

# Probabilistic Streamflow Forecast for Narmada River Basin

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# Introduction

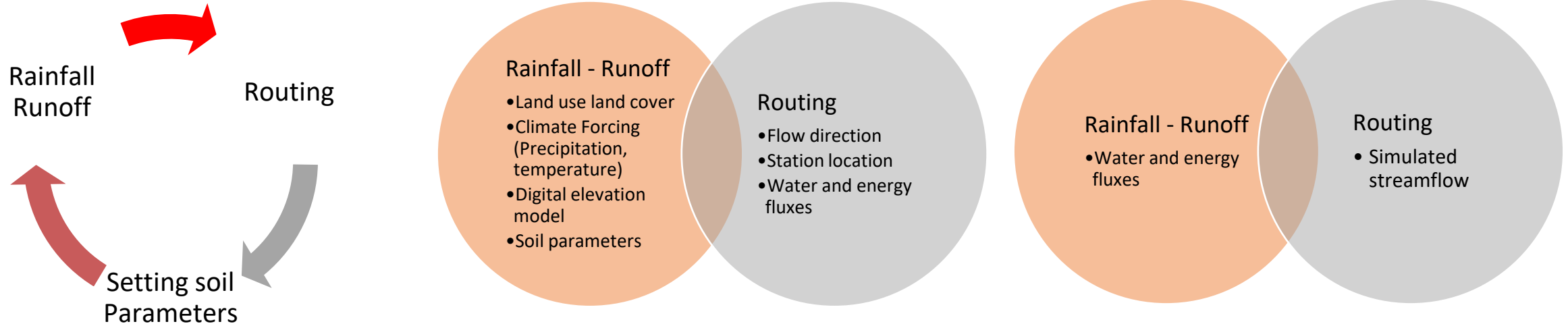
& problem statement

- Ensemble Streamflow Prediction (ESP) is a widely used method in forecasting streamflow, particularly for extremely low or high flows. Over the recent years, the impact of anthropogenic interventions on river basins has increased, there is an urge to develop various approaches for representing human–water interactions in large-scale hydrological and land surface models.
- One of the widely used model, VIC model generally does not take into account the reservoir and their operations in simulating the flow. Here, aim is to perform Ensemble Streamflow Forecast considering the effect of reservoirs.

# Objective

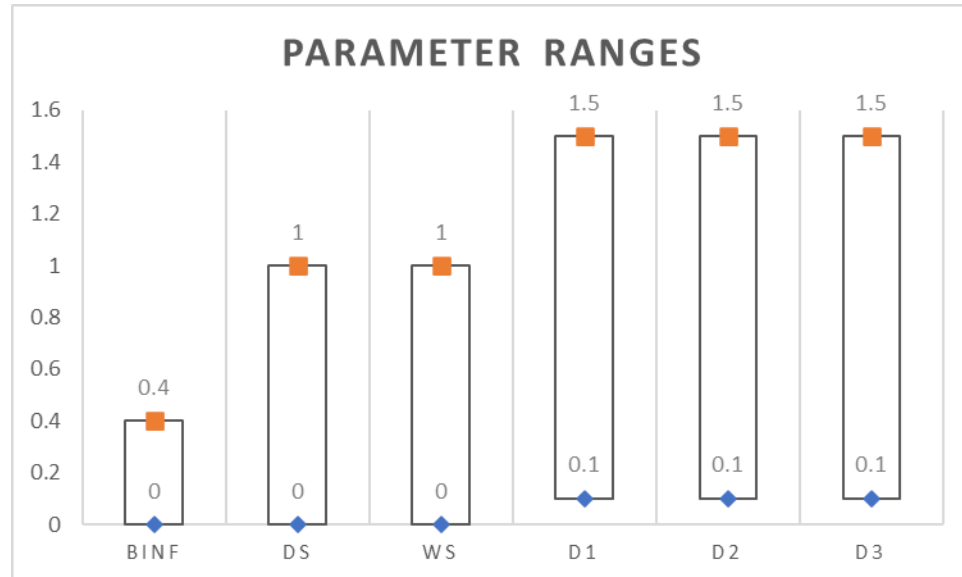
- To calibrate and validate VIC-Res model on the selected basin.
- To generate probabilistic forecast of streamflow with the use of 16 members ensemble climate forecast data.

# VIC Model



- VIC is a large-scale, land hydrological model maintained and developed by the University of Washington. VIC consists of two core components, namely a rainfall–runoff and routing model.<sup>[2]</sup>
- We focus on seven main soil parameters which control the rainfall runoff progress.

# Soil Parameters

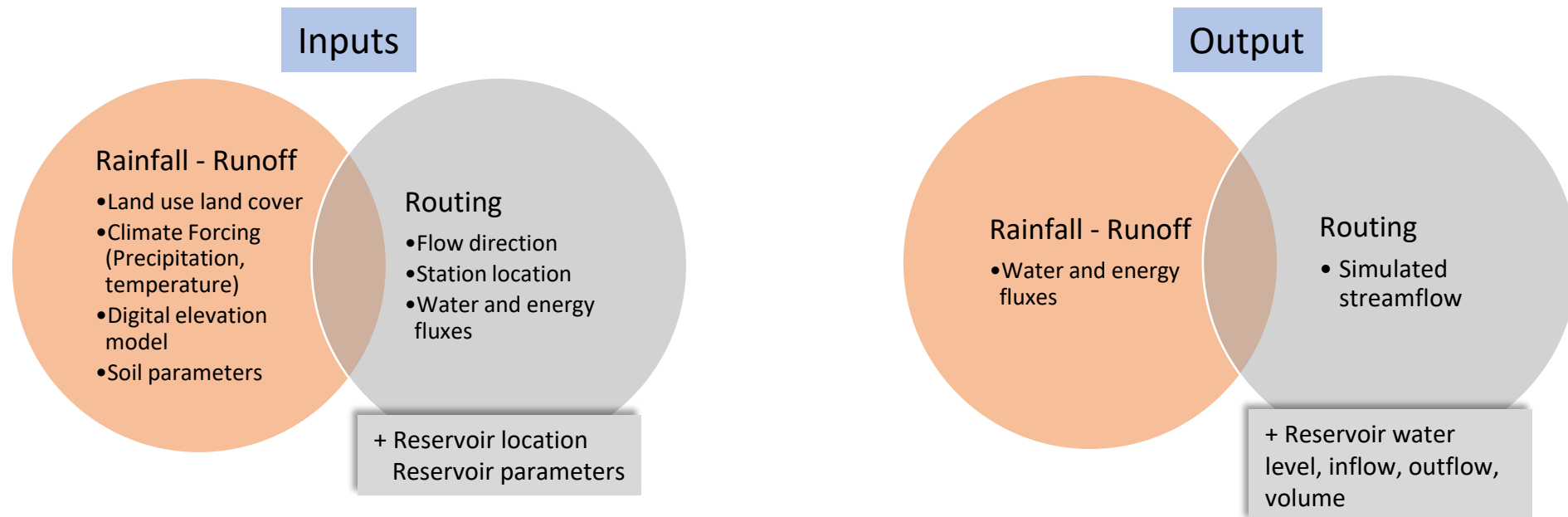


Value range of soil parameters

- The parameter  $b_{inf}$  influences the available infiltration capacity. A higher value of  $b$  leads to a lower infiltration rate and higher surface runoff.
- The thickness of the soil layers ( $d1, d2$  &  $d3$ ) affects several processes. In general, thicker layers delay the seasonal peak flow and increase the evaporation losses since they increase water storage capacity.
- $D_s$ ,  $D_{max}$ , and  $W_s$  determine the shape of the baseflow curve, which relates the soil moisture in the lower layer to the amount of baseflow.
- The value of  $D_{smax}$  may vary from 0 to 30

# *VIC-Res Model (i.e. with reservoirs)*

Land cover modifications or hydraulic infrastructures affect both surface and subsurface hydrological processes by redistributing water over time and space. Hence, an accurate representation of the anthropogenic interventions within hydrologic models is thus of importance.



# Reservoir location (ASCII file)

Software used – ArcGIS

Data used – LandSAT 7 ETM+ (Source : USGS earth explorer)

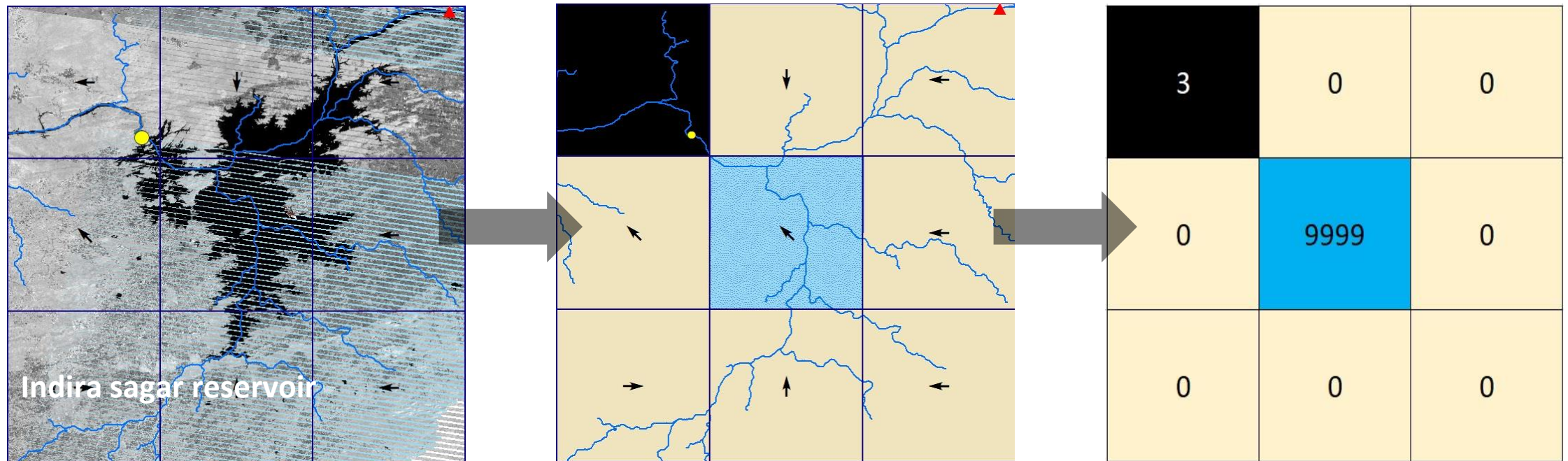
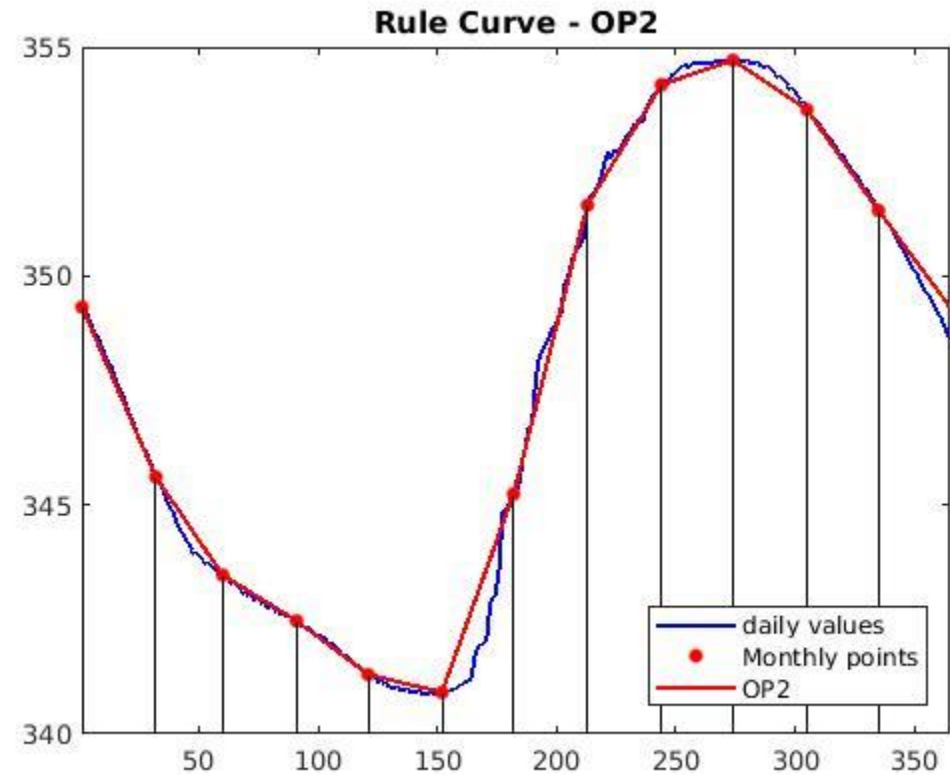
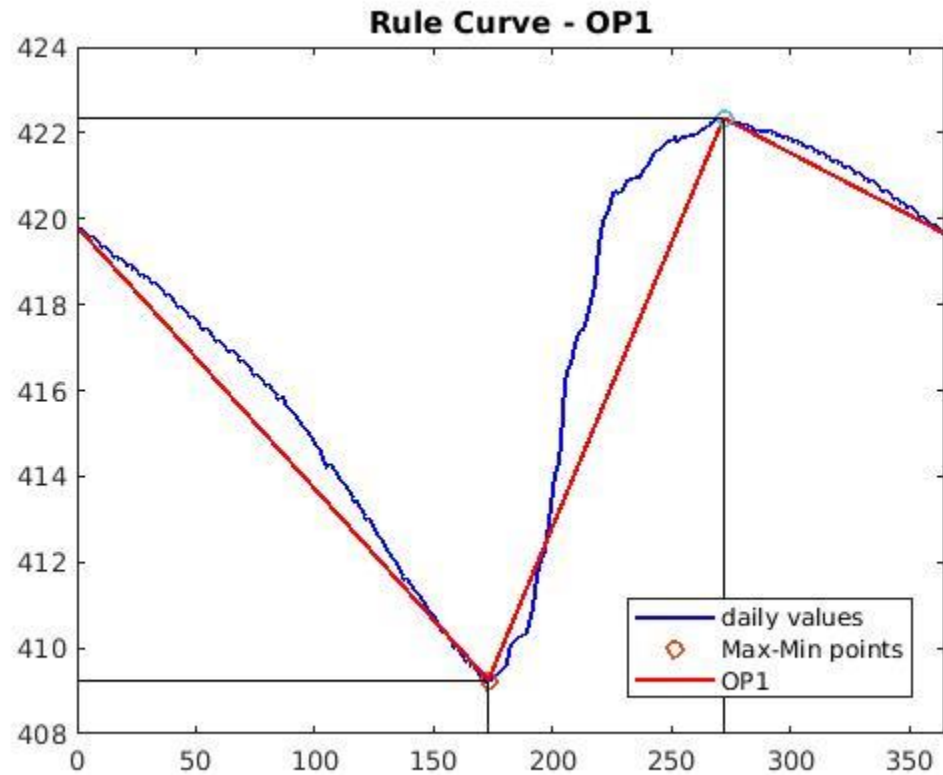
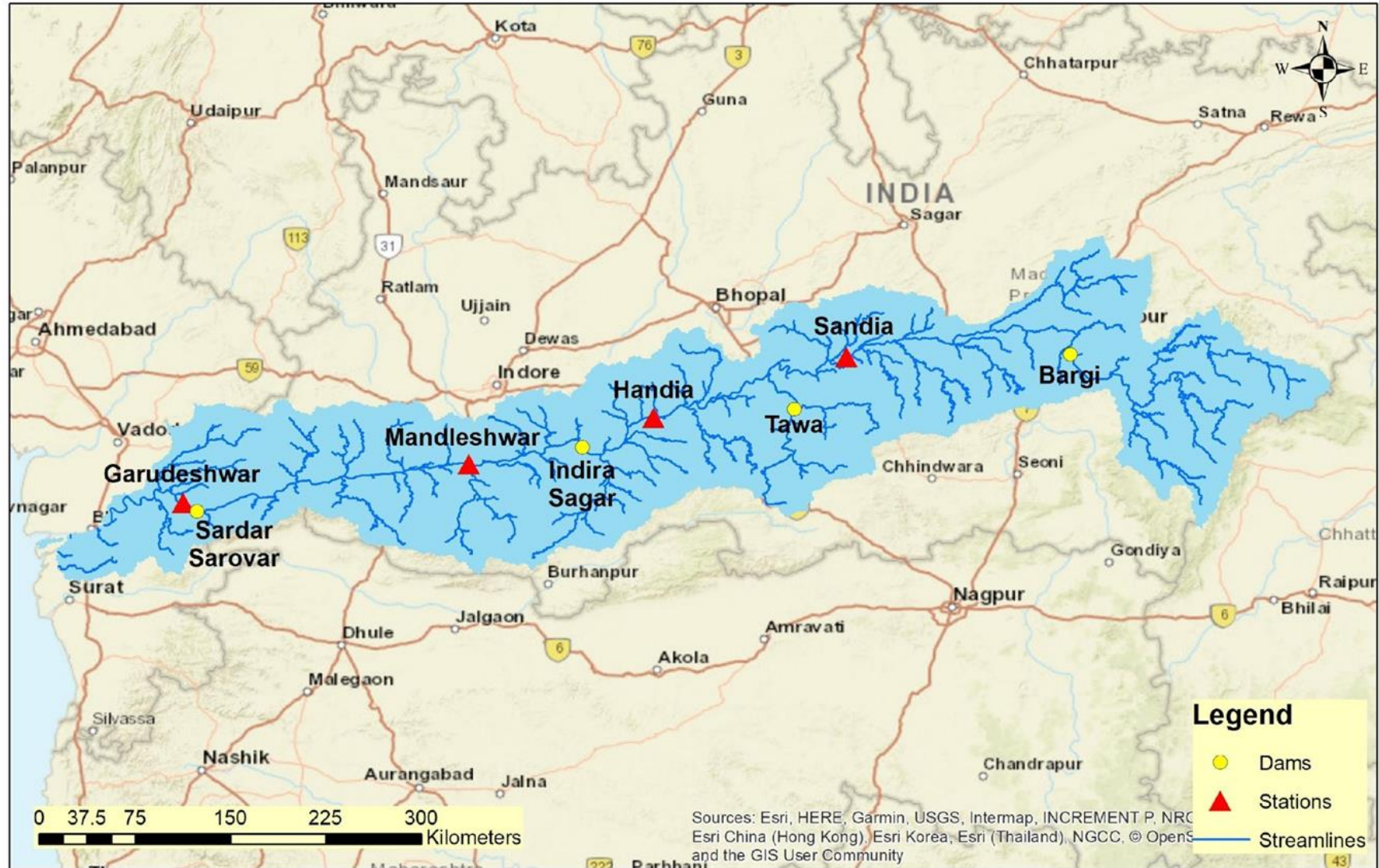


Fig. process of making reservoir location ASCII file

# Rule Curve

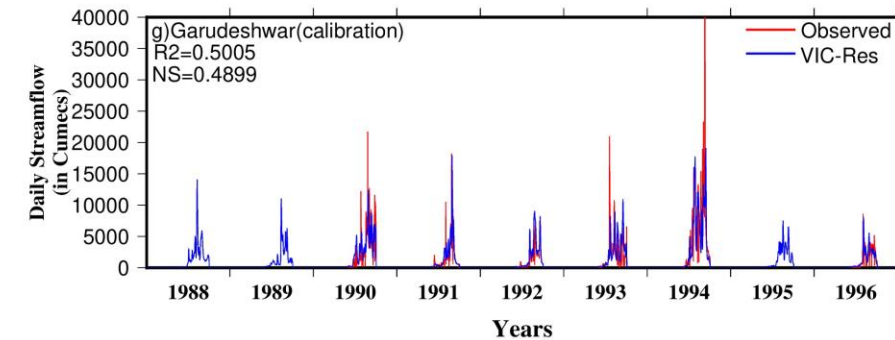
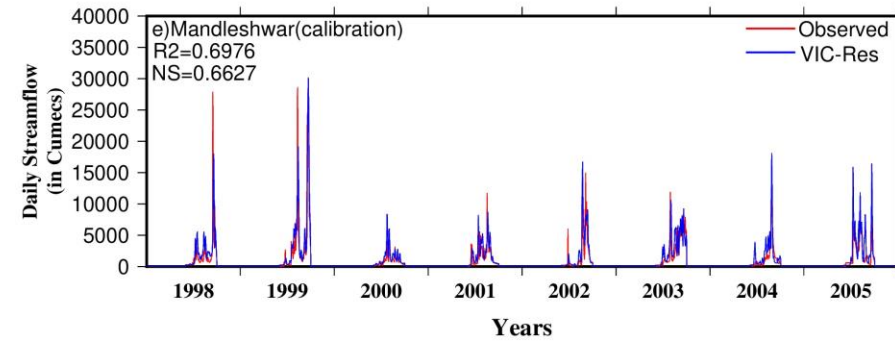
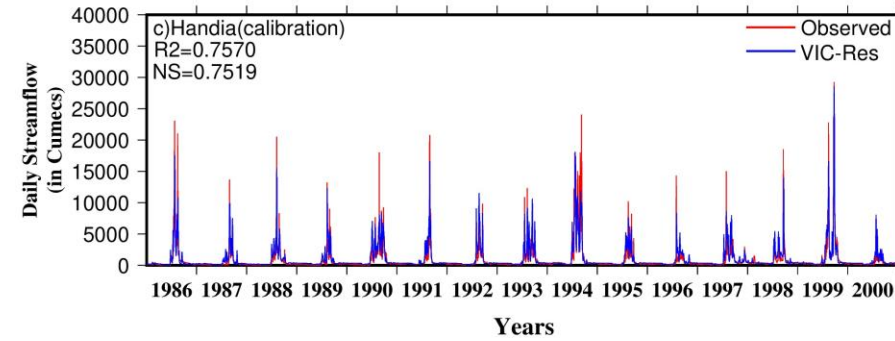
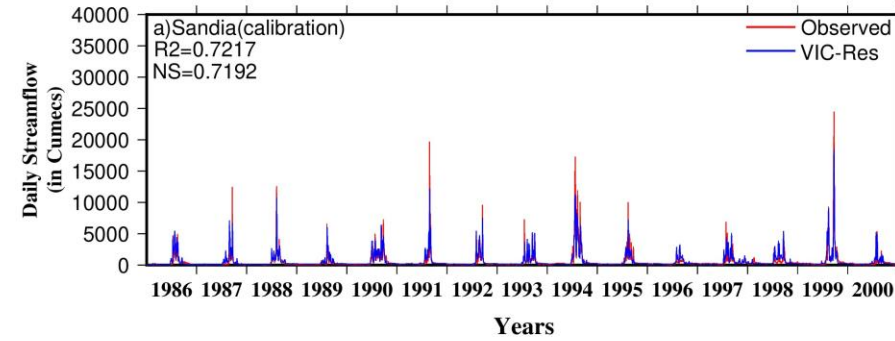


## Narmada River Basin

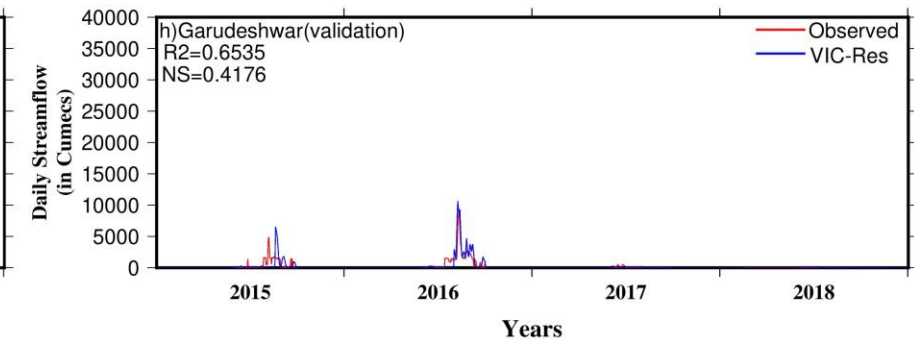
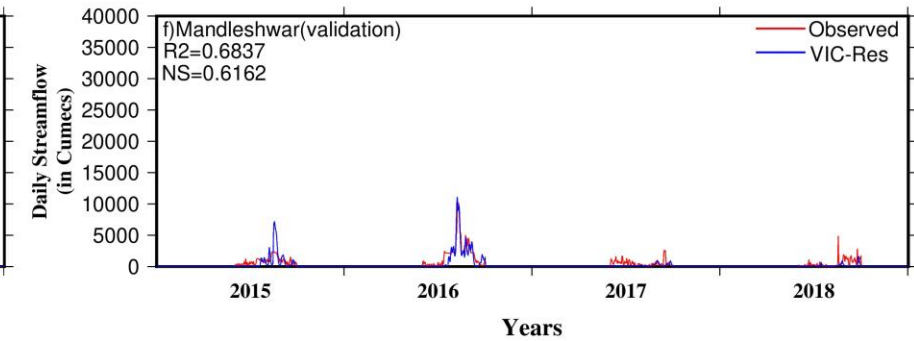
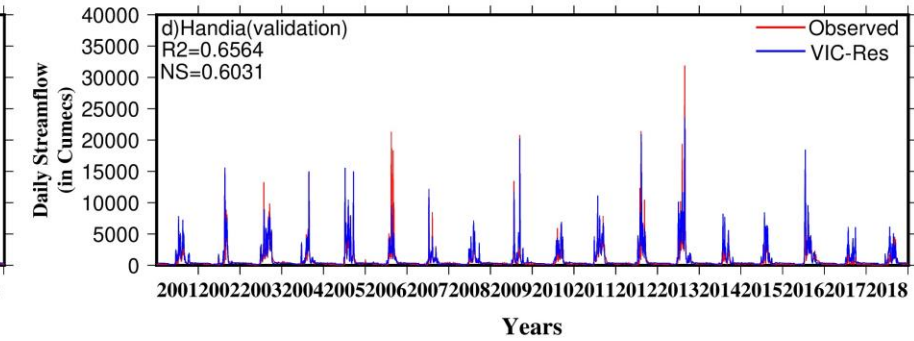
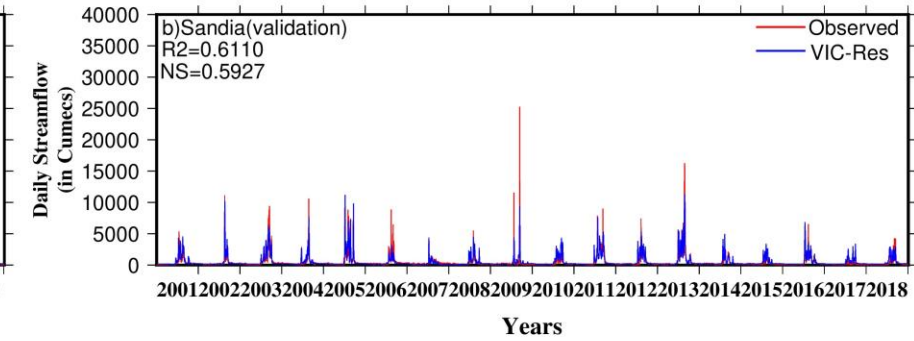


# Calibration & Validation Result - Stations

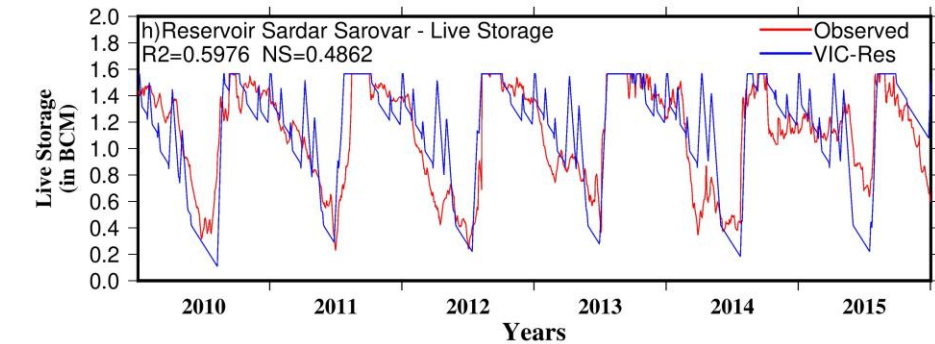
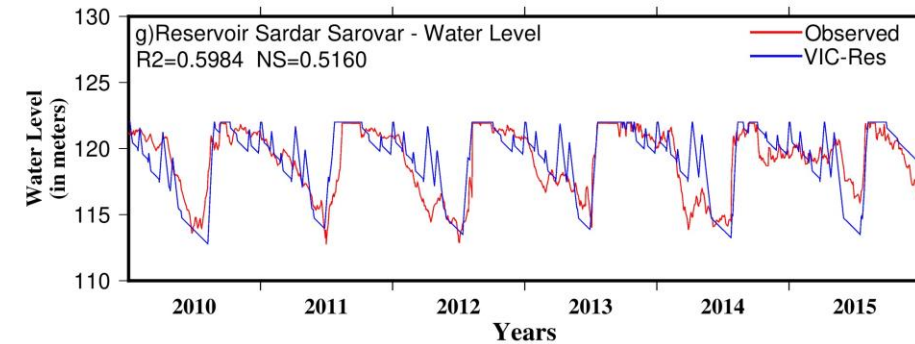
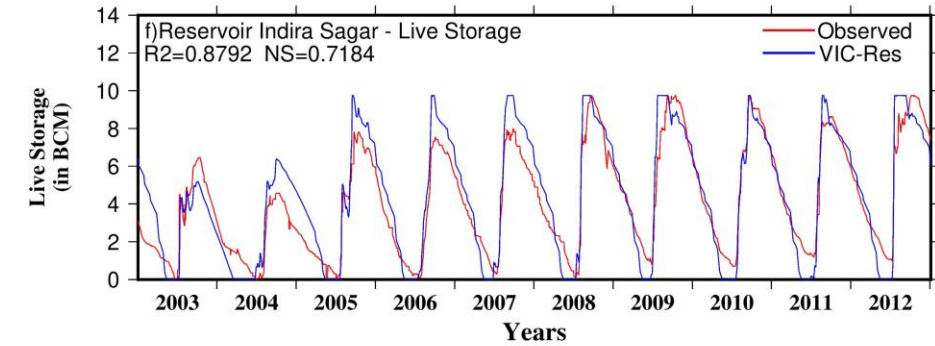
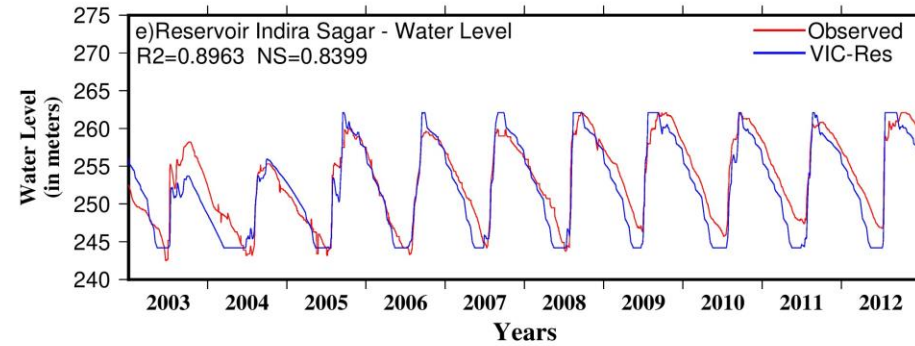
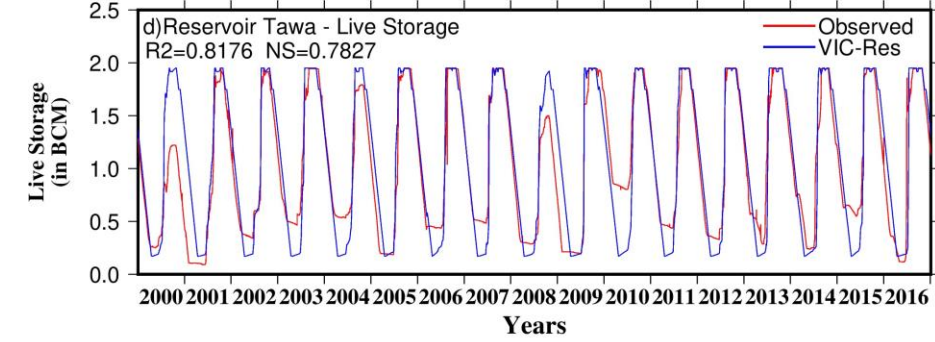
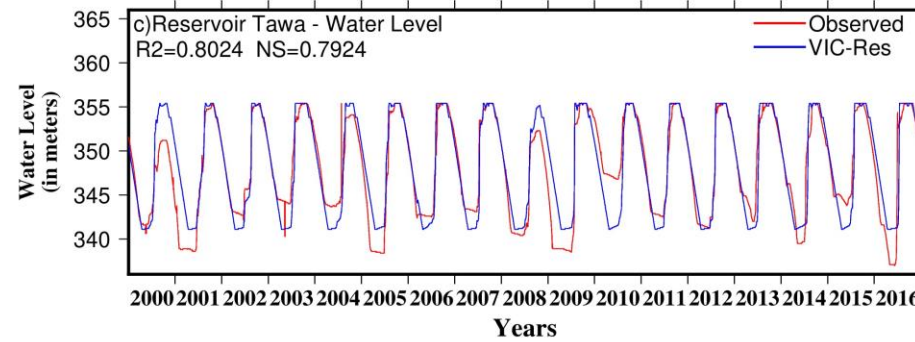
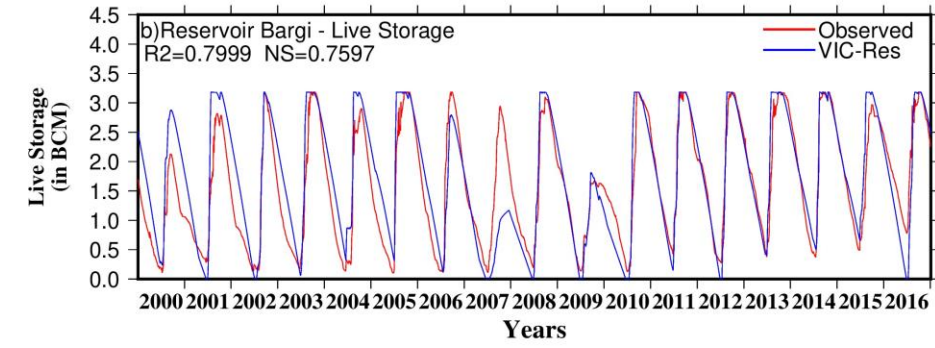
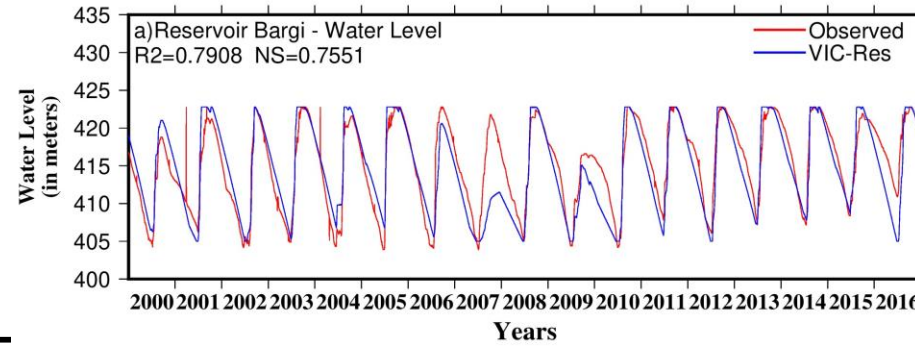
## Training Period



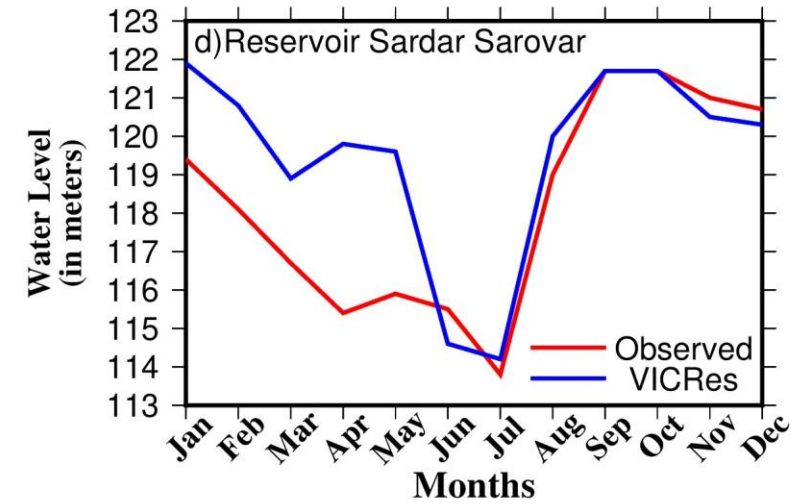
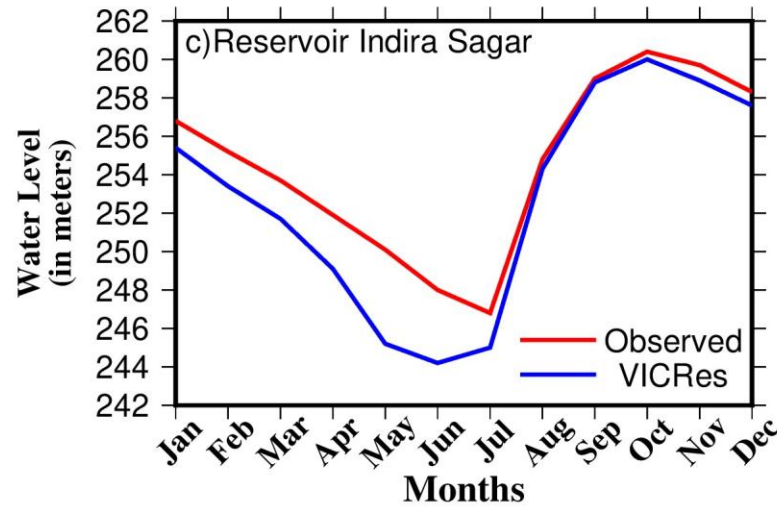
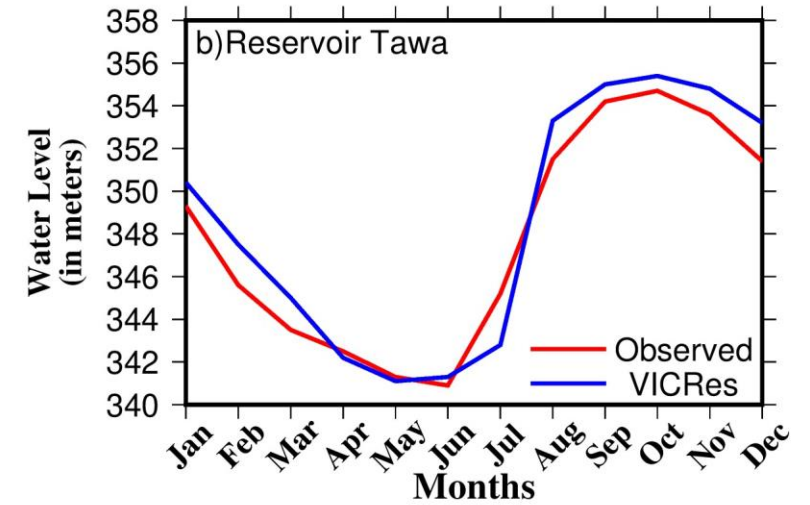
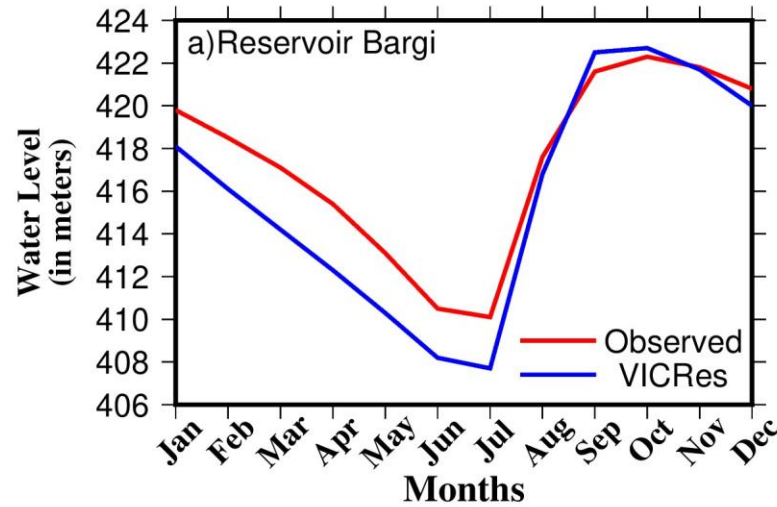
## Testing Period



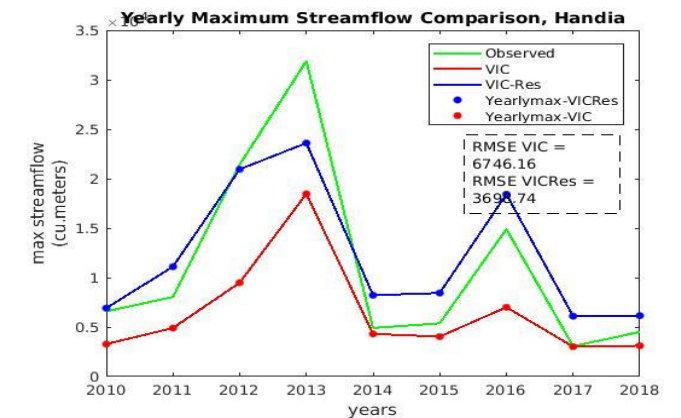
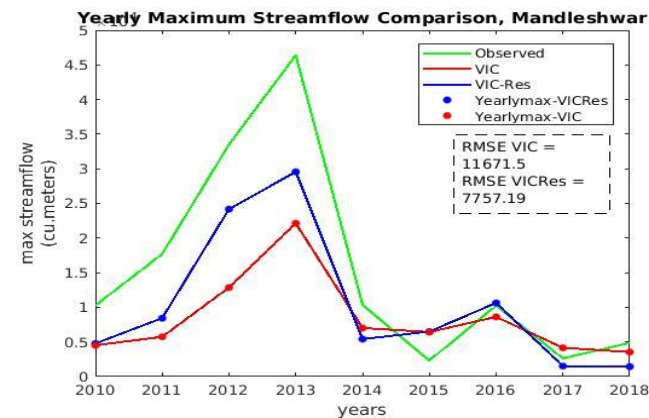
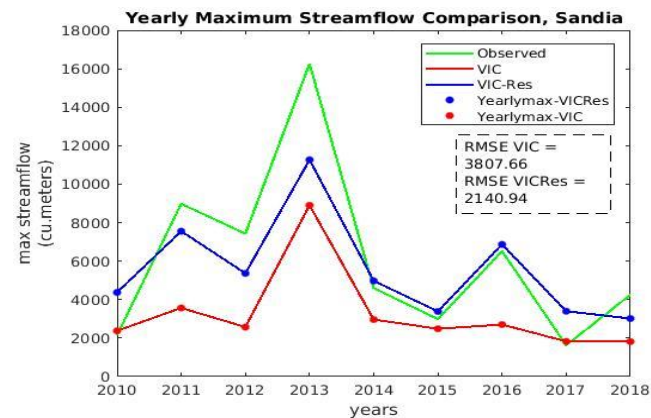
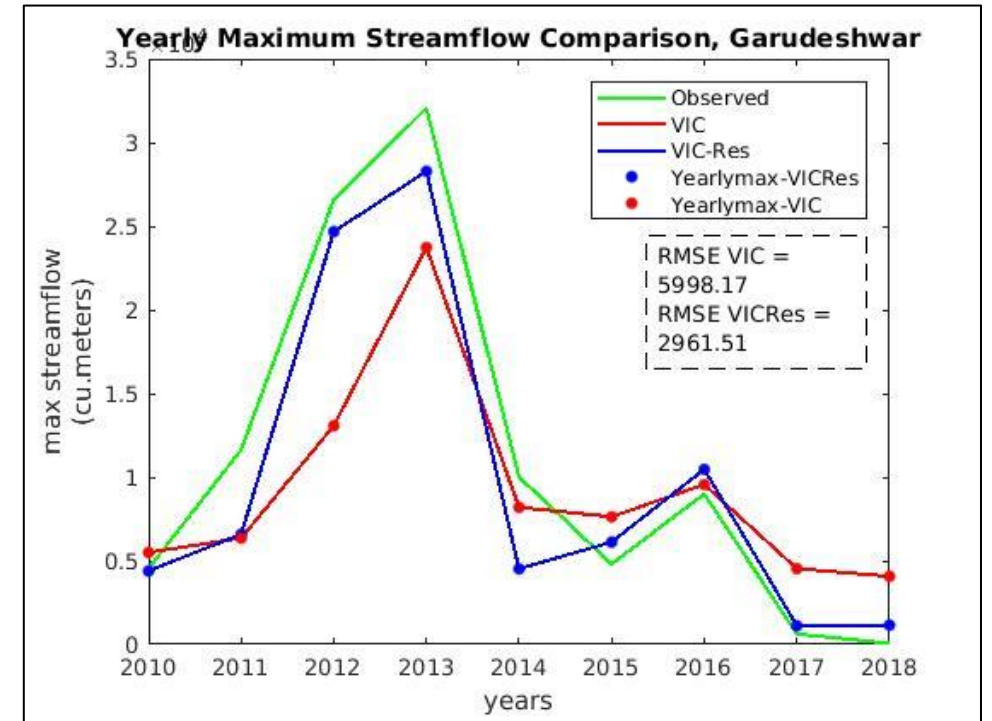
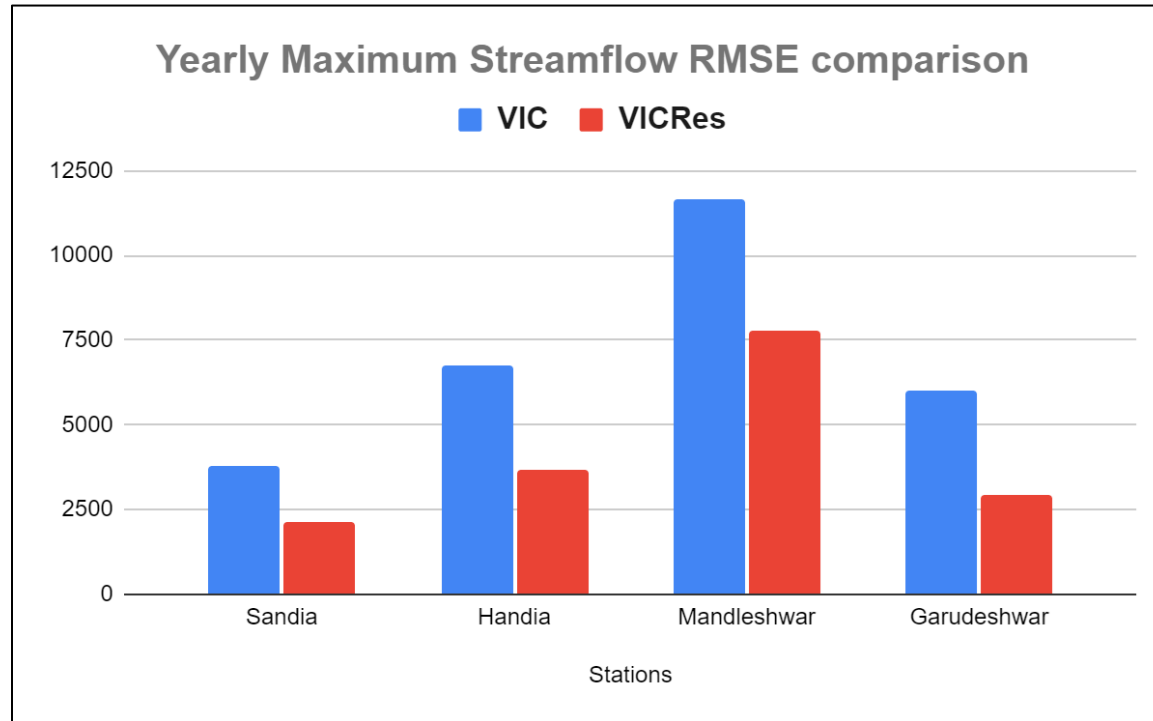
# Calibration & Validation Result - Reservoirs



# Calibration & Validation Result – Rule Curves (monthly)



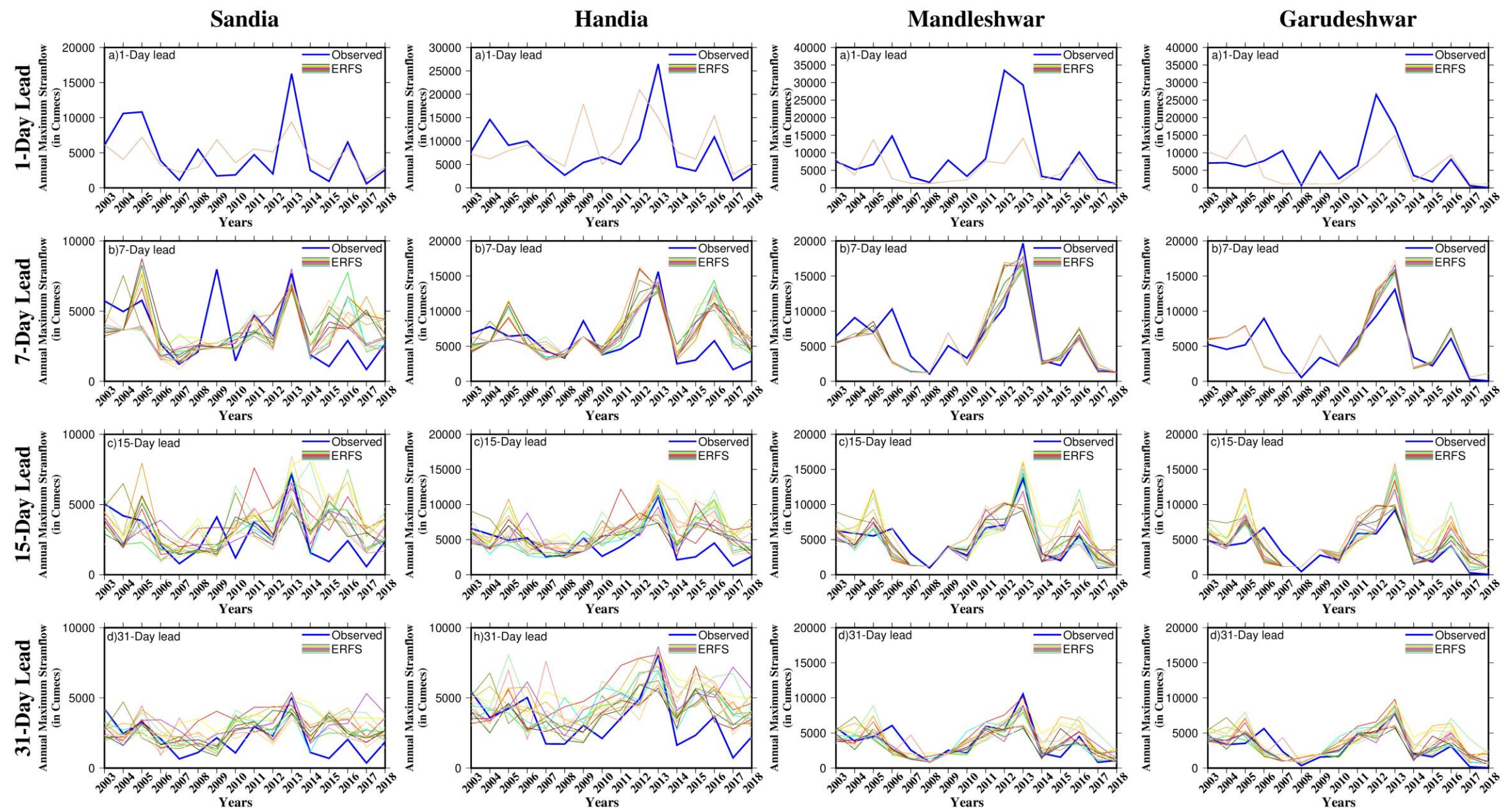
# Why VIC-Res?



# Streamflow forecast using ERFS ensembles

- In Ensemble Forecast, we run a single model several times. Each time the initial condition will be different.
- Performing the same lead us towards the possible range of forecast. Ensemble prediction also quantifies the uncertainty in observations and within model.
- Ensemble Streamflow Prediction (ESP) provides the means for statistical post-processing of forecasts and estimating the inherent uncertainties(Here, high-flow).<sup>[1]</sup>
- For the given purpose we are using Extended Range Forecast System(ERFS). ERFS is a weather forecast model developed by Indian Institute of Tropical Meteorology (IITM) and is made up of 16 separate forecasts, or ensemble members.

# ESP of Annual Maximum Streamflow

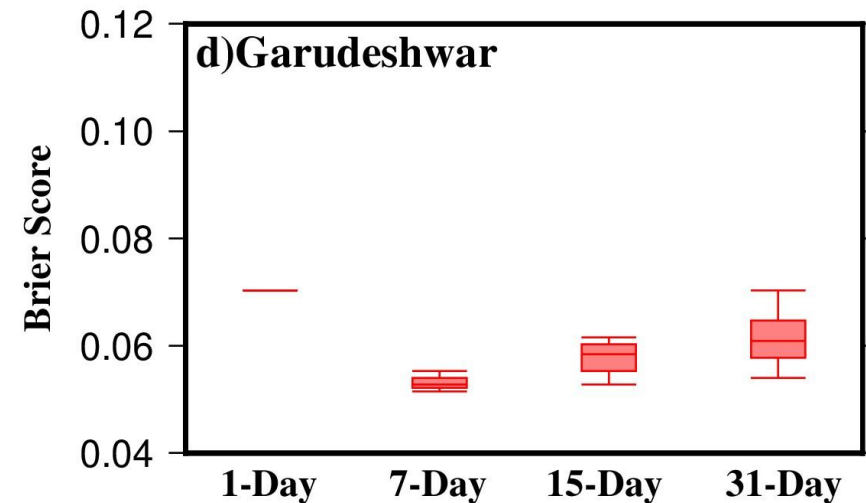
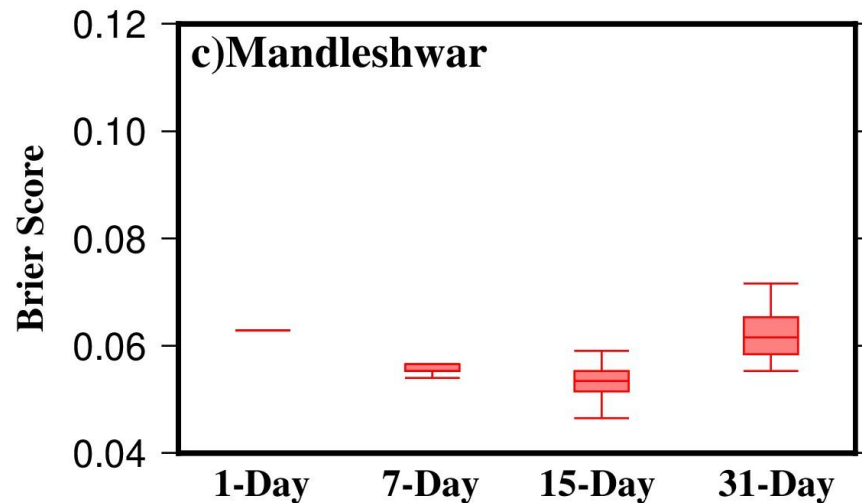
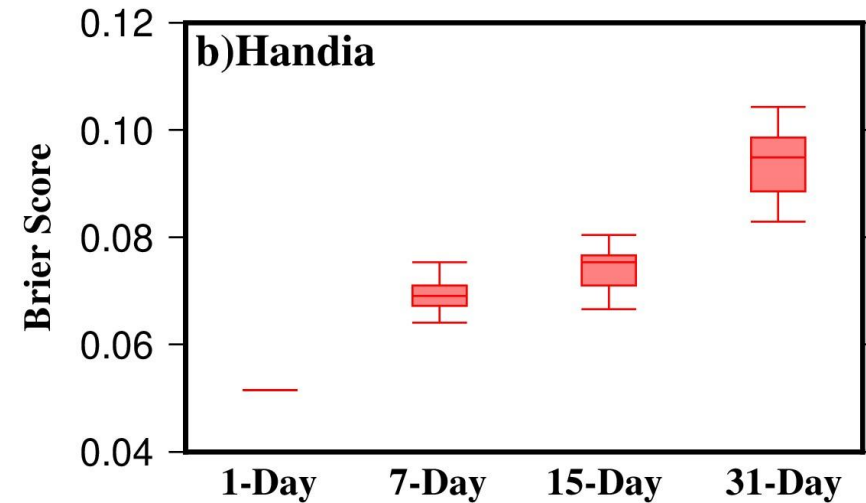
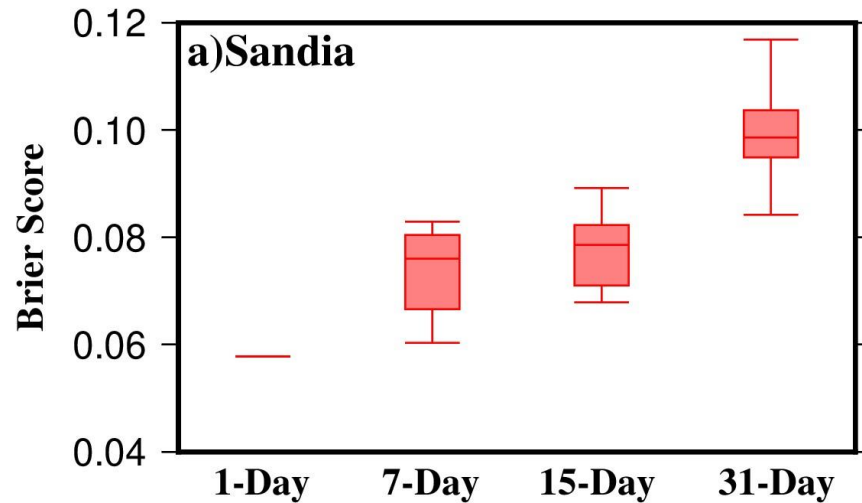


# Skill scores for ensemble forecasts

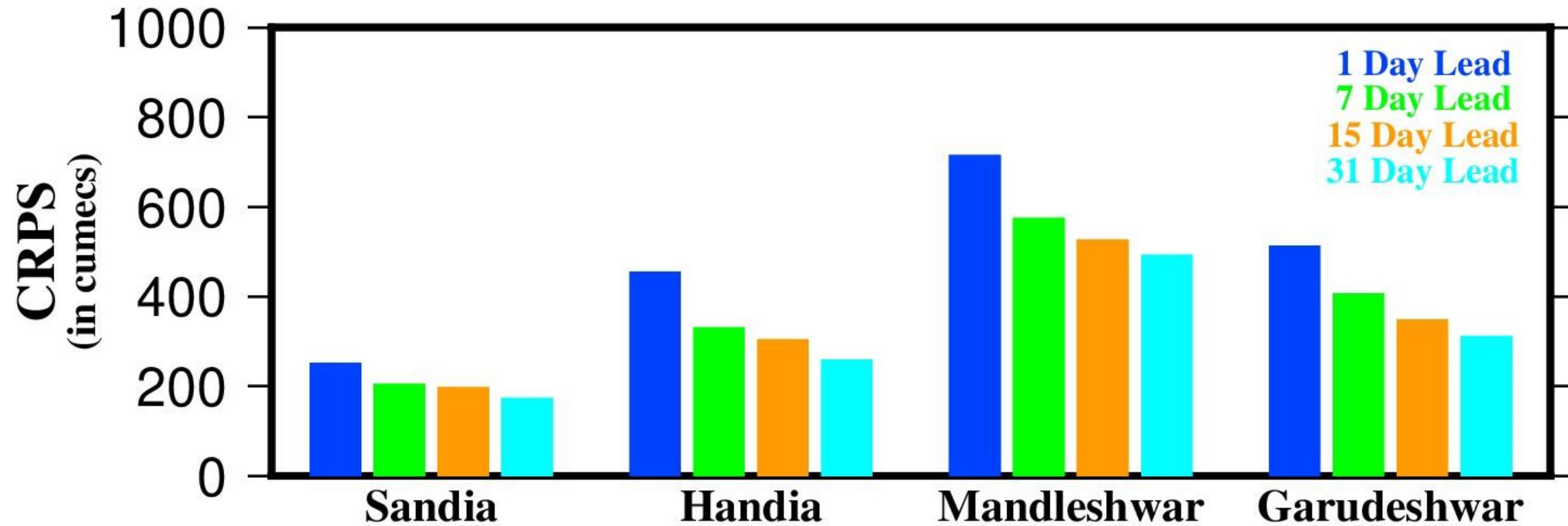
**Brier score** - Brier score calculates the mean squared error between predicted probabilities and the observed values (actuals). The value of the Brier score is always between 0.0 and 1.0, where a model with perfect skill has a score of 0.0 and the worst has a score of 1.0.<sup>[5]</sup>

**Continuous ranked probability score** - CPRS is one of the most widely used accuracy metrics where probabilistic forecasts are involved. The Continuous Ranked Probability Score (CRPS) generalizes the Mean Absolute Error (MAE) to the case of probabilistic forecasts.

# Skill of Ensemble Forecast (Brier Score)



# Skill of Ensemble Forecast (CRPS)



# References

1. Najafi, Mohammad Reza, Hamid Moradkhani, and Thomas C. Piechota. "Ensemble streamflow prediction: climate signal weighting methods vs. climate forecast system reanalysis." *Journal of Hydrology* 442 (2012): 105-116.
2. Dang, Thanh Duc, AFM Kamal Chowdhury, and Stefano Galelli. "On the representation of water reservoir storage and operations in large-scale hydrological models: implications on model parameterization and climate change impact assessments." *Hydrology and Earth System Sciences* 24.1 (2020): 397-416.
3. Dang, Thanh Duc, et al. "A software package for the representation and optimization of water reservoir operations in the VIC hydrologic model." *Environmental Modelling & Software* 126 (2020): 104673.
4. Liang, Xu, et al. "A simple hydrologically based model of land surface water and energy fluxes for general circulation models." *Journal of Geophysical Research: Atmospheres* 99.D7 (1994): 14415-14428.
5. <https://www.machinelearningplus.com/statistics/brier-score/>

Thank you.