Assessment of WRF-Hydro Performance in Simulating Streamflow during Super Typhoon Carina (2024)-enhanced southwest monsoon event in the Pasig–Marikina River Basin, Philippines

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ABSTRACT

Flooding remains one of the most destructive natural hazards in the Philippines, exacerbated by intense hydrometeorological events and rapid urbanization. The Pasig–Marikina River Basin is particularly vulnerable to flooding because it drains mountainous watersheds into the highly urbanized floodplains of Metro Manila. During extreme rainfall events, such as the Super Typhoon Carina-enhanced southwest monsoon (Habagat) event in July 2024, the basin experienced widespread flooding, highlighting the need for accurate representation of atmospheric forcing and watershed hydrologic response. While conventional hydrologic models are typically forced by observed or prescribed rainfall, the Weather Research and Forecasting Hydrological Modeling System (WRF-Hydro) provides a physically based framework that couples atmospheric simulation with land surface and hydrologic routing processes. However, its performance and parameter sensitivity remain insufficiently evaluated for tropical cyclone–monsoon interactions in the Philippines. Therefore, this study aims to assess the performance of a one-way (offline) WRF–WRF-Hydro modeling system in simulating river discharge during the Super Typhoon Carina-enhanced southwest monsoon event over the Pasig–Marikina River Basin. Meteorological forcing generated by the Weather Research and Forecasting (WRF) Model will drive the Noah Multi-Parameterization Land Surface Model (Noah-MP LSM) within WRF-Hydro, while hydrologic routing will simulate overland flow, subsurface flow, and channel discharge. Automatic calibration using the Dynamically Dimensioned Search (DDS) algorithm will be applied to optimize key hydrologic parameters governing runoff generation and flow routing. Model performance will be evaluated against observed streamflow derived from PAGASA water-level observations using statistical metrics, including the Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Nash–Sutcliffe Efficiency (NSE), Kling–Gupta Efficiency (KGE), Percent Bias (PBIAS). In addition, sensitivity analysis will be conducted to identify the parameters that most strongly influence simulated streamflow. The findings of this study may improve THE understanding of the interactions between atmospheric forcing, land surface processes, and hydrologic routing during extreme rainfall events, while providing guidance for the application and calibration of WRF-Hydro in tropical urban watersheds and also may also contribute to improved flood forecasting and disaster risk reduction in the Philippines.

Keywords: WRF-Hydro, Pasig–Marikina River Basin, Super Typhoon Carina, flood forecasting, parameter sensitivity, hydrologic modeling.