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Heat budget at a river water surface and its thermal effects on surrounding built-up areas

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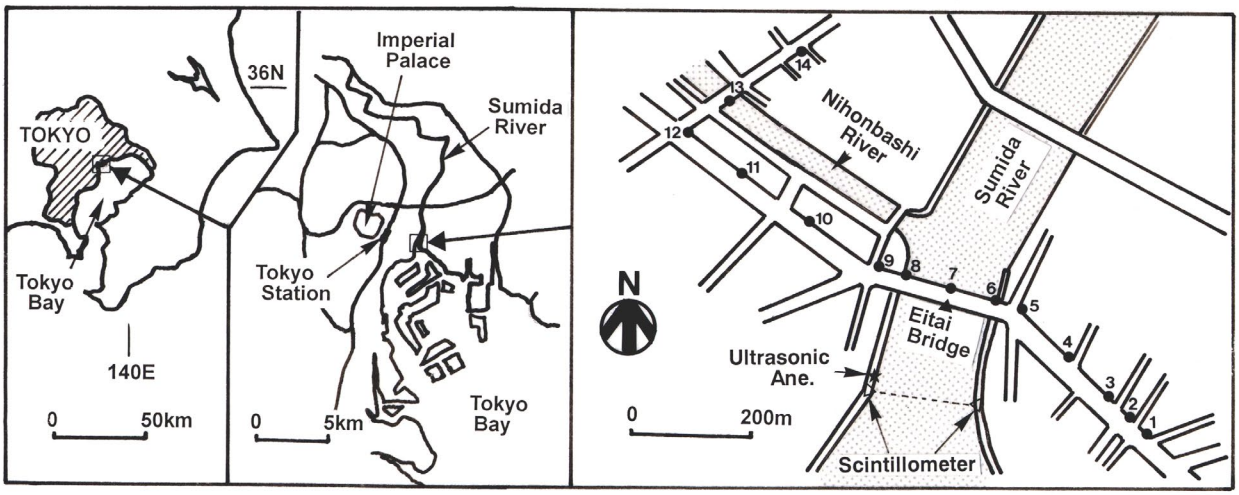
INTRODUCTION

Water bodies in urban area have been expected to mitigate the urban heat island as well as green space. In Japan, its cooling effect in hot and humid summer is especially important and it is considered as a natural resource to be available for city planning. In this paper, we show the results of observations about heat budget at river water and moving observations to clarify horizontal extent of its thermal effects. These measurement were conducted around Eitai-Bridge which is laid across the Sumida River flowing through CBD in Tokyo

MEASUREMENT METHOD

Air temperature and vapor pressure distributions were measured along the street crossing the river using some bicycles equipped with thermometer and hygrometer within ventilated shelter. Wind speed and direction were also recorded during 3 minutes at each point, and these were compared with simultaneous data in stationary point at the center of the bridge. In addition, special measuring cart mounted with three-dimensional ultrasonic anemometer-thermometer and infrared absorption hygrometer were used to confirm the limit of river-effect. The correlation coefficient between temperature or absolute humidity and the component of wind from the river were expected to decrease according to distance from the river.

As for the heat budget, downward and upward short wave radiation and downward long wave radiation were measured at riverside terrace, respectively. Sensible heat flux were estimated by eddy correlation method on the bridge and riverside terrace, by scintillation method across the river, and by bulk method using air and water temperature and bulk transfer coefficient included stability effect.



RESULTS AND CONCLUSIONS

During the observation period (Aug.19,6:00～Aug.20,18:00), wind direction was almost constant from S-SSW, parallel to the river. On the contrary, within the measuring street, wind direction was from SE, along the street. This street wind made cooler and more humid area only to the western part of the river. The horizontal limits of river-effect were about 300m from river-edge, and there was no clear relation between this limits and wind speed. Within this cooler area, the wind from the river tended to be accompanied with air temperature drop, which suggests that the correlation between these instantaneous variations is useful for identification of river effects.

As water temperature was always cooler than above air in this season, sensible heat flux acted to warm river water. Diurnal variations of sensible heat flux estimated by several methods corresponded closely with each other, though these values didn't exceed 100W/m^2 even in the peak about midday. Latent heat flux was calculated by supposing the analogy between convective heat and mass transfers, then conductive heat storage into water was estimated as a residual. Heat storage term occupied more than 90% of net radiation during daytime, which is completely different from that of green space characterized large latent heat flux. This dominant heat storage into water could not explain by conductive heat transfer of stagnant water. According to the numerical simulation, observed water temperature variation required equivalent heat conductivity for actual stirred water about thirty times as much as that of stagnant water.

Horizontal sensible heat flux from adjacent built-up area to the river space also estimated by eddy correlation method at riverside terrace. Turbulent heat flux across the river-edge amounted to 250 W/m^2 in daytime, it greatly surpassed vertical sensible heat flux at water surface.