Proceedings
of the Philippine Meteorological Society

Volume 5, March 2022 ISSN 2599-5537

Abstracts of Papers Presented in the

2022 PMS Annual Convention

Theme: "Early Action: Responding to Hydro-Meteorological Challenge under the New Normal"

ISSN 2599-5537

Published by the Philippine Meteorological Society, Inc.
PAGASA Science Garden Complex
Agham Road, Diliman, Quezon City
Tel. No.: (+63 2) 929-4570

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Session I: Advances in Weather Observation, Analysis, Forecast and Warning, and Local Responses

Pre-landfall rapid intensification of Typhoon Odette

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Rapid intensification (RI) of tropical cyclones (TCs) is defined as the upper 95th percentile increase of TC maximum winds in a 24 hour period (25 kt). From 1951 to 2020, of the 522 TCs that made landfall in the Philippines, 146 TCs (28%) underwent RI. RI TCs pose a larger threat to the country as the region conducive for RI bounded by 123°-140°E and 10°-20°N is just to the east of the Philippines. 82% of the 146 landfalling RI TCs made landfall as typhoons, as opposed to only 12% of non-RI TCs as making landfall as typhoons. RI forecasts still have relatively low skill with threat scores ranging from 0.08-0.24. In the case of TY Odette, an RI of 75 kt from 65-140 kt was observed from 15-16 of December 2021. A high resolution model shows a good relationship between the radial profile of sea surface temperature (SST) and RI process where high SST near the TY eye region on 0-6z (8am-2pm PST) of 16 December resulted in convective bursts in the primary circulation leading to its RI. The opposite case is true prior to its RI where SST was higher in the secondary circulation of the TC which led to updrafts in the outer rainbands inhibiting RI.

Keywords: *Typhoon Odette, rapid intensification, WRF, SST*

Typhoon Odette (RAI) 2021

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Odette is the 15th and the last tropical cyclone that enters the Philippine Area of Responsibility (PAR) in 2021. It developed into a tropical depression over the waters of Palau on 12 December. It intensified into a tropical storm on the next day. On 14 December, it intensified into a severe tropical storm and entered the PAR. Due to favorable environmental conditions, the tropical cyclone was upgraded to the typhoon category the next day. ODETTE underwent rapid intensification and reached its peak intensity on 16 December with estimated maximum sustained winds of 195 km/h. The tropical cyclone traversed the northeastern Mindanao, Visayas, and Palawan. ODETTE made a total of 9 landfalls. ODETTE made its 1st landfall over Siargao Island, Surigao del Norte, 2nd over Cagdianao, Dinagat Island, 3rd over Liloan, Southern Leyte, 4th over Padre Burgos, Southern Leyte, 5th over Pres. Carlos P. Garcia, Bohol, 6th over Bien Unido, Bohol, 7th over Carcar, Cebu. On 17 December, it made its 8th landfall over La Libertad, Negros Oriental and 9th landfall over Roxas, Palawan. ODETTE slightly weakened while traversing the central Philippines but remained a typhoon category. When the tropical cyclone emerged over the West Philippines Sea, it began to re-intensify and once again. ODETTE left the PAR on 18 December.

Very destructive typhoon-force winds of ODETTE caused massive damages to infrastructures and agriculture. In addition, intense to torrential rains lead to widespread flooding and landslides over Visayas, Palawan, and the northern portion of Mindanao**.**

Keywords: *Typhoon Odette, PAR, tropical cyclone*

DRRM and the Case of Typhoon Odette in the Province of Cebu

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In the past few years, the Province of Cebu were affected with severe and high impact weather events that caused significant such as severe flooding and caused massive disruption to people's livelihood and other economic activities. Very recently, the wrath of Typhoon Odette in December 2021 caused irreversible and widespread damages in the Province of Cebu. The Provincial Disaster Risk Reduction and Management Council recorded significant number of casualties and substantial damages to infrastructure and agriculture, among others. The presentation will highlight some of the Best Practices on Disaster Risk Reduction and Management (DRRM) in the Province of Cebu. Specifically, it presents the (1) Cebu's Risk Profile, the four (4) thematic areas on DRRM, (3) Cebu's response on hydro-meteorological hazards and the case of typhoon Odette, and (4) unwritten laws of disaster management. The Province of Cebu through the PDRRMO continues to engage in local partners to promote disaster risk reduction and management in the province.

Keywords: *DRRM, risk profile, typhoon Odette*

Session II: **Societal Impacts of Climate Information and Services**

National Framework for Climate Service (NFCS) to support Climate Risk Management to avert, minimize and address loss and damage

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Climate change, variability and extreme weather events adversely impact on power and water supplies, planting and harvesting periods in agriculture, transportation networks, human health and above all lives and livelihoods. These impacts are often cross-sectoral and require coordinated responses among various agencies at national to local level, within the broader frameworks of sustainable development, disaster risk reduction and green growth. Therefore, there is a critical need for effective and timely climate, weather and water related information services to cater to social needs and to manage climate risk in a comprehensive manner to avert, minimize and address loss and damage, which are emerging from climate change.

The WMO's Global Framework for Climate Service (GFCS) answers to that demand by improving capacity in climate services and enhancing dialogue with users and providing reliable climate information in timely manner. The vision of the GFCS is to enable better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale. The GFCS will be implemented on three levels: global, regional and national level. The National Framework for Climate Services (NFCS) implements the Global Framework for Climate Services (GFCS) at national level with the engagement of key sectoral agencies to integrate their demand of climate services. This also helps to build joint-ownership among the sector agencies, which would help towards sustaining the effort and ensuring the services from NMHSs.

Climate risk management (CRM) is a comprehensive process, which is achieved through assessing climate risk, selecting suitable CRM measures and decision making and implementation of CRM measures. CRM is now used to avert, minimize and address loss and damage, which are emerging from climate change. Estimation of loss and damage is widely discussed (after establishing Warsaw International Mechanism (WIM) in 2013 at COP19 of UNFCCC) and encouraged to integrate into NAP and NDCs processes in countries. Therefore, National Framework for Climate Services (NFCS) is important for comprehensive CRM as it needs climate information to assess climate risks.

Keywords: *Climate change, GFCS, Climate Risk Management, sustainable development*

Potential impacts of climate change on major Philippine tropical cyclone events in the future

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The Philippines is frequently affected by tropical cyclones (TCs) which bring substantial threats to life and cause property damage and disruption. With climate change (CC), projections for Philippine TCs are generally consistent with global studies with a decrease in TC frequency, but an increase in the frequency of intense TCs and increase in the TC-associated rainfall, which would then lead to an increase in TC impacts in the future. The potential future changes in the characteristics and damage potential of three of the observed most damaging TC events (Haiyan, Mangkhut and Bopha) in the Philippines was analysed. In particular, we looked at how the TCs' track, speed, intensity, size, and rainfall might change, combining downscaling with the pseudo global warming technique. Simulations were performed using the Weather Research and Forecasting model, with CC deltas derived from the latest Coupled Model Intercomparison Project Phase Six (CMIP6) Global Climate Models or as prescribed changes to SSTs. We found that re-forecasting the three TCs under warming scenarios causes small changes in the track, except when using only surface variable perturbations, which results in northward shifts in the track, primarily due to the weakening of the Western North Pacific Sub-tropical High. We also found that, relative to the current climate conditions, future warming leads to more intense TCs (lower central pressure and higher maximum winds), particularly for Haiyan and Mangkhut, and more intense TC-associated rainfall for all TC cases, with varying magnitude of change depending on the TC case. The changes in size and translation speeds are relatively small. The results also suggest that the more intense TC cases – Haiyan and Mangkhut - would have even higher damage potential in the future. The results warrant investigation of a larger number of TCs and have implications for early warning and disaster response in the future.

Keywords: *Tropical Cyclones, WRF, Pseudo-Global Warming technique, Climate Change, Global Warming, Uncertainty, CMIP6*

<u>Session III:</u> Improvements in Rainfall Estimation, Flood Forecasting and Warning System

Hydrological Response of Selected River Basins to Intense Rainfall

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The Philippines is frequently affected by tropical cyclones (TCs) and other mesoscale convective systems resulting in repeated, intense rainfall events. Likewise, our country is composed of many river basins and too much rainwater could cause flooding when it surpasses the basins' carrying capacity. Therefore, understanding the flood response of the river basins is needed in effective disaster risk management. This study selected two river basins of different characteristics to investigate their response to intense rainfall using observational and modeling methods. The first part focuses on the Pampanga River Basin (PRB), a large river system equipped with gauging stations for monitoring and flood forecasting. Hydrological responses in terms of flood onset and lagtime as being affected by TCs directly or indirectly were studied using the observed data from 2013-2018. Flood events were selected based on the assessed threshold levels (alert, alarm, critical) established by the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) in the Arayat station as forecast point. The second part focuses on Matina River Basin (MRB), a small ungauged river basin in highly urban Davao City. The hydrological response of this data-scarce river to intense rainfall brought by localized thunderstorms was studied by simulating two flash flood events using the Physically-Based Distributed Hydrological Model (PBDHM). Results show that TCs induced all flood events in the PRB during the study period. All intense TCs that directly traversed the PRB resulted in critical-level river floods. These TCs also had the shortest onset of 7 – 27 h from alert to the critical level. On the other hand, floods from distant landfalling TCs are dependent on the season. TCs traversing north (south) of the basin induced flooding only during southwest (northeast) monsoon season. These TCs can raise water levels from alert to critical in 11 – 48 hr. As large uncertainties remain in TC rain forecasting, a simple checklist method for flood forecasting that depends on the general TC track, season, and accumulated rainfall was proposed for groups with limited forecasting resources. Meanwhile, the PBDHM simulation showed good correspondence between the simulated time difference from peak rainfall to flood peak with the reports on the ground, which is equal to 80 minutes and less. This result can serve as a basis for developing a flood forecasting system in the rivers of Davao City and elsewhere.

Keywords: *river basin, flood events, physically based distributed hydrological model*

Investigation of the Seasonal Variation of Microphysical Characteristics of rainfall over Metro Manila using PARSIVEL^2 Disdrometer

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The seasonal variability of raindrop size distribution (RSD) and integral rainfall parameters over Metro Manila during the Northeast Monsoon (NEM) (November 2018 – February 2019), Transition (Pre-SWM) (March 2019- May 2019), and Southwest Monsoon (SWM) (June 2019 – September 2019) periods are studied by using one-year worth of measurements from the PARSIVEL^2 Optical Disdrometer installed at the Manila Observatory. Soundings, satellite, and reanalysis data sets are also used to determine the possible dynamical and microphysical processes that affect the RSD evolution during the three different periods. Results show that NEM period has the highest number concentration of small raindrops ($D < 1\ mm$), while SWM has more significant quantities of large raindrops ($D \geq 3\ mm$) among the three seasons during the study period. These results suggest that the high number concentration of (small) large raindrops during the (NEM) SWM season is due to the (low) high frequency of occurrence of convective rainfall. The SWM season has the highest values of Convective Available Potential Energy (CAPE), which extends clouds further above the freezing layer (~ 5 km), resulting in cold-rain processes that promote aggregation and riming of ice particles and produces relatively larger raindrops at the surface. This work is one of the first rainfall microphysics study in the Philippines that is based on actual RSD measurements. The results obtained from this study will provide a physical basis for improving rainfall retrievals in weather radars and the parameterization of microphysics schemes in numerical weather prediction models.

Keywords: *rainfall microphysics, raindrop size distribution, disdrometer, seasonal*

Session IV: Science Communication: Public Weather Services

#MAGHANDA Para sa Ligtas na Pilipinas

Michael S. Bala

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Project #MAGHANDA, or Meteorological and Geological Hazard Advisories, Notifications and Warnings for Decisive Action, is a nationwide campaign to improve understanding of warning messages and alert systems issued by the disaster risk reduction (DRR) agencies of the Department of Science and Technology (DOST) -- DOST-PAGASA and DOST-PHIVOLCS. The initiative is borne out of the recognition or realization that products and services from both agencies, apart from being accurate and timely, should also be easily accessed and consumed from the perspective of the local government units (LGU). The rationale behind the project is that during times of high-impact events, where time-sensitive science-based information is key, a definitive and operational understanding of warnings and alerts issued by DOST-PAGASA and DOST-PHIVOLCS is very important to drive the appropriate response or action from the general public. The objective of #MAGHANDA, therefore, is to capacitate each city and municipality in the Philippines, specifically local chief executives, DRR management officers, municipal local government operations officers, uniformed personnel, Information Officers, as well as the media. In partnership with the Department of Interior and Local Government and its training arm, the Local Government Academy, a total of 28 online learning sessions will be conducted -- 17 for each region in the country, four for Governors and Mayors, and seven for the media -- between June and March this year. Asynchronous lessons will be conducted via a learning management system as well as online workshops aimed to discuss the knowledge gained and application to their respective contingency plans and DRR protocols.

Keywords: *DRR, Local Government Unit, warnings*

A Study on Evacuation Decisions and the Role of Media Reporting in Flood Emergencies – The Case of Typhoon Hagibis

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This research aims to clarify effective means for encouraging proactive evacuation in communities and avoid casualties by efficient dissemination and use of disaster information. Focusing on the areas damaged by Typhoon Hagibis in Japan, evacuation behavior is clarified using regression analysis while media coverage is described using content analysis and hierarchical cluster analysis. In this paper, evacuation behavior is investigated using interview surveys of residents from Osaki Kashimadai, Osato and Marumori in Miyagi Prefecture. In addition, the relationship between the media exposure and the scope of damages was investigated using the broadcast of NHK General TV on October 11th to 14th. From this research, it is found that casualty-free areas have higher disaster consciousness, were more prepared and took proactive evacuation. Moreover, the media did not broadcast sufficient area-specific disaster mitigation-related information, so residents relied on local broadcast systems for their evacuation decision.

Key Words: *flood evacuation behavior, proactive evacuation, media reporting, disaster information, Typhoon Hagibis*

The Transport Process and Deposition of Ashfall Over CALABARZON and National Capital Region During the January 2020 Eruption of Taal Volcano, Philippines

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On January 12, 2020, after 43 years, Taal Volcano erupted that resulted in ashfall incidents in several communities in Luzon Island, Philippines. This study aims to describe the transport process and deposition of ashfall during the eruption over CALABARZON and National Capital Region by using eruption data, meteorological parameters, ashfall images and air quality data on January 12-16, 2020. It was identified that various wind speed and direction at different atmospheric pressure levels contributed to transport of ashfall at different areas. On January 12, high ash plume was influenced by southerly winds based from NOAA HYSPLIT trajectory and dispersion models as supported by ERA-5 reanalysis data, sounding data, and satellite images. Same data was used to analyze the transport of low volcanic ash plumes on January 13-16 which was generally influenced by northeasterly winds as prevailing winds. Ashfall incidents were identified in the Provinces of Cavite, Laguna, Batangas, Rizal, and Cities of Quezon, Marikina, Muntinlupa, Taguig, Parañaque, Mandaluyong, Las Piñas and Pasig based from the ashfall images collected that underwent image analysis. Based on image analysis, highest ashfall area was identified in Batangas Province. Moreover, 24-hour concentration of total suspended particulates from January 13-14 in Lipa City, Batangas reached acutely unhealthy level. Emission flux on January 13 reached 399, 168 ug m^{-2} which can be linked to the particles released during the eruption. From January 12-16, PM_{10} and $PM_{2.5}$ concentration on January 12 from the Lung Center of the Philippines air quality monitoring station had the highest total emission flux equivalent to 17,460 ug m^{-2}. On January 12, long range transport of high ash plume was observed while low volcanic ash plume affected the southwestern part of the volcano during the succeeding days. The study can serve as supplementary data in disaster risk reduction and management and forecasting future events.

Keywords: *ashfall; deposition; eruption; Taal; transport*

Poster Session

Enhancement of the DOST-PAGASA Monthly Climate Impact Assessment for Philippine Agriculture using Satellite Products

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Since 1985, DOST-PAGASA has been extending its assistance to agricultural researchers, agricultural extension workers, farm technicians and local farmers by providing agroclimatic assessment information relevant to local rice and corn farms. However, the worsening climate change condition further exacerbates the vulnerability of the Philippine agriculture sector to weather and climate related hazards. To address this matter, an investigation was conducted to enhance the DOST-PAGASA Monthly Climate Impact Assessment for Philippine Agriculture from an in-situ observation dependent issuance to one that is formulated entirely from satellite-derived data, with the integration of new research and survey findings related to rice and corn farming. The satellite products used are the daily and monthly rainfall estimates (RE) of the Integrated Multi-satellitE Retrievals for General precipitation model (IMERG) at ~10-km resolution, and the monthly Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) of the Terrra Moderate Resolution Imaging Spectroradiometer (MODIS/Terra), both at ~5-km resolution. The RE and LST were used to derive the provincial-level crop water requirement at crucial crop stages, from which rainfall sufficiency was subsequently determined. These parameters were then used to compute the gridded Standardized Precipitation and Evapotranspiration Index (SPEI) at 1-month and 3-month timescale. Daily RE were utilized to determine days of highest precipitation by computing the maximum 1-day and maximum 5-day rainfall indices (i.e. Rx1day and Rx5day, respectively). Initial comparison of the revised and previous assessment method revealed the advantage of using gridded information over in-situ observation in terms of the spatial coverage of derived information regarding moisture availability, crop condition and the impacts of drought and heavy rainfall events. Further validation is to be performed on the derived parameters using historical data on crop production and reported damage from notable weather/climate events.

Keywords: *climate impact assessment, agriculture, MODIS, IMERG, SPEI*

Removing Interference Echoes in Philippine Radars Using a Fuzzy Logic Approach

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Ideally echoes in radar reflectivity data correspond to precipitating particles, however they do not, and as a result, automated weather radar products that use these data are drastically affected when conditions are not ideal. Weather radar data of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) is one such case that often suffer contamination, in particular by electromagnetic interference and the identification and mitigation of interference echoes is an ongoing problem in radar meteorology in these regions. To improve the quality of the data and consequently the automated products, a fuzzy logic algorithm is applied upon the radar reflectivity data to provide a probability guidance for segregating interference-contaminated echoes from precipitating echoes. Specifically, adequate features to highlight interference characteristics are required for the algorithm to be effective based on prior experiences. This approach is presented in this study to derive membership functions and their relatively objective weights are determined based on the superior result of sensitivity test from interference cases. The result of which produced a value that quantifies the possibility of each bin being affected by interference. Cases that highlighted the interference were exhaustively examined and demonstrated the ability of the fuzzy logic algorithm to remove interference echoes from radar reflectivity map. Moreover, the presented method can be feasibly implemented in real-time multi-radar operations as a quality control (QC) aid.

Keywords: *radar reflectivity, fuzzy logic, quality control, interference*

Reflectivity-Rain rate relationship for TY Mangkhut (Ompong) in Subic radar station using window probability matching method

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Tropical cyclones (TCs) are considered one of the most destructive and costliest natural phenomena on earth. Weather forecasting can help reduce the detrimental effects of severe weather like TCs. Weather radar provides real-time high-resolution spatial and temporal precipitation estimates and delivers early warnings and information that alerts affected areas about approaching severe weather. However, radar does not measure rainfall directly. Radar reflectivity (Z) to Rain rate (R) conversion using the empirical power-law in the form of Z-R relationship ($Z = aR^b$) gives rainfall measurements estimate. Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) uses the Marshall-Palmer equation ($Z = 200R^{1.6}$) to derive rainfall estimates from radar. This research focuses on the Z-R relationship derivation for rainfall estimates in Northern Luzon. The Z-R relationship was developed using Traditional Matching Method (TMM), Probability Matching Method (PMM), and Window Probability Matching Method (WPMM). For this purpose, observations from weather radar at Subic station and automatic weather rain gauge station during TY Mangkhut were obtained. The result shows that the established relationship using WPMM ($Z = 113R^{2.38}$) provides the best relations compared to MP.

Keywords: *TC, weather radar, Z-R relationship, WPMM*

Analysis of Satellite-Derived Rainfall Clustering in the Philippines

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Traditionally, the Philippines were classified into four distinct climate zones and are based on the Modified Coronas Classification (MCC), which uses average monthly totals of rainfall from the rain-gauges network available during 1920. Due to undoubted claims of warming and changes in climate, this present study was then encouraged to redefine the climate types or zones around the Philippines through applying cluster analysis, specifically single linkage technique and K-means clustering algorithm, to the satellite daily data of rainfall from Asian Precipitation–Highly Resolved Observational Data Integration Towards Evaluation of Water Resources (APHRODITE) of National Center for Research (APHRODITE).

With the combined solutions of the aforementioned clustering techniques, the satellite dataset of rainfall from 1951 to 2019 generated 5 distinct climate zones or clusters across the Philippines. Although climate clusters 1 and 2 have the same climatological rainfall pattern throughout the year, which gradually starts to increase from May and peaks in August, climate cluster 2 exhibits a greater rainfall amount (500mm in its peak month) compared to climate cluster 1. Additionally, climate clusters 4 and 5 are somehow identical in rainfall pattern, however, climate cluster 5 has a greater rainfall amount compared to climate cluster 4. Comparing the spatial distribution and the temporal rainfall pattern of MCC climate types and the generated climate zones, climate cluster 2 and MCC Type 1, as well as climate cluster 1 and MCC Type III, are most likely identical.

Keywords: *Philippines, cluster analysis, climate zones, single-linkage, K-means, satellite precipitation data*

Dynamics of Tropical Cyclone Activity in Northern Philippines

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Tropical cyclone (TC) has been regarded as the most catastrophic and most expensive natural disaster to hit the Philippines. Since TCs cross the country annually, Filipino lives have adapted this way of lifestyle and mitigated its threat. Using the 30-year (1990-2020) data from Joint Typhoon Warning Center (JTWC), this study aimed to produce a climatological study and investigate the trend of TCs in the Philippines and find the relationship of atmospheric oscillations such as the El Nino Southern Oscillation and Pacific Decadal Oscillation. Based on the new PAGASA category of TC, results showed that an average of 19 TCs entered PAR annually and 80% (468) of 585 TC entered PAR from June to November, mostly typhoon and super typhoon category. Furthermore, findings showed that more landfalling than non-landfalling TCs in the country during the first semester and weaker typhoons during November, mostly STY. Moreover, results showed a decrease in the total number of strong typhoons (typhoon and super typhoon category) and an increase in a weaker typhoon (tropical depression, tropical storm, and severe tropical storm categories). Also, results showed a decrease in the trend for landfalling tropical cyclones. In terms of track, two distinct tracks were observed where westward TC during December to May and west to northeast track during June to November. The influence of ENSO and PDO are manifested unto the TCs' characteristics where weaker TCs were likely to landfall during the Neutral ENSO phase while stronger TCs during El Nino. In terms of track, more TCs made landfall during the cold phase of PDO and Neutral ENSO and La Nina phase.

Keywords: Tropical cyclones, Northern Luzon, Trend

Analysis of Rainfall and Temperature Variability and Trends in Northern Luzon

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The characterization of trends and uncertainty in climate extremes is useful in the derivation of time series for input to process models used in a wide array of planning and management sectors, such as the hydrologic models used in flood risk management, ecological impact models, water allocation and source protection and crop yield models. Therefore, understanding the changes in temperature and precipitation is vital, particularly in an area where rainfed agriculture is predominant and at high risks of hydrometeorological hazards. Rainfall and temperature variability and trends in northern Luzon were investigated using the rainfall (CHIRPS) and the temperature (MODIS11C3) satellite dataset. Different climate extreme indices were used to examine the trends and variability. Most of the area in Northern Luzon shows a significant increasing trend in extreme rainfall events. A significant increase in rainfall trend is observed particularly in the east to the southeastern side of northern Luzon. Also, a significant rainfall increase is mostly observed in the lower half of Northern Luzon. While, an increasing trend is observed for the extreme temperature events, particularly in the northeastern side of Northern Luzon, whereas a significant decreasing temperature extreme events trend is observed in the western region of the area. Furthermore, trends of temperature showed a significant increase. Also, an increasing temperature trend is observed on the northeastern side and southwestern side of the study area from June to December. Therefore, frequent extreme rainfall and temperature events are expected. Also, rainfall amount increases in the eastern and lower half section of Northern Luzon. And the eastern and lower half section of Northern Luzon experienced an increase in rainfall. Whereas the temperature increase is mostly experienced in the northeastern side and southwestern side of Northern Luzon especially during June to December.

Keywords: *Rainfall, Temperature, Variability, Trends, Extremes, Northern Luzon*

Case Study: Habagat 2021 Rainfall Event

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In July 2021, major flooding incidents in Metro Manila, Central Luzon, CALABARZON, and Ilocos Region resulted in massive property and agricultural losses due to the enhancement of the southwest monsoon. The purpose of this study is to identify the atmospheric conditions that may have led to the mentioned event. Rainfall data from ground stations and gridded observation data, as well as horizontal winds and surface pressure from the reanalysis, were evaluated weeks prior to the major event to understand the synoptic patterns that may have triggered the southwest monsoon enhancement. Results showed that the moisture flow brought by the southwest monsoon may have been influenced by large-scale systems such as the Madden-Jullian Oscillation in phase 5 and 6, Rossby waves, the expansion and deepening of the monsoon trough, and the presence of tropical cyclone near the line segment connecting the Luzon landmass and Okinawa, Japan. Interaction of the strong moisture flow from the monsoon and the mountainous terrains of Luzon can result in heavy precipitation in the area.

Keywords: *monsoon, heavy precipitation, Philippines*

Analysis of Drought Occurrences Using Satellite Data

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Drought is a natural disaster that is a result of a prolonged precipitation deficit. It can be classified into four types: meteorological, agricultural, hydrological, and socioeconomic. Meteorological drought occurs first because of precipitation deficit which may be followed by agricultural and/or hydrological then socioeconomic drought. To mitigate the drought's domino effect, different satellite data was used to determine and examine drought occurrences in the Philippines from 2000 to 2020. The satellite data gathered for this study are Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), and Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). Percent of Normal Precipitation Index (PNI) and Standardized Rainfall Anomaly Index (SRA) were used as a drought index using CHIRPS data. In analyzing the drought events, both meteorological indices were used along with the anomaly of both the vegetation indices. Climatological normal of NDVI and EVI anomaly were calculated. Similarly, the ENSO phases and dry and wet seasons were averaged and plotted along with the anomaly of these indices during the ENSO phases. Both the agricultural drought indices, NDVI standardized anomaly and anomaly of EVI, show similar results in determining drought. They also have a strong positive correlation with each other in most of the flatlands while in mountainous regions, specifically near the eastern region of the country, they have a weak to a moderate positive correlation. In analysis of the historical meteorological and agricultural drought events, it can be concluded that agricultural drought is most sensitive on the first quarter of the year even though the detected precipitation deficit occurred longer.

Keywords: *Drought, precipitation, drought index*

Influence Of Cordillera and Sierra Madre Mountain Ranges On Precipitation And Wind Flow

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The mountain ranges of Cordillera and Sierra Madre have long been protecting Northern and Central Luzon from the devastating threat of tropical cyclones and is affecting the weather and climate in the area. Weather and climate vary between the sides of mountain ranges due to the orographic effect. Using the ERA-5 Reanalysis single-level and 1000hPa-750hPa pressure-level data from 1991-2020, the study aimed to find the influence of these mountain ranges on the flow and distribution of wind, moisture, and precipitation in Luzon's two mountain ranges, the Cordillera, the Northern Sierra Madre (NSM) and the Southern Sierra Madre (SSM). Spatiotemporal analysis and their mechanism using seasonal variations was conducted for the moisture flux, precipitation, horizontal wind, and vertical wind using trend analysis and ANOVA for the difference of the precipitation and zonal wind within the study area. Result showed that there is a significant difference in the precipitation received by the three study areas which include their east and west sides. Precipitation varies on each side of the mountain ranges depending on the time of year. DJF (Dec-Feb) season shows a significant accumulation of moisture and precipitation on the east (windward) side of NSM and SSM of up to twice the amount on the west (leeward) side. While during the JJA (Jun-Aug) season, the accumulation was on the west side of Cordillera and SSM. The higher precipitation during this season allowed the precipitation difference closer to the study areas unlike in DJF where the difference is exponential between the east side of Luzon and its west side. Wind direction changes seasonally which means that windward and leeward sides change also.

***Keywords**: Wind, Precipitation, Orographic effect, Mountain ranges*

Derivation of Reflectivity – Rain Rate (Z-R) relationships for Subic and Tagaytay Radar systems using Drop Size Distribution measurements from a network of PARSIVEL^2 Disdrometer

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This study evaluates the microphysical characteristics of rainfall over the National Capital Region (NCR). The two-year (2020-2021) worth of Drop size distribution (DSD) and Integral rainfall parameter (IRP) measurements from four disdrometer stations within the study area (i.e., Science Garden, La Mesa, Clark, and Malolos) were utilized to derive reflectivity-rain rate (Z-R) relations to improve Quantitative Precipitation Estimates (QPE) of Philippine weather Radar system. Results show that convective rains over the study area have broader DSDs, suggesting the influence of cold and warm rain processes in warm precipitating clouds. This results in higher concentrations of medium-sized and large raindrops during convective rains. DSDs of different rain rate classes show that the DSD variation is more evident at lower rain rates and becomes more uniform as it reaches equilibrium conditions at higher rain rate due to combined effects of drop breakup and collision coalescence processes. The DSD-derived Z-R relations show that convective (stratiform) rains have larger (smaller) *A* values and smaller (larger) *b* values. The obtained b values also suggest that DSD variations in the area are mainly due to mixed-controlled processes. Point-rainfall analysis for specific rain events show that the derived Z-R relation from the total rainfall of 2020-2021 ($Z_{Total} = 237.1R^{1.55}$) statistically outperformed the conventional Marshall and Palmer ($Z_{MP}=200R^{1.6}$) and Rosenfeld's Tropical ($Z_{RT}=250R^{1.2}$) relations in providing rainfall estimates. Moreover, Z_{Total} captures the timing of rainfall peaks better compared to Z_{MP} and $Z_{Total.}$ However, Z_{Total} tends to slightly underestimate the intensity of convective rains and could be a result of the data set being dominated by stratiform samples. These observations will help assess rainfall intensities and can provide a physical basis in improving the QPE capabilities of Subic and Tagaytay Radar systems.

Keywords: *Drop size distribution, Z-R relationship, Disdrometer, Radar*

Seismic-Driven Obliquity Change as a Driver and Predictor of El Niño and La Niña Episodes

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The global climate disruptor El Niño Southern Oscillation (ENSO) is difficult to forecast some years in advance due to lack of understanding of its root cause. An alternative physical mechanism is hereby proposed to describe the nature and sustaining force, and predict the occurrence of El Niño and La Niña phenomena. This is based on the earthquake-perturbed obliquity change model previously proposed as a major mechanism of the global climate change problem. Massive quakes can impart a very strong oceanic force that can move the moon which in turn pulls the earth's axis and change the planetary obliquity. Analysis of the annual geomagnetic north-pole shift and global seismic data revealed this previously undiscovered force. Using a higher obliquity and constant greenhouse gas forcing in the global climate model EdGCM showed that the seismic-induced polar motion and associated enhanced obliquity could be the major mechanism governing the mysterious climate anomalies attributed to El Nino and La Nina cycles. The apparent eastward migration of high SST in the Pacific and the warming of the Indian and Atlantic Oceans south of the equator during ENSO years was correctly simulated by the model. The global average precipitation during El Niño-La Niña years also showed realistic rainfall patterns. With increased planetary obliquity, EdGCM model successfully predicts past ENSO episodes and further predicts that El Niño events would also occur for the years 2022, 2025, 2030, 2032 and 2034, while the years 2035-2037 are predicted to be anomalously wet. This study can help affected countries in water shortage contingency planning, disaster mitigation and may help prevent adverse economic and commercial impacts due to ENSO.

Keywords: *ENSO, EdGCM, obliquity*

Development and evaluation of high-resolution gridded rainfall data of the Philippines

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Gridded datasets, in lieu of dense in situ rainfall observations, are commonly utilized to recommend appropriate responses during high-impact rainfall events. Such datasets must represent reliable rainfall patterns and detect various rainfall intensities. To create a high-resolution daily rainfall gridded dataset (~1km x ~1km) for the Philippines for the period of 1998-2020 (ClimGridPh-RR), observation data from 48 PAGASA synoptic stations was merged with Tropical Rainfall Measuring Mission (TRMM) satellite rainfall estimates (RFEs). Multiple merging and interpolation (M-I) techniques were tested to select the best M-I combination using a 5-year analysis period (2008-2012). Leave-one-out cross-validation statistical scores revealed the superiority of Simple Bias Adjustment and Modified Shepard (SBA+SH) M-I combination over others, hence selected to establish the resulting dataset. To post-validate, daily and seasonal rainfall behavior of ClimGridPh-RR is compared with existing global satellite RFEs and observation-based interpolated datasets using three numerical statistical scores (r, Bias, Root Mean Square Error (RMSE)) and three categorical scores (Probability of Detection (POD), False Alarm Ratio (FAR), Critical Success Index (CSI)). Numerical statistical results show that the ClimGridPh-RR dataset, although slightly overestimated, well captured the daily and seasonal rainfall in the Philippines. Similarly, categorical score results suggest that the dataset has the best rain detection ability similar to that of the Climate Prediction Center Morphing Technique (CMORPH) dataset, and slightly higher POD and lower FAR on daily heavy rainfall events compared to Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation (APHRODITE) gridded data. Furthermore, the gridded rainfall product showed a slight overdetection of light to low moderate rain categories and a slight underdetection of very light and high moderate to violent rainfall events. This novel gridded dataset will be digitally available and derived information will serve various applications.

Keywords: gridded rainfall data, data merging, interpolation, the Philippines

Characterization of Southwest Monsoon Events in the Philippines

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The climate in the Philippines from July to September is characterized by rains due to the prevalence of the southwest monsoon transporting moisture-bearing winds from the South China Sea, and are enhanced during occurrence of tropical cyclones. Strengthening of the southwest monsoon results in the Western Philippine regions being battered by strong winds and experiencing substantial amount of precipitation, which consequently lead to loss of lives and properties. In this study, observational analyses were done for four cases of previous southwest monsoon events. This aims to provide the general characteristics of these events, and will hopefully provide insight for future research. ERA5 datasets such as total precipitation, u-wind and v-wind components for different pressure levels, and PAGASA rainfall station data were utilized to examine vertical wind profiles, spatial and temporal distribution of rainfall as well as wind and rainfall anomalies. ENSO and MJO indices were also considered to analyze the connection to the large-scale weather system. There are a few noted similarities in the monsoon's characteristics, such as 1.) the surge of rainfall during the deepening of the upper-level winds to 400 hPa; 2.) the surge or rainfall that comes with strengthening of winds at the 850 hPa level; and 3.) the spatial distribution of rain. However, the four monsoon events still differ in terms of the total amount of rainfall experienced on land. It is speculated that these differences are brought by large-scale moisture conditions, and/or by synoptic scale factors such as their MJO phase and ENSO phase. It is also hypothesized that the nature of the inducing tropical cyclone and monsoon trough dictates the nature of the southwest monsoon. The cases have also shown extensive differences in correlation of zonal winds with rainfall.

Keywords: *southwest monsoon, heavy precipitation, zonal wind, Philippines*

An Evaluation of the Weekly Hindcasts of Tropical Cyclone Activity in the Philippines

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With the aim to improve the tropical cyclone (TC) forecast guidance at the extended-range timescales (i.e., 5-30 days) in the Philippines, this study examines the predictability of TC activity within the Tropical Cyclone Information Domain of PAGASA (bounded by 110°-160°E and 0°-40°N) up to four (4) weeks in advance. Hindcast data from three ensemble prediction systems, namely: the NCEP Coupled Forecast System version 2 (NCEP-CFSv2), the European Centre for Medium-Range Weather Forecasts Ensemble Prediction System (ECMWF-EPS), and the NCEP Global Ensemble Forecast System version 12 (NCEP-GEFSv12) covering the period from 1 June 2020 to 31 October 2021 were used. TC-like vortices (TCLVs) were detected and tracked based on a set of dynamic and thermodynamic conditions, and a hierarchical clustering method was employed to identify and extract information on the TC tracks from each model. These were then evaluated against the Joint Typhoon Warning Center (JTWC) best track dataset. Verification showed that the ECMWF-EPS model performed best in Week-1 (forecast days 1-8), obtaining the highest hit rate of 0.30 and a false alarm rate of 0.08 in this forecast period. Although this model acquired a lower hit rate of 0.20 in Week-2 (forecast days 9-15), its false alarm rate was much lower compared to the other models. In Week-3 (forecast days 16-22) and Week-4 (forecast days 23-30), the CFSv2 model outperformed the others with consistent hit rates, while the other two models showed little skill in Week-4, in which they obtained hit rates less than 0.10. In addition, comparison of the forecast and observed tracks of westward-moving TCs revealed that the forecast tracks have a significant poleward bias in latitudinal position starting from Week-2 (95% confidence level) and that most of them tend to propagate slower than the observed tracks.

Keywords: *extended-range forecasting of tropical cyclones, ensemble prediction systems, the Philippines*

Society Profile

The **Philippine Meteorological Society (PMS)** is a non-stock, non-profit governmental organization dedicated to the advancement of the atmospheric sciences and related disciplines in the Philippines.

Objectives of the Society

- Formulates, implements and coordinates projects to strengthen education, research and development in the atmospheric and related sciences;
- Establishes linkages with universities/colleges, operational forecast centers/offices, meteorological societies, non-government organizations and the private sector;
- Conducts research and extension services in various sectors impacted by climate change;
- Conducts training, seminars, workshops, symposia, etc. on atmospheric science and related disciplines;
- Publishes and distributes results of research and other scientific information on atmospheric and other related fields;
- Promotes meteorology, hydrology, climatology, agrometeorology, and astronomy as a profession; and
- Administers gifts, grants and donations of cash, property and services that will redound to the benefit of the society.

Society's mission

- To develop and disseminate knowledge of meteorology and related hydrologic sciences (hereinafter referred to as "Meteorology")
- To promote and advance the professional application of Meteorology
- To encourage collaboration amongst Members of the Society, individuals, bodies both corporate and non-corporate who may share the Society's interest in Meteorology
- To promote among the public an understanding of weather and an appreciation of the value of Meteorology and its applications

Society's Structure

The Society's affairs are run by an elected Board of Trustees, within the constraints of the By-laws of the Society. The Society is served by Executive officers composed of a President, a Vice-President, Secretaries, a Treasurer, an Auditor and a Business Manager duly appointed by the Board of Trustees. In addition, the Board of Trustees appointed members to serve certain committees such as the Membership and Awards Committee.

Services Offered by the Society

- Consultancy (weather, climate, hydrology, air pollution and water quality assessment)
- Client-customized weather forecasts and extended outlooks
- Wind and wave forecast
- Capacity building in the mitigation of impacts of extreme weather and climate
- Conducts lectures, seminars and conference on current environmental issues

Past Activities of the Society

In order to meet its responsibilities and challenges, the PMS has sponsored a number of symposia both local and international.

- 2021 PMS Annual Convention – 29-30 March 2021
  Theme: "Disastrous Hydro-Meteorological Events in the Middle of Pandemic: Challenges, Lessons Learned and Way Forward"
- 2020 PMS Annual Convention – 21-23 July 2020
  Theme: "Current Trends, Challenges and Opportunities in Meteorology"
- METeorology for YOUng Scientists (MET4YOU) – 6 March 2020
- 5th Pag-Asa Para sa mga Bata: A blood-letting Activity – 26 June 2019
- IEC to PAGASA Non-Technical Personnel (in line with the celebration of the 2019 Typhoon and Flood Awareness Week) 19 June 2019
- Essay Writing Contest (in line with the celebration of the 2019 Typhoon and Flood Awareness Week) 19 June 2019
- 4th Pag-Asa Para sa mga Bata: A blood-letting Activity – 26 March 2019
- Mangrove Tree Planting – 23 March 2019, Pagbilao Mangrove Experimental Forest, Pagbilao, Quezon
- 2019 PMS Annual Convention – March 20, 2019
  Theme: "Leveling up Meteorological Service to Meet Societal Needs"
- 2018 PMS Annual Convention – March 15, 2018
  Theme: "Recent Advances in Philippine Weather, Climate, and Hydrologic Information
- 12th National Meteorological Hydrological Convention – March 2, 2017

Theme: “Shaping the Future of Philippine Meteorology and Local Governance”

- 11th National Meteorological Hydrological Convention – February 17-18, 2016
  Theme: "The Role of Meteorology in Disaster Prevention and Mitigation"
- 10th National Meteorological Hydrological Convention – November 19-20, 2014
  Theme: "Extreme Weather and Climate: Impacts and Preparedness"
- 9th National Meteorological Hydrological Convention – February 20-21, 2014
  Theme: “State-of-the-Art Technologies in response to Extreme Weather Climate Events”
- 8th National Meteorological Hydrological Convention – February 21-22, 2013
  Theme: “Today’s Meteorologists: Scaling up Effective Early Warning Services (EWS)”.
- 7th National Meteorological Hydrological Convention – November 17-18, 2011
  Theme: "Dots, Isobars and Meteograms: Understanding the Science of Meteorology"
- 6th National Meteorological Hydrological Convention - November 18-19, 2010
  Theme: “Adaptation Strategies: Building Blocks for a Climate Change Resilient Phil.”
- 5th National Meteorological Hydrological Convention – November 19-20, 2009
  Theme: “Understanding the Climate Change Issues: A Key to a better planning and investment.” Makati Convention Hall
- 4th National Meteorological Hydrological Convention – November 27-28, 2008
  Theme: “Connection and Fusion: Coping with Winds of Change.”
- Co-Organized the Symposium titled “Rediscovering Philippine Setting: Meteorology and Mineralization and Tectonics” – October 2-4, 2008
- 3rd National Meteorological Hydrological Convention – March 26-27, 2008
  Theme: “Climate Change: Local, Regional and Global Initiatives”
- 2nd National Meteorological Hydrological Convention – November 27-28, 2006
  Theme: “Weather Climate and Water Implication to Sustainable Development.”
- 1st National Meteorological Hydrological Convention – December 12-13, 2005
  Theme: “Towards Understanding Weather, Climate and Consequences to Hydrology for Socio-Economic Development”.
- PMS-ADPC National Workshop (May 15, 2003)
- Symposia on Tropical Cyclones in the South China Sea and Western North Pacific Ocean
- Extreme Climate Events (ECE)
- National Symposium on the Application of Weather and Climate information

Aside from the sponsored local and international symposia, PMS also conducted other activities in 2018 as follows:

- "3rd PAG-ASA para sa mga Bata: A Blood Letting Activity" in partnership with Weather Bureau Multipurpose Cooperative (WBMPC) – June 19, 2018
- Information, Education and Communication (IEC) Campaign for PAGASA employees entitled “IEC on PAGASA Products and Services for New PAGASA Personnel” – June 22, 2018

Published by the Philippine Meteorological Society, Inc.
PAGASA Science Garden Complex
Agham Road, Diliman, Quezon City
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http://www.facebook.com/phmetsoc/