# WRF MODEL PERFORMANCE FOR THE SIMULATION OF HEAVY RAINFALL EVENT AT BHUR IN BHUTAN- A CASE STUDY

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## ABSTRACT

The constantly improving capabilities of Numerical Weather Prediction (NWP) models offer the opportunity to reduce the problem of space and time by providing nearly accurate precipitation fields and other meteorological variables of high spatial and temporal resolution. In this study, Weather Research and Forecasting (WRF-ARW) model with two nested outer and inner domains at spatial resolutions of 9 and 3 km respectively has been used to retrieve rain that occurred at Bhur (latitude 26.54° Longitude 90.26°, Elevation 375 m) in the southern part of Bhutan on 18 July 2010. The spell of very heavy rainfall of about 430 mm was recorded in 24 hours of 18 July 2010 over the study area. The rainfall amount over Bhur has been underestimated by both the cumulus parameterization schemes. The results show that the Kain-Fritsch (KF) scheme was able to capture the heavy rainfall event better than the Grell-Devenyi (GD) ensemble scheme over the study area. The output of the model in each resolution is compared to the Tropical Rainfall Measuring Mission (TRMM, 3B42RT V6) dataset.

Keywords: Heavy rainfall, TRMM, WRF, Cumulus parameterization scheme, Kain-Fritsch (KF) scheme, Grell-Devenyi (GD) ensemble scheme.

## 1. INTRODUCTION

Severe weather systems are generally associated with storms, gusty winds and heavy precipitation. The numerical prediction of such events remains one of the most challenging problems in the field of meteorology. Most of the global models developed thus far generally underestimate the total rainfall produced in any heavy precipitation event, and also contain errors in terms of their prediction on the timing and location of the event. The rainfall over Bhur, southern foothill of Bhutan on 18 July, 2010 was recorded at 430 mm within 24 hours which was extremely heavy during the summer monsoon season.

The present paper represents the simulation of heavy rainfall occurrence over Bhur, in Bhutan using the Advanced Research Weather Research and Forecasting ARW Model. Two-way multi-nested experiments of 2 model domains of 9 km (D1) and 3 km (D2) horizontal resolution and 27 vertical levels is used for this simulation (Fig. 1).

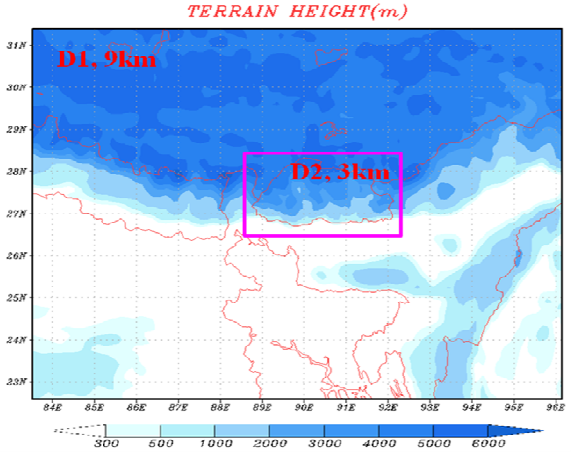



Fig.1: Model domain with terrain height.

## 2. MODEL, DATA AND METHODOLOGY

Weather Research and Forecasting (WRF_ARW) model (Skamarock, et al. 2008) is used to simulate extreme rainfall event observed over Bhur, southern Bhutan on 18 July 2010.

To test the sensitivity of the results to the cumulus parameterization scheme used in the model, we made the model runs with two different cumulus schemes viz Kain-Fritsch (KF) scheme and Grell-Devenyi (GD) ensemble scheme.

The initial and lateral boundary conditions are provided by the NCEP global final analyses $1^{o}$x$1^{o}$ degree at 6 hours interval. TRMM 3B42RT V6 3 hourly rainfall data also used for analysis.

## 3. RESULTS AND DISCUSSION

The both KF and GD scheme simulated rainfall captures the heavy rainfall events though the intensity of the rainfall is less compared to the observed. Area averaged (90.2E–90.2E and 26.7N–27.1N) 24 hours accumulated rainfall (Fig. 2) shows that the KF scheme simulated rainfall was 200mm by D2 and GD scheme simulated rainfall was 129mm by D2 and TRMM observed rainfall was 230mm over the study area. KF scheme simulated rainfall closer to the observations compared to the other schemes although there are some temporal and spatial biases.

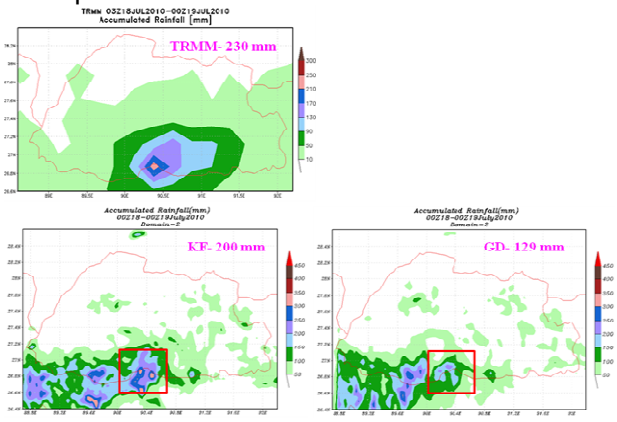
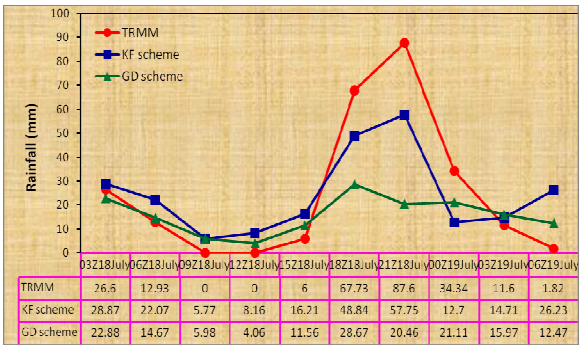



Fig. 2: Comparison between TRMM observed & Model simulated 24 hrs accumulated rainfall

Three hourly accumulated rainfall (Fig. 3) shows that the KF scheme simulated rainfall closer to the observations compared to the other schemes throughout the period.




| | 03Z18July | 06Z18July | 09Z18July | 12Z18July | 15Z18July | 18Z18July | 21Z18July | 00Z19July | 03Z19July | 06Z19July |
|---|---|---|---|---|---|---|---|---|---|---|
| TRMM | 26.6 | 12.93 | 0 | 0 | 6 | 67.73 | 87.6 | 34.34 | 11.6 | 1.82 |
| KF scheme | 28.87 | 22.07 | 5.77 | 8.16 | 16.21 | 48.84 | 57.75 | 12.7 | 14.71 | 26.23 |
| GD scheme | 22.88 | 14.67 | 5.98 | 4.06 | 11.56 | 28.67 | 20.46 | 21.11 | 15.67 | 12.47 |

Fig. 2: Three-hourly accumulated area averaged rainfall time series from the different experiments along with TRMM observation.

Both the upper and lower level wind were simulated well using the model. The KF and GD simulated 2m temperature and relative humidity and it can be seen that the structure of the isotherm is almost the same and relative humidity more than 95% in both the scheme.

## 4. REFERENCE

Skamarock, W. C., J. B. Klemp, J. Dudhia, D. O. Gill, D. M.Barker, M. G. Duda, X-Y. Huang, W.Wang, and J. G. Powers, 2008: A description of the Advanced Research WRF version 3. National Center for Atmospheric Research, Boulder, Colorado.

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