

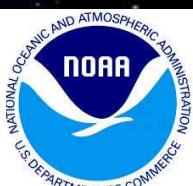
*Towards understanding the
hydro-climatic implications
of urbanization in the GFDL
global climate and earth
system modeling framework*



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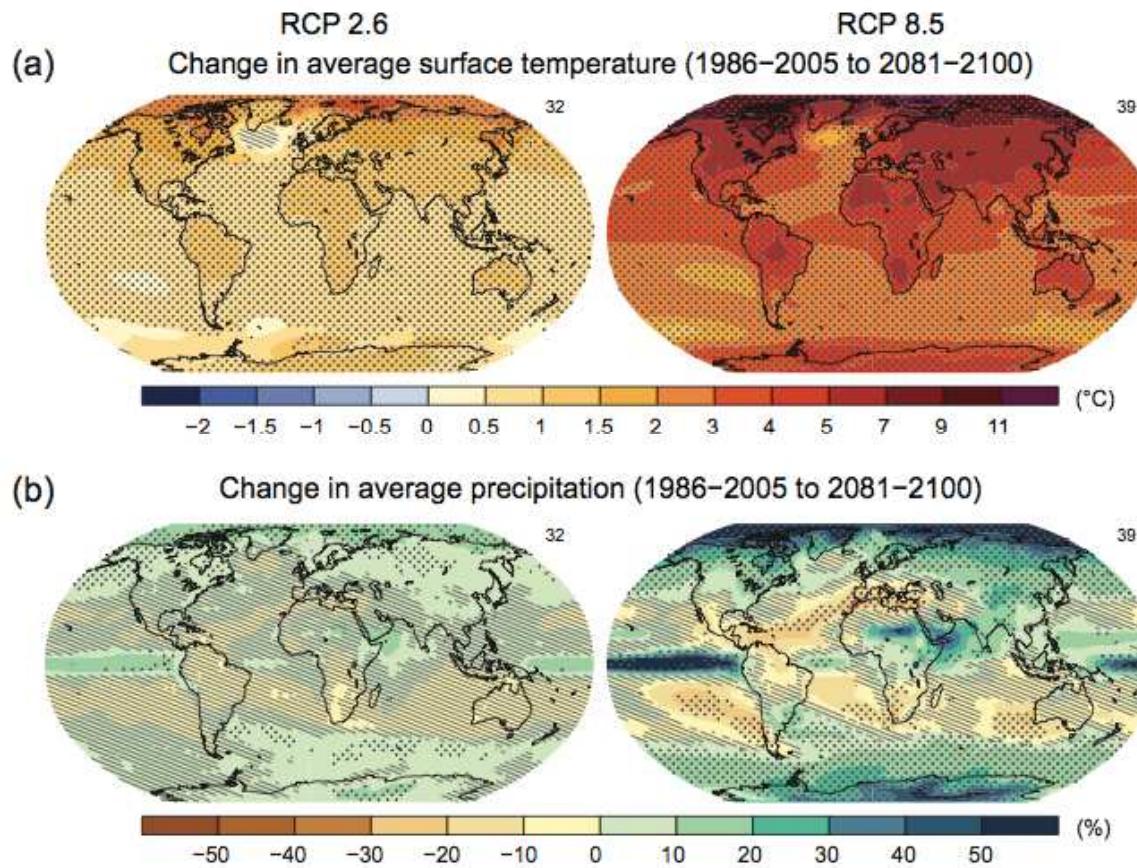


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Missing cities in global models

Introduction



Most global climate change simulations failed to account for urban areas where over 50% of the global population live.

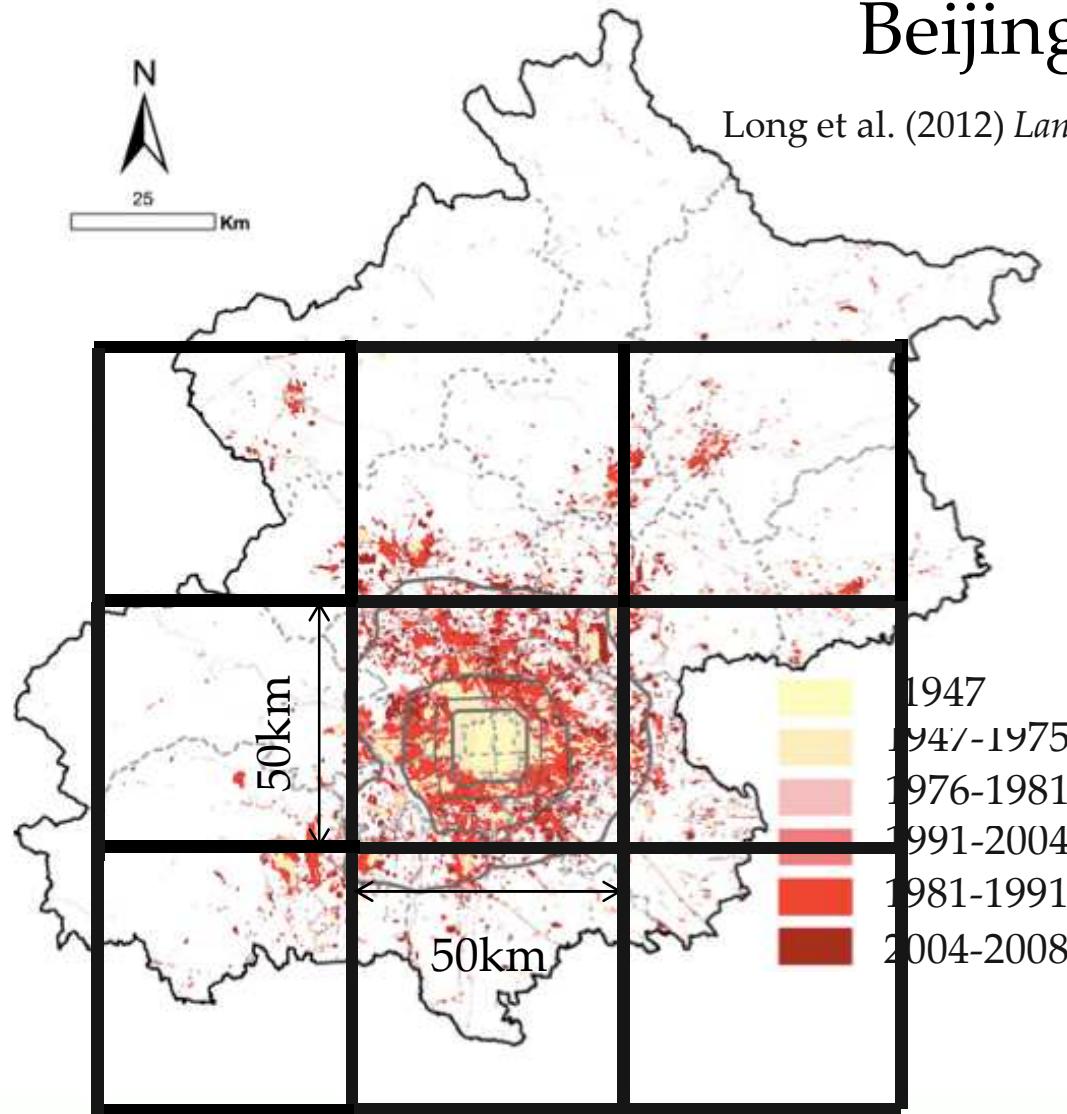
Cities are expanding

Introduction

Conceptualization
Methodology
Conclusion

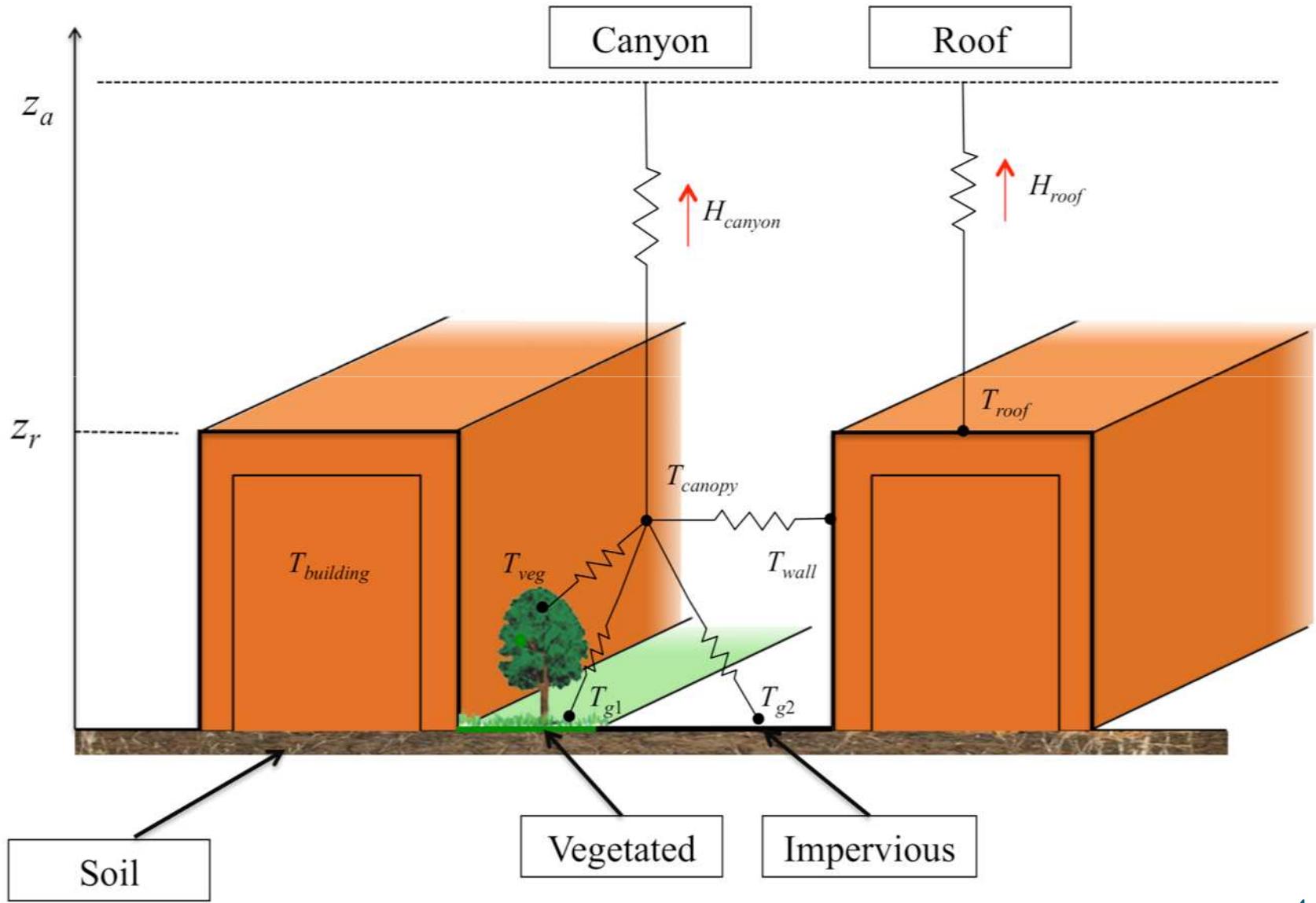
Beijing, China

Long et al. (2012) *Landscape and Urban Planning*



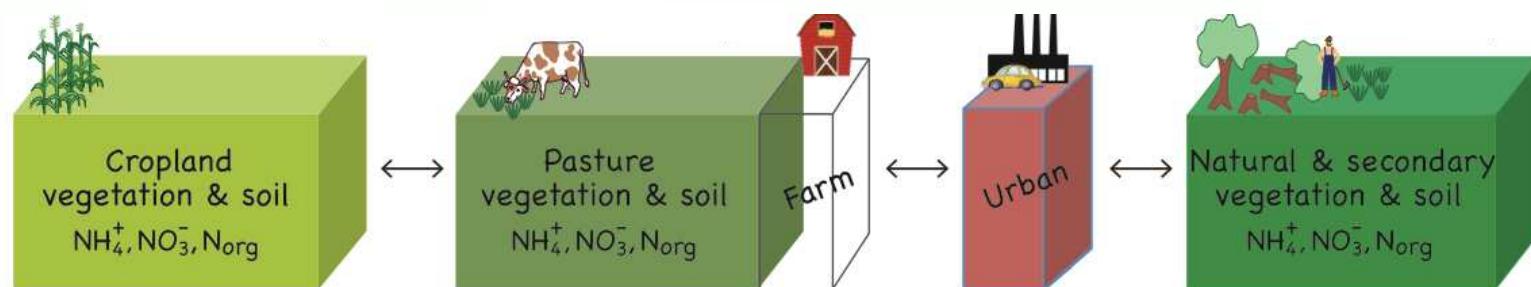
GFDL-Urban Canopy Model (UCM)

Introduction



Two unique features

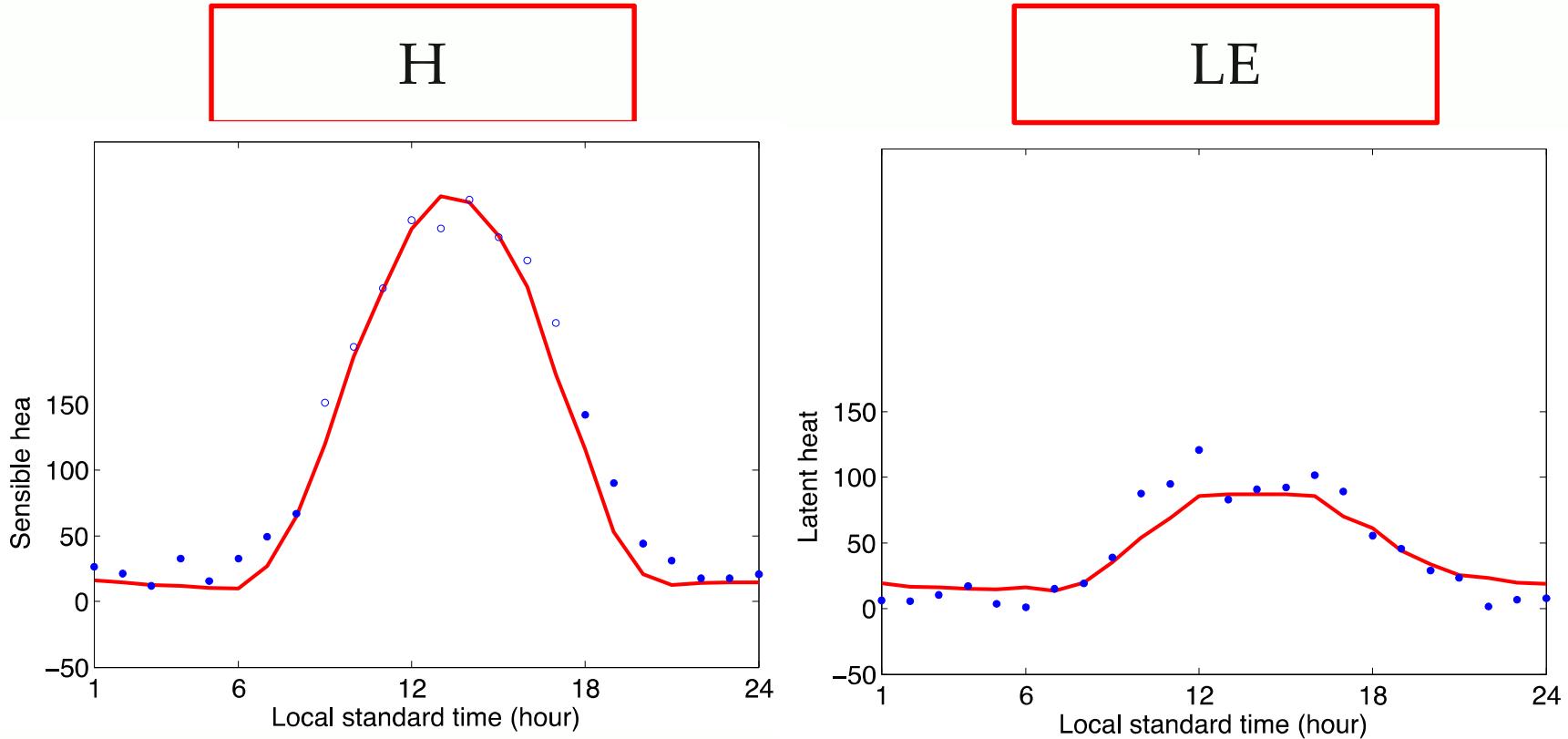
- Coupled to a dynamic vegetation model which allows investigations of the urban carbon cycle and vegetation management strategies (Shevliakova et al. 2009, GBC).
- Allows transition between urban and other land-use tiles with transition rates specified by external data sets used for IPCC simulations (Hurtt et al. 2011, Climatic Change).



Validation: H and LE

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Results



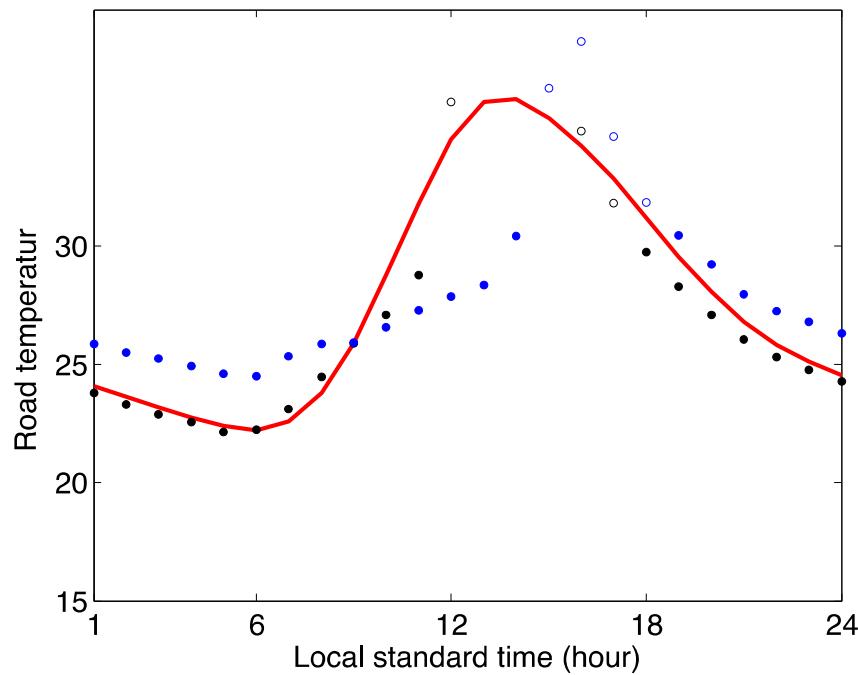
Data from Basel, Switzerland from June 10 to July 10, 2002.
Results here are averaged over 10 clear days.

Validation: Road and wall temperatures

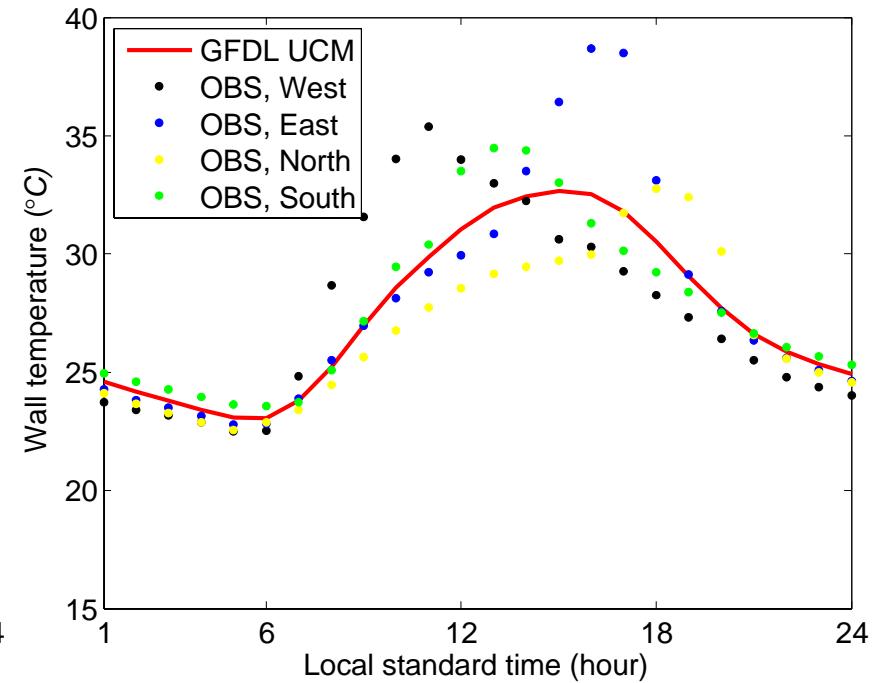
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Results

Road
temperature



Wall
temperature



Data from Marseille, France from June 28 to July 10, 2001.
Results here are averaged over the whole period.

Urban heat islands over the continental US

Results

- Atmospheric forcing is prescribed, taken from ESM2M outputs for CMIP5 (2 degree resolution).
 - The simulation is of 50 km resolution.
 - Urban properties from Jackson et al. (2010 AAAG).
 - Simulations from 1700 to 2100. The analyses focus on the period from 1861 to 2100.
 - The urban heat island effect is defined as the difference in daily-averaged canopy air temperature between urban canyon and natural vegetation.

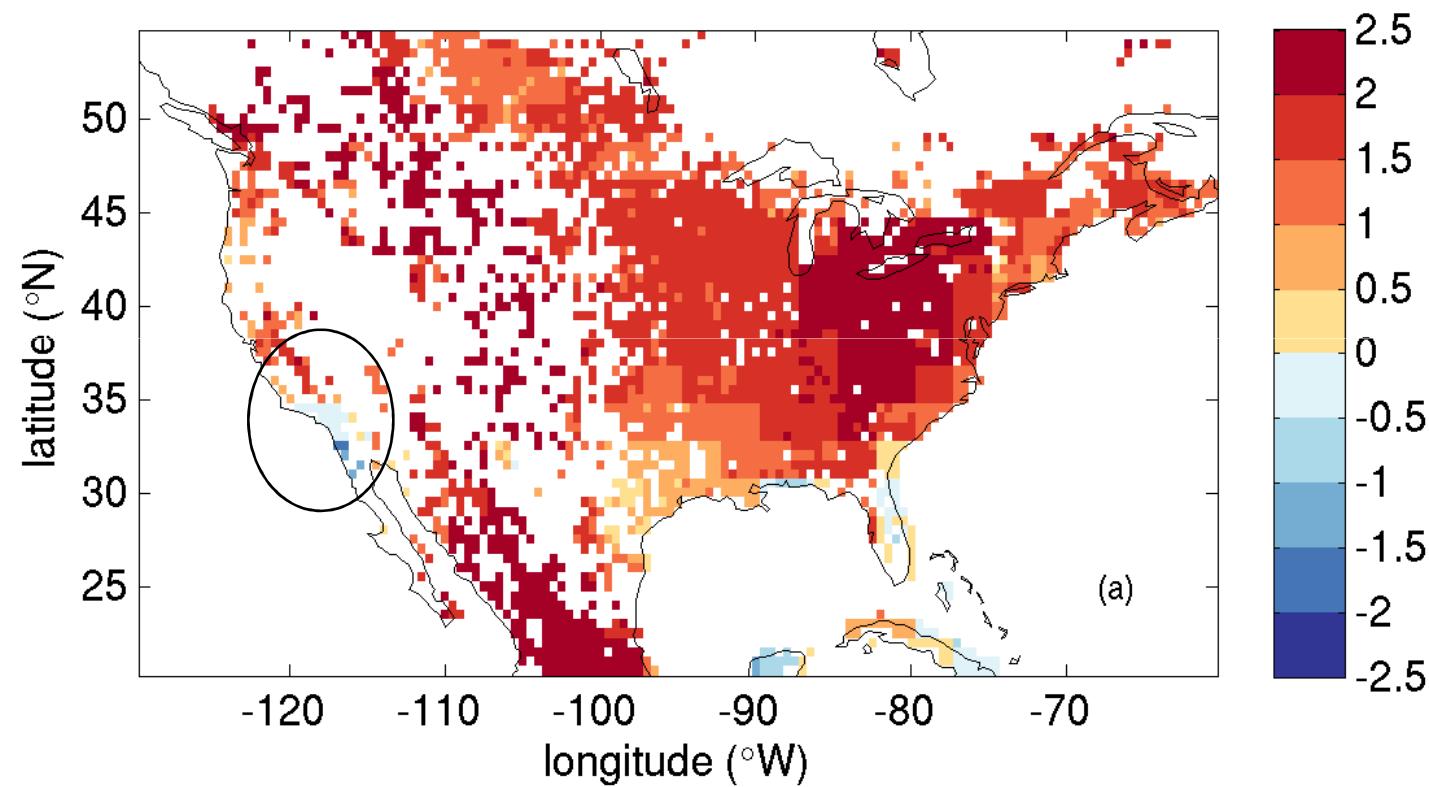
Summer urban heat islands in 1981-2000

Introduction

Results

Conclusions

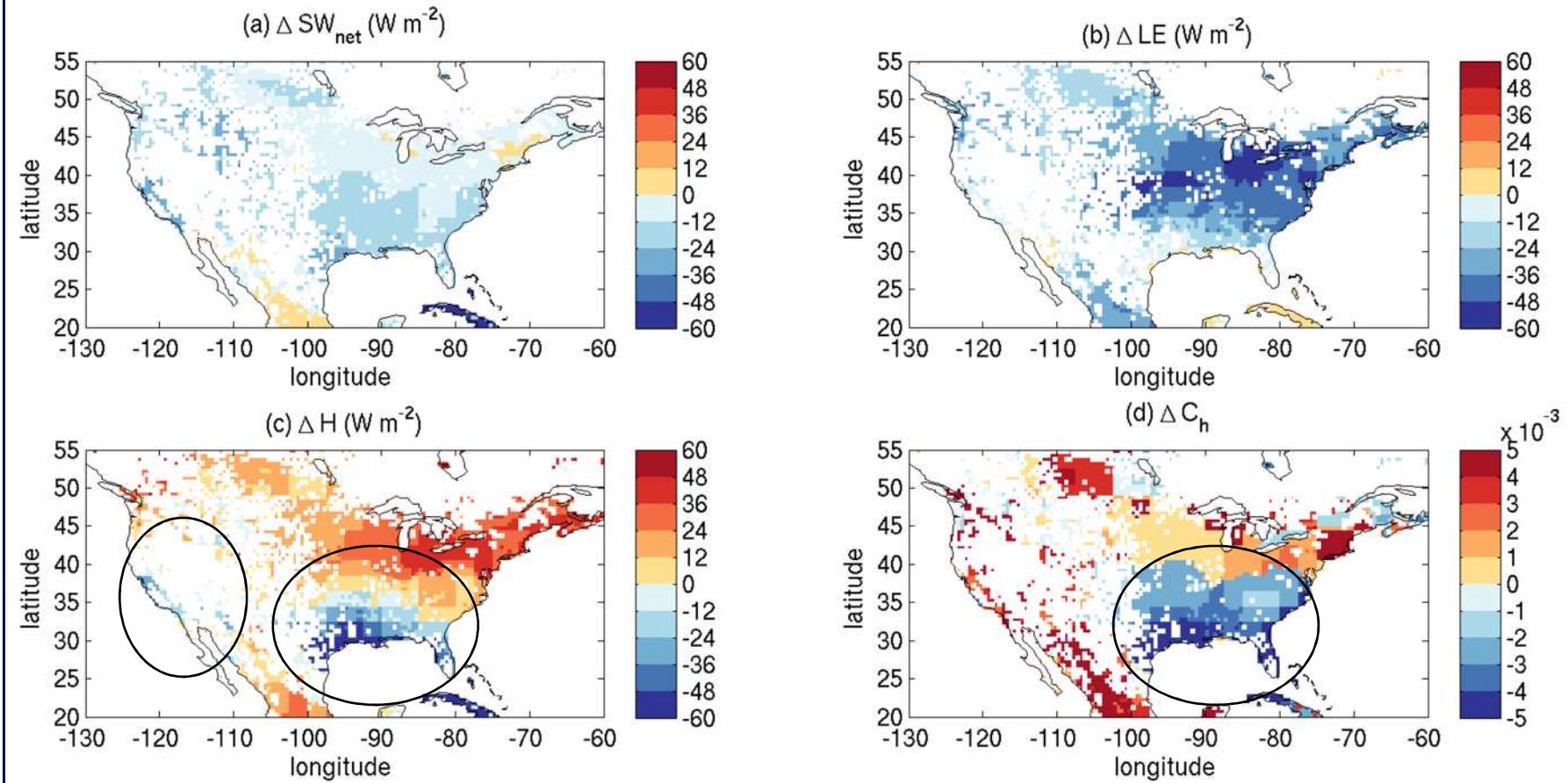
References



Blank areas are grid cells ($50\text{km} \times 50\text{km}$) that do not have any urban fractions.

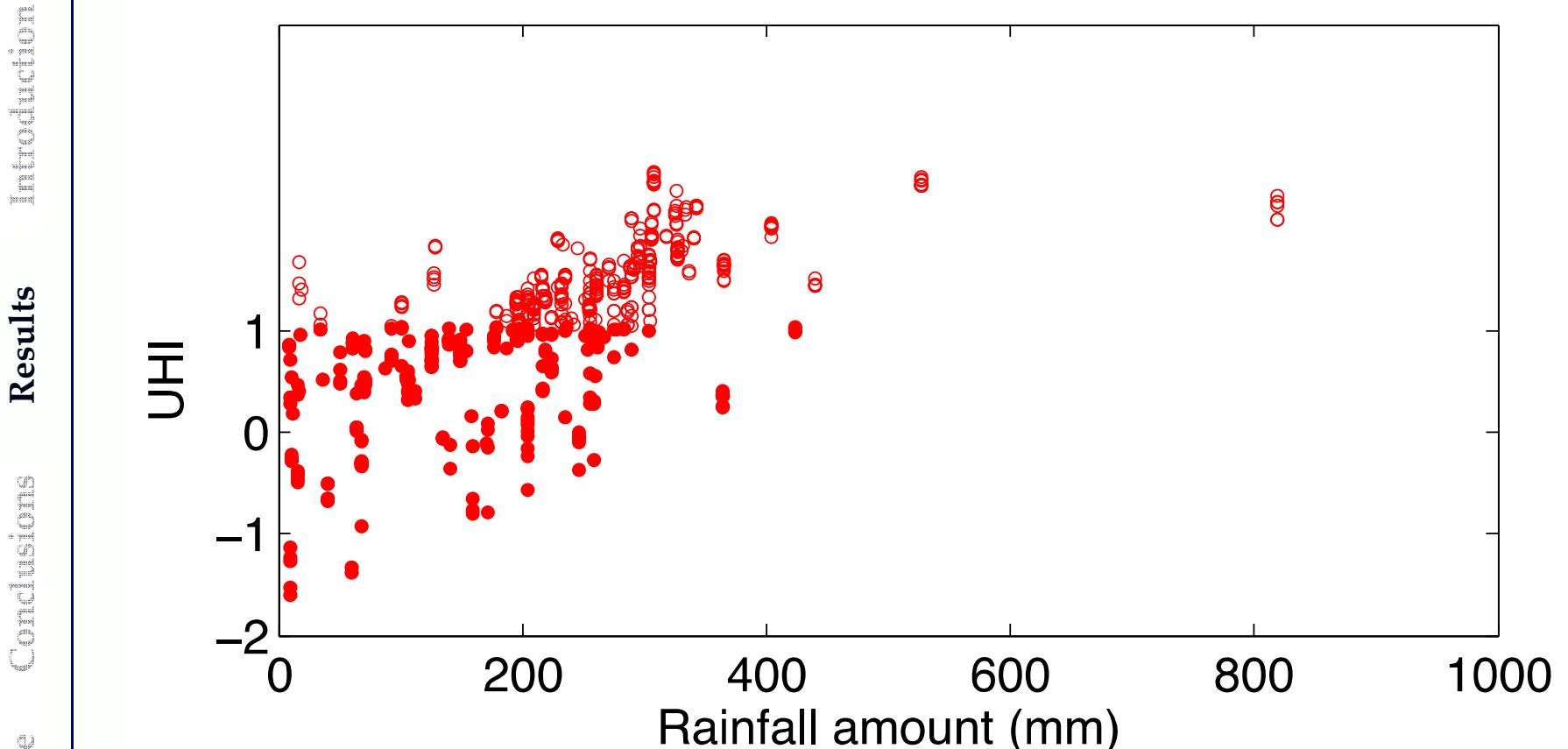
Results

Urban-rural contrasts in climate variables



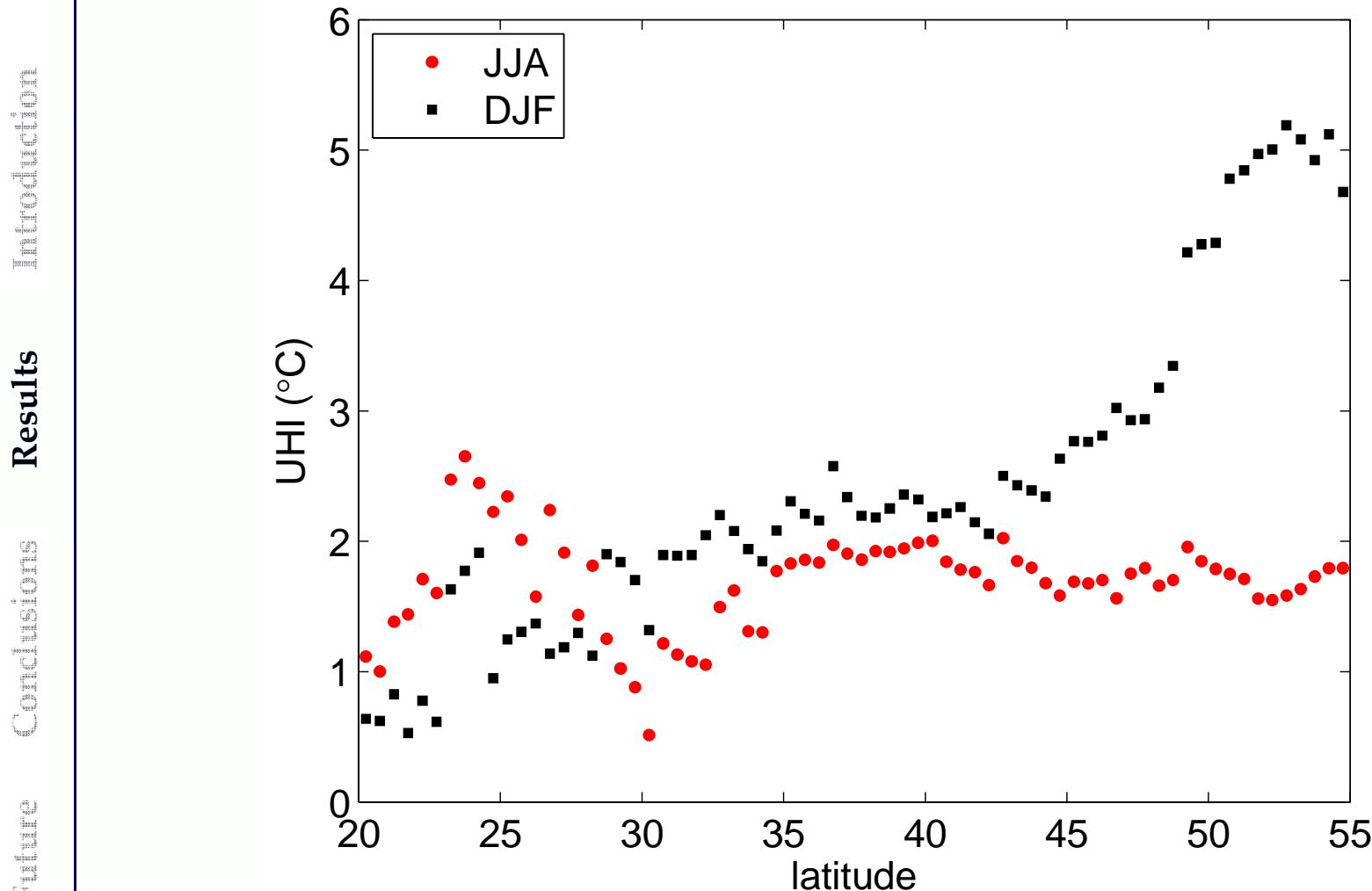
Urban-rural contrasts of (a) net shortwave radiation, (b) latent heat flux, (c) sensible heat flux, and (d) turbulent transfer coefficient.

Summer precipitation amount



Summer urban heat islands affected by the precipitation amount.

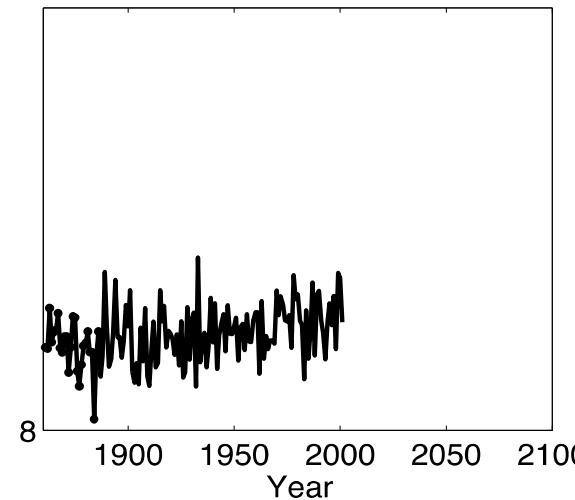
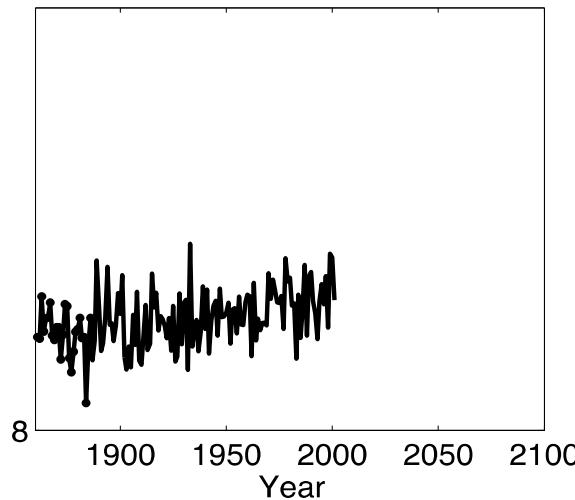
Zonally-averaged urban heat islands



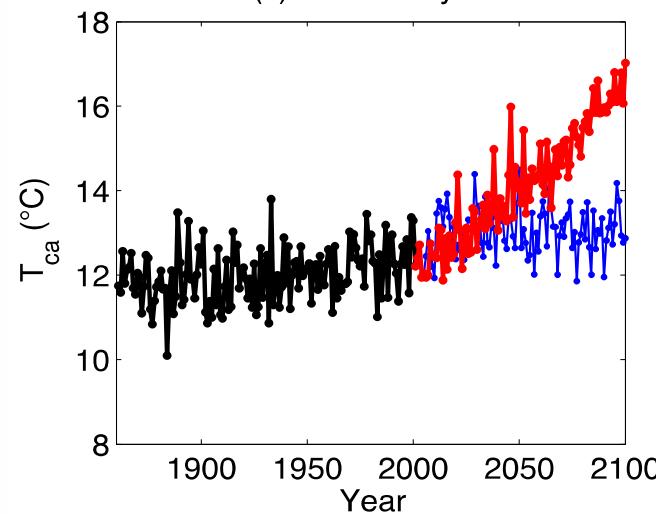
Strong latitude dependence of winter (DJF) urban heat islands.

Temporal trends

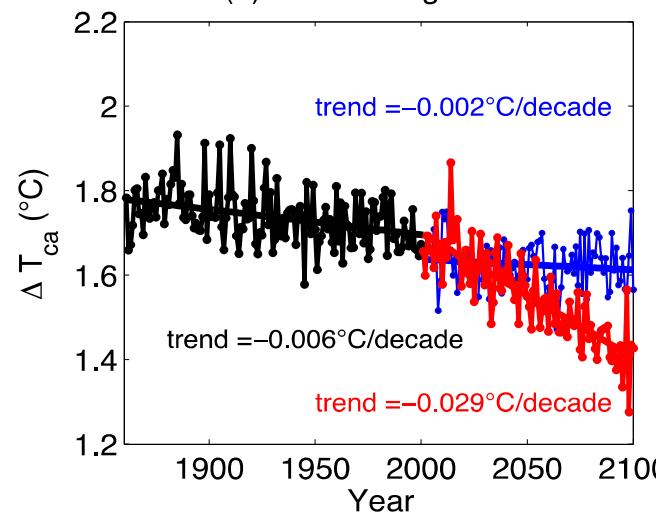
Results

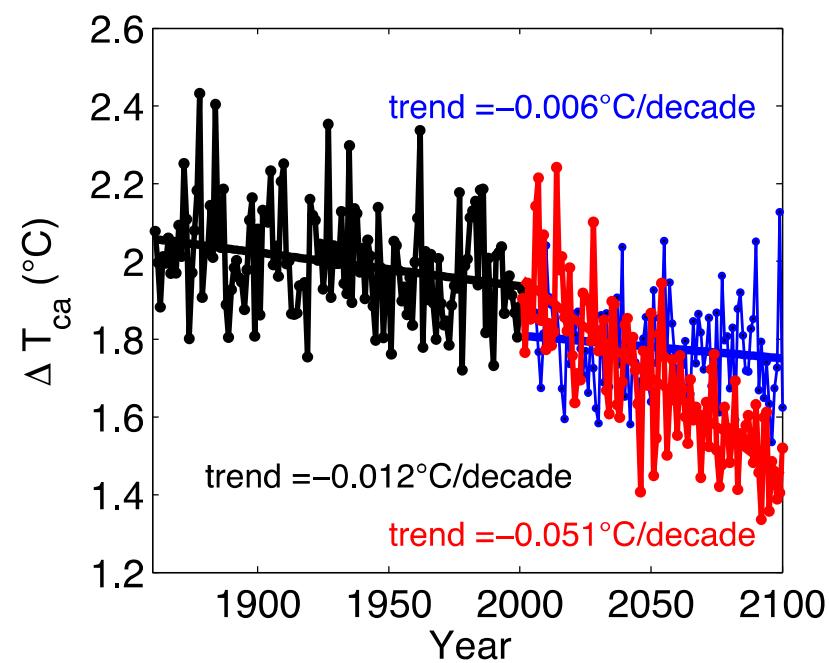


(c) urban canyon



(d) urban – vegetation





Summary

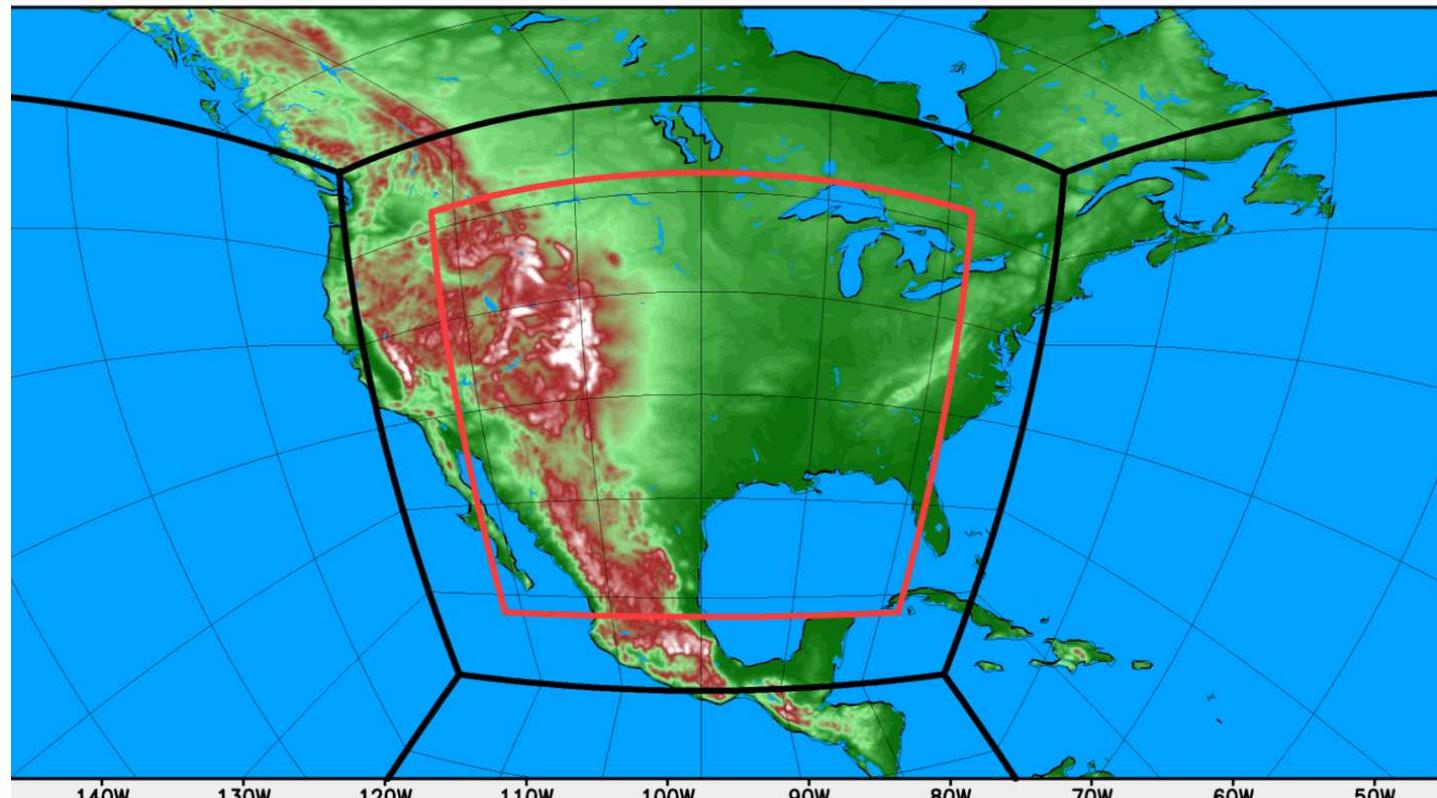
- ☞ An urban canopy model (UCM) is developed and validated.
- ☞ Summer UHIs over the continental US are strongly affected by the precipitation amount. Winter UHIs are more affected by the building heating.
- ☞ UHIs are projected to decrease primarily in the winter due to reduced heating requirements in a warming climate.

Future work

Future
Climate
Change
Projections

Harris and Lin(2013, MWR)
Harris and Lin(2014, JCLI)

Stretched + nested weather-climate model



Example: 3-5 km without the nest (black)
~1 km with a 2-way nest (red)

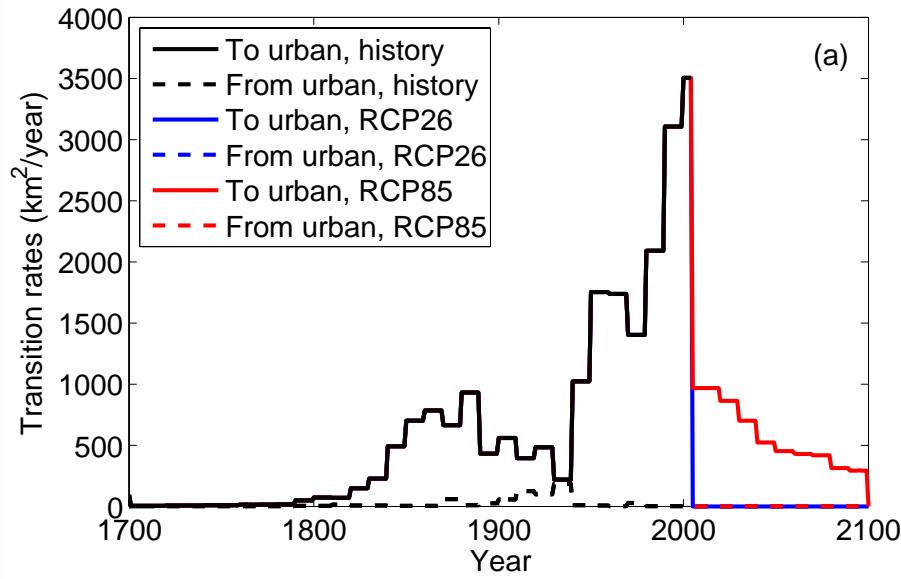
Urban fraction over the continental US

Introduction

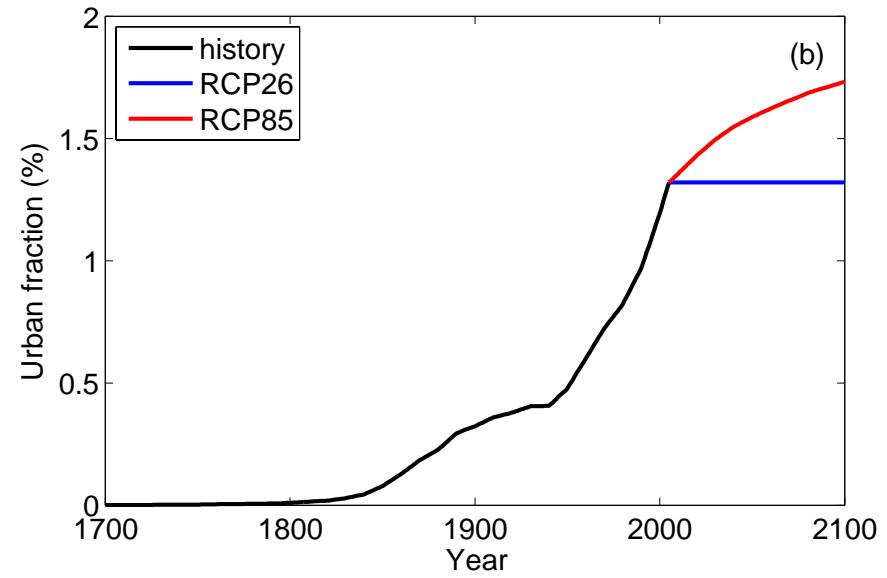
Background

Conceptualization

Implementation



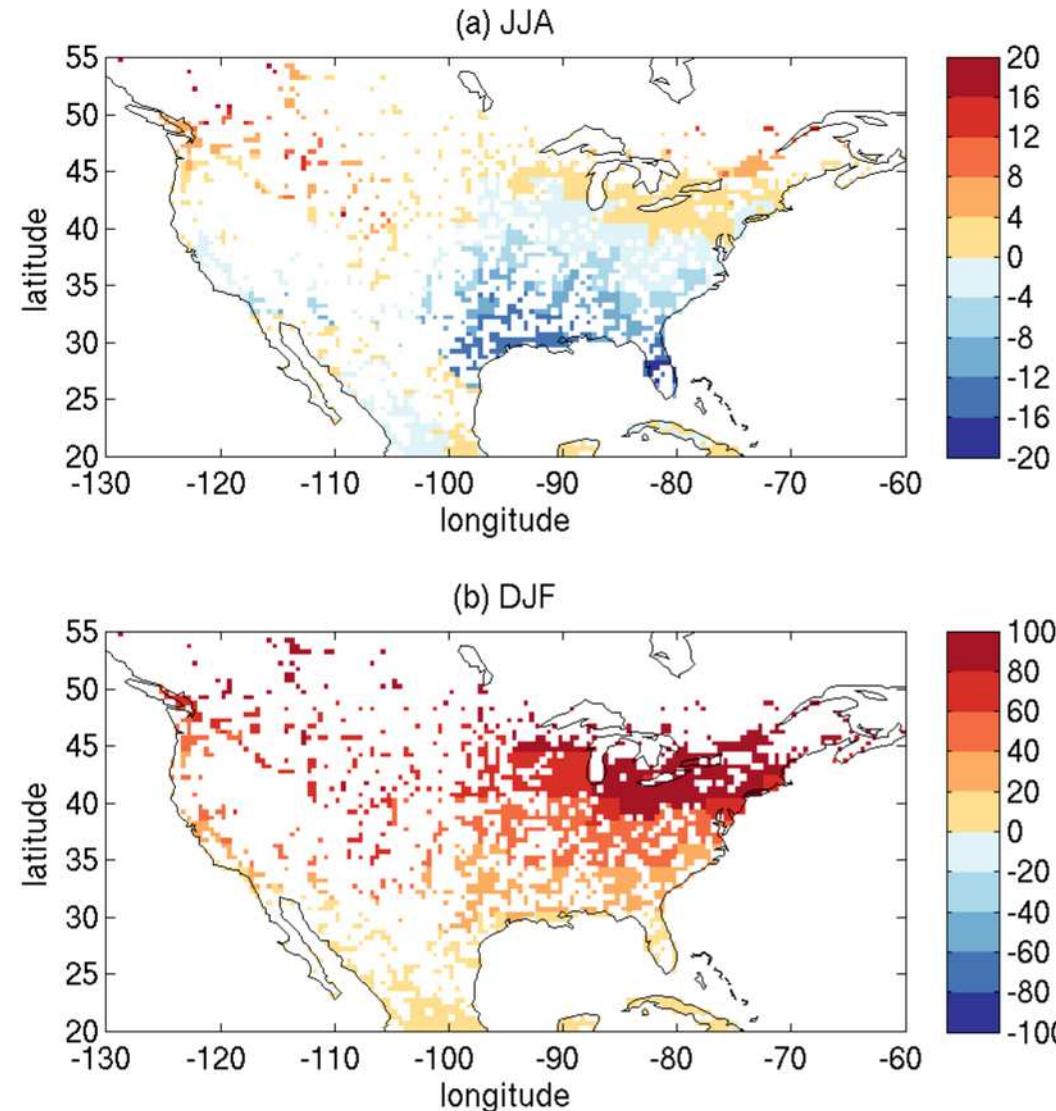
(a)



(b)

- 1, The urban fraction increases during 1800 to 2005 due to transitions from other land use categories.
- 2, The urban fraction no longer changes in RCP26 but increases in RCP85.

Heat flux entering (-) and leaving (+) buildings



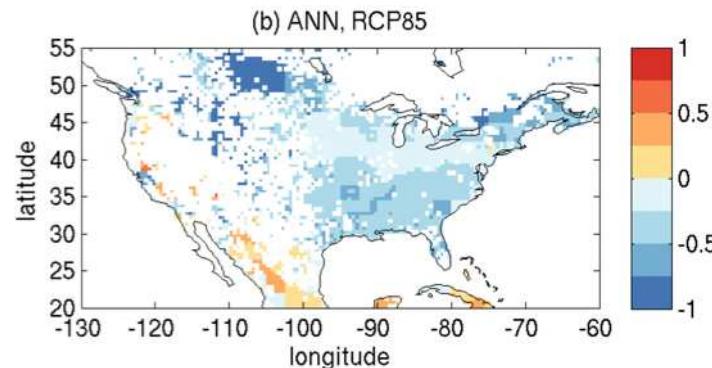
Changes in UHI between 2081-2100 and 1981-2000

Urban Heat Island
Urban Heat Island
Urban Heat Island
Urban Heat Island

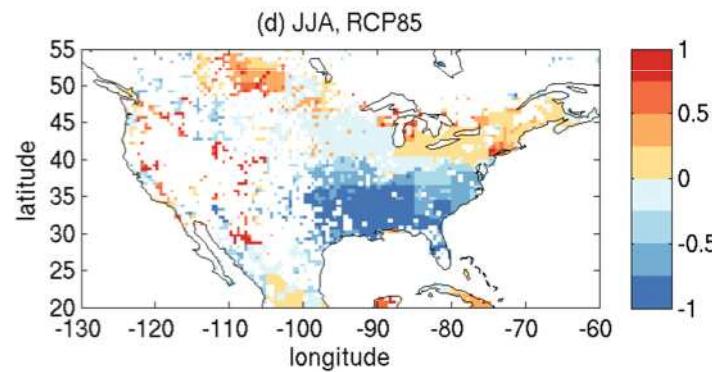
Results

Urban Heat Island
Urban Heat Island
Urban Heat Island
Urban Heat Island

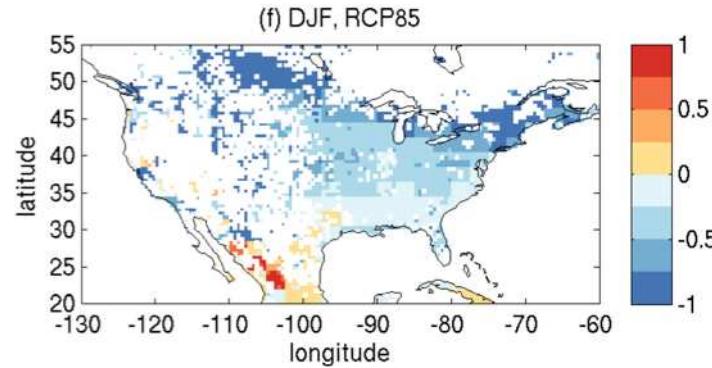
Annual



Summer



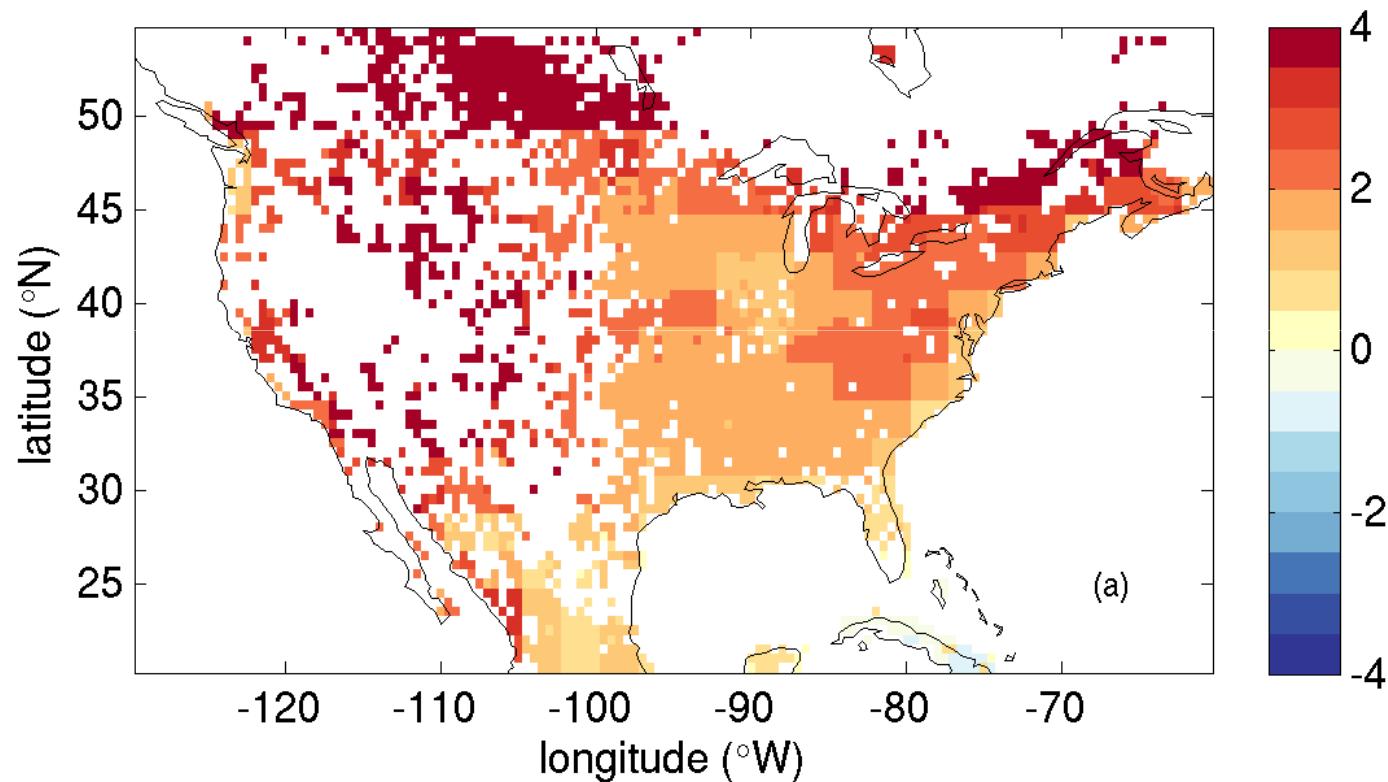
Winter



Winter (DJF) urban heat islands in 1981-2000

Urban Heat Islands

Results



Blank areas are grid cells ($50\text{km} \times 50\text{km}$) that do not have any urban fractions.