GPS TPW Assimilation with the JMA Nonhydrostatic 4DVAR and Cloud Resolving Ensemble Forecast for the 2008 August Tokyo Metropolitan Area Local Heavy Rainfalls

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On 5 August 2008, scattering local heavy rainfalls occurred various places over the Tokyo metropolitan area (Fig. 1a), and five drainage workers were claimed by abrupt flooding. The JMA's operational mesoscale model[1,2] of the day failed to predict occurrence of the local heavy rainfalls (Fig. 1b), which were given by deep convective cells developed on unstable atmospheric conditions without strong synoptic/orographic forcing. A 11-member mesoscale ensemble prediction with a horizontal resolution of 10 km was conducted using the JMA global EPS peruturbation as the initial and lateral boundary perturbations, but the associated intense rains exceeding 20 mm /3 hour were hardly predicted (Fig. 1c). A downscaling ensemble forecast experiment with a horizontal resolution of 2km was conducted using the 6 hour forecast of 10 km ensemble as the initial condition. Scattered intense rains were predicted in some members, but their distribution was not enough (Fig. 1d).

The total precipitatable water vapor (TPW) observed by GEONET (Fig. 2a) showed that the initial field of the operational MSM produced by the hydrostatic Meso-4DVAR (Fig. 2b) underestimated water vapor over the Tokyo metropolitan area. To modify the initial condition, a reanalysis data assimilation experiment was conducted with the JMA's nonhydrostatic 4DVAR (JNoVA[3]), where GPS TPW data from GEONET were assimilated 2.5 days with 3-hour data assimilation cycles. Figure 2c shows the modified TPW analysis obtained by JNoVA, where data thining of GPS observations was conducted with 15 km.

The 2 km downscale ensemble run from JNoVA analysis properly predicted the areas of scattering local heavy rains (Fig. 3). Threat scores (Fig. 4) and ROC area skill scores (Fig. 5) suggest that even in the ensemble prediction, accuracy of initial condition is critical to numerically predict small scale convective rains. Fractions skill scores[4] indicated the value of the cloud resolving ensemble forecast for such the unforced convective rain case.

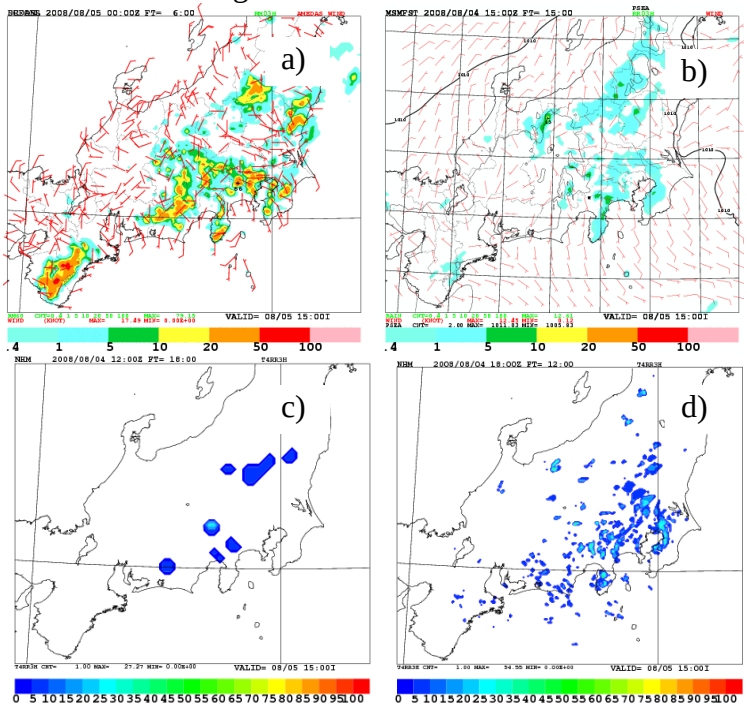

Fig. 1. a) Observed precipitation for 03-06 UTC, 5 August 2008. b) Forecast of the operational MSM. Initial time is 12 UTC 4, August 2008. c) Probability of precipitation over 20 mm / 3 hours by a 11-member EPS with a horizontal resolution of 10km. d) Same as in c) but downscale ensemble prediction of horizontal resolution of 2 km.

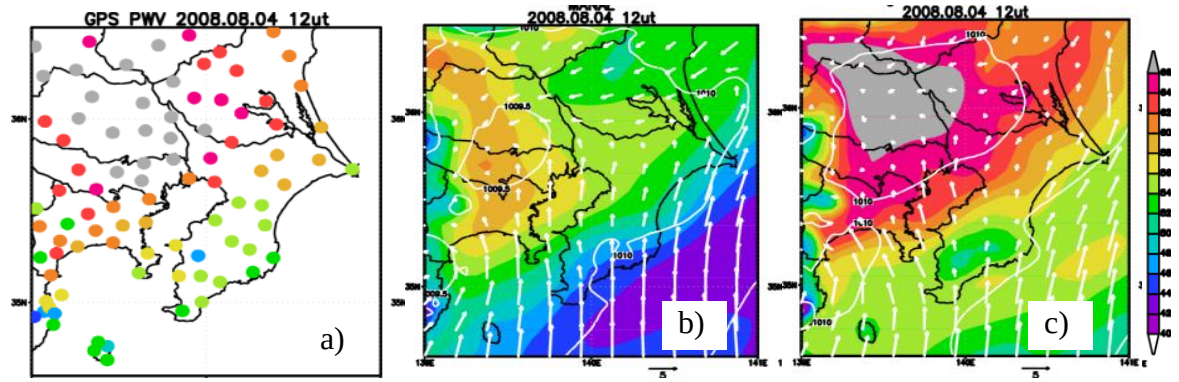

Fig. 2. a) TPW observed by GEONET at 12 UTC, 4 August 2008. b) TPW by Meso4DVAR analysis. c) Same as b) but TPW obtained by JNoVA analysis.

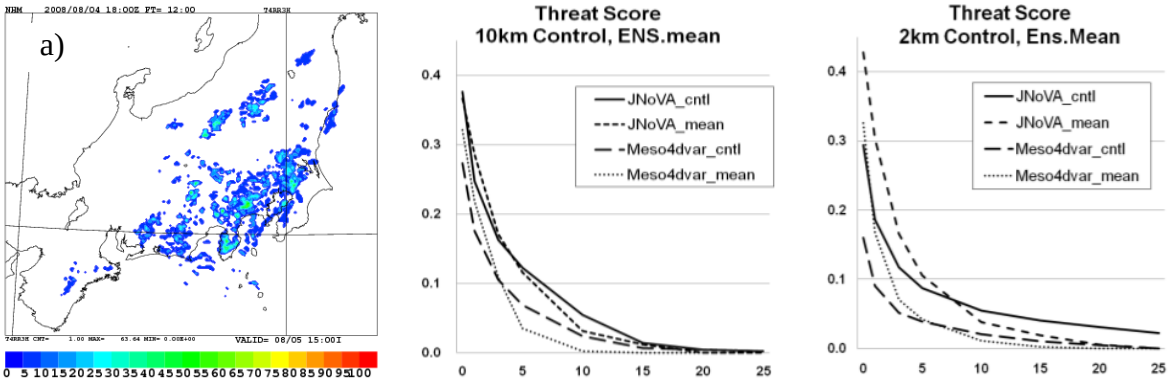

Fig. 3. (Left) Same as Fig. 1d, but EPS with JNoVA initial condition assimilating GPS TPW.
Fig. 4. (Right) a) Threat scores for 10 km EPS. b) Same as a) but 2 km EPS.

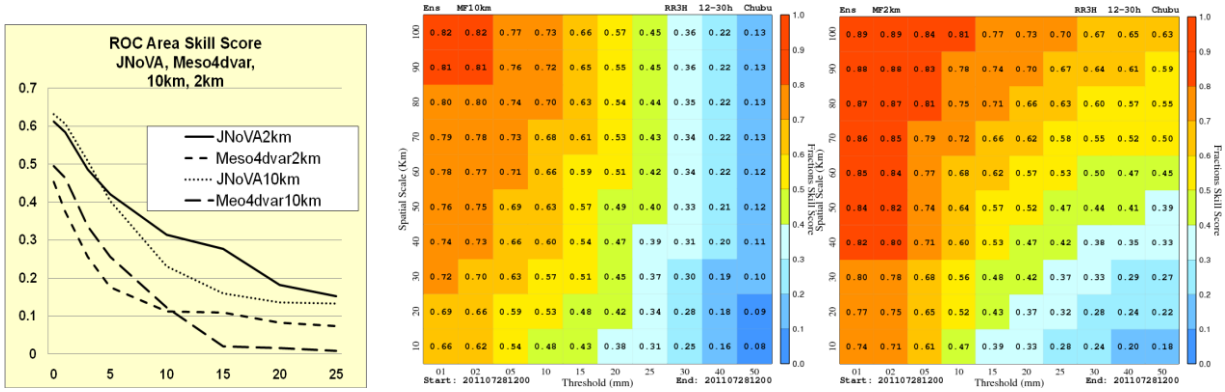

Fig. 5. (Left) ROC area skill scores by four ensemble prediction systems.
Fig. 6. Fractions skill score scale-intensity diagram for 10 km EPS (left) and 2km EPS (right).

References

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