Contribution of local background climate to urban heat islands

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Background: Urban Heat Island

Source: Oleson et al., 2008
Background: Urban Heat Island

- Multi-concepts of UHI
  - UHI in UCL – screen height temperature (UHIa)
  - UHI in UBL – air temperature within boundary layer
  - UHI at surface – skin temperature in the surface (UHIs)

- UHIs vs. UHIa

- Daytime vs. Nighttime
Method: Samples

- Selected cities
Method: Definition of UHI

- Atmospheric urban heat island
  \[ \text{Air UHI} = T_{2m,\text{urban}} - T_{2m,\text{rural}} \]

- Surface urban heat island
  \[ \text{Surface UHI} = T_{s,\text{urban}} - T_{s,\text{rural}} \]
Method: Data

- MODIS Aqua (Overpassing: 1:30 pm and 1:30 am)
  - LST: 8-day composite, 1km
  - NDVI: 16-day composite, 500m
  - Albedo: 8-day composite, 500m
  - 2003 to 2011

- Climatology
  - Precipitation
  - Air temperature

- Reanalysis: NARR

- Census
Method

- Remote sensing – MODIS LST
  - Surface UHI (UHIs)
    - Distinguish between daytime and nighttime

- Modeling – CESM
  - Surface UHI (UHIs) and screen height UHI (UHIa)
    - Offline 10 years’ simulation: 1995-2004

- Both analyzed on the annual scale – in the context of climatology
• Components:
  – land, atm, ocean, land ice, sea ice
  – coupler

• Land component: CLM4

• Component Set:
  – land: active
  – atm: data (Qian et al. 2006)
  – other components: stub

• Forcing: revised NCEP-NCAR reanalysis
Daytime UHIs
Spatial distribution of annual UHIs

Daytime MODIS Surface UHI

Yale
Spatial distribution of annual UHIs
Results

- Nighttime UHIs
Spatial distribution of annual UHIs

Nighttime MODIS Surface UHI
Spatial distribution of annual UHIs

Nighttime CLM Surface UHI
Annual UHI vs. Precipitation

The graph shows the relationship between annual mean nighttime surface UHI (in Kelvin) and annual mean precipitation (in millimeters) for two different models: MODIS and CLM. The data points are scattered across the plot, indicating variability in the relationship between UHI and precipitation for different sites or conditions.

Key Observations:
- There is a noticeable spread of data points, suggesting a wide range of UHI values across varying precipitation levels.
- The MODIS and CLM data sets appear to have different patterns, with MODIS showing a slightly higher spread at higher precipitation levels.

Further analysis or specific details about the data collection methods and sources are not provided in the image.
• Daytime & Nighttime UHIIa
Spatial distribution of annual UHIa
UHIs vs. UHIa

- Annual Mean Precipitation (mm)
- Annual Mean Daytime Air UHI (K)
- Annual Mean Daytime Surface UHI (K)

- MODIS
- CLM
Annual UHI vs. Precipitation

Annual Mean Precipitation (mm)

Annual Mean Nighttime Air UHI (K)
Results

• UHI in future
Data source: Oleson
Results

The graph illustrates the relationship between annual mean modeled daytime air UHI (K) and annual mean precipitation (mm). The data points are color-coded to represent different scenarios labeled as GMR, RCP8.5, RCP4.5, and RCP2.6. The trend line indicates a negative correlation, suggesting that higher precipitation is associated with lower UHI values.
Results
Conclusions

- Surface UHI and air UHI show opposite response to precipitation

- The physics of daytime and nighttime UHI show asymmetry
  - Daytime UHI is largely driven by background climatology
  - Nighttime UHI is driven by the city morphology

- Spatial sensitivity is different from temporal sensitivity
Thank you