Evaluation of the SKEBS impact on WRF-based mesoscale ensemble prediction system

Chih-Hsin Li [1], Jing-Shan Hong [1], AND Xing-Qin Fang [2]

[1]Central Weather Bureau, Taiwan, AND [2] National Center for Atmospheric Research, Boulder, Colorado

1. The ensemble prediction system

The performance of a WRF based ensemble prediction system (EPS) through the stochastic kinetic energy backscatter scheme (SKEBS) is presented in this study.

The model version was V3.3.1 and was configured as three nested domains with horizontal resolution of 45/15/5-km (Fig. 1) and 45-levels in the vertical. This study only shows the results of the outermost domain.

There are 20 members with perturbations from initial condition, boundary condition and model physics. The random perturbation from the WRF 3DVAR background error covariance was then applied on the control analysis to create initial condition perturbations. The boundary perturbations were from the NCEP Global Ensemble Forecast System. In addition, the model perturbations were produced by different methods in this study.

2. Experimental design

Three model-error schemes for EPS were used in this study. The first one (MP) used multiple model physics, and the detailed configuration about the physical package was given Table 1. The second one (SKEB) only used the SKEBs with single model physics; the third one (S+M) used multiple model-error scheme which combine the SKEBS and multi-physics parameters. During the experiment period 1 June – 15June 2012 was reported here.

In addition, the forth experiment (Tune-S+M) used the same configuration with the third one, except the different setting of parameters of SKEBs (Table 2).

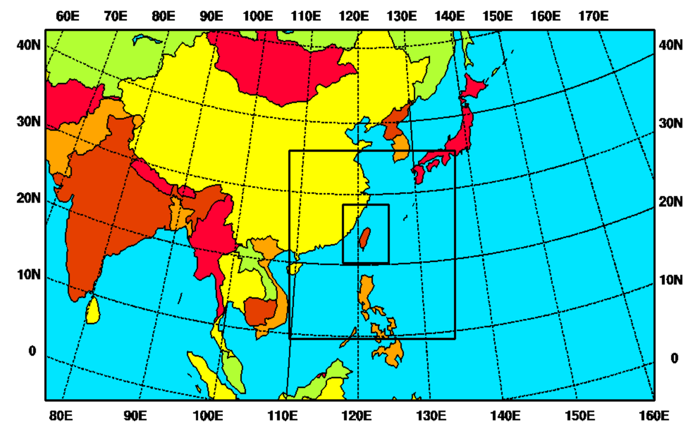

Figure 1. The coverage of the model domains

Table 2. The Setting of the parameters of SKEBS

	Control amplitude of rotational wind perturbation	Control amplitude of temperature perturbation
SKEB And S+M	0.6e-6	0.6e-5
Tune-S+M	0.4e-6	2.0e-5

Table 1. The combination of the 20-model physics suite.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cumulus scheme	Grell	Tiedtke	Betts-Miller	New KF	Tiedtke	Old SAS	New SAS	Grell	Tiedtke	New SAS	Tiedtke	Betts-Miller	New KF	Tiedtke	Old SAS	New SAS	Grell	Tiedtke	New SAS	Grell
PBL	YSU	YSU	MYJ	MYJ	MYJ	MYJ	MYJ	ACM2	ACM2	ACM2	YSU	MYJ	MYJ	MYJ	MYJ	MYJ	ACM2	ACM2	ACM2	YSU
Micro-physics	Goddard	Goddard	Goddard	Goddard	Goddard	Goddard	Goddard	Goddard	Goddard	Goddard	WSM5	WSM5	WSM5	WSM5	WSM5	WSM5	WSM5	WSM5	WSM5	WSM5

3. Results

The performances of first three experiments were shown in Fig. 2. The figure shows the S+M/MP experiment can get the largest/smallest spread. It indicates applying SKEB scheme is able to improve the spread. Besides, accuracy of MP is the best. Compare to the root mean square error between experiments of MP and S+M, the performance of root mean square error are similar. It shows the accuracy of the ensemble system is dominated by the configuration of the multi-physics parameters. Among the three experiments, the S+M gives the best spread–error relationship.

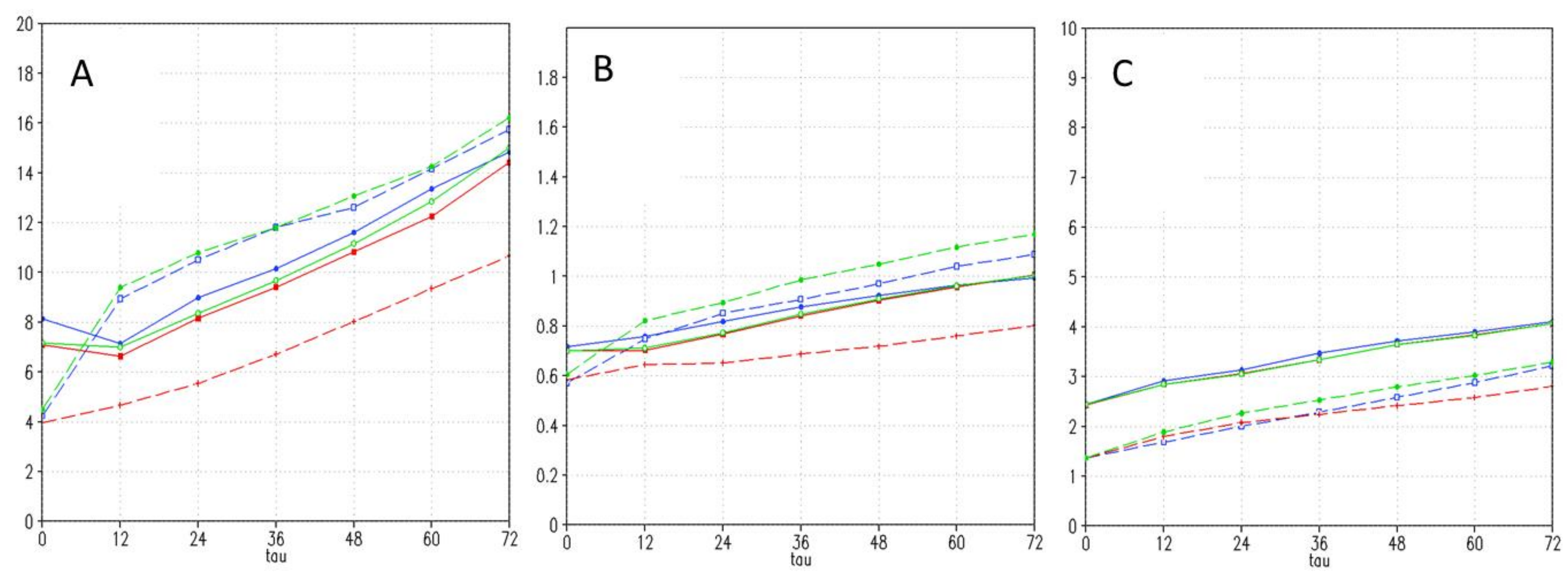

Figure 2. RMSE and spread of MP (red line), SKEB (blue line), and S+M (green line) for 500 hPa geopotentail height (A), 850 hPa temperature (B), and 500 hPa meridional wind (C). The solid line is the RMSE, and the dash line is spread of the forecast.

However, the spread of S+M still have room to improve. The spread of geopotential height and temperature are over-dispersed, and the spread of wind is too small. So the tuning tests were conducted with smaller amplitude of temperature perturbations and larger amplitude of rotational wind perturbations . The performance of the tuning test was shown in Fig. 3. The spread of geopotential height and temperature can reduce, and the spread of wind is increase. Tuning the parameter of amplitude of perturbations can really optimize the spread-error relationship.

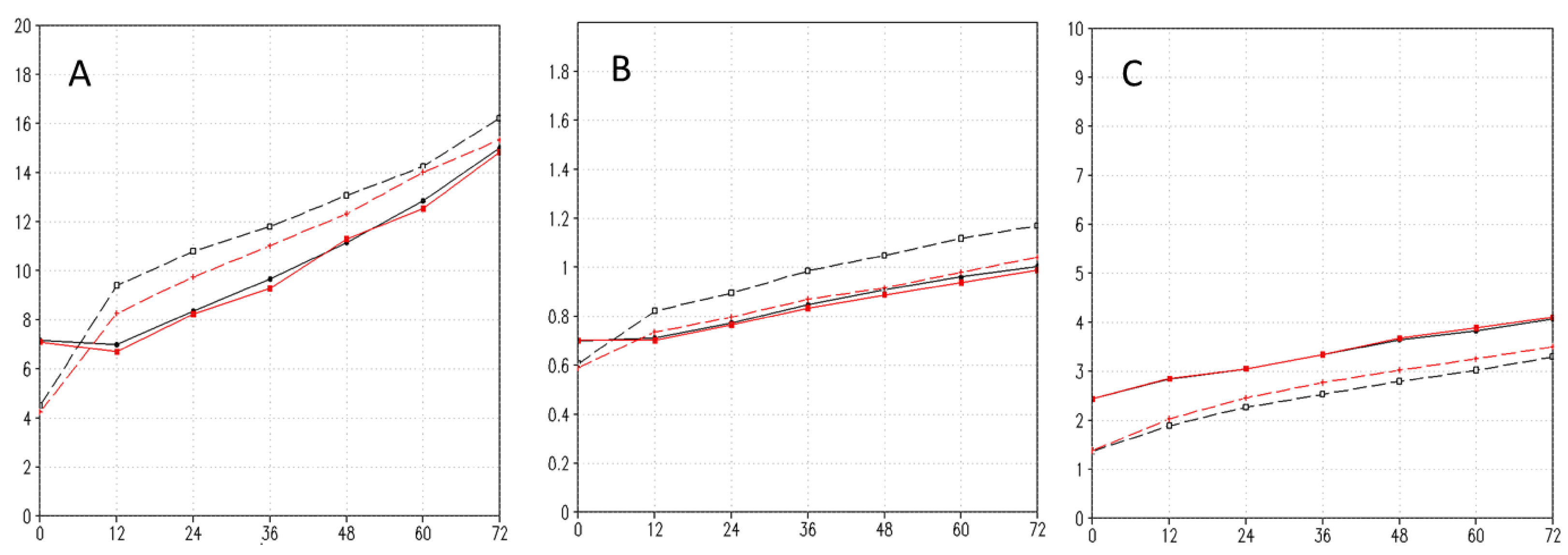

Figure 3. Same as Fig. 2 but for S+M (black line) and Tune_S+M (red line). .

4. Summary

This research evaluates the performance and uncertainty of a WRF based ensemble prediction system (EPS) through the stochastic kinetic energy backscatter scheme (SKEBS). Three model-error schemes for EPS over subtropical area were evaluated, including multi-physics parameters, SKEBS and a multiple model-error scheme which combine the SKEBS and multi-physics parameters.

The results shows that the applying the SKEB scheme is able to improve the spread, and the multiple model-error schemes gives the best spread–error relationship. However, the spread of multiple model-error scheme still has the room to be improved. By increasing the amplitude of temperature perturbations and reducing the amplitude of rotational wind perturbations, the spread-error relationship was improved. This study demonstrates the success of the proposed ensemble prediction system with SKEB scheme, and in advance shows the role and importance of the parameters in SKEB scheme.

5. Reference

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