

## Surface urban heat island across 419 global big cities from satellites observations

Shushi Peng<sup>1</sup>, Shilong Piao<sup>1</sup>, Philippe Ciais<sup>2</sup>, Pierre Friedlingstein<sup>3</sup>,  
Catherine Ottle<sup>2</sup>, François-Marie Bréon<sup>2</sup>, Ranga B. Myneni<sup>4</sup>

<sup>1</sup> Department of Ecology, College of Urban and Environmental Sciences, Peking University, Beijing 100871, China

<sup>2</sup> Laboratoire des Sciences du Climat et de l'Environnement, CEA CNRS UVSQ, 91191 Gif-sur-Yvette, France

<sup>3</sup> School of Engineering, Computing and Mathematics, University of Exeter, Exeter EX4 4QF, UK

<sup>4</sup> Department of Geography and Environment, Boston University, Boston, MA 02215 USA

**Abstract:** Urban heat island is among the most evident aspects of human impacts on the earth system. Here we assess the diurnal and seasonal variation of surface urban heat island intensity (SUHII) defined as the surface temperature difference between urban area and suburban area measured from the MODIS. Differences in SUHII are analyzed across 419 global big cities, and we assess several potential biophysical and socio-economic driving factors. Our results emphasize the key role of vegetation feedbacks in attenuating SUHII of big cities during the day, in particular during the growing season, further highlighting that increasing urban vegetation cover could be one effective way to mitigate the urban heat island effect.

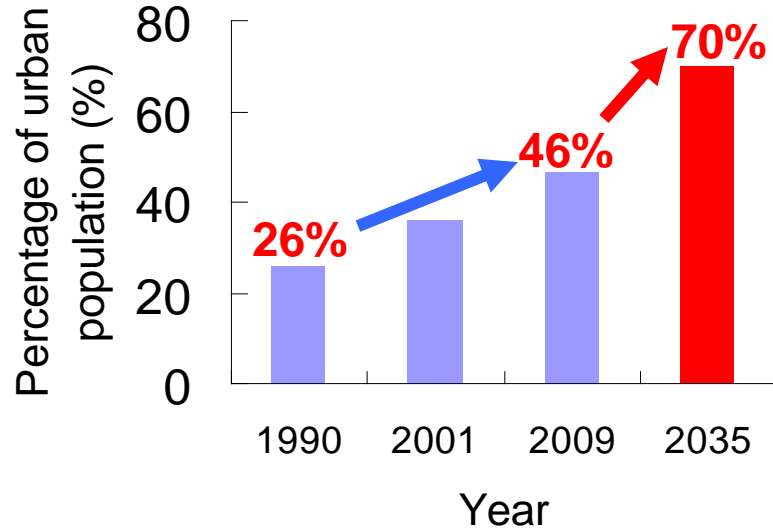
# Surface urban heat island across 419 global big cities

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**PKU and LSCE**

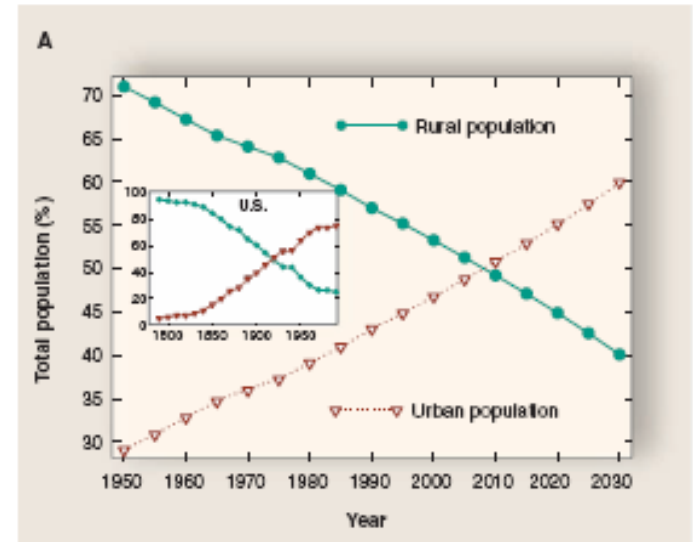
# Motivation

## China Urbanization



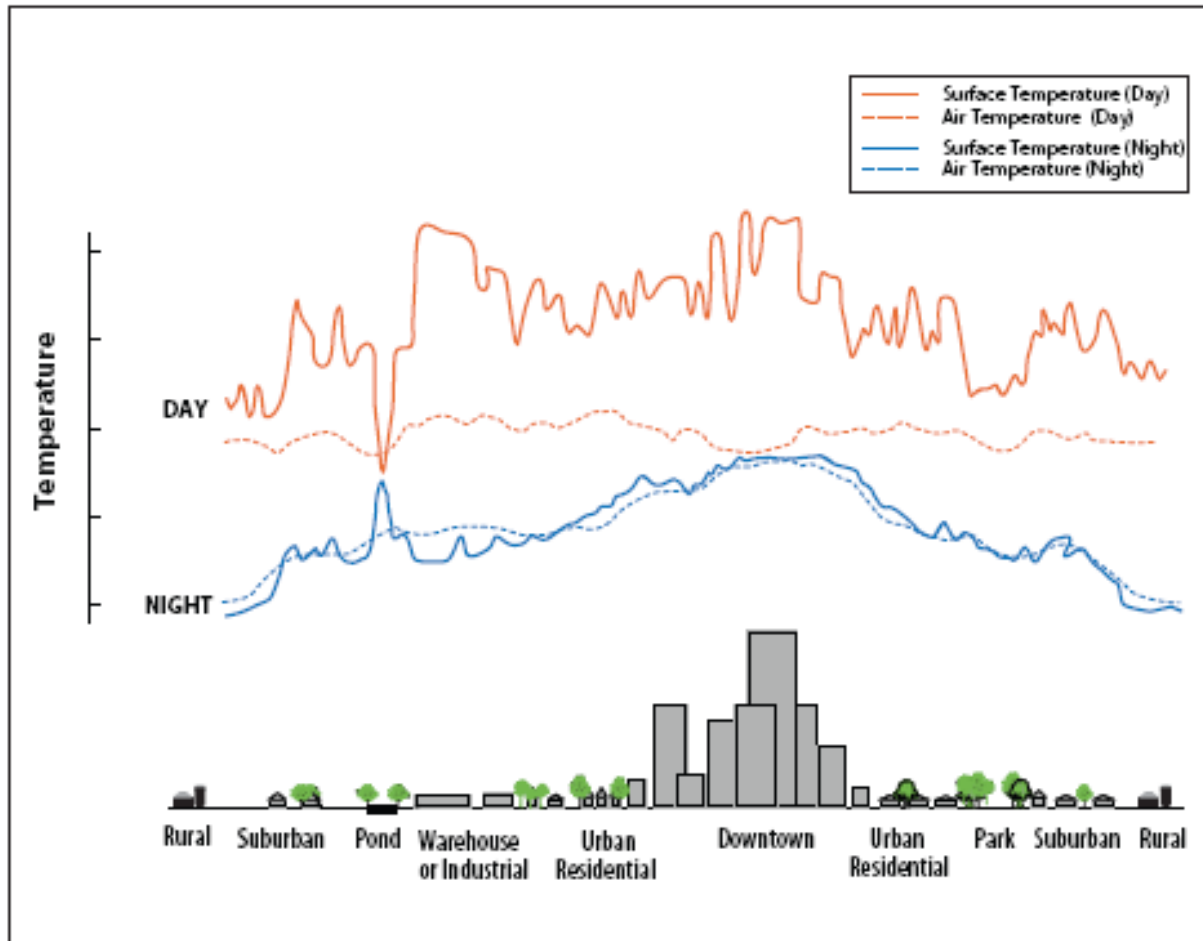
Data from UN

## Global Urbanization

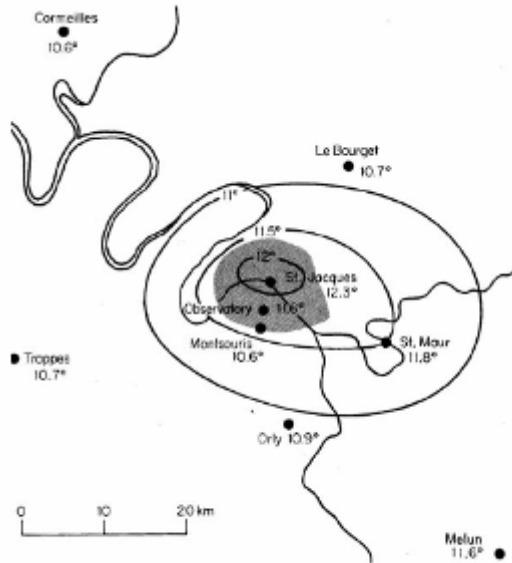


(Grimm et al., 2008)

# Urban heat island



from EPA (2004)



Mean annual surface temperatures for Paris and Surroundings (Crutchfield 1983)



**Urban heat island intensity (UHII) = Urban site – Rural site**

**How large area** one meteorological station can **stand for**, especially in so **complex** urban regions?

# Land surface temperature from Satellites

## Shanghai

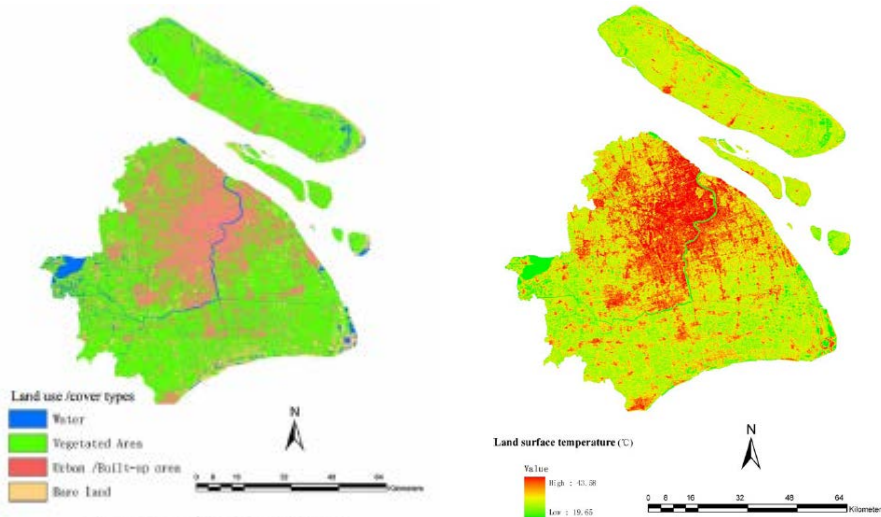
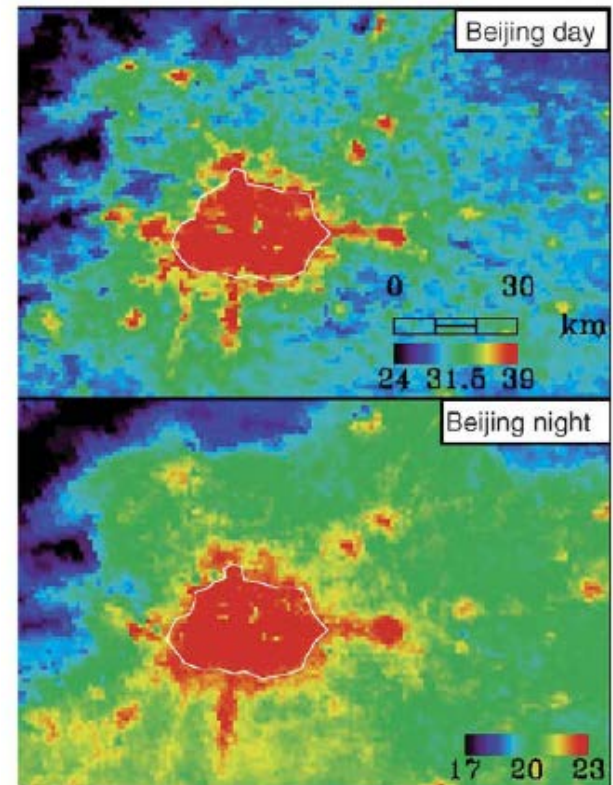


Fig. 3. LULC maps of Shanghai on 10 July 2004.

Fig. 5. Spatial pattern of LST<sub>2004</sub> in Shanghai.

(Li et al., 2009) Landsat TM/ETM



MODIS, 2006

# Data and Methods

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## Global big Cities:

428 global big cities with a population larger than 1 million in 2007

## Land Surface Temperature (LST):

MODIS Land Surface Temperature, 1km $\times$ 1km, 8 days, Daytime (~13:30) and Nighttime (~01:30), 2003-2008

## Global Land Cover Map:

MODIS Global Land Cover Map, 1km $\times$ 1km, 2004

# Datasets for biophysical variables

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## Vegetation:

- MODIS Vegetation Continuous Fields (VCF), 1km $\times$ 1km, 2004
- MODIS Enhanced Vegetation Index (EVI), 1km $\times$ 1km, 16 days, 2003-2008

## Albedo:

- MODIS White Sky Albedo (WSA), 1km $\times$ 1km, 8 days, 2005
- MODIS Black Sky Albedo (BSA), 1km $\times$ 1km, 8 days, 2005



# Datasets for socio-economic and climate variables

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## Population:

- Population, 5km × 5km, 2005 (GPWv3)
- Population density, 5km × 5km, 2005 (GPWv3)

## Nighttime light:

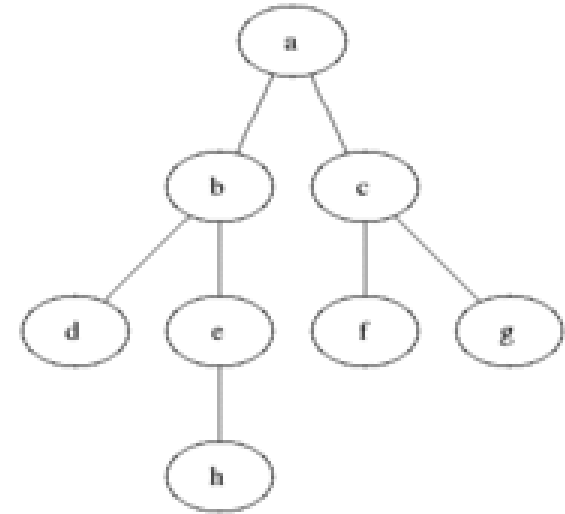
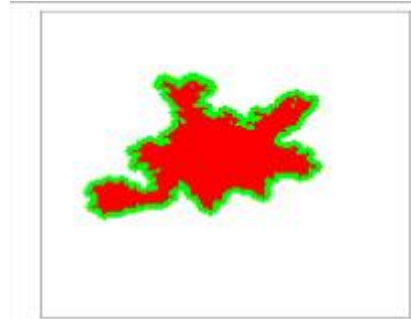
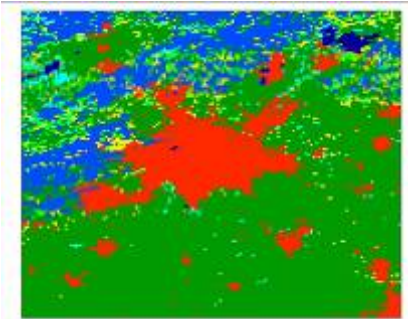
- 1km × 1km, 2003-2008 (NOAA/NGDC)

## Climate:

- Temperature and precipitation (CRU)

# Definitions of urban and suburban regions

## Breadth-First-Search Algorithm



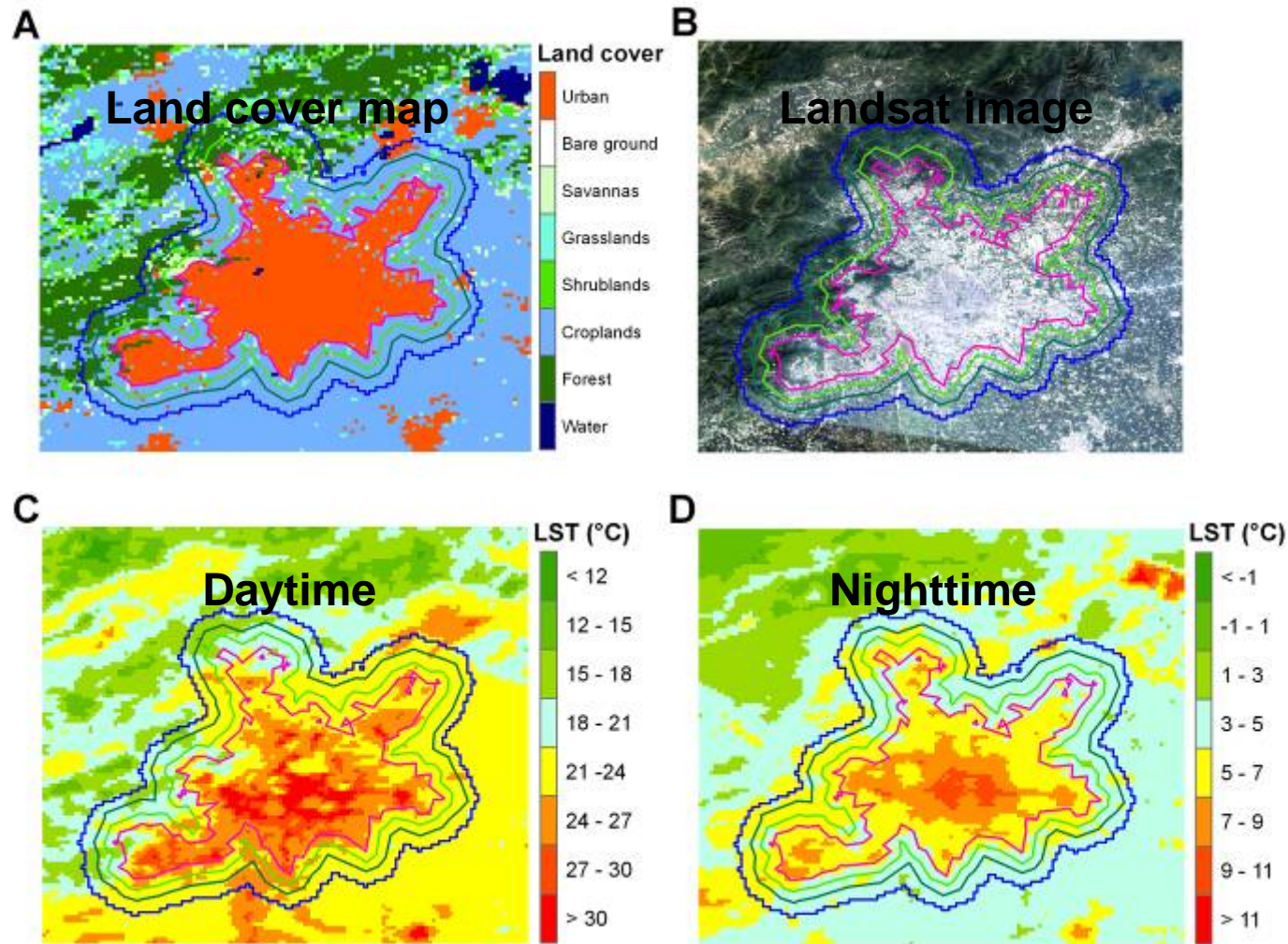
**Surface urban heat island intensity**  
**SUHII = Urban LST – Suburban LST**

Rozenfeld et al., (2008), PNAS

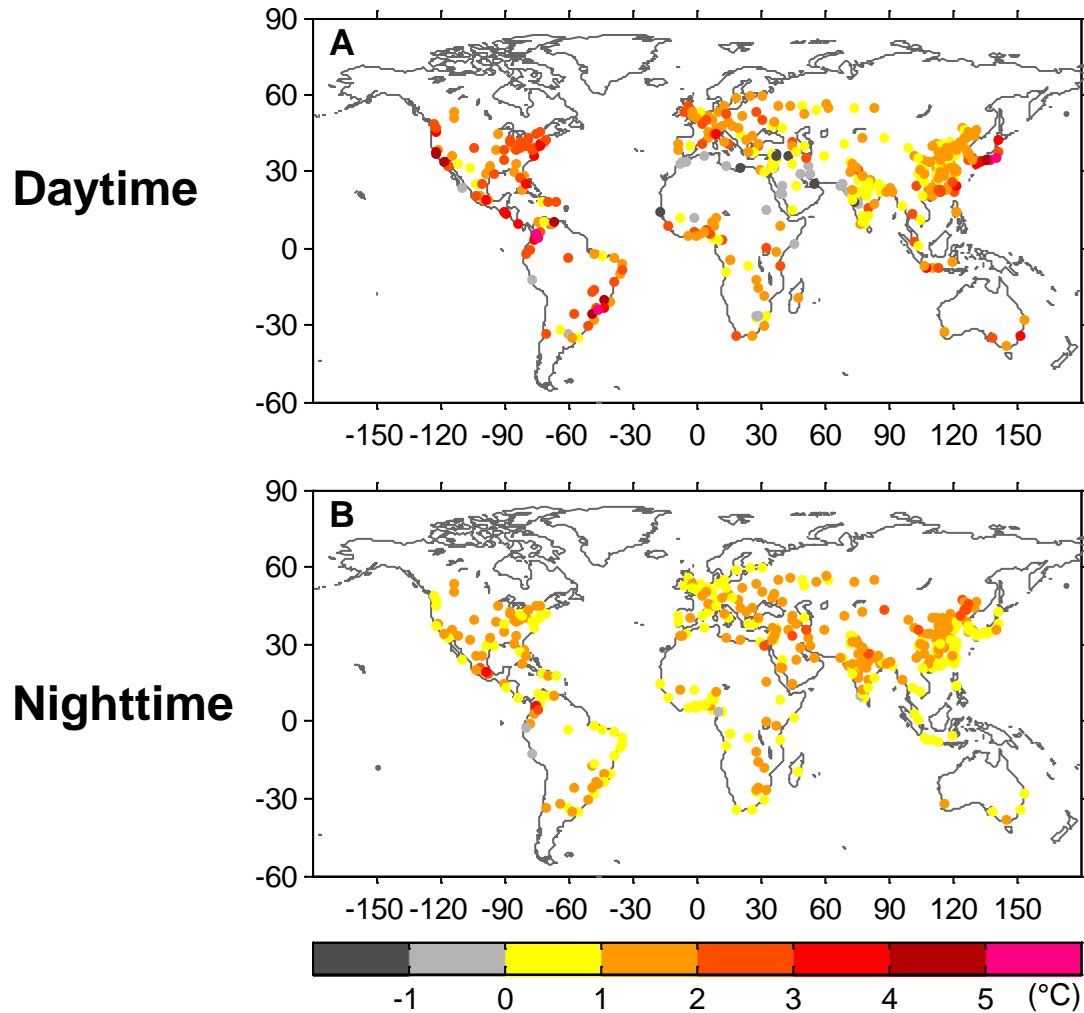
**$\delta VCF$ ,  $\delta EVI$ ,  $\delta WSA$ ,  $\delta NL$  and  $\delta PD$**

**MAT, MAP, MT0**

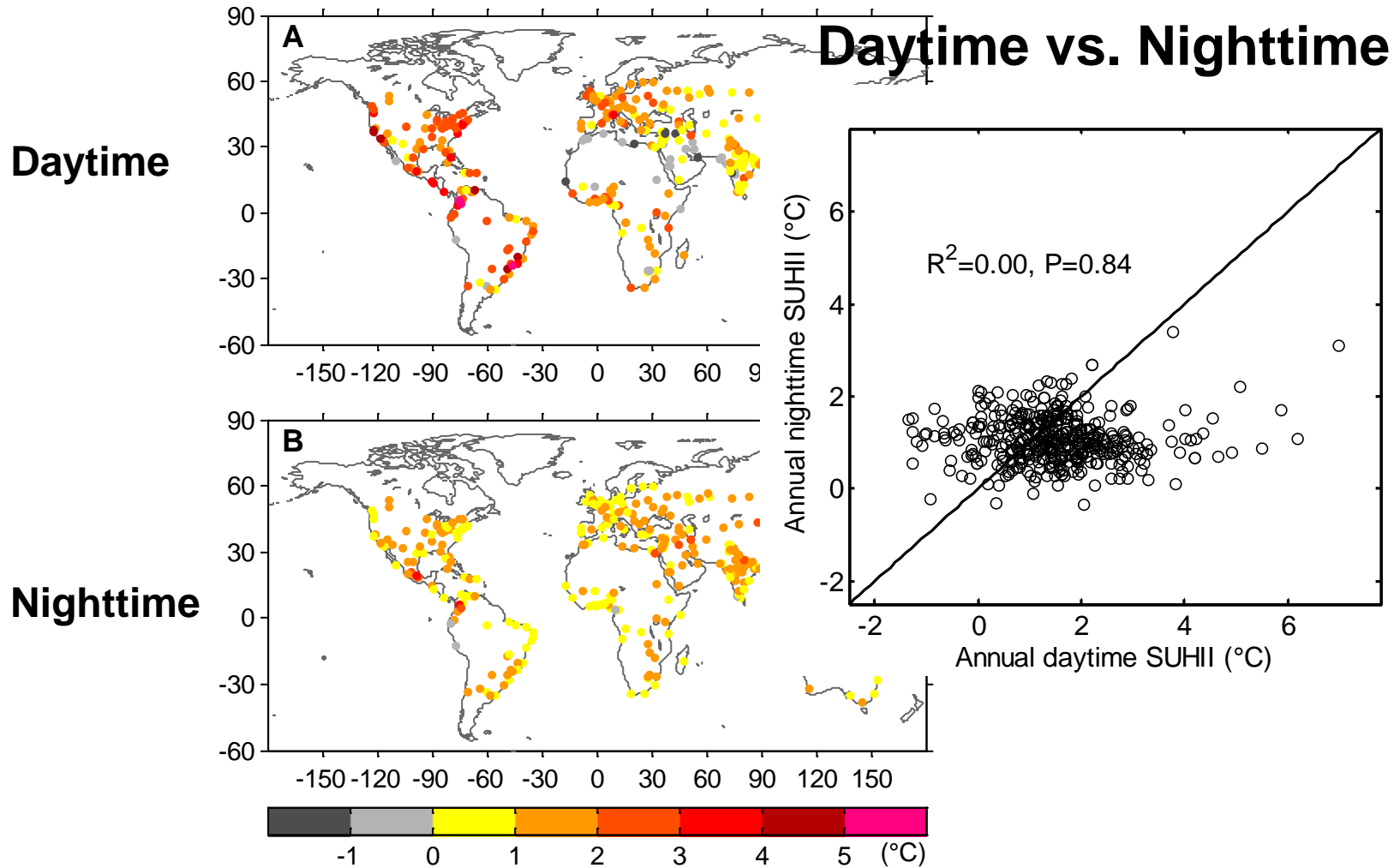
# Take Beijing for example



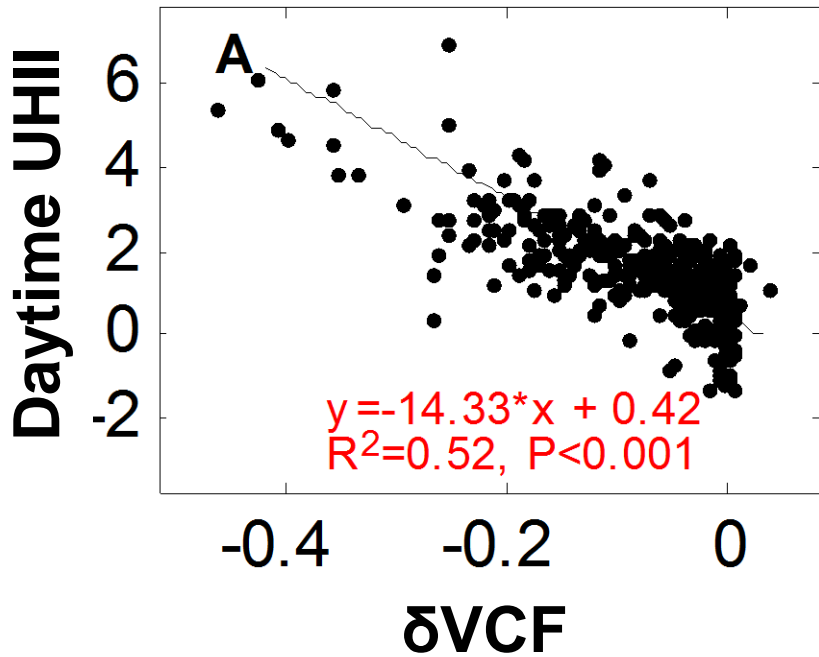
# SUHI spatial patterns



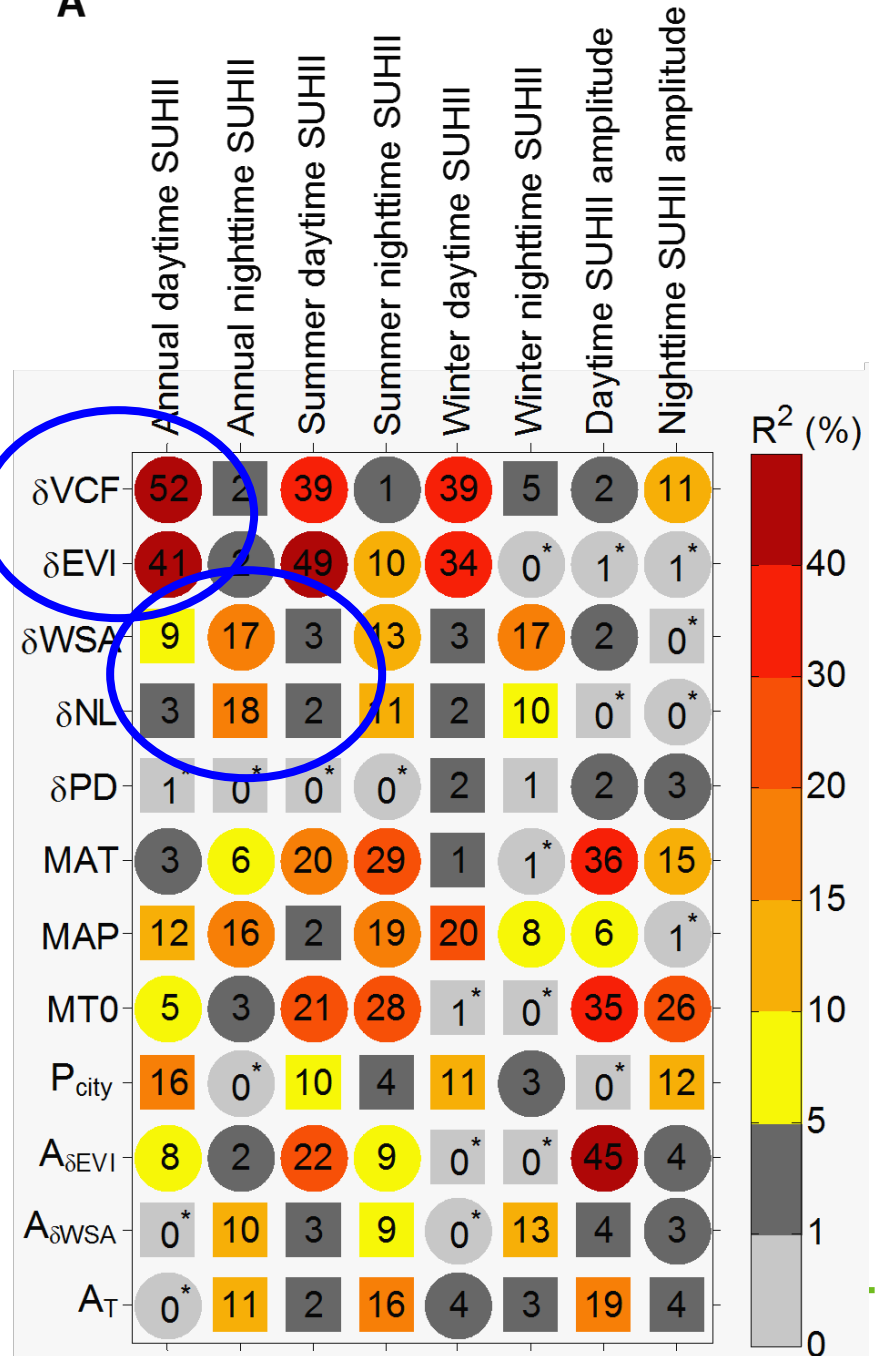
# SUHI spatial patterns



# Drivers summary I



A

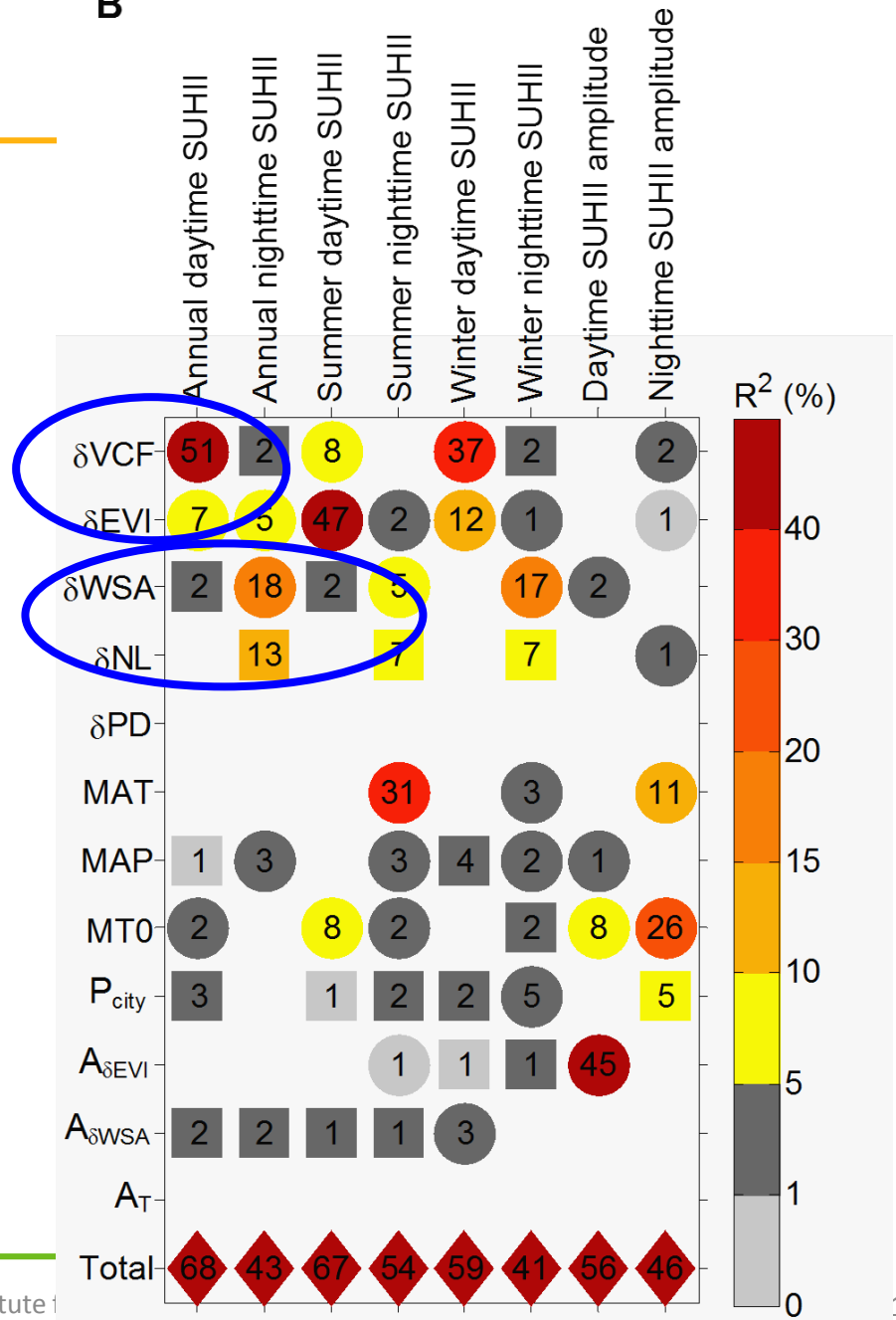


# Drivers summary II

● Vegetation fraction and activity can explain **60%** variance of daytime UHII

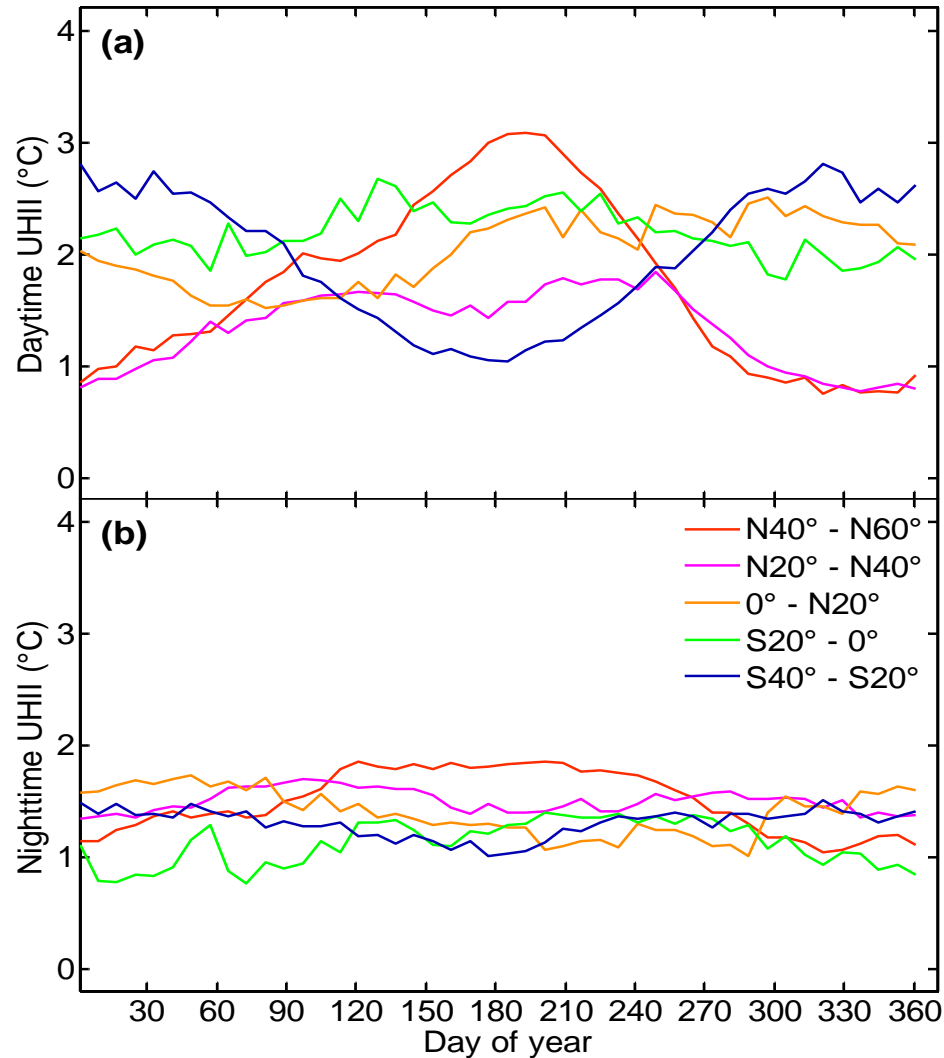
● Nighttime light and albedo can explain **31%** variance of nighttime UHII

B



# SUHI seasonal cycle I

Daytime

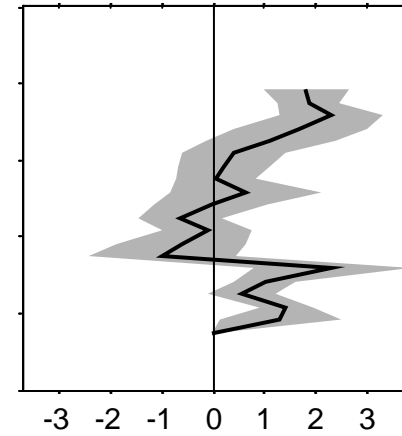
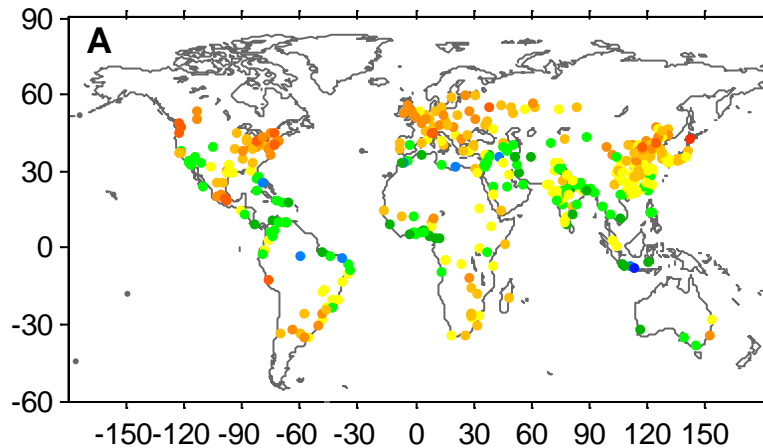


Nighttime



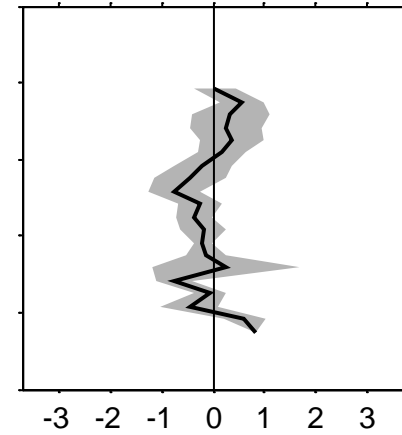
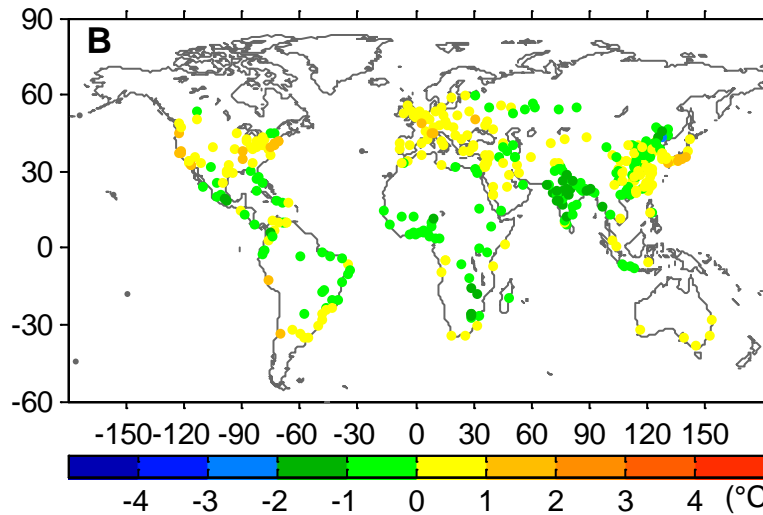
# SUHII seasonal cycle II

Daytime



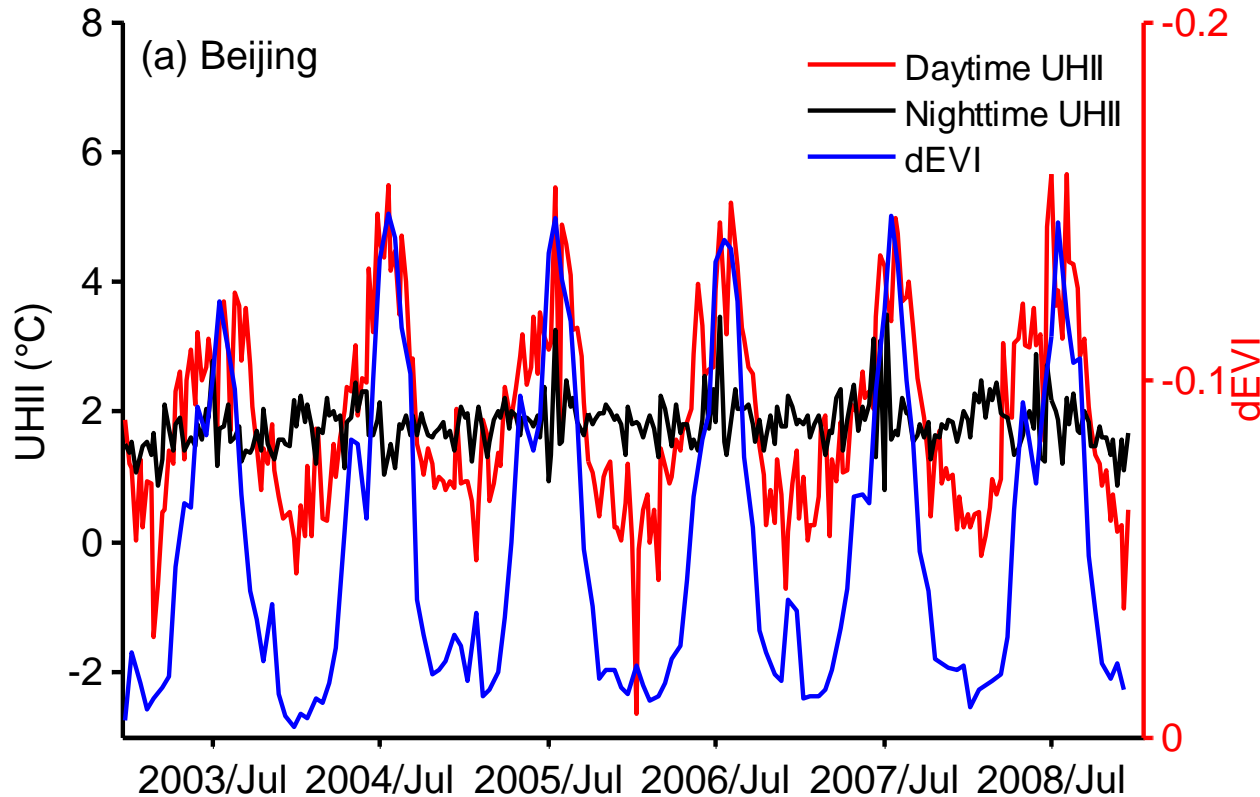
Daytime SUHII difference between summer and winter (°C)

Nighttime



Nighttime SUHII difference between summer and winter (°C)

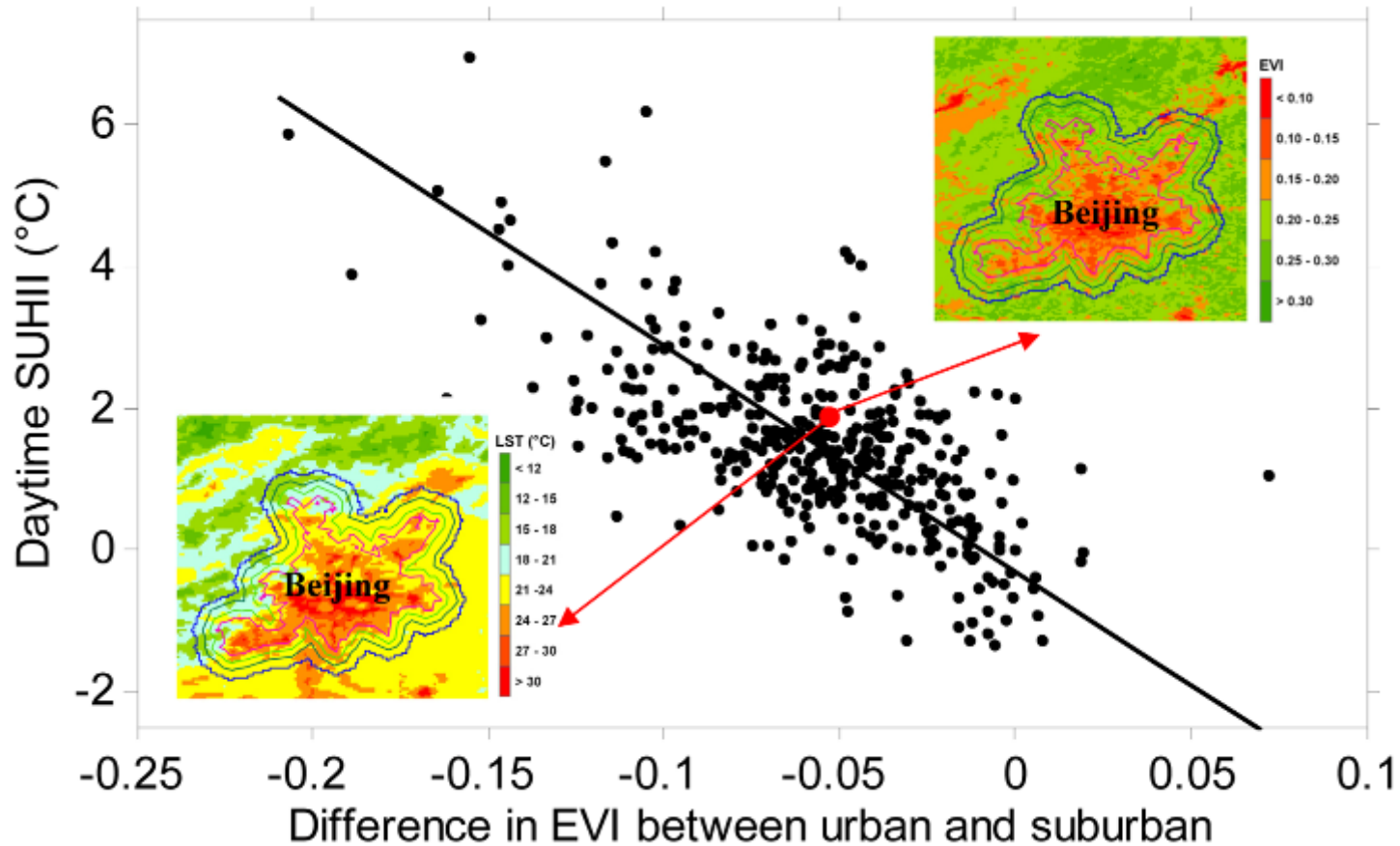
# Vegetation controls SUHII seasonal cycle



Seasonal cycle of  $\delta\text{EVI}$  can explain **45%** variance of SUHII seasonality

# Summary and Implication I

## The greener, the cooler



# Summary and Implication II

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## 1. How to adapt to climate change for cities?



GEOPHYSICAL RESEARCH LETTERS, VOL. 37, L03701, doi:10.1029/2009GL042194, 2010

**Effects of white roofs on urban temperature in a global climate model**

K. W. Oleson,<sup>1</sup> G. B. Bonan,<sup>1</sup> and J. Feddema<sup>2</sup>

**Model predictions, especially for the extreme heat wave?**