Influence of Eastern and Central Pacific El Niño Events on Marine Heatwaves and Tropical Cyclone Activity in the Philippines

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ABSTRACT

El Niño events occur in two main forms, the Eastern Pacific type (EP) and the Central Pacific type (CP). These patterns reorganize winds, currents, and ocean heat in different ways, yet their effects on marine heatwaves (MHWs) and on tropical cyclones (TCs) in the Philippines are not yet clearly established. This study will cover 1980 to 2024 and will examine how EP and CP El Niño relate to the occurrence and severity of MHWs, and how those ocean conditions are connected to TC behavior in the Philippines. Event years for EP and CP El Niño will be identified using established classification indices based on sea surface temperature anomalies. EP events will be characterized by anomalous warming concentrated in the Niño-3 region of the eastern Pacific, while CP events will be identified using the El Niño Modoki Index (EMI), which captures sea surface temperature anomalies centered in the central Pacific. MHW events and metrics will be derived from daily sea surface temperature (SST) using the standard definition, in which SST exceeds the 90th percentile for at least five consecutive days. To explain why warm anomalies develop and persist, the study will use a mixed-layer heat budget that separates the contribution of net surface heat exchange with the atmosphere, horizontal transport by surface currents, and entrainment caused by changes in mixed-layer depth, and will assess the large-scale environment relevant to TCs by composite analysis of vertical wind shear, mid-level humidity, low-level vorticity, and upper-level divergence, stratified by El Niño type and MHW occurrence. TC tracks and intensities will be drawn from International Best Track Archive for Climate Stewardship (IBTrACS). The analysis will compare MHW characteristics across EP, CP, and neutral years and test links between MHW conditions and TC characteristics in the Philippines, including where TCs form, how often they occur, intensity at landfall, and rapid intensification. The study is designed to identify the physical mechanisms that connect El Niño types to MHWs and to quantify how those ocean states relate to TC risk in the Philippines. The results are intended to support TC forecasting and risk communication.

Keywords: Eastern Pacific (EP), Central Pacific (CP), marine heatwaves (MHWs), tropical cyclones (TC), mixed-layer heat budget