Analysis Of New York City's Summer Heat Wave Using Weather Station Observational Data And Weather Prediction Models

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Abstract

The purpose of the project is to determine how well City College of New York's (CCNY) weather model accurately forecasts the weather and under what wind conditions does the model falter. Throughout this project, New York City's summer heat wave was analyzed to compare the temperature differences from the WRF model data to the observed values of New York City's summer heat wave temperatures. Two locations were specifically picked; Central Park and John F. Kennedy (JFK) Airport. Using Python, Weather Research and Forecasting (WRF) data was plotted onto charts that displayed the predicted temperatures over the course of 12 days, June 29th, 2018 to July 10th, 2018. Throughout the 12 days, it was observed that there was a heat wave event in Central Park for four days while JFK had no event. These days were extracted from the observed data and then compared to the corresponding predicted WRF data to understand how accurate the CCNY's weather model was during the summer heatwave between June 29, 2018 to July 10, 2018.

Introduction

Urban weather with the construction of new infrastructure differentiates from the rural weather. On average, the temperature in urban cities can be hotter by 1-3 °C than the surrounding rural areas. Not only do urban areas experience an increase in temperature but tend to have an increase in precipitation. The temperature difference is usually larger at night than during the day and is even more apparent when wind activities are weak. The cause of which has mainly due the to Urban Heat Island effect.

Heat waves are a product of air trapped above an area. The trapped air does not circulate and allows time for the air to heat up. Heat waves have been found occurring more frequently in the past years. Heat waves can impact the populations, agriculture, livestock, and wildlife. A heat wave is defined as three or more consecutive days in which the maximum temperature reached 32.22°C or higher (90°C). If the consecutive days are broken, those days are considered an event.

A commonly used Numerical Weather Prediction (NWP) system known as Weather Research and Forecasting (WRF) model are designed to serve as an atmospheric research guide as well as for operational forecasting needs. This system allows for parallel computation and system extensibility, aiding researchers to access a wide range of meteorological applications across scales ranging from meters to thousands of kilometers. Radars, weather stations, and satellites can depict the weather of a given area at any given time within a limit. Observations such as pressure, wind speed, and temperature obtained from ground sensors and weather satellite information are all used to predict the forecast using numerical equations and brought into models known as data assimilation.

Methodology

- Weather measurements from June 29, 2018 to July 10, 2018, were extracted from weather stations located in New York at Central Park and John F. Kennedy Airport. Data was obtained for air temperature and wind observations from the National Climatic Data Center (NCDC).
- Using Python, temperature, wind speeds and wind direction were plotted for observed data and predicted measurements from the WRF model for each day for the event. Wind rose plots were created to display the data of the wind observations for the selected days.
- For the WRF model data, temperature was mapped on a shape file of New York City. The plots and maps were able to determine the effectiveness of the CCNY Weather Prediction model and under which circumstances the model would fall behind.

Heatwave Timelines and Wind Roses

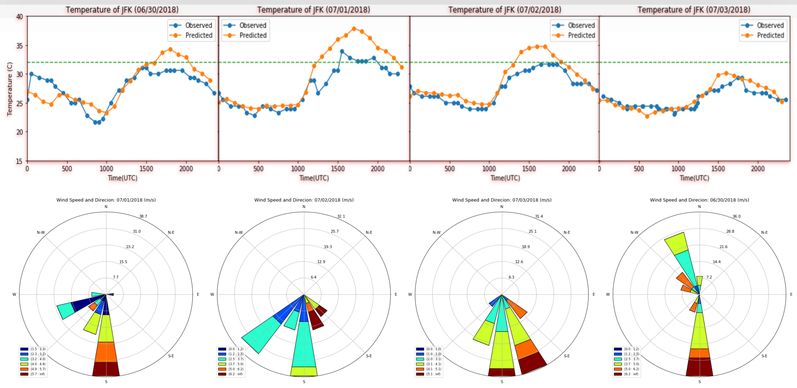

Figure 1a: The figure above displays the change of temperature over the course of four days at John F. Kennedy Airport and the corresponding wind roses for the wind speed and direction.

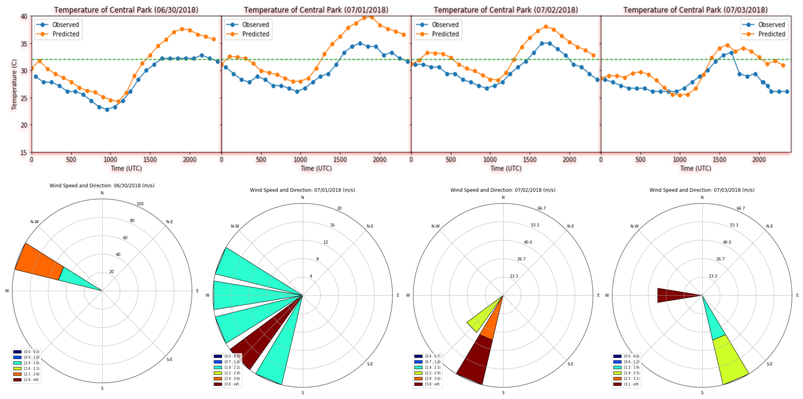

Figure 1b: The figure above displays the change of temperature over the course of four days at Central Park and the corresponding wind roses for the wind speed and direction.

WRF Data

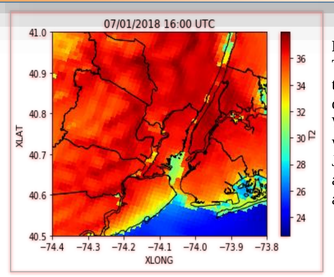

Figure 3a: The map on the left displays the WRF heat wave data on July 1st, 2018 at JFK airport.

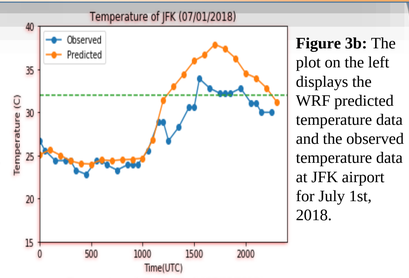

Figure 3b: The plot on the left displays the WRF predicted temperature data and the observed temperature data at JFK airport for July 1st, 2018.

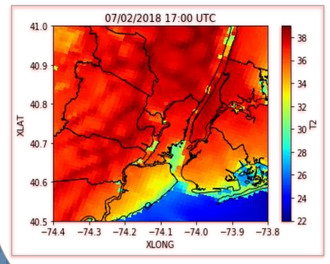

Figure 4a: The map on the left displays the WRF heat wave data on July 2nd, 2018 at Central Park.

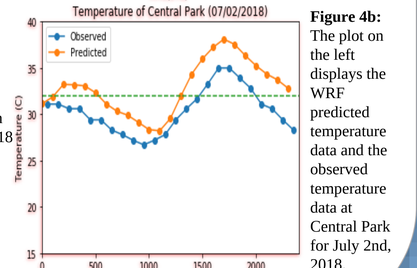

Figure 4b: The plot on the left displays the WRF predicted temperature data and the observed temperature data at Central Park for July 2nd, 2018.

10 Year Wind Roses

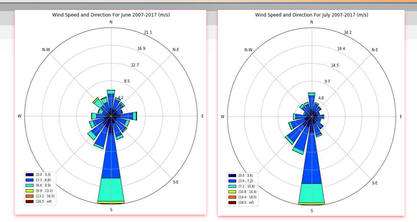

Figure 5: The two figures on the right display the wind speed in meters per second and the direction of the wind for JFK. It also exhibits the quantities of winds to the corresponding direction. The wind data is from 2007 to 2017 for the month of June and July.

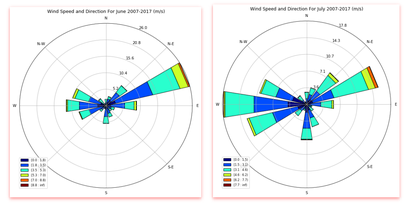

Figure 6: The two figures on the right display the wind speed in meters per second and the direction of the wind for Central Park. It also exhibits the quantities of winds to the corresponding direction. The wind data is from 2007 to 2017 for the month of June and July.

Conclusion

In this project, New York City's summer heat wave was analyzed using weather station observational data and weather prediction models. The main objective was to determine how accurate City College of New York's weather model forecasts the weather. Wind conditions affected the model as it generated less accurate predictions.

In order to identify the preciseness of the WRF data to the measured data, weather measurements from June 29th, 2018 to July 10th, 2018 were recorded from weather stations located in New York City. The weather stations from Central Park and John F. Kennedy Airport (JFK) gave the observed air temperature and wind observations from the National Climatic Data Center (NCDC) . Using the software Python, the correlating functions were used to plot the temperatures for the 12 days and in that way, the heat wave events were identified. A heat wave event can be identified if the temperatures are above 90 degrees Fahrenheit or 32 degrees Celsius and continues on for at least three days. Using this information, in the 12 days, Central Park had a heat wave occurring from June 30th, 2018 to July 3rd, 2018. However, throughout these 12 days, JFK had no occurrence of heatwaves. The hottest day of Central Park was on July 2nd, 2018 where the peak temperature was about 95 degrees Fahrenheit while the hottest day located at JFK was on July 1st, 2018 where the highest temperature was 93.2 degrees Fahrenheit or 34 degrees Celsius. As observed, according to Figure 1a and 1b, CCNY's weather model had exceeded the observed temperature between June 30th to July 3rd. There wasn't any correlation between CCNY's weather model's accuracy and wind patterns.

Acknowledgements

"NOAA-CREST program is funded by NOAA/EPP Grant # NA16SEC4810008" and *"NOAA CREST HIRES program is a part of the Science Research Mentoring Program and funded by the Pinkerton Foundation".* We would like to thank David-Melecio and Hannah Aizenman for helping us through our research.