URBAN HEAT ISLAND SIMULATION OVER JAKARTA, INDONESIA, USING A CLOUD RESOLVING MODEL

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1. INTRODUCTION

Asian countries are experiencing rapid urbanization. In Indonesia particularly, the ratio of the population in urban areas in the year 2000 grew by 3.59 times compared with that in 1980. Population concentration in urban areas is associated with extensions in artificial land cover and increases in energy consumption, which can lead to various problems such as urban heat island effects.

Higher air temperatures over urban areas (so-called urban heat islands) degrade residential environments and increase the risk of heat-related illnesses. Furthermore, some studies have shown that urban activities can enhance heavy rainfall. Therefore, weather forecasts that can account for urban activity effects are highly desirable.

In this study, we estimate urban activity information (artificial land cover and anthropogenic heat) in Jakarta and introduce the acquired data into a cloud-resolving meteorological model that can be used for short-term weather forecasts. As a first step, we simulated a heat island observed over Jakarta using the developed method and validated the results by comparing them with the observed data.

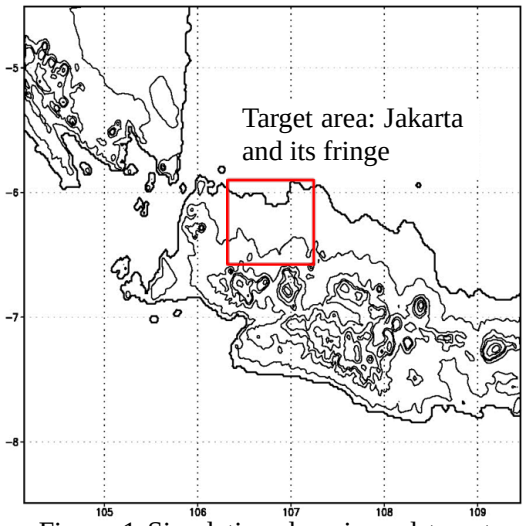

Figure 1 Simulation domain and target area analyzed in this study.

2. METHODOLOGY

To estimate detailed land cover information around Jakarta, we combined data from the Global Land Cover Characterization (GLCC) database and Landsat satellite data from 2006 [1].

To estimate the anthropogenic heat, we analyzed the relationship between population density and daily averaged anthropogenic heat over the Kanto area in Japan. The Gridded Population of the World (GPW) v3 database was used for the population data, and the daily averaged anthropogenic heat distribution in August was calculated from the dataset by Senoo et al. [2]. Then, the distribution of anthropogenic heat around Jakarta was estimated using the regression obtained in Japan and the population density data for around Jakarta.

By considering the estimated urban activity information (land cover and anthropogenic heat), heat island simulations using the cloud-resolving weather model CReSiBUC [3] were carried out.

In this study, we carried out simulations within the domain shown in Figure 1 with a horizontal resolution of 2 km. On the 16th of September in 2012, which was a typical sunny day during the dry season, detailed observation data were collected by the University of Yamanashi; hence, this date was chosen as the target for simulations. The Japan Meteorological Agency Climate Data Assimilation System (JCDAS) reanalysis data (with a horizontal resolution of 1.25 degrees) were used for the initial and boundary conditions of the atmosphere. The Group for High-Resolution Sea Surface Temperature (GHRSST) data were used for sea surface temperatures.

Figure 2 Observation sites by the University of Yamanashi in 2012 (Google Maps was used for this figure).

The first simulation ignored anthropogenic heat and only consider the land cover information obtained from the GLCC database (hereafter this is called the “GLCC” simulation). The second simulation also ignored the anthropogenic heat but considered the land cover information using both the GLCC and Landsat datasets (hereafter this is called the “COMB” simulation). The third simulation considered both anthropogenic heat and land cover information derived from the GLCC and Landsat datasets (hereafter this is called the “AHFP” simulation). The land cover and anthropogenic heat data used in the simulations are shown in Figure 3.

Keywords: Cloud resolving model, Urban activity information, Heat island, Jakarta
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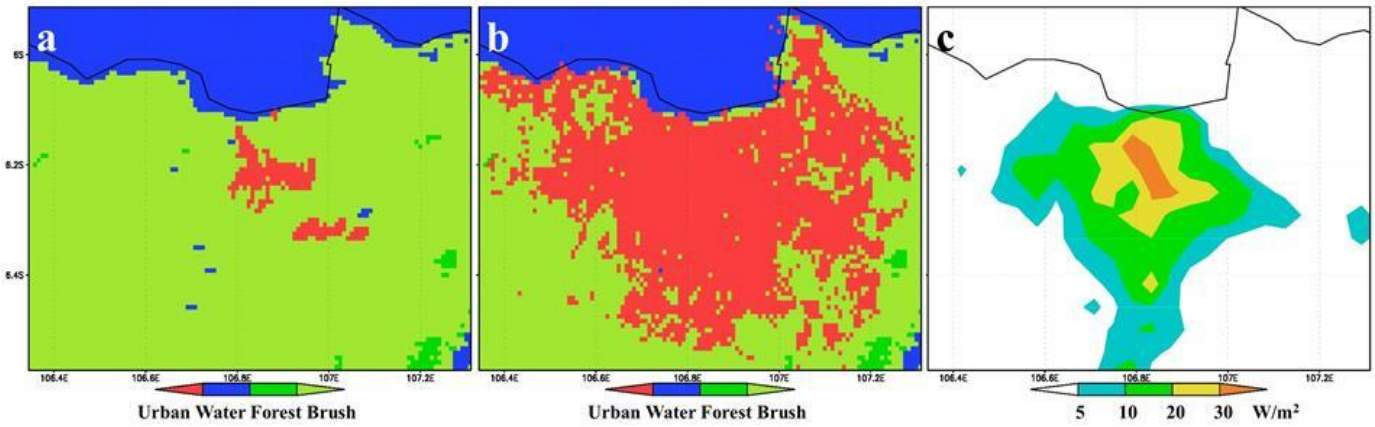

Figure 3 (a) Land cover considered in the "GLCC" simulation. (b) Land cover considered in the "COMB" and the "AHFP" simulations. (c) Anthropogenic heat distribution considered in the "AHFP" simulation.

3. RESULTS AND DISCUSSION

The simulated results were compared with the temperature data observed by the University of Yamanashi for Jakarta in 2012 (at the sites shown in Figure 2) [4]. The results for the comparison in the urban center (Kramat Jati) are shown in Figure 4. From these data, it was found that the "GLCC" simulation underestimated the temperature in the urban center of Jakarta. Although the temperature was still underestimated, the simulated temperature became closer to the observed values both in the "COMB" and "AHFP" simulations. The accuracy of simulated temperature in the "AHFP" simulation was slightly better than that in the "COMB" simulation. Similar tendencies were also seen during comparisons over other observation sites (data not shown).

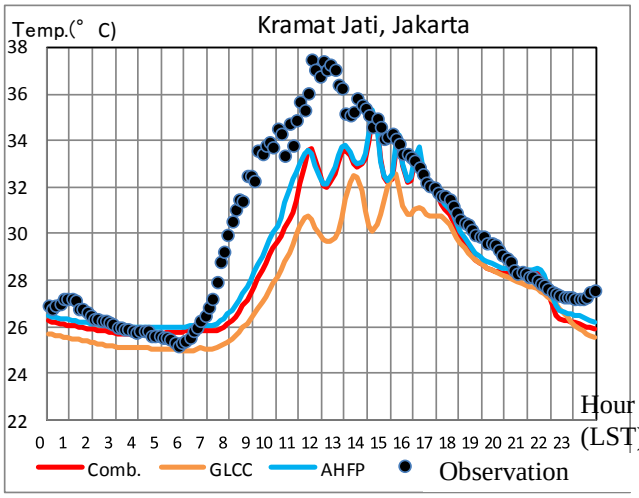

Figure 4 Time series of observed and simulated temperature at the Kramat Jati observation site.

From these results, it was concluded that GLCC data are not able to reproduce the heat island observed over Jakarta accurately. It was also found that use of detailed land cover data can be an effective way to improve the simulation accuracy of the heat island over Jakarta. While the inclusion of anthropogenic heat slightly improved the simulation accuracy, the effect was smaller compared with that of detailed land cover data. This indicates that the estimation method for anthropogenic heat used in this study have been too simple to express the detailed urban activities in Jakarta.

4. CONCLUSION

In this study, we estimated urban activity information in Jakarta and carried out heat island simulations by the use of a cloud-resolving meteorological model that incorporated the urban activity information. The results indicate that GLCC data are not able to reproduce the urban heat island over Jakarta accurately and that detailed land cover data will be required to improve the simulation accuracy of heat islands. Inclusion of the effect of anthropogenic heat slightly improved the simulation accuracy, but the effect was smaller compared with that of detailed land cover data.

In the future study, the estimation method of urban activity information should be improved. Furthermore, not only heat island in the dry season, but also the heavy rainfall cases in the rainy season should also be simulated using the method developed in this study.

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