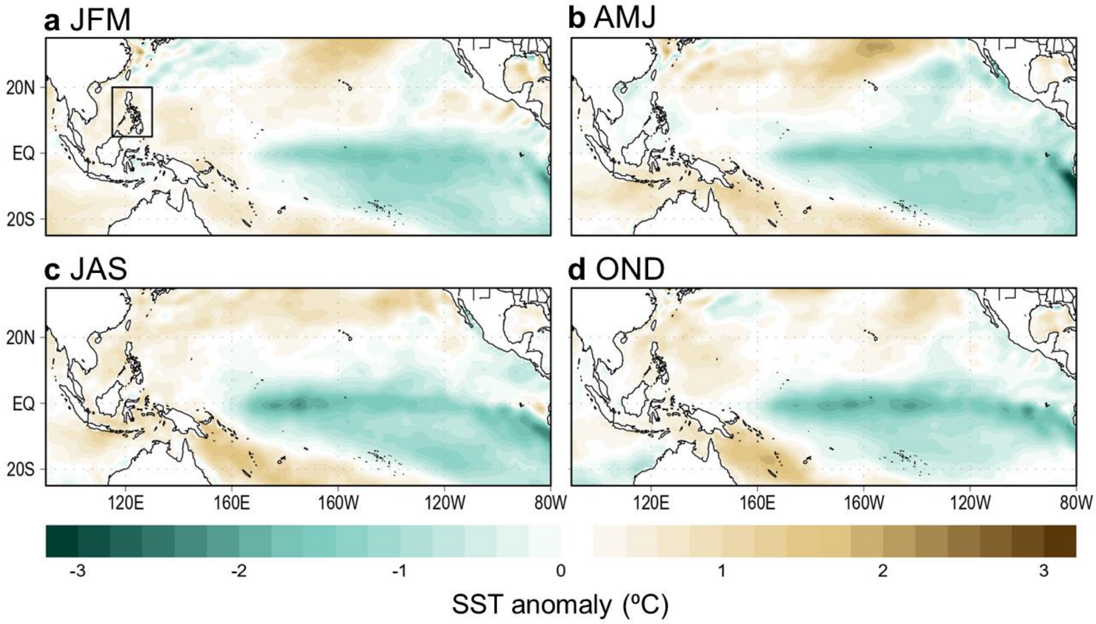
The climate variability of the Philippines is influenced by its geography and topography (Basconcillo et al. 2022). Due to its location in the tropical Pacific, the Philippine climate is characterized by a humid maritime environment, which, in turn, is influenced by various climate drivers across different 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 (i.e. atmospheric bridge effect) and its implication on the oceanic environment, 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 an increased chances in rainfall and convective activities over maritime continent and Western Pacific.

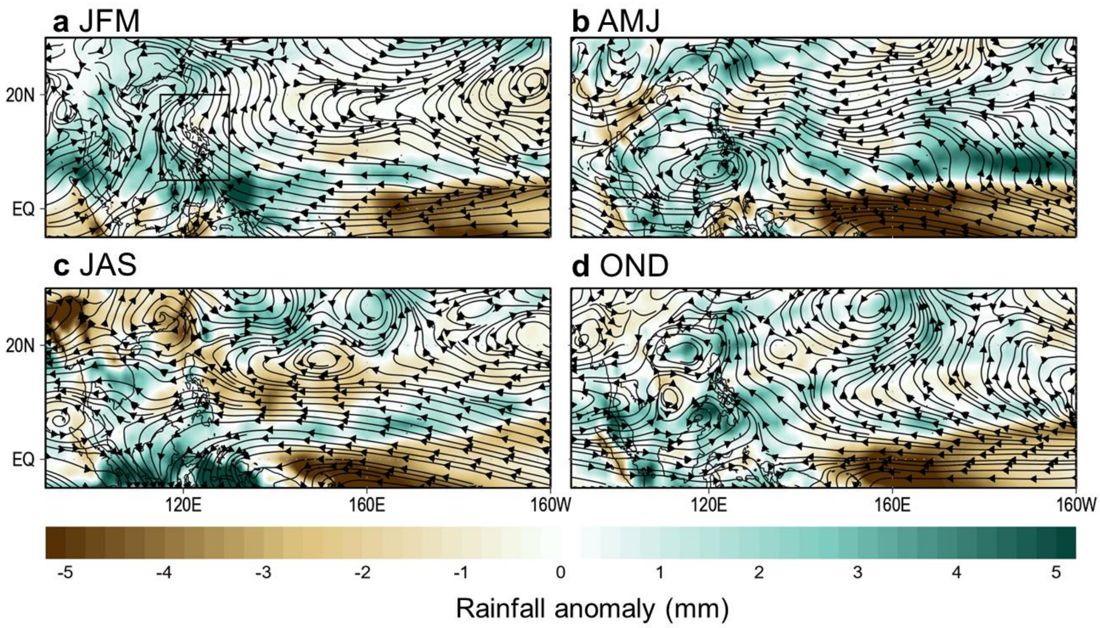
The La Niña episode was in its third consecutive year in 2022 marking the rare occurrence of a triple-dip La Niña (CPC 2023). Persistent cooler than average sea surface temperature (SST) anomalies were observed in most parts of the tropical Pacific from January to December 2022. Based on the Oceanic Niño Index (ONI), the coolest SST anomaly was -1.06 C observed in April 2022 while the warmest (but well remains within La Niña threshold) was -0.81 C observed in July 2022. The cold tongue of SST anomalies was prominent in most seasons of 2022 but evidence of warming was observed beginning in July-August-September (JAS) 2022 near the coast of South America. Typical of the asymmetric SST anomaly patterns associated with ENSO, warm SST anomalies were observed in the marginal seas of the Philippines across all seasons in 2022.



Monthly Oceanic Niño Index from January 2020 to July 2023

Rainfall anomalies over the Philippines and Southeast Asia in January-February-March (JFM), April-May-June (AMJ), and October-November-December (OND) were generally above normal with prominent anomalous cyclonic circulation observed over Mindanao Island during the AMJ and OND, respectively. Such anomalous cyclonic circulation might have influenced the above normal rainfall observed in their respective seasons. 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 to the east of 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 a La Niña condition, **the dominant wind pattern is enhanced easterlies throughout the year 2022**.



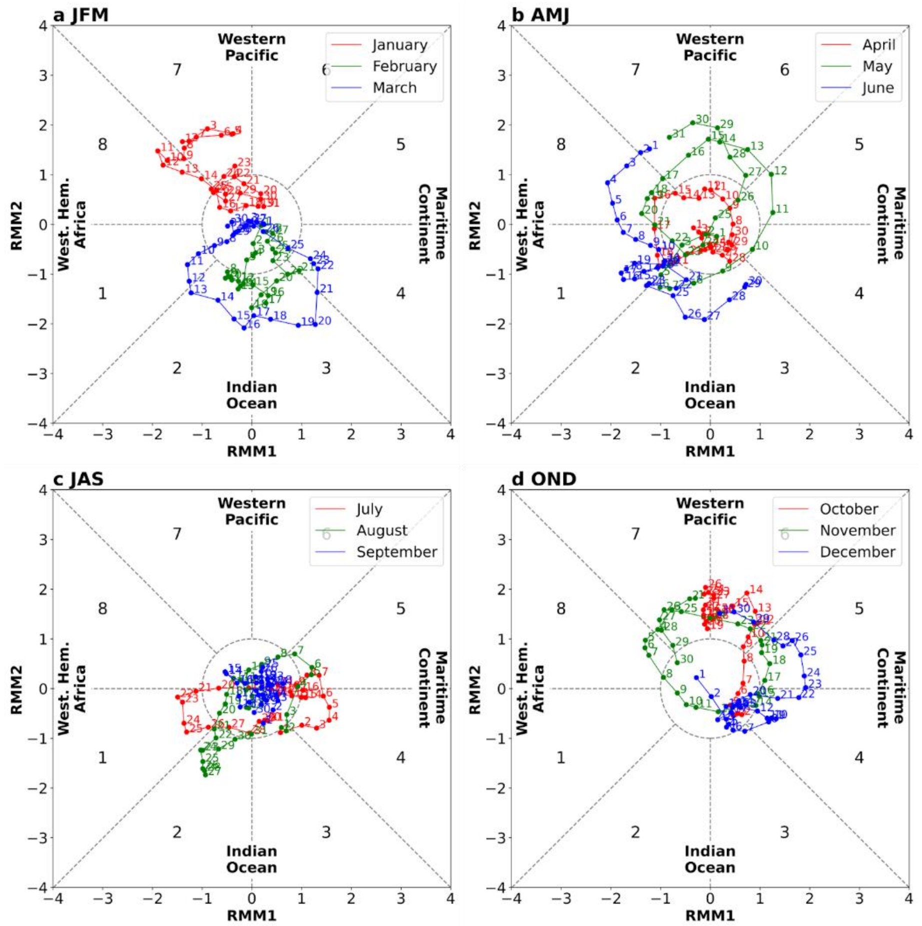


Seasonal streamline and rainfall anomalies (clockwise) for 2022: January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively.

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 (MC) and Western Pacific (WP)). Conversely, when the convective centers of the MJO (Phases 8,1, and 2) are found in the Western Hemisphere and Africa (WHA) and the Indian Ocean (IO) 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.

During the January-February-March (JFM) season, the rainfall over MC and WP were generally suppressed. In April-May-June (AMJ), the MC and WP rainfall were enhanced at the beginning of May followed by suppressed activity until June. The remaining second-half 2022 experienced active MJO Phases 4-6 indicative of above normal rainfall over the Philippines, especially during December.

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.



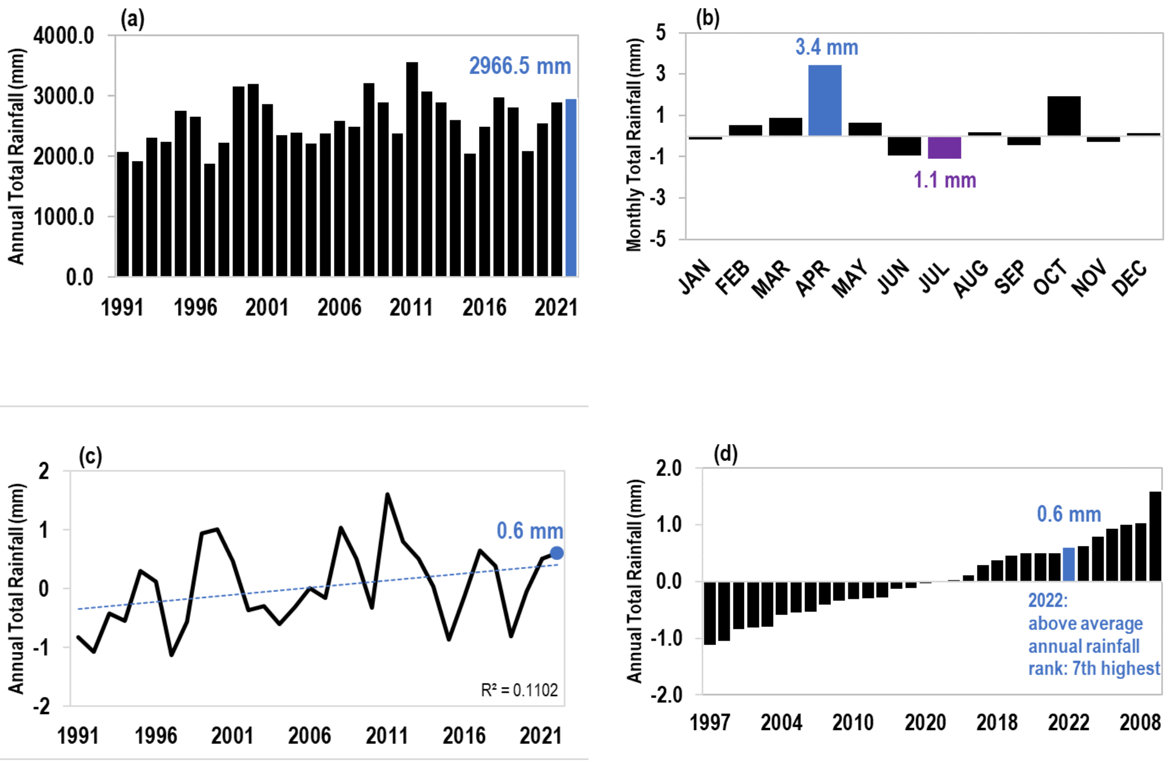
Phase-space diagram of the Realtime Mutivariate MJO index (clockwise) for 2022: January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively. Dots represent the daily MJO activity wherein dots inside the circle denote weak or no MJO. Colors indicate the corresponding months for each season.

NATIONAL CLIMATE
Rainfall

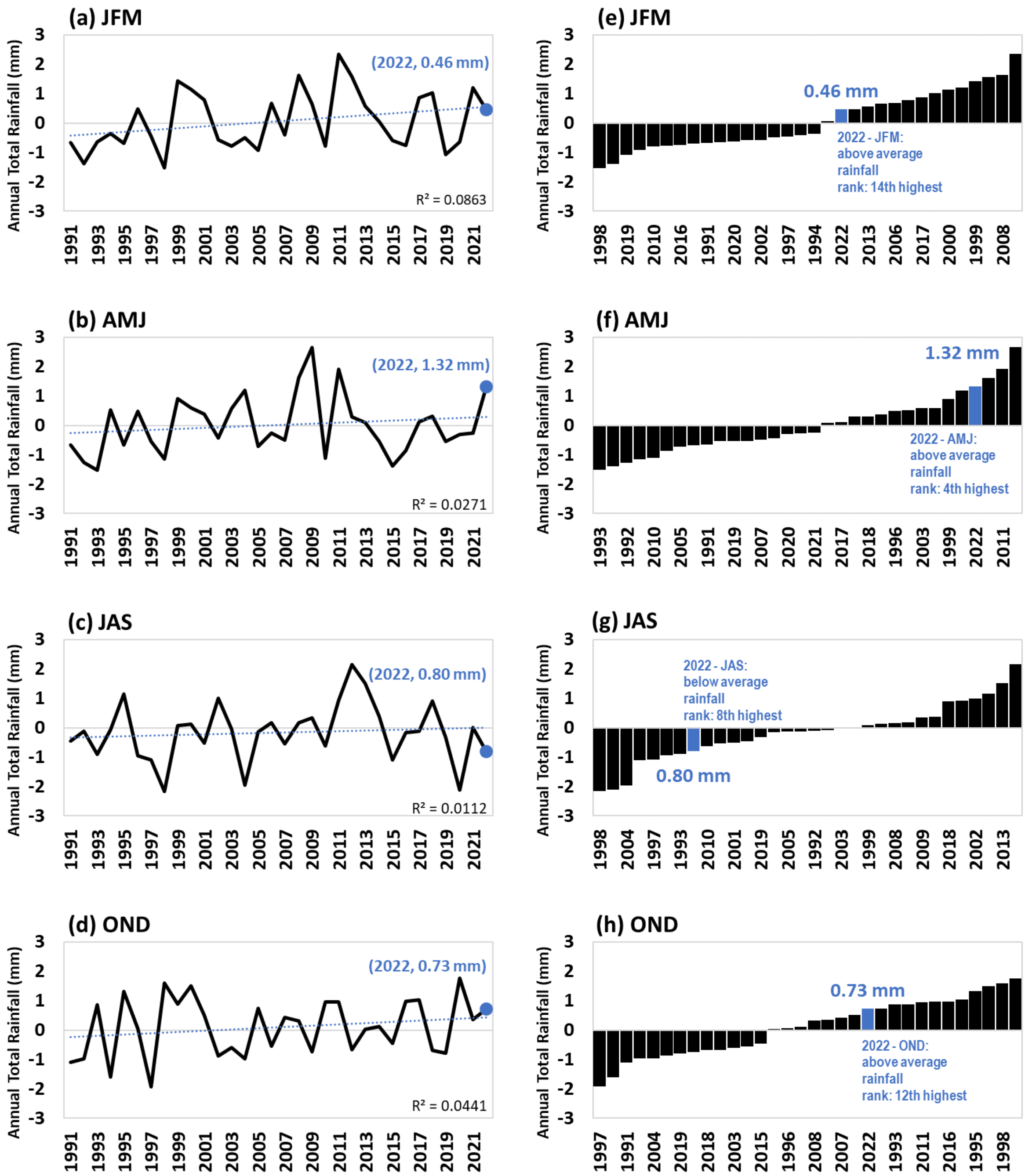
The nationwide rainfall was obtained by getting the average rainfall from more than 50 PAGASA Synoptic Stations, while the calculation of the standardized anomaly was similarly based on the 1991-2020 climatological standard normal.

In 2022, the Philippines experienced a **mean annual rainfall of 2,966.5 mm** that is wetter than the 1991-2020 base period **by 0.6 mm**, which ranks as the **7th wettest year since 1991**. In the face of a persistent La Niña episode throughout the year, the country observed an above average monthly rainfall in April at 3.4 mm, which led the **AMJ season to be the 4th wettest since 1991**.

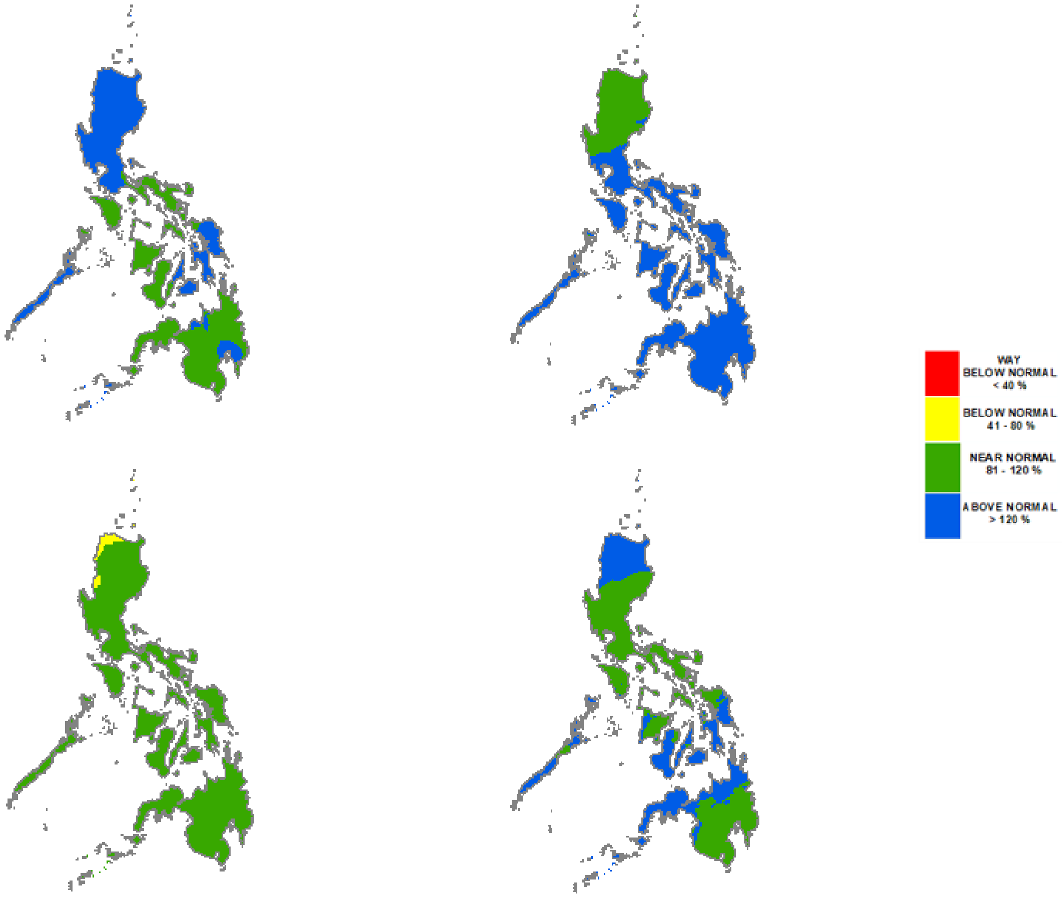
On the other hand, below average rainfall was experienced in July, resulting in a mere 0.8 mm for the July-August-September (JAS) season. This appears to align with the seasonal reversal of rainfall described by Lyon et. al. (2006, 2008) during a La Niña event when certain regions of the country may witness below average rainfall in JAS and above average rainfall in OND.



Timeseries of mean annual rainfall from 1991-2022 indicating (clockwise) the total annual rainfall, monthly rainfall anomaly in 2022, 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).



Observed seasonal rainfall distribution during January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively.

During the JFM season, above normal rainfall conditions were observed over most parts of Luzon, Cebu, Bohol, Eastern Visayas, Misamis Oriental, and portions of Davao Region, respectively, with near normal rainfall conditions experienced most elsewhere. Subsequently, the AMJ season observed predominantly above normal rainfall conditions in most parts of the country, except some segments of Central and Northern Luzon where rainfall conditions reached near normal rainfall.

In the JAS season, the observed rainfall pattern shifted to near normal rainfall conditions in the country, except Ilocos Norte, Apayao, and Cagayan, respectively, where below normal conditions were experienced. During the OND season, near normal rainfall conditions characterized most regions in the country. However, patches of above normal rainfall conditions emerged in the northern parts of Luzon, Palawan, and Negros Occidental, as well as in Central and Eastern Visayas, with Northern Mindanao experiencing a similar pattern.

MONSOON

The onset of the Southwest Monsoon (locally known as Habagat) was declared on 18 May 2022 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 05 October 2022. Based on available records, both the onset and termination dates of the Southwest Monsoon are considered normal, respectively.

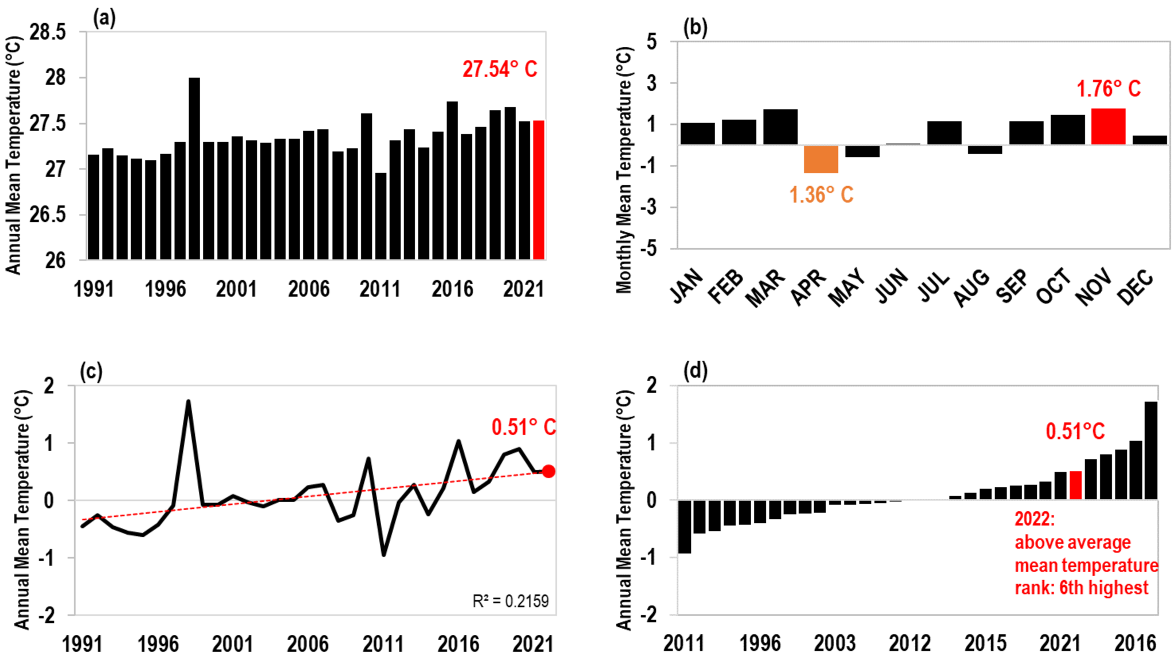
Meanwhile, the Northeast Monsoon (locally known as Amihan) typically begins in the latter part of the year and terminates in the following year. The termination of Northeast Monsoon 2021-2022 was declared on 16 March 2022 while the onset of the Northeast Monsoon 2022-2023 was announced on 20 October 2022. Based on available records, the termination and onset dates of the Northeast Monsoon in 2021-2022 and 2022-2023 are both normal, respectively.

Monsoon system	Declared onset	Declared termination
Northeast Monsoon 2021-2022		16 March 2022/Normal
Southwest Monsoon 2022	18 May 2022/Normal	05 October 2022/Normal
Northeast Monsoon 2022-2023	20 October 2022/Normal	

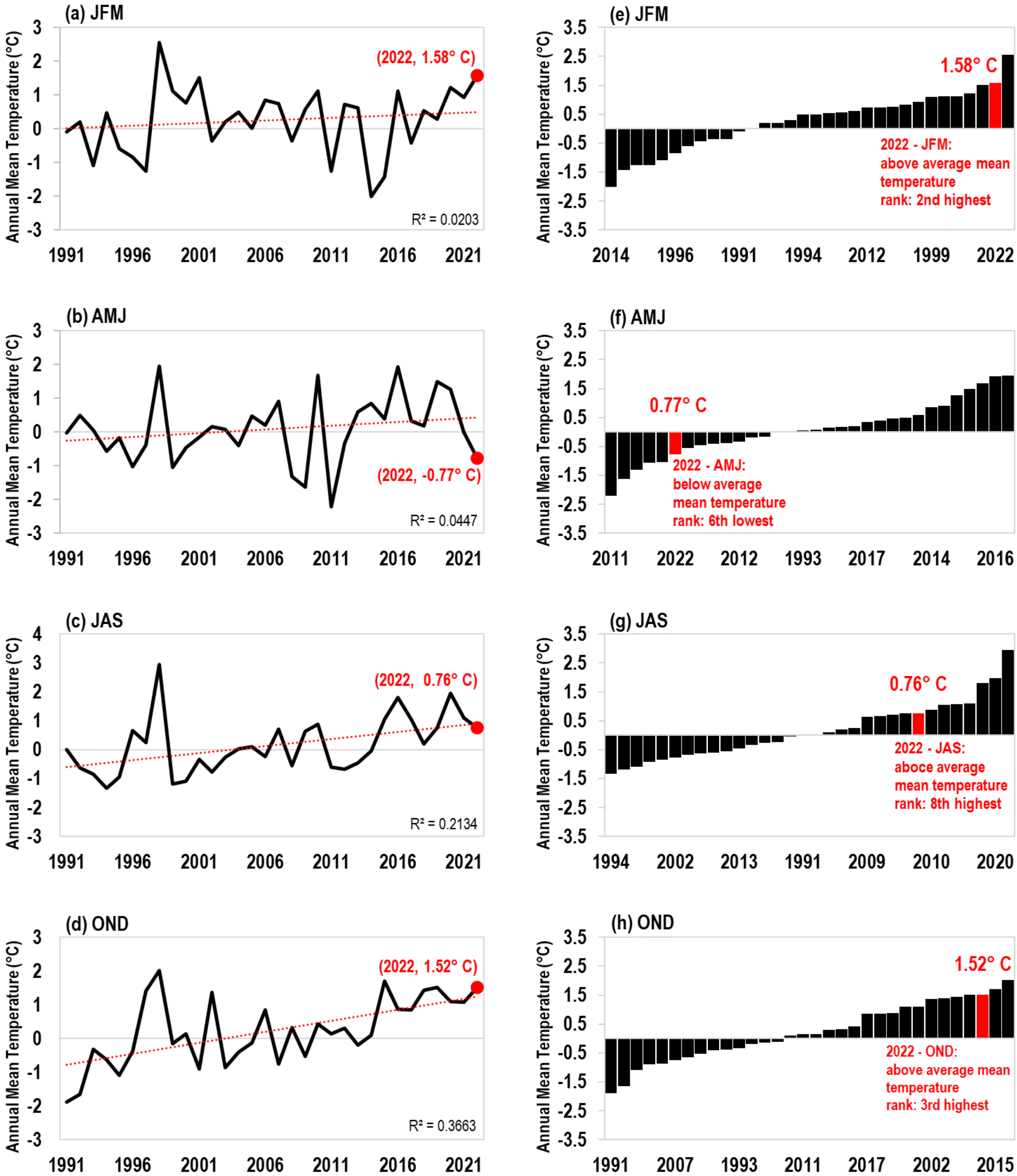
NATIONAL CLIMATE
Temperature

In 2022, the Philippines observed a **mean annual temperature of 27.54°C**, corresponding to **0.51°C warmer** than the 1991-2020 base period. This temperature anomaly positions 2022 as the 6th warmest year since 1991. It is noteworthy that the six warmest years (1998, 2016, 2020, 2010, 2022, and 2021), except for 2010, coincided with La Niña episodes during the second half of the said years.

The country experienced warmer monthly mean temperatures throughout the year, with a notable emphasis on the second half of 2022. Notably, November exceeded its monthly normal by 1.76 °C, making the **OND in 2022 as the 3rd warmest since 1991**. All seasons, except AMJ, observed warmer than average temperatures, which might be attributed to the increased rainfall in the same season.



Timeseries of annual temperature from 1991-2022 indicating (clockwise) the mean annual temperature, monthly temperature anomaly in 2022, standardized mean annual temperature anomaly, and ranked mean annual temperature standardized anomaly, respectively

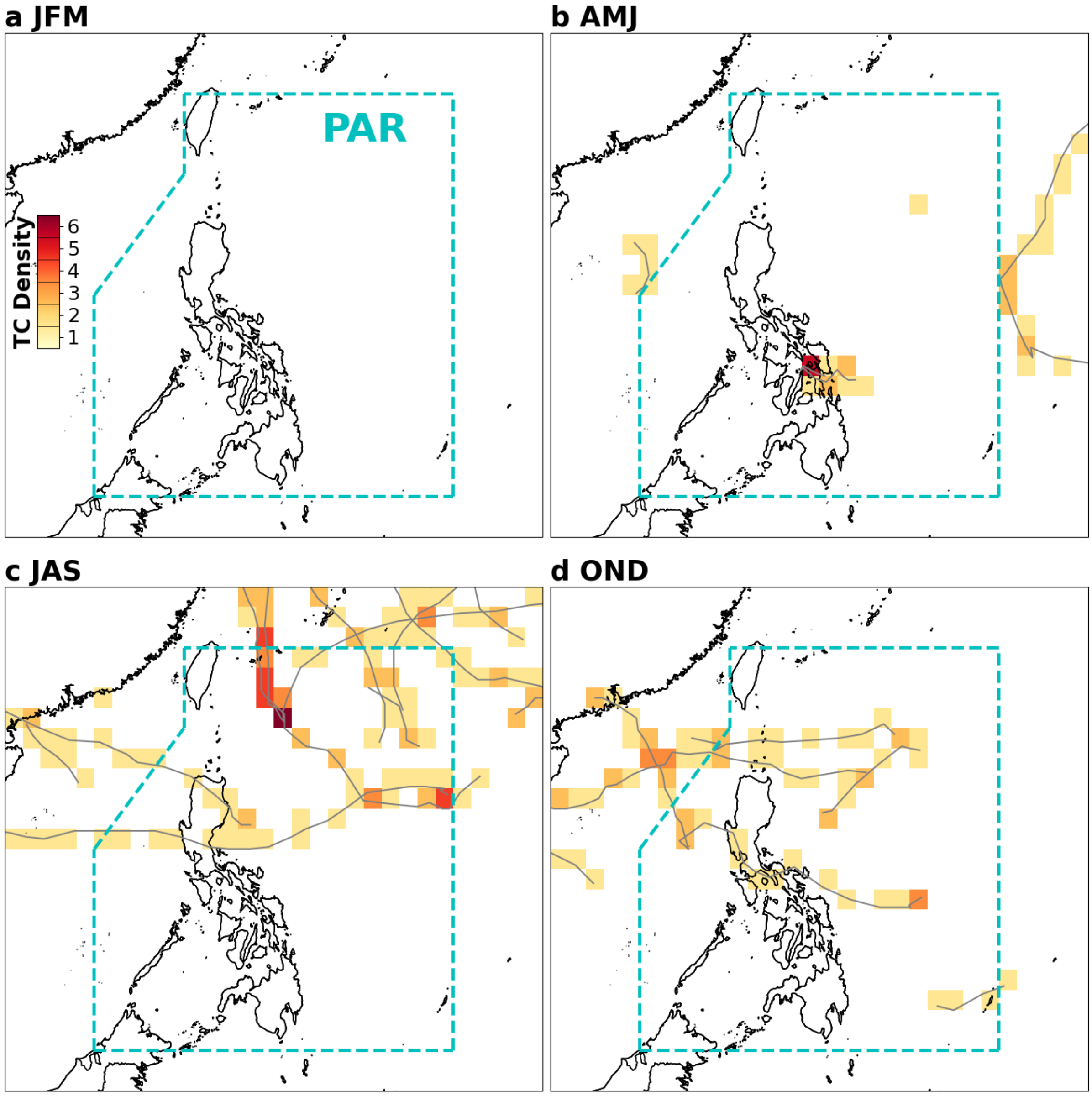


Timeseries of seasonal mean temperature during January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively, expressed in standardized anomaly (left) and ranked standardized anomaly (right).

NATIONAL CLIMATE

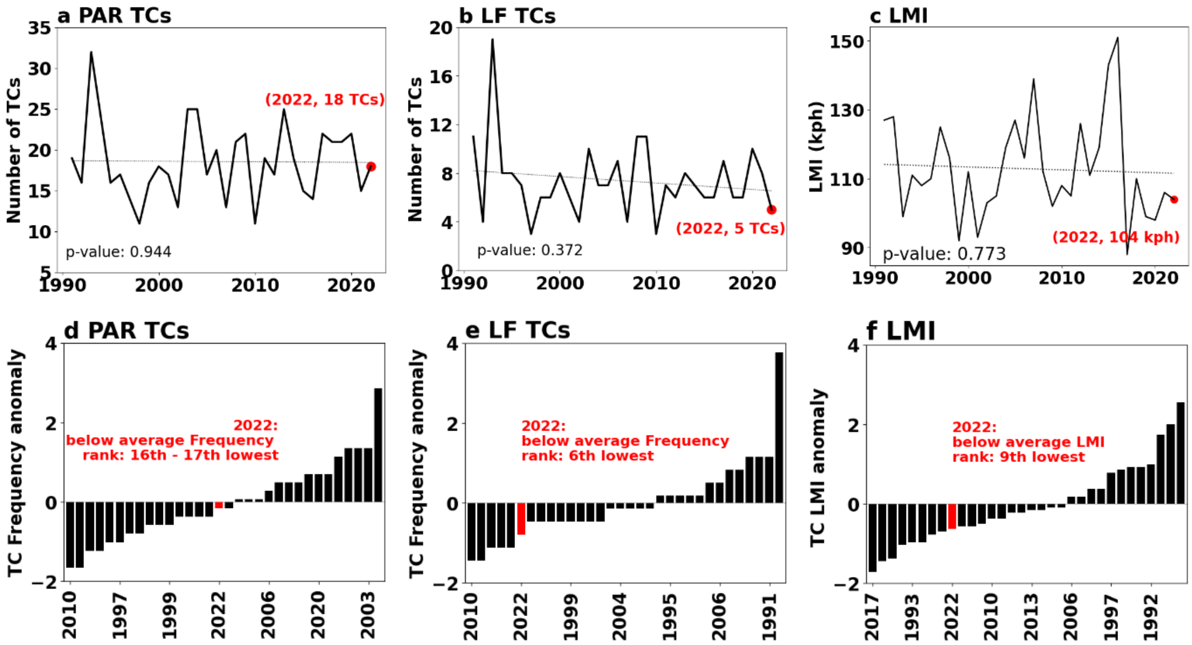
Tropical Cyclones

In 2022, most tropical cyclones (TCs**) traversed Luzon and the northwestern quadrant of the PAR**. There is no TC recorded in JFM. while there is one landfalling TC in AMJ. Most TCs observed in JAS stayed in the open ocean with two landfalling cases. Lastly, TC passages in OND are closer to the Philippine landmass with two landfalling cases as well.



Seasonal tropical cyclone track density map (clockwise) for 2022: January-February-March (JFM), April-May-June (AMJ), July-August-September (JAS), and October-November-December (OND), respectively.

The frequency of landfalls and TC Passages in PAR in 2022 is both **below average and ranked 5th lowest and 16th-17th lowest since 1991**, respectively. Out of 18 TCs that entered or developed the Philippine Area of Responsibility (PAR) in 2022, only 5 TCs made landfall. Meanwhile, the **observed lifetime maximum intensity of TCs in 2022 is also below average, which is ranked 9th lowest since 1991**.



Timeseries of annual passage frequency of PAR TCs and landfalling (LF) TCs, and annual TC LMI for 1991-2022 expressed in absolute frequency (top) and ranked standardized anomaly (bottom).

In 2022, the **strongest TCs are Super Typhoon (STY) Karding and STY Henry** both with a lifetime maximum intensity of 195 kph, respectively. STY Karding swept across central Luzon in September, while STY Henry briefly skimmed through the northern boundary of the PAR.

While **STY Karding was the most powerful landfalling TC in 2022**, it was Severe Tropical Storm Paeng (110 kph) that inflicted the most extensive damage, totaling Php 7 billion in losses to agriculture, infrastructure, and houses (PAGASA 2022). The disparity in damage can be attributed to Paeng's diagonal trajectory, which traversed a larger expanse across Luzon compared to Karding's nearly horizontal path. **The cost of damage incurred by Karding exceeded Php 3.4 billion.**

NATIONAL CLIMATE

Notable Extreme Climate Records

There were **15 new monthly extreme rainfall records observed in 2022 in 14 PAGASA Synoptic Stations**. Two of these rainfall extremes were recorded at PAGASA Roxas Synoptic Station on 11 April and 28 October, respectively. Out of all the new extremes, **the highest rainfall extreme** was recorded at PAGASA **Tanay Complex Station** on **29 October** with a value of **217.6 mm**. Both extremes at PAGASA Laguindingan and Mactan Complex Stations in March and August broke 40-year historical records, respectively.

STATION	New Rainfall Record (mm)	Date	Previous Rainfall Record (mm)	Date
BUTUAN CITY	133.8	10/24/2022	107.4	10/24/2003
CLARK	55.6	3/15/2022	37.0	03/14/2013
DAGUPAN	103.4	1/30/2022	83.0	01/22/2021
GUIUAN	207.8	4/9/2022	136.3	04/13/2014
HINATUAN	171.2	5/1/2022	130.2	05/10/2010
IBA	77.8	4/8/2022	72.2	04/18/1998
LAGUINDINGAN	87.6	3/6/2022	84.2	03/19/1982
MAASIN	148.8	4/9/2022	138.4	04/04/1994
MACTAN	107.0	8/3/2022	96.6	08/17/1982
NAIA	63.5	3/14/2022	36.0	03/07/2011
PUERTO PRINCESA	147.9	1/26/2022	120.4	01/03/2013
ROXAS CITY	172.0	4/11/2022	148.0	04/09/1996
	241.0	10/28/2022	231.4	10/07/2004
SCIENCE GARDEN	68.2	4/5/2022	64.8	04/21/2015
TANAY, RIZAL	217.6	10/29/2022	204.6	10/28/2000

For monthly maximum temperature (TMAX), **10 PAGASA Synoptic Stations broke their extreme records in 2022**. PAGASA Catbalogan Synoptic Station registered two new TMAX records on 31 October and 15 December, respectively. Both PAGASA **Clark** and **Zamboanga** Synoptic Stations recorded three new TMAX extreme records on 09 September, 09 October, and 30 November, and 03 January, 09 February, and 13 November, respectively. From these new extreme records of TMAX, the highest record was **36.7°C** observed **at PAGASA San Jose Synoptic Station on 27 February 2022**. The extreme TMAX record at PAGASA Catbalogan Synoptic Station broke a 35-year historical record.

STATION	New Tmax Record (°C)	Date	Previous Tmax Record (°C)	Date
BUTUAN CITY	36.5	9/17/2022	36.4	09/20/1991
CATBALOGAN	35.9	10/31/2022	35.8	10/23/1987
	35.0	12/15/2022	34.8	12/04/1998
CLARK	36.4	9/18/2022	35.4	09/26/2021
	35.6	10/9/2022	34.2	10/30/2020
	34.6	11/30/2022	34.5	11/07/2021
INFANTA	34.6	1/30/2022	34.1	01/18/1998
ITBAYAT	32.5	3/22/2022	32.0	03/28/2020
LEGAZPI	32.7	1/30/2022	32.7	01/24/1912
MALAYBALAY	34.0	1/8/2022	34.0	01/23/1988
MASBATE	34.5	12/17/2022	34.2	12/16/1997
SAN JOSE	36.7	2/27/2022	36.5	02/09/2019
ZAMBOANGA	36.0	1/3/2022	35.8	01/29/2016
	36.1	9/2/2022	35.8	09/02/2004
	36.4	11/13/2022	36.0	11/15/2020 11/21/2020 11/23/2020

The PAGASA **San Jose Synoptic Station** is the only synoptic station that broke its **monthly minimum temperature** (TMIN) in 2022. However, it has observed three lowest TMIN on 05 February (**17.5°C**), 12 July and 31 July (**19.5°C**), and 20 September (**19.0°**C), respectively. The extreme records at PAGASA **San Jose Synoptic Station** in July and September, respectively, broke more than 42-year historical records.

STATION	New Tmin Record (°C)	Date	Previous Tmin Record (°C)	Date
SAN JOSE	17.5	05/2/2022	20.5	05/27/1986
	19.5	07/12/2022, 07/31/2022	20.0	07/30/1980
	19.0	09/20/2022	19.0	09/17/1980

Dataset and Method

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 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/).

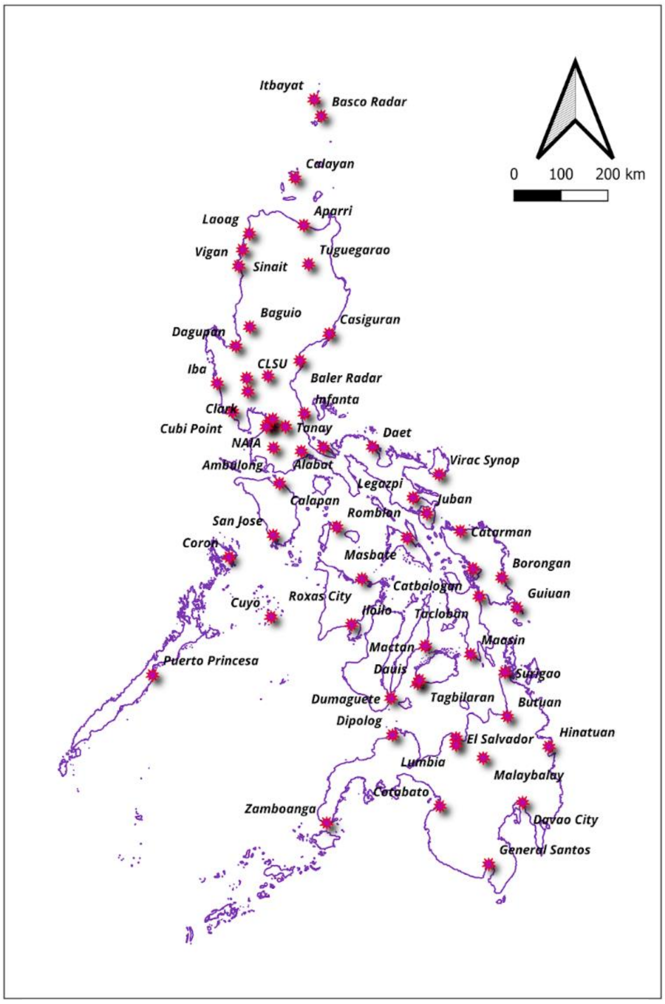
The global mean temperature is based on the downloaded data from the National Aeronautical and Space Administration (https://data.giss.nasa.gov/gistemp/ via https://psl.noaa.gov/data/climateindices/list/).

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 Agrometeorology 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/), and the International Best Track Archive for Climate Stewardship (IBTrACS) of the National Centers for Environmental Information (NCEP), National Oceanic and Atmospheric Administration (NOAA) (https://www.ncei.noaa.gov/).

OBSERVED DATA, SCALE OF ANALYSIS AND STATISTICAL TESTS

Observed data, scale of analysis and statistical tests. The monthly rainfall and temperature are obtained from 56 PAGASA Synoptic Stations from 1991-2022. The scale of analysis used the annual and seasonal terms defined as January-February-March (JFM), April-May-June (AMJ), July-August-September, 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



Map of PAGASA Stations

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.

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CLIMATE AND AGROMETEOROLOGICAL DATA SECTION (CADS)
Climatology and Agrometeorology Division (CAD)
Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA)

Tel Nos. (632) 284-0800 loc. 1121 & 1122
Mobile No.: (0999) 959-9202
E-mail Address: cadpagasa@gmail.com

Science Garden Complex, Senator Miriam Defensor-Santiago Ave., Diliman, Quezon City

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