Improving Mesoscale Model Forecasts for Daily Weather Analysis in New York City

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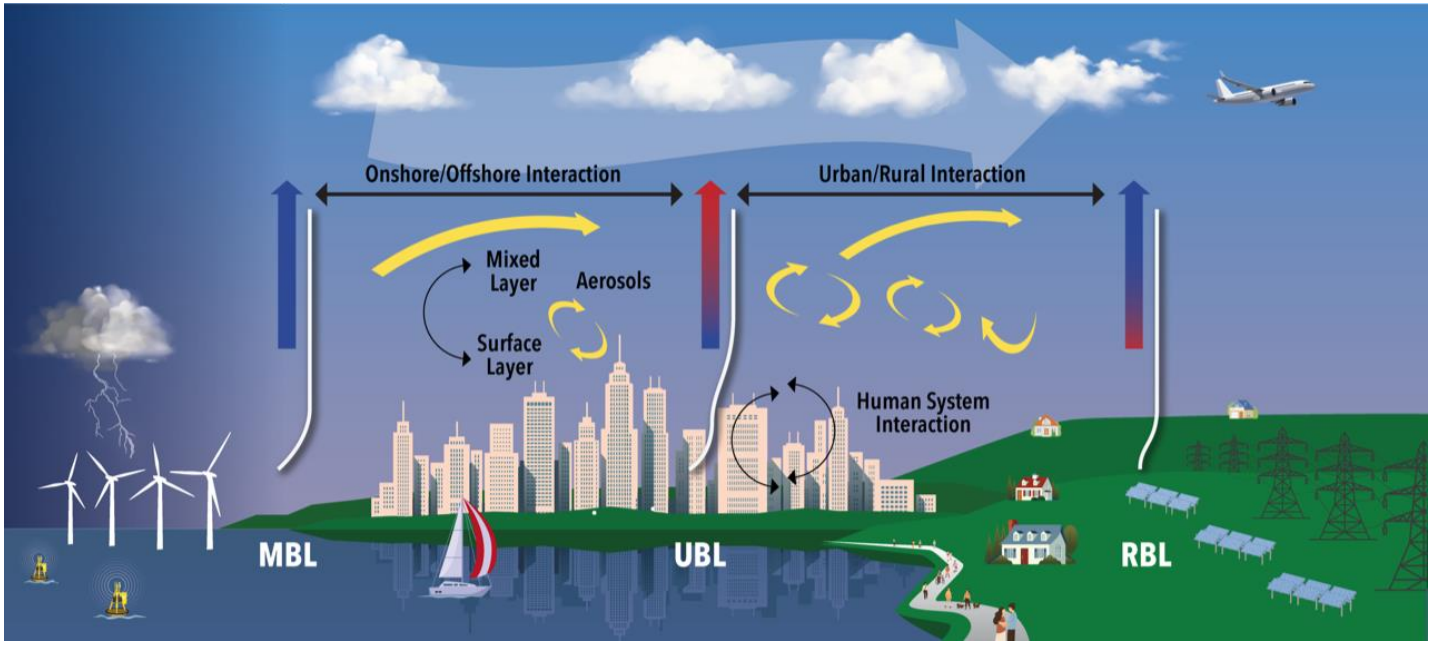
November 13-15, 2024

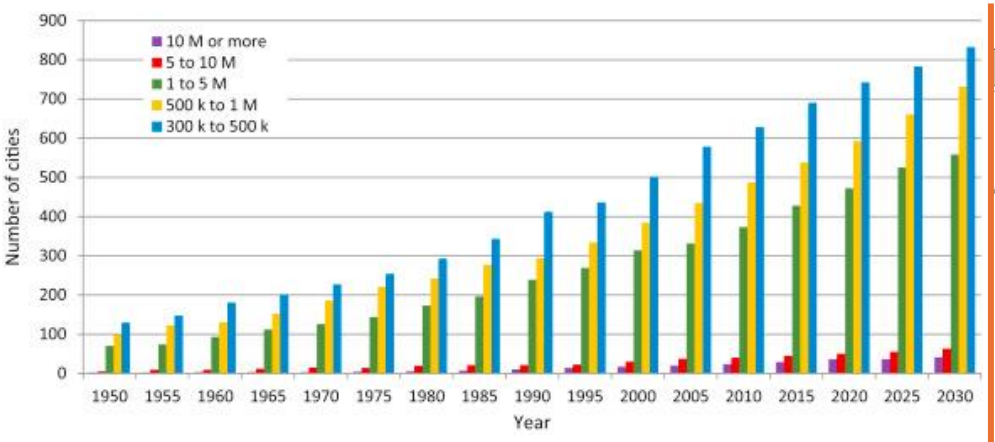
Session K: NYS Mesonet Applications II

Outline

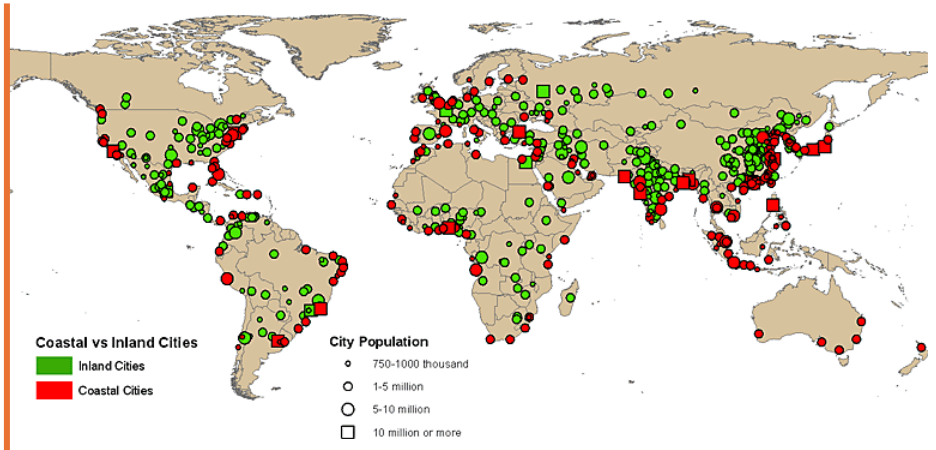
- Coastal-Urban Environment
- Urban Weather Research Forecasting (uWRF) Model
- Extreme Event Validation
  - Heat Wave
  - Precipitation
- Long-range Weather Validation
- NYC Website

Coastal-Urban Environments





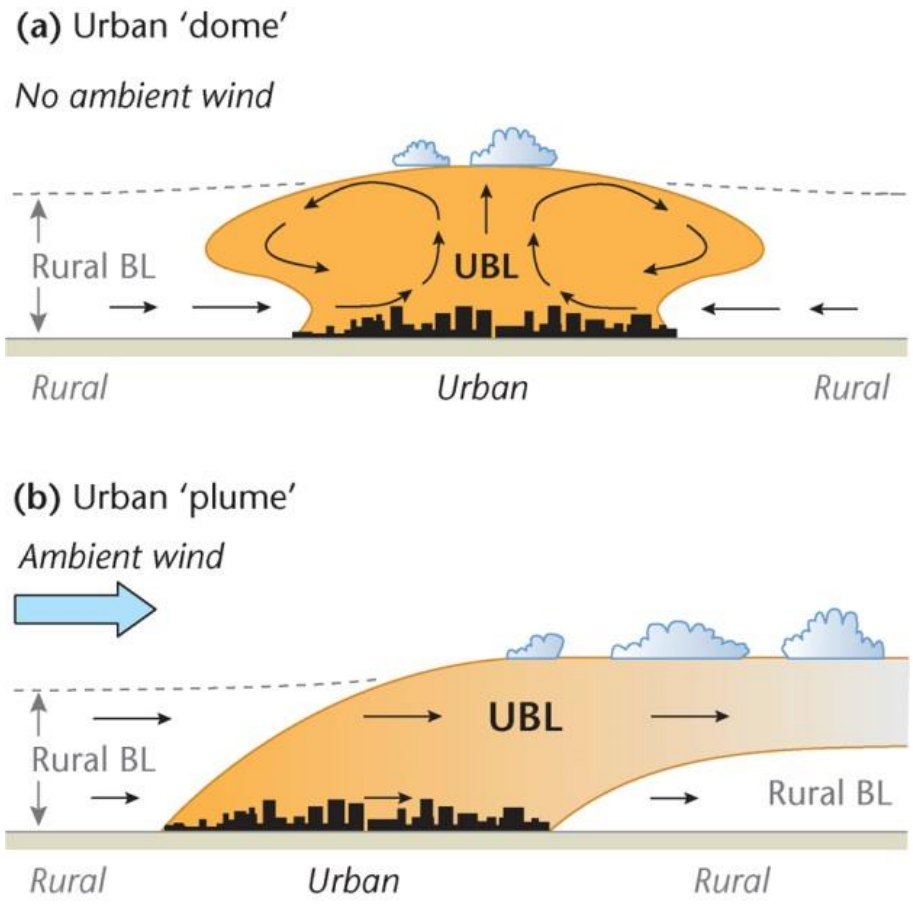
The growth rate in number of cities with various populations during 1950–2030



Urban agglomerations by size class and inland or coastal location (UN Economics & Social Affairs)

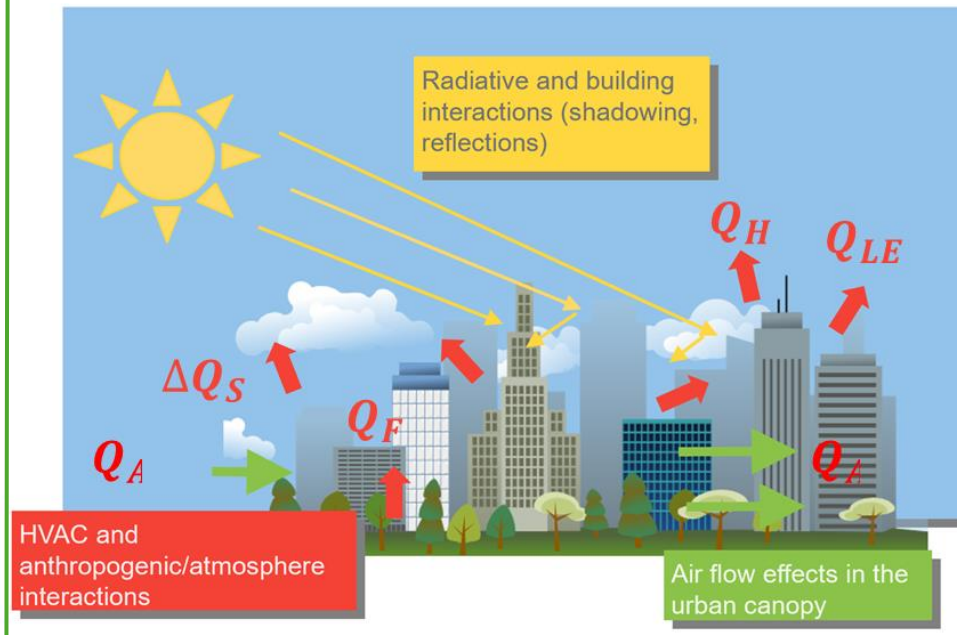
Scientific Grand Challenges on Urban Environment

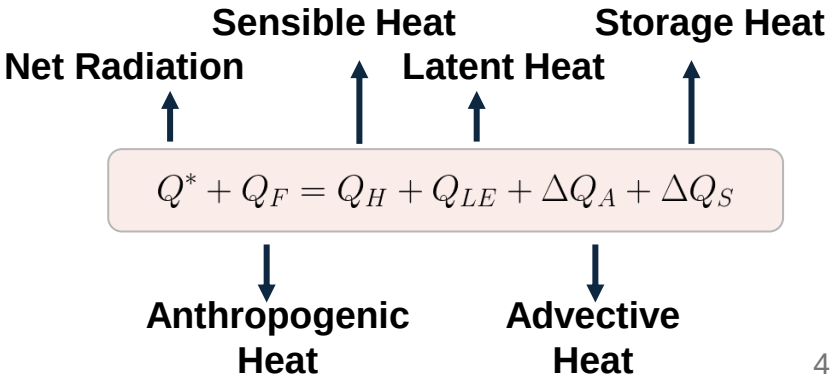
1. The Urban Boundary Layer (UBL)



Oke *et al.*, 2017, *Urban Climates* © Cambridge University Press 2017

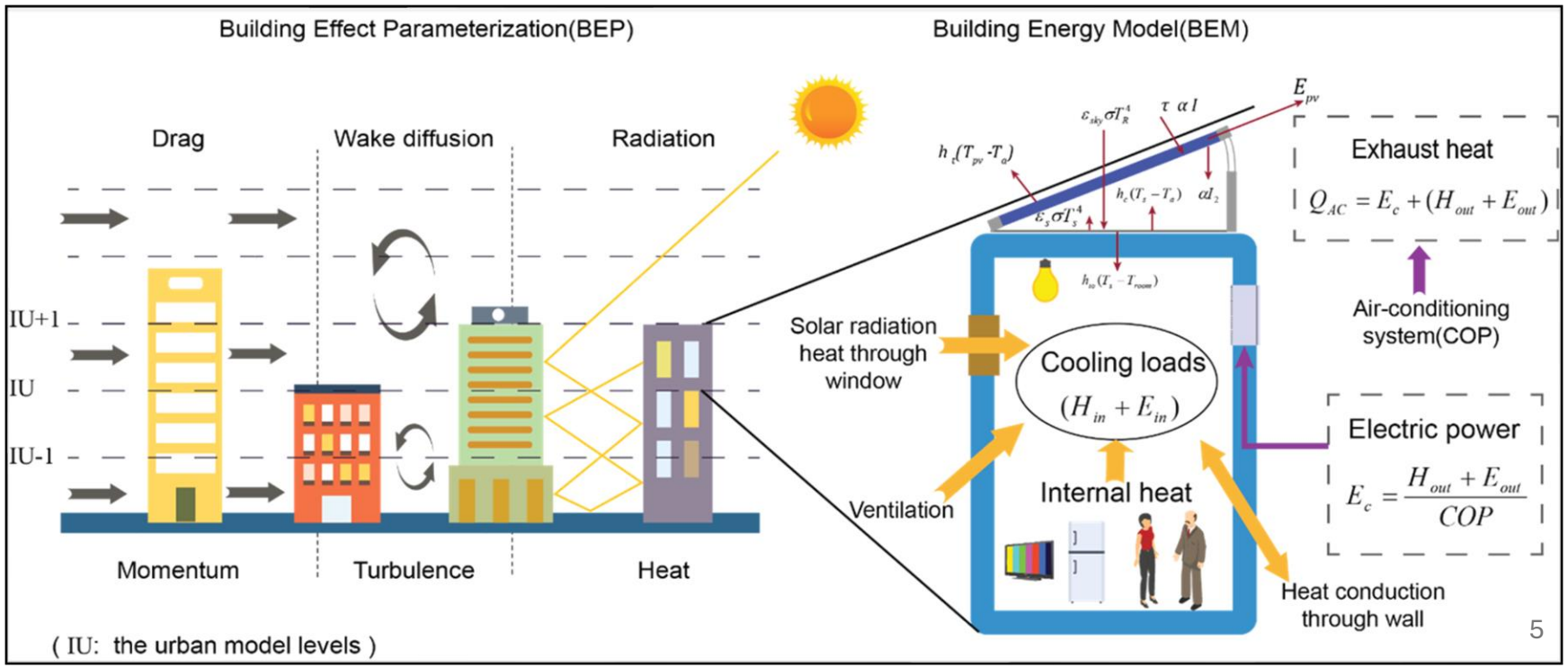
2. Energy, Water, and Mass Balances





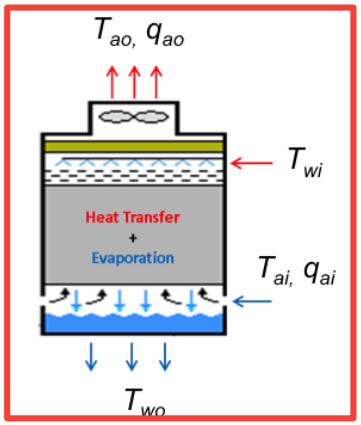
uWRF Modeling Methods:
Quantifying Anthropogenic Heat:
Building Effect Parameterization (BEP) + Building Energy Model (BEM)

- **BEP** is a multiple layer urban scheme that permits a direct interaction with the boundary layer, and recognizes different urban surfaces [Martilli et al., 2002].
- **BEM** takes into account the interaction of the built and natural environments including anthropogenic heat emissions [Salamanca et al., 2010].
- **Cooling tower** and **variable drag** effects partition QF into sensible and latent heat & accounts for building topologies [Gutierrez et al., 2015 a, b]



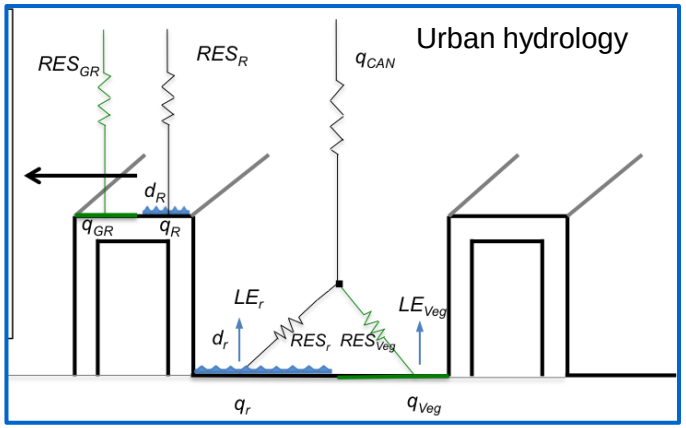
Modeling Methods: Latent Heat, Mechanical Drag, Energy Urban Parameterizations

Cooling Tower Parameterization -to represent AH latent heat



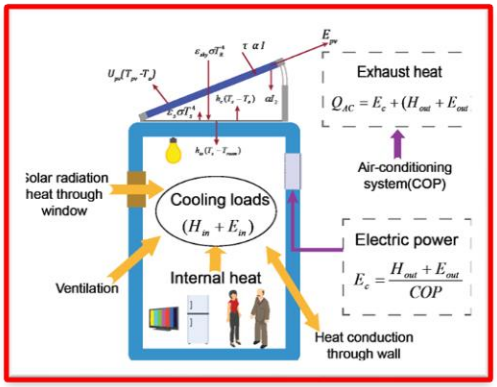
Gutierrez et al., 2015a

Urban Latent Heat



Gutierrez et al. 2016

Solar photovoltaic (PV) Parameterization



Pokhrel et al., 2019

Variable Mechanical Drag

Sectional drag coefficient (Default) = 0.4

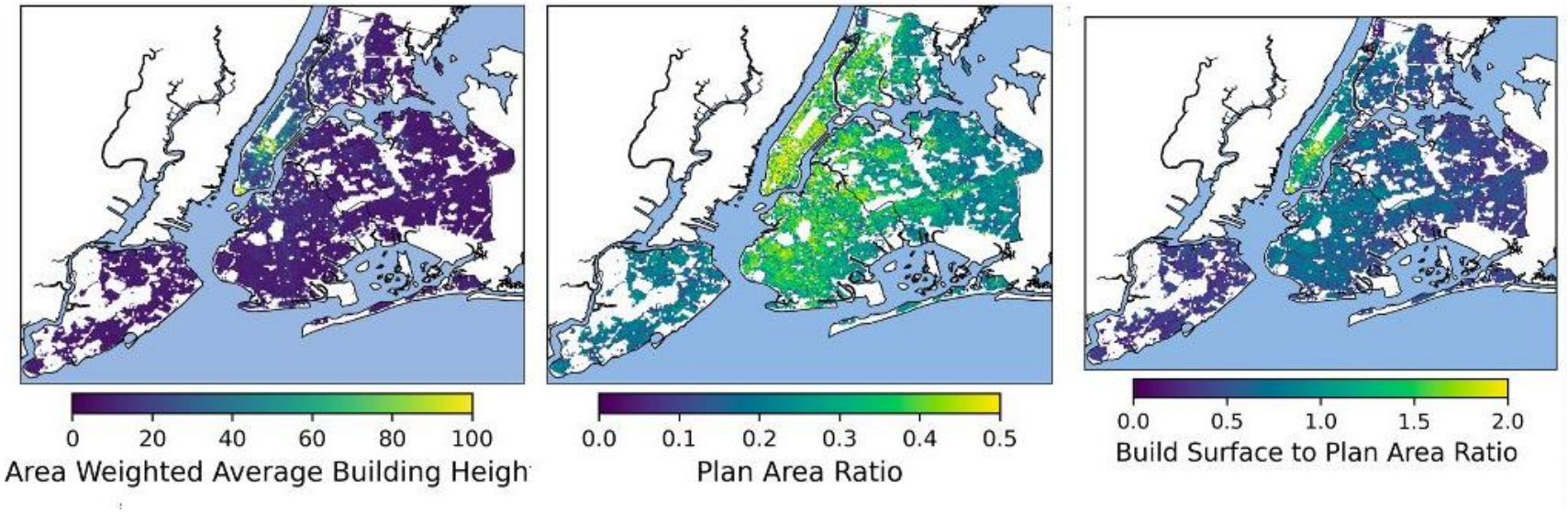
Drag coefficient as a function of the building packing density (Santiago and Martilli 2010):

$$C_{deq}(\lambda_p) = \begin{cases} 3.32x\lambda_p{}^{0.47} & for\ \lambda_p \le 0.29 \\ 1.85 & for\ \lambda_p > 0.29 \end{cases}$$

Gutierrez et al., 2015b

uWRF Model

- The urban-WRF model is initialized every day using the 00-UTC NAM forecast and runs for 84 hours.
- Therefore, the previous day is modeled at least 3 times.
- uWRF model with MYJ planetary boundary layer scheme and Pluto NYC land cover data.

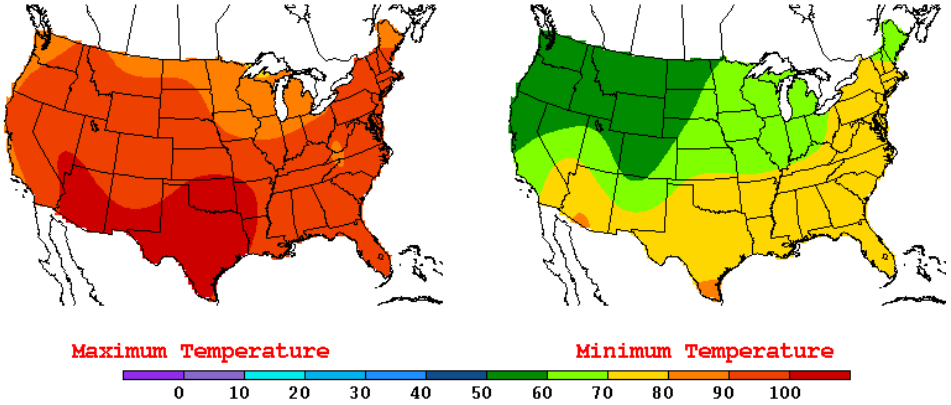


Pluto NYC land cover data

https://data.cityofnewyork.us/City-Government/Primary-Land-Use-Tax-Lot-Output-PLUTO-/64uk-42ks/data

Heat Wave Case: 19-24 July 2022

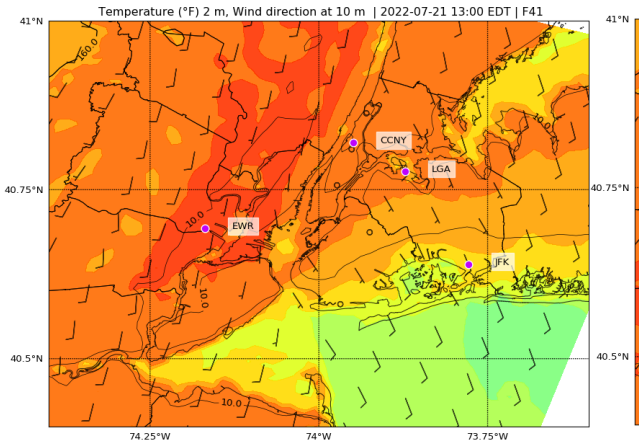
NCEP Daily weather map: 21 July



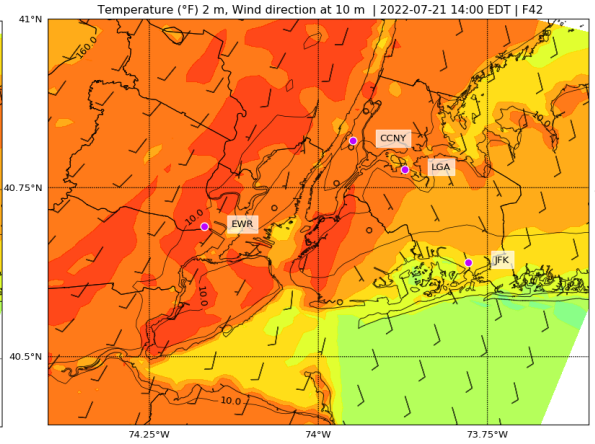
https://www.wpc.ncep.noaa.gov/dailywxmap/index_20180918.html

CUERG Model forecast

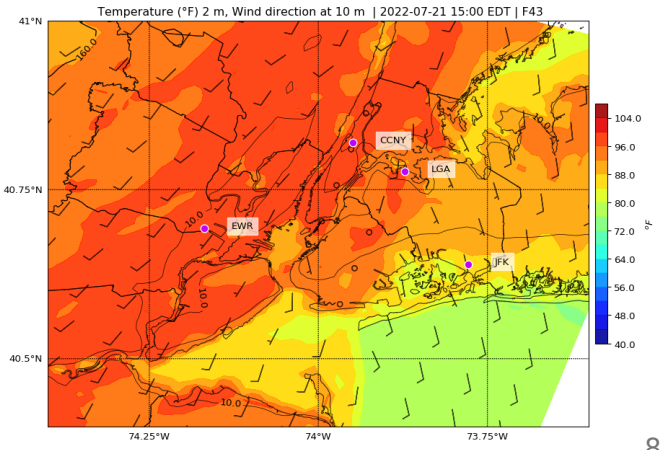
1pm EST



2pm EST



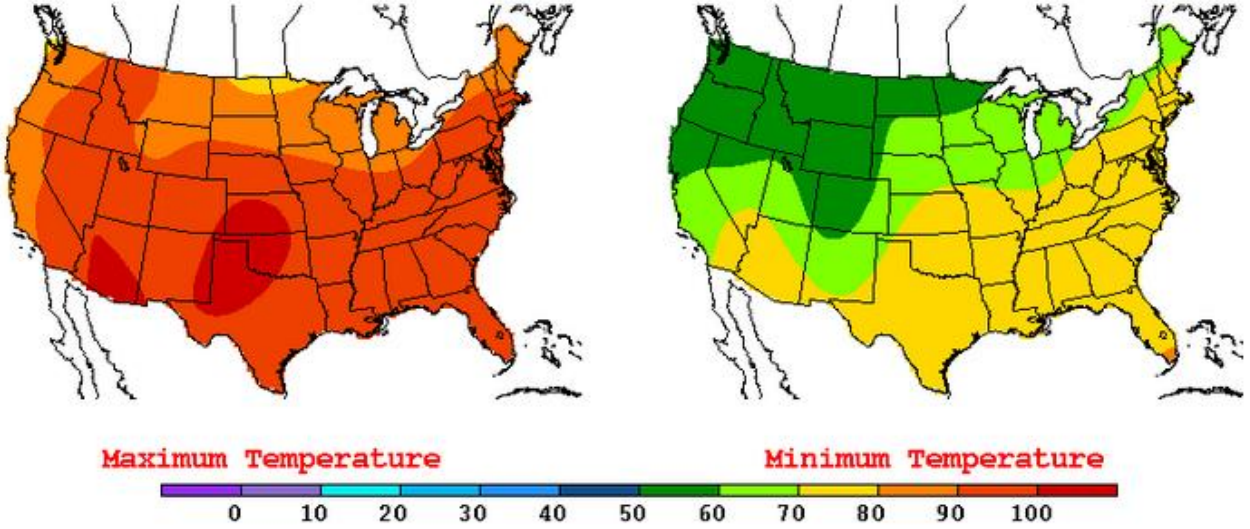
3pm EST



https://cuerg-web.asrc.albany.edu/new-york-forecast/

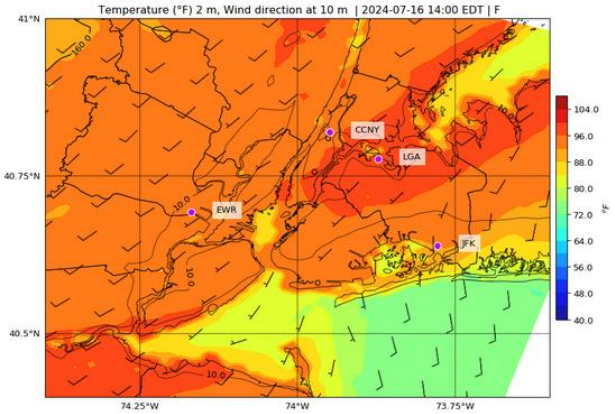
Heat Wave Case: 15-19 July 2024

NCEP Daily weather map: 16 July

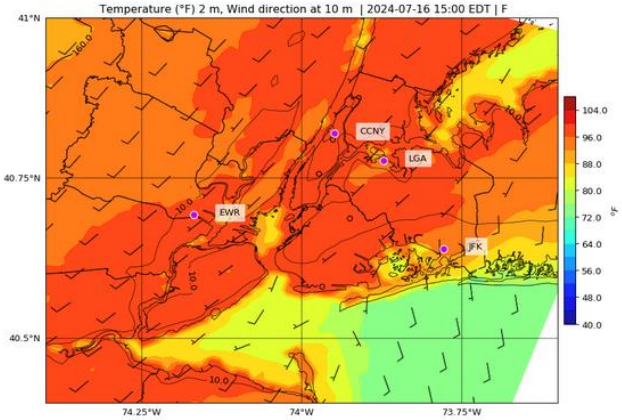


CUERG Model forecast

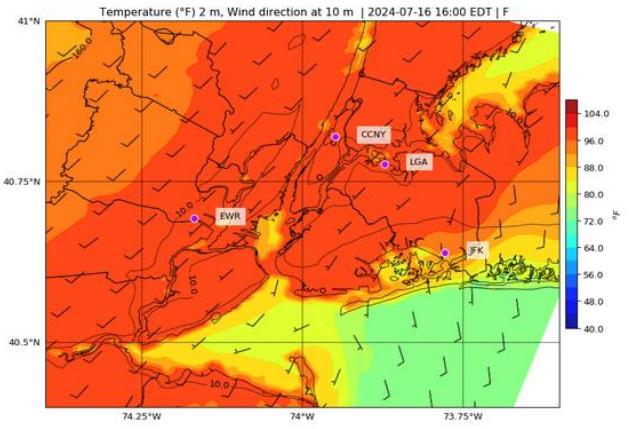
1pm EST



2pm EST



3pm EST



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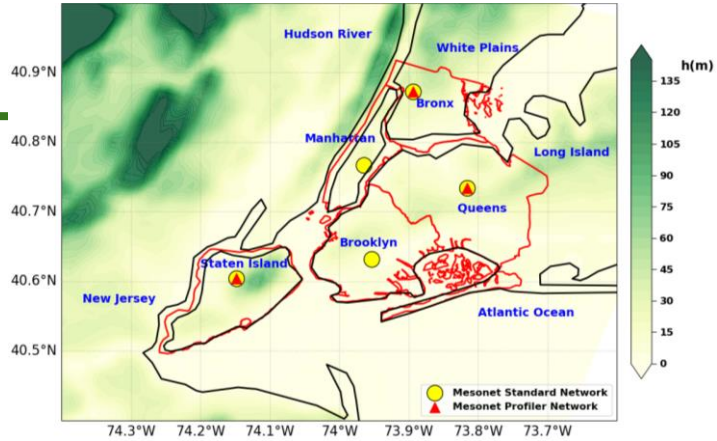
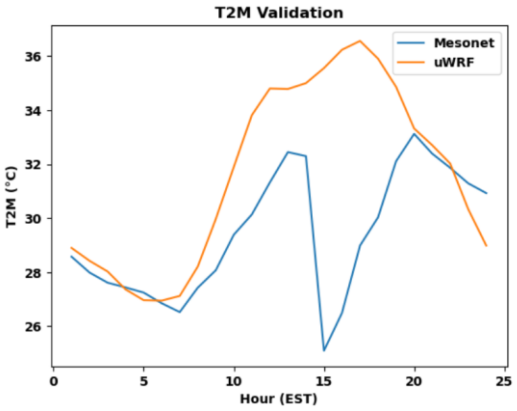
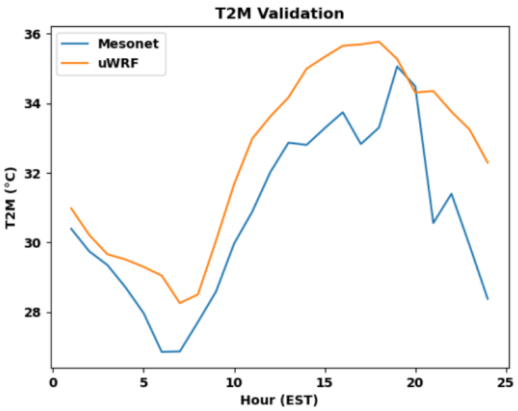
Heat Wave Cases: Weather Parameters

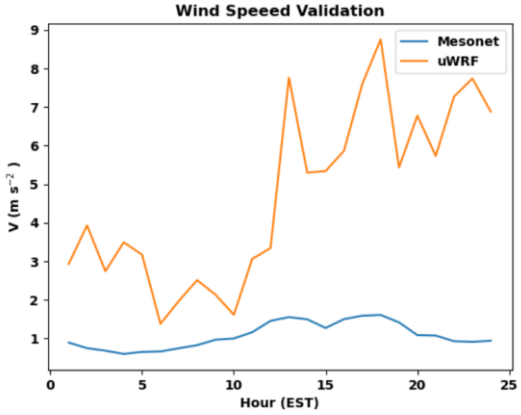


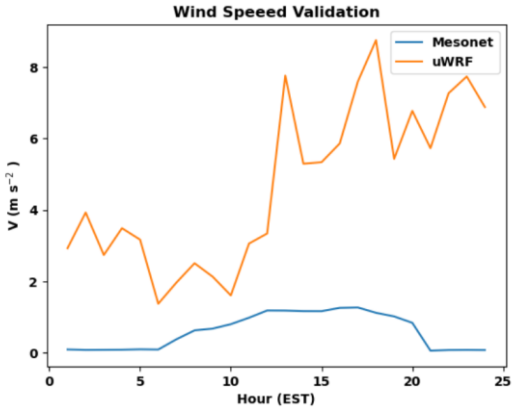
21 July 2022



16 July 2024





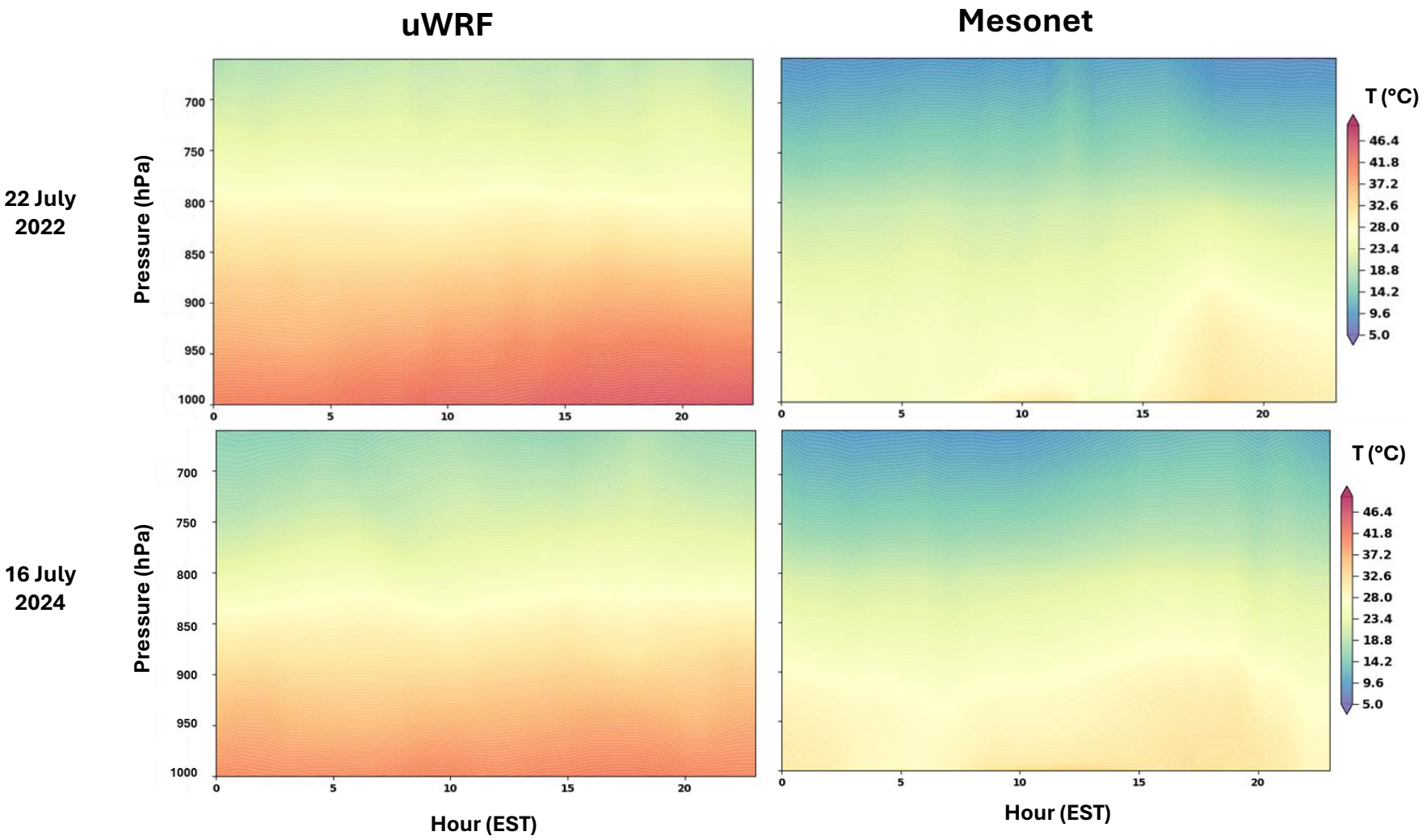


Weather Parameters	Corr Coef		MSE	
	uWRF3.9	uWRF4.2	uWRF3.9	uWRF4.2
T2M (°F)	0.4	0.9	48.3	13.2
Wind Speed (ms^{-1})	0.6	0.2	17.3	21.2

Results shows:

- **Correlation between Mesonet and uWRF for T2M increased from 0.4 to 0.9**
- **Correlation between Mesonet and uWRF for wind speed decreased from 0.6 to 0.2**

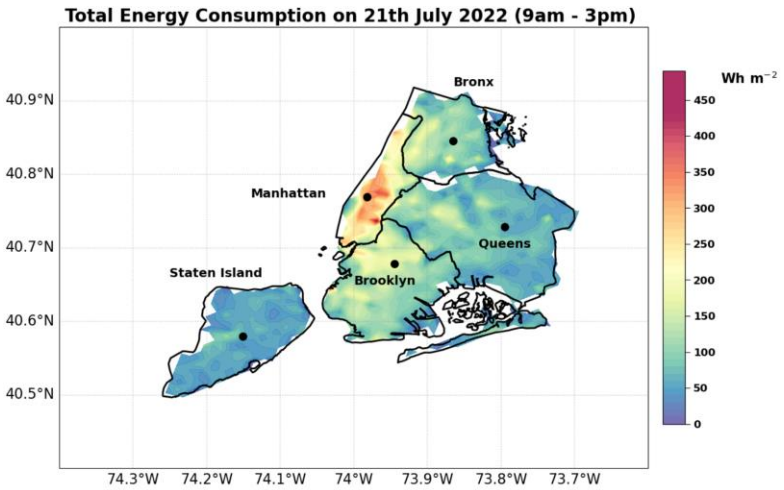
Heat Wave Cases: Weather Parameters

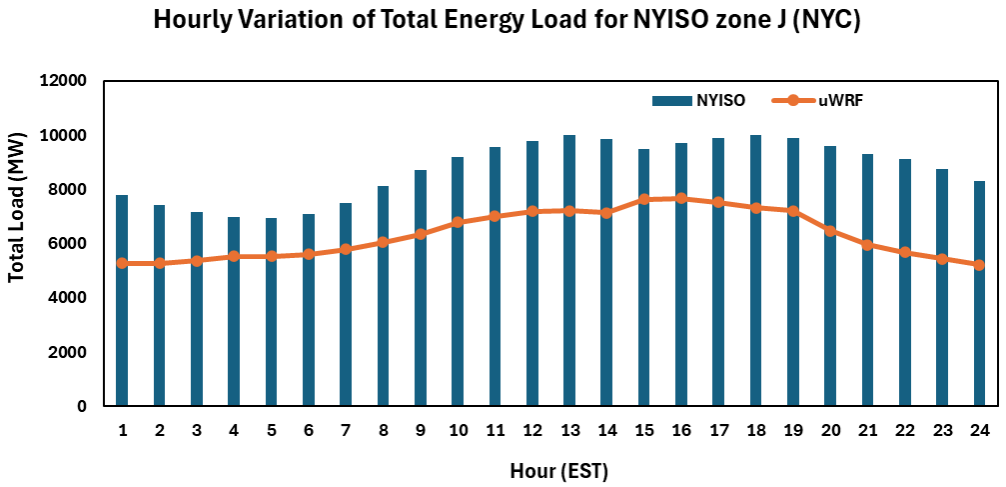


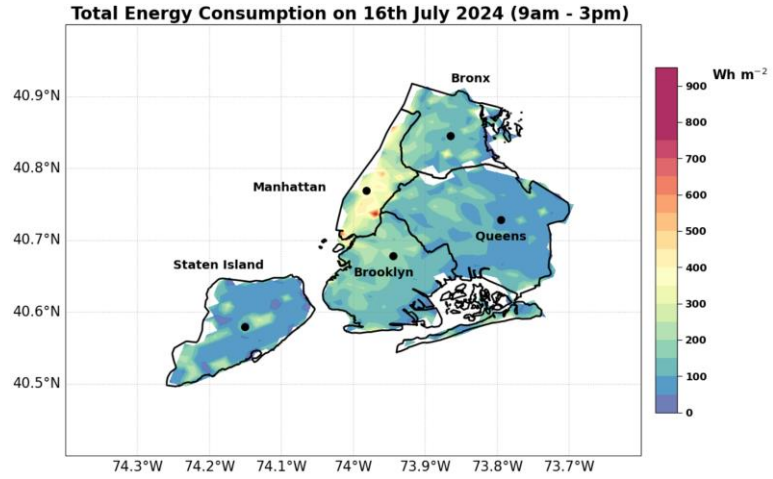
Results shows:

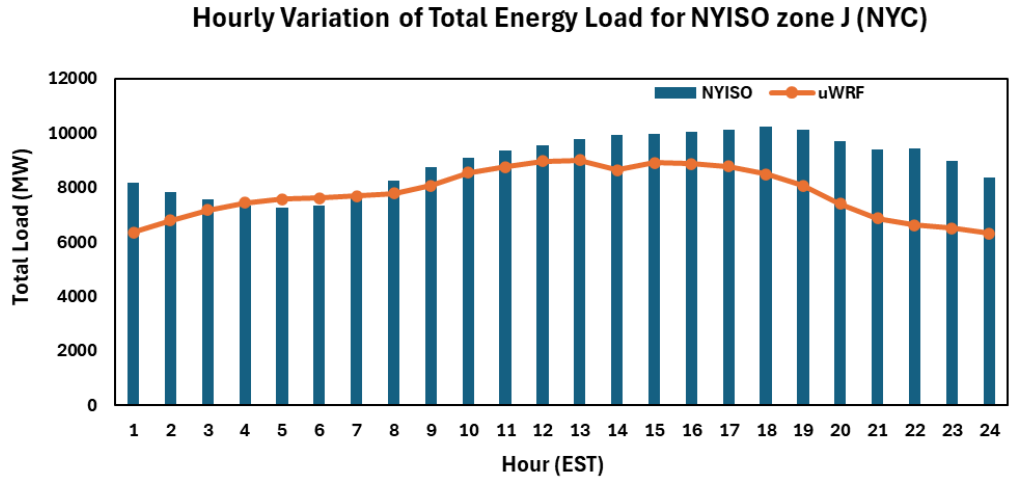
- **Model predicts a warmer boundary layer than what is observed in the actual measurements.**

Heat Wave Case: Energy Load









Results shows:

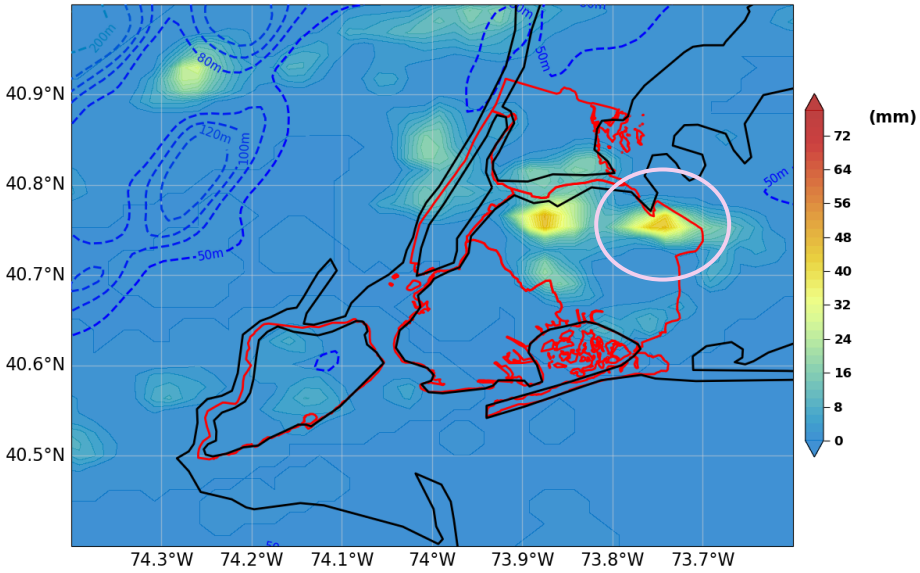
- **Correlation between NYISO and uWRF increased from 0.6 to 0.68**

NYISO: New York Independent System Operator

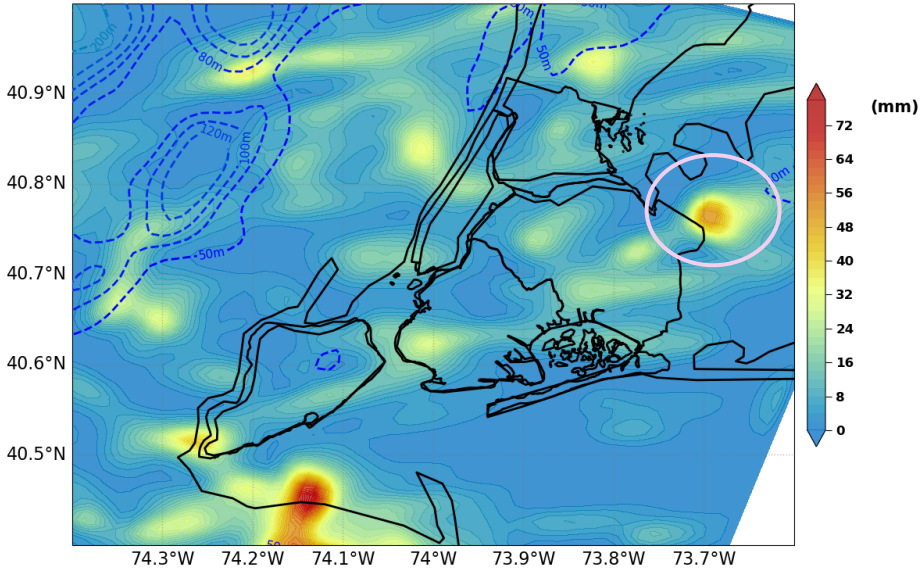
Extreme Precip Case: 12 August 2020

Daily accumulated Precipitation (mm)

NEXRAD



uWRF

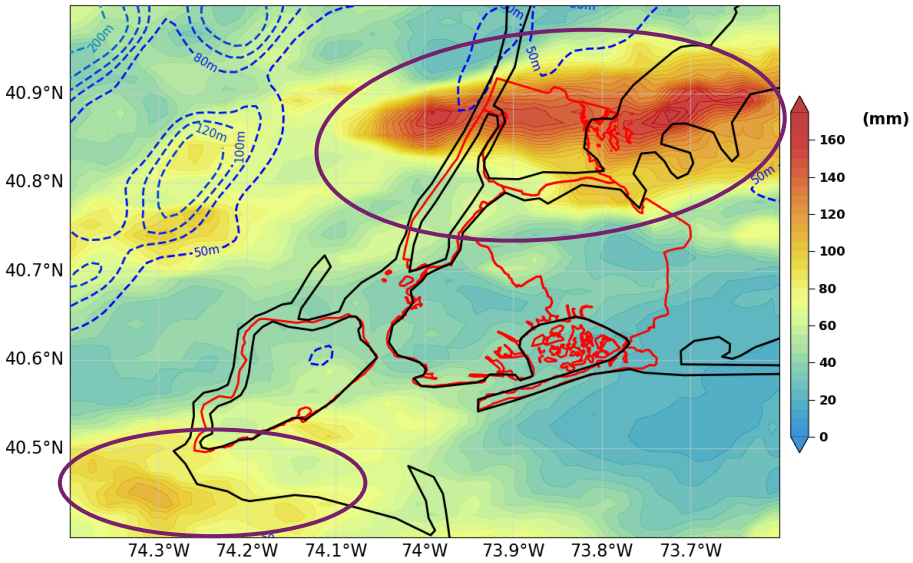


- The model can predict a single rainfall extreme over the city during the day, but its location is slightly shifted.

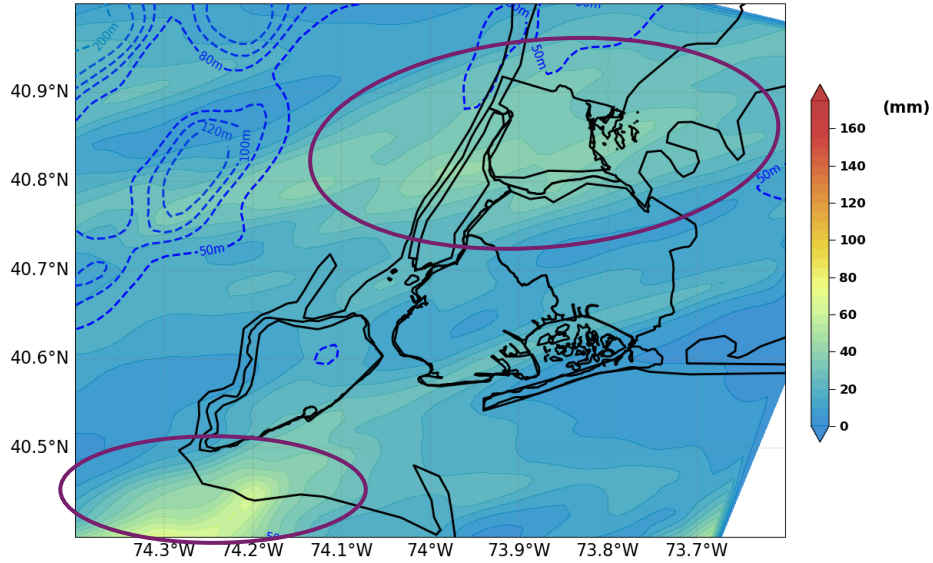
Extreme Precip Case: 06 August 2024

Daily accumulated Precipitation (mm)

NEXRAD

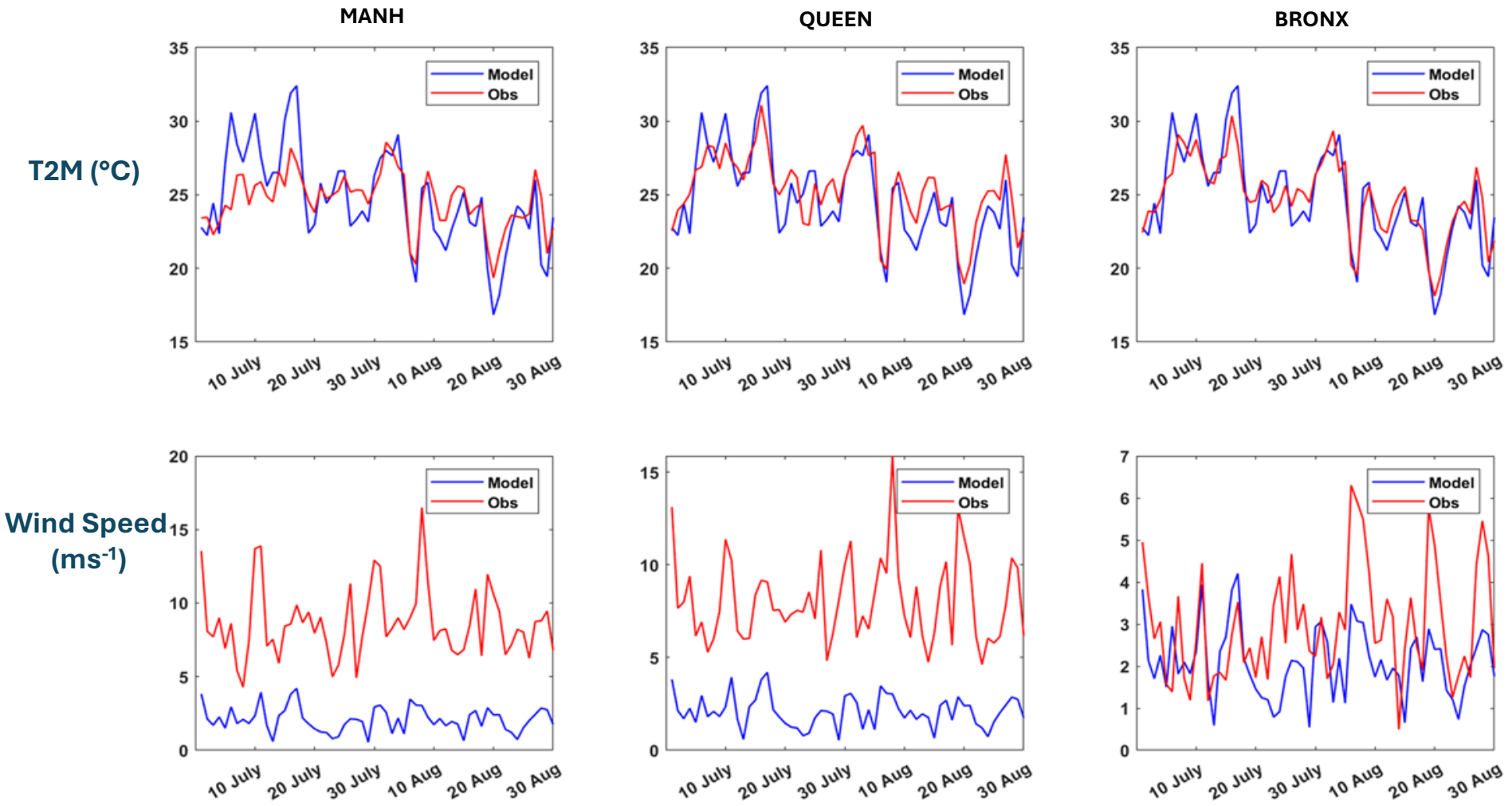


uWRF



- The model has better captured the spatial occurrence of rainfall extremes, but the predicted intensity remains lower than observed.

Long-range Weather Forecast: Weather Parameters



- The model predicts T2M more accurately than wind speed for long-range forecasts.

Long-range weather forecast: Weather Parameters

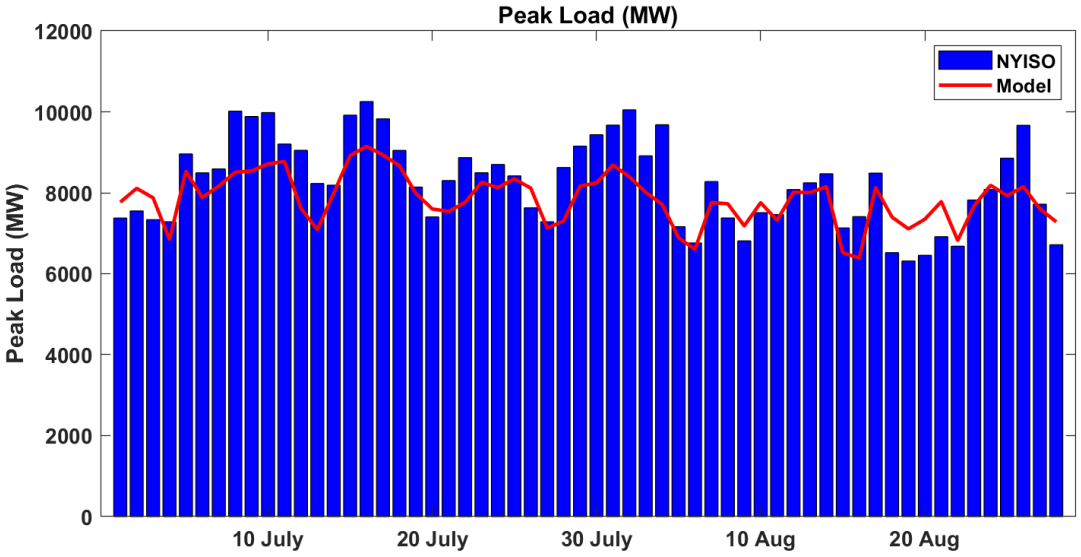
Statistics with comparison to Mesonet stations

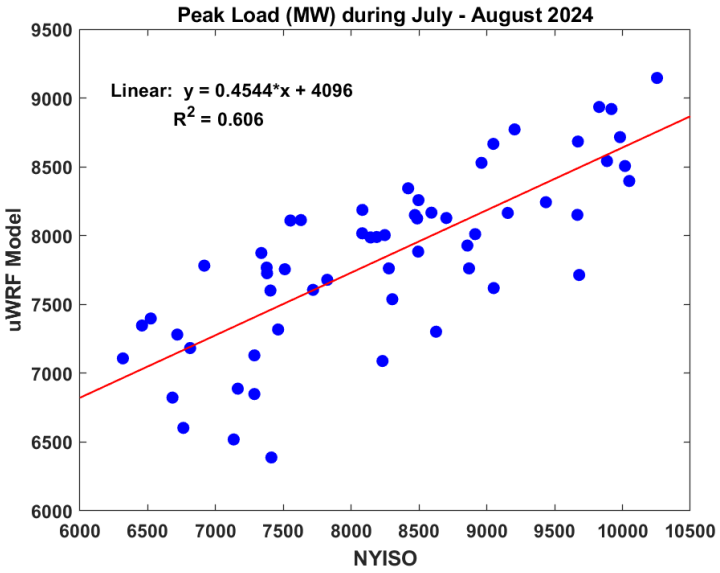
Station (Lat, Lon)	RMSE		MAE		Correlation Coefficient		Bias	
	T2M (°C)	10 m Wind (ms-1)	T2M (°C)	10 m Wind (ms-1)	T2M (°C)	10 m Wind (ms-1)	T2M (°C)	10 m Wind (ms-1)
MANH	2.15	6.84	1.63	6.54	0.78	0.55	0.08	-6.54
QUEEN	1.83	6.25	1.53	5.95	0.86	0.57	-0.66	-5.95
BRONX	1.56	1.45	1.24	1.19	0.88	0.49	-0.13	-0.86

Results show:

- The model predicts T2M well at each station
- There is a positive bias at the station in the city center, while the other two stations show a negative bias
- All three stations exhibit a negative bias in wind speed.

Long-range Energy Forecast



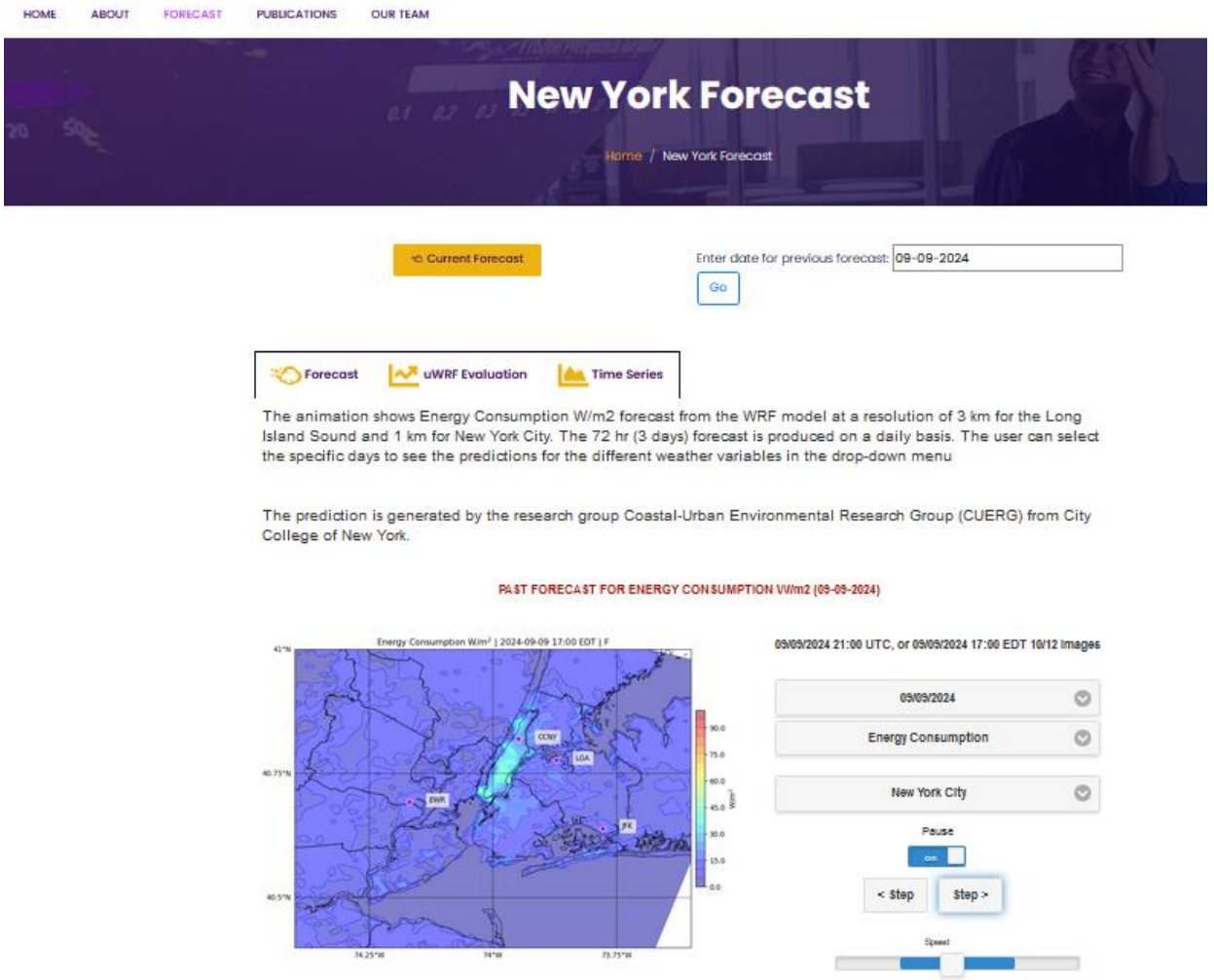


Results show:

- Peak load is accurately predicted by the model
- It explains about 60% of the observed energy load

New York City Daily Weather and Energy Forecast: Website

https://cuerg-web.asrc.albany.edu/new-york-forecast/



Thank you!

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