WRF Model Performance for the Simulation of Heavy Rainfall Event at Bhur in Bhutan- A Case Study

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Sequence of the talk

- Objectives
- Data and Methodology
  - Data used
  - Model Description
- Results and Discussion
- Conclusion
Objectives

- To study the performance of WRF_ARW for the prediction of extreme weather phenomena.
- To understand the mechanisms of heavy rainfall.
- To simulate the model experiments.
NCEP final analysis (FNL) 1° X 1° at 6 hourly data are used for preparing both the initial and boundary conditions for the model integration. TRMM 3B42RT V6 3 hourly rainfall data also used for analysis.
Weather Research and Forecasting (WRF_ARW) model version 3.2.1 has been used.

The model has been integrated with two nested domains.

Two cumulus parameterization schemes Kain-Fritsch and Grell-Devenyi have been used for the sensitivity experiments.

### Model Features

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<th>Model Features</th>
<th>Configurations</th>
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<td>Horizontal Resolution</td>
<td>Mother Domain 9km</td>
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<td>Vertical Levels</td>
<td>Nested Domain 3km</td>
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<td>Topography</td>
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<td>USGS</td>
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### Dynamics

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<td>Time Integration scheme</td>
<td>Third-order Runge-Kutta scheme</td>
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<td>Horizontal grid</td>
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<td>Vertical grid</td>
<td>Terrain following sigma coordinate</td>
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### Physics

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<td>Surface Layer</td>
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<td>Radiation</td>
<td>RRTM (LW), Dudhia (SW)</td>
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<td>Land Surface Processes</td>
<td>Unified Noah Land Surface Model</td>
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Microphysics (mp_physics):

WRF Single-Moment 6-class scheme: A scheme with ice, snow and graupel processes suitable for high-resolution simulations. (Time split fall terms with melting)

Cumulus Parameterization (cu_physics):

2. Grell-Devenyi ensemble scheme: Multi-closure (CAPE removal, quasi-equilibrium), multi-parameter (maximum cap, precipitation efficiency) and ensemble method is applied. Weights can be tuned (spatially, temporally) to optimize scheme.
Total Area - 38,394 sq.km. Population - Approx. 7 lacs
Climatic Condition in Bhutan

Bhutan experience a wide range of climatic conditions, that is dominated by South western monsoon, which originates from Bay of Bengal. Generally the monsoon starts from the month of June until the first week of September.

Climatic condition in Bhutan can be grouped in four:

- **Sub – Tropical Zone**
- **Temperate Zone**
- **Sub Alpine Zone**
- **Alpine Zone**

**Sub – Tropical Zone**

- Ranges 200m to 2000 meters above sea level.
- Winter mean temperature about 15 degree C
- Summer mean temperature about 28 degree C
- The total annual rain fall is usually above 2000mm.
Outline of simulation

KF Scheme
D-1, 198 mm
D-2, 200 mm

GD Scheme
D-1, 116 mm
D-2, 129 mm
Comparison between TRMM observed & Model simulated 24 hrs accumulated rainfall

TRMM - 230 mm

KF - 200 mm
GD - 129 mm
Maximum rainfall intensity was 26.31 mm/h simulated by KF scheme.
Model simulated vertical profile of qcloud & qrain (Lat. 26.9°N fixed)

Kain-Fritsch Scheme

Grell-Devenyi Scheme
700 mb wind vector and wind speed shaded (m/s)
300 mb wind vector and wind speed shaded (m/s)
Wind Shear (200 hPa-700hPa)

KF Scheme

GD Scheme
Model simulated vertical wind profile (Lat. 26.9°N fixed)

Kain-Fritsch Scheme

Grell-Devenyi Scheme
Max Reflectivity (dbz)

Kain-Fritsch Scheme

Grell-Devenyi Scheme
Conclusion

- WRF model with nesting has the capability to forecast extreme weather event (Heavy Rainfall).
- The localized heavy precipitation around Bhur is captured reasonably well with some temporal and spatial displacement. (Data assimilation, ensemble forecast is needed for better simulation)
- High horizontal grid resolution is required for better simulation.
- Also more sensitivity experiments with parameterization schemes need to be carried out for further experiments.
Kain-Fritsch Scheme

Grell-Devenyi Scheme