Assessing the quality of snow depth simulated by NHRCM in urban areas of Japan

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With an increase in horizontal resolution of numerical model, the model can resolve not only large scale urban areas but also mid- and small-scale ones. There are some relatively small urban areas scattered around snowy regions in Japan, and weather and climate in the areas are affected deeply by a snow pack during the winter season. Therefore, to provide more reliable information about climate changes in the areas, it is important that accumulating and melting of snow are accurately simulated in models. Two snow pack schemes have been introduced into a square prism urban canopy (SPUC) model (Aoyagi and Seino 2011) in a non-hydrostatic regional climate model (NHRCM) developed at MRI/JMA for a successful replication of urban snow. Scheme_S01 (scheme_S02) uses statistical methods (fluxes from the snowpack) for changes of snow temperature and melting and freezing amounts and Penman-Montieth equation (bulk equation) for sensitive and latent heat fluxes.
In this study, we assess the effects of the snow schemes on the simulated snow depth over Japanese urban areas, by comparing the depths simulated with and without SPUC to the observed depths by JMA. The model horizontal resolution is 5 km. The Japanese 55-year reanalysis data was used as initial and boundary conditions. We focus on the mean values for the period of 2006 to 2010.
The scheme_S01/S02 decreases the model bias of the annual maximum depth averaged over the five years at the urban site grids where the model without SPUC (scheme_NU) overestimates the maxima. The RMSE is reduced over the grids by the scheme_S02. The stronger spatial correlation between the simulation and the observation is shown when the snow pack schemes are used. The scheme_S02 represents the closest maxima to the observation. Seasonal variation of the depth is estimated at the 22 site grids where the peak of depth averaged over the five years is more than 10 cm and, at the about half number of the sites, the scheme_S01/S02 performs better than the scheme_NU. Comparing with the observation, the variation in scheme_NU was overestimated during the periods of snow pack. The scheme_S01/S02 suppresses the overestimation. In Morioka where the variation is improved, all the schemes represent the depth well until December. The simulated depth in the scheme_NU, however, gets separated from the observation and the other simulated depth when the daily maximum temperature reaches less than 0˚C and then the depth keeps increasing while the temperature is minus. On the other hand, the increased temperature by the scheme_S01/S02 is close to the observation in the accumulating period and thus the higher precision is shown on the variation. In Toyama with the improved variation by the scheme, because of a good accuracy of the simulated temperature, the improvement can be seen on the variation in the period of accumulating and melting. The scheme_S01/S02 promotes the melting overly after the temperature increase starts at both sites. The simulated seasonal variations at some urban site grids were degraded by the schem_S01/S02. The depth is underestimated even in the scheme_NU at the grids, and the depth is less in the scheme_S01/S02 than in the scheme_NU because of the high temperature simulated by the schemes. The effects of the schemes on the depth are indistinct in the small-scale urban areas which are expressed as one grid in the model.

Keywords: Snow depth, Urban area, Urban canopy scheme, Regional climate model

