Real data simulation of a thunderstorm over Kolkata using RAMS

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1. Introduction

Thunderstorm is one of the most frequent severe weather systems that affect eastern and north-eastern states of India. Due to smaller spatial and temporal dimension, thunderstorms are generally not resolved by conventional synoptic observational network of India. Consequently the prevailing instability that triggers the development of the system is often absent in the initial analyses. Model initialized with such initial condition fails to simulate/predict the system. Keeping this in view, an attempt is made to study the impact upper air and surface data on the simulation of 14 July 1998 thunderstorm over Kolkata using RAMS. The upper air stations namely Kolkata, Ranchi and Patna are located in the Gangetic plains in a suitable distance (~250-300 km) and there are number of stations over the region which provides surface observations. Two experiments are carried out to simulate the storm. In one of the experiment GAME analyses (0.5 x 0.5 lat-lon) is used to initialize the model and in the other upper air and surface data are blended to enhance the initial condition and subsequently the model is initialized with enhanced input.

2. Methodology

RAMS version 4.30 is used to carry out the simulation experiments. RAMS is used with two way interactive nested grids of resolutions 16 km and 4 km as shown in Fig. 2. The grids are centered at 22.6^{o} N, 88.4^{o} E and the number of grid points for 16 km resolution is 68 x 68 in east-west and north-south direction and that for 4 km grid are 58 x 58. The numbers of vertical terrain following levels in both the domains are 36. The height of the top of the model domain is 25 km. The vertical levels are stretched in the ratio 1.1:100; 2000 which implies the first level will have a thickness of 100 m, the next level will be of thickness 110 m and so on till the level reaches the thickness of 2000 m. The Klemp and Wilhelmson (1978) radiative boundary condition is applied in the lateral boundary and Davies (1983) nudging is applied as upper boundary condition. A Modified Kuo convection scheme (Tremback, 1990) is used for the large scale precipitation and Bulk microphysics of Walko et al. (1995) is used for prognosing cloud constituents and grid scale precipitation. A two-stream radiation scheme developed by Harrington (1997) is used. It allows interaction of three solar and five infrared bands with model gas constituents and cloud hydrometeors. The horizontal and vertical eddy diffusion coefficients are computed as the product of the 3D rate-of-strain tensor and a length scale squared. The length scale is the product of the vertical grid spacing and a constant. The model is initialized with 14 July 1998 0000 UTC analyses and run in FDDA nudging mode till 0600 UTC of 14 July and subsequently run in forecast mode till 1800 UTC of 14 July 1998.

3. Discussion of results

In the first experiment (EXP-1) the GAME analyses is interpolated to RAMS 16 km grid and model is run in nudging mode for initial 6 hour and in the other experiment (EXP-2), model is initialized with enhanced input and run in similar manner as in EXP-1. Simulation experiments suggest that the incorporation of the upper air and surface data have significantly improved the initial condition in terms better representation of the thermodynamic instability prevailing over the region. Different thermodynamic instability indices derived from the enhanced input is found to be closely matching with the values derived from the RSRW data of the stations (Kolkata, Ranchi and Patna). Mainly due to this improvement the 12 forecast by EXP-2 has significantly improved in comparison to that of EXP-1. Fig-3 shows the hourly evolution of x-z cross section of wind (u, w) and total cloud condensate (g kg^{-1}). It is seen from Fig. 3 that at 6, 7 and 8 hour forecast the vertical motion and total cloud condensate has reached a maxima. The total cloud condensate distribution even shows an anvil shape which is typical to such thunderstorm. More over the location of the storm at maturity is better simulated by EXP-2. Fig.4 shows 12 hour accumulated forecast precipitation. The precipitation distribution, amount and location is reasonably well simulated as compared to the observation The observed station rain gauge report at Kolkata is 5 cm.

Figure 1

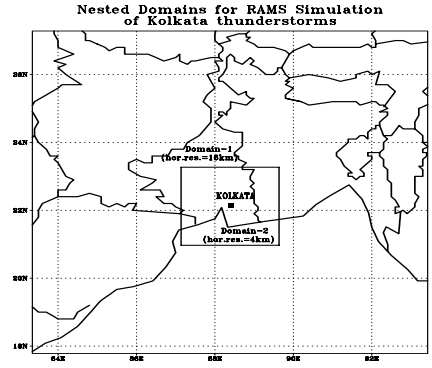

Figure 2

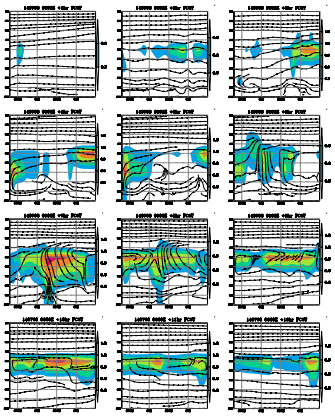

Figure 3

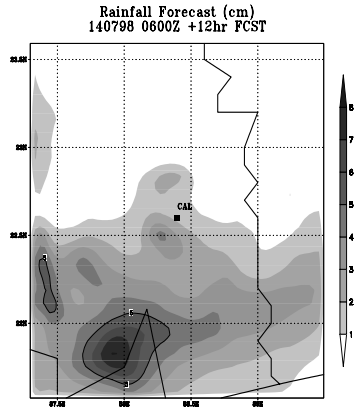

Figure 4

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