Impacts of Radial Wind measured by Doppler radar and GPS-derived Water Vapor on Numerical Prediction of Precipitation

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1. Introduction

Because summer thunderstorms sometimes cause heavy rainfall that is particularly hazardous in urban areas, the accurate forecast of the thunderstorms has been desired. To predict the precipitation more accurately, the variational assimilation systems are developed by the Japan Meteorological Agency (JMA).

On 21 July 1999, a thunderstorm was generated in Tokyo south from the Baiu front and caused the heavy rainfall, of which the hourly rainfall exceeded 100 mm/hour. In general, thunderstorms are generated by the convergence of the low-level humid airflow. Therefore, the radial wind (RW) of Doppler radar and GPS precipitable water vapor (PWV), which have the information of the convergence and humidity, are expected to improve the forecast when they are used as assimilation data.

In this study, the analyzed fields are obtained by 3-dimensional assimilation system (JNoVA0) for the Non-hydrostatic Model (NHM) of JMA (Miyoshi 2003), and the impact of the RW and PWV data was investigated by comparison between the observed and the simulated rainfall fields.

2. Assimilation data

In this study, the RW data that was observed by Narita and Haneda radars, which are about 50km northeast of Tokyo and in the southeastern Tokyo, were used. Because the number of RW data was much larger than that of the model grids, a "super observation method" was used; RW data from the radar were interpolated onto the horizontal grid by a Cressman scheme. Simulated RW at interpolated RW data points were interpolated from the NHM grid point values by using the weight of the radar beam intensity in the vertical direction and a Cressman interpolation in the horizontal direction. The radar beam intensity was assumed to have a Gaussian distribution. As for the GPS PWV data, PWV estimated from the GPS Earth Observation Network (GEONET) data of Geographical Survey Institute (GSI) was used. The mean of horizontal interval of GEONET is about 25 km and the time resolution of PWV data is 5 minutes.

3. Tangential component distribution of analyzed wind

At first, we explain how tangential wind was changed by the assimilation of RW data. Figure 1 shows the distribution of the radial wind and tangential wind of the elevation angle of 0.7 degree. The observed radial and tangential winds were estimated from the horizontal wind observed by Narita and Haneda radars by the dual Doppler radar analysis. In the northern part of the Dual analysis region, the northwesterly inflow expanding eastward and westward was observed (Fig. 1a). When the radial wind of two radars was used, the analyzed wind fields were very close to observed ones (Fig. 1c). When only the radial wind of Haneda radar was used, the radial wind was similar to the observed one and the tangential wind that expanded eastward and westward was obtained (Fig. 1d). The comparison of the tangential wind indicated that the RW data changed the tangential wind to one similar to the observed one even if RW data of single radar was used.

4. Impact of radial wind of Doppler radar and GPS-derived Water Vapor

Comparisons between forecasted rainfall regions with and without the assimilation help define the impacts of RW and PWV data. When the assimilation was not performed (Fig. 2a), the rainfall region did not move southward and the thunderstorm was not generated in Tokyo. When the RW and PWV data were assimilated, the low-level inflow became more humid, and low-level northerly flow was reproduced in the north of Tokyo (Fig.2 b). This northerly flow intensified the low-level convergence and the thunderstorm was generated near Tokyo (red circles in Fig. 2b). For this rainfall event, the assimilation of RW and PWV data improved the precipitation prediction.

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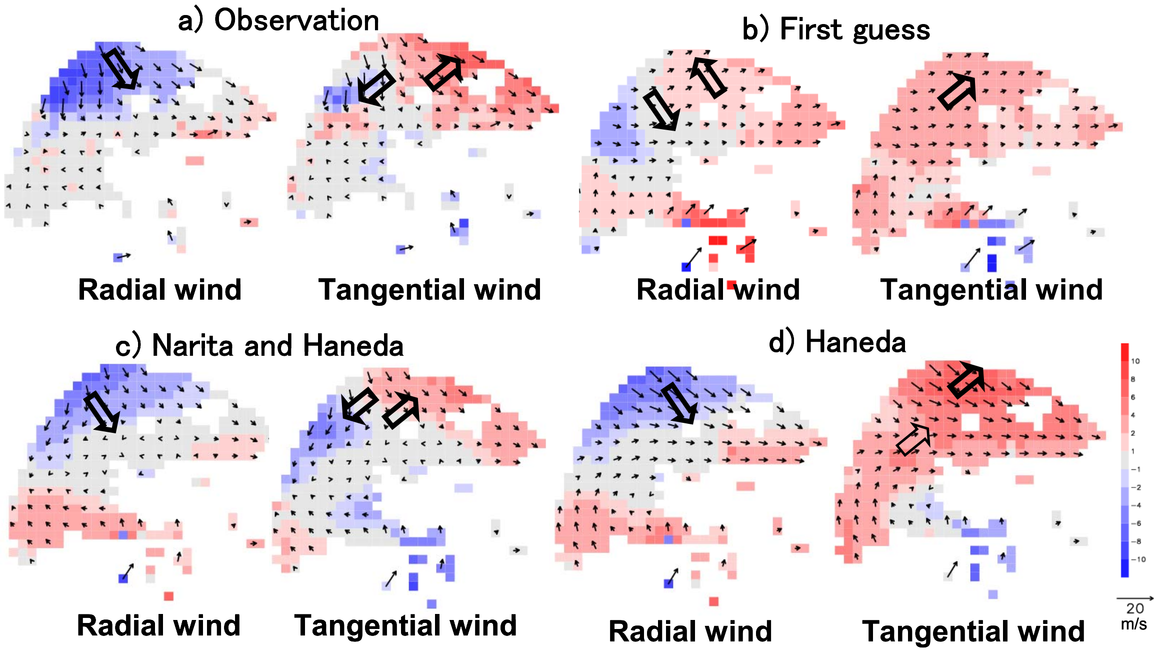

Fig. 1 Distribution of the radial and tangential wind of the elevation angle 0.7 deg. (a) Observed wind estimated from the horizontal wind obtained from Narita and Haneda radar data by the dual Doppler radar analysis. (b) First guess wind fields. (c) and (d) Analyzed radial and tangential wind obtained from the analyzed horizontal wind.

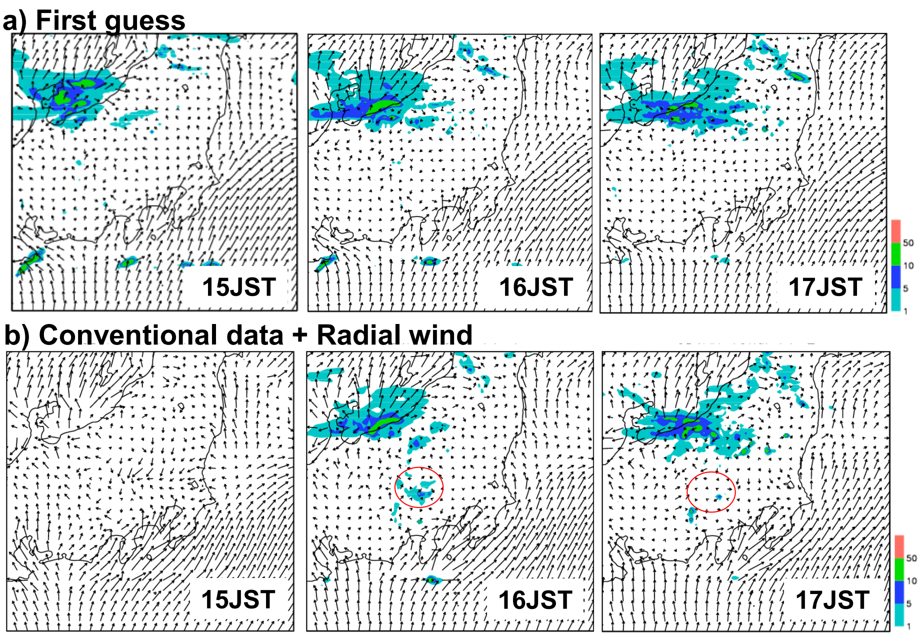

Fig. 2 Rainfall region simulated from the initial fields (a) without assimilation and (b) with assimilation of conventional data, radial wind of Haneda and Narita radars and GPS-PWV data.