Hydrological Analysis of the Upper French Broad Basin

1. Introduction to the Upper French Broad Basin

The Upper French Broad River Basin, located in the southeastern United States, encompasses an area of 4867.99 km^2. This report details a hydrological simulation conducted for the period from January 1, 2020, to December 31, 2022, focusing on streamflow at USGS gauge #03455000 (35.981611, -83.161088). This analysis aims to evaluate the performance of the CREST hydrological model in replicating observed streamflow dynamics within the basin.

2. Basin & Gauge Map

The Upper French Broad basin has a teardrop shape, oriented north-south. USGS gauge 03455000 is centrally located within the basin, with downstream gauges including 03447687, 03444000, 02162350, and 03439000. Higher elevations are present in the northern portion of the basin. The basin centroid is located at approximately 35.607° N, -82.6728° W.

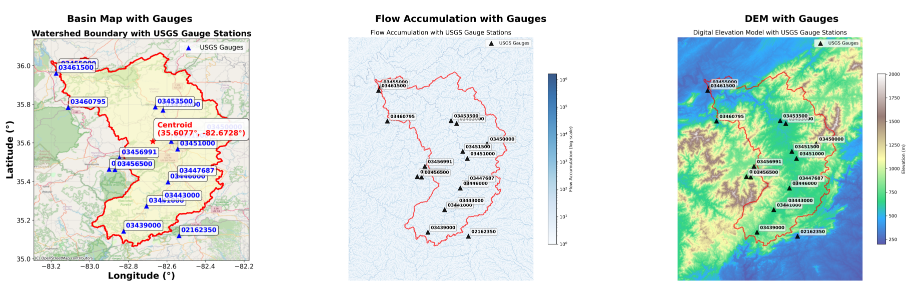

Figure 1: Basin & Gauge Map

3. Fundamental Basin Data

The Digital Elevation Model (DEM) confirms significant relief, ranging from approximately 250m in the south to over 2000m in the northern portion of the basin. The Flow Accumulation Map (FAM) delineates the main channel network, with high accumulation values corresponding to major river courses. The Drainage Direction Map (DDM) shows a complex drainage pattern, with high drainage density in steeper regions.

4. Simulation vs. Observation

The hydrograph plot compares simulated (black line) and observed (red dots) discharge values at gauge 03455000, alongside precipitation data (blue bars). The simulated hydrograph generally follows the shape of the observed data but

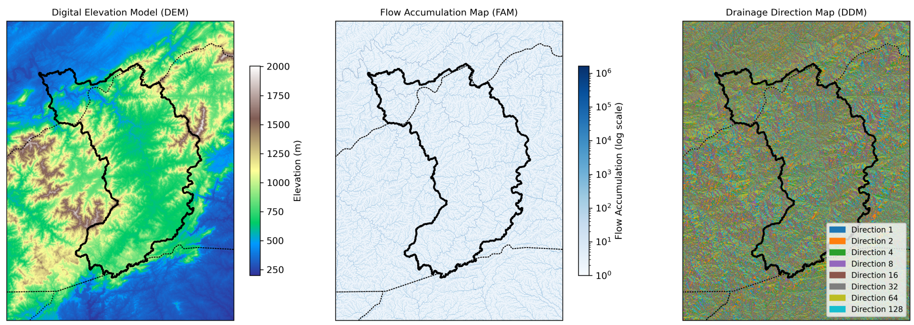

Figure 2: Fundamental Basin Data

with significant underestimation. The model captures some peak timing, but simulated peaks are much smaller than observed peaks. There is a clear negative bias, with simulated discharge consistently lower. Precipitation events correlate with peaks in the observed hydrograph, suggesting a rainfall-driven system. The simulation seems to miss the magnitude of response to precipitation events, suggesting potential issues with parameterization related to runoff generation, baseflow, or routing.

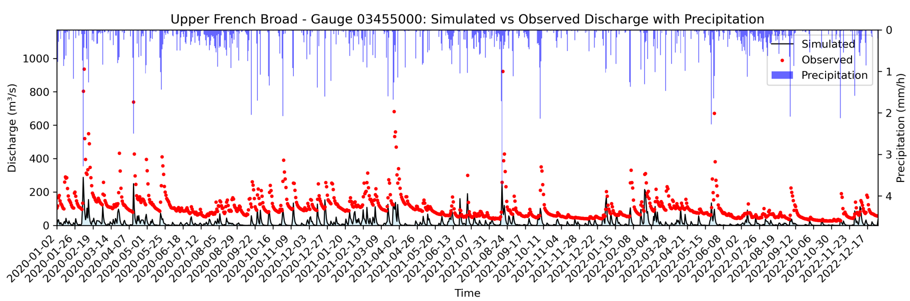

Figure 3: Simulation vs Observation

5. Model Performance Metrics

Metric	Value
Nash-Sutcliffe Efficiency (NSCE)	-0.845
Kling-Gupta Efficiency (KGE)	-0.142
Correlation Coefficient	0.582
Bias (m^3/s)	-93.92
Bias (%)	-83.9%
Root Mean Square Error (RMSE) (m^3/s)	120.09

6. CREST Model Parameters

6.1 Water Balance Parameters

Parameter	Value	Description
Water capacity ratio (WM)	200.0	Maximum soil water capacity in mm.
Infiltration curve exponent (B)	10.0	Controls water partitioning to runoff.
Impervious area ratio (IM)	0.12	Represents urbanized areas.
PET adjustment factor (KE)	0.85	Affects potential evapotranspiration.
Soil saturated hydraulic conductivity (FC)	75.0	Rate at which water enters soil (mm/hr).
Initial soil water value (IWU)	25.0	Initial soil moisture (mm).

6.2 Kinematic Wave (Routing) Parameters

Parameter	Value	Description
Drainage threshold (TH)	50.0	Defines river cells based on flow accumulation (km^2).
Interflow speed multiplier (UNDER)	1.8	Higher values accelerate subsurface flow.
Interflow reservoir leakage coefficient (LEAKI)	0.6	Higher values increase interflow drainage rate.
Initial interflow reservoir value (ISU)	0.0	Initial subsurface water.
Channel flow multiplier (ALPHA)	0.8	In Q = A equation.
Channel flow exponent (BETA)	0.6	In Q = A equation.
Overland flow multiplier (ALPHA0)	0.8	Similar to ALPHA but for non-channel cells.

7. Run Arguments (Basin Details)

Argument	Value
Basin Area (km^2)	4867.99
Start Date	2020-01-01
End Date	2022-12-31

Argument	Value
Gauge ID	03455000
Gauge Latitude	35.981611
Gauge Longitude	-83.161088

8. Conclusion/Discussion

The hydrological simulation of the Upper French Broad basin using the CREST model demonstrates limited success in accurately replicating observed streamflow, as indicated by the performance metrics. The NSCE of -0.845 and KGE of -0.142 suggest a poor model fit. The correlation coefficient of 0.582 indicates some agreement in the timing of flow variations, but the significant negative bias of -93.92 m^3/s (-83.9%) highlights a substantial underestimation of streamflow.

Given the substantial negative bias (>-90%), it is essential to consider the impact of the initial model state and the necessity of a sufficient warmup period. It is possible that the initial soil moisture conditions were not adequately calibrated, leading to an underestimation of baseflow and overall discharge.

Recommendations:

1. **Extend Simulation Period:** Expanding the simulation period to include a longer warmup period (e.g., 1-2 years prior to 2020) can help stabilize the model state and reduce the impact of initial conditions on the results.
2. **Parameter Calibration:** Conduct a sensitivity analysis to identify the most influential parameters affecting streamflow simulation. Focus on calibrating parameters related to baseflow (e.g., LEAKI), runoff generation (e.g., B, FC), and PET (KE).
3. **Data Quality Assessment:** Ensure the quality and consistency of both precipitation and streamflow data used for model calibration and validation. Investigate potential data gaps or errors that might affect model performance.
4. **Model Structure Review:** Consider refining the model structure to better represent the hydrological processes in the Upper French Broad basin. This may involve incorporating additional processes such as groundwater interaction or snowmelt, if applicable.

By addressing these points, the accuracy and reliability of hydrological simulations for the Upper French Broad basin can be significantly improved. Further analysis and refinement are needed to ensure robust and dependable streamflow predictions for water resource management and decision-making purposes.