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The heterogeneity of urban thermal environment during summertime as observed by *in situ* and remotely sensed measurements

Feng CHEN[#, *], Song YANG[#, *], and Yongzhu XIONG[¢]

[#] Department of Atmospheric Sciences, Sun Yat-sen University, Guangzhou, China;
**Institute of Earth Climate and Environment System, Sun Yat-sen University, Guangzhou, China;*
¢ Institute of Resource and Environmental Information, Jiaying University, Meizhou, China

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Outlines

1. Introduction
2. Cases of observation
3. Discussion(challenges)
4. Conclusions

1. Introduction

- **Heat waves occurred**

1995 Chicago: approximately 700 heat-related deaths in five days;

1999 eastern United States: 15,400 km^2 consumed by fire, and 502 deaths;

2003 European (June to August): covering mostly western Europe and more **than 40,000** Europeans died ;

2007 European: Bulgaria with temperatures above 45℃, and Greek forest fires;

2007 Asian: Datia (India) at 48℃, Dhaka(Bangladesh) over 40℃, Sibi(Pakistan) at 52℃, Moscow(Russia) at 32.9℃;

2009 Australia: in Victoria large bushfires claimed more than 210 people and destroyed more than 2,500 homes;

2010 Japan (Tmax>35℃): Kyoto 33 days, Tottori 29 days and Osaka 25 days;

2010 Northern hemisphere: impacted most of the United

2011 North American heat wave

2012-2013 Australia “Angry summer”

2013 Southwestern United States, China …

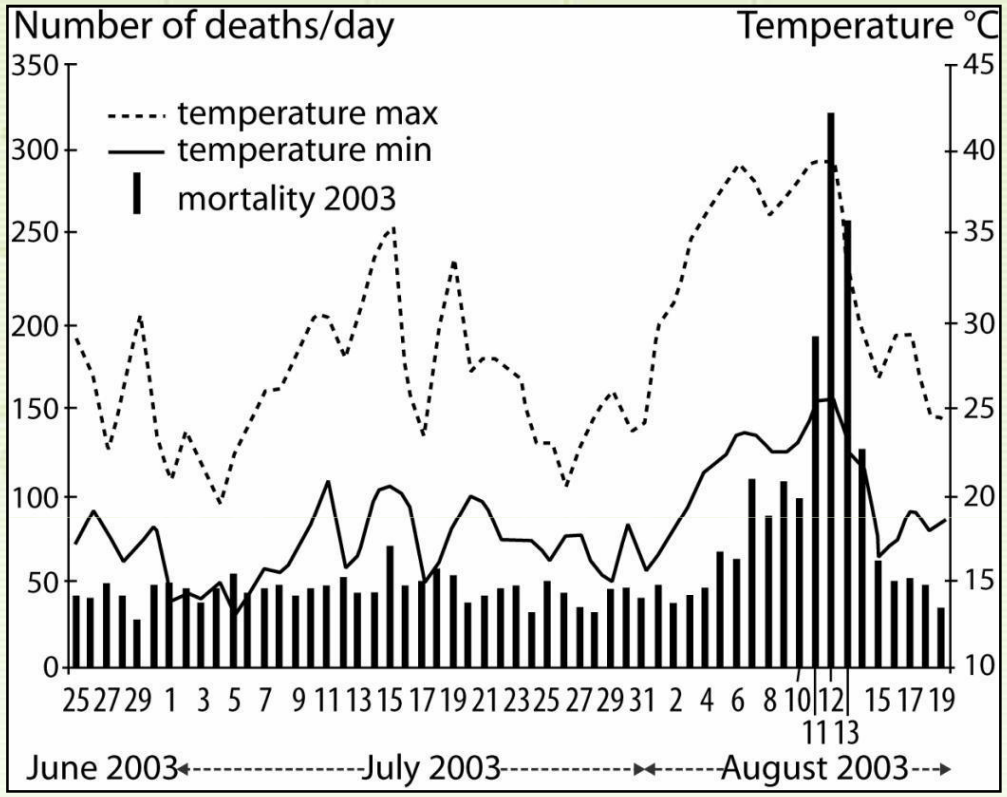


Fig The number of deaths spiked in Paris during a sweltering heat wave in 2003.

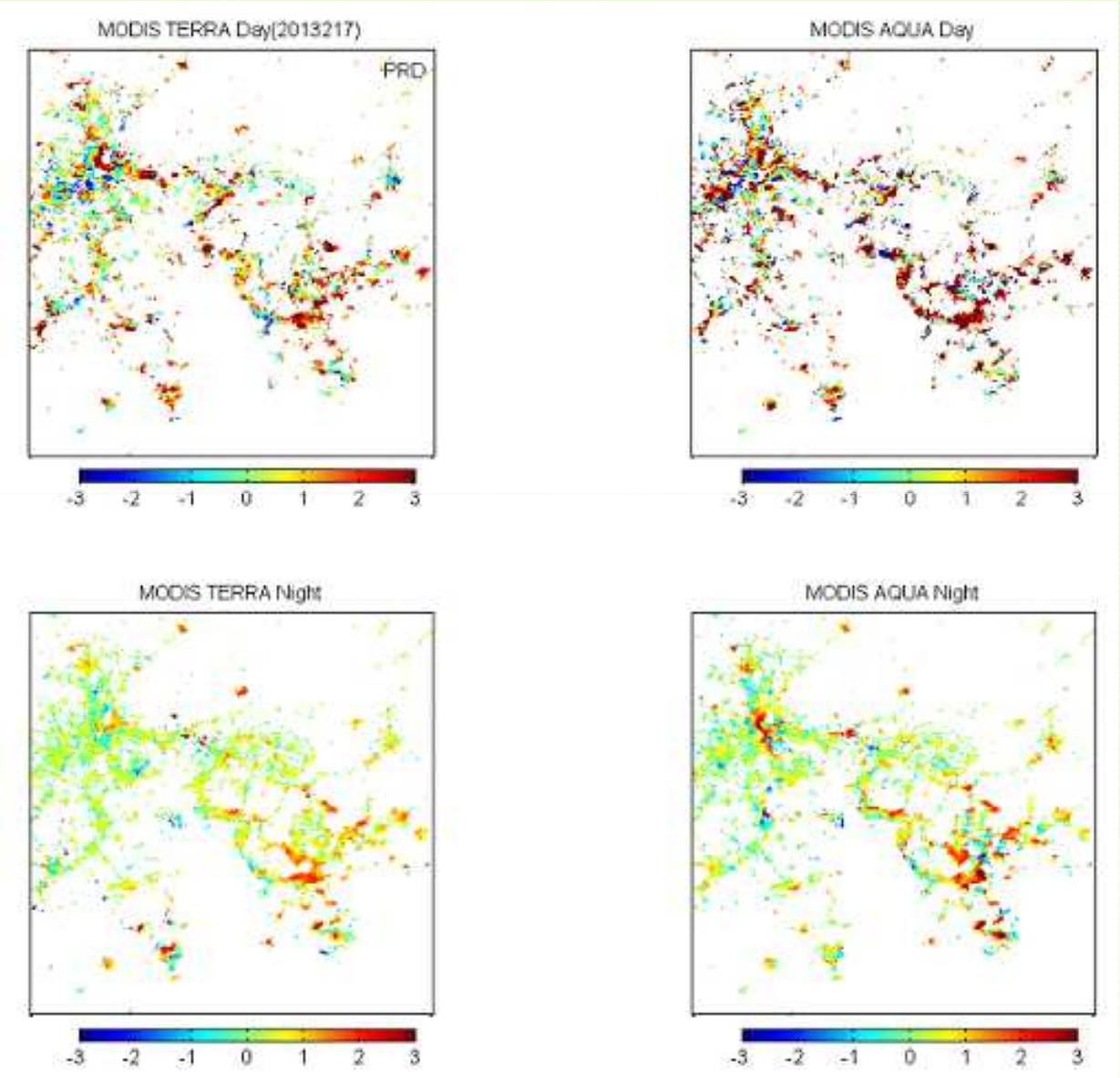
Pakistan heatwave: Death toll crosses 800 people in Sindh

26 June 2015 | Asia

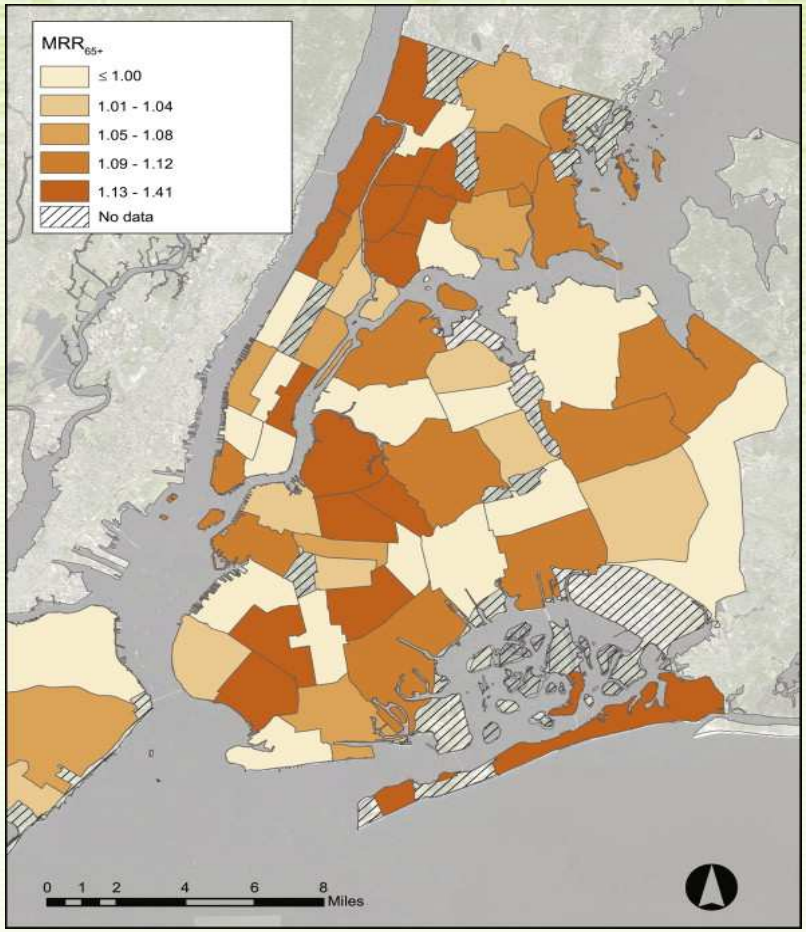
India heat wave kills 2,330 people as millions wait for rain

By Hilary Whiteman, CNN
Updated 0517 GMT (1217 HKT) June 2, 2015

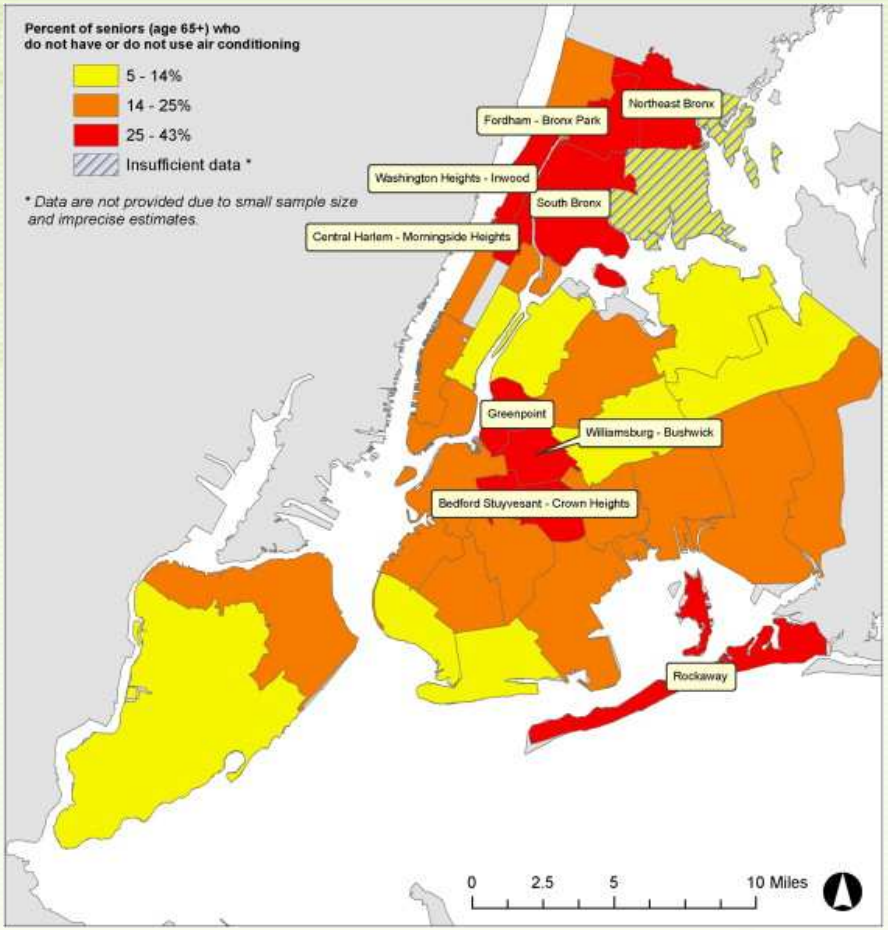
Credit: Benedicte Dousset, University of Hawaii at Manoa BBC.com CNN.com



Heterogeneity over Pearl River Delta (PRD)



Mortality Rate Ratios for seniors age 65 and older (MRR_{65+}) under hot days (New York)

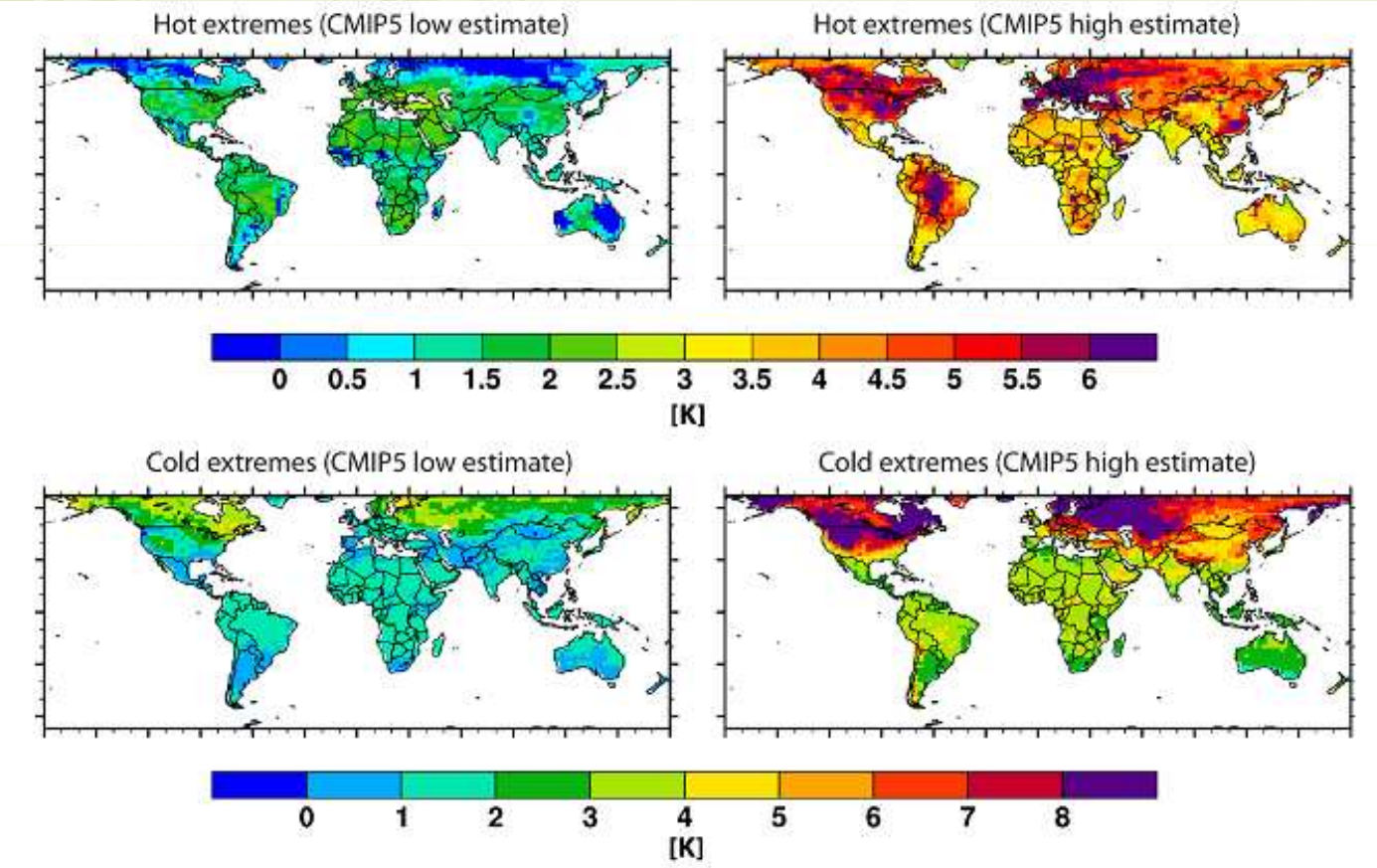


Air-conditioning ownership and use

Rosenthal et al., 2014. Health & Place, 30: 45-60.

Ongoing global warming will potentially increase the incidence, intensity, and duration of summertime heat wave events (Meehl and Tebaldi, 2004; Fischer et al., 2013).

However, uncertainty of projection is large.



Fisher. Nature climate change, 2013,DOI: 10.1038/NCLIMATE2051

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Climate change poses a particular **threat to urban residents** and at the same time is expected to further drive urbanization, ultimately placing more people at risk to the clusters of impacts.

However, the **data** on climate change and its impact on urban areas for **South Asian** cities **are extremely difficult** to be searched for. The **data gap** for urban areas in this region. **Much more work is needed in this area.**

(*The World Bank*, ***2013***)

In order to safeguard citizens, economic assets and supporting eco-systems, cities need to adapt to the climate change that is already underway. **We urge cities to map the risks to which their citizens are most vulnerable, to reduce those risks where it is possible, and build resilient social and physical structures where it is not.**

(*The Memorandum from the 4th Nobel Laureates Symposium on Sustainability*, ***2015***)

II. Observation

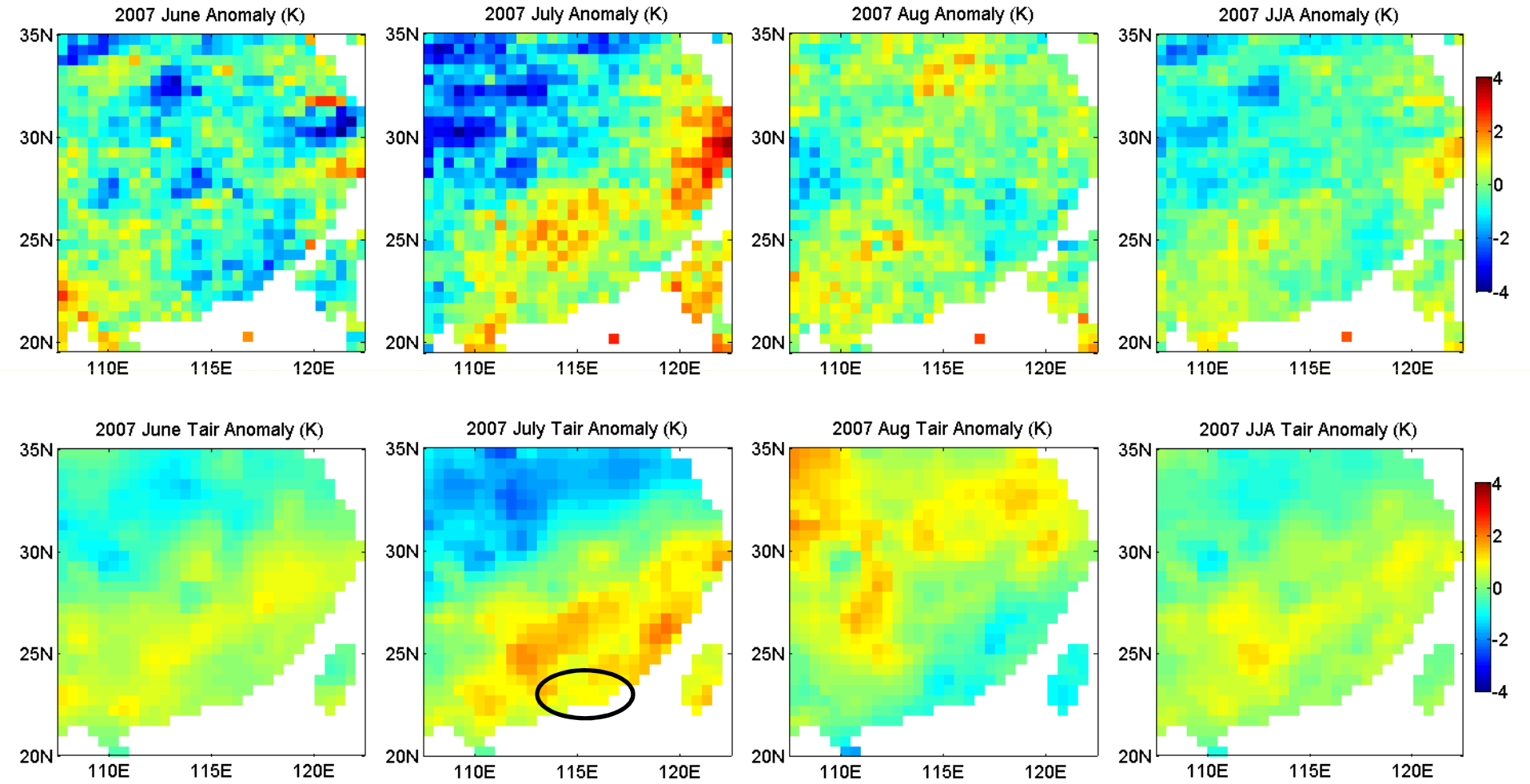


Fig Monthly anomaly during 2007, **LST** (up) and **air mean temperature** (bottom).

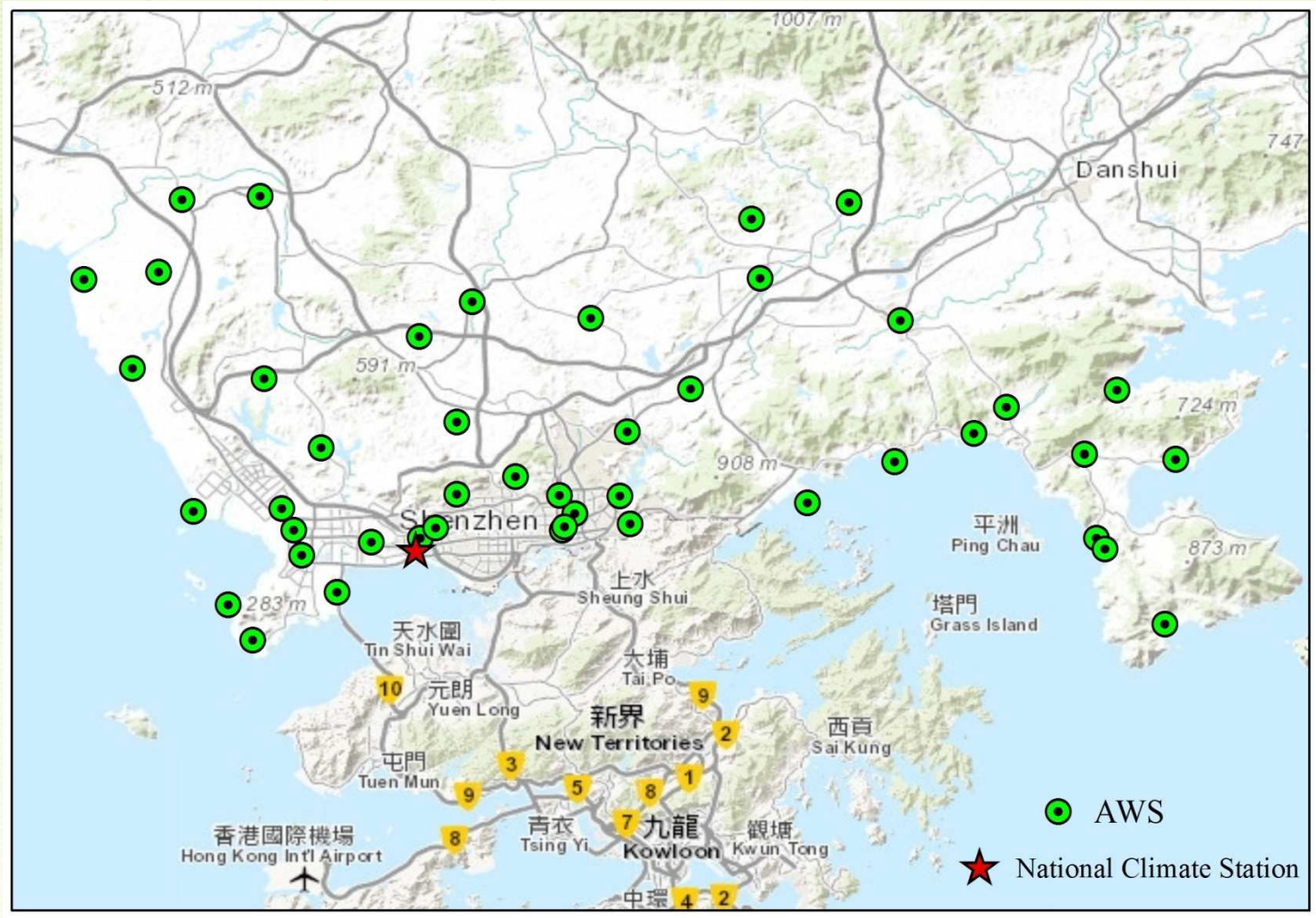


Fig Selected stations including 45 AWSs and a National Climate Station

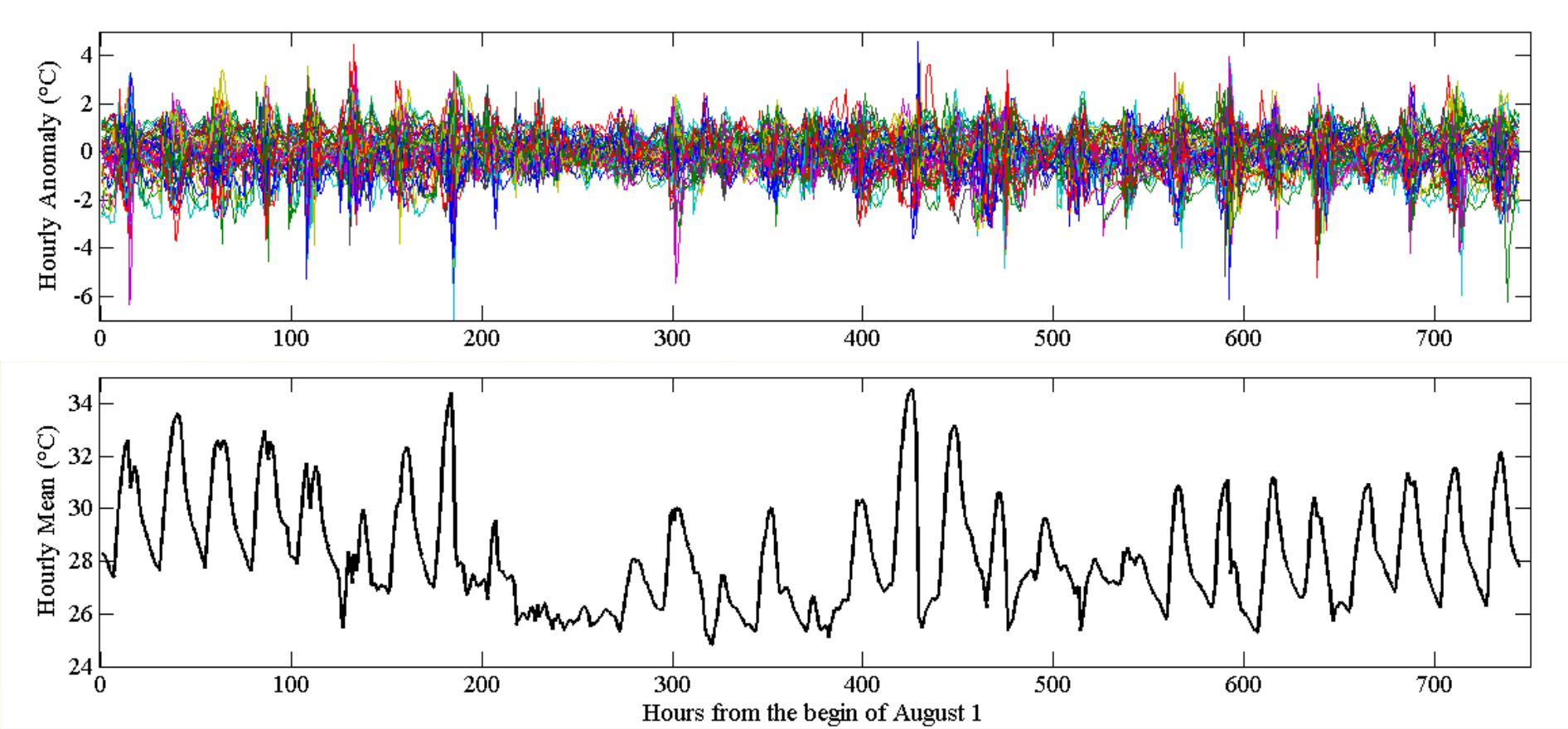


Fig Hourly anomaly recorded at the **45** AWSs (the Top panel) and the hourly average of temperature (the Bottom panel) in **August** 2007.

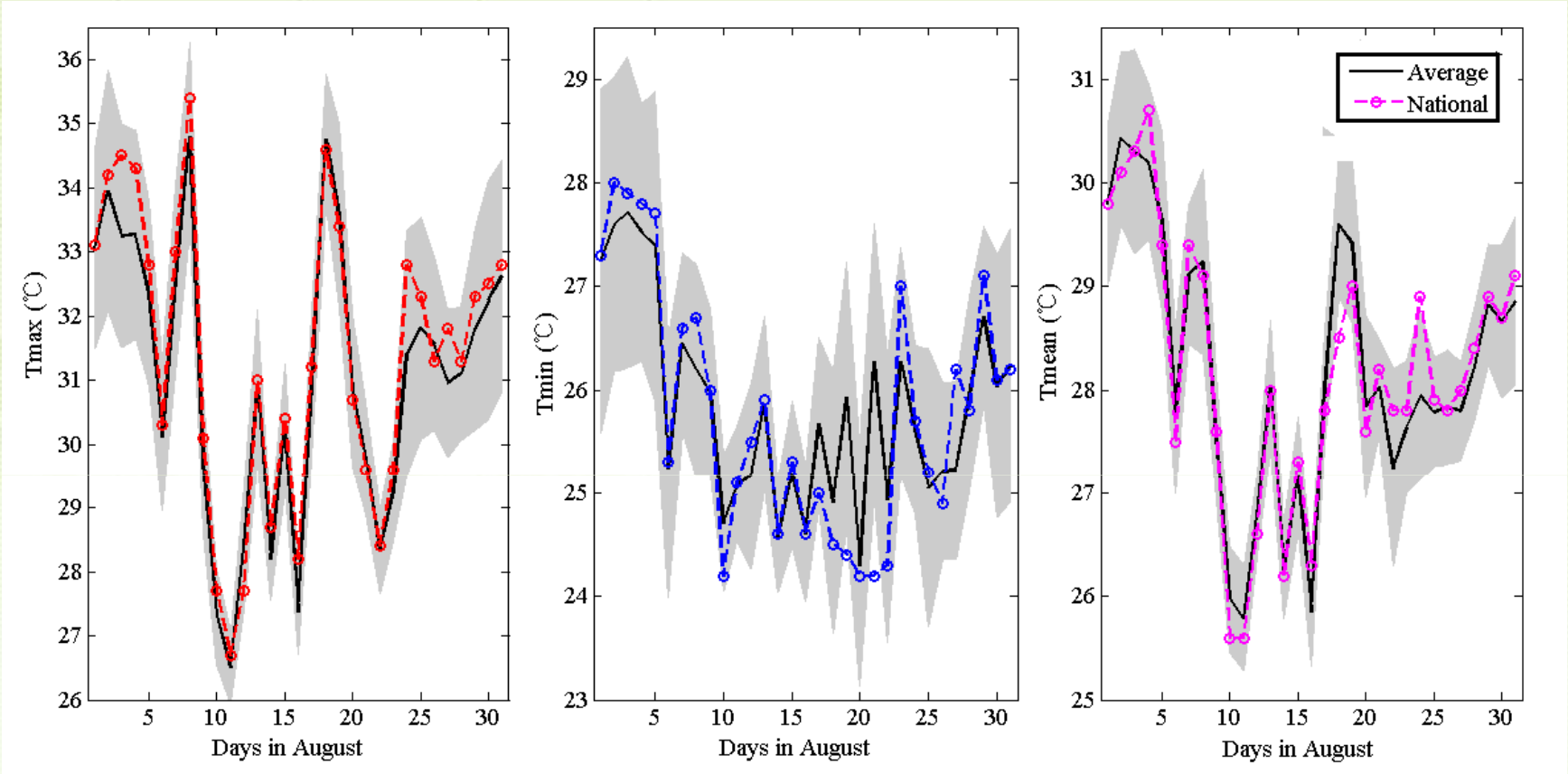


Fig The urban thermal heterogeneity in the daily maximum (left), minimum (center), and daily mean (right). The black line shows the average records of the AWSs, while the colored dot dash line shows the daily record at the National Climate Station (No.59493). The gray shadow shows the boundary of the variation (±1.5 stds).

Cautions the temperature in range in different figures.

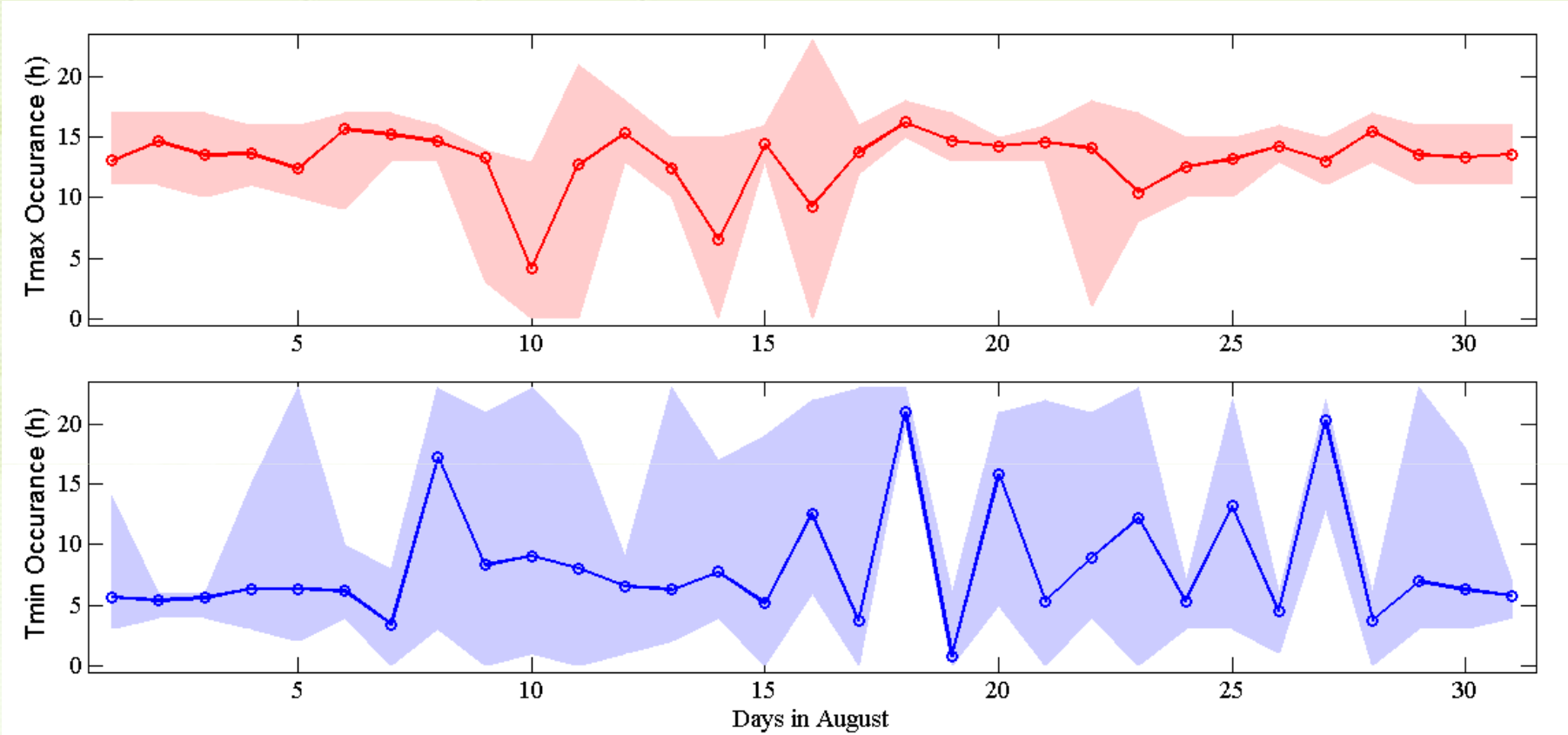


Fig The urban thermal heterogeneity in view of the occurrence of time. The daily maximum and daily minimum temperatures are presented at top and bottom panels respectively. The shadow shows the boundary of the variation of occurrence, while the upper and the lower boundaries are the earliest and latest occurrences.
The dotted line represents the mean values of the occurrence of time.

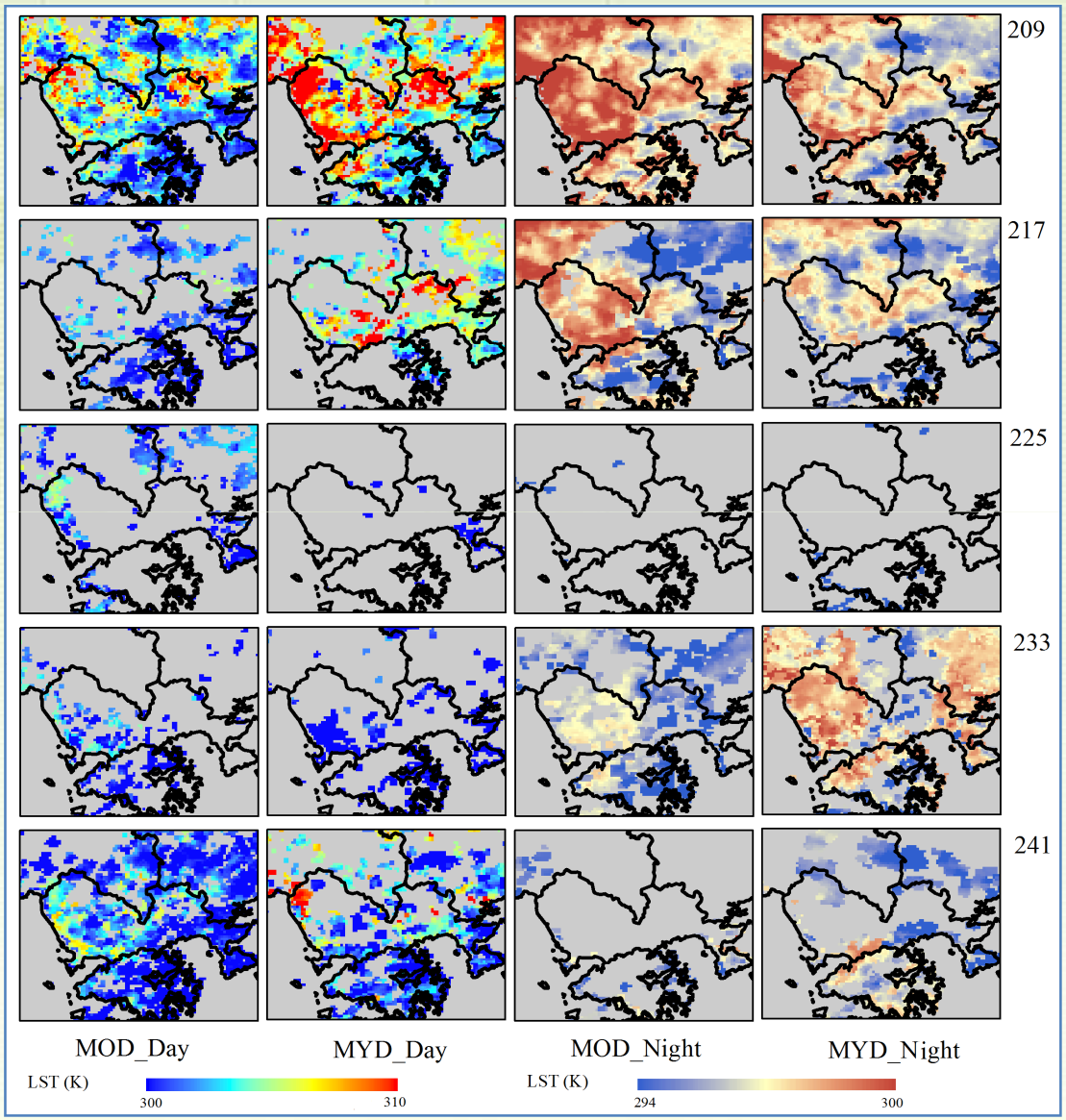


Fig The urban thermal heterogeneity recorded by MODIS LST, the gray color shows the invalid LST. Day and night records are stretched using Min-Max strategy, and different color bars are used.

3. Discussions

More specific cases are necessary

Data

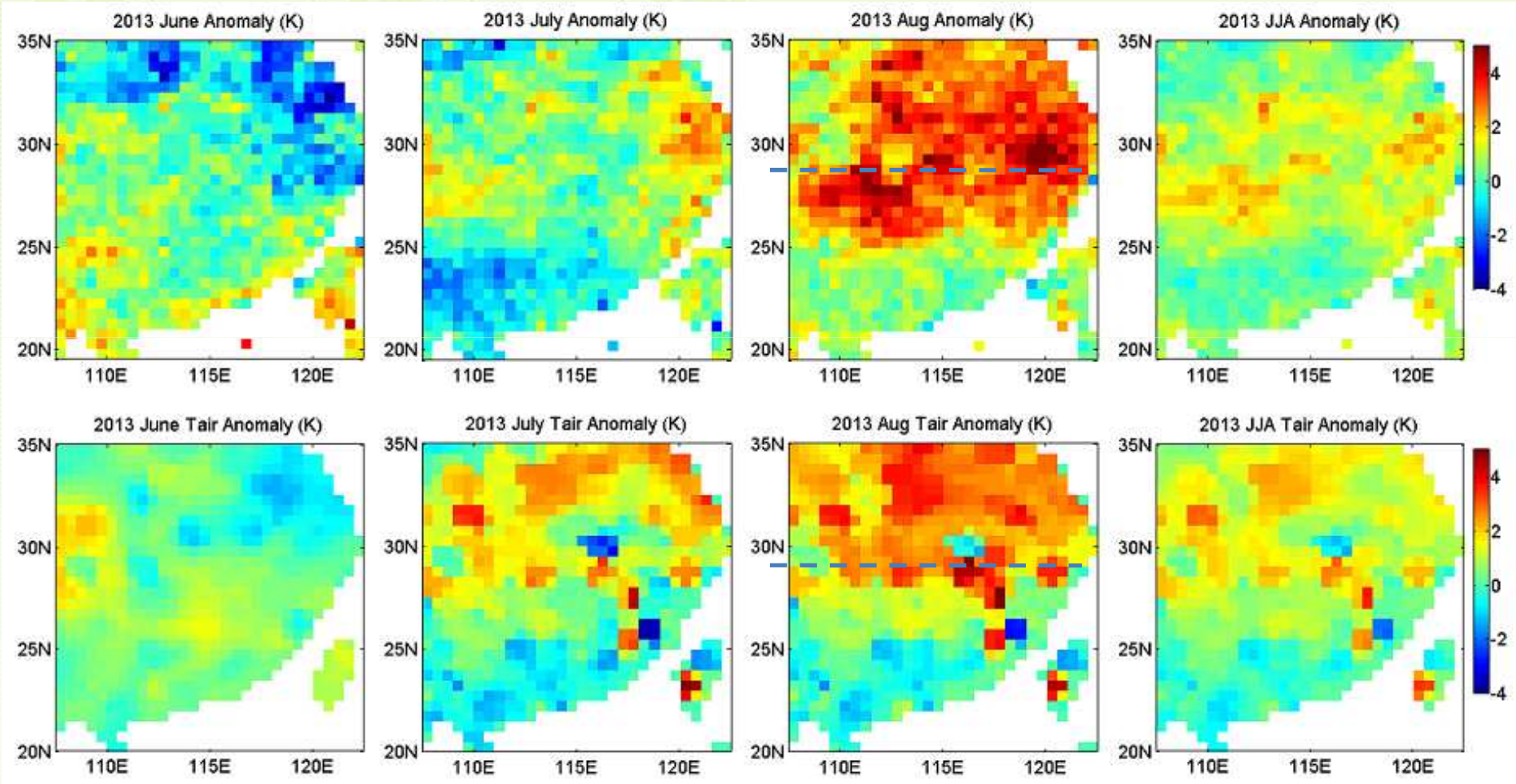


Fig Monthly anomaly during 2013, **LST** (up) and **air mean temperature** (bottom).

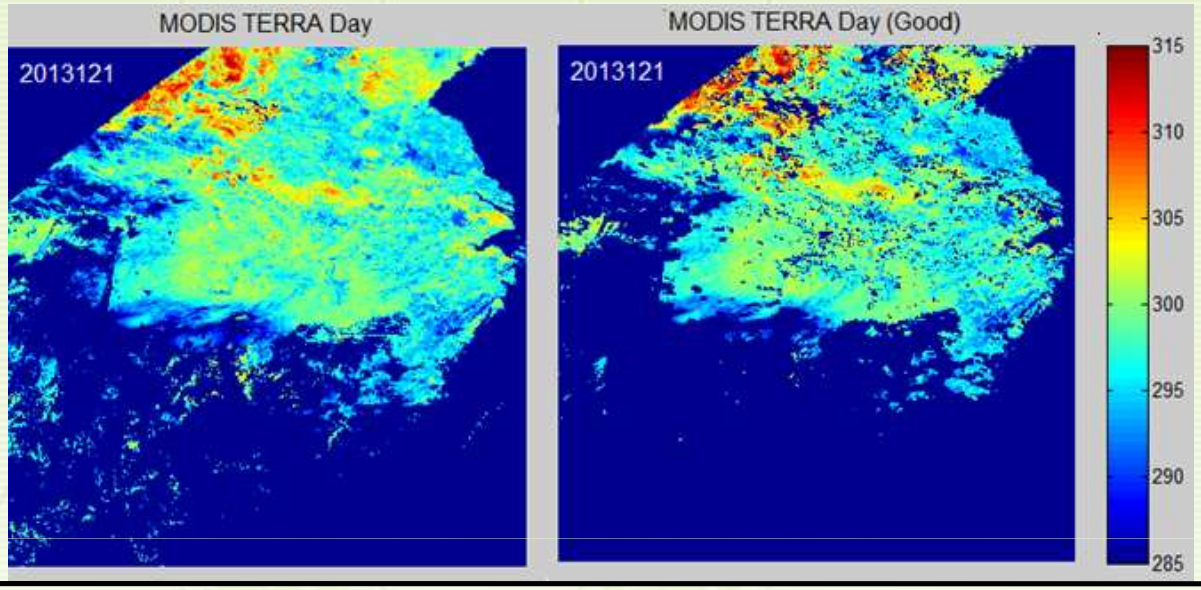
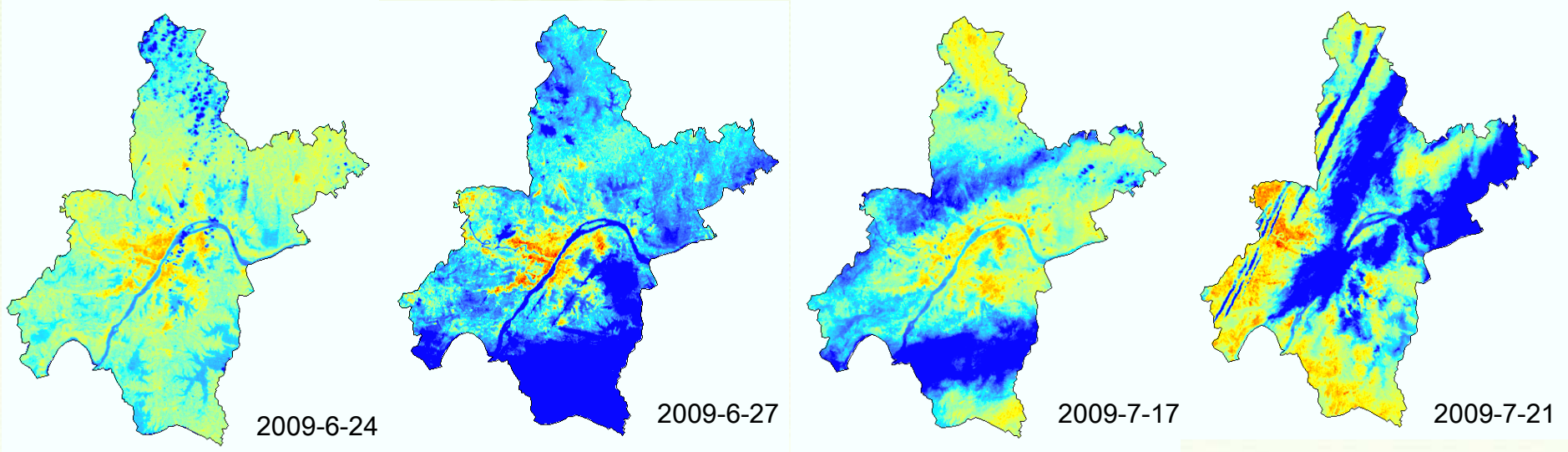


Fig A case of LST (unit: K) demonstrated for showing the challenges of data availability. MOD11A2 (left), and valid LST after accuracy checking (right).



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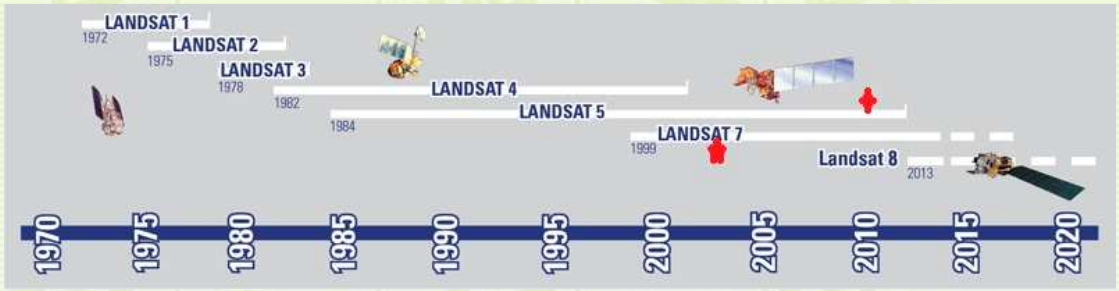
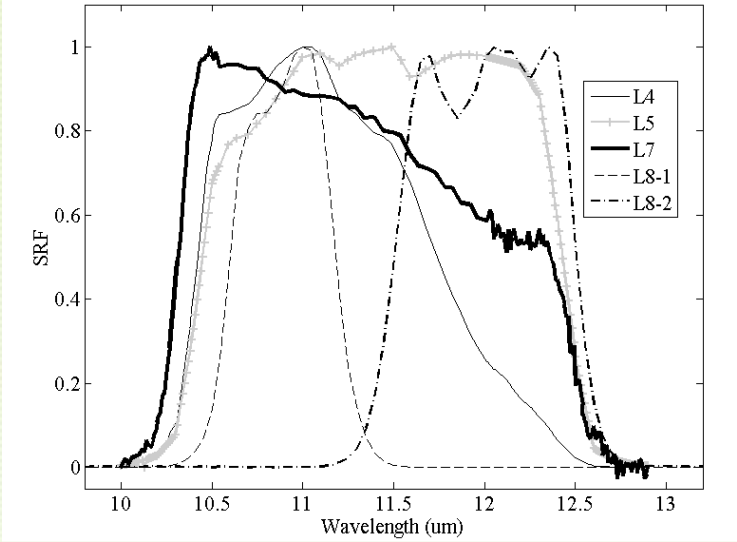
Comparability and Data gap





The average error predicted by JPL from 1999-2006 is 0.081 W/m^2 sr μm and by RIT, it is 0.121 W/m^2 sr μm

TM *(Barsi, et al., 2006. SPIE)*

leaves a seasonal error and is probably only valid for the Northern Hemisphere summer. Though the calibration won't truly be correct until the stray light contribution is removed, the TIRS Band 10 calibration is within ±0.12 W/m^2 sr μm (0.87 K) and Band 11 within ±0.20 W/m^2·sr·μm (1.67 K). While this is a larger error than was available for the Landsat-7 ETM+ (0.48 K), the hope is that Band 10 is still usable for most applications as a single band for thermometry while work is underway to improve the calibration of both bands. The cause for the larger bias and scatter in the Landsat-8 band 11 data is still under investigation.

(Barsi, et al., 2014. Remote Sensing)

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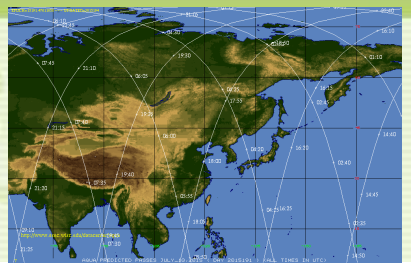
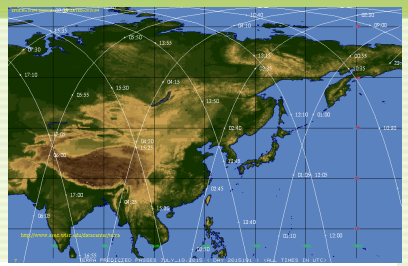
Temporal limitation





http://www.ssec.wisc.edu/datacenter/terra/

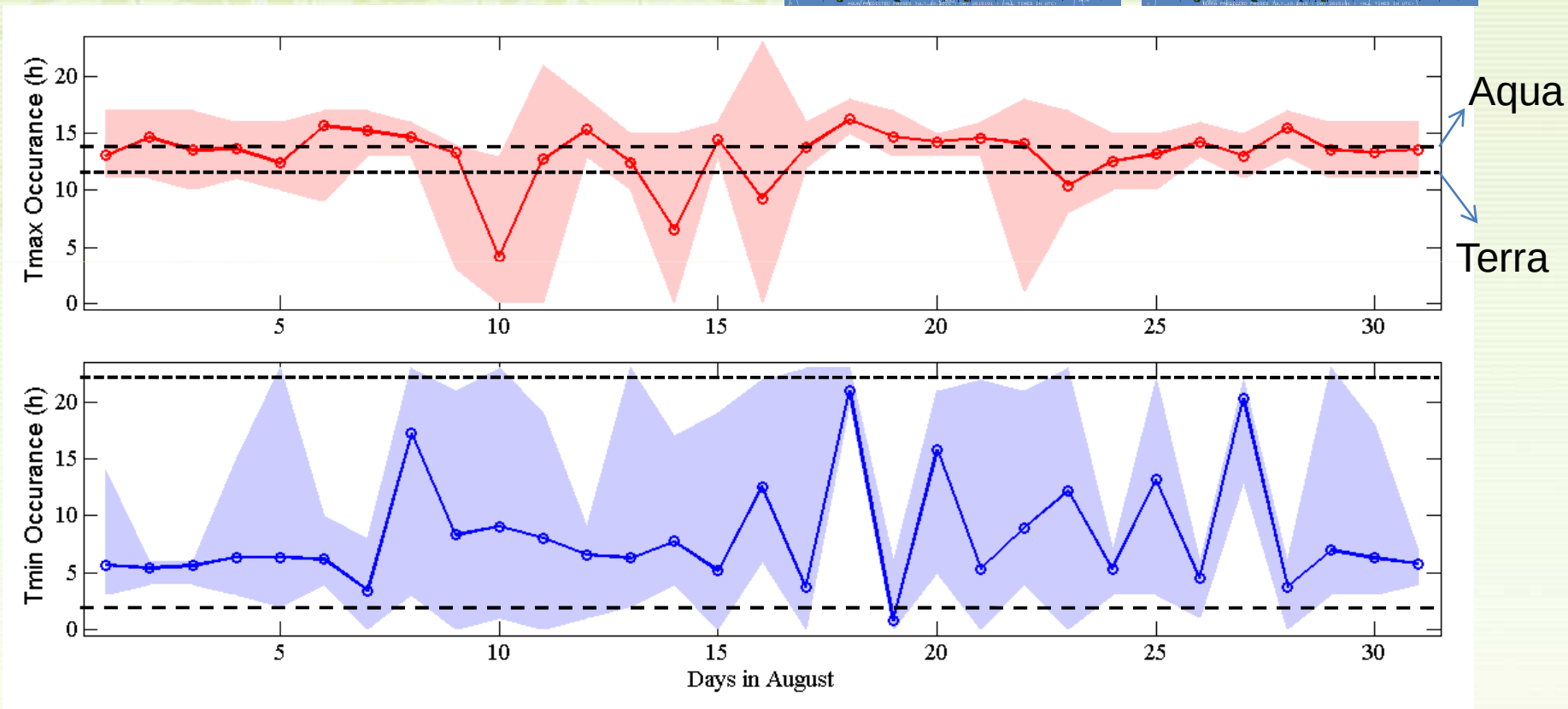


Fig The boundary of the variation of maximum occurrence, while the upper and the lower boundaries are the earliest and latest occurrences. The dotted line represents the mean values of the occurrence of time.

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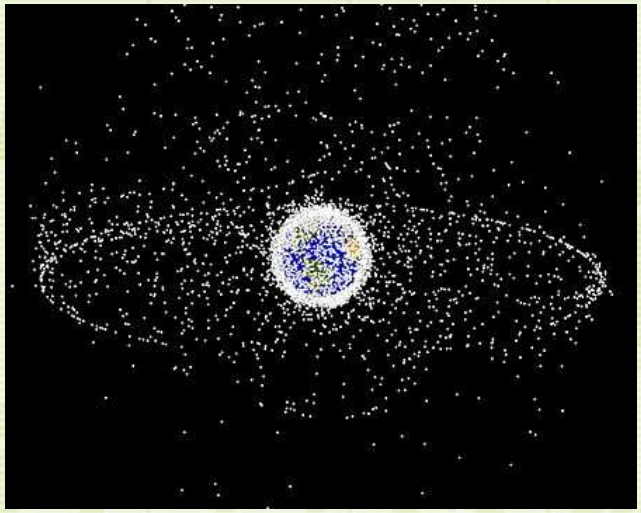

- Governments and researchers must decide which values need to be tracked, and establish **monitoring mechanisms;**

- **Earth observation**, ground-based **monitoring** and **information-processing** capabilities need to be expanded;

- Scientists and governments need to design robust approaches to standardize and verify data collection and processes;

—*Five priorities for the UN Sustainable Development Goals*
(Lv, et al., 2015. Nature,520, 432-433.)

Distilling meaning from data

It is a breathtaking time in science as masses of data pour in, promising new insights. But how can we find meaning in these terabytes? To search successfully

BIG DATA

(Nature , 2008)

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Conclusions

•Exacerbated warming over the built-up environment, not only over the **megalopolitan areas** but also **medium and small cities (previous findings)**;

•Urban thermal heterogeneity in August 2007 is observed by air temperature, and the remotely sensed land surface temperature;

• Getting more insights into urban thermal heterogeneity is necessary;

• **However**, data availability (both AWS, and thermal RS) is usually limited and the challenges;

• Preliminary results are shown, more efforts are under way.

Acknowledgement

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Thanks！