Comparison of precipitation forecasts from MM5, WRF-ARW and WRF-NMM over the Korean Peninsula during summer season

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1. Introduction

In spite of geographical similarity, mechanisms for rainfall over the Korean Peninsula differ in several ways from the convective system which occur over the US (Hong 2004). Several researches related to comparison of impacts of mesoscale dynamic cores over the US have been performed (Gallus 2006). But there are few studies including both WRF-ARW and WRF-NMM over the East Asia. We built the multi-model ensemble prediction system with the members using MM5, WRF-ARW and WRF-NMM. We compared the precipitation forecasts during the summer season (June – August) of 2006.

2. Ensemble Members

The short-range multi-model ensemble prediction system was built with the 16 members constituted from MM5 version 3.6.3, WRF-ARW version 2.1.2 and WRF-NMM version 2.1.2 (Grell 1995; Skamarock 2005). A few members of MM5 used the microphysics and planetary boundary layer schemes of WRF-ARW physics. Each member was run with the initial and lateral boundary conditions provided by the NCEP Final Analysis (FNL) data except two members. M4 and M6 used the analysis data from Local Analysis and Prediction System (LAPS). Table 1 summarizes detail characteristics of the different physics configuration utilized to construct the ensemble members.

3. Numerical Experiments

The model grid resolution of this study is 18km with a mesh of 210×181 in the horizontal and 35 levels in the vertical and the model top is 50 hPa. Because WRF-NMM has Arakawa E-grid system, we configure different horizontal mesh including previous domain for the members of WRF-NMM.

The model domain with topography is illustrated in Fig. 1a. The verification of modeled rainfall has been performed with precipitation observed by a rain gauge network (Fig, 1b). The number of rain gauge stations is 592 and the average distance of stations is about 18 km.

The Relative Operating Characteristic Curve (ROC) measures the ability of a probabilistic forecasting system to discriminate between situations preceding the occurrence and the non-occurrence of an event of interest (Wilson 2000). ROC curve illustrates the distribution of HR (Hit rate) and FAR (False Alarm Rate) for each probability interval. HR measures the fraction of observed events that were correctly forecast and FAR is the measure of false alarm given the event did not occur:

$$HR = H / (H + M), \quad FAR = F / (F + R) \quad (1)$$

where H, M, F, R represent hit, miss, false, rejection respectively. The precipitation forecasts are verified for a few thresholds.

4. Results and Discussion

Fig. 2 shows the ROC curves of ensemble probabilistic forecast for 6-hour accumulated precipitation for thresholds (a) 1 mm, (b) 5 mm, (c) 10 mm, and (d) 25 mm. The areas of ROC curves are over 0.78 for threshold 25 mm as well as over 0.8 for thresholds 1 mm, 5 mm and 10 mm. The result shows that the ensemble probabilistic forecast has better skill score. For model core, the WRF-ARW members have the better skills than others.

The differences between HR and FAS of each member for threshold 1 mm and 25 mm are shown in Fig. 3. For threshold 1 mm, ensemble forecast has the great difference. W2 has the biggest difference and M2 has the least skill between members. The skill decreased as the threshold values increased. For threshold 25 mm, ensemble mean forecast's skill is below a few members. Because ensemble mean has the smoothing effect, ensemble mean cannot increase the skill for heavy precipitation.

Although the members of each model does not same, the differences of WRF-ARW models are bigger than other model core. W1 and W4 have better skill for both light rainfall and heavy rainfall events.

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References

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Table 1. Ensemble member characteristics.

member	Model	Microphysics	Cumulus	PBL	LAPS
M1	MM5	Schultz	KM2	YSU	
M2		WSM5	BM	MY	
M3		WSM5	KF2	YSU	
M4		WSM5	KF2	YSU	O
M5		WSM5	KF2	YSU	
M6		Schultz	KF2	YSU	O
W1	WRF-ARW	WSM3	BMJ	MYJ	
W2		WSM3	KF2	YSU	
W3		WSM5	KF2	YSU	
W4		WSM5	BMJ	MYJ	
W5		WSM5	KF2	YSU	
W6		WSM5	NOC	YSU	
W7		Ferrier	BMJ	MYJ	
N1	WRF-NMM	Ferrier	BMJ	MYJ	
N2		Ferrier	KF2	MYJ	
N3		Ferrier	SAS	MYJ	

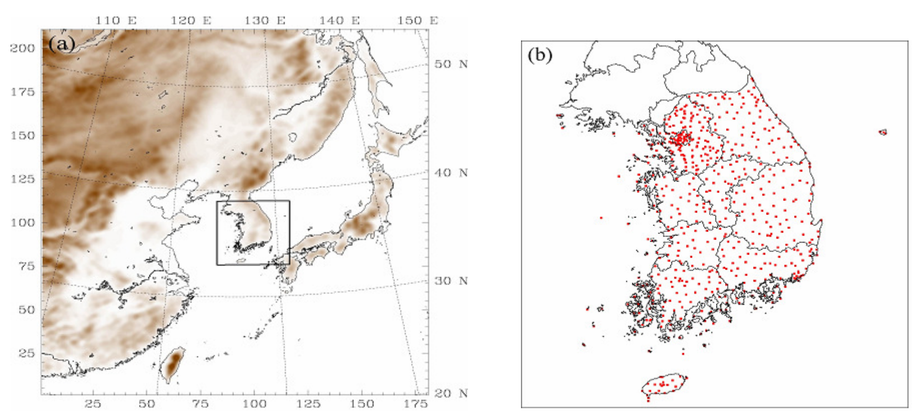

Fig. 1. (a) Domain configuration with topography. The inner box indicates the verification area. (b) The location of the rain gauge stations in Korea used for the QPF verification.

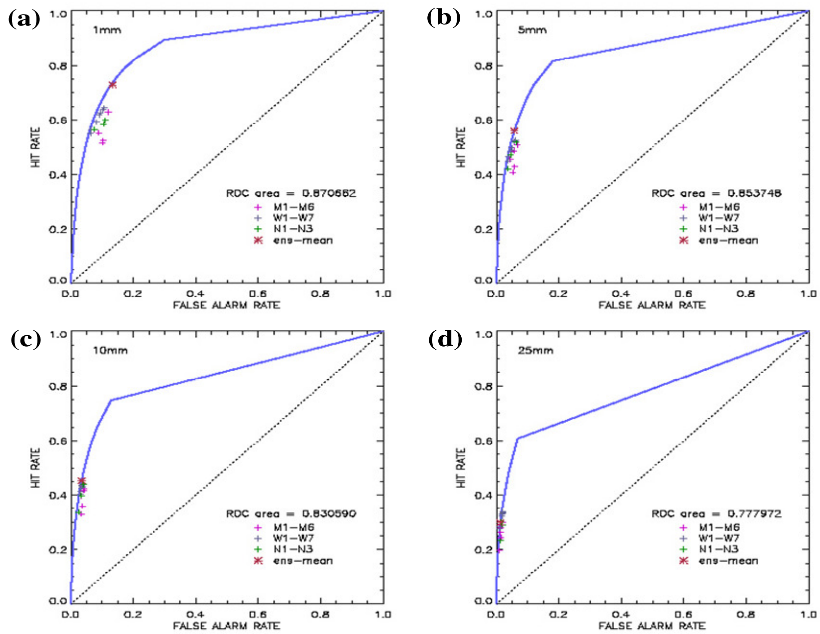

Fig. 2. ROC curves for 6-hourly accumulated precipitation exceeding (a) 1 mm, (b) 5 mm, (c) 10 mm, and (d) 25 mm for the ensemble probabilistic forecast. The symbols indicate ensemble mean and individual members**.**

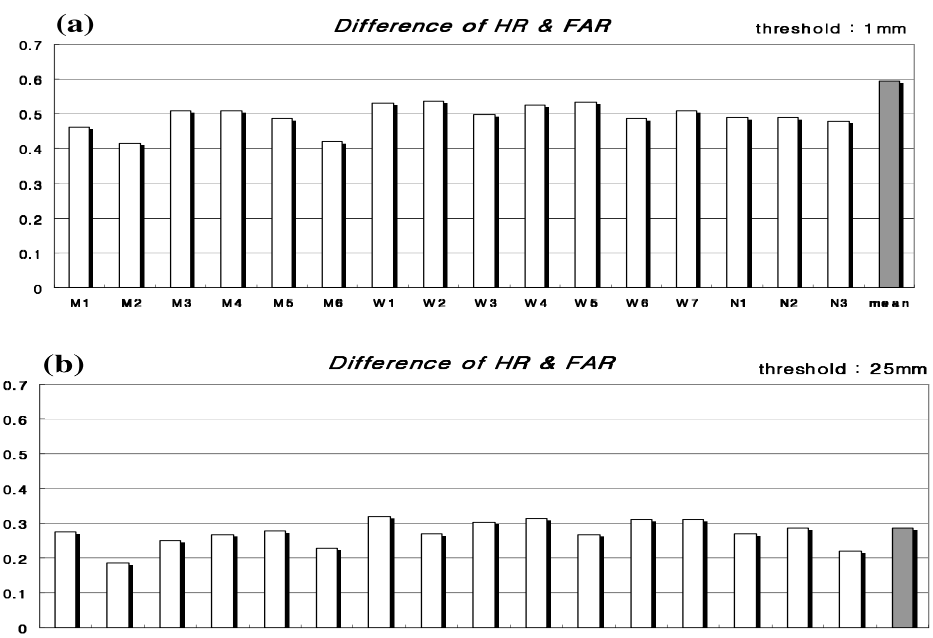

Fig. 3. Differences between HR and FAR for 6-hourly accumulated precipitation exceeding (a) 1 mm and (b) 25 mm for the ensemble mean and individual members**.**