Assimilation of JMA high-resolution radiosonde observation data into the mesoscale 4D-Var data assimilation system

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Introduction

In recent years, the Japan Meteorological Agency (JMA) has introduced GPS radiosondes for all its radiosonde stations. Conventional TEMP bulletins contain observation values for standard-pressure levels and significant levels but no positional information on radiosondes, which drift with the wind. However, the technological introduction of GPS radiosondes enables atmospheric observation at intervals of a few seconds (i.e., at several thousand altitudes in total) along with collection of positional information and storage of the results in high-resolution data (HRD) format. The assimilation of HRD with positional information is expected to improve the quality of initial atmospheric conditions and forecast accuracy. In consideration of such assimilation, JMA developed a new algorithm for quality control and data selection and evaluated the related impacts on forecasts using its mesoscale numerical weather prediction (NWP) system. The results showed that forecasts of precipitation and surface meteorological variables were improved by the use of HRD. Consequently, JMA began to assimilate HRD in its mesoscale NWP system in March 2016 using the new algorithm.

Quality control and data selection

The quality of HRD requires stringent control because greater amounts of data are more likely to be affected by measurement sensor problems and other issues. The quality control approach adopted for this purpose involves evaluation to determine the appropriateness of observation values and positions (i.e., whether temporal changes in observation values are rational). In addition, JMA's mesoscale 4D-Var data assimilation system is operated on the assumption of a no-error-correlation among observation data used in the process. Accordingly, HRD are thinned out with appropriate height intervals by following time displacements of around 60 seconds for temperature and dew point temperature, around 120 seconds for winds at levels lower than 850 hPa, around 120 seconds at levels from 850 through 200 hPa and around 240 seconds at levels higher than 200 hPa for all elements.

Impact of HRD on forecasts

Observing system experiments were performed for two months in summer 2015 and in winter 2014 – 2015 to evaluate the impact of JMA's HRD in its mesoscale NWP system. Forecasts with a lead time of 39 hours produced using JMA's mesoscale model (MSM) were run from each corresponding mesoscale analysis. In test runs, HRD were checked with the above-mentioned algorithm and selected data were assimilated at observed vertical and horizontal positions.

The equitable threat scores (ETSs) of three-hourly cumulative precipitation forecasts indicate that the quantitative precipitation forecasts of the test run were better than those of the control run for most precipitation thresholds in summer, while the impacts in winter were rather neutral (Fig. 1). A slight reduction of root mean square errors was seen in forecasts of variables such as surface temperature and surface wind (in summer) and sea-level pressure (in both summer and winter) (Fig. 2). Figure 3 shows an example of improved precipitation forecasting. A strong rain band was observed in the area enclosed with the dashed blue line (c), and was found to be accurately forecast in the test run.

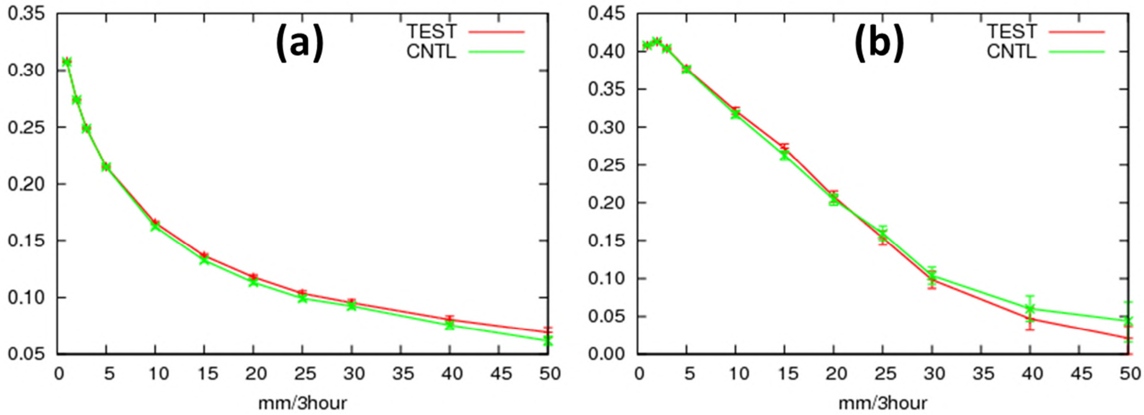

Fig. 1 Equitable threat scores (ETSs) of three-hourly cumulative precipitation in MSM forecasts against radar-raingauge analyzed precipitation: (a) summer experiment, (b) winter experiment. The scores of the test runs (TEST) are indicated by the red line, while those of the control runs (CNTL) are indicated by the green line, with error bars showing a 95% confidence interval.

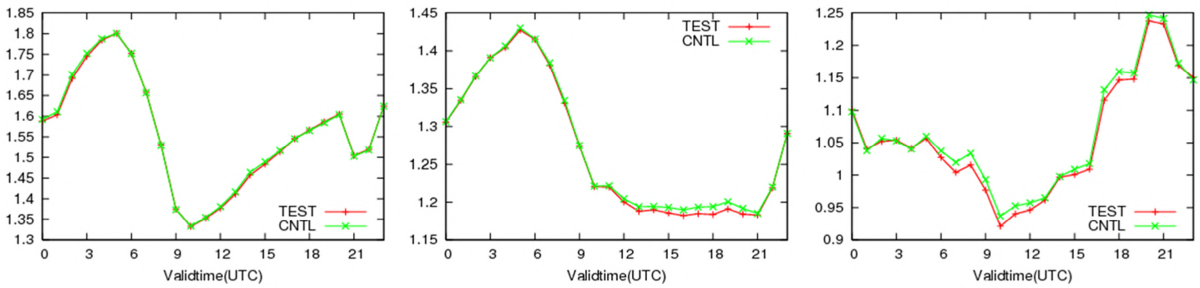

Fig. 2 Root mean square errors of surface temperature (left), surface wind velocity (middle), and sea-level pressure (right) in summer. The results of test runs (TEST) and control runs (CNTL) are shown in red and green, respectively. The horizontal axes indicate the forecast valid time (UTC).

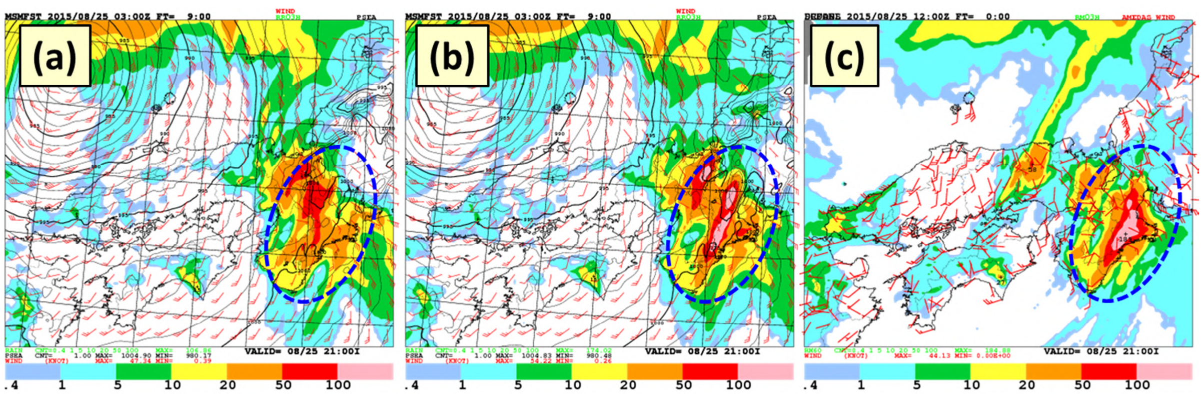

Fig. 3 Three-hourly cumulative precipitation at the forecast lead time of nine hours: (a) control run, (b) test run, and (c) observation