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Urban Climate Projection in Tokyo for the 2050's August: Impact of Urban Planning Scenarios and RCMs

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1. Introduction

Greater Tokyo is the world's largest metropolitan area, with a population of about 32.5 million. Due to Urban Heat Island (UHI) and Global Warming (GW), heat stroke mortality rate has been increasing in Tokyo, and has exceeded the fertilities from other weather disasters in Tokyo. With continuing UHI and GW, how worse will the urban environment be in the future?

For urban climate projections, Kusaka et al. (2012a) conducted downscaling from three GCMs. However, there are other sources of uncertainties for urban climate projection. In particular, urban planning scenarios and selection of regional models (in which local processes are treated differently) may have significant impacts. This study presents urban climate projection for the 2050's Augusts in Tokyo. Projection is conducted using dynamical downscaling from a single GCM (MIROC5) under the RCP4.5 scenario, by two RCMs (namely WRF and NHRCM). Furthermore, three different urban scenarios are considered, (i) status-quo city, (ii) compact city, and (iii) spread city, created by Yamagata et al. (2011).

2. Experimental Design

The WRF includes a single-layer urban canopy model (UCM) developed by Kusaka et al. (2001), Kusaka and Kimura (2004a, b). The NHRCM is a regional climate model version of the Non-hydrostatic Model by the Japan Meteorological Agency. This model includes another single-layer UCM developed by Aoyagi et al. (2012). Both UCMs consider the urban geometry, green fraction, and anthropogenic heat emission with diurnal variation at the urban grid. Model performances of WRF and NHRCM, each coupled with their UCM, have been validated for current climate urban climatology (Kusaka et al. 2012b and Aoyagi et al. 2012).

The model uses the nested domains. The larger domain with 20km horizontal grid spacing covers entire Japan islands and the smaller domain with the 4km horizontal grid spacing covers central Japan including Tokyo.

3. Results

We compare Impacts of RCM and urban scenario differences on August mean temperature increase in Tokyo and its rural town Tsukuba. The impact of RCM difference is 0.25 K and 0.37 K for Tokyo and Tsukuba, respectively. On the other hand, the impact of urban scenario difference is 0.16 K and 0.31 K for Tokyo and Tsukuba, respectively. These results indicate that impacts of RCM and urban scenario differences are comparable.

Acknowledgment

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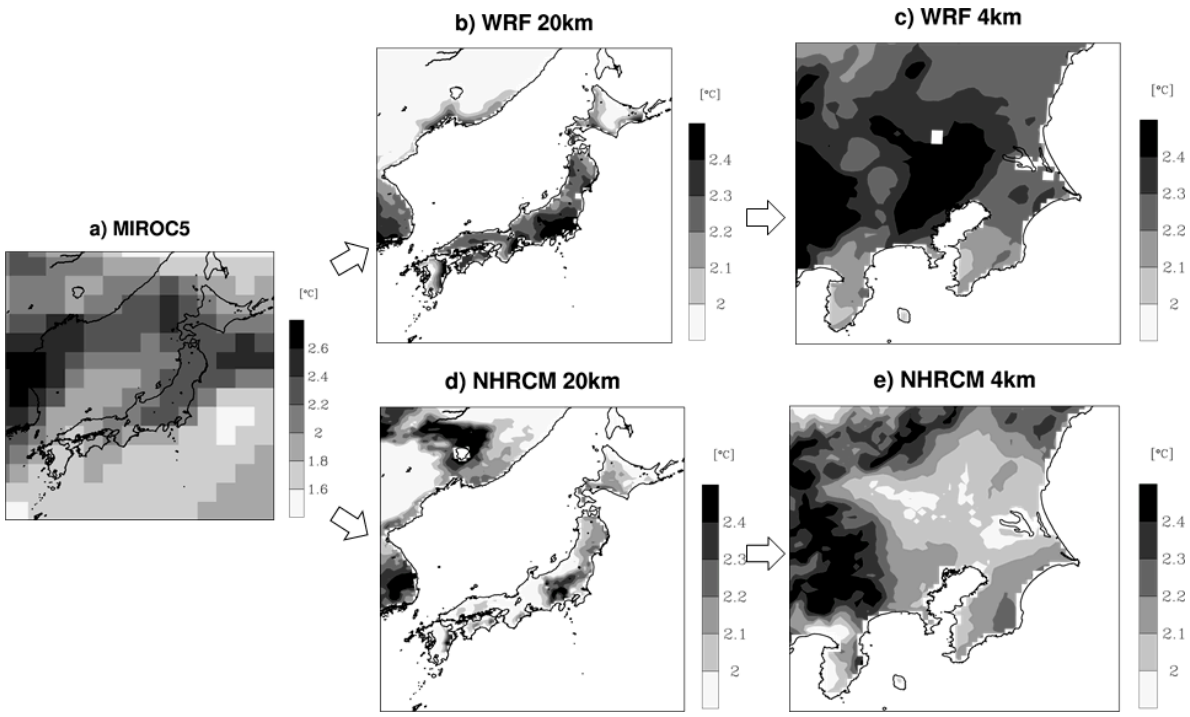

Figure 1. Projected increase of August mean surface air temperature by (a) MIROC5, (b) WRF with 20km resolution, (c) WRF with 4km resolution, (d) NHRCM with 20km resolution, and (e) NHRCM with 4km resolution.

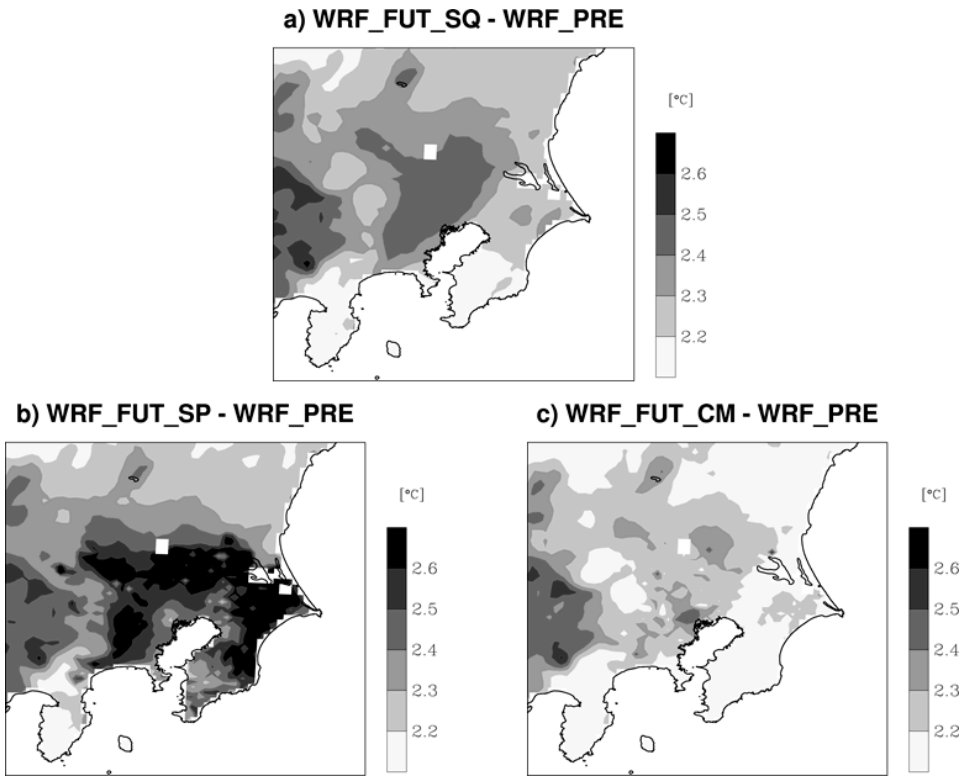

Figure 2. Projected increase of August mean surface air temperature by WRF (a) with status-quo urban scenario, (b) with spread city urban scenario, and (c) with compact city scenario.