How Do Variations in Heat Islands in Space and Time Influence Household Water Use?

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NEED FOR THE STUDY

The interaction between heat island effect and household water consumption is very complex, as water use , as water use is influenced not only by observable factors (such as temperature, housing characteristics, demographics, vegetation type etc.) but also by unobservable site specific micro level factors. A single-year cross sectional study cannot capture the dynamic interaction between water use and urban heat island effect. Only a longitudinal study can help to isolate the effect of the different contributory factors, and provide robust estimates of the impact of heat islands on residential water use.
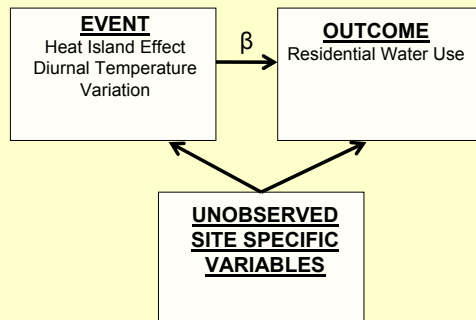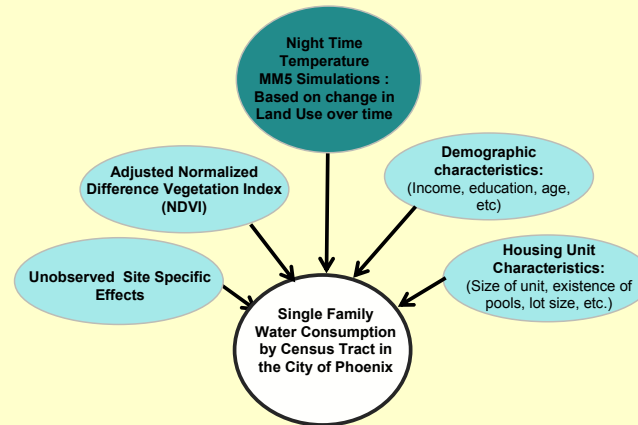
PREVIOUS WORK
Guhathakurta and Gober 2007

- Heat islands in Phoenix have been associated with an increase in summer nighttime temperatures of 3.9° F and afternoon temperatures of 1.1° F

- Over 30% of combined evapo-transpiration and evaporation was found to occur post sundown when the heat island is at a maximum

- Each percent rise in nighttime temperatures was found to increase water consumption of single-family residences by 2%

METHODOLOGICAL INNOVATIONS

- Landsat TM images are used to estimate change in land use in Phoenix over time (1990 | 1995| 2000)

- The change in land use is incorporated in the fifth-generation Mesoscale Meteorological Model (MM5) to estimate daily minimum and maximum 2 m air temperatures for the Phoenix metropolitan region

- Panel data analysis techniques are used to estimate the relation between heat islands and water consumption, after adjusting for the effect of unobserved variables
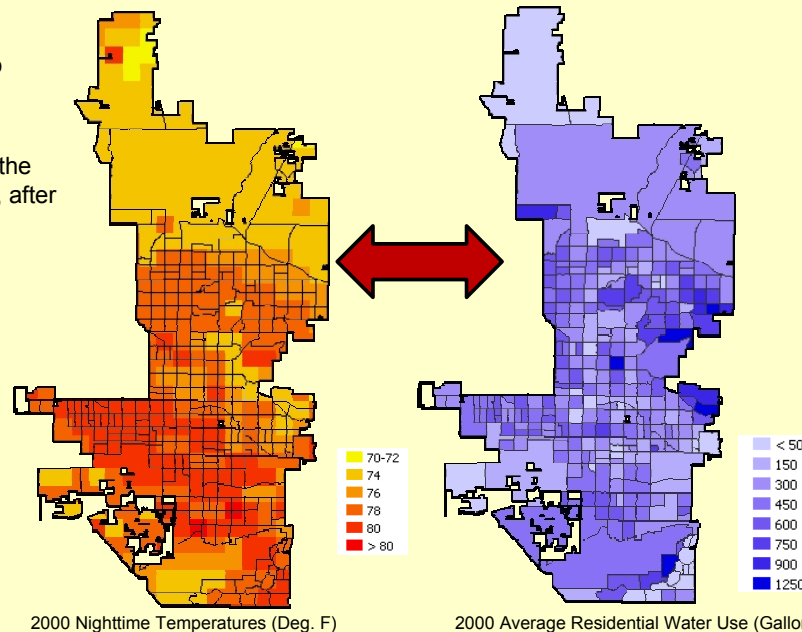

CONCEPTUAL FRAMEWORK: Panel data analysis

(center diagram)

Night Time Temperature MM5 Simulations : Based on change in Land Use over time

Adjusted Normalized Difference Vegetation Index (NDVI)

Demographic characteristics: (Income, education, age, etc)

Unobserved Site Specific Effects

Housing Unit Characteristics: (Size of unit, existence of pools, lot size, etc.)

Single Family Water Consumption by Census Tract in the City of Phoenix

DOES THE RELATIONSHIP BETWEEN HEAT ISLAND EFFECT AND WATER USE STAY ROBUST OVER TIME?

2000 Nighttime Temperatures (Deg. F)

Legend
70-72
74
76
78
80
> 80

2000 Average Residential Water Use (Gallons)

Legend
< 50
150
300
450
600
750
900
1250

MODEL ESTIMATION

$$Ln (SFWD_i) = K + a H_i + bD_i + c SV_i + d T_i + e_i$$

OUTCOME CONTROL VARIABLES EVENT UNOBSERVED EFFECTS

WHERE:-

i	=	Census tracts
SFWD	=	Average Single-Family Water Consumption in Census Tract
H	=	Characteristics of the housing units in tract -Size of unit, existence of pools, lot size, among others
D	=	Demographic characteristics of population in tract -Income, education, median age, among others
SV	=	Adjusted Normalized Difference Vegetation Index (NDVI) -a measure of vegetation cover
T	=	Minimum temperature in tract -derived from simulations with fifth generation MM5 model
E	=	random error term -Captures the effect of all the unobserved variables

EXPECTED RESULTS

- This project will provide a deeper understanding of the impact of changing land use patterns and urban heat island effect in Phoenix, and their relationships with residential water use

- Panel data analysis will provide robust estimates of the influence of urban heat island effect on residential water use compared to previous studies

References
Guhathakurta, S. and Gober, P. (2007). The Impact of the Urban Heat Island on Residential Water Use: The Case of Phoenix Metropolitan Area. *Journal of American Planning Association.*