Comparison of Impacts between Global Climate Change and Urbanization on Future Urban Climate in Tokyo Metropolitan Area

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Abstract

Several previous papers discussed the effect of land-use change on the warming trend of surface temperature, which is observed in many parts of the world. Particularly in Japan, there are many populous regions where the artificial alteration of land use seems to strongly affect local-scale climate *(1)*. Heat stress for citizen in urban area is predicted to greatly increase in the future because of both effects of the urban heat island and the global warming. This study focuses on the Tokyo metropolitan area (TMA) in Japan (Fig. 1), which is the largest urban agglomerate in the world with a population of 35.6 million. Purpose of this study is to quantitatively estimate the thermal impacts of land-use change and global climate change on the future surface temperature in TMA.

The TERC-RAMS, a modified version of the Regional Atmospheric Modeling System (RAMS) *(2)*, was used for downscaling. A parameterization expressing urban surface was given by a single layer urban canopy model presented by Kusaka et al. (2001) *(3)*. We used the Pseudo Global Warming (PGW) method for the future climate simulation instead of the dynamical downscale method *(4)*. The PGW method had been applied to several downscale researches for projection of future climate. However, it has not been used for the urban climate projection. Firstly, this study applied the PGW method for past climate change to validate the method. And then, the future climate experiment was conducted.

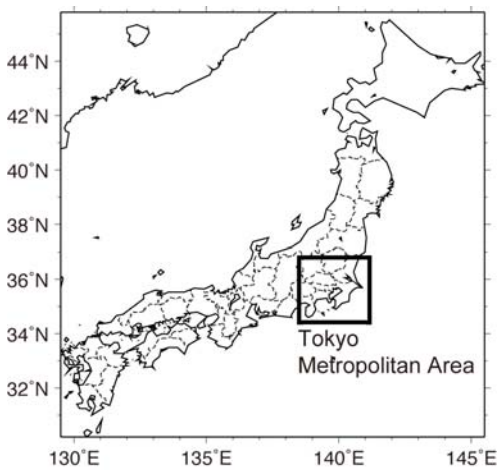

Figure 1. Analysis area.

The experimental design is shown in Tables 1 and 2. In past climate change experiment, the simulation period is divided into two seven-years periods, which are centered on 1987 and 1997 when land-use data are available. These periods are defined as Period I and Period II. The comparison between PCTL87 and PLAND allows the estimation of the effect of land-use change to temperature change during two periods. The effect of global warming on local climate was estimated using a Pseudo Climate Change (PCC) method, which is same as PGW method, but it is applied for past climate. The boundary condition of the method is given by the pseudo climate data, which were obtained by 6-hourly reanalysis data adding the climate difference between Period I and Period II. In the future climate change experiment, eight numerical simulations were carried out as listed in Table 2. The urban area in 2070s is distributed throughout Kanto plain. The BCCR, CSIRO, GFDL, INGV and MRI are

Figure 2. Map of prefecture in Tokyo Metropolitan Area.

PGW simulation that estimate the regional climate in 2070s based on the coarse grid projections given by each GCM assuming SRES A1B emission scenario. The climate difference used for preparing boundary data was provided by the monthly mean difference between the future and present climates estimated by GCMs. The boundary data of MULTI uses the multi model ensemble mean of climate difference calculated by 5 GCM.

Table 1. Descriptions of numerical experiments for past climate.

Run		Boundary data	Landuse
PCTL87	Hindcast for Period I (84-90)	JRA25 Period I	1987
PCTL97	Hindcast for Period II (94-00)	JRA25 Period II	1997
PLAND	Sensitivity experiment (SE) of land-use	JRA25 Period I	1997
PCC	SE of climate change	PCC data Period I + Climate difference	1987

Table 2. Descriptions of numerical experiments for future climate.

Run		Boundary data	Landuse
FCTL06	Hindcast for Period III (06-08)	JRA25 Period III	1997
FLAND	SE of land-use	JRA25 Period III	2070s
MULTI	SE of global climate change	PGW data of MME (Period III + Climate difference)	1997
BCCR		PGW data of BCCR-BCM2.0	1997
CSIRO		PGW data of CSIRO-Mk3.0	1997
GFDL		PGW data of GFDL-CM2.1	1997
INGV		PGW data of INGV-SXG	1997
MRI		PGW data of MRI-CGCM2.3	1997

The results from past climate change experiment shows that the temperature warming between Period I and Period II is about 0.5 ºC averaged in TMA. The PCC run indicated the PCC method enable to reproduce past climate change as well as the direct downscale method. The rate of contribution of land-use change to total temperature change was about 0.15-0.5.

In the future climate, the effect of land-use change on surface temperature change was about 0.4 ºC, while the warming due to global climate change reached 2 ºC in MULTI run. However, PGW simulations with one GCM projection indicated that the range of the warming depends on the selection of GCM and varies from 1.2 to 3.5 and.

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