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Short-range forecast using MPradar network and 3DVAR assimilation for the heavy rainfall in north Tokyo on July 5th 2010

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Title : Short-range forecast using MP-radar network and 3DVAR assimilation for the heavy rainfall in north Tokyo on July 5th 2010

National Research Institute for Earth Science and Disaster Prevention, Japan (NIED) designed a real-time radar network (X-NET) consisting of MP radars and Doppler radars over Kanto Plain, Japan. We developed a real-time 3DVAR assimilation system using radial velocity of radar and GPS precipitable water (PWV) for a short-range (up to 1-3 hours) forecast of severe weather. The 3DVAR assimilation procedure was developed in non-hydrostatic cloud-resolving storm simulation (CReSS) model. A thunderstorm observed in 5th July 2010 was simulated with radial velocity and precipitable water vapor derived from GPS assimilation.

The thunderstorm provided heavy rainfall (107 mm/hr) at Itabashi city from 19:30 to 20:30 Japan Standard Time (JST). The thunderstorm rapidly developed from 17:00 to 19:00 JST. We tried to forecast the heavy rainfall between 19:00 and 20:00 JST using initial condition obtained at 18:00 JST. From 18:00 to 18:30 JST, the thunderstorm was gradually dissipated, but it soon developed again after 18:30 JST. Therefore, short-range forecast around 18:00 JST such as a nowcasting that assumes the conservation of rainfall area and constant migration speed would be difficult for such thunderstorms with large temporal variation of rainfall. 3DVAR assimilation is one of most suitable method for the short-range forecast of such non-steady thunderstorms in terms of calculation cost.

Optimization for our 3DVAR was implemented by Limited-memory quasi-Newton method (L-BFGS), which provides optical state quickly with small iterations. It takes only a few minutes to obtain optical initial condition. CReSS users can optionally use Semi-Lagragian advection scheme to utilize large time-step for reducing calculation times for real-time forecasting. As a result, it takes 10-15 minutes for the forecast up to 4 hours with 3DVAR initialization. GPS-PWV dataset is available after about one-hour. Therefore, GPS-PWV-3DVAR provides forecast starting from 1 hour and a few tens of minutes to 4 hours.

Figure 1 shows radar observation (Fig. 1a), control run (no assimilation experiment: Fig. 1b), 3DVAR forecast (Fig. 1c) and increment of vapor by GPS-PWV 3DVAR (Fig. 1d) at 19:20 JST. The increment of vapor around Itabashi city (Fig. 1d) and wind convergence at lower level (not shown) improved the forecasted location of severe thunderstorm rather than CNTL (Fig 1b and 1c). Further improvements (e.g., assimilation of radar reflectivity) should be made for accurate forecast of severe thunderstorm.

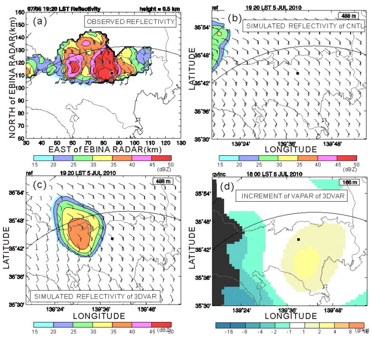

Fig.1 (a): observed radar reflectivity at 19:20 JST at a height of 500 m, (b): simulated radar reflectivity in control run, (c): simulated radar reflectivity in GPS-PWV and WIND 3DVAR, and (d) increment of vapor at 166m at 18:00 JST in GPS-PWV 3DVAR

Keywords: MPradar, 3DVAR, Doppler velocity, GPS precipitable water