CALCULATION METHOD FOR OUTDOOR AIR TEMPERATURE OF WOODED URBAN AREA

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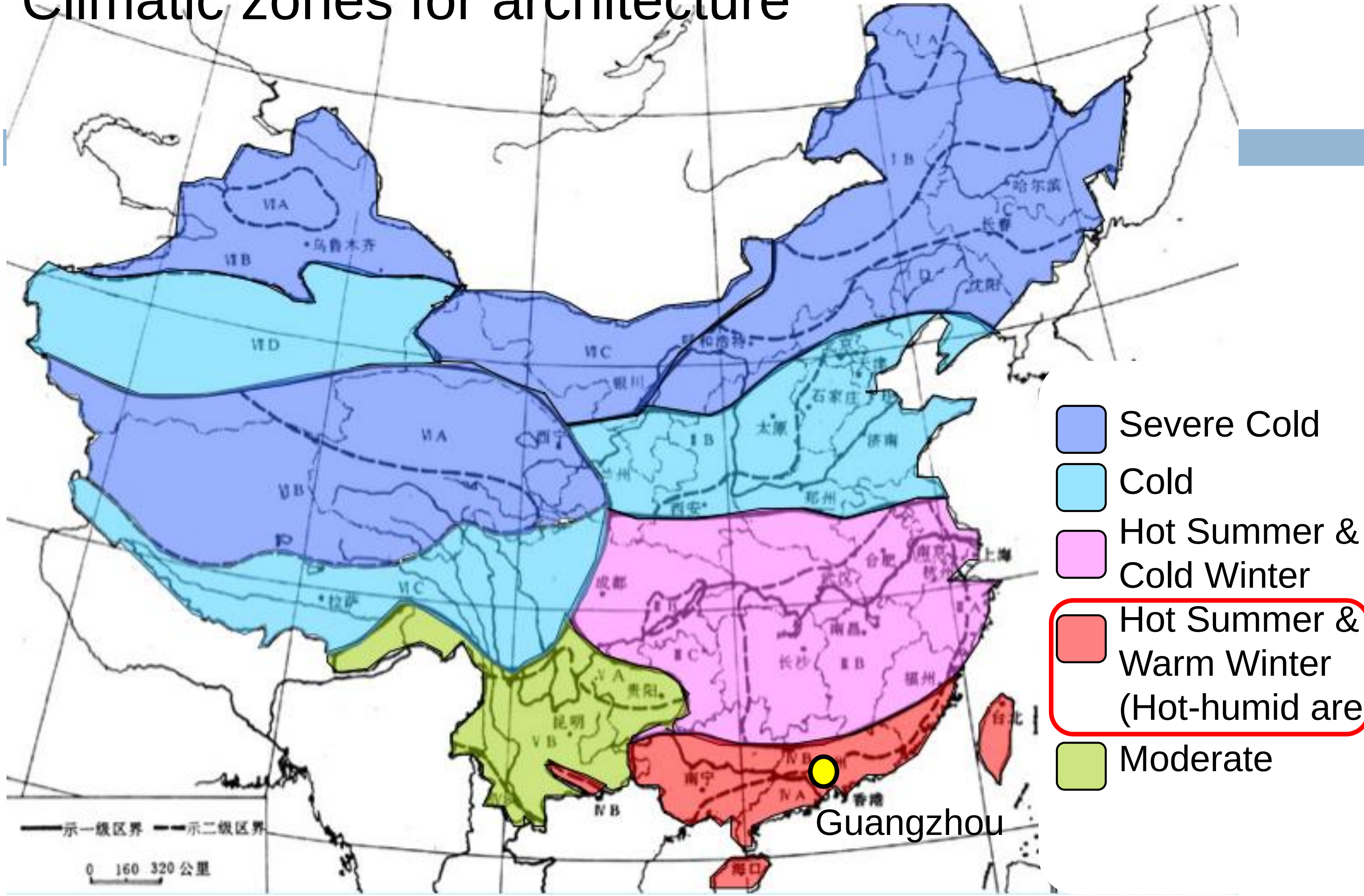
Climatic zones for architecture



Urban area microclimate

- Outdoor safety, comfort and building energy consumption
- Design phase is most crucial, important and lack of scientific means to support
- Quick and easy prediction
- Urban designers

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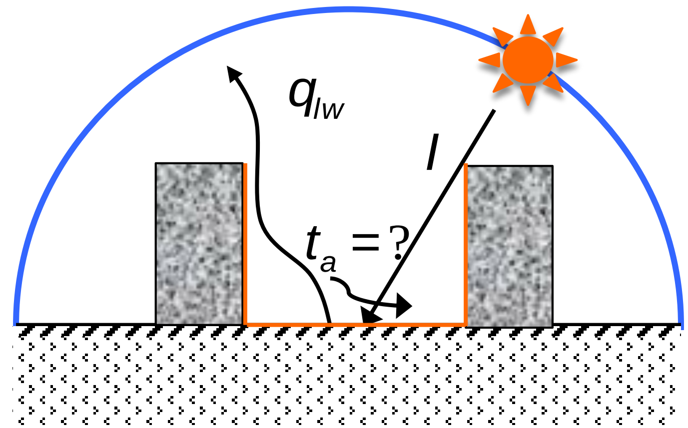
CTTC model

- Cluster thermal time constant
- Swaid & Hoffman, 1990
- Heat transfer model + empirical equation



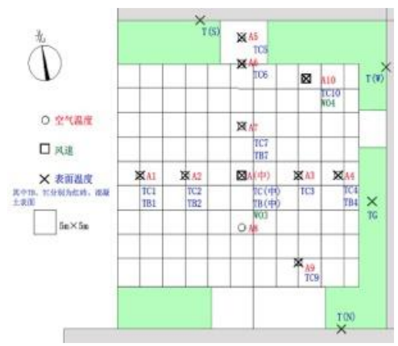
$$t_a = t_b + Dt_{sol} - Dt_{lw}$$

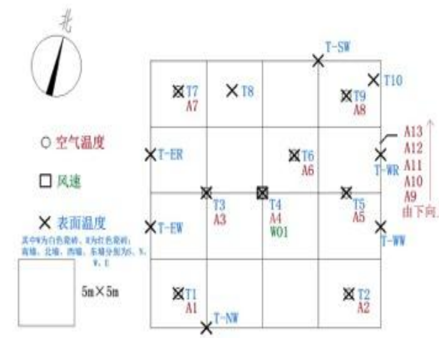
$$Dt_{sol} = \sum_{i=0}^{t} \frac{1}{h} DI \, (1 - \exp \frac{i - t}{CTTC})$$

$$Dt_{lw} = \frac{q_{lw}}{h}$$

Unwooded areas

- 2012.9-10, warm sunny days
- Semi-enclosed and enclosed urban areas
- Ground and walls solar radiations
- Area-average TTC of ground and walls





$$\Delta t_{sol} = \frac{1}{\sum A} \sum_{i=0}^{t} \left[\left(A_G \frac{\mu_G}{h_G} \Delta I_G + A_W \frac{\mu_W}{h_W} \Delta I_W \right) \left(1 - \exp \frac{i - t}{CTTC} \right) \right]$$

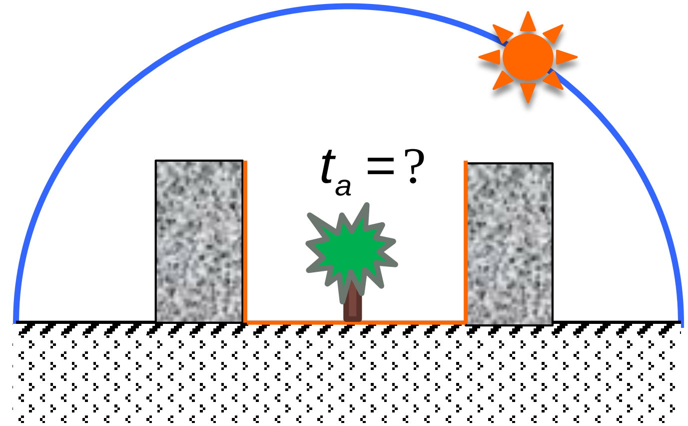
$$CTTC = \frac{1}{\sum A} \left(A_G TTC_G + A_W TTC_W \right)$$

Purpose

- Field measurements on air temperatures of wooded urban areas
- Analyze heat island intensity
- Test the performance of Green CTTC model

Green CTTC model

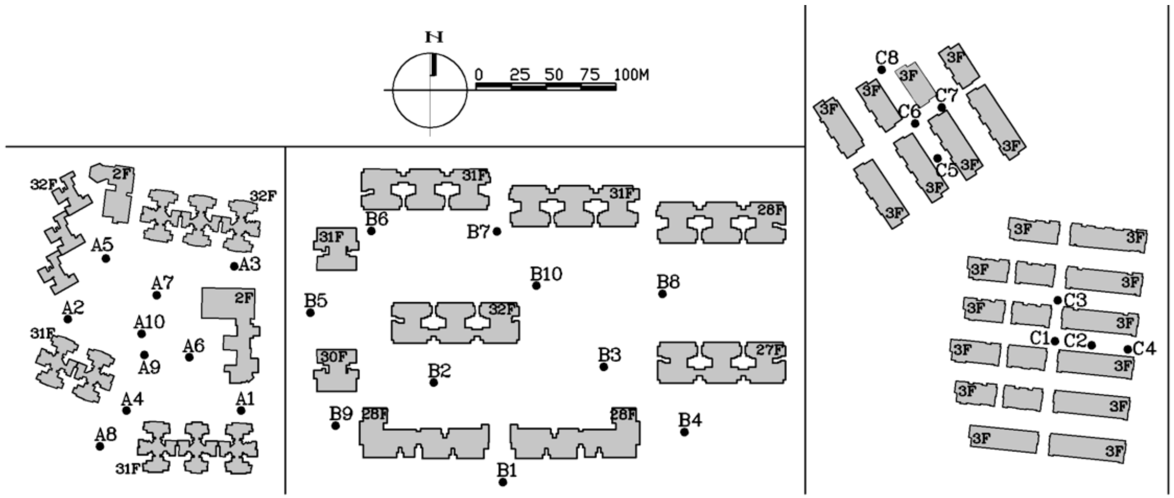
- Shashua-Bar & Hoffman, 2002
- CTTC model + Trees' effect
- Shading effect
- Sensible heat flux of trees



$$q_{sol,T} + q_{lw,T} = q_{s,T} + q_{l,T}$$

$$Dt_{sol} = \frac{1}{\sum A}\left(\sum_{i=0}^{t}\left[(A_G \frac{m_G}{h_G} DI_G + A_W \frac{m_W}{h_W} DI_W)(1 - \exp\frac{i - t}{CTTC})\right] + A_T q_{s,T}\right)$$

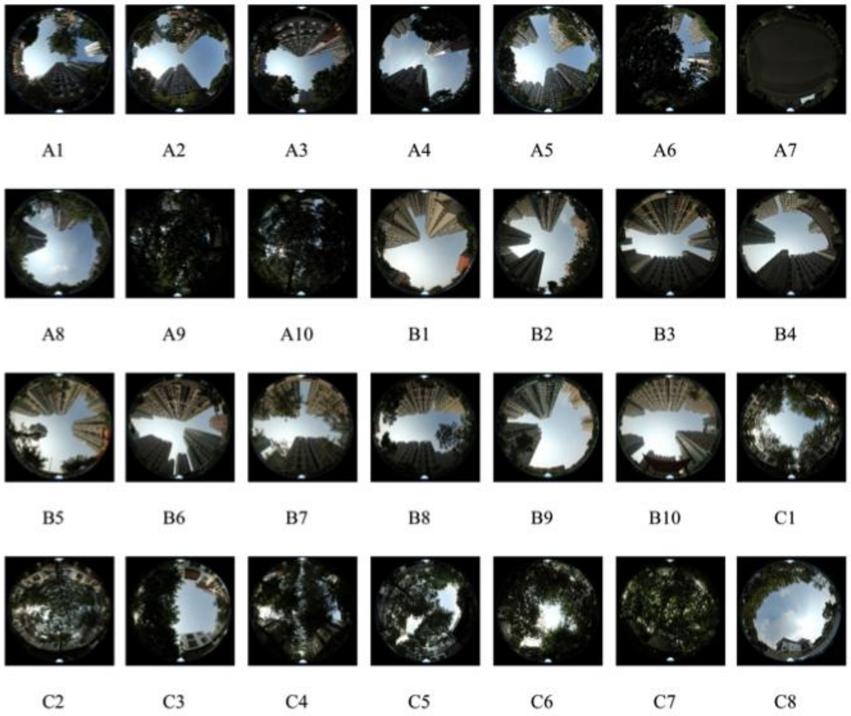
Wooded communities



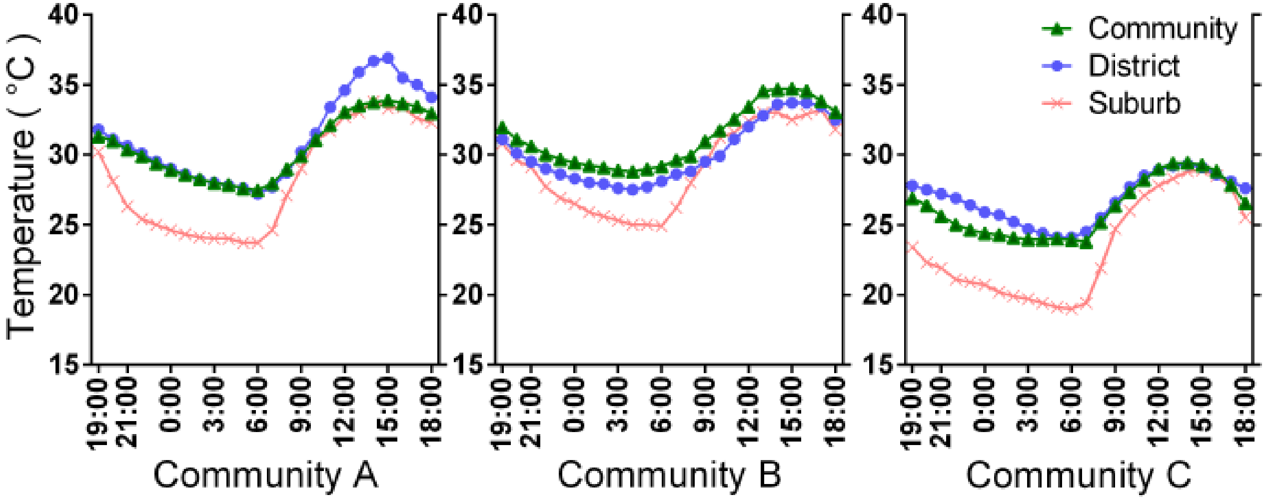
	A	B	C
Green area ratio	56%	35%	31%
Building density	20%	25%	48%
Floor area ratio	5.0	4.6	1.5

Field measurements

- 2013.8-10, warm sunny days
- Air temperature at 1.5 m with aspirated radiation shield
- Parameter of LAI, SVF, SAR



Heat island intensity



Community	Urban Weather Station			Suburb Weather Station		
	Day	Night	All	Day	Night	All
A	-1.5	-0.1	-0.7	0.6	3.7	2.3
B	1.2	1.1	1.1	1.4	2.9	2.2
C	-0.1	-1.0	-0.6	1.1	4.2	2.8

$$CHI = t_{community} - t_{district}$$

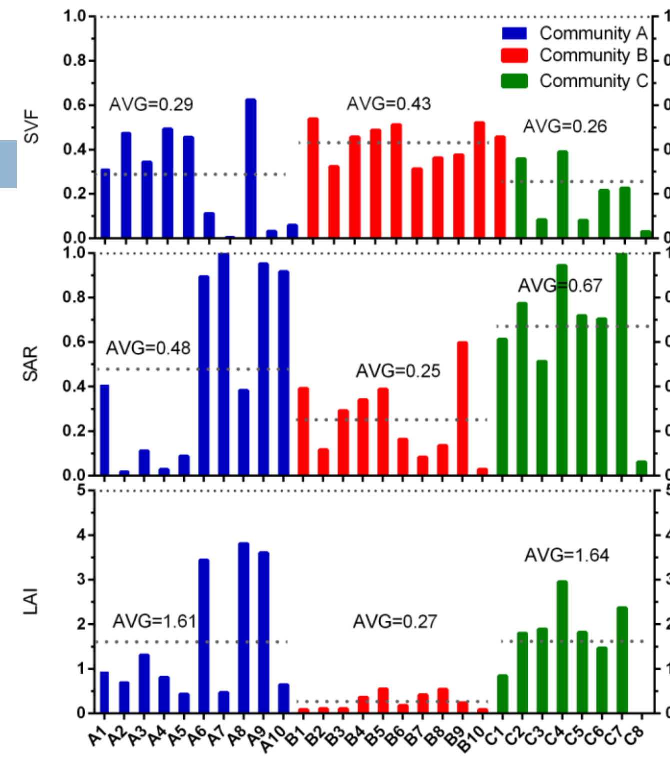
Heat island intensity

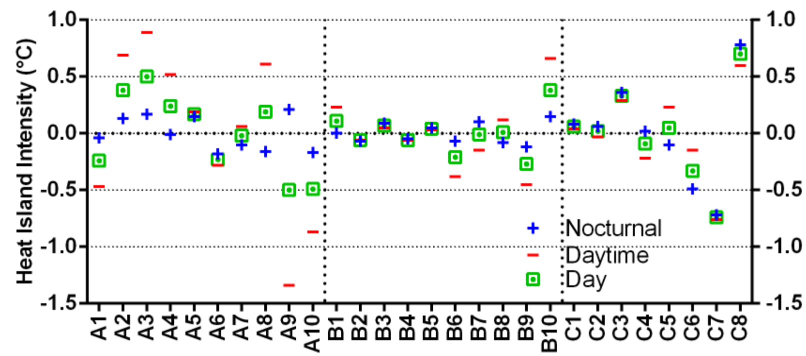
$$PHI = t_{point} - t_{community}$$

$$PHI_{day} = -1.23\Delta SAR \qquad (R^2=0.524)$$

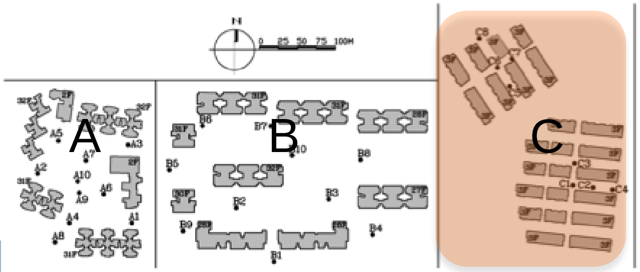
$$PHI_{night} = -0.448\Delta SAR \qquad (R^2=0.244)$$

$$PHI_{all} = 0.602\Delta SVF - 0.541\Delta SAR \qquad (R^2=0.618)$$

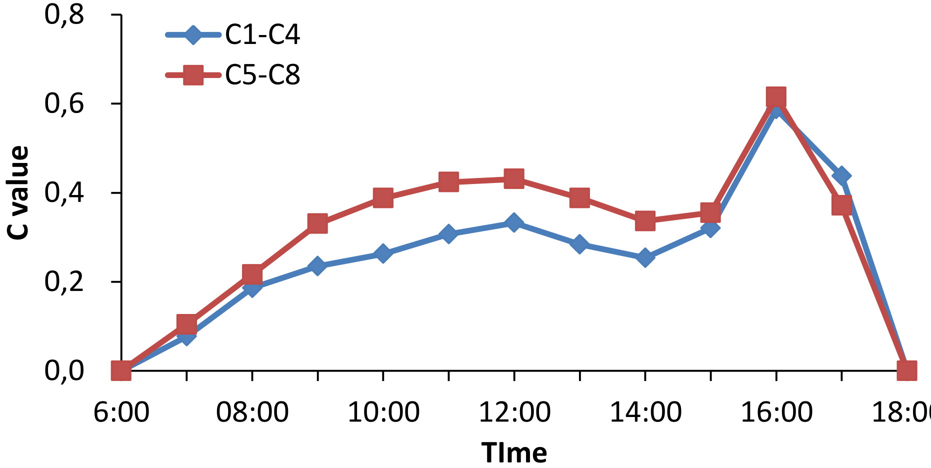


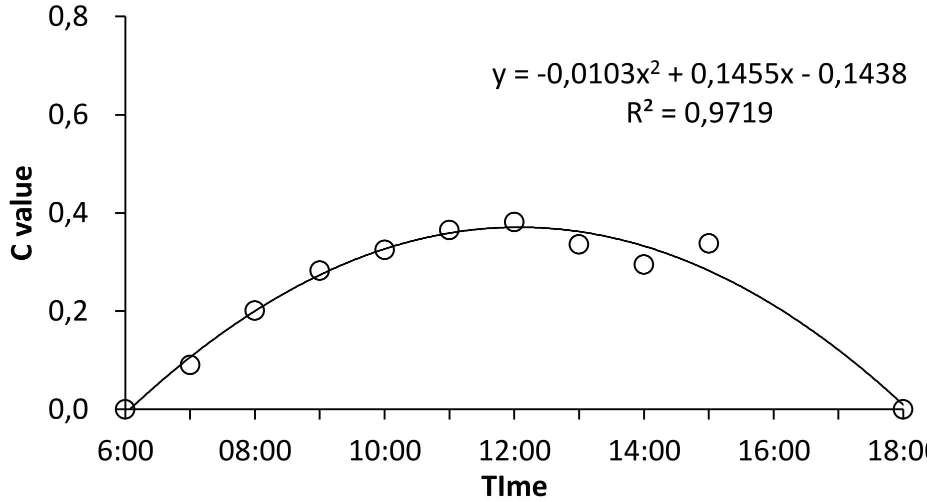


Sensible heat flux ratio

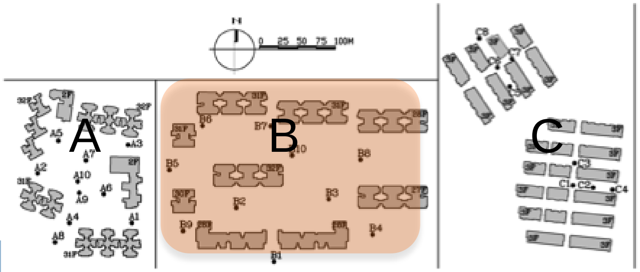


- Sensible heat flux / Solar radiation absorbed and reflected by trees
- The outliers at 16:00~17:00 are due to abnormal solar radiation records
- 0→0.4→0

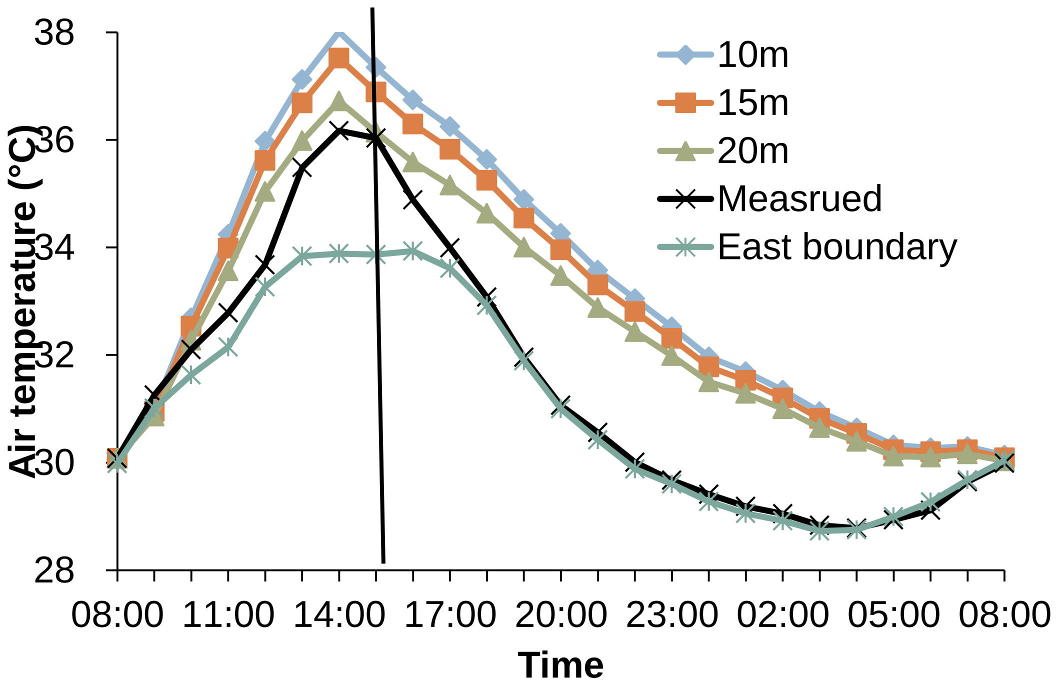




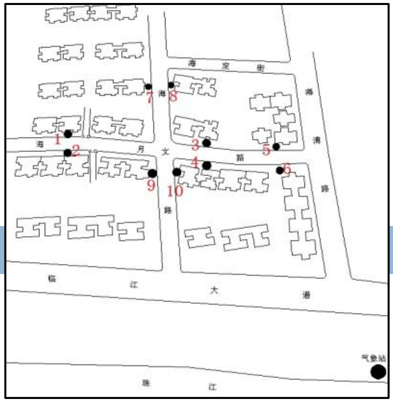
Green CTTC model



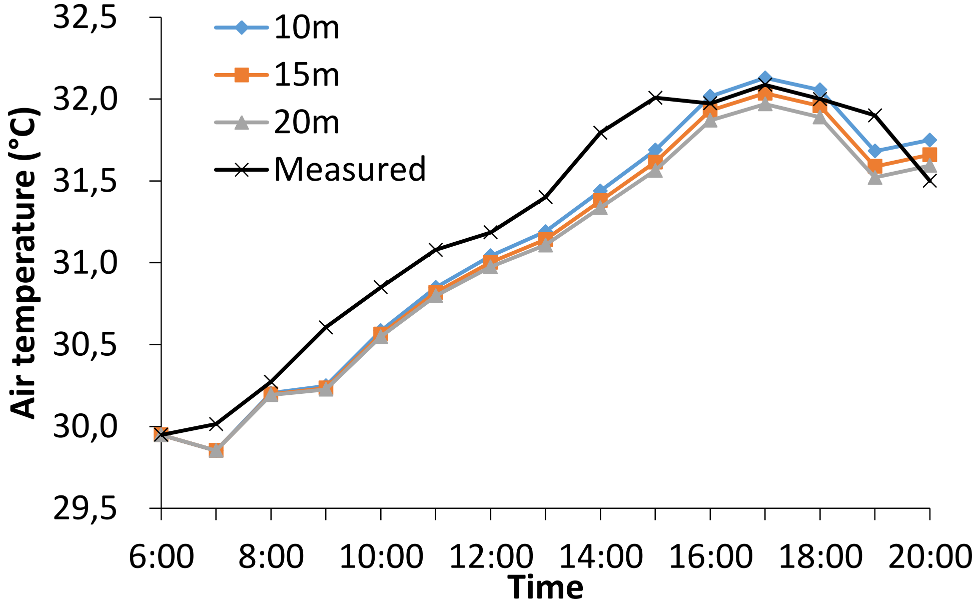
- Before 15:00, measured temperature close to predicted one with 20m height wall
- RSME=0.7°C, d>0.97
- After 15:00, measured temperature goes closely with east boundary due to strong east wind



Green CTTC mode



- Two wooded street canyons
- RSME=0.3°C, d>0.96



Conclusions

- The heat island intensity of community is recommended to be defined as the air temperature difference between community and district.
- The heat island intensity of point is influenced by parameters of SAR and SVF.
- The sensible heat flux ratio (C value) increases in the morning and decrease in the afternoon, in a range of (0, 0.4).
- The Green CTTC model can predict the trees' effect well.
- Further studies on advection and water need to be done.

THANK YOU!