UNIVERSITY OF THE PHILIPPINES

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Determination of Z-R Relationship for Radar-based Quantitative Precipitation Estimation (QPE) using In-situ Measurements in Metro Manila

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ABSTRACT

Weather radar is an effective meteorological tool that gathers high spatial and temporal data through the detected backscattered energy called reflectivity factor (Z). Radar-based quantitative precipitation estimation (QPE) is a key feature of weather radars that converts reflectivity (Z) to precipitation rate (R) by means of the Z-R relationship ($Z=aR^b$). The aptitude of radar rainfall conversion using the empirical equation varies in time and space; hence, the determination of geographically best fit Z-R relationship is important. In this study, the operational use of Marshall-Palmer (MP) Z-R equation ($Z=200R^{1.6}$) in Tagaytay radar-based QPE was evaluated by using rain observation data at all-year and seasonal (i.e., JJAS, NDJF, MAM) scale with the application of *wradlib* python module preprocessing techniques (static clutter removal, attenuation correction) and varying grid resolution (i.e., 1x1 km, 3x3 km, 5x5 km, 7x7 km, 9x9 km). This study determined alternative radar reflectivity to rain rate equations from using the same sampling and test method of preprocessed all-year radar dataset, reckoning fifteen (15) total equations. The derived Z-R relationship assessed against Marshall-Palmer radar reflectivity to rain rate conversion skill such that the radar rainfall estimates must equal or be closest to in-situ measurements. The validation result of Marshall-Palmer Z-R relationship rainfall estimates showed below 0.42 correlation using all-year dataset in all data type inputs and grid sizes; while the noise corrected (i.e., Z_cln, Z_pia) data

inputs displayed increase of QPE confidence with the highest correlation equal to 0.88 during MAM period. The seasonality of Marshall-Palmer Z-R relationship rainfall estimation skill was highly influenced by the change of raindrop size and rainfall distribution as a consequence of cloud type (i.e., cumuliform, stratiform) variation as well as the frequency of rainfall events (number of rainy days) in the study area. The larger values of *a* and *b* coefficients in derived Z-R relationships proved the direct proportionality of high reflectivity factor (Z) to bigger diameter (D) size of raindrops ($Z \alpha D$), a characteristic of tropical convective rain in greater Manila area. The verification result of the newly developed Z-R relationship surpassed the ability of MP radar-based rainfall estimates in all test groups with optimum correlation (equation) equivalent to 0.799 ($Z=320R^{2.60}$), 0.986 ($Z=410R^{4.65}$), and 0.986 ($Z=420R^{4.70}$) in 5x5 km grid resolution using raw (Z_raw), clutter-removed (Z_cln), and attenuation-corrected (Z_pia) radar reflectivity data, respectively. Finally, the use of noise corrected radar reflectivity data and the newly derived Z-R relationship in no distinct grid size presented an advancement of radar-based quantitative precipitation estimation compared to the existing equation currently used by PAGASA.