Development of a detailed land surface state estimation method toward usage in weather prediction

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In Japan, localized heavy rainfalls have caused severe damages in recent years. It is indicated that the effects of the land surface states including urban activities on local heavy rainfall. Thus, the detailed land surface processes including urban activities are introduced into the numerical meteorological models used for weather prediction. Introduction of the detailed initial land surface state (land surface temperature, etc.) is required for such numerical meteorological models. Therefore, it will be effective to estimate the land surface state using detailed solar radiation and precipitation data, with advanced urban activity information.

In this study, we will develop a method which estimates realistic land surface states based on a detailed land surface model, introducing solar radiation data based on geostationary meteorological satellites, rainfall data provided by Japan Meteorological Agency (JMA), and detailed urban activity information data. We also estimate the land surface state for about one month in the Keihanshin region to validate the developed method.

In this study, in order to give the boundary conditions of the atmosphere, the initial values of the JMA meso objective analysis data (5km horizontal resolution) were used. For the distribution of precipitation, the Radar-Raingauge Analyzed Precipitation data provided by JMA (1km horizontal resolution) were used. For the distribution of solar radiation, the solar radiation consortium data (1km spatial resolution) were used. For land use including artificial land cover in each cell was calculated from the digital national land information (based on the 2009 survey; around 100m horizontal resolution) provided by GSI. As advanced urban activity data, the anthropogenic sensible heat distribution (Noyori et al., in press; 1km horizontal resolution), and the building height distribution based on the Zmap-AREA II 2010-2 version were also introduced. The introduction of the advanced urban activity data and the ability to support arbitrary grids can be indicated as the improvement compared with previous studies.

These data were introduced into a detailed land surface model called as Simple Biosphere model including Urban Canopy (SiBUC), which consists of the green area, water body, and urban area sub-models. The calculation of each sub-model is carried out based on the heat, radiative, and water budget equations.
In this study, the developed method was applied to the Keihanshin region for 31 days from 09:00 JST on the 1st August 2018 within a domain (480km x 480km; horizontal resolution about 2km), which is the same as that used in a weather prediction experiment by Takayama et al. (2016). In August 2018, an intensified observation of localized heavy rainfalls was conducted. For validation, the time series of roof surface temperature was extracted from within the cell closest to the Sumiyoshi Elementary School in Kobe City, where University of Yamanashi conducted field observations. In the validation, the maximum, minimum, and average roof surface temperatures for each day were extracted from estimated and observed values, to calculate mean error (ME), root mean squared error (RMSE), and correlation coefficient (CC). Regarding the CC, all (the daily maximum, minimum average roof temperature) showed high correlation exceeding 0.8. The ME and RMSE become higher in the order of daily maximum, average, minimum roof surface temperature. The reason for the higher ME and RMSE in the daily maximum roof

surface temperature is expected to be that the ground heat flux (the heat penetrates building) was overestimated. The SiBUC model considers the anthropogenic sensible heat by adding that to the net radiation when calculating the heat budget, that will be resulted in the overestimation of ground heat flux. It is also possible that the roof surface albedo (reflectance) value used in the estimation was lower than that on the roof of the observation site.

Keywords: Land surface state estimation, land surface temperature, Land surface model (SiBUC), Solar radiation consortium data, Advanced urban activity data

