Nocturnal Temperature Distribution under Fine and Weak Wind Conditions Based on Spatially High Density Observation Data in the Tokyo Metropolitan Area: Features in Summer

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Temperature distribution in urban areas varies in response to factors such as daily weather conditions and interactions with local wind systems such as land and sea breezes. In the present study, we first examined the variability in the nocturnal temperature difference (*TD*) between central Tokyo and the outside of Tokyo wards area in summer. We considered *TD* in terms of weather conditions (cloud amounts, wind speed, water vapor content and solar radiation during the previous daytime) using the hourly meteorological data from five summers (2006–2010). We next analyzed characteristic features of the nocturnal temperature distribution in and around the Tokyo wards area using datasets from spatially dense observation networks (208 observation stations) for three summers (2006–2008). During the analysis, we focused on relations between temporal changes in the nocturnal temperature distribution and those in wind systems. Finally, we compared the results of this study with those of winter nights.
The observation networks used for temperature distribution analyses were the Automated Meteorological Data Acquisition System (AMeDAS) of the Japan Meteorological Agency (JMA), air pollution monitoring system (APMS) of the Tokyo Metropolitan Government and adjacent prefectures, and Meteorological Environmental Temperature and Rainfall Observation System (Extended-METROS). The AMeDAS and APMS datasets were also used to obtain the wind data.
The results obtained in this study are summarized as follows:
(1) According to multiple regression analysis (stepwise method), wind speed and cloud amounts showed equally large effects on *TD* between central Tokyo (Otemachi, JMA) and the outside of Tokyo wards area (average temperature from four AMeDAS stations). This result was different from that of winter nights, indicating that cloud amounts have a larger effect than wind speed on *TD*.
(2) A steep horizontal temperature gradient zone (HTGZ) in the western part of Tokyo wards area was unclear even during nights with fine and low wind speeds in comparison with winter nights, where the steep HTGZ was clear under the same conditions. This may be related to the relatively lower decrease rate of temperature in summer, especially around sunset when the wintertime HTGZ begins to become conspicuous. It is considered that the difference in radiation cooling by season is one of the key factors. In addition, because high-temperature areas tended to remain in the northwestern part of Tokyo wards area in summer, central Tokyo did not become the highest-temperature area until after midnight, which was also different from the findings of winter nights.
(3) To identify effective factors for large differences in *TD* for fine and weak wind nights, the corresponding cases were divided into three categories in accordance with the observed values of *TD* at 04:00 JST just before sunrise. For cases of large *TD*, in which high-temperature areas were concentrated in central Tokyo, inland wind systems initiated relatively earlier and showed a relatively larger wind speed before midnight. Subsequently, the local wind front migrated to the coastal area of Tokyo Bay by early morning. For cases of low *TD*, inland winds were weak, and the local wind front could not be clearly observed. For cases of intermediate *TD*, a large amount of solar radiation and a relatively strong sea breeze system were observed during the preceding daytime. Clear high-temperature areas remained from the northern part of Tokyo wards area to southern Saitama prefecture throughout the night, and the local wind front stagnated in this area. We conclude that the nocturnal *TD* in and around the Tokyo wards area in summer is affected by

inland wind systems and the location of the local wind front.

Keywords: urban heat island, nocturnal temperature distribution, spatially high density observation, Tokyo wards area, summer

