INFLUENCES OF THE URBAN HEAT ISLAND EFFECT AND BROWN OCEAN EFFECT AND THEIR IMPACTS ON LANDFALLING TROPICAL CYCLONES AN PROVINCIAL ATMOSPHERIC CONDITIONS

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INTRODUCTION

Through the decades, tropical cyclones have shaped our coastal infrastructure and continue to do so. During the 2017 Hurricane Season alone, Hurricanes Harvey, Irma, and Maria have shown us our flaws in urban development and planning, costing billions of dollars in damages and loss of life. Tropical Meteorology has shown that these cyclones intensify over warm, tropical, oceanic waters with low vertical wind shear and a moist atmosphere; however, could a large metropolitan area do the same? Records exist of overland cyclone intensification, such as Tropical Storm Erin (2007). This particular system intensified over the state of Oklahoma, only 65 miles (105 kilometers) northwest of Oklahoma City, reaching winds of 80 miles per hour (mph).

Two phenomena exist that, in theory, could intensify a cyclone once landfall has occurred. These being the Urban Heat Island Effect (UHIE) and the Brown Ocean Effect (BOE). Individually, these phenomena have been studied and are well understood but a scenario where these two forces were affecting atmospheric conditions together has not yet been observed. The methodical analysis and investigation in this inquiry scrutinize the influences of the UHI and BOE along with their impacts on atmospheric conditions.

METHODOLOGY

For this research endeavor, there were multiple methods of study in regards to this theory. One of which is the elaboration of known meteorological processes and impact along with discussions with professors from the University of North Carolina in Asheville and researchers from the United States' Naval Research Laboratory. Additionally, the examination of Tropical Cyclone Reports by the National Oceanic and Atmospheric Administration's National Hurricane Center along with publications sponsored by various universities and the American Metrological Society provided details which greatly facilitated the progression of this project.

In order to study the effects of an urban environment on an overland tropical cyclone, the formation of case studies was needed to focus on one tropical system (TS) individually. The criteria for selecting a TS for the study was fairly simple. The necessary aspects of each system were that it over went intensification overland (characterized by an increase in wind speed and a decrease of central pressure), that the location of the TS was within 75 miles (121 kilometers) of a major metropolitan area (characterized by containing a population more than 500 thousand residents), and was substantially far enough from an ocean so as not to be directly influenced in intensification. With the use of satellite, it was possible to determine the area and magnitude of an urban heat island remotely and accurately.

Once TS case studies were developed, the exact location(s) of overland intensification were isolated and historical meteorological data was gathered from the selected area with the main focus on surface temperature, humidity, and wind speed. When these three values were found, they were used to calculate the surface and latent heat fluxes of the urban centers with the use of the Bulk Aerodynamic Formulae. The fluxes were then compared to the average oceanic latent heat flux which was found to be approximately 200 watts.

Additionally, counties of various Gulf Coast states' (Florida, Louisiana, and Texas) were compared in terms of average countywide temperature, and dew point to calculate the K-Index or the local thunderstorm potential. By finding the K-Index, atmospheric instability can be estimated. With minimal instability, convection would not be able to form and intensify, however with high instability, thunderstorm formation is widespread and development is facilitated which can allow convective systems to become severe (wind gusts greater than 58 miles per hour and/or one-inch diameter hail). Such convection is the main mechanism of tropical cyclone intensity maintenance and intensification; therefore, it is practical to assume that the higher the atmospheric instability, the easier it is for a cyclone to intensify even if another factor is not conducive. The method which the counties were compared was with the selection of two counties per state, one urban (characterized by containing a metropolitan area with a population of at least 200

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thousand residents) county, and one rural (characterized by a population less than 200 thousand residence) county. Although comparing these counties does not directly prove that an urban center can allow for overland cyclone intensification, it does show how urbanization effects local atmospheric conditions.

CONCLUSIONS

It is important to note that during the time of this publication, research and experimentation was still being performed; therefore, conclusions are broad but definitive.

This theory relies on these two phenomena (UHIE and BOE) being present and influencing tropical systems simultaneously during the land-falling process. The concept is that since tropical systems require tropical oceanic waters, usually greater than 79 degrees Fahrenheit to develop and intensify, a large metropolitan area where the center of circulation would pass over, undergoing a BOE event would allow conditions to exist for brief intensification or intensity maintenance. This would be because the BOE would provide ample soil moisture and humidity, while the UHI would increase temperatures leading to a dramatic increase in evaporation and condensation further increasing temperatures and humidity in the surrounding area. This process would also be affected by existing atmospheric conditions and cyclone structure. Additionally, these factors may cause thunderstorm development by creating and exaggerating atmospheric lift and instability.

As a result of these factors, it is practical to hypothesize that the UHIE and BOE are able to affect weather conditions and tropical cyclones in a significant way. Since the UHIE may provide increased heating and evaporation rates and the BOE may simulate a tropical atmosphere, this idea must be further researched and experimented on to explore all possibilities that may put citizens' lives and property at risk and make urban life uncomfortable.

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