A Generalized Approach for Operational Flood Forecasting System of the Monsoon Driven River Basins of South and Southeast Asia

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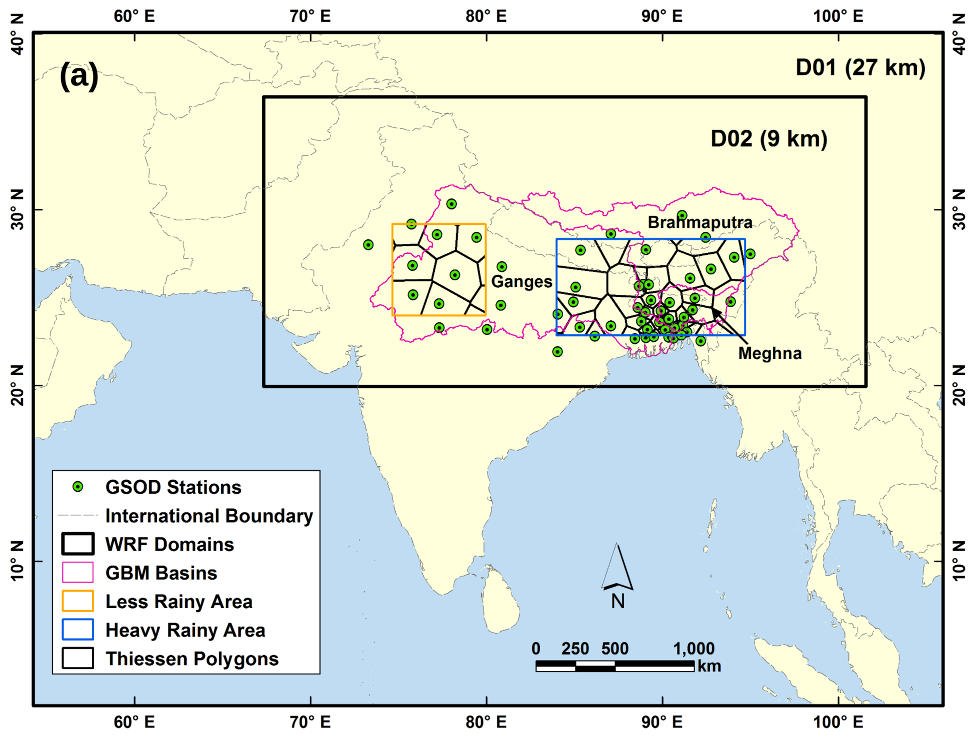
Introduction

Monsoon flooding is a common natural disaster in South and Southeast Asia, where more than a billion people are affected by it. Forecasting flood with an effective lead time is a challenge in this part of the world as a few heavily populated international river basins are located there and the countries are reluctant to share hydrometeorological data. Due to lack of real-time hydro-meteorological data, downstream nations are more vulnerable to transboundary riverine flooding. Numerical Weather Prediction (NWP) is a feasible source of hydro-meteorological data in this region. Furthermore, the forecasting system using NWP has the benefit of extended lead time beyond the travel time of the basin that is possible with nowcasting of hydrometeorological variables from remote sensing. Therefore, a common method for predicting precipitation using NPW model can assist the responsible agencies in this region. A general approach of precipitation forecast for South Asia using a mesoscale NWP model is shown here. At first, the Weather Research and Forecasting (WRF) model was used to generate the forecasted precipitation data for extreme events of the Ganges-Brahmaputra, and Indus river basins. Twelve different WRF model setups used here, originated from the combinations of three cloud microphysics, along with four different sets of model initial condition experiment cases. The simulated precipitation was then compared with observed precipitation. The results of this study illustrate that a generalized approach for forecasting precipitation using WRF in the monsoon climate is feasible.

WRF Model



Features:

- Two one-way nesting
- Nesting ratio: 1:3
- In GBM: two analysis extent
- 3 hourly GFS forecast as initial (IC) and boundary (BC) condition
- GFS-Final to produce IC in hot start experiments

Model Parameterization:

- Cumulus: BMJ
- PBL: YSU
- S-Radiation: Dudhia SW
- L-Radiation: RRTM LW
- Land Surface: Unified Noah
- Surface Layer: MM5 Similarity

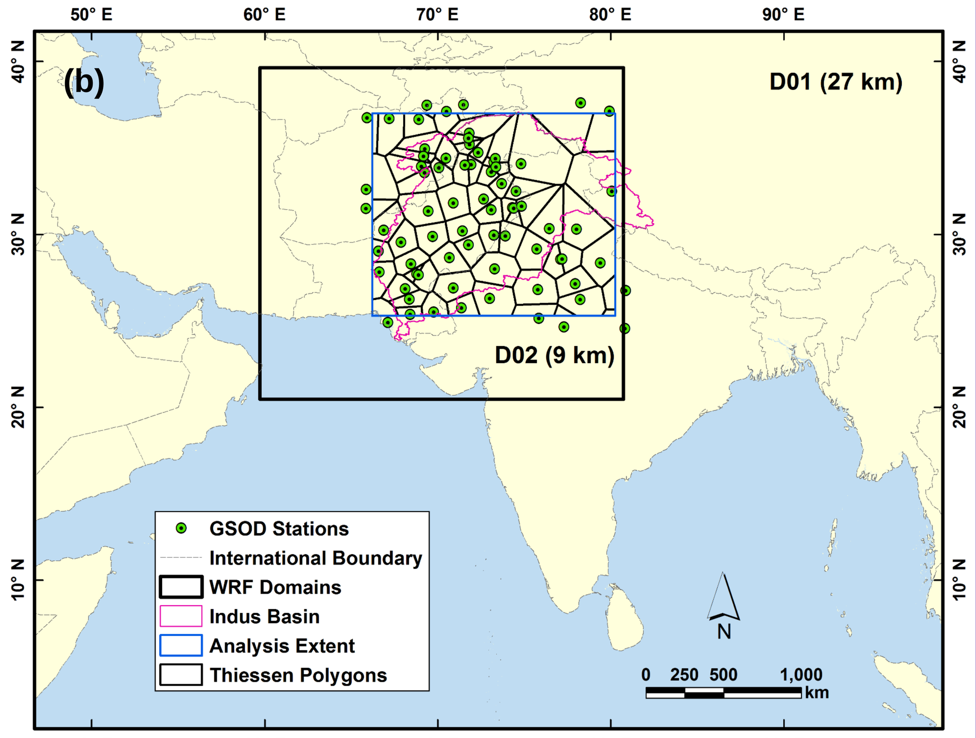


Figure 1: WRF model setup of a) GBM, and b) Indus river basin.

Study Approach

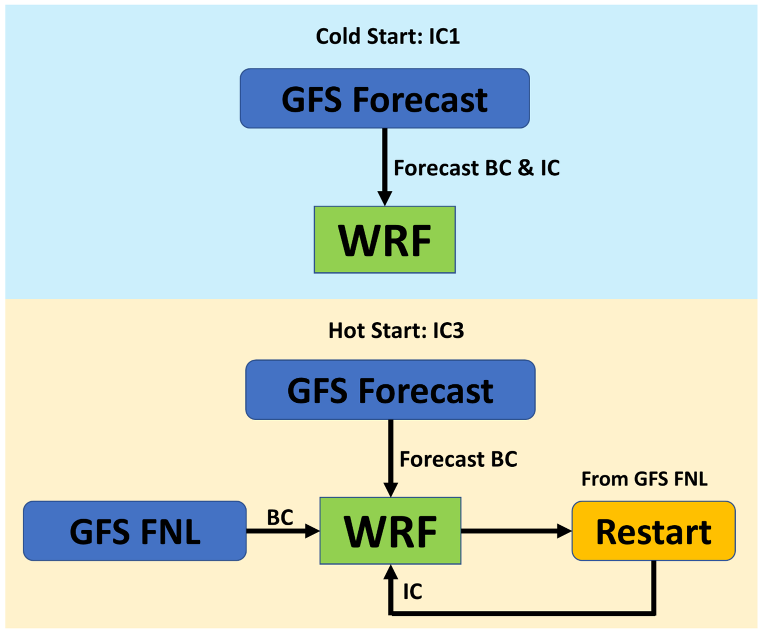


Figure 2: WRF model IC experiment cases; cold start (upper panel) and hot start (lower panel). Two more IC experiment cases used here, where the 00H GFS forecast was replaced by GFS-FNL and denoted as IC2 (cold start), and IC4 (hot start)

Table 1: Selected storm events and simulated combinations (the blue and red color for cold and hot start, respectively)

Event	Simulation Period	Simulation Lead Time (Day)	IC	Microphysics			Number of Simulations
				WSM5	WSM6	TS	
Indus 2007	22 Jun - 28 Jun, 2007	7	IC1	X	X	X	21
Indus 2010	22 Jul - 29 Jul, 2010	7	IC1	X	X	X	24
			IC2	X	X	X	24
			IC3	X	X	X	24
			IC4	X	X	X	24
Indus 2012	01 Sep - 09 Sep, 2012	8	IC4	X	X	X	27
GBM 2007	20 Jul - 26 Jul, 2007	7	IC1	X			7
			IC2	X			7
			IC3	X			7
			IC4	X	X	X	21
GBM 2015.1	11 Aug - 20 Aug, 2015	10	IC1			X	10
			IC2			X	10
			IC3			X	10
			IC4	X	X	X	30
GBM 2015.2	21 Aug - 30 Aug, 2015	10	IC4	X	X	X	30

Note: WSM5, WSM6, and TS are short from of WRF Single Moment 5 class, 6 class, and Thompson scheme, respectively.

Analysis Technique

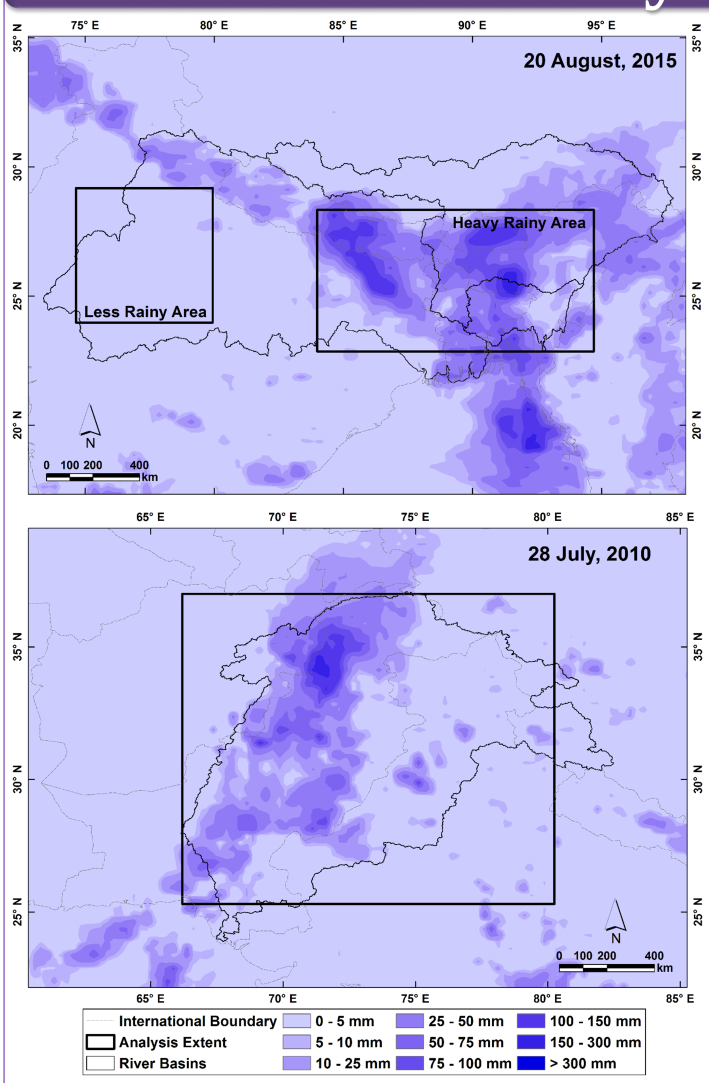


Figure 3: Spatial extent of storm event derived by TRMM-3B42V7 for GBM 2015.1 (upper panel), and Indus 2010 (lower Panel)

Reference Data:

- NCDC GSOD: Precipitation amount
- TRMM – 3B42V7: Spatial distribution

Error Metrics:

- Four Categorical: POD, CSI, FBI, FAR
- Three Continuous: MBE, RMSE, SD

$$Unified\ Score = \left(\frac{POD_r + CSI_r + FAR_r + FBI_r + RMSE_r + MBE_r + SD_r}{7}\right)$$

$$Spatial\ Extent\ Score = \left(\frac{POD_r + CSI_r + FAR_r + FBI_r}{4}\right)$$

Note: Subscript 'r' is for rescaled metrics, rescaled from 0 (worst) to 1 (best).

Results

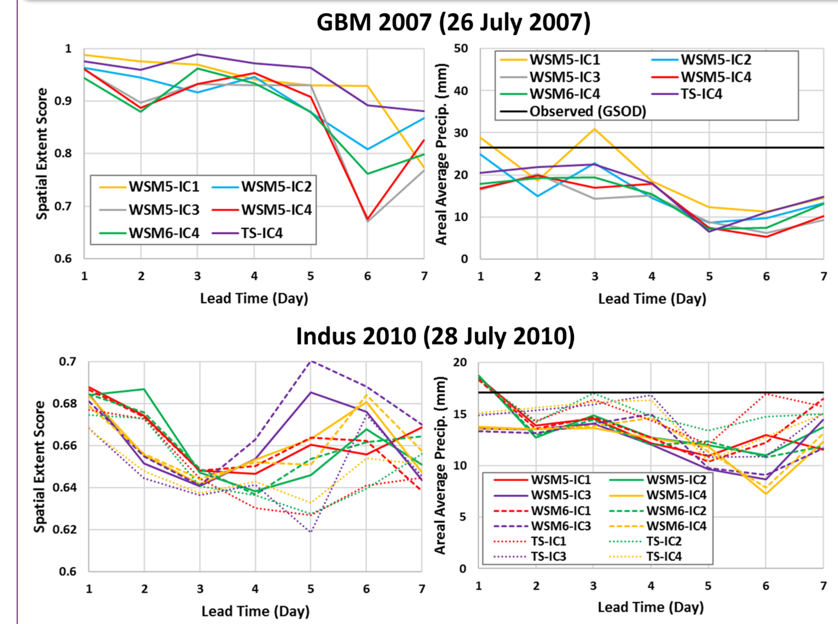


Figure 4: Precipitation forecast accuracy on the maximum rainy day of GBM 2007 (upper panel), and Indus 2010 (lower panel) in terms of spatial distribution (left panel), and total amount of precipitation (right panel). Analysis of GBM conducted in the heavy rainy area.

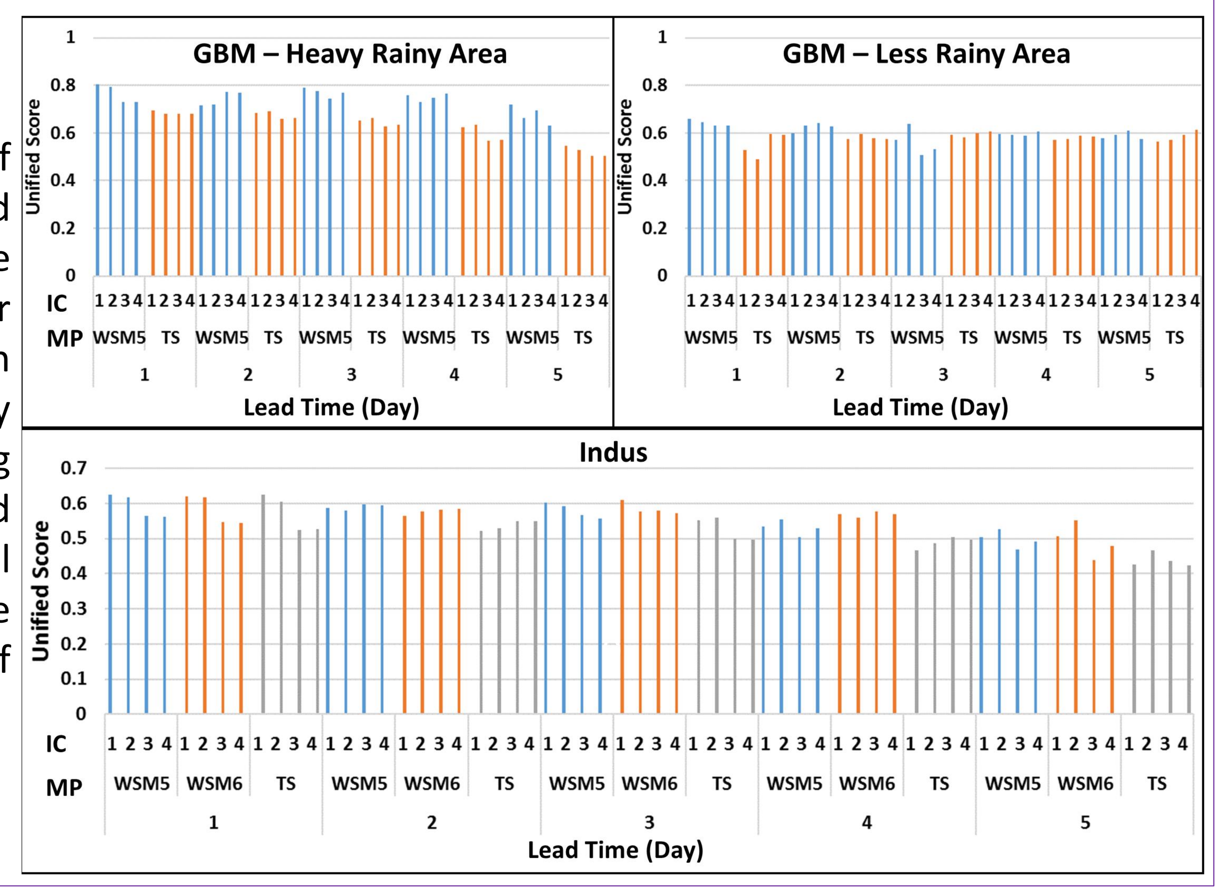


Figure 5: Accuracy of the WRF forecasted precipitation in the GBM basin (upper panel), and Indus Basin (lower panel). Accuracy was determined using the forecasted precipitation of several days, including the maximum rainy day of each event.

Conclusions

- Resolution of the IC seems more sensitive in this case than the IC with 10-15% more observed data. Hence, high resolution IC may improve the NWP derived precipitation forecast in South Asian river basins.
- The performance of WSM5 and WSM6 with cold start experiments is consistent over time and region in the monsoon climate.
- In both river basins the trends of the sensitivity of microphysics and IC experiment cases are similar. Therefore, a generalized approach is feasible for the river basins in the Monsoon climate regime.

Acknowledgement

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References

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