DISPLACED ENSEMBLE VARIATIONAL ASSIMILATION EXPERIMENT USING BRIGHTNESS TEMPERATURES OF MICROWAVE IMAGER

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1. Introduction

Displacement erorrs in large-scale appear between the precipitation distributions of the ensemble forecast results and the actual observation data in many cases. In the recent study, the experiment of data assimilation about typhoon's case was performed using ensemble forecast results that corrected displacement error by observation data, and we can know that those results were the analysis results of high precision compared with case of no correction (Aonashi and Eito (2011)). In the present study, we selected heavy rain event within the Baiu frontal zone that was appeared diurnal variation in the precipitation regions for weak rain (The Baiu frontal zone extended from southern part of the East China Sea to southern sea of Japan between 12 June 2009 and 13 June 2009). For this event, at first, we performed displacement error correction (DEC) of the ensemble forecast results (first guesses) using brightness temperatures (TBs) of Microwave Imager (MWI) on the satellite. Next, we performed the experiment of ensemble-based variational assimilation (EnVA) from the displaced first guesses, and we compared with ensemble mean before DEC, ensemble mean after DEC and EnVA analysis value.

2. Method of DEC

We calculated displacement error ($\vec{d}$) from TBs (Y) of MWI and ensemble mean ($\bar{X}^f$) using the following cost function (Hoffman and Grassotti (1996)).

$$J_d = \frac{1}{2\sigma_o^2}\{Y - H(\bar{X}^f(\vec{d}))\}^T\{Y - H(\bar{X}^f(\vec{d}))\} + \frac{1}{2\sigma_d^2}|\vec{d}|^2$$

H : Forward operator, σ_o : Observation error, $\sigma_o^2 = 10K^2$
σ_d : Scale of displacement error, $\sigma_d = 150km$

Next, we corrected physical elements, radiational calculated TBs for each members and ensemble mean from the optimized displacement error ($\vec{d} = \tilde{d}$). DEC scheme was considered horizontal direction only.

3. Experiment of EnVA

We calculated analysis value of ensemble mean ($\bar{X}^a$) from TBs (Y), displaced ensemble mean ($\bar{X}^f(\tilde{d})$) and displaced each ensemble members ($\vec{X}_i^f(\tilde{d})$) using the following cost function.

$$J_X = \frac{1}{2}\{\bar{X}^a - \bar{X}^f(\tilde{d})\}^T(P^f)^{-1}\{\bar{X}^a - \bar{X}^f(\tilde{d})\} + \frac{1}{2\sigma_o^2}\{Y - H(\bar{X}^a)\}^T\{Y - H(\bar{X}^a)\}$$

Where, back ground error covariance (P^f) consists of the displaced ensemble forecast error, and its covariance is implemented by using flow-dependency localization. In this experiment, we used the vertical polarized waves of the lower frequency three channels of 10, 19 and 21GHZ for the reasons that the horizontal polarized waves was the large sensibility for variation of wind speed over the sea and higher frequency components had the large error in the calculation of cloud resolving model and forward operator of non-spherical solid precipitation particles (Aonashi and Eito (2011)).

4. Results of Experiment

At first, we performed ensemble forecast in settings as resolution is 5km, horizontal grid size is 400×400, total members is 51 (CNTL and perturbative 50 members), and we compared with the results of ensemble mean, ensemble mean after DEC and EnVA analysis value. Where, Fig 3(a) and (b) show the precipitation intensity and the updrafts of ensemble mean before DEC at FT=14 (Validtime: 02UTC 13 June 2009), Fig3(c) and (d) show same as in Fig3(a) and (b) but of ensemble mean after DEC, Fig3(e) and (f) show same as in Fig3(a) and (b) but of EnVA analysis value respectively. Physical elements were moved using the estimated displacement error vectors by the DEC scheme (Fig2). Precipitation regions of ensemble mean after DEC were corrected mainly around the Amami and the Okinawa islands compared with ensemble mean before DEC, and it approached actual precipitation distribution (Fig1). Entirely homogeneus updraft regions were moved mainly toward the Amami and the Okinawa islands by the DEC scheme. Updrafts of EnVA analysis value were enhanced mainly around the Amami and the Okinawa islands compared with ensemble mean after DEC, and precipitation amounts also increased. Precipitation amounts of EnVA analysis value were consistent with the Radar observation data (Fig1). Next, in order to evaluate the impact of precipitation, we performed the extented 6hr forecast ensemble mean, ensemble mean after DEC and EnVA analysis value at FT=14 as initial values. As a result, the extended forecast using EnVA analysis value was the best result in the three forecast cases. These results indicate the effectivity of DEC and EnVA for the severe event of the Baiu frontal zone.

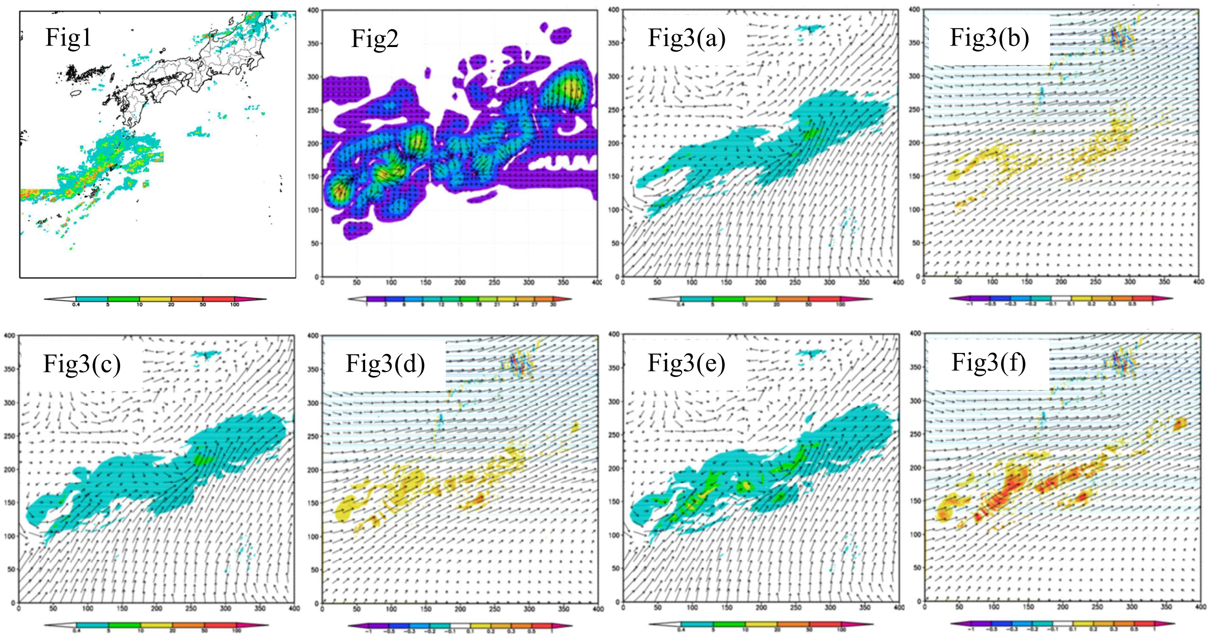

Fig1: Radar data (mm/hr) of JMA. Fig2: The estimated displacement error vectors by the DEC scheme. Fig3: (a) and (b) show the precipitaion intensity and the updrafts of ensemble mean before DEC at FT=14 respectively. (c) and (d) show same as in (a) and (b) but of ensemble mean after DEC respectively. (e) and (f) show same as in (a) and (b) but of EnVA analysis value respectively.

References

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