P-05

# Simulation of a Severe Thunderstorm and its Characteristics over Dhaka, Bangladesh Using WRF Model

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## Abstract

An attempt has been made to simulate a thunderstorm event which was occurred over Dhaka on 23 April 2020 using Weather Research and Forecasting (WRF-ARW version 4.2.0) model. The WRF model was run for 48 hours on a single domain of 09 km horizontal resolution utilizing six hourly Global Final (FNL) datasets from 0000 UTC of 22 April 2020 to 0000 UTC of 24 April 2020 as initial and lateral boundary conditions. The model has been run using Yonsei University (YSU) scheme as Planetary Boundary Layer (PBL), Kessler scheme for microphysics, Kain-Fritsch (KF) scheme for cumulus physics, Revised MM5 scheme for surface layer physics, Rapid Radiative Transfer Model (RRTM) for long wave radiation, Dudhia scheme for shortwave radiation respectively. One hourly model output is visualized by Grid Analysis and Display System (GrADS). The model performance is evaluated by analyzing Mean Sea Level Pressure (MSLP), temperature, Relative Humidity (RH), wind pattern at various pressure levels, vertical wind shear, latent heat, Convective Available Potential Energy (CAPE), and Rainfall and compared with the observed data of BMD. From the comparison it is found that the performance of WRF model is reasonably well to predict the thunderstorm event over Dhaka, Bangladesh.

Keywords: Thunderstorm, WRF-ARW Model, and CAPE.

## 1. Introduction

Nor'westers are severe thunderstorms that originate in the eastern and northwestern parts of Bangladesh during the pre-monsoon season, and travel from Northwest to Southeast direction. They are locally known as 'Kalbaishakhi'. The Nor'westers produces heavy rainfall, showers, lightning, thunder, hail-storms, dust-storms, surface wind squalls, down-bursts and tornadoes. They create lot of damage to properties and crops and, cause loss of life through strong surface wind, squalls, large hail, lightening and occasional tornadoes accompanyingthem. Thunderstorms constituent a family of severe local storms, which comprises events such as tornadoes, hail stones, strong surface wind speed (gust) and squally winds and flash floods [4], which may also include wind shear and turbulence. The `Nor'westers' are severe thunderstorms that form and move from northwest to southeast over the eastern and northeastern states of India during the pre-monsoon season, and are locally named as `Kal-Baisakhi' which means calamities in the month of Baishakh [2, 5]. Litta et al., [6] performed a simulation of a severe thunderstorm event using WRF-NMM model. Hu et al., [7] examined the sensitivity of the performance of the Weather Research and Forecast (WRF) model to the use of three different PBL schemes [MellorYamada-Janjic (MYJ), Yonsei University (YSU), and the asymmetric convective model, version 2 (ACM2)]. They found WRF simulations with di erent schemes over Texas in July-September 2005 shows that the simulations with the YSU and ACM2 schemes give much less bias than with the MYJ scheme. Mannan et al., [8] tried to examine the environmental conditions during severe thunderstorms in Bangladesh by using WRF model. Rahman et al., [9] examined the simulation of thermodynamic features of a thunderstorm event over Dhaka using WRF-ARW model

## 2. Objectives

The objective of my study is as follows:

- ✓ To simulate severe thunderstorm over Dhaka using WRF model
- ✓ Time and location specific TS Prediction
- ✓ To find out TS Characteristics

## 3. Methodology, Data Used and model set up

Weather Research and Forecasting (WRF) is a next generation mesoscale numerical weather forecasting community model. It has the potential to simulate meteorological phenomena ranging from meters to thousands of kilometers. Advance Research WRF (ARW) is a dynamic solver which is compatible with the WRF system to simulate broad spectrum of meteorological phenomena.

The NCEP high-resolution Global Final (FNL) Analysis data on 1.0°×1.0° grids covering the entire globe every 6-h were taken as the initial and lateral boundary condition. 30 sec United States Geological Survey (USGS) data (Interpolated depending on resolution) were used as Topography and 25 Categories United States Geological Survey (USGS) data were taken as vegetation/land use coverage. Grads is used to visualize the different graphics. Model set up is as follows:

```
WRF Version 4.2.0
wrf_core = 'ARW',
max dom = 2
e_we      = 127  (No. of grid points in WE direction)
e_sn      = 111  (No. of grid points in SN direction)
e_vert    = 38
time_step = 50
geog_data_res = '10m'
dx = 10000 m   (Horizontal grid resolution (m) in WE direction)
dy = 10000 m   (Horizontal grid resolution (m) in SN direction)
map_proj = 'mercator'
Input data = NCEP FNL
mp_physics = WDM5 microphysics scheme
cu_ physics = 3 Schemes (Kain–Fritsch (new Eta) Scheme, Betts–Miller–
              Janjic Scheme, Grell–Freitas ensemble Scheme)
pbl_physics   = Mass Flux(TEMF) Scheme
surface_physics = 5-layer thermal diffusion
ra_lw_physics   = RRTM Scheme
ra_sw_physics   = Dudhia Scheme
```

## 4. Result and Discussion

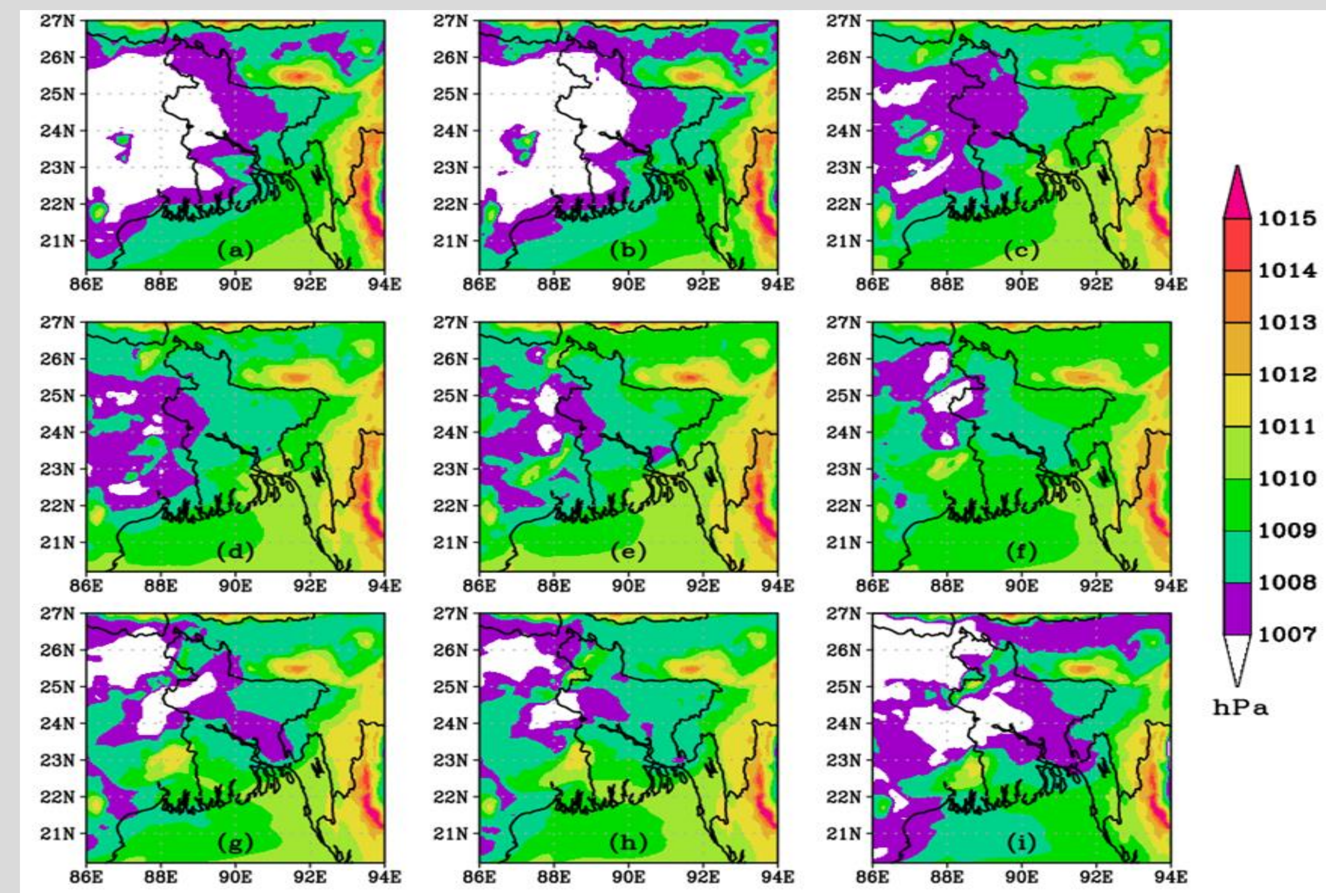


*Figure 1: ARW model simulated MSLP using GFS data at (a) 1100 UTC (b) 1130 UTC (c) 1200 UTC (d) 1230 UTC (e) 1300 UTC (f) 1330 UTC (g) 1400 UTC (h) 1430 UTC and (i) 1500 UTC on 23 April 2020 based on 0000 UTC 22 April 2020 initial conditions.*

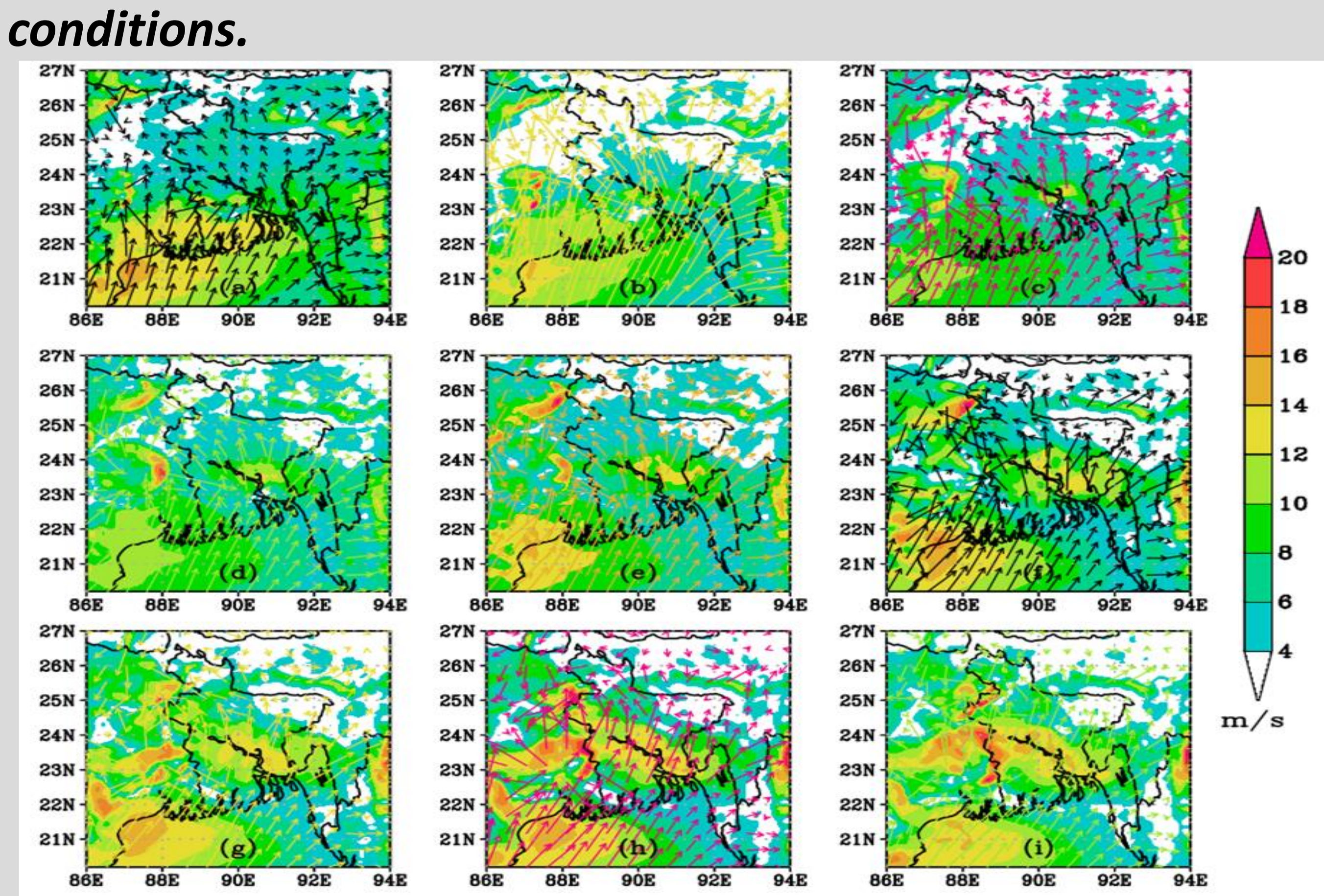


Figure 2: ARW model simulated wind speed and direction at 850 hPa level using GFS data from 1100 UTC to 1500 UTC on 23 April 2020.

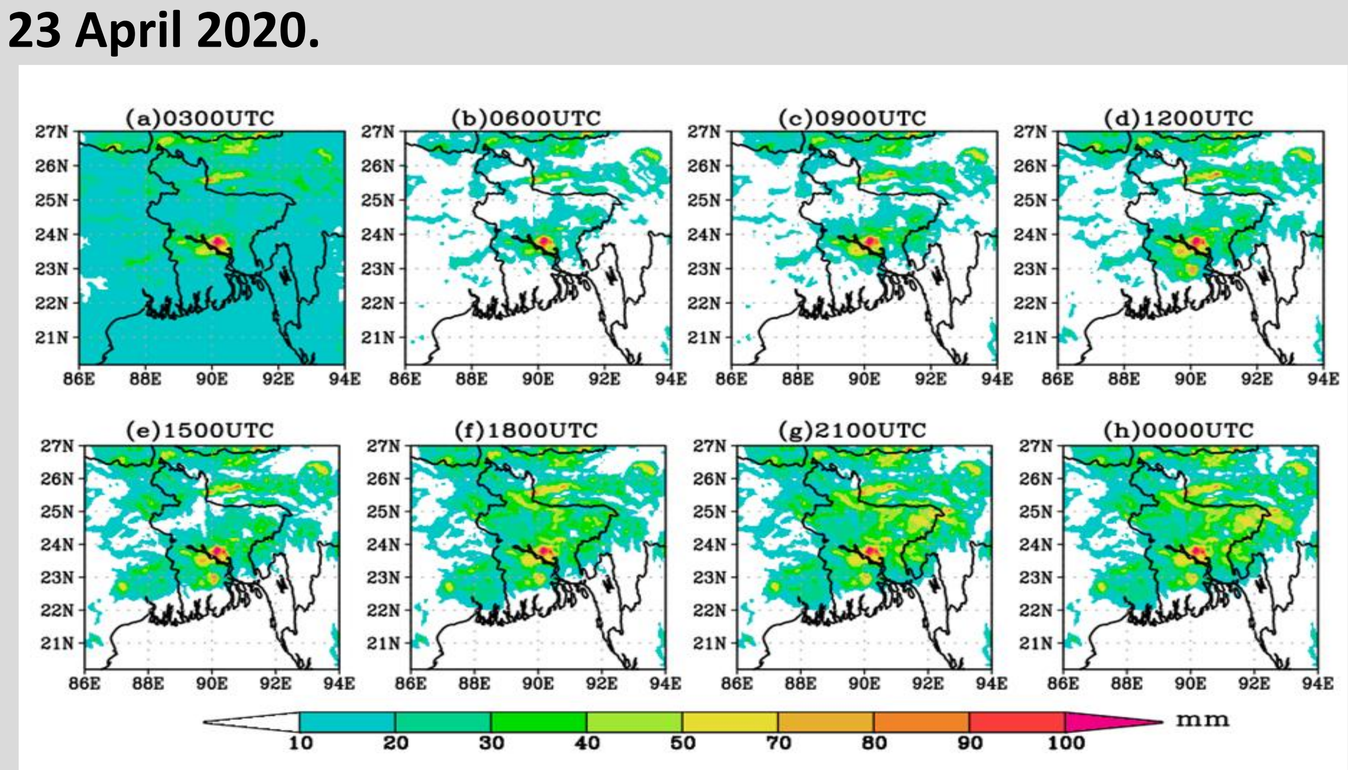


Figure 3: ARW model accumulated simulated rainfall using GFS data from 0300 UTC to 0000 UTC with 3 hours' interval on 23April 2020 based on 0000 UTC 22 April 2020 initial conditions

## 5. Conclusion

The WRF model is capable to predict TS over Dhaka.

References: References will be provided on request.