Data Assimilation Experiments of Refractivity Observed by JMA Operational Radar

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1. Introduction

Radio waves, which are transmitted by Doppler radars and reflected from static structures (e.g. electronic power supply towers) are delayed by water vapor on paths between Doppler radars and static structures. If the delays of radio waves can be obtained from their phase data, refractivity - which is a function of water vapor and temperature - can be obtained from the delay data. This refractivity is expected to be useful in assimilating data for convection generations, because convergence of water vapor that generates convections is reproduced by assimilation of the refractivity. In this report, preliminary results of data assimilations, in which 'temporal increments of refractivity (abbreviated to TIR, hereinafter)' are used in producing initial conditions of numerical forecasts, will be presented.

2. Estimation methods of temporal increments of refractivity

In this report, phase data observed on 4th August 2008 by Tokyo radar of Japan Meteorological Agency (JMA) with the elevation angle of 0.0 degrees was used as assimilation data. It is difficult to estimate the absolute values of delays, because reflection points of radio waves, which are needed in the estimation of absolute wave numbers, cannot be determined. Then, 'temporal increment of difference between the transmitted phase and the received phase' (abbreviated to TIP) is used. The TIP, which is obtained by Radar observation, is the integrated value of TIR along the path of radio waves. The TIR, which will be used as assimilation data, is produced by making the difference of TIP in radial direction of Radar. The radio waves that are received by Radar are not only those reflected from static structures. It is necessary to remove the delays reflected from moving structures, such as trees and wind turbines. In Seko et al (2009), the radio waves reflected from static structures were picked out from all reflected radio waves by using the temporal dispersion of TIP. Namely, radio waves, of which TIP fluctuated largely with time, were removed as ones reflected from moving structures. However, operational radars of JMA conduct volume scan observations and then the observation with the elevation angle 0.0 degrees, which is the most favorable elevation angle for the observation of static structures, was performed every 10 minutes. It is difficult to identify the radio waves reflected from static structures by using this intermittent data. Instead of temporal fluctuations of TIP, horizontal variations of TIP are used. Namely, (1) TIP is averaged over

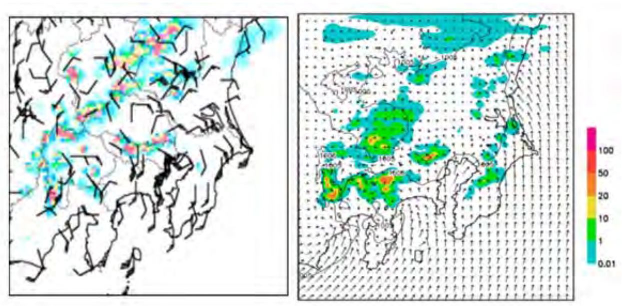

Fig.1 Observed distributions of rainfall region and horizontal wind at 16 JST (Left), and rainfall region and horizontal wind reproduced by the Inner LETKF at 15 JST (Right).

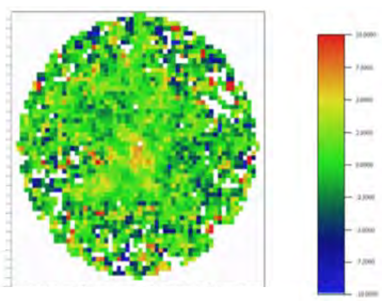

Fig. 2 Increment of refractivity from 1600 to 1610 JST.

small area, into which the Radar range is segmented. (2) The radio waves, of which temporal increment of refractivity is far from its areal average, are removed. After a few iterations of these procedures, the radio waves reflected from static structures are expected to remain. Though the threshold value used in identifying the moving structures in this study was determined by trial and error, it should be tuned because it might depend on atmospheric conditions.

3. Data assimilation methods and impact of refractivity

The system used in this experiment is a two-way nested system of LETKF (Seko et al. 2013). Outer LETKF, of which grid interval was 15 km, was performed from 09 JST 1st August to reproduce the mesoscale convergence, and the Inner LETKF was performed from 03 JST 4th to reproduce the convections. Conventional assimilation data of JMA was used by the outer and inner LETKFs, and refractivity data was added to the conventional assimilation data in the assimilation of the Inner LETKF. The interval of the inner LETKF's data slots is 10 minutes. We assumed that the analyzed distributions of 1500 JST are correct and obtained the refractivity distributions from 1510 JST to 1600 JST by adding the temporal increments of refractivity to this analyzed distribution of 1500 JST.

Figure 1 shows the rainfall regions observed by conventional radars and reproduced by the Inner LETKF. The rainfall region over the mountainous area surrounding the Kanto Plain was well reproduced. The rainfall region over the eastern part of the Tokyo Metropolitan area was also reproduced, though its generation time was 1 hour earlier than the actual one. Apart from these rainfall regions, weak rainfall regions that were not generated in reality extended in the eastern part of the Kanto Plain. Figure 2 is the observed temporal increment of refractivity at 1610 JST, which was estimated by using the aforementioned method. This distribution indicates that refractivity was increased where the rainfall region over the eastern part of the Tokyo Metropolitan area would be generated and decreased on its northeastern and eastern sides. When temporal increments of refractivity including one shown in Fig. 2 were assimilated, the fake rainfall regions became weaker (Fig. 3). The assimilation of the decreasing refractivity over the eastern part of the Kanto Plain reduced water vapor there, making the fake rainfall weaker. This result indicates that temporal increment of refractivity has the potential to improve the rainfall forecasts.

References

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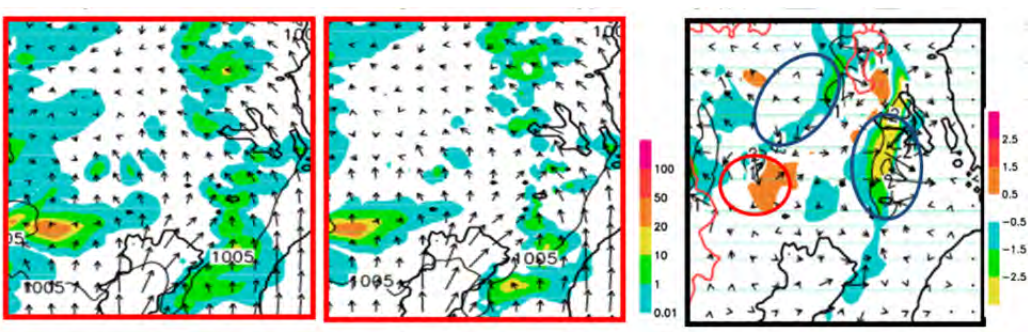

Fig. 3 Rainfall regions and horizontal wind at 16 JST reproduced by the Inner LETKF. (left) w/o refractivity, (center) with refractivity, and (right) increments caused by the refractivity data. Colored regions and contour indicate water vapor and temperature increments.