Simulating the urban heat island of Greater Houston, Texas

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“The System for Integrated Modeling of Metropolitan Extreme Heat Risk (SIMMER)”

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Motivation and Goals

• Urban extreme heat and climate change are public health concerns
  – Observed impacts
  – Projected changes in extreme heat events

• Impacts (adverse health outcomes) are distributed unevenly
  – Societal vulnerability

• Relationship between human health and extreme heat is a complex medical, social and environmental issue
  – Information is needed for public health interventions and climate adaptation

• Advance methodology for assessing current and future urban vulnerability from heat waves through integration of physical and social science models, research results, and remote sensing data; Provide actionable results.
Integrating diverse data into spatial heat-health models

Multi-level map of extreme heat vulnerability

Heaton et al. (submitted to Spatial and Spatio-Temporal Epidemiology)
Population exposure and sensitivity to heat

- Focus on Houston, TX
- Quantitative analysis of spatial and temporal patterns of vulnerability indicators
- Incorporate high-resolution numerical models, satellite data, parcel data, census data, survey data and health outcomes into a spatial statistical model for public-health end-points
Land surface model simulations of Houston’s urban heat island.

- Employ the offline version of the Noah LSM, called “HRLDAS”; 1-layer UCM
- Driven by the NLDAS-II forcing fields
- Use of 30-m Nat. Land Cover Database to specify 3 urban types
- Treatment of urban land use fraction explicitly with NUDAPT (Ching et al. 2009)
  - This 2D treatment provides more realistic spatial depiction of heat island over the default 3-category urban “look up table” treatment (e.g., Salamanca et al. 2011)
- Performed 21 years of 1-km simulations; daily summary fields compiled from hourly output and used for vulnerability mapping
- Validation versus weather stations and MODIS imagery
1-layer Urban Canopy Model

Kusaka et al. (2001)
Simulations of the Houston Heat Island
August 2010 Average 2-m Temperature

Daytime

August 2010 Average Daily Cycle of Air Temperature over Houston, TX

Nighttime

August 2010 Average Daily Cycle of Air Temperature over Houston, TX
Local Scale: HRLDAS vs. Wx Obs

HNWA, Lat=30.0394, Lon=95.6739, LU=5, N=30

HALC, Lat=29.901, Lon=95.326, LU=31.0599, N=27

BAYP, Lat=29.6958, Lon=95.4992, LU=31.1316, N=30

HROC, Lat=29.7353, Lon=95.3156, LU=32.3181, N=30

DRPK, Lat=29.6697, Lon=95.1286, LU=31.1351, N=30
Day-minus-Night LST: 2006 July/Aug
48-day composite

HRLDAS

MODIS
Can we reduce uncertainty by adding complexity to our simulations?
Next Steps
Improving representation of urban land cover

- **Data source:**
  - Building information from the Houston city housing database ~1.36 million parcel records;
  - ~1.07 million residential buildings
  - ~188,000 commercial

- Use the database to determine the typical house properties by neighborhood

- Develop typical wall thermal and radiative properties by reconstructing wall types

- Added a scenario creation methodology to simulate different future scenarios – allows for policy simulations (e.g. insulation improvements, albedo change, etc.)

- Presently validating the data against the NUDAPT dataset.

Johan Feddema, U. Kansas
Parameterizing urban systems for use in models

Johan Feddema, U. Kansas
Future heat stress

NWS index; Mid-century climate simulations

Oleson et al. (submitted to Climatic Change)