Impacts of urban heat-island circulation on distributions of air pollutants over Tokyo

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Impacts of urban heat-island (UHI) on distributions of air pollutants such as ozone, nitrogen oxides (NOx) and volatile organic compounds over the Tokyo metropolitan area, Japan and its suburbs are investigated by using regional chemistry transport model (CTM) simulations and surface observations. In order to elucidate the UHI impacts, a control simulation and two sensitivity simulations were performed for the period of July to August 2010, using a regional CTM developed at Meteorological Research Institute (MRI), Japan Meteorological Agency (JMA), called NHM-Chem. NHM-Chem is a high-resolution CTM coupled online with a JMA non-hydrostatic model (NHM), which covers the Tokyo area and its suburbs with the horizontal resolution of 2 km.

The control simulation was firstly performed without considering anthropogenic heat (AH) release and without implementing an urban canopy model developed for NHM, called SPUC. Secondly, the two sensitivity simulations were conducted with/without the AH release and with implementing SPUC. Results of the three simulations were evaluated against the hourly surface observations obtained from Atmospheric Environmental Regional Observation System of the Ministry of the Environment of Japan. The surface concentrations of ozone and NOx are improved almost over the Tokyo area, especially at night, when SPUC is implemented. Compared to the control simulation, the surface NO concentrations are decreased at night, especially at dawn, by ～40 % over the Tokyo area and by 5～20 % over the suburbs. This is due to enhanced vertical turbulent diffusion in the atmospheric boundary layer and induced UHI circulation in the two sensitivity simulations. During the daytime there are also small but significant differences of the ozone and NOx surface concentrations between the control run and the two sensitivity simulations. In comparison between the two sensitivity simulations, impacts of the implementation of SPUC on distributions of pollutants are much larger than those of the AH release.