Comparing the diurnal and seasonal variabilities of atmospheric and surface urban heat islands based on the Beijing urban meteorological network

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Outline

- Background
- Data and study area
- Results
- Conclusions

➢ *Background*

Similarities and differences exist between atmospheric and surface urban heat islands (UHIs), which were well described but poorly understood in previous studies.

➢ *Objective*

Investigate the determining factors of atmospheric and surface UHIs by comparing their diurnal and seasonal variabilities.

➢ *Data*

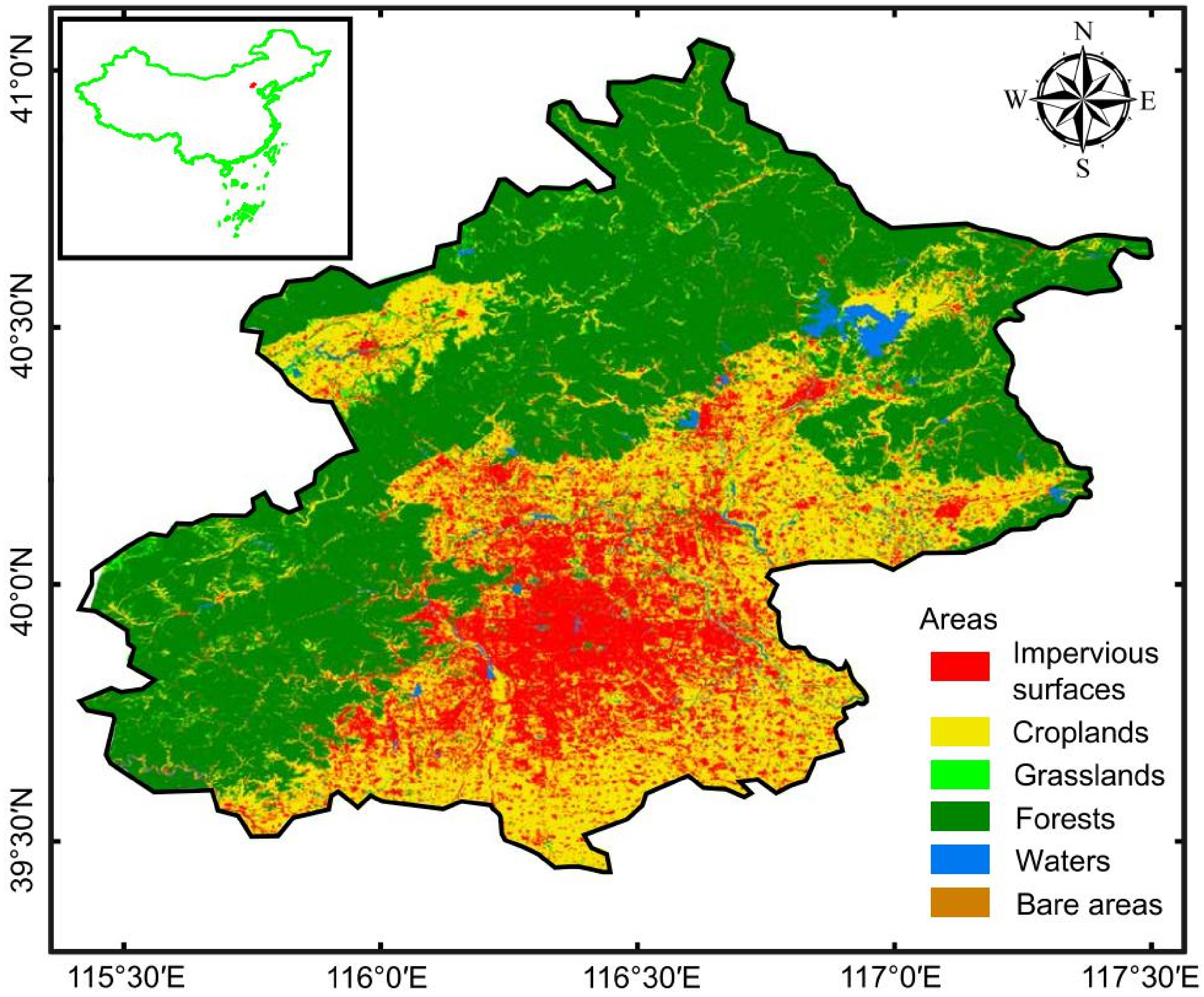
- Beijing, 2013-2014
- Hourly air temperature at 262 AWSs (automatic weather stations) obtained from China Meteorological Administration
- MODIS Satellite-Derived Land Surface Temperature:

  4 observations per day: at 1:30, 10:30, 13:30 and 22:30 local Beijing time

  Resolution: 1 km

➢ *Study Area*

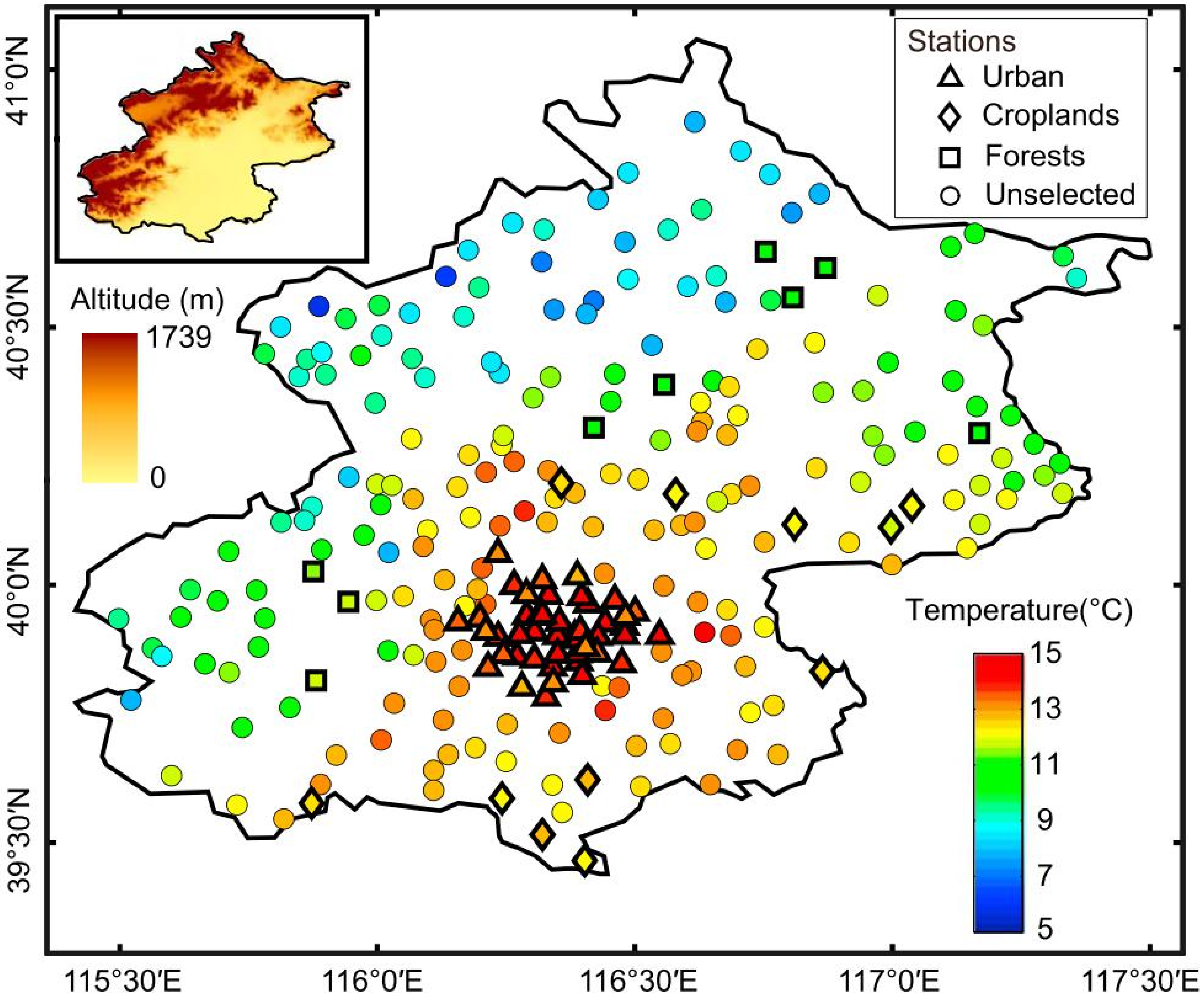
Beijing, 2013



The land cover type data were provided by Peng Gong from Tsinghua University

➢ *Data*

- 262 AWSs
- 45 urban stations
- 11 rural croplands stations
- 9 mounatinous forests stations



➢ *Data*

An example of rural cropland stations

a: photo

b: Google Earth maps during *summer*

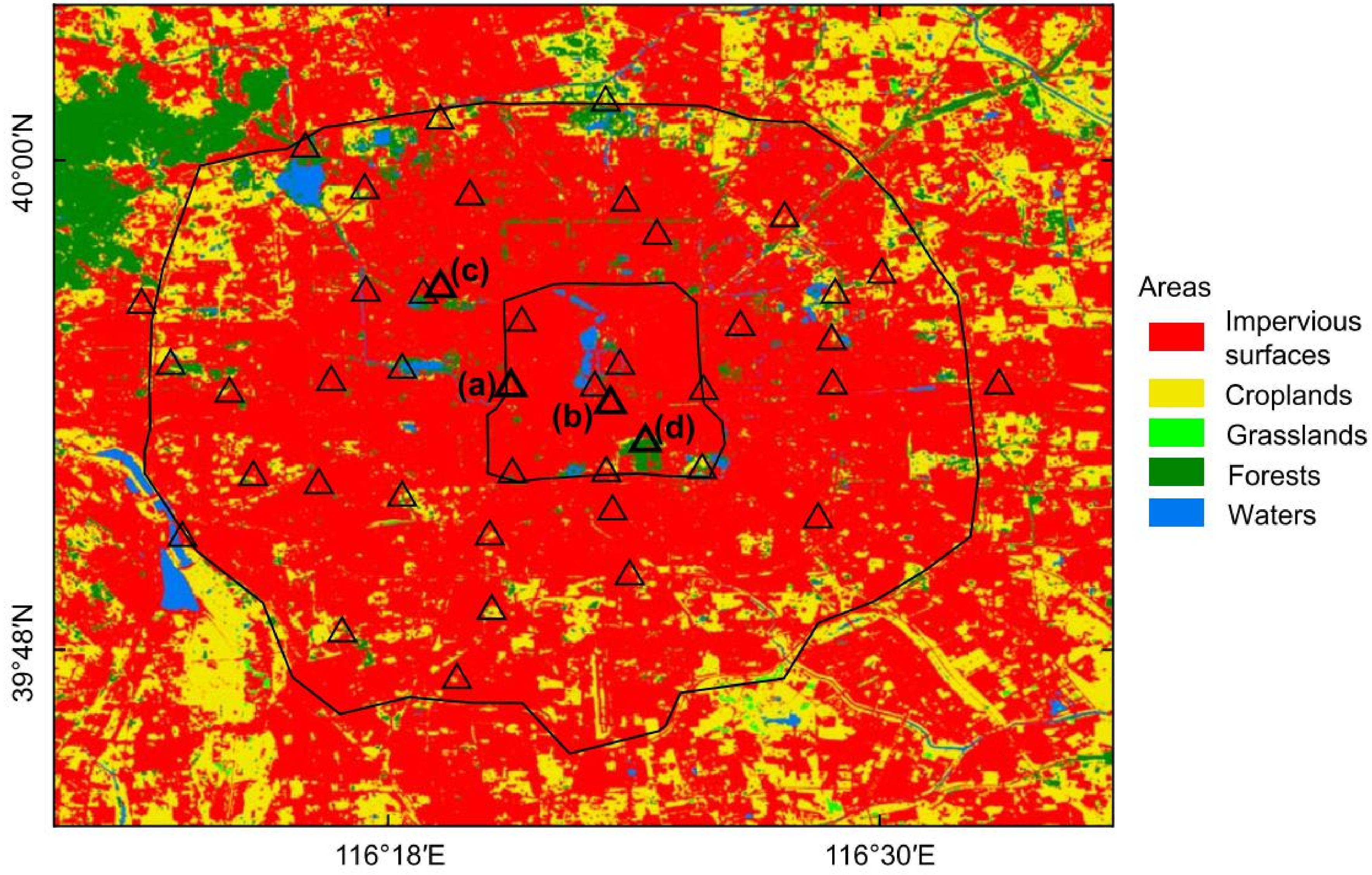
c: Google Earth maps during *winter*

➢ *Data*

4 typical

urban stations

- (a) Warning tower
- (b) Tian'anmen square
- (c) China Meteorological Administration
- (d) Temple of heaven park



➢ *Data*

4 typical urban stations

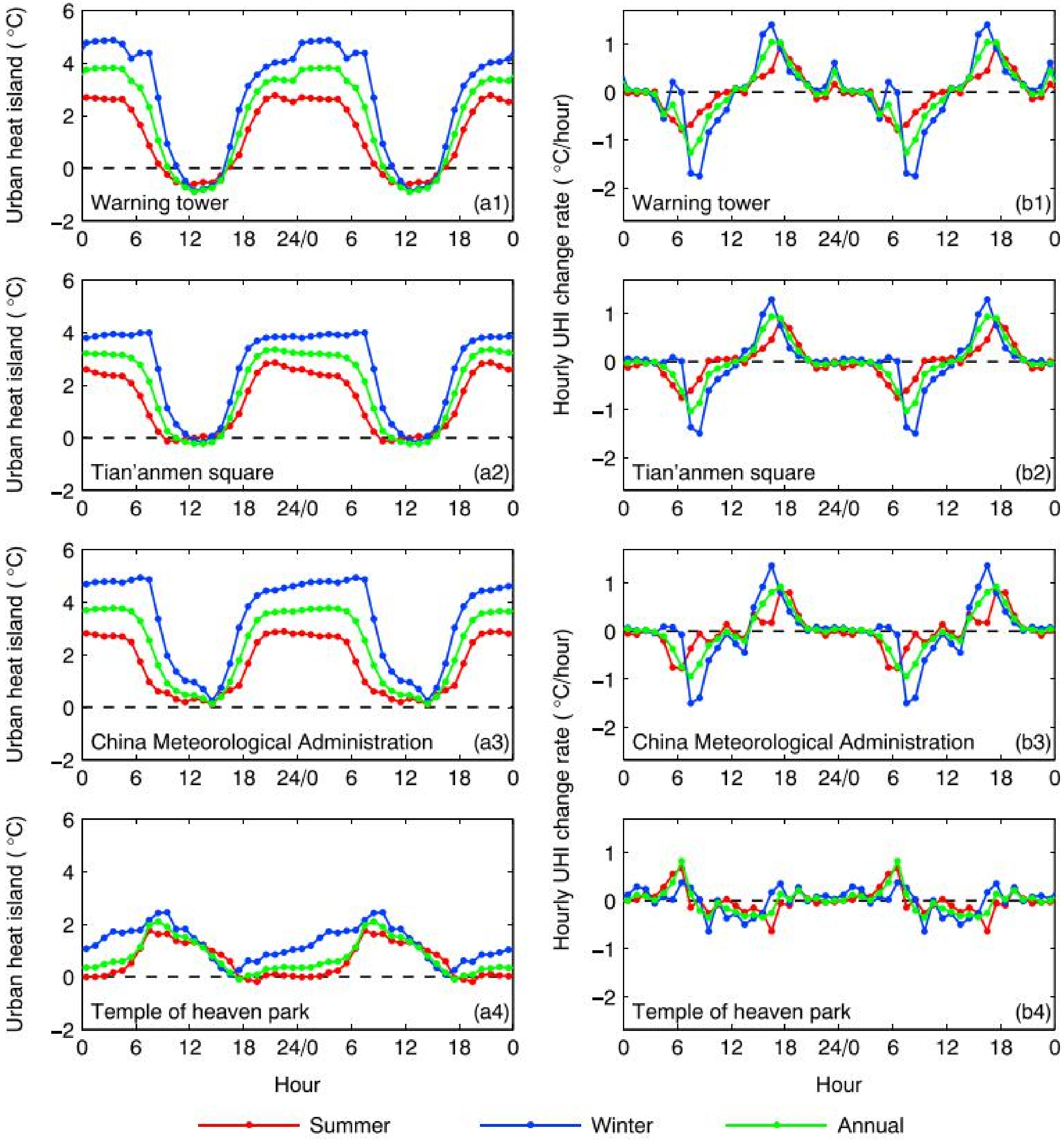
- 1 Warning tower
- 2 Tian'anmen square
- 3 China Meteorological Administration
- 4 Temple of heaven park

a1-a4: photos

b:1-b4 Google Earth maps

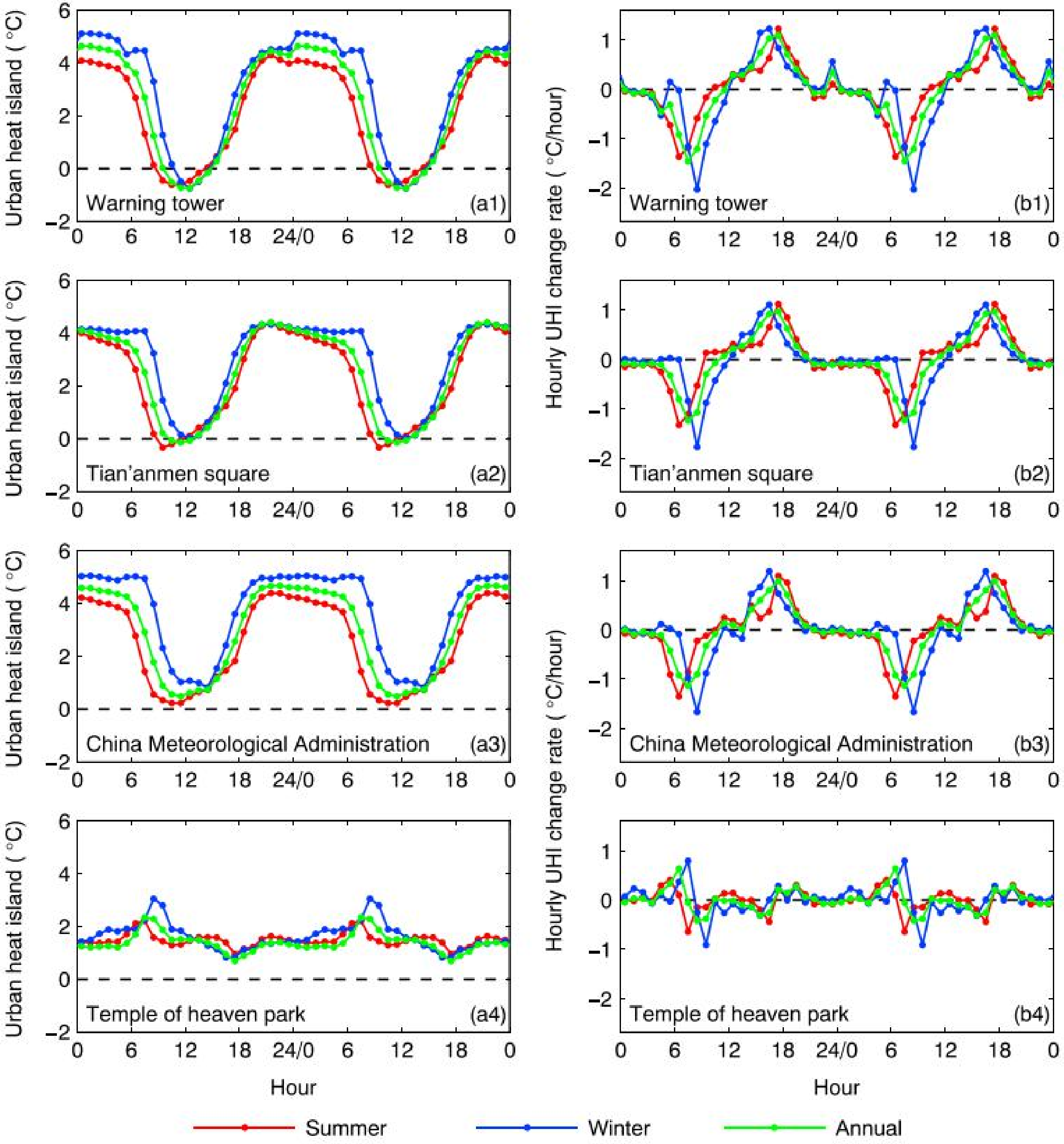
➢ ***Results***

- Diurnal variation of atmospheric UHI
- Reference: *rural croplands*



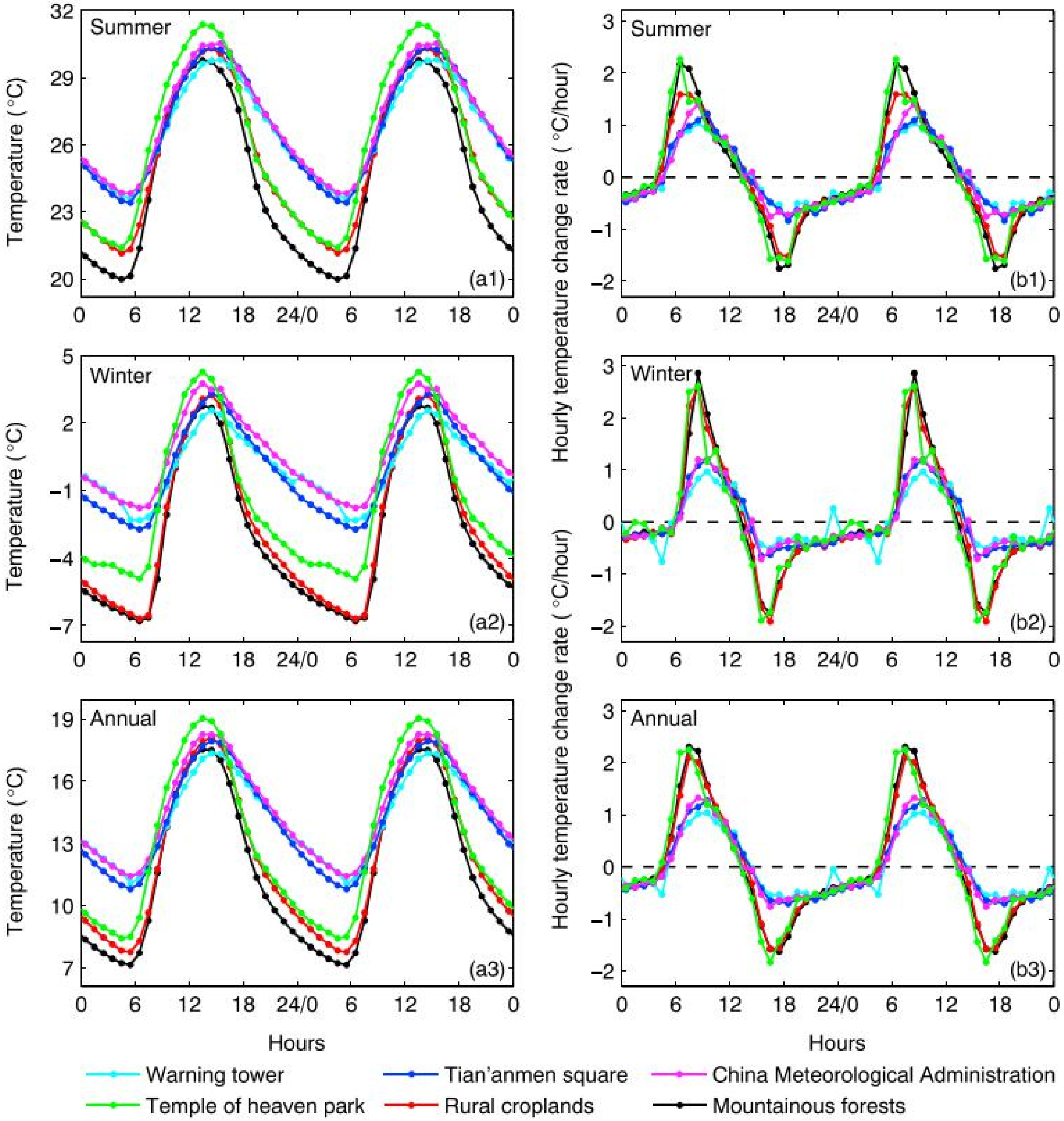
➢ ***Results***

- Diurnal variation of atmospheric UHI
- Reference: *mountainous forests*



➢ *Air temperature*

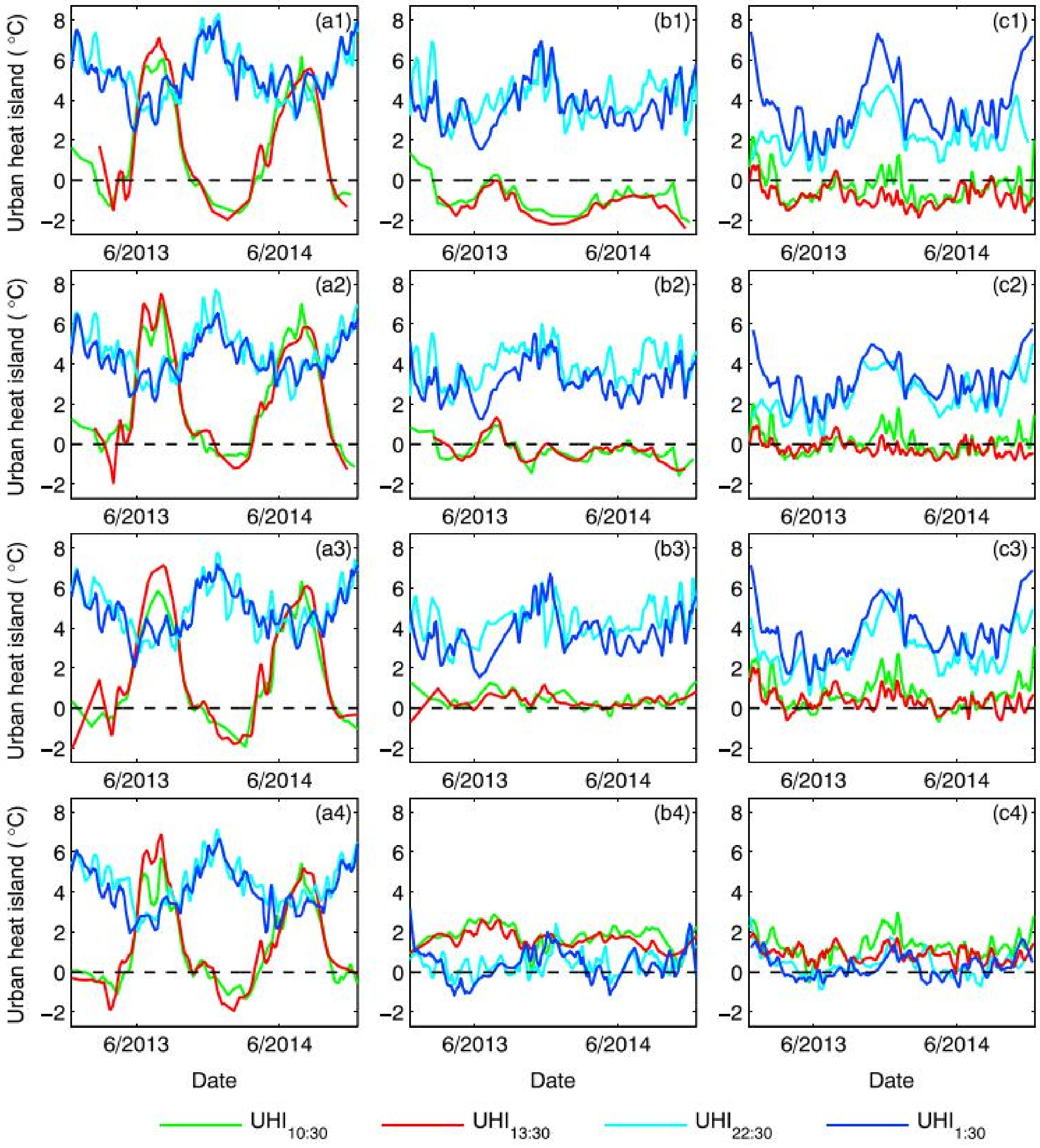
Diurnal variations



➢ ***Results***

- Seasonal variation of atmospheric and surface UHI
- Reference: *rural croplands*

- 1 Warning tower
- 2 Tian'anmen square
- 3 China Meteorological Administration
- 4 Temple of heaven park



a1-a4: surface UHI

b1-b4: atmospheric UHI under *clear* sky conditions

c1-c4: atmospheric UHI under *cloudy* sky conditions

➢ ***Results***

- Seasonal variation of atmospheric and surface UHI
- Reference: *mountainous forests*

- 1 Warning tower
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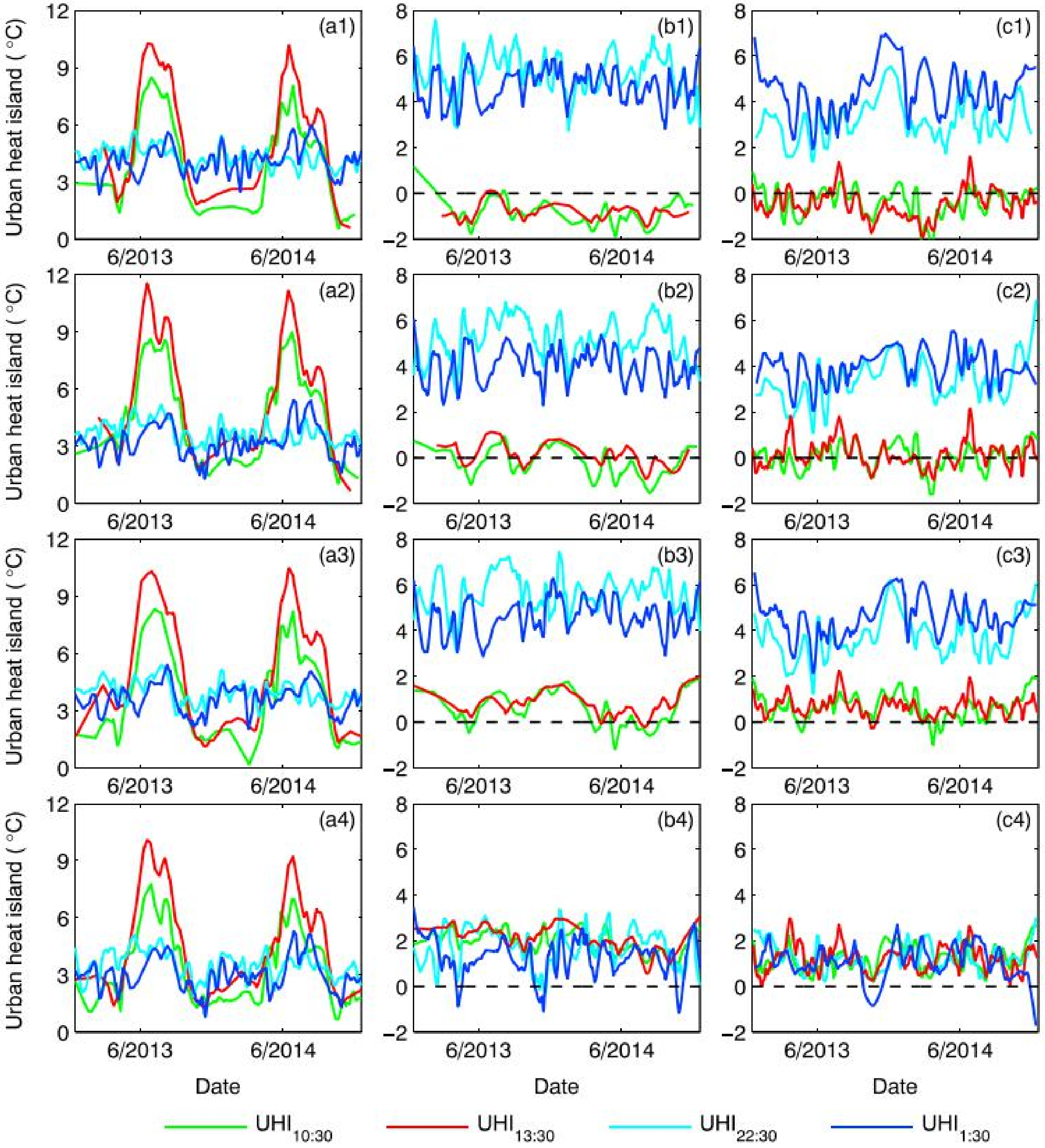


a1-a4: surface UHI

b1-b4: atmospheric UHI under *clear* sky conditions

c1-c4: atmospheric UHI under *cloudy* sky conditions

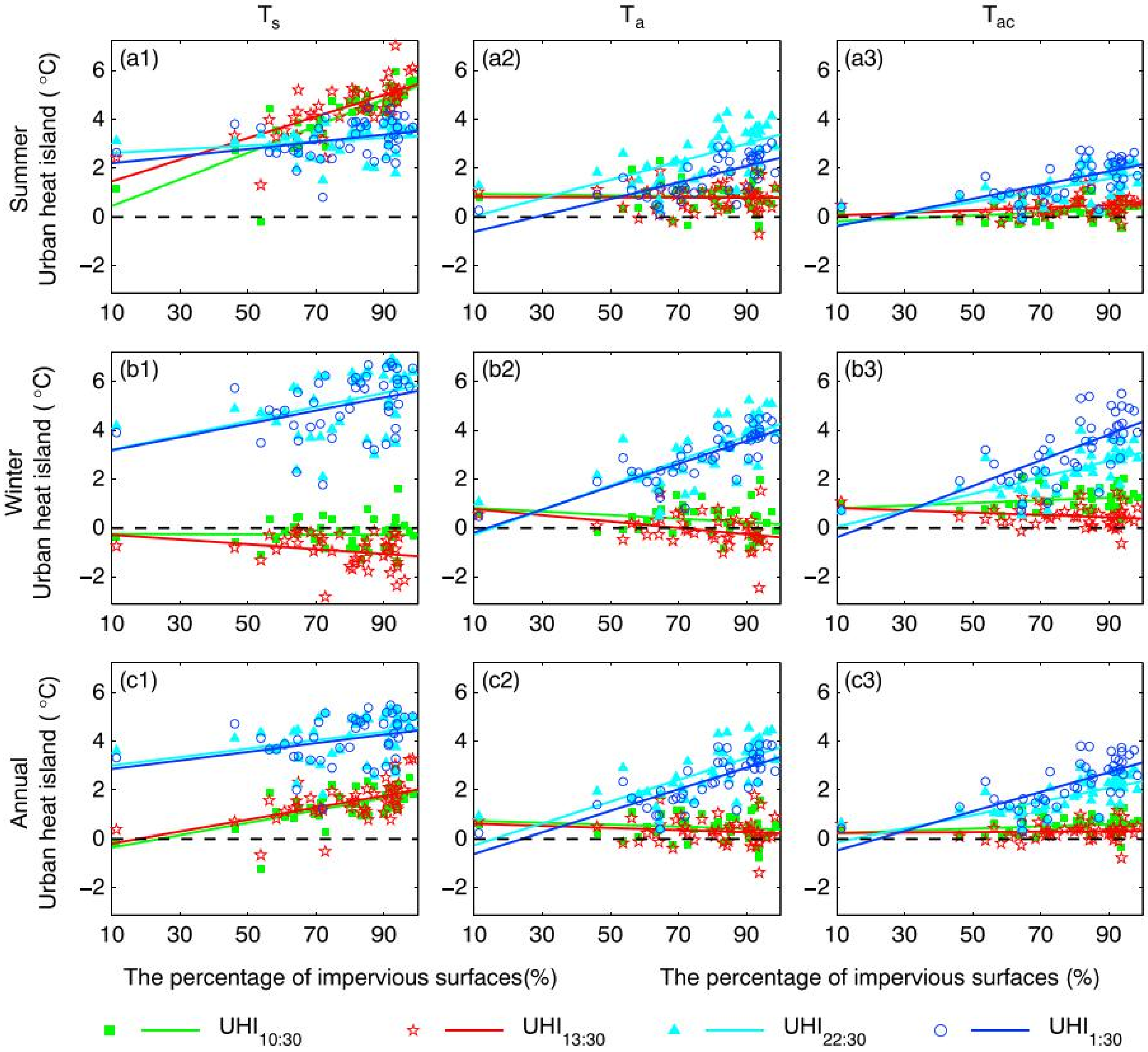
➤ ***Results***

- 45 urban stations
- Seasonal variation of atmospheric and surface UHI
- Reference: *rural croplands*

(a1): $R_{10:30,\ 13:30} = 0.69\text{-}0.74$

(a2,b2,c2): $R_{22:30,\ 1:30} = 0.66\text{-}0.74$

(a3,b3,c2): $R_{22:30,\ 1:30} = 0.61\text{-}0.7$



a1-a4: surface UHI

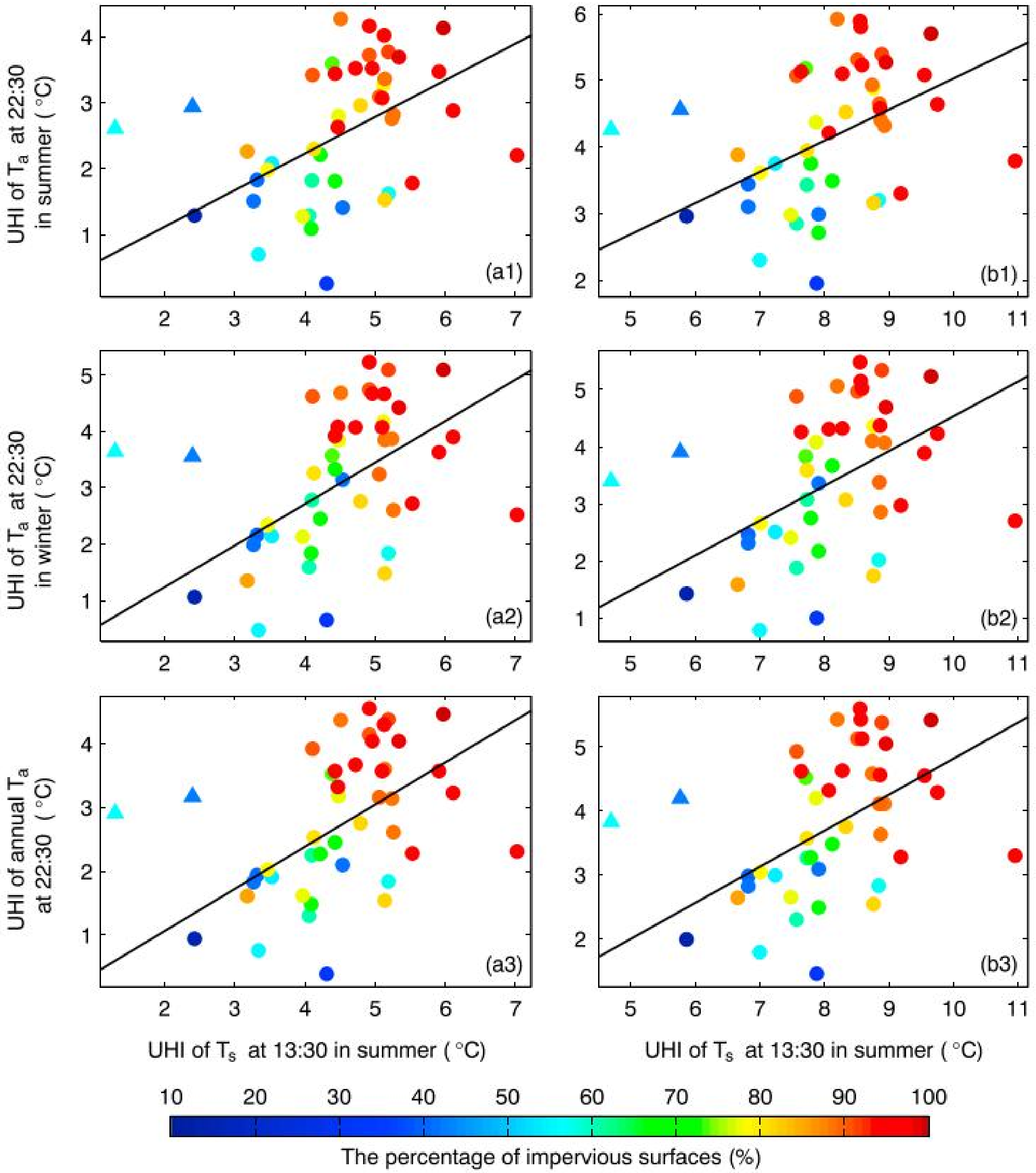
b1-b4: atmospheric UHI under *clear* sky conditions

c1-c4: atmospheric UHI under *cloudy* sky conditions

➢ Results

- 45 urban stations
- Correlation between atmospheric UHI and surface UHI

R = 0.37-0.41



a1-a3: referenced to *rural croplands*

b1-b3: referenced to *mountainous forests*

➢ *Data*

45 urban staions

Correlation between UHI during summer and UHI during winter

(a1,b1): $R_{22:30,\ 1:30} = 0.91\text{-}0.96$

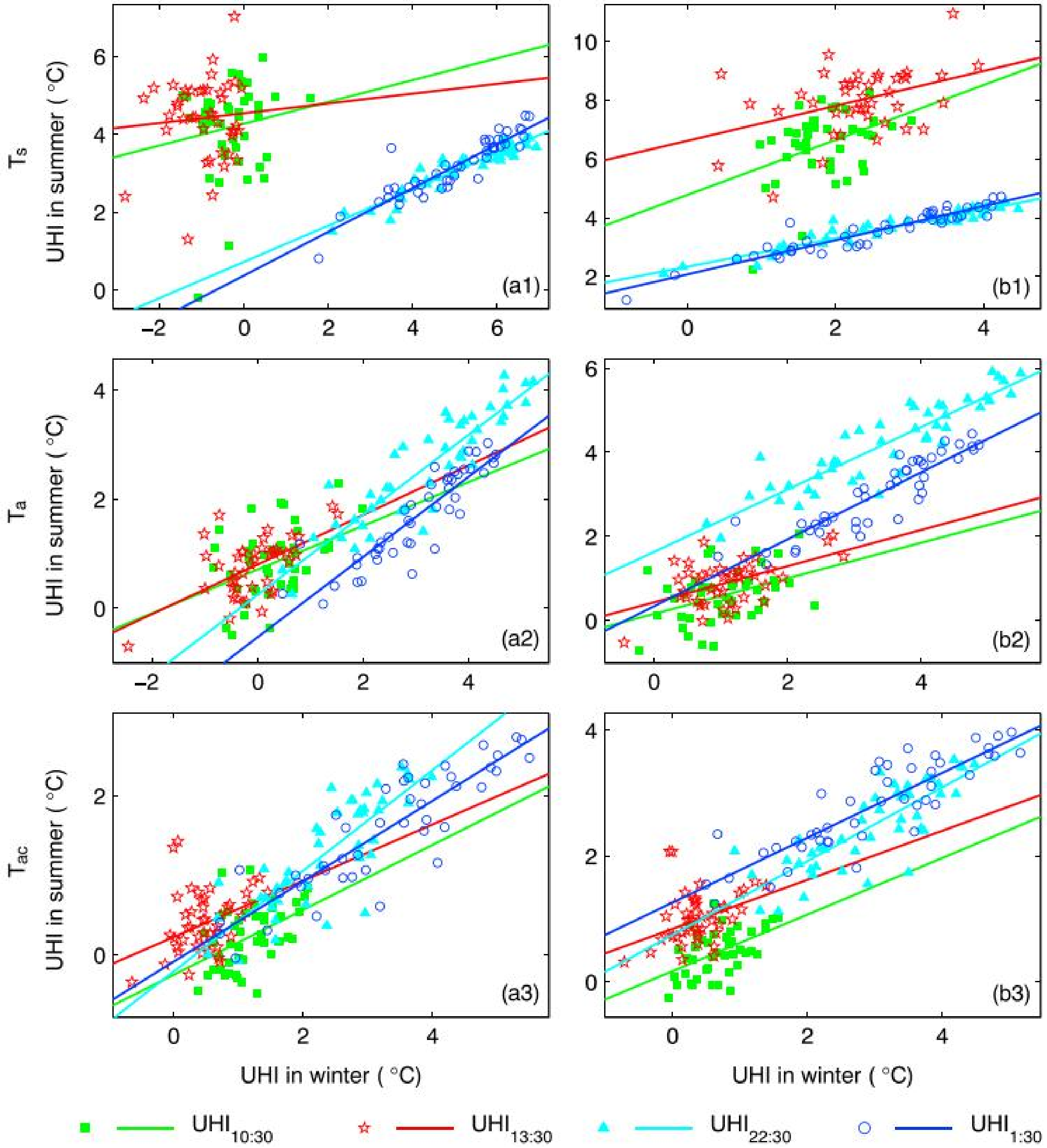
(a2,b2): $R_{22:30,\ 1:30} = 0.89\text{-}0.9$

(a3,b3): $R_{22:30,\ 1:30} = 0.82\text{-}0.88$

(a1,b1): $R_{10:30,\ 13:30} = 0.08\text{-}0.15$

(a2,b2): $R_{10:30,\ 13:30} = 0.41\text{-}0.57$

(a3,b3): $R_{10:30,\ 13:30} = 0.41\text{-}0.46$



a1-a3: referenced to *rural croplands*

b1-b3: referenced to *mountainous forests*

➢ Conclusions

There are three determining factors working together but differently for atmospheric and surface UHIs:

- Longwave radiation
- Anthropogenic heat
- Evapotranspiration

For *atmospheric* UHI:
1. The stronger anthropogenic heat release in winter makes atmospheric UHI increase with time during winter nighttime while it decreases with time in summer nighttime.
2. The cloud reflection of longwave radiation during cloudy sky conditions enhanced the energy re-emission process during nighttime, which explains that the atmospheric nighttime UHI increases with time under cloudy sky conditions and it decreases with time under clear sky conditions.

For *surface* UHI:
1. The reduction of cooling effect of evapotranspiration due to more impervious surfaces in the urban areas dominates seasonal cycle of surface UHI at daytime.
2. The multi-reflection between urban fabrics make it less efficient in longwave radiative cooling, this is the major reason for surface UHI at nighttime.

➢ ***The impervious surface***

- It can be an index of spatial variability of evapotranspiration and anthropogenic heat release.
- It can’t reflect the three dimensional structure of urban fabrics, which needs further studies.

Thank you