Enhanced simulating of latent heat flux in the Noah/single-layer urban canopy coupled model(SLUCM) from urban surfaces

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Outline

- Introduction
- Material and Method
- Result and Discussion
- Conclusion
- Other work

Introduction

- With the acceleration of urbanization, the urban population is increasing , and the increased anthropogenic water vapor release due to increased urban water consumption, such as green area watering, road watering, and residential and industrial water use (Moriwaki et al., 2008).
- "The International Urban Surface Energy Balance Model Comparison Project" pointed out that the model before substantially overestimated the surface sensible heat flux and underestimated the surface latent heat flux (Grimmond et al., 2010).
- Some researchers implement physically-based parametrizations of anthropogenic latent heat into the single layer urban canopy model in the WRF model, such as (1)use of air conditioning systems, (2)residential release, and (3)vehicle release (Miao et al.,2014).
- In this study, the improved urban canopy model above was used to improve the simulation results of urban surface latent heat flux.

Material and Method

1 Observational Data

The data of this study are from 31 automatic stations in Nanjing Meteorological Bureau, including 2-m temperature, 2-m relative humidity, 10-m wind speed.

2 The WRF Model

2.1 Enhanced Anthropogenic Latent Heat Model

In this Model, it Implementing physically-based parametrizations of anthropogenic latent heat into the single layer urban canopy model in the WRF model.

Adopting the above model, two cases are used.

One case: Adding anthropogenic latent heat , defined as ALH,

The other case: Not add it, defined as NALH.

2.2 Experimental Design

The simulation time is from August 1, 2010 to August 3rd, the simulation area as shown below：

(a) (b)

Fig.1 WRF Simulation Area and The Innermost Landuse.

5

2.3 Anthropogenic Latent Heat Scheme

$$R_N + Q_F = LE + H + G \quad (1)$$

$$Q_F = ALH_{max} * alhdiuprf(t) * alhseason \quad (2)$$

$ALH_{max} = 48\ W/m^2$ (3)

When the season is summer, $Alhseason = 1.0476$ (4)

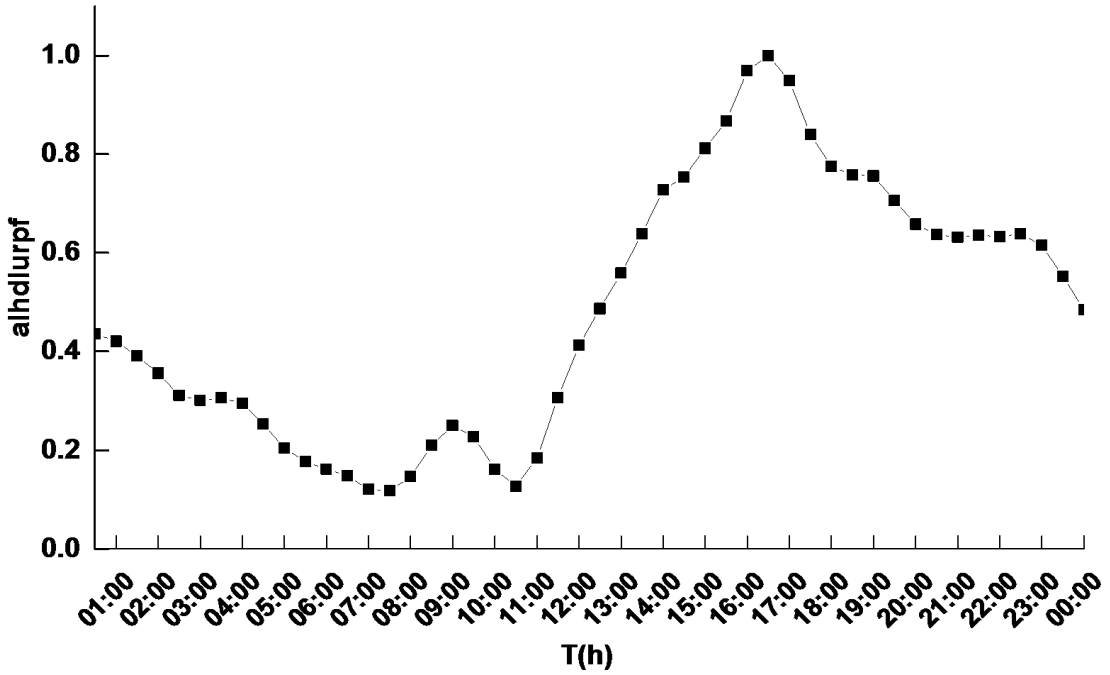

Fig.2 Diurnal Variation Coefficient of Anthropogenic Latent Heat Release.

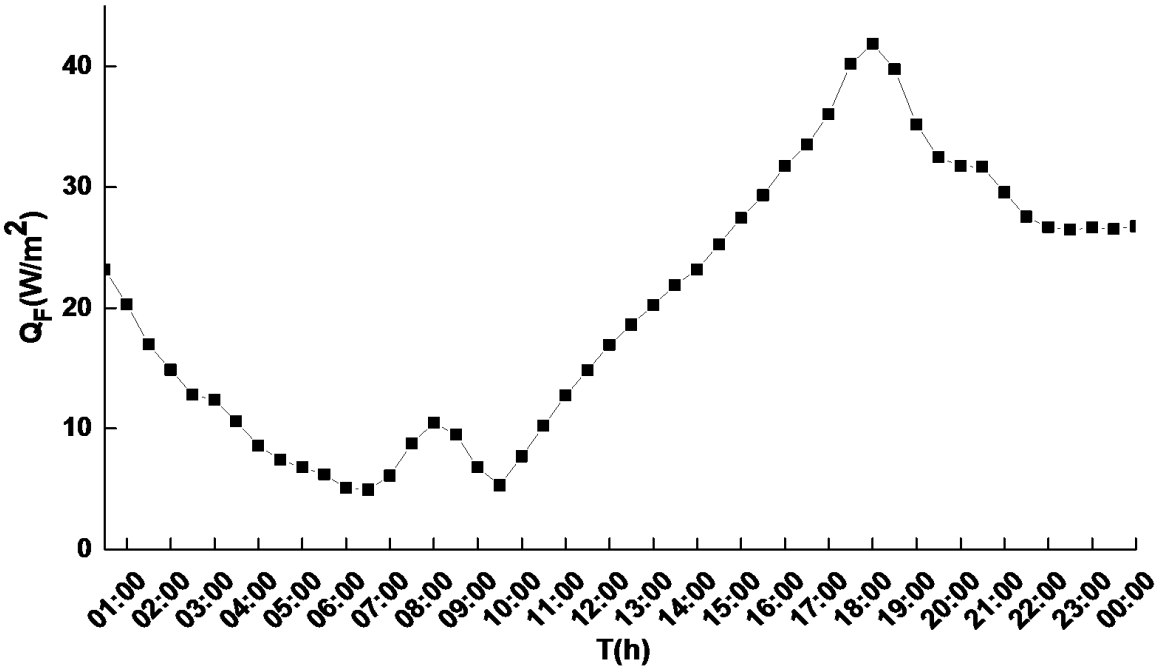

Fig.3 Diurnal Variation of Anthropogenic Latent Heat Release.

Result and Discussion

3 Model Evaluation

3.1 2m Temperature

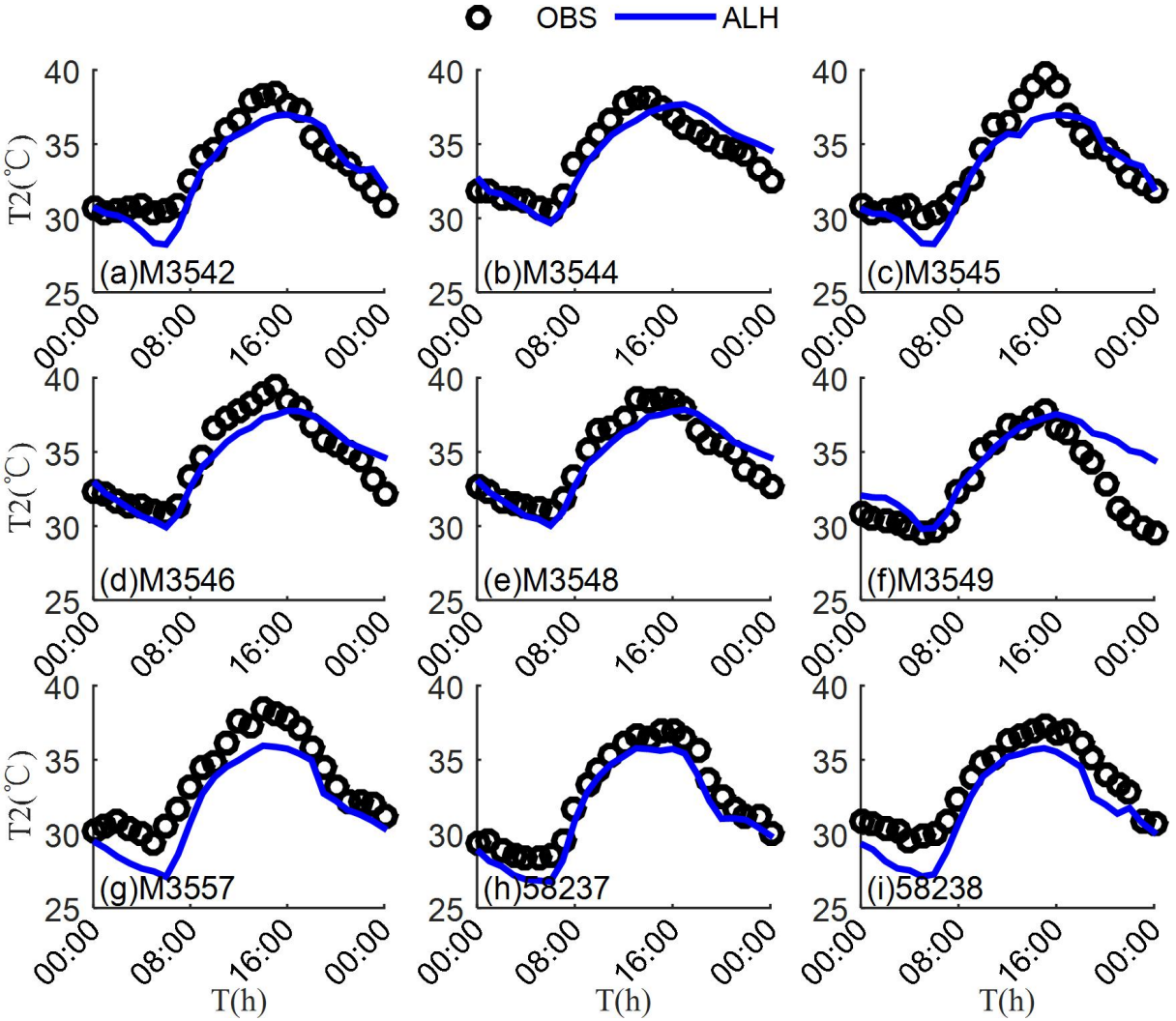

Fig.4 The Comparision between Simulations and Observations of 2m Temperature on August 2

3.2、 Relative Humidity

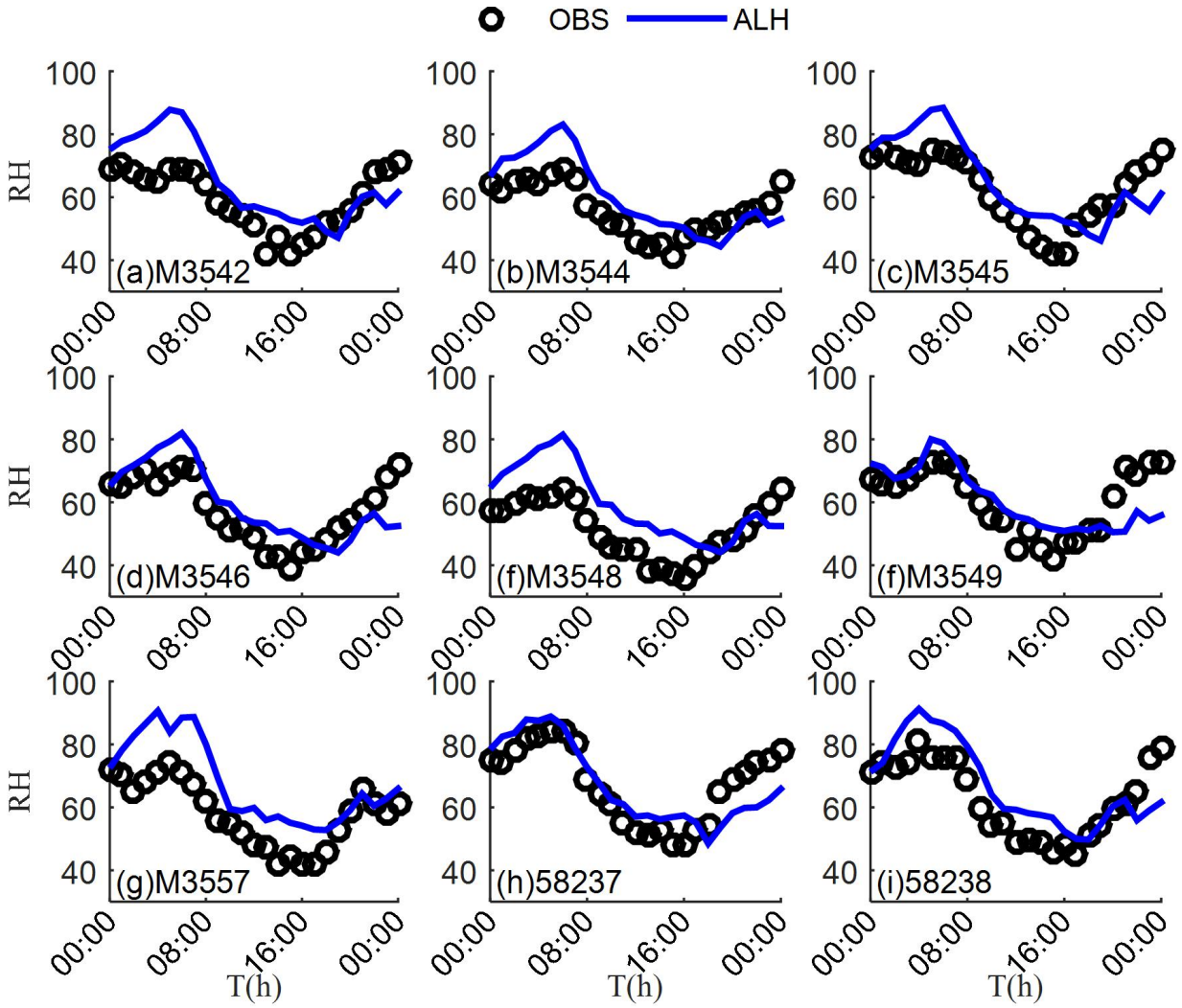

Fig.5 The Comparision between Simulations and Observations of Relative Humidity on August 2.

3.3 10m Wind Speed

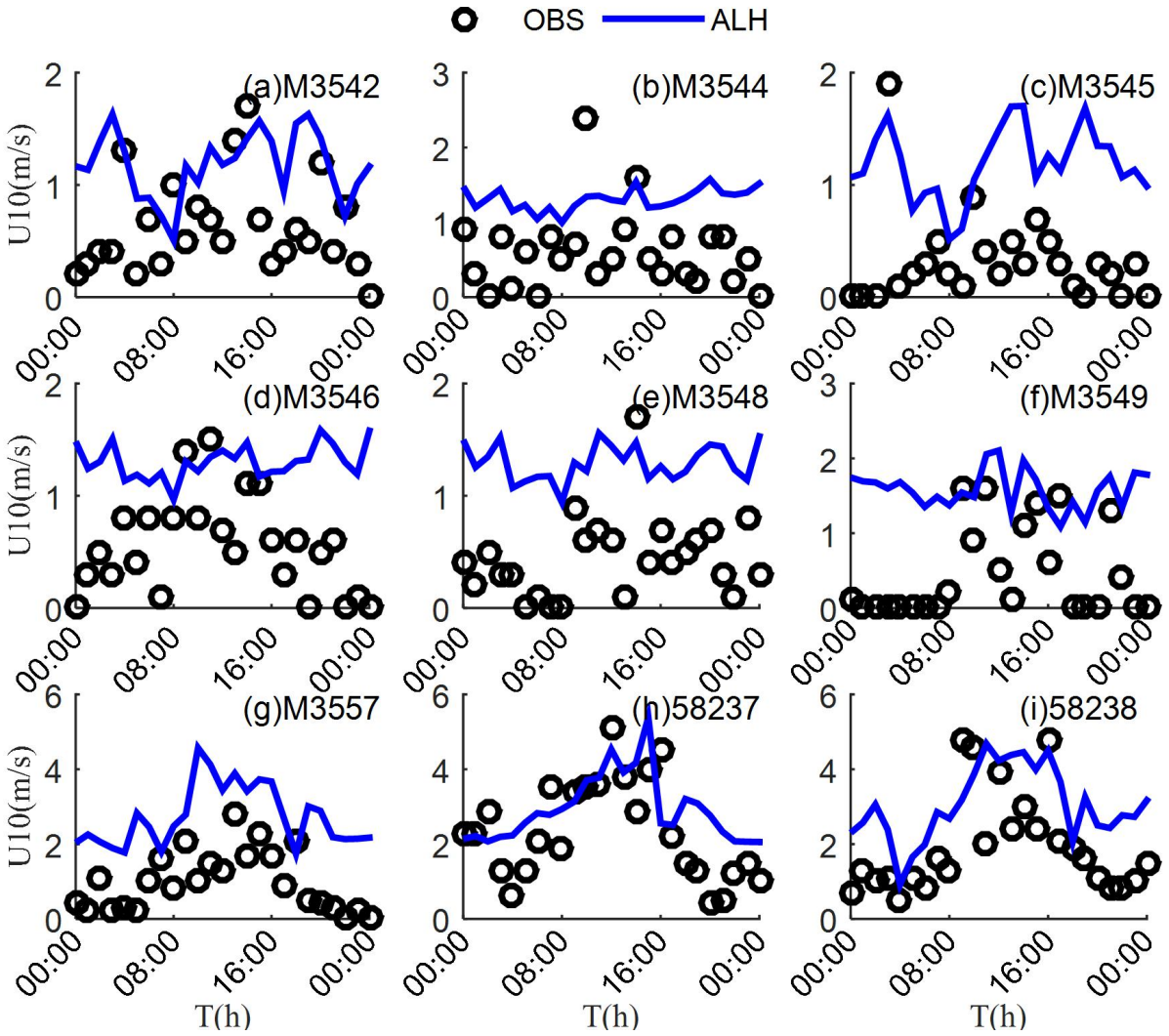

Fig.6 The Comparision between Simulations and Obserbations of 10m Wind Speed on August 2.

3.4 Sensible Heat and Latent Heat

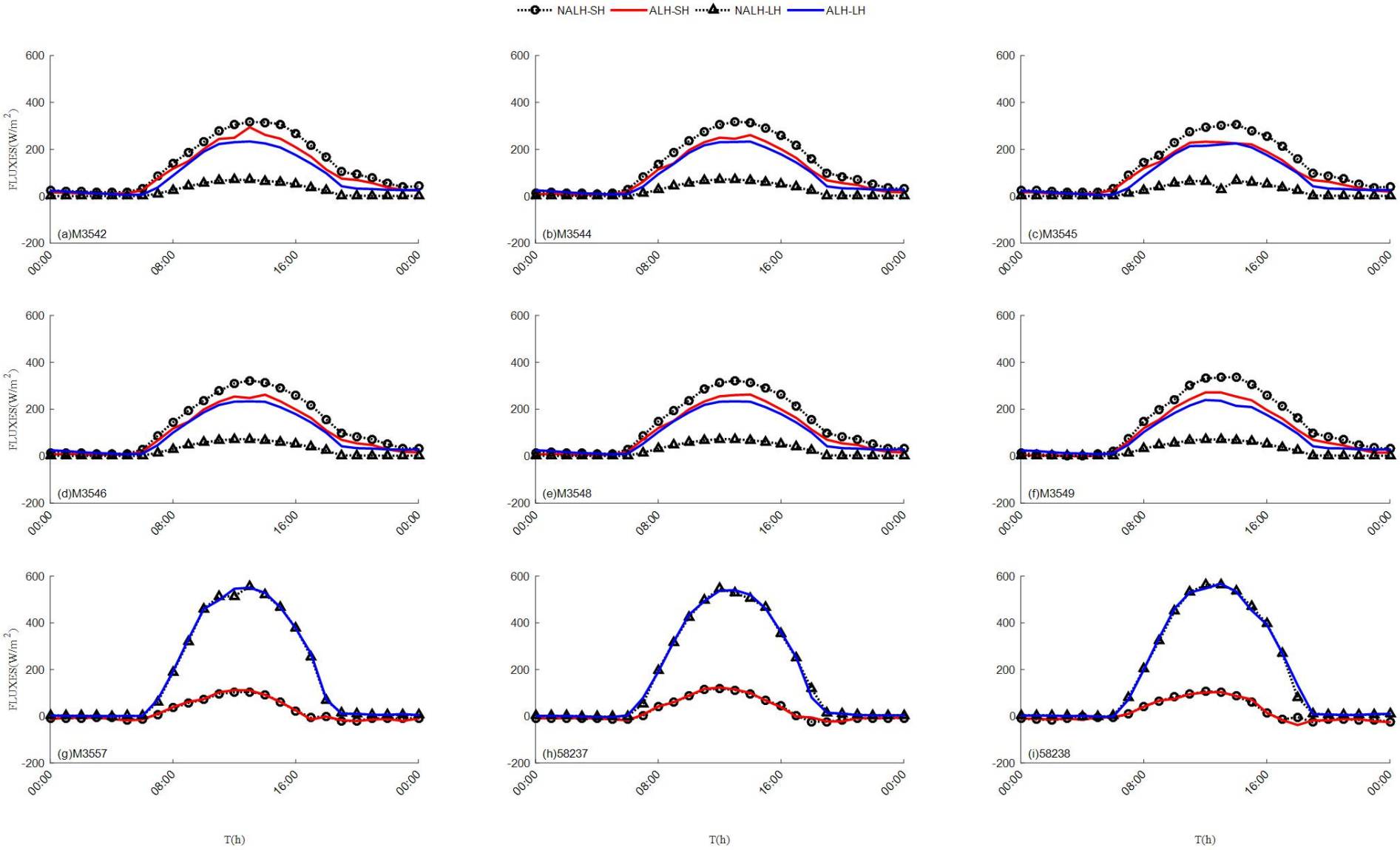

Fig.7 The Comparision between Two Cases of Sensible Heat and Latent Heat on August 2.

4 Analysis of Results

4.1 The Influence of Anthropogenic Latent Heat on 2m Specific Humidity

(a)

(b)

(c)

(d)

Fig.8 2m Specific Humidity Basis of Two Cases on August 2 (a)0600LST, (b)0800LST, (c)1800LST, and (d) diurnal mean values.

4.2 The Influence of Anthropogenic Latent Heat on Urban Surface Temperature

(a)

(b)

(c)

(d)

Fig.9 Surface Temperature Basis of Two Cases on August 2 (a)0600LST, (b) 0800LST, (c) 1800LST, and (d) diurnal mean values.

4.3 The Influence of Anthropogenic Latent Heat on Latent Heat Flux

(a)

(b)

(c)

(d)

Fig.10 Latent Heat Flux Basis of Two Cases on August 2 (a)0600LST, (b)0800LST, (c)1800LST, and (d) diurnal mean values.

4.4 The Influence of Anthropogenic Latent Heat on Sensible Heat Flux

(a)

(b)

(c)

(d)

Fig.11 Sensible Heat Flux Basis of Two Cases on August 2 (a)0600LST, (b)0800LST, (c)1800LST, and (d) diurnal mean values.

4.5 The Influence of Anthropogenic Latent Heat on Vertical Distribution of TKE

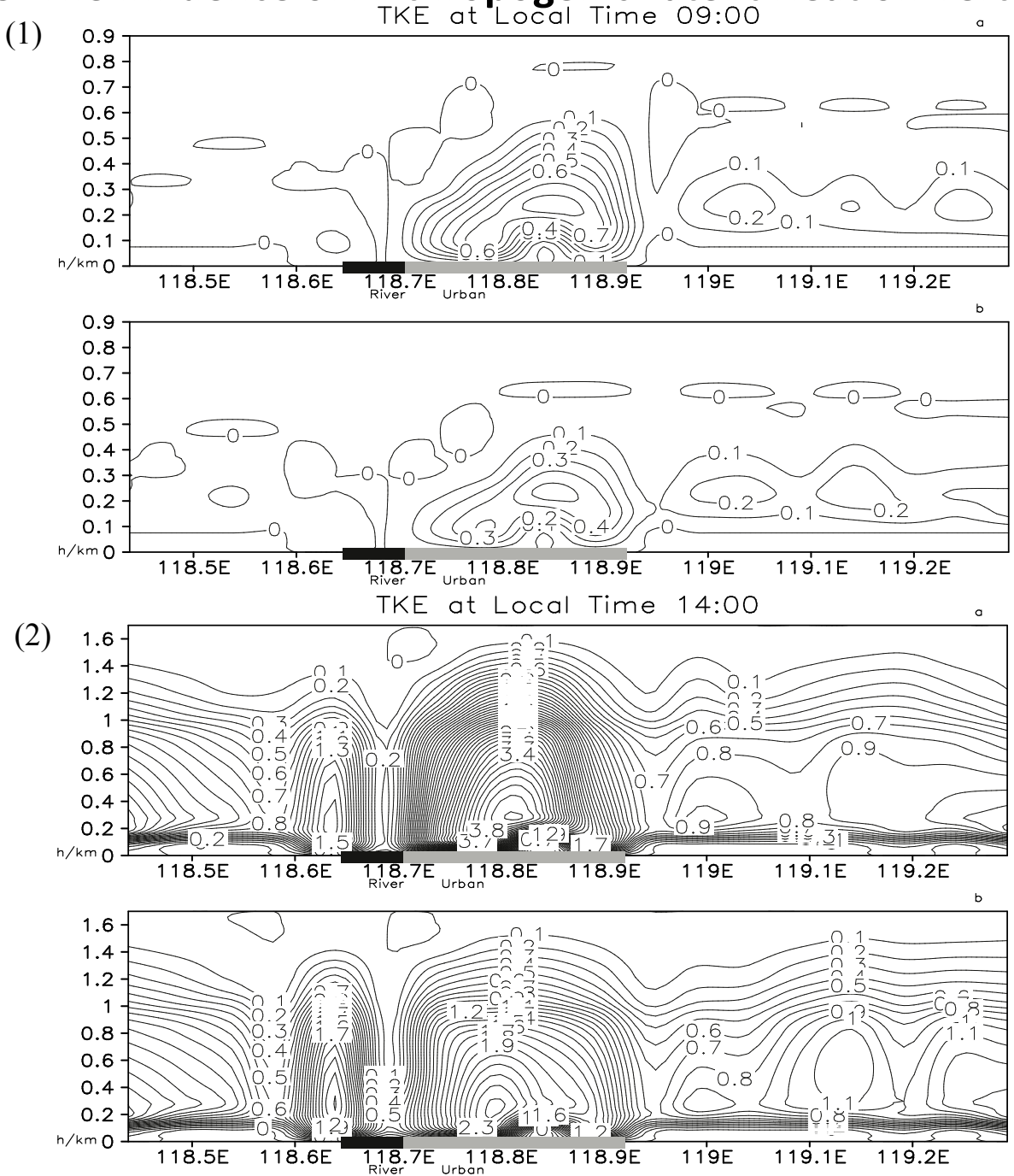

Fig.12 The Vertical Distribution of TKE Situated 32.05°N on August 2 (a)The case of NALH, (b) The case of ALH.

(3)

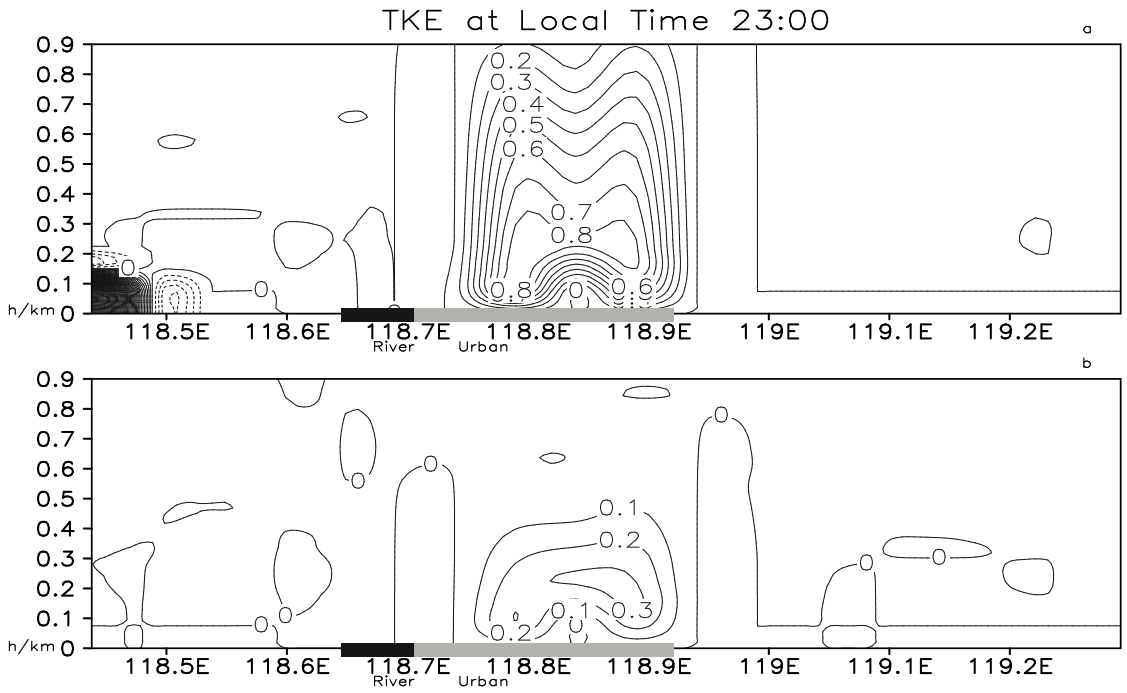

Fig.12 The Vertical Distribution of TKE Situated 32.05°N on August 2 (a)The case of NALH, (b) The case of ALH.

4.6 The Influence of Anthropogenic Latent Heat on urban heat island intensity

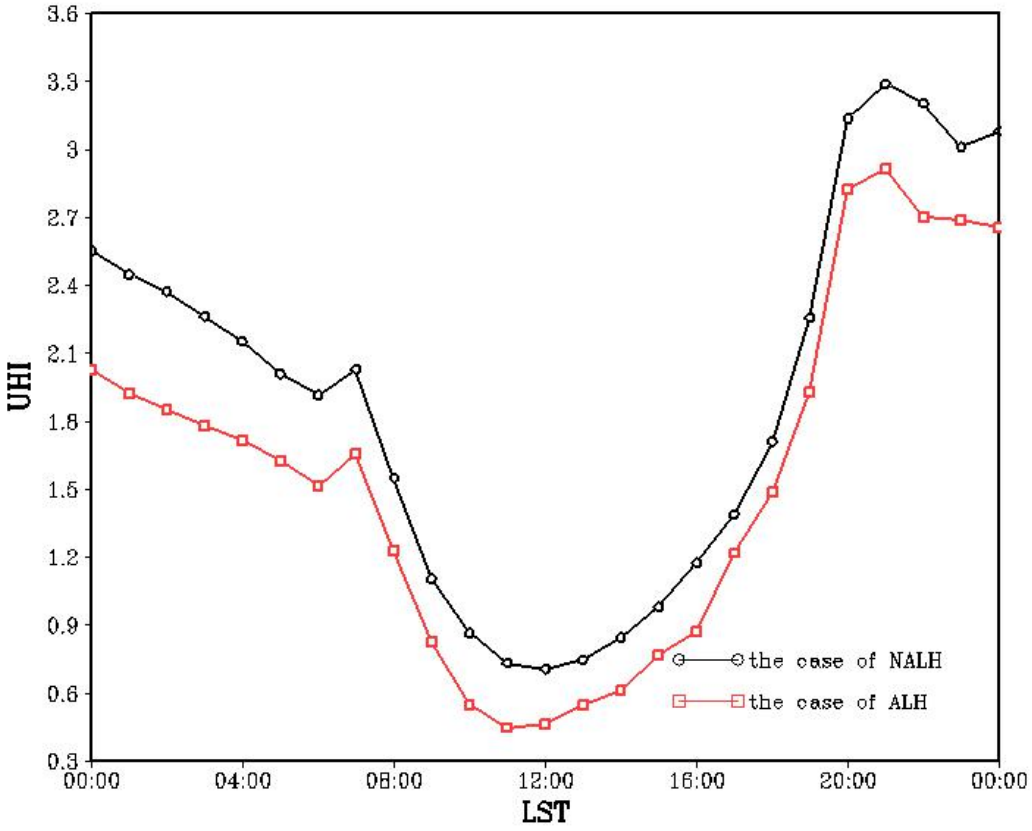

Fig.13 Diurnal Variation of the UHI Intensity of Two Cases on August 2.

4.7 The Influence of Anthropogenic Latent Heat on boundary layer height

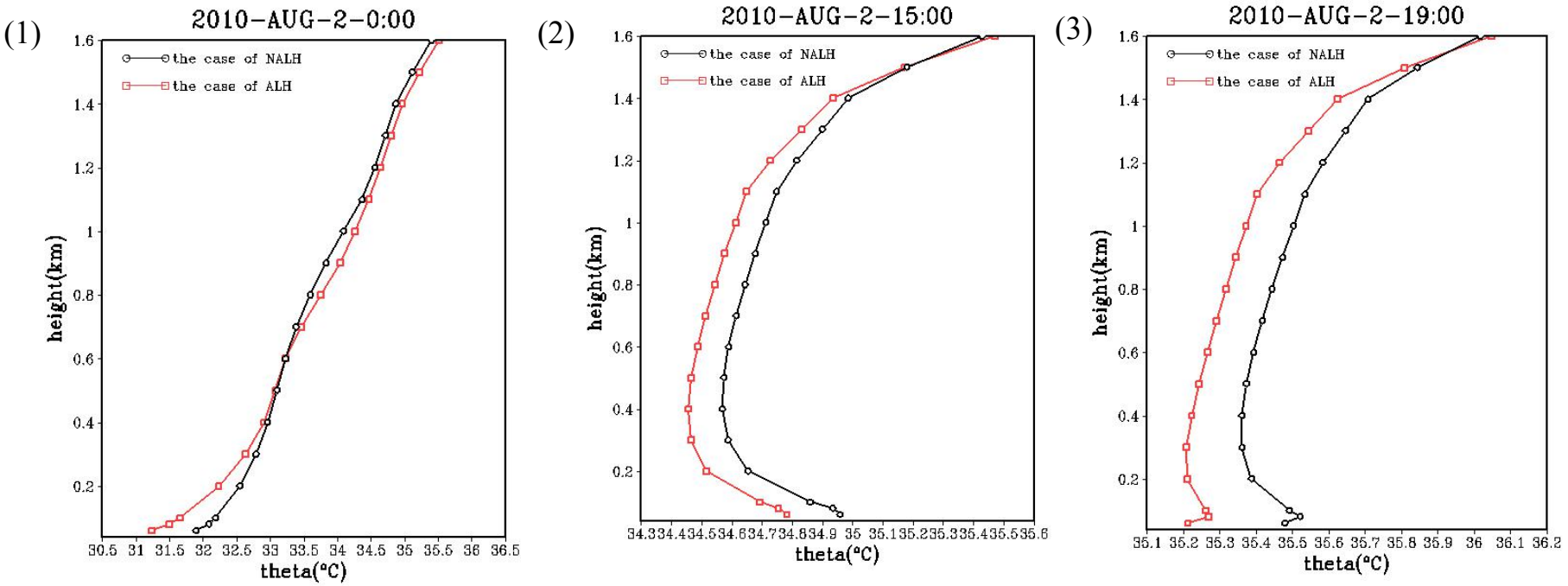

Fig.14 Potential Temperature Profiles of two cases on August 2.

Conclusion

- The simulation results of 2m temperature and relative humidity are very good, which is close to the observed value after adding the latent heat, nevertheless,10m wind speed is not good.
- The simulation results of latent heat flux can be improved by adding the anthropogenic latent heat, and the simulation of sensible heat flux is reduced.
- After adding anthropogenic latent heat, the turbulence kinetic energy and urban heat island intensity is obviously reduced over urban areas.

Other work

- A preliminary simulation was carried out on a sunny day in August 2010, in the future, the simulation time will be increased, and the simulation of artificial latent heat will be added to more weather conditions.
- The correlation coefficient and root mean square error between simulated and observed values are calculated, and Make a table to analyze the effect of the simulation is more intuitive and quantitative.
- The other sources of water vapor in the city are simulated, such as urban irrigation and oasis effect.

Thank you