

8TH PHILIPPINES-TAIWAN EARTH SCIENCES INTERNATIONAL CONFERENCE

MANILA, PHILIPPINES
JUNE 2-6, 2025



**INNOVATIONS IN EARTH
SCIENCES: STRENGTHENING
PHILIPPINES-TAIWAN
COLLABORATION FOR
RESILIENT AND
SUSTAINABLE FUTURE**

ABSTRACT VOLUME

**The 8th Philippines-Taiwan Earth Sciences International Conference
Eastwood Richmond Hotel, Quezon City, Philippines
June 2-3, 2025**

Program

Day 1. June 2, 2025

07:30 – 08:30 AM	REGISTRATION
08:30 – 08:35 AM	NATIONAL ANTHEM
08:35 – 08:45 AM	OPENING MESSAGE Dr. Teresito C. Bacolcol Director, DOST – Philippine Institute of Volcanology and Seismology
08:45 – 08:55 AM	MESSAGE OF SUPPORT Dr. Leah J. Buendia Undersecretary for Research and Development, DOST
08:55 – 09:00 AM	INTRODUCTION OF THE KEYNOTE SPEAKER Dr. Ma. Mylene M. Villegas Deputy Director, DOST- Philippine Institute of Volcanology and Seismology
09:00 – 09:20 AM	KEYNOTE ADDRESS Dr. Renato U. Solidum Jr. Secretary, Department of Science and Technology
09:20 – 09:30 AM	PRESENTATION OF TOKEN / GROUP PHOTO
09:30 – 09:45 AM	COFFEE BREAK
	PLENARY TALKS
09:45 – 10:10 AM	The Beginnings of ESIC Dr. Carla Dimalanta Professor, National Institute of Geological Sciences University of the Philippines, Diliman, Philippines
10:10 – 10:30 AM	The Philippine Fault zone and the segmentation of the Manila subduction zone Dr. Shu-Kun Hsu Dean, Graduate College of Sustainability and Green Energy Technology, National Central University, Taiwan Professor, Department of Earth Sciences, NCU, Taiwan
10:30 – 10:45 AM	COFFEE BREAK
	SCIENTIFIC SESSIONS
	Moderator: Dr. Decibel Faustino-Eslava and Dr. Shing-Lin Wang
10:45 – 11:00 AM	<i>Typhoon-Induced Landslide Dynamics: Mapping Runout and Flow Paths in Laurel, Batangas (October 2024)</i> Ms. Precious Joy P. Teaño, UPLB IRNR
11:00 – 11:15 AM	<i>Understanding Rainfall-Landslide Thresholds and Soil Characteristics in Volcanic Terranes: Towards Integrating Site-Specific Insights into Regional-Scale Models</i> Ms. Jenielyn T. Padrones, UPLB IRNR
11:15 – 11:30 AM	<i>Optimizing Input Parameters of the Deterministic Earthquake-induced Landslide Assessment under Slope Displacement NEWMARK Model</i> Dr. Arturo S. Daag, DOST PHIVOLCS
11:30 – 11:45 AM	<i>Seismic Response of Landslide Deposits due to Heavy Rainfall and Large Earthquakes</i> Prof. Ruey-Juin Rau, NCKU

11:45 – 12:00 PM	<i>Characterizing Soil Physical Properties and their Implications for Landslide Susceptibility in Mt. Makiling Forest Reserve</i> Mr. Roel C. Velina, UPLB IRNR
12:00 - 12:30 PM	<i>Empowering Communities: A People-centered Approach to Early Warning System for Landslides in the Philippines</i> Engr. Roy Albert N. Kaimo, DOST PHIVOLCS
12:30 – 01:45 PM	LUNCH
	SCIENTIFIC SESSIONS
	Moderator: Dr. Jillian Gabo-Ratio and Prof. Po-fei Chen
01:45 – 02:00 PM	<i>Mid- to late Holocene marine reservoir age variability and the marine reservoir age correction (ΔR) for the Taiwan Strait and the northeastern South China Sea</i> Dr. Shing-Lin Wang, NTU
02:00 – 02:15 PM	<i>Alkaline rocks and associated gold-copper mineralization in Cordon, Isabela, north Luzon, Philippines: Confluence products of an open system magma chamber and lithospheric mantle diapir</i> Dr. Graciano P. Yumul CEXCI
02:15 – 02:30 PM	<i>Subduction-related 42 Ma Dalun metagranite, SE Taiwan: an age constraint for tectonic evolution of the southernmost of Eurasia continental margin</i> Prof. Yuan Hsi Lee, NCCU
02:30 – 02:45 PM	<i>Eruption History and Magma Chamber Dynamics of the Tatun Volcano Group, Taiwan: Insights from Mineral Chemistry and Advanced Geochronological Methods</i> Mr. Karl D. Jabagat, NCCU
02:45 – 03:00 PM	<i>Seismotectonic stress heterogeneities within the Philippine archipelago</i> Mr. John Fungo, NCKU
03:00 – 03:30 PM	COFFEE BREAK
	SCIENTIFIC SESSIONS
	Moderator: Dr. Marcelino Q. Villafuerte II and Prof. Wei-Yu Chang
03:30 – 03:45 PM	<i>Microphysical Properties of Southwest Monsoon Rainfall based on C-band Dual Polarization Radar and Disdrometer Observations</i> Mr. Generich H. Capuli, DOST PAGASA
03:45 – 04:00 PM	<i>Application of C-Band Dual-Pol Radar on Precursor Recognition in Heavy Rain Systems</i> Dr. Chi-June Jung, NTU
04:00 – 04:15 PM	<i>Improving Dual-Polarization Radar QPE with Disdrometer Observations in Taiwan</i> Ms. Yu-Shuang Tang, CWA
04:15 – 04:30 PM	<i>Strengthening Operational Capacity through Radar Data Quality Enhancement: A CWA-PAGASA Collaboration</i> Dr. Pin-Fang Lin, CWA
04:30 - 04:45 PM	<i>Initial Assessment of the Impact of Assimilating the PAGASA Aparri Radar Data on the Forecast of Typhoon Doksuri (2023)</i> Dr. Ting-Chi Wu, CWA
04:45 – 05:30 PM	POSTER PRESENTATION

	Day 2. June 3, 2025
08:00 – 09:00 AM	REGISTRATION
	SCIENTIFIC SESSIONS
	Moderator: Dr. Winchelle Ian G. Sevilla and Prof. Ruey-Juin Rau
09:00 – 09:15 AM	<i>From Block to Belt: Integrating New Geophysical Models and Datasets in Reexamining the Tectonic Framework of the Northern Central Philippines</i> Dr. Leo T. Armada, UP NIGS
09:15 – 09:30 AM	<i>Enhancing Ground Motion Predictions with Field-Measured Vs30: A Departure from Proxy-Based GMPE Inputs</i> Dr. Rhommel Grutas, DOST PHIVOLCS
09:30 – 09:45 AM	<i>Recent Earthquakes and Paleoseismic Studies along the Leyte Segment of the Philippine Fault</i> Mr. Jeffrey S. Perez, DOST-PHIVOLCS
09:45 – 10:00 AM	<i>Verification of High Rupture Speed of the 1990 Luzon Earthquake, Philippines from Taiwan Seismic Network Observations</i> Dr. Bor-Shouh Huang, Academia Sinica
10:00 – 10:30 AM	COFFEE BREAK
10:30 – 10:45 AM	<i>Finite Fault Solution of the 2025 MW 7.7 Myanmar earthquake</i> Prof. Po-Fei Chen, NCU
10:45 – 11:00 AM	<i>Active tectonic characteristics of the southern Bohol Island, central Philippines, from uplifted late Quaternary marine terraces</i> Prof. J. Bruce H. Shyu, NTU
11:00 – 11:15 AM	<i>Origin and significance of areas of low relief perched at high elevations in an arc-continent collision, Taiwan</i> Dr. Timothy B. Byrne, UConn
	SCIENTIFIC SESSIONS
	Moderator: Ms. Thelma A. Cinco and Dr. Pin-Fang Lin
11:15 – 11:30 AM	<i>Investigating the microphysical characteristics of precipitation systems during the 2018 Southwest Monsoon (SWM) season in South Luzon, Philippines</i> Mr. John Ruel L. Locaba, NCU
11:30 – 11:45 AM	<i>Utilizing the Rainfall-Runoff-Inundation Model for Flood Forecasting in the Philippines</i> Dr. Marcelino Q. Villafuerte II, DOST PAGASA
11:45 – 12:00 PM	<i>Advancing Sounding Capabilities within the Atmospheric Boundary Layer Using In-situ Platforms</i> Mr. Kun-Wei Lin, CWA
12:00 – 01:30 PM	LUNCH
	Moderator: Dr. Jenielyn T. Padrones

	and Dr. Ting-Chi Wu
01:30 – 01:45 PM	<i>Evaluation of CWA Regional and Global Forecast Models for the Philippines</i> Mr. Junie G. Ruiz, DOST PAGASA
01:45 - 02:00 PM	<i>Statistical Analysis of the Evolution of the Convective Precipitation Dual-Polarimetric Variable Over Northern Taiwan</i> Prof. Wei-Yu Chang, NCU
02:00 – 02:15 PM	<i>Projecting Quality of Quantitative Precipitation Forecasts before Events through Machine Learning: Preliminary Results for Westbound Typhoons in Taiwan from A Cloud Model</i> Prof. Chung-Chieh Wang, NTNU
02:15 – 02:30 PM	<i>The Evaluation of CWA Seasonal Forecast Model</i> Mr. Helio Tseyi Lee, CWA
02:30 – 02:45 PM	<i>Verification of Machine Learning Weather Prediction Models for Typhoon Track Forecasting Operations</i> Dr. Yung-Lan Lin, CWA
02:45 – 03:00 PM	<i>Overview of CWA TWRP Model and the AI/ML Applications for Tropical Cyclone Forecasting</i> Mr. Der-Song Chen, CWA
03:00 – 03:15 PM	BUSINESS MEETING
03:15 – 3:30 PM	COFFEE BREAK
03:30 - 5:00 PM	CLOSING CEREMONIES

POSTER PRESENTATIONS

<i>Volcano-hydrothermal system models of Philippine volcanoes: tracking the fluids and related hazards in Cagua and Hibok-Hibok Volcanoes, Philippines</i> Dr. Raymond Patrick R. Maximo, DOST-PHIVOLCS
<i>Rupture Characteristics of the 2025 Southern Leyte Mw 5.8 Earthquake from Aftershock Relocation and Finite Fault Inversion using Teleseismic Waveform and GPS Data</i> Dr. Winchelle Ian Sevilla, DOST-PHIVOLCS
<i>Geologic Controls to the Spatial Distribution of Knickpoints in the Abra River Basin</i> Dr. Noelynna T. Ramos, UP-NIGS
<i>Lithofacies of the Upper Oligocene to Lower Miocene Lubuagan Formation in Northeastern Cagayan, Luzon Island, Philippines</i> Ms. Alliah Linel D. Santos, UP-NIGS
<i>Paleoclimatic Reconstruction of Luzon Island from the Late Eocene to Pleistocene Based on Whole-Rock Geochemical Proxies</i> Dr. Carla B. Dimalanta, UP-NIGS
<i>The Blue Soil Hills in Sagada, Mt. Province: Geological insights for informed geotourism</i> Dr. Betchaida D. Payot, UP-NIGS
<i>Structural and Gravity-Based Constraints on Moho Depth Variations in West Central Philippines</i> Mr. Joshua Godwin Cuevas, UP-NIGS
<i>Sedimentary provenance and depositional history of Oligocene-Miocene clastic rocks in southwestern Mountain Province, Central Cordillera Range, Philippines</i> Dr. Jillian Aira Gabo-Ratio, UP-NIGS
<i>Localized Climate Hazard Management in Shellfish Farming: Strengthening Resilience in Capiz, Philippines</i> Ms. Ma. Elena V. Tan, DOST-PAGASA

<p><i>Benchmarking the Effect of Background Error Covariance Tuning on a WRF 3D-Var Data Assimilation System over the Philippines using Central Weather Authority's Scale Configuration</i></p> <p>Mr. Michael B. Simora, DOST-PAGASA</p>
<p><i>Modeling Event-Based Severe Wind Risk in the Philippine Housing and Building Sector</i></p> <p>Ms. Thelma A. Cinco, DOST-PAGASA</p>
<p><i>Neogene climatic cooling recorded in geochemical signatures of Lower Miocene to Lower Pliocene clastic sequences in Northwestern Luzon, Philippines</i></p> <p>Mr. Kenneth Jan Sangalang, UP-NIGS</p>
<p><i>Assessing Wave Model Performance Using Reanalysis Data During Typhoon Pepito (2024)</i></p> <p>Engr. Monico Alejo, DOST-PAGASA</p>
<p><i>Assessment of original and filtered magnetic anomaly maps for Curie point depth and heat flow estimation</i></p> <p>Ms. Chae Ann V. Malipol, UP-NIGS</p>
<p><i>Intraplate seismicity in the subducting South China Sea slab: Constraints from perfect-elastic flexural modeling</i></p> <p>Mr. Armando Salvador M. Bambao, UP-NIGS</p>
<p><i>Site-specific rainfall threshold for landslide risk: A Gumbel-based extreme value analysis in LIGTAS-AGAD sites.</i></p> <p>Mr. Gerard Anthony E. Delos Reyes, UPLB SESAM</p>
<p><i>Geomorphological characteristics and geoheritage value of the coastal sand dunes of Sanchez Mira, Cagayan Province, Northern Philippines</i></p> <p>Ms. Ruth C. Madrideo, MGB</p>
<p><i>Ilocos Norte (Philippines) as a potential UNESCO Global Geopark: Assessing the Geoheritage Value, Opportunities, and Challenges</i></p> <p>Mr. Edrian M. Tubalado, MGB</p>
<p><i>Constraining the Recent Eruptive History of Mt. Natib, Philippines: Zircon Fission Track (ZFT) Geochronology and Mineral Chemistry analyses of youngest eruptive products</i></p> <p>Mr. Ivan Andrei B. Apilado, Adamson University</p>
<p><i>U-Pb geochronological constraints on the timing of arc magmatism with associated U mineralization in Camarines Norte, Philippines</i></p> <p>Dr. Americus Perez, DOST-PNRI</p>
<p><i>Exploring the Use of Facebook as a Platform for Disaster Risk Reduction Communications: A Systematic Literature Review</i></p> <p>Mr. Jason R. Rodriguez, UPLB SESAM</p>
<p><i>Analysis of Critical Post-Rainfall Hours in Rainfall-Induced Landslide Events</i></p> <p>Ms. Judy-Ann M. Legaspi, UPLB SESAM</p>
<p><i>Preliminary Analysis on the LIGTAS-AGAD Philippine Landslide Database using GIS hotspot analysis, source evaluation analysis, and descriptive statistics</i></p> <p>Mr. Refeim M. Miguel, UPLB SESAM</p>
<p><i>Ligtas na komunidad: Enhancing landslide mitigation and public information system with developed LIGTAS landslide crowdsourcing mobile app.</i></p> <p>Mr. Gabriel Angelo R. Mamaril, UPLB SESAM</p>
<p><i>Landslide Susceptibility Studies in the Philippines: A Systematic Review of Methods, Factor Inputs, and Spatial Distribution</i></p> <p>Ms. Czequinna Dainty A. Tanguihan, UPLB-IRNR</p>
<p><i>Tree Root Characteristics and Their Role in the Soil Stability of Landslide-Prone Areas</i></p> <p>Ms. Jorinelle S. Hagos, UPLB IRNR</p>

Spatial Correlations Between Land Subsidence and Population Density: A Case Study from Jakarta, Indonesia
Mr. Muhammad Yunus, NCKU

Assessing the Geosite Suitability of Volcanic Landscapes in the Philippines: A case study of Cagua Volcano in Northeastern Cagayan
Larissa Gabrielle O. Babon, UP-NIGS

The Philippine Fault zone and the segmentation of the Manila subduction zone

*Shu-Kun Hsu¹, Lien-Kai Lin¹, Yi-Ching Yeh¹, Leo Armada², Carla B. Dimalanta²,
Wen-Nan Wu¹, Shiao-Ya Wang³, Ching-Hui Tsai³, Chung-Liang Lo¹*

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The Philippine Fault roughly bisects the Philippine mobile belt. The Philippine Fault system contains several branch faults. Although the Philippine Sea Plate is converging northwestward toward the Eurasian Plate, to the south of 16°N the Philippine mobile belt has generally rotated anti-clockwise relative to the Sunda Plate with a rotation pole near the NE Borneo Island, while to the north of 16°N the Philippine Sea Plate has rotated clockwise relative to the Eurasian Plate.

To understand the configuration of the northwest Philippine Fault system and its tectonic implications, we have conducted marine geophysical surveys off western Luzon. Our results show that the main NW-SE trending Philippine Fault in central Luzon has extended northwestward to offshore and terminated at the Manila Trench. The termination of the principal Philippine Fault marks a segmentation of the Manila subduction zone. A new transform fault is formed to connect the northern and the southern Manila Trench segments. The trend of the Manila Trench has changed ~35° counterclockwise from north to south. Coinciding with the NW-SE trending Philippine Fault in central Luzon, the Manila subducting slab beneath central Luzon has been torn, as evidenced by seismic tomography and seismicity. The northern subducted slab dips 40° eastward, while the southern slab dips 80° eastward. The segmentation of the Manila subduction zone along the NW-SE trending principal PFZ could be due to the southeastward collision of the Palawan microcontinental block against the Philippine mobile belt near Mindoro and the northwestward docking of the Benham Rise. The segmentation of the Manila subduction zone and slab tearing could predominate the regional crustal deformation and earthquake hazards.

Typhoon-Induced Landslide Dynamics: Mapping Runout and Flow Paths in Laurel, Batangas (October 2024)

Precious Joy P. Teaño^{1}, Jenielyn T. Padrones¹, Decibel V. Faustino-Eslava², Roel C. Velina¹, Jorinelle S. Hagos¹, Czequinna Dainty A. Tanguihan¹, Jayson L. Arizapa¹, Cristino L. Tiburan, Jr.¹, Juan Miguel R. Guotana², Carla B. Dimalanta³, Beth Zaida H. Ugat⁴*

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The prolonged and heavy rainfall associated with typhoons heightens the danger of landslides, posing serious risks to communities, infrastructure, and ecosystems in vulnerable terrains. In October 2024, Severe Tropical Storm Kristine (Trami) brought torrential rains, resulting in widespread flooding, destructive landslides, and mudflows in Laurel, Batangas. During October 24-25 alone, Batangas received 435.0 mm of rain—equivalent to approximately two months' worth of precipitation—contributing to slope instability and triggering mass movements. This study aimed to analyze the landslide's runout and flow paths using remote sensing (RS) and geospatial modeling. High-resolution Digital Elevation Model (DEM), satellite imagery, and the USGS (United States Geological Survey) Grfin Tool was utilized to delineate the landslide's extent and assess its zones of mobility. Grfin Tool relies on TauDEM, a hydrologic modeling software package, to trace the landslide debris source areas, probable flow inundation paths, and runout zones. Validation of the identified mobility zones involved the comparative analysis of pre- and post-event imagery and on-site field verification. The primary goal was to establish a holistic methodology for landslide runout and flow path prediction that could be applied to other typhoon-affected regions in the Philippines. Preliminary findings indicated that the landslide runout closely followed pre-existing drainage networks, highlighting the role of hydrological connectivity in landslide propagation. The results suggested that integrating GIS and RS tools provided a reliable approach for assessing post-landslide hazards, aiding in risk mitigation. The methodology developed in this study can support disaster response agencies and policymakers in designing effective early warning systems and land-use strategies to minimize future landslide impacts. Further refinements, including the incorporation of machine learning-based susceptibility modeling, may enhance predictive accuracy for future studies.

Keywords: *Debris flow, Typhoon Kristine (Trami), geohazard mapping, GIS-based landslide modeling, remote sensing*

Understanding Rainfall-Landslide Thresholds and Soil Characteristics in Volcanic Terranes: Towards Integrating Site-Specific Insights into Regional-Scale Models

Jenielyn T. Padrones^{1*}, *Precious Joy P. Teaño*¹, *Roel C. Velina*¹, *Czequinna Dainty A. Tanguihan*¹, *Jorinelle S. Hagos*¹, *Jayson L. Arizapa*¹, *Decibel V. Faustino-Eslava*², *Juan Miguel R. Guotana*², *Loucel E. Cui*², *Bianca Maria Laureanna P. Pedrezuela*³, *Beth Zaida H. Ugat*⁴, *Jefferson J. Rapisura*², *Maria Regina V. Regalado*², *Rosemarie Laila D. Areglado*², *Cristino L. Tiburan, Jr.*¹, *Carla B. Dimalanta*⁵

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Developing effective early warning systems and mitigation strategies requires an understanding of the complex relationship between rainfall patterns and the occurrence of landslides. For shallow landslides, the stability of slopes is intricately linked to the characteristics and properties of the soil. This study looked at the physical characteristics of the soil in landslide-prone regions in Laguna, Batangas, and the Bicol Region that are underlain by volcanic rocks. Bulk density, soil texture, Atterberg limits, and hydraulic conductivity were among the physical parameters analyzed. Moreover, the mineralogical composition of the soils was assessed to understand its influence on the degree of expansion. Soil texture, which reflects the proportion of sand, silt, and clay, can serve as a representative soil characteristic for regional-scale models, as it is closely correlated with key soil behaviors such as hydraulic conductivity, infiltration capacity, and bulk density. The unsaturated hydraulic conductivity measurements range from 16.24 to 347.04 cm/hr for sandy loam soils and 0.57 to 0.62 cm/hr for clay-textured soils. Representative samples yielded saturated hydraulic conductivity values of 0.40 to 0.42 cm/hr. An empirical rainfall-landslide (RL) threshold based on soil texture was developed, revealing that clay and clay loam soils require higher rainfall thresholds to trigger landslides compared to sand and sandy loam soils. Preliminary data will be used in integrating site-specific thresholds into a regional-scale map.

Keywords: *rainfall-landslide threshold, soil texture, slope stability*

Optimizing Input Parameters of the Deterministic Earthquake-induced Landslide Assessment under Slope Displacement NEWMARK Model

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Recent advances in computational modelling of earthquake-induced landslides (EIL) were adopted to optimize hazard modelling using physics-based input parameters. Part of the Department of Science and Technology - Philippine Institute of Volcanology and Seismology (DOST-PHIVOLCS)'s mandate is to produce provincial-level EIL hazard maps for the entire country. This research will present several approaches to optimize workflows based on Newmark Sliding Block Analysis and TauDEM. The models are deterministic in nature with several input parameters, including seismic ground motion, soil and rock shear strength parameters, soil and rock factor of safety (FOS), critical acceleration, displacement based on Newmark Analysis, and landslide inventories.

The Deep Learning U-NET CNN (Convolutional Neural Network) tool was developed to semi-automate landslide inventory using high-resolution optical satellite images. Invasive drilling techniques have traditionally been the most direct approach to evaluate soil thickness and geotechnical information. Using non-invasive geophysical techniques, such as Refraction Microtremor and 3-component Microtremor, resulted in a good estimation of soil thickness and other geotechnical values. The Morphologically Indexed Soil Thickness (MIST) Model was developed to extrapolate soil thickness with sparse data sets and interpolation accounts the DEM-derived morphometric attributes such as slope, curvature, and elevation. Other geotechnical parameters were measured in the field and interpolated using the Krigging techniques.

The Newmark model only predicts the landslide zone of failure, not the runout, which is another critical component of the hazard. The shift to TauDEM Avalanche Run-out was utilized, resulting in faster and more objective findings. To date, all of the operations will be integrated with the ArcGIS model builder, making the process more efficient. Finally, ongoing research employed physics-based machine learning techniques to integrate all processes to further optimize the EIL hazard modeling methodology.

Keywords: *earthquake-induced landslides, newmark model, geophysics, remote sensing, deep learning, landslide inventory*

Seismic Response of Landslide Deposits due to Heavy Rainfall and Large Earthquakes

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Assessing how landslide deposits respond to heavy rainfall and large earthquakes is crucial for evaluating the stability of landslide bodies during extreme events. We placed two seismographs on Dalun Mountain, a deep-seated landslide in northern Taiwan, for approximately one year to study the responses of the landslide deposits to the frequent large earthquakes and heavy rainfall caused by the northeast monsoon seasons in northeastern Taiwan. The seismic stations were installed on March 10, 2024, and have continuously recorded signals from the mainshock and aftershocks of the April 3, 2024 M_L 7.2 Hualien earthquake, as well as heavy rainfall events in July and September 2024, with maximum accumulated rainfall exceeding 300 mm over 1-5 days. We examined these signals using the horizontal-to-vertical spectral ratio method. Furthermore, we analyzed peak ground acceleration and velocity from significant shaking due to large earthquakes, considering the depth to the sliding interface, groundwater level, and topographic effects of the landslide body. The results indicate that during the 2024 mainshock, at a station approximately 120 km from the epicenter, strong ground motion caused a sudden drop in the predominant frequency of the stratum from 6 Hz to 5 Hz, while the H/V amplitude ratio decreased from 3.0 to 2.5. However, both the predominant frequency and H/V amplitude ratio gradually returned to their original levels within 5-10 days, suggesting velocity variations in the shallow layers due to significant ground motions. During the heavy rainfall event in July, we observed a decrease in the H/V amplitude ratio, while the predominant frequency remained unchanged. The responses of the landslide deposits to large earthquakes and heavy rainfall are likely related to the shaking intensity from the earthquake, the depth to and impedance contrast at the sliding interface, the saturation of the sediment deposits caused by rainfall, and the topography of the landslide body. Our study will provide essential reference indicators for subsequent research on landslide failure mechanisms.

Characterizing Soil Physical Properties and their Implications for Landslide Susceptibility in Mt. Makiling Forest Reserve

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The occurrence of landslides in the Philippines has been one of the recurring problems in the country, posing a threat to the community and the economy. This was often triggered by rainfall and intensified by local terrain and soil conditions. While topographic and climatic factors are frequently emphasized in landslide susceptibility studies, the role of soil properties remains less explored despite their critical influence on slope stability. This study analyzed the soil samples collected from landslide areas in Mt. Makiling Forest Reserve (MMFR). The analyses focused on soil properties with numerical values to elucidate the relationship between various parameters. These properties include moisture content, texture (sand, silt, and clay), porosity, bulk and particle densities, water holding capacity, soil pH, organic matter, carbon content, and Atterberg Limits. Using the Principal Component Analysis (PCA) and Pearson Correlation, the study aims to identify key soil property combinations that likely contributed to their inherent susceptibility to slope failure. The PCA results highlighted critical soil characteristics, such as Atterberg Limits and moisture content, as significant factors in landslide zones, while soil pH and percent carbon are part of the least influential factors. Further, Pearson correlation analysis revealed a strong positive correlation between moisture content and porosity ($r=0.908$; $p<0.1$), a perfect positive correlation between percent organic matter and carbon content ($r=1$; $p<0.1$), and a strong negative correlation between bulk density and porosity ($r=-0.990$; $p<0.1$). The study offers valuable insights into integrating soil characteristics into landslide hazard models and supports data-driven approaches for risk assessment and mitigation planning.

Keywords: *Principal Component Analysis (PCA), Pearson Correlation, soil properties*

Empowering Communities: A People-centered Approach to Early Warning System for Landslides in the Philippines

Roy Albert N. Kaimo^{1*}, Melody B. Teodoro¹, Cathleen Joyce N. Cordero¹, Kennex H. Razon¹, Arturo S. Daag¹, Teresito C. Bacolcol¹

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The Philippines ranks among the world's most landslide-vulnerable countries, with 80% of its land area at risk due to mountainous terrain, frequent earthquakes, and intensifying typhoon rainfall (MGB, 2010; UNISDR). To mitigate the risks associated with landslides, the Dynaslope Project, under the Department of Science and Technology-Philippine Institute of Volcanology and Seismology (DOST-PHIVOLCS), developed and deployed early warning system for deep-seated landslides (EWS-L), now operational in 52 high-risk communities nationwide. This system integrates real-time geotechnical monitoring with community-based observations to deliver site-specific, timely warnings.

A defining feature of Dynaslope's EWS-L is its people-centered approach, where at-risk communities actively participate through Landslide Early Warning Committees (LEWCs)—composed of residents and local leaders—who contribute ground-truth data and lead warning dissemination and response. The system aligns with the four pillars of effective early warning (risk knowledge, monitoring, dissemination, and response) as defined by the United Nations (UNDRR, 2006), while embedding disaster governance, multi-hazard approach, community participation, and inclusivity.

By emphasizing community ownership and continuous capacity-building, the Dynaslope Project demonstrates how locally-led resilience can bridge the gap between technical monitoring and actionable preparedness. The EWS-L framework—combining hard science with social innovation—offers a replicable model for landslide early warning in other disaster-prone regions.

Ongoing efforts focus on transition to fully community-managed EWS-L, ensuring long-term sustainability. This experience highlights the importance of multistakeholder collaboration—between scientists, local government, and communities—in building adaptive, inclusive, and effective disaster risk reduction systems for a more resilient future.

Keywords: *early warning system for landslide, deep-seated landslide, community-based early warning system, people-centered approach*

Mid- to late Holocene marine reservoir age variability and the marine reservoir age correction (ΔR) for the Taiwan Strait and the northeastern South China Sea

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In this study, we report new marine reservoir age correction (ΔR) values from the Marine20 calibration for the Penghu Islands located in the southern Taiwan Strait and for Hengchun above the Luzon Strait over the past 7500 cal BP, derived from paired ^{14}C and U-Th ages of Holocene corals. We developed a pretreatment protocol that ensures low calcite content ($<1\%$, $0.8\pm 0.2\%$) in coral samples, and compared our new measurements with published ΔR values from the region, recalculated to conform to the Marine20 dataset. The weighted mean ΔR value of -155 ± 10 ^{14}C yr for the past 5500 cal BP are determined as the marine reservoir age correction in the southern Taiwan Strait and the northeastern South China Sea (SCS), where the SCS water mixes with seawater from the Pacific Ocean through the Luzon Strait. A slightly higher weighted mean ΔR value of -86 ± 18 ^{14}C yr was obtained at Hengchun in the same period of time. Higher ΔR values at Hengchun than Penghu were observed between 1200 and 2000 cal BP, while the higher ΔR records near Xisha and Hainan in the SCS were between 2000 and 2500 cal BP. Since the regional ocean circulation, including SCS and Taiwan Strait, was closely related to the East Asian monsoon and the remote ENSO forcing, our result may imply an intensity shift of East Asian monsoon and likely the ENSO variation in the late Holocene.

Alkaline rocks and associated gold-copper mineralization in Cordon, Isabela, north Luzon, Philippines: Confluence products of an open system magma chamber and lithospheric mantle diapir

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There are two alkaline rock-hosted operating mines and one active exploration program in the alkaline complex, along the southern terminus of the Cagayan Valley basin. The active exploration program is that of the Cordillera Exploration Company Inc. (CEXCI) Cordon Gold-Copper Project (CGCP). Comparison of the three areas shows similarities and differences in terms of their geological characteristics.

The CGCP is underlain by the Late Oligocene to Early Miocene Cordon Syenite Complex (CSC) and Middle to Late Oligocene Mamparang Formation. The CSC is made up dominantly of porphyritic syenite intruded by equigranular monzonite. These two rocks are the main subject of this study. The feldspathoid-bearing lusitanite intruded both rocks. The monzonite is the main gold-copper host in Cordon. The syenite and monzonite overlap in almost all geochemical diagrams. Syenites are mostly made up of alkali feldspars with minor plagioclase, biotite, pyroxene and hornblende. Monzonite is made up of equal amounts of plagioclase and alkali feldspar, intermediate between syenite and diorite. The syenite and monzonite are characterized by subduction signatures (high Pb, Sr, negative Ti, Nb, Ta). Simple fractionation nor magma mixing cannot explain the chemistry. Slab fluid and sediment contributions are apparent. The change from syenite to monzonite is a shift from a silica-undersaturated to a silica-saturated melt. An open system magma chamber could account for this change. Later, the melt returned to a dominant alkaline signature with the introduction of feldspathoid-bearing lusitanites. The mantle diapir component is well-preserved as suggested by the depleted heavy REE. The relative depletion of the middle REE would explain the adakitic character of the rocks. The monzonite intrusion could have coincided with the later phase of oceanic plateau subduction which was also associated with gold-copper mineralization.

Keywords: *Alkaline rocks, Gold, Copper, Subducted Plateau, Cordon, Isabela, Luzon, Philippines*

Subduction-related 42 Ma Dalun metagranite, SE Taiwan: an age constraint for tectonic evolution of the southernmost of Eurasia continental margin

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The age of the arc-magmatic event is crucial for understanding the evolution of plate tectonics. The Talun meta-granite, located in southern Taiwan, was initially thought to be 200 Ma due to the subduction of the palaeo-Pacific plate beneath the South China Block (Yui et al., 2009, 2017). However, new zircon U-Pb dating for the Talun meta-granite indicates that the magmatism event occurred around 42 Ma, and the 200 Ma zircon grain ages are inherited zircon rather than representing the timing of magmatism.

Detailed mapping shows that the Talun granite intrudes into the Wulu schist, and the youngest detrital zircon found is ca. 55 Ma, indicating the upper limit of the deposit ages, which is consistent with the intrusion relationship. Additionally, we conducted Raman spectroscopy of carboniferous material from the wall rock, which showed temperatures near 500°C near the Talun meta-granite and decreased to around 350°C further away from the granite, consistent with the intrusion relationship.

We propose that the 42 Ma magmatism event is linked to the westward subduction of the Pacific Plate beneath the Eurasian Plate, an event that has also been observed in the South China Sea and Palawan.

Eruption History and Magma Chamber Dynamics of the Tatun Volcano Group, Taiwan: Insights from Mineral Chemistry and Advanced Geochronological Methods

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Growing evidence for an active magmatic system in the Tatun Volcano Group (TVG), northern Taiwan, has intensified efforts to understand its eruption history. Determining both the timing of past eruptions and pre-eruptive conditions is crucial for assessing volcanic hazards, particularly given TVG's proximity to the Taipei metropolis. However, previous studies have reported conflicting age results, highlighting the need for reliable dating methods to establish a robust geochronology. This study focuses on the Shamao lava dome, considered the youngest eruptive product in TVG, using a combination of zircon U-Th disequilibrium and (U-Th)/He dating (zircon double-dating) alongside high-precision ⁴⁰Ar/³⁹Ar groundmass dating. These geochronological methods are further supported by petrographic and mineral chemistry analyses, which provide insights into magmatic processes and storage conditions. New ⁴⁰Ar/³⁹Ar groundmass dating (15.0 ± 6.3 ka) aligns with zircon (U-Th)/He dating (16.3 ± 4.9 ka) and radiocarbon ages (23–13 ka), contradicting earlier interpretations of Holocene (1.3 ka) volcanism. Zircon U-Th disequilibrium data constrain the maximum eruption age to 16.3 ± 1.2 ka and reveal a prolonged magmatic history (~200 ka) with episodic recharge events, indicated by age clusters at ~23, 60, and 117 ka, as well as older grains in secular equilibrium (>300 ka). Petrographic and geochemical analyses of Shamao lava flow samples reveal disequilibrium textures in plagioclase phenocrysts, variable pyroxene compositions, and opacitic-rimmed hornblende, suggesting magma mixing or decompression. Amphibole-based geothermobarometric calculations indicate crystallization depths of 4–6 km (100–220 MPa), temperatures of 790–870°C, magmatic water content of 4–6 wt%, and oxidizing conditions (NNO+1.2 to NNO+2.2). These findings suggest that Shamao's lava flows originated from a shallow, water-rich, oxidized magma chamber during the late Pleistocene. Although further data are required to refine eruption recurrence models, these findings serve as a crucial basis for enhancing hazard assessments and risk evaluations in northern Taiwan.

Seismotectonic stress heterogeneities within the Philippine archipelago

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The Philippine Archipelago (PA), bounded by opposing subduction zones, represents a complex plate boundary between two converging plates. The region hosts earthquakes with varying mechanisms, reflecting the intricate nature of its deformation processes. We invert slip data from focal mechanism solutions to determine the relationship of the stress regimes across the PA and its tectonic assemblage.

First, we obtained 3287 seismicities from the ISC-GEM Global Instrumental Catalogue, Version 11 to establish the background seismicities within the PA, as well as the seismic profile for every 1° latitude. We also included the relocated historical earthquakes from Bautista & Oike (2000), with the surface wave magnitudes converted to moment magnitude using Equations 14 and 15 of Scordilis (2006).

For the stress inversion, we garnered 1760 focal mechanism solutions from the Global Central Moment Tensor Catalog with depths of 40 km and above, following the crustal thickness range of 13-33 km from PHILCRUST 3.0. Then we used MSATSI, which uses the damped inversion method in a MATLAB interface. We also divided the PA into several zones based on the results of *k*-means clustering before performing stress inversion. Previous studies have used the elbow method to obtain the optimum number of clusters; however, the elbow method only returned two clusters for the study area, which we deemed insufficient to represent the seismotectonic zones of the PA. Therefore, we continued using arbitrary numbers of *k* until each subduction zone is included in one independent cluster. We ended up with 13 clusters, then we used StressInverse, which uses fault instability constraints before performing iterative inversion for each cluster.

Generally, the stereomaps and stress directions show an almost EW-trending σ_1 that runs perpendicular to the curvature of the semi-parallel subduction zones. Meanwhile, the NW orientation of σ_3 in southwestern Luzon aligns with the direction of extension in Macolod Corridor and the conjugate strike-slip fault system between Luzon and Mindoro islands. In some cases, such as in southern Visayas, σ_1 is oriented NW, which reflects the shortening in the Visayan Sea Basin as exhibited by NE-striking reverse faults that produced recent large earthquakes in the area.

We also noticed that, while the elbow method following *k*-means clustering has been effective for determining the seismotectonic zoning prior to stress inversion in previous studies, it may not be suitable for areas with larger scope such as the PA.

Keywords: *Philippine archipelago, stress inversion, k-means clustering*

Microphysical Properties of Southwest Monsoon Rainfall based on C-band Dual Polarization Radar and Disdrometer Observations

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Extreme rainfall events during the Southwest Monsoon (SWM) and tropical cyclones (TCs) frequently impact the Philippines, leading to widespread flooding in urban areas such as Metro Manila. Accurate forecasting remains a challenge due to the complex microphysical processes involved. This study examines the microphysical characteristics of SWM rainfall using integrated observations from the Tagaytay C-band dual-polarimetric radar (14.123°N, 120.974°E) and disdrometer at the DOST-PAGASA Science Garden (14.6°N, 121.04°E). Three events were analyzed: two SWM rainfall events (29 July 2023 and 04 September 2024; Event 1 and Event 2) and one TC-enhanced SWM event (23–24 July 2024; Event 3). All events exhibited modest instability, high near-surface moisture and column-integrated precipitable water, and higher freezing level (FZL) height – favorable for warm-rain processes. Disdrometer observations illustrated predominantly small to medium drop sizes and stratiform-type drop size distributions (DSD) for Events 1 and 2, while Event 3 exhibited broader DSDs, larger drops, higher rainfall rates and liquid water content. Polarimetric radar profiles revealed event-specific precipitation structures. Events 1 and 2 showed enhanced differential reflectivity (Z_{DR}) near the surface and modest reflectivity (Z_H) and specific differential phase (K_{DP}), indicative of warm-rain collision-coalescence processes accompanied by shallow convection. Meanwhile, Event 3 displayed higher Z_H and K_{DP} below 3 km, suggesting deeper convection and efficient warm-rain growth. Polarimetric diagnostics indicate equilibrium DSDs are governed by both coalescence and breakup. Log₁₀ N_w – D_m relationships further differentiated the events, with Events 1 and 2 aligning with stratiform warm-rain regimes, and Event 3 indicating mixed- and/or ice-phase processes. These results emphasize the dominant role of warm-rain process in SWM-related precipitation over Metro Manila, with occasional mixed- and/or ice-phase contributions during convective enhancements. The findings underscore the need to improve radar-based quantitative precipitation estimation (QPE) and forecast (QPF) techniques and to refine microphysical parameterizations in numerical weather prediction models for more accurate representation of tropical rainfall systems in the Philippines.

Keywords: *C-band Dual-Polarization Radar; Disdrometer; Precipitation-Cloud Microphysics; Southwest Monsoon; Metro Manila*

Application of C-Band Dual-Pol Radar on Precursor Recognition in Heavy Rain Systems

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Since 2014, the Central Weather Administration (CWA) has upgraded the RCWF operational Doppler weather radar to include dual-polarization functionality. Starting in 2017, C-band polarimetric radars were gradually incorporated into operations, and by 2023, the upgrade of S-band weather radars across Taiwan to dual-polarization was completed. Integrating the polarimetric radar network significantly enhances the utility of observational data, strengthening the monitoring of severe weather systems that produce heavy rainfall.

The study analyzes the characteristics of the polarimetric parameters of the C-band radar in Taiwan in observing very short-term heavy rain systems and tries to establish the early warning threshold using the polarimetric parameters. The extreme values of the specific differential phase K_{DP} ($> 2^\circ \text{ km}^{-1}$) can be used to identify the heavy rainfall region's location, intensity, and movement. For flash floods downstream of the catchment area, there is potentially a priori warning capability. For the afternoon thunderstorm, if there is an area with $K_{DP} > 2.5 \sim 3.0^\circ \text{ km}^{-1}$ below the melting level, there will be a rainfall intensity $> 60 \text{ mm h}^{-1}$ (Rainfall $> 10 \text{ mm}$ in 10 minutes) after one or two volume scanning periods (7 to 14 minutes). In the case of frontal rainfall, when the rainfall intensity is $> 120 \text{ mm h}^{-1}$, K_{DP} appears leading characteristics only before one volume scanning period: $K_{DP} > 3^\circ \text{ km}^{-1}$ at a height of 3 km. Before heavy rainfall, the volume and average values of the high K_{DP} areas increase over time, while their vertical spatial distribution exhibits a process of decreasing core areas 15 minutes before.

Keywords: *dual-polarization radar, specific differential phase K_{DP} , heavy rain systems, warning threshold*

Improving Dual-Polarization Radar QPE with Disdrometer Observations in Taiwan

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In this study, a three-year (2016–2018) dataset from an operational Parsivel disdrometer network was used to derive localized coefficients and optimize dual-polarization radar-based quantitative precipitation estimation (QPE) algorithms. To improve the accuracy and applicability of the Parsivel measurements, quality control procedures, including cross-validation with rain gauge observations were conducted.

The derived radar–rainfall relationships were evaluated using radar observations from Mei-Yu season cases. A synthetic QPE product, incorporating localized R(A), R(Z), and R(KDP) relationships, was compared with the existing operational QPE. The results indicated an approximately 11% reduction in relative root mean squared error and a 3% reduction in normalized mean error. These findings underscore the effectiveness of using disdrometer-derived, localized radar–rainfall relationships to enhance the accuracy of operational rainfall estimation products.

Keywords: *dual-polarization radar, quantitative precipitation estimation, Parsivel*

Strengthening Operational Capacity through Radar Data Quality Enhancement: A CWA-PAGASA Collaboration

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Taiwan and the Philippines are located along the main path of typhoon (TY) in the Northwest Pacific. An early warning and forecasting of TYs is one of the most important and challenging issues for the both countries. The bilateral cooperation project, VOTE (Volcanoes, Ocean, Typhoon, and Earthquake), offers an opportunity to enhance our understanding of TY movement, structure, and intensity evolution through the sharing radar technology and data between Taiwan and the Philippines.

The bilateral cooperation project, MECO – TECO VOTE (Volcanoes, Ocean, Typhoon, and Earthquake) Project aims to enhance the cooperation between Taiwan and the Philippines to enhance further the monitoring and prediction of heavy rainfall events using weather radar. In this context, the radar teams in CWA (Central Weather Administration) of Taiwan and PAGASA (Philippine Atmospheric, Geophysical and Astronomical Services Administration) of Philippines have dedicated to the further development of Radar data QC (Quality Control) technology for providing more accurate information on Radar QPE (Quantitative Precipitation Estimation) and QPN (Quantitative Precipitation Nowcasting) on Typhoons and Convective systems.

This year, the MECO – TECO VOTE project has entered its third phase VOTEIII. During the first phase of VOTE project, through technical exchanges between the two parties, a fuzzy logic radar data quality control algorithm was jointly developed to remove one of non-meteorological echo, interferences. In the second phase VOTEII, in addition to enhancing the fuzzy logic radar data quality control algorithm to remove ground and sea surface echoes, radar QPE formulas were derived using radar data and ground rain gauge observations. Subsequently, radar QPE based on quality-controlled data was implemented and made available on the PAGASA website (<https://bagong.pagasa.dost.gov.ph/radar>).

In the third phase, data quality control efforts will be continued, focusing on the development and implementation of dual-polarization QC algorithms. Moreover, analysis and research will be conducted on the motion and dynamic fields of typhoons that have recently been observed within the radar networks of both CWA and PAGASA, also affecting both the Philippines and Taiwan. The goal is to provide radar observation information for typhoons that may impact both countries at an earlier stage, contributing to the shared objectives of disaster prevention and mitigation.

From Block to Belt: Integrating New Geophysical Models and Datasets in Reexamining the Tectonic Framework of the Northern Central Philippines

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The northern central Philippines is the locus of overlapping tectonic processes and complex plate interactions, including subduction, collision, and shearing. The Verde Passage Fault and Sibuyan Sea Fault are key features of this region and are major geologic features accommodating significant shearing associated with complex interactions of the Philippine Mobile Belt and adjacent microblocks. Given new tectonic models and geophysical datasets, reexamining the geologic framework is timely and necessary. This study integrates new geophysical (gravity, magnetics, bathymetry) data with seismic strain rate analysis to investigate the region's structure, deformation patterns, and geodynamic context. We also explore the geohazard implications of the present tectonic regime in the area.

Keywords: *Strike-slip, Strain, Crustal deformation*

Enhancing Ground Motion Predictions with Field-Measured Vs30: A Departure from Proxy-Based GMPE Inputs

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Accurate site characterization is critical in seismic hazard assessment, particularly when using Ground Motion Prediction Equations (GMPEs) to estimate ground shaking. In the Philippines, GMPE applications have traditionally relied on the rock-site value as the standard for local site conditions. While widely accepted, this value may not fully capture site variations across a specific area, introducing uncertainties in ground motion predictions.

Previous efforts - such as the collaborative study between the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and the Global Earthquake Model (GEM) Foundation - have significantly contributed to the selection of appropriate GMPEs for the Philippine setting. Building on this foundation, the present study introduces a data-driven enhancement through the incorporation of field-measured Vs30 values obtained via refraction microtremor (ReMi) surveys in the province of Ilocos Sur. These values were integrated into a Python-based application utilizing the OpenQuake Ground Motion Toolkit. Developed under the DOST-PHIVOLCS ACER Program, the application offers a user-friendly platform for simulating earthquake scenarios, computing GMPE-derived peak ground acceleration (PGA), and comparing results with observed data from the Philippine Strong Motion Network (PSMNet).

The observed strong-motion data, which includes PGAs recorded during the 27 July 2022 Mw 7.0 Northwestern Luzon earthquake and five additional seismic events, were used for comparison with the predicted PGAs. This analysis demonstrates that incorporating field-measured Vs30 significantly improves the alignment between predicted and recorded ground motion. Residual analyses underscore the value of empirical site characterization in enhancing GMPE performance and understanding localized ground motion behavior. This shift from proxy-derived to measured site inputs marks a significant step towards more accurate and region-specific seismic hazard modeling in the Philippines.

Keywords: *Vs30, Refraction Microtremor, GMPE, Seismic Hazard, Strong-Motion*

Recent Earthquakes and Paleoseismic Studies along the Leyte segment of the Philippine Fault

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Located in the central part of the Philippines, the Leyte segment of the Philippine Fault is approximately 140 km long and extends along the backbone range of Leyte Island. This fault is characterized by tectonic geomorphic features such as linear valleys, offset streams, hillside ridges, and wind gaps. A large portion of the slip along this segment is accommodated by creeping based on field observations, geodetic measurements, and InSAR analysis.

In 2023, a magnitude (M_w) 4.7 ruptured a portion of the northern creeping segment while in 2017, a M_w 6.7 earthquake generated a 26-km-long surface rupture along the northern part of the Leyte segment. The surface rupture of the 2017 event was manifested by left-lateral offset, continuous fault scarps, open cracks, and en echelon steps that coincide with previously identified morphotectonic features. To characterize and understand the seismic activity of this segment, two (2) paleoseismic trenches were excavated. Analysis of the trench sites revealed stratigraphic evidence for at least three (3) surface rupturing events. Radiocarbon dating of collected charcoal samples, suggests the recurrence interval of surface rupturing earthquakes is about 60-120 years. The result of this study is essential to augment the limited historical and instrumental data we have for a better assessment of seismic hazards related to the Philippine Fault.

Verification of High Rupture Speed of the 1990 Luzon Earthquake, Philippines from Taiwan Seismic Network Observations

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On July 16, 1990, a magnitude (Ms) 7.8 earthquake struck central Luzon Island in the Philippines. This earthquake generated a surface rupture exceeding 100 kilometers along the Philippine Fault Zone system. Using data from the global seismic network, seismologists conducted detailed studies on the overall rupture behavior of the earthquake source. However, analyses relied solely on far-field seismic data, leading to uncertainties in constraining the rupture speed of the earthquake source. In this study, we examine a regional seismic array waveforms of earthquake sequence from the Taiwan Seismic Network and conduct an explosion of the rupture characteristics of the Luzon earthquake. To leverage the similarity in source mechanisms and wave propagation paths between the mainshock and aftershocks, we select an aftershock recorded by this seismic network as empirical Green's functions to examine the Luzon earthquake source rupture. We identify two regions of concentrated energy release along the rupture fault plane. To match the envelope patterns of P-wave and S-wave arrivals in the observed mainshock waveforms, we synthesize seismic wave travel times and confirm that the rupture of the Luzon earthquake requires a high rupture velocity (comparable to the S-wave velocity of the source region) to fit the observations. A review of related post-earthquake studies reveals that the Luzon earthquake exhibited several unique source characteristics. Comparing these observations with analysis from significant high rupture speed earthquakes, we infer that the rupture of the Luzon earthquake may have exhibited super-shear rupture behavior.

Keywords: *Luzon Earthquake, Philippine Fault, Taiwan Seismic Network, Source Analysis, High Rupture Velocity*

Finite Fault Solution of the 2025 M_w 7.7 Myanmar earthquake

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The Sagaing Fault is a major tectonic structure in Myanmar, accommodating approximately 24 mm/yr of dextral slip and marking the boundary between the Burma microplate and the Sunda plate. Unlike the northern and southern segments, which have frequently experienced destructive earthquakes, the Meiktila segment in central Myanmar has long been recognized as a significant seismic gap, having lacked major earthquakes during the instrumental period (1908–2020). On 28 March 2025, a M_w 7.7 earthquake occurred near this region and may have ruptured the previously identified seismic gap.

To characterize the rupture dynamics of this event, we performed a joint finite-fault inversion of teleseismic body waves (P and SH), surface waves (Love and Rayleigh), and regional strong-motion waveforms using the Wavelet and Simulated Annealing SliP inversion method. Additionally, all available strong-motion data (6 stations) from the Myanmar seismic network were included. The hypocenter parameters, centroid location, and initial moment tensor solution were adopted from the Global Centroid Moment Tensor (GCMT) catalog. The fault plane was segmented into four sections to match the geometry of the Sagaing Fault based on previous geodetic studies.

Our finite-fault inversion revealed an asymmetric bilateral rupture with dominant propagation toward the south, spanning a total along-strike length of ~410 km and extending ~22.5 km down-dip. The rupture initiated from the hypocenter of Myanmar earthquake at 10 km depth, then propagated southward into all four fault segments. While the southward rupture reached over 350 km, a limited northward extension of ~60 km was also observed. The slip distribution was highly heterogeneous, with peak slip ~6 m concentrated around the hypocenter. Moderate slip (~1–3 m) were observed throughout the southern segments, with lower yet coherent slip (~0.5–1.1 m) in the southernmost one, indicating continuity across structural boundaries. The moment rate function revealed two primary pulses at ~20 sec (first maximum peak) and ~77 sec for second peak, with a total rupture duration of ~90 seconds. This event emphasizes the seismic potential of previously identified gaps on major strike-slip faults, underscoring the necessity for continuous seismic monitoring and updated seismic hazard assessment for Myanmar.

Active tectonic characteristics of the southern Bohol Island, central Philippines, from uplifted late Quaternary marine terraces

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The island of Bohol is located in the central part of the Philippine Mobile Belt, and is a tectonically active area. The disastrous October 2013 earthquake, for example, has produced significant life and economic losses, and illustrated the importance of understanding potential seismogenic structures on and around the island. Along the southern coast of Bohol, multiple levels of late Quaternary marine terraces are present. We mapped and analyzed these terraces, and our results show that a widespread Terrace 3 that is distributed throughout the coast was likely formed during the Marine Isotope Stage (MIS) 5e. West of the Loboc River, three higher terraces may have been formed during older sea-level highstands. East of the river, on the other hand, two lower terraces may correlate with MIS 5a and 5c. Using the elevation of the terraces and their ages, we calculated the late Quaternary uplift rates of the southern Bohol coast to be between 0.1 and 0.4 mm/yr. This coastal uplift may have been produced by the North Mindanao Sea fault offshore southern Bohol, which has been mapped by PHIVOLCS and appears to be a major active fault in the area. Across the Loboc River, the major difference of terrace distribution patterns and uplift rates suggests that there may be a potential active backthrust, probably branching out from the North Mindanao Sea fault, rather than the previously mapped East Bohol fault. Our results suggest that the North Mindanao Sea fault may pose significant earthquake and tsunami hazard for both Bohol and surrounding islands.

Keywords: *Bohol Island, marine terraces, active tectonics, coastal uplift rate, U-Th dating*

Origin and significance of areas of low relief perched at high elevations in an arc-continent collision, Taiwan

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Areas with relatively low topographic relief occur throughout the metamorphic core of the Taiwan orogen (Lin, 1957). Recent mapping of these low-relief areas shows they occur at high and low elevations and are not correlated with structural, lithologic, or tectonostratigraphic units (Vohra, 2021). Instead, areas of low relief dominate the lower elevations in the northern and southern parts of the range or are perched at high elevations along the drainage divide of the range. The latter areas are particularly conspicuous considering the youthfulness of the orogen and the documented high rates of erosion and surface uplift (Dadson et al., 2003; Derriex et al., 2014; Hsu et al., 2016). We integrate detailed structural mapping with compilations of low-temperature geochronological data and propose the orogen developed in three stages: An early stage recorded by the development of a regional-scale, overturned syncline, which defines the primary structure in the Slate Belt, the western part of the metamorphic core. A middle stage marked by the cessation of overturning in the syncline ca 0.9 Ma, regional extension throughout the eastern part of the metamorphic core, and the progressive development of the fold-and-thrust belt in the foreland. We propose that the transfer of horizontal shortening from the metamorphic core to the foreland during this stage initiated a period of extension in the eastern part of the core, allowing exhumation to outpace rock uplift and create erosional surfaces with relatively low topographic relief. Finally, the youngest stage of orogen growth was initiated less than a few hundred thousand years ago and is marked by the resurgence of surface uplift in the metamorphic core, evidenced by the uplifted low-relief surfaces and the high rates of surface uplift (up to 10 mm/yr) in the center of the range (Hsu et al., 2018).

Investigating the microphysical characteristics of precipitation systems during the 2018 Southwest Monsoon (SWM) season in South Luzon, Philippines

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The Southwest Monsoon (SWM), which brings almost half of the Philippines' annual rainfall, has been extensively studied, however its rainfall microphysics remain largely unexplored. This study investigates the microphysical characteristics of rainfall in South Luzon, Philippines during the 2018 SWM season (June to September) using data from a PARSIVEL disdrometer and the Tagaytay C-band dual-polarization weather radar. Time-height plots of radar parameters such as reflectivity (Z_H), differential reflectivity (Z_{DR}), specific differential phase (K_{DP}) and correlation coefficient (ρ_{HV}), and integral rain parameters such as normalized gamma number concentration ($\log_{10}N_w$), mass-weighted mean diameter (D_m), rain rate (R) and liquid water content (LWC) were analyzed. Using principal component analysis (PCA) on the drop size distribution (DSD) revealed groups corresponding to dominant microphysical processes. Three precipitation types are presented: strong widespread convection (SWC), strong isolated convection (SIC), and weak stratiform (WS). SWC and WS have small to mid-sized drops, while SIC recorded high concentrations of mid-to-large drops, typical for deep convective systems. Multiple PCA groups can be observed from SWC, showing the transitions within the system. SIC DSDs are clustered above the convection-stratiform separation line with high LWC, Z_H and Z_{DR} values. DSD groups, including ice-based convective groups, were observed during the time of highest R and Z_H in the SIC case. In contrast, the WS case has a low R with an evident bright band. These findings provide a more detailed perspective on these rainfall events which were not presented in previous studies.

Keywords: *rainfall microphysics, southwest monsoon, drop size distribution*

Utilizing the Rainfall-Runoff-Inundation Model for Flood Forecasting in the Philippines

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Tropical cyclone-associated extreme rainfall events are the typical cause of widespread floodings in the Philippines. Forecasting their occurrence a few days in advance could be beneficial in minimizing the known destructive impacts of floods in the country. Thus, this study introduces a novel approach combining near-real-time satellite-based rainfall estimates with numerical weather prediction (NWP) model-based rainfall forecasts to improve the flood forecasting and early warning systems in the Philippines. The study utilizes antecedent rainfall occurrence based from the estimates of the Global Satellite Mapping of Precipitation (GSMaP) provided by the Japan Aerospace Exploration Agency (JAXA), while rainfall forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF) are used to drive the Rainfall-Runoff-Inundation (RRI) model in producing the past 5-day and the forecast 5-day flood inundation maps, respectively, in an hourly interval across the major river basins in the country. Initial RRI simulations indicate that the recent floodings experienced in many areas in the Bicol Region brought by Severe Tropical Storm Kristine (International Name: Trami) that occurred in the latter part of October 2024 were almost captured by the model. With such promising results, the operational use of RRI in flood forecasting and early warning system is underway, which could be of great help in disaster risk reduction and management efforts in the country.

Advancing Sounding Capabilities within the Atmospheric Boundary Layer Using In-situ Platforms

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Taiwan's complex terrain, dominated by the Central Mountain Range that runs north to south and divides the island into eastern and western regions, results in significant regional meteorological variability. Over the years, the Central Weather Administration (CWA) has established a comprehensive surface weather observation network. Recently, efforts have intensified to enhance observation capability within the atmospheric boundary layer by developing vertical profile techniques, aiming to improve the completeness of three-dimensional meteorological data. This study employs two in-situ vertical observation systems: a multirotor unmanned aerial vehicle (UAV) weather observation system and a mini-sonde observation system. The UAV platform enables vertical profiles from the surface to approximately 3 kilometers in height, while the mini-sonde system extends the observation range to over 12 kilometers. Both systems are equipped with compact sensors capable of measuring essential meteorological parameters such as temperature, humidity, pressure, wind direction, and wind speed. Additionally, the UAV system can simultaneously monitor PM2.5 concentrations.

These observational systems are characterized by their flexible deployment and mission-oriented operation, allowing customization based on specific observational objectives. Notably, during Intensive Observational Periods (IOPs), the UAV system can conduct hourly vertical profiling to provide high temporal resolution data, significantly contributing to the understanding of regional weather phenomena and improving short-term weather forecasting capabilities.

Evaluation of CWA Regional and Global Forecast Models for the Philippines

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To support the development of sector-specific forecast information, this study evaluates the performance of regional to global climate models from the Central Weather Administration (formerly known as the Central Weather Administration, CWA). To evaluate their respective accuracy, hindcast data from the regional (CWB-RSM, 12 km) and global (CWB-CFSv2, 55km) forecast models were compared against the high-resolution ClimGridPh (1km) gridded dataset for the Philippines.

Preliminary analysis of rainfall suggests that the CWB-CFSv2 (CWB-RSM) model tends to underestimate (overestimate) rainfall compared to the ClimGridPh data. Statistical comparison using the indicated 15 station data points yields significant correlation values ($r \approx 0.99$, $p < 0.01$). Error metrics, such as the Root Mean Square Error and the Mean Absolute Error, indicate lower errors and fewer outliers at the monthly timescale compared to the seasonal. Both models further exhibit negative bias relative to the ClimGridPH across the analyzed timescales, except for the CWB-CFSv2 model in the seasonal timescale.

Temperature assessment indicates underestimation by CWB-CFSv2, while CWB-RSM captured spatial patterns in the ClimGridPh more accurately, particularly during the dry season. During the December-January-February season, both models are found to be aligned with the observed patterns in the ClimGridPh dataset in demonstrating lower temperatures in Luzon and Mindanao, specifically around the mountain ranges. This indicates the models' ability to represent the influence of topography on temperature.

These initial results highlight the respective strengths and limitations of each model. Further evaluation using advanced skill scores is expected to provide a more comprehensive performance assessment.

Statistical Analysis of the Evolution of the Convective Precipitation Dual-Polarimetric Variables over Northern Taiwan

Wei-Yu Chang and Lien-Hsiang Chin

Short-duration and intensive precipitation from afternoon thunderstorms in summer often cause disasters. The early warning of these rapidly developing convective systems remains challenging. This study utilizes dual-polarimetric measurements (DPMs) to investigate the microphysical characteristics of convective cells at different evolution stages (developing, maturing, and dissipating). The afternoon thunderstorm events from the Taiwan-Area Heavy Rain Observation and Prediction Experiment (TAHOPE) were employed and analyzed using the Storm Motion Analysis by Radar Tracking (SMART). Intensive convective systems were identified with a reflectivity threshold of 40 dBZ and a minimum area of 10 km². The temporal evolution of the convection was investigated by their DPM fraction ($Z_{DR} > 1.5$ dB, $K_{DP} > 0.5$ °km⁻¹). At the early developing stage, the Z_{DR} -fraction exhibits high values at mid-level, then gradually decreases as the precipitation transits to the mature stage and dissipates. The K_{DP} -fraction remains relatively low in the initial phase, and subsequently increases at mid-to-upper levels before the mature stage. During the mature stage, K_{DP} -fraction exhibits high values at lower to mid-levels and then significantly weakens during dissipation. The evolution of Z_{DR} - and K_{DP} -fractions indicate the microphysical process of large raindrops being carried aloft by updrafts, subsequently, high liquid water content at mid-level; then, the raindrop descends to the surface during the dissipating stage. The statistical analysis indicates that significant vertically Integrated liquid (VIL) maxima correspond to more pronounced changes in Z_{DR} - and K_{DP} -fractions. In particular, Z_{DR} -fraction shows significantly high values and fractions at the onset of the developing stage, suggesting that this feature may serve as an early warning indicator for intensive convection driven by thermal forcing.

Projecting Quality of Quantitative Precipitation Forecasts before Events through Machine Learning: Preliminary Results for Westbound Typhoons in Taiwan from A Cloud Model

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A long-standing problem of all numerical weather predictions, regardless deterministic or ensemble, is the more accurate assessment in probability (or likelihood) for the predicted scenario to occur, especially at longer lead times due to typically larger errors. The rapid development of artificial intelligence today may offer an effective method to tackle this issue. In this study, a neural-network machine-learning model is developed to, after training, project the expected value of the similarity skill score (SSS) of predicted total rainfall distribution in Taiwan for westward-moving typhoons during their influence period, thus serving as an objective guidance for the quality of the prediction. Ten typhoons are included, and a total of 105 parameters linked to rainfall are used from time-lagged forecasts (out to 8 days) every 6 h by a cloud-resolving model, when they cover the entire influence period (inside 300 km from Taiwan) with enough lead time. For each typhoon, only data from the other nine cases are used to train the model.

The results indicate that machine learning can capture the tendency of the actual SSS (calculated against observed rainfall) for most cases (eight out of ten), thereby informing the forecasters which quantitative precipitation forecasts (QPFs) are more trustworthy and which other ones are less so beforehand. Such guidance is particularly valuable at longer lead times, when the forecast uncertainty is relatively high. Thus, our results are highly encouraging. Nevertheless, if a typhoon behaves differently in forecasts from those that serve as the training data, the outcome would be less useful. Possible directions to remedy this issue and make further improvement are also offered.

The Evaluation of CWA Seasonal Forecast Model

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Short-term climate models, which generate forecasts months in advance, have become essential tools in climate prediction. These models provide critical information for sectors such as agriculture, water resource management, energy planning, and disaster preparedness. Seasonal forecasts—long-range projections of climate conditions—aim to anticipate general trends in temperature variability and precipitation patterns by simulating key drivers such as atmospheric circulation and sea surface temperature. A key challenge in seasonal forecasting lies in the accurate prediction of extreme climate events, which often have significant socio-economic consequences. By systematically examining model performance in representing historically warm, cold, wet, and dry events, the study provides insights into the relative strengths and limitations of each model, offering guidance for improving operational seasonal forecasts and enhancing preparedness for future extremes.

Keywords: *Seasonal Forecast*

Verification of Machine Learning Weather Prediction Models for Typhoon Track Forecasting Operations

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In recent years, the application of Artificial Intelligence (AI) has rapidly progressed across various sectors, including weather forecasting. Industry and academia have introduced AI-based models—collectively known as Machine Learning Weather Prediction (MLWP) models—such as FourCastNet, Pangu-weather, GraphCast, FuXi, Fengwu, and the AI Forecasting System (AIFS) from ECMWF.

To integrate MLWP models into operational forecasting, it is crucial to assess their performance relative to traditional numerical weather prediction (NWP) systems and to establish suitable development frameworks. Since 2023, MLWP models have demonstrated promising skill in typhoon track prediction. The Taiwan Central Weather Administration (CWA) has adopted the Pangu-weather model with real-time inputs, and developed an automated typhoon tracking algorithm.

This study verifies typhoon track forecasts during the 2023-2024. Results show that MLWP track errors are comparable to those of existing NWP systems, supporting their role as valuable supplementary tools. CWA's Typhoon Analysis and Forecast Integration System (TAFIS) has integrated real-time MLWP guidance, with ongoing efforts to improve model accuracy and reduce forecast errors through refinement and post-processing.

Keywords: *MLWP, typhoon track, TAFIS*

Overview of CWA TWRf Model and the AI/ML Applications for Tropical Cyclone Forecasting

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With violent winds and intense rainfall, tropical cyclones rank among the most destructive weather systems affecting oceans and coastal regions. Providing precise forecasts for the track and intensity of tropical cyclones is a critical responsibility of the national weather services in impacted countries. Taiwan is particularly vulnerable to such storms and enhancing tropical cyclone forecasting has become a top priority for Taiwan's Central Weather Administration (CWA).

The advancements in tropical cyclone forecasting over the past decade can be largely attributed to improvements in numerical weather prediction. A specialized version of the Advanced Research Weather Research and Forecasting Model (ARW WRF), known as TWRf (Typhoon WRF), was developed and implemented by the CWA for operational tropical cyclone forecasting in 2011. Over the years, various techniques have been researched and integrated into TWRf, including partial update cycling, cyclone bogus schemes, relocation schemes, hybrid 3DnVar, upgrades to the physical parameterization, analysis and analysis field blending schemes, as well as updates to sea surface temperature (SST) (Hsiao et al. 2010, 2012, 2015). The latest version, featuring resolutions of 15 km and 3 km with 52 vertical levels, became operational in 2016 and has resulted in significant enhancements in predictive performance (Hsiao et al., 2020).

This study will also investigate quantitative rainfall predictions in conjunction with AI/ML technology in the Taiwan region. Further details will be presented at the conference.

POSTER PRESENTATIONS

Volcano-hydrothermal system models of Philippine volcanoes: tracking the fluids and related hazards in Cagua and Hibok-Hibok Volcanoes, Philippines

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Located at the Pacific Ring of Fire, the Philippines hosts numerous volcanoes, with 24 active and 27 potentially active volcanoes. To better understand these volcanoes and mitigate related hazards, the Department of Science and Technology-Philippine Institute of Volcanology and Seismology (DOST-PHIVOLCS), in collaboration with National Chung Cheng University (CCU), initiated a focused study on the magmatic-hydrothermal system of a volcano. Studying the geochemical properties of gas and fluids from surface manifestations, such as thermal springs, fumaroles, and mud pools, may reveal information regarding their flow path and possible interaction with wall rocks or other fluids. It may also aid with the characterization of the magmatic intrusion and the dissolved gases, which are vital for monitoring the activity of the volcanoes.

Two active volcanoes were selected for this study, Cagua Volcano and Hibok-Hibok Volcano, located along two different volcanic arcs: the Taiwan-Luzon volcanic arc and the Central Mindanao volcanic arc, respectively. Three (3) types of geothermal fluids circulate within Cagua volcano: the acid-sulphate fluids within the crater, the neutral-chloride-bicarbonate fluids on the northwest side of the volcano, and the neutral-chloride-sulphate fluids on the northern part of Cagua Volcano.

Previous geochemical studies by DOST-PHIVOLCS on Hibok-Hibok Volcano provided a database of chemical compositions for Ardent spring, found in the northeast of the volcano, from 1982 to 1988. The water in Ardent Spring is slightly acidic and was identified to have a magmatic source based on the high concentration of silica, magnesium, sulfate, and chloride. Aside from the spring, Nangkawa crater lake was also studied and found to be a rainwater surface run-off based on the absence of weathering of silicate minerals from the surrounding rocks, the pH, and the concentration of ions.

This project aims to establish a baseline of geochemical components for thermal manifestations using modern methodology, utilizing some existing data from previous researchers on Cagua and Hibok-Hibok Volcanoes. The geochemical and isotopic behavior of sulfur, chlorine, and deuterium will be studied to supplement the effort in enhancing and strengthening eruption prediction. Interpretations of these data will help further understanding the degassing history of the said volcanoes and their magmatic-hydrothermal system.

Rupture Characteristics of the 2025 Southern Leyte Mw 5.8 Earthquake from Aftershock Relocation and Finite Fault Inversion using Teleseismic Waveform and GPS Data

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On 23 January 2025 at 07:39 PST (23:39 UTC), a shallow (11 km depth) Mw5.8 earthquake struck approximately 6 km southeast of San Francisco, Southern Leyte, Philippines. This event, the largest recorded in the epicentral area in at least 400 years, generated over 2000 aftershocks within the subsequent week, with the largest M3.1 occurring roughly two hours after the mainshock. Strong ground shaking, reaching a maximum intensity of PEIS VI, was reported in the epicentral area.

No surface trace of an active fault has been identified at the epicenter, and the nearest major structure, the Panaon Strand of the Philippine Fault, lies approximately 10.5 km to the east. While regional seismicity on Leyte Island is typically characterized by strike-slip faulting consistent with the Philippine Fault's movement, initial focal mechanism solutions for this event indicate oblique-reverse slip.

To investigate the causative fault and its rupture characteristics, we conducted a precise relative relocation of the aftershock sequence and performed a finite fault inversion using teleseismic waveforms and GPS data. The relocated aftershocks exhibit a dominant NE-SW trend, aligning with the inferred reverse left-lateral fault plane striking at approximately 9°. This orientation is also consistent with the preferred fault model derived from the joint inversion of teleseismic and GPS datasets. Furthermore, we used the estimated fault model to calculate the Coulomb Failure Function, exploring potential stress interactions in the epicentral region and its possible relationship to a nearby earthquake swarm near Mount Cabalian, located about 30 km to the northeast of the epicenter.

Keywords: *Southern Leyte Earthquake, aftershock relocation, finite fault inversion*

Geologic Controls to the Spatial Distribution of Knickpoints in the Abra River Basin

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Knickpoints are sharp, localized topographic changes along a river profile, marking a river's response to past and ongoing tectonic and climatic changes, or differential erosion across varying lithologic units. Given their relationship with bedrock characteristics and various geological processes, we explore knickpoint analysis as a qualitative tool for understanding the long-term evolution and tectonic deformation of the Abra River Basin (ARB). The ARB spans approximately 5125 km² and lies within the provinces of Abra, Benguet, and Ilocos Sur in northwest Luzon. The sinistral Abra River Fault runs through the river basin along the foot of the Central Cordillera. Using a 5-m resolution IFSAR DEM, more than 2800 knickpoints were extracted in the ARB using the TopoToolbox in Matlab and were analyzed to determine their topographic, geomorphological, and lithological controls. Initial frequency distribution plots reveal that most knickpoints occur at a mean elevation of 830 m, along moderately dipping (22.5°) and slightly convex (-0.03 openness) slopes. More than 1000 knickpoints occur on Mesozoic igneous basement rocks, followed by occurrences on Cenozoic sedimentary units. An initial analysis of knickpoint clusters was also performed using the Getis-Ord G_i^* statistic, revealing hotspots (i.e., clusters of high slope values) in the northernmost ARB, approximately 1.7 km away from Naglibacan Fault and 4 km away from the Vigan-Aggao Fault. Hotspots are also found at the southern end of the basin, approximately 2 km from the Abra River Fault and 4 km from the Ambuklao Fault. Future work entails further analysis of all knickpoint characteristics to provide insights into long-term geological and environmental processes (e.g., river incision, hillslope erosion), geomorphic adjustment (i.e., knickpoint migration), and tectonic deformation of the Abra River Basin.

Keywords: *knickpoints, landscape evolution, tectonic geomorphology, Abra River Basin, Philippines*

Lithofacies of the Upper Oligocene to Lower Miocene Lubuagan Formation in Northeastern Cagayan, Luzon Island, Philippines

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The Cagayan Valley Basin (CVB), located in northern Luzon, Philippines, is the largest sedimentary basin in the country. The CVB preserves a 2,700-meter succession of marine and terrestrial clastics, volcanoclastics and pyroclastic rocks, and carbonates. This provides key insights into the region's geologic history, tectonic activity, and paleoenvironmental conditions. The Lubuagan Formation consists of thick interbedded sandstone and mudstone with minor pyroclastic components, which is typically exposed along the western side of the Northern Sierra Madre and the eastern margins of the northern Central Cordillera. Based on recent paleontological dating, the Lubuagan Formation was deposited from Late Oligocene to Early Miocene.

This study reports new exposures of the Lubuagan Formation in the coastal municipalities of Santa Ana and Gonzaga, Cagayan—specifically in Brgy. Rapuli and Matara Beach—marking the northeasternmost extent of the formation to date. The exposures show a sequence of calcareous mudstone, organic-rich sandstone, and conglomerate beds, reflecting varying depositional conditions. Two main facies are observed: a deep-marine facies and a shallow-marine-transitional facies. The deep-marine facies consists of turbiditic mudstone-sandstone intercalations (i.e., normal graded sandstone, parallel and cross laminated sandstone, massive mudstones) interbedded with debris flow deposits characterized by thick massive sandstones capped by parallel laminated sandstones. The shallow-marine to transitional facies is characterized by abundant conglomerates interbedded with shell-rich beds of coarse-grained sandstones, suggesting phases of high-energy deposition typically associated with the transitional environment. The occurrence of abundant organic fragments suggests proximity to terrestrial sources, such as vegetated coastal plains, swamps, or tidal flats. This implies repeated shifts between terrestrial and marine environments.

By examining the lithological characteristics, sedimentary structures, and fossil content, we will unravel the complex depositional history of the Lubuagan Formation, thus contributing to the understanding of the Late Oligocene to Early Miocene evolution of the Cagayan Valley Basin.

Paleoclimatic Reconstruction of Luzon Island from the Late Eocene to Pleistocene Based on Whole-Rock Geochemical Proxies

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Whole-rock major and trace element geochemistry is employed to reconstruct the paleoclimatic evolution of Luzon Island, Philippines, from the Late Eocene to the Pleistocene. The study analyzes samples from key clastic sedimentary formations, including the Bangui, Bojeador, and Laoag Formations (Ilocos Region); the Lubuagan and Ilagan Formations (Cagayan Valley Basin); the Zigzag, Klondyke, Amlang, and Cataguintingan Formations (Baguio District); and the Santa Cruz Formation of Zambales and Pangasinan provinces.

Geochemical proxies such as the Chemical Index of Alteration (CIA) and Chemical Index of Weathering (CIW), along with immobile trace element ratios including Rb/Sr and Sr/Cu, are utilized to assess the intensity of chemical weathering and infer paleoclimatic conditions. These trends are interpreted within the broader framework of regional tectonics and correlated with major global climatic events such as the Middle Miocene Climatic Optimum and Late Miocene cooling. The integration of geochemical datasets from multiple regions across Luzon aims to provide a comprehensive and robust reconstruction of long-term paleoclimatic evolution.

Keywords: *sedimentary geochemistry, paleoclimate, paleoweathering, Luzon*

The Blue Soil Hills in Sagada, Mt. Province: Geological insights for informed geotourism

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The last few decades have seen the rise in global conservation efforts to preserve geosites (i.e. sites of geological significance or interest). While the Philippines shows diverse geology and high potential for geotourism, there is still a need to highlight its geodiversity and raise awareness on geoheritage. One of the challenges in the assessment of geological sites in the country is the limited information, and at times misinformation, on how these geosites formed.

In this work, we present the results of the geological characterization of the Blue Soil Hills, one of the famous tourist attractions in Sagada, Mountain Province. From its name, the Blue Soil Hills (BSH) refer to several hills in the locality of Suyo which appear blue to bluish green. This distinct color has been previously attributed to the presence of Cu or Cu-bearing minerals in the area. However, neither Cu nor Cu-bearing minerals were detected in the geochemical analyses of the BSH samples in this study. X-ray diffraction (XRD) analyses of the BSH samples reveal the presence of various minerals such as quartz, zeolite, glauconite and phengite. Moreover, electron probe microanalysis (EPMA) of black oxide minerals in the BSH samples led to the identification of these minerals as ilmenite, an Fe and Ti-rich mineral.

Our results confirm that the distinct hue of the Blue Soil Hills is unlikely related to the accumulation of Cu or hydrothermal alteration. Considering the geological context of the area, the BSH forms part of the Sagada Formation which comprise pyroclastic rocks with intercalated dacitic flows, sandstones, mudstones and limestones. The distinct color of the Blue Soil Hills can be possibly attributed to glauconite, a K- and Fe-rich clay mineral which can be found in sedimentary rocks formed in the marine setting. Hence, an accurate interpretation of the formation of the Blue Soil Hills is crucial to elevating the geotourism potential as well as fostering informed appreciation of this geosite.

Structural and Gravity-Based Constraints on Moho Depth Variations in West Central Philippines

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The tectonic architecture of West Central Philippines reflects its complex history of arc-continent collision, subduction-related compression along the Manila Trench, and strike-slip deformation from the Philippine Fault System. Key segments, such as the Verde Island Passage Fault and the Sibuyan Sea Fault, traverse internal seas within the region and contribute to numerous structural expressions—from thrust and fold zones to pull-apart basins—depending on the dominant stress regime. These tectonic forces result in either localized crustal thickening or thinning. To map crustal thickness variations, mantle residual gravity anomalies from the WGM2012 model were analyzed using Euler deconvolution to estimate the Moho depth. Strike-slip fault geometries were similarly constrained using Bouguer anomalies with adjusted structural indices. The resulting depth models reveal how transtensional and transpressional forces associated with local fault kinematics and regional subduction-collision dynamics control crustal thickness variations across West Central Philippines.

Keywords: *Moho depth, crustal thickness, mantle residual anomalies, strike-slip faults, tectonics*

Sedimentary provenance and depositional history of Oligocene-Miocene clastic rocks in southwestern Mountain Province, Central Cordillera Range, Philippines

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Sedimentary geochemistry, particularly whole-rock, trace element, and rare earth element analyses, has proven to be an effective tool for provenance studies, especially in geologically complex regions such as the Philippines. These techniques enhance the delineation of tectonic boundaries and provide critical insights into a region's petrogenesis and tectonic evolution.

In Northern Luzon, Philippines, much of the geological framework of the Central Cordillera Range has been established by geochemical research that has largely concentrated on igneous lithologies, especially those related to the hydrothermal mineralization in the area. However, recent studies on sedimentary sequences within the Baguio Mineral District – specifically the Late Oligocene to Early Miocene Zigzag Formation and the Middle to Late Miocene Klondyke Formation – have helped constrain the source rock composition, tectonic setting and depositional history in the area. This study employs sedimentary geochemical techniques to investigate analogous Oligocene-Miocene clastic successions exposed in southwestern Mountain Province, northwest of the Baguio Mineral District.

Geochemical signatures from these clastic units indicate derivation from mafic igneous source rocks, which serve as the volcanic basement rocks in the area. The sedimentary sequences were shown to be deposited within a sedimentary basin associated with an oceanic island arc system. Paleontological and geochronological data suggest a Middle Miocene unconformity. This event is likely associated with the transition from a west-verging to an east-verging subduction in Luzon, consistent with findings of previous studies in the region. These results offer additional constraints on the geodynamic evolution of northern Luzon throughout the Oligocene-Miocene, contributing to a more refined understanding of the region's tectonic history and its broader implications for the evolution of the Philippine Mobile Belt.

Localized Climate Hazard Management in Shellfish Farming: Strengthening Resilience in Capiz, Philippines

Tan, M.E., Ortega, R., Solis, A.L., & Niño, D., & Robles, M.

Climate-induced hazards and the spread of invasive species pose escalating threats to shellfish farmers in the Philippines. Despite the sector's substantial contribution to national shellfish production, the sustainability of the oyster and mussel is increasingly threatened by adverse meteorological events. Guided by the Hazard Domino Effect model, this study explored the question: What risks do weather systems pose to oyster and mussel fisherfolk and their farming practices in Capiz? Findings reveal that during tropical cyclones, mussel fisherfolk are unable to dive and monitor their plots due to heavy rains and strong winds. Turbulent waters hinder mussel attachment to substrates, while suspended solids stemming from landslides, erosion, and increased turbidity degrade water quality and lead to shellfish emaciation. In the northeast monsoon season, particularly during heavy rains, oysters experience slower growth and altered quality due to flash floods, while debris accumulation from increased turbidity necessitates frequent scrubbing. Moreover, El Niño events further exacerbate challenges by elevating seawater temperatures, increasing the risk of red tide blooms, which endanger both livelihoods and public health. In response, fisherfolk have applied adaptive practices and farming methods for aquaculture to withstand these hazards. This study supports broader initiatives in climate-resilient aquaculture and provides localized approaches to adapting to the impacts of extreme meteorological events on coastal communities. As part of the "Transforming Climate Information and Services for Climate-Resilient Agriculture and Health" (CIS4A&H) initiative, science- and evidence-based informational materials drawn from this study—developed by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and the Bureau of Fisheries and Aquatic Resources (BFAR)—were disseminated to shellfish-oriented organizations, Local Government Units, and the Provincial Fisheries Office in Capiz. This initiative aims to strengthen local preparedness and serve as a model for replication in other climate-vulnerable coastal areas across the Philippines.

Keywords: *Hazard Domino Effect, weather systems, shellfish farming, adaptive practices, informational materials*

Benchmarking the Effect of Background Error Covariance Tuning on a WRF 3D-Var Data Assimilation System over the Philippines using Central Weather Authority's Scale Configuration

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Numerical Weather Prediction (NWP) uses mathematical models of the atmosphere to forecast future weather based on current observational data. A key challenge in NWP lies in accurately estimating the initial conditions, as even small errors at the start can rapidly accumulate and degrade forecast accuracy. To address this, the process of data assimilation (DA) is employed, which adjusts the initial conditions to better match observations while accounting for both observation and model errors.

A crucial component of the data assimilation system is the background error covariance (BEC), which represents model uncertainty and influences how differences between the observations and the model background affects the updates to the control variables. In this experiment, the BEC was computed for the PAGASA-WRF (Weather Research and Forecasting) model domain using one year of operational forecast data. Two distinct sets of control variables were used: CV5 for the large-scale domain and CV7 for the convective-scale domain.

BEC tuning in WRF involves two groups of adjustable parameters for each control variable: variance scale, which controls the intensity of the updates, and length scale, which determines their spatial extent. To evaluate the impact of BEC tuning on the PAGASA-WRF model, benchmark configurations for variance and length scales from the Central Weather Administration were applied through the MECO-TECO VOTE Program, leveraging their relevance due to similar resolution and geographic proximity.

This study highlights the benefits of BEC tuning and international sharing of NWP best practices and its potential to improve NWP forecasts. By working together, both the Philippines and Taiwan can enhance early warning systems. Future work consists of empirical estimation of the most applicable BEC scale configuration on the PAGASA-WRF domain.

Keywords: *WRFDA, Philippines, Background Error Covariance, Numerical Weather Prediction, 3D-Var.*

Modeling Event-Based Severe Wind Risk in the Philippine Housing and Building Sector

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The Philippines is highly vulnerable to tropical cyclones (TC), with an average of 19 to 20 TCs entering its area of responsibility each year. Severe winds, which refer to the peak gusts measured over a 3-second interval during a TC event, pose significant threats to the housing and buildings sector, particularly in the last-mile communities. To enhance resilience and support anticipatory action, a comprehensive severe wind risk assessment framework was developed. The framework integrates three key components: (1) hazard modeling using the Tropical Cyclone Risk Model (TCRM), (2) localized exposure data on building distribution, and (3) vulnerability analysis through fragility curves for various building typologies. The stochastic nature of TCRM is primarily used in modeling the probabilistic hazard maps in RP/AEP, which are statistically based on historically similar synthetic TC tracks. Exposure data was gathered in collaboration with local government units at pilot sites. Fragility curves represent the performance of building materials and construction practices commonly used in the Philippines, categorized into wood, masonry, concrete, and steel building types. Using 3-second gusts as the hazard parameter, the framework applies fragility curves to estimate the likelihood of structures reaching slight, moderate, extensive, or complete damage states. By integrating exposure data, fragility functions, and predefined impact thresholds, municipality-level damage state curves were produced. These curves were then used to define four levels of impact severity—Minimal, Minor, Significant, and Severe—corresponding to the forecasted percentage of structures expected to be damaged in each municipality based on the projected tropical cyclone gusts. Time-Lagged Ensemble (TLE) method was applied on six-hourly issuances to generate worst-case and likely-case three-day impact forecasts. Case simulations for TCs Kristine, Leon, Marce, Nika, Ofel, and Pepito have demonstrated the framework's capacity to produce actionable, localized impact estimates. These estimates support early warning issuance and disaster response planning.

Keywords: *severe wind, building vulnerability, tropical cyclone risk model, impact forecast*

Neogene climatic cooling recorded in geochemical signatures of Lower Miocene to Lower Pliocene clastic sequences in Northwestern Luzon, Philippines

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This study explores the potential of utilizing geochemical proxies used in the South China Sea Basin (SCSB) to decode climatic shifts preserved in the Neogene clastic sediments in northwestern Luzon, Philippines. We focus on two key stratigraphic units overlying the Zambales Ophiolite Complex (ZOC) — the Early Miocene Cabaluan Formation and the Late Miocene to Early Pliocene Santa Cruz Formation — to investigate the prevailing climate operating over northwestern Luzon during the Neogene.

By utilizing traditional weathering indices (Chemical Index of Alteration, Revised Chemical Index of Alteration, Chemical Index of Weathering) alongside various elemental ratios of mobile and immobile trace elements, the data reveal dynamic weathering conditions: from intense chemical weathering under a warmer climate in the Early Miocene, to relatively subdued weathering associated with cooler conditions during the Late Miocene to Early Pliocene. These geochemical fingerprints not only mirror regional climate trends across the northern SCSB but also reflect broader global patterns.

Moreover, the sedimentary archive over the ZOC offers compelling evidence for the possible long-term influence of the East Asian Summer Monsoon (EASM) in shaping the paleoclimatic evolution of northern Luzon since the Early Miocene.

Keywords: *weathering indices, paleoclimate, Neogene, East Asian Summer Monsoon*

Wave Model Performance Using Reanalysis Data During Typhoon Pepito (2024)

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Accurate wave predictions are of great importance for maritime safety, especially during extreme weather events such as tropical cyclones (TC). This study evaluated the accuracy of the WaveWatch III model by comparing global wave reanalysis data derived from satellite and altimeter-observed data against the forecasted significant wave heights (SWH) during Typhoon Pepito (16-17 November 2024) in the Philippine region. The anomalies contain model overestimation of 6-8 meters. To assess model accuracy, metrics such as bias, root mean square error (RMSE), mean absolute error (MAE), correlation coefficient (r), and scatter index (SI) were used in the 0-72 forecast hour (FH) period.

Forcing wind data from the Global Forecast System (GFS) model generates SWHs with bias of 0.16-0.34 meters, RMSEs of 0.58-1.47 meters, and r values of 0.68-0.95. On average, the simulated wave heights exceeded satellite estimates, with a mean bias of 0.25 m. This overestimation agrees with issued gale warnings with waves of 8-14 meters.

Further analysis using the scatter index (SI) exhibits increasing values over time. The short-term forecast (FH 0 to 24) was relatively reliable, with an SI value of just 0.23-0.28. However, the accuracy decreased significantly beyond the 36-hour forecast, reaching an SI of 0.52 at FH 72. Even during the same period, the r value decreased from 0.95 to 0.68. RMSE and MAE followed a similar trend reaching 1.47 and 1.08 meters, respectively, at FH 72. Although bias remained constant at initial FHs, the prediction showed a slight underestimation after FH 60, slightly compensating for initial overestimations.

The findings show that WaveWatch III operates well within short-term forecasts but demonstrates decreased performance beyond 48 hours. Results underline the need of optimizing model configuration. Large waves in the affected tropical cyclone area exemplify the challenges in translating model data into effective marine guidance.

Keywords: *WAVEWATCH III model, wave heights, satellite observations, Global Forecast System*

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Assessment of original and filtered magnetic anomaly maps for Curie point depth and heat flow estimation

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Curie point depth (CPD) is a widely used proxy for estimating subsurface heat flow. However, methodologies vary in utilizing magnetic anomaly data, leading to discrepancies in CPD and heat flow estimations. Some studies rely on unprocessed magnetic anomalies, while others apply filtering techniques such as reduced-to-pole (RTP) and reduced-to-equator (RTE) transformations to enhance magnetic source location. A more recent approach involves the differential reduced-to-pole (dRTP) filter, which uses a simpler algorithm than the standard RTP and variable geomagnetic inclination and declinations. This study generated and analyzed three types of magnetic anomaly maps (the original magnetic anomaly, an RTE-transformed map, and a dRTP-filtered map). Each map was processed to generate a CPD and heat flow map of the Philippines. The different maps will be assessed and evaluated by comparing the resulting model to the known heat flow data points.

Keywords: *Magnetic anomaly, Curie point depth, heat flow*

Intraplate seismicity in the subducting South China Sea slab: Constraints from perfect-elastic flexural modeling

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The South China Sea (SCS) slab is currently subducting along the Manila Trench with an associated outer-rise morphology due to the flexure of the slab. Flexure is a consequence of the elastic nature of the slab responding to the vertical load applied by the overriding Luzon arc. Flexural modeling, utilizing bathymetric and gravimetric data, allows for the estimation of the elastic thickness of the slab, which is synonymous with the seismogenic depth limit. The SCS was formed from the Early Oligocene to the Early or Middle Miocene, corresponding to a seismogenic thickness of 15-23 km according to the plate cooling model. We determined parameters such as regional depth, bulge amplitude, and flexure wavelength. A perfectly elastic rheology yielded elastic thickness estimates that were comparable to those from thermal models. Seismicity is constrained within the elastic thickness, revealing a functional relationship with deformation and rheology.

Keywords: *outer-trench rise, elastic thickness, subduction zone*

Site-specific rainfall threshold for landslide risk: A Gumbel-based extreme value analysis in LIGTAS-AGAD sites.

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Understanding the stochastic nature of extreme rainfall is crucial for landslide hazard risk assessment, particularly in tropical regions with abundant rainfall. Rainfall-induced landslides, often triggered by typhoons and thunderstorms, are one of the major rainfall-related geological hazards. However, quantifying the stochastic behavior of extreme rainfall events remains a challenge. This study investigates extreme rainfall patterns and their implications for landslide risk using PAGASA historical rainfall data from 1991 to 2020 in Baguio and Ambulong synoptic station. Maximum daily rainfall for each year was extracted to create an annual maximum daily rainfall series, which was fitted to a Gumbel extreme value distribution. The model enabled the estimation of return levels and probabilities of exceedance for extreme rainfall events, with the goodness of fit confirmed through quantile-quantile plots and the Kolmogorov-Smirnov test. Random rainfall patterns (RRP) were simulated at a finer scale using the Bounded Random Cascade Model as input for physically-based models of rainfall-induced landslides. Calculations based on Project LIGTAS thresholds revealed exceedance probabilities of 0.83571 for a 92mm threshold in CALABARZON and 0.87088 for a 12mm threshold in Benguet—both corresponding to a 1-year return period. These results provide valuable insights into the temporal behavior of extreme rainfall events that may induce landslides, enhancing disaster risk reduction strategies. Furthermore, the estimated Gumbel parameters and simulated rainfall patterns serve as crucial inputs for physically-based models such as TRIGRS, aiding the development of robust landslide prediction systems.

Keywords: *Rainfall-induced landslide, extreme rainfall, extreme value analysis, random rainfall patterns.*

Geomorphological characteristics and geoheritage value of the coastal sand dunes of Sanchez Mira, Cagayan Province, Northern Philippines

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Coastal sand dunes are common in coastlines where there is an abundant supply of sand-sized sediments. However, these coastal landforms are rare in the Philippines. The most prominent is the Paoay Sand Dunes of Ilocos Norte, a National Geological Monument (NGM) declared by the National Committee on Geological Sciences (NCGS) of the Philippines. A relatively “unknown” coastal sand dunes was observed in Sanchez Mira, a coastal town in western Cagayan approximately 90 kilometers northeast of Paoay, Ilocos Norte. This study aims to characterize the landforms and associated processes and to assess the geoheritage value of the Sanchez Mira Sand Dunes.

The coastline of Sanchez Mira, spanning about 16 kilometers, features a wide sandy beach influenced by fluvio-marine interaction. Sediments are primarily being fed from the Cabicungan River and its distributaries, transporting abundant sediments from its headwaters at the northern Cordillera Mountain Range. During the northeast monsoon (locally known as Amihan) season, Cagayan experiences strong northeast-driven winds. Satellite images show that northeast monsoon driven wave action affects the transport of sediments in Sanchez Mira, as indicated by the NE-SW trending sand dune deposition. River sedimentation was enhanced by the cascading effects of the five consecutive tropical cyclones from October to November 2024, which generally increased the coastal sediment budget in the area. The active landward migration of the sand dunes is attributed to the abundant sediment budget and strong northeast monsoon. The coastal-fluvial plains of Sanchez Mira is also susceptible to coastal flooding, erosion, and storm surge, which pose risks to communities and local infrastructure development. Nonetheless, the scenic value of the coastal sand dunes highlights its potential as a geotourism site. This study will help the local government of Sanchez Mira develop the geoheritage of the coastal dunes, providing vital information that will help increase the geotourism potential of the site.

Ilocos Norte (Philippines) as a potential UNESCO Global Geopark: Assessing the Geoheritage Value, Opportunities, and Challenges

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A single, unified geographical area composed of sites of international geological significance can be declared as UNESCO Global Geopark (UGGp), governed by the holistic concept of protection, education and sustainable development. In 2023, the Bohol Island Geopark was declared the first UGGp in the Philippines. The Philippine Government, through the UNESCO Philippine National Commission (UNACOM), aims to increase the number of UGGp by engaging the Local Government Units (LGUs), National Government Agencies (NGAs), academic institutions, and professional organizations. To date, there are five aspiring UNESCO Global Geoparks in the Philippines, namely a) Mount Apo Geopark, b) Ilocos Norte Geopark, c) Northern Samar Island Geopark, d) Taal Lake Geopark, and e) Hundred Islands Geopark.

The Mines and Geosciences Bureau (MGB), as a member of the National Geopark Committee (NGC) and the National Committee on Geological Sciences (NCGS), provides technical assistance to the LGUs in assessing the geological significance of the proposed geosites. A series of assessments was conducted in Ilocos Norte to evaluate the aesthetic and geoheritage values of potential geosites. Geomorphological surveys and field sampling surveys were carried out at these sites. Among various sites, the MGB has identified the Currimao Uplifted Terraces, Paoay Sand Dunes, Pasuquin Coral Boulders, Kapurpurawan Rock Formation, and Dos Hermanos Melange as proposed geosites. Consultative meetings and focus group discussions with provincial and municipal LGU officials and technical personnel were done to discuss the concept of geoparks, the findings of the assessment, and these potential challenges.

Despite the risks of environmental degradation and human-induced modification, the Philippines boasts a wealth of geologically significant and aesthetically beautiful landscapes and rock formations. The establishment of UNESCO Global Geoparks in these areas, guided by legislation and policy guidelines that preserve the natural landscape and protect the geoheritage value, holds the promise of preserving these natural wonders for future generations.

Keywords: *UNESCO Global Geopark, Geoheritage, Ilocos Norte, Philippines*

Constraining the Recent Eruptive History of Mt. Natib, Philippines: Zircon Fission Track (ZFT) Geochronology and Mineral Chemistry analyses of youngest eruptive products

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Mt. Natib, a potentially active volcano in the Bataan segment of the Luzon arc, exhibits geothermal activity but has no recorded historical eruptions. Given its proximity to the Bataan Nuclear Power Plant (BNPP, located just 5.5 km away) and its potential for large-magnitude (VEI 6-7) eruptions, understanding its recent eruptive history is critical for hazard assessment. We employed zircon fission-track (ZFT) geochronology and mineral chemistry analyses to constrain the age and characteristics of its youngest eruptive deposits. Zircons extracted from a pyroclastic flow deposit on the volcano's eastern flank yielded a ZFT age of 0.03 ± 0.01 Ma. The low spontaneous track count ($N_i = 2$) and prevalence of induced tracks confirm the deposit's young age. Since ZFT closure temperature occurs at $\sim 240 \pm 50^\circ\text{C}$ and pyroclastic materials cool rapidly during eruption, this age robustly dates the eruptive event.

Mineral chemistry analyses of magnesian hornblendes from a porphyritic hornblende-andesite sample from Natib's youngest dome-forming deposits reveal pre-eruptive magma chamber temperatures of $840\text{-}900^\circ\text{C}$, high magmatic water contents (6-8 wt% H_2O), and subvolcanic storage depths of ~ 6 km, indicating volatile-rich conditions conducive to explosive eruptions. The new eruption age aligns with previously reported Late Pleistocene ^{14}C estimates, supporting the classification of Mt. Natib as inactive (i.e., no eruptions in the last 10,000 years) based on current PHIVOLCS criteria. This study not only validates the utility of ZFT dating for young volcanic deposits but also provides critical data for volcanic risk assessment in the Luzon arc.

U-Pb geochronological constraints on the timing of arc magmatism with associated U mineralization in Camarines Norte, Philippines

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Several localities with elevated (2-3x background) radioactivity have been reported in the Camarines Norte mineral district. Localities with verified occurrence of nuclear minerals (e.g., Bessemer, Nakalaya) are spatially related with iron (Fe) skarn mineralization and hosted by the Eocene Tumbaga (Universal) Formation. To constrain the timing of regional intrusive activity with associated iron skarn and uranium mineralization, we report whole-rock geochemical data and zircon U-Pb ages for the Tamisan Diorite and Paracale Granodiorite. The metaluminous Tamisan Diorite consists of plagioclase and amphibole, whereas the mildly peraluminous Paracale Granodiorite consists of plagioclase, biotite, and quartz. MORB-normalized trace element patterns of Camarines Norte intrusives show large ion lithophile element (LILE) enrichment and HFSE (high field strength element) depletion with Yb+Ta and Y+Nb abundances characteristic of volcanic arc granites. Zircon separates extracted from Camarines Norte intrusives are prismatic showing simple zoning with dark-U-rich cores and thin bright rims. Zircons were analyzed using an Agilent 7700x quadrupole inductively-coupled plasma mass spectrometer (ICP-MS) equipped with a NWR213 (Elemental Scientific Lasers) laser ablation (LA) system. The system was calibrated with the primary zircon standard TEMORA-2 and secondary zircon standard OD-3 analyzed as an unknown. Tamisan Diorite samples yield U-Pb weighted mean ages of 14.12 ± 0.21 Ma and 14.48 ± 0.29 Ma. A single zircon grain from a Paracale Granodiorite sample has a corresponding U-Pb age of 23.48 ± 0.29 Ma. Previously reported K-Ar ages of Paracale Granodiorite and Tamisan Diorite are younger, implying that the K-Ar ages are potentially reheating events. When combined with available K-Ar and ^{40}Ar - ^{39}Ar radiometric ages, the U-Pb ages reported here define an early Miocene magmatism and metamorphism peak which coincides with the uraninite EPMA chemical ages.

Keywords: *zircon U-Pb ages, Tamisan Diorite, Paracale Granodiorite*

Exploring the Use of Facebook as a Platform for Disaster Risk Reduction Communications: A Systematic Literature Review

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Social media (SM) platforms continuously push the boundaries of modern communication. They offer innovative communication features absent from traditional media. Disaster risk agencies leverage SMs as an alternative source of disaster-related information. While existing studies explored the use of multiple social media sites for disaster communication (Twitter, YouTube, WhatsApp, etc.), research on Facebook as a primary platform remains limited. Through a systematic literature review, this study aims to identify how organizations and users utilize Facebook to share information related to disasters. Publications (n=11) from prominent academic databases—WebOfScience, Scopus, Dimensions, and Directory of Open Access Journals—were curated for analysis. Initial findings revealed that disaster organizations often present information through multimedia (photos and videos). Status updates and live streams reportedly generate strong engagement among audiences. Users take advantage of Facebook’s “Hashtag” feature and “Safety Check” to report their status during disasters. The platform is perceived to be more reliable during disasters, due to the accessibility of mobile phones. It allows for immediate sharing and retrieval of information compared to traditional media. It is also capable of empowering communities to launch their own mobilization efforts, even in the absence of disaster managers and agencies. Pitfalls of using Facebook as a DRR communication platform were also recognized. Disaster agencies rely on push-tactics to disseminate information. Despite Facebook’s potential for participatory initiatives, agencies rarely adapt systems for consolidating crowdsourced information. The study presents both the potential and the limitations of Facebook for DRR communication, highlighting areas for future research.

Keywords: *Facebook, systematic analysis, social media, disaster communication, crowdsourcing*

Analysis of Critical Post-Rainfall Hours in Rainfall-Induced Landslide Events

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Rainfall-induced landslides are among the most devastating natural hazards, posing significant threats to human life, infrastructure, and ecosystems, particularly in regions with steep terrain and intense rainfall events. This study examined the timing of landslides and slope failures during and after rainfall events in the CALABARZON region, Philippines. The QGIS 3.40 software was employed to determine the various slope types and land cover classifications of each landslide point. Descriptive statistics were also utilized to understand the distribution of post-rainfall durations and identify critical thresholds. Results showed that most of the landslide points are in Slope class 1 (0-8% – level to undulating), Slope class 2 (8%-18% – Undulating to rolling), and Slope class 3 (18%-30% - Rolling to moderately steep slope) types. Descriptive statistics revealed that slope failure duration is more extended in Slope 1 (Mean = 37.88 hours) compared to Slope 2 (19.8 hours) and Slope 3 (18.33 hours). Slope 1 also revealed higher standard deviation and range (SD = 84.16 hours, Range = 367 hours) than the other slopes. For the land cover classification, most of the landslide points are built-up areas that exhibit the longest mean duration (41.17 hours); conversely, open forest shows the shortest mean duration (4.8 hours). Built-up areas also revealed the highest variability, as shown by a standard deviation of 88.77 hours and a range of 353 hours. This preliminary analysis revealed that the timing after rainfall events plays a significant role in landslide occurrences. The findings also suggest that factors such as rainfall intensity, slope condition, and land cover may influence the duration and timing of slope failure. However, due to the limited dataset and scope, the results should be interpreted with caution until further validation is conducted.

Keywords: *rainfall-induced landslide, post-rainfall hours, slope, land cover*

Preliminary Analysis on the LIGTAS-AGAD Philippine Landslide Database using GIS hotspot analysis, source evaluation analysis, and descriptive statistics

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The Philippines experiences numerous typhoons annually due to its geographic and climatic conditions. Its geological and environmental features also contribute to frequent landslides across various regions. Traditionally, landslide reports were generated by national and local government units. Recently, social media has emerged as a valuable tool for enhancing landslide data collection, with online reports now incorporated into the LIGTAS-AGAD database. To evaluate the reliability of these submissions, the CRAAP test—examining currency, relevance, authority, accuracy, and purpose—was applied. Additionally, a GIS hotspot analysis was conducted to identify landslide reports' geographic concentration and density, complemented by descriptive statistical analyses. A total of 2,139 validated landslide reports, spanning from 1970 to 2023, were reviewed in the LIGTAS-AGAD database. Hotspot analyses identified concentrated landslides in the Cordillera Administrative Region (CAR), CALABARZON, and Bicol Region. These areas, characterized by volcanic and mineralized terrains, fall within the study scope of LIGTAS-AGAD. Landslide-related information is also more reported and popularized in these regions. Report sources were categorized into six groups: government agencies, international institutions, LIGTAS, news, citizen science, and unknown. Notably, only 10.80% (n=231) originated from citizen science, with 70.56% (n=163) classified as good, 15.15% (n=35) as excellent, and 13.85% (n=32) as average-quality reports. The CRAAP test preliminary results for all reports in the database yielded an average score of 48.31, indicating that 90.04% (n=1,926) of reports were of excellent quality. While the database showcased excellent-quality landslide reports overall, citizen participation remains relatively low (n=231). This study emphasizes the need to explore strategies for encouraging citizen engagement and adopting innovative methods to enhance the contribution of citizen science in landslide monitoring. Incentivization, social media strategies, and information, education, and communication campaigns will be explored to improve citizen participation.

Keywords: *landslide reports, citizen science, report evaluation analysis, community participation*

Ligtas na komunidad: Enhancing landslide mitigation and public information system with developed LIGTAS landslide crowdsourcing mobile app.

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The Philippines is highly susceptible to extreme tropical events, leading to widespread flooding and landslides. These events can cause significant damage to structures and result in the loss of human life. This study leverages public information to build a landslide crowdsourcing platform that extracts the coordinates of pinned landslide exact location on the map and occurrences of historical landslide events in the Philippines. Most of the landslide reports posted online often lack critical information, such as the specific location of the event and, most importantly, the exact date and time it occurred. Having access to accurate information about landslides is essential for building effective alerts. This information is vital for developing a rainfall-induced landslide early warning system. The project "Landslide Investigations on Geohazards for Timely Advisories in the Philippines (LIGTAS)" introduced a data-driven solution for providing historical information about recorded rainfall-induced shallow landslides. This study uses a mobile application for public information and a crowdsourcing tool to gather reliable data on landslides, incorporating geotagging capabilities through smartphones equipped with Global Positioning System (GPS) feature. The application enables individuals, particularly citizen scientists and local government units, to accurately mark the locations and upload photos of on-the-spot landslide events, along with the date and time of their occurrences. These reports are kept in a cloud-based centralized database linked to the Project LIGTAS portal. Additionally, the app features an interactive map that displays reported landslide locations and provides important information such as triggering factors, as well as the time and date of each occurrence.

The mobile application developed for reporting landslides emphasizes the importance of establishing a national landslide database for citizen science. The outputs generated are consolidated under the National Hazard Database, including the Georisk-Hazard Hunter portal, to enhance comprehensive data integration. This achievement also marks a significant milestone for the project.

Keywords: *Crowdsourcing platform, Mobile Application, rainfall-induced shallow landslides, National Landslide Database, Early Warning Information*

Landslide Susceptibility Studies in the Philippines: A Systematic Review of Methods, Factor Inputs, and Spatial Distribution

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The Philippines is particularly prone to landslides due to its complex geology, moderate to steep terrain, and frequent rainfall, compounded by its location along the typhoon path in the Pacific. This highlights the significance of landslide susceptibility assessments and mapping as critical components of the country's disaster risk reduction efforts. This systematic review analyzes published articles and conference proceedings on landslide susceptibility studies in the Philippines, retrieved in March 2025 from databases including Scopus, Web of Science, SpringerLink, and Google Scholar using the keywords “landslide,” “Philippines,” and “landslide susceptibility”. No year restriction was imposed to include existing relevant research. Records were screened by title, abstract, and full text, removing duplicates across databases, resulting in 15 relevant studies. This review focuses on methods employed, causative factors considered, and the geographical focus of the published studies. Landslide inventories were mainly sourced from field surveys (n=9), satellite imagery (n=7), existing reports (n=5), and aerial photographs (n=3). Findings indicate that statistical and heuristic methods are the most prevalent, particularly logistic regression (n=5), analytic hierarchy process (AHP) (n=3), and frequency ratio (n=3). The most used factor inputs are slope (n=14), lithology (n=11), and aspect (n=10), alongside other variables. For validation, most often relied on comparison with known landslide locations (n=8), receiver operating characteristic (ROC) curve analysis (n=7), success and prediction rate curve analysis (n=4), training and validation data splits (n=4), , and field checks (n=1), with several studies combining multiple methods. Geographically, research efforts show notable concentration in Luzon (n=10), particularly in Benguet (n=7), located in the mountainous region, with central and southern areas having comparatively limited coverage. The review further notes that published studies on landslide susceptibility within the Philippines are limited, suggesting more research is recommended to address these gaps.

Keywords: *landslide, Philippines, landslide susceptibility*

Tree Root Characteristics and Their Role in the Soil Stability of Landslide-Prone Areas

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Tree roots play a crucial role in stabilizing soil and mitigating landslide risks, particularly in steep or erosion-prone terrains. To investigate the relationship between tree root characteristics and soil stability, a study was conducted in landslide-prone areas within the Mt. Makiling Forest Reserve. The research focused on tree species affected by landslides during Severe Tropical Storm Kristine (Trami) in October 2024. Key parameters examined included root cross-sectional area ratio (RAR), root number density (RND), tensile strength, and root distribution. The results of the computed RAR showed that 98% of the roots are distributed within the 0-20 cm depth section. The RND is highest in the 0-20 cm section, while it is lowest at 140 cm depth. In terms of root diameter, more roots measuring 1-3 mm were observed in the 0-100 cm depth, while roots exceeding 3 mm were found in the shallow soil. The findings indicate that soil stability is greatly influenced by root distribution, with the highest root number density (RND) and root area ratio (RAR) concentrated in the 0-20 cm depth, suggesting stronger soil stabilization at shallower depths. As root diameter decreases and fewer larger roots are found deeper in the soil, soil stability may weaken with increasing depth, as evidenced by the lower RND and RAR values below 20 cm. The results highlight the crucial role of root distribution in soil stability, with the highest root density and area ratio found in the 0-20 cm soil depth, indicating stronger stabilization near the surface. As root size and density decrease with depth, soil stability tends to decline, emphasizing the importance of shallow root systems in maintaining soil integrity.

Keywords: *root cross-sectional area ratio (RAR), root number density (RND), soil stability, root distribution, depth influence*

Spatial Correlations Between Land Subsidence and Population Density: A Case Study from Jakarta, Indonesia

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High population density in urban areas intensifies groundwater extraction, leading to increased subsidence rates and accelerated land deformation over time. However, the empirical relationship between population density and subsidence rate are not yet clearly accounted. This study integrates population density as a predictive factor for land subsidence rates across areas with varying population levels. 1275 pairs of LiCSAR product were utilized using LiCSBAS InSAR processor to calculate the land subsidence rate in 10 years time span. Here, Moran's I algorithm were then incorporated to estimate the spatial heterogeneity. An advanced spatial econometric framework, evolving from traditional Geographically Weighted Regression (GWR) to Multiscale Geographically Weighted Regression (MGWR) and Semi-parametric Geographically Weighted Regression (SMGWR) were used to enhance localized modeling accuracy and adaptability to spatial heterogeneity between population density and land subsidence. The evolved-GWR shows progressively enhanced model accuracy and adaptability in study area and it can clearly identify spatial interconnected ground deformation. The model evaluation indicates a progressive improvement in performance from Geographically Weighted Regression (GWR) to Multiscale GWR (MGWR) and Semi-parametric GWR (SMGWR), as demonstrated by the respective R^2 values of 0.960, 0.978, and 0.979. This enhancement is further supported by the corresponding AICc values of 1150, -716, and -615, indicating increased model efficiency and goodness-of-fit. The calculated annual deformation rate within the study area measured, ranges from -72 mm/year to +20 mm/year. The estimated subsidence rate and population density were used to construct a spatial model. Ordinary Least Squares (OLS) regression was then applied to quantify their empirical relationship. The model was successfully tested and validated in Bandung City. In addition, the SM-GWR model result were then also used to estimate groundwater volume decrease using mogi source model. These findings indicate a clear presence of localized subsidence area due to effect of widespread groundwater depletion.

Keywords: *Land subsidence, Population density, S-BAS InSAR. Mogi source*

Intraplate seismicity in the subducting South China Sea slab: Constraints from perfect-elastic flexural modeling

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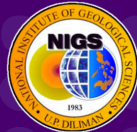
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The South China Sea (SCS) slab is currently subducting along the Manila Trench with an associated outer-rise morphology due to the flexure of the slab. Flexure is a consequence of the elastic nature of the slab responding to the vertical load applied by the overriding Luzon arc. Flexural modeling, utilizing bathymetric and gravimetric data, allows for the estimation of the elastic thickness of the slab, which is synonymous with the seismogenic depth limit. The SCS was formed from the Early Oligocene to the Early or Middle Miocene, corresponding to a seismogenic thickness of 15-23 km according to the plate cooling model. We determined parameters such as regional depth, bulge amplitude, and flexure wavelength. A perfectly elastic rheology yielded elastic thickness estimates that were comparable to those from thermal models. Seismicity is constrained within the elastic thickness, revealing a functional relationship with deformation and rheology.

Keywords: *outer-trench rise, elastic thickness, subduction zone*



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Department of Science and Technology - International Technology Cooperation Unit



National Central University



National Cheng Kung University



National Chung Cheng University



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National Taiwan University



Central Weather Bureau



National Science and Technology Council