Hydrologic Modelling of Narmada Basin by using GWAVA Model

Collaborative Work with CEH, United Kingdom

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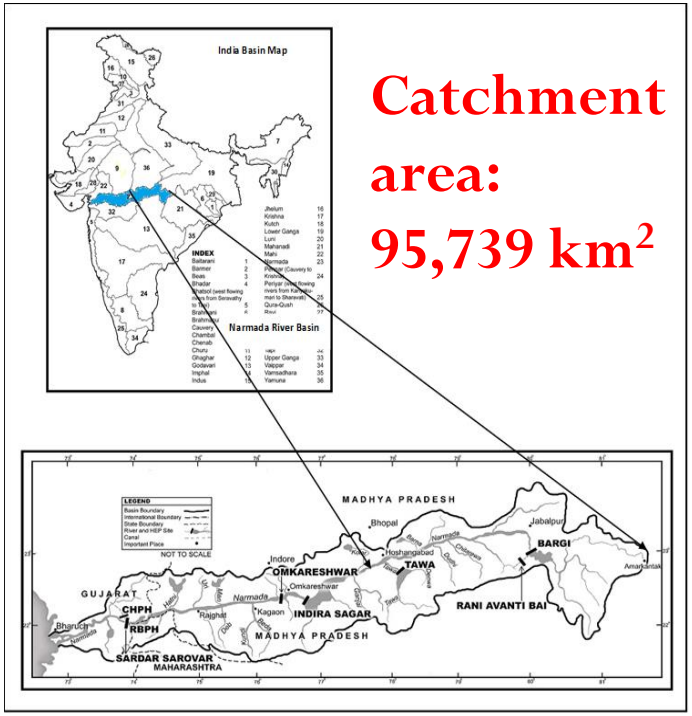
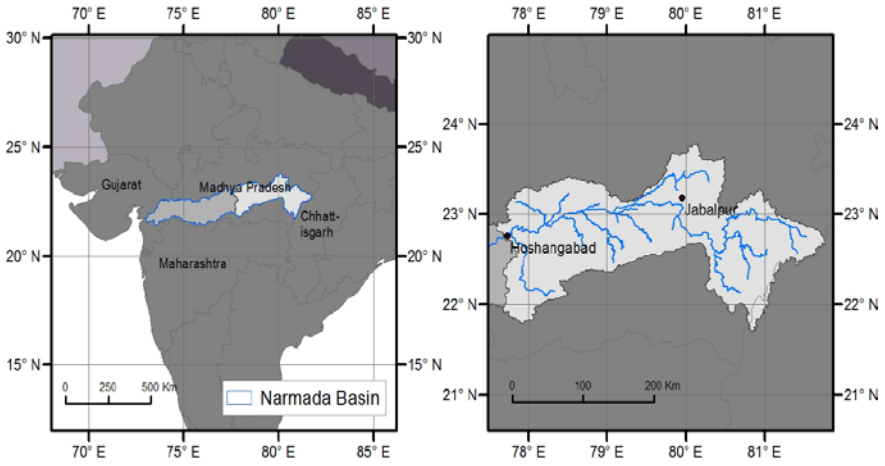
Objectives

- To simulate hydrologic response of the study area by using **G**lobal **W**ater **AVA**ilability (GWAVA) model.
- To investigate the impact of land use change on hydrologic response of the study area.
- To estimate flows at ungauged locations by using model results.
- To investigate the impact of landuse and climate change on hydrologic response of the study area.

Study Area





- Narmada river is the largest perennial west flowing river in Central India, flowing through three states.
- Study area: Narmada basin up to Hoshangabad GD site; **to be extended to whole basin later.**
- Intensive development; three large dams, Tawa, Bargi and Barna.
- Significant landuse changes are taking place.
- Climate change scenario analysis is helpful for assessment of water stress and extreme events due to its impacts.

GWAVA Model Capabilities

- GWAVA: **Global Water AVailability Assessment;** a model developed by Centre for Ecology & Hydrology, UK.

- Based on the water balance; can incorporate reservoirs, abstractions, and water transfers, which modify water quantity and flow regime.

- The model typically operates on 0.5 degree latitude-longitude grid. Grid size is selected based on the availability of data.

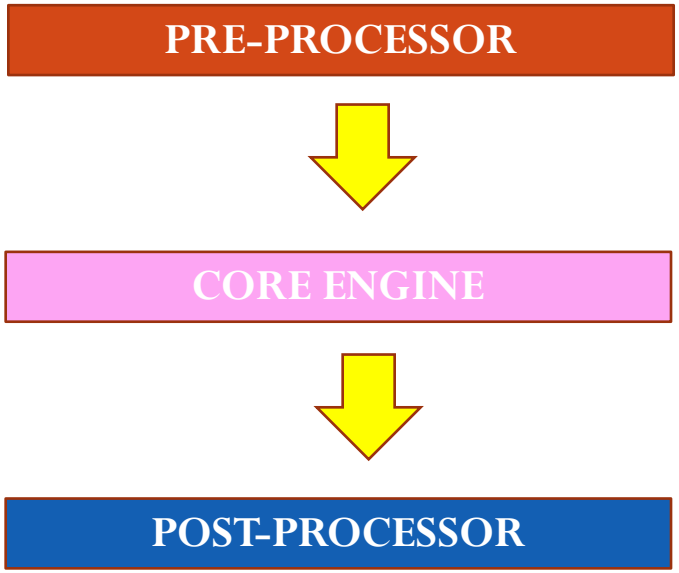
- Model outputs include simulated daily/monthly flows and a cell-by-cell comparison of water availability.

- GWAVA can be used to examine scenarios of change – catchment, climate and water demands.

- GWAVA has been applied to river basins in different countries.

Model working

GWAVA MODULES



- ✓ Converts ASCII input files into a binary file,
- ✓ Checks the data for anomalous values.

- ✓ Reads the pre-processed files,
- ✓ Runs the water balance model
- ✓ Generates the water availability indices.

- ✓ Interprets the data that is produced by the core engine;
- ✓ Creates outputs in various formats required by the user.

Input files

COMPULSORY INPUT FILES

- ✓ physical parameters
- ✓ general water demands
- ✓ climate data

OPTIONAL INPUT FILES

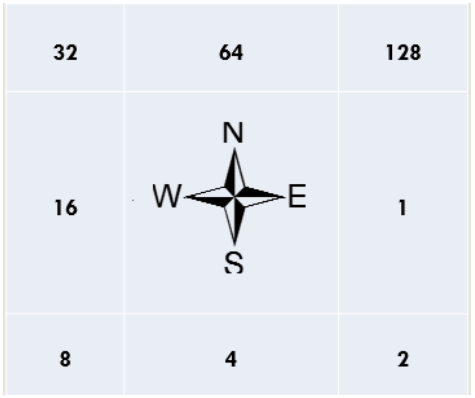
- ✓ sub-catchment calibration information
- ✓ mountainous region information
- ✓ glacier information
- ✓ transfers between cells
- ✓ daily water demands
- ✓ groundwater availability
- ✓ climate scenarios

Physical parameters file

- x-coordinate
- y-coordinate
- sub-catchment code
- mountain region code
- area of cell (km^2)
- flow direction
- soil class proportional loss
- routing parameter
- lake (%)
- wetland (%)
- lake characteristic: shape parameter
- lake characteristic: surface area (km^2)
- lake characteristic: capacity (Mm^3)
- lake characteristic: outflow constant
- lake characteristic: outflow power

How Coding works

GWAVA MODULE – HOW THE CODING WORKS?



Coding pattern to explain Flow Direction

Soil Class No.	Description
1	sand
2	sandy loam
3	silt loam
4	clay loam
5	clay
6	lithosol
7	organic

Coding pattern to explain Soil Class

In the similar fashion, codes has been assigned for every inputs like land category, lake category, etc.

Data requirement

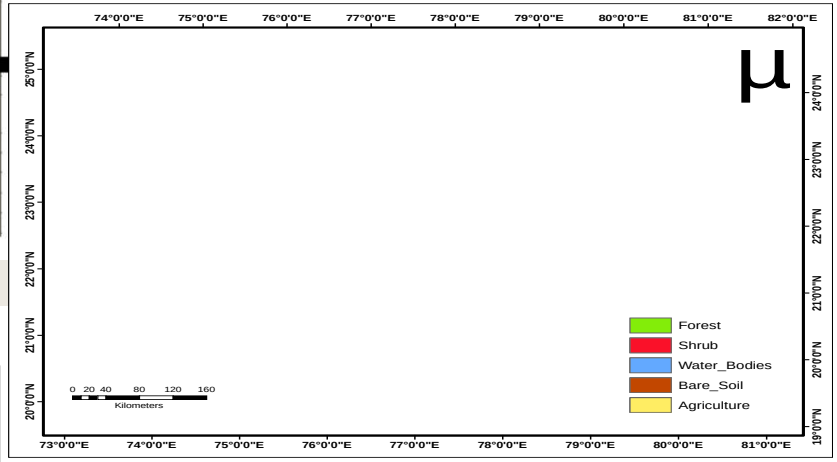
Inputs for first tier GWAVA Application

- Spatially and temporally explicit inputs
  - Rainfall, temperature (daily)
  - Potential evapotranspiration or wind speed + relative humidity + solar radiation (daily)

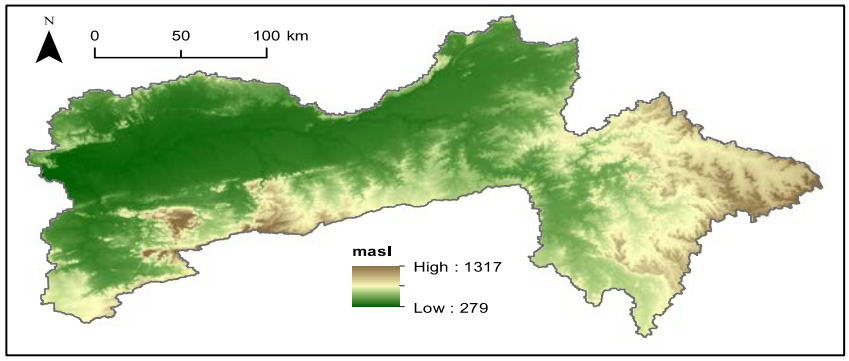
- Spatially explicit inputs
  - Elevation & flow direction grid
  - Coverage by different irrigated crop types
  - Drainage and other location of water bodies
  - Soil type and texture
  - Land use/land cover
  - Lake, reservoir and wetland parameters (areal cover, maximum water volume, vertical shape, type of reservoir)
  - Urban and rural water demand per capita/ Industrial water demand
  - Rural population/ Total population; Cattle, sheep and goat population

Some Spatial Inputs

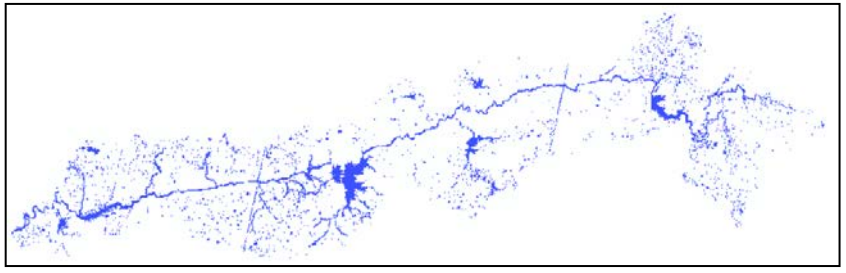
Grid Size : 0.125 x 0.125 degree Total grids: 661



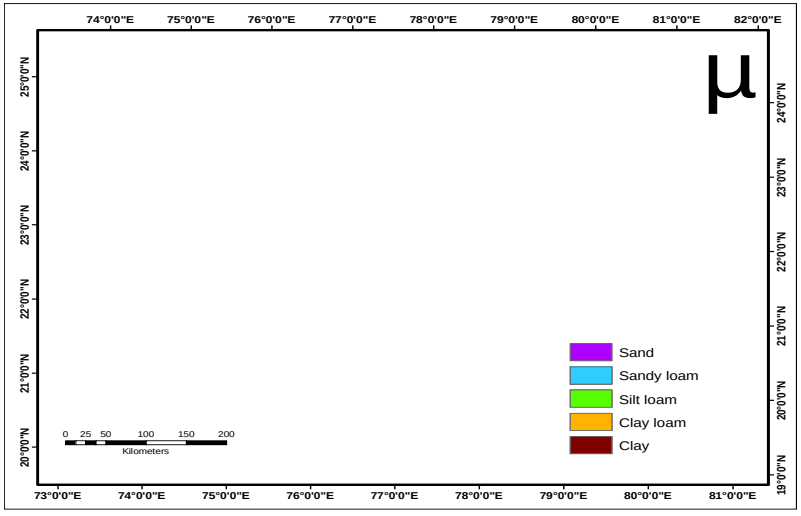
LULC map



DEM



Waterbodies



Soil map

All these data layers have been reclassified as per GWAVA classification scheme in ArcGIS and data extracted in ASCII format, which forms basic input to the model.

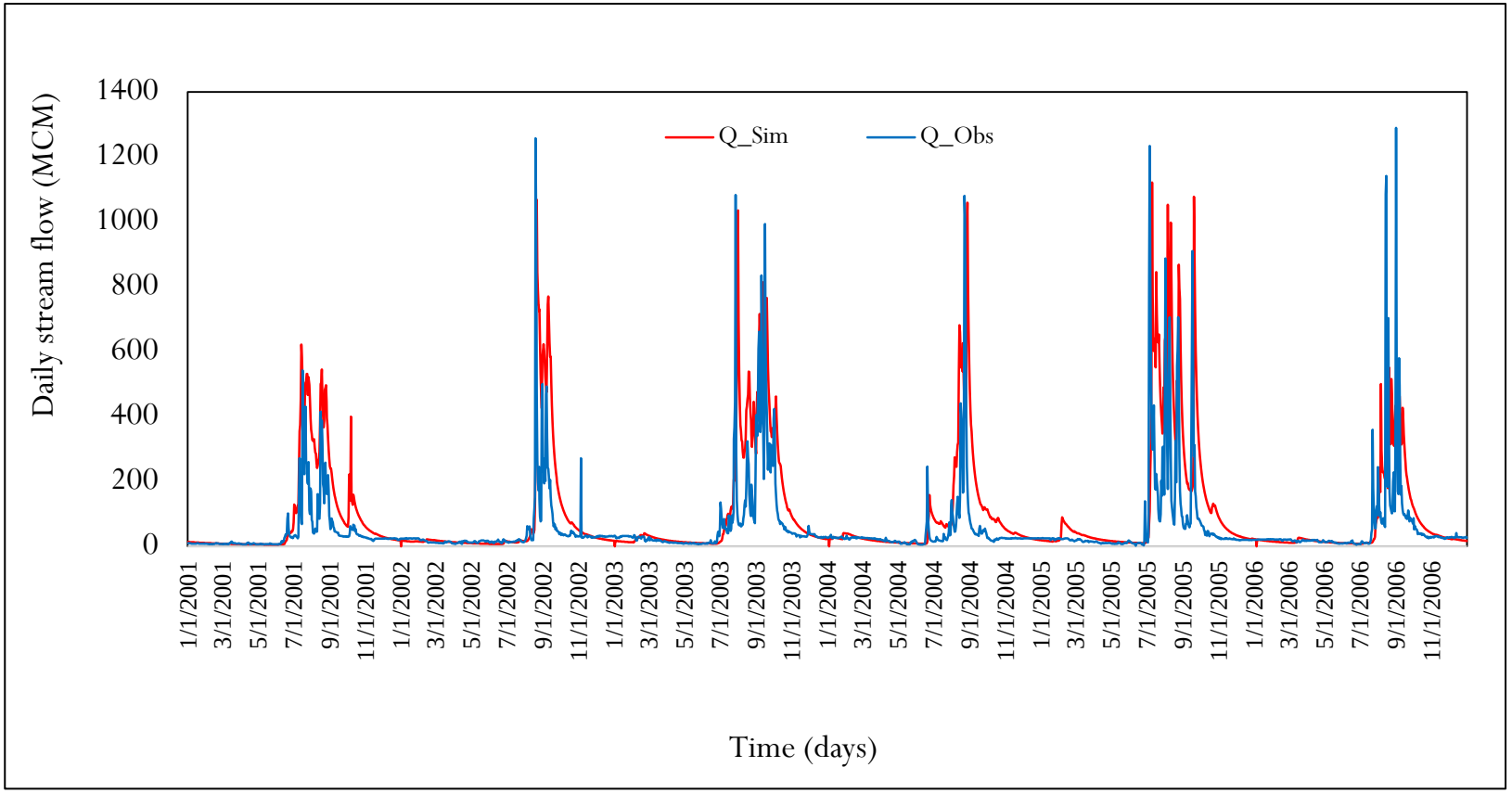
Input Data

- Rainfall data provided by the India Meteorological Department (IMD) was used.
- Processed gridded RF is available at 0.25*0.25 degree grids.
- In the present study, smaller gird size of 0.125 * 0.125 degree was adopted.
- Temperature (maximum and minimum) gridded data was available at 0.5*0.5 degree grids.
- Flow data was obtained from the sites of Central Water Commission (CWC) – typically discharge is measured daily.

Modeling Steps

- The mandatory input files viz., Physical Parameter files, Water Demand Files and Climate Files have been prepared.
- The source code has been updated many times to remove the bugs and consider smaller gird size of 0.125 degree.
- Due to the use of a fine grids size, model code required changes.
- The pre-processor of the model was also updated to remove some bugs those arose due to use of small grid size.
- The cropping pattern data (season-wise) has been prepared (model can consider 7 types of crops).

Model early run

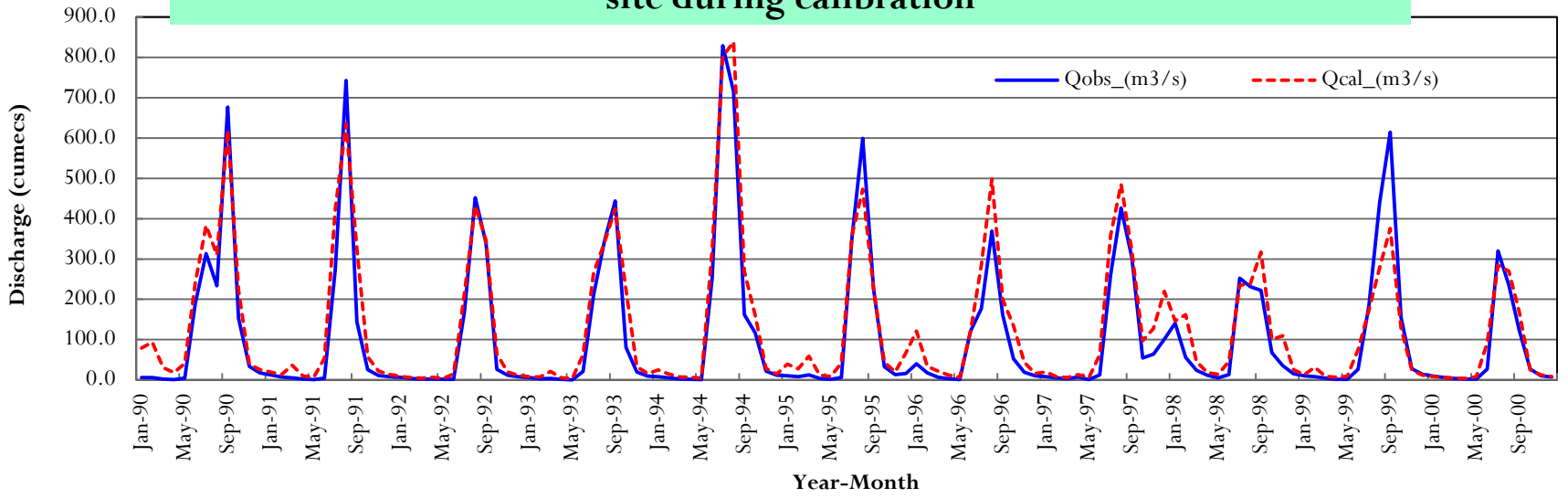


*Comparison of observed and simulated daily flows for the **early run** at Hoshangabad (without the incorporation of Bargi, Tawa and Barna reservoirs)*

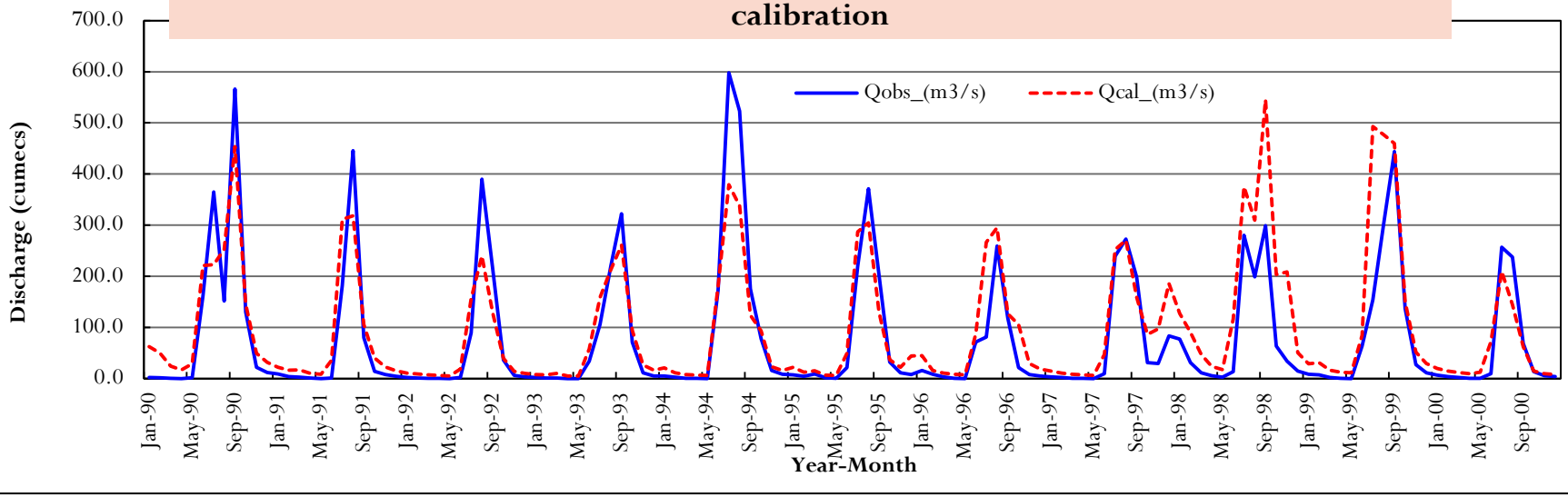
Model Set up and Calibration

- In the initial runs, it was observed that the boundary cells were not contributing flow to the outlet.
- The bug was removed to ensure that the boundary cells too contribute to the flows at the gauging sites.
- Next, three reservoirs including their hydrologic particulars, water spread area, command area and cropping pattern were incorporated in the model.
- Multi-site calibration considering the 5 GD sites viz., Manot, Mohgaon, Patan, Belkheri (on the tributaries) and Hoshangabad (on the main river) has been completed.

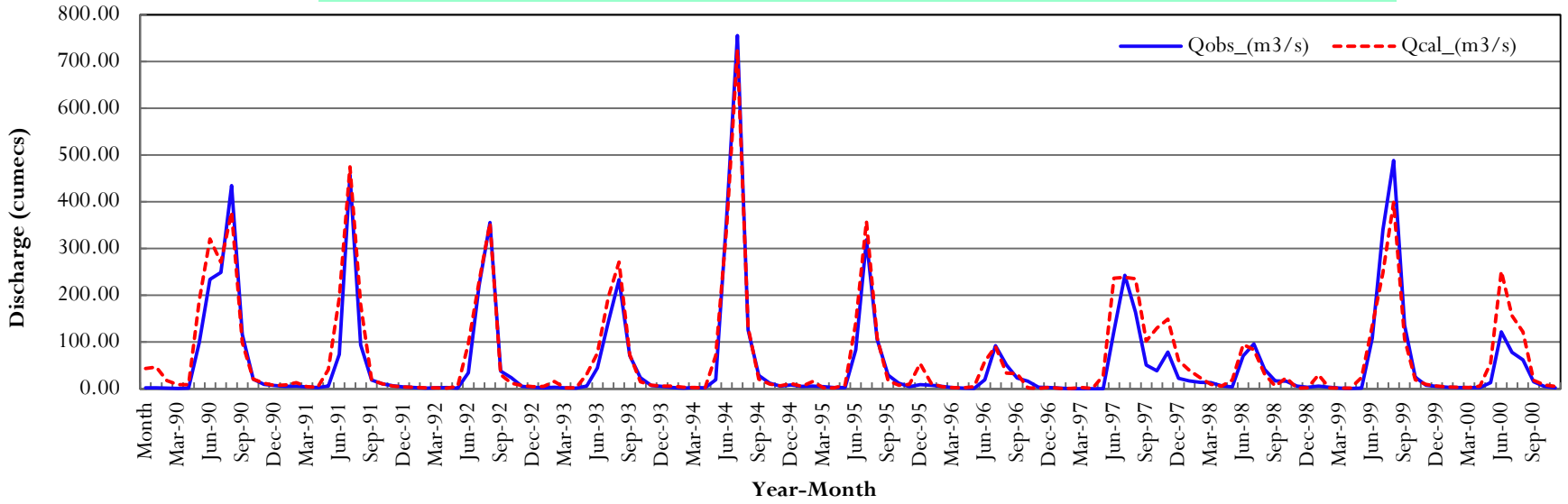
Comparison of Observed and Simulated Monthly Discharges at Manot GD site during calibration



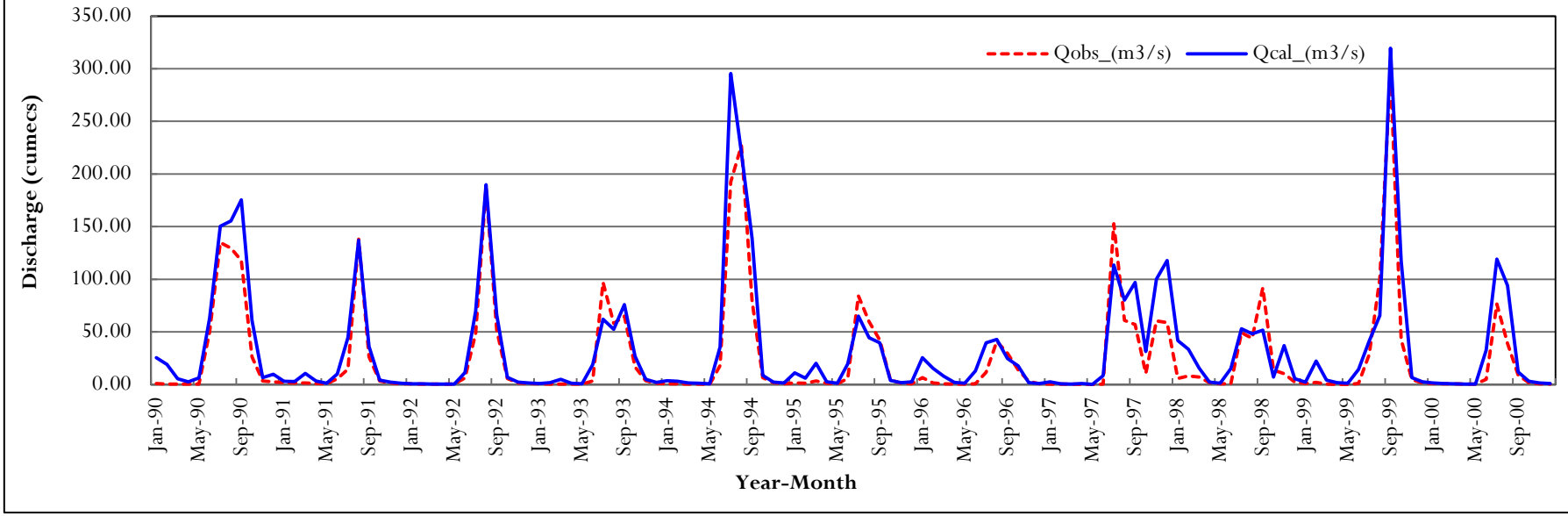
Comparison of Observed and Simulated Monthly Discharges at Mohgaon GD site during calibration



Comparison of Monthly Observed and Simulated Discharge at Patan during calibration



Comparison of Observed and Simulated Monthly Discharge at Belkheri at GD site during calibration



RESULTS

Calibrated parameters and NSE (Daily time step)

Sub-catchment	b	fact	Srout	Grout	facemelt	tempsnow	tempmelt	bfpowerg	NSE
Manot	1.319	1.969	0.983	2.118	4	2	1	3	0.427
Mohgaon	1.376	2.854	0.957	0.210	4	2	1	3	0.409
Patan	0.764	3.875	0.972	4.673	4	2	1	3	0.746
Belkheri	2.891	3.610	0.991	7.086	4	2	1	3	0.274
Hoshangabad	0.630	3.760	0.861	33.04	4	2	1	3	0.361

Calibration run: 1990-2000
Validation run : 2001-2010

NSE (Monthly time step)

Sub-catchment	**NSE**
Manot	0.899
Mohgaon	0.730
Patan	0.886
Belkheri	0.954
Hoshangabad	0.822

Future Actions

- Set up a fully tested and calibrated GWAVA model for Narmada basin up to Hoshangabad (after calibration and testing with independent data).

➢ Upscale the model for the entire Narmada basin.

➢ Environmental flow assessment.

➢ Stakeholder workshop.

Future Plans

- Generate future land use scenarios and run model.
- Analyze outputs for future land use change scenario runs.
- Generate future climate scenarios for the model.
- Produce outputs for future climate change scenarios.
- Disseminate findings and interact with stakeholders.

➢ Extend the work to other basins.

Meteorological Data Products from IMD

- Everyday meteorological forecasts for the next 10 days at 12 km * 12 km (global).
- Everyday meteorological forecasts for the next 7 days at 28 km * 28 km (global) – 21 members.
- Every Thursday meteorological forecasts for the next 4 weeks at 100 km * 100 km (global) – 16 members.
- Every month meteorological forecasts for the next 9 days at 38 km * 38 km (global) – 15 members.

National Centre for Medium Range Weather Forecasting (NCMRWF)

Centre of Excellence in Weather and Climate Modelling under the Ministry of Earth Sciences

10-DAY FORECAST

- **Variables:**
  - **Rainfall,**
  - **Temperature**
  - **Wind speed**
  - **Relative Humidity**

- A Unified Model based 45 members (44 + 1 control) Global Ensemble Prediction System with horizontal resolution of ~33 km and 70 vertical levels.
- 44 members – based on different initial conditions
- The forecast perturbations from 6 hr short forecast run of 45 members - updated four times a day (00, 06, 12 and 18 UTC).
- 10 day forecast generated everyday

http://www.ncmrwf.gov.in/

Thanks