Data assimilation experiments of SSR mode-s downlink data using Meso-NAPEX system of JMA

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1. Introduction

The new air control radar system provides SSR mode-s downlink data very frequently. The horizontal wind and temperature at the positions of airplanes can be obtained from SSR mode-s downlink data that include the heading directions of airplanes, the speeds against the ground and against the airflow, the magnetic headings, and Mach numbers. Because the temporal and spatial intervals of downlink data are very short, the downlink data are expected to be useful for data assimilation of numerical weather prediction.

The data assimilation experiments on the horizontal winds of downlink data were performed by using LETKF (Local Ensemble Transform Kalman Filter; Hunt et al 2007, Miyoshi and Aranami, 2006), and showed that the rainfall forecast was improved by the assimilation of downlink data (Seko et al 2016). As the next step of this study, the quality of downlink data were investigated by the comparison with the operational mesoscale analysis data of Japan Meteorological Agency (JMA), and the data assimilation experiments of downlink data were conducted with the meso-NAPEX system (a part of JMA's 4-dimensional data assimilation system), which had been implemented to Meteorological Research Institute (MRI).

2. SSR mode-s downlink data

The downlink data observed by air control radar of the Electronic Navigation Research Institute was used in this study. It covers the Eastern and Central Japan, and its temporal interval is 10 seconds.

The horizontal wind and temperature were converted from the downlink data according to Shigetomi et al (2013). Figure 1 shows the vertical profiles of bias and RMSE between the downlink data and mesoscale analysis. The period of comparison is 30 days of September, 2015. Before the comparison, the pressures at the positions of downlink data were obtained from their heights, because the pressures of downlink data were converted to their heights using the ICAO standard profile of atmosphere before sending to the radar.

The comparison shows that the temperature of downlink data are lower than that of mesoscale analysis data by 1 degree, and that the large difference is seen below the height of 3 km. As for the horizontal wind, there is the large difference when the airplanes were turning or ascending and descending with large speed. Then, the horizontal winds in these conditions were removed before the comparison. The bias of horizontal wind is relatively small. Considering this result, the temperature above the height of 3 km was used in the assimilation after removing the bias. The horizontal wind of whole layers were assimilated without subtracting the bias.

3. Outline of data assimilation experiments

In this study, the Meso-NAPEX system, which includes JNoVA (JMA Non-hydrostatic Model based Variational Data Assimilation System; Honda, 2008), was used. Its grid intervals of forecast and assimilation are 5 km and 15 km respectively, and its domain is the same as the operational mesoscale analysis.

The case event to which the Meso-NAPEX was applied is the intense rainfall that passed the Kanto Plain. Because the intense rainfall region and shear-lines passed the Haneda and Narita International airports, the flight operations were affected by this rainfall event. The rainfall and shear-lines were reproduced by the predictions from the initial conditions that were obtained by using the operational data only and by adding the downlink data to operational data. The impact of downlink data were indicated by the comparison with the observed ones.

4. Results of data assimilation experiments

Figure 2 shows the positions of downlink data. Many downlinks were distributed around the Haneda and Narita International airports. The results of assimilation were shown in Fig. 3. The intense rainfall was reproduced by assimilation of the operational data only (Fig. 3, left). However, the rainfall region was smaller and the rainfall was generated on the western side of the observed one. When the downlink data were assimilated, the position of rainfall region became more similar to the observed one, though the rainfall was too intense (Fig. 3, center). The positions of shear-lines were improved by the assimilation of downlink data, too. Next, the differences in the initial fields between these two experiments were investigated. The easterly flow from the eastern side of Kanto Plain became more intense when the downlink was assimilated. This result indicates that the SSR mode-s downlink data have a potential to improve forecasts of rainfalls and shear-lines, even though that the horizontal grid interval and slot interval of the assimilation are as long as 15 km and 1 hour, respectively.

Reference:

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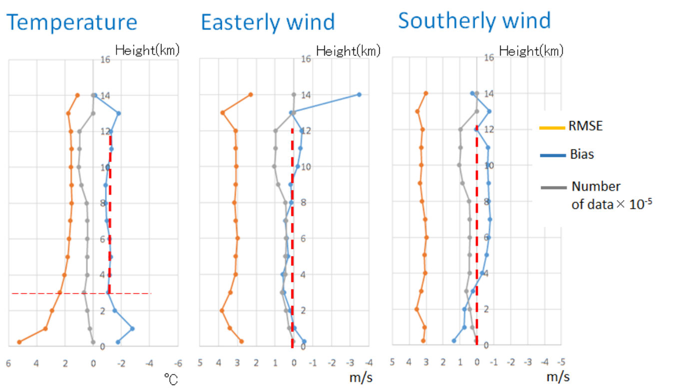

Fig.1 : Comparison between the downlink data and mesoscale analysis of JMA. Vertical profiles of the bias and RMSE of temperature, and horizontal wind.

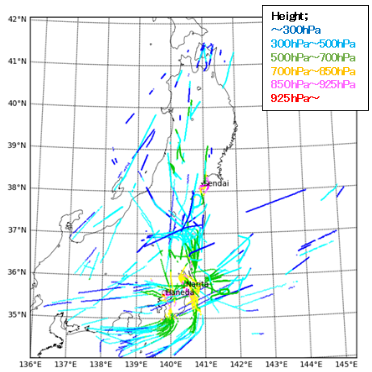

Fig.2 Positions of the assimilated downlink data. Colors indicate the height of data.

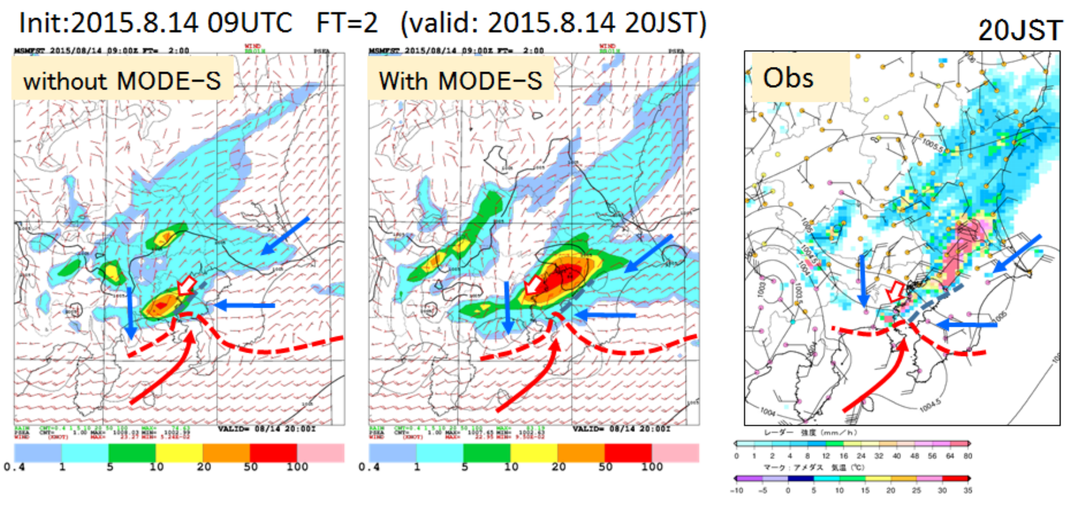

Fig. 3: Rainfall distributions predicted from the initial fields that were produced by assimilation (left) without downlink data and (center) with downlink data. (right) Observed rainfall distribution. Broken line, red and blue arrows indicate the shear-line and airflows around the rainfall region, respectively.