Urban Hydrometeorology and Flood Forecasting

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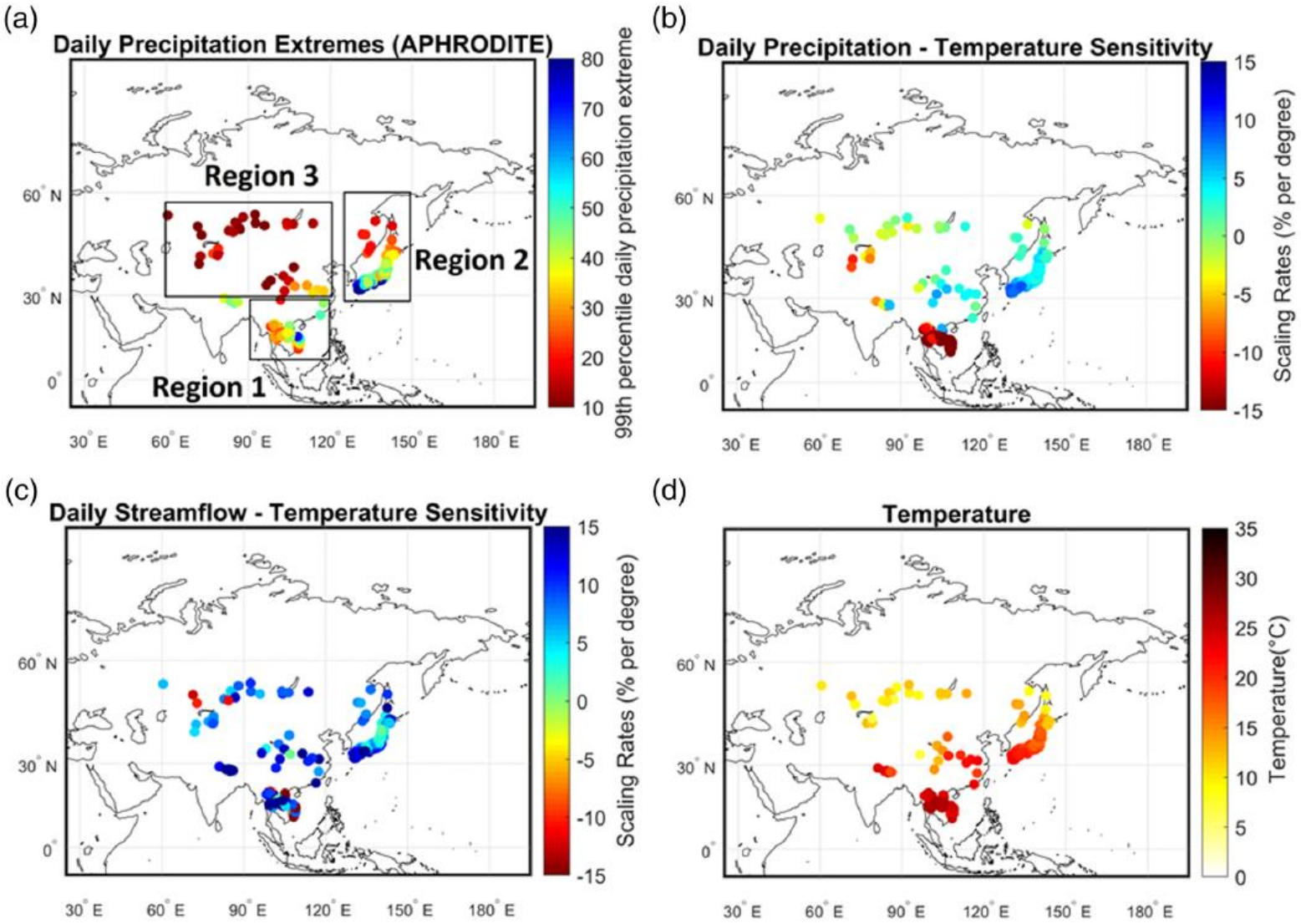
Warming and Extreme Precipitation

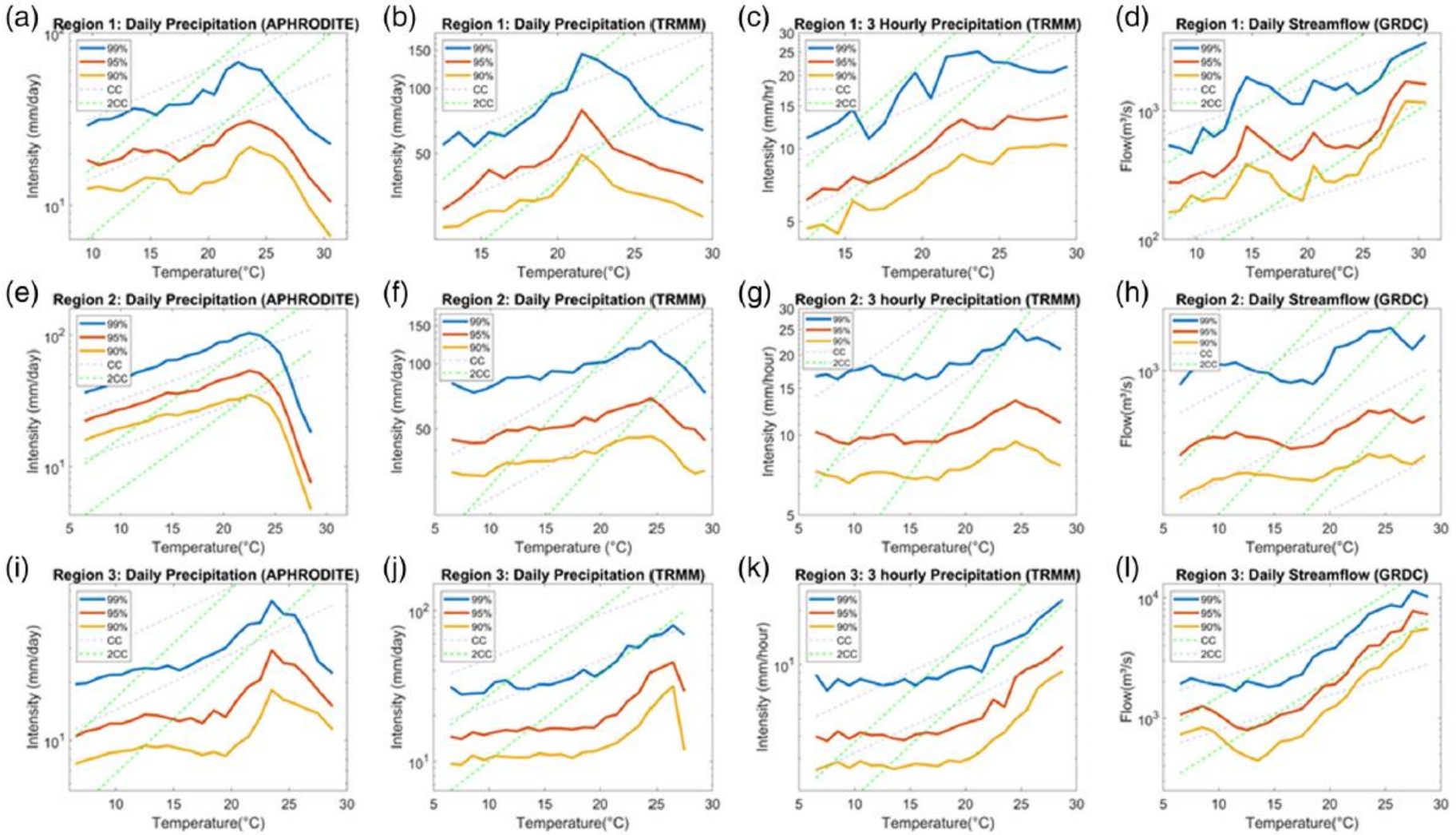
- Clausius Clapeyron Theory
  - With per degree C increase in temperature, the water vapor capacity of atmosphere increases by 7.5%
  - Such an increase is only reflected in Extreme Precipitation
- IPCC AR5 & SREX Report
  - Observed Trend:
    - Likely more number of regions in crease in precipitation extremes compared to decrease in precipitation extremes.
  - Future Changes
    - Likely increase in frequency of heavy precipitation events or increase in proportion of total rainfall from heavy falls over many areas of the globe, in particular in the high latitudes and tropical regions

Scaling results over Central and South Asia

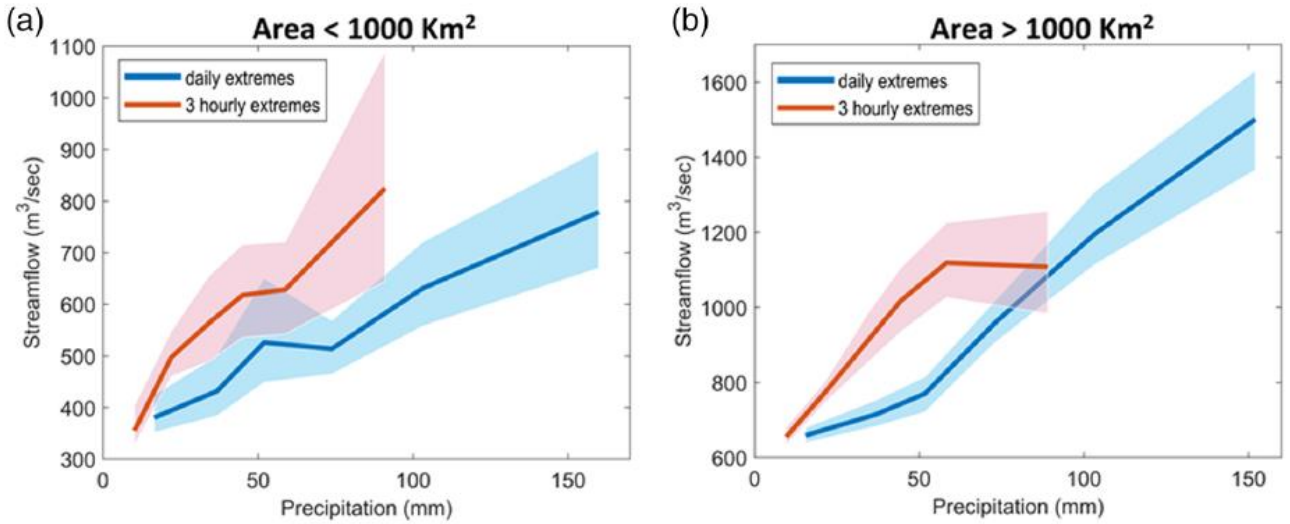


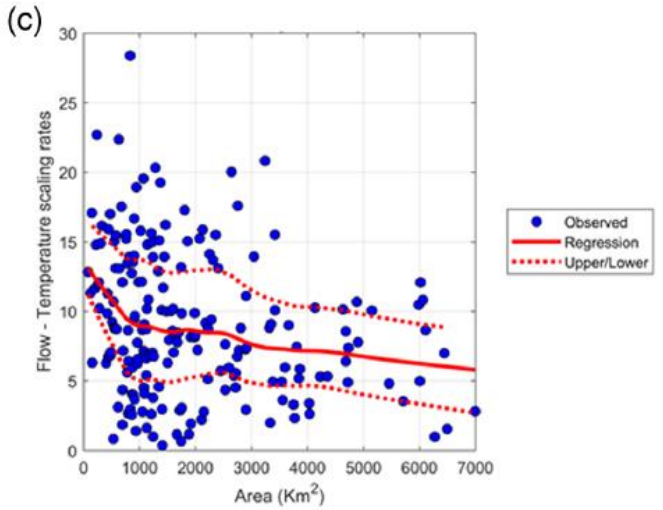
Ghausi and Ghosh (2020), GRL

Opposite Scaling between Streamflow and Daily Precipitation Extremes

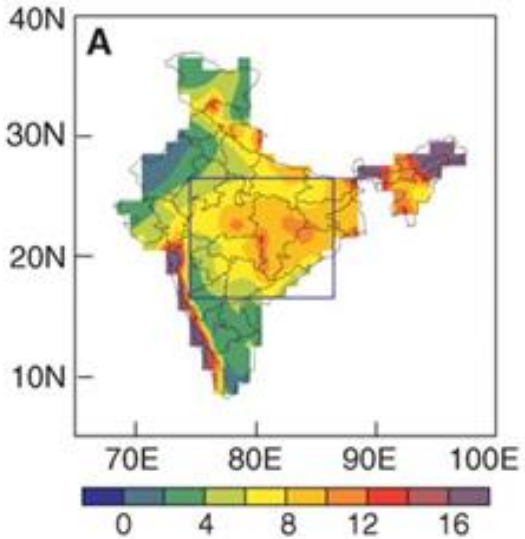


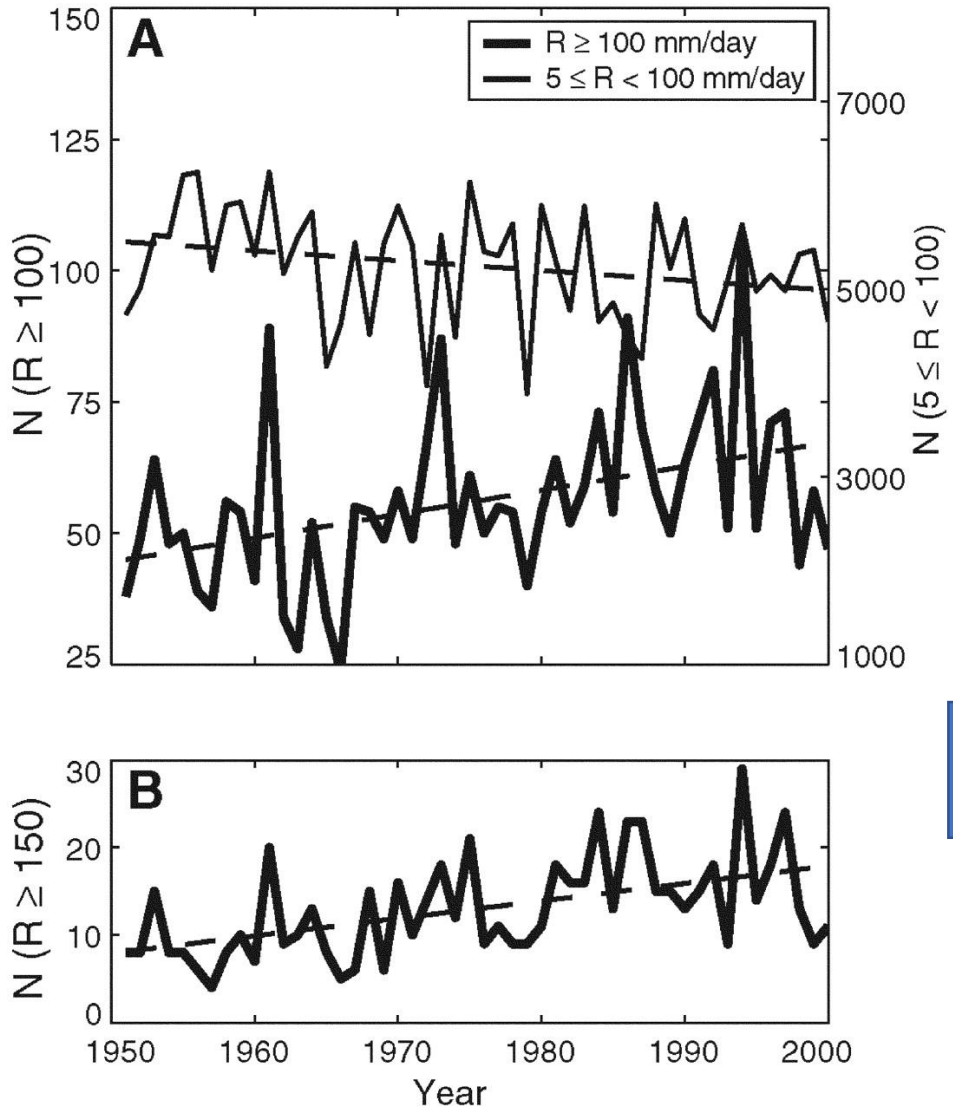
Small Catchments: Scaling rates driven by short duration extreme precipitation





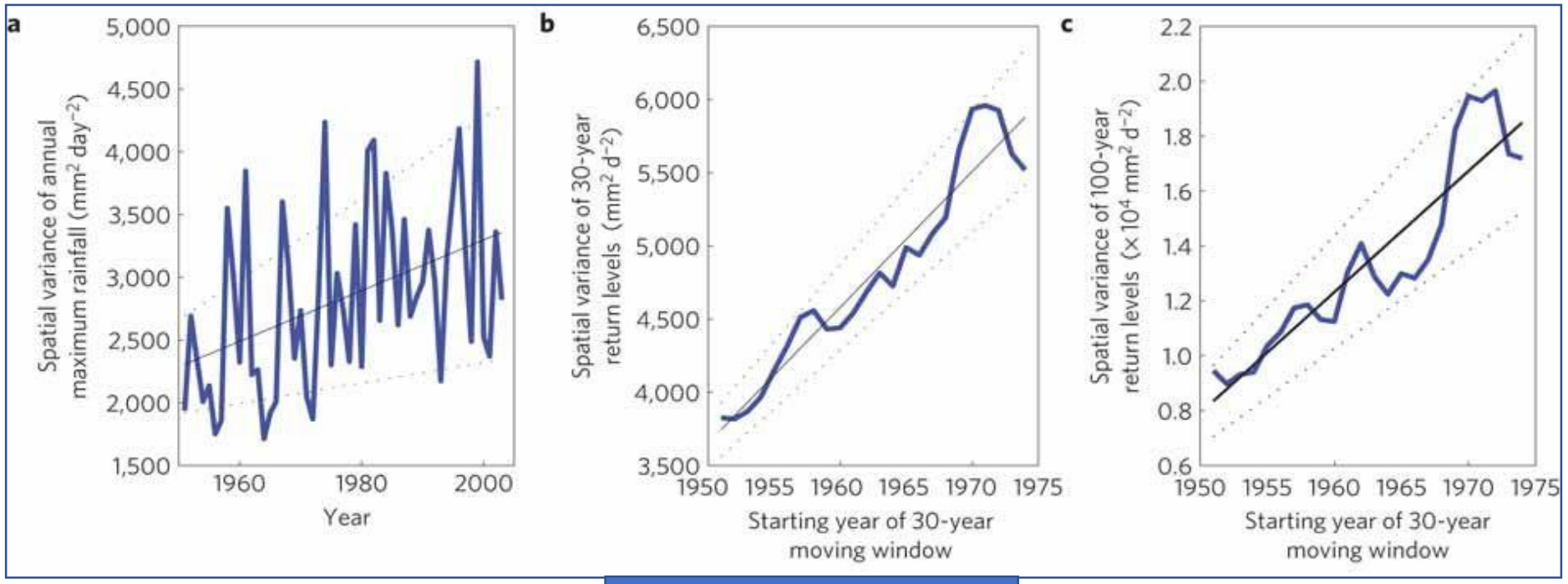
Extremes over India: Increase over Central India





Goswami et al. (2006), Science

But, with an Increase in Spatial Variability



Ghosh et al. (2012)
Nature Climate Change

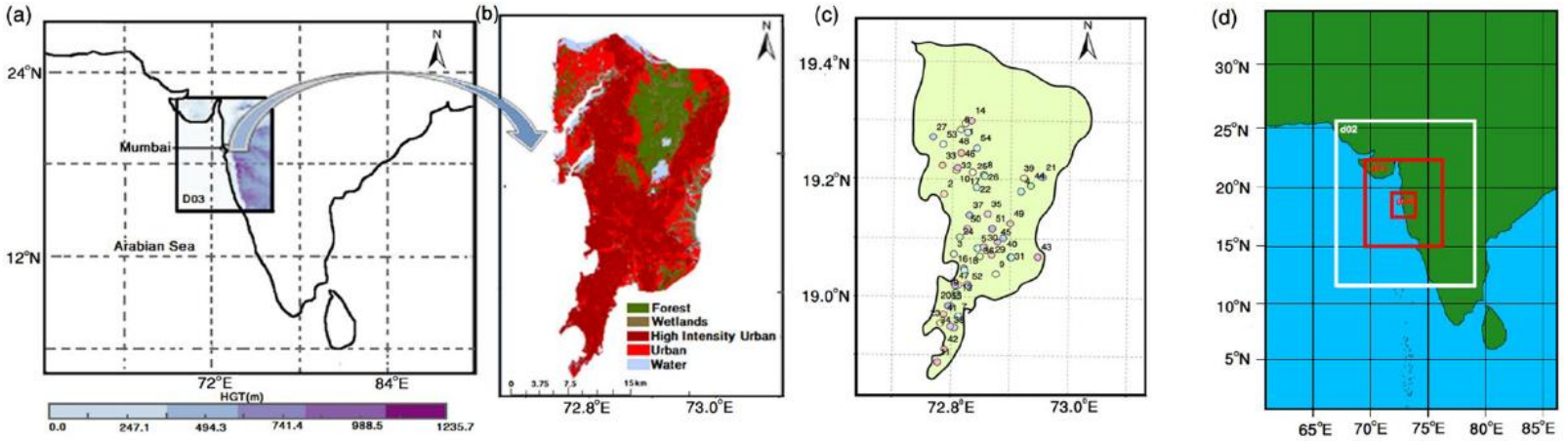
Important Land Factors

- Urbanization
- Land Use Land Cover Change
- Water management on land
- Aerosols and dust

Impacts of Urbanization on Rainfall

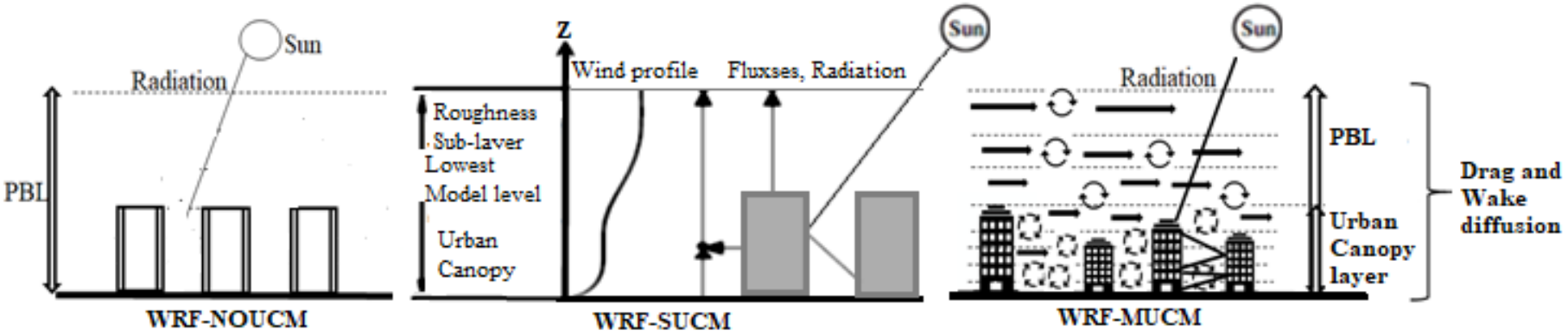
- Urban heating and more moisture
- Urban heat island and differential urban-non urban heating
- Aerosol
- Urban structures, eddies and instability

Impacts of Urbanization on Extreme Rainfall: A Numerical Experiment



SL No.	Physical Sensitivity scheme
Cumulus Schemes	Kain-Fritsch (new Eta) scheme[51]
	Betts-Miller-Janjic scheme[S4]
	Grell-Freitas ensemble scheme [S5]
	Grell 3D ensemble scheme [S6, S7]
	Modifed Tiedtke scheme (ARW only)[S8, S9]
PBL schemes	Bougeault and Lacarrere (BouLac) PBL[55]
	Mellor-Yamada-Janjic TKE scheme(MYJ scheme)[S10]

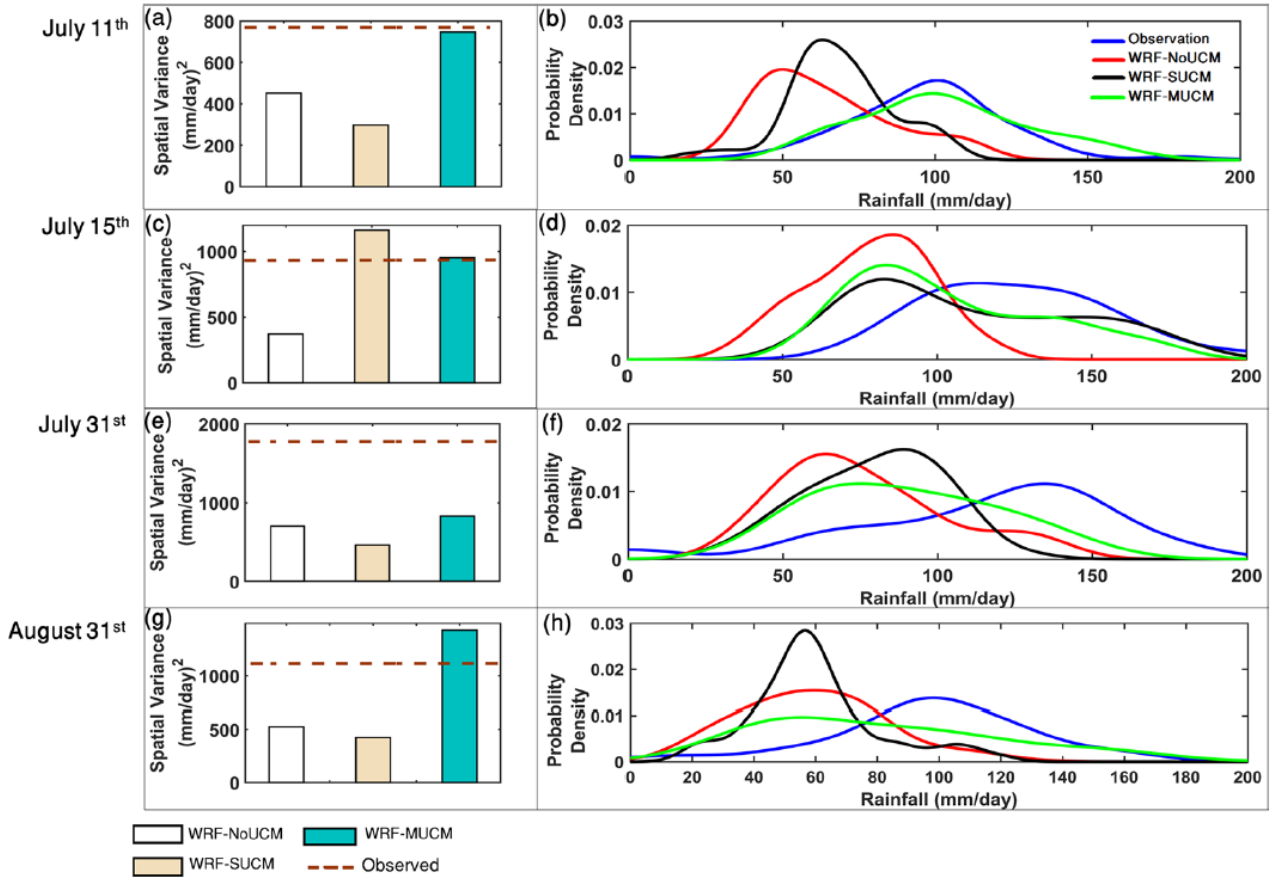
Mechanism/ Hypothesis



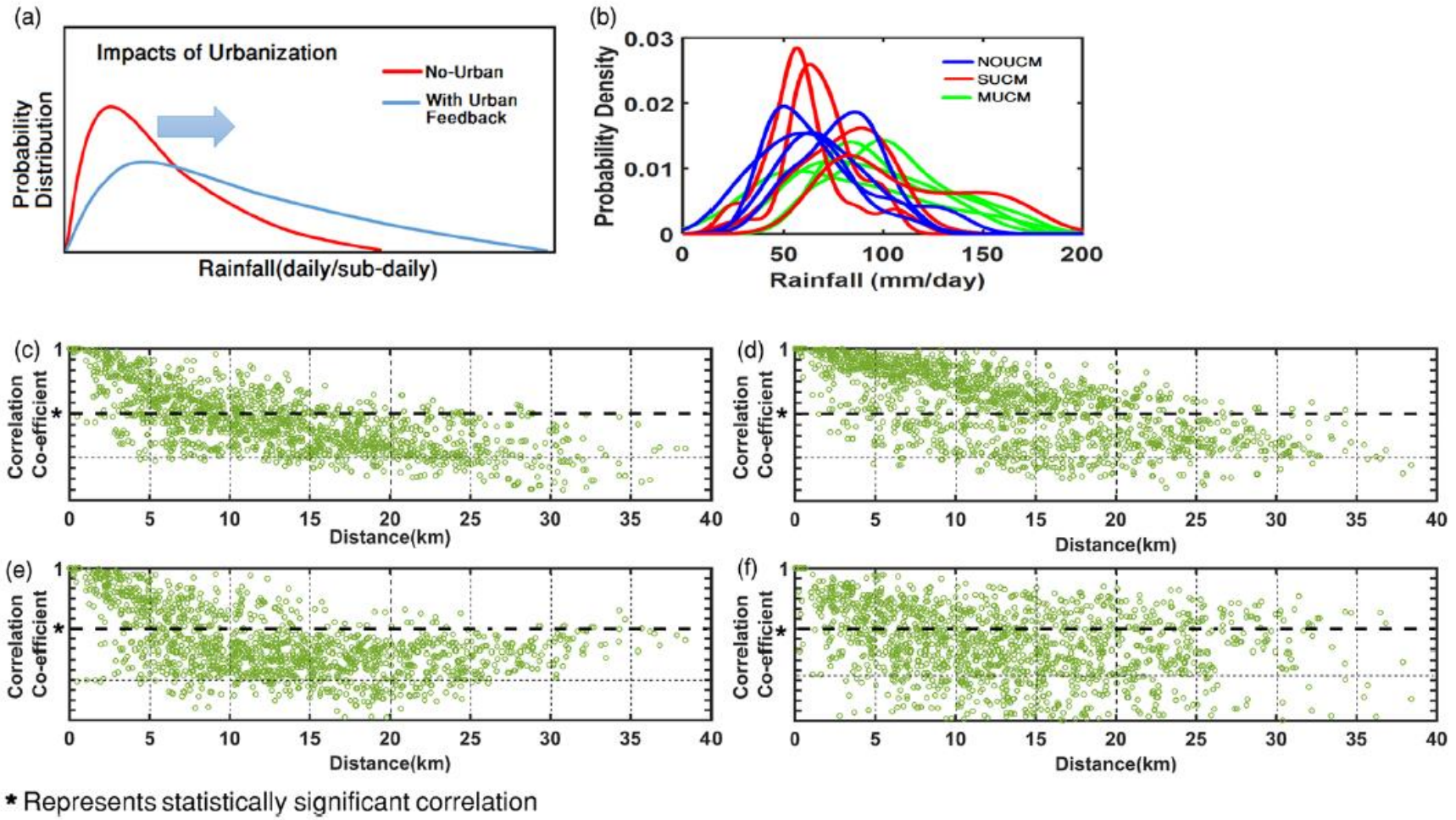
Spatial Average

Extreme Event Date (2014)	Observed Rainfall(mm)	Simulated Rainfall (WRF-NoUCM)	Simulated Rainfall(WRF-SUCM)	Simulated Rainfall (WRF-MUCM)
July 11th	96.30	64.48	68.94	102.90
July 15th	126.90	78.08	109.98	104.00
July 31st	113.60	76.00	79.85	89.80
August 31st	96.80	58.00	59.78	81.00

Spatial Variability

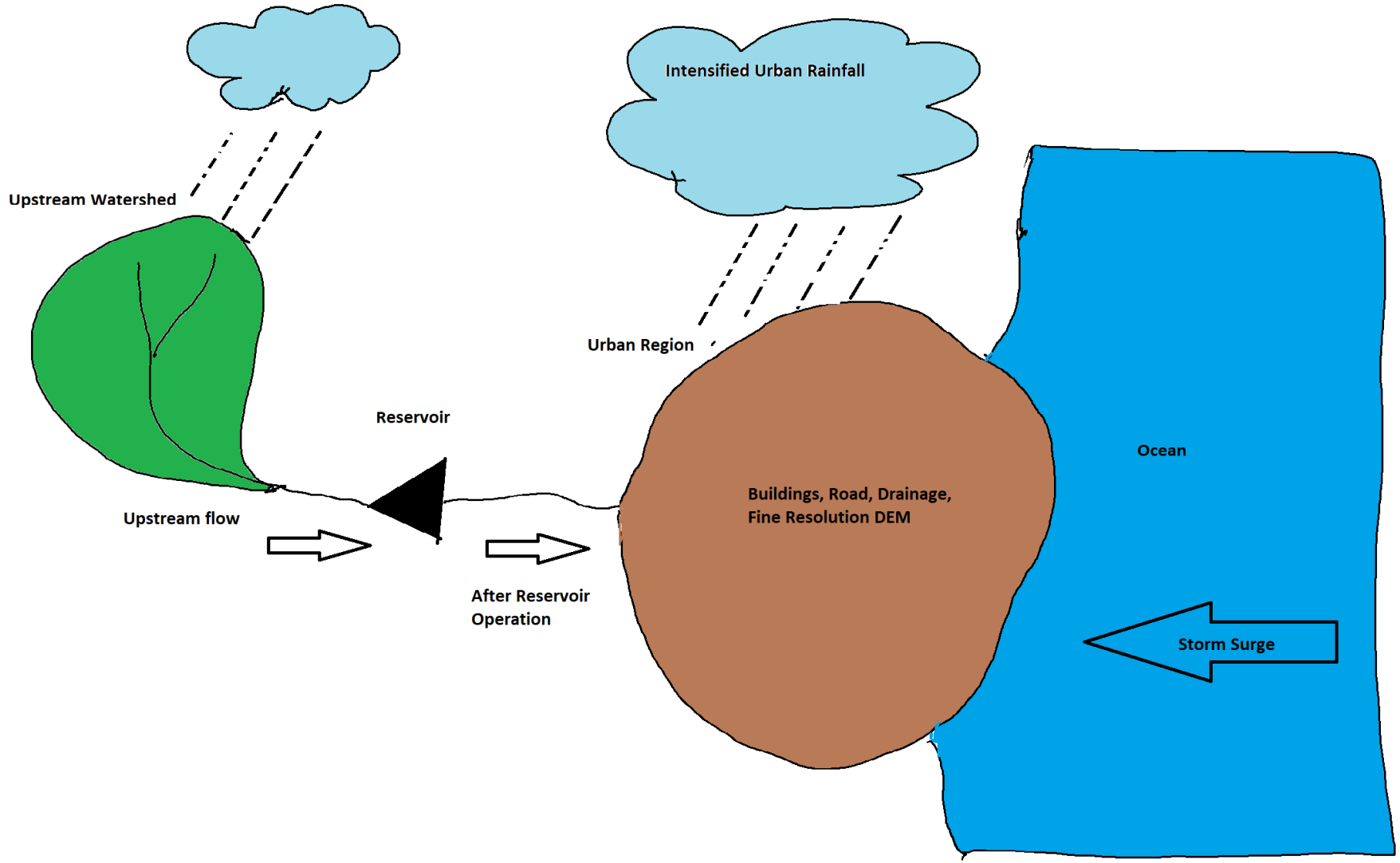


Spatial Variability

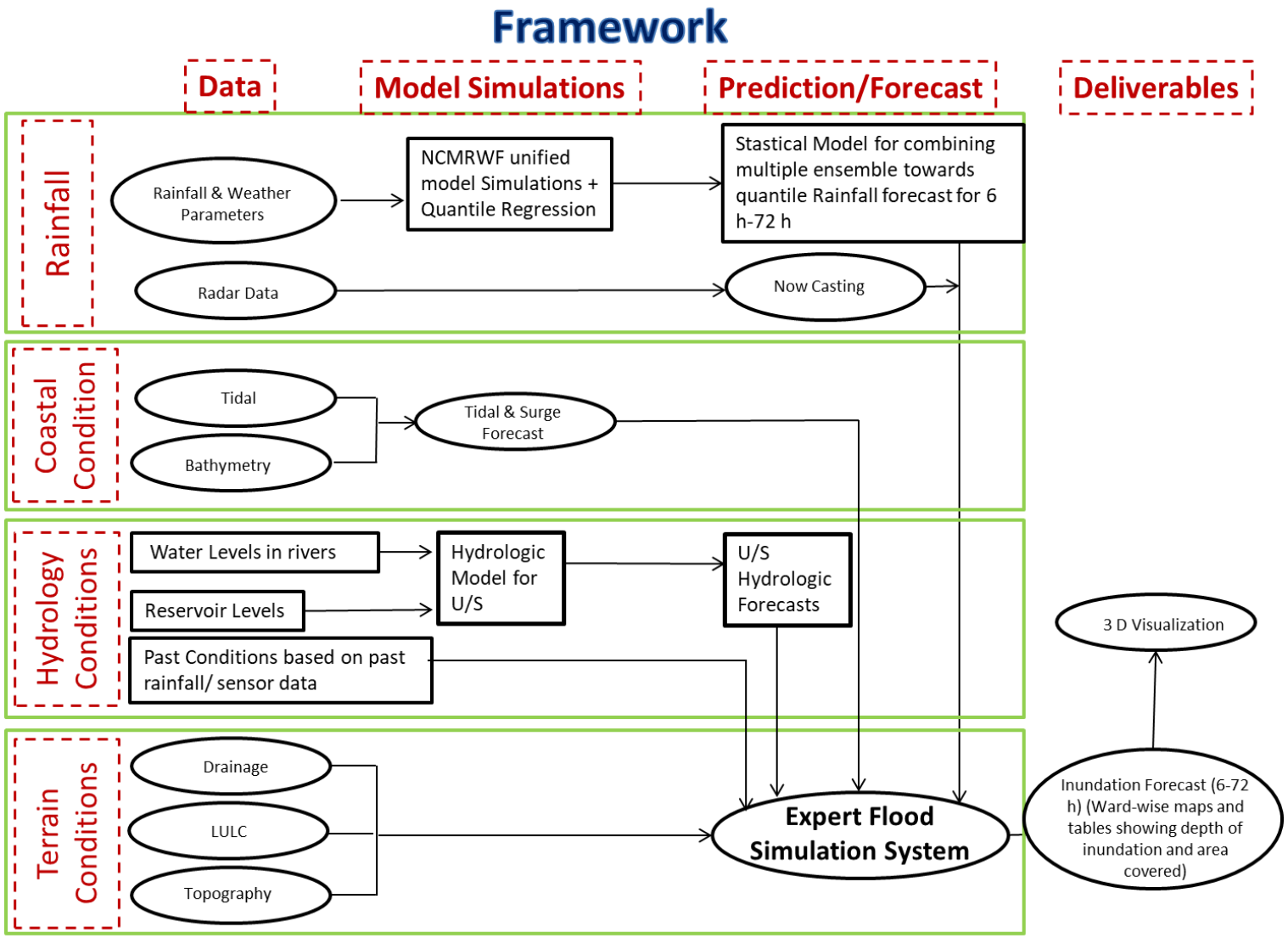


* Represents statistically significant correlation

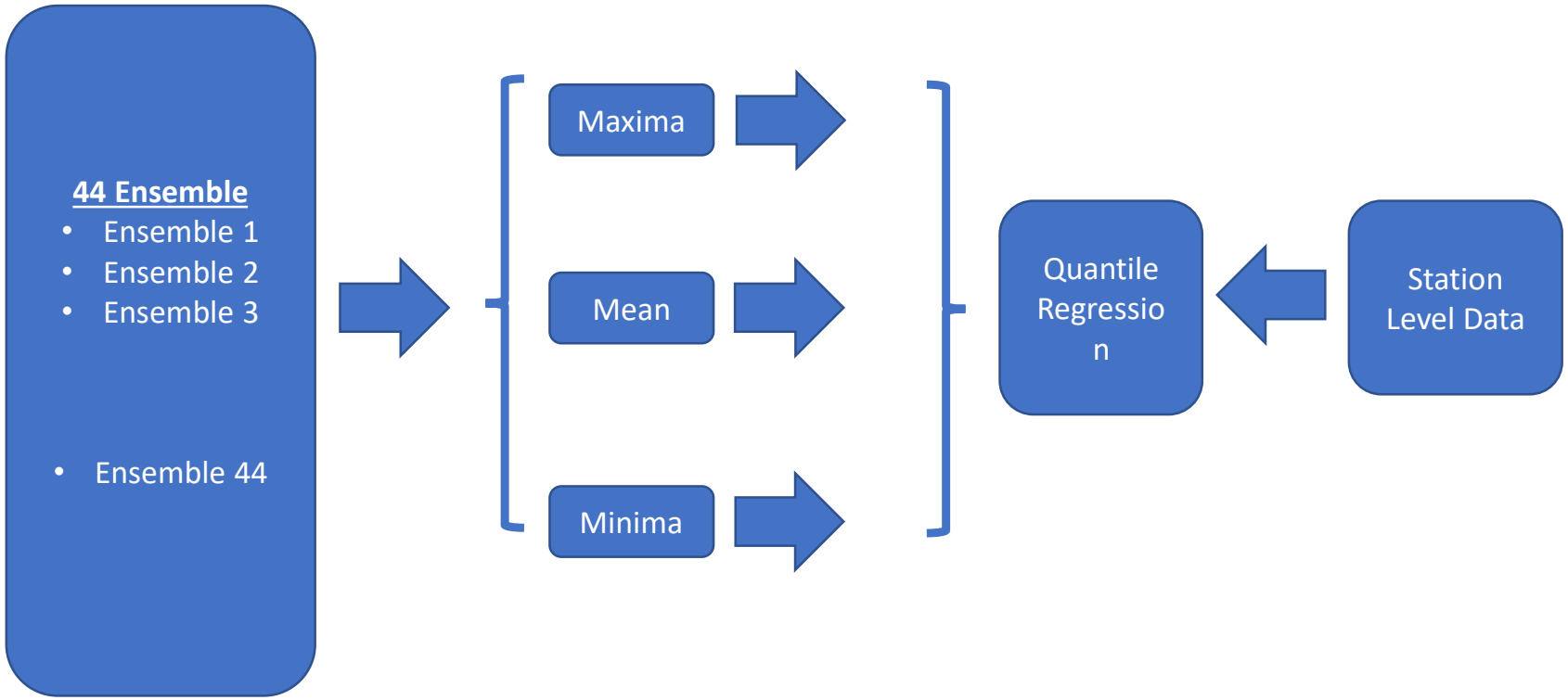
India’s First Real Time Urban Flood Forecasting System (for Chennai)



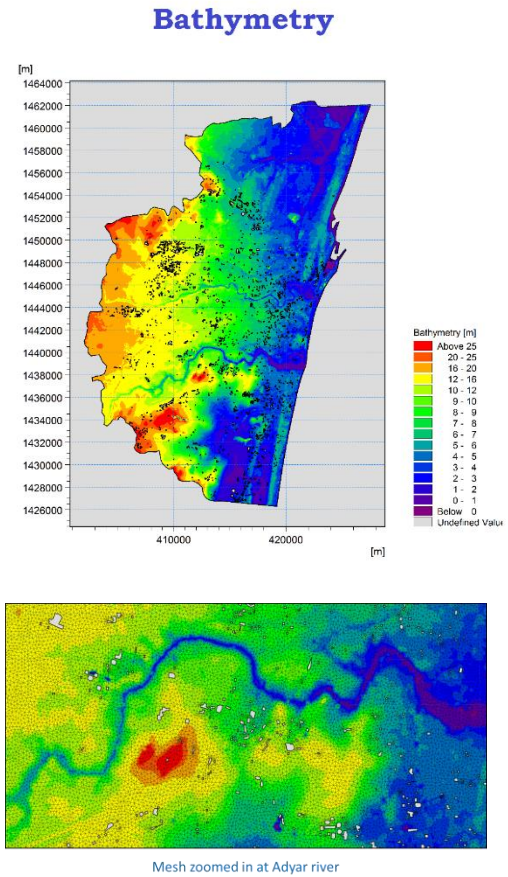
Different Components Needed



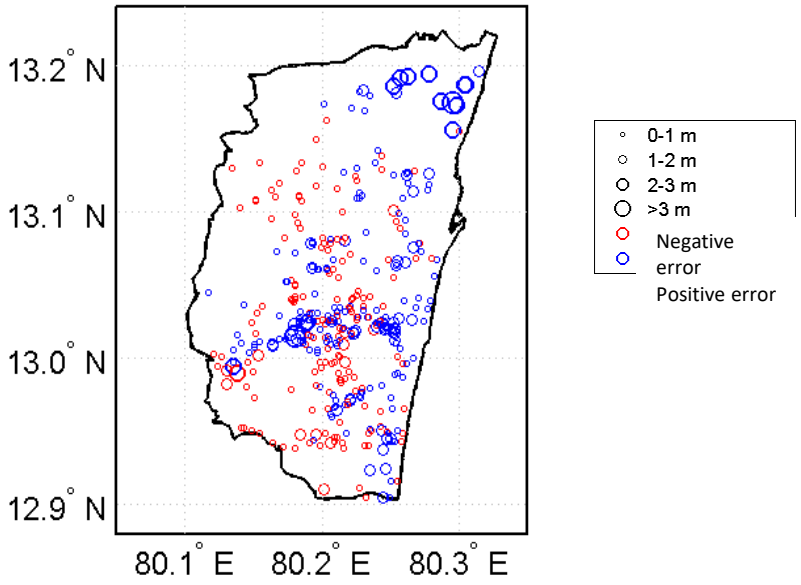
Training Algorithms



Performance of Flood Model



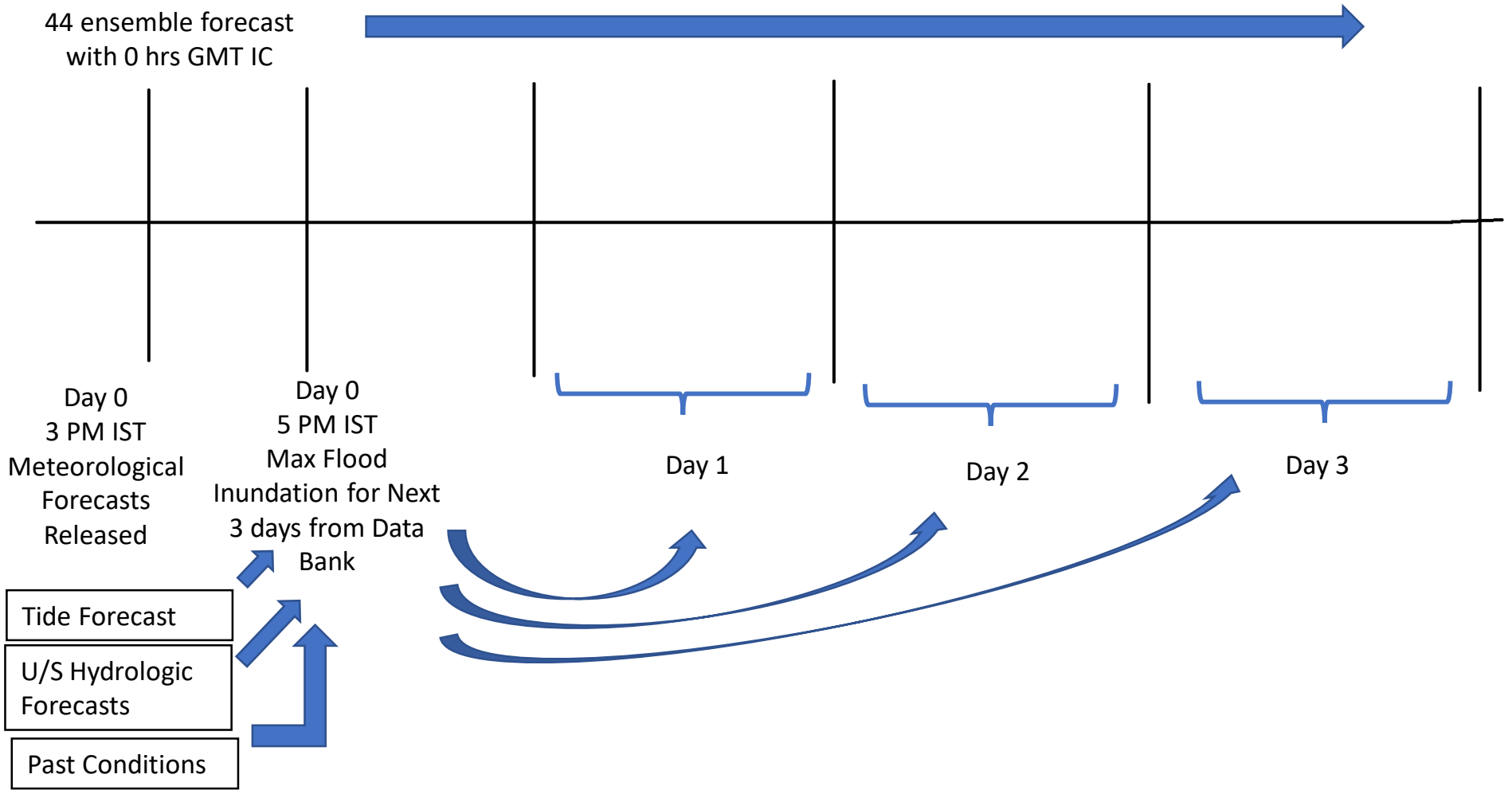
Mesh zoomed in at Adyar river



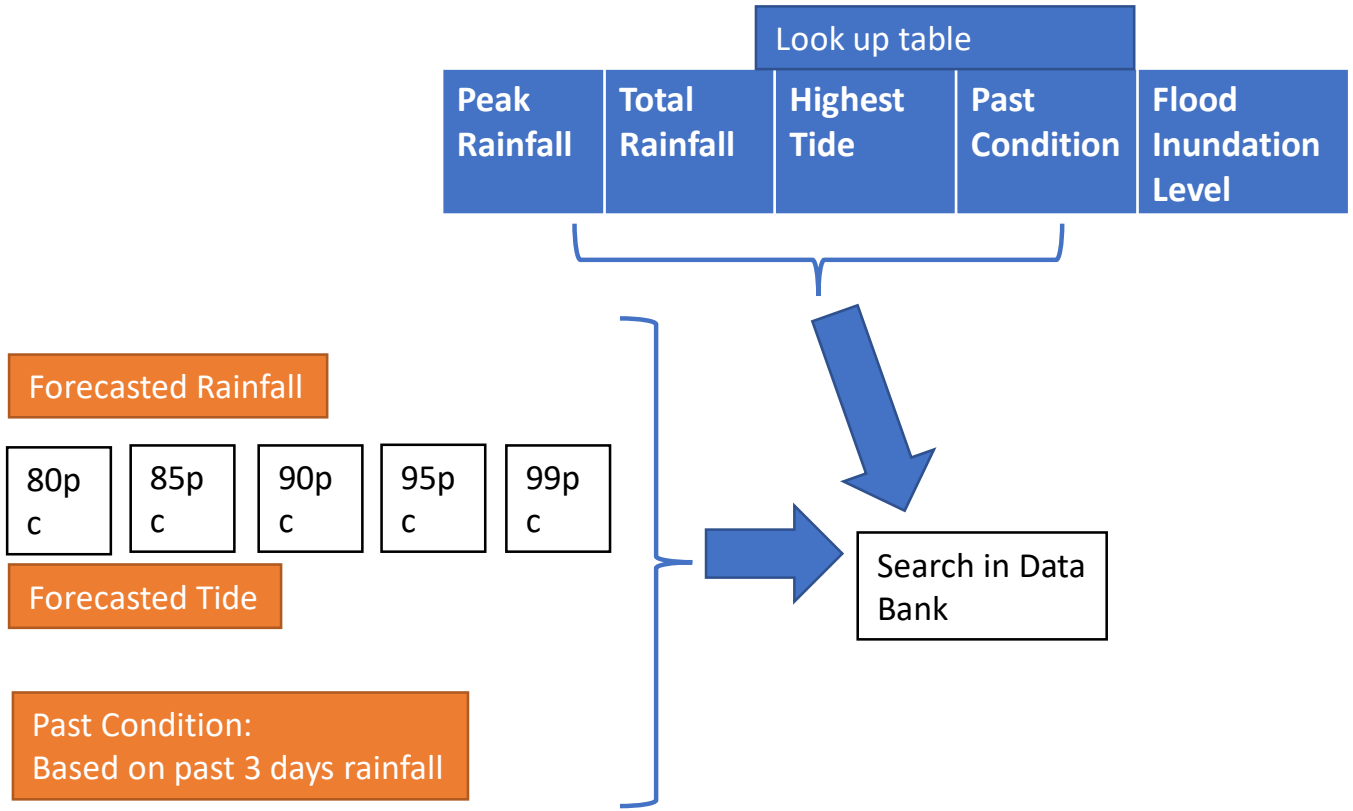
Flood Data Bank

- Cases
  - Return Periods (2, 5,10, 25, 50, 75, 100 and 200 years)
  - Storm Duration (1, 3, 6, 12, 18, 24 hours)
  - Past Condition (Wet, Normal and Dry)
  - Tide Conditions (6 conditions, HH and LL with 3 types of cyclones)
- Simulations Completed: 792

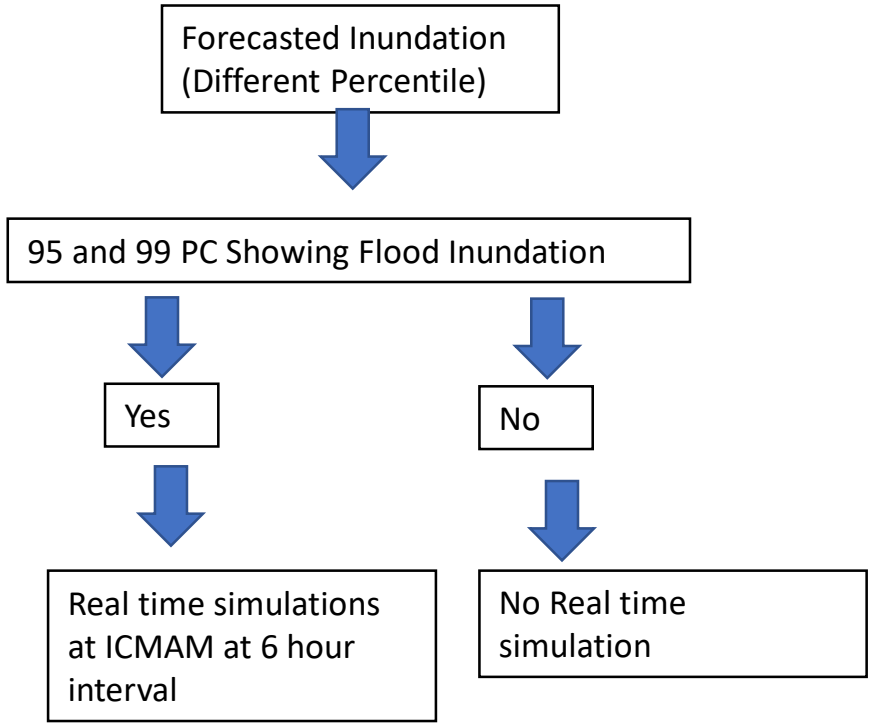
Forecast Lead Time



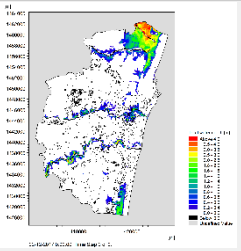
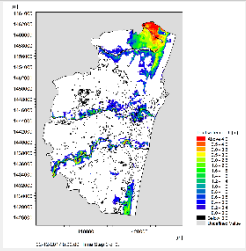
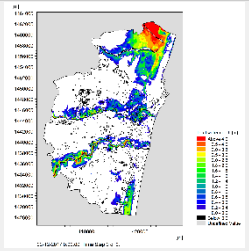
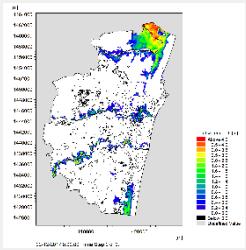
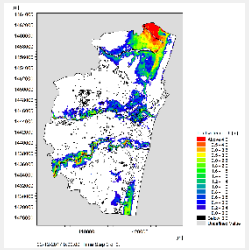
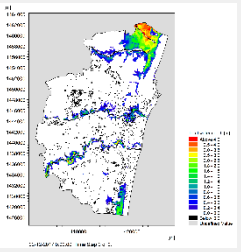
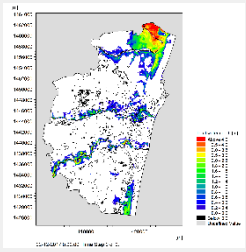
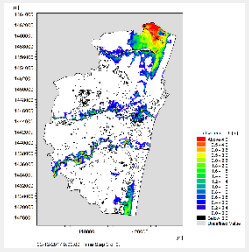
Algorithms (0-72 Hours Prediction)



Flowchart with Real Time Flood Simulations at 6 hrs Interval with Single Member Forecast



A Recent Example

Initial Condition	Forecast Day	80 percentile	85 percentile	90 percentile	95 percentile	99 percentile
31.10.2017	01.11.2017	No Flood	No Flood			
	02.11.2017	No Flood	No Flood	No Flood		
	03.11.2017	No Flood	No Flood			

Summary

Both Global and local changing factors change the extreme rainfall and flooding patterns

A forecasting or prediction system should consider both the factors carefully.

Thank You