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# Kerala floods: A million in camps and thousands stranded

18.09.18, DownToEarth


Nearly 400 people have died and thousands remained stranded by the worst flooding in the Indian state of Kerala in a century. 22.08.18, BBC

## Tourism industry estimates losses worth Rs 20 bn due to Kerala floods

25.08.18, Business Standard

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## Western Ghats region prone to disaster if conservation is delayed: Madhav Gadgil, leading ecologist

28.10.13, Economic Times

*"The natural forest cover in the region has dwindled to 7%. Most rivers have dried up and waters are contaminated. Hills are disappearing due to quarrying," he said.*

## Defying Gadgil sunk Kerala

21.08.18, The Pioneer

**Committee had recommended ban on mining activities 7 years ago but State Govt flouted it**

Majority of the areas deluged in this year's monsoon flood in Kerala were cited as fragile by the Madhav Gadgil Committee report seven years ago, recommending a complete ban on mining, construction activities and use of land for non-forest purposes.

was junked by the

## Remote sensing data shows massive erosion of forests in Kerala

23.05.17, livemint

## Ecologist Madhav Gadgil Predicted Kerala Floods, Warns Of Floods In Goa

22.08.18, Times Now

22 AUGUST 2018 | ENGLISH | URBAN | GENERAL AUDIENCE

**Indian Ecologist Madhav Gadgil who predicted the Kerala floods in 2011, has now said that Goa may face similar floods if required steps are not taken. Gadgil's team had warned the government about floods in several states in 2011.**

## Kerala ignored environment warnings for reckless development: experts

21.08.18, Hindustan Times

Push to build power plants. coal mines, hotel resorts and new housing have upset state's ecological balance, say experts.

# Role of land-use-land-cover changes in the 2018 Mega-floods over Kerala (India)


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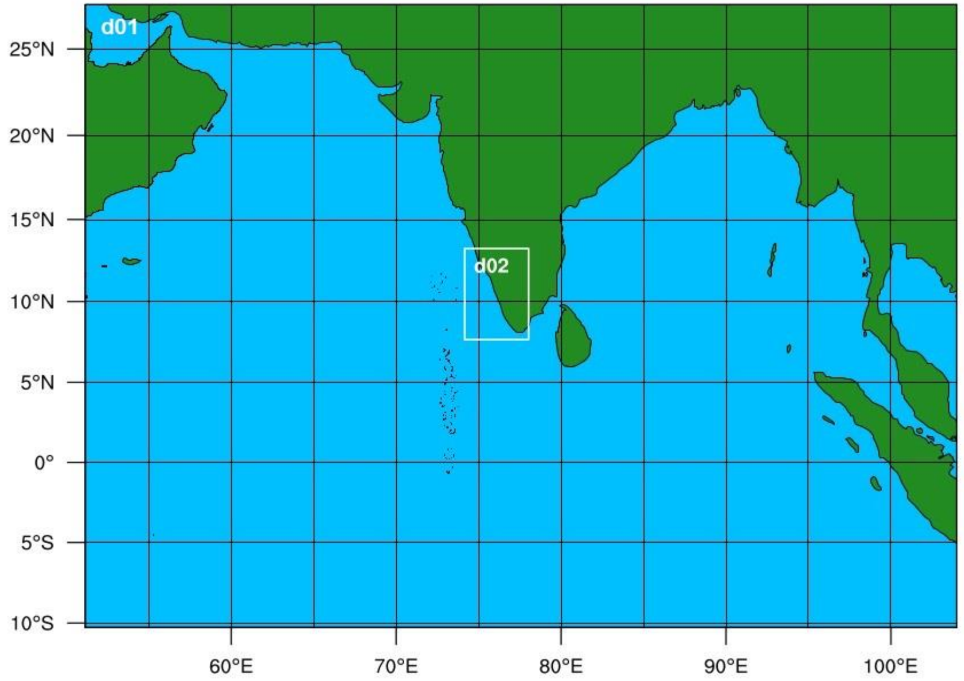
**Indian Institute of Technology- Delhi**


**EGU GA – 2019**
**Vienna, Austria**

# Study Area

- Bounded by Western Ghats (48% of total land) in the east and the Arabian sea in the west.
- Valleys, Mountain Passes, low lying plains, and coastal belts
- One of the richest biodiversity hotspots of India and classified as ecologically sensitive zone (Asserted in Gadgil Report 2011).
- 68% rainfall through south-west monsoon (Jun to Sep) and 17% from north-east monsoon (Dec to Feb).
- More than 50 reservoirs and 44 rivers.
- Nominal GDP of Kerala is approximately USD $125 billion.



# LULC Change Assessment over Kerala

LULC Data Source: ISRO Decadal and Bhuvan Data

| LULC Type | 1985 | 1995 | 2005 | 2018 |
|---|---|---|---|---|
| Urban and Built-up Land (UBL) | 23.74 | 33.56 | 24.56 | 51.3 |
| Cropland and Pasture (CLP) | 105.37 | 105.44 | 189.66 | 128.95 |
| Grassland (GL) | 17.13 | 17.26 | 11.69 | 0.65 |
| Shrubland (SL) | 57.66 | 59.26 | 8.3 | 2.04 |
| Evergreen Forest (EF) | 228.48 | 220.46 | 150.38 | 163.36 |
| Mixed Forest (MF) | 882.99 | 886.56 | 848.66 | 584.88 |

Unit: Pixels

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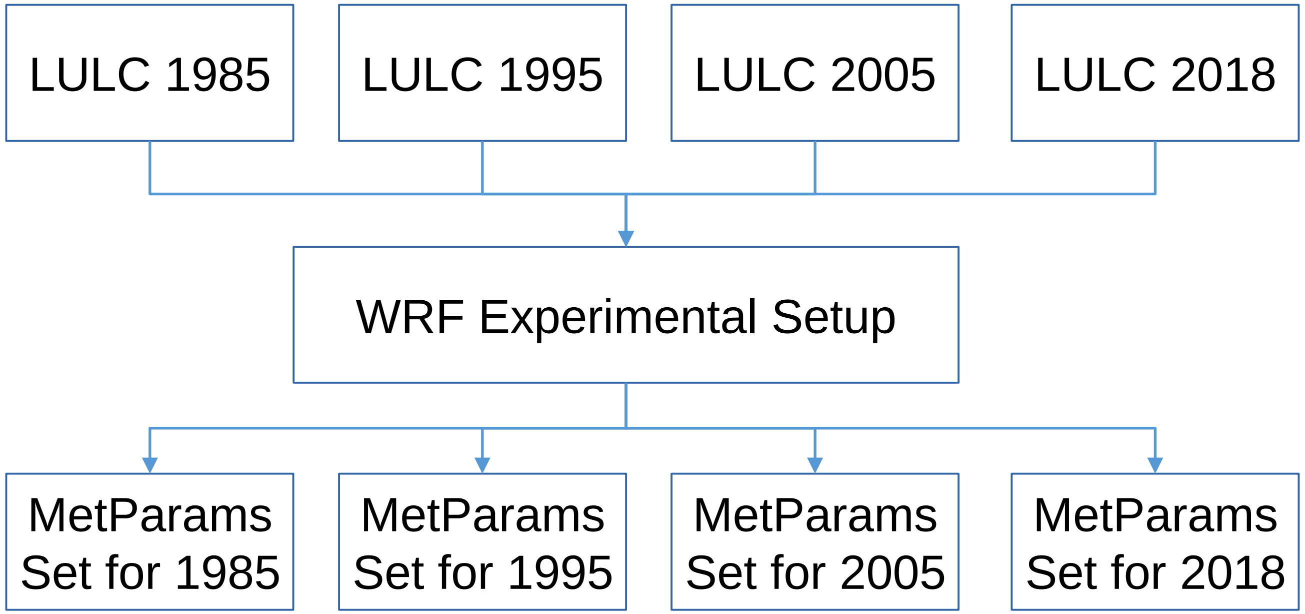
- UBL showed increasing trend except 2005.
- EF decreased in 1985-1995 (-4%)
  1995-2005(-32%)
  2005-2018 (8%).
- MF showed almost negligible change during 1985-1995 while experienced reduction during
  1995-2005 (-4%)
  2005-2018 (-31%).
- In the later years (2005-2018), EF and MF migrated to CLP, which led to an increment in CLP area fraction.
  In 2005-2018, CLP has reduced; probably because of reduced pasture field.
- GL experienced reduction in 1995-2005 (-32%) and 2005-2018 (-94%).
- SL reduced excessively during 1995-2005 (-85%) and 2005-2018 (-75%) with small growth in 1985-1995 (3%).

# WRF Experimental Setup

| Model Attributes | Options used |
|---|---|
| Solver | ARW |
| Number of domains (grid spacing) | 2; Outer domain (25 km); Inner domain (5 km); one-way nesting |
| Microphysics scheme | WSM 6 (Hong and Lim, 2006) |
| Convection scheme | Kain-Fritsch (Kain, 2004) |
| Longwave radiation scheme | RRTM (Mlawer et al., 1997) |
| Shortwave radiation scheme | Dudhia (Dudhia, 1989) |
| Planetary Boundary layer | YSU (Hong et al., 2006) |
| Land surface | Noah MP (Niu et al., 2011) |
| Surface layer option | Monin-Obukhov Similarity scheme (Cheng et al., 2005) |
| SST (update frequency) | FNL Analysis (6- hourly) |
| Adaptive time step | True |
| Number of land categories | 24 |

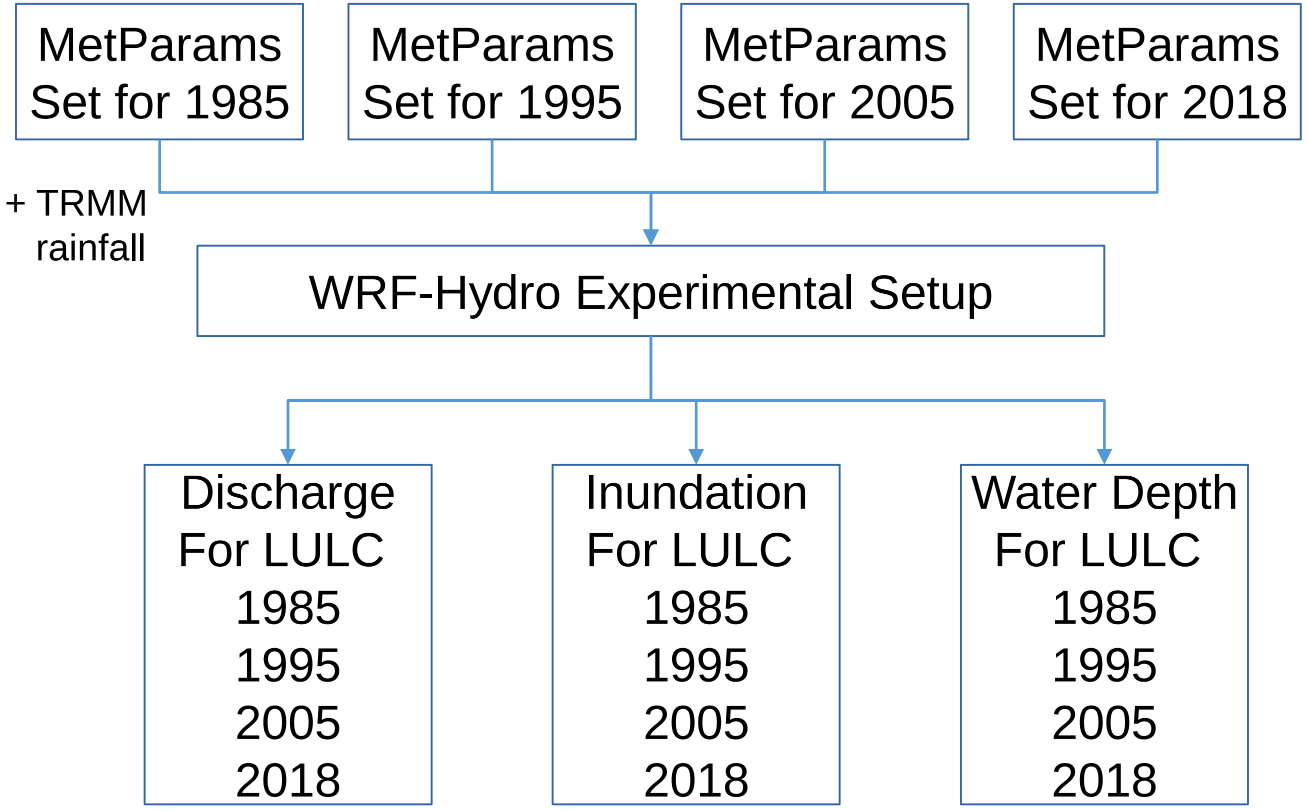
- Initial Condition and Boundary conditions are taken from NCEP FNL 6 hourly 1 degree data (NCEP/NOAA/UD-DoC 2000) from 11 May 2016 to 12 September 2018.

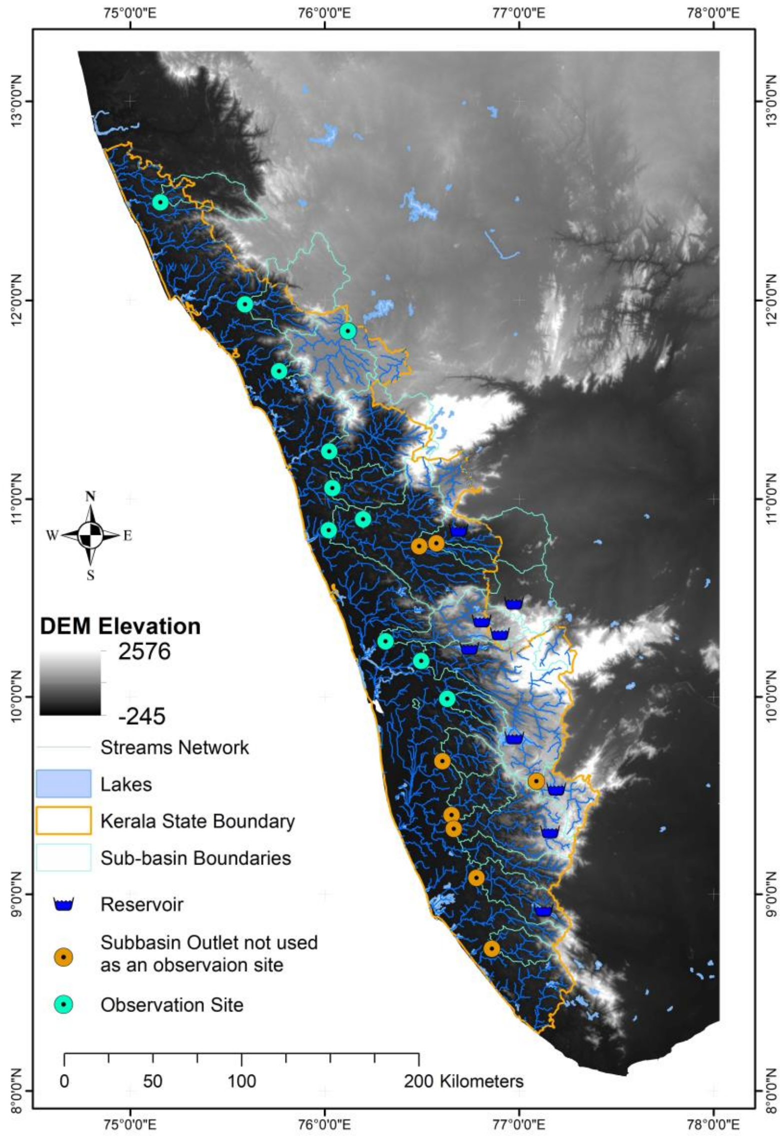



MetParams : T2D, Q2D, PSFC, U2D, V2D, LWDOWN, SWDOWN, RAINRATE (Using TRMM instead of this)

European Geosciences Union

# WRF-Hydro Experimental Setup

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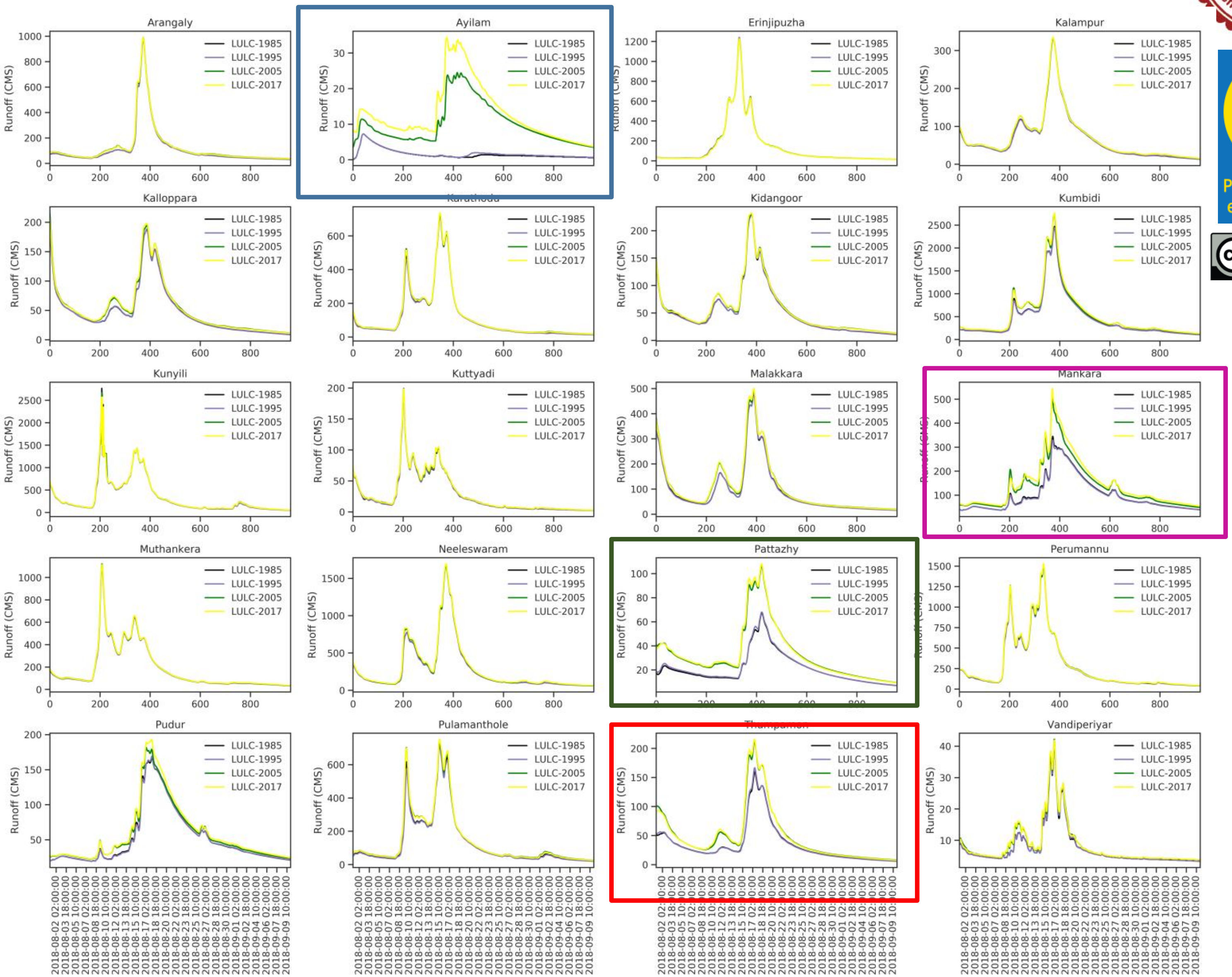
# WRF-Hydro Calibration/Validation

| Stations | R-Squared | D | MAE | ME | MDE | MDAE | RMSE | Pearson_R | Spearman_R |
|---|---|---|---|---|---|---|---|---|---|
| Arangaly | 0.3 | 0.703 | 23.391 | -7.192 | 6.212 | 10.1 | 34.662 | 0.55 | 0.78 |
| Erinjipuzha | 0.4 | 0.755 | 33.397 | -25.511 | -3.937 | 6.794 | 66.142 | 0.63 | 0.95 |
| Kalampur | 0.27 | 0.603 | 20.707 | -11.574 | 0.7 | 14.442 | 33.758 | 0.52 | 0.43 |
| Karathodu | 0.57 | 0.733 | 9.221 | -7.231 | 0.1 | 0.2 | 24.834 | 0.76 | 0.79 |
| Kumbidi | 0.47 | 0.702 | 40.552 | -15.15 | 8.6 | 12.3 | 87.236 | 0.69 | 0.82 |
| Kuniyili | 0.4 | 0.753 | 45.656 | -24.953 | -20.112 | 26.02 | 82.755 | 0.63 | 0.86 |
| Kuttyadi | 0.63 | 0.544 | 17.771 | -17.765 | -3.163 | 3.163 | 31.897 | 0.8 | 0.87 |
| Muthankera | 0.4 | 0.705 | 26.647 | -17.139 | -4.96 | 6.379 | 56.512 | 0.63 | 0.85 |
| Neeleswaram | 0.26 | 0.652 | 80.508 | -58.337 | -5.408 | 29.335 | 128.404 | 0.5 | 0.68 |
| Permannu | 0.5 | 0.806 | 50.581 | -33.954 | 1.095 | 13.066 | 93.948 | 0.71 | 0.88 |
| Pulanthole | 0.36 | 0.605 | 14.982 | -11.929 | -0.988 | 3.2 | 33.545 | 0.6 | 0.84 |

R_Squared = coefficient of determination; D = index of agreement; MAE = Mean Absolute Error; ME = Mean Error; MDE = Median Error; MDAE = Median Absolute Error; RMSE = Root Mean Square Error; Pearson_R = Pearson Correlation Coefficient; Spearman_R = Spearman Correlation Coefficient

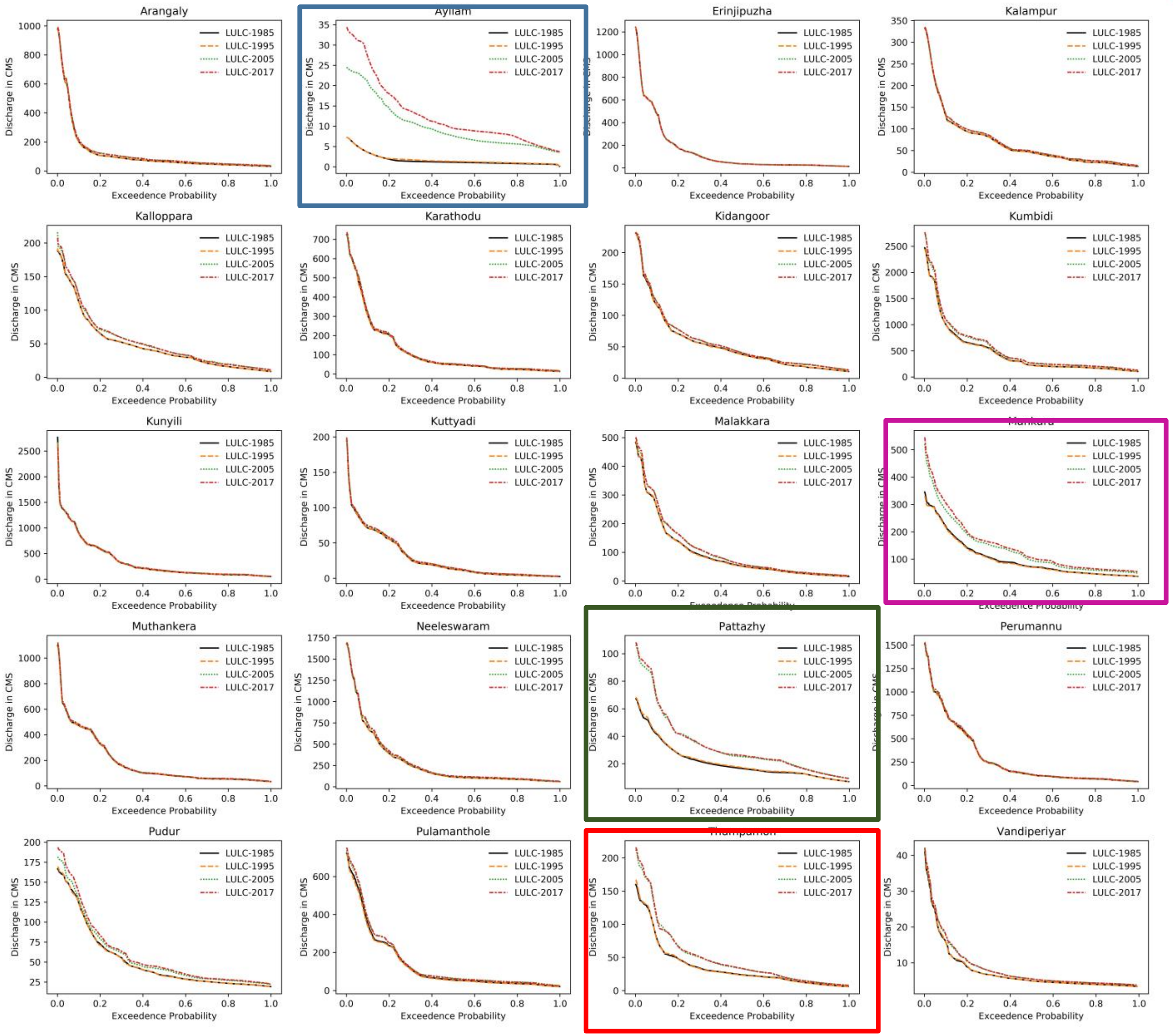
# WRF-Hydro Discharge (Aug-2018)

| Stations | 1985-1995 (%) | 1995-2005 (%) | 2005-2018 (%) |
|---|---|---|---|
| Arangaly | <1 | 8.8 | <1 |
| Ayilam | 9.69 | 462.89 | 28.35 |
| Erinjipuzha | <1 | <1 | <1 |
| Kalampur | <1 | 5.37 | <1 |
| Kalloppara | <1 | 11.22 | <1 |
| Karathodu | <1 | 5.79 | <1 |
| Kidangoor | <1 | 7.42 | <1 |
| Kumbidi | -1.21 | 14.21 | 2.16 |
| Kuniyili | <1 | 3.43 | <1 |
| Kuttyadi | <1 | 5.71 | <1 |
| Mallakkara | <1 | 13.04 | <1 |
| Mankara | -2.24 | 37.76 | 7.31 |
| Muthankera | <1 | 2.86 | <1 |
| Neeleswaram | <1 | 4.36 | 1.84 |
| Pattazhy | 2.41 | 52.31 | 1.16 |
| Permannu | <1 | 2.87 | <1 |
| Pudur | <1 | 10.66 | 4.95 |
| Pulanthole | -2.66 | 12.2 | <1 |
| Thumpamon | <1 | 38.79 | <1 |
| Vendiperiyar | <1 | 11 | <1 |

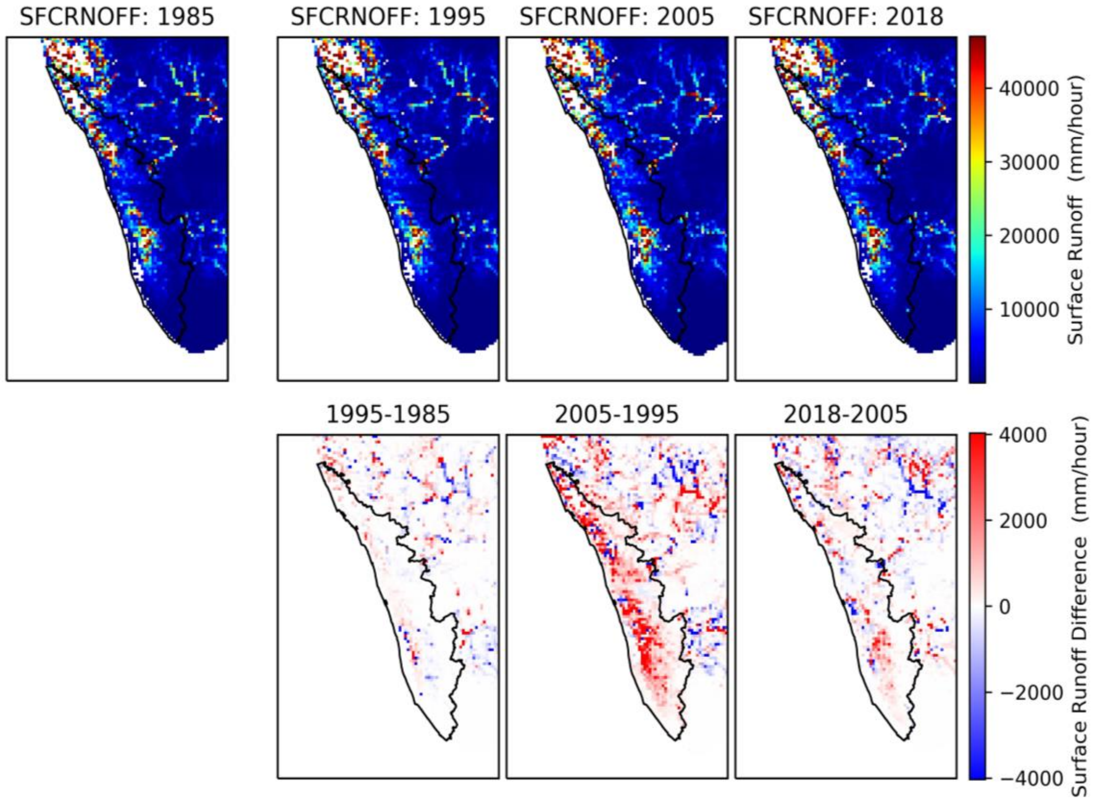


# WRF-Hydro FDC

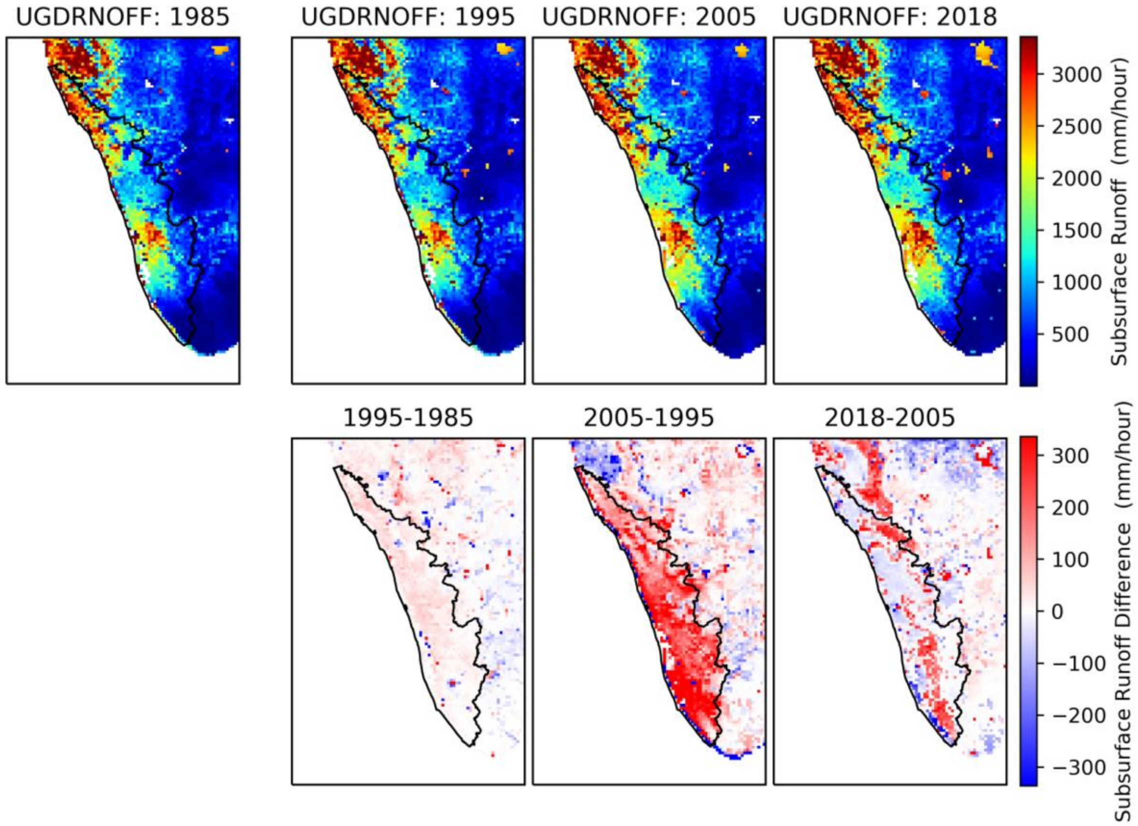
- 50% of the stations undertaken in this study have observed changes in runoff by more than 10%.
- The 10 percent exceedance flow (Q10) raised by more than 10% for many stations.



# WRF-Hydro Runoff, Subsurface Runoff, and ET



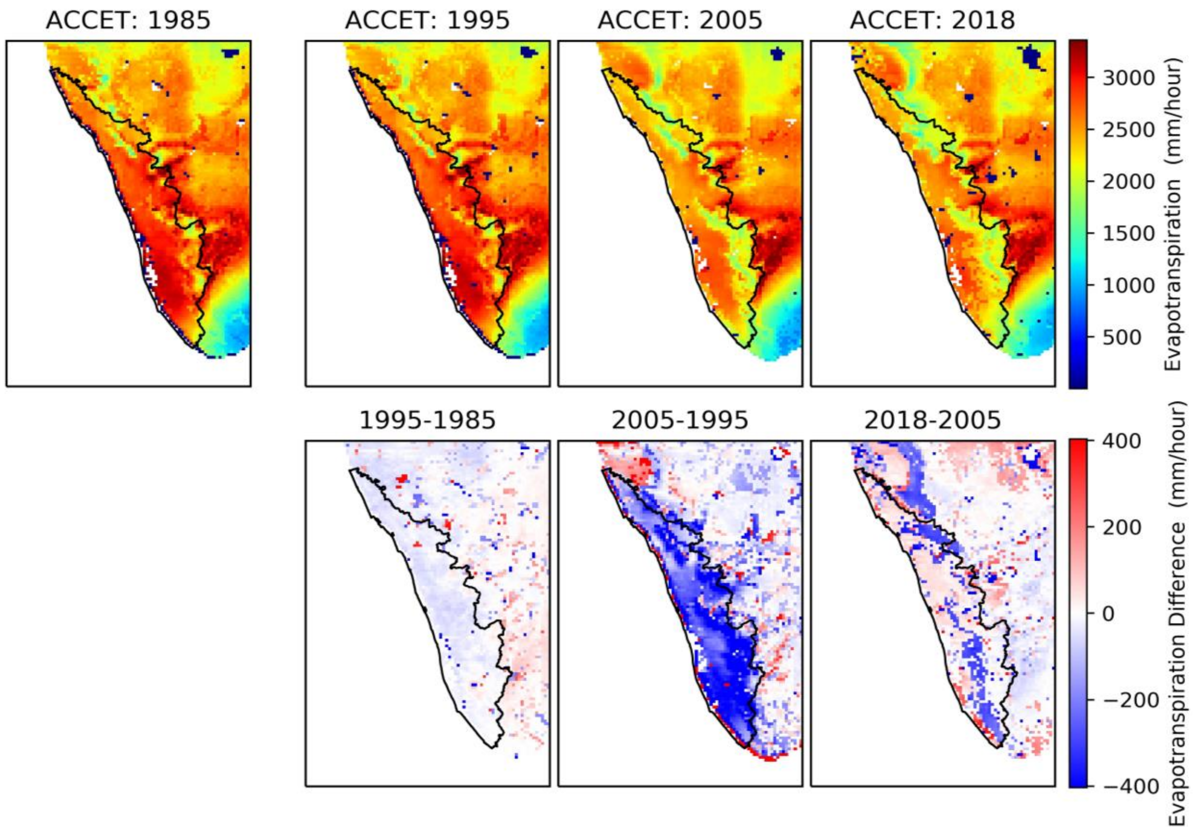

Average accumulated surface runoff




Average accumulated sub-surface runoff

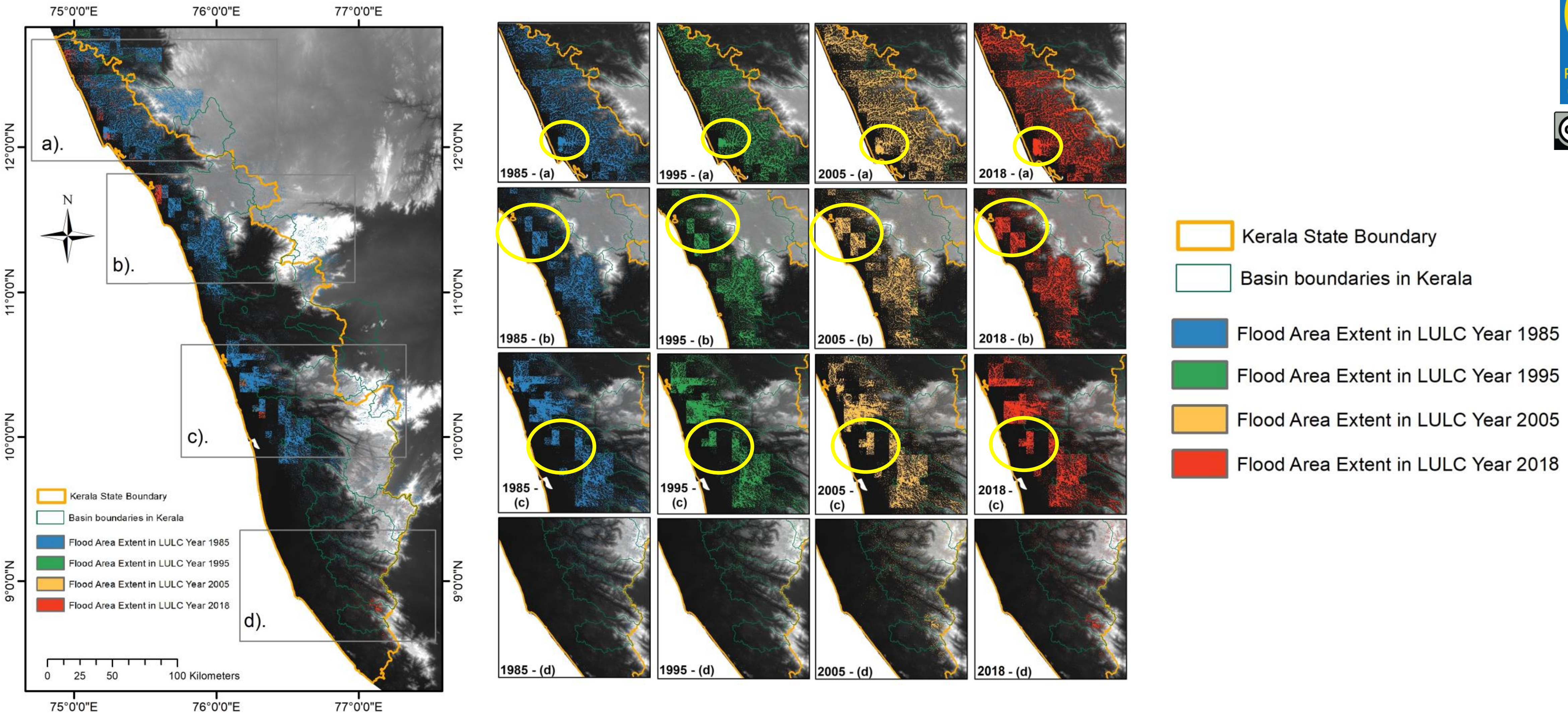
Photography encouraged

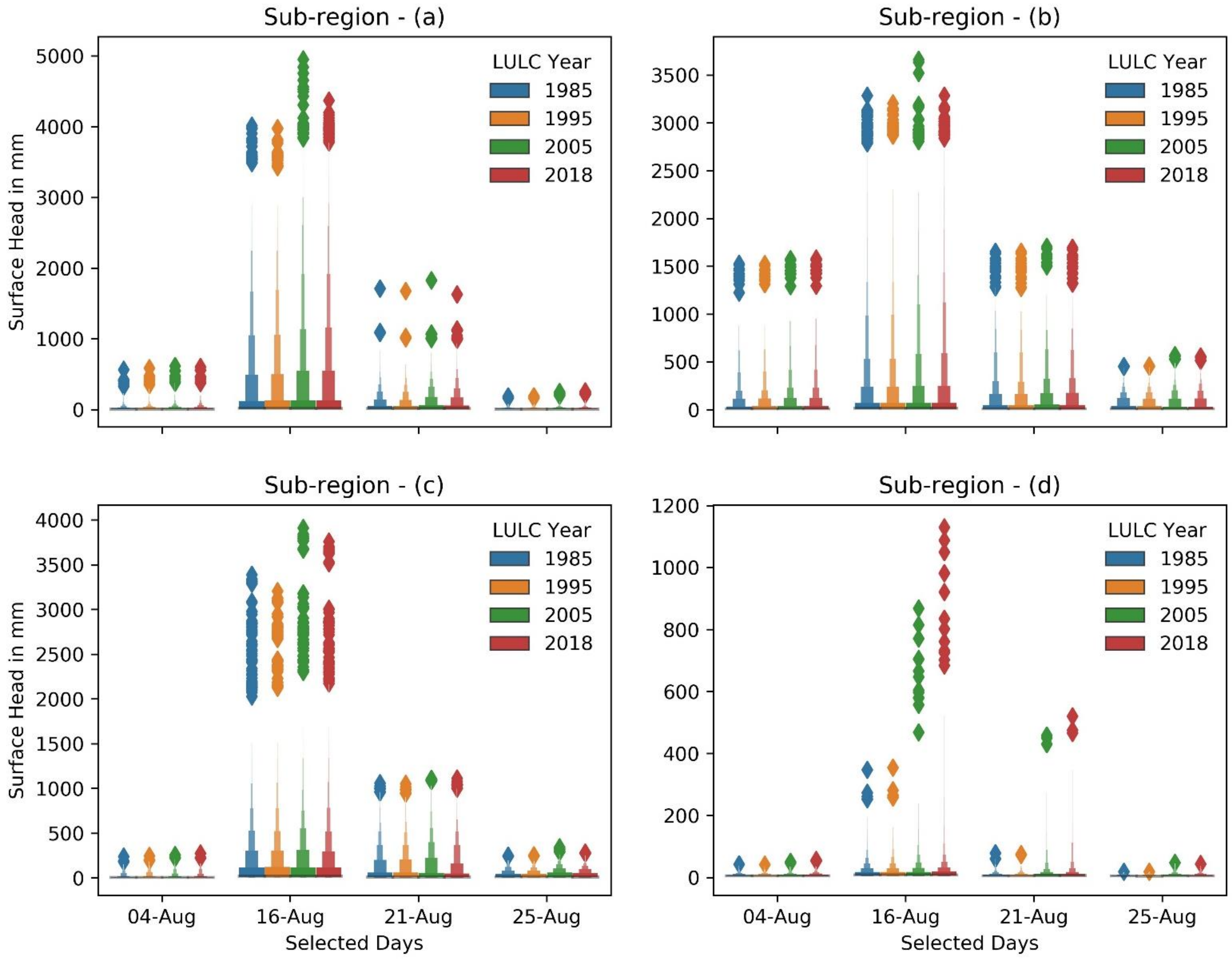
# WRF-Hydro Runoff, Subsurface Runoff, and ET




Average accumulated evapotranspiration

# WRF-Hydro flood inundation

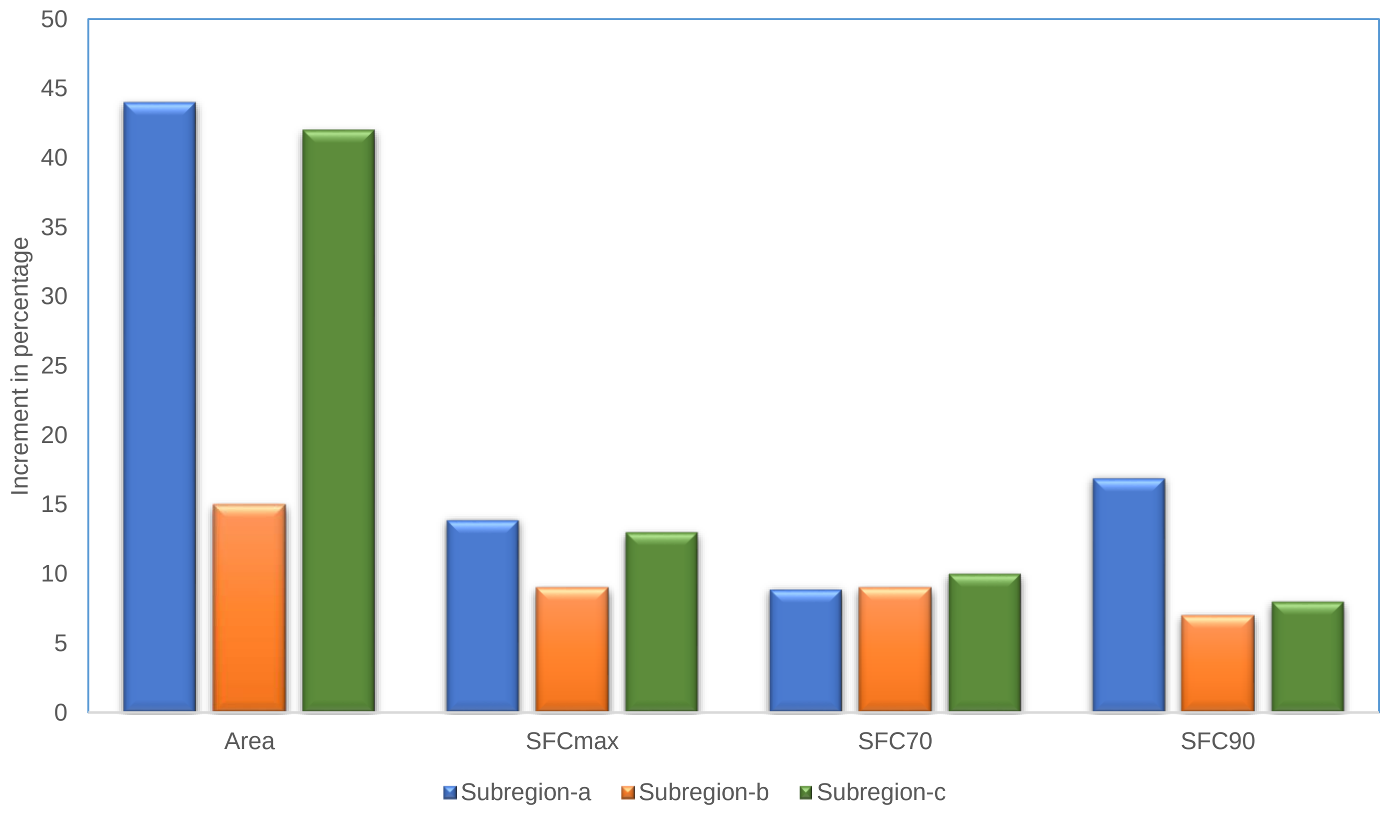





- We also analysed the surface water head for four representative days, i.e., 4 August (before heavy rainfall), 16 August (a day after heavy rainfall), 21 August (a day before heavy rainfall) and 25 August 2018 (after heavy rainfall).
- 2005 and 2018 demonstrated higher water head than in 1985 and 1995 for almost every sub-region on all four days
- Day 3: 21 Aug 2018 demonstrated higher surface heads in 2005 and 2018, with lesser difference than Day 2, explain the slower withdrawal of impounded water in 2005 and 2018.

# Conclusion

- In this study, we observed increased surface and sub-surface runoff in the period 1985 to 2018 with rapid change in 1995 to 2005. The heavy destruction in forest cover and green vegetation could be attributed as one of the reason for hydrological changes in the region along with massively increasing agricultural practices.




**Are the development, we have focused on, sustainable???**

# Thank you !!!!