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NEWSLETTER
ON URBAN HEAT ISLAND COUNTERMEASURES

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Observational Studies of the Urban Heat Island - Cooling Effect of Urban Park -

AIJ SUBCOMMITTEE ON HEAT ISLAND
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Introduction

The mitigation effect of green space in urban area has been expected to be comparable to that of water surfaces. In Japan, its cooling effect in hot and humid summer is especially important and it is considered as an important method available for city planning. In this paper, results are shown from micro-climatological observations performed in and around a large park, "Shinjyuku Gyoen", during summer. Its area is 58.3ha, and it is located in one of the main CBD, which includes Tokyo Metropolitan Government Office. It consists of dense forest area, lawn area, and gardens with ponds. Topography is mostly flat except areas around ponds that are few meters lower. No irrigation system is used, so natural rain is the only water supply.

Measurement method

Air temperature was measured at 1-minute intervals at totally 88 points along three cross sections of the park (Figure 1). In order to catch the phenomena of cool air seeping-out in calm conditions, four 3-dimensional ultrasonic anemometer-thermometers were set along the boundary as well as at the center lawn area. Measuring height was 1.5m above the ground and sampling frequency 10Hz.

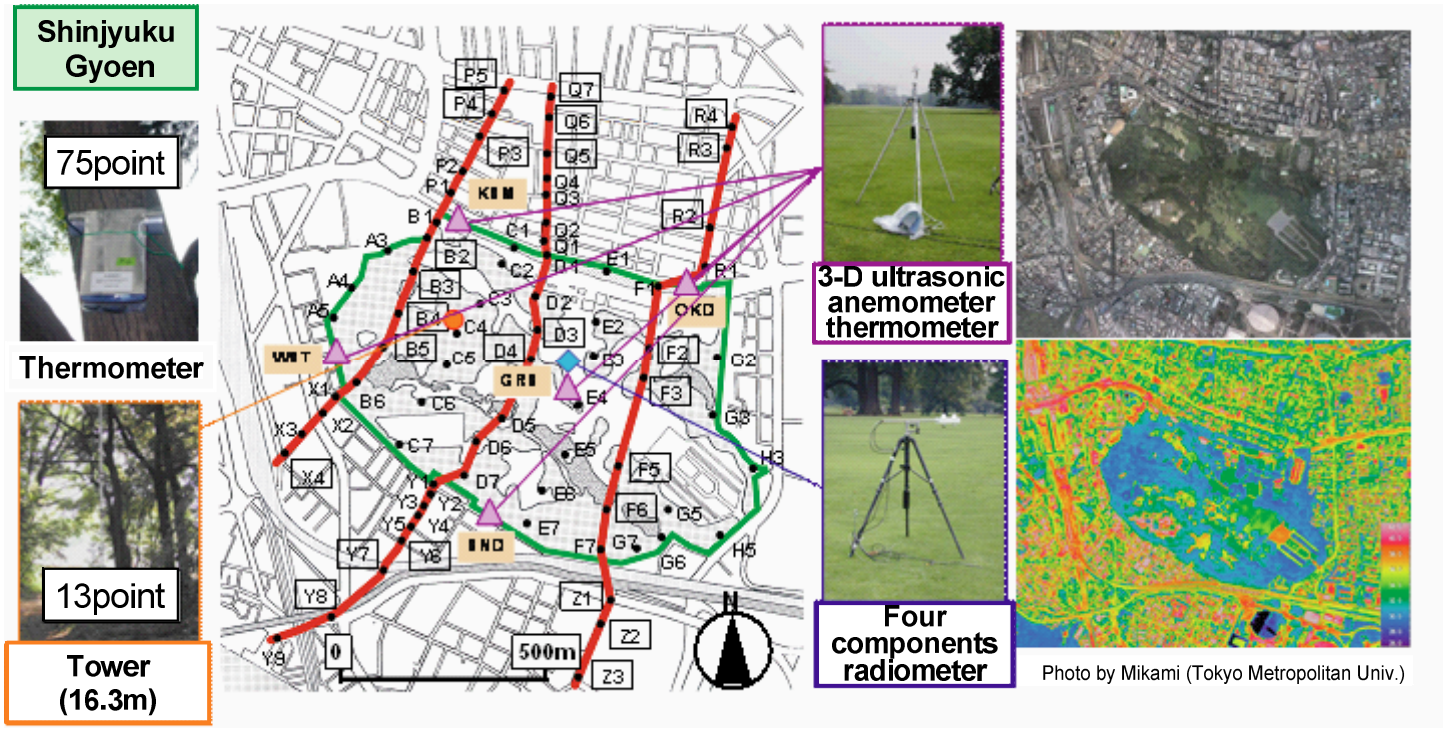

Figure 1 Map of observation site.

Cool-island intensity

In order to define the cool-island intensity, averaged temperatures of the urban area and the green area (lawn and forest) were calculated using the data at the measuring points which are marked by square frames in Figure 1. These points were chosen to be representative of each respective area. This meant omitting points near the boundary, which may be influenced by advection or cold air seeping phenomena. The green areas were always cooler than the surrounding residential and commercial areas. There was a temperature difference between forest area and lawn area. The cool-island intensity was larger in the forest during daytime, but larger in the lawn surface during nighttime (Figure 2). In daytime during windy conditions, cold air masses from the green space chilled the leeward built-up area to an extent of about 250m from the boundary. On the contrary, warm air advection from windward built-up area into the green space also existed (Figure 3).

Seeping-out phenomena in a calm night

In a clear calm night, flow-out wind directions from green spaces to surrounding areas were discerned at all measuring points along the boundary (Figure 4). In this case, obvious shift of wind direction appeared at 21:00 - 22:00 with a sharp temperature fall of 1 degree. After that, the decline of air temperature was not constant, periodical oscillation could be seen at some points. These imply an accumulation of a cold air mass in the park and its gravitational flow-out into the surrounding area. During this condition, a significant air temperature drop in adjacent built-up area was observed within the range of 80-90m from the boundary (Figure 5). This limit was more or less fixed all through the night, regardless of the cool-island intensity.

The air temperature above the lawn surface was lower than what was recorded under the tree crowns during the night. This temperature difference was diminished by intermittent wind and cloud cover (Figure 6). It implies that the open lawn surface was effectively cooled by radiative cooling. Moreover the cold air deposition sometimes stopped and forced convection led to a break up of the surface inversion layer.

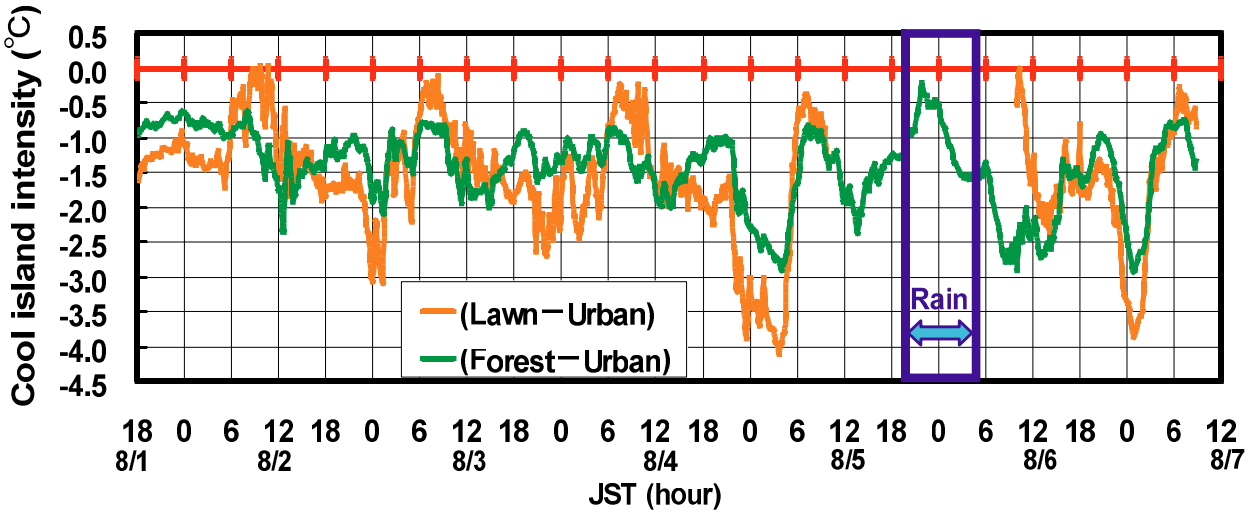

Figure 2 Time variation of cool-island intensity.

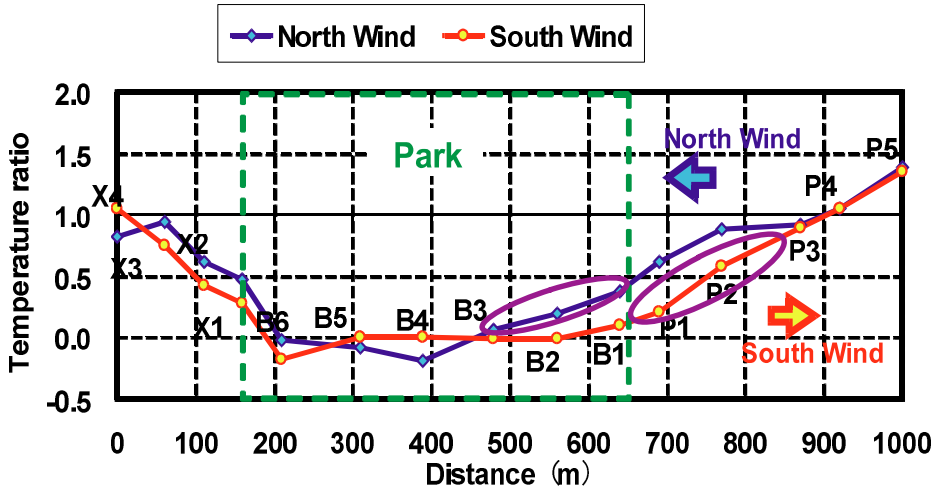

Figure 3 Comparison of temperature distributions along measure line under north wind and south wind.

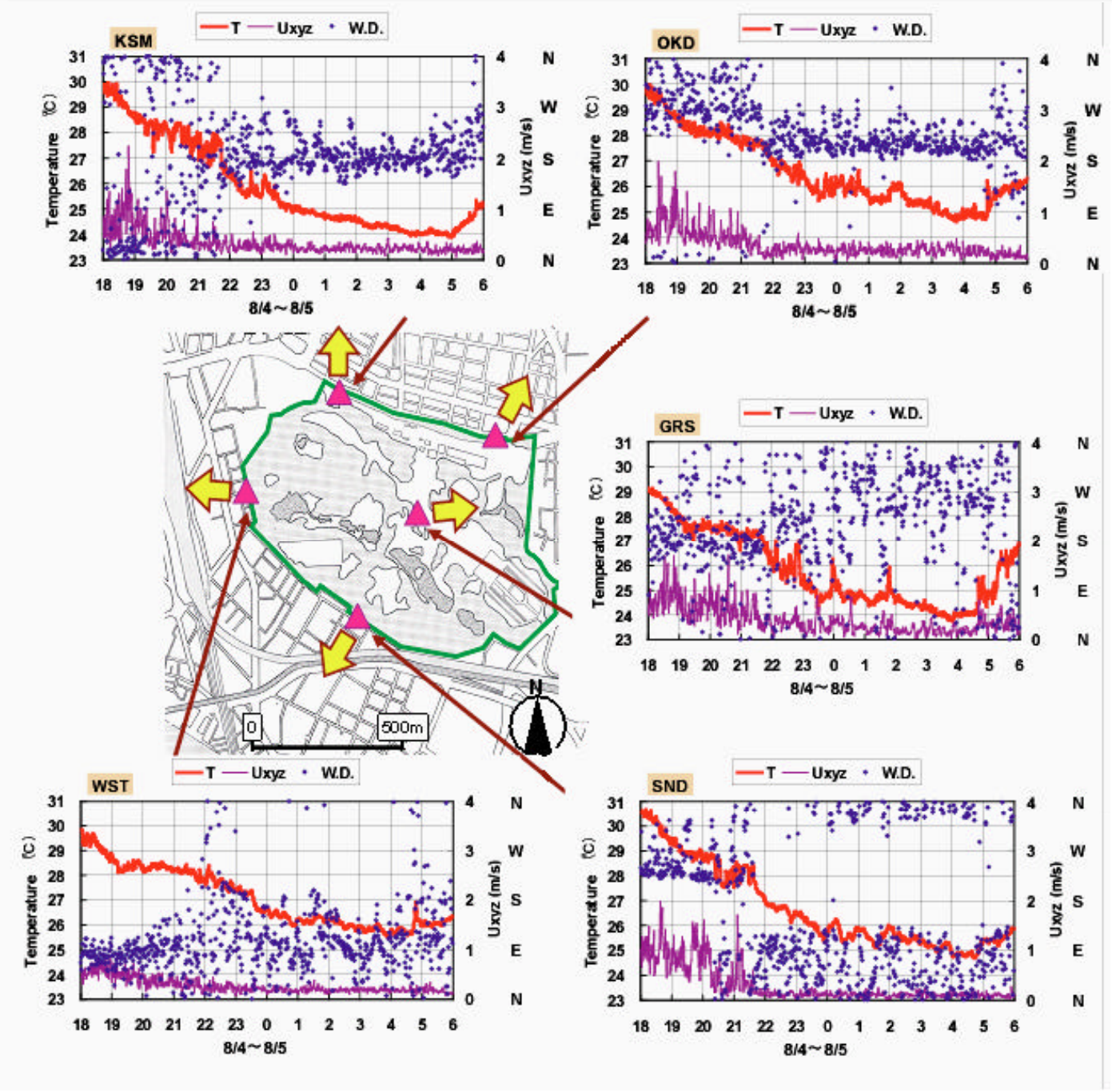

Figure 4 Seeping-out phenomena of cool air in a calm night
~1-minute average time variations of temperature, wind speed and direction at boundary points~
wind direction of all point change to outgoing direction from the park at 21:00 - 22:00.

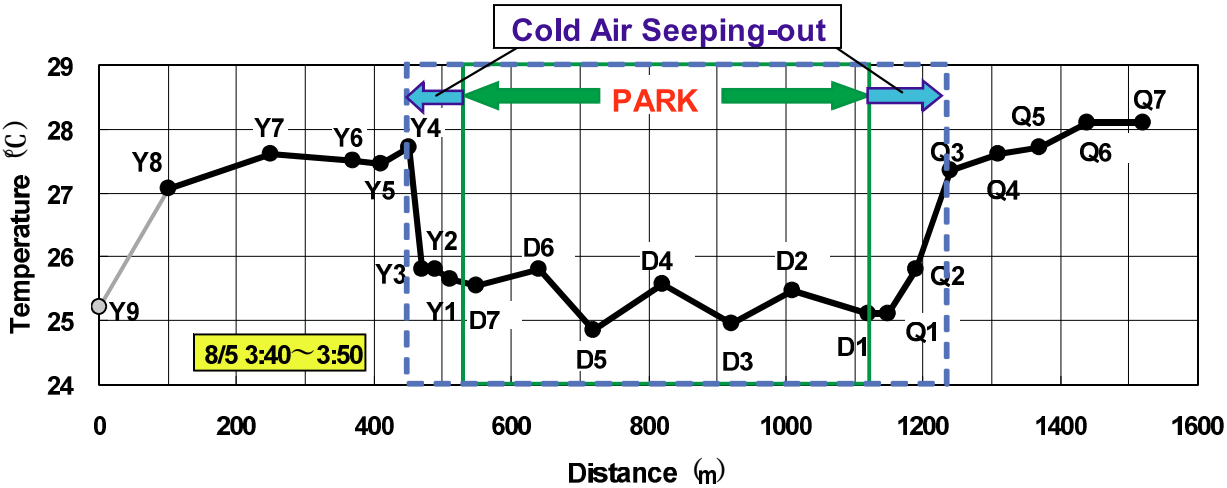

Figure 5 Temperature distribution along a cross section line when the seeping-out phenomena occurred.

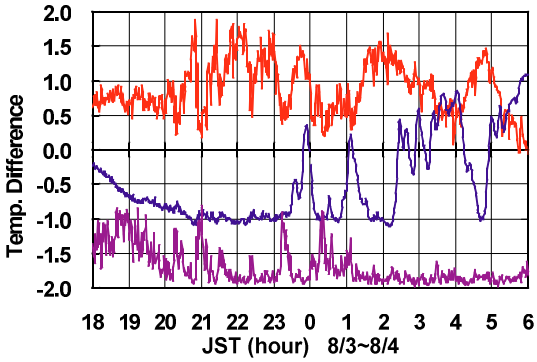

Figure 6 Air temperature difference between "under the tree crowns" and "above lawn surface", and its relationship with wind speed and downward longwave radiation.

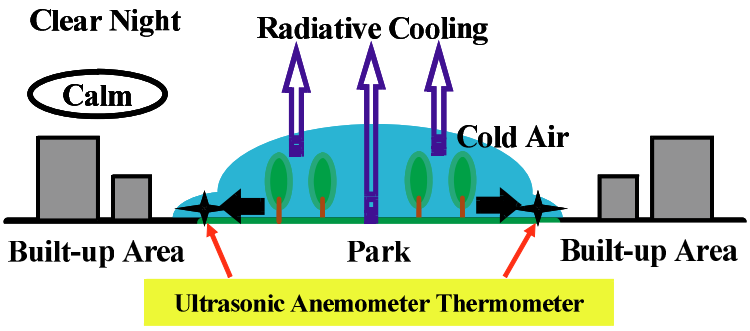

Figure 7 Schematic image of the seeping-out phenomena.

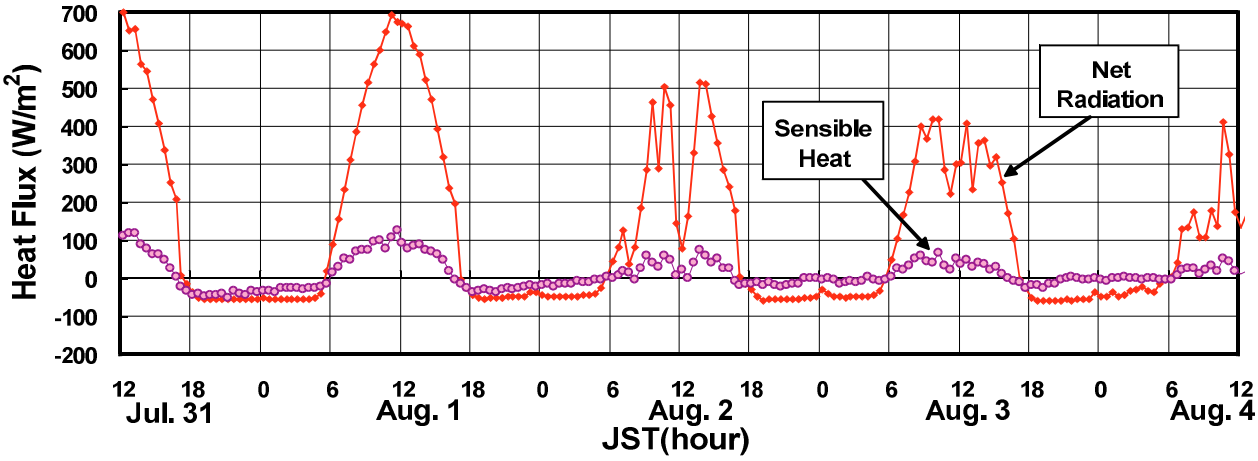

Figure 8 Time variation of heat flux at lawn surface. (sensible heat flux: eddy correlation method)

Heat budget at the lawn surface

According to the eddy correlation measurements, the sensible heat flux at the lawn surface was about 100W/m2 in mid-day, which amounts to 15% of the net radiation. It changed to negative immediately after sunset, after which the lawn surface acted as a heat sink all through the night (Figure 8). During the seeping out of cold air, the cool-island intensity increases, but sensible heat flux (at the park lawn surface) was almost zero. The cooling ability of parks is not directly related to cool-island intensity.

(Ken-ichi Narita, Nippon Institute of Technology)

Information

"International Conference on Advances in Wind and Structures", the 4th Conference (AWAS'08) will be held on 29-31 May 2008 in Jeju, Korea in a close cooperation with the Wind and Structures, An International Journal.

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