11.7 AN INTRIGUED ANALYSIS TO QUANTIFY THE CAUSES FOR URBAN HEAT ISLAND BY THE REVISED ARCHITECTURE - URBAN -SOIL - SIMULTANEOUS SIMULATION MODEL, AUSSSM

PART.1 THEORETICAL BACKGRAOUND AND MODEL FRAME SHOWING WITH A RESULT OF STANDARD SOLUTION

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1. INTRODUCTION

Examining the earlier numerical researches based on the meso-scale model, it has been understood qualitatively that an increase of anthropogenic heat and alternation of land covering are regarded as the primary causes of Urban Heat Island (UHI). However, we would like to point out that a sufficient quantitative analysis of UHI has not yet been made, because the practical impediment of its huge computational load has had the following consequences:

- Estimation of evaporative heat transfer at the surface of vegetation, soil and buildings is so much simplified that might cause a significant crucial problem, particularly if the urban vegetation is regarded as affecting the UHI.

- It's very difficult to carry on a large number of numerical experiments, so model users have not been able to reach any general or universal conclusions.

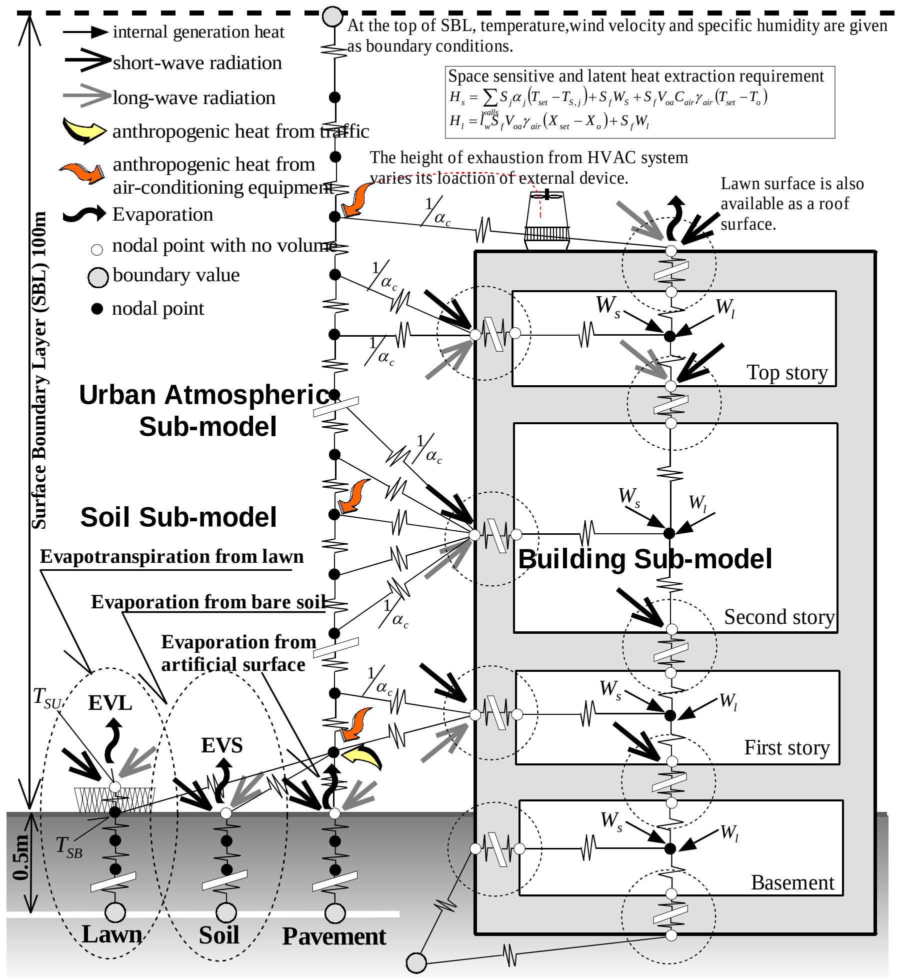

Fig. 1 Schematic frame of the revised-AUSSSM

Under these circumstances, we proposed the Architecture-Urban-Soil Simultaneous Simulation Model (AUSSSM) classified as an Urban Canopy Model (UCM). The AUSSSM was defined not as a sub-model for a meso-scale model but as a stand-alone estimating methodology for UHI. We developed the AUSSSM to clarify the quantitative effects of UHI for reference data of urban planning and architecture design, paying special attention to ensure both the accuracy and the appropriate calculation load so the model could be used for a large number of numerical experiments systematically. The early version of the AUSSSM was classified as a single-layer model. During the last couple of years we have steadily worked to revise the AUSSSM drastically. In this paper, we describe details of the revised-AUSSSM, which can be classified as a multi-layer model. And a calculation result under a typical condition is also reported.

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2. THE FEATURES OF THE REVISED-AUSSSM

Figure1 shows the schematic diagram of the revised-AUSSSM, in which buildings are assumed to be arranged in a rectangular lattice space endlessly and homogeneously in an urban area. The revised-AUSSSM consists of three main 1D sub-models relating to urban atmospheric conditions, land surface and buildings. In a practical calculation process, all sub-models are coupled dynamically.

The Urban Atmospheric Sub-Model is based on 1D transport equations for momentum, heat and vapor, containing the UCM (Kondo and Liu 1998). The roughness parameter contained in the friction force term of momentum equation is expressed by the roughness volume ratio. We confirmed the fact that the wind tunnel measurement data of the vertical wind profile are in fairly good agreement with the calculation results derived from the UCM. The eddy coefficients are parameterized based on Gambo (Gambo 1978).

In the Soil Sub-Model, three types of land surface are assumed, which are bared soil, lawn and pavement. In order to clarify the relation between UHI and alternation of land usage, Soil Sub-Model contains the simplified methods developed by authors for identifying dynamic evaporation efficiency of bare soil surfaces, lawn vegetation and pavements. They can drastically reduce the calculation load compared with the conventional procedure based on the simultaneous hygrothermal transfer equations.

The Building Sub-Model is principally based on the dynamic calculation theory for a building thermal load. We assumed a hypothetical three-storied building with a basement, of which the middle story represents several stories in reality. Surface temperatures of every wall at each direction and every floor are deduced from a discrete nodal 1D heat transfer equation. Multiple solar reflections are calculated by the radiosity method. Infrared radiation, emitted in proportion to the surface absolute temperature to the fourth power, is exactly considered in the process of iterative calculation. Anthropogenic heat from buildings originally coming from the building thermal load are added to the source terms of Urban Atmospheric Sub-Model.

3. STANDARD SOLUTION

Figure 2 shows the calculation results under the typical summer conditions targeting the urban district in Tokyo. The profiles of air temperature and specific humidity near the ground surface fluctuate intensively as compared with those near the top of surface boundary layer. The profile of wind velocity changes remarkably around 25m, the height of a building. Specific humidity near roof height when the air-conditioning is operated is much higher than that at nighttime because of the exhausted vapor from a cooling tower of an HVAC system.

4. CONCLUSION

The revised-AUSSSM was proposed, which is characterized by its light-computing load that still allows for relatively high accuracy. A standard solution targeting typical urban district of Tokyo was reported also.

REFERENCES

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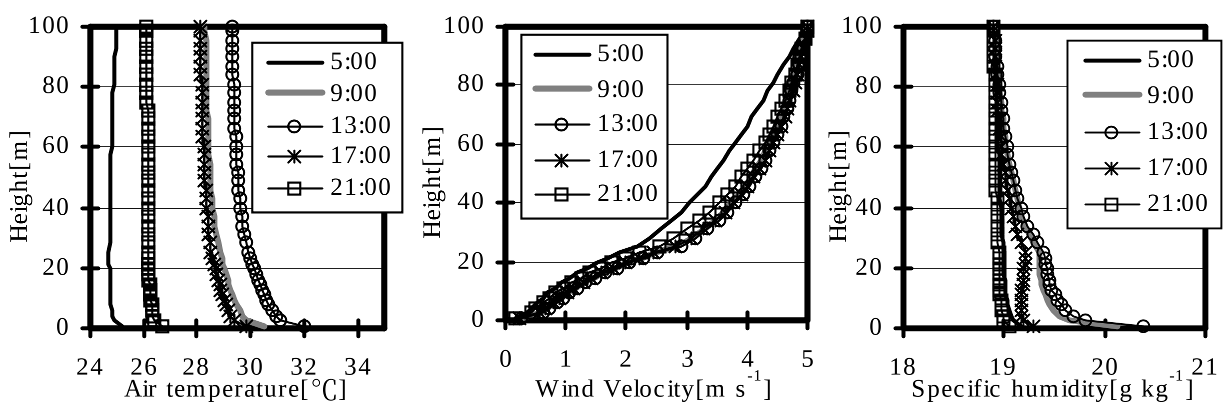

Fig. 2 Vertical distribution of air temperature, wind velocity and specific humidity