# Effects of an Urban Canopy Scheme and Surface Observation Data on a Heavy Rain Event through Data Assimilation

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## 1 Introduction

In order to improve the accuracy of forecasting localized heavy rainfall around urban areas, it is important to effectively utilize high frequent and high density surface observation data that have not been used for data assimilation so far. From the viewpoint of the data assimilation, the use of a forecast model that has the ability to accurately represent the city-specific heat island effect is required, to reduce the biases from observed data and to assimilate more observation data.

In this study, we incorporated a forecast model with an urban scheme into an ensemble-based assimilation system and assimilated dense surface data from Atmospheric Environmental Regional Observation System (AEROS, Soramame-Kun in Japanese nick name [1]), then, investigated how the use of the urban scheme and the surface data contributes to improve the reproducibility of the rainfall through numerical experiments for a heavy rain event in Tokyo metropolitan area on August 30, 2017.

## 2 Experiments and Results

We incorporated a forecast model (NHM) with a single-layered square prism urban canopy model (SPUC; Aoyagi and Seino 2011 [2]) as the urban scheme into a regional mesoscale assimilation system using the local ensemble transform Kalman filter (NHM-LETKF; Kunii 2014 [3]). Using this assimilation system, we conducted numerical experiments of a short-time heavy rainfall event that occurred in the Tokyo metropolitan area (Kanto) during the southward movement of an autumn rain front on August 30, 2017 (over 100 $\mathrm{mm\,h^{-1}}$ heavy rainfall for the vicinity of Nerima Ward, Tokyo, the location of which is indicated in Fig. 3). This analysis-forecast system has $200 \times 200$ horizontal grid points with 2 km resolution and the domain covers whole Kanto plain. The ensemble-size is 51 and the analysis-forecast cycle experiments start at 15 JST on August 28th with the analysis time interval of 3 hours. Almost as same as the observation data used in JMA's operational meso analysis system are assimilated. The settings of forecast model are the same as in Seino et al. 2018 [5].

The additional AEROS data (temperature, humidity, and wind speed) used in this study generally have a distribution as shown in Figure 1, although there are some differences depending on the assimilation time. We note that the temperature and humidity data within 2 m height and the wind speed data within 10 m height are used, by simple quality control method.

In the following, we refer to the analysis and forecast experiment using the conventional NHM-LETKF as CTRL, the NHM-LETKF experiment with SPUC as URB, and the URB experiment using the AEROS data for assimilation as URB_S.

SPUC scheme has the effects of increasing temperature of the lower troposphere mainly in the evening, developing the mixing layer and increasing the the amount of water vapor in the middle troposphere. It is also known that the rise in surface temperature is delayed in the morning. Figure 2 shows that the time series of temperature and wind speed at Nerima station are improved in URB. We can see that the initial temperature in URB is almost the same as the observation and the change of the wind speed in URB with the passage of the front (at 12 JST on August 30) is clearer than that in CTRL.

Figure 3 shows the one-hour accumulated precipitation in the forecasts from the initial data at 03 JST on August 30. In URB and URB_S experiments, the shape of the heavy rain area along with the local front becomes closer to that of observed (RA) than CTRL. We also note that the beginning of the construction of the heavy rainfall is getting earlier in URB and URB_S experiments. This implies that the improvement of the near surface temperature and wind fields by the use of SPUC scheme and AEROS data contributes to properly construct the convection which results in well reproduced heavy rain distribution.

## 3 Summary

The implementation of the urban scheme SPUC into the data assimilation system NHM-LETKF has improved the reproducibility of precipitation distribution in the localized heavy rainfall event on August 30, 2017. On the other hand, since AEROS is not specialized for capturing the atmospheric fields (Nishi et al. 2015 [4]), it is sometimes difficult to see a clear improvement in accuracy through its use. Thus, we need to continue to research and develop our system to make more effective use of the surface observations.

## References


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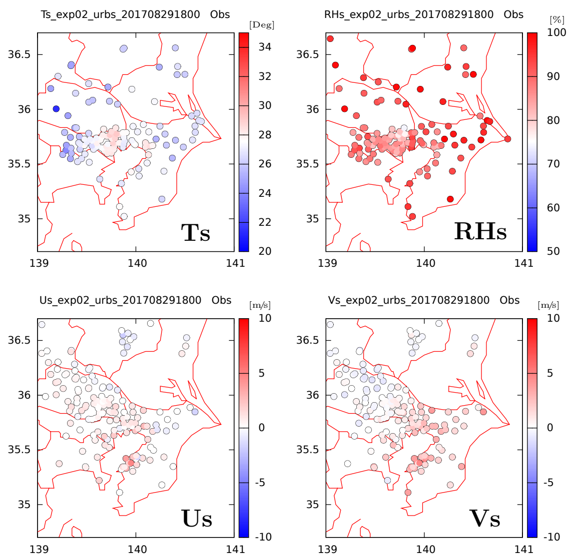


Figure 1: Distribution of the AEROS data used in the URB_S experiment at 03 JST on August 30.

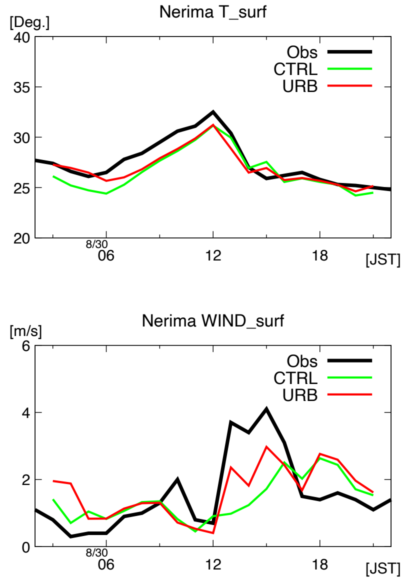


Figure 2: Time Series of surface temperature(upper) and wind speed(bottom) at Nerima observation station(AMeDAS).

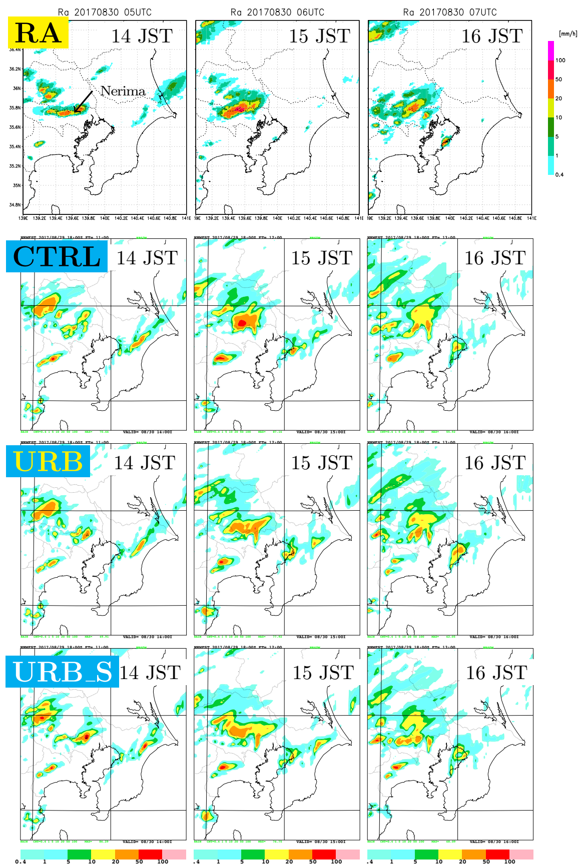


Figure 3: One-hour accumulated precipitation ([mm/h]; shaded as in the color bar) on August 30, 2017. The different panels show the radar/raingauge analyzed precipitation (RA) and the forecasts of CTRL, URB and URB_S.