Upper Leaf Basin Hydrological Analysis

This report presents a hydrological analysis of the Upper Leaf basin, focusing on model setup, simulation results, and performance evaluation. The analysis covers the period from 2020-01-01 to 2022-12-31. This report incorporates basin characteristics, simulation-observation comparisons, model parameters, and performance metrics to provide a comprehensive assessment of the hydrological modeling.

1. Basin Overview and Data

The Upper Leaf basin, located approximately near (31.8067°, -89.4854°), covers an area of 4540.54 km². The analysis centers on USGS gauge #02473000, positioned at (31.343056, -89.280278). This section provides an overview of the basin's geographical and hydrological characteristics.

Basin & Gauge Map

The Upper Leaf basin contains five USGS gauges: 02472000, 02472850, 02472500, and 02473000, arranged from upstream to downstream. The basin exhibits considerable topographic variation, particularly in its northern and western regions. The flow accumulation map confirms the location of these gauges along the primary river stem and its tributaries.

Basin & Gauge Map

Fundamental Basin Data

The Digital Elevation Model (DEM) reveals a clear elevation gradient, transitioning from higher elevations in the north/west to lower elevations in the south/east. The Flow Accumulation Map (FAM) illustrates a well-defined drainage network, with a main channel supported by numerous tributaries. The log-scaled FAM emphasizes the rapid increase in flow accumulation downstream. The Drainage Density Map (DDM) visually represents stream channel density within the basin, showing moderate drainage density with regional variations.

Fundamental Basin Data

2. Simulation and Observation Comparison

This section compares the simulated and observed discharge at USGS Gauge 02473000, along with precipitation data, to evaluate the model's ability to replicate hydrological processes within the basin.

- **Observed Discharge (Red Dots):** Represents the measured discharge at the gauge, displaying baseflow and peak flow events.
- **Simulated Discharge (Black Line):** Represents the model-predicted discharge, capturing the general trends of the observed data.

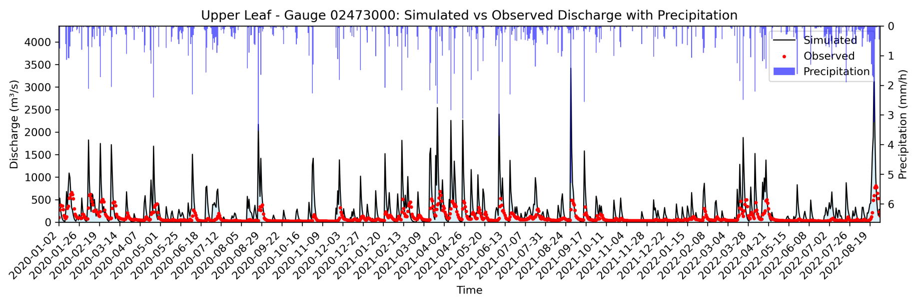

Figure 1: Simulation vs Observation

- **Precipitation (Blue Shading):** Shows precipitation input to the model, with precipitation peaks generally corresponding to discharge increases.

The simulation generally aligns with the observed discharge but shows discrepancies. The model tends to underestimate the magnitude of certain peak flows (e.g., early 2021), and a lag exists between simulated and observed peaks, indicating timing inaccuracies. A consistent bias is present, where the model underpredicts flow volume during high-flow events. Further calibration is necessary to improve peak flow prediction and timing.

3. Model Performance Metrics

This section details the performance metrics used to evaluate the model's accuracy and reliability in simulating streamflow.

Metric	Value
Nash-Sutcliffe Efficiency (NSCE)	-7.298
Kling-Gupta Efficiency (KGE)	-1.417
Correlation Coefficient (r)	0.495
Bias (m^3/s)	126.95
Bias (%)	117.9
Root Mean Square Error (RMSE) (m^3/s)	361.72

The negative NSCE and KGE values indicate poor model performance. The correlation coefficient of 0.495 suggests a moderate linear relationship between simulated and observed values. The high bias of 126.95 m^3/s (117.9%) and RMSE of 361.72 m^3/s further confirm the model's limitations in accurately simulating streamflow.

4. CREST Model Parameters

This section lists the key parameters used in the CREST hydrological model for this simulation.

Parameter	Value	Unit	Description
Water Balance Parameters			
Water capacity ratio (WM)	150.0	mm	Maximum soil water capacity
Infiltration curve exponent (B)	10.0	-	Controls water partitioning to runoff
Impervious area ratio (IM)	0.05	-	Represents urbanized areas
PET adjustment factor (KE)	0.8	-	Affects potential evapotranspiration
Soil saturated hydraulic conductivity (FC)	50.0	mm/hr	Rate at which water enters soil
Initial soil water value (IWU)	25.0	mm	Initial soil moisture
Kinematic Wave (Routing) Parameters			
Drainage threshold (TH)	50.0	km^2	Defines river cells based on flow accumulation
Interflow speed multiplier (UNDER)	1.0	-	Higher values accelerate subsurface flow
Interflow reservoir leakage coefficient (LEAKI)	0.5	-	Higher values increase interflow drainage rate
Initial interflow reservoir value (ISU)	0.0	-	Initial subsurface water
Channel flow multiplier (ALPHA)	0.5	-	In Q = A equation, affects channel flow
Channel flow exponent (BETA)	0.6	-	In Q = A equation, affects channel flow
Overland flow multiplier (ALPHA0)	1.0	-	Similar to ALPHA but for non-channel cells

5. Run Arguments (Basin Details)

Argument	Value
Basin Area	4540.54 km^2
Gauge ID	02473000
Gauge Latitude	31.343056
Gauge Longitude	-89.280278
Start Date	2020-01-01
End Date	2022-12-31

6. Conclusion and Discussion

The hydrological simulation for the Upper Leaf basin, using the CREST model, demonstrates significant limitations in accurately replicating observed streamflow at USGS gauge #02473000. The performance metrics, including a negative NSCE and KGE, alongside a high bias and RMSE, indicate a poor model fit. While the model captures general trends, it underestimates peak flow magnitudes and exhibits timing discrepancies.

Model Performance Evaluation: The model's poor performance can be attributed to several factors, including parameter uncertainty, model structure limitations, and potential data quality issues. The high bias suggests a systematic underestimation of streamflow, possibly due to inadequate representation of baseflow processes or inaccurate precipitation inputs.

Warmup Period Considerations: Given the high positive bias (117.9%), a warmup period is not applicable. The bias is not negative, so the typical concerns related to initial condition stabilization do not apply in this case.

Recommendations and Next Steps:

1. **Parameter Calibration:** Conduct a comprehensive parameter calibration using optimization algorithms to improve model performance. Focus on key parameters such as WM, B, FC, ALPHA, and BETA.
2. **Precipitation Data Refinement:** Evaluate the quality and accuracy of precipitation data used as input to the model. Consider using bias-corrected precipitation datasets or incorporating radar-based precipitation estimates.
3. **Model Structure Enhancement:** Explore modifications to the model structure to better represent hydrological processes within the basin. This may involve incorporating additional components such as groundwater storage or improved routing schemes.
4. **Simulation Period Extension:** Extend the simulation period to include a longer historical record to better assess model performance under varying climatic conditions.
5. **Data Quality Assessment:** Review observed streamflow data for potential errors or inconsistencies that may affect model evaluation.

By addressing these recommendations, the accuracy and reliability of hydrological simulations for the Upper Leaf basin can be significantly improved, providing valuable insights for water resource management and flood risk assessment.