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INTRODUCING BUILDING ARCHITECTURAL ASPECTS IN THE URBAN CANOPY MODEL

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1. INTRODUCTION

There is a growing interest for developing urban canopy models since these models could describe physical phenomena related to the environmental problems such as the urban heat island, pollution, and weather change. An improvement is made to the SUMM (Kanda et al, 2005) by incorporating several building architectural settings, namely ventilation ratio, wall and roof thickness, glazing ratio and heating and cooling effects. One of the advantages of these additional effort is that they can facilitate the simulation in the context of a more complex real urban surface area.

2. METHOD

In this study SUMM, the simple theoretical scheme analyzing radiation and heat balance for infinitely extending orderly/staggered array of evenly sized building is used. New menus have been developed in the SUMM. These menus have two distinguished cases, namely the natural cases and the heating/cooling cases. In the natural cases, only the passive components of the building, such as passive ventilation ratio, glazing ratio and thickness of roof and wall, have been taken into account during the calculation. In the heating/cooling cases, in addition to the passive components, the anthropogenic energy, from heating/cooling systems, has also been calculated. Moreover, SUMM can be automatically adjusted to the winter and summer model.

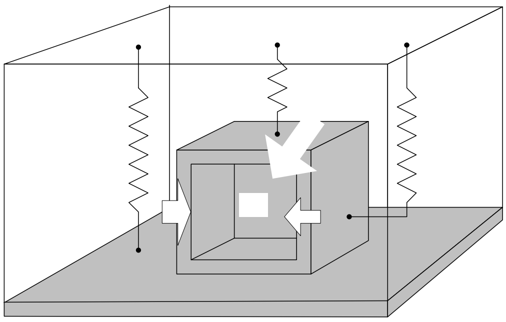

Figure 1 Schematic figure of SUMM

G_{in} : Conductive heat flux from the solid urban material into the room per unit lot area

Q_G : Short wave radiation transmitted into the room per unit lot area

Q_V : Ventilated heat flux from the room to the outside through crevices or openings per unit lot area.

T_{in} : indoor temperature

2.1. Natural Case

Assuming no use of artificial energy, the room temperature T_{in} is solved using the heat balance equation of the air inside a building

$$c_p \rho V_{in} \frac{\partial T_{in}}{\partial t} = G_{in} A_{lot} + Q_G A_{lot} - Q_V A_{lot}$$

The heat storage in the room air (the left hand side of equation above should be equal to the sum of conductive heat fluxes from walls and ceiling into the room (the first term of the right hand side of equation), the shortwave radiation transmitted to the room through glazing (the second term), and the naturally-ventilated heat flux from the room to the outside through crevices or openings (the third term). Q_V is formulated by

$$Q_V = c_p \rho V_{in} \alpha_{vent} (T_{in} - T_a) / A_{lot}$$

where α_{vent} is the ventilation ratio (s^{-1}), which is defined as the frequency for the volume of the room air fully to be exchanged.

2.2. Heating/Cooling Case

The rule for operating heater in this scheme is by replacing T_{in} with T_{set} as

$$VTL = G_{in} A_{lot} + Q_G A_{lot} - c_p \rho V_{in} \alpha_{vent} (T_{set} - T_a)$$

As long as VTL is negative, actually that is likely to be in winter, we input additional energy equivalent to −VTL into the room air to maintain the room temperature T_{set}, that is

$$Q_{Ain} A_{lot} = -VTL ,$$

where Q_{Ain} is the artificial heat input into the room by heater, per unit lot area. The rule for operating cooler in this scheme is the same as that of heater use, except introducing the concept of heat pump. If VTL is positive, that is likely to be in summer, we pump up the heat equivalent to VTL from the room to the outside using cooler.

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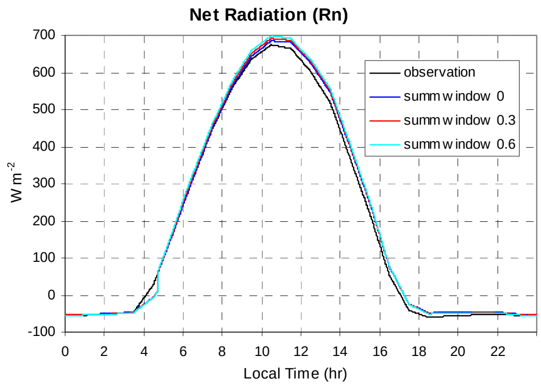
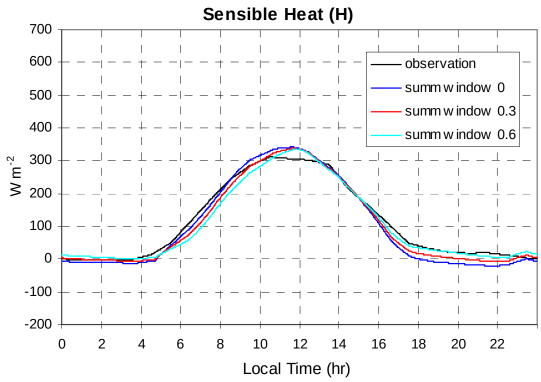
$$Q_P A_p = VTL,$$

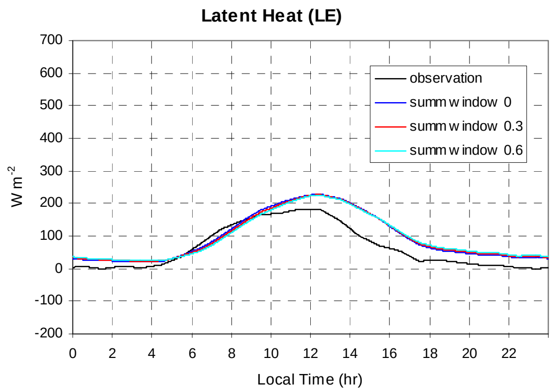
where Q_P is the pumped up heat flux from the room to the outside using cooler, per unit lot area.

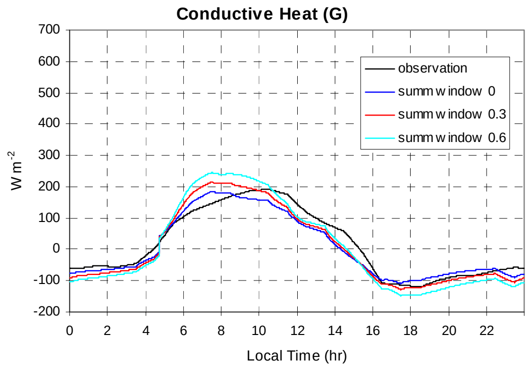
3. RESULTS

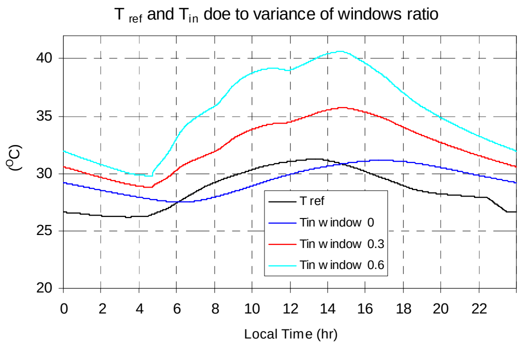
a. Sensitivity of urban energy balance to windows ratio in summer/natural case



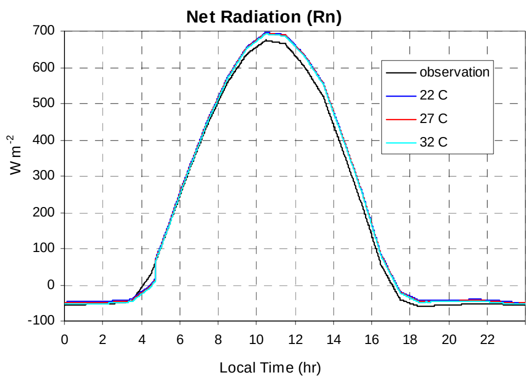


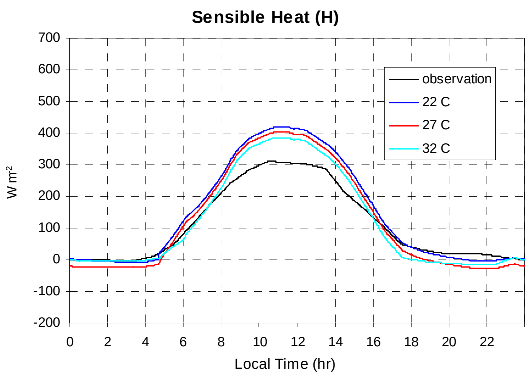


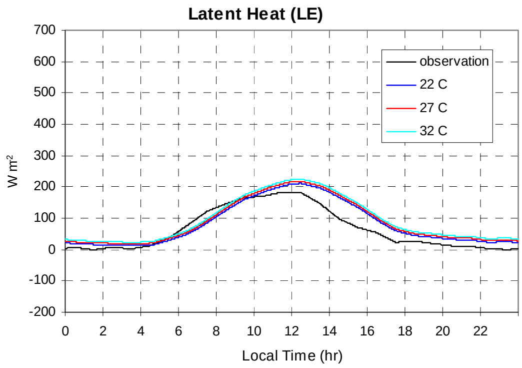


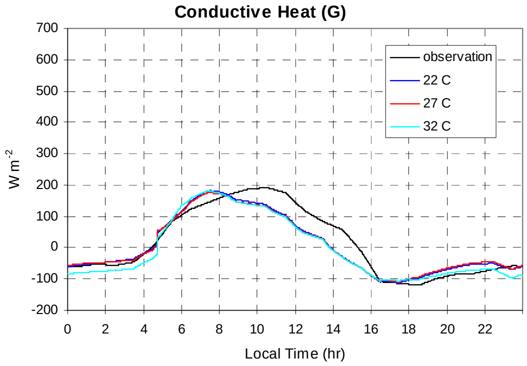


b. Sensitivity of urban energy balance to T-set in summer/cooling case









The simulation results showed that various building architectural settings in the natural cases have no significant impacts on the urban energy balance in the reference height. Whereas in the heating and cooling cases, even though heating intensity is generally lower than the incoming solar flux, the anthropogenic heating from heating and cooling systems has a significant contribution. Furthermore, we observed significant effect from the various architectural settings on the change of temperature inside the building.

4. REFERENCES

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