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USE OF MM5 MODEL FOR WEATHER FORECASTING OVER BANGLADESH REGION

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ABSTRACT

The severity of weather appears almost every year in Bangladesh. It causes damage of property and takes a very high death toll due to absence of timely and proper forecasting facility. Thus the focus of this paper is to demonstrate the usefulness of weather model for forecasting and estimating convective system. A high resolution mesoscale model MM5 has been used in this regard to observe the accurate rainfall estimation over Bangladesh. The model is run at two nested domains at 45 km and 15 km resolutions for two durations i.e. 31 March to 05 April 2002 and 20 to 25 May 2002. In both the cases, results indicate that the MM5 model has a good capability to estimate rainfall over Bangladesh.

Key words: Weather model, precipitation, forecast, rain-gauge, radar.

I. INTRODUCTION

Bangladesh is a deltaic land at the end of the funnel shaped Bay of Bengal. This special geographical configuration results cyclones, floods, droughts, tornadoes, heavy rainfalls as common incidents. These weather phenomena depend upon the formation of convective clouds, which is measured by mesoscale used to describe systems that lie in between synoptic scale and local scale [1]. So, different structure of mesoscale convective systems (MCS) or precipitation systems gives the idea about the occurrence of severe weather [2].Therefore, it is very pertinent to quantify the convective clouds and precipitation. In view of this, the rainfall is being measured on instant basis using the weather radar of Bangladesh Meteorological Department (BMD) and 34 rain-gauges located at different places of the country. But we do not have means to estimate the upcoming precipitation or rainfall so that the people can be warned properly. Considering the necessity of estimating the precipitation systems developed in and around Bangladesh area, non-hydrostatic PSU/NCAR (Pennsylvania State University/National Centre for Atmospheric Research) mesoscale model MM5 [3-4] has been chosen to work with for simulation purpose. It has become one of the more widely used prognostic mesoscale models within the research community.

In this study, our main purpose is to find out a good forecasting means which will be helpful for flood forecasting, heavy rainfall estimation as well as early warning of harsh weather. In this regard convective systems for critical periods of April-May are simulated for the Bangladesh region using MM5 model. Output results from MM5 simulation are then compared to observed data such as Tropical Rainfall Measuring Mission (TRMM) 3B42RT products datasets [5], BMD rain-gauge and radar data for the assessment of confidence limit.

II. MODEL AND EXPERIMENTS

A. Model Description

The 5th generation PSU/NCAR mesoscale model (MM5) is a limited-area, non-hydrostatic and terrain-following sigma-coordinate model designed to simulate or predict mesoscale & regional scale atmospheric circulation [6]. Two way nested domains i.e. coarse domain (D1) of 45 km resolutions with grid cells 49×49 and fine domain (D2) of 15 km resolutions with grid cells 79×79 (Fig.1) have been prepared using MM5. These domains have covered the areas 12-30N; 80-100E for coarse grid mesh and 18-28N; 84.8-96.2E for fine grid mesh. The topography in the model has been obtained from six resolutions (1 degree, 30, 10, 5 and 2 minutes, and 30 seconds) USGS (United States Geological Survey) land cover data set. At the boundaries of the coarse domain, 1x1 degree resolution NCEP (National Center for Environmental Prediction) data have been provided at every 6 hrs as input. The model has then been run using the Anthes-Kuo [7] option for cumulus parameterization and MRF for the boundary layer parameterization [8]. The simple ice scheme of Dudhia [9] is employed for explicit treatment of moisture and water vapor. Cloud radiation interaction is allowed for radiation anticipation. Five layer soil option is used for soil temperature. The model is run with 24 sigma levels in the vertical from the ground to the 100 hPa top surface.

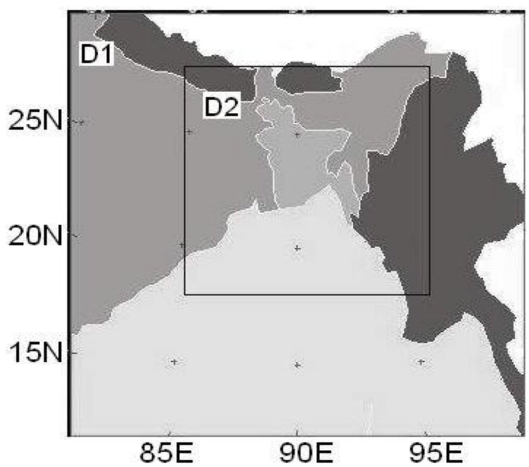

Fig 1: Simulated area of two domains D1 and D2

The time frames of simulation for two case studies are 00.00 UTC of 31 March to 18.00 UTC of 05 April 2002 and 00.00 UTC of 20 May to 18.00 UTC of 25 May 2002, i.e. the duration length for both the cases is 138 hours. Precipitation outputs of MM5 have been generated at one hour intervals and processed using Grid Analysis and Display system (GrADS) software for visual and calculation purpose.

B. Observational data and experimental method

For both the time slots the precipitation outputs of MM5 for D2 have been compared structurally and numerically with the observed data TRMM 3B42RT. Mentionable that the TRMM 3B42RT is Real-Time (RT) Multi-Satellite Precipitation Analysis data product [10].The data of 3-hour temporal resolution and a 0.25-degree by 0.25-degree spatial resolution in a global belt extending from 60 degrees South to 60 degrees North latitude is obtained from TRMM.

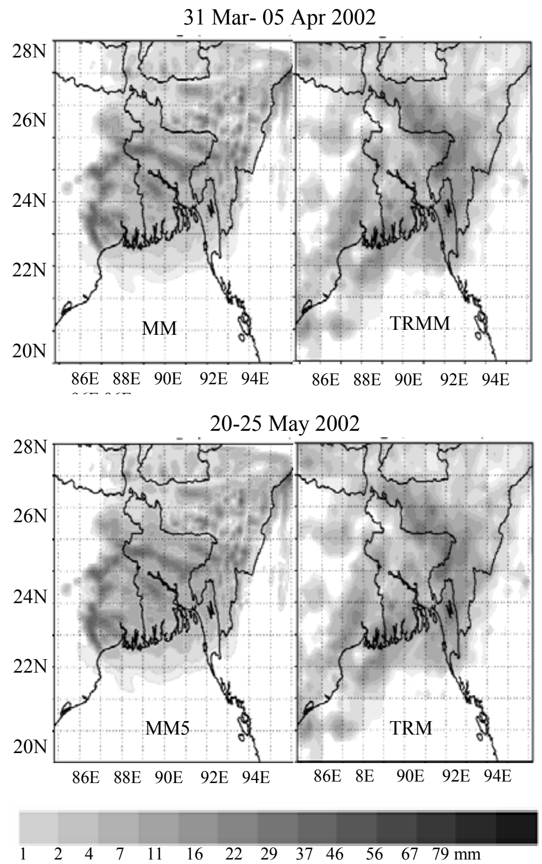

Fig 2: Structural Comparison of Average precipitation (mm/hr) simulated by MM5 with that of TRMM for D2

In the current study, 3 hourly rain-gauge data collected by BMD rain-gauge stations are utilized. MM5 generated precipitations have been extracted at all rain-gauge sites for D2 and they have been compared with the corresponding data collected by the BMD through rain-gauges.

Also PPI (Plane Position Indicator) scans of BMD radar on 20 may 2002 and MM5 generated figures for the same time frame are compared.

III. RESULTS AND DISCUSSION

A. TRMM Data vs MM5 Output

Figure 2 shows structural comparison on average precipitations (mm/day) simulated by MM5 with TRMM data product. Here the model has successfully displayed the correct pattern of precipitation distribution as to that of TRMM. The intensity of precipitation is not exactly the same in MM5 all over the country compared to TRMM, but MM5 can simulate precipitation very well in the northeast region of Bangladesh which is more significant. As NE area is one of the heaviest rainfall area of Bangladesh [11]

B. Rain-gauge vs MM5 Extract Data

The average rainfall measured by the rain-gauges for the period of 31 March to 05 April 2002 is found 2.308 mm. The precipitation at the same location points generated by MM5 is found 2.141 mm on average. Again for the period of 20 to 25 May 2002 the average rainfall observed by rain-gauges and simulated by MM5 stations are 2.24 mm and 3.040 mm respectively.

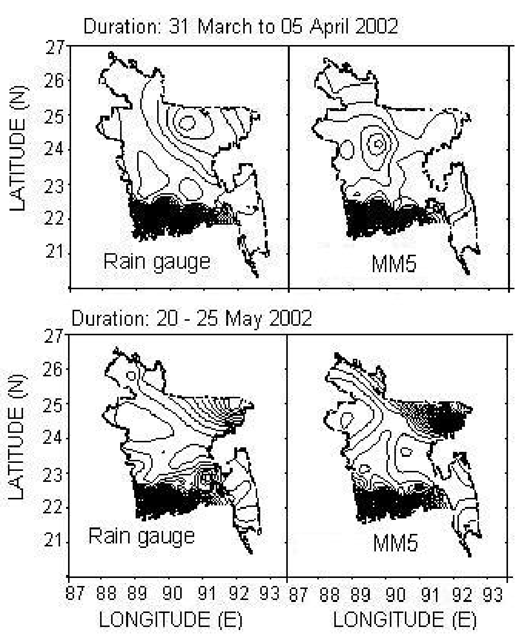

Fig 3: Comparison of MM5 outputs with rain gauge data

The observed data collected by the BMD rain-gauges have also been compared in structural form with the extracted values of MM5 options. The Figure 3 displays the spatial distribution of rainfall between the observed rain-gauges data and MM5 outputs for the same stations in both case studies. From these objective analyses MM5 results illustrate the closer value to Rain-gauges.

The graph of Fig 4 shows the rain gauge stations' precipitations. Here, the station wise numerical values indicate that MM5 can produce almost acceptable outputs; even it detects the peak very well for Khepupara and sylhet stations.

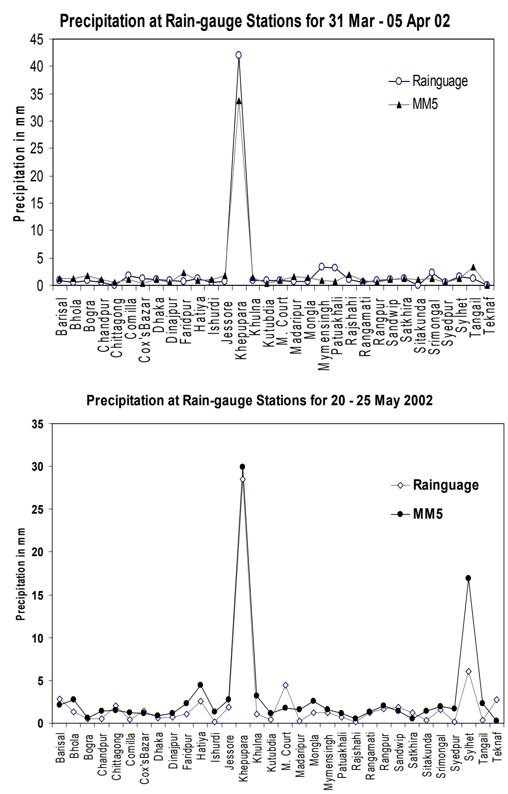

Fig 4: Station wise precipitations observed by rain-gauge and simulated by MM5

The correlation between rain-gauge data and model simulated rainfall are calculated. The correlation coefficients are 0.99 and 0.93 for two durations respectively (Figure 5), which indicates the very high level of consistency.

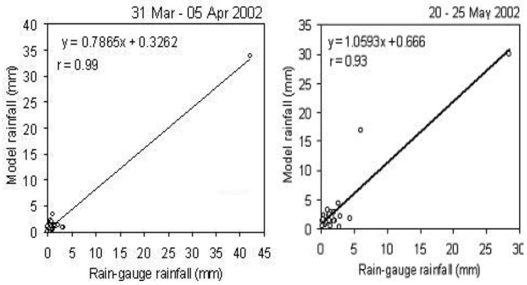

Fig 5: Correlation between the model output and rain-gauge data

C. Comparison with Radar

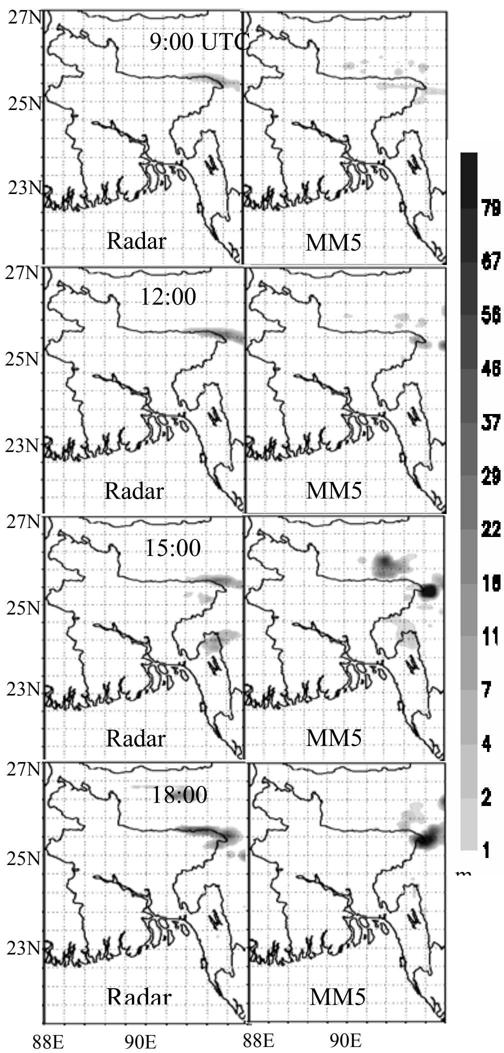

Fig 6: Precipitation observed by Radar and MM5 graphical output at different time on 20 May 2002

The comparison between PPI scans of radar and MM5 generated figures at 09.00, 12.00, 15.00, 18.00 UTC of 20 May 2002 is shown in Figure 6. From these pictures it is clear that MM5 gives almost similar cloud development as to the radar pictures.

IV. CONCLUSIONS

Non-hydrostatic mesoscale model MM5 is used to simulate rainfall for two durations of 138 hours each. The data have been collected every after one hour. These simulated precipitation outputs have been found structurally and numerically at par with the TRMM data product. The spatial distribution of the observed rain gauge data and MM5 outputs extracted at the locations of rain-gauges depicts a reasonable performance of MM5 model. Comparison of graphical outputs of MM5 with the available PPI scans of BMD radar for the cloud formation at different time also gives the similarity in the result. Considering the results of MM5 in comparison with TRMM, BMD rain-gauges and radar data it is evident that MM5 can simulate precipitation in well manner. So, it can be a good means for estimating and forecasting purpose for Bangladesh.

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