Assessing Impact of Land Use Change on Urban Hydroclimate for three Metropolitan cities in Colorado River Basin

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Introduction

Rapid urbanization and population growth in the arid and semi-arid areas of Colorado River Basin (CRB) make it vulnerable to climate change impacts. Both local and regional climate changes are expected to have massive impacts on the hydrology of the Colorado River, thereby accentuating the need of study of hydro-climatic impacts in CRB. In this study, three densely populated urban areas, viz. Phoenix, Las Vegas and Denver in the CRB are selected to capture the variable dimensions of the impacts of land use changes on their regional hydroclimate (temperature) and in general entire CRB.

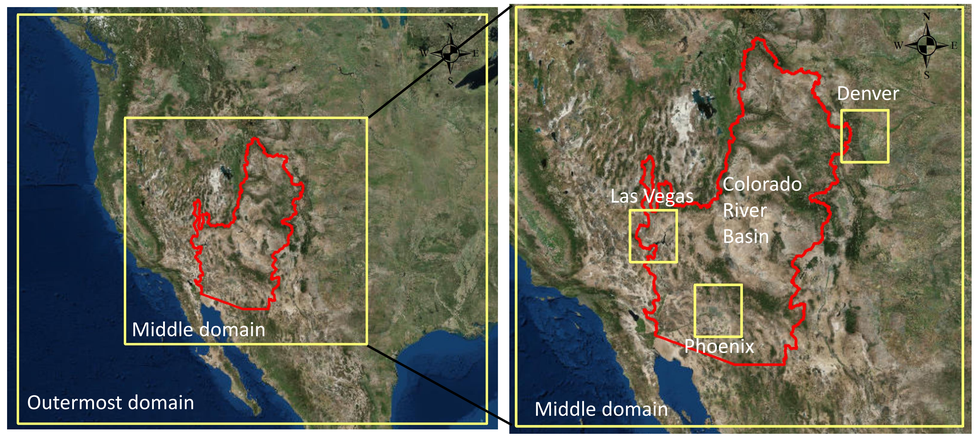
Research Question:
How does future land use change impact urban hydroclimate of Phoenix, Denver and Las Vegas?

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:** 5 nested domains; outermost- 48km, middle -12km and 3 innermost-3km resolution each
- **Innermost domains:** Covers Metropolitan areas of Phoenix, Las Vegas and Denver
- **Simulation Period:** June 01-08, **Control case time:** 2010
- **Projected case time:** 2100
- **Land Use data for 2010**: NLCD2006
- **Land Use data for 2100**: EPA , A2 scenario

Land Use Change

Land use projection is based on Environment Protection Agency (EPA) , (Integrated Climate and Land Use Scenarios) ICLUS.

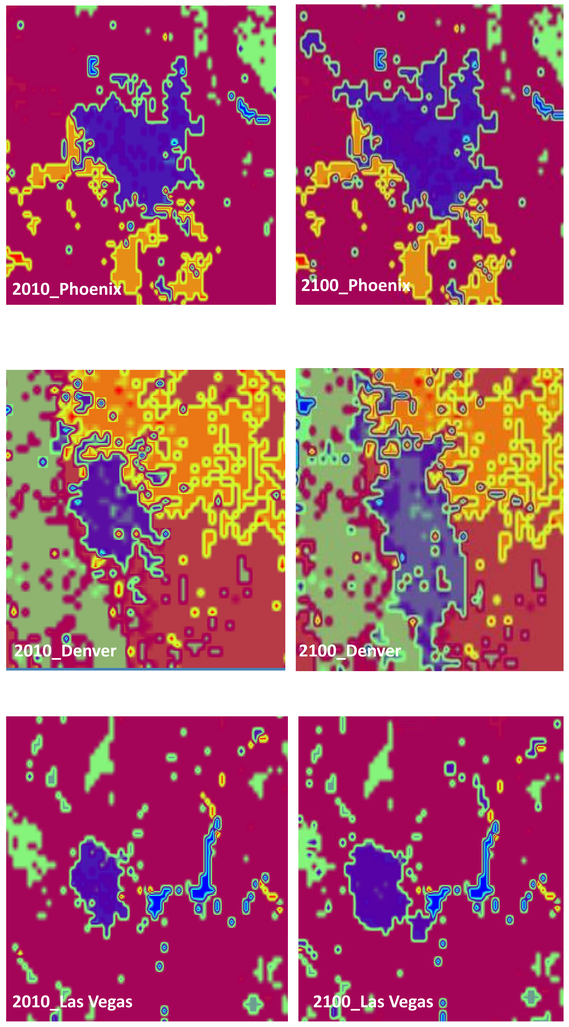
Four major EPA scenarios:

Development	Economically driven (A)	Environmentally driven (B)
Global (1)	A1	B1
Regional (2)	A2	B2

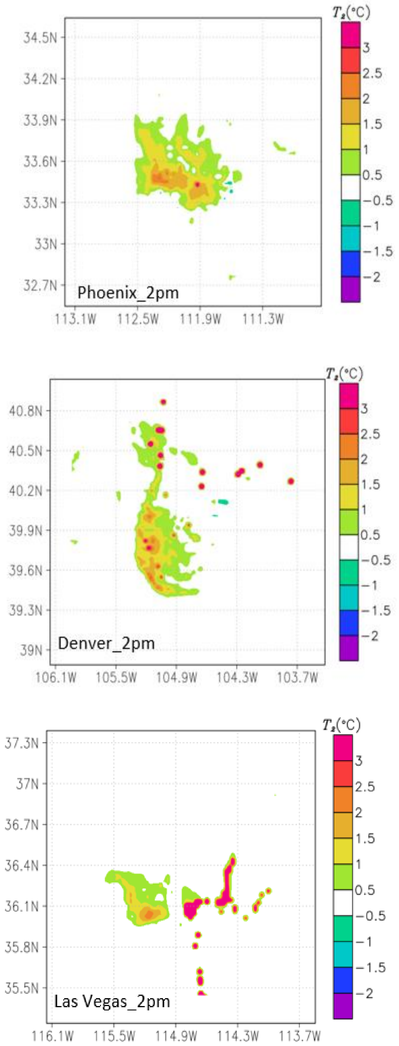
Among all the scenarios, A2 scenario camaximum growth thus this scenario was applied in the study.

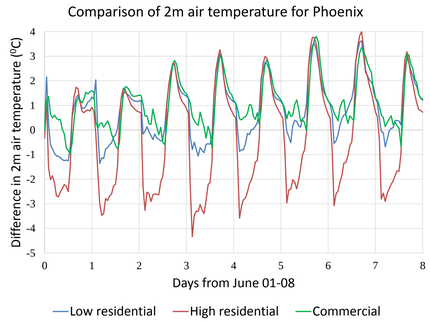
Impervious surface projection for 2100 was applied to obtain land use change in urban categories.

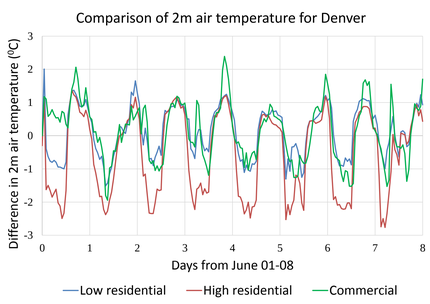
The urban fraction for each of the urban categories is given by: Low residential – 0.60, High residential – 0.75 and Commercial – 0.85.

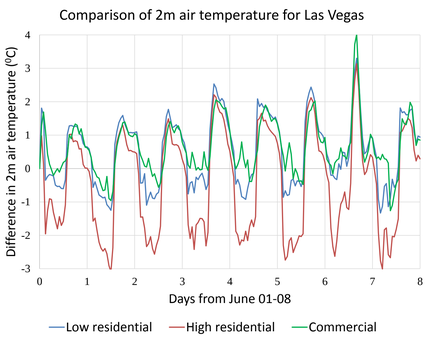


Impact of Land Use Change



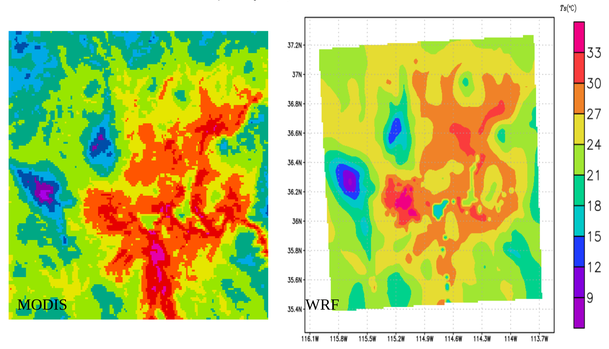






Validation

Comparison land surface temperature between model results and observed data from MODIS for summertime in Las Vegas (10 pm)



Findings and Conclusion

- The model results nearly approximate the observed data obtained from the satellite images (above).
- The average and maximum values of the difference between 2m air temperature(^{0}C) of June (01-08) 2010 and 2100 are given by:

Urban Categories	Low Residential		High Residential		Commercial	
Domains	Average	Maximum	Average	Maximum	Average	Maximum
Phoenix	0.816	3.628	-0.23	4.005	1.07	3.807
Denver	0.13	2.008	-0.52	1.37	0.15	2.39
Las Vegas	0.506	3.3	-0.41	3.13	0.63	4.015

- Among the three cities, highest impact of land use change on temperature is observed in Phoenix and Denver shows the least impact.
- Future work includes simulation of urban hydroclimate for longer time period and in depth analysis and comparison for three cities.

References and Acknowledgement

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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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