Precipitation Predictability of MM5 in the Simulation of Heavy Rainfall over Korea

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1. Introduction

In the heavy rainfall prediction in Korea, one of major deficient components is lack of mesoscale data for the model initial conditions. However, potential predictability of MM5 in heavy rainfall simulations can be estimated using synoptic-scale data such as the NCEP/NCAR reanalysis, because mesoscale models using sophisticated physical processes have potential ability to evolve internal variability of mesoscale features under synoptic-scale situation. Using the NCEP/NCAR reanalysis data the MM5 model has reproduced, to a certain degree, the amount and pattern of heavy rainfall through the simulation of heavy rainfall cases over Korea (Lee et al., 2001). One of the issues would be how much quantitatively reproduce intense precipitation. Cumulus parameterization schemes (CPSs) and grid-scale resolvable schemes (GRSs) in the MM5 have showed successful performances in specific convective environments through case studies. However, the general applicability of physical process schemes in a mesoscale model to intense precipitation in heavy rainfall events is still uncertain. Wang and Seaman (1997) conducted a comparison study of four CPSs. Yang and Tung (2003) tested the same four CPSs for six heavy rainfall cases occurring over Taiwan. Lee et al. (2001) compared four CPSs in different horizontal resolutions with four heavy rainfall cases over Korea in the monsoon season.

The objective of this study is to investigate precipitation predictability and CPS performance of the MM5 through the simulations of thirty heavy rainfall events occurring over the Korean Peninsula during the summer monsoon season.

2. Experiments

The model domains of 30- and 10- km horizontal resolutions are nested in the model domains of 90 km and 30 km, respectively. The model of 10-km horizontal resolution starts integration with the 12-h forecast data of the 30-km horizontal resolution model for initial data. The NCEP/NCAR reanalysis data are reanalyzed on the model grids using observed sounding data. For this study, 30 heavy rainfall cases are randomly chosen out of 377 heavy rain cases occurring over the Korean Peninsula during the period of 1980-2003.

The CPS schemes chosen for this study are the Anthes-Kuo scheme (AK: Grell et al, 1994), the Betts-Miller scheme (BM: Betts and Miller, 1986), the Grell scheme (GR: Grell et al, 1994), and the Kain-Fritsch scheme (KF: Kain and Fritsch, 1993), and two GRSs chosen are the explicit moisture scheme with the simple ice-phase scheme and the mixed-phase ice scheme. The Eta model PBL scheme and the Blackardar high resolution PBL scheme are used for the planetary boundary layer. The four CPSs are combined with each of two GRSs and two PBLs, respectively, to examine the appropriate combinations between various physical processes in the simulations of heavy rain cases. No scheme does not use any CPSs in this study. The differences between the horizontal grid resolutions of 30 and 10 km are also examined. Hence, we have 40 simulations for each heavy rainfall case and the total number of simulations is 1200.

3. Results

The results show that the rainfall amount at the maximum rainfall grid point are about 60 % observed rainfall amount in the 30 km resolution and about 70 % in the 10 km horizontal resolution. The location error of maximum rainfall is 150 km in both horizontal resolutions (Figure 1). Increased horizontal resolution does not increase accuracy of the maximum rainfall location. The maximum rainfall location slightly shifts northward. This is related to overestimated low level southerly or southwesterly wind compared to observation. The model simulates better prediction of the area-averaged rainfall, and about 10% accuracy is also increased using the 10 km horizontal resolution (Figure 2). The time series of ratio of simulated area-averaged rainfall to observed rainfall amount for all 30 cases is shown in Figure 3. The area-averaged rainfall in both horizontal resolutions tends to follow observation with

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less rainfall amount. The accuracy in the 10 km resolution increases about 5 % in the 3 hourly accumulated area-averaged rainfall.

The impact of horizontal resolution on the performance of the combined sets of physical processes schemes also varies from scheme to scheme. The simulated rainfall is most sensitive to CPSs and more sensitive to PBLs than GRSs except in NO. Generally, results from the 10 km resolution give better rainfall amount, and the differences between the 10 km and 30 km results are largest in NO. The time series of 3-hour accumulated rainfall at the maximum grid point are shown in Figure 4. Most of CPSs show similar time trend of observation especially in 10 km resolution. The simulated rainfall of AK and GR schemes are better than other CPSs in the 30 km resolution. NO scheme shows good performance in terms of rainfall amount in both resolutions, but its accuracy decreases rapidly in 10 km resolution. The 10 km simulation results show better performances in terms of time change of maximum rainfall than that of 30 km.

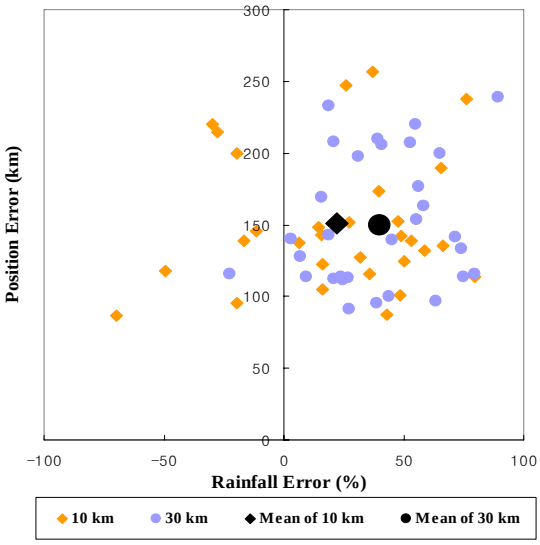

Figure 1. Errors of maximum rainfall location and amount.

Acknowledgments

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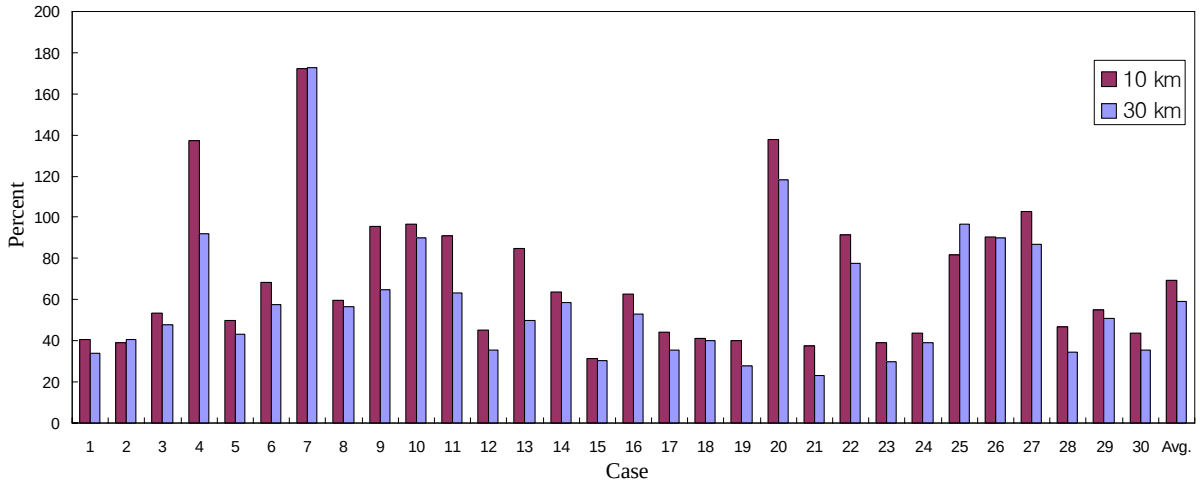

Figure 2. Area-averaged rainfall amount normalized by observed rainfall amount over the southern Korean peninsula.

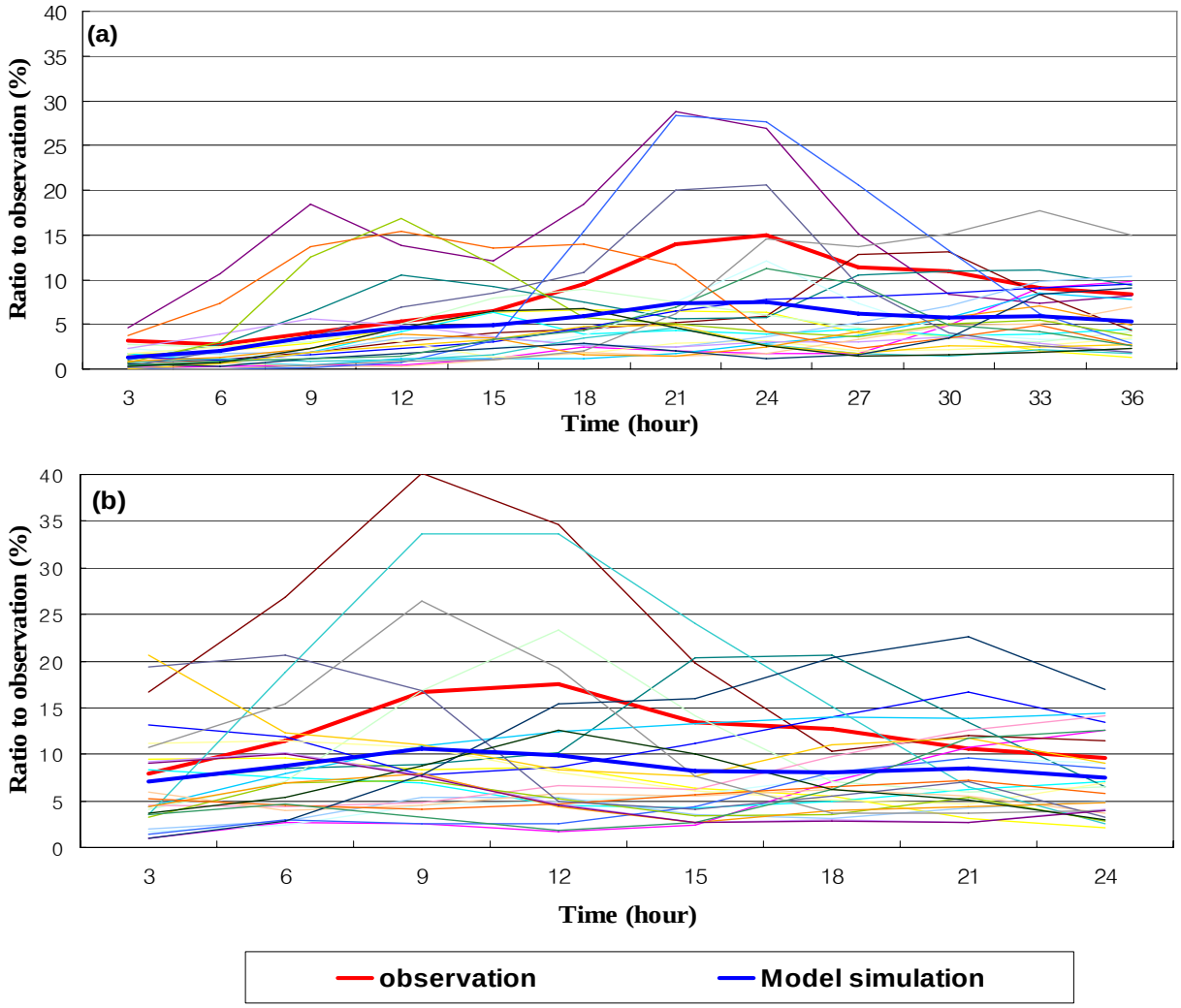

Figure 3. Time series of the ratio of simulated 3-hour area-averaged rainfall to total accumulated observed rainfall over Korea for (a) 30 km resolution and (b) 10 km resolution.

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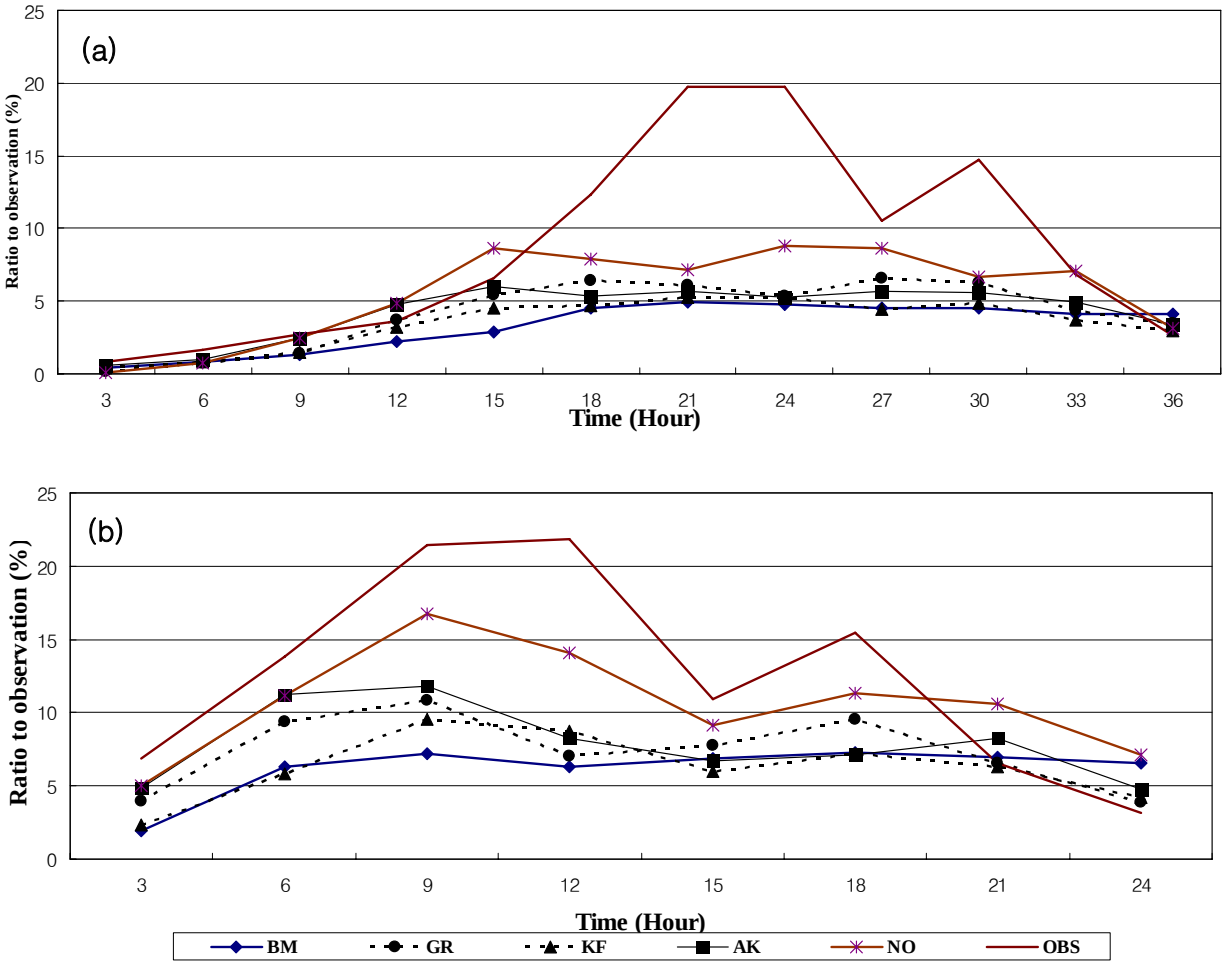

Figure 4. Time series of the ratio of simulated 3-hour rainfall to total accumulated observed rainfall at the maximum rainfall location for (a) 30 km resolution and (b) 10 km resolution.