Data assimilation experiment of SSR mode-s downlink data

Hiromu Seko (MRI/JMA), Takayuki Yoshihara, and Atsushi Senoguchi (ENRI)
e-mail: hseko@mri-jma.go.jp

1. Introduction

New air control radars provide the high-frequent data (4-10 seconds) of horizontal wind and temperature, as well as the positions of airplanes. This data, which is known as SSR mode-s downlink data (hereinafter referred to as downlink data), is expected as assimilation data of operational numerical prediction systems. In this study, the impact of downlink data on a heavy rainfall that occurred in the Kanto region, Japan on 26th August 2011 was investigated with the data assimilation systems by using a Local Transform Ensemble Kalman Filter (LETKF).

The data assimilation experiment shows that the low-level convergence that caused the heavy rainfall was intensified by the downlink data and that the reproduced distribution of rainfall regions became similar to the observed one. This result indicates that the downlink data has potential to improve rainfall forecasts.

2. SSR mode-s downlink data

The information of airplanes (downlink data) as well as their positions was obtained by new air control radars (SSR mode-s) by inquiring each airplane individually from the radar. The downlink data includes the heading direction of airplanes, speeds relative to the ground and to the airflow, magnetic headings, and Mach numbers, from which the horizontal wind and temperature can be obtained.

The downlink data observed by air control radar of the Electronic Navigation Research Institute (ENRI, Koganei, Tokyo) was used in this study. The temporal interval of the data is 10 seconds. In addition to this frequency, many airplanes arrived at and departed from Haneda and Narita International Airports. The temporally and spatially dense profiles of horizontal wind and temperature around the airports were obtained by high-frequently requesting the responses from many airplanes. Figure 1 shows the spatial and temporal distribution of downlink data of 26th August. The temporal distribution indicates that the frequency of downlink data is high, except the midnight (from 00 LT to 06 LT).

It is known that the moderate vertical wind shear causes long-lasting convection systems, because the vertical wind shear shifts the position of downdraft from that of updraft. Therefore, the vertical profiles of horizontal wind are expected to be the important assimilation data that affect the duration and intensity of the convection systems.

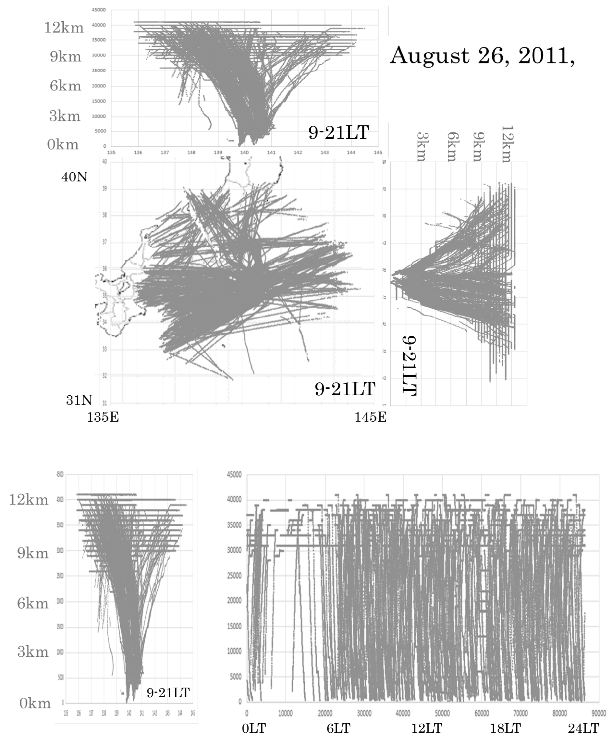

Fig. 1 Distributions of downlink data.

3. Heavy rainfall event

A heavy rainfall event that occurred in the southern part of the Kanto Plain on the 26th of August 2011 was focused on as an object of data assimilation experiment. Intense rainfall regions were generated at mountainous areas of Japan and over the Kanto Plain (Fig. 3a). The intense rainfall regions over the Kanto Plain (indicated by a red rectangle in Fig. 3a) were generated around the convergence line of the southerly flow from the south and of the easterly flow that entered from the north-eastern side of the Kanto Plain (not shown). This airflow pattern is one of the popular ones when the heavy rainfalls occurred in the

Kanto Plain in summer.

4. Data assimilation experiments

The temperature and horizontal wind that were used in this study were obtained in accordance with Shigetomi et al. (2013). The difference histogram of the observed horizontal wind and first-guess was shown in Fig. 2. There is a bias in the histogram of easterly wind, because the histogram was produced by only one day's data. Because this histogram looks like normal distribution, the horizontal wind from 09 LT to 15 LT (just before the occurrence of heavy rainfall) was used as assimilation data.

Data assimilation experiment was conducted by using the LETKF data assimilation system. The horizontal grid interval was 15 km. Data assimilation using a part of the Japan Meteorological Agency's conventional data started at 09 LT, 24, and downlink data was added to the assimilation data of 09 LT to 15 LT, 26.

Preliminary results of the data assimilation is shown in Fig. 3. When the downlink data was assimilated, the horizontal wind speed from the east at the height of 500 m became larger, and the convergence was intensified. Then, the rainfall distribution became similar to the observed one.

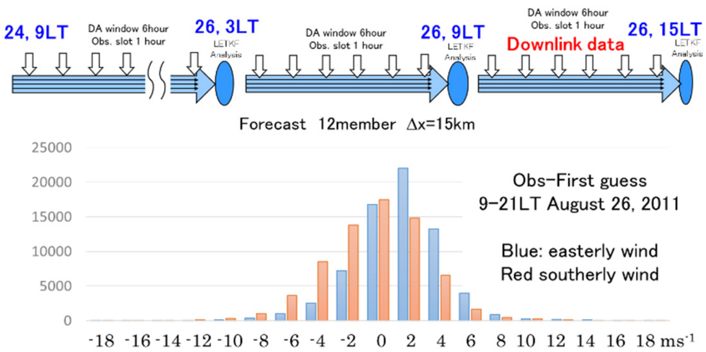

Fig. 2 Schematic illustration of assimilation experiment and difference between observation and first-guess of horizontal wind.

5. Summary

The downlink data obtained by air control radars provided the high-frequent vertical profiles of temperature and horizontal wind. Because the bias of horizontal wind that was observed on 26th August 2011 was a few meters, the downlink data was used as assimilation data. The reproduced rainfall distributions show that the downlink data made the rainfall region more similar to the observed one by modifying the horizontal wind fields. However, the observation error and the interval of data thinning were determined from one day's data. To further improve the rainfall forecasts, the observation error of downlink data and the optimal method of data thinning should be investigated. Further experiments are needed to obtain more conclusive results.

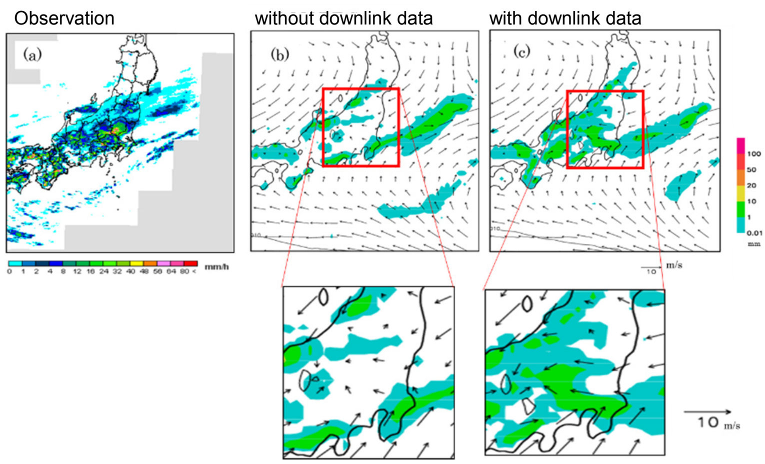

Fig. 3 Rainfall and horizontal wind distributions. (a) Observation, (b) and (c) the reproduced distributions obtained by assimilation of conventional data and downlink data. Height of horizontal wind is 500 m.

Reference:

Shigetomi et al., The evaluations and analyses of weather forecasts by using the SSR mode-s downlink data. The preprints of 51st airplane symposiums, JSASS-2013-5158 (In Japanese).

Acknowledgements:

This study was supported partly by the research project of "Tokyo Metropolitan Area Convection Study for Extreme Weather Resilient Cities (TOMACS)".