6.7 MITIGATING URBAN HEAT ISLAND: POSSIBILITY AND EFFECT OF REDUCING ANTHROPOGENIC HEAT EMISSION FROM VEHICLES AND BUILDINGS

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1. INTRODUCTION

Land use alteration and anthropogenic heat increase are the major causes of the urban heat island over the Tokyo metropolitan area. In the area, cities sprawl out to suburbs and inland cities are suffering from severe heat problems as well as the central Tokyo. Although several works focused on the impact of anthropogenic heat on the temperature field over the central Tokyo area; e.g., Kimura & Takahashi (1991), no works are carried out for the future prediction giving possible changes in the anthropogenic heat emission derived from plausible scenarios of energy demand increase and energy savings. However, the strategy of heat island mitigation has to be set considering future scenarios of energy use changes and the impact over the entire region. In this study, the spatial and temporal distributions of present and future anthropogenic heat emission are quantified. Future prediction was carried out according to the scenarios for the future demand increases and the adoption of possible energy saving actions. Then, a mesoscale model was employed to estimate the impact of future changes of anthropogenic heat emission.

2. ANTHROPOGENIC HEAT AT PRESENT

2.1 *Household and business*

Heat emission from residential houses and business buildings over the Metropolitan area was estimated from data of the distribution of households, population, the amount of floor space for 7 types of building, the amount of energy use per unit household and floor area, and the seasonal and diurnal patterns of air conditioning, kitchen, light and power energy use. The results shown in figure 1 illustrate the intensified heat emission from the central Tokyo area.

2.2 *Road traffic*

Energy consumption and accompanied heat emission due to road traffic was quantified as an integration of traffic magnitude on every road for 9 types of automobile and motorcycle, and their energy consumption rates, which depend on type of vehicle and velocity. The estimated amount of energy consumption was found to be 24% less than that of the fuel selling record in the statistical report.

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3. FUTURE CHANGES

A variety of uncertain factors could affect energy use in the future. For the purpose of future prediction, factors listed in Table 1 and 2 were taken into account. Primary factors of energy use increase in the future are supposed to come from domestic and business sectors. As for the energy saving measures, high-insulation houses, the diffuse of energy efficient appliances and vehicles could reduce energy demand as well as taking individual energy saving actions.

Table 1. Factors that influence energy consumption for domestic, business and traffic uses

Households	Aging society (+) Diffusion of electric appliances (+) Life-style change (+, -) Increase in the number of households (+) Increase in single households (-)
Business	Office automation (+) Floor area increase (+)
Road traffic	Traffic increase (+)

(+): increase, (-): decrease

Table 2. Countermeasures to mitigate energy consumption for domestic, business and transportation purposes

Households and Business	High energy efficiency High-insulation house Energy saving action Utilization of water heat pumps
Road traffic	High fuel efficiency Conversion to public transportation Total demand management

3.1 *Household and business*

Although a detached residential house in Japan is typically made of wood, the number of high-insulation houses is increasing year after year. It is assumed that 46% of single houses and 71% of condominiums achieve high insulation at 2010, and 20% of cooling load is reduced by the wall insulation and window shielding.

Life style change includes various concepts such as personalization (family members behave at their own way), pursuing amenity, working at home and consciousness of energy saving. According to some reports on the effect of energy saving actions, 20% of heat energy used in kitchen, cooling, lighting and other electricity is supposed to be saved.

3.2 *Road traffic*

Based on the past records and the assumption that

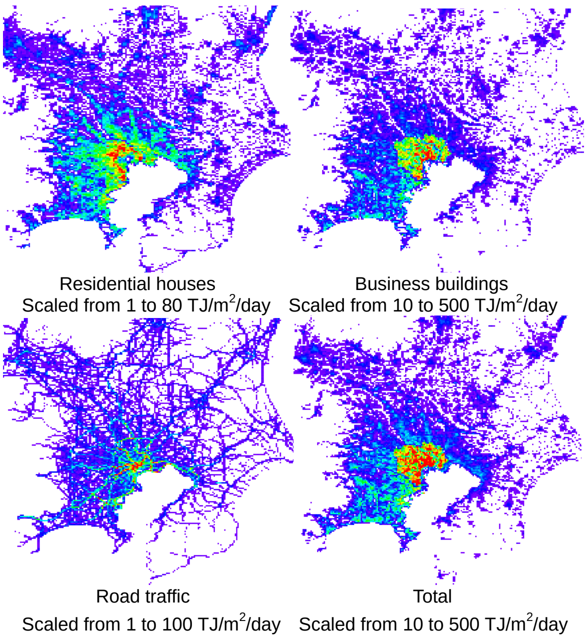

Figure 1. Spatial distribution of daily amount of anthropogenic heat emitted from residential houses, business buildings, road traffic, and their total.

the total traffic magnitude is saturated around 2010, it is supposed that the traffic magnitude increases by 15% over the Metropolitan area at 2010. The potential of heat emission from road traffic is greatly controlled by measures to ease congestion and the diffusion rate of high-efficiency vehicles. By the diffusion of vehicles with high fuel efficiency, it is assumed that the energy consumption is saved by 1 to 8% than present for each type of vehicle. Introducing a road pricing system, shift to public transportation and bicycles, and constructing roads are considered to suppress increase in the magnitude of road traffic.

4.NUMERICAL SIMULATION

4.1 *Mesoscale model and simulation setup*

A modified PSU/MM5 ver.2.12 can be used for urban heat island simulations for Japanese cities. The description of the model and its validation can be found in Kinouchi and Yoshitani (2001). It incorporates a subgrid scale parameterization scheme and the land surface model ISBA. The effect of anthropogenic heat emission was included in the boundary layer model, so that the heat is emitted to the surface layer.

The model was applied to the Metropolitan area including the central Tokyo. One coarse domain and one nested domain are used with the 2-way nesting method. The outer and nested domains have grid sizes of 61x61 and 57x57 points and grid increments of 6 and 2 km, respectively. 26 vertical sigma levels are set and the pressure level at the top boundary is 100hPa. Physical options used in the model include simple cooling and the Mellor-Yamada closure model.

The base-case simulation is 57 hours in duration, starting from 2100LST 23 August to 0500LST 26 August 1995 under clear sky conditions, with present conditions of land-use and anthropogenic heat.

4.2 *Scenario-based future prediction*

Among several scenarios drawn on the energy consumption in 2010, results of 2 scenarios are shown in this paper. Case 1 takes all negative factors into accounts with no countermeasures or energy saving actions. Case 2 accounts for taking possible measures to save energy use for houses, buildings and road traffic against future demand increases. Figure 2 shows the result of changes in 1.5m-height air temperature between case 1 and the base-case simulations at 1300LST and 2000LST, showing that the impact of the future energy use increase is limited to the central Tokyo and its southwestern part in the daytime, while the area of temperature rise is widened at night. This is due to the accumulation of increased heat and the difference of stability of the atmosphere between the day and the night.

The difference of simulation results between case 1 and case 2 are shown in figure 3 along with the distribution of the amount of reduced anthropogenic heat emission. Future energy savings as a combined result of several measures could bring air temperature decrease by 0.8°C in the central Tokyo in the evening, as well as the impact over a very wide area where only slight reduction of anthropogenic heat emission is possible.

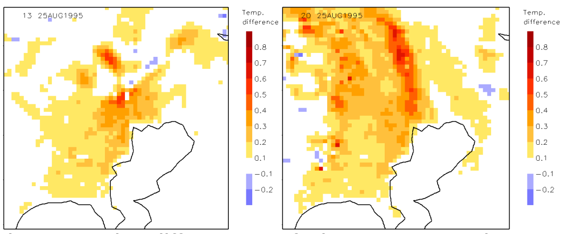

Figure 2. The differences of air temperature between the base-case and case 1: 1300LST and 2000LST.

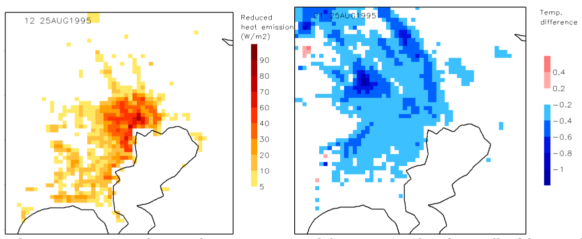

Figure 3. Reduced amount of heat emission (left) and resulting air temperature decreases at 2100LST(right).

5. REFERENCES

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