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東京都区部における夏季晴天日の地表面熱放射量とその低減施策
Geographical distribution of outgoing thermal radiation intensity in downtown Tokyo on hot days and mitigation measures

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Annual mean air temperatures in downtown Tokyo have increased about 3 degrees Celsius in the past 100 years due to global warming and urban heat island (UHI) (Japan Meteorological Agency, 2014). Also, the frequency of heat stroke outbreaks tends to increase. These promote implementation of measures for summer heat in Tokyo. We have investigated the impacts of UHI mitigation and adaptation strategies such as making highly reflective pavements, creating green and water spaces, etc.

As part of the investigations, we analyzed data from thermal infrared (TIR) remote sensing in downtown Tokyo on four different extremely hot days: Aug. 7, 2007, Aug. 10, 2007, Aug. 19, 2013, and Aug. 19, 2014. The TIR measurements were carried out in the daytime (12-13 local time: LT) and the nighttime (around 21 LT) (except for Aug. 10, 2007) under similar weather conditions, using a long-wave infrared (8-14 um wavelength) camera (NEC Avio; TS7302) installed on a helicopter. The helicopter was flying at Flight Level 20 (2,000 ft, i.e., 610 m). The lower flight level allows horizontal spatial resolution of data from the thermal imaging camera to be significantly high (approximately 2 m) in spite of airborne TIR measurements. Although sea breezes prevailed over downtown Tokyo, daily maximum air temperatures on those days reached around 34 degrees Celsius.

Areas for the airborne measurements on Aug. 19, 2013 and Aug. 7, 2007 include ”Ochanomizu”, ”Marunouchi”, ”Otemachi”, and ”Ginza”. To verify impacts of recent UHI mitigation and adaptation strategies in those cities, we analyzed changes in the surface infrared radiation intensities (outgoing longwave thermal radiation intensities) between 2007 and 2013. Surface infrared radiation intensity is one of the important factors that strongly affect sensible temperatures. Compared with other factors affecting sensible temperatures, surface infrared radiation can be easily controlled by UHI mitigation and adaptation strategies for lowering surface temperatures without the negative influences on other places, i.e., no trade-off relationship between changes in the radiation intensities (surface temperatures) at a specific place and another place.

The results show that daytime surface infrared radiation intensities in 2013 are relatively high in the greater part of the area, compared with the ones in 2007, owing to extremely hot weather conditions in 2013, nevertheless, lower intensities of surface infrared radiation can be recognized in some redevelopment areas where several new buildings were constructed between 2007 and 2013. This appears to be due to green and water spaces created in the redevelopment areas through the UHI mitigation and adaptation strategies. Incidentally, surface infrared radiation intensity changes between 2007 and 2014 in the ”Shinjuku” city and the neighboring areas will also be analyzed.

By using the TIR remote sensing data, we picked out hot spots where mitigation and adaptation strategies for lowering surface temperatures should be required. For instance, the daytime TIR images superimposed on GIS (geographic information system) applications showed higher infrared radiation intensities (higher temperatures) on surfaces of intersections and the northern parts of streets running from east to west. To clarify the causes of those hot spots, we investigate relationships among surface infrared radiation intensities (surface temperatures), sky view factors, etc. Also, we analyze thermal environment around venues of the 2020 Summer Olympic and Paralympic Games.

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Keywords: urban heat island, downtown Tokyo, surface infrared radiation intensity, mitigation and adaptation strategies, airborne remote sensing, GIS applications