Numerical Simulations of a Summer 2010 Heat Wave in New York City using WRF's Building Energy Parameterization

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INTRODUCTION

The Weather Research and Forecasting (WRF) model, coupled with a multi-layer urban canopy parameterization (Martilli *et* al, 2002) and a building energy model (Salamanca, 2009), is used to evaluate the energy consumption due to air conditioning systems during a summer 2010 heat wave event in New York City. The building energy model considers the diffusion of heat through walls, roofs and floor; natural ventilation; radiation exchange between indoor surfaces; generations of heat due to occupants and equipments and the consumption due to air conditioning systems. The impact on the temperature and energy consumption of changing the albedo of the roofs is analyzed.

METODOLOGY

Initial Conditions/Urban Canopy Data:

NAM data at 12 km resolution were assimilated every three hours for the period between 07/06/10 00Z and 07/08/10 00Z. NCEP/MMAB data at 0.5 degree were employed to update the sea surface temperature every 24-h. National Building Statistics Database (Burian *et al.*, 2008) at 250-m was used to represent the urban canopy in New York City. To take into account the heterogeneity of New York's urban environment, NDSD information was assimilated as a grid instead of calculating mean values for each urban class.

WRF Simulations:

Two 48-h simulations were performed on four domains (9, 3, 1, 0.33 km) with 51 terrain following terrain sigma levels centered over Manhattan. Two albedo values were defined to represent dark and white roofs. An albedo of 0.2 was assigned to the dark roofs and for the white roofs the albedo was increased to 0.8. The parameterizations/options used were RRTM, Dudhia, WSM3-class, Kain Fritz and BouLac. The outputs from the model were validated with weather data from NYCMetNet.

SUMMARY & CONCLUSIONS

- The change of the roof albedo decreased the surface temperature throughout the region for most of the 24-h period analyzed. During the day, the increase in the albedo produced a decrease in temperature and also in the amount of energy accumulated by the paved structures. As a result, less sensible heat was released and cooler temperatures were registered during the night compared to the dark roof simulations.
- The AC consumption clearly matches the building height distribution with higher values in midtown and downtown Manhattan where the highest buildings are located. The consumption reaches its peak at the time of the maximum temperature. The albedo has a bigger impact during the night with a consumption difference of about 5 W/m2 between cases.
-The surface winds low values reflect the barrier effect of the buildings. The change in the albedo affected the velocity of the surface wind. In the morning an early afternoon, simulations with white roofs presented higher wind speeds than the dark roof run.
- The temperature spatial distribution shows the presence of what it seems to be convective rolls vortices. Further investigation is needed to determine if the vortices are formed due to numerical instability.

References

Burian S., Augustus N., Jeyachandran I., and Brown M., 2008. Final Report for the National Building Statistics Database. LA-UR-08-1921 April 4, 2008.

Martilli A., Clappier A., and Rotach M. W., 2002: An urban surface exchange parameterization for mesoscale models, *Boundary-Layer Meteorol.*, 104, 26, 304.

Salamanca, F., and A. Martilli, 2009: A new Building Energy Model coupled with an Urban Canopy Parameterization for urban climate simulations._Part II: Validation with one dimension off-line simulations'. Theor Appl Climatol.

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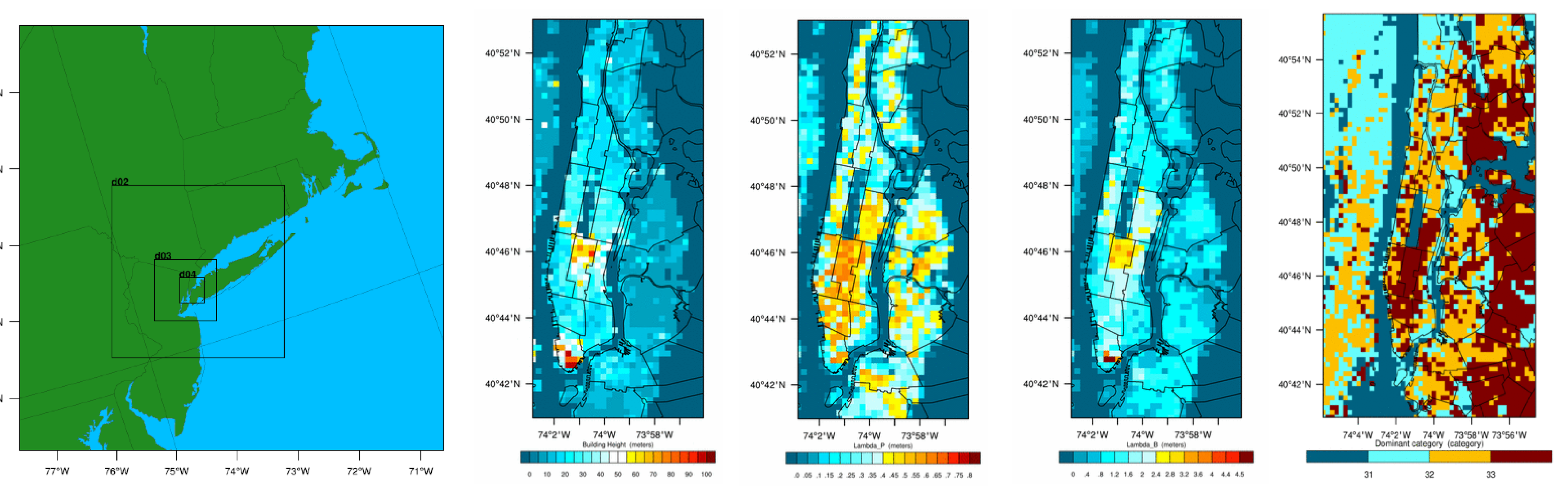
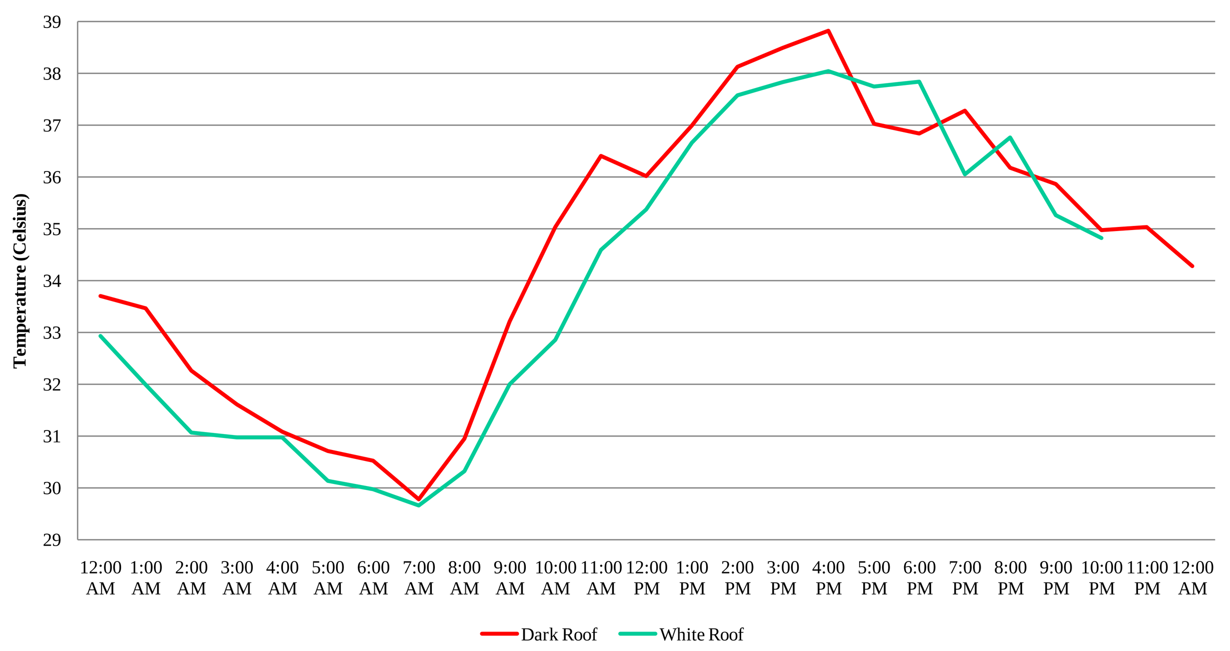
Model Domains and National Building Statistics Database

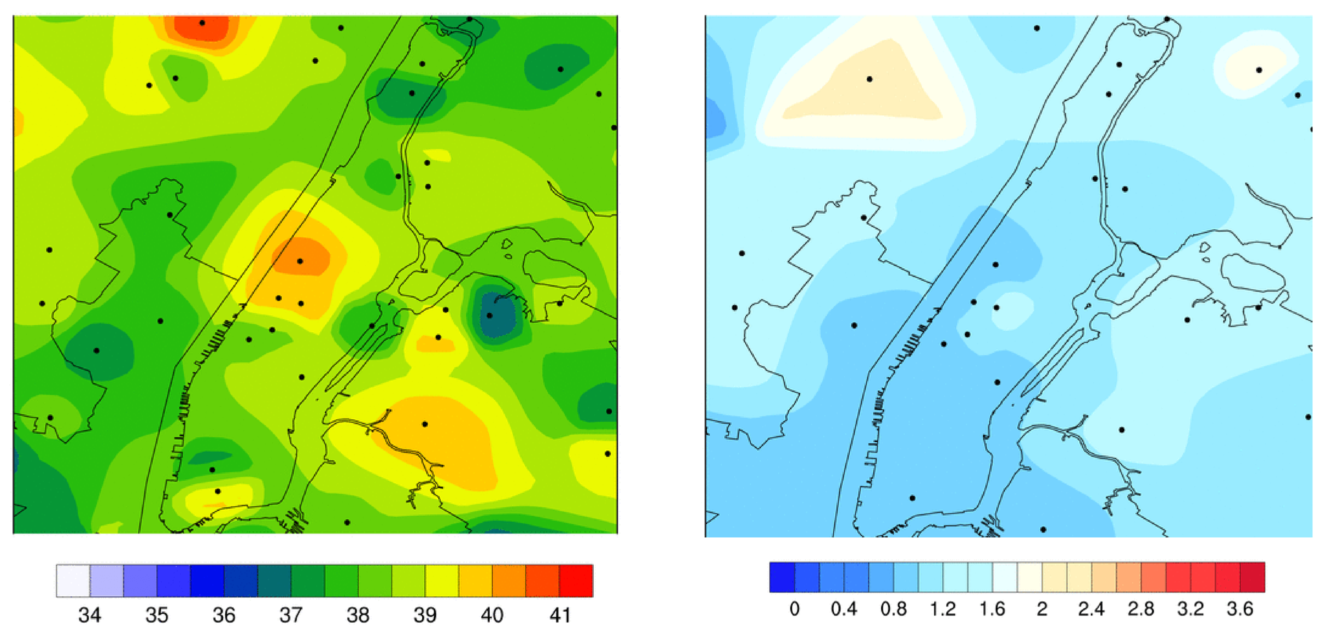


Building Height | Building Area Fraction | Building Surface Ratio | Urban Classes

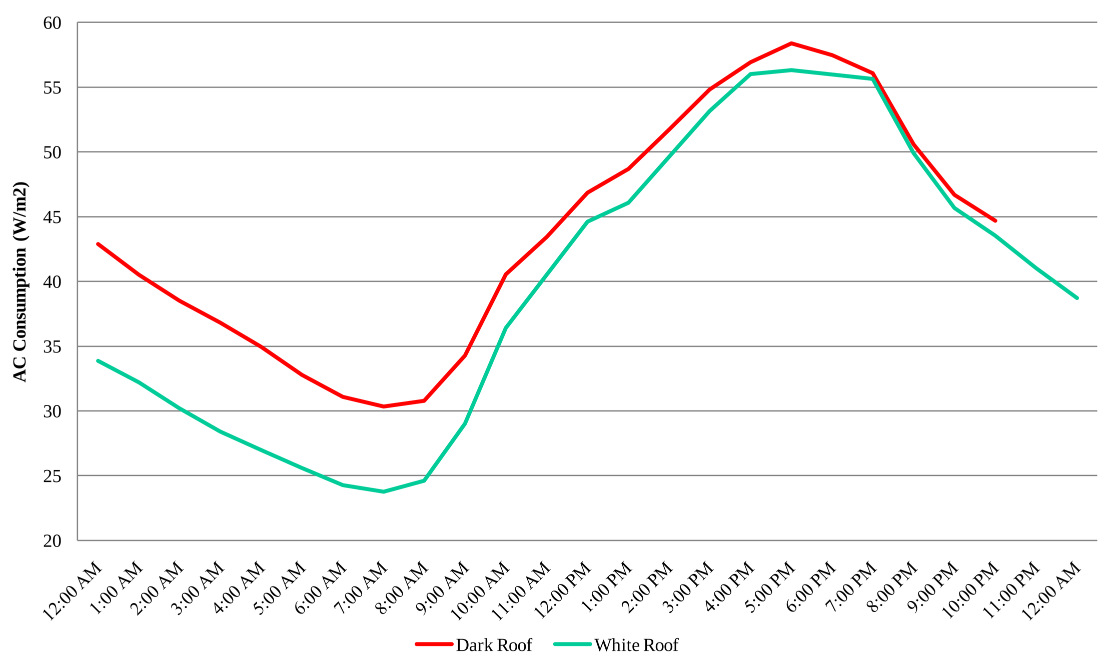
Surface Temperature (K) (Midtown)



Maximum Surface Temperature (K) 07/06/10 and RMSE

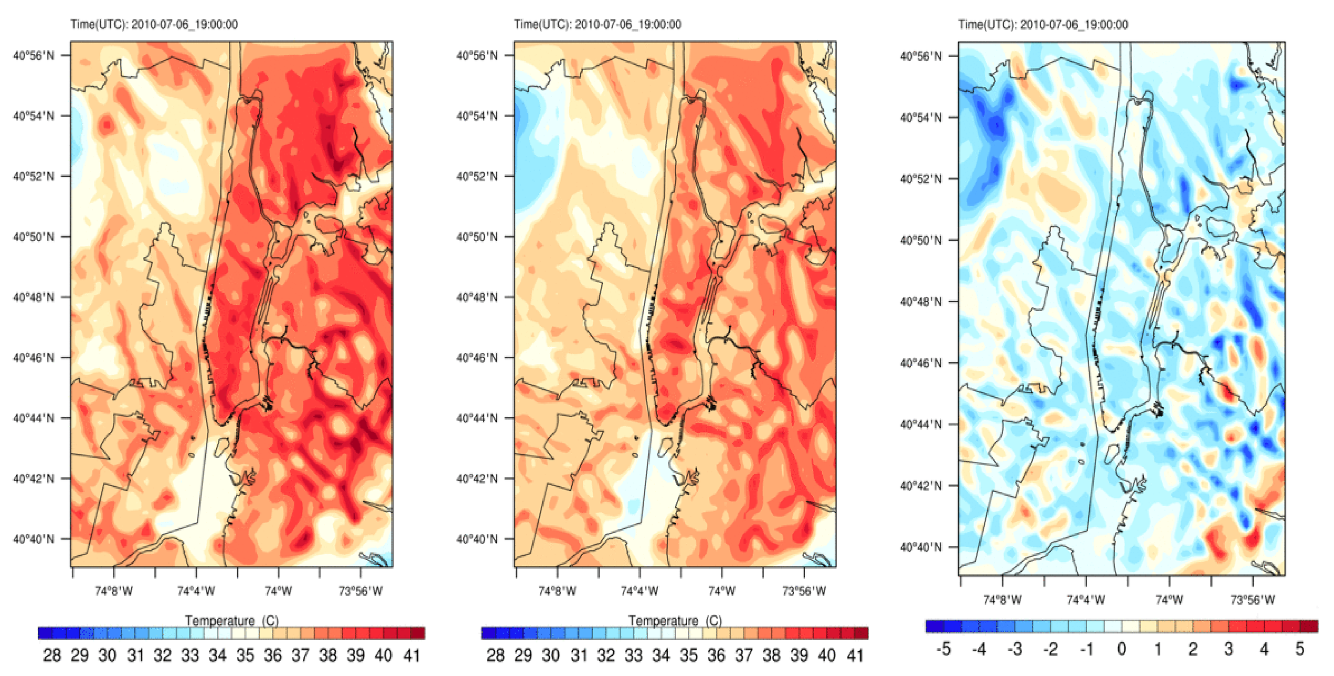


AC Consumption (W/m2) (Midtown)



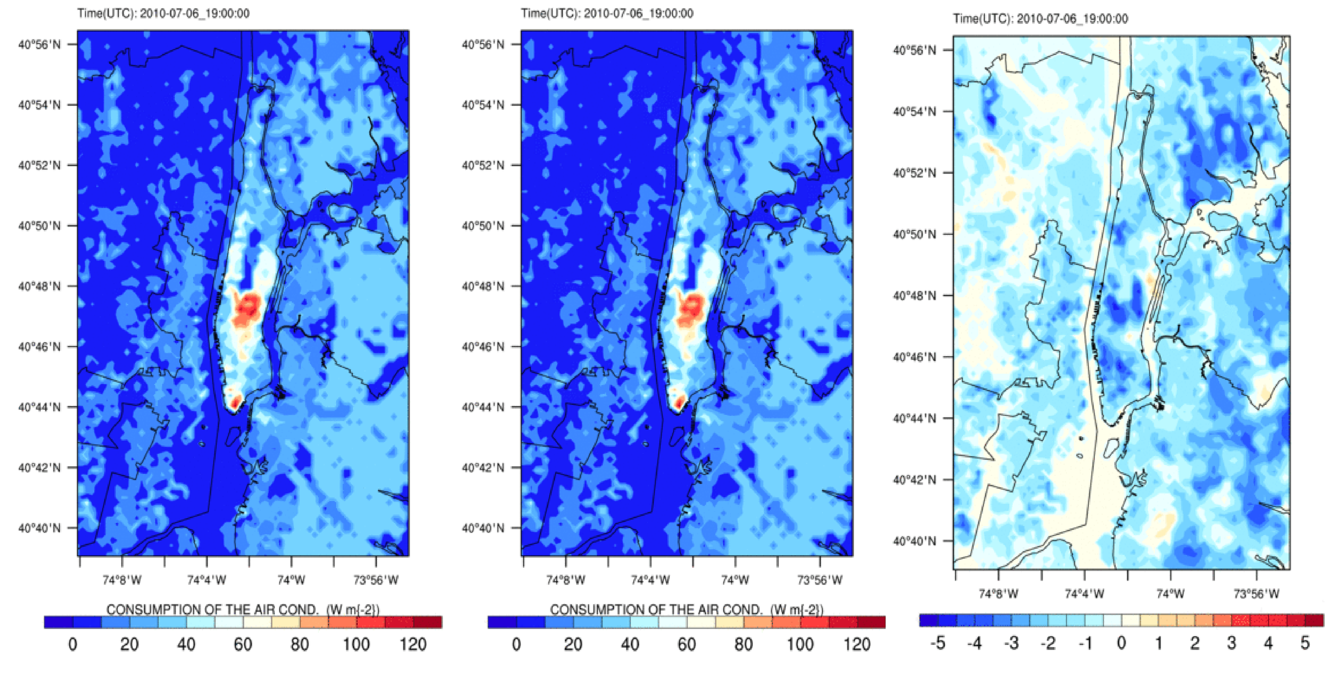
Wind Speed (m/s) (Midtown)

Surface Temperature (K) 07/06/10 15:00 EST



Dark Roofs | White Roofs | White Roofs -Dark Roofs

AC Energy Consumption (W/m2) 07/06/10 15:00 EST



Dark Roofs | White Roofs | White Roofs -Dark Roofs

Coastal Environmental Research Group: http://cuerg.ccny.cuny.edu/ NYCMetNet: http://nycmetnet.ccny.cuny.edu/

Future Work

- Obtain energy consumption measurements around the New York City to validate the model outputs.
- Expand the analysis on the horizontal roll vortices to determine if they are real or numerical noise.
- Assimilate measured data from NYCMetNet into the model to improve temperature and wind speed simulations

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