Assessing Impact of Landscape Characteristics on Urban Hydroclimate

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Introduction

The land use and land cover (LULC) changes due to urbanization play a vital role in local climate change. The replacement of the natural surfaces with manmade structures modifies the surface energy and water budgets of the environment. This is responsible for the urban climate change of places like Phoenix which is one of the fastest growing cities in the U.S. To understand the underlying physics of urban climate modeling, in-depth knowledge is needed on the impact of various urban landscape characteristics on the urban climate.

Research Question:
How does the change in percentage of urban area impact urban climate?

Models

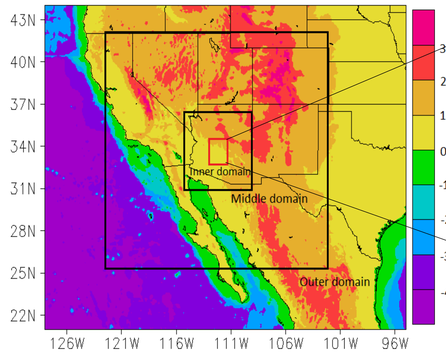
For realistic representation of urban climate, Weather Research and Forecast (WRF) model with urban energy-water processes developed by Wang and Co-workers, based on the single layer urban canopy model (UCM) is used.

- **WRF model:** It is a numerical weather prediction system designed for operational forecasting and atmospheric research.
- **UCM:** This model accounts for urban geometry, shadowing from and reflection of buildings, anthropogenic heating and roof, road and wall biophysical representation.

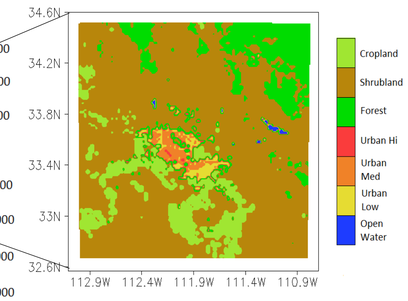
Application of WRF Simulation Incorporating UCM

- **Domains:** 3 nested domains; 32km, 8km and 2km resolution
- **Simulation Period:** July, 2012, hourly data
- **Innermost domain:** Phoenix Metropolitan City
- **LULC data**: NLCD2006
- **Default Urban fraction:** 0.95, 0.85, 0.7 for high, medium and low density residential
- **Applied Urban Fraction Change:** 25% increase and decrease

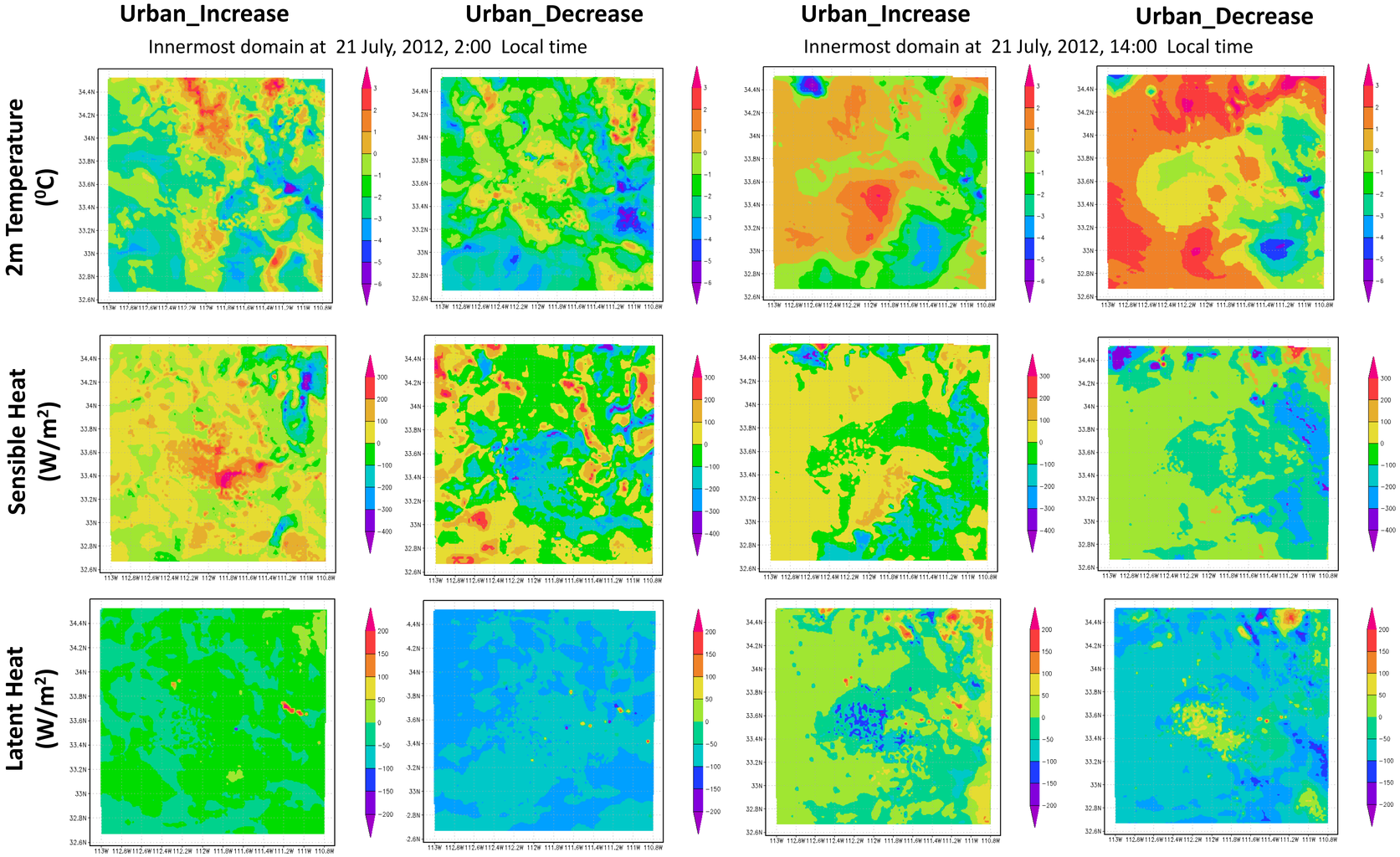
3 domains used in the model



Land use of innermost domain



Impact of Urban Fraction Change



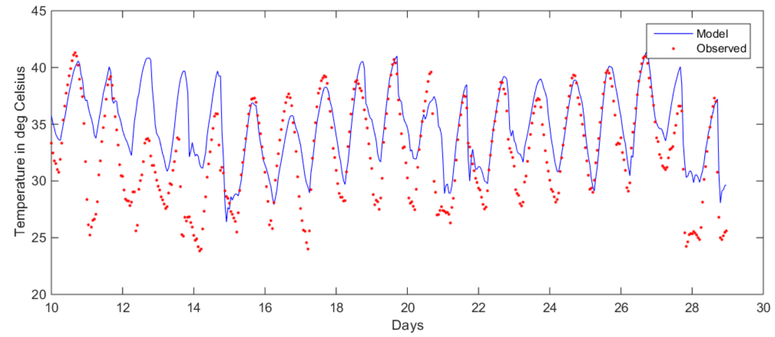
Urban_Increase: Difference between Increased urban fraction and Default urban fraction

Urban_decrease: Difference between Decreased urban fraction and Default urban fraction

2m Temperature: Air temperature above 2m surface
Sensible heat: Heat exchange due to temperature difference
Latent heat: Heat exchange due to phase change

Validation

Comparison of temperature 2m above surface between model results and observed data from AZMET stations



Parameters	Root Mean Square Error (RMSE)
2-m temperature [T2] (°C)	3.1
Sensible heat [H] (W/m²)	60.8
Latent heat [LE] (W/m²)	44.1

Findings and Conclusion

- The model results nearly approximate and follow the trend of observation data. The high differences between the observed data and result from model are the days with precipitation (July 10-15 and July 26-28) , which Weather Research and Forecasting model hasn't simulated correctly.
- The 25% increase in urban fraction of Phoenix increased temperature at the urban areas of phoenix. Similarly, 25% decrease in urban fraction decreased the temperature. The sensible heat followed the same trend.
- Latent heat on the other hand, decreased with increase in urban fraction and increased with decrease in urban fraction. This is because Latent heat is due to evaporation from the vegetation. The increase in urban fraction decreases the vegetation fraction , thus decreasing latent heat and vice versa.
- Since Urban Canopy Model only modifies the parameters of urban areas, so the changes in non-urban areas might not reflect the impact accurately.
- Future works will include impact of different land use scenario on the urban climate.

References and Acknowledgement

Wang ZH*, Bou-Zeid E and Smith JA (2013) A coupled energy transport and hydrological model for urban canopies with evaluation using a wireless sensor network. Quarterly Journal of the Royal Meteorological Society, 139: 1643-1657.

Yang J., Wang Z., Chen F., et al. (2015). Enhancing Hydrologic Modelling in the Coupled Weather Research and Forecasting–Urban Modelling System. Boundary layer Meteorology, 2014.

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