Philippine Meteorological Society, Inc.

PROCEEDINGS

Abstract of Papers presented in the

PMS CONVENTION 2024

Weather, Climate, and Society:
Interdisciplinary Approaches to Challenges and Solution

March 18-20, 2024
Quezon City, Metro Manila, Philippines

Volume VII *March 2024* *ISSN*

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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Layout and Design: Ms. Karen P. Conda-Botin

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Christian Jacob P. Misagal[1,2], Shane Laiza G. Mahait[1,2], Yesha Nicole L. Eclipse[1,2], Dewey Kiershan I. Tajo[1,3], Elron Mark V. Verzosa[1,3], Wayne David C. Padullon[1,2], and Almer H. Bugal[1,3*]

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Project PagsaSAKA aims to develop and implement a solar-powered real-time data collecting and monitoring system for tracking meteorological conditions in agricultural regions of the Philippines, such as temperature, precipitation, and humidity. Designed as an automated alert system, timely warnings and advisories are sent to farmers when such weather variable conditions are recorded via an attached monitor to the device as well as an SMS message. The Project PagsaSAKA device works by using data log sheets for tracking weather conditions, system alerts, and crop yield data over a specific period. Continuously collecting these real-time data, a linear regression model for temperature, precipitation, and humidity is incorporated in the device to predict the potential of drought or flood. To guarantee the quality control of collecting the data, a power bank is attached that acts as its primary energy source in cases where solar panels cannot fully sustain power in low-lighting conditions. The primary method of data analysis and interpretation in the device involves computing descriptive statistics, allowing to draw conclusions and make informed recommendations based on the numerical findings. Once the said monitor has analyzed the data, an associated warning and advisory is provided through an SMS notification system to reach the farmers. This device can be a proponent for economic impact by evaluating its contribution to reducing agricultural losses, increasing crop yields, and enhancing the overall economic sustainability of the agricultural sector in the study area. In addition, this project will also exemplify technological innovation and encourage collaboration among government and stakeholders to address agricultural challenges and improve disaster risk preparedness. Finally, with its implementation, the innovation can provide useful data that can be used to inform future research and policy decisions, improving our country's response to extreme weather events and reducing their impact on agriculture and society.

Keywords: *automated weather alert system, real-time weather monitoring, agricultural innovation, disaster risk preparedness*

PROJECT HATID: AN ON-SITE INIT-FACTOR WARNING SYSTEM

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The increase in temperature worldwide also causes extreme heat waves. According to World Health Organization (WHO), it can have a significant impact on a society including. Heat-related deaths is among the most dangerous natural hazards, but rarely receives inadequate attention because its detrimental effects are not always immediately obvious. In the Philippines, an estimated 1.1 million children had already been exposed to high heat frequency - or 4.5 or more heatwaves per year - in 2020. About 1.9 million children in the country were affected by high heatwave duration or prolonged heatwave, which usually lasts 4.7 days or longer, during the same year. The number of children that will be exposed to heatwaves is also expected to increase in 2050 (Baclig, 2023). Although there is no solution yet to the rapidly increasing temperature caused by climate change and global warming, mitigating its detrimental effects to the people is necessary. This study creates a device that provides an early disaster warning sign by measuring the temperature and humidity of the area where the instrument is placed. If the measured temperature or humidity exceeds the limit set, it will produce a warning sign that will alert people nearby to act for safety. The instrument will use a modified sensor taken from the components of an incubator, making the instrument very effective, affordable, and cost-efficient for everyone. Target areas of use are the school playground, open-parks, sports field and farms. The warning system was demonstrated at six (6) DepEd Schools in District of Iba from December 2023 to January 2024. The Head of School, Disaster Risk Reduction and Readiness team, as well as some teachers are the respondents of the questionnaires pertaining to the warning system's viability, cost-effectiveness, easy operation. The on-site early warning system is composed of varied alert indicators: (1) orange-colored rotating flags, (2) a light probe, and (3) a horn. The three indicators are used as warning systems to include people with special needs. For visually impaired people, the horn serves the auditory need. Rotating flag and the light probe will serve as for visual requirements for people of hearing difficulties. All indicators mean only one thing - that synergy of temperature and humidity (heat-index) on site is deem risky to human health. In such event people are advised to hydrate and stay in shades. Moreover, the three warning indicators can be manipulated according to the preference of the user. It is possible to turn on all three warning indicators simultaneously, a combination of any of two or one - choosing any of the three indicators. The warning systems can function according to the preferred combination of warning indicators of the user. The structure of the early warning system is designed to be stationary and waterproof. It is powered by a solar panel which charges the battery inside the system. The use of solar panels renders the system to have low carbon signature and practical use for remote location, where its capability is required. The result of the survey on its viability and cost effectiveness has received a 100% agreement from the respondents. It also received 95% agreement on its easy-operation criterion. Overall, respondents agreed that the early warning system is an effective mitigating solution to alert the people and minimize the effects of extreme heat as it offers the community an effective, affordable, and easy to use warning system device.

INFLUENCE OF TROPICAL CYCLONE ON THE AEROSOL OPTICAL DEPTH (AOD) IN NATIONAL CAPITAL REGION (NCR): A CASE STUDY OF SANTI (NARI) 2013

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With the large and rapidly growing population, National Capital Region (NCR) become more vulnerable to natural disasters such as tropical cyclones (TCs). Aerosol Optical Depth (AOD) is a parameter of aerosol which characterize the physical quantity of atmospheric turbidity and air pollution. Due to the frequency of TCs and the consequent concern over population exposure to air pollution, this study correlated the meteorological data with AOD, and quantitatively analyze the temporal variations in AOD during the TC lifecycle of Santi (Nari) in 2013. This study used ground based AOD data of Manila Observatory (MO) and Modern-Era Retrospective analysis for Research and Applications (MERRA-2) of NASA, meteorological data from PAGASA-Science Garden, and TC data from International Best Track Archive for Climate Stewardship (IBTrACS). The AOD of MERRA-2 data was compared with MO for the period 2009-2013 and found good agreement between the two (R = 0.67, RMSE = 0.13), with MERRA-2 derived AOD slightly underestimating the MO AOD (MBE = -0.05). Correlations of AOD with meteorological observations during the lifecycle of TC Santi were found to be: (i) positively weak for temperature (r=0.102), wind speed (r = 0.216); (ii) very weak negative for relative humidity (r - -0.017), and; (iii) moderate positive for precipitation (r = 0.438). A notable increase in AOD were observed during the lifecycle of TC Santi suggesting that TCs might be linked to elevated aerosol concentrations in the atmosphere.

Keywords: *Tropical Cyclone, Santi (Nari) 2013, Aerosol Optical Depth, National Capital Region*

RADIAL DISTRIBUTION OF DEEP CONVECTIVE CLOUDS PRECEDING RAPID INTENSIFICATION OF TROPICAL CYCLONES IN THE WESTERN NORTH PACIFIC

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This study investigates the radial distribution of deep convective clouds 24 hr prior to the rapid intensification (RI) of the tropical cyclones (TCs) in the Western North Pacific. Sixty five (65) TCs are categorized according to the 24 hr future intensity change (ΔV_{max}), as follows: non-RI (ΔV_{max} < 30 kt; 28 TCs), short RI (RI-S, ΔV_{max} > 30 kt for less than a day; 18 TCs), and long RI (RI-L, ΔV_{max} > 30 kt continuously for at least 1 day; 19 TCs). RI-S TCs have the strongest intensity and shortest radius of maximum wind (RMW) within 24 hr prior to RI, whereas non-RI TCs have the weakest intensity and longest RMW within 24 hr prior to its lifetime ΔV_{max}. In all categories, highest DCC percentage (DCC-P) and coldest temperature (DCC-T) are found within 3 RMW from the storm's center. Non-RI has the lowest DCC-P and warmest DCC-T anywhere within 10 RMW, whereas RI-L has the highest DCC-P and coldest DCC-T within 2 RMW especially at the onset of RI. DCC-P starts to increase 6 hr prior to RI with sharpest 3-hr increase of 15% at 1-3 RMW in RI-L. DCC-T within 1 RMW is always colder than that within 2-3 RMW, 9 hr prior to RI onset (with RI-L having the largest DCC-T gap between 1 RMW and 2-3 RMW) and 6 hr prior to lifetime ΔV_{max} for non-RI TCs. Sharpest DCC-T decrease of ~2.5^{o}C is found within 1 RMW of RI-L TCs, 6 hr before the onset of RI. Results in the study can be used to identify TCs that are more likely to undergo prolonged RI prior to its onset.

Keywords: *Deep convective cloud, rapid intensification, tropical cyclone*

SEASONAL DIURNAL VARIATIONS OF DEEP CONVECTIVE CLOUDS OVER THE PHILIPPINE CLIMATE REGIONS

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This study characterizes the seasonal diurnal variations of deep convective cloud (DCC) over the Philippine climate regions based on the Modified Corona Classification. DCCs during non-tropical cyclone days were identified using infrared brightness temperature threshold of 208 K. Hourly DCC temperature, percentage, and frequency distributions were obtained from 2016 to 2018 during the northeast monsoon season or Amihan (December to February), warm-dry season (March to May), southwest monsoon season or Habagat (June to August), and transition season (September to November). The temperature and percentage distributions of DCC follow a general diurnal pattern in all climate regions and seasons except Type II and during Amihan. Coldest and maximum percentage of DCC occurs in the afternoon (1500-1800 LST), whereas warmest and minimum percentage of DCC happens in the late morning (0900-1200 LST). Although both temperature and percentage display a general pattern, spatiotemporal maps reveal that coldest DCC (<199 K) does not coincide and are not collocated with areas of high DCC frequency. Reanalysis data were used to further examine the environmental conditions associated with the development of DCC. Warm surface temperature and moisture convergence shows a significant influence on the diurnal development of DCC, while low inhibition, large-scale upward wind, and unstable boundary conditions control the existence and development of deep convective clouds. The findings from this study can improve the understanding of deep convective activity in the Philippines, facilitating more effective disaster risk management associated with deep convective systems.

Keywords: *deep convective clouds, diurnal, the Philippines*

SYNOPTIC CONTROLS AND LOCAL PROCESSES OF THE SEASONAL DIURNAL VARIATION OF RAINFALL OVER THE PHILIPPINES

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This study investigates the environmental conditions and local processes affecting the diurnal variation of Mean Rainfall Rate (MRR) in the Philippines using GPM-IMERG data from 2011 to 2021. Results showed that the precipitation rate peaks in the late afternoon (1600 LST) except during December-January-February (DJF) season. The spatial distribution of MRR reveals that across the Philippines, relatively higher MRR is present over the eastern coast during DJF, over mountainous regions during March-April-May (MAM) and September-October-November (SON), and over mountainous regions and the western coast during June-July-August (JJA) seasons, with the JJA having the most pronounced maximum. The vertically integrated moisture flux convergence exhibited that in the late afternoon, JJA season is characterized by the total dominance of moisture sink, whereas DJF, MAM, and SON seasons showed spatially wide extent of adjacent moisture sources and sinks. Furthermore, high convective available potential energy values are found during the late afternoon (1600 LST), especially during the JJA season. A pronounced maximum surface temperature generally occurs at 1300 LST, indicating that intense solar insolation sets a favorable condition for maximum MRR to occur in the late afternoon. The vertical cross sections of wind vector and relative humidity of the Cordillera Mountains and Mt. Baco revealed that during the transition seasons (MAM and SON), the local processes (land/sea breezes and orographic lifting) may have most likely played an important role in enhancing localized rainfall. Lastly, it is worth noting that areas of high rainfall rate are associated with strong updrafts of moist air (or high relative humidity) aloft.

Keywords: *environmental conditions, local processes, wind, surface temperature, moisture*

INFLUENCE OF EL NIÑO SOUTHERN OSCILLATION AND MONSOON IN THE HEAT INDEX TRENDS AND PATTERNS IN WESTERN LUZON, PHILIPPINES

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Global temperatures are generally on an upward movement over the last 130–160 years, exhibiting strong correlation with climate change. The Philippines is also experiencing similar trend which might be the same for Heat Index (HI), the human perceived temperature. However, only few studies concerning HI in the country exist. Hence, this study investigated the trends and patterns of HI in the Western Luzon (WL) area as well as the influences of El Niño Southern Oscillation (ENSO) and monsoon on it. Monthly HI values were computed from the monthly temperature and relative humidity data record of weather stations and ERA5 reanalysis of ECMWF in the WL area. The trend analysis showed an increasing HI trend in 8 out of 12 weather stations in WL with magnitude of increase ranging from 0.03 to 0.15 °C. Seasonal average of HI shows an elevated values in the months of March, April and May which persist until June, July and August. Most parts of the WL area are in caution level in terms of danger level classification of HI. Further analysis revealed that HI values in La Niña phase during northeast monsoon tends to increase by up to 2 °C, while ENSO effects on HI are relatively small during southwest monsoon.

Keywords: *Heat Index, El Niño Southern Oscillation, Monsoon, Western Luzon*

ESTABLISHING EMPIRICAL ANTECEDENT RAINFALL THRESHOLD FOR DEEP-SEATED LANDSLIDE EARLY WARNING SYSTEM OF PHIVOLCS-DYNASLOPE

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Rainfall events are characterized by parameters such as intensity, duration, cumulative rainfall, and antecedent rainfall. Combinations of these parameters are used to define thresholds in landslide early warning systems. In the Philippines, a cost-effective and reliable early warning system for deep-seated landslides (EWS-L) was developed by the Dynaslope Project under the Department of Science and Technology - Philippine Institute of Volcanology and Seismology (DOST-PHIVOLCS). In its current implementation, the rainfall threshold is based on the one-day cumulative rainfall with a two-year return period. Antecedent rainfall, however, is not explicitly considered in the threshold despite being an important factor in triggering landslides. The influence of antecedent rainfall on ground movements for varying periods was demonstrated by plotting it against event cumulative rainfall. A total of 109 rainfall events with associated ground movements (i.e., manifestation of movements, surficial, and subsurface) from January 2016 to May 2023 were considered. Time duration of the antecedent rainfall considered for the ground movement events analyzed in this study were 2, 3, 7, 10, 15, 20, 25, 30, and 90 days. From the results, event cumulative rainfall has more significant impact than 2-day and 3-day antecedent rainfall but that influence significantly decreased in comparison with 15-day antecedent rainfall. Results showed that antecedent rainfall is more influential starting 15 days prior to the onset of ground movement-triggering rainfall event. K-means algorithm was employed to cluster the rainfall datasets, representing distinct categories of rainfall patterns based on attributes such as intensity and antecedent conditions. Cluster 1 indicates events characterized by relatively low 15-day antecedent rainfall, Cluster 2 corresponds to events associated with high 15-day antecedent rainfall, and Cluster 3 represents events characterized by moderate 15-day antecedent rainfall. Rainfall values within these clusters could potentially serve as valuable antecedent thresholds for enhancing the efficacy of the current monitoring operations.

Keywords: *antecedent rainfall, rainfall threshold, early warning, landslide*

ESTABLISHING RAINFALL THRESHOLD FOR FLOOD OCCURRENCES IN LEGAZPI CITY, ALBAY

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Legazpi City, bound by river networks, is vulnerable to flooding, particularly during typhoon and monsoon season, posing diverse environmental, social, and economic problems. In this study, the researchers provided an adaptive solution to these challenges through the establishment of an empirical rainfall threshold centered on urban flooding in the city using rainfall data and historical flood records. The analysis of these data identified 30 Flood-Inducing Rainfall (FIR) events from 2010 to 2021, determining the rainfall thresholds derived from the intensity-duration (ID) power law curves. The equations, $I = 6.8544 \times D^{-0.394}$ and $I = 10.588 \times D^{-0.286}$ for the lower and upper threshold, indicate critical rainfall conditions that can trigger flooding in the city. These revealed that FIR events may occur in a duration between 96 to 528 hours with rainfall intensity from at least 1.13 mm/hr and 0.59 mm/hr. Moreover, an improved threshold relating rainfall intensity and the Antecedent Precipitation Index (API), along with the inclusion of a color-coded rainfall warning system varying from blue, yellow, orange, and red warning alerts to indicate the conditions and threat levels, was generated to reduce the uncertainties in the middle section of the threshold. The combination of rainfall intensity and duration presented a good relationship in identifying flood-triggering conditions. However, further validation and refinement of these thresholds can be explored in the future upon access to an expanded compilation of flood events and associated rainfall conditions.

Keywords: *Empirical Rainfall Threshold, Intensity-Duration (ID), Antecedent Precipitation Index (API), Flood-Inducing Rainfall (FIR)*

CLASSIFICATION OF PRECIPITATING CLOUDS DURING THE 2020 NORTHEAST MONSOON SEASON IN THE BICOL REGION, PHILIPPINES

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Clouds are major drivers of regional climate, shaping temperature and precipitation patterns. The Bicol Region in the Philippines is particularly vulnerable to rainfall during the boreal winter (November-March). This study examined the relationship between precipitating cloud types and non-tropical cyclone (TC) heavy rainfall events in the region during the 2020 Northeast Monsoon (NEM) season. The study utilized the International Satellite Cloud Climatology Project (ISCCP) Cloud Classification derived from the Himawari-8 satellite and rainfall intensity data acquired from the Global Precipitation Measurement- Integrated Multi-satellitE Retrievals for the Global Precipitation Measurement (GPM-IMERG) from November 2020 to March 2021. The prevailing synoptic and local systems were considered. Rainfall events were categorized based on the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) Rainfall Classification. Results showed that weak NEM surged the season. Precipitating cloud types present during this period were dominated by Deep Convective Clouds (DCC) with a prevalence of 68%. During the final weeks of the NEM season, when easterlies prevailed, DCC remained dominant (54%), along with Stratus (St) clouds at 28%. Shear lines, consistently present throughout the season, exhibited DCC as the most frequent cloud type (37%), followed by Nimbostratus (Ns) at 35%. Notably, the presence of precipitating clouds did not guarantee heavy rainfall, highlighting the complex interplay of factors influencing rainfall intensity. These findings suggest that while specific cloud types are associated with precipitation, their influence is not always sufficient to generate heavy rainfall.

Keywords: *cloud type, Bicol Region, northeast monsoon, easterlies, shear line*

DIURNAL VARIATIONS OF PRECIPITATION OVER MAYON VOLCANO: IMPLICATION FOR INTRASEASONAL RAINFALL IN AN ISOLATED TERRAIN

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Mayon Volcano, verging to a height of 2,462 meters above the coast of Albay Gulf, is one of the most prominent topographic features in the Bicol Peninsula. As a small-scale, isolated topography, it is a salient component in shaping the diurnal rainfall characteristics of Albay. Based on high-resolution reanalysis data and multi-satellite precipitation products, this study investigated the spatiotemporal distribution and variability of rainfall within the 15-kilometer radius of Mayon Volcano. Analyzing daily averages and diurnal variation of the zonal and meridional winds retrieved from the European Center for Medium-Range Weather Forecasts Reanalysis version 5 (ERA5) unveiled the effects of local terrain and meteorological conditions on the diurnal pattern of rainfall. The analysis of this data yielded 143 cases, further classified as strong, moderate, or weak synoptic and local wind events based on percentile rank. The upper 90th percentile and lower 10th percentile of the observed December–February (DJF) days correspond to synoptic and local wind events, respectively. On the other hand, analysis of the precipitation data obtained from Integrated Multi-satellitE Retrievals for GPM (IMERG) version 6 Final Run revealed the rainfall differences between the windward and the leeward sides of Mayon volcano in terms of diurnal variation and spatial distribution for DJF from 2012-2021. Results show that rainfall diurnal variation is weak in synoptic wind events but becomes more pronounced from local wind events. During local wind events, increases in the prevailing wind speed result in a significant difference between the windward and the leeward side of Mayon. Afternoon (morning) rainfall peak becomes a notable feature in the leeward (windward) region predominantly due to increased rainfall frequency of light-moderate rain rates. Furthermore, an inconsistent relationship exists between rainfall and wind speed over both sides of Mayon, suggesting the role of topography in regulating regional circulation and precipitation.

Keywords: *rainfall, diurnal variation, Northeast monsoon, isolated topography, Mayon volcano*

TEMPORAL ANALYSIS OF GNSS-BASED PWV DURING HEAVY TO TORRENTIAL RAINFALL EVENTS OVER METRO MANILA, PHILIPPINES FROM 2016 TO 2021

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Precipitable water vapor (PWV) is a crucial metric in understanding water vapor variability and its impact on rainfall events. This study analyzes the temporal variation of PWV in Metro Manila utilizing the Global Navigation Satellite System (GNSS) data from the PIMO station in Quezon City, from the year 2016 to 2021 during torrential, intense, and heavy non-tropical cyclone rainfall events. Concurrently, data from the Automatic Rain Gauge (ARG) at Marikina Youth Camp is used to validate rainfall patterns. The variations of PWV are presented per rainfall category. The findings reveal strong positive correlations between GNSS-derived PWV and rainfall, ranging from +0.49 to +0.60 across all event categories. Derivative analysis indicates that PWV values are slightly higher before the onset of rainfall, reaching negative values at some point, suggesting that PWV accumulation precedes rainfall onset. Cross-correlational analysis shows synchronous signals with a 0-minute lag, indicating alignment without noticeable time lag. Conversely, lead–lag analysis suggests a GNSS-PWV lead of approximately 2 hours before severe rainfall events, underscoring the anticipation of PWV accumulation before significant rainfall. Additionally, robust correlations are established between GNSS-PWV and relative humidity (+0.79 to +0.93) and temperature (-0.66 to -0.92), with a moderate correlation with atmospheric pressure (-0.10 to -0.60). These findings deepen the understanding of the intricate relationships among GNSS-PWV, severe rainfall patterns, and meteorological variables in Metro Manila.

Keywords: PWV, Torrential Rainfall, Intense Rainfall, Heavy Rainfall

INFLUENCE OF INDIAN OCEAN DIPOLE (IOD) PHASES ON THE INTERANNUAL RAINFALL VARIABILITY OF THE SOUTHWEST MONSOON OVER NORTHWEST PHILIPPINES

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The Indian Ocean Dipole (IOD), recognized as a climate phenomenon within the general cycle of global climate, is based on annual sea surface temperature anomalies in the west and east Indian Ocean. Active IOD phases influence the variability of monsoons connected to the Indian Ocean basin, including the Philippine Southwest Monsoon (SWM). This research aims to investigate their connection by analyzing SWM rainfall variability over the western Philippines during each IOD phase. By correlating the Dipole Mode Index to Southwest Monsoon Rainfall Anomaly Index (SWMRAI) and composite analysis with the use of Grid Analysis and Display System (GrADS) to determine the relationship through ocean-atmospheric dynamics, results show that years with a positive IOD phase tend to exhibit higher values of SWMRAI. However, the correlation between the Dipole Mode Index (DMI) and the SWMRAI is low which can be attributed due to other factors such as Tropical Cyclones (TCs), El Niño-Southern Oscillation (ENSO), and the topography. Additionally, it was found that the impact of IOD on SWM is most pronounced during extreme IOD years, where the westerly wind is enhanced during extreme positive IOD due to a high pressure gradient over the Philippines that efficiently transports moisture toward the West Philippine Sea. During extreme negative IOD, the westerly wind is suppressed, leading to a reduction in moisture transport towards the West Philippine Sea.

Keywords: *Indian Ocean dipole, Southwest monsoon, rainfall, Philippines*

AIR POLLUTION DYNAMICS IN LUZON USING IN-SITU, REMOTE SENSING, AND MODELING

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In the past five years, there have been significant advancements in our understanding of the physical, chemical, and dynamical characteristics of air pollutants in Luzon. Particulate observations in Metro Manila shows the highest concentrations where 60-70% are fresh and aged (secondary) anthropogenic emissions and around 25% are from sea salt and resuspended soil/dust, with the rest unaccounted. Signature of biomass burning marker such as levoglucosan was also observed and appears to be advected by mesoscale winds from Central Luzon. In addition, sampling along the port area also reveals 31% of particulates are coming from ship/vehicular emissions. High pollutant concentration days are highly influenced by the interaction of various mesoscale winds. Stagnant winds over the metro due to opposing regional winds (i.e. sea/land breeze, mountain/valley breeze, monsoon, winds from upslope of Rizal, etc.) are responsible for most high pollution events in Metro Manila rather than due to low mixing layer depth or thermal inversions. Power plants around Luzon, as well as volcanic emissions, appear in remote sensing observations which suggest significant contributions that are difficult to measure from land, primarily due to the elevation of plume release. In addition, long-range transboundary transport of pollutants during both northeast and southwest monsoon have been confirmed. During Amihan season, monsoon cold surges due to a strong Siberian and/or continental high transports pollutants (i.e. PM2.5, Hg, CO, etc.) to Luzon. Moreover, biomass burning emission from Southeast Asia were measured aloft in northern Luzon. In Habagat season, aged aerosols were observed in Metro Manila during a 2018 measurement campaign. In Feb 2024, an airborne measurement by NASA measured various volatile organic compounds and other pollutants that will further reveal the state of our atmospheric environment.

RECENT ADVANCES IN PHILIPPINE CLIMATE RESEARCH

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This presentation reports the recent changes in the Philippine climate in the context of the new climate normal period (i.e., 1991–2020). Expectedly, questions are raised on what are the recent changes in the observed Philippine climatology and the driving mechanism of such shifts. We present evidence that the Philippine climate has become warmer (i.e., increased annual surface temperatures) and wetter (i.e., increased annual rainfall) since the mid-1990s while an abrupt increase in tropical cyclone (TC) activity in the Philippines is detected in the mid-2000s. Such regime changes are mainly attributed with the shift of the Atlantic Multidecadal Oscillation (AMO) to its positive phase since the mid-1990s. A positive AMO enhances the Pacific Walker Circulation where the more intense convection center typically shifts towards the western Pacific – this translates to more rainfall, narrowing diurnal temperature range, warmer sea surface temperatures, and more intense TC activity in the Philippines. However, the recent positive AMO phase is reported as externally and possibly driven by anthropogenic warming rather than it is naturally oscillatory, which likely implies that the detected abrupt regime shifts in the Philippine climate, particularly in increased surface temperatures, are also externally driven. Our findings provide new insights on the long-term trends and variability of the Philippine climate in support of its disaster risk reduction preparedness and seasonal forecasting.

Keywords*: Philippines, climate, tropical cyclones*

Note: Abstract is adapted from Basconcillo, J., *et al.* Influence of Multiyear Variability on the Observed Regime Shifts in Philippine Climatology. *Asia-Pac J Atmos Sci* **59**, 151–166 (2023). https://rdcu.be/cXLyU

GEOMAGNETIC AND IONOSPHERIC RESPONSES TO MAJOR SOLAR FLARES OVER THE PHILIPPINES

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Major solar flares (SF) erupted on 20-21 April 2022, during which the Philippines was on the sunlit hemisphere. An X2.25 occurred on 20 April and M9.7 on 21 April during quiet geomagnetic conditions which are reflected in the Kp, Hp, and Dst measurements. The effects generated by the Sun's ionizing radiation, in the X-ray and EUV (117.5nm) regimes, on the magnetic field (MF) and ionosphere are investigated. It is known that enhanced conductivities in the ionosphere due to increased ionization by solar radiation affect Earth's current systems. This manifests as short-lived variations in the MF components, known as solar flare effects (Sfe). These Sfes are observed using the data from MAGDAS/CPMN in two ground-based observatories in the Philippines: one in the low-latitude region, Muntinlupa (MUT) and one near the magnetic equator, Davao (DAV). Measurements showed that Sfes are more pronounced near the equator, where the Earth's MF experiences more variations due to high conductivities. At MUT, there are no significant Sfes observed. Meanwhile, the largest variations at DAV were found during the M9.7. This shows that X-class SFs don't always guarantee the largest magnetic responses. Furthermore, the ionospheric electron density is investigated using the total electron content (TEC). Data were acquired from the GNSS receiver station in Taguig (PTGG). The difference relative STEC is calculated to observe electron density increases. It was found that despite the X2.25 being stronger than M9.7, TEC increases due to enhanced EUV were larger for the M-class SF. This signifies the immense contribution EUV has to the E and F ionospheric regions, compared to the X-ray. $\Delta STEC$ values during M9.7 for PRNs 4,8 and 27, were ~ 0.71, ~ 0.45, and ~ 0.50 $TECU$. It was inferred that the Sfe increases corresponded to the X-ray radiation. Whereas changes in TEC manifested as responses to the EUV radiation, which peaked shortly before the maximum X-ray peaks.

Keywords: *space weather, magnetometer, ionosphere, total electron content*

ELECTRON DENSITY VARIATIONS IN THE IONOSPHERE ASSOCIATED BY THE TONGA VOLCANO ERUPTION IN 2022 OVER THE PHILIPPINES USING GNSS

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On January 15, 2022, at 04:15 UT the Hunga Tonga-Hunga Ha'apai Volcano eruption was powerful enough to reach and cause disturbances in the atmosphere. Volcanic events can trigger severe disturbances that reach into the atmosphere above the epicenter and produce periodic waves in both charged and neutral particles. A strong eruption like the Tonga volcano, with a volcanic explosivity index (VEI) 5, can cause long-period ionospheric fluctuations in the atmosphere. Traveling ionospheric disturbances (TIDs) are plasma density fluctuations that propagate as waves through the ionosphere at a wide range of velocities and frequencies and play an important role in the exchange of momentum and energy between various regions of the upper atmosphere. This paper used ionospheric total electron content (TEC) and Global Navigation Satellite Systems (GNSS) ground receiver, one from Taiwan and one from the Philippines, to produce one-dimensional satellite data over a geographic area. The ionospheric irregularities accompanied by TIDs were spatially and temporally varied from 10:00 UT to 13:00 UT in response to the movement and intensity change of the TIDs. This paper also shows that the ionospheric anomalies traveling from southeast to northwest with a calculated speed of 0.27km/s to 0.32km/s was observed 7 hours after the eruption. From the eruption, the event triggered the propagation across the earth at a consistent speed of ~0.3 km/s- a speed of the ionospheric disturbances that was as fast as the atmospheric Lamb wave that resulted to a global impact on the ionosphere.

Keywords: *GNSS, Tonga volcano, total electron content, traveling ionospheric disturbance*

PRECIPITATION AND RICE PRODUCTION IN ZAMBALES, PHILIPPINES: A CLIMATOLOGICAL TIME SERIES ANALYSIS

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Patterns in precipitation have been changing due to climate change and pose significant impacts on crop production and productivity. Local scientists have explored rainfall variation, but not on rice and observable trends. This study employed a climatological time series analysis of the long-term relationship between precipitation and rice production of the rain-fed rice-producing areas of Zambales, Philippines, from 1991-2021. Using the shapefiles of the National Irrigation Administration (NIA) of Zambales and the raster data of the total rice producing regions of the Philippine Rice Research Institute (PhilRice), the subtraction method produced the assumed purely-rainfed rice producing areas of the province. With this output region, the accumulated precipitation was obtained from the Climate Hazards Group Pentad InfraRed Precipitation with Station dataset (CHIRPS) using geospatial analysis through Google Earth Engine (GEE) and GIS. The trend analysis for the precipitation showed no significant overall trend (MK = 0.8650). Meanwhile, rice production showed a significant increase (MK = 1.7821×10^{-6}). The anomalies show significant rises and dips in each variable for the 31 years caused by extreme events, ENSO years, and changes in agricultural practices. The correlational tests between the precipitation and rice production produced a significantly weak overall linear relationship (r = -0.0904). However, after splitting the dataset into ten years, results show that the correlation between each variable exhibited a negative trend with r = 0.07, -0.24, and -0.37 from 1991-2000, 2001-2011, and 2012-2021 respectively. Each year in the time series shows that the Zambales region is vulnerable to El Niño events and more resilient to La Niña regarding precipitation and rice production. Further, the Southwest Monsoon (Habagat) and Tropical cyclones affect the purely-rainfed rice-producing regions. Rice farmers in the area who depend solely on rainfall are therefore advised to follow the start of the rice planting season developed by DA-PhilRice, and PAGASA.

Keywords: *Precipitation; Rice production; Climatological time series analysis; Trend Analysis.*

TIME SERIES ANALYSIS OF ENSO INDUCED PRECIPITATION RESPONSE OF RICE YIELD IN SCIENCE CITY OF MUÑOZ NUEVA ECIJA PHILIPPINES

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Precipitation patterns are driven by different factors including El Niño Southern Oscillation (ENSO) and constitute significant effects on crop growth and production. Several studies examined variations in rainfall, however, most of them, if not all, do not encompass the effects of rainfall trends and its other characteristics on rice crops. This study analyzed the time series of precipitation during the El Niño and La Niña periods and the corresponding rice yield response in rainfed areas in Science City of Muñoz, Nueva Ecija, from the year 2006-2023. The El Niño and La Niña periods have been identified through the NOAA Optimum Interpolation Sea Surface Temperature (OISST) V2.1. Moreover, the total rice-producing areas and their yield have been obtained from the Department of Agriculture (DA) in the Science City of Muñoz. These data are categorized into irrigated-bounds and rainfed areas, thereby separating the rainfed areas from the total rice-producing area which is the focus of this study. The accumulated precipitation in these areas during the identified periods of ENSO was acquired from the Climate Hazards Group InfraRed Precipitation with Station dataset (CHIRPS). The expected outcome of the study will show that rice harvested in rainfed areas is affected by El Niño and La Niña periods. The trend analysis of precipitation during El Niño precipitation will show that there is decreasing trend, the rice yield during this period will show downward trend. Meanwhile, during La Niña period, there would be increasing trend in precipitation, and the rice yield in this period will show upward trend. This will highlight that each year in the time series, the city is susceptible to El Niño occurrences and resistant to La Niña precipitation. It will recommend that rice farmers in rainfed areas adhere to the DA and PAGASA's guidelines for the commencement of the rice planting season.

Keywords: *ENSO, Time Series, Rainfed, Rice Yield, Nueva Ecija*

CHARACTERIZING SHEARLINE-INDUCED RAINFALL EVENTS IN EASTERN SAMAR, PHILIPPINES DURING THE WINTER MONSOON SEASON

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This case study aimed to characterize shearline-induced rainfall events (SREs) in the province of Eastern Samar, Philippines during the winter monsoon season (WMS). The researchers utilized 6-hourly and daily rainfall amount data from the DOST-PAGASA Guiuan Weather Station in Guiuan, Eastern Samar for 20 WMSs from October 2003 to March 2023. A total of 119 SREs were identified through a defined criterion based on "consecutive wet days" (CWD), along with verification of the presence of shear line using ERA5 reanalysis data. The researchers quantitatively described the averages and extremes in SRE duration and rainfall amounts and determined the progression of shearline-induced rainfall through time. The results suggested that, on average, around six (6) SREs affect Eastern Samar in every WMS. SREs were found to generally cause light rainfall, but their maximum precipitation can range from light rainfall up to heavy or intense rainfall and they can persist typically for around four (4) days. Data analyses also indicated that the onset of shearline-induced precipitation generally occurs in November, followed by a spike in activity towards a two-month peak in December–January with decreasing trend thereafter. There is also an observable variability in shearline-induced rainfall per WMS, with some WMS having conspicuously high accumulated rainfall amounts compared to other WMS. Further research with more robust methodologies is highly recommended, particularly in scrutinizing the possible influence of tropical intraseasonal and interannual variability (e.g. El Niño Southern Oscillation, Madden-Julian Oscillation) on the development of shear lines and their associated precipitation.

Keywords: *shear line, winter monsoon, rainfall event*

EFFECTS OF LAND USE AND LAND COVER CHANGE ON LAND SURFACE TEMPERATURE IN SIERRA MADRE MOUNTAIN RANGE REGION, PHILIPPINES

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Extensive deforestation, uncontrolled logging, mining activities, meteorological factors, and inappropriate land use practices have undermined the Philippines' Sierra Madre's capacity to protect mainland Luzon from typhoons. In this study, we explored the variations in land surface temperature (LST) resulting from changes in land use and land cover (LULC) that were obtained using the statistics tool in Quantum Geographic Information System (QGIS). The Sierra Madre Mountain Range Region (SMMR) was classified into seven types of land cover: (1) forest, (2) non-forest vegetation, (3) wetlands, (4) croplands, (5) urban and built-up area, (6) barren lands, and (7) waterbodies. Two decades of Moderate Resolution Imaging Spectroradiometer (MODIS) Imagery were utilized, and LULC, LST, and Normalized Difference Vegetation Index (NDVI) components were preprocessed in Google Earth Engine, and image corrections were made in QGIS for further analysis. The results showed a notable decline in forest cover and an increase in urban/built-up areas and croplands in twenty (20) years. The croplands, urban/built-up areas, and barren lands exhibit higher LST than forest and non-forest vegetation. These shifts were linked to a temperature increase observed during the same period. Also, the study found a negative linear relationship between the NDVI and LST, suggesting that areas with denser vegetation have lower LST values. Urban and built-up areas and croplands showed the highest temperatures, indicating that urbanization and agricultural expansion have contributed to the rise in land surface temperature. This research is critical for providing insights for improving land use policies in the Philippines, leading to more sustainable land use changes.

Keywords: *Land Use and Land Cover Change (LULC), Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI), Sierra Madre Mountain Range (SMMR)*

MULTI-YEAR ANALYSIS OF PRECIPITABLE WATER VAPOR AND SEA SURFACE TEMPERATURE ANOMALIES FROM 1993 TO 2022 USING RADIOSONDE OVER TANAY, LEGAZPI, AND LAOAG

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Precipitable Water Vapor (PWV) characterizes the amount of water vapor present in the vertical column of the atmosphere, while SST is used as a key parameter in the prediction of El Niño Southern Oscillation (ENSO) events. In this study, variations of PWV over Tanay, Legazpi, and Laoag and SST from Niño 3.4 and Niño 4 regions from 1993–2022 are presented. PWV uses radiosondes from the Integrated Global Radiosonde Archive (IGRA), and SST is from the Climate Prediction Center of the National Weather Service (NWS). This study presents a long-term analysis of the PWV and SST using the anomaly method, the lag of the PWV in relation to the SST response, and their relationship from 1993 to 2022. The anomaly method highlights the variation of PWVa and SSTa with an inverse relationship, where higher SSTa values were observed in Niño 3.4 than in Niño 4. The periodicity of PWV for Tanay, Legapzi, and Laoag shows annual and bi-annual variations. The Augmented Dickey Fuller (ADF) Test confirms stationary responses in PWV at three stations. An annual trend was observed using autocorrelation functions (ACF), which supports the result of the periodicity. The dynamic linear model presents the smooth and filtered PWV series for 2013–2022, where a minor lead was observed compared to the main time series of PWV. Correlation analysis highlights a stronger correlation between PWV and SST using the adjusted PWV method. The correlation in the SST between Niño 3.4 and PWV stations shows a peak in the three-month adjusted PWV, while the Nino 4 region peaks with a one-month adjusted PWV.

Keywords: *PWV, SST, Anomaly, Nino 3.4 region, Nino 4 region*

INTEGRATING DATA FROM PHILIPPINE GNSS CORS STATIONS AND ERA5 REANALYSIS FOR PRECIPITABLE WATER VAPOR ESTIMATION

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In recent years, Global Navigation Satellite System (GNSS) stations have continuously been increasing in number. As a result, studies in the field of GNSS-Meteorology have since been gaining traction. One parameter that can be derived using data from GNSS stations is precipitable water vapor (PWV). It is a widely used variable that aids in describing the state of the atmosphere. As such, PWV is beneficial in climatological studies. While estimating PWV through the use of GNSS data is fairly straightforward, the method requires surface meteorological readings that may not always be available. By utilizing surface parameters from ERA5 alongside GNSS signal delay, this paper aims to evaluate the performance of using ERA5 data as a substitute for synoptic readings needed in GNSS-PWV estimation. GNSS zenith total delay data used in the study were taken from the Philippine Active Geodetic Network (PAGeNet), specifically from PLEG, PCEB, and PDAV stations located in Legaspi City, Mactan City, and Davao City, respectively, for the years 2015 to 2017. Results showed that when comparing radiosonde-PWV values with the values obtained using the proposed methodology, the R-scores from the three aforementioned stations were 0.9846, 0.9806, and 0.8773, respectively. Hence, the proposed method has the potential to be an alternative method for estimating GNSS-PWV. Further studies are recommended to apply this methodology to mapping PWV.

KEYWORDS: *PWV, GNSS, ERA5, Philippines*

CMIP6-DERIVED MULTI-DECADAL PROJECTIONS OF CHANGES IN RAINFALL AND TEMPERATURE OVER THE PHILIPPINES IN HIGH-RESOLUTION GRIDS

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To meet the growing demand for high-resolution climate change projections needed for sectoral impact modeling applications in the Philippines, this study constructs the projected changes in monthly rainfall and temperature over the country at 1km-by-1km horizontal resolution for six different future periods (2021–2050, 2031–2060, 2041–2070, 2051–2080, 2061–2090, 2071–2100). Future projections were derived from the changes obtained from the historical and future simulations of 31 participating models in the Coupled Model Intercomparison Project Phase 6 (CMIP6), assuming the Shared Socio-economic Pathways (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5). The obtained changes were then added to the climatological mean rainfall and temperature taken from the newly developed high-resolution observation-based gridded rainfall and temperature datasets of the country. Climate projections show that based on all SSP scenarios and for all future periods, the country is expected to become warmer towards the end of the 21st century by up to 4.4 °C more pronouncedly during the month of May. Meanwhile, the rainfall in most parts of the Philippines is projected to decrease (increase) mainly during the month of April (up to 27% decrease; July, up to 45.6% increase) for almost all future periods. To serve various users of such information, the datasets of derived historical and projected changes in climate for every region, province, and city/municipality across the country will be made available on an interactive map. The talk will also cover an overview of the online platform, where the datasets will be disseminated.

Keywords: *climate change, CMIP6 scenarios, global climate models, the Philippines*

SPATIOTEMPORAL VARIABILITY OF MONSOON SEASON IN THE PHILIPPINES USING MULTIPLE LOCAL MONSOON INDICES

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Monsoon intensity varies in different subregions in the Philippines. This study examines multiple monsoon indices in characterizing the spatiotemporal variability of the southwest and northeast monsoon season at a local scale. Derived local monsoon indices include the southerly shear and westerly shear indices, outgoing longwave radiation-, and mean sea level pressure-based indices. In general, the strength and development of the southwest monsoon season were more defined as compared to the northeast monsoon season. Temporal analysis emphasized the distinct capabilities of the monsoon indices in describing the inception, propagation, and intensification of monsoon season, but generally highlighted the escalation of the season propagating from northern to southern Philippines. Moreover, assessment of the monsoon indices with ground-based datasets revealed their potential in sufficiently capturing excessive rainfall occurrences in the western Philippines. Overall insights from this study signify the importance of utilizing multiple localized indices in describing and quantifying monsoon rainfall intensification, critical for monsoon monitoring and early action initiatives in the country.

Keywords*: Summer monsoon, Monsoon indices, Rainfall*

U.S. OFFICE OF NAVAL RESEARCH GLOBAL OVERVIEW

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An overview of the U.S. Office of Naval Research Global (ONRG) and its mission will be given. Focus will be given to available funding mechanisms and scientific collaboration. ONRG seeks to encourage basic science research in many fields, including the physical environment from the seafloor to space.

Poster Session

VALIDATION OF MODIS-PWV USING GNSS-DERIVED PWV OVER METRO MANILA, PHILIPPINES

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The critical role of Precipitable Water vapor (PWV) in atmospheric phenomena and climate has recently been the focus of attention in meteorology. Several data sources have been utilized to establish better techniques in investigating its behavior. Moderate Resolution Imaging Spectroradiometer retrieved PWV (MODIS-PWV) data products are often validated using Global Navigation Satellite System derived PWV (GNSS-derived PWV) over various study areas globally. However, the data for MODIS-PWV over the Philippine archipelago has not been utilized as frequently. This study validated and effectively confirmed MODIS-PWV using GNSS-derived over Metro Manila, Philippines from 2015 to 2017 through Pearson correlation, linear regression analysis, RMSE, time series analysis, and t-test. The MODIS-PWV showed overall good accuracy: A high positive correlation of R=0.89, a large positive linear association of R^2=0.81, and a fairly low RMSE of 5.53 mm. The overall good accuracy is consistent for its annual, seasonal, and monthly analyses, particularly during the dry seasons. There was an overall daily mean difference of merely 5.1 mm, and a monthly mean difference of 4.05 mm with the PWV values normally varying from 28 mm to 64 mm. MODIS-PWV and GNSS-derived PWV correlate well with rainfall and relative humidity but have a weak positive correlation with surface temperature. MODIS-PWV was underestimating the GNSS-derived PWV, particularly more significant during the dry seasons; this is attributable to MODIS-PWV's different spatial positioning, cloud cover sensitivity, and data availability. The observed seasonal variations of PWV from both sources agree well with the Type 1 climate of Metro Manila. Finally, there was a statistically significant difference due to the MODIS-PWV underestimation, which could be improved through proper calibration of MODIS-PWV in its future studies.

Keywords: *PWV, MODIS-PWV, GNSS-derived PWV, Accuracy, Underestimation*

THE WARMING POTENTIAL OF BLACK CARBON IN METRO MANILA, PHILIPPINES

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Black carbon (BC) is a known component of air particulate matter and has been identified as the second top contributor to global warming due to its strong positive radiative forcing. In Metro Manila, increased black carbon concentrations have been observed coming from public utility vehicles (PUVs). As such, increased absorption of solar radiation is expected, which can result in a warming effect in the region. The aim of the study was to investigate the relationship between BC concentrations and regional warming. BC data from PM_{10} was gathered from the long-term monitoring stations of DENR-EMB from 2014 - 2020 at five sampling stations in NCR, namely, DOH, Muntinlupa, MMDA, Marikina, and NPO. A multi-wavelength absorption black carbon instrument (MABI) was used to measure the BC concentrations at seven different wavelengths. These wavelengths, along with the corresponding absorption coefficient (b_{abs}), were further utilized to determine the absorption Ångström exponent (AAE), single-scattering albedo (SSA), and aerosol optical depth (AOD) of BC. Cloud optical depths were determined using the Wyoming upper air sounding at the Tanay station. These parameters were used as inputs on the tropospheric ultraviolet and visible (TUV) radiation model to simulate the total solar irradiance on each sampling day. The results showed that the highest daily BC concentration was observed in Marikina on September 20, 2019, peaking at 26.83 $\mu g/m^3$, while the highest annual mean BC concentration was observed in 2015 at NPO with a value of 23.52 $\mu g/m^3$. Meanwhile, daily and annual mean radiative forcing values were both observed to be highest in Muntinlupa with values of 1.31 and 0.80 W/m^2nm, respectively.

Keywords: *Black carbon, radiative forcing, global warming, MABI, TUV model*

DEEP CONVECTIVE CLOUDS OVER THE PHILIPPINE CLIMATE REGIONS PART 1: SEASONAL DIURNAL VARIATIONS

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The seasonal diurnal variations of deep convective clouds (DCC) were identified over the Philippine climate regions based on the Modified Corona Classification. Using IBTrACS, non-tropical cyclone days were determined using a threshold distance of 1100 km. HIMAWARI-AHI 11.2 μm infrared brightness temperature threshold value of 208 K was used for DCC detection. Hourly area-averaged DCC percentage (DCC-P), normalized 6-hour DCC occurrence frequencies (DCC-F) per datapoint, and corresponding DCC temperature (DCC-T) were obtained per climate region from 2016 to 2018 during the northeast monsoon season or Amihan (December to February), warm-dry season (March to May), southwest monsoon season or Habagat (June to August), and transition season (September to November). Results shows DCC-P over the Philippines exhibited a diurnal variation with minimum and warmest in the late morning (1500-1800 LST), and maximum and coldest in the afternoon (0900-1200 LST). Observed pattern is conspicuous during warm-dry, Habagat, and transition seasons, with Habagat being the most prominent. Amihan season showed no diurnal variation in DCC-P. Spatially, coldest DCCs (<199 K) did not collocate to areas with highest DCC-F (12-15%) but were found enclosed by mountains suggesting topography and humidity playing an active role in enhancing isolated local DCC formation. Normalized joint frequency histograms (NJFH) of DCC-F and DCC-T showed that high DCC-F occurrences preferred DCC-T within 202-203 K. Furthermore, the western Philippines (Type I) experienced the highest diurnal variation during the Habagat season. The central portion (Type III and IV) showed similar high diurnal variation for all seasons during Amihan while the eastern coast of the Philippines (Type II) shows no DCC variation for all seasons. The findings of this study help in understanding the seasonal-diurnal deep convective cloud variation which can be expanded as a potential field of study for future works.

Keywords: *deep convective clouds, diurnal, the Philippines*

DEEP CONVECTIVE CLOUDS OVER THE PHILIPPINE CLIMATE REGIONS PART 2: ENVIRONMENTAL CONDITIONS

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Using reanalysis data, environmental conditions that contributed to the development of deep convective clouds (DCC) along with its seasonal diurnal pattern were examined from 2016-2018 over the Philippines. The results showed that the stability indices such as convective available potential energy, k-index and total totals index values deviates from the global threshold in predicting convective activity, except the lifted index. Values from the lifted index coincide and collocate with DCC occurrence, suggesting boundary conditions playing a crucial role in DCC formation. Spatiotemporal maps of convective inhibition (CIN) also showed low inhibition favoring DCC development, except in the Cordillera Mountains during the Habagat season. However, wide areas of ascent with high DCC frequency imply strong mountain updrafts potentially overcoming high CIN. Warm surface temperatures, particularly during Habagat, provided favorable conditions for surface moisture to ascend, further aiding DCC formation. Remarkably, the prevalent presence of moisture sinks in the afternoon are associated with abundant DCC which implies that such DCC are precipitating deep convective clouds, and that the diurnal patterns of heavy-to-torrential rain and DCC are likely similar. Warm surface temperature and moisture convergence are found to be the key factors influencing the growth and development of DCC. Meanwhile, low inhibition, large-scale upward vertical velocity, and unstable boundary conditions may contribute to establishing a favorable condition and encourage the development and retention of already developed DCC. The findings from this study contributes to the refined understanding of environmental conditions governing the deep convective cloud development in the tropics, specifically in the Philippines.

Keywords: *deep convective clouds, environmental conditions, the Philippines*

DISTRIBUTION OF PRECIPITATING CLOUDS ACROSS THE BICOL REGION, PHILIPPINES DURING THE 2020 NORTHEAST MONSOON SEASON

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The tropical climate of the Bicol region, categorized into Climate Types II, III, and IV, features high rainfall amounts, particularly during the boreal winter (November-March). This study investigated the association between cloud types and non-tropical cyclone (TC) heavy rainfall events during the 2020 Northeast Monsoon (NEM) season. The study utilized the International Satellite Cloud Climatology Project (ISCCP) Cloud Classification derived from the Himawari-8 satellite and rainfall intensity data acquired from the Global Precipitation Measurement-Integrated Multi-satellitE Retrievals for the Global Precipitation Measurement (GPM-IMERG) from November 2020 to March 2021. The prevailing synoptic and local systems that caused heavy rainfall events were identified using the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) Rain Rate Classification. Locations of synoptic stations were selected as point representatives for each province in the region. Throughout the season, three prevailing weather systems were present – NEM, easterlies, and shear line. Results reveal that during the rainfall events caused by the weak NEM system, Daet experienced the most precipitating clouds, or (36%); with Deep Convective Clouds (DCC) accounting for 16% of the total. During easterlies, precipitating clouds dominated over Virac Station (8%); with 6% corresponding to DCC. Meanwhile, during the prevalence of the shear line, 27% of the total cloud cover was identified as precipitating clouds; of which 16% and 22% are attributed to DCC over Daet and Juban, respectively. Point representatives within Climate Type II exhibited the most precipitating clouds, with high clouds being the most frequent type across all stations and weather systems. Light rainfall, however, was the dominant classification during all-weather events. These findings suggest a potential link between cloud types and rainfall in the Bicol Region, warranting further investigation into the influence of specific cloud types on precipitation intensity.

Keywords: *cloud type, Bicol Region, northeast monsoon, easterlies, shear line*

EXAMINING THE IMPACT OF EL NIÑO AND LA NIÑA PHASES ON HEAT STRESS IN THE BICOL REGION, PHILIPPINES

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Heat stress occurs when the body cannot get rid of excess heat. In the past decade, heat stress has become more frequent, and Heat Index (HI) values often exceed the Extreme Caution level, reducing the number of safe days, which can lead to an increasing number of heat-related problems. One of the potential causes of rising heat stress is the short-term rise in average temperatures caused by ENSO events. This research explores the relationship between heat stress, using the Heat Index (HI) as a heat stress index, and El Niño Southern Oscillation (ENSO) through comprehensive analysis that aims to determine the patterns and impacts of ENSO phases in the local heat stress condition of the Bicol Region. The analysis was done using the 30-years of data observation from four PAGASA synoptic stations in the Bicol Region and the ERA5-Land reanalysis dataset during 1991–2020. The seasonal, geographical, and local weather have significant effects on the overall heat stress in the region. Extreme caution for HI (33–41ºC) is more frequent during La Niña events, particularly in the province of Daet, as it is more often observed during MAM and JJA seasons in which naturally high heat stress is observed, while no extreme caution for HI was observed in El Nino events as it occurred more often during DJF, where HI is least throughout the year. All data observations show moderate causality with the Oceanic Niño Index (ONI). Positive anomalies occurred on MAM and JJA for the HI, while negative anomalies were observed for SON during El Niño. La Niña events cause positive anomalies during DJF and SON, while negative anomalies occur in the MAM and JJA seasons.

Keywords: *Bicol, El Niño Southern Oscillation (ENSO), Heat Stress, Heat Index, Trend*

INFLUENCE OF EXTREME INDIAN OCEAN DIPOLE (IOD) PHASES ON THE INTERANNUAL RAINFALL VARIABILITY OF THE SOUTHWEST MONSOON OVER NORTHWEST PHILIPPINES

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The Indian Ocean Dipole (IOD) is an ocean-atmospheric system of interchanging sea surface temperature anomalies between west and east Indian Ocean (IO), divided into positive and negative phases that tend to intensify into extreme IOD phases. The Dipole Mode Index (DMI), representing IOD intensity based on the SST difference between west and east IO, was used to determine years under these extreme phases. These IOD phases influence the variability of monsoons connected to the Indian Ocean basin, including the Philippine Southwest Monsoon (SWM). To find the connection between each extreme IOD phase and SWM rainfall variability, the DMI and Southwest Monsoon Rainfall Anomaly Index (SWMRAI) were correlated using the Pearson correlation coefficient. Composites generated through Grid Analysis and Display System (GrADS) were also analyzed. Results show that during extreme positive IOD phase years, westerly winds are enhanced due to a high-pressure gradient over the Philippines which efficiently transports moisture toward the West Philippine Sea, while during extreme negative IOD phase years, the westerly winds get suppressed, reducing moisture transport. However, the correlation between the DMI and the SWMRAI is low which can be due to other factors not explored in this study, such as Tropical Cyclones (TCs), the El Niño-Southern Oscillation (ENSO), and topography.

Keywords: *Indian Ocean dipole, Southwest monsoon, rainfall, Philippines*

VALIDATION OF THE ESTABLISHED RAINFALL THRESHOLD FOR FLOOD OCCURRENCES IN LEGAZPI CITY, ALBAY

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The concept of rainfall threshold serves as an adaptable solution to mitigate the impacts of flooding, playing a crucial role in facilitating early warning systems, enhancing risk assessment, implementing cost-effective flood management strategies, and refining forecasting capabilities. In this study, the researchers conducted multiple validation procedures subsequent to establishing the empirical rainfall threshold centered on urban flooding in Legazpi City using rainfall data and historical flood records from 2010 to 2021. The reliability and effectiveness of the threshold were assessed by employing contingency and confusion matrices, and its performance was visualized through performance diagrams to ensure its accuracy in predicting the occurrence or non-occurrence of floods. Out of the 14 events in the validation set, the threshold accurately predicted 12 flood occurrences indicating its effectiveness. The evaluation metrics used to analyze the threshold revealed that Legazpi City exhibited Probability of Detection (POD) values of 0.86, 0.80, and 0.92, False Alarm Ratio (FAR) values of 0.43, 0.20, and 0.45, and the overall effectiveness and assessment resulted in F1 scores of 0.69, 0.80, and 0.69 for Legazpi, Urban Area 1, and Urban Area 2 (CBD), respectively. These results demonstrate the reliability of the established threshold in predicting flood and non-flood occurrences in the city. Furthermore, the high skill scores confirm its effectiveness in detecting flood events in the study area, with most Flood-Inducing Rainfall (FIR) events captured. Overall, these findings highlight the effectiveness of the established rainfall threshold in mitigating urban flooding. Future studies could further strengthen this assessment through the expanded compilation of rainfall and flood event data.

Keywords: *Empirical Rainfall Threshold, Probability of Detection (POD), False Alarm Ratio (FAR), F1 score, Flood-Inducing Rainfall (FIR)*

WEIGHTED ANALOG INTENSITY PREDICTION (WAIP) GUIDANCE FOR PHILIPPINE TROPICAL CYCLONES: INITIAL ASSESSMENT IN INTENSITY BIFURCATION CASES IN 2022

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The intensity forecasts generated by the operational runs of the bifurcation version of the seven-day Weighted Analog Intensity Prediction (WAIP) model for 13 tropical cyclone (TC) events that occurred within the Philippine Area of Responsibility (PAR) in 2022 using the preliminary best track intensities from the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) as verifying dataset. The method generates a rank-weighted average of intensity evolutions of 16 historical analogs from the 1945-2018 Joint Typhoon Warning Center (JTWC) best track data that closely resemble the PAGASA official track forecast and initial intensity at the time WAIP was run. Furthermore, hierarchical cluster analysis is used to separate analog intensity evolutions into two clusters, provided that a substantial intensity bifurcation (e.g., threshold intensity difference ≥ 15 kt at each forecast time) is observed. For the 2022 test cases comprising 105 WAIP intensity forecasts, the 16-analog WAIP showed generally increasingly negative bias errors with increasing forecast time and root mean square error (RMSE) ranging from 7.5 kt at 12-hour to 23.4 kt at 120-hour. In 36 of 105 WAIP intensity forecasts where substantial intensity bifurcation was observed, there was a considerable improvement in the intensity RMSE relative to the original 16-analog WAIP if an always perfect selection of the correct intensity cluster is made. The "perfect-cluster section" WAIP forecasts had generally smaller bias errors and lower RMSE across nearly all forecast times, with percent decrease in RMSE ranging from 14.1 to 33.1% relative to those observed in the intensity forecasts from all 16 analogs. While further verification will be performed for TC cases from the 2018 to 2023 seasons, this preliminary evaluation using demonstrated the viability of the WAIP as an operational intensity forecast guidance tool compared to the original 10-analog, seven-day WAIP in operational use at PAGASA, especially in intensity bifurcation situations.

Keywords: *bifurcation, analog, intensity*

BIAS CORRECTION OF REAL-TIME GSMAP SATELLITE-RETRIEVED RAINFALL DATA IN THE CONTEXT OF LANDSLIDE MONITORING AND EARLY WARNING

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Real-time and accurate rainfall information is vital for early warning systems addressing hydrometeorological hazards like rainfall-induced landslides. Due to significant gaps in the spatial coverage of synoptic rain gauges specifically in mountainous areas, the Dynaslope Project under DOST-PHIVOLCS has installed automatic rain gauges (ARG) in 52 sites all over the Philippines. The Project also uses the REDAS Satellite Rainfall Monitoring (SRM) Tool to retrieve satellite rainfall data of its sites which serves as secondary rainfall data. The tool uses real-time GSMaP_NOW of the JAXA Precipitation Measuring Mission. Satellite products such as GSMaP_NOW are prone to systematic errors including reports of underestimation or overestimation of precipitation. We attempted to apply a well-grounded bias correction methodology to reduce uncertainty and discrepancies in the satellite rainfall dataset using gauge observations. A modified linear-based moving bias correction scheme was applied to site-specific GSMaP satellite data in which a rolling correction factor (CF) is calculated for the current hour based on rainfall observations in the preceding hours. The preliminary assessment was employed on 7 Mindanao sites with a 1-day window size. The bias correction scheme was proven effective in minimizing the errors of the GSMaP_NOW dataset compared to a fixed CF for each site. The evaluation of corrected and raw GSMaP_NOW estimates against Dynaslope ARGs revealed enhancements in key statistical metrics. Better agreement was found between the ARGs and satellite rainfall, as indicated by significant reductions in mean absolute error, root mean square error, and bias. While the hourly correlation coefficients showed minimal changes, notable improvements were observed at longer intervals (e.g. 24H and 72H). The method primarily transformed the magnitude of rainfall values, preserving consistent patterns over longer time intervals rather than altering the relationship or trend between datasets.

Keywords: *landslide, GSMaP_NOW, rainfall, early warning, bias correction*

SEVERE WEATHER ANALYSIS OF TORNADO (SWAT): SYNOPTIC AND CONVECTIVE SETTING OF EF1 MANILA TORNADO (14 AUGUST 2016) OVER PHILIPPINES

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This is the first case study conducted and related to a tornadic event in the Philippines. An extensive ground-relative, mesoscale, synoptic, and dynamic analyses was constructed to understand the cause of Manila Tornado development, which occurred at 14th of August 2016 and rated in Enhanced Fujita (EF) Scale as an EF1. Prior to the tornado occurrence, the tropospheric environment over Luzon resembles to an efficient convection process; a surface inverted trough along with the common monsoonal flow induced convergence and instability along the western Luzon and divergence aloft caused by an upper- level ridge. Along a typical tropic set up over the aforementioned area, the surface was moist and the warm buoyant air parcels managed to tap along the prime environment, especially at the peak of convective heating. A tornadic mini-supercell TSTM developed in the area of potentially unstable atmosphere with undiluted Convective Available Potential Energy (CAPE) $\geq$ 1750 J kg^{-1} and low-level CAPE $\geq$ 200 J kg^{-1} in both 00 and 12 UTC Tanay soundings. Without capping, this instigated a stout updraft that can withstand environmental entrainment and realize the available buoyancy by 70 to 80%. The updraft column also gained rotation because of the kinematics in place with ample and near-pure streamwise vorticity close to the ground accompanied in the substantial Storm-Relative Helicity (SRH) indices. This caused a tornado to occur from 0830 to 09 UTC 14 August 2016. When compared to the established U.S. baseline climatology, the Manila Tornado's cumulative vertical profile is within the distribution norms associated with tornadic supercell environmental setups. This study showed that tornadic event in Manila was caused by a combination of; (a) Potential vorticity (PV) anomaly and possible ducted waves, which increased vorticity over the Metropolis, (b) Kinematic support due to the curved hodographs and wind profile, and (c) Thermodynamic instability that triggered the severe TSTM and tilted the vortex into vertical.

Keywords: *Tornado, Thunderstorm (TSTM) – Supercell, Synoptic Scale, Mesoscale – Thermodynamics and Kinematics, Dynamics*

THE EFFECT OF CLIMATE CHANGE IN THE CLIMATE CLASSIFICATION OF THE PHILIPPINES

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Climate change has already been seen in multiple parts of the world, including the Philippines. The climate classification of the Philippines is based on the seasonality of rainfall only, as other variables like temperature have minor seasonal variations. This study redefines the climate classification by applying hierarchical clustering to the averaged pentad rainfall from 52 meteorological stations and used Tension Spline (TS) interpolation in the reference period (1973-2011) and the recent period (1983-2021). Analysis revealed that there are three identified clusters in both periods. Cluster 1 is characterized by a rainy season in mid-May and ends in mid-October and a dry season in the rest of the months, located in the western part of Luzon Island. Cluster 2 is characterized by a pronounced rainy season that starts in October and ends in mid-February but does not have a pronounced dry season in the country's eastern portion. Cluster 3 has no pronounced rainy and dry seasons and is characterized by almost evenly distributed yearly rainfall in the eastern part of Northern Luzon, including the rest of Palawan, the center of Luzon, Visayas, and a large portion of Mindanao. By comparing the reference and recent period, four meteorological stations shifted in another cluster: the Butuan, Catbalogan, Maasin, and Tacloban stations. Based on the spatial maps created using TS interpolation, the affected areas include the western portion of Samar, Biliran Island, Leyte, Agusan del Norte, and half of Agusan del Sur. Trend analysis also revealed that the rainfall trends of the mentioned stations, possibly influenced by Tropical Cyclones and Monsoons, are increasing, which is the leading cause of the shift in their climate. The temperature trend was also increasing, coinciding with the rainfall trend. These findings could be helpful in various ways, such as planning in the agricultural sector and disaster mitigation.

Keywords: *hierarchical clustering, spatial map, TS*

RECALIBRATION AND EVALUATION OF CERES MAIZE MODEL FOR CORN YIELD FORECASTING IN IFUGAO PROVINCE

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Ifugao province is exposed to extreme events brought by erratic weather conditions and climate variability and have a detrimental effect to corn production especially that the crop is grown in open field rainfed condition. Hence, there is a need to improve management practices to reduce the impact of such events. With the capability of crop models (e.g., CERES Maize) in simulating growth, development, and yield of a crop, certain management practices can be assessed to determine if it can be an activity that could alleviate the impending effect of extreme weather or climate variability. Thus, this study aimed to recalibrate and validate the CERES Maize model for yield forecasting in Ifugao.A calibrated CERES Maize model in Isabela did not perform well in Ifugao, thus recalibrated by fined-tuning the ecotype coefficients of the model. Recalibration utilized the observed experimental data collected from field experimentation (i.e., 2017 dry cropping season). Data includes weather, soil, crop management, phenological events, aboveground biomass, leaf area index (LAI), and yield. For validation, yield data from 4 participating farmers on the same cropping was used. Results showed that recalibration improved the simulation of aboveground biomass, LAI, yield and phenological events of corn. Calculated coefficient of determination (r^2) and index of agreement (d-index) were approaching unity for all parameters. Moreover, values of root mean square error (rmse) were within the acceptable error (i.e., normalize root mean square error (nrmse) < 20%) except for LAI. The recalibrated CERES Maize model was evaluated by comparing the simulated yield and observed yield from the 4 participating farmers. Calculated r^2, rmse, nrmse and d-index were 0.60, 437.3 kg ha^{-1}, 18.4%, and 0.84, respectively indicating good model performance. The calibrated CERES Maize can be used for climate change impact assessment, management practice optimization, and as a decision support tool for corn production in Ifugao.

Keywords: *CERES Maize; Crop modeling; Yield forecasting; Corn*

VARIABILITY OF THE CLOUD COVER OVER THE PHILIPPINES DURING ENSO AND MONSOON PHASES

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Cloud cover variability is an important meteorological phenomenon with significant implications for agriculture, climate research, and renewable energy. Cloud cover variability over the Philippines is significantly influenced by two large-scale climate patterns: the El Niño-Southern Oscillation (ENSO) and the Monsoon system. This study aimed to investigate the variability of the total cloud cover (TCC)/cloud fraction cover observed over the Philippines. This study utilized TCC data of the European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis 5 (ERA5) spanning across a 30-year period from January 1991 to December 2020. Northeast monsoon normally occurs from November to March, while Southwest monsoon occurs from June to September. The data of the different El Niño-Southern Oscillation (ENSO) phases are from Oceanic Niño Index (ONI). These were used as basis to perform composite analysis and produce TCC climatological maps. In general, TCC over Visayan and Mindanao region is greater during La Niña than during El Niño, but with less TCC over Western Luzon during La Niña. Interestingly, the distribution of TCC maximizes in both phases in the mountainous areas of Luzon. During southwest monsoon, increased TCC were observed over Southwestern Luzon and Western Visayas Region, while decreased TCC happened over Northwestern Luzon during northeast monsoon. It was also found out that ENSO La Niña have increased TCC over the country when it coincides during northeast monsoon and monsoon transition phase.

Keywords: *Cloud Cover, Monsoon, ENSO, Philippines*

SEASONAL DIURNAL VARIATION OF RAINFALL OF THE DIFFERENT CLIMATE REGIMES IN THE PHILIPPINES

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Previous studies on diurnal rainfall pattern focused on specific regions only; however, the entirety of the Philippines as an area of interest still needs to be accomplished. This study investigates the seasonal diurnal rainfall patterns in the Philippines across its four climate types (CTs), as classified by the Modified Corona Climate Classifications. The research covered a period of 11 years, classified days into TC (Tropical Cyclone) and Non-TC days and utilized precipitation data from the Integrated Multi-satellitE Retrievals for Global Precipitation Measurement. The results revealed that the general mean rainfall rate (MRR) is maximum in the afternoon (CT1, CT3, and CT4 at 1600 LST; CT2 at 1300 LST). All seasons resemble the general MRR diurnal pattern, regardless of CT, with December-January-February (DJF) season having the lowest peak. The spatiotemporal distributions of rainfall further reveal the important role of prevailing winds in enhancing the rainfall over the eastern and western coast of the Philippines during DJF and June-July-August, respectively. During transition seasons (March-April-May and September-October-November), higher MRR is located over mountainous regions suggesting a more active role of local process in rainfall formation. The spatiotemporal distribution of negative vertical integrated moisture flux convergence is similar to the distribution of MRR suggesting the influence of humidity and wind to the diurnal pattern. Moreover, convective available potential energy, solar insolation, and topography are some additional factors that may be attributed to the diurnal signal. Non-TC days show varied magnitude of rainfall rate and a more pronounced diurnal signal than TC days. Results from this study may be used by the Filipino community and sectors that are heavily dependent on precipitation occurrences such as disaster management and agriculture.

Keywords: *diurnal variation, rainfall, Philippines*

NEWLY DERIVED RADAR-BASED PRECIPITATION ESTIMATION IN THE PHILIPPINES: IMPLEMENTATION AND VALIDATION OF SUBI Z-R RELATIONSHIP

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Marshall-Palmer (MP) reflectivity to rain-rate (Z-R) relationship ($Z=200R^{1.6}$) is widely utilized globally for radar-based quantitative precipitation estimation (QPE), particularly for stratiform rainfall. However, the implementation of a standardized Z-R is constrained by the diverse characteristics of a specific geographical area. SUBI Z-R ($Z=409.78R^{1.21}$), a newly derived Z-R relationship based on radar and gauge 2018 data, is being implemented across all radar stations in the Philippines. In this study, we assessed the performance of SUBI Z-R using radar and gauge data from 2022 to determine its accuracy in estimating rainfall, despite being derived from 2018 data. Radar reflectivity and rain gauge rainfall within a 50km vicinity spanning from June to December 2022 were matched using the Traditional Matching Method (TMM). The QPE derived from the SUBI Z-R relationship outperformed MP. SUBI is more effective for higher rainfall rates, whereas MP performs better for lower rainfall rates.

Keywords: *Z-R Relationship, Radar Reflectivity, Quantitative Precipitation Estimation*

TIME-LAGGED ENSEMBLE QUANTITATIVE PRECIPITATION FORECASTS (QPF) FOR TYPHOON NORU IN THE PHILIPPINES USING THE WRF MODEL: VERIFICATION USING QUANTITATIVE PRECIPITATION ESTIMATES (QPE) FROM SUBIC AND TAGAYTAY RADAR

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In this study, we assess different QPFs generated using the Weather and Research Forecasting (WRF) model for Typhoon Noru (local name Karding) that impacted most areas in Luzon Island including Metro Manila last September 2022. We validate the forecasts against the Subic and Tagaytay Radar mosaic QPE, which covers not only Metro Manila but also nearby areas. The QPEs were generated using the community version of the Short-Range Warning of Intense Rainstorms in Localized Systems (Com-SWIRLS) provided by the Hong Kong Observatory (HKO). For the WRF QPF, model outputs from different initialization times were combined and averaged using the time-lagged ensemble method to generate a single deterministic forecast. For the case of Typhoon Noru, we analyzed a 3-hour rainfall period on 25 September, from 15:00 to 18:00 UTC. In the short-range (48hr lead time) 3km resolution QPF, a better performance was observed, compared to the 12km QPF with a 6-day lead time. When considering the entire event duration, the performance of the Model QPF was shown to underestimate rain when compared to the radar QPE, especially for the case of the 12km QPF where no rain was forecasted. Observations show that the ensemble members with longer lead times may decrease the accuracy of the ensemble performance for typhoon forecasts due to the early initialization time. In terms of the Typhoon structure, the 1km Radar QPE generally agrees with the case of the 3km WRF QPF, showing that the quality of the Radar QPE during the event was generally suitable for QPF verification. However, the 12km WRF QPF with a longer lead time was not able to capture the rainfall extent during the study period. This can be further improved by introducing weights to each member to lessen the contribution of the least performing members.

Keywords: *Quantitative Precipitation Forecasts and Estimates, Time-Lagged, WRF model, Radar, Typhoon*

EFFECT OF RADAR DATA ASSIMILATION ON THE FORECAST TRACK, INTENSITY, AND RAINFALL FOR TROPICAL CYCLONE NORU

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This study investigates the impact of assimilating radar reflectivity on tropical cyclone prediction. The effect on tropical cyclone (TC) Noru, a high-impact tropical TC that passed through Central Luzon in September 2022 is examined. This study uses Weather Research and Forecasting Model Data Assimilation (WRFDA) three-dimensional variational assimilation (3DVAR) in assimilating conventional observations and radar reflectivity. The radar reflectivity is assimilated by using indirect assimilation which uses an observation operator to estimate rainwater and water vapor from the radar reflectivity prior to the variational assimilation. Experiments without data assimilation are also conducted to establish the control case. The tropical cyclone forecasts are evaluated on the following parameters: TC Track, TC Intensity (central pressure and maximum winds), and rainfall. The TC tracks, central pressure, and maximum winds are evaluated against International Best Track Archive for Climate Stewardship (IBTrACS), while the rainfall is evaluated against synoptic station reports within a 1000-km radius from the observed TC track. Model TC centers are identified using the pressure centroid method, and minimum pressure and maximum winds are extracted within an area centered at these locations. The results show that assimilating radar reflectivity reduces the errors on track position, and also reduces the underestimation of the TC intensity. Rainfall forecasts at synoptic stations resulted in lower false alarm ratio and higher probability of detection scores at higher thresholds, resulting in a better equitable threat score compared to the control experiments. Overall, the results show the potential of radar reflectivity assimilation in improving TC forecasts. Despite the improvements, the TC intensity is still underestimated. Further studies on fine-tuning and radial velocity assimilation are recommended as improving the wind fields may further enhance intensity predictions.

Keywords: WRF, 3DVAR, Radar data assimilation

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

PMS Significant Milestones

Over the years, PMS conducted several activities to boost meteorology in the country through various trainings, conferences, and competitions, among others in partnership with several institutions, to wit:

- "MET-Innovation" and "MET-Education", conducted under MET4YOU Project for Central Luzon held at Central Luzon State University (CLSU), at the Science City of Muñoz, Nueva Ecija on 26-27 January, 2024.
- "MET-Innovation" and "MET-Education", conducted under MET4YOU Project for Eastern Visayas Region held at Visayas State University (VSU), Baybay City, Leyte on 23-26 November 2023
- Tackling Typhoon and Flood Vulnerability: A Typhoon and Flood Awareness (TFAW) Webinar on 21 June, 2023
- "MET-Innovation" and "MET-Education", conducted under MET4YOU Project for Ilocos Region held at Mariano Marcos State University (MMSU), City of Batac on 18 February 2023.
- "Virtual Research Clinic" for 4th Year BS Meteorology students of the Central Luzon State University (CLSU) on 02 December 2022
- "MET-Innovation" and "MET-Education", conducted under MET4YOU Project for Bicol Region held at Bicol University on 19 November 2022.
- Scientific Session on "Onset of the Southwest Monsoon in the Philippines: An Observational Study" conducted by Dr. Leoncio A. Amadore, in partnership with the National Research Council of the Philippines on 21 June 2022.
- "MET-Kaalaman: Video Contest" and "MET-Olympiad: Battle of the Brains", Competitions undertaken under MET4YOU Project conducted on 25 March 2022.
- 2022 PMS Annual Convention – 24-25 March 2022
  Theme: "Early Action: Responding to Hydrometeorological Challenges under the New Normal"
- 2021 PMS Annual Convention – 20-21 April 2021
  Theme: "Disastrous Hydro-Meteorological Events in the Middle of Pandemic:

Challenges, Lessons Learned and Way Forward"Signing of the Memorandum of Agreement (MOA) between the Philippine Meteorological Society (PMS) and DOST-Science Education Institute (SEI) on the implementation of the Project "Meteorology for Young Scientists" of MET4YOU: Science, Technology and Innovations" – 14 April 2021

- Webinar on "Meteorology for Science Enthusiasts" – 24 March 2021
  As part of the 156th National and 71st World Meteorological Day Celebration
- Webinar on "Basic Meteorology for Teachers"
  Batch 1: 18 August 2020
  Batch 2: 21 August 2020
- 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
- "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

PHILIPPINE METEOROLOGICAL SOCIETY, INC.

PAGASA SCIENCE GARDEN COMPLEX

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