The Ecological Effects of Hurricane Harvey and the Black Forest Fire on West Nile Virus

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Abstract

Extreme weather events are becoming increasingly frequent and destructive as a result of large-scale climate change, leading to changing environments for organisms ranging from the microbial level to the macroscopic level. The purpose of this research is to identify and analyze the ecological effects that extreme weather events, specifically hurricanes and droughts, have regarding the spread of West Nile Virus. In addition, by utilizing this study's data, we will form a data-driven hypothesis of the long-term effects of more frequent weather events on similar regions over time. Using GLOBE's Advanced Data Access Tool, disease reports created by the Texas Department of State Health Services and the Colorado Department of Public Health and Environment, NOAA Climate Monitoring Tool, and NASA's Land Assimilation Data Tool, we will conduct two case studies using Hurricane Harvey in Texas (2017) and the Black Forest Fire in Colorado (2012). For the former, we will focus on Harris County, Texas, and for the latter, we will focus on El Paso County, Colorado. For each individual case study, we will conduct a comparative analysis of the region utilizing data five years prior to and post each event as well as data gathered during the event period. The data collected will be analyzed through time series models and standardized anomaly indexes to determine the effects of the events on the soil moisture, precipitation, average temperature, air temperature, and West Nile Virus risk in the corresponding regions. From our research, we expect our findings to display the relative effects of each extreme weather event on the spread of the West Nile Virus with an overall increase in risk due to the creation of more habitable environments for mosquitoes in each respective climate.

Research Questions

1. **How do the meteorological effects of hurricanes and droughts affect West Nile Virus?**
2. **How did Hurricane Harvey affect the spread of the West Nile Virus in Harris County, Texas?**
3. **How did the Black Forest Fire affect the spread of the West Nile Virus in El Paso County, Colorado?**

Introduction

As climate change is increasing at alarming rates, the direct links between a rapidly changing climate, more frequent extreme weather events, and West Nile Virus risk is not often made. One of the most vividly seen effects of climate change is seen through a series of disastrous weather events experienced in diverse areas around the United States. According to the World Meteorological Organization, in the last 50 years the quantity of natural disasters has quintupled as a result of climate change (WMO,2021). Additionally, the number of hurricanes is predicted to intensify throughout this century, urging researchers to analyze the direct effects of such events on human health (Juarez, 2008). Vector-borne diseases pose devastating consequences to different diasporas in human life, including declined health, death, and even economic downfall; a consensus conducted by the World Meteorological Organization reflected that related health care related to mosquito disease is estimated to be over 56 million dollars per year in the U.S. alone (WMO, 2021). In the United States, West Nile Virus is considered to be the dominant cause of mosquito-borne disease; its effects on humans ranges from very mild to fatal (CDC, 2019). As extreme weather events become more frequent, the risks of vector-borne diseases increase exponentially. For example, one study discovered that extreme flooding has been found to have a positive impact on malaria transmission in Uganda, leading to a 30% increase (Fouque, 2019). Similarly, a study on the increasing frequency of droughts as a result of climate change determined that over the next 30 years, increased droughts could significantly increase West Nile Virus cases by up to 30% depending on human immunity (Paull, 2017). Similar to the studies cited above, the research conducted within this paper analyzes the link between extreme weather and vector-borne diseases. In this report, we focus on the distinct effects two specific extreme weather events have on the risk and transmission of West Nile virus: hurricanes and droughts. This is essential to understanding the risk that humans living in similar regions face and how the effects of climate change will further increase these risks. The data analyzed in this report can give us insight into starting the process of creating solutions to a diaspora of different problems. Within this study, an array of meteorological variables bridge together to create an understanding that can assist in comprehending the effects of extreme weather events on human health.

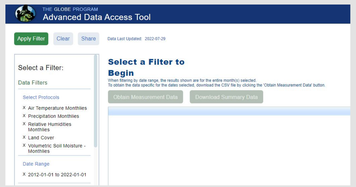
Methodology

GLOBE Data Utilization

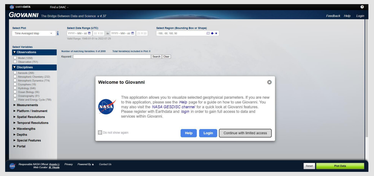
- The data spanned from five years before and after each event in order to evaluate the environmental context and the long-term effects.
- Therefore, for each variable we collected a minimum of 120 data points.
- The first source we utilized was the GLOBE Advanced Data Access Tool (ADAT) where we selected the four protocols that matched our chosen variables.
- In order to gather information for specific counties, we input coordinates for each respective region and a radius that depended on the size of the county.

It was important to our analysis that the data had equal temporal resolutions so we had to incorporate data from other sources besides GLOBE. Listed below are the methods used for all **NON-GLOBE** data collection & analysis

- Using the Giovanni database, we searched for air temperature data by using the coordinates of the GLOBE sites in Colorado and Texas.
- In order to acquire consistent average temperature and precipitation data, we used NOAA's Climate Monitoring Tool to gather monthly average temperature and precipitation data in each county. .
- Our data analysis process revolved around creating time series models, analyzing each variable's change over time, and tracking anomalies. In order to account for seasonality and randomness, we removed the extrinsic trends from the data by calculating the difference between every two variables.
- From this point, we can align the time series models, as long as they are plotted on the same time scale, and analyze the changes in variables before and after each event.
- Additionally, to track the anomalies in the data, such as average precipitation over time, we calculated the standard deviation of the precipitation values, then calculated the difference between the average precipitation amount for the entire data collection period, and lastly, divided that difference by the meteorological standard deviation.
- This allowed us to create a standardized anomaly index model. This data analysis displays the significant changes in West Nile incidents and meteorological variables after the occurrence of Hurricane Harvey and the Black Forest Fire as well as the flooding and droughts that caused or resulted from these events.

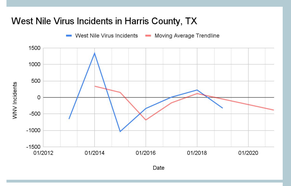


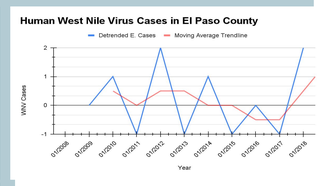
NASA Globe Advanced Data Access Tool (ADAT)

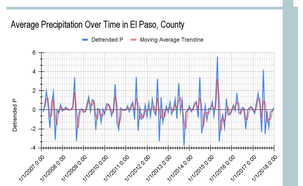


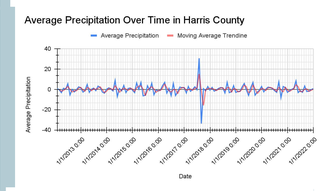
NASA Giovanni EarthData

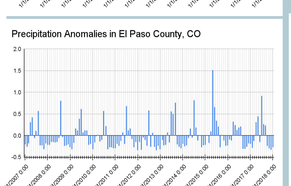
Results

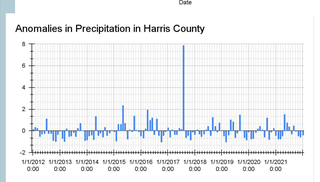


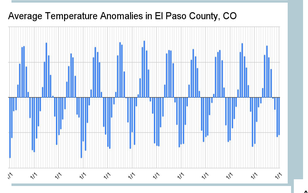


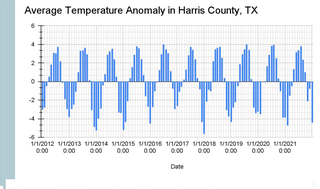


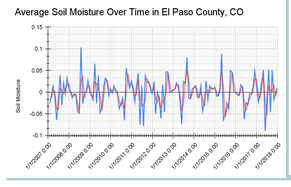


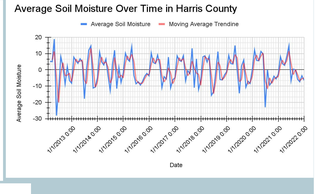


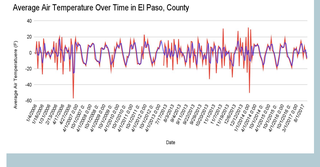












After analyzing the data through time series models and utilizing a standardized anomaly index on certain variables, we can determine that Hurricane Harvey did affect West Nile virus incidents in Harris County, Texas. Additionally, we can conclude that the drought that contributed to the Black Forest fire affected West Nile virus human cases in El Paso County, Colorado. In contrast, the Black Forest fire itself did not have a distinct effect on West Nile in El Paso County; this result was affected by a discrepancy in West Nile virus data as Colorado does not provide information on non-human West Nile incidents

Discussion

These results reveal the significance of region and climate on a location's reaction to extreme events. For instance, we discovered a positive correlation between precipitation/soil moisture and West Nile Virus incidents in Harris County, but in El Paso County we discovered a negative correlation between precipitation/soil moisture and West Nile Virus incidents. This is likely due to the flooding after a hurricane which leads to more pools of water and the stagnant nature of water in a drought which also results in pools of water. Due to this analysis, we determined that regions familiar with arid conditions and droughts would experience increases in West Nile Virus risk as temperatures intensify and precipitation decreases. Additionally, gulf-coast regions that are familiar with tropical storms, hurricanes, and flooding would experience an overall increase in West Nile Virus risk as the frequency of extreme weather events increases. Our findings are rather consistent with peer-reviewed journals although the inaccessibility to certain data and our limited scope affected some aspects. For instance, in a peer-reviewed journal titled "Impact of Past and Ongoing Changes on Climate and Weather on Vector-borne Diseases Transmission: a Look at the Evidence", the temperature is attributed to significant changes in mosquito habitats and is considered to be a major factor in the spread of vector-borne diseases. Although Texas's Hurricane Harvey did not immediately increase the West Nile virus (WNV) infection rate that is to be expected as the hurricane itself likely disrupted mosquito habitats, the result of the hurricane was more mosquito habitats were created from the abnormal precipitation. These new habitats increased the propagation of WNV amongst the mosquitos. The West Nile Virus incident data in El Paso County was difficult to analyze due to its inconsistency as well as the unavailability of data concerning all vectors and mammals affected by West Nile Virus. Without this complete dataset, it is difficult to predict the effects of droughts and wildfires on the risk of West Nile Virus. Some sources of error include other variables affecting our data such as mosquito population and disease control, population density in areas affected by extreme weather, and the effects of immunity to West Nile Virus.

Conclusion

At the start of this study, we sought answers to questions regarding the meteorological effects of extreme events, specifically droughts and hurricanes, on the risk of West Nile Virus. By conducting an analysis of four variables affected by such events (soil moisture, average temperature, air temperature, and precipitation), we determined that these events do directly affect the risk of West Nile Virus by creating more habitable environments for mosquitoes. Droughts and wildfires contribute to arid environments accompanied by stagnant water due to a lack of precipitation, both of these factors create environments that are more likely to attract mosquitoes. Hurricanes and floods contribute to damp and humid environments accompanied by pools of water thus also contributing to mosquito-friendly environments. As climate change leads to an increase in hot temperatures and extreme weather events, the increasing frequency of droughts and hurricanes will significantly affect the risk of West Nile virus in coastal and dried areas around the country.

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