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## Study of mobile measurements for detailed temperature distribution in a high-density urban area in Tokyo

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# Outline



1 Introduction



2 Methods

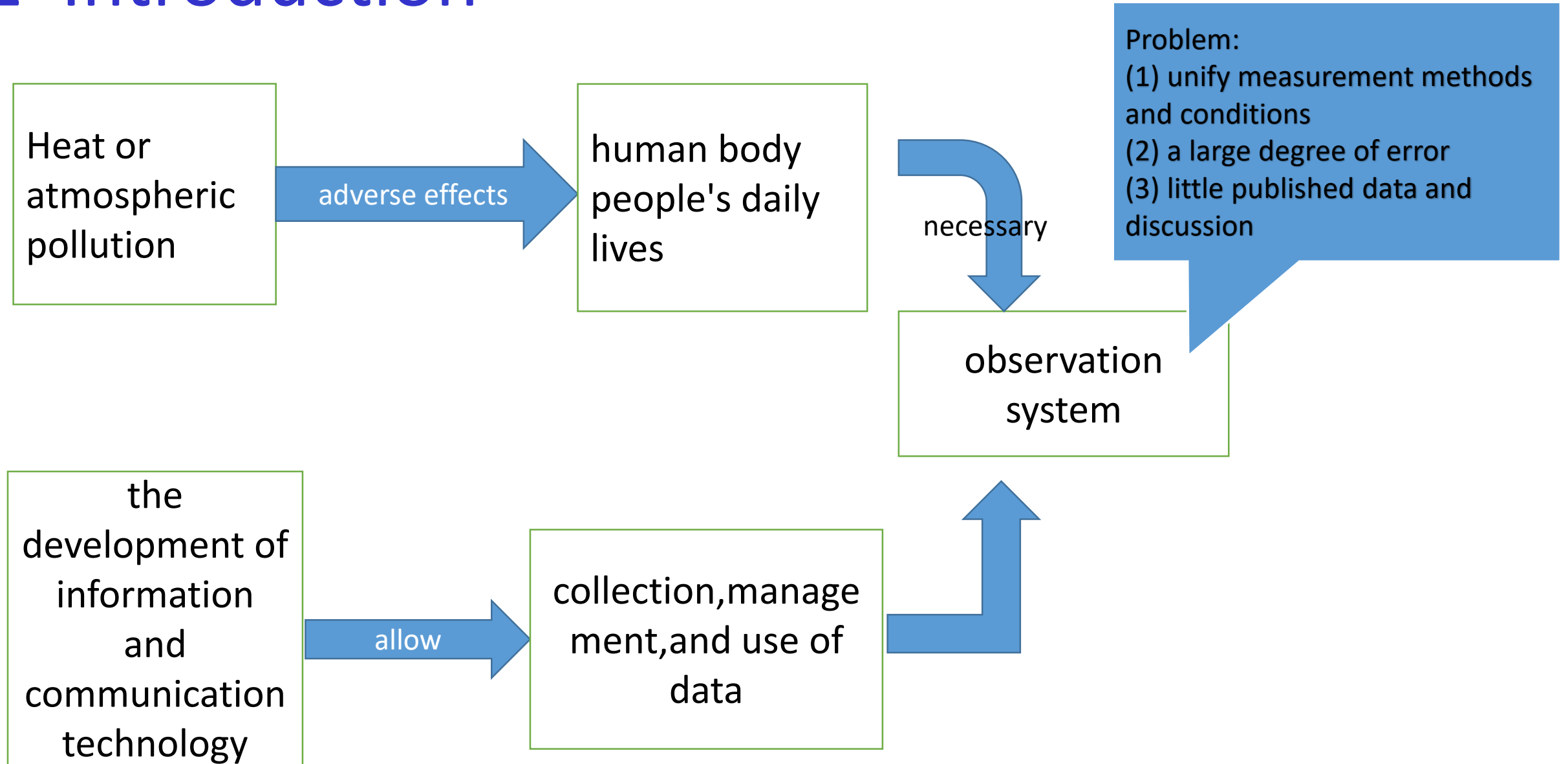


3 Results and discussion



4 Concluions

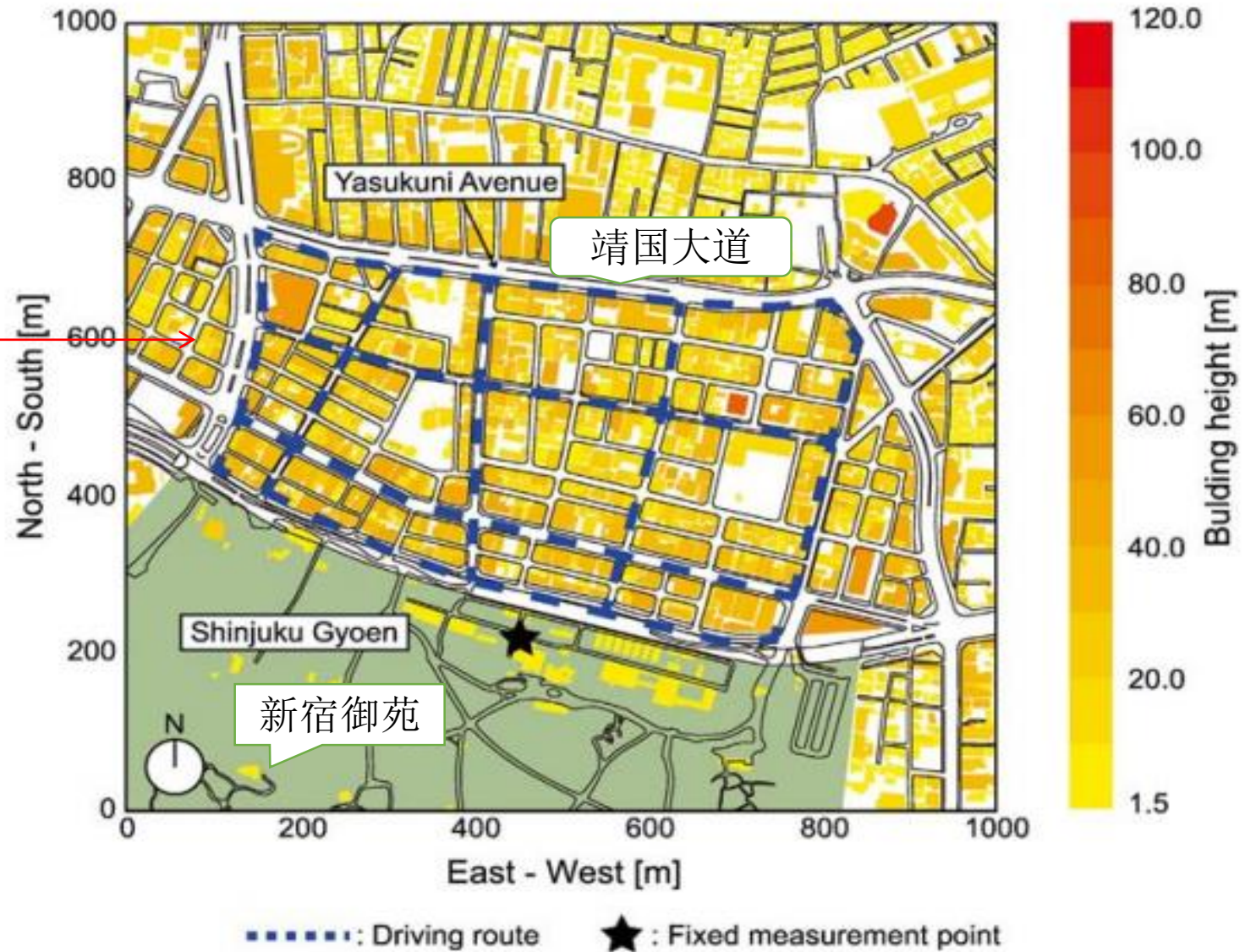
# 1 Introduction



# 2 Methods

## 2.1 Experiment outline

several city blocks in  
Shinjuku, Tokyo  
proportion: 26.2 hecuare  
mean building height: 17 m  
location: contiguous to Shinjuku  
Gyoen  
period: August 25th to 28th, 2015  
10:00 - 12:00 and 13:00 - 14:00





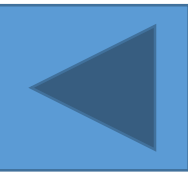






图片来源：视觉中国 [www.vcg.com](http://www.vcg.com)

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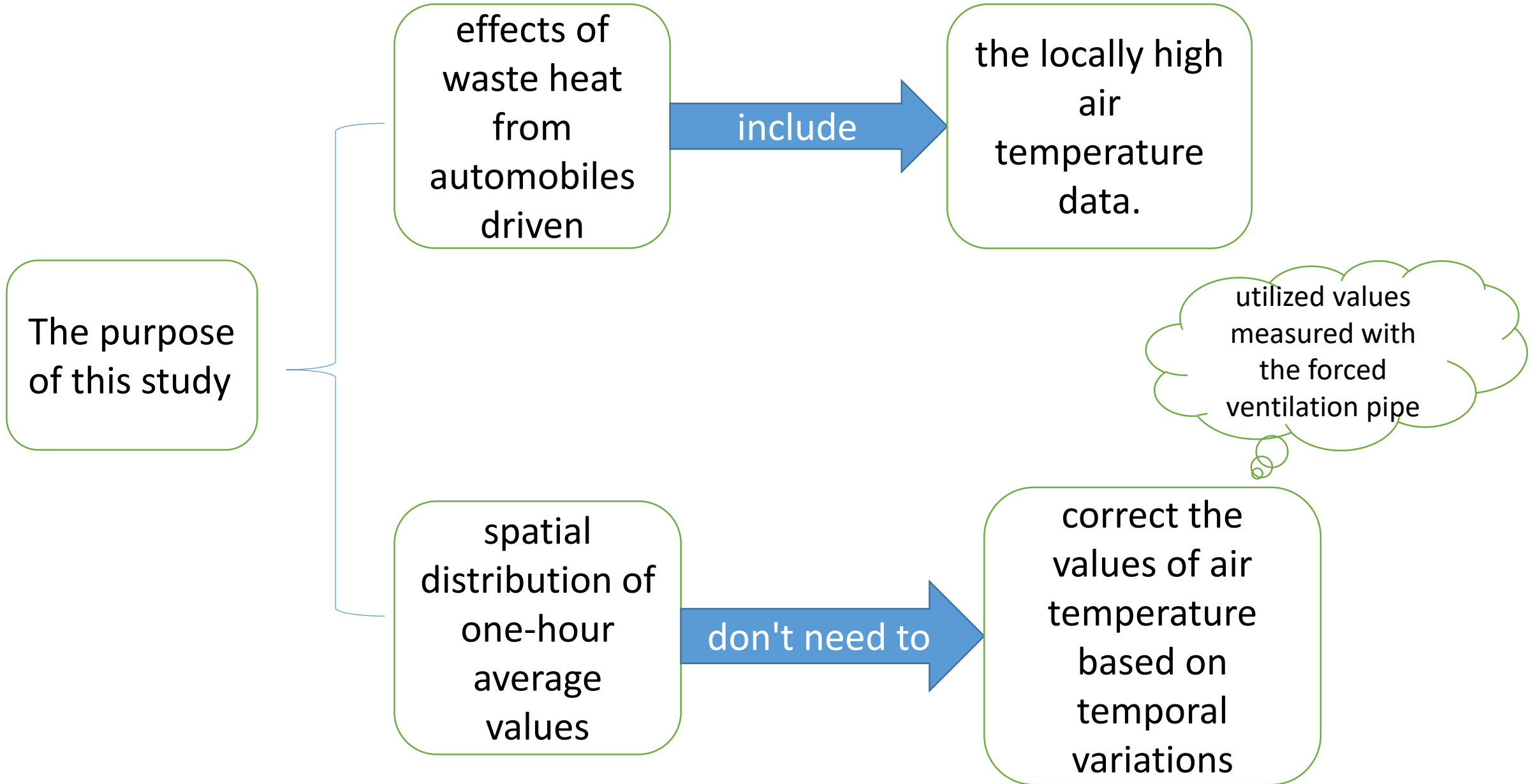
# 2.2 Instrument specifications

Table 1  
Instrument specifications.

Method	Instrument	Item	Specification	Record interval
Mobile	Platinum resistance (0.5 mm $\phi$ )	Air temperature	Range: $-200$ to $250$ , $\pm 0.15$ $^{\circ}\text{C}$ Time constant: $2.2$ s	1.0 s
	GPS logger (747proS, Transystem)	Latitude, longitude	GPS accuracy: $<3.0$ m 2D-RMS	
	Data logger (NR-600, Keyence)	-		
Fixed	Thermo-hygrometer (RTR-507, T&D)	Air temperature	Range: $-30$ to $80$ , $\pm 0.3$ $^{\circ}\text{C}$ Time constant: $7$ min	10 min
		Humidity	Range: $0$ to $99$ , $\pm 2.5\%$ RH Time constant: $20$ s	
		Weather station		
	Weather station	Wind velocity	Three cups anemometer	1.0 s
		Wind direction	Feather	
		Solar radiation	Silicon photocell	
	GPS logger (747proS, Transystem)	Latitude, longitude	Accuracy: $<3.0$ m 2D-RMS	

Fig. 1. Mobile measurement platform.

## 2.3 Air temperature correction





## 2.4 Sampling positional data correction

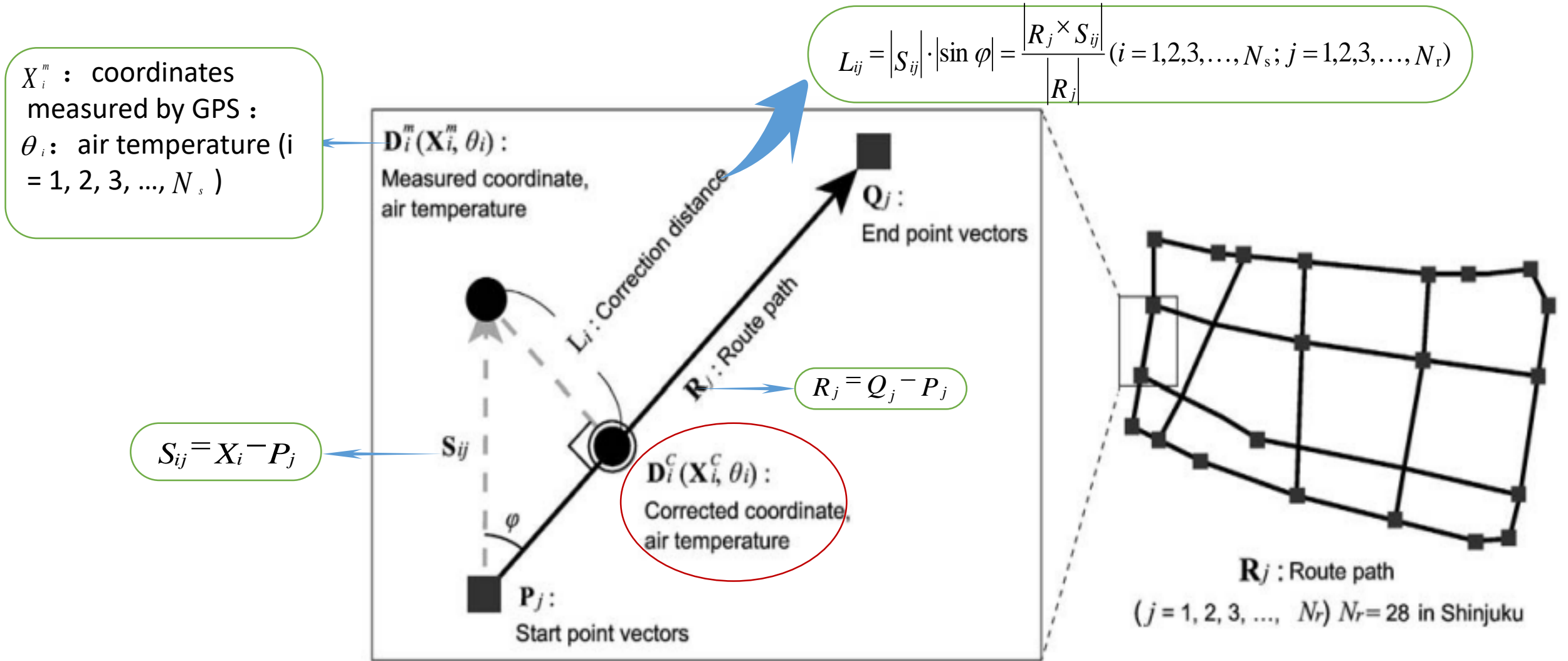
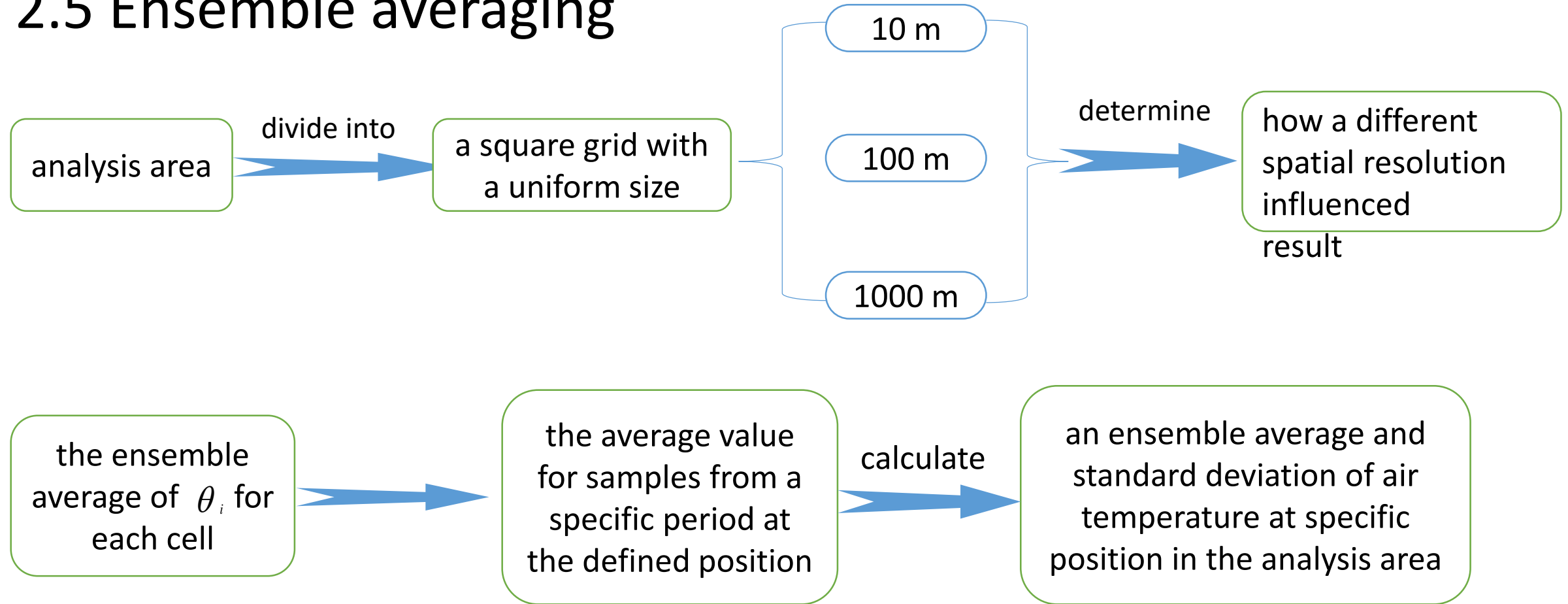


Fig. 3. Schematic diagram of the correction method for the positional data.

## 2.5 Ensemble averaging



# 3 Results and discussion

## 3.1 Weather condition

mean wind velocity: 0.66m/s  
solar radiation flux: low  
the temporal variation of air temperature: very small

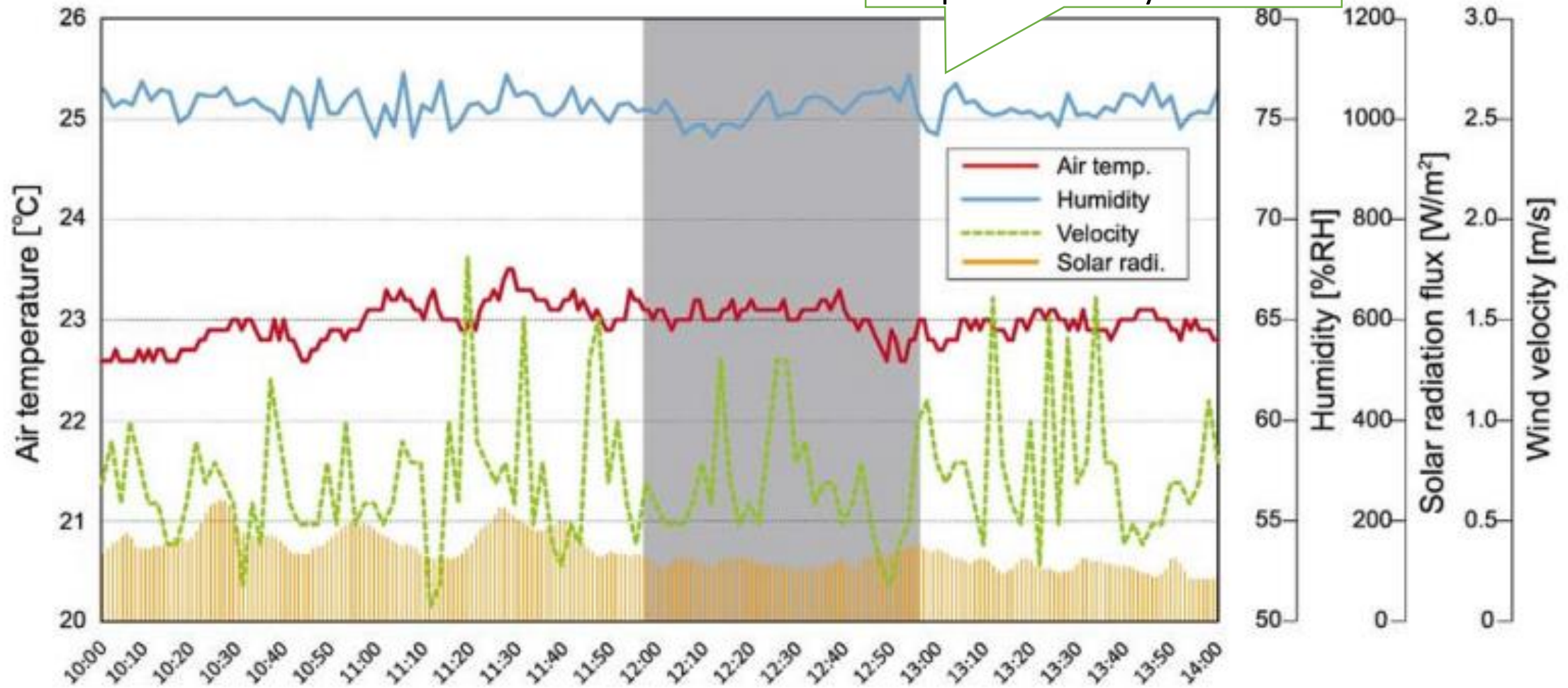


Fig.4. Weather conditions measured by the weather station located in Shinjuku Gyoen(August 28th,2015,10:00 to 14:00).



# 3.2 Measurement error of GPS

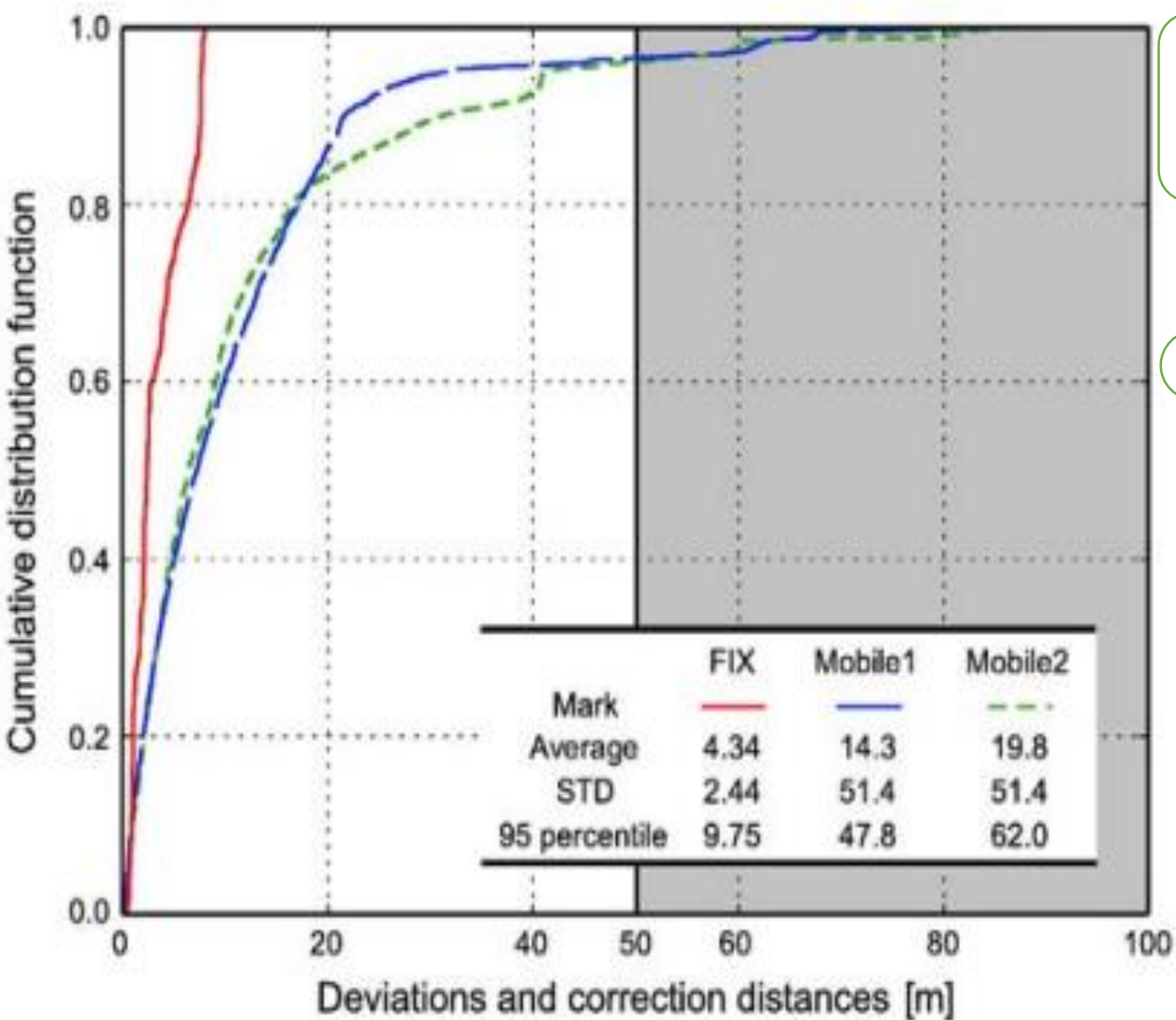
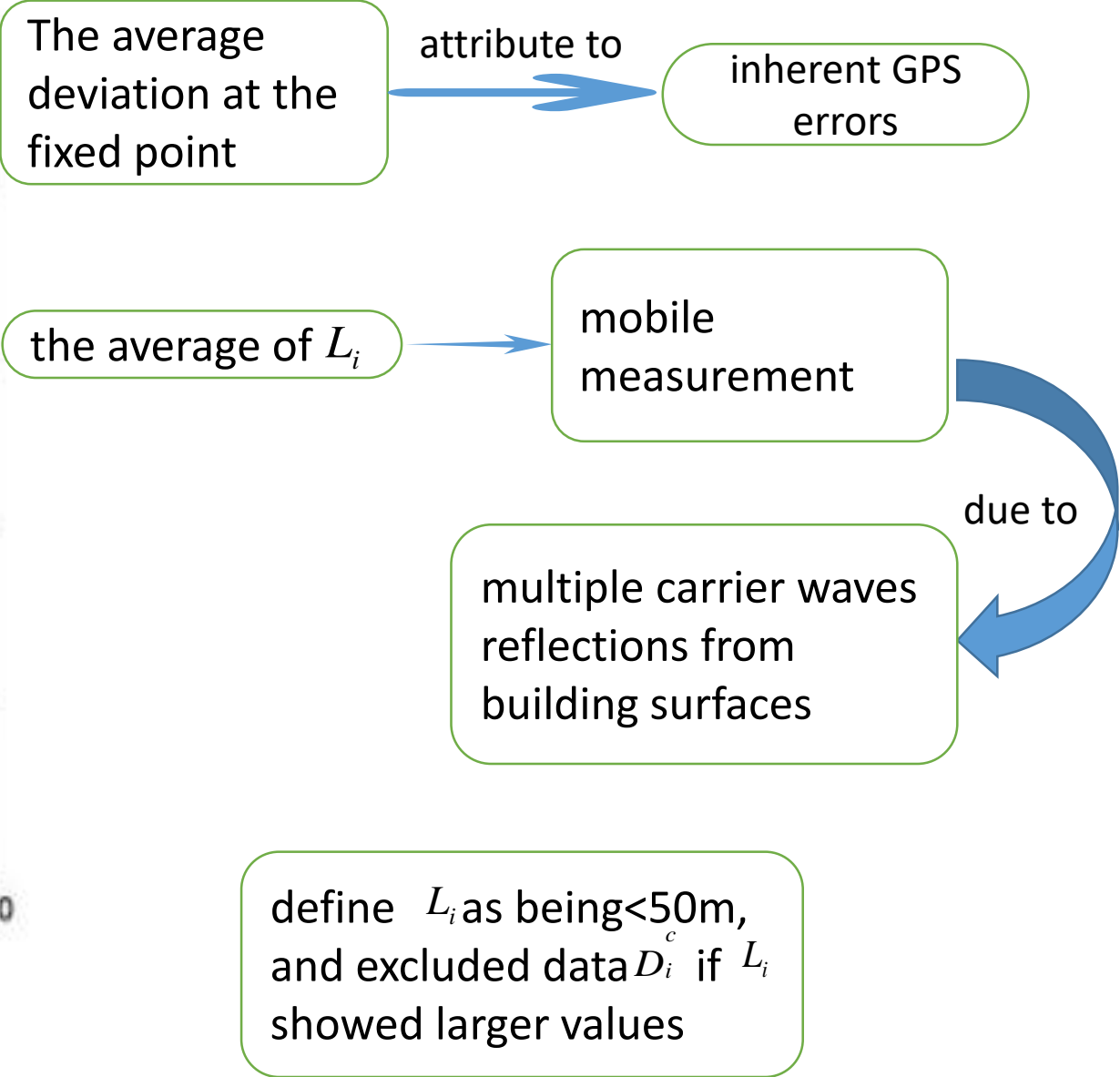


Fig.5.Cumulative distribution function of deviations of positional data for the fixed point,and correction distances of positional data for the mobile measurements (August 28th, 2015,10:00 to 11:00)



### 3.3 Estimated uncertainties of mobile measurement results

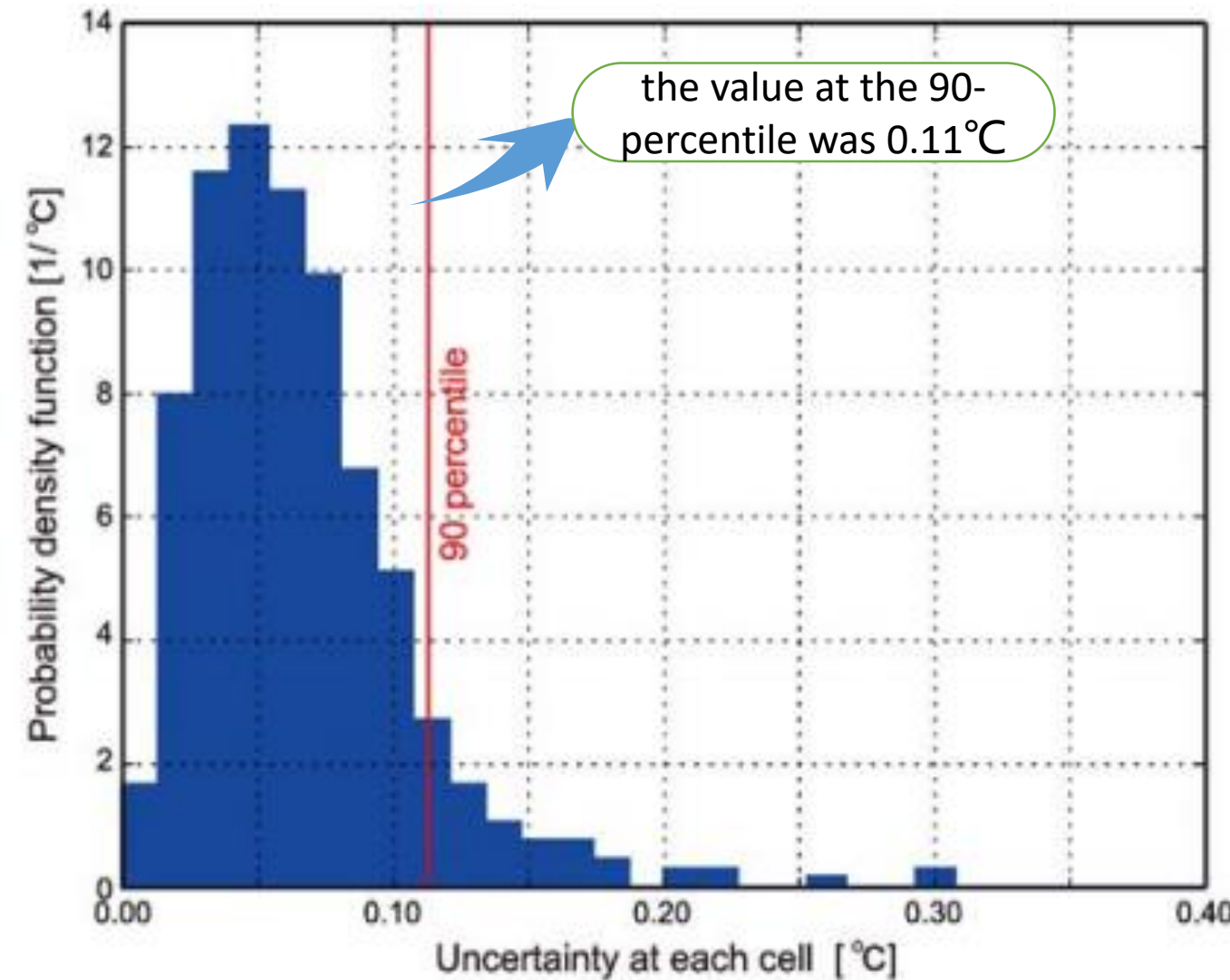


Fig.6. Probability density function uncertainties in the air temperature measurement at each grid cell (August 28th, 2015, 10:00 to 11:00).

the central limit theorem in statistics

examine

the uncertainty associated with the average of  $\theta_i$  at each cell

$\sigma$  : The standard deviation of the temperature at each cell

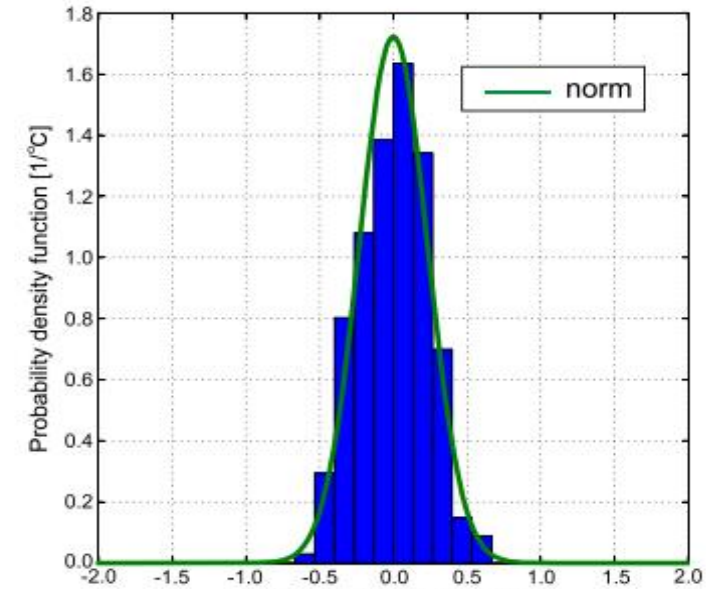
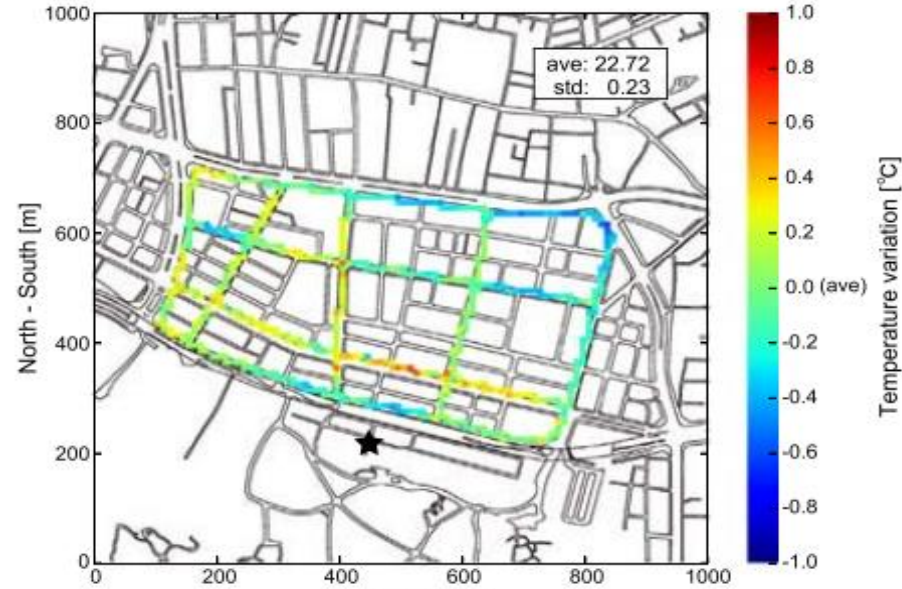
$n$  : The sample number for each cell was approximately 20

$\sigma / \sqrt{n}$  : the index of uncertainty for the average air temperature

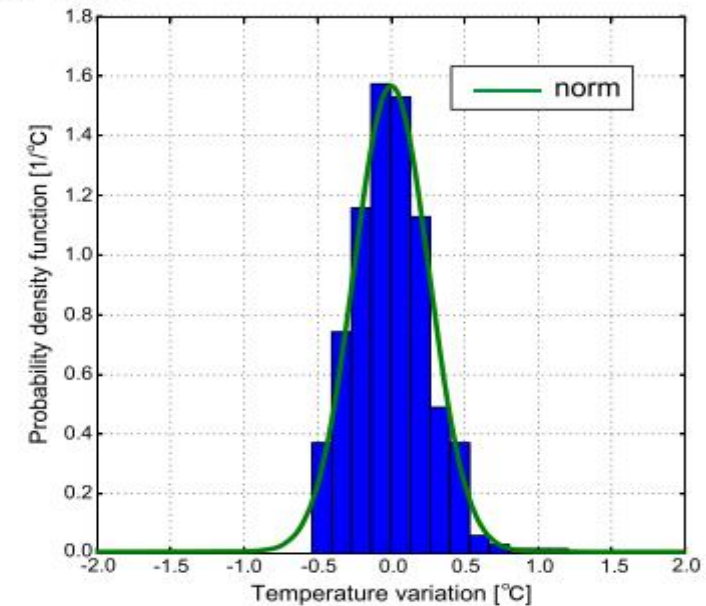
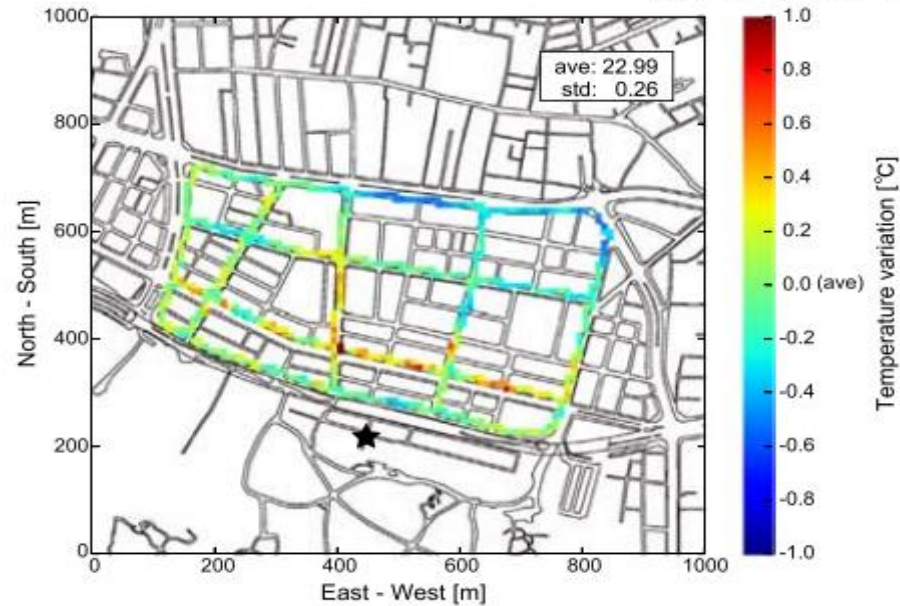
the average of uncertainty is  $0.065^{\circ}\text{C}$  (std:  $0.040^{\circ}\text{C}$ )

# 3.4 Spatial distribution

Aug. 28<sup>th</sup>, 2015 10:00 to 11:00



Aug. 28<sup>th</sup>, 2015 11:00 to 12:00





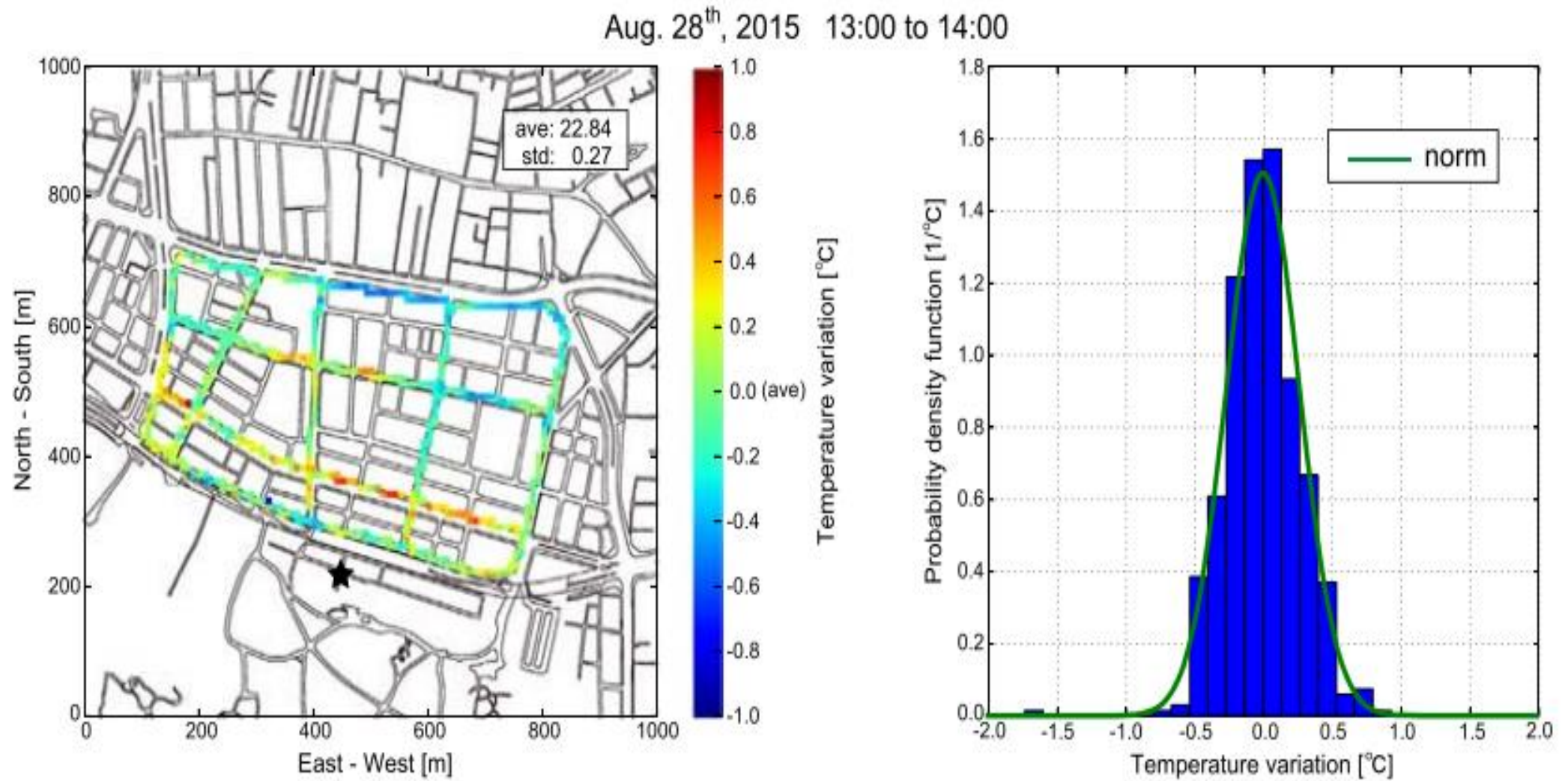


Fig.7.Spatial distribution for air temperature and probability density function for air temperature variation(August 28th.2015)

# 3.5 Influence of the grid size

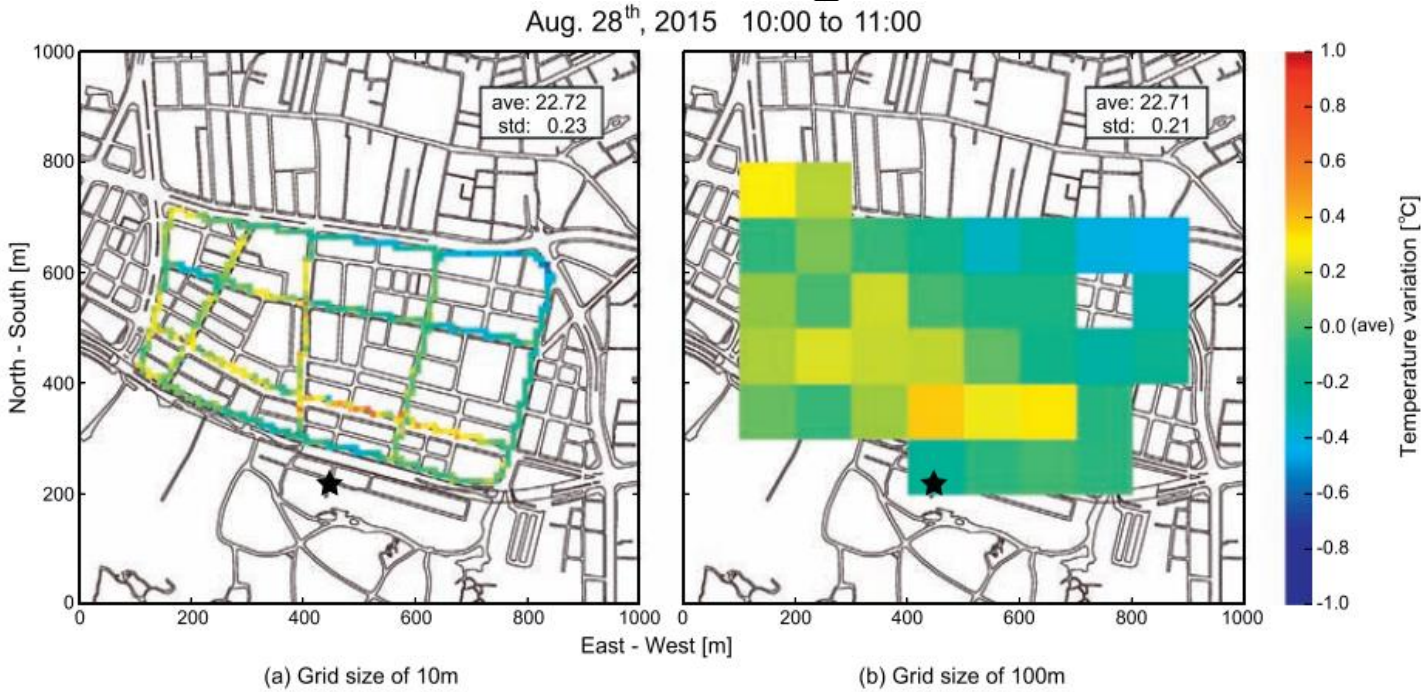


Fig.8. Spatial distribution of air temperature variation with different spatial resolutions(grid size of 10 m and 100 m)

**Table 2**  
Average and standard deviation of air temperature in the measurement field with different spatial resolutions (grid size of 10 m, 100 m, and 1000 m).

Spatial resolution (grid size) [m]	Date, time, temperature [°C]					
	Aug. 28th, 10:00 to 11:00		Aug. 28th, 11:00 to 12:00		Aug. 28th, 13:00 to 14:00	
	Mean	Std	Mean	Std	Mean	Std
10	22.72	0.23	22.99	0.26	22.84	0.27
100	22.71	0.21	22.98	0.22	22.83	0.20
1000	22.75	–	23.01	–	22.86	–

- The spatial resolution of 1000 m failed to capture variations of approximately 0.2°C(std) on cloudy days.
- A grid size in the order of 10<sup>1</sup> m was required to observe hot spots in the densely developed urban area.

## 4 Concluions

- The average GPS error in the urban area was 20 m (std:50 m).
- The measurement were obtained on cloudy days and indicated a temporal vriation of air temperature of approximately  $0.15^{\circ}\text{C}$ (std) over 1 h.
- The spatial variations of air temperature for hourly averages was identified within the study area of  $0.26 \text{ km}^2$ .The range of the variation was  $-0.9^{\circ}\text{C}$  to  $0.9^{\circ}\text{C}$ (min to max).
- A grid size of  $10^1 \text{ m}$  was required in order to observe locations where the air tempera-  
ture was locally high.With a grid size of 100 m,we were able to determine a general spa-  
tial distribution of air temperature.





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Thank you for your attention