



Nanjing University of Information Science & Technology

南京信息工程大学

Observation and Simulation on the Characteristics of Summer Urban Heat Island in Nanjing, CHINA

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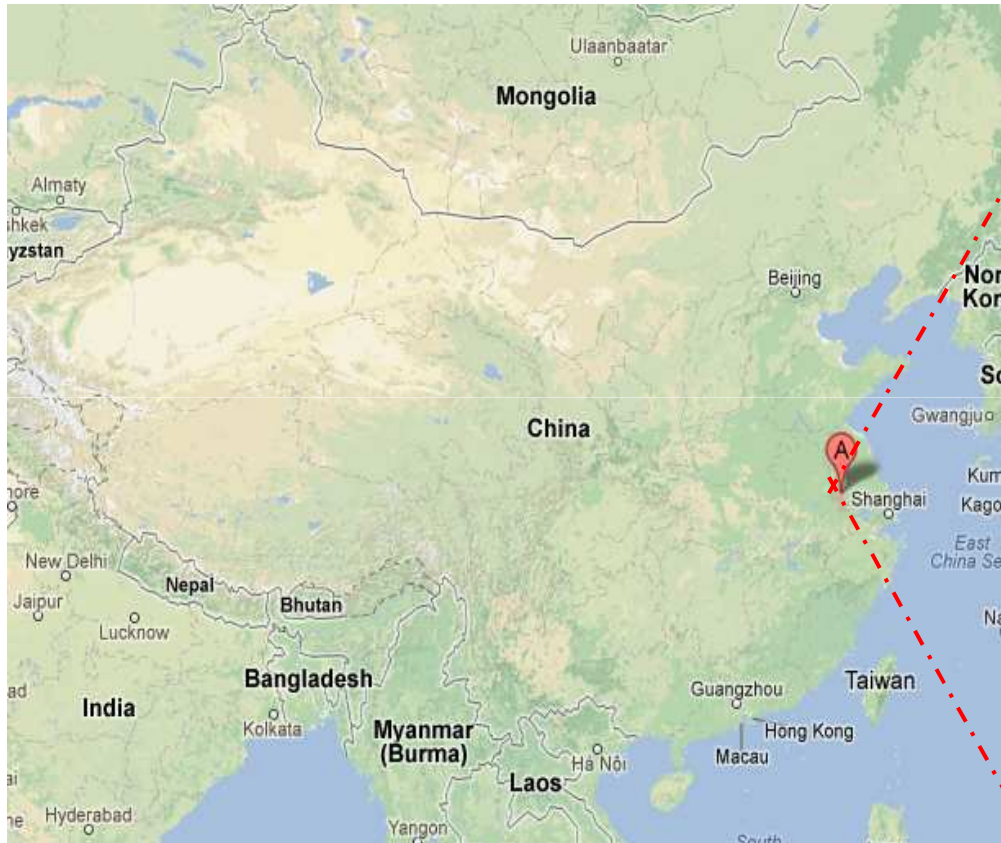
(Yale-NUIST Center on Atmospheric Environment, NUIST, CHINA)

July, 20, 2015

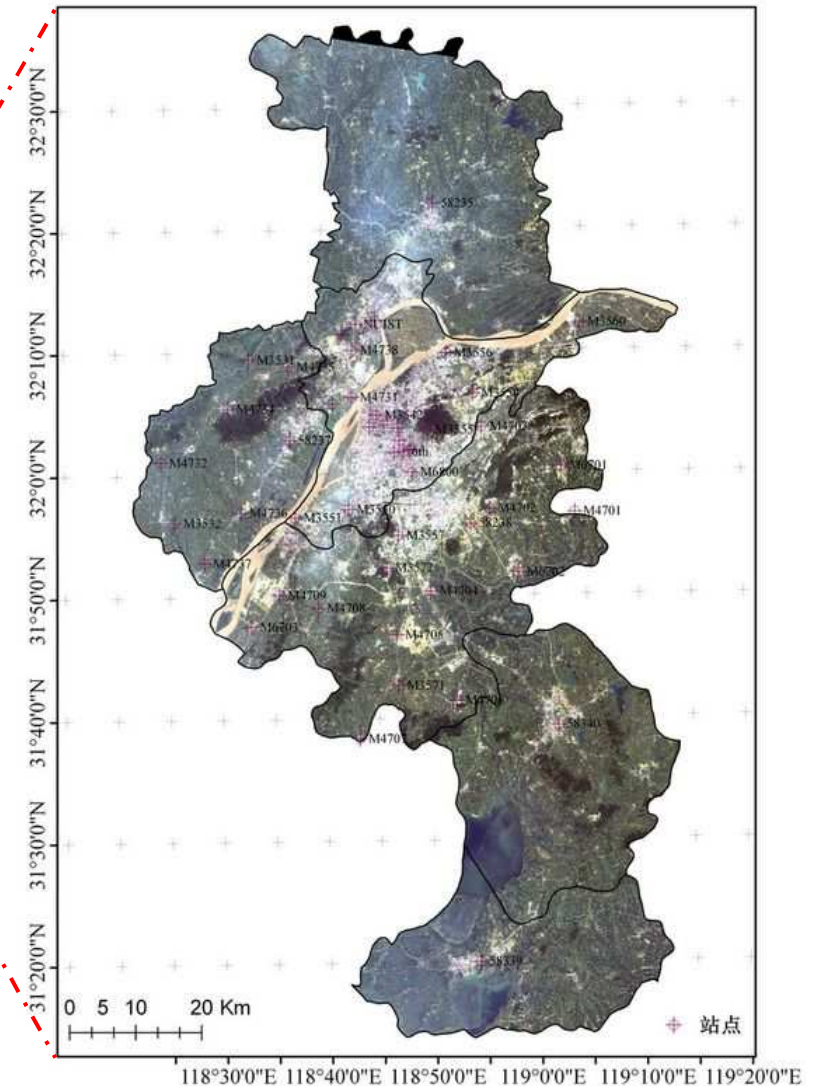
Outline

- **Introduction of the Experiment**
- **Observation Results**
- **Simulation Results**
- **Conclusions**

1. Introduction of the Experiment

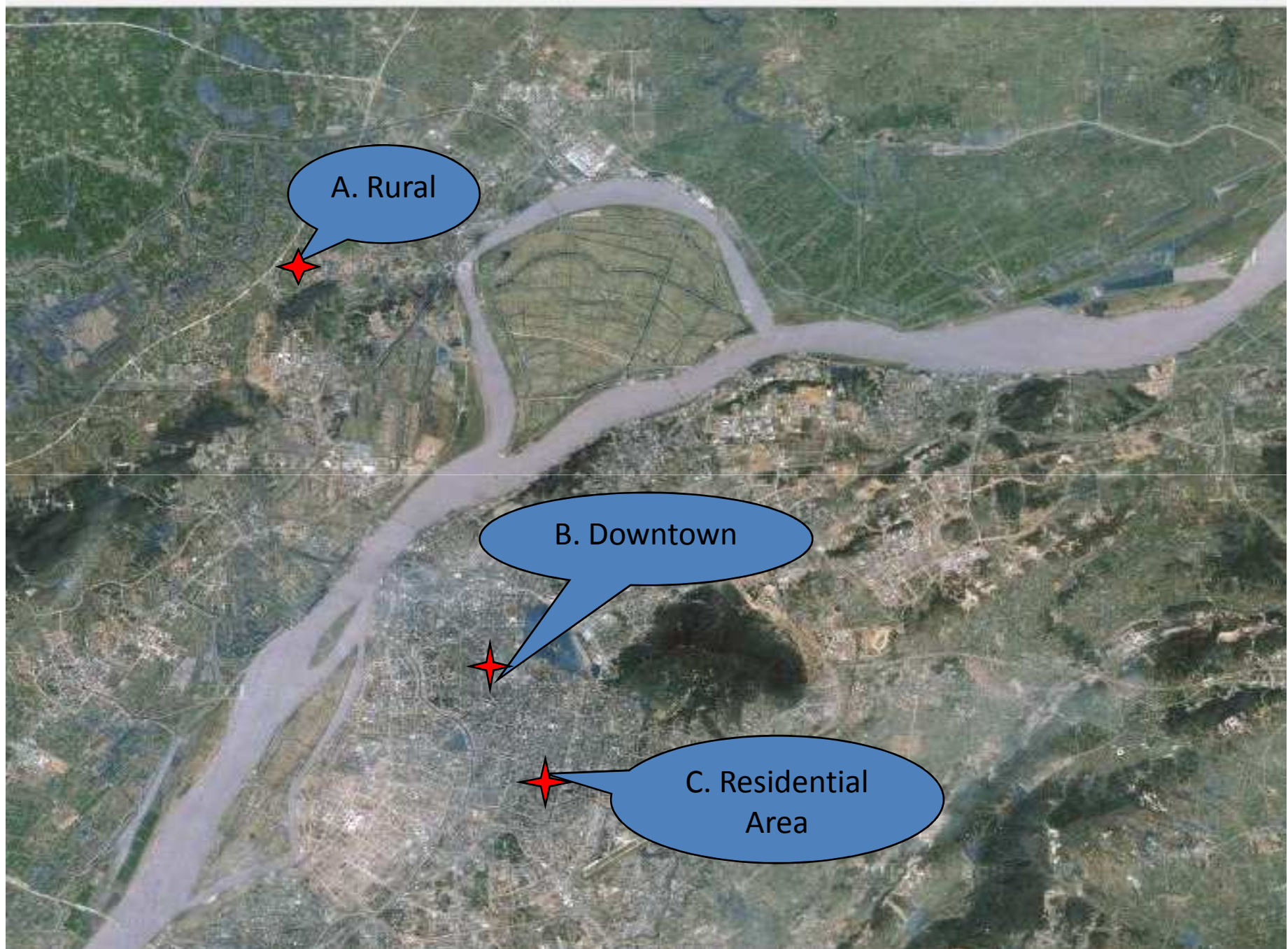


Population: 8 Million
Urban area: 5600 km^2
Vehicle: 2 Million



Experiment Plan

- Time:
 - July,25-Aug,5,2010
- Stations
 - A=Rural, B=Downtown, C=Residential Area
- Instruments
 - Tether Balloons
 - Automatic Weather Stations
 - Lidars
 - Wind Profiler
 - Sonic Anemometer, ...



A. Rural

B. Downtown

C. Residential
Area

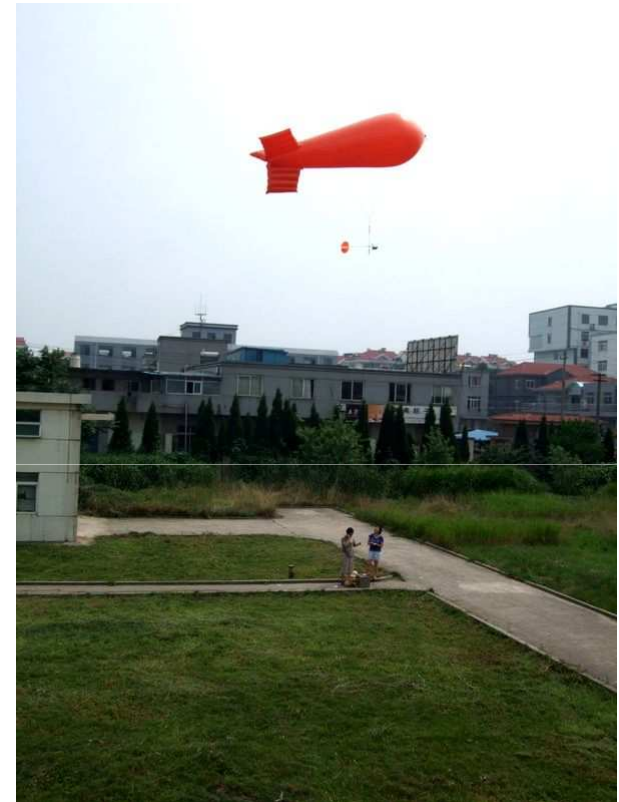
Tether Balloon Stations



RURAL (A)



DOWNTOWN(B)



RA (C)

Detection Height: 500-1000
Frequency: 6-8/day
Valid Obs: 77.
Simultaneously Obs: 17

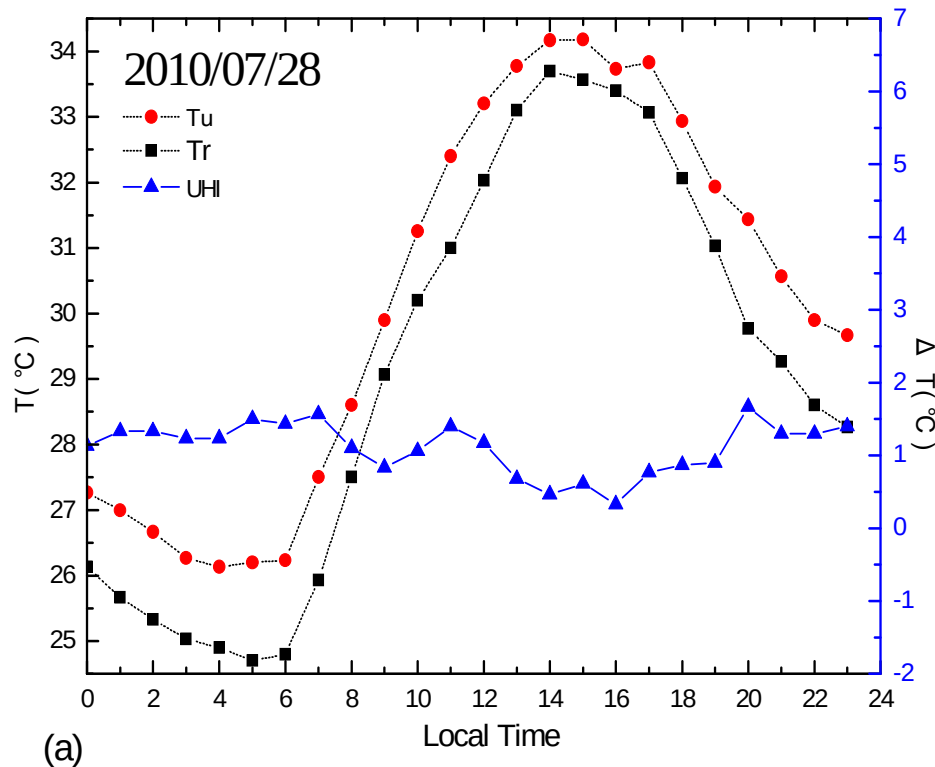
Weather Condition During the Experiment

Date	Temperature °C			RH % averaged	Total Pre. mm	Cloud T/L	WD degree	WS m·s ⁻¹
	Ave	Max	Min					
July,25	28.7	32.2	25.9	77	0	6.7/2.5	105	4.7
July,26	28.5	31.9	25.6	75	0	5.4/3.0	120	4.4
July, 27	27.8	31.8	25.0	78	0	5.5/5.5	100	3.1
July28	28.5	32.7	24.3	78	0	4.1/3.5	137	1.6
July, 29	29.9	35.1	26.7	78	12.3	4.4/3.0	165	2.0
July30	30.2	35.3	27.3	77	0	2.8/1.8	163	2.3
July,31	30.9	34.8	26.1	70	0	0.7/0.6	184	2.9
Agu,1	32.6	36.6	29.2	64	0	3.1/1.2	224	2.8
Agu, 2	33.4	37.3	29.5	62	0	4.8/1.4	230	1.9
Agu3	33.6	38.0	28.8	63	0	2.5/1.1	195	2.0
Agu,4	33.8	37.5	30.2	64	0	5.0/0.8	146	2.3
Agu,5	32.1	36.6	26.1	71	2.2	5.1/2.0	115	3.3
Total / Ave	30.8	38.0	24.3	71	14.5	4.2/2.2	157	2.8

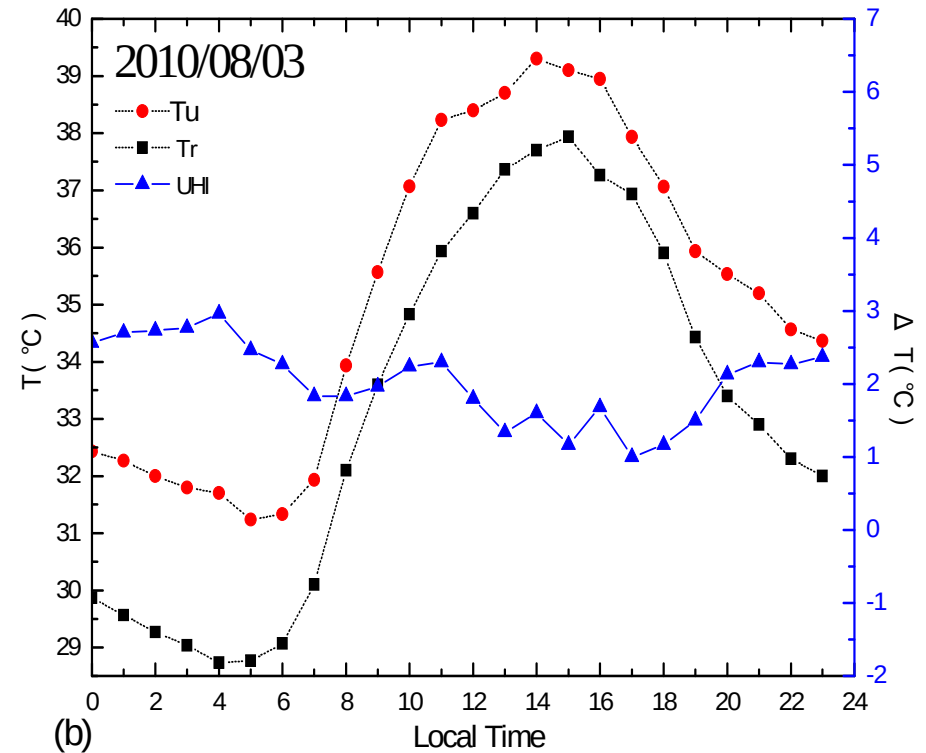
2. Observation results — UHI

$$\text{UHI} : \Delta T = T_{\text{urban}} - T_{\text{rural}}$$

T = Averaged Temp of Multi-Stations

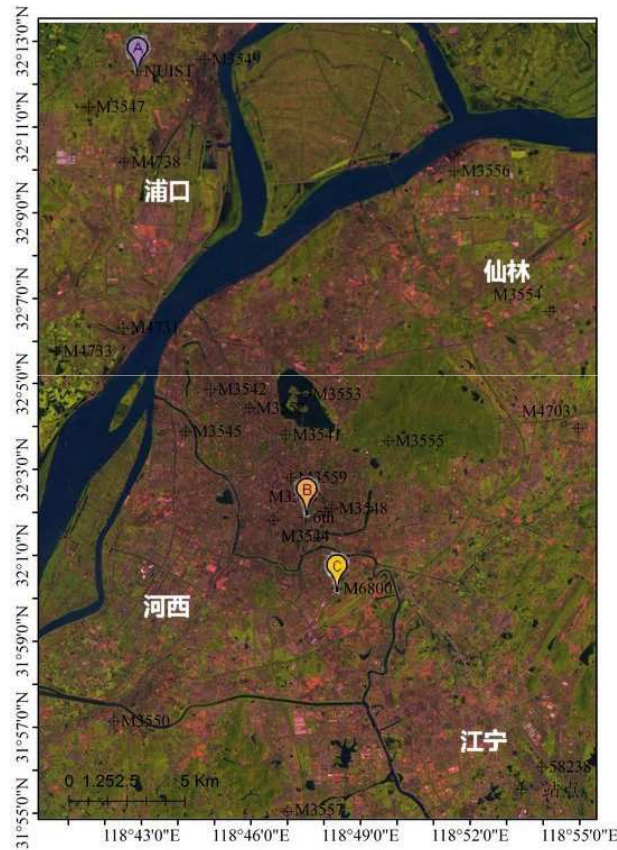


July, 28: $\text{UHI}_{\text{ave}} = 1.1^\circ\text{C}$;

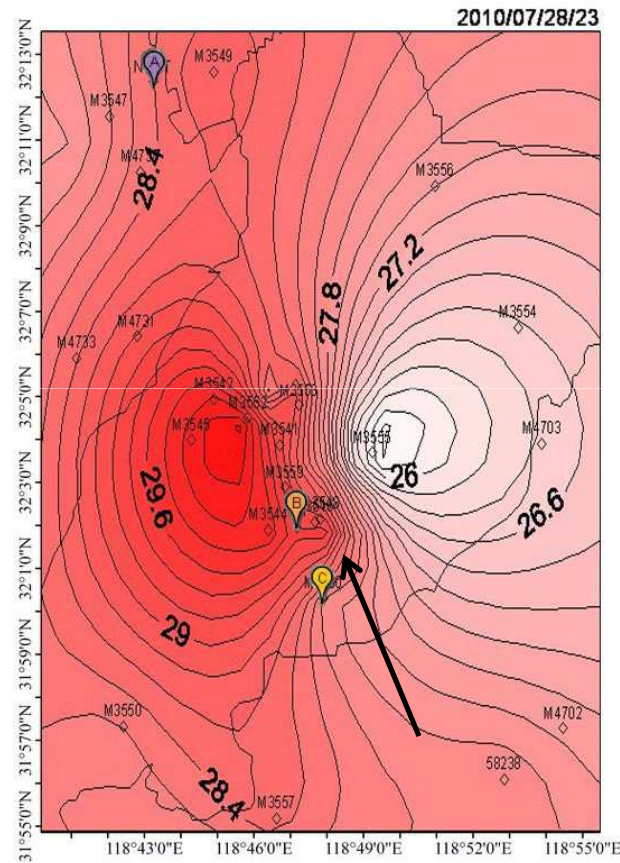


Aug, 3: $\text{UHI}_{\text{ave}} = 2.0^\circ\text{C}$.

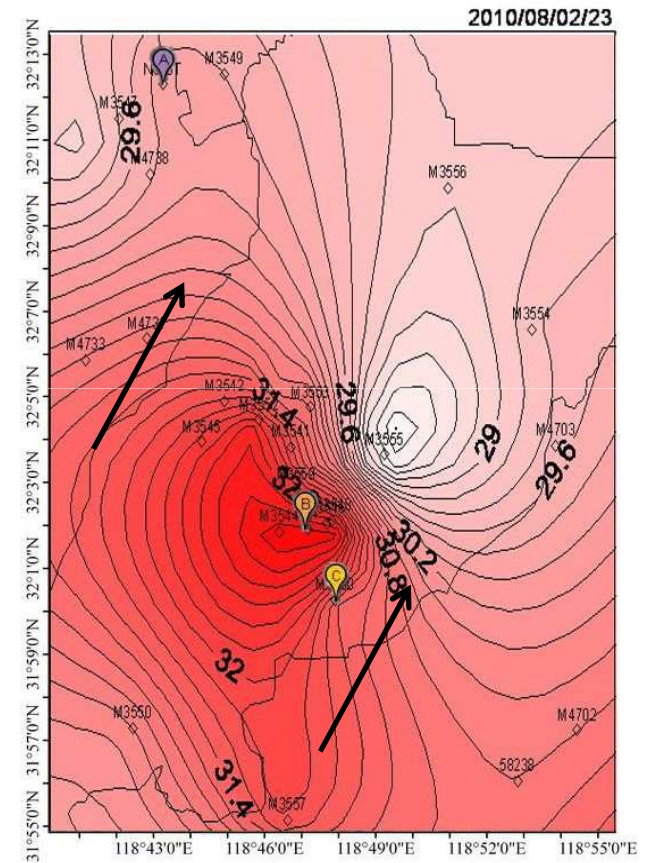
2. Observation results — UHI Pattern



(a) Terrain



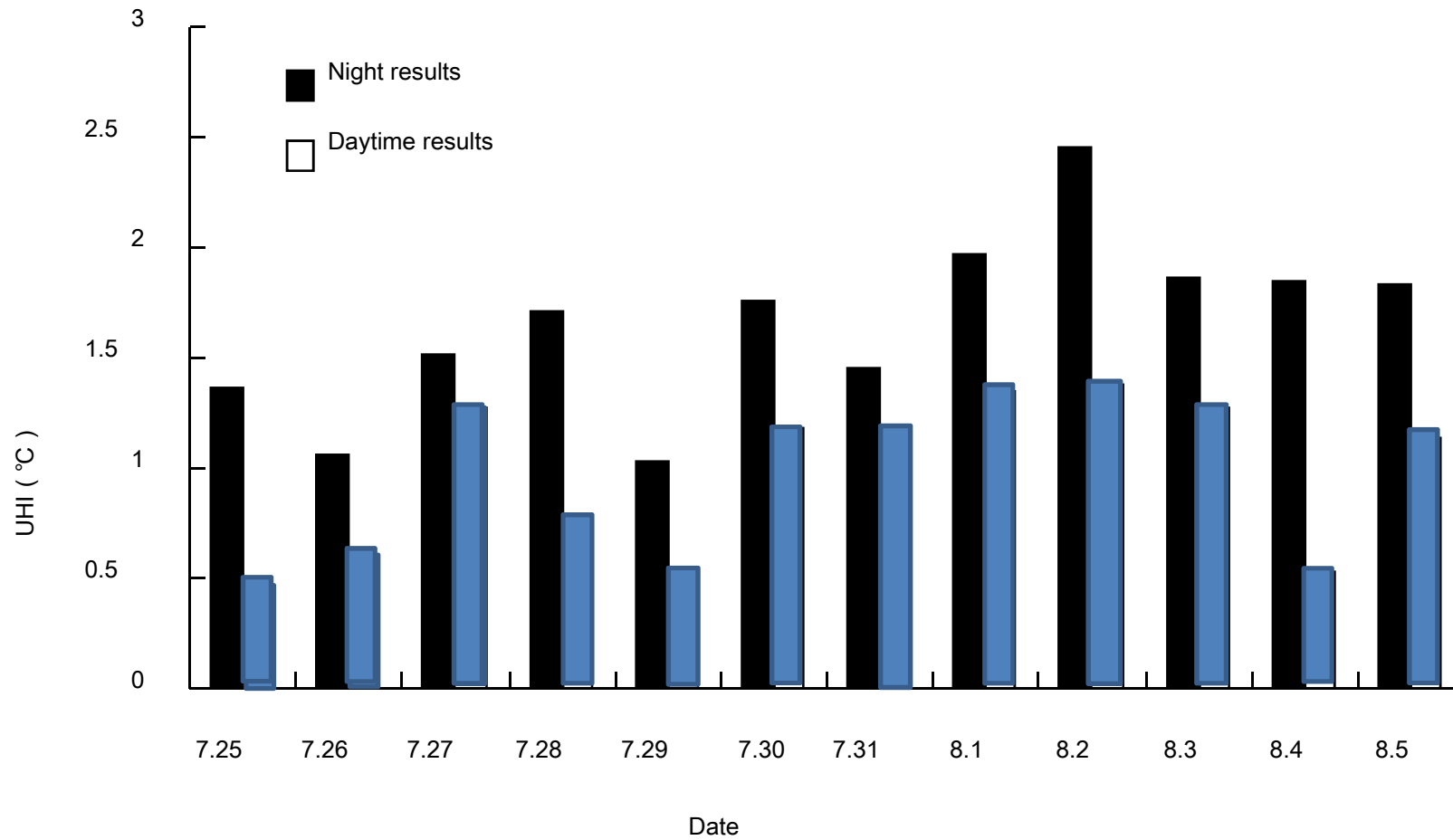
(b) UHI Pattern in the SE wind



(c) UHI Pattern in the SW wind.

Heat Plume Influence can be seen from these results

2. Observation results — UHI Distribution



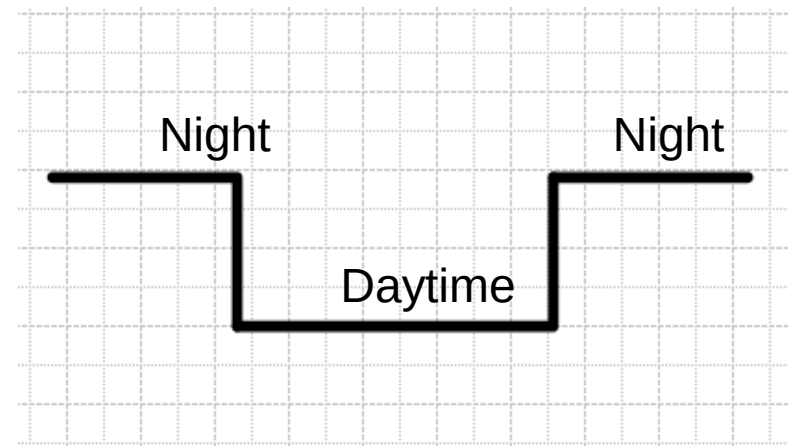
2. Observation results — UHI Distribution

Distribution of UHI at 4 periods

UHI(°C)	Sun Rising 05:00~07:00	Daytime 07:00~17:00	Sun Set 17:00~20:00	Nighttime 20:00~04:00
NULL (<0.5)	2%	30%	19%	2%
Weak [0.5,1.5]	48%	51%	41%	44%
Middle [1.5,2.5]	44%	17%	17%	37%
Strong [2.5,3.5]	6%	2%	17%	14%
Super Strong (>3.5)	0	0	6%	3%

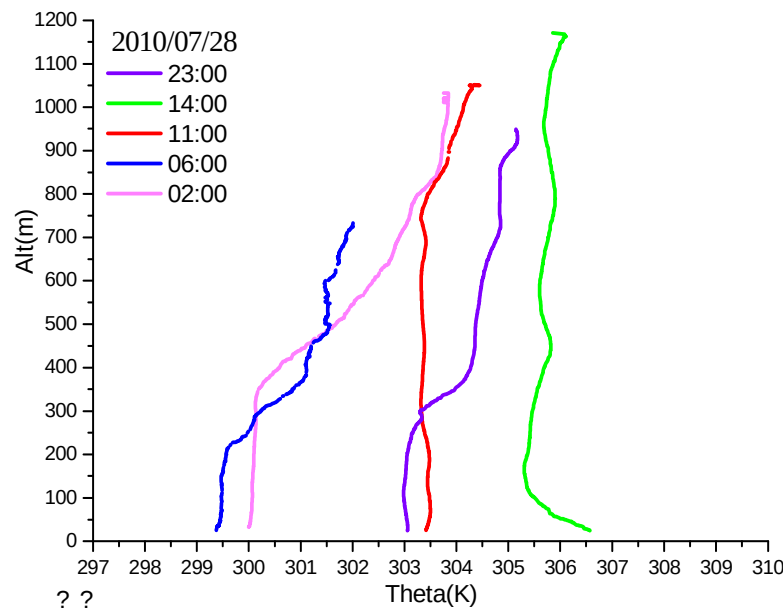
Nighttime UHI : 1.63°C.

Daytime UHI : 0.98°C.

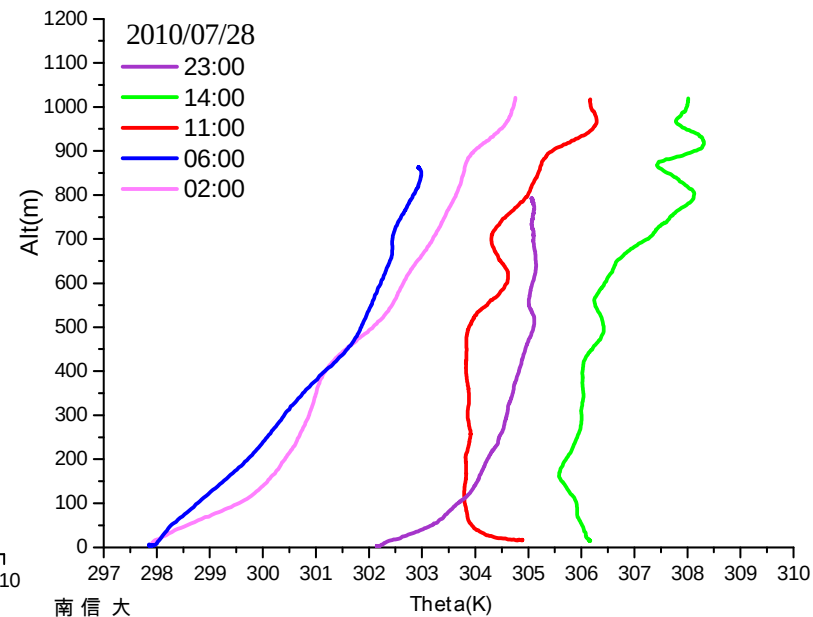


2. Observation results — Vertical Profiles

Evolution of Potential Temp. Profiles in Urban and Rural



(a) Urban



(b) Rural

Nighttime; Mixing layer still exist in Urban;

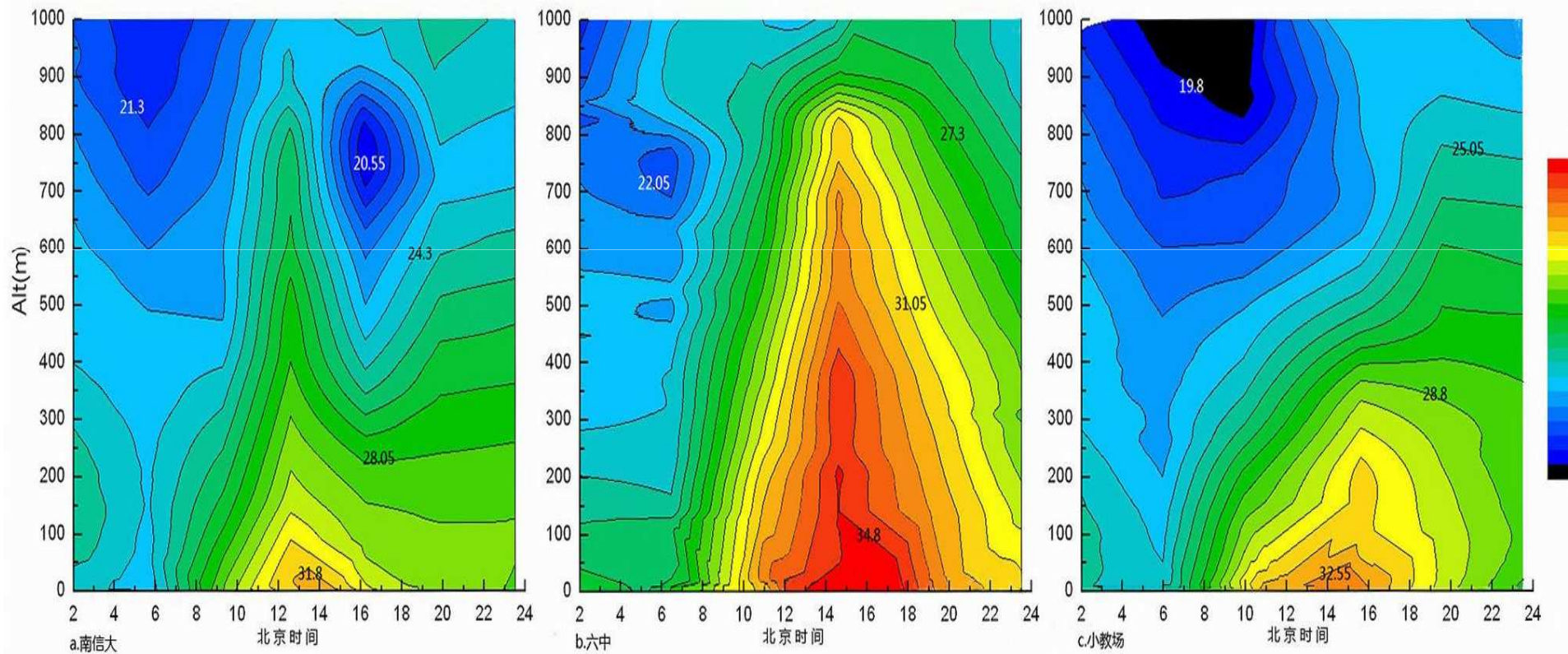
Typical stable Layer in rural;

Daytime : Mixing layer of Urban is higher than rural.

Development speed is faster than rural too.

2. Up-level Results of Temperature at 3 Stations

Time & Height Sections of Temp at 3 stations on July,28

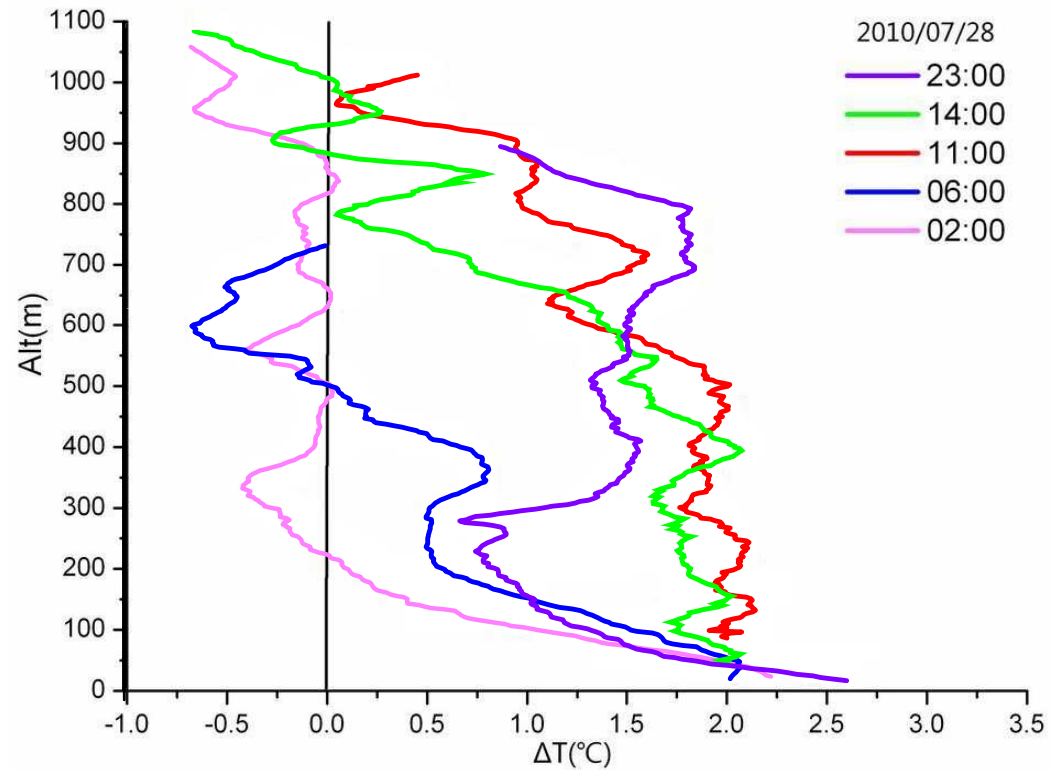


(a) Rural

(b) Downtown

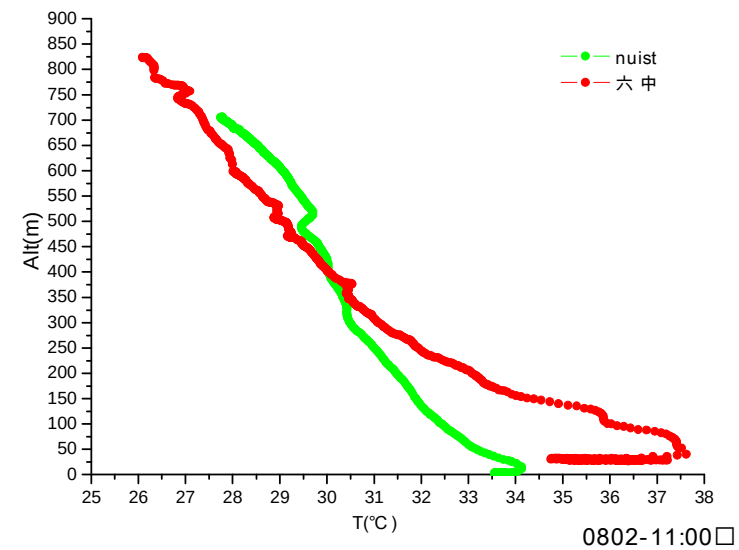
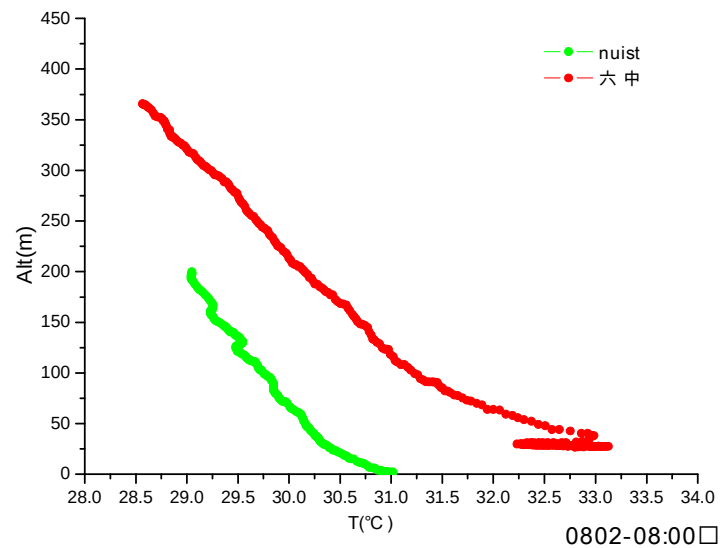
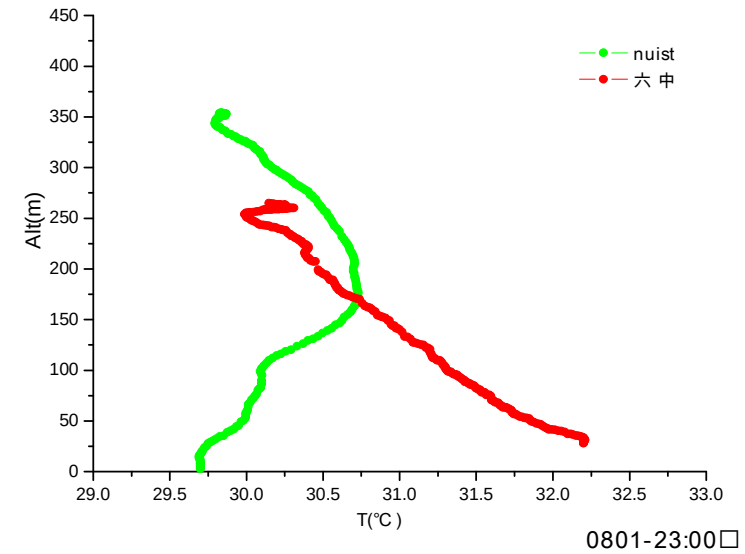
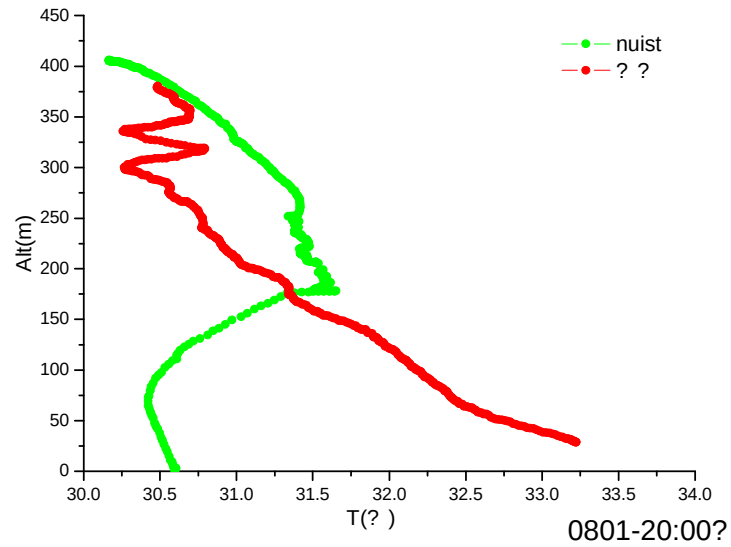
(c) RA

2. UHI Profiles and Temp. Crossover



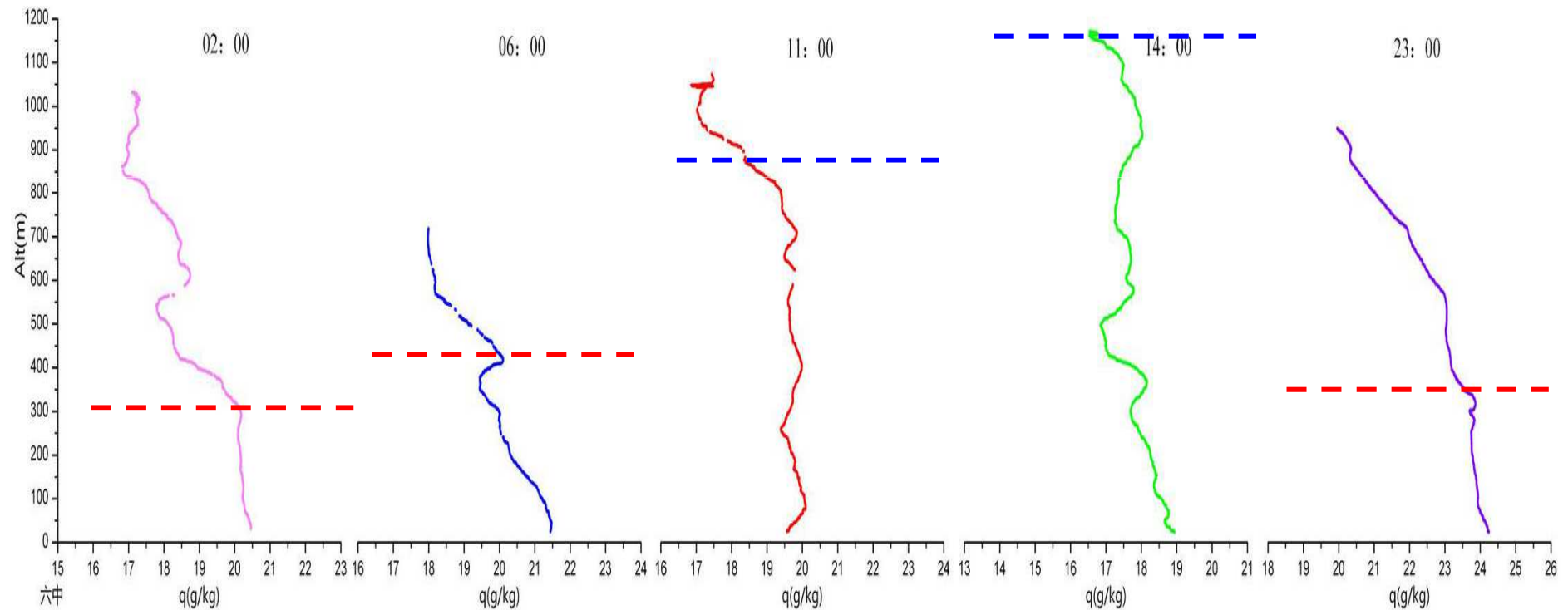
$$\Delta T(z) = T(z)_{\text{urban}} - T(z)_{\text{rural}}$$

2. Temperature Crossover



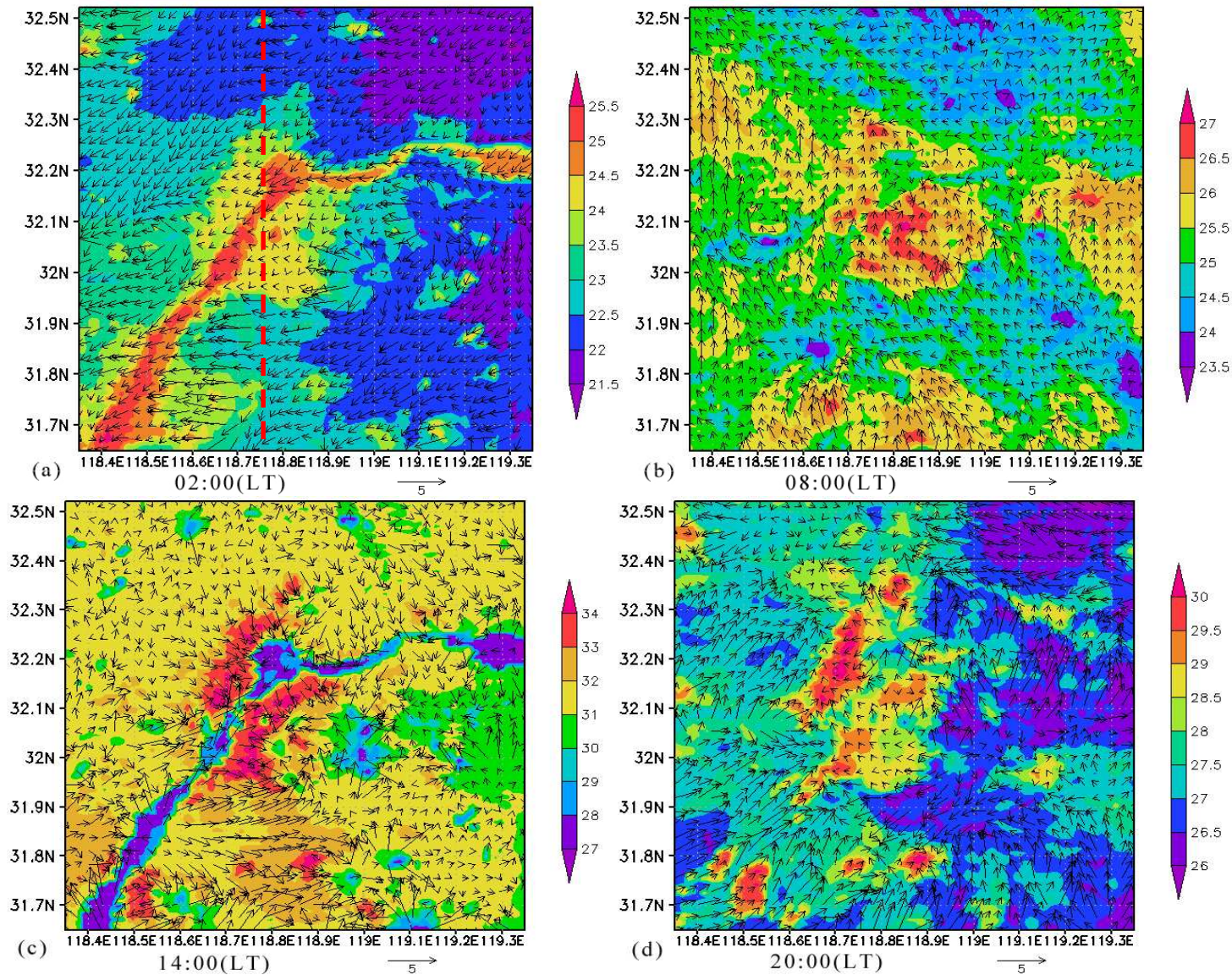
2. Vertical Profiles of Specific Humidity

Top of BLH detected by Humidity Profiles



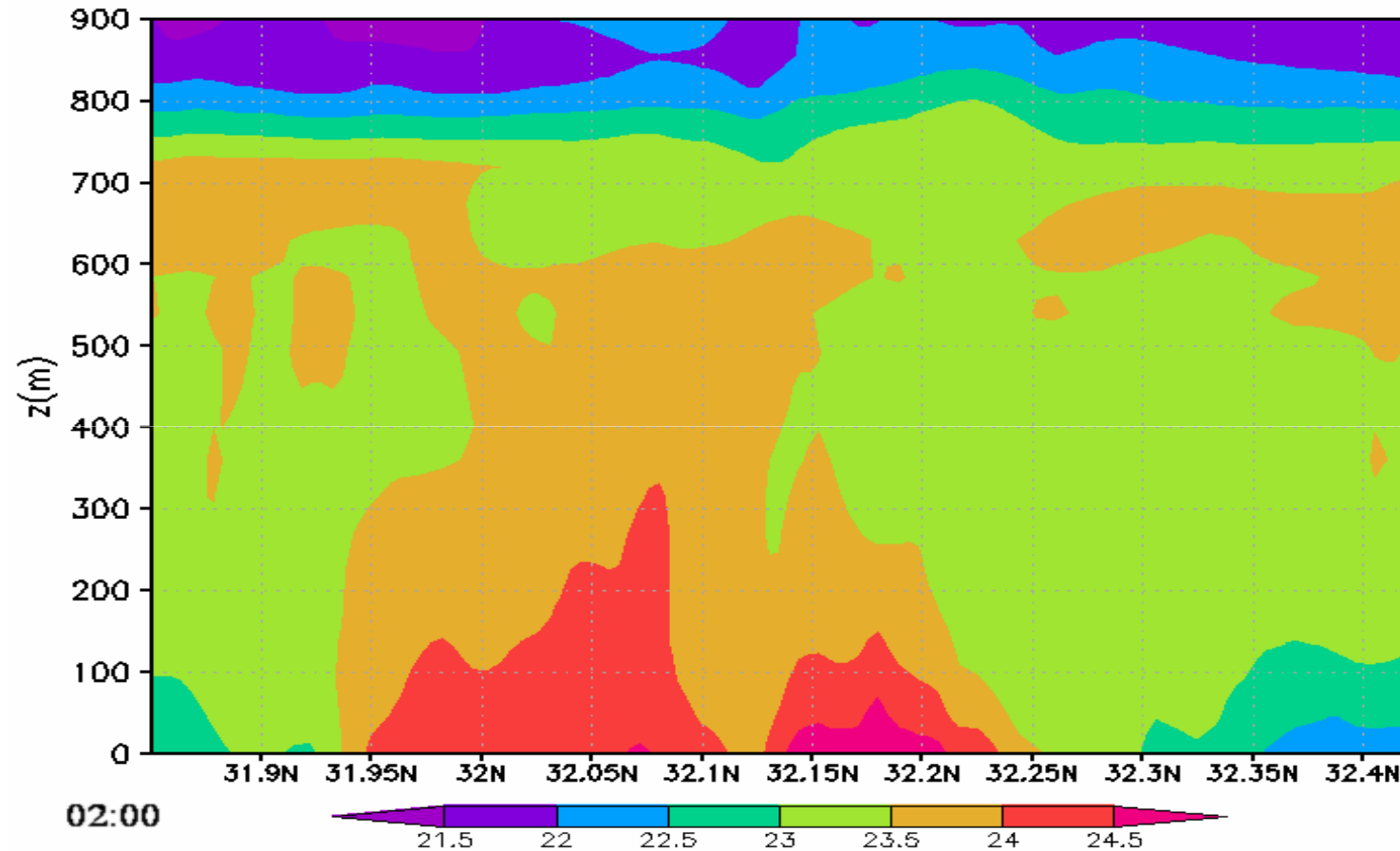
Urban Station on July 28, 2010

3. Simulation results — UHI



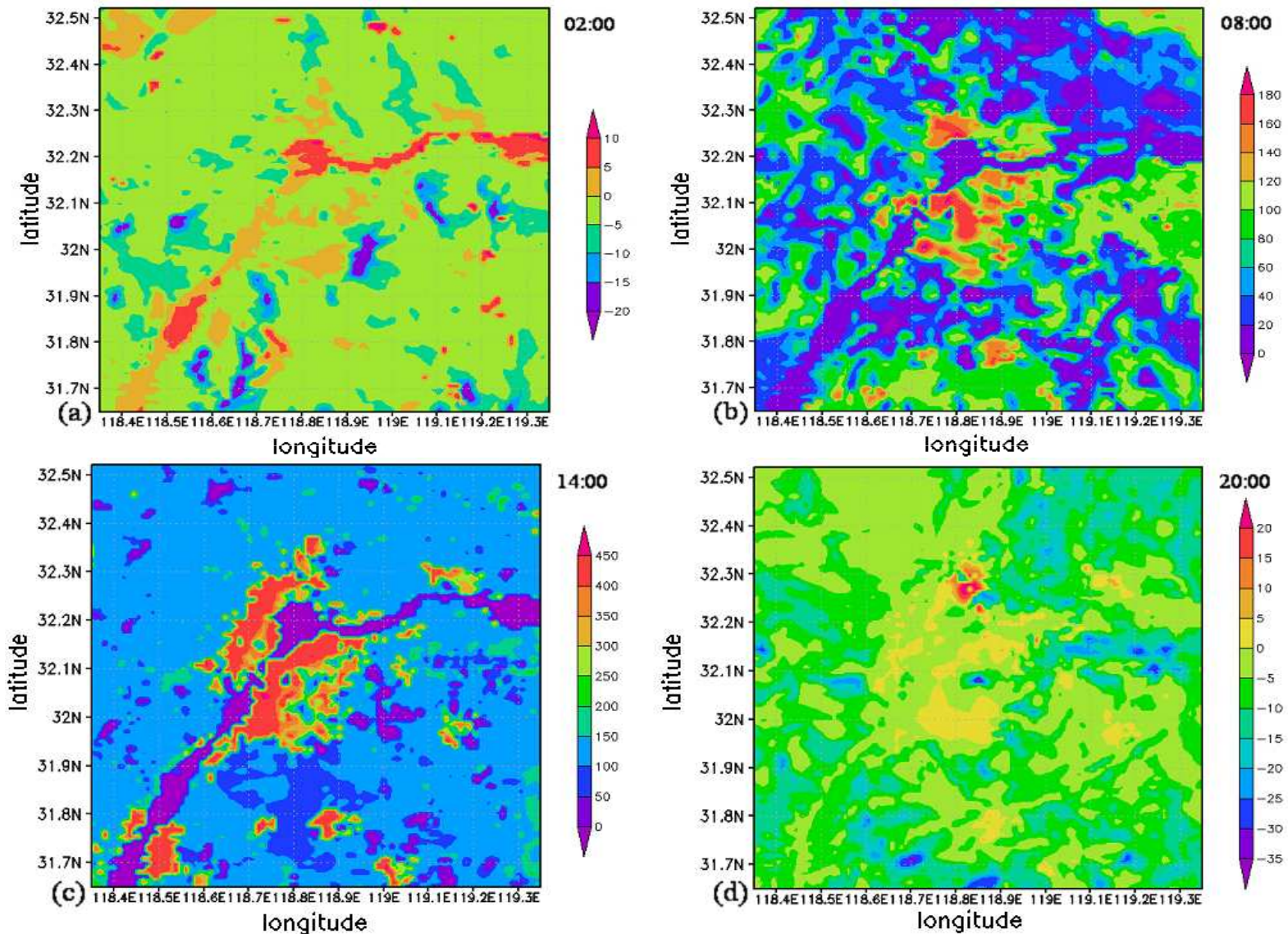
Temp & Wind, at 02, 08, 14, 20, on Jul. 28 2010.

3. Simulation results — Crossover



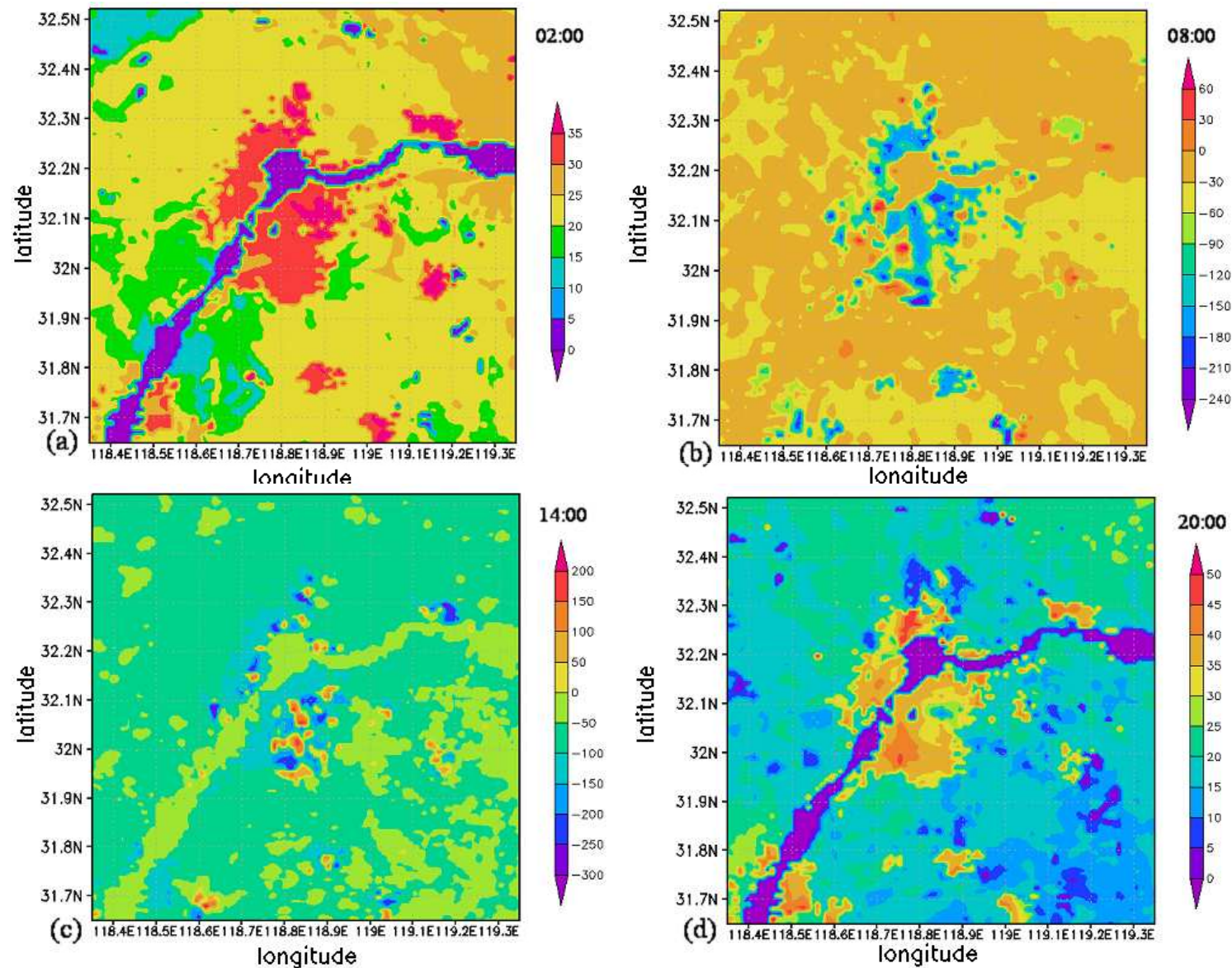
**The vertical temperature field along the Nanjing center longitude 118.79E
at 02:00 on Jul. 28 2010.**

3. Simulation results — Sensible Heat Flux



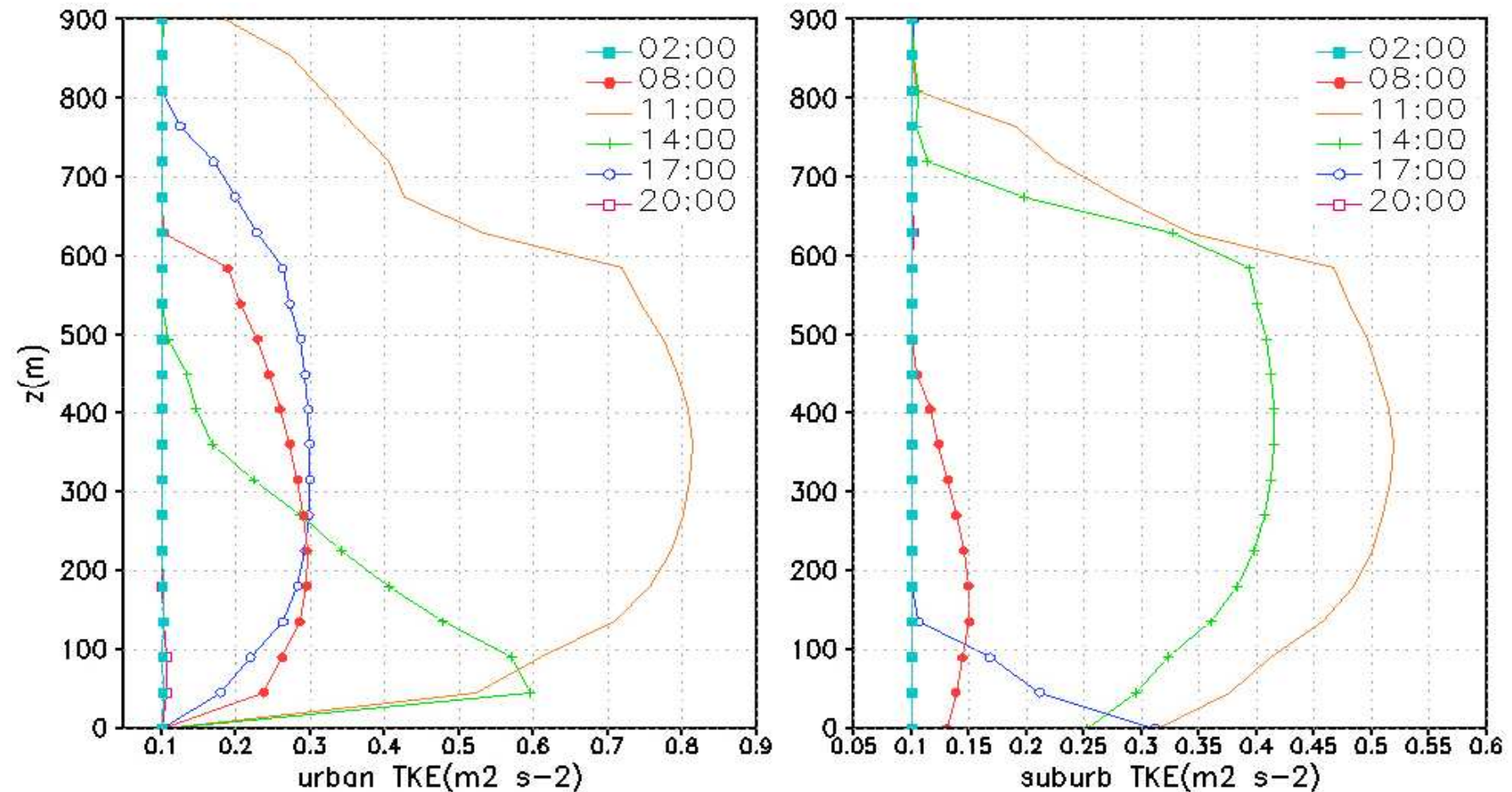
Sensible Heat Flux, at 02, 08, 14, 20, on Jul. 28 2010.

3. Simulation results — Soil Heat Flux



Soil Heat Flux, at 02, 08, 14, 20, on Jul. 28 2010.

3. Simulation results — TKE Profiles



TKE Profiles, at 02, 08, 11, 14, 17, 20, on Jul. 28 2010.

4. Conclusions

- The daily UHI on typical sunny day was above 1°C. UHI was stronger and more stable in the nighttime. UHI pattern corresponded well to urban land use status.
- Urban mixed layer height was estimated as 300m in the nighttime and 1300m in the daytime in this observation. Owing to high heat storage and strong turbulent transport of urban underlying surface, heat island in boundary layer extended up to 900m in the daytime and maintained at 300m in the nighttime.
- Simulation results showed that, at 02:00 p.m., sensible heat flux reached 350W/m² in city, twice as that in suburbs. The soil heat flux reached 200W/m² in city as four times that of the suburbs. TKE in city reached the higher value of 1.2m²/s² in 200-700m, twice as that in suburbs.

Thanks

For Your Attention