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Indoor/outdoor climate design by CFD based on the Software Platform

Shuzo Murakami *

Faculty of Science and Technology, Keio University, 2-14-1 Hiyoshi, Kohoku-ku, Yokohama 223-8522, Japan

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Abstract

The difficulties in CFD analysis of indoor/outdoor environments is described in this paper and new techniques in CFD for overcoming these difficulties are developed. A 'Software Platform' is proposed that integrates various numerical analysis tools and that is able to give a complete evaluation of indoor/outdoor climates. A number of case studies on designing indoor/outdoor climates are reported based on this newly developed Software Platform.
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1. Introduction

The development of CFD techniques in the last 20 years has been remarkable. CFD is now utilized in many engineering fields as a practical analysis tool. This paper describes the application of CFD to environmental design ranging from human-scale indoor climates to urban-scale outdoor climates. Here CFD is used, not only as an analysis tool, but also as a design tool which is a more advanced style of CFD application.

2. Developing a design method for indoor/outdoor environments based on CFD

In the process of CFD development, our group has applied CFD techniques to a large number of applications involving various indoor/outdoor environmental problems. In this process, we have been forced very often to face a range of difficulties, such as the treatment of solid boundary conditions, relatively large grid sizes due to the scale of the original phenomena, etc. Among these difficulties, we will point out two major ones that are peculiar to CFD analysis related to environmental design; (1) the interaction of various physical parameters and (2) the interaction of various scale phenomena.

2.1. Two major difficulties in the CFD analysis of indoor/outdoor environments

2.1.1. Interaction of various physical parameters

The first difficulty is the interaction of various physical parameters in human environments, such as airflow, radiation, heat transfer, moisture transfer, etc. Thus the conventional CFD, in which two parameters—i.e. velocity and temperature—are treated, is not useful for coping with this difficulty. In order to overcome this difficulty, the simultaneous analysis of multiple physical parameters is required. The answer to this assignment is the development of a coupled simulation technique.

Murakami et al. (2000a,b) and Yoshida et al. (2000) illustrated an example of the interaction of various physical parameters in Fig. 1, which features the first difficulty. It shows the complex effects of planting trees on thermal environment in the summer season. The tree planted has various effects on the thermal comfort of the human body, including both positive and negative ones as shown in Fig. 1. As the phenomena are so complicated, only a coupled simulation can clarify the interacting effects of the various physical parameters on the human body.

*2.1.2. Necessity for the development of an integrated indicator SET**

One of the final targets of environmental design is the evaluation of human comfort. Murakami et al.

* Fax: +81-45-566-1770.
E-mail address: murakami@sd.keio.ac.jp (S. Murakami).

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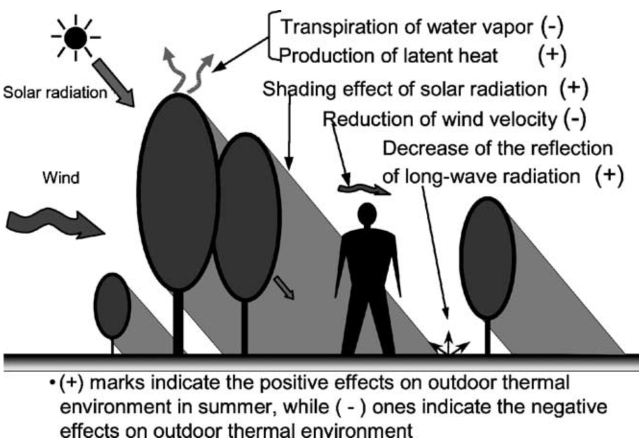

Fig. 1. Positive and negative effects of planting on the thermal environment in summer.

(1999a,b) clarified the complicated mechanism of heat exchange between the human body and the surrounding outdoor environment as shown in Fig. 2. The situation is similarly complicated in the case of indoor climates. Since it is so complicated, we are presented with many assignments to be solved in the design of thermal environments, which include the development of various indicators and tools to use for the analysis and evaluation of human comfort. One answer to the assignment is to derive a value for SET* (standard effective temperature), an indicator that gives an overall evaluation of human comfort including a range of parameters. Murakami et al. (1999a,b) explained the necessity for developing an integrated indicator for evaluating human comfort as shown in Fig. 3. Calculating the value of SET* is a key process in evaluating human comfort and in designing the human environment as denoted in Fig. 3, and this is made possible by a simulation coupling of the various heat exchange procedures around the human body. The physical concept and parameters which features SET* are illustrated in Fig. 4. The heat loss from the human body through radiation is very large, as shown later in Fig. 15. The value of SET* in which radiative heat transfer plays an important role cannot be derived without the technique of coupled simulation.

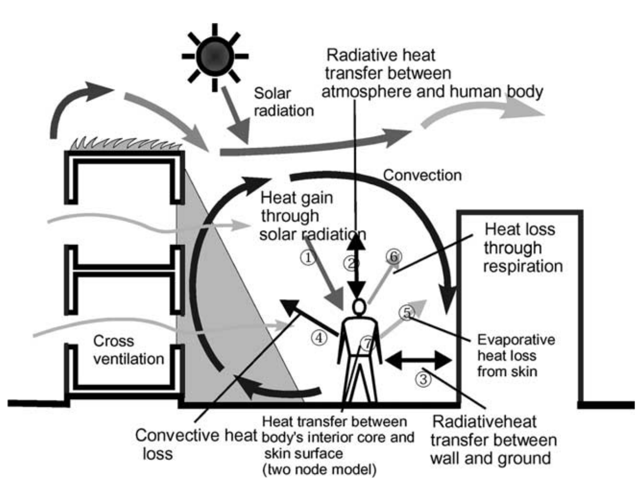

Fig. 2. Complicated mechanism of heat exchange between the human body and the surrounding outdoor environment.

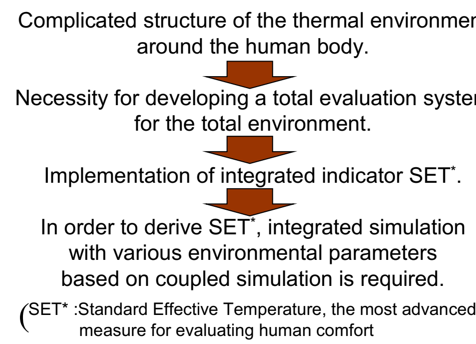

Fig. 3. How to evaluate human comfort and how to design a human environment.

2.1.3. Interaction of various scale phenomena

Adding to the first difficulty of the interaction of physical parameters, the second difficulty is the interaction of phenomena at various scales, ranging from the human scale to the urban scale, as shown in Fig. 5. Murakami et al. (2000a,b) reported that the nested grid analysis is a key technique in overcoming this difficulty.

Murakami et al. (2002, 2003a,b) explained the effectiveness of the nested grid technique in Fig. 6, using the example of micro–macro analysis for selecting the best position of the windmill. Here the meteorological model for the larger scale and engineering model for the smaller scale are combined. In Fig. 6, the models from the meso-scale analysis (Domain A, 500 km × 500 km) to the windmill scale analysis (Domain E, 1 km × 1 km) are combined by the nested grid technique. We are forced to use a fairly large grid size in the analysis of Domain A, for which we cannot expect a high prediction accuracy. The target area for the analysis of where the windmill is to be constructed is scaled down step by step, accom-

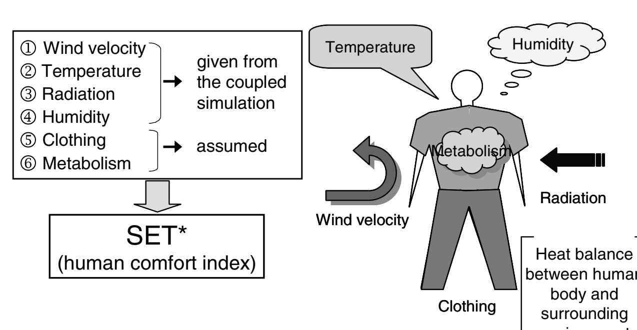

Fig. 4. Physical concept of SET*.

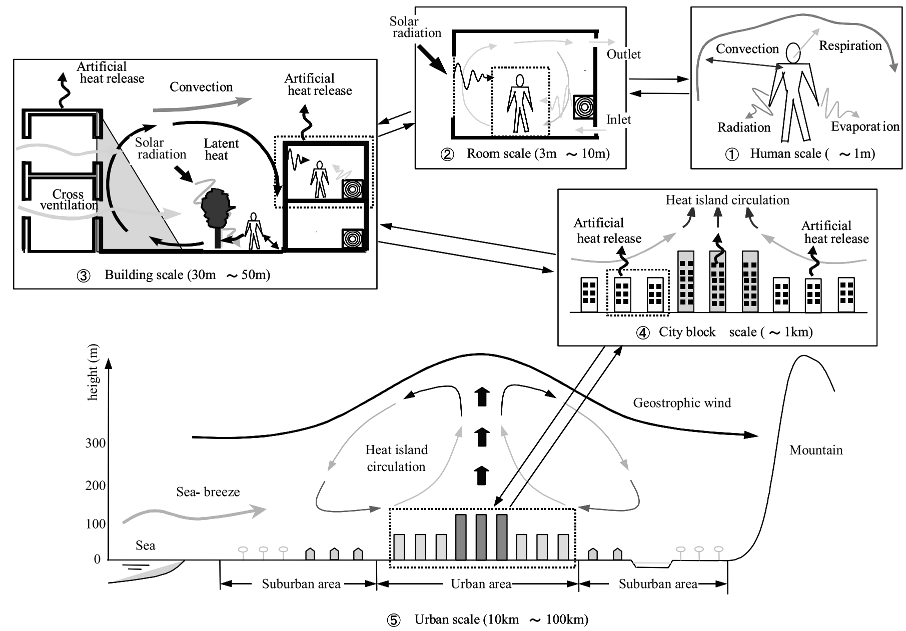

Fig. 5. Interaction of phenomena at various scales from indoor to urban.

panied by a scaling down of the grid size, with the aid of the nested grid technique. It is possible to apply a finer grid in the case of Domain E with improved accuracy, allowing us to take in ground obstacles such as trees. As the physical phenomena, numerical models, and physical parameters used in the models are different between the meteorological model (for Domains A, B, C) and the engineering model (for Domains D, E), the connection of the various scales using the nested grid technique is not easy.

2.2. Two major numerical techniques for environmental design

In the design of human environments, evaluating the thermal comfort of the human body has continued to be the main target of the analysis from the start of CFD application. Based on our vast experience in applying CFD to environmental design, we have refined the following two major techniques which are indispensable for indoor/outdoor climate design; (1) coupled simulation and (2) a feedback system. Both of these have become essential tools in the analysis of human environments.

2.2.1. Coupled simulation technique

In conventional CFD analysis related to the thermal environment, it is usual to carry out the analysis using the physical parameters of velocity and temperature. Thus the convective heat transfer is analyzed here. However, in the evaluation of human comfort, the effect of radiative heat transfer is very important in addition to convective heat transfer. The new technique of the coupled simulation of convection and radiation, which was developed in the early 1990s by our group, has made it possible to carry out a combined simulation including a variety of environmental parameters such as velocity, radiation, heat, moisture, etc. This technique has had a great impact on the application of CFD to environmental design. Coupled analysis with multiple physical parameters is made possible only by numerical techniques, including CFD. With the development of coupled analysis, the CFD technique had acquired a trigger that has enabled it to develop from a simple analysis tool to a design tool well-suited to practical use.

2.2.2. Feedback system

The next critical step in applying CFD to environmental design is the development of a feedback system, something that was also proposed by Murakami et al. (1999a,b) in the late 1990s. This feedback system changed the procedure of environmental design. The conventional design procedure is mainly based on a trial-and-error system supported by experience. The process of decision-making is empirical rather than deterministic. With the development of a feedback system, it becomes possible to solve the inverse-problem: i.e. the target design conditions for environmental control are given by solving the inverse-problem. The feedback system has made it possible to satisfy the combination of high-priority design conditions automatically. At this stage, the CFD technique combined with coupled simulation and the feedback system have developed into a fully fledged design tool.

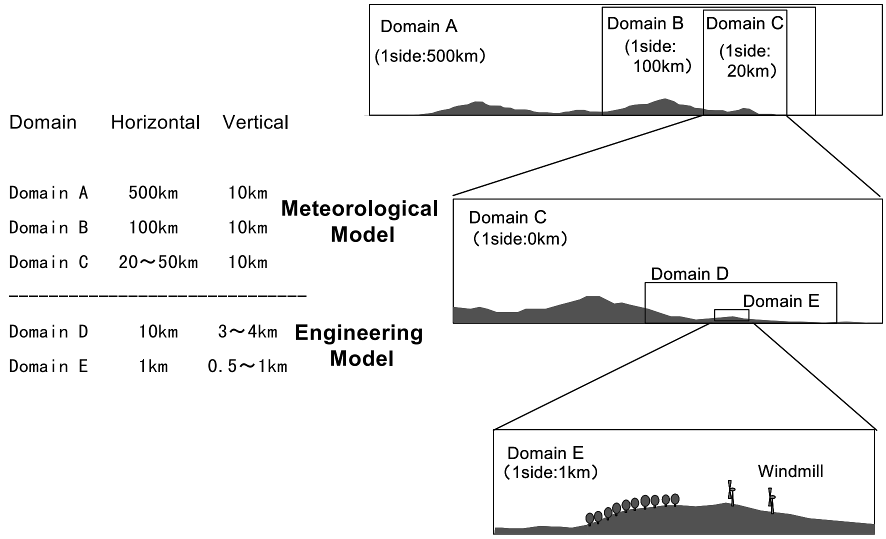

Fig. 6. Micro–macro analysis with the nested grid technique for selecting the best position of the windmill.

2.3. Necessity for the development of a Software Platform

Reflecting the two difficulties described in Section 2.1 and the new techniques developed to overcome these difficulties described in Section 2.2, it became necessary to develop the integrated simulation system for evaluating and designing indoor/outdoor climates shown in Fig. 7. The development of a Software Platform is thus proposed to fulfil this assignment, and a prototype Software Platform is shown in Fig. 13.

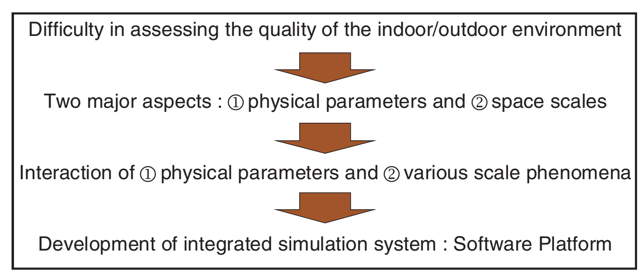

Fig. 7. Necessity for the development of integrated simulation system for evaluating indoor/outdoor environments.

2.4. Application of feedback system for the optimized design of indoor climates

2.4.1. Concept of the feedback design system

Murakami et al. (1999a,b) showed the concept of the feedback system as shown in Fig. 8, where the two simulation methods—the conventional method and the new method—are compared. In the conventional method (Fig. 8(1)), the boundary conditions for the simulation are fixed naturally. In the new method, which includes the feedback system (Fig. 8(2)), the boundary conditions are modified according to the simulation results with the aid of the feedback system.

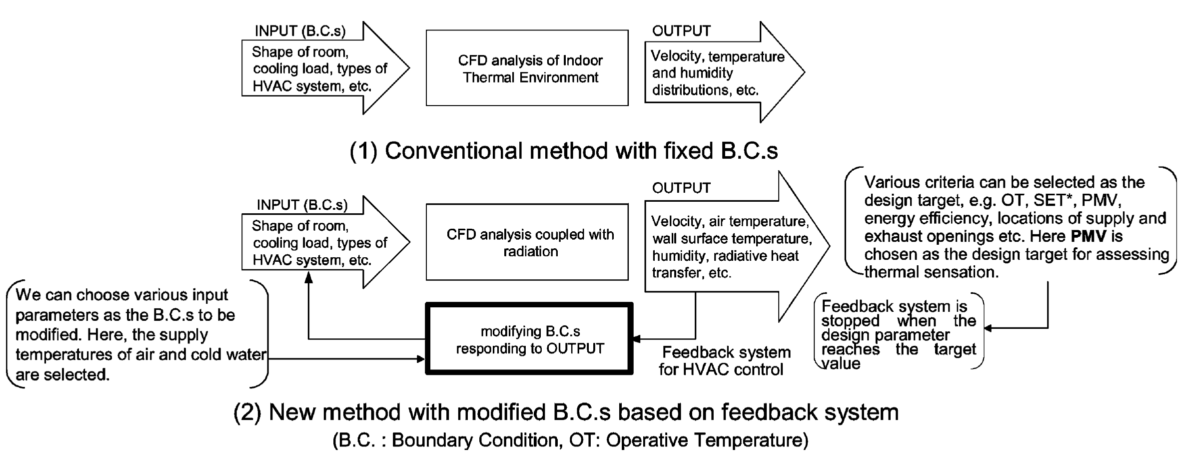

Fig. 8. Concept of indoor climate simulation with/without feedback system for HVAC control.

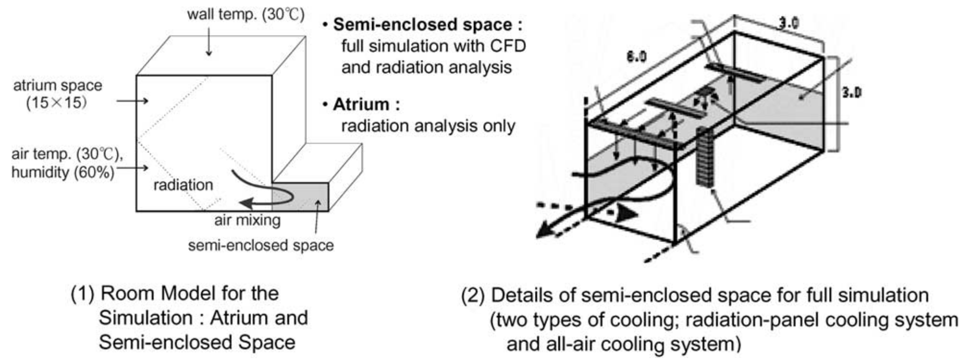

Fig. 9. Room model used for the case study (summer season).

2.4.2. Case study of the simulation with a feedback system of HVAC control

The newly developed feedback system was applied to the HVAC (heating ventilating air-conditioning) control problem by Murakami et al. (1999a,b), confirming the effectiveness of this system. Fig. 9 shows the room model used for the case study. The target for the analysis is a semi-enclosed space with cooling, which opens onto an atrium space with no air conditioning. Two types of cooling system are applied to this semi-enclosed space; (1) a radiation-panel cooling system and (2) an all-air cooling system.

2.4.3. Results of the case study

The temperature fields are illustrated for both types of cooling system as shown in Fig. 10. The value of PMV (an integrated indicator for evaluating the thermal environment, similar to SET*) for both cooling systems is maintained at 0.5, which means that a person feels the same thermal comfort in either room. In the former system, the supply water temperature to the cooling panel is controlled to satisfy the design target PMV of 0.5, while the supply air temperature to the diffuser is controlled in the latter system. Setting the value of PMV as the target value and determining the supply water/air temperature is made possible only by the technique of a feedback system.

Average room air temperatures are 29.2 and 26.3 °C respectively for the radiation-panel cooling system and the all-air cooling system, showing a big difference, although the value of PMV is maintained at 0.5 in both rooms.

Fig. 11 shows the heat loss from the human body. As the PMV is maintained at 0.5, the total heat loss from the human body is the same for both cooling systems. However a breakdown into separate items shows large differences. In the case of the radiation-panel cooling system, the heat loss through radiation is very large, while in the case of the all-air cooling system the heat loss through convection is predominant, reflecting the difference in the predominant physical mechanisms of heat transfer from the human body between the two cooling systems.

The structural difference in these two cooling systems is well clarified by an analysis using the feedback system.

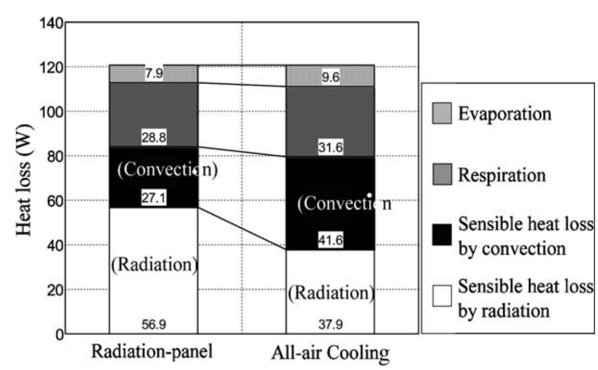

Fig. 11. Comparison of heat loss factors from the human body (PMV is kept at 0.5 for both cooling systems).

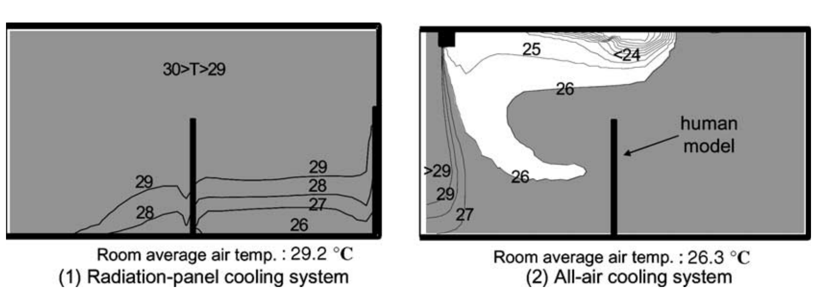

Fig. 10. Comparison of air temperatures (PMV is kept at 0.5 by means of the feedback system).

3. Development of a Software Platform as a universal design tool for indoor/outdoor environments

The necessity for developing an integrated simulation system, i.e. the Software Platform, is described in Fig. 8. As indoor/outdoor environments are composed of many elements and controlled by many interacting physical processes at various scales, it is extremely difficult to evaluate the impact of individual factors separately. As already stated, research efforts should thus be devoted to developing a method for integrating the simulation models for the various phenomena into a comprehensive and total simulation system. Thus a new Software Platform is to be developed that can handle many subsystems. It will be capable of analyzing each scale phenomena with its corresponding physical parameters, and of integrating them to enable a complete evaluation of the environment, such as for a heat island.

The Software Platform needs to include a range of functions. At first it will form the framework of a simulation system that bridges the gap between (1) existing software to analyze various phenomena related to indoor/outdoor environments, and (2) databases required to specify initial/boundary conditions and to confirm the accuracy of the simulation.

In order for the Software Platform to perform well, it must include all the functions shown in Fig. 12.

Murakami et al. (2000a,b) developed a prototype of the Software Platform as shown in Fig. 13, including a number of sub-systems, that will enable the complete analysis of urban climate and heat islands.

(1) CFD solvers based on numerical models for analyzing each specific phenomenon
(2) Databases required for the simulations
(3) Interface between various solvers and various databases
(4) Guidance which enable users to select appropriate solvers and databases, according to the purpose of the simulations, from the elements on the platform.

Fig. 12. Contents of the Software Platform.

The thick box in Fig. 13 is the main part of the Platform. On the left side of this thick box is a list of various research target scenarios that will improve the urban heat-island phenomena. The top of the figure shows several databases that are necessary to specify the initial and boundary conditions. The initial/boundary conditions are generated from the scenarios on the left and the databases at the top. This process is illustrated in the upper part of the thick box. Several solvers for micro-scale/meso-scale climates, etc., and several numerical models for energy consumption, CO_2 emission, etc., are included in the lower part of the thick box. These are the main components of the Software Platform. The main part is well supported by a number of sub-models, which are shown at the bottom of the figure. The outputs provided by the Platform as a result of the detailed analysis are listed on the right of the thick box. This output module contains data obtained directly from the simulation, and this information is ready to be

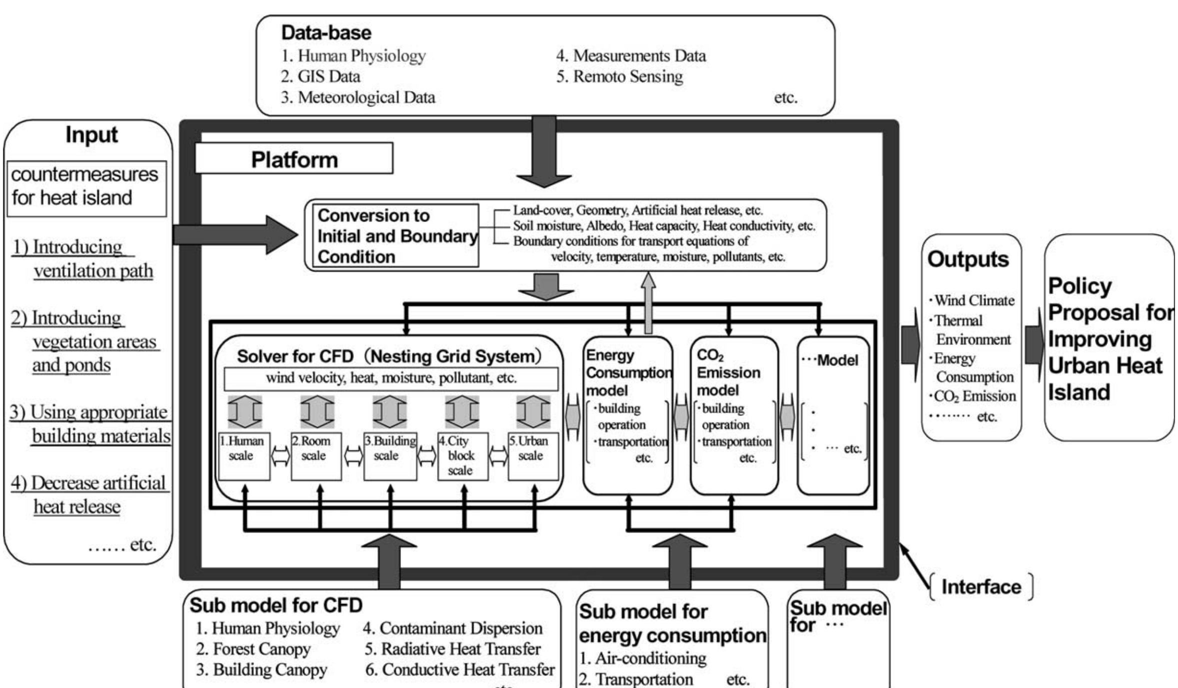

Fig. 13. Prototype of the Software Platform for the total analysis of urban climate and heat island.

used in the preparation of policy proposals for city planning and regional planning.

A number of case studies based on the newly developed Software Platform are reported in the next section.

4. Case studies of environmental design based on the Software Platform

4.1. Case study 1: Heat exchange between the human body and the surrounding environment

The analysis of the thermal comfort of the human body forms the starting point of environmental design. In order to evaluate the thermal comfort of the human body quantitatively, it is necessary to analyze the micro-climate around the human body. The human body exchanges heat with the surrounding environment in various ways, as illustrated in Fig. 14. A coupled simulation of CFD and radiative heat transfer is carried out in order to clarify these complicated phenomena by Murakami (2002). CFD is based on the low-Reynolds-number k–ε model which is developed by Launder and Sharma (1974).

The micro-climate analysis around the human body is an important sub-system of the Software Platform. Fig. 15 illustrates the result of the coupled simulation. The heat loss through radiation is larger than the losses through convection and evaporation in this case. Such an analysis became possible after the development of the coupled simulation technique. It has clarified where and how the human body discharges heat. Thus it becomes possible to determine the operating conditions for an HVAC system by giving a target value for a human comfort index such as SET*. This is the inverse-problem in the design of indoor climates, utilizing the feedback system.

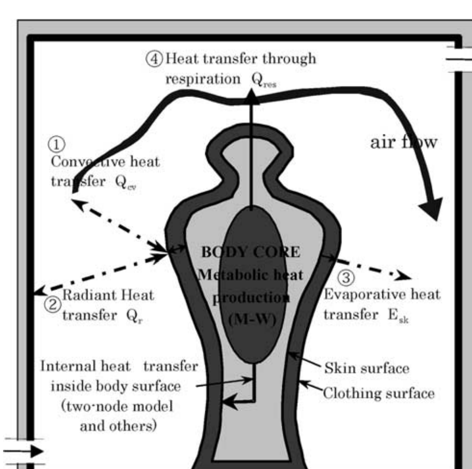

Fig. 14. Various manner of heat transfer around human body.

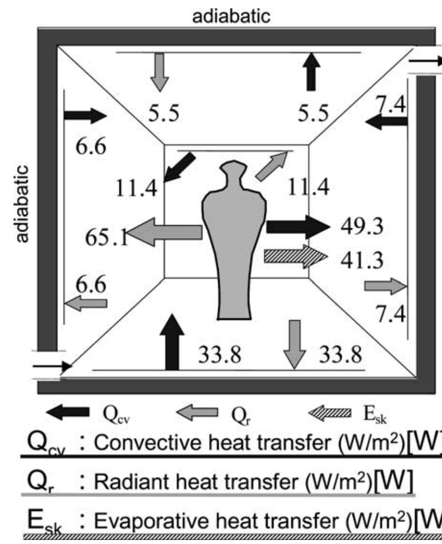

Fig. 15. Heat transfer between human body and surrounding environment (based on coupled analysis of convection, radiation, internal heat transfer within human body).

4.2. Case study 2: Design of IAQ for coping with the sick-building problem

Nowadays, indoor air contamination by chemical compounds has become a serious environmental problem, widely known as the 'sick-building syndrome.' The second case study is the analysis and design of IAQ (indoor air quality) related to the inhalation of contaminated air by the human body by Murakami (2002). As the human body discharges heat due to the process of metabolism, a rising stream is generated around the human body, as shown in Fig. 16. The body thus inhales the air transported from the lower part, i.e. the air near the floor. The floor is usually dirty, and so the air near the floor is also usually dirty. In order to analyze the air quality inhaled by the human body, we propose a new indicator, CRP (contribution ratio of pollution source), which evaluates the contribution from each position in the room to the inhalation of contaminants emitted from each position. CRP is defined so that the total CRP for each position comes to 100%. The concept of CRP is illustrated in Fig. 17. In this example, CRP at the floor is 65%, while at the ceiling it is 10%. In order to calculate the value of CRP, it is necessary to carry out a coupled analysis of the micro-climate around the human body as shown in Fig. 15 and the emission/transportation of chemical compounds within a room.

The prediction result of CRP for a standing posture is shown in Fig. 18(1). Here the CRP at the floor is 53% and at the ceiling it is just 1%. Fig. 18(2) shows the result in the case of a sleeping posture. In this case, the CRP at the floor is a high 73%. It becomes clear through these analyses that the floor is very important from the

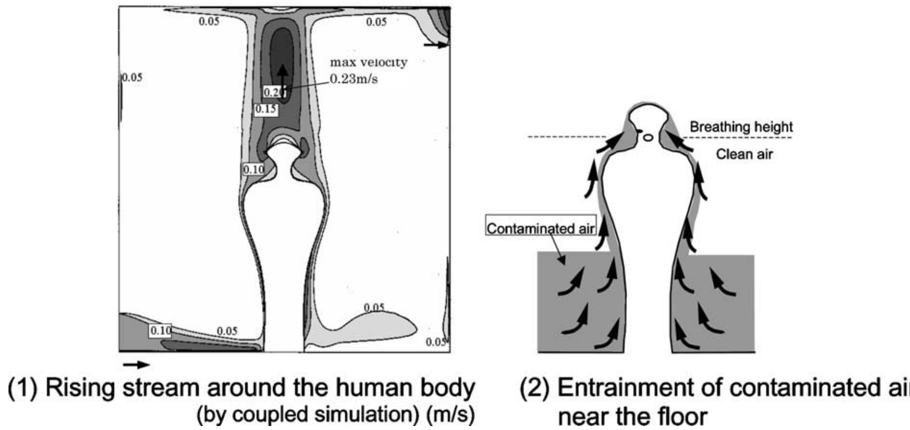

Fig. 16. Flowfield around a human body.

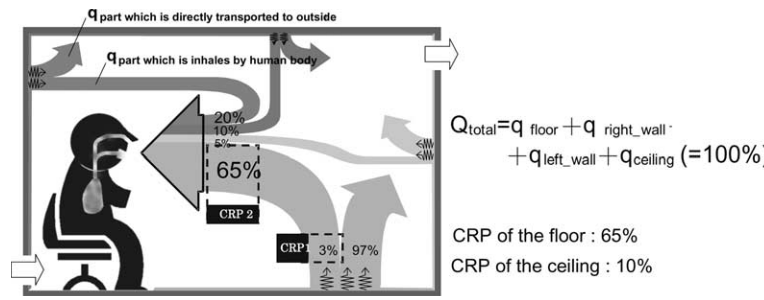

Fig. 17. Concept of CRP (CRP: contribution ratio of pollution source from each position to inhalation by the human body).

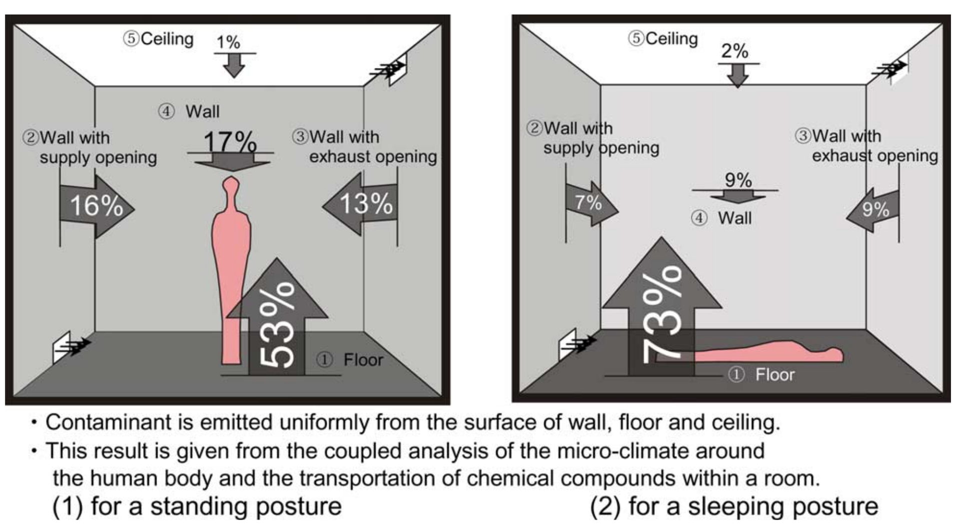

Fig. 18. Prediction result of CRP.

viewpoint of controlling the cleanliness of the air inhaled by the human body.

At the next stage, we can clarify which part of the room has the highest priority for implementing countermeasures to reduce the inhalation of chemical contaminants.

4.3. Case study 3: Effect of green area ratio on the outdoor thermal environment

Deterioration of the summer outdoor environment in urban areas is becoming more serious year by year. The third case study examines the effects of greening, using

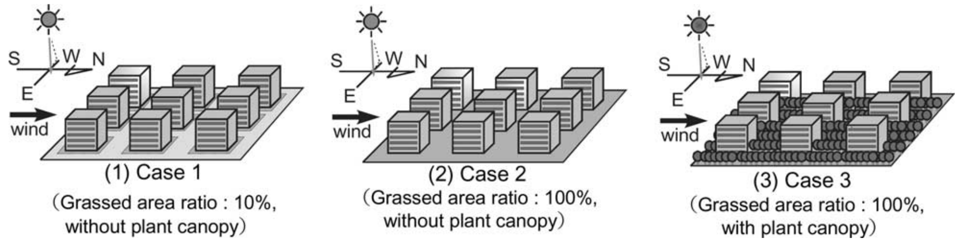

Fig. 19. City block model used.

grass or a plant canopy, on the outdoor thermal environment by Murakami et al. (1999a,b). The city block models used are shown in Fig. 19. Three city blocks with different greening or planting schemes are compared here. There are many elements which comprise the outdoor thermal environment as shown in Figs. 2 and 28. The Software Platform is well utilized to analyze such phenomena. Thus some integrated indicator is needed in order to evaluate such a complicated set of phenomena, and SET* is the most suitable for this purpose, as has already been mentioned. The prediction results with temperature and SET* are compared and the effectiveness of SET* as an overall indicator is clarified here. CFD is based on the modified k–ε model in which two revisions are applied. The first is the revision to prevent the overestimation of turbulent energy k at the frontal corner of the building model (Launder–Kato model explained by Launder and Kato (1993) and Mochida et al. (2000)). The second is the one to include buoyancy effects based on the WET model explained by Yoshida et al. (2000).

Distributions of surface temperature for the ground and the wall are illustrated in Fig. 20. The difference between the sunny area and the shaded area is very large in Cases 1 and 2, while it is small in Case 3. The surface temperature in the sunny asphalt space exceeds 50 °C (Case 1), while the surface temperature on the sunny grass area is 40 °C (Case 2) and that under the plant canopy is 26–28 °C (Case 3). The effect of greening or planting on the surface temperature is very large.

Fig. 21 shows the distributions of air temperature, which show rather small differences between the sunny area and the shaded area for the three cases. Fig. 22 shows the distribution of SET*, where we can observe a

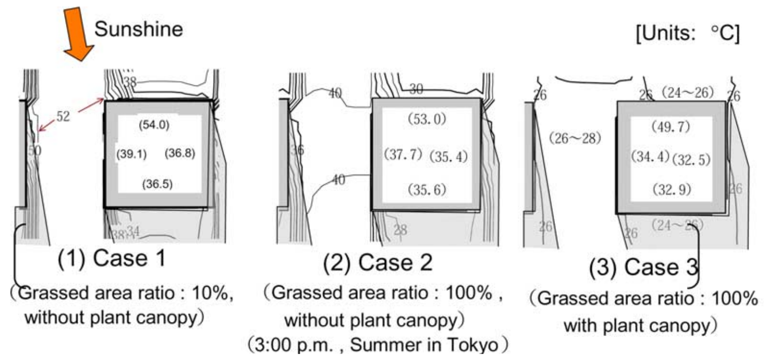

Fig. 20. Distribution of surface temperature of ground and wall.

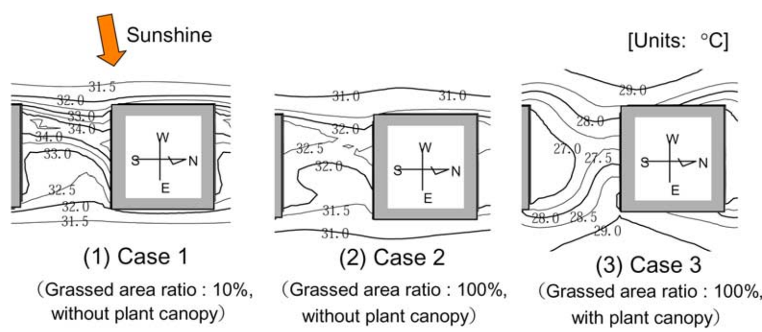

Fig. 21. Distribution of air temperature.

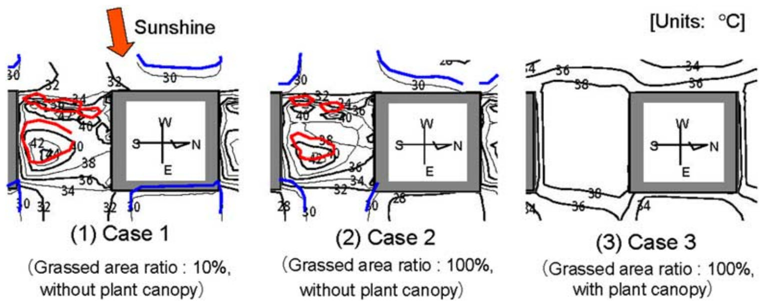

Fig. 22. Distribution of SET*.

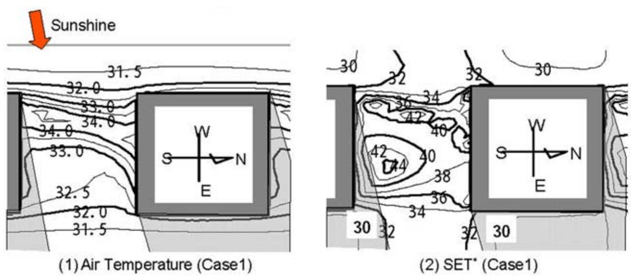

Fig. 23. Which is the better indicator of thermal comfort; air temperature or SET*?

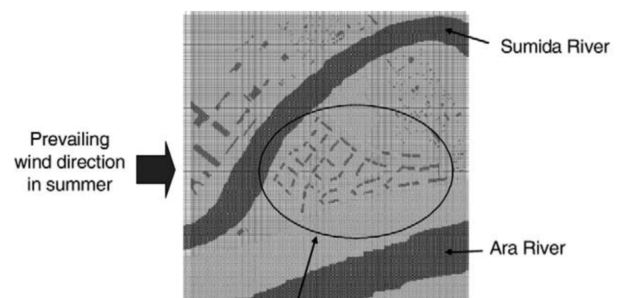

Fig. 25. Target area for the analysis.

large difference between the sunny area and the shaded area. The distributions of air temperature and SET* are compared for Case 1 in Fig. 23. A big difference in SET* between the sunny area and the shaded area is observed (Fig. 23(2)), corresponding well to the feeling we experience in summer in an outdoor environment. In the case of air temperature (Fig. 23(1)), the difference between the sunny area and shaded area is very small, which does not correspond to our experience. The effectiveness of SET* is well clarified here. Fig. 24 shows a sensitivity analysis of SET*, in which Cases 1 and 2 are compared, and the positive effects or negative effects of greening on SET* are analyzed separately from various viewpoints. From the viewpoint of humidity, increased greening has a negative effect on SET*, while the positive effects of greening are recognized from the viewpoints of air temperature and MRT (mean radiant temperature).

The effect of greening on the outdoor environment becomes clear through such a sensitivity analysis. Thus

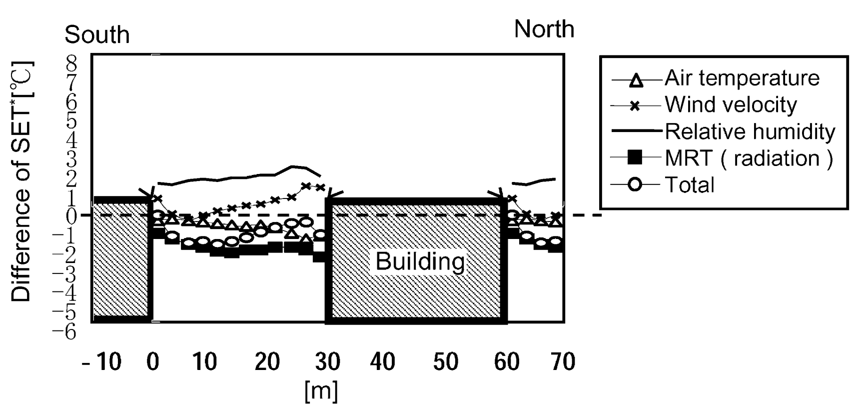

Fig. 24. Sensitivity analysis of SET* by greening.

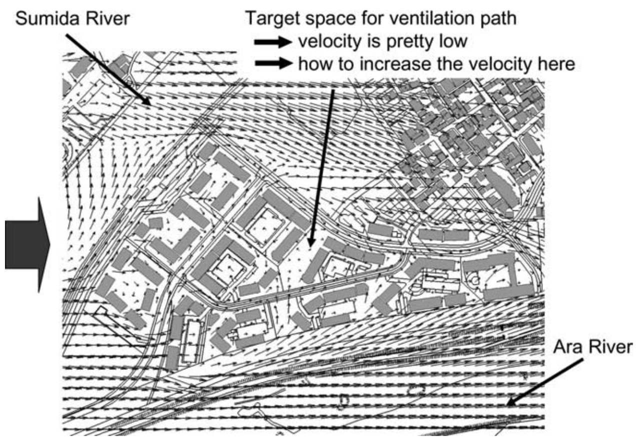

Fig. 26. Distribution of velocity vectors (at height of 2 m).

it becomes possible to determine the green area ratio by giving the target value of SET*.

4.4. Case study 4: Utilizing the potential of rivers for cooling the outdoor environment

Water space can be efficiently utilized to improve the urban environment in summer. The effect of rivers on cooling the outdoor environment is surveyed by Oguro et al. (2002). Here the design of building locations is examined from the viewpoint of how to introduce the cool wind that flows over a river into a housing complex. Fig. 25 illustrates the target area for the analysis, which is sandwiched between the Sumida River and the Ara River (Kita Ward in Tokyo). The prediction result of velocity vectors is shown in Fig. 26. The target space for the ventilation path is located in the center area of the housing complex. However, the wind velocity in this

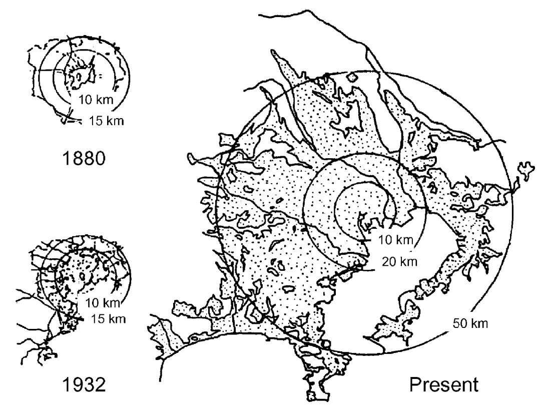

Fig. 29. Progress of urbanization in Tokyo (Ojima et al.).

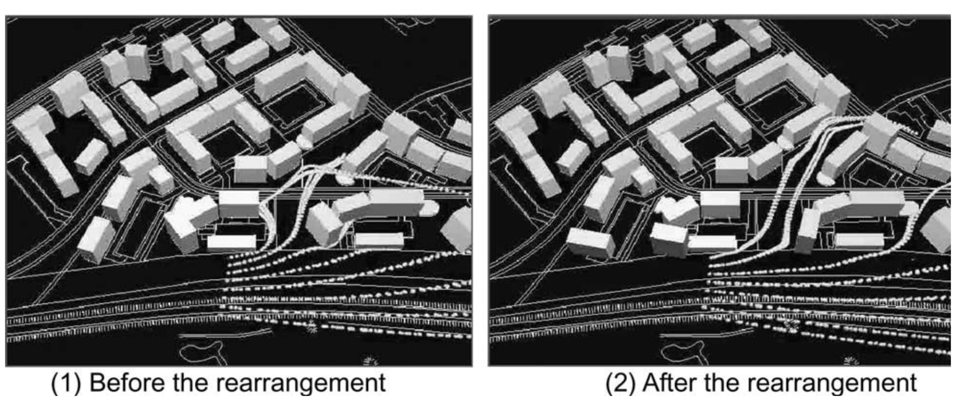

Fig. 27. Movement of markers in the ventilation path.

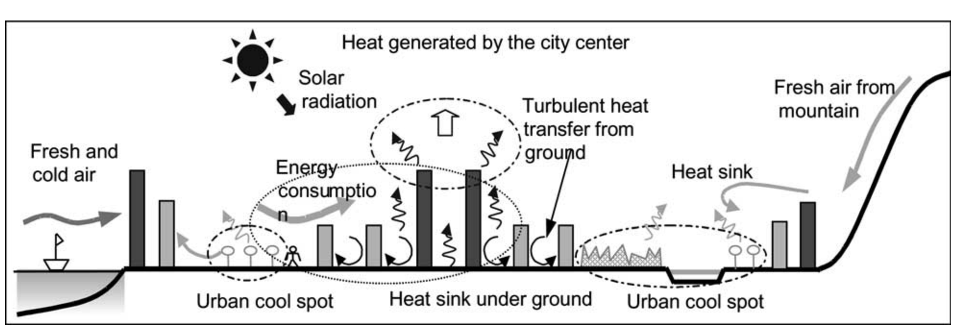

Fig. 28. Model of urban meso-scale climate.

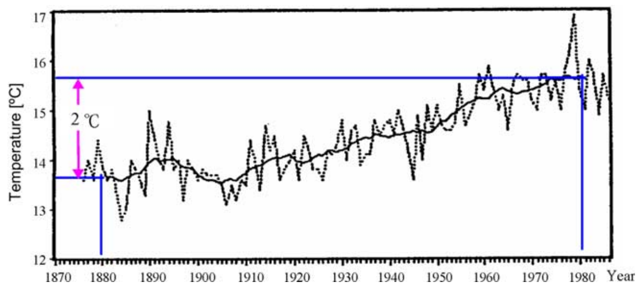

Fig. 30. Increase in air temperature in Tokyo in the last 100 years (at height of 1.5 m).

space is somewhat below the original design of the housing complex as shown in Fig. 26.

Thus buildings are rearranged in order to increase the wind velocity in the ventilation path. Fig. 27 shows the movement of markers in the ventilation path, in which the two cases are compared; i.e. before the rearrangement and after the rearrangement. The three buildings located on the windward side of the ventilation path are rearranged as shown in Fig. 27(2). After the rearrangement, the movement of the markers becomes very active in the area of ventilation path (Fig. 27(2)). Thus the cool wind over the river can be efficiently introduced into a ventilation path through the housing complex. The potential of rivers on the outdoor environment can be utilized well using such design techniques. Thus it becomes possible to design the outdoor environment in harmony with water spaces such as rivers and lakes.

4.5. Case study 5: Historical change in the urban climate—a comparison between the present and the Edo Era

Murakami et al. (2000a,b) reported the urban climate was very complex as shown in Fig. 28, and includes almost all the physical phenomena related to environmental design. Thus the prototype Software Platform shown in Fig. 13 is proposed for a complete analysis of

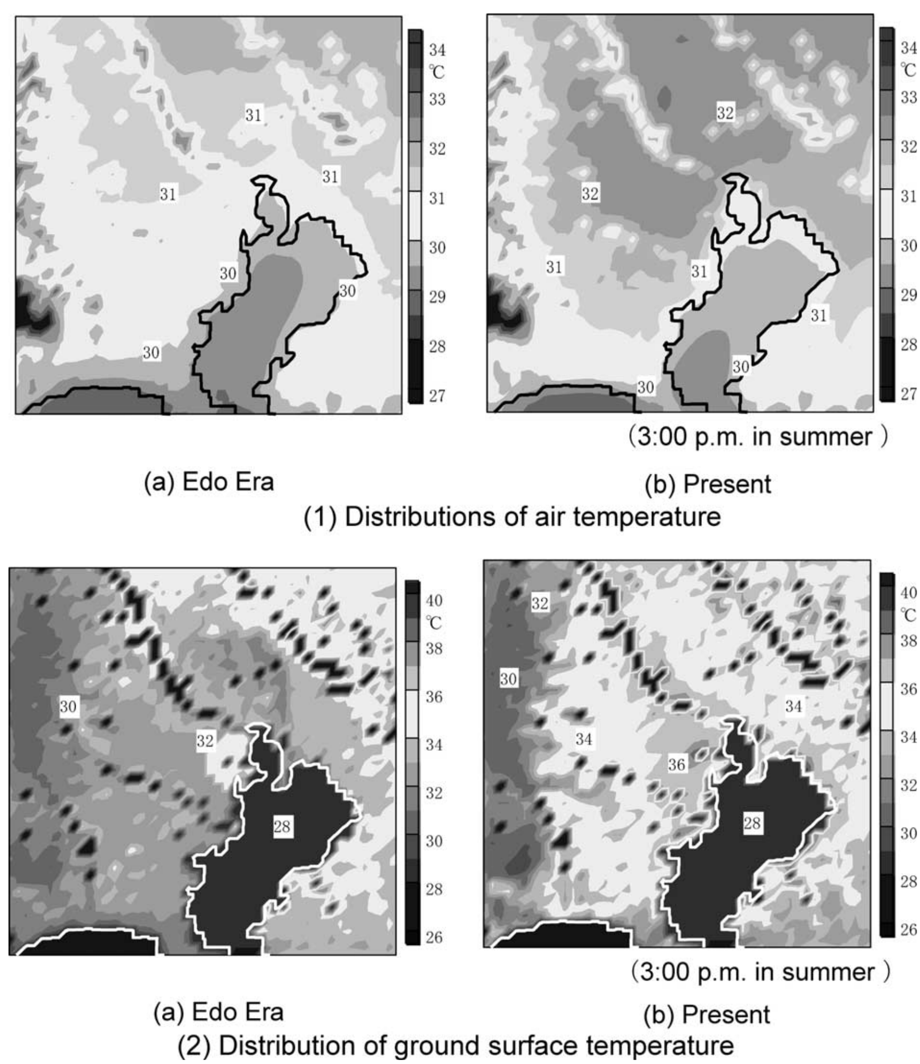

Fig. 31. Comparison between the present time and the Edo Era.

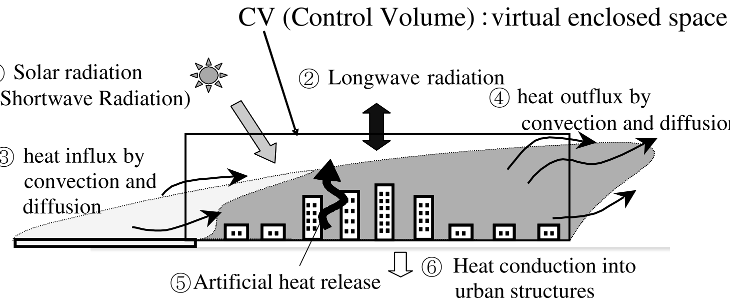

Fig. 32. Concept of Urban Heat Balance model.

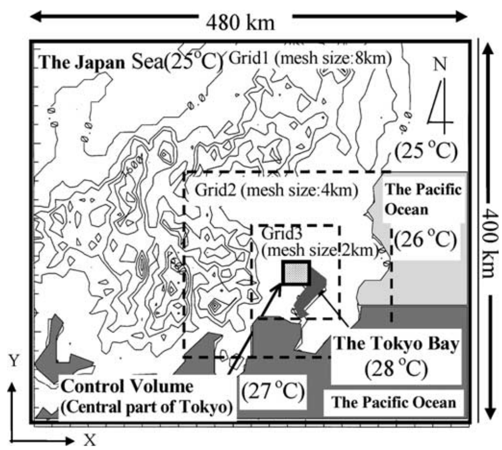

Fig. 33. Computational domain and control volume.

the urban climate and heat-island effect. The Platform is composed of multiple sub-systems for analyzing the climate from the human scale to the urban scale as described in case studies 1–4. Here, historical changes in the climate of Tokyo were analyzed based on the Software Platform by Mochida et al. (1999). CFD is based on the Mellor–Yamada model (level 2.5) which is the mixture of the k–ε model and DSM proposed by Mellor and Yamada (1982).

The remarkable progress of urbanization in Tokyo over the last 120 years is shown in Fig. 29. Fig. 30 shows the increase in the air temperature in Tokyo over the last 100 years given by measurements. The increase is about 2 °C at a height of 1.5 m. Changes in air temperature and ground surface temperature are compared in Fig. 31(1) and (2).

The increases in air temperature (at a height of 10 m) and ground surface temperature are about 1 and 4 °C respectively for an average within grid size 4 km × 4 km, which corresponds fairly closely to the measured increase of 1.5 °C at a height of 1.5 m.

The CFD technique is now able to clarify the changes in urban climate due to urbanization. Thus it becomes possible to design cities and buildings that have a smaller effect on the original climate.

4.6. Case study 6: Evaluation of the impacts of urban tree planting in Tokyo based on Urban Heat Balance model

In order to take full advantage of countermeasures for heat-island effects it is important to understand the mechanism of the heat balance in the urban space. Murakami et al. (2003a,b) proposed a new concept called "Urban Heat Balance model" for evaluating the environmental impacts of countermeasures. Here, urban scale planting of trees was selected as the countermeasure and its effect was examined.

Fig. 32 illustrates the concept of the Urban Heat Balance model. This model examines the total balance of heat (enthalpy: sensible heat + latent heat) in a virtual enclosed space, i.e. in a control volume (CV) within an urban space as shown in Fig. 32. In this study, the CV is located at the center of Tokyo as shown in Fig. 33. The

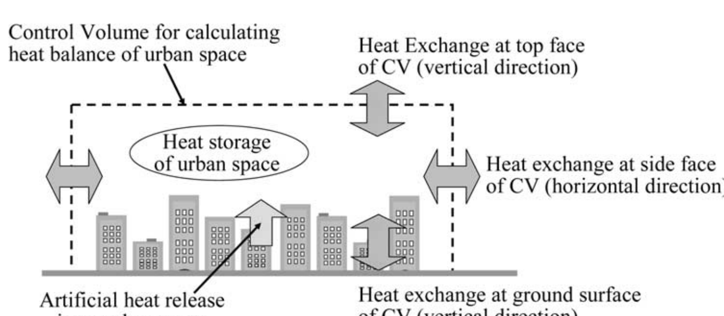

Fig. 34. Each surface and direction of incoming and outgoing heat fluxes.

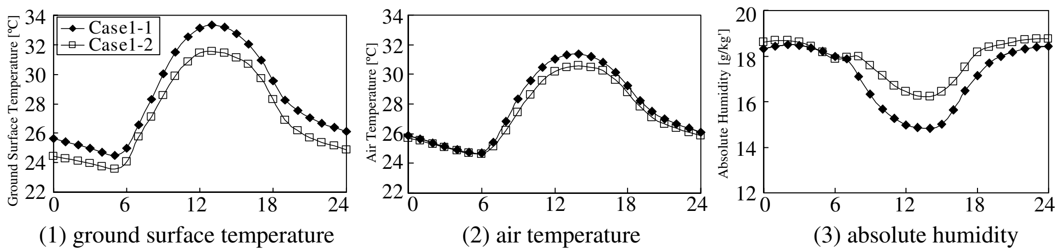

Fig. 35. Diurnal variations of ground surface temperature, air temperature and absolute humidity[12,13] (the average value of CV, August 6).

domain of CV covers 30 km (north–south direction) ×28 km (east–west direction), corresponding to the area of Tokyo's 23 Wards. The model is composed of incoming and outgoing heat fluxes through all the surfaces of the CV, and artificial heat release and heat storage in the CV as shown in Fig. 34.

Two cases are computed in this study by Murakami et al. (2003a,b) and Sato et al. (2004). Case 1 predicts the present situation in Tokyo, whereas Case 2 predicts the situation where urban planting is performed in all building areas in the central part of Tokyo.

Fig. 35 shows diurnal variations of the average ground surface temperature, the spatial average values of air temperature and absolute humidity in the CV, respectively. The ground surface temperature in Case 2 is 0.5–1.3 °C lower than that in Case 1 in the daytime due to the effect of urban planting. Consequently, the air temperature in Case 2 is 0.1–1.0 °C lower than that in Case 1. The absolute humidity in Case 2 is 0.1–1.5 g/kg higher than that in Case 1, since the generation of water vapor from the ground surface is greatly increased by urban planting in this case.

5. Concluding remarks

(1) In the analysis and design of indoor/outdoor climates by CFD, the interaction of various physical parameters and the interaction between the phenomena at various scales pose the major difficulties.
(2) Two new numerical techniques, i.e. the coupled simulation technique and the feedback system are newly developed in order to overcome these difficulties in environmental design.
(3) A Software Platform is proposed for integrating various sub-systems for numerical methods, and also to give a complete evaluation of the indoor/outdoor climate.
(4) A number of case studies are carried out based on the proposed Software Platform and thus the effectiveness of the Platform for designing the human environment is clarified.

6. Uncited references

Gagge et al. (1971), Kim et al. (2000), Kobayashi et al. (2000), Mochida et al. (1997), Murakami et al. (1997), Murakami et al. (1998), Murakami and Mochida (1999) and Omori et al. (1990).

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