Composite characteristics of severe thunderstorms over Bangladesh simulated by WRF-ARW Model

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I. INTRODUCTION

Severe thunderstorms known as Nor'westers are among the most common natural phenomena in Bangladesh and adjoining northeastern parts of India, especially during pre-monsoon season. These systems are embedded within squall lines, which travel several hundred kilometres and cause high number of loss of life and property each year. Several hundreds people died and few ferries were capsized due to lightning and gusty winds triggered by the Nor'westers during the pre-monsoon season of 2008. These systems develop mainly due to merging of cold dry northwesterly winds and southerly low level warm moist winds from the Bay of Bengal. As the lifetime of these systems is only few hours, prediction of these systems is challenging using any conventional forecasting technique. These systems develop mainly due to merging of cold dry northwesterly winds and southerly low level warm moist winds from the Bay of Bengal. As the lifetime of these systems is only few hours, prediction of these systems is challenging using any conventional forecasting technique.

II. DATA AND METHODOLOGY

Advanced Research WRF (ARW) model, developed by the National Centre for Atmospheric Research (NCAR) of USA is utilized to simulate Nor'wester events in and around Bangladesh. NCEP-FNL data is utilized as initial and lateral boundary conditions (LBCs) at six hourly intervals. Domain is selected to cover the whole Bangladesh at 9 km horizontal resolution and 27 vertical sigma levels. Kain-Fritch cumulus parameterization scheme is used for simulating all the events. Similarly, surface layer is treated using Monin-Obukhov with Carslon-Bolan viscous sub-layer option and boundary layer is treated with Yonsei University scheme.

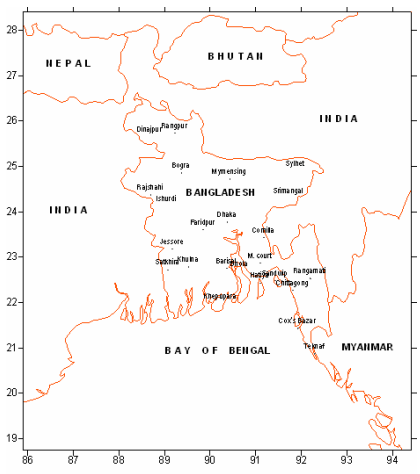


FIG. 1: Map showing meteorological stations in Bangladesh.

III. RESULTS AND CONCLUSIONS

About 15 Nor'wester events observed over Bangladesh and it's surrounding, during pre-monsoon season in 2008, were selected for the study. Rainfall rates (mm/h) of selected events, derived from Dhaka radar, are shown in Fig. 2. Figure 3 shows vertical structure of these events in terms of rainfall rate (mm/h) derived from 2A25 TRMM data. Selected Nor'wester events were simulated by WRF-ARW model to investigate the structure of the systems.

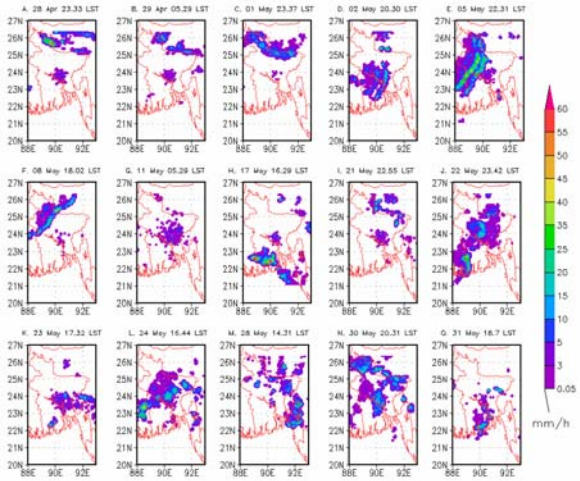


FIG. 2: Rainfall (mm/h) observed by Dhaka Radar during Nor'wester events.

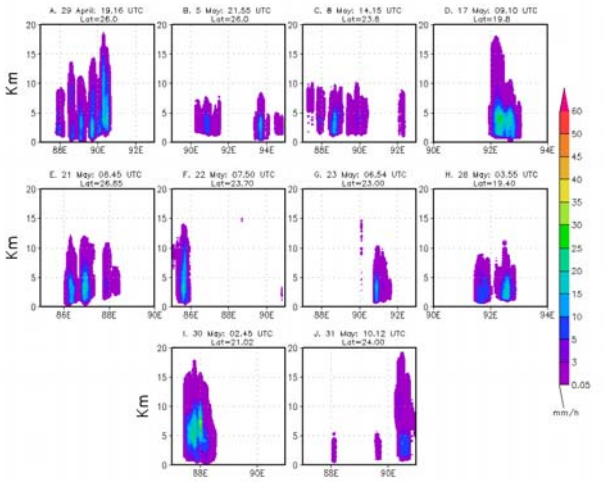
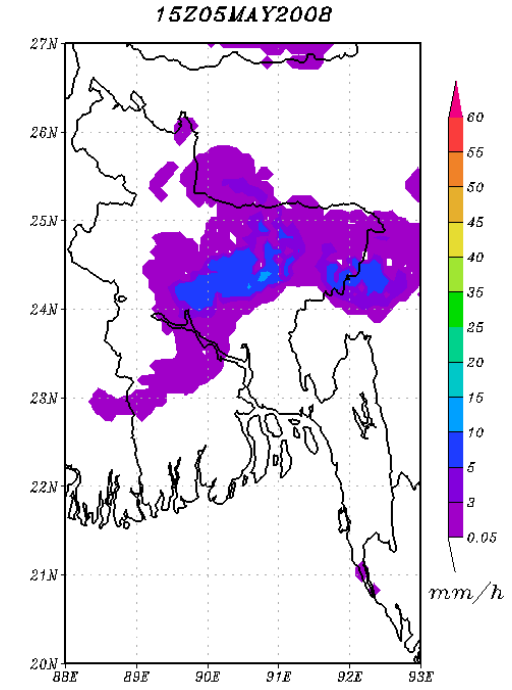


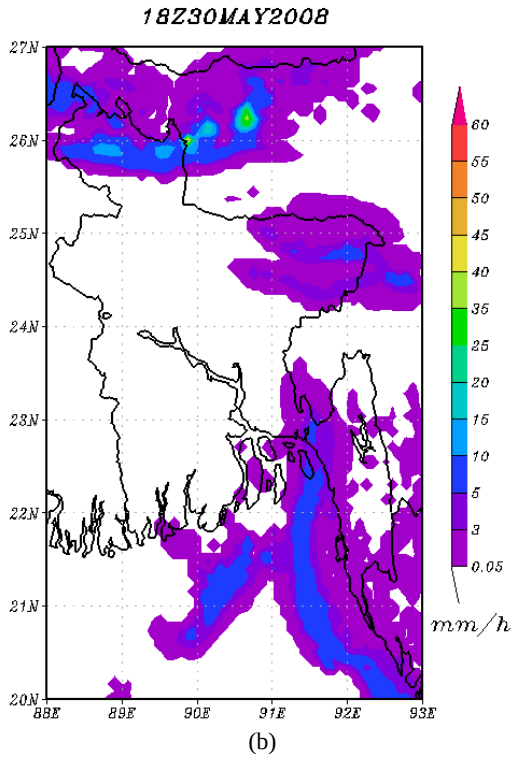
FIG. 3: Vertical structure of rainfall rate (mm/h) associated with Nor'westers derived from 2A25 TRMM data.

Model simulated Nor'wester events are shown in figure 4. WRF model is able to simulate the rainfall associated with the events with some spatial and temporal

shifting. Figure 4(a) shows model simulated rainfall pattern at 1500 GMT on 05th May 2008. It turns out that model underestimates the intensity of this event as it unable to simulates double-squall line shape system. Model simulated Nor'wester event on 30th May 2008 is shown in figure 4(b). Intensity of model simulation is somewhat comparable with the radar observation (Fig. 3). However it simulated with a temporal shifting of about 4 hours.



(a)



(b)

FIG. 4: Model simulated rainfall (mm/h) of Nor'wester events (a) 05th May 2008 (b) 30th May 2008.

Composite characteristics of 15 selected events are calculated (Table 1). It is interesting to see that the model simulated direction of movement, speed of movement and precipitation rate at the surface of the system is well comparable with the observations. However there are some differences of the characteristics simulated by the model with the observations.

Characteristics	Observation	Model
Cloud Top Altitude (km)	13.1	15.2
Altitude of Core precipitation (km)	3.6	7.3
Intensity of Core precipitation (mm/h)	21.3	107.8
Precipitation rate at surface (mm/h)	29.7	26.5
Direction of movement (°)	293	263
Speed of movement (km/h)	47.8	48.7
Maximum wind speed at surface (m/s)	20	7.1
Length of Squall line (km)	186.3	271.4
Updraft speed (max) (m/s)	NA	2.33
Downdraft speed (max) (m/s)	NA	0.36
Liquid water content (mg/m3)	NA	610

TABLE I: Composite characteristic of selected Nor'wester events.

IV. AKNOWLEDGMENTS

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