A Stochastic physics scheme for model uncertainties in the JMA one-week Ensemble Prediction System

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1 Introduction

Since 2001, the Japan Meteorological Agency (JMA) has operated the one-week Ensemble Prediction System (WEPS). On 16 December, 2010, it began employing a stochastic physics scheme as a model ensemble method and reduced the amplitude of the initial perturbations over the Tropics. This paper outlines and reports on the performance of the new WEPS.

2 Implementation of a stochastic physics scheme into JMA's WEPS

In the current WEPS, the Singular Vectors (SVs) method (Buizza and Palmer, 1995) is used as the initial perturbations generator. Table 1 outlines the specifications of the SVs method in the WEPS.

Table 1: Specifications of the initial perturbations generator.

	Northern Hemisphere	Tropics
Targeted region	30°N-90°N	20°S-30°N
Resolution of tangent-linear and adjoint model	T63L40	
Physical processes	Initialization, horizontal diffusion, surface and vertical turbulent diffusion	Full physics processes
Optimization time	48 hours	24 hours
Norm	Moist total energy	
Amplitude of initial perturbation	12% of the climatological temperature variance at the 500hPa level	24% of the climatological temperature variance at the 850hPa level

The stochastic physics scheme (Buizza et al., 1999) was newly introduced into the operational WEPS. This scheme represents random errors associated with parametrized physical processes as follows:

$$\frac{\partial \mathrm{x}}{\partial t} = F(\mathrm{x}) + \alpha(\lambda, \phi, \mathrm{t})\mathrm{P}(\mathrm{x})$$

where t, x, F(x) and P(x) are the time, the set of forecast variables, the total tendency of the forecast model and the tendency of the parametrized physical processes, respectively. λ and ϕ show latitude and longitude; $\alpha(\lambda, \phi, t)$ is a random variable described in a spectral space (Berner et al. 2009), featuring spatial correlation with a total wave number of 20 and a time correlation of six hours. The average of α is set to zero. Its value is limited to the range from -0.7 to 0.7 to avoid excess perturbations, and its value in the stratosphere also is set to zero. The whole globe is perturbed by the scheme in initially perturbed forecasts. The unperturbed forecast is conducted without the stochastic physics scheme.

Concurrently with the introduction of model error perturbations, we also reduced the amplitude of the initial perturbations from 28% to 24 % of the climatological temperature variance at the 850hPa level over the Tropics (20°S-30°N). This modification was employed to reduce the occurrence of unrealistic initial states of specific humidity over the region.

3 Performance of the new WEPS

To assess the performance of the new WEPS, preliminary experiments were carried out for boreal summer and winter. Hereafter, the experiments with and without the stochastic physics scheme are referred to as WITH and W/O respectively. Figure 1 shows the spread and root mean square error (RMSE) of the experiments over the Tropics (20°S-20°N) in August 2007. The spread of temperature at the 850 hPa level (T850) in WITH increases greatly over the Tropics (Figure 1(a)) in comparison to that of W/O. Figures 1(b) and 1(c) also show that the ratio ($\frac{m+1}{m-1}\frac{spread^2}{RMSE^2}$, where m is the number of members) of WITH is also closer to one than that of W/O. These impacts result from the introduction of model error perturbations and the alleviation of the inadequacy of spread to RMSE. Figure 2 shows the receiver operating characteristic (ROC) area and the Brier skill score (BSS) for the probability of casess in which the T850 anomaly over the Tropics is larger (i.e., high temperature events) and smaller (i.e., low temperature events) than 1.5 and -1.5 times of climatological standard deviation. The verification period is the same as that for Figure 1. For high-temperature events, both the ROC and BSS of WITH are superior to W/O for all forecast times. For low-temperature events, the improvement of WITH is more obvious after forecast time of 24 hours. In winter, WITH also shows better BSS values than W/O (not shown).

The results indicate that the new WEPS has positive impacts on both deterministic and probabilistic forecasts especially in the summer season.

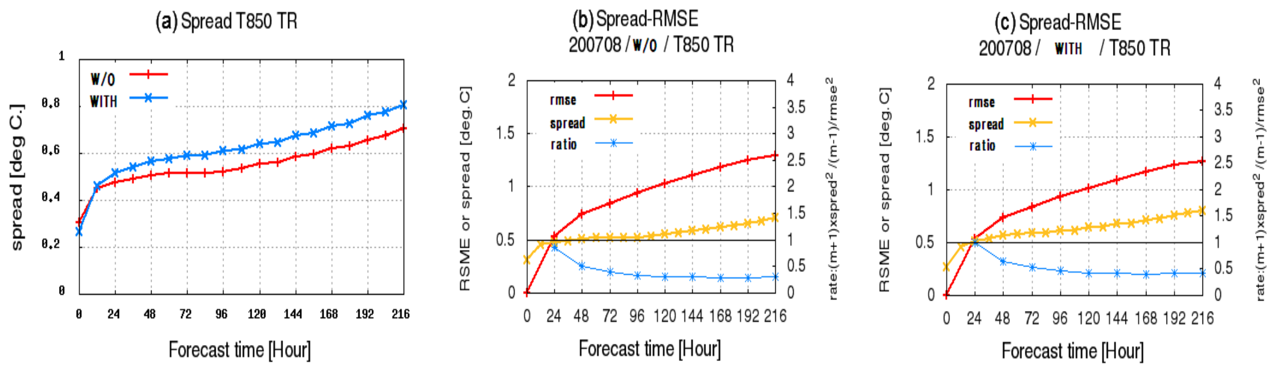

Figure 1: (a) comparison of spread and RMSE for the Tropics (20°S-30°N) between the two experiments in August 2007, (b) relationship of spread (yellow line) and RMSE (red line) and their ratio (blue line) of T850 over the Tropics for WITH, (c) same as (b) but for W/O. The ratio is defined as $\frac{m+1}{m-1}\frac{spread^2}{RMSE^2}$ where m is the number of ensemble members.

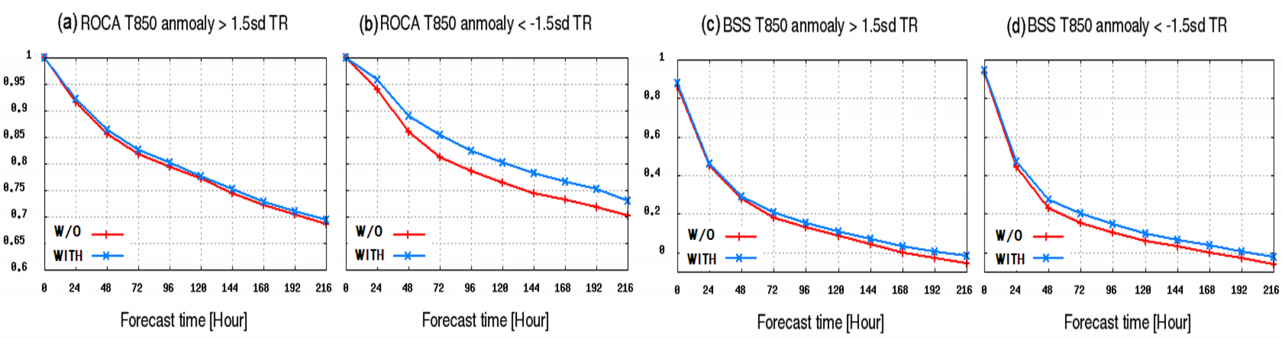

Figure 2: ROC area for the probability of T850 anomalies (a) above 1.5 and (b) below -1.5 times of climatological standard deviation over the Tropics (20°S-20°N) in August 2007 . (c), (d) same as (a), (b) but for Brier skill score.

References

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