Hydrological Simulation Report for the Upper French Broad

1. Title and Basin Information

Basin & Gauge Map

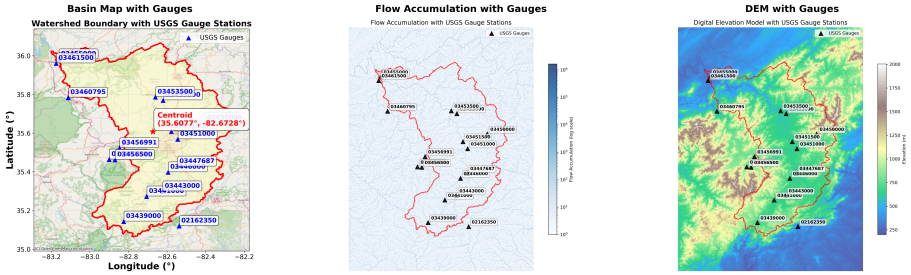

Figure 1: Basin & Gauge Map

Basin Introduction
The Upper French Broad basin encompasses an area of approximately 4867.99 km², with varied topographical features ranging from high-elevation areas above 1500 m in the western and southern fringes to lower terrain of around 500 m near the southeastern boundary. USGS gauge #03455000, located at (35.981611, -83.161088), serves as a key monitoring point for hydrological studies.

2. Fundamental Basin Data

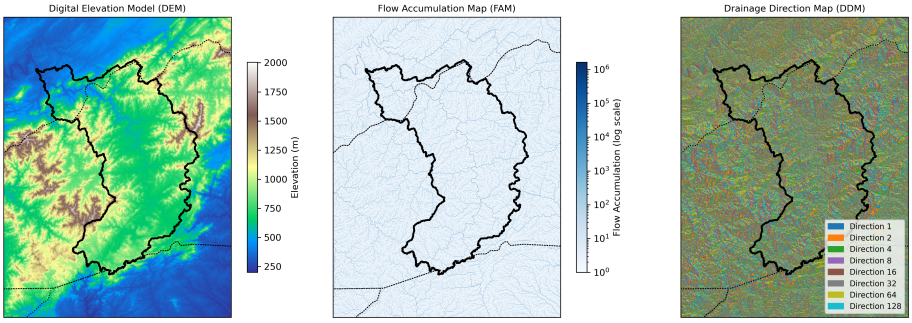

Figure 2: Fundamental Basin Data

- **DEM (Digital Elevation Model)**
The localized relief showcases higher altitudes in the west and south, gently sloping toward the main channel in the southeast.

- **FAM (Flow Accumulation Map)**

Flow lines converge into trunk streams, indicating steeper gradients in mountainous areas transitioning to flatter regions downstream.

- **DDM (Drainage Direction Map)**

Color-coded flow directions reveal a dense drainage network in hilly sections, exhibiting swift runoff in elevated areas and converging channels in lower plains.

3. Analysis Sections

3.1 Simulation vs Observation

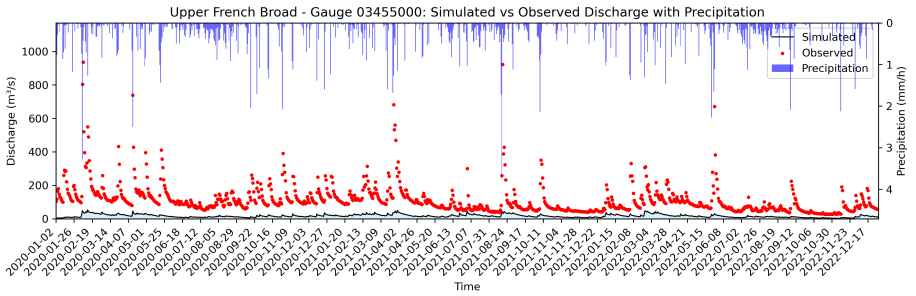

Figure 3: Simulation Results

The observed discharge (red circles) shows peaks exceeding 800–900 m^3/s during major rainfall events. The simulated discharge (black line) generally tracks the observed values but underestimates peak flows and exhibits slight delays in the rising limb. Precipitation (blue bars) is plotted as hourly intensity (mm/h). While baseflow and moderate events are captured reasonably well, high-flow conditions require further calibration to reduce bias and improve timing.

3.2 Model Performance Metrics

Below is a summary of the performance metrics for the simulation from 2020-01-01 to 2022-12-31:

Metric	Value
Nash-Sutcliffe (NSCE)	-1.048
Kling-Gupta (KGE)	-0.299
Correlation	0.605
Bias (m^3/s)	-95.22 (-85.0%)
RMSE (m^3/s)	126.54

The negative NSCE and KGE indicate the model underperforms with respect to observed data at high flows. The bias of -85% underscores the need to adjust parameters to increase simulated outputs, particularly during large storm events.

3.3 CREST Parameters

3.3.1 Water Balance Parameters

Parameter	Value	Description
WM (mm)	200.0	Maximum soil water capacity (higher values allow soil to hold more water, reducing runoff).
B (–)	10.0	Infiltration curve exponent (higher values reduce infiltration, increasing runoff).
IM (–)	0.15	Impervious area ratio (higher values represent larger urbanized areas increasing direct runoff).
KE (–)	0.8	PET adjustment factor (higher values increase evapotranspiration losses, reducing streamflow).
FC (mm/hr)	50.0	Soil saturated hydraulic conductivity (higher values allow easier soil infiltration, reducing runoff).
IWU (mm)	25.0	Initial soil water content (higher initial moisture means less storage capacity, increasing runoff early in simulation).

3.3.2 Kinematic Wave (Routing) Parameters

Parameter	Value	Description
TH (km^2)	100.0	Drainage threshold (defines which cells are river channels; higher values yield fewer but larger channels).
UNDER (–)	1.0	Interflow speed multiplier (accelerates underflow movement).
LEAKI (–)	0.05	Interflow reservoir leakage coefficient (higher values increase subsurface drainage rate).
ISU (mm)	0.0	Initial interflow reservoir content (higher values may lead to increased early peak flow).
ALPHA (–)	1.5	Channel flow multiplier in Q = A^ (higher values slow wave propagation in the channel).
BETA (–)	0.6	Channel flow exponent in Q = A^ (larger exponents tend to slow flow response in channels).
ALPHA0 (–)	1.0	Overland flow multiplier (similar to ALPHA but for non-channel cells).

4. Conclusion and Discussion

Model Performance Evaluation

The current simulation underestimates peak flows, as indicated by a considerable negative bias (-85%) and negative efficiency metrics (NSE, KGE). A correlation of 0.605 suggests moderate alignment with the observed hydrograph,

but improvements are needed to capture storm-driven peaks and timing more accurately.

Warmup Period Considerations

Given the significantly high negative bias, a more extended warmup period or adjustment of the initial soil and interflow reservoir conditions (IWU, ISU) may help reduce early systematic errors. Increasing the infiltration capacity or altering imperviousness may also help refine runoff generation.

Recommendations for Simulation Period and Next Steps

- Refine and lengthen warmup to ensure initial states do not skew early-simulation flow volumes.
- Calibrate infiltration (B, FC) and impervious (IM) parameters to better match peak responses and overall volume.
- Investigate increasing the PET coefficient (KE) if overestimation of ET is leading to under-predicted streamflows, especially during high flows.
- Conduct sensitivity analyses to identify key parameters driving negative bias and refine them systematically.
- Extend the simulation period or include additional events if more robust statistics are needed to evaluate performance over various hydrologic conditions.

Data Tables

All Run Arguments (Basin Details)

Argument	Value	Description
Basin Name	Upper French Broad	Study region
Basin Area (km^2)	4867.99	Area of the watershed
Gauge ID	USGS #03455000	Reference hydrological station
Gauge Coordinates	(35.981611, -83.161088)	Latitude, Longitude
Simulation Start	2020-01-01	Initial date of simulation
Simulation End	2022-12-31	Final date of simulation

Performance Metrics

Metric	Value
NSCE	-1.048
KGE	-0.299
Correlation	0.605
Bias (m^3/s)	-95.22 (-85%)

Metric	Value
RMSE (m^3/s)	126.54

All CREST Parameters

Group	Parameter	Value	Description
Water Balance	WM	200.0	Max soil water capacity (mm)
Water Balance	B	10.0	Infiltration curve exponent
Water Balance	IM	0.15	Impervious area ratio
Water Balance	KE	0.8	PET adjustment factor
Water Balance	FC	50.0	Soil saturated hydraulic conductivity (mm/hr)
Water Balance	IWU	25.0	Initial soil water storage (mm)
Kinematic Wave Routing	TH	100.0	Drainage threshold (km^2)
Kinematic Wave Routing	UNDER	1.0	Interflow speed multiplier
Kinematic Wave Routing	LEAKI	0.05	Interflow reservoir leakage coefficient
Kinematic Wave Routing	ISU	0.0	Initial interflow reservoir (mm)
Kinematic Wave Routing	ALPHA	1.5	Channel flow multiplier ($Q = \quad A\hat{}$)
Kinematic Wave Routing	BETA	0.6	Channel flow exponent ($Q = \quad A\hat{}$)
Kinematic Wave Routing	ALPHA0	1.0	Overland flow multiplier