Examining a Heat Wave Event in New York City Using Weather Station and GOES-16 Satellite Data: July 2019 Case Study

Ishrat Jabin[1], Equisha Glenn[2], Dr. Jorge E. González Cruz[3]

[1]NOAA EPP Summer Bridge Program Scholar, The City College of New York, NY 10031 (ijabin000@citymail.cuny.edu)
[2]NOAA EPP Earth System Sciences and Remote Sensing Scholar, The City College of New York, NY 10031 (eglenn00@citymail.cuny.edu)
[3]NOAA Center for Earth System Sciences and Remote Sensing Technologies and Department of Mechanical Engineering, City College of New York, The City College of New York, NY 10031 (jgonzalezcruz@ccny.cuny.edu)

Introduction

Heat waves are extreme weather events, defined for the New York City (NYC) region as a period of 3 consecutive days where temperatures reach or exceed 90 degrees Fahrenheit (NWS, n.d.). Heat advisory warnings may deviate based on conditions in which the population is acclimated to as well as local weather events.

Heat waves may also be identified in humid regions by reaching the heat index (HI) thresholds defined by the National Weather Service (NWS). The NWS criteria maintains that two nighttime lows must exceed a heat index of 81 °F and two daytime highs must exceed 103 °F, consecutively (Robinson, 2001).

A satellite based heat index for cities will be developed using GOES-R downscaled data. The development of this product requires an analysis of the heat index from surface weather stations and how land surface temperature (LST) changes in response.

The July (19-21), 2019 heat wave was examined for New York City using weather station data from the National Climatic Data Center (NCDC) at the National Ocean and Atmospheric Administration (NOAA), and with data from the operational geostationary weather satellite GOES-16. The Coastal Urban Environmental Research Group of City College of New York also provides a 72 hour forecast for NYC at 1 km spatial resolution using the Weather Research and Forecasting (WRF) model coupled with a multi-layer urban canopy and building energy model (CCNY, 2019).

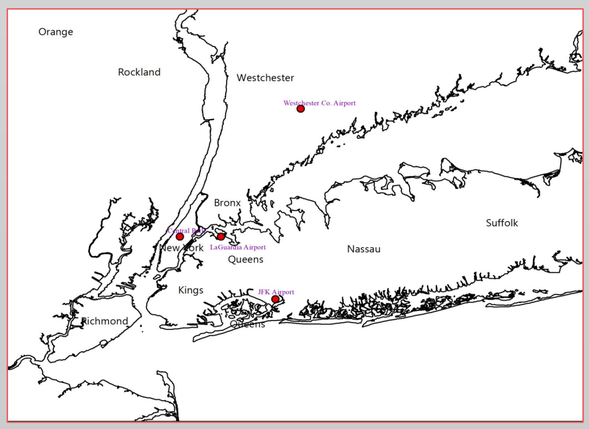
Motivation of Study

- Heat index is a combination of air temperature and relative humidity that measures how hot it feels to the human body. In humid weather, the rate of evaporation decreases. Consequently, humans have a more difficult time cooling down after sweating.
- Defining heat wave events is done by considering the thresholds to which local communities are acclimated. Heat wave advisories and warnings are necessary to take precaution against extreme temperatures.
- New York City is also impacted by the Urban Heat Island effect. Urban areas trap and retain more heat as a result of the type of building material, human activities, and the size and shapes of cities. Rural areas tend to cool off faster at night.

Methods

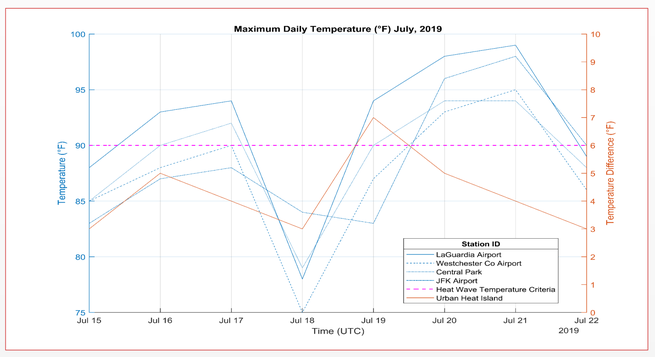
1. Weather station data (July 15 to July 22, 2019) were collected from NCDC for 3 stations in urban areas: JFK Airport, LaGuardia Airport, and Central Park. Westchester County Airport was selected as a rural reference station. Land Surface Temperature (LST), from GOES-16 satellite, was downloaded in netCDF format for July 19 to July 22, 2019. The 72 hour forecast for July 19 to July 21 was collected from CUERG.
2. The maximum observed daily temperatures were plotted to identify the heat wave event. The heat index was computed by scripting Lans P. Rothfusz's regression into MATLAB.
3. LST was plotted in MATLAB for 3 different times of the day for each day of the heat wave. The average LST over the domain of NYC was then plotted as a time series graph.
4. Euclidean distance was calculated to find grid point of WRF output that is nearest to the stations of interest. WRF relative humidity and heat index were calculated for each grid point and plotted in comparison to observation data.

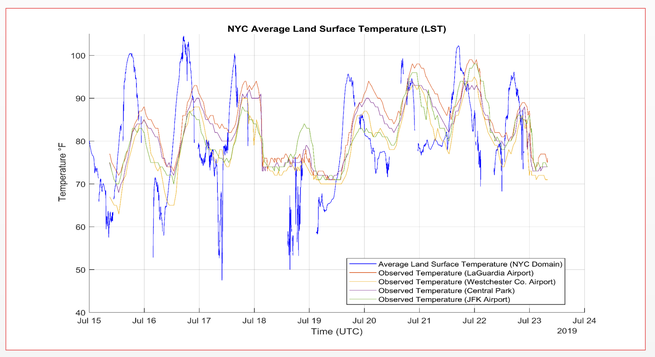
Results

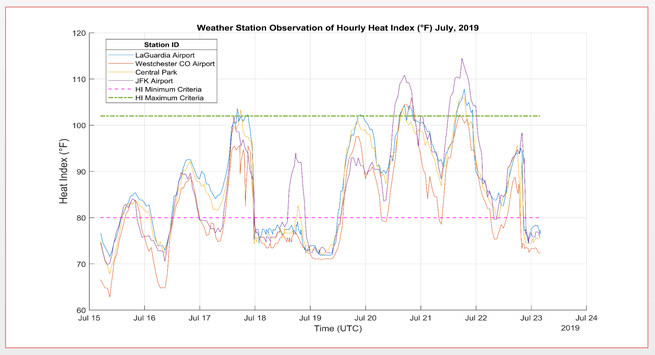


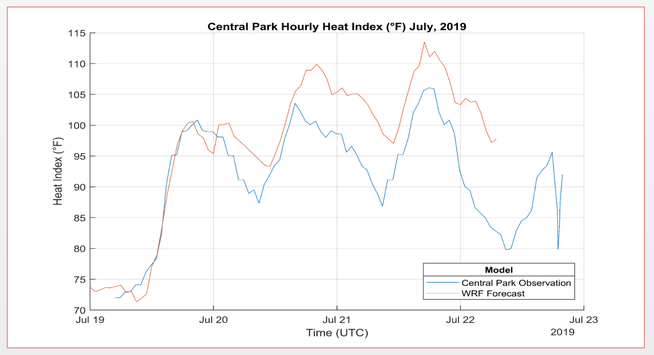
Station ID	Maximum Temperature (°F)	Maximum HI (°F)	Relative Intensity (°F)	Average Temperature (°F)	Average HI (°F)
LaGuardia Airport	99	107.8	9	82.4	85.5
Westchester Co. Airport	95	105.9	5	78.5	81.6
Central Park	94	106	4	80.2	83.6
JFK Airport	98	114.5	8	80.5	85.9

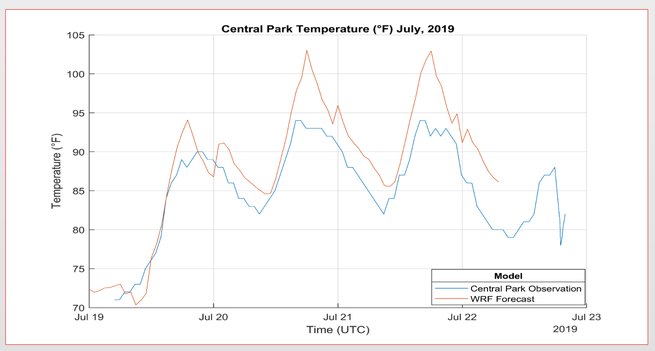
Results Continued

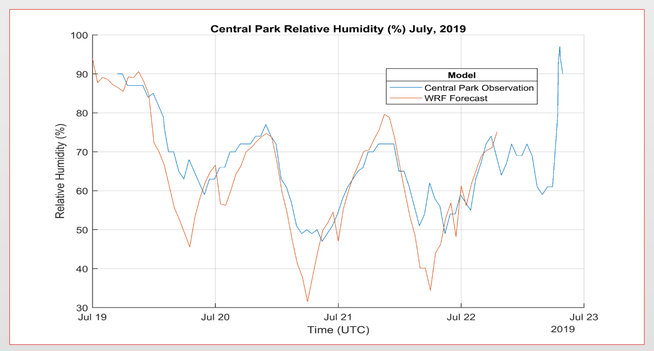


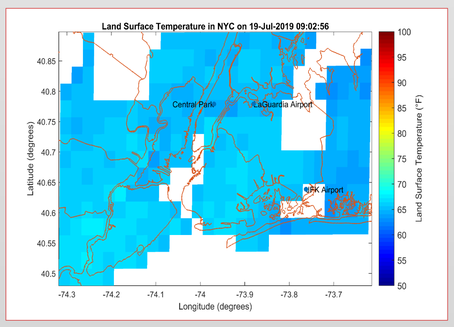


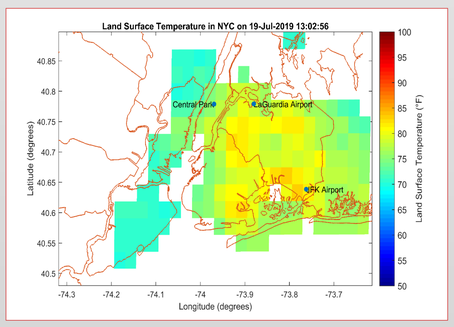


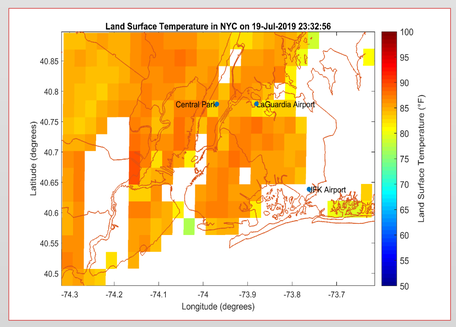












Discussion

- Observations show that New York City experienced a heat wave of 3 days at all urban weather stations.
- The maximum heat index of 114.5 °F was observed at JFK Airport. At this temperature, sunstroke and heat exhaustion is likely. Prolonged exposure can result in possible heat stroke.
- The rural reference station, Westchester Co. Airport, did not meet the NWS criteria of a heat wave because it did not meet the temperature or heat index thresholds and maintained lower average temperatures overall in comparison to its urban counterparts.
- The UHI is represented as the difference of maximum temperatures between LaGuardia Airport and Westchester Co. Airport. The UHI maintains at least a 3 degree value throughout the week.
- The LST displayed by the pcolor maps show increasing surface temperatures as nighttime approaches, rather than a cooling effect. This is also represented in the time series plot that shows LST averages over NYC. The peaks of LST appear to occur just before the maximum daily temperatures. A similar trend is displayed by the minimum LST values just before the daily observed minimum temperatures.
- The CUERG model produces forecast values of heat index for the region of New York City and Long Island Sound. The CUERG forecast displays an overestimation of temperature and underestimation of relative humidity. As a result, the peaks of the heat index are also over estimated. However, the observations and WRF outputs display similar trends.
- This forecast may be used to assist vulnerable communities at risk of extreme weather events.

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