ABSTRACT

Tropical Cyclone Non-decay within the Philippine Archipelago

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Recent studies emphasize tropical cyclones (TCs) that sustain or strengthen after making landfall, challenging conventional decay models. With its archipelagic geography and location in the typhoon belt of the Pacific basin, the Philippines faces a significant threat from direct TC impacts yearly. Evaluating the potential of TC non-decay in the country could enhance accuracy of post-landfall TC intensity forecasts and risk assessment and preparedness. This study presents an analysis of TC non-decay in the Philippines divided into three main parts. First, a spatio-temporal analysis was conducted encompassing the Philippines using TC track, minimum central pressure (MCP), and maximum wind speed (MWS) data derived from the International Best Track Archive for Climate Stewardship (IBTrACS) from 1979 to 2023. A novel TC filter using the IBTrACS distance-2-land and landfall flags for the archipelago was utilized to identify non-decay cases. In the span of the study period, 36 maintenance and 21 intensification events were determined in the country, with a majority being tropical storm strengths (maximum wind speed ≥ 34 kt) lasting for 6 hours. These represent 11% of Luzon crossings and 36% of Visayas crossings during the period. Further analysis of TC intensity tendencies 6 hours post-landfall revealed that Visayas-crossing TCs were initially weaker than Luzon-crossing ones and showed a 53–69% smaller MCP increase and a 59–62% smaller MWS decrease, reflecting a much slower decay rate. Yearly TC crossings showed weak correlation with non-decay events in Luzon (r=0.39) and Visayas (r=0.55). Monthly TC crossings, meanwhile, showed a stronger correlation for

both Luzon (r=0.86) and Visayas (r=0.95). Second, with most non-decay events occurring in the Visayas, an extensive study of environmental factors in the region, such as sea surface temperature (SST), heat fluxes, and vertical wind shear, was conducted using the 5th Generation European Center for Medium-range Weather Forecast Reanalysis data. Average SST in the Visayas region was found to be notably higher 48 hours before landfall. In addition, near-core analyses indicated that minimal deep layer vertical wind shear was crucial for non-decay in the region across different TC intensity classifications and seasonalities. And lastly, the Weather Research and Forecasting model was utilized to model non-decaying TC cases and quantify the inland sea contribution in the Visayas and the land cover contribution in Luzon. In the Visayas, a dynamic asymmetry was observed where substituting inland seas with uninterrupted land decreased MWS by 25–50 kts, whereas exchanging islands for continuous ocean only increased MWS by 15–23 kts. This shows that the inland seas mainly function as a thermodynamic buffer, supplying adequate enthalpy flows to counterbalance the swift frictional loss caused by adjacent islands. These intensity differences, however, were not observed over Luzon with modified land cover indices. Overall, this research demonstrates the presence of non-decay after landfall in the archipelago, questioning standard forecasting assumptions and emphasizing important implications for local disaster risk reduction and tropical cyclone forecasting.

Keywords: tropical cyclones, weather analysis and prediction, tropical meteorology