Improvement of Conventional Observation Data Usage in the JMA Mesoscale 4D-VAR Data Assimilation System

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1. Introduction

In JMA, the operational mesoscale data assimilation system based on a hydrostatic model (Meso 4D-Var) (Ishikawa and Koizumi, 2002) was replaced with a four-dimensional variational data assimilation system based on JMA's non-hydrostatic model (JNoVA) (Honda and Sawada, 2008) in April 2009. Consequently, there is a need to examine the usage of conventional observation data and the quality control (QC) method for JNoVA.

2. Observation Error and Observation Error Correlation

We estimated the level of observation error and observation error correlation suitable for JNoVA through a statistical study. In the study of Desroziers et al. (2005), observation error and observation error correlation were estimated from the covariance of observations minus the first guess (O-B) and observations minus the analyzed value (O-A). Figure 1 shows the estimated observation errors for temperature, U-component and V-component wind, and relative humidity. Figure 2 shows the observation error correlation for AMDAR (Aircraft Meteorological DAta Relay). In JNoVA, the estimated observation error is smaller than the current observation error estimated under the hydrostatic Meso 4D-Var system. Accordingly, the conventional observation error was investigated along with an experiment for estimated radiosonde observation error. In addition, the thinning distance of AMDAR was estimated along with an experiment in which a two-layer thinning distance was employed, and values of 60 km for reports above 500 hPa and 15 km for those below 500 hPa were obtained.

3. Variational Quality Control

As a new way of ensuring quality, we developed variational quality control (VarQC; Andersson and Järvinen, 1999). The VarQC approach uses the probability density function (PDF) of observation in which the Gaussian function is changed to a statistically proper function considering rough errors in observation. The new PDF of observation (p^{QC}) is given as follows:

$$p^{QC} = (1 - A)N + AF \qquad (1)$$

$$N = \frac{1}{\sqrt{2\pi}\sigma_o}\exp\left[-\frac{(y_o - Hx)^2}{2\sigma_o^2}\right] \qquad (2) \qquad F = \frac{1}{2d\sigma_o}\text{, if } |y_o - Hx| < d\sigma_o\text{, otherwise } 0 \qquad (3)$$

where A is the prior probability of gross error, y_o is the observation, x is the model state, H is the observation operator, σ_o is the observation error's standard deviation, and d is the maximum number of standard deviations allowed for gross error.

Here, VarQC parameter A was estimated from a statistical study from April 7 to July 31, 2009, and d is defined as 5.0 according to Andersson and Järvinen (1999).

4. Improvement of forecast results

Experiments were performed over a one-week period with heavy rainfall during the Baiu season in 2009. Figure 3 shows the equitable threat score (ETS) of three-hourly accumulated precipitation forecasts for each precipitation threshold. This outcome demonstrates that the revised observation error and thinning distances of AMDAR and VarQC gave better results.

References

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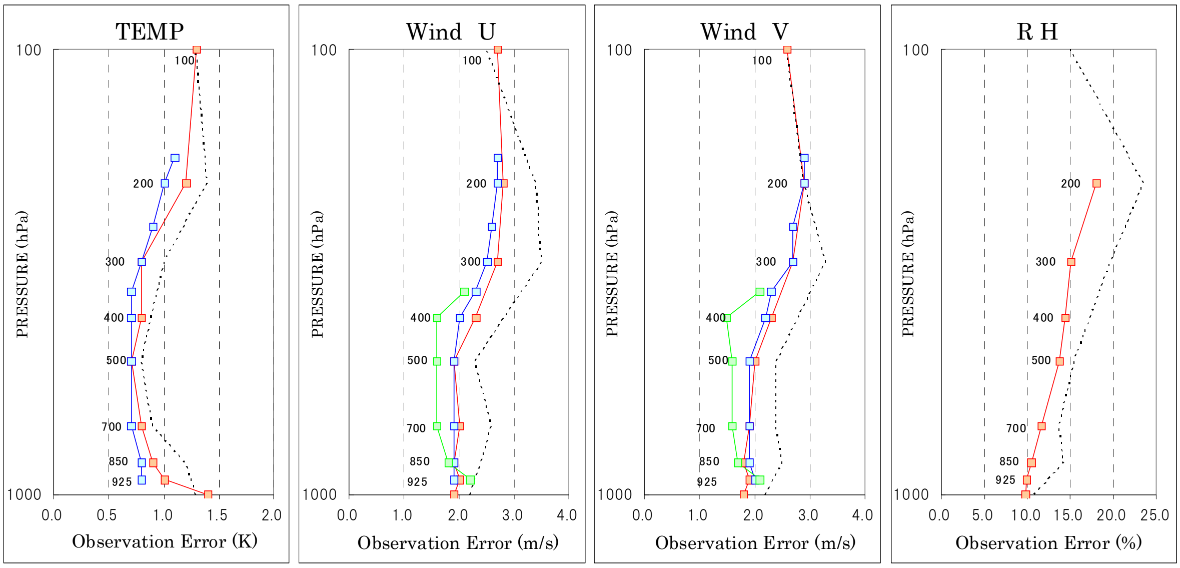

Figure 1: Estimated observation errors. The statistical period is from April 7 to July 26, 2009. The red lines are radiosonde values, the blue lines aircraft values, the green lines wind profiler values, and the dashed lines show the observation error currently used in JNoVA.

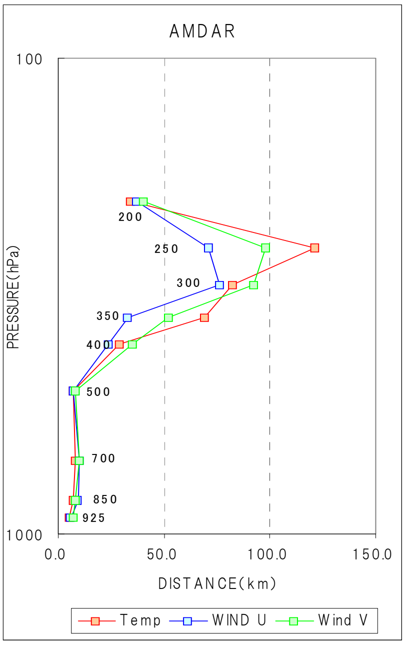

Figure 2: Estimated observation error correlation. The statistical period is from April 7 to July 26, 2009. The red line is for temperature, the blue line is for U-component wind, and the green line is for V-component wind.

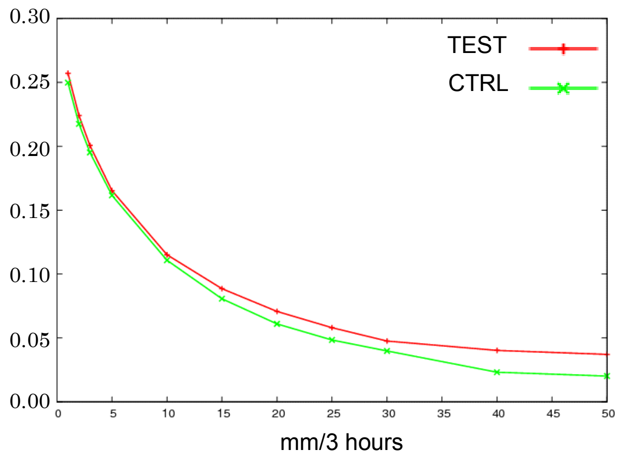

Figure 3: Equitable threat scores for three-hourly accumulated precipitation forecasts. The red and green lines show the results for TEST and CTRL, respectively. The horizontal axis is the threshold value of the rainfall amount.