# Predicting the Effect of Measures to Mitigate Urban Heat Island in 23 Wards of Tokyo

## Background

The urban heat island phenomenon is one of the reasons for the increase in the number of people transported to hospital for heatstroke and energy demands by air conditioning in summer. The national government formulated a framework of measures to mitigate the heat island in March 2004. This triggered many local governments to take actual steps. Tokyo metropolitan is one of the most active governments for mitigating the heat island by promoting various measures such as greening of rooftops, water-retentive pavement, and so on. In case of introducing these measures, it is desired to presume the effect of measures in order to introduce them more effectively.

## Objectives

To presume the effect of various measures taken against the heat island phenomenon expected to be introduced in the future in 23 wards of Tokyo by three dimensional numerical simulation;

## Principal Results

### 1. Comparison of numerical results with high-density field observation data

A three dimensional numerical model developed by CRIEPI (CHARM) is applied to a typical summer day. The numerical results are compared with the field observation data with METROS (Metropolitan Environmental Temperature and Rainfall Observation System). The effectiveness of METROS is to have high-density continuous observation points unprecedented anywhere in the world. The METROS data with such high resolution can grasp the horizontal distribution of temperature over Tokyo in detail. As a result, we confirmed that the numerical results are in good agreement with the observation of horizontal distribution of air temperature, wind velocity, and wind direction near the surface (Fig.1).

### 2. Prediction for the effect of measures to mitigate heat island

Five mitigation measures (promotion of greening, introduction of water-retentive pavement, introduction of high reflective paint, reduction of anthropogenic heat from automobiles, and reduction of anthropogenic heat from buildings) are supposed to be introduced in 23 wards of Tokyo. These measures are assumed as their expected value after 30 years (Table 1). Numerical simulations with the same meteorological condition as mentioned above are carried out, but with the future condition after introducing these measures. The principal results of decrease in temperature at 2pm are as follows:

(1) If all five of the measures mentioned above were implemented, the average fall in temperature in central Tokyo, where the level of implementation is high (an area of 16km$^2$ including Ohtemachi and Kasumigaseki), would be 0.8K, or double the average fall for the 23 wards of Tokyo. Furthermore, the heat island in the center of the city is pushed by the sea breeze from Tokyo Bay, and the area downwind from the city center susceptible to increased heat is also affected by the measures to lower temperature that are implemented in the city center (Fig.2).

(2) Of the five measures mentioned above, promotion of greening has the greatest effect on lowering temperature and it was found that this accounted for an average temperature fall of 0.2K for the 23 wards of Tokyo, or approximately half the amount when all measures are implemented (Fig.2).

This work is done as a collaborated research with “Tokyo Metropolitan Research Institute for Environmental Protection” and “Tokyo Metropolitan University”.

## Future Developments

We plan to extend the coverage of our research from only days with low wind speeds to days with strong wind in order to investigate the effect of measures under various wind conditions.

***Main Researcher:*** Hidetoshi Tamura,
Research Engineer, Fluid Dynamics Sector, Civil Engineering Research Laboratory

***Reference***

H. Tamura, et al., 2006, “Numerical prediction of heat island mitigation effect on decrease in air temperature in Tokyo”, 6th symposium on the Urban Environment, The 86th AMS Annual Meeting

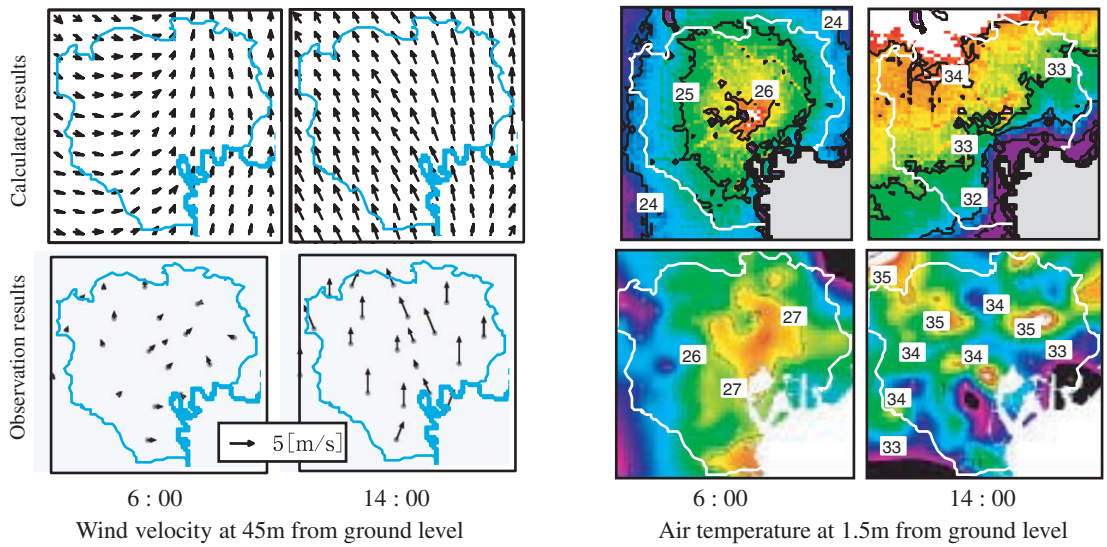


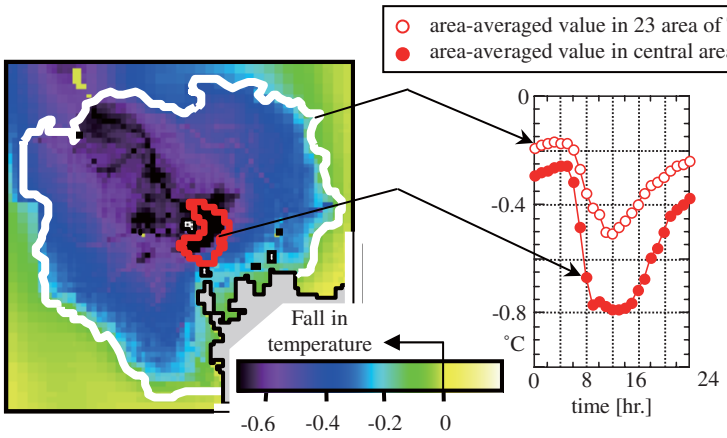

**Fig.1** Comparison of numerical results with field observation data (METROS) on a typical summer day

The METROS data with very high resolution can grasp the horizontal distribution of temperature over Tokyo in detail. As a result, we confirmed that the numerical results are in good agreement with the observation of horizontal distribution of air temperature, wind velocity, and wind direction near the surface.

**Table 1** Mitigation measures supposed in this study and their expected value after 30 years

Mitigation measures are assumed as their expected value after 30 years by considering planning of Tokyo and development of technology. But the increase in population and economic growth are not taken into consideration.

| Technological measure | Approach to implementation | Level of implementation after 30 years |
|---|---|---|
| 1) Promotion of greening | The level of greening of rooftops with an area of at least 10 ha and the ground in urban areas increase by 6%. | Rooftops: 2,463.0 ha (15% of all rooftops)<br>Ground: 1,565.2 ha (5.0% of urban land) |
| 2) Introduction of water-retentive pavement | Half of the amount introduced in Japan (approx. 10 ha) is introduced in the 16km$^2$ of central Tokyo every year | 140.0 ha (31.2% of roads in the central metropolitan area) |
| 3) Introduction of highly reflective paint | The level of implementation within the 23 wards of Tokyo is 20% of all rooftop. | 3,284.1 ha (20% of all rooftops) |
| 4) Reduction of anthropogenic heat from automobiles | In addition to considering future improvements in fuel consumption, travel speeds would improve after 15 years and hybrid cars is more popular | Sensible heat reduction of 41.5%<br>Latent heat reduction of 41.3% |
| 5) Reduction of anthropogenic heat from buildings | An improvement in the energy saving performance of both residential and commercial buildings, with efficiency improving due to the spread of Top Runner devices | Sensible heat reduction of 20.4%<br>Latent heat reduction of 25.6% |




| Technological measure | 23 Wards of Tokyo | Central area of Tokyo |
|---|---|---|
| Promotion of greening | -0.20˚C | -0.24˚C |
| Introduction of water-retentive pavement | -0.01˚C | -0.15˚C |
| Introduction of highly reflective paint | -0.09˚C | -0.09˚C |
| Reduction of anthropogenic heat from automobiles | -0.08˚C | -0.15˚C |
| Reduction of anthropogenic heat from buildings | -0.06˚C | -0.14˚C |
| All measures | -0.46˚C | -0.78˚C |

**Fig.2** Numerically predicted results of the change in air temperature by introducing

If all five of the measures mentioned above were implemented, the average fall in temperature in central Tokyo would be 0.8K (left and middle figures). Of the five measures mentioned above, promotion of greening has the greatest effect on lowering temperature (right table).